AMOS Australian Meteorological & Oceanographic Society

ARC CENTRE OF EXCELLENCE FOR CLIMATE SYSTEM SCIENCE

AMOS/ARCCSS National Conference 2016

Minutes to Millennia

traversing the scales

MCEC, Melbourne, 8-11 February 2016

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Plenary Sessions

Session Time: MONDAY 09:30-10:15

RH CLARKE LECTURE

Detecting anthropogenic climate forcing in the ocean

Dr Susan Wijffels

CSIRO Oceans and Atmosphere

Owing to its immense heat capacity, the global ocean is the fly-wheel of the climate system, absorbing, redistributing and storing heat on long timescales and over great distances. Of the extra heat trapped in the Earth System due to rising greenhouse gases, over 90% is being stored in the global oceans. Tracking this warming has been challenging due to past changes in the coverage and technology used in past ocean observations. Here, I'll review progress in estimating past warming rates and patterns. The warming of Earth's surface is also driving changes in the global hydrological cycle, which also intimately involves the oceans. Global ocean salinity changes reveal another footprint of a warming Earth. Some simple model runs that give insight into observed subsurface changes will also be described, along with an update on current warming rates and patterns as tracked by the global Argo programme.

Plenary Sessions

Session Time: MONDAY 13:30-14:30

Hiatus on the global warming staircase

Prof Shang-Ping Xie

XIE Shang-Ping[1]; KOSAKA Yu[2]

1) Scripps Institution of Oceanography; 2) University of Tokyo

Since the 19th century, global-mean surface temperature (GMT) has risen in staircase-like stages due to contributions from both radiative forcing and internal variability. Our earlier study showed that tropical Pacific variability, specifically the La Nina-like cooling, caused the current hiatus of global warming. We have extended the Pacific Ocean-Global Atmosphere (POGA) pacemaker experiment back to the late 19th century, by restoring tropical Pacific sea surface temperature anomalies towards the observed history. POGA reproduces annual-mean GMT variability with high correlation. We quantify relative contributions from the radiative forcing and tropical Pacific variability for various epochs of the staircase. Beyond the global mean, POGA also captures observed regional trends of surface temperature for these periods, especially over the tropical Indian Ocean, Indian subcontinent, North and South Pacific and North America. The POGA effect for the recent hiatus is comparable in magnitude with that at the beginning of the 20th century, but lasts the longest in duration over the past 150 years. The attendant strengthening of the Pacific trade winds since the 1990s is unprecedented on the instrumental record.Intensive research on the early 21th century hiatus has generated a few controversies, including whether it is a hiatus, and how it will end (in the face of growing super El Nino). The presentation will discuss these issues and clarify some widespread misconceptions regarding ocean heat uptake related to the hiatus.

Plenary Sessions

Session Time: TUESDAY 09:00-09:45

PRIESTLEY MEDAL

Buoyancy in the global ocean circulation

A/Prof Andy Hogg

Australian National University

The ocean circulation is driven by a combination of mechanical wind stress on the ocean's surface and buoyancy fluxes, such as heating/cooling and freshening/salinification. There remains active debate in the oceanographic community about the relative importance of these two types of forcing. One point of view is that buoyancy fluxes applied at the surface put no net energy or momentum into the fluid when applied at a single level, and therefore cannot drive a circulation. However, observations and models both show that ocean circulation can be driven by buoyancy fluxes, even in the absence of mechanical forcing.

This talk will review the role of buoyancy in driving ocean currents and supplying energy to the ocean. It will include:

- An outline of the ocean energy budget in which the separate contributions of wind and buoyancy can be delineated;
- A review of the mechanisms by which buoyancy forcing can input momentum to the ocean, and thereby drive strong zonal flows (such as the Antarctic Circumpolar Current); and
- New work showing how surface buoyancy fluxes can modify surface potential vorticity and thereby drive mid-latitude gyres.

The goal is to reconcile wind-driven and buoyancy-driven views of ocean circulation into a consistent framework that informs efforts to understand the ocean's role in climate change.

Plenary Sessions

Session Time: TUESDAY 13:30-14:30

Attribution of extreme weather and climate-related events

Dr Peter Stott

UKMO

Whether it be fires in Australia or floods in Britain, in the aftermath of such devastating events the public and politicians alike want to know what caused them and whether human-induced climate change played a role. Event attribution studies seek to address these questions by determining to what extent anthropogenic climate change has altered their probability or magnitude of particular classes of events. Such studies have shown clear evidence for human influence having increased the probability of many extremely warm seasonal temperatures but the evidence for human influence on extreme precipitation events, droughts, and storms has been more mixed. Since my first and only previous visit to Australia in early 2013 there has been a rapid development of attribution science towards an operational capability. This talk explores this rapid progress and asks what is required for attribution to take its full part in climate services alongside climate monitoring and prediction.

Session Time: WEDNESDAY 09:00-09:45

From UV to climate extremes: the many influences of stratospheric ozone

Dr Julie Arblaster

Bureau of Meteorology & School of Earth, Atmosphere & Environment, Monash University

Since the discovery of the Antarctic ozone hole in the 1980s, extensive research has shown that manufactured chemicals, such as chlorofluorocarbons (CFCs), are the cause of ozone depletion in the upper atmosphere. The ozone layer, which sits in the stratosphere approximately 10-30 km above the Earth's surface, has been depleted by more than 50% of pre-1980 levels over Antarctica.

The ozone layer helps to protect us from the harmful effects of ultraviolet radiation. The good news is that the Montreal Protocol was ratified in 1987 to ban CFCs and other substances that destroy the ozone layer and is on track to restore ozone levels over Antarctica to 1980 levels by the middle to end of this century. Without the Montreal Protocol in place, one estimate suggests an additional one thousand or more skin cancer cases per million people per year would occur in Australia by 2030.

Over the past decade research has also established a connection between ozone depletion and climate patterns at the surface. A reduction in ozone has led to local cooling in the stratosphere over Antarctica, changing the temperature gradient between Antarctica and latitudes further north. Simultaneously, a strengthening and southward shift of the Southern Hemisphere mid-latitude jet located over Southern Ocean has been observed in austral summer. Robust evidence based on theoretical arguments as well as simple and comprehensive climate models has built a strong case for the dominance of ozone depletion in driving these summertime wind changes. The altered winds have associated impacts on the ocean circulation and rainfall patterns over the Southern Hemisphere. How the recovery of the ozone layer will interact with increasing greenhouse gases in driving future climate change in the Southern Hemisphere is currently uncertain.

Recent studies have also highlighted that short-term variability in stratospheric ozone over Antarctica is associated with surface temperature and rainfall changes on daily to seasonal timescales. For example, a smaller than usual spring Antarctic ozone hole is strongly correlated with a subsequent hot summer in Australia. These findings have the potential to provide exciting new avenues for improvements in climate prediction and projections.

Session Time: THURSDAY 09:00-09:45

AMOS DISTINGUISHED RESEARCHER AWARD

Tropical-midlatitude interactions and significant summertime weather in the Australian region

Prof Michael Reeder

Monash University

Rossby waves are, of course, large-scale disturbances with horizontal wavelengths of many hundreds to thousands of kilometres, and are often thought to be the building blocks of weather systems. The motion of the air parcels induced by the wave is predominantly horizontal (or more precisely confined to isentropic surfaces, which slope relatively gently). On occasion these waves break, producing sharp troughs and isolated lows (alternatively viewed as isolated potential vorticity anomalies or streamers). As the motion of the air parcels is predominantly confined to a gently sloping surface (an isentropic surface), wave breaking stirs the atmosphere predominantly in the horizontal. In the Australian region during summer, Rossby waves preferentially break anticyclonically around the longitudes of eastern Australia, and in the process, cyclonic potential vorticity is transported equatorward and anticyclonic potential vorticity is transported poleward. Much of the significant weather in the region can be attributed to this kind of stirring of the potential vorticity field and the potential vorticity anomalies so produced. For example, wave breaking produces heatwaves over the southeastern part of the continent while simultaneously promoting convection and rain over the northern part. For this perspective, heatwaves and flooding are sometimes two sides of the same coin. Moreover, wave breaking and the accompanying heat wave can be amplified by the tropical convection, and especially tropical cyclones. In this way, tropical rainfall can be inextricably tied to heat waves, and possibly the development of severe fire conditions. As another example, the active and break phases of the monsoon are controlled by the equatorward propagation of Rossby waves and their associated surface fronts (alternatively viewed as potential vorticity streamers).

Submission ID: 194
Presenting Author: Kial Stewart*
Session Time: WEDNESDAY 09:45-10:30

1

Transition zone oceans: conduits to the deep

STEWART Kial[1]; HAINE Thomas[2]*

1) Australian National University; 2) The Johns Hopkins University

The local role of the ocean in Earth's climate is fundamentally influenced by the locally dominant stratifying species, which in turn can be used to categorise the ocean into three classes: alpha, beta and transition zone oceans. Alpha and beta oceans are regions where the stratification is permanently set by heat and salt, respectively. Transition zone oceans exist between alpha and beta oceans and are regions where the stratification is intermittently set by heat or salt, and, despite their large ranges of temperature and salinity, are the weakest stratified regions of the upper oceans. Given their weak stratification and wide temperature and salinity distributions, transition zone oceans are ideal locations for thermobaric dynamics arising from the nonlinear equation of state of seawater. Here, 4 years of Argo data are employed to partition the upper 2km of the global ocean into its alpha, beta and transition zone components, and to identify thermobaric instabilities. The upper ocean is comprised of 54% alpha, 9% beta and 34% transition zone oceans, with 5% identified as thermobarically unstable. Over 75% of these thermobaric instabilities occur in transition zone oceans, suggesting these are ideal locations for efficient vertical transport of water mass properties. The potential energy associated with the thermobaric instabilities is estimated to be comparable with inertial waves and internal tides (0.5EJ).

Submission ID: 16
Presenting Author: Callum Shakespeare*
Session Time: WEDNESDAY 09:45-10:30

2

Mode water formation via cabbeling at a strained TS-front

*SHAKESPEARE Callum**[1]

1) Australian National University

Temperature-salinity (TS) fronts such as the Gulf Stream, Kuroshio, and sub-Antarctic fronts are important sites for the formation of mode water. The formation of mode water involves significant uptake of atmospheric CO_2, and understanding its dynamics is therefore vital to accurately predicting future climatic changes. Recent modelling studies (Urakawa and Hasumi, 2012; Nycander et al., 2015) have suggested that cabbeling is a major mechanism for the formation of mode water. Cabbeling refers to the process by which two water masses of equal density but different temperature and salinity are combined to create a new, denser water mass, as a result of non-linearities in the equation of state for seawater. Urakawa and Hasumi (2012) employed a mesoscale-resolving model to investigate the water mass transformation associated with cabbeling and found it largely relied on numerical lateral diffusion, implying that mode water formation via cabbeling is associated with unresolved submesocale processes. Exactly how the combination of submesoscale processes and cabbeling give rise to substantial mode water formation is not yet understood. Here we use a combination of theory and idealised numerical modelling to elucidate a potential mechanism for steady state mode water formation at a TS-front. This mechanism is motivated in part by recent observations of the Gulf Stream which show intense submesoscale activity and associated strong lateral mixing over scales of O(1km). Sharp fronts such as the North Wall of the Gulf Stream are also actively strained by mesoscale eddies and ocean gyres. From our theoretical analysis we derive a scaling for the amount of water mass transformation occurring at a given front as a function of strain rate and submesoscale mixing. This scaling appears consistent with results from our submesoscale resolving numerical model and suggests that cabbeling may be responsible for a significant fraction of global mode water formation.

Submission ID: 96
Presenting Author: Byju Pookkandy*
Session Time: WEDNESDAY 09:45-10:30

3

Dynamics of re-emergences of sea surface temperature anomalies associated with the seasonal cycle of the ocean mixed layer

POOKKANDY Byju[1]; DOMMENGET Dietmar[2]*

1) Monash University; 2) Monash University

Re-emergence is the mechanism through which sea surface temperature (SST) anomalies formed in winter over a deep mixed layer are trapped beneath the shallow summer mixed layer and then re-entrained into the deepening mixed layer during the next fall or winter season. This persistence of winter-to-winter SST anomalies is mostly perceived in the midlatitude oceans, where the annual variability in mixed layer is deep. It thus provides a mechanism for long lead seasonal predictions.

We detect re-emergence areas of SST anomalies in the world oceans using ocean reanalysis datasets, CMIP model simulations and a single column mixed layer ocean model (KPP) coupled to ACCESS. It is revealed that re-emergence is far more widespread than previously thought. It not only exists through out the midlatitudes of the Southern and Northern hemisphere, but also in the subtropics and even in the tropics. High-pass (5yrs) filtered SST anomalies show the anti-correlation between winter and summer variability, especially in the midlatitude. These regions are mostly associated with the strong seasonality in mixed layer depth. The integration of SST anomalies over decadal time scale suppress this anti-correlation feature. The CMIP and KPP model simulations show results consistent with the observations.

S2.1b General Ocean Science

Submission ID: 296
Presenting Author: Benoit Legresy*
Session Time: WEDNESDAY 11:00-12:30

1

Sea-level rise reconstruction from 1900 to present, sensitivity and new method development

LEGRESY benoit[1]; CHURCH John[2]; MONSELESAN Didier[3]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) CSIRO Oceans and Atmosphere

We reconstruct the sea level rise from 1900 to present, revisiting the reconstruction from Church and White (2011). We updated this reconstruction, which is based on satellite altimetry learning and projects tide gauges records on the derived modes of variability. We performed or repeated a number of sensitivity tests on the learning period, number of modes, and inversion parameters. We also tested the sensitivity to variations in the mathematical method, in the learning process as well as the number of tide gauges. Using 22 years of quality satellite altimetry we use virtual tide gauges from the altimetry dataset to reconstruct the mean sea level that is then compared to the effective globally integrated sea level from the same altimetry. This gives us robust criteria to evaluate the reconstruction method. The method is found to perform well on long-term trends and not as best for inter-annual to decadal scales. From the results of the sensitivity analysis we developed a new reconstruction method, based on the same reduced space optimal interpolation principle, but solving for different time scales iteratively. We will present the results of this new method compared to the previous one.

S2.1b General Ocean Science

Submission ID: 264
Presenting Author: John Church*
Session Time: WEDNESDAY 11:00-12:30

2

Reduced Space Optimal Interpolation estimates of steric sea level and heat content of the upper ocean derived from the Argo observations

CHURCH John[1]; MONSELESON Didier[2]; WIJFFELS Susan[3]; DOMINGUES Catia[4]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) CSIRO Oceans and Atmosphere; 4) Institute for Marine and Antarctic Studies

Global steric sea level and ocean heat content are critical in balancing the Earth's sea-level and energy budgets and important in attributing changes to natural or anthropogenic sources. Here, we explore the sensitivities of estimates of global steric sea level and ocean heat content to a range of factors, including mapping techniques, choices of climatological periods, a priori covariance fields, and ocean bathymetrical mask. Our primary tool is a Reduced Space Optimal Interpolation (RSOI) technique. We use Argo observations from 2006 to 2015, and present updated estimates of steric sea level and ocean heat content for these periods.

S2.1b General Ocean Science

Submission ID: 29
Presenting Author: Helen Phillips*
Session Time: WEDNESDAY 11:00-12:30

3

Eastward flows and eddies in the southeast Indian Ocean

PHILLIPS Helen[1]*

1) IMAS, University of Tasmania

A striking feature of the South Indian Ocean circulation is near-surface eastward flows that extend from Madagascar to Australia. The eastward flow concentrates into jets that have recently been described as branches of the South Indian Countercurrent (SICC), the northern branch of which feeds into the Eastern Gyral Current (EGC). The eastward flows are remarkable because they flow against the Sverdrup gyre circulation and against the wind-driven surface Ekman flow. There are near-surface eastward flows in the subtropics of other ocean basins, but none so strong, and none extending all the way to the eastern boundary, as in the South Indian Ocean.

Recent work has provided a detailed description of the observed 3-dimensional vertical structure of near-surface eastward flows and their seasonal variability from an exploration of gridded climatologies, altimetry and mean dynamic topography (Menezes et al. 2013, 2014). We complement this broad-scale view with a detailed description of the physical and biogeochemical structure of the southern SICC, the strongest jet, from hydrographic sections along 100E and 105E conducted in 2012 and 2013. Although the eddies that are ubiquitous in the region obscure the weaker eastward flows, we have quantified the volume and property transport of the near-surface flows that feed into the eastern boundary current, the Leeuwin. At deeper levels westward flow carries Southern Ocean watermasses into the interior of the Indian Ocean.

References:

Menezes, V. V., H. E. Phillips, A. Schiller, C. Domingues, N. L. Bindoff, M. Vianna, 2014: South Indian Countercurrent and Associated Fronts. J. Geophys. Res.,119, 10, 6763-6791. DOI:10.1002/2014JC010076.

Menezes, V. V., H. E. Phillips, A. Schiller, C. Domingues, N. L. Bindoff, 2013: Salinity dominance on the Indian Ocean Eastern Gyral Current. Geophysical Research Letters. Vol. 40, 1—6, doi:10.1002/2013GL057887.

Submission ID: 18
Presenting Author: Helen Beggs*
Session Time: WEDNESDAY 11:00-12:30

4

IMOS sea surface temperature products suitable for near-coastal applications

BEGGS Helen[1]; GRIFFIN Christopher[2]; MAJEWSKI Leon[3]; KING Edward[4]; SISSON Janice[5]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) CSIRO Oceans and Atmosphere Flagship; 5) Bureau of Meteorology

Sea surface temperature (SST) products within a few kilometres of coasts that can resolve such features as ocean upwelling are increasingly in demand. Although there are a multitude of gridded, gap-free "level 4" SST products available, derived from interpolating remotely sensed observations, few can resolve surface features of spatial scales less than 20 km, making them unsuitable for many coastal applications. Gridded composite ("level 3") satellite SST products do not spatially interpolate between observations. However, most multi-decadal, level 3 SST products of 4 km resolution that resolve ocean features up to 4 km from coasts (eg. NOAA Pathfinder AVHRR, CSIRO AVHRR composite), do not provide uncertainty estimates for each SST value, making them less useful for ingestion into or validation of coastal ocean models. As part of the Integrated Marine Observing System (IMOS), the Bureau of Meteorology in collaboration with CSIRO Oceans and Atmosphere Flagship, produces a range of 2 km resolution, level 3 SST products in real-time (within 3 to 24 hours of final observation) that include error estimates and quality flags for each grid cell. The SST values were derived using direct broadcast, infra-red AVHRR data from NOAA polar-orbiting satellites. The level 3 products are available in a range of averaging periods from single orbit to 1 month to suit different applications and have been reprocessed to cover the period from 1992 to 2015. They form a unique 23 year data set that supplies quality-assured SST values to within 2 km of coasts, covering oceans around Australia, Papua New Guinea, Indonesia, New Zealand and much of the south-west Pacific and Antarctica. See http://imos.org.au/sstproducts.html for more information and data access. The presentation will describe the new IMOS SST data sets and their research and operational applications. Results of validation against in-situ observations, including coastal ship SST from IMOS, will be presented.

S2.1b General Ocean Science

Submission ID: 261
Presenting Author: Henrique Rapizo Gomes*
Session Time: WEDNESDAY 11:00-12:30

5

On the relevance of ocean surface currents in wave modelling in the Southern Ocean

GOMES Henrique Rapizo[1]; DURRANT Tom[2]; BABANIN Alexander[3]*

1) Swinburne University of Technology; 2) MetOcean Solutions; 3) Swinburne University of Technology

It is well known that currents can have a significant effect on wave generation and propagation. In coastal areas, this interaction is apparent due to the usually higher current speeds. However, little is known on the relevance of ocean currents in affecting deep water waves at global scales. In this study we analyse the impact of ocean currents on waves by coupling a hydrodynamic to a global wave model. Our interest is specifically on the Southern Ocean and the validation of model results is performed by using wave buoy data from the Southern Ocean Flux Station (SOFS), which is part of the Australian Integrated Marine Observing System (IMOS). The current fields are provided by the CSIRO Bluelink ReANalysis (BRAN v. 3p5), a data assimilation model which uses an Ensemble Optimal Interpolation (EnOI) called BODAS (Bluelink Ocean Data Assimilation System). We show that the relevance of including surface currents on wave forecast is small. The wave parameters of significant wave height (Hs), peak period (Tp) and peak direction (Dp) show a mean relative variation of 1%, 0.4% and 4%, respectively. Differences in Hs and Tp are likely to be related to decreasing of effective winds and fetch in the wave generation, specially around the Antarctic Circumpolar Current (ACC). Dp is modified along wave propagation by refraction induced by mesoscale vortices. The addition of ocean currents shows an improvement in the prediction of Tp as well as mean period. However, the small changes in Hs increased the bias when validating the model results against the SOFS data. An additional analysis is performed to investigate the effects on swell and wind-sea separately. The results reveal that due to very weak currents around the SOFS location, wind-sea cases are practically not affected. Long swells are more affected, which suggests that the ACC decreases wave generation intensity in high southern latitudes and it is the main responsible for current-induced changes in the wave climate.

S2.1b General Ocean Science

Submission ID: 333
Presenting Author: Fernando Andutta*
Session Time: WEDNESDAY 11:00-12:30

6

Larger waves driven by Australian Monsoons affect suspended sediment concentration in Darwin Harbour

ANDUTTA Fernando[1,2]; WANG Xiau Hua[2]; WILLIAMS David[3]; LEMCKERT Charles[1]; RIDD Peter[4]*

1) School of Engineering, Griffith University; 2) Sino-Australian Research Centre for Coastal Management (SARCCM), UNSW; 3) Australian Institute of Marine Sciences (AIMS); 4) James Cook University

The effect of larger waves, driven by active Australian Monsoons, on suspended sediment concentration (SSC) was investigated for Darwin Harbour (DH), which is a turbid, relatively shallow macro-tidal tropical mangrove bay system, in the Northern Territory (NT), Australia. Measurements of tides, water temperature, salinity, light, and suspended sediment concentration, were taken from 23 stations in DH. Air temperature, rainfall, wind, and cloud coverage were obtained from 19 stations on land around DH. These measurements allowed us to show how larger waves generated by two active Australian Monsoon events in the summer of 2013 caused daily averaged SSC to increase by a factor of ~6 in coastal waters when compared to maximum SSC measured at spring tides outside periods of active monsoon events. As a result, for over 10 consecutive days the Photosynthetic Active Radiation (PAR) decreased to zero for benthic species. Our measurements also provided evidence that prolonged periods of larger wave's action driven by Australia Monsoons may yield an upstream dispersion of SSC into DH. This upstream dispersion is caused by increased re-suspension of sediment in coastal area, resulting on higher and lower SSC outside and inside DH, respectively. The findings may be used to draw similar conclusions to many other tropical systems under the influence of increased wave action driven by monsoonal events.

Submission ID: 42
Presenting Author: Sarah Perkins-Kirkpatrick*
Session Time: MONDAY 14:30-15:30

1

A hierarchical approach for defining marine heatwaves

HOBDAY Alistair[1]; ALEXANDER Lisa[2]; PERKINS-KIRKPATRICK Sarah[3]; SMALE Dan[4]; STRAUB Sandra[5]; OLIVER Eric[6]; BENTHUYSEN Jessica[7]; BURROWS Michael[8]; DONAT Marcus[9]; FENG Ming[10]; HOLBROOK Neil[11]; MOORE Pippa[12]; SCANNELL Hillary[13]; SEN GUPTA Alexander[14]; WERNBERG Thomas[15]*

1) CSIRO; 2) UNSW Australia; 3) Climate Change Research Centere UNSW Australia; 4) Marine Biological Association of the United Kingdom; 5) University of Western Australia; 6) University of Tasmania; 7) Australian Institute of Marine Science; 8) Scottish Association of Marine Science; 9) UNSW Australia; 10) CSIRO; 11) University of Tasmania; 12) Aberyswyth University; 13) Maine University; 14) UNSW Australia; 15) University of Western Australia

Marine heatwaves (MHWs) have been observed around the world and are expected to increase in intensity and frequency under anthropogenic climate change. Adverse impacts have been associated with these anomalous events, including shifts in species ranges, local extinctions and economic impacts on seafood industries through declines in important fishery species and impacts on aquaculture. Extreme temperatures are increasingly seen as important influences on biological systems, yet a consistent definition of MHWs does not exist.

Building on research into atmospheric heatwaves, we propose both a general and specific definition for MHWs, based on a hierarchy of metrics that allow for different data sets to be used in identifying MHWs. We generally define a MHW as a prolonged discrete anomalously warm water event that can be described by its duration, intensity, rate of evolution, and spatial extent. Specifically, we consider an anomalously warm event to be a MHW if it lasts for five or more days, with temperatures warmer than the 90th percentile based on a 30-year historical baseline period. This structure provides flexibility with regard to the description of MHWs and transparency in communicating MHWs to a general audience. The use these metrics is demonstrated and compared across a selection of recent MHWs, including the extraordinary Western Australia 'Ningaloo Niño', which occured in 2011. We recommend a specific quantitative definition for MHWs to facilitate global comparisons and to advance our understanding of these phenomena.

Submission ID: 323
Presenting Author: Neil Holbrook*
Session Time: MONDAY 14:30-15:30

Poster: Session 1, Poster #3

2

Physical underpinnings of marine heat waves: Drivers and global patterns

HOLBROOK Neil[1]; SCANNELL Hillary[2]; BENTHUYSEN Jessica[3]; FENG Ming[4]; SEN GUPTA Alexander[5]; OLIVER Eric[6]; ALEXANDER Lisa[7]; BURROWS Michael[8]; DONAT Marcus[9]; HOBDAY Alistair[10]; MOORE Pippa[11]; PERKINS-KIRKPATRICK Sarah[12]; SMALE Dan[13]; STRAUB Sandra[14]; WERNBERG Thomas[15]*

1) University of Tasmania; 2) University of Washington; 3) Australian Institute of Marine Science; 4) CSIRO; 5) The University of New South Wales; 6) University of Tasmania; 7) The University of New South Wales; 8) Scottish Marine Institute; 9) The University of New South Wales; 10) CSIRO; 11) Aberystwyth University; 12) The University of New South Wales; 13) Marine Biological Association of the United Kingdom; 14) The University of Western Australia; 15) The University of Western Australia

Marine ecosystem health can be adversely affected by frequent, or persistent, extreme ocean temperatures. In particular, marine heatwaves (MHWs) are relatively rare ocean warming events that persist over an extended period of time (days to weeks) and can have devastating consequences for marine species. MHWs have recently occurred off Western Australia (2011), in the northwest Atlantic (2012), and the northeast Pacific (2014). Further, global patterns of MHWs suggest that their magnitude, timing and distribution may be driven by known modes of climate variability. Importantly, drivers represent a combination of both local and remote processes — with the remote, larger-scale processes offering the potential for MHW predictability. However, relative to atmospheric heatwaves over land, little is collectively known about MHWs, and there have been no comprehensive global studies undertaken to identify the physical drivers responsible for MHWs.

This study synthesises what is known about the climatic drivers and ocean-atmosphere processes that underpin MHW events. Our findings are based on a global meta-analysis of historical MHW events identified in the peer-reviewed literature since 1950, and collating MHW driver information within a framework that unifies our understanding. To achieve this, we classify the characteristic drivers and processes underpinning the identified events across regions and time scales, based on a recently developed hierarchical MHW framework (*), and a confidence assessment of the metainformation. Estimates of intensity and duration of these events were quantified through a unified analysis of the multi-decadal record of global satellite sea surface temperatures, using the MHW definition from the hierarchy — that is, five or more days with temperatures warmer than the 90th percentile, based on a 30-year historical baseline period.

Reference:

Hobday et al (2015) A hierarchical approach to defining marine heatwaves. Submitted to Prog Oceanogr.

S2.2a Extreme Events in the Marine Environment

Submission ID: 153
Presenting Author: Eric Oliver*
Session Time: MONDAY 14:30-15:30

3

Long-term trends in marine heatwaves since 1900

OLIVER Eric[1]; DONAT Markus[2]; BURROWS Michael[3]; MOORE Pippa[4]; ALEXANDER Lisa[5]; BENTHUYSEN Jessica[6]; FENG Ming[7]; SEN GUPTA Alexander[8]; HOBDAY Alistair[9]; HOLBROOK Neil[10]; PERKINS-KIRKPATRICK Sarah[11]; SCANNELL Hillary[12]; SMALE Dan[13]; STRAUB Sandra[14]; WERNBERG Thomas[15]*

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Several marine heatwaves (MHWs) have occurred over the past two decades, devastating regional ecosystems globally. These events have caused observable destruction to local marine ecology, species range extensions and contractions, and measurable economic impacts on fisheries. While it has been suspected that MHWs, like other extreme events, are becoming increasingly prominent as the climate warms, there has been no test of this hypothesis. Here we use extensive historical records of daily satellite observations, daily in-situ measurements, and gridded monthly in-situ SSTs to reveal significant global trends in marine heatwaves over the past century. Both the frequency and duration of MHWs has doubled since 1900, resulting in a four-fold increase in the global number of annual MHW days. These increases were generally consistent with average sea surface warming, although notable regions were identified where trends in MHW characteristics were greater than that explained by the trend in the mean alone. Interestingly, we did not detect any significant global increase in the intensity of MHWs which was unexpected when set against the significant background global warming. Therefore, we concluded that rising mean temperatures had a stronger impact on trends in MHW frequency and duration than on intensity. Continued increases in MHWs, as anticipated with accelerated warming of the Earth during the 21st Century, will have serious implications for marine ecosystems, biodiversity and major industries fisheries, aquaculture, and tourism.

Submission ID: 55
Presenting Author: Ningning Zhang*
Session Time: MONDAY 14:30-15:30

4

Freshening anomalies in the Indonesian throughflow and impacts on the Leeuwin Current during 2010-11

FENG Ming[1]; BENTHUYSEN Jessica[2]; ZHANG Ningning[3]; SLAWINSKI Dirk[4]*

1) CSIRO Oceans and Atmosphere; 2) AIMS; 3) CSIRO Oceans and Atmosphere; 4) CSIRO Oceans and Atmosphere

During the 2010-11 La Niña and Ningaloo Niño, excessive precipitations in the Maritime Continent and Indonesian-Australian Basin caused surface waters to freshen by 0.3 psu in the southeast Indian Ocean. The low salinity anomalies are observed to be carried westward by the Indonesian throughflow and the South Equatorial Current and transmitted into the poleward-flowing eastern boundary current, the Leeuwin Current, along the Western Australian coast. Low salinity anomalies contribute to about 30% of the anomalous increase of the southward Leeuwin Current transport during the evolution of the 2010-11 Ningaloo Niño, resulting in unprecedented warming off the coast of Western Australia. Episodical freshening of the Leeuwin Current has been observed at the Rottnest coastal reference station of Western Australia during extended La Niña conditions over the past several decades; low salinity anomalies at the station during the 2010-11 Ningaloo Niño are comparable with strong historical events.

S2.2b Extreme Events in the Marine Environment

Submission ID: 45
Presenting Author: Jochen Kaempf*
Session Time: MONDAY 16:00-17:00

1

On the Majestic Upwelling System of the Arafura Sea

KAEMPF Jochen[*1]*

1) Flinders University, School of the Environment

A three-dimensional hydrodynamic model is applied to explore the development of phytoplankton blooms in the Arafura Sea during the southeast monsoon (June-November). Before this season, blooms are restricted to near-shore waters covering a total area of ~25,000 km^2. Satellite data indicate that the bloom area grows substantially to >90,000 km^2 during the southeast monsoon covering most of the northwestern Arafura Sea. Findings confirm that the southeast monsoon creates undercurrents via the classical lee effect driving nutrient-rich Banda Sea slope water into this region. This nutrient-rich slope water is driven over vast distances (~300 km) into the northwestern Arafura Sea where it upwells and/or is entrained into the surface mixed layer. The associated overturning circulation is slow but continuous and it takes 1-2 months before nutrient-rich water appears in surface waters of the region. The predicted pathways of nutrient-rich inflows across the shelf break both north and south of the Aru Islands agree with observational evidence.

References:

Kämpf, J. (2015) Interference of wind-driven and pressure gradient-driven flows in shallow homogeneous water bodies. Ocean Dynamics: Volume 65, Issue 11, Page 1399-1410. DOI: 10.1007/s10236-015-0882-2.

Kämpf, J. (2015) Undercurrent-driven upwelling in the northwestern Arafura Sea. Geophysical Research Letters, in press.

Kämpf, J. (2015) On the majestic upwelling system of the Arafura Sea. Journal of Geophysical Research, under review.

Submission ID: 260
Presenting Author: Arnold Sullivan*
Session Time: MONDAY 16:00-17:00

2

Simulating the Pacific Decadal Meridional Mode and its impact on ENSO in ACCESS model

SULLIVAN Arnold[1]; YU Jin-Yi[2]; LIN Chungyi[3]; LUO Jing-Jia[4]; HIRST Anthony[5]; BI Dave[6]; YAN Hailin[7]; CAI Wenju[8]*

1) CSIRO Marine and Atmospheric Research; 2) University of California; 3) Research Center for Enviornmental changes Academia Sinica Taipei; 4) Bureau of Meteorology; 5) CSIRO Marine and Atmospheric Research; 6) CSIRO Marine and Atmospheric Research; 7) CSIRO Marine and Atmospheric Research; 8) CSIRO Marine and Atmospheric Research

Previous studies have shown that decadal variability in the tropical Pacific may affect the occurrence and characteristics of El Niño-Southern Oscillation (ENSO). For instance, the frequent occurrence of central-Pacific (CP) type of El Niño in recent decades, which exerts distinct impacts on global climate and socio-economics from those of eastern-Pacific (EP) El Niño, has been linked to decadal/multi-decadal background change in the Pacific. It has been found that a decadal Pacific meridional mode (PMM) may play an important role in triggering the development of CP El Niño. However, the exact mechanism remains unclear. To understand the linkage between the PMM and the El Niño behaviour, we setup three experiments by using atmospheric general circulation model (AGCM) simulated from the Australian Community Climate and Earth-System Simulator (ACCESS-AM). In the first experiment, monthly raw sea surface temperature (SST) from 1952 to 2005 is used to force the ACCESS-AM. In the second and third experiment, band-pass filtered (5-month to 7 years) and low-pass filtered (greater than 7 years) SST forcing is used. Separating the interannual and decadal SST forcing allows a better understanding the role of the interannual ENSO and decadal PMM in driving atmospheric response. Our preliminary results suggest that the decadal PMM generates distinct atmospheric winds that may influence the evolution of El Niño (including extreme El Niño) events.

S2.2b Extreme Events in the Marine Environment

Submission ID: 106
Presenting Author: Ian Simmonds*
Session Time: MONDAY 16:00-17:00

3

Antarctic sea ice: Has the retreat finally started?

SIMMONDS Ian[1]*

1) School of Earth Sciences

In contrast to the Arctic, the sea ice extent (SIE) around the periphery of the Antarctic continent has exhibited statistically significant increases since 1979. This observed behaviour is also considerably at variance with Antarctic sea ice retreat exhibited by the overwhelmingly vast majority of coupled models and ensembles participating in the CMIP5. Simmonds (2015) offered some thoughts as to why these negative SIE trends in the CMIP5 simulations differ so dramatically from the observed Antarctic increases.

In this presentation we consider the Antarctic monthly SIE over the period 1979-2015. It will be shown that the greatest annual mean SIE was reached in 2013, and that the record since that time has shown some interesting variations. For example, a new high record of 5.54 million km^2 for the mean January-March period was set in 2015, while the extent for July-September 2015 was some one million km^2 less than the previous year. Discussion will centre about whether we are now seeing a reversal of the positive trends of the past few decades, and moving into a period of consistency with the Arctic changes and with the CMIP5 simulations.

Reference:

Simmonds, I., 2015: Comparing and contrasting the behaviour of Arctic and Antarctic sea ice over the 35-year period 1979-2013. Annals of Glaciology, 56(69), 18-28, doi: 10.3189/2015AoG69A909.

S2.3a Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 148
Presenting Author: Stefan Zieger*
Session Time: TUESDAY 09:45-10:30

1

Wave modelling under ACCESS-TCX

ZIEGER Stefan[1]; GREENSLADE Diana[2]; KEPERT Jeffrey[3]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology

Wave forecasts for North West Western Australia (NW WA) issued by the Bureau of Meteorology are largely limited to the resolution of the global (1/2 degree) and regional (12km) operational wave model products. Because of these relatively coarse resolutions these forecasts are limited in accuracy during the tropical cyclone (TC) season. Forecasting sea state is part of a project to improve tropical cyclone forecasting for NW WA, that focuses on the development of sophisticated and highly accurate sea state forecasts for the TC season. To achieve this, a dedicated high-resolution grid was nested within the global domain. The new domain is forced with winds from a high-resolution atmospheric model that is able to accurately represent the track, intensity and structure of a TC system. The performance of the system was tested globally with the next generation of global atmospheric model and for a number of TCs that occurred in the 2014/15 season. Initial validation shows improved results when compared to current products from the operational centre. Once in operation, the system will provide a forecast of sea state for NW WA twice-daily.

Submission ID: 217
Presenting Author: Changlong Guan*
Session Time: TUESDAY 09:45-10:30

2

Occurrence of rogue waves and statistics of wave field

GUAN Changlong[*1]*

1) Physical Oceanography Laboratory, Ocean University of China

Rogue wave is one of the most concerned issues in the ocean wave studies in recent decades, on which the studies are still in a preliminary stage at present. In the present studies, the WW3 wave model is used to investigate the statistical characteristics of wave attributes as rogue waves occur. Chosen from historical literature and shipwreck reports in which the moment and location of rogue wave occurrences are clearly reported, several rogue wave events have been studied. It is shown that rogue waves always occur, as the sea state is severe with large wave steepness, small directional spreading, narrow spectral width, large spectral kurtosis, and four-wave nonlinear interaction playing a leading role on energy balance at low frequencies. The correlation between the occurrence of rogue waves and any single wave attribute is not obviously evident. It is shown that the values of Benjiemin-Feir Index (BFI) are all less than 0.4, which is far away from the criterion BFI>1 predicted by Janssen (2003) with the laboratory experiment results for one dimensional case. On the basis of the evolution in the scatter diagram of joint wave steepness and directional spreading during the rogue wave occurrence, it is revealed that the rogue wave occurrence points in the diagram are always located at or near the inflection points in the section with large wave steepness and narrow directional spreading.

S2.3a Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 255
Presenting Author: Alexander Babanin*
Session Time: TUESDAY 09:45-10:30

3

Wind waves as a link between the ocean and atmosphere

BABANIN Alexander[*1]*

1) Swinburne University

In air-sea interaction and ocean-mixing models, the wind stress is usually parameterised to directly drive the dynamics of the upper ocean. The wind provides momentum and energy fluxes to the ocean surface and thus mixes the upper ocean. Dominant part of the wind stress, however, is supported by the flux of momentum from wind to waves. The wind slowly grows the waves, and the waves then facilitate or moderate the upper-ocean dynamics referred to as air-sea interactions.

In the paper, we will review recent results of both field observations of wind-wave interactions and numerical modelling of the wave boundary layer in the atmosphere. New insights will be offered into dynamics of the constant flux layer perturbed by the surface waves, into influence of waves on the wind, into parameterisations of the sea drag employed by the general circulations models.

S2.3b Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 46
Presenting Author: Jochen Kaempf*
Session Time: TUESDAY 11:00-12:30

1

New approach of lateral turbulent diffusion in hydrodynamic models

KAEMPF Jochen[1]; COX Darren[2]*

1) Flinders University School of the Environment; 2) Flinders University School of the Environment

A new approach for lateral diffusion, based on a concept proposed by Cushman-Roisin (2006), is successfully tested in high-resolution hydrodynamic simulations of turbulent velocity fields. The new approach, which — in difference form — is only a slight modification of the classical Fickian diffusion term, is controlled by a well-defined turbulent velocity scale, which replaces the ill-defined eddy diffusivity. We postulate that the proposed diffusion scheme will revolutionize the description of sub-grid-scale diffusion in hydrodynamic models.

References:

Cushman-Roisin, B., 2008: "Beyond eddy diffusivity: An alternative model for turbulent dispersion," Env. Fluid Mech., 8, 543-549.

Kämpf, J., and D. Cox (in preparation) New approach of lateral turbulent diffusion in hydrodynamic models.

S2.3b Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 305
Presenting Author: Julian O'Grady*
Session Time: TUESDAY 11:00-12:30

2

Validation of nearshore wave models to extreme sea level observations for fringing reef environments

O'GRADY Julian[1]; HOEKE Ron[2]; REYNES Johan[3]; BECKER Janet[4]; MERRIFIELD Mark[5]; MCINNES Kathleen[6]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) UNESCO-IHE; 4) University of Hawaii; 5) University of Hawaii; 6) CSIRO Oceans and Atmosphere

Low lying tropical islands, characterized by steep nearshore topography and fringing reefs, are vulnerable to extreme water levels driven by the interaction of tide and wind-wave processes. The wave driven processes are highly sensitive to reef morphology, roughness and tide level, as well as background sea level. The problem is sufficiently complex that analytic or numerical approaches are necessary to estimate current hazards and explore potential future changes. n this study, we evaluate the capacity of several analytic/empirical approaches and phase-averaged and phase-resolved numerical consideration when exploring possible future scenarios. In this study, we evaluate the capacity of phase-averaged and phase-resolved numerical model to resolve the observed extreme water levels. Observations from three locations in the western Pacific Ocean are used to explore the sensitivity of different reef morphologies on extreme water levels. The validated analytic and numerical modes are important tools for predicting future changes to extreme water levels as a result of global sea level rise and possible changes to the roughness in the reef morphology.

S2.3b Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 182
Presenting Author: Ivica Janekovic*
Session Time: TUESDAY 11:00-12:30

3

2-way coupled wave and ocean model for Australia, using a 3D unstructured high resolution grid

JANEKOVIC Ivica[1]; PATTIARATCHI Charitha[2]; HETZEL Yasha[3]*

1) School of Civil Environmental and Mining Engineering & UWA Oceans Institute UWA; 2) School of Civil Environmental and Mining Engineering & UWA Oceans Institute UWA; 3) School of Civil Environmental and Mining Engineering & UWA Oceans Institute UWA

Much of the human population is drawn to coastal regions for economic, lifestyle, and recreational benefits that exist there. However, with the benefits come threats to life and property related to storms, extreme sea levels, high waves, flooding and erosion. This is especially true for Australia, where damage from such events can rise to tens of millions of dollars as was the case for Cyclone Alby in Western Australia in April 1978. In order to predict and analyse extreme water levels for all of Australia we used the newly developed 3D SCHISM numerical model. Two-way coupling with the advanced Wind Wave III model allowed for the computation of the wind induced wave contribution to sea level changes at scales ranging from regional to local inundation maps. The model is based on the finite element (FE) method with a semi-implicit time integration scheme, with new unstructured LSC2 vertical coordinates. Despite the extremely large domain we managed to resolve coastal features at order of 100m using a carefully optimised unstructured 3D FE mesh. Recent advances in super computing technology allow for fast simulations as the modelling system is fully MPI parallelised scaling well on hundreds of CPUs. The model reproduced major storm - ocean- wave dynamics along the entire Australian coastline, from tropical to extra-tropical transitioning storms (Alby) along Western Australia, to East Coast Low pressure systems including the Pasha Bulker storm in New South Wales, record breaking extratropical storms in South Australia, and tropical cyclone Yasi that devastated Queensland. We found that the contribution due to wave-breaking for certain regions can add on a significant percentage to the “classical” storm surge.

Submission ID: 72
Presenting Author: Diana Greenslade*
Session Time: TUESDAY 11:00-12:30

4

Development of an operational storm surge forecasting system. Part I - overview

GREENSLADE Diana[1]; FREEMAN Justin[2]; SIMS Holly[3]; COLBERG Frank[4]; ALLEN Stewart[5]; SCHULZ Eric[6]; DIVAKARAN Prasanth[7]; KEPERT Jeffrey[8]; TAYLOR Andy[9]; DONALDSON Andrew[10]; BROWNLEE Jason[11]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology; 5) Bureau of Meteorology; 6) Bureau of Meteorology; 7) Bureau of Meteorology; 8) Bureau of Meteorology; 9) Bureau of Meteorology; 10) Bureau of Meteorology; 11) Bureau of Meteorology

The Australian coastline is vulnerable to the impacts of extreme coastal sea-levels. There are a number of different factors contributing to coastal sea-level — Tropical Cyclone storm surge, storm surge from other atmospheric disturbances, wind waves, tides, etc. The Bureau of Meteorology is currently developing a system to provide forecasts of coastal sea-level for the Australian coast. This system comprises two major components - a tropical ensemble system focussing on storm surge driven by Tropical Cyclones, and a national deterministic system focussing on non-Tropical Cyclone driven coastal sea-level variability. This presentation will provide an overview of the system, highlighting some of the major challenges and how these are being overcome. The development and performance of individual components of the system will be described in more detail in Sims et al (submitted to AMOS/ARCCSS National Conference 2016) and Allen et al (submitted to AMOS/ARCCSS National Conference 2016).

S2.3b Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 154
Presenting Author: Diana Greenslade*
Session Time: TUESDAY 11:00-12:30

5

Development of an operational storm surge forecasting system. Part II - Queensland and tropical system

SIMS Holly[1]; GREENSLADE Diana[2]; FREEMAN Justin[3]; COLBERG Frank[4]; SCHULZ Eric[5]; DIVAKARAN Prasanth[6]; KEPERT Jeffrey[7]; TAYLOR Andy[8]; ALLEN Stewart[9]; DONALDSON Andrew[10]; BROWNLEE Jason[11]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Australian Bureau of Meterology; 4) Australian Bureau of Meterology; 5) Australian Bureau of Meterology; 6) Australian Bureau of Meterology; 7) Australian Bureau of Meterology; 8) Australian Bureau of Meterology; 9) Australian Bureau of Meteorology; 10) Australian Bureau of Meteorology; 11) Australian Bureau of Meteorology

Northern Australia is highly vulnerable to storm surge events associated with Tropical Cyclones (TCs). An initial version of a storm surge forecast system for the Queensland coast has been developed. The ocean model component of this system is the ROMS (Regional Ocean Modelling System) model. Wind forcing is based on the Bureau of Meteorology's operational regional NWP (National Weather Prediction) model (ACCESS-R) merged with a TC vortex derived from the official TC forecast track. A method to create ensemble fields from the official TC forecast track is used to provide an ensemble of storm surge forecasts. Experiments using tide gauge observations of sea-level during past TC events have been run in order validate the model and to determine the time-step, domain and resolution to be used. The domain is being extended to Western Australia and Northern Territory and preliminary results from this tropical version of the system will also be presented.

S2.3b Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 115
Presenting Author: Stewart Allen*
Session Time: TUESDAY 11:00-12:30

6

Development of an operational storm surge forecasting system. Part III - National system

ALLEN Stewart[1]; COLBERG Frank[2]; FREEMAN Justin[3]; SIMS Holly[4]; GREENSLADE Diana[5]; SCHULZ Eric[6]; TAYLOR Andy[7]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology; 5) Bureau of Meteorology; 6) Bureau of Meteorology; 7) Bureau of Meteorology

Given the high proportion of the Australian population that live near the coast, many are vulnerable to impacts from extreme sea levels. There can be many causes of extreme sea levels, with contributions from effects such as tides, storms, inter-annual variability and sea level rise. Here, we focus on changes of coastal sea levels due to wind and pressure effects alone. These are commonly known as storm surges.

A storm surge modeling system is being developed to provide routine deterministic forecasts of weather induced sea level variability for coastlines in all Australian territories. These forecasts can serve as an input to determine whether alerts need to be issued for extreme sea level events. This system will serve as a separate and contrasting system to the event-driven ensemble-based tropical storm surge system that is also currently under development by the Bureau of Meteorology.

This presentation will outline the research and development undertaken to produce the national storm surge system. The talk will cover model configuration, grid design, testing and verification. There will be a brief description of how it is intended to be run operationally.

S2.3c Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 150
Presenting Author: Frank Colberg*
Session Time: TUESDAY 14:30-15:30

1

A high-resolution coastal ocean model for the Great Barrier Reef

COLBERG Frank[1]; BRASSINGTON Gary[2]; SANDERY Paul[3]; SAKOV Pavel[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorlogy; 3) Bureau of Meteorology; 4) Bureau of Meteorology

The Australian Bureau of Meteorology (BoM) is in the process of developing an operational coastal ocean forecasting system for the Great Barrier Reef. As part of this endeavour 4km and 500m resolution coastal ocean models using the Regional Ocean Modelling System (ROMS) have been configured. The 4 km resolution model is designed as the modelling component of the forecast system to be implemented as an operational system at the BoM and will be constrained by real-time observations using Ensemble Kalman Filter data assimilation. The relatively course resolution of the model provides a computational advantage for performing a large ensemble O(100). At 4km it is critical to optimise the sub-grid scale parameterisations to minimise system biases and improve the representation of the ocean circulation.

A 500 m resolution model has been configured to resolve more of the reef matrix and provide a realistic representation of the ocean circulation features and transports. In the absence of a comprehensive observing system this “nature-run” will be used as reference data to calibrate the sub-grid scale parameterisations in the 4 km model.

Both ocean models incorporate river sources and implement passive and age tracers allowing concentrations and age from source to be tracked following river plume events. No representation is included of the sedimentation deposition or the biological response to nutrients within the plume. An age tracer is included to permit a time dependent adjustment of concentrations from these processes to be parameterised. Here we present results of the modelling efforts to date

S2.3c Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 152
Presenting Author: Frank Colberg*
Session Time: TUESDAY 14:30-15:30

2

An operational coastal ocean forecasting system for the Great Barrier Reef region

BRASSINGTON Gary[1]; COLBERG Frank[2]; SANDERY Paul[3]; SAKOV Pavel[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology

The Australian Bureau of Meteorology (BoM) is currently developing an operational coastal ocean forecasting system for the Great Barrier Reef region in order to assist the management of the reef. The main focus is on water-borne materials, particularly those that are introduced by land based farming practices into the river catchments. Following river flooding events these materials can discharge into the lagoon and be distributed to the surrounding reefs through the coastal ocean circulation. These events can lead to elevated nutrient levels and responses in the ecosystem for example increased algal growth and in the longer term (subsequent years) crown of thorns starfish outbreaks.

The system developed at the BoM consists of 2 main output streams: (a) an operational ocean forecast system, providing both nowcast (estimates of the state of the reef) and forecasts of the ocean circulation in the GBR out to 3 days, (b) multi-year historical simulations involving a hindcast and a reanalysis. The ocean forecast system developed at the BoM makes use of an Ensemble-based data assimilation of ocean observations such as satellite altimetry, satellite sea surface temperature and Argo profiles. A coastal ocean model of the Regional Ocean Modelling System (ROMS) has been setup for the GBR region. It is nested inside OceanMAPS and uses regional NWP atmospheric forcing. Here we present some early results from the emerging forecasting system.

S2.3c Advances in Modelling and Prediction of Coastal Oceanographic Processes

Submission ID: 98
Presenting Author: Xiao (Hua) Wang*
Session Time: TUESDAY 14:30-15:30

3

Effects of dredging and its spoil dumping on suspended-sediment dynamics: Observation and numerical simulation in Darwin Harbour, Australia

WANG Xiao (Hua)[*1]*

1) Sino-Australian Research Centre for Coastal Management, UNSW

The suspended-sediment dynamics in Darwin Harbour, Australia were investigated using field measurements and numerical modeling. The model suspended-sediment concentration (SSC) agreed well with observation; the root-mean-square error was less than $0.02 kgm^{-3}$ and the anomaly-correlation-coefficient greater than 0.6. Model results indicate that the tide is the dominant forcing for suspended-sediment transport: total sediment transport was seaward in the channel and landward at the East and Middle Arm entrances, dominated by the Eulerian residual current. Dredging for the East Arm Wharf affected the SSC upstream in East Arm. According to the model, material from dredging disposed of at a location outside the harbor will be transported back into the outer harbor, generating higher SSC values there.

S2.4 Innovations in Ocean Climate Modelling

Submission ID: 170
Presenting Author: Daohua Bi*
Session Time: THURSDAY 13:45-15:45

1

Ocean performance in the ACCESS-CM2 model experiments

BI Daohua[1]; YAN Hailin[2]; SULLIVAN Arnold[3]; MARSLAND Simon[4]; HIRST Anthony[5]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) CSIRO Oceans and Atmosphere; 4) CSIRO Oceans and Atmosphere; 5) CSIRO Oceans and Atmosphere

A prototype version of the new generation Australian Community Climate and Earth System Simulator Coupled Model (ACCESS-CM2) has been developed at the Collaboration for Australian Weather and Climate Research (CAWCR). It comprises the UK Met Office atmospheric model (UM8.5/GA6), the NOAA/GFDL ocean model (MOM5), the Los Alamos National Laboratory sea ice model (CICE5.1), and the French led OASIS coupler (OASIS3-MCT). The ACCESS coupled OAGCM is configured with both low and high horizontal resolutions in the atmosphere (N96, N216) and ocean-sea ice (1° and 1/4°). A series of development runs with various combinations of the atmosphere-ocean resolutions has been conducted to evaluate the models computational efficiency and diagnostic/metric performance.

We present ACCESS-CM2 results from these simulations, with a focus on the performance of ocean model (1° and 1/4° MOM5) under standard CMIP preindustrial forcing. It is found that enhancing the atmospheric resolution overall improves the 1° ocean performance, especially leading to reduction of the surface warm bias in the southern hemisphere western coastal regions, which is a common feature of the coarse resolution ocean model, largely associated with misrepresentation of wind forcing off the coasts. With the lower resolution atmospheric model (N96), the 1/4° ocean yields significantly better results than the 1° ocean, including a smaller South Ocean warm bias and more realistic Indian Ocean Dipole mode. Additionally, we show that the eddy-permitting 1/4° ocean, which “normally” has both the eddy parameterization (GM scheme) and neutral-physics turned off, will generate quite different global climate (at ocean surface and in the ocean interior) if the neutral-physics is partly applied. Such results indicate a possible physical tuning of the ocean model for more realistic climate simulation, particularly in the South Ocean.

S2.4 Innovations in Ocean Climate Modelling

Submission ID: 253
Presenting Author: Siobhan O'Farrell*
Session Time: THURSDAY 13:45-15:45

2

Ice Ocean interaction in 1 degree and ¼ degree ACCESS2 coupled model runs

O'FARRELL Siobhan[1]; BI Dave[2]; YAN Hailin[3]; HANNAH Nicholas[4]; SPENCE Paul[5]*

1) CSIRO Ocean and Atmosphere; 2) CSIRO Ocean and Atmosphere; 3) CSIRO Ocean and Atmosphere; 4) ARCCSS UNSW; 5) ARCCSS CCRC UNSW

During the development of the ACCESS2 coupled model, the use of the MOM5 ocean model at two resolutions have been explored (1 degree and ¼ degree), both coupled to a N96 GA6 UM atmosphere model. This talk will discuss some of the high latitude results focussing on the ice -ocean interaction and problem areas where open ocean convection and coastal upwelling cause too much melting (or reduce ice formation) leaving semi-permanent polynyas or regions of thinner ice cover. The model runs are of 200 year duration and have been coupled to both CICE5.0 and CICE5.1 ice model versions. Whilst the Arctic sea ice results develop a different climatology, the more seasonal Southern Ocean sea ice results are very similar between both versions.

Our ARCCSS colleagues are running parallel experiments with ¼ degree MOM5 ocean model and the CICE4.1 ice model coupled to an atmospheric version of ACCESS1.4. We will discuss in the talk the differences we see in their simulations in the ice-ocean response that cannot be explained by the different ice climatology, we would expect from the different atmospheric components used.

S2.4 Innovations in Ocean Climate Modelling

Submission ID: 276
Presenting Author: Marshall Ward*
Session Time: THURSDAY 13:45-15:45

3

Scalability of parameterizations in global high-resolution ocean models

WARD Marshall[1]*

1) National Computational Infrastructure

The National Computational Infrastructure (NCI) has supported the Australianresearch community's adoption of eddy-resolving global ocean models byproviding performance analysis and improvements to scalability on the Raijinsupercomputing platform.

Results are based on the Modular Ocean Model (MOM) and Sea Ice Simulator (SIS)for global 0.25° and 0.1° resolution simulations, each based on the GeophysicalFluid Dynamics Laboratory (GFDL) CM2.6 and CM2.6 models and adapted for use byARCCSS ocean modelling community.We focus on the scalability of individual parameterizations, with respect toboth performance and resource requirements.

We focus on schemes which are bothrelevant to high resolution grids and computationally demanding, such as finitevolume tracer advection, biharmonic viscosities, and barotropic free surfacesolvers. We also assess the impact of sea ice modelling on scalability, suchas load imbalances caused by elasto-visco-plastic (EVP) solvers.

Using these results, we assess the viability of such experiments on Raijin andother petascale systems, as well as future exascale platforms.

S2.4 Innovations in Ocean Climate Modelling

Submission ID: 132
Presenting Author: Bishakhdatta Gayen*
Session Time: THURSDAY 13:45-15:45

4

High resolution numerical simulation of convection and dissolution at a vertical ice-seawater interface

GAYEN Bishakhdatta[*1]; GRIFFITHS Ross[2]; KERR Ross[3]*

1) The Australian National University; 2) The Australian National University; 3) The Australian National University

We investigate the convection during dissolution of ice wall into seawater under Antarctic ocean conditions using direct numerical simulations. The ambient water temperatures are kept between -1 degree Celsius and 6 degree Celsius and salinities around 35 ppm, where diffusion of salt to the ice-water interface depresses the freezing point and further enhances heat diffusion to the ice. We use three coupled interface equations, along with the Boussinesq approximation and the equation of state for seawater, to solve for interface temperature, salinity and melt rate. Fluxes of both heat and salt to the interface play a crucial role in governing the rate of dissolution of ice.

Melting at ice face reaches a constant rate above a certain height when turbulence inside the boundary layer becomes very active. At the presently achievable Grashof numbers turbulence is equally produced from both buoyancy and velocity shear, which indicates the importance of turbulent shear production at geophysical scales.

Submission ID: 74
Presenting Author: Andreas Klocker*
Session Time: THURSDAY 13:45-15:45

5

Wave-turbulence-mean flow interaction in the Antarctic Circumpolar Current

KLOCKER Andreas[*1]*

1) Institute for Marine and Antarctic Studies, University of Tasmania

A high-resolution ocean model and altimetric observations are used to investigate the interactionof waves, turbulence and mean flow in the Antarctic Circumpolar Current (ACC). Particularemphasis is placed on the dynamical role of radiation stresses that result from the organisation ofthe turbulence by the waves and mean shear and give rise to systematic, long-range momentumtransports, which predominantly accelerate the ACC. The dynamics of the wave-turbulence-meanflow interaction is investigated by diagnosing the eddy momentum fluxes and their relation tothe downstream evolution of the mean zonal velocity and eddy kinetic energy. The kinematicsuppression of eddy diffusivities by the mean flow, closely related to the radiation stresses viathe Taylor-Bretherton identity, is also diagnosed. It is found that radiation stresses in the ACC,organised by the baroclinic jets and standing barotropic Rossby waves, are limited in range by majortopographic features. Immediately downstream of topographic features, the standing Rossby wavesbecome barotropically unstable, leading to regions of enhanced eddy kinetic energy and mixing oftracers, often referred to as storm tracks; in turn, the lateral redistribution of eddy energy is foundto be important in understanding the downstream evolution of the radiation stresses and their rolein transferring energy back to the mean flow.

Submission ID: 294
Presenting Author: Clothilde Langlais*
Session Time: THURSDAY 13:45-15:45

6

Stationary Rossby waves and carbon subduction in the Southern Ocean

LANGLAIS Clothilde[1]; RINTOUL Steve[2]; LENTON Andrew[3]; MATEAR Richard[4]*

1) CSIRO O&A; 2) CSIRO O&A; 3) CSIRO O&A; 4) CSIRO O&A

Mesoscale features such as coherent eddies, fronts, and jets contribute significantly to horizontal and vertical transport. They also facilitate important interactions with the larger and smaller scale circulation of physical and biogeochemical tracers. However, at present, many aspects of their structure, evolution, and impacts are not fully understood. Here, we explore the impact of mesoscale circulation on the rate and spatial distribution of anthropogenic carbon uptake in the Southern Ocean. Specifically, we assess the impact of topography-induced stationary Rossby waves on the time-mean subduction in the Southern Ocean.

Here we present new biogeochemical eddy-resolving ocean simulations (1/10°) that allow us to assess the role of ocean dynamics in controlling carbon sequestration. The net subduction of anthropogenic carbon amounts 0.61 Pg C / yr for intermediate and mode waters. However, the pattern of the transport of carbon and other tracers from the surface ocean into the ocean interior is set by a complex pattern of regional ventilation and reventilation. This pattern is mainly due to the interaction of the Antarctic Circumpolar Current and the shallowing/deepening mixed layer. However, at smaller scales, the stationary Rossby waves introduce 300km-scale upwelling-downwelling systems downstream of topography. At coarser resolution, the net subduction of anthropogenic carbon is reduced by 41%. Specifically these Rossby waves reveal different dynamical pathways to the ocean interior, with more transfer on the northern and southern sides of the deep mixed layer pools.

We also present preliminary results from a projection experiment with the biogeochemical eddy-resolving ocean simulations (1/10°). In the future (2050), despite an increase in CO_2 air-sea flux by almost 50%, the carbon transfer through the mixed layer stays approximately the same due to a balance between increase of vertical gradient of anthropogenic carbon and a reduction of physical transfer.

Submission ID: 47
Presenting Author: Angus Gibson*
Session Time: THURSDAY 13:45-15:45

7

The effect of mixing locality on overturning circulation

GIBSON Angus[*1]*

1) Australian National University

Diapycnal mixing is an important process for maintaining the meridional overturning circulation in the ocean. One contribution to diapycnal mixing in models is spurious, resulting from numerical operators such as horizontal advection. The spurious mixing present in models leads to a lower bound on effective diffusivity, so that low diffusivity regimes can't be simulated. Commonly-used methods for quantifying the spurious mixing in models require closed basins without buoyancy forcing, and are at best able to provide a single vertical profile for the entire domain. An estimate of the amount of spurious mixing and its spatial location can however be diagnosed from tracer variance statistics (e.g. Burchard and Rennau, 2007).We investigate the sensitivity of an overturning circulation to variations in mixing by specifying the spatial location of diffusivity in an idealised numerical model. To minimise spurious mixing in the interior, a hybrid vertical coordinate is used, combining a geopotential mixed layer with an isopycnal interior, with a transition layer in between. The spurious diffusion is diagnosed using the variance decay method. By reducing the lower bound on spurious diffusivity, we are able to directly test a wide range of diffusivity profiles, including profiles that are uniform with depth, surface-enhanced, and boundary-enhanced.

S2.5a Variability in the East Australian Current and the Tasman Sea: Past, Present and Future

Submission ID: 290
Presenting Author: Nina Ribbat*
Session Time: THURSDAY 09:45-10:30

1

Drivers of variability across the inner shelf off Sydney

RIBBAT Nina[*1]*

1) Coastal Oceanography Lab UNSW

Shelf seas are highly dynamic transitions zones connecting the open ocean and the coast. Along the south east coast of Australia, submeso and mesoscale eddies are the dominant features of the shelf circulation downstream of the East Australian Current (EAC) separation point. The NSW shelf circulation has been studied through long-term mooring, satellite and glider observations. But despite the observations, the coarse spatial and temporal resolution of the sampling does not provide a complete understanding of the cross-shelf transport dynamics.

This study investigates what drives the variability of the cross-shelf transport along the NSW shelf using across-shelf momentum balances to understand the variability of forcing mechanisms driving the cross-shelf transport. This will indicate which balances are of importance near the Sydney region, and which external forcings are the drivers of variability. This will be accomplished using a state of the art numerical model that provides velocity and water property outputs over a region that spans both the shelf and open ocean at high spatial and temporal resolution. Specifically, a 750 m version of the Regional Ocean Modelling System (ROMS) has been configured and validated for the shelf region off Sydney. The configuration consists of a one-way nested domain inside a coarser (2.5- 6 km), eddy resolving, data assimilating ROMS domain. Hint-cast simulations have been conducted for 2 years from 2012-2013 recording outputs in 2 hourly increments capturing the submesoscale dynamics. We use these model outputs to describe the mean shelf circulation, the mean cross-shelf transport and the dominant modes of variability across the shelf. This high resolution ROMS configuration for the productive Sydney Shelf region will also aid future assimilation and forecasting efforts.

S2.5a Variability in the East Australian Current and the Tasman Sea: Past, Present and Future

Submission ID: 149
Presenting Author: Eric Oliver*
Session Time:

2

Circulation on the eastern Tasmanian continental shelf: The mean state and seasonal cycle

OLIVER Eric[1]; HOLBROOK Neil[2]*

1) Institute for Marine and Antarctic Studies University of Tasmania; 2) Institute for Marine and Antarctic Studies University of Tasmania

The eastern Tasmanian continental shelf is highly biologically productive and home to significant fisheries and aquaculture industries. Unfortunately, the marine climate there is poorly understood. We use a high-resolution (~2 km in the horizontal), three-dimensional ocean model (ETAS) to simulate the ocean variability in this region over the 1993-2014 period. The ETAS model provides an estimate of the mean state and seasonal cycle of temperature, salinity, and circulation over the eastern Tasmanian continental shelf. We also use the model to examine the roles of river input and tidal forcing. The model is evaluated using remotely-sensed sea surface temperature and in-situ observations of sea level and subsurface temperature, salinity, and currents. The mean state demonstrates a clear influence of two large-scale ocean currents (the East Australian Current, EAC, and the Zeehan Current, ZC) as well as local freshwater input from river runoff. The EAC is dominant in summer and the ZC in winter; the EAC influence also increases northwards and in the offshore direction. In addition, we find a persistent subsurface (50-100 m depth) northward flow trapped near the coast. Freshwater runoff from the Derwent and Huon Rivers impacts the temperature and salinity in their estuaries but has little influence more distantly. Tidal forcing impacts the mean state through tide-river interactions which flush Frederick Henry Bay and Norfolk Bay with freshwater. Tidal forcing also impacts the variability of temperature all along the coastline. The ETAS model output data is available as a high-resolution representation of the mean state, seasonal variations, and interannual variability in marine climate of the eastern Tasmanian continental shelf.

S2.5a Variability in the East Australian Current and the Tasman Sea: Past, Present and Future

Submission ID: 250
Presenting Author: Amandine Schaeffer*
Session Time:

3

Submesoscale frontal meanders and eddies along the East Australian Current observed by HF Radars

SCHAEFFER Amandine[*1]; MANTOVANELLI Alessandra[2]; GRAMOULLE Anthony[3]; ROUGHAN Moninya[4]*

1) University of New South Wales; 2) University of Western Australia; 3) University of New South Wales; 4) University of New South Wales

The East Australian Current (EAC) and its eddies influence the water temperature, phytoplankton to fish distribution and regional climate along the east coast of Australia. While the shedding of mesoscale warm core eddies at the EAC separation of the coast is relatively well understood, little is known about its sub-mesoscale instabilities.

More than 1 year of surface currents from HF Radars, in conjunction with mooring measurements, satellite sea surface temperature and ocean colour, highlight for the first time the occurrence and propagation of submesoscale meanders on the inshore edge of the EAC. These instabilities appear to be mostly barotropic and migrate poleward as far as 500 km south, with advection speeds of ~0.3 m/s. Investigation into the flow field kinematics shows high Rossby numbers and a strong impact on horizontal divergence and particle dispersion. Wind stress appears to influence the fate of these ageostrophic meanders, their growth and potential evolution into cyclonic cold core eddies. Such coherent structures are a major mechanism for the transport of coastal waters, impacting physical and biological connectivity over large distances.

Submission ID: 350
Presenting Author: Tatiana Rykova*
Session Time: THURSDAY 11:00-12:30

1

Observing East Australian Current eddies from Argo float data

RYKOVA Tatiana[1]; OKE Peter[2]*

1) CSIRO; 2) CSIRO

Western boundary current eddies are primary contributors to mass, heat and freshwater transport from low- to mid-latitudes. Eddies are essential for many applications, ranging from operational oceanography to climate — hence, understanding their structure, properties and space-time evolution is important. We analyse the evolution of water masses in the East Australian Current (EAC) eddies from individual Argo float and present a new method of linking T/S profiles to eddies. It allows us to use Argo data to resolve the properties of typical cyclonic and anticyclonic EAC eddies and estimate their contribution to poleward heat and freshwater transports.

S2.5b Variability in the East Australian Current and the Tasman Sea: Past, Present and Future

Submission ID: 32
Presenting Author: Moninya Roughan*
Session Time: THURSDAY 11:00-12:30

2

An observational study of the biophysical characteristics of two contrasting cyclonic eddies in the Tasman Sea

ROUGHAN Moninya[*1]*

1) University of New South Wales

Mesoscale cold core eddies are known to be highly productive regions of the ocean due to their cyclonic rotation which drives upwelling at the core. Lesser known however are the dynamics and productivity of smaller frontal eddies that form on the inside edge of western boundary currents. In this study we investigate the physical and biogeochemical properties of two contrasting cyclonic eddies in the Tasman Sea. The first being a frontal eddy that formed from a shelf water billow at ~ 32S on the continental shelf of SE Australia and was advected offshore along the EAC front. The second is a larger meso scale cyclonic eddy that formed at ~ 28S and was trapped off Brisbane, blocking the southward flow of the EAC. We present results from a dedicated research voyage on the RV Investigator to study the biophysical interactions and productivity in cyclonic eddies of the Tasman Sea. Our results show that not all cyclonic eddies are created equal, ie the smaller frontal eddy is significantly more a-geostrophic, more energetic and more productive than the mesoscale cyclone, despite its small size and short life. We show that frontal eddies contribute significantly to the net productivity of the Tasman Sea region.

Submission ID: 141
Presenting Author: Andrew Kiss*
Session Time: THURSDAY 11:00-12:30

3

Can we cleanly attribute ocean time-dependence to forced or intrinsic variability? Insights from an idealised study of the East Australian Current

KISS Andrew[1]; FRANKCOMBE Leela[2]*

1) University of New South Wales Canberra (ADFA) and ARCCSS; 2) Climate Change Research Centre University of New South Wales and ARCCSS

We present results from a very large ensemble of experiments with an idealised two-layer model of the South Pacific driven by the observed climatological wind stress curl cycle. Under steady wind forcing the model EAC sheds anticyclonic eddies, either periodically or chaotically depending on parameters. We then include the variable component of the wind and investigate how the forced variations of the EAC alter the time-dependence of eddy-shedding. We conduct many experiments in which the forcing amplitude and frequency are shifted from their observed values and find that the EAC response depends strongly on the ratio of the intrinsic and forcing timescales. When this ratio is close to a simple rational number, the model EAC can shift its behaviour to lock onto the periodic forcing cycle (even if it was intrinsically chaotic). In other situations the EAC variability can remain independent of the forcing, or forcing variation can cause an intrinsically periodic EAC to become chaotic, producing low-frequency variability at timescales that were not intrinsic to the EAC or the forcing. These complex nonlinear behaviours can occur with realistic parameters, suggesting that it may not always be possible to make a clear-cut attribution of observed variability to either forced or intrinsic dynamics alone.

S2.5b Variability in the East Australian Current and the Tasman Sea: Past, Present and Future

Submission ID: 9
Presenting Author: Andréa Taschetto*
Session Time: THURSDAY 11:00-12:30

4

How projected changes in the Tasman Sea will impact Australian mid-latitude weather systems?

TASCHETTO Andréa[1]; HAARSMA Reindert[2]; SEN GUPTA Alexander[3]*

1) University of New South Wales; 2) The Royal Netherlands Meteorological Institute; 3) University of New South Wales

Australian climate is projected to change with increases in greenhouse gases. Mean rainfall is projected to decrease, while extremes in daily rainfall are very likely to increase across the country. One robust change in the oceans surrounding Australia is an intensification of the East Australian Current, due to the spin up and poleward shift of the South Pacific subtropical gyre, that in turn produces a warming of the Tasman Sea. In this study we investigate how Australian rainfall is impacted by projected changes in sea surface temperature in a warmer scenario. In particular we examine the effect of the projected Tasman sea warming for the mid-latitude weather systems impacting Australian rainfall over the southern regions. To address this question, a suite of numerical experiments is performed with the earth system model EC-EARTH. Two 6-member ensembles are produced for the present day conditions and a future scenario at a spatial resolution of about 25km globally. The present day ensemble is forced with the observed daily sea surface temperature (SST) from the NOAA National Climatic Data Center from 2002 to 2006. The future scenario simulation is integrated from 2094 to 2098 using the present day SST field added onto the future SST change created from a 17-member ensemble based on the RCP4.5 scenario. Comparison of those set of experiments show that Tasmanian mean and extreme daily rainfall is increased by enhanced local convection due to the surrounding sea warming. Further investigation is underway to assess the impact of SST projections onto the mid-latitude weather systems in the Australian sector, such as blocking highs and cut-off low events.

S3.1a General Climatology

Submission ID: 241
Presenting Author: Christoph Rüdiger*
Session Time: TUESDAY 16:30-17:30

1

Remote sensing of soil moisture - Capabilities and pitfalls

RÜDIGER Christoph[*1]*

1) Monash University

Soil moisture is one of the main drivers regulating land surface fluxes and is therefore a key variable in land surface and atmospheric modelling, be it for coupled or uncoupled systems. It can be readily observed from space, with a range of satellite missions providing low- to high-resolution data products, which - when combined - provide an almost daily global coverage of the Earth's surface. While this means that data are available at a sufficiently temporal resolution to constrain model performances, the variations in satellite technologies and retrieval algorithms lead to potentially significant differences in the final soil moisture product. In this presentation, the available remotely sensed soil moisture products are presented for the Australian mainland, including their availability, coverage, and mission lifetimes. A subset of those products is then analysed for their differences, to highlight the differences between those satellites, before being compared against the MERRA-Land soil moisture product for the period 2010-2014. It is shown that there is not only a distinct difference between most of the soil moisture products, but also in comparison with MERRA-Land, which displays a dynamic behaviour which is vastly different to the satellite observations, in particular over central Australia. The differences found through this study underline that model predictions and observations can significantly diverge, but that remotely sensed data products should have the capability to constrain models. However, it will be discussed that care needs to be taken when doing so, in particular when remotely sensed data are assimilated into land surface models.

Submission ID: 41
Presenting Author: Sarah Perkins-Kirkpatrick*
Session Time: TUESDAY 16:30-17:30

2

Relationships between climate variability, soil moisture, and Australian heatwaves

PERKINS-KIRKPATRICK Sarah[1]; ARGÜESO Daniel[2]; WHITE Chris[3]*

1) Climate Change Research Centere UNSW Australia; 2) Climate Change Research Centre UNSW Australia; 3) School of Engineering & ICT University of Tasmania

It is well established in the literature that low-frequency climate variability modes have a dominant role on Australia's climate. However, limited work to date has focused on relationships between climate variability andAustralian heatwaves. This presentation identifies the relationships between known modes of climate variability that influence Australian climate, and seasonal characteristics of the intensity, frequency, duration, and timing of heatwaves. The large-scale seasonal modes of the El Niño/Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), and the Southern Annular Mode (SAM) are investigated for the Austral heatwave season (November-March) commencing between the years 1911 and 2012 (thus including Australia's hottest summer on record, to date). We employ a slightly modified version of the Excess Heat Factor (EHF), the heatwave definition used by the Australian Bureau of Meteorology in their pilot heatwave forecasts.

While ENSO is found to have the strongest relationship with Australian heatwave characteristics, this differs between heatwave frequency, duration, intensity, and timing. Regions dominated by ENSO experience more, longer lasting and hotter heatwaves, combined with an earlier commencement of the heatwave season during El Niño phases. The exception to this is southeast Australia, where SAM is generally more dominant. The IOD provides little indication of seasonal heatwave characteristics due to its relative inactivity during the Austral summer months. For regions where ENSO dominates, there is an increased likelihood of severe seasons with respect to heatwave intensity and frequency during El Niño.

Lastly, we show that antecedent soil moisture has varying strengths of relationships with Australian heatwave characteristics, exhibiting relationships with heatwave intensity and timing over some regions where none are detected between large-scale modes.

Submission ID: 95
Presenting Author: Julia Andrys*
Session Time: TUESDAY 16:30-17:30

3

Current and future changes in regional climate for the southwest of Western Australia

ANDRYS Julia[1]; KALA Jatin[2]; LYONS Thomas[3]*

1) Murdoch Univeristy; 2) Murdoch Univeristy; 3) Murdoch Univeristy

High-resolution climate projections (5 to 10 km) are important for informing adaptation planning strategies and impact assessment studies at the regional scale. General circulation models (GCMs) have too coarse a resolution (100 to 250 km) to be used for such purposes and regional climate models (RCMs) can be used to dynamically downscale GCMs to bridge this gap. We use the Weather Research and Forecasting (WRF) Model, a widely adopted RCM, to downscale 3 GCMs from the 3rd Coupled Model Intercomparison Project over the south west of Western Australia for current (1970-99) and near future climate (2030-59) under the A2 emissions scenario. Our results show that WRF adds value to the GCMs by improving the representation of topographically induced rainfall and the high rainfall gradient of the region. A statistical approach based on relative entropy is used to quantify changes in climate variability in addition to examining the significance of changes in the mean.

Maximum temperatures are projected to rise by up to 2°C with the greatest change in the summer along the western coastline. Minimum temperatures are not expected to increase by the same magnitude as maxima, however they do show a significant increase in variability. As a consequence of the differences in minimum and maximum temperature increases, much of the SWWA is expected to experience expanded diurnal temperature ranges of up to 0.5°C. The direction and magnitude of rainfall changes are less certain than those of temperature, however models do consistently demonstrate a decline in winter rainfall. There were no significant changes in winter rainfall intensity and a reduction in the number of rain days in the SWWA during winter can be attributed to fewer storm fronts traversing the region.

S3.1a General Climatology

Submission ID: 222
Presenting Author: Andrew King*
Session Time: TUESDAY 16:30-17:30

4

Emergence of heat extremes attributable to anthropogenic influences

KING Andrew[1]; BLACK Mitchell[2]; MIN Seung-Ki[3]; MITCHELL Daniel[4]; FISCHER Erich[5]; HARRINGTON Luke[6]; PERKINS-KIRKPATRICK Sarah[7]*

1) ARC Centre of Excellence for Climate System Science University of Melbourne; 2) ARC Centre of Excellence for Climate System Science University of Melbourne; 3) POSTECH; 4) University of Oxford; 5) ETH Zurich; 6) Victoria University Wellington; 7) ARC Centre of Excellence for Climate System Science University of New South Wales

In recent years climate scientists have investigated whether recent extreme events may be attributed to human-induced climate change. However, it is likely that some climate extremes occurring over previous decades may also be attributable to anthropogenic influences. This study is the first to investigate when past climate extremes could be attributed to anthropogenic climate change for the first time. Here we calculate the time when a human influence becomes apparent in the case of record-breaking warm summers, and calendar years for five regions of the world and the globe as a whole. We find that for many regions and time periods, record-breaking hot events prior to the most recent record can also be attributed to climate change. Earlier records may be attributed to anthropogenic influences in Australia than in regions of the northern hemisphere as the cooling effect of anthropogenic aerosols has been weaker there. The last 16 hottest years on record globally may be attributed to anthropogenic climate change. This analysis combines ideas and methods used in event attribution and studies of time of emergence to offer a new perspective on anthropogenic influences on extreme climate events. The results are of interest to the event attribution community and may be used as a tool in the communication of climate change impacts to the broader public.

Submission ID: 118
Presenting Author: Steven Siems*
Session Time: WEDNESDAY 11:00-12:30

1

Evaluation of the AWAP daily precipitation spatial analysis against an independent gauge network in the Snowy Mountains

CHUBB Thomas[1]; SIEMS Steven[2]*

1) Monash University; 2) Monash University

The Bureau of Meteorology's Australian Water Availability Project (AWAP) daily precipitation analysis provides high resolution rainfall data by interpolating rainfall gauge data, but when evaluated against a spatially dense independent gauge network in the Snowy Mountains large systematic biases are identified. Direct comparisons with the gauge data in May—September between 2007 and 2014 reveal average root mean square errors of about 4.5°mm, which is slightly greater that the average daily precipitation amount, and the errors are larger for higher elevation gauges. A standard Barnes objective analysis is performed on the combined set of the independent gauges and the Bureau of Meteorology gauges in the region to examine the spatial characteristics of the differences. The largest differences are found on the western slopes, where the Barnes analysis is up to double the value of the AWAP analysis. These differences are attributed to a) the lack of Bureau of Meteorology gauges in the area to empirically represent the precipitation climatology, and b) the inability of the AWAP analysis to account for the steep topography exposed to the prevailing winds. Differences of about 15% are also noted at high elevations (>1400°m), where the difficulties of measuring frozen precipitation likely have a large impact.

Submission ID: 164
Presenting Author: Scott Clark*
Session Time: WEDNESDAY 11:00-12:30

2

Changes in rainfall regimes and associated synoptic patterns over north-western Australia

CLARK Scott[1]*

1) Monash University

Since 1950, there has been a significant increasing trend in rainfall over many parts of northern Australia, particularly in the northwest corner of the continent. A K-means algorithm was used to cluster daily rainfall over northern and north-western Australia, with their associated wind and geopotential height composites determined. It is found that over north-western Australia, the days on which isolated storms develop (typical of the "build-up" period) make up approximately 70% of all rainy days, but are becoming less frequent over time. On the other hand, days of widespread heavier rain become more frequent. Wetter regimes are associated with low-level westerly or north-westerly flow, while drier clusters are associated with easterlies.

Submission ID: 214
Presenting Author: Milton Speer*
Session Time: WEDNESDAY 11:00-12:30

3

The 1970s Pacific climate shift - changes in east Australian atmospheric circulation and annual-seasonal rainfall extremes

SPEER Milton[*1]*

1) Climate Change Research Centre, The University of New South Wales

Annual and seasonal extremes in eastern Australian rainfall remain lower after the mid-1970s climate shift, except for 2010. Changes in the jet stream structure brought on by contributions from stratospheric ozone loss, increased greenhouse gases (GHGs) and natural climate variability, including a positive phase of the inter-decadal Pacific oscillation (IPO), are the main reasons. In relation to the extreme 2010 rainfall, a strong La Nina and a return to the negative phase of the IPO after 1998 are key factors.

Using NCEP/NCAR atmospheric reanalysis anomalies of surface pressure, pressure height, vector wind and moisture, it will be shown that large amplitude mid-tropospheric troughs extending through subtropical latitudes over eastern Australia prior to the mid-1970s provided a mechanism for increased rainfall there during winter (JJA) and autumn (MAM). Since then the zonal westerlies have contracted poleward and the polar jet stream wind anomaly has dominated over a weaker subtropical jet stream wind anomaly, thereby mostly constraining mobile mid-latitude troughs to latitudes south from the Australian continent. As a consequence, less mid-latitude induced low pressure systems influence eastern Australian rainfall during winter. Thus, it is via regional atmospheric circulation changes, unique to east Australian/Tasman Sea longitudes that changes in annual and seasonal rainfall extremes have occurred since the 1970s climate shift. These rainfall changes for eastern Australia provide a background state as GHGs increase and stratospheric ozone recovers.

Submission ID: 93
Presenting Author: Josephine Brown*
Session Time: WEDNESDAY 11:00-12:30

4

Will a warmer world mean a wetter or drier Australian monsoon?

BROWN Josephine[1]; MOISE Aurel[2]; COLMAN Robert[3]; ZHANG Huqiang[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology

Multi-model mean projections of the Australian summer monsoon show little change in precipitation in a future warmer climate, even under the highest emission scenario. However there is large uncertainty in this projection. To understand the source of this model uncertainty, we divide a set of 33 climate models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) into groups based on their future precipitation projections ("DRY", "MID" and "WET" terciles). The DRY model mean has the largest sea surface temperature (SST) warming in the western equatorial Pacific, where large increases in precipitation occur. The DRY model mean also has a large cold bias in present day SSTs in this region. The WET model mean has the largest warming in the central and eastern equatorial Pacific, with precipitation increases over much of Australia. These results suggest lower confidence for projections of reduced monsoon precipitation due to the influence of model SST biases on the SST warming pattern and precipitation response. The precipitation changes for the DRY and WET models are also decomposed into dynamic and thermodynamic components following the approach of Chadwick et al. (2013). The component due to spatial shifts in the location of convergence and precipitation is responsible for most of the difference between DRY and WET models. As spatial shifts in precipitation are closely associated with patterns of SST change, reducing uncertainty in model SST warming patterns will be crucial to improved projections of Australian monsoon precipitation.

Reference:

Chadwick, R., I. Boutle, and G. Martin (2013) Spatial patterns of precipitation change in CMIP5: Why the rich do not get richer in the tropics. J. Climate, 26, 3803—3822, doi:10.1175/JCLI-D-12-00543.1.

Submission ID: 25
Presenting Author: Blair Trewin*
Session Time: WEDNESDAY 11:00-12:30

5

2011-2015 — the world's hottest five-year period on record

TREWIN Blair[1]*

1) Bureau of Meteorology

Preliminary figures show that the five-year period from 2011 to 2015 was the world's hottest five-year period on record. Mean global land-ocean temperatures from January 2011 to August 2015, averaging three major international data sets (NOAA, NASA, Hadley Centre), were 0.56° C above the 1961-1990 average. This exceeds the previous record anomaly of +0.51° C set in 2006-2010. With a global temperature anomaly of +0.61° C, 2014 is the world's hottest year, but 2015 is very likely to break this, being 0.70° C above average for January-August. 2011, 2012 and 2013 were not as hot, but each was hotter than any year prior to 1998.

No land areas were consistently cool through the period, although some were cool in individual years, such as northern Australia in 2011 and 2012, and central North America in 2014. Many continents and large countries had record hot years during the period, including Europe in 2014, Australia in 2013 and the United States in 2012, whilst South America is on course for its hottest year in 2015.

Many notable extreme events occurred during the period. The most destructive were typhoon Haiyan (Philippines, 2013) and hurricane Sandy (USA, 2012). Major multi-year droughts occurred in eastern Brazil and the western United States, while notable floods included those in Thailand, eastern Australia and Pakistan in 2011, and the Parana basin in South America in 2014.

Whilst no individual heatwave on the scale of those in central Europe in 2003 or Russia in 2010 occurred, there were still many major heatwaves, including in Europe (2015), Australia (2013 and 2014), east Asia (2013) and South America (2014). In contrast, abnormal snow and cold affected parts of eastern North America in 2014 and 2015, and Europe in 2012 and 2013.

Sea levels continued to rise consistently through the period. Arctic sea ice extent hit a record low in 2012, while Antarctic sea ice extent reached record high levels in 2013 and 2014 but returned to near normal by late 2015.

S3.1b General Climatology

Submission ID: 62
Presenting Author: Catherine Ganter*
Session Time: WEDNESDAY 11:00-12:30

6

Australian climate in 2015: strong El Niño, but Indian Ocean initially clouds its effect

GANTER Catherine[1]; TREWIN Blair[2]*

1) Bureau of Meteorology; 2) Bureau of Meteorology

With a near-miss El Niño in 2014, the tropical Pacific started 2015 already warmer than average, and warmed rapidly, tipping into El Niño conditions by early May. This strong El Niño has consistently been compared to the 1997—98 El Niño. A positive Indian Ocean Dipole (IOD) emerged during winter—about half of El Niño events have a positive IOD develop concurrently. However, a record-warm Indian Ocean during winter (and each individual month of winter) offset the influence of El Niño to some degree over Australia. The Southern Annular Mode was also positive during winter, with a seasonal average of +1.150.

2015 was again significantly warmer than normal, although well short of record levels, with a January—September mean temperature 0.46 °C above normal (15th highest). Queensland and Western Australia were particularly warm, while temperatures were near normal for this period in the southeast.

The combination of a strong El Niño and a record-warm Indian Ocean is an unusual set of drivers, and the presence of both appear to have limited broad-scale rainfall anomalies in the cooler part of the year in southern and eastern Australia, although southwest Western Australia (which recorded its second-driest May to July) and, to a lesser extent, Victoria and southern South Australia were dry. As the positive IOD set in properly during September, very dry conditions developed in spring over most of the continent, with October also exceptionally warm in southeast Australia.

Much of northern and central Australia, after a wet January, was very dry from February onwards. Long-term rainfall deficiencies persisted in much of inland Queensland, as well as in western Victoria and eastern South Australia. In the south, the multi-year failure of cool season rainfall continued with pressures at record highs and rainfall widely near record lows. This highlights the continued and growing influence of long-term trends on Australian seasonal and annual climate.

Submission ID: 198
Presenting Author: Damien Irving*
Session Time: THURSDAY 09:45-10:30

1

Caught in the middle: the Pacific-South American pattern and its relationship with tropical SSTs, ENSO and West Antarctic warming

IRVING Damien[1]; SIMMONDS Ian[2]*

1) University of Melbourne; 2) University of Melbourne

The Pacific-South American (PSA) pattern is an important mode of climate variability in the mid-to-high southern latitudes. It is widely recognised as the primary mechanism by which the El NiÑo Southern Oscillation (ENSO) influences the south-east Pacific and south-west Atlantic, and in recent years has also been suggested as a mechanism by which longer-term tropical sea surface temperature trends can influence the Antarctic climate. Despite this recognition, relatively little is known about the climatological characteristics of the pattern. This issue is addressed here via the development and application of a novel methodology for objectively identifying the PSA pattern from ERA-Interim reanalysis data. By rotating the global coordinate system such that the equator (a great circle) traces the approximate path of the pattern, the identification algorithm utilises Fourier analysis as opposed to a traditional Empirical Orthogonal Function approach. The resulting climatology reveals that the PSA pattern has a strong influence on temperature and precipitation variability over West Antarctica and the Antarctic Peninsula, and on sea ice variability in the adjacent Amundsen, Bellingshausen and Weddell Seas. Identified seasonal trends towards the negative polarity of the PSA pattern are consistent with warming observed over the Antarctic Peninsula during autumn, but are inconsistent with warming observed over West Antarctica during winter. Only a weak relationship is identified between the PSA pattern and ENSO, which suggests that the pattern would be better conceptualised as a preferred atmospheric response to various external (and internal) forcings.

S3.1c General Climatology

Submission ID: 83
Presenting Author: Robert Colman*
Session Time: THURSDAY 09:45-10:30

2

Climate feedbacks: from seasons to decades

COLMAN Robert[1]; POWER Scott[2]; HANSON Lawson[3]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology

Climate 'sensitivity' — the magnitude of the global response to greenhouse gas forcing — is largely driven by the strength of large scale atmospheric feedbacks (in particular those due to changes in water vapour, clouds, lapse rate and surface albedo). Much progress has been made in recent years understanding and evaluating climate change feedbacks, but estimates of the magnitude of global sensitivity have not narrowed from a range of 1.5 to 4.5°C. Understanding climate feedbacks, and if possible narrowing this range, remain critical tasks for climate science. A promising approach is to examine feedbacks operating on shorter timescales, which may be observed directly. Even as short as seasonally, feedbacks act to amplify the annual cycle of temperature, as confirmed by both models and observations. However, temperature patterns of variability differ significantly from those of climate change, and other factors confound the comparison — including the effect of CO2 forcing itself on cloud responses. How can we disentangle this range of effects?This paper evaluates the strength and structure of water vapour, lapse rate, surface albedo, cloud and temperature feedbacks operating at seasonal, interannual and longer timescales in CMIP3 and CMIP5 models. The structure and magnitude of these feedbacks are then compared with climate change feedbacks. The implications of these comparisons will be discussed.

S3.1c General Climatology

Submission ID: 17
Presenting Author: James Risbey*
Session Time: THURSDAY 09:45-10:30

3

Was there ever a 'pause' or 'hiatus' in greenhouse warming?

RISBEY James[1]*

1) CSIRO Oceans and Atmosphere

This work assesses the range of ways in which the alleged 'pause' ingreenhouse warming has been defined and used in the literature. Thereis no single agreed upon hypothesis to define the 'pause', nor isthere an agreed upon period that defines it. We test the range ofdefinitions and periods implicit in the literature for evidence of astatistically meaningful pause in observational data. We also examinethe frequency and likelihood of related events in climate models. Wediscuss sources and the role of the 'pause' concept, along withanalysis and recommendations for communication on climate variability.

S3.1d General Climatology

Submission ID: 121
Presenting Author: Scott Power*
Session Time: THURSDAY 11:00-12:30

1

Will global warming make future rainfall variability less predictable?

POWER Scott[1]; CHUNG Christine[2]*

1) Bureau of Meteorology; 2) Bureau of Meteorology

Previous work indicates that rainfall variability in many places will increase in response to global warming. Two important sources of rainfall variability are: (i) internally generated atmospheric variability; and (ii) variability arising as a forced response to sea-surface temperature (SST) variability. Variability arising from (i) generally exhibits very little predictability beyond a week or so, whereas variability linked to (ii) can exhibit predictability up to and beyond several seasons. In this study we analyse a series of SST-forced Atmospheric General Circulation Model experiments using ACCESS to provide an estimate of the impact of unmitigated global warming on late 21st century rainfall variability and the relative importance of (i) and (ii) to the changes evident.

S3.1d General Climatology

Submission ID: 331
Presenting Author: Markus Donat*
Session Time: THURSDAY 11:00-12:30

2

Total and extreme precipitation changes in the world's dry and wet regions

DONAT Markus[*1]*

1) University of New South Wales

Precipitation affects many aspects relevant to our society, including water availability and heavy rain leading to pluvial flooding. Therefore, understanding changes in precipitation is important to prepare for and adapt to possible future changes in water supply and risk of flooding.

Intensification of the hydrological cycle is expected as a direct consequence of a warming climate. On global average, both rainfall totals and extremes are expected to increase, but there are large regional differences in changes, and spatial patterns of precipitation change are uncertain across observations and climate models.It has been suggested that dry regions would become drier and the wet regions wetter but this hypothesis has also been challenged based on observations over land. Furthermore, changes may not only differ between regions but also between different aspects of precipitation, such as totals and extremes.

In our study we investigate changes in total and extreme precipitation in the wet and dry regions of the world, based on observations and global climate models. We find statistically significant increases in both rainfall totals and extremes in the dry regions and extreme rain in the wet regions. These changes are robust in observations and climate models, but there are uncertainties about changes in precipitation totals in the wet regions.

Climate projections show continued intensification of daily precipitation extremes as the climate warms, but there is a large inter-model spread for the changes by the late 21st century. In particular in the dry regions, precipitation increases show a strong scaling with the model-specific global temperature changes, so that the inter-model spread in projected global warming in part explains the spread in precipitation intensification by the late 21st century. This intensification has implications for increasing risk of flooding as the climate warms, particularly in the world's dry regions.

Submission ID: 218
Presenting Author: Chris Lucas*
Session Time: THURSDAY 11:00-12:30

3

The mean meridional circulation in isentropic coordinates: Climatology, variability and its relevance to southern Australia

LUCAS Chris[1]*

1) Bureau of Meteorology

The mean meridional circulation (MMC) is often defined by vertically integrating the zonal mean meridional wind in an isobaric coordinate system. This calculation produces the familiar 'three-cell' model, with the majority of the overturning circulation found in the Hadley Cells, two counter-rotating cells found between (roughly) 30° in each hemisphere. In this view, the extratropical circulation (i.e. the Ferrel and Polar cells) is comparatively weak and little interaction is suggested between the tropics and extratropics.

Alternatively, the MMC can be examined in an isentropic system, with (dry) potential temperature as the vertical coordinate, with the zonal mean mass-weighted meridional wind is vertically integrated. This calculation identifies a 'geostrophic' mode of the flow, containing the mass transports due to amplifying baroclinic waves. Consequently, this view of the MMC depicts a single circulation cell encompassing the entire hemisphere, which better captures the tropical-extratropical interactions crucial to understanding the climate in southern Australia.

Here, isentropic MMC is computed using ERA Interim reanalysis data from 1979-2014. Monthly averages show a strong evolution of the circulation over the course of the annual cycle. Regression analysis used to relate the MMC to modes of climate variability like ENSO and the annular modes. Temporal trends are also examined. Significant relationships are seen with the ENSO index, primarily in the tropics, suggesting a contraction of the Hadley Cell during El Nino. Annular mode indices show an effect in the extratropics of their respective hemispheres. Trends are noted in the Southern Hemisphere in particular. In the subtropics, an apparent tropical expansion signal is seen; near Antarctic latitudes, the surface circulation strengthens, coincidental with a surface cooling observed there.

Submission ID: 43
Presenting Author: Stacey Osbrough*
Session Time: THURSDAY 11:00-12:30

4

The role of external forcing on trends and projections of Southern Hemisphere storm formation

OSBROUGH Stacey[1]*

1) CSIRO Oceans and Atmosphere

Large changes in the Southern Hemisphere circulation over the last sixty years have impacted on the properties of weather systems associated with mid-latitude storms and consequently reductions in rainfall particularly over southern Australian. An assessment of reanalysis datasets (NCEP, ERA40 and 20CR) shows that there have been significant negative trends in the baroclinic instability of the mid-latitude atmospheric circulation resulting in a reduction in storm formation at these latitudes, while increases in baroclinicity further poleward have led to increased storm development. Whether these trends are likely to continue into the future under increasing anthropogenic Greenhouse Gas forcing is an important question with consequences for rainfall over southern Australia. Here, we assess the ability of 37 coupled climate models from the Coupled Model Intercomparison Project phase 5 (CMIP5) to simulate the observed trends in baroclinic instability during the 20th century in all months. The results show that the models best reproduce the trends during summer, and perform worst in winter. The models also tend to underestimate the trends, being typically less than a half the observed. In a similar fashion, negative trends in rainfall over southern Australia are generally about half the observed. We also consider the future Representative Concentration Pathway 8.5 (RCP8.5), with the largest radiative forcing of 8.5W m-2 (or equivalent CO2 concentration of 1360ppm), to assess the impact on future trends in baroclinic instability. Taking an ensemble of seven of the "best" models, we show that the observed 20th century trends in baroclinic instability continue up to 2100, resulting in continuing downward rainfall trends in Australia, and also rainfall in an hemispheric band between 20S-40S; positive trend occur poleward of 40S.

Submission ID: 223
Presenting Author: Ariaan Purich*
Session Time: THURSDAY 11:00-12:30

5

Modelled trends in Antarctic sea ice may be linked to underestimated changes in the westerly wind jet

PURICH Ariaan[1]; CAI Wenju[2]; ENGLAND Matthew[3]; COWAN Tim[4]*

1) CSIRO / UNSW; 2) CSIRO; 3) UNSW; 4) University of Edinburgh

Despite global warming, total Antarctic sea ice coverage increased over 1979-2013. However the majority of Coupled Model Intercomparison Project phase five (CMIP5) models simulate a decline. Mechanisms causing this discrepancy have so far remained elusive. Here we show that weaker trends in the intensification of the Southern Hemisphere westerly-wind jet simulated by the models may contribute to this disparity. During austral summer a strengthened jet leads to increased upwelling of cooler subsurface water and strengthened equatorward transport, conducive to increased sea ice. Because the majority of models underestimate summer jet trends, this cooling process is underestimated compared to observations, and is insufficient to offset warming in the models. Through the sea ice-albedo feedback, models produce a high-latitude surface ocean warming and sea ice decline, contrasting the observed net cooling and sea ice increase. The influence tropical teleconnections exert on high-latitude atmospheric circulation, regional-scale winds and Antarctic sea ice will also be discussed. A realistic simulation of observed wind changes may be crucial for reproducing the recent observed sea ice increase.

Submission ID: 85
Presenting Author: James Screen*
Session Time: THURSDAY 11:00-12:30

6

Effects of Arctic sea-ice loss on Australasian climate

SCREEN James[*1]; DESER Clara[2]; TOMAS Robert[3]; SUN Lantao[4]*

1) University of Exeter; 2) National Center for Atmospheric Research; 3) National Center for Atmospheric Research; 4) CIRES - NOAA & U. Boulder

Yes, you read that right! Despite being a million miles away (well, more like 13,000 km), the ongoing loss of Arctic sea-ice is relevant for future Australasian climate. In fact, the effects of projected Arctic sea-ice loss may be felt across the Southern Hemisphere (SH) from the tropics to Antarctica. In support of this statement, this talk will present evidence from a fully coupled ocean-atmosphere simulation in which sea-ice has been constrained to mimic the sea-ice loss projected in the RCP8.5 scenario. All other external forcings where fixed at 2000 levels to isolate the atmospheric response to solely sea-ice loss projected by year 2090. Arctic sea-ice loss induces a global-mean annual-mean surface warming of 0.62oC, which represents 17% of the global warming projected in the RCP8.5 simulation. In the tropics, 15% of the annual precipitation increase in the RCP8.5 simulation is reproduced in response to solely Arctic sea-ice loss. The loss of Arctic sea-ice induces a robust warming response in the tropical upper troposphere of both hemispheres, consistent with enhanced convection and latent heat release. Farther south in the high latitudes, the lower troposphere warms whilst the stratosphere cools, again consistent with the overall response to increased greenhouse gases. The reduced lower tropospheric meridional temperature gradient leads to a weakening and slight poleward shift of the circumpolar westerlies, reminiscent of the positive shift of the Southern Annular Mode seen in most climate projections. Zonal-mean annual precipitation is enhanced over the SH mid-latitudes but decreased in the sub-tropics. The temperature and precipitation responses over Australasia will be revealed in the talk. Analogous simulations using an uncoupled atmospheric model or coupled to a slab-ocean model do not show a robust SH response, highlighting the important role of ocean dynamics in driving the SH atmospheric response to Arctic sea-ice loss.

S3.2a Past Climate Reconstruction and Modelling

Submission ID: 347
Presenting Author: John Hellstrom*
Session Time: TUESDAY 14:30-15:30

1

Speleothem growth as a palaeoenvironmental proxy

HELLSTROM John[1]; SNIDERMAN Kale[2]; WOODHEAD Jon[3]; DRYSDALE Russell[4]; GREEN Helen[5]; PAUL Bence[6]*

1) The University of Melbourne; 2) The University of Melbourne; 3) The University of Melbourne; 4) The University of Melbourne; 5) The University of Melbourne; 6) The University of Melbourne

Speleothem growth requires that water is able to transport carbon dioxide from the soil atmosphere to the cave atmosphere below. In general, warmer or wetter conditions lead to more, faster growing speleothems; and cooler or drier conditions to less and slower growth. Aridity or glaciation can prevent growth entirely.

It has long been recognised that speleothem growth intervals have paleoclimatic significance. In the decades since radiometric U-Th dating became available there have been a number of prominent studies utilising speleothem growth frequency to investigate climate change on glacial-interglacial timescales. It has also become clear that growth rate variability within an individual speleothem typically records environmental change. Both types of record can be considered as speleothem growth probability versus time.

Radiometric dating of speleothems is a difficult and expensive procedure and producing growth probability records requires very many age determinations. New developments in laboratory automation of U-Th dating for samples of up to 500,000 years in age and in the widespread applicability of U-Pb dating for samples older than this are leading to the production of new, detailed records for the Australian region.

Current Australasian speleothem growth probability research covers from annually-resolved records of recent centuries to a U-Pb-dated record covering millions of years of changing effective precipitation. Whilst Australian records typically reflect water availability, New Zealand and some Tasmanian locations are dominated by changes in biological productivity of the surface above and broadly reflect glacial-interglacial temperature changes. In this way we have been able to constrain changes in southern Australian effective precipitation over almost ten million years, and to constrain the timing of warmer-than-present past interglacials.

Submission ID: 179
Presenting Author: Georgina Falster*
Session Time: TUESDAY 14:30-15:30

2

Climate variability in south-eastern Australia during the last glacial-interglacial transition: a multi-proxy (micro XRF and stable isotope) record from Lake Surprise

FALSTER Georgina[1]; TYLER Jonathan[2]; TIBBY John[3]; GRANT Katharine[4]; KERSHAW Peter[5]; BARR Cameron[6]*

1) The University of Adelaide; 2) The University of Adelaide; 3) The University of Adelaide; 4) Australian National University; 5) Monash University; 6) The University of Adelaide

Our understanding of global climate variability during the last deglaciation is limited in part by the paucity of high resolution, well dated records from the continents of the Southern Hemisphere. A new project aims to address this uncertainty through high-resolution elemental and isotope geochemical analyses of lateglacial crater lake sediments in south-eastern Australia.

Crater lakes are ideal candidates to provide a detailed record of terrestrial environmental change due to their sensitivity to changes in effective moisture. Palaeoecological analyses of a number of such sites in south-eastern Australia have revealed considerable potential as archives of lateglacial environmental change, however existing data are challenging to interpret on a purely climatic basis.

Here we present a multiproxy record of lateglacial (~30,000 — 10,000 years BP) climatic change from a core retrieved from Lake Surprise, in south-western Victoria. Preliminary analysis of the core suggests continuous deposition from a basal age of ca. 30,000 years BP, making Lake Surprise an ideal location for the derivation of a lateglacial climate record. We used an Avaatech core scanner to acquire a continuous record of major-element geochemistry. These data are supported by preliminary geochemical (δ13Corg, TOC, C/N) analyses of bulk sediment samples, which clearly track the transition from glacial to interglacial conditions, and highlight the considerable potential of Lake Surprise as a key archive of southern Australian climate change. Future analyses will include oxygen isotope geochemistry of carbonates, which will be combined with clumped isotope analyses to obtain independent estimates of lake water temperature and source water δ18O.

Coupled with the continued development of a robust radiometric chronology, these data promise new insights into the nature of Australian and Southern Hemispheric climate variability since the Last Glacial Maximum.

Submission ID: 155
Presenting Author: Ailie Gallant*
Session Time: TUESDAY 14:30-15:30

3

Can we use 20th Century climate reanalysis products to support Antarctic ice core interpretation?

GALLANT Ailie[1]; DURAN Earl[2]; VANCE Tessa[3]; ROBERTS Jason[4]*

1) School of Earth Atmosphere and Environment, Monash University; 2) University of Tasmania; 3) University of Tasmania; 4) Australian Antarctic Division

Ice cores are useful proxies for interpreting past climate, particularly for those areas where instrumental data are short and/or scarce, such as Antarctica. However, ice core proxies cannot be used in complete isolation and interpretation of proxy data is often complemented by an examination of the climate through instrumental observations or reanalysis data. In Antarctica, much of the instrumental data, including reliable reanalysis data, is limited to the post-satellite era (~post-1978). This poses problems when decadal-to-multidecadal scale features are being examined.

Recently, several reanalysis products have become available that assimilate only surface measurements, thereby extending reanalyses throughout the 20th Century. This extension helps with the interpretation of ice core proxies for decadal-to-multidecadal scale features, but is reliant on the skill of these reanalysis products over Antarctica, which we test here for the first time.

This study examines the skill of one of the newer 20th Century reanalysis data sets, the ERA-20C by comparing it to radiosonde measurements of temperature, geopotential height, wind speed and direction over Antarctic stations from 1957—2010. The radiosonde data provides an independent comparison as only surface measurements have been assimilated into the ERA-20C reanalysis. The results demonstrate variation in skill with meteorological variable, with season and over time, which are attributable to a number of factors.

Submission ID: 230
Presenting Author: Bethany Ellis*
Session Time: TUESDAY 16:30-17:30

1

Late Holocene Indian Ocean Dipole variability from Indonesian corals

ELLIS Bethany[1]; ABRAM Nerilie[2]; GRANT Katharine[3]*

1) Australian National University; 2) Research School of Earth Sciences Australian National University; 3) Research School of Earth Sciences Australian National University

The Indian Ocean Dipole (IOD) is an ocean-atmosphere climate oscillation within the Indian Ocean basin, and one of Australasia's key climate drivers that influences the distribution of rainfall across the region. Future projections of the activity of the IOD are largely uncertain and the short duration of instrumental records makes it difficult to separate anthropogenic-related trends from natural variability. To extend the knowledge of natural IOD activity back prior to the 1950s, high-resolution palaeoclimate reconstructions of Indian Ocean sea surface temperature (SST) are needed to provide a comprehensive view of IOD upwelling activity during the Holocene and give context to recent changes in IOD activity. Massive Porites corals from Indonesia have been identified as sensitive recorders of past SST that can be used to reconstruct the history of IOD variability prior to instrumental records.

In this study, a suite of modern and fossil corals is being used to reconstruct past SST from Sunda Strait, between the Indonesian islands of Java and Sumatra. Sunda Strait (6.5°S, 105.5°E) is a key area for measuring IOD activity, as the cold upwelling waters associated with a positive IOD event have a clear signature that is captured by geochemical changes in coral skeletal material. In this study we present results trialing a new, rapid methodology of assessing coral trace element geochemistry using an XRF (X-Ray Fluorescence) core scanner in combination with ICP-AES (Inductively-Coupled Plasma Atomic Emission Spectrometer). Rapid geochemical analysis of coral material would enable palaeoclimate reconstructions of the IOD across a much larger set of corals than is possible using traditional microsampling and geochemical analysis methods.

Submission ID: 138
Presenting Author: Mandy Freund*
Session Time: TUESDAY 16:30-17:30

2

ENSO flavors- Spatial dynamics of ENSO during the pre-industrial period

FREUND Mandy[*1]*

1) University of Melbourne

A few studies have investigated the intensity and frequency of unconventional ENSO and compared with canonical ENSO events. Most of the studies cover only a few events based on relatively short instrumental records. A trend towards more frequent dateline or Modoki events is present in observations since the late 1970s. Various studies suggest a shift from canonical El Niño events towards unconventional El Niño as a consequence of global warming. A lack of instrumental observations before 1950s makes it hard to differentiate between recent trends and long-term climate variability. Current ENSO reconstructions are missing a spatial component or are commonly based on single-record records generally from teleconnected regions, limiting our ability to adequately detail past ENSO dynamics.

This study aims to use a coral network with subseasonal resolution and terrestrial archives like speleothems to reconstruct Pacific SSTs. Subannual sampling of underlying proxy data may provide the high temporal and spatial resolution needed tocharacterise features such as the onset, duration and frequency of ENSO events over past centuries.

S3.2b Past Climate Reconstruction and Modelling

Submission ID: 78
Presenting Author: Ryan Batehup*
Session Time: TUESDAY 16:30-17:30

3

The influence of non-stationary ENSO teleconnections on reconstructions of paleoclimate using a pseudoproxy framework

BATEHUP Ryan[1]; MCGREGOR Shayne[2]; GALLANT Ailie[3]*

1) University of New South Wales; 2) Monash University; 3) Monash University

Reconstructions of ENSO ideally require high-quality, annually-resolved and long-running paleoclimate proxy records in the eastern tropical Pacific Ocean, located in ENSO's centre-of-action. However, to date, the paleoclimate records that have been extracted in the region are short or temporally and spatially sporadic, limiting the information that can be provided by these reconstructions. Consequently, most ENSO reconstructions exploit teleconnections of ENSO, where longer records from paleoclimate proxies exist. However, using teleconnections to reconstruct ENSO relies on the assumption that the relationship between ENSO and the remote location is stationary in time, which is tenuous at best.

This study examines the implications of non-stationary teleconnections on modern multi-proxy reconstructions of ENSO. The sensitivity of the reconstructions to non-stationary teleconnections were tested using a suite of idealized pseudoproxy experiments that employed output from a fully coupled global climate model. ENSO reconstructions in the pseudoproxy experiments were shown to not be sensitive to non-stationary teleconnections when global, uniformly-spaced networks of a minimum of approximately 20 proxies were employed. Neglecting proxies from ENSO's center-of-action still produced skillful reconstructions, but the chance of generating a skillful reconstruction decreased. Reconstruction methods that utilized raw time series were the most sensitive to non-stationary teleconnections, while calculating the running variance of pseudoproxies first, appeared to improve the robustness of the resulting reconstructions. The results suggest that caution should be taken when developing reconstructions using proxies from a single teleconnected region, or those that use less than 20 source proxies.

Submission ID: 302
Presenting Author: Benjamin Henley*
Session Time: TUESDAY 16:30-17:30

4

Decadal variability in the Pacific: palaeoclimate reconstruction of the IPO

HENLEY Benjamin[1]; GERGIS Joelle[2]; KAROLY David[3]; FREUND Mandy[4]*

1) University of Melbourne; 2) University of Melbourne; 3) University of Melbourne; 4) University of Newcastle

Our understanding of decadal variability in the Pacific Ocean is limited due to short observational records, uncertainty in palaeoclimate reconstructions and imperfect model simulations. This presentation summarizes recent work on reconstructing the Interdecadal Pacific Oscillation (IPO) from a multi-proxy network of palaeoclimate data spanning the Pacific basin.

The reconstruction target, the tripole index (TPI), tracks the distinct tripole pattern of Pacific sea surface temperature anomalies (SSTA) varying on decadal timescales. The index is computed as the difference between the SSTA averaged over the central equatorial Pacific and the average of the SSTA in the Northwest and Southwest Pacific. The TPI timeseries bears a close resemblance to previously published indices, is free from assumptions about the nature of global warming and has the advantage of being simpler to compute and more consistent with methods used to track other climate modes.

Previous IPO or PDO reconstructions have focussed on palaeoclimate data from single regions or sites. However, there is poor agreement between existing reconstructions, possibly due to regional teleconnection non-stationarity or regional climate influences. A new multi-proxy palaeoclimate reconstruction of the IPO is presented, incorporating a network of palaeoclimate records from around the Pacific basin. The reconstruction provides the latest annually-resolved estimate of the temporal variability of the IPO and provides an opportunity to investigate the past influence of the IPO on modulating global surface temperatures on decadal timescales. The implications for decadal-scale hydroclimatic variability and periods of surface warming acceleration and hiatus are discussed.

S3.2c Past Climate Reconstruction and Modelling

Submission ID: 340
Presenting Author: Helen McGregor*
Session Time: WEDNESDAY 09:45-10:30

1

Global ocean cooling over the past millennium induced by episodic volcanic eruptions

MCGREGOR Helen[1]; ADDISON Jason[2]; ERSEK Vasile[3]; EVANS Michael[4]; FILIPSSON Helena[5]; GOOSSE Hugues[6]; LEDUC Guillaume[7]; MARTRAT Belen[8]; MORTYN Peter[9]; OPPO Delia[10]; PHIPPS Steven[11]; SEIDENKRANTZ Marit-Solveig[12]; SELVARAJ Kandasamy[13]; SICRE Marie-Alexandrine[14]; THIRUMALAI Kaustubh[15]*

1) University of Wollongong; 2) U.S. Geological Survey; 3) Northumbria University; 4) University of Maryland; 5) Lund University; 6) Université de Louvain; 7) Aix Marseille Université; 8) Institute of Environmental Assessment and Water Research (IDÆA) Spanish Council for Scientific Research (CSIC); 9) Universitat Autonoma de Barcelona; 10) Woods Hole Oceanographic Institution; 11) University of Tasmania; 12) Aarhus University; 13) Xiamen University; 14) Sorbonne Universités; 15) University of Texas at Austin

The oceans mediate the response of global climate to natural and anthropogenic radiative forcing, yet observations of global maritime surface climate variations in the late Holocene, and the mechanisms that drive the variations, are relatively unknown. Here we synthesize 57 sea surface temperature (SST) reconstructions, sourced from all major ocean basins, and spanning at high resolution some or all of the past 2000 years. The reconstructions are derived from marine archives (Mg/Ca, alkenones, TEX86, faunal assemblages in sediment cores, and coral), and meet strict chronological control criteria. The reconstructions are geographically sparse, however analysis of multi-millennial AOGCM output and historical gridded SST observations suggest the reconstructions are spatially sufficient to resolve global mean SST. The reconstructions were standardised into 200-year bins and the resulting Ocean2k SST synthesis reveals a robust SST cooling trend for 0-1800 years of the Common Era (CE), with the strongest cooling after 1100 CE. The cooling trend is not sensitive to localized upwelling, marine archive type, seasonality of response, chronological control, water depth, sampling resolution, sedimentation rate, basin, latitude or hemisphere. The Ocean2k SST cooling trend is qualitatively consistent with an independent synthesis of terrestrial paleoclimate data, and with simulations from the multimodel PMIP3 ensemble, driven by the full suite of hypothesized radiative forcings. Comparison with ensembles of single and cumulative radiative forcing simulations suggests that the cooling trend arises not from orbital forcing, but from the increased frequency of explosive volcanism and/or land use change in the most recent millennium. We find that episodic volcanic eruptions induce a net negative radiative forcing that results in a centennial and global scale-cooling trend via a decline in mixed-layer oceanic heat content.

Submission ID: 300
Presenting Author: David Etheridge*
Session Time: WEDNESDAY 09:45-10:30

2

Terrestrial uptake due to cooling responsible for low atmospheric carbon dioxide during the Little Ice Age

ETHERIDGE David[1]; ALLISON Colin[2]; CURRAN Mark[3]; ENTING Ian[4]; LANGENFELDS Ray[5]; MULVANEY Robert[6]; RAYNER Peter[7]; RUBINO Mauro[8]; SMITH Andrew[9]; STEELE Paul[10]; STURGES Bill[11]; TRUDINGER Cathy[12]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) Australian Antarctic Division; 4) The University of Melbourne; 5) CSIRO Oceans and Atmosphere; 6) British Antarctic Survey; 7) The University of Melbourne; 8) Seconda Università di Napoli; 9) Australian Nuclear Science and Technology Organisation; 10) CSIRO Oceans and Atmosphere; 11) University of East Anglia; 12) CSIRO Oceans and Atmosphere

Models of future carbon cycle-climate changes predict a large range in atmospheric CO2, mainly because of uncertainties in the response of the land carbon cycle to temperature. The Little Ice Age (LIA, 1500-1750 AD) decrease is the most significant pre-industrial CO2 atmospheric change over the last two millennia and has been used to derive the climate sensitivity of the global carbon cycle (gamma). While a recent study confirms that pre-industrial CO2 variations were caused by changes in land carbon stores, there are open questions about the size of the atmospheric LIA CO2 decrease reconstructed from ice cores, and about what caused the land to sequester CO2. To quantify the size of the LIA CO2 decrease, we have produced new CO2 measurements from DML ice, that support the DSS LIA CO2 decrease as a real atmospheric feature. To partition the contribution of ocean and land, we have measured the 13C-CO2, showing that the cause of the CO2 decrease was uptake by the terrestrial biosphere. To identify whether the land uptake was caused by temperature, or by a decline in farming due to pandemics, we have simulated the effect of a temperature perturbation on atmospheric Carbonyl Sulfide (COS). In agreement with the previously published positive COS anomaly, our results indicate that Global Primary Productivity (GPP) decreased during the LIA, ruling out the early anthropogenic land use change hypothesis as the dominant cause of increased terrestrial carbon storage. This allows us to obtain a new, more coherent estimation of gamma.

S3.3a Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 219
Presenting Author: Harun Rashid*
Session Time: MONDAY 10:45-12:15

1

Factors affecting the ENSO amplitude in CMIP5 models

RASHID Harun[*1]*

1) CSIRO Oceans and Atmosphere

Since Bjerknes' original proposal, the atmosphere-ocean interaction processes involved in the ENSO evolution have been extensively studied. In particular, the oceanic feedbacks, such as the zonal advective and thermocline feedbacks, have been shown to play a prominent role in the ENSO dynamics. These feedbacks now form the oceanic branch of an extended Bjerknes' feedback loop. Although, the tropical zonal wind stress (ZWS) is a central part of this feedback loop, much emphasis has been placed to date only on the SST—zonal wind feedback, by which the ENSO-related eastern Pacific SST anomalies induce anomalous westerlies in the central Pacific. However, the ZWS forcing of the eastern Pacific SST anomalies has been recently shown to be important for the ENSO amplitude change under global warming (Rashid et al. 2015). In this work, we examine more closely the relationship between the ZWS forcing efficiency (ZFE) and the ENSO amplitude (i.e., the anomalous variability of eastern Pacific SSTs) in a set of CMIP5 models using the historical experiments. We find a strong correlation between the anomalous variability of the central Pacific ZWS and the ENSO amplitude. Further, we show that the ZFE explains about half of the inter-model variations of the ENSO amplitude, significantly more than that explained by the SST—ZWS feedback (25%). This highlights the importance of the ZFE in ENSO dynamics. The role of the eastward shifting tropical deep convection, associated with the ENSO-induced SST warming, in determining the magnitude of the ZFE is also examined. The results will be discussed in this presentation.

Reference:

Rashid, H.A., Hirst, A.C., and Marsland, S.J., 2015. An atmospheric mechanism for ENSO amplitude changes under enhanced CO2 forcing in CMIP5 models. Submitted to GRL.

Submission ID: 266
Presenting Author: Esteban Abellán*
Session Time: MONDAY 10:45-12:15

2

Analysis of the southward wind shift of ENSO in CMIP5 models

ABELLÁN Esteban[1]; MCGREGOR Shayne[2]; ENGLAND Matthew[3]*

1) University of New South Wales; 2) UNSW; 3) UNSW

The southward wind shift (SWS) that occurs during the mature phase of the El Niño-Southern Oscillation (ENSO) is examined in phase 5 of the Coupled Model Intercomparison Project (CMIP5). It is found that most models successfully reproduce the observed SWS although the magnitude of zonal wind stress is underestimated. The models with better performance in simulating the SWS tend to also exhibit a more realistic ENSO sea surface temperature (SST) anomaly and precipitation patterns. However, these patterns are shifted westward compared to the observations in models with poor simulation of the SWS. It is demonstrated that the SWS is driven by the Philippine Sea anticyclone (cyclone) for strong El Niño (La Niña) events, whereas near-normal values of SST over the western equatorial Pacific and decreased precipitation over the northwestern region influence the SWS during moderate El Niño. Further, it is shown that the modeled SWS plays a significant role on peak time for extreme El Niño, leading to more abrupt termination, in sharp contrast to that for moderate El Niño, in which is negligible. For La Niña events, it is revealed that the simulated SWS results in a partly seasonal synchronization of these events to the seasonal cycle. Our findings also indicate that models not capable to simulate SWS have lower spatial resolution in both atmospheric and oceanic components.

S3.3a Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 77
Presenting Author: Shayne McGregor*
Session Time: MONDAY 10:45-12:15

3

Charging El Niño with off-equatorial westerly wind events

MCGREGOR Shayne[1]; TIMMERMANN Axel[2]; JIN Fei-Fei[3]; KESSLER Billy[4]*

1) Monash University; 2) University of Hawaii; 3) University of Hawaii; 4) NOAA/PMEL

The buildup of the warm water in the equatorial Pacific prior to an El Niño event is considered a necessary precondition for event development, while the event initiation is thought to be triggered by bursts of westerly wind. However, in contrast to the view that warm water slowly builds up years before an El Niño event, the volume of warm water in the equatorial Pacific doubled in the first few months of 2014 reaching values that were consistent with the warm water buildup prior to the extreme 1997/1998 El Niño. It is notable that this dramatic warm water buildup coincided with a series of westerly wind bursts in the western tropical Pacific. This study uses linear wave theory to determine the effect of equatorial and off-equatorial westerly wind events on the Warm Water Volume (WWV) of the Pacific. It is found that westerly wind events have a significant impact on equatorial WWV with all events initially acting to increase WWV, which highlights why WWEs are so effective at exciting ENSO. In fact, our results suggest that the single westerly wind burst, which peaked in the first few days of March in 2014, was largely responsible for the coincident dramatic observed increase in WWV. How long the equatorial region remains charged, however, depends on the latitude of the westerly wind event. For instance, a single equatorially symmetric westerly wind event ultimately acts to discharge WWV via the reflection of upwelling Rossby waves, which makes it difficult to more gradually build WWV given multiple WWEs. In contrast, when the wind events occur off the equator, the subsequent discharge is significantly damped and in some cases the equatorial region can hold the heat charge for up to 9 months. As such, off-equatorial WWEs can not only charge equatorial region WWV in the short term, but are also a mechanism to more gradually build equatorial region WWV in the longer term. Given that these off-equatorial WWEs have a relatively small projection onto the equatorial Kelvin wave, we argue these events can be considered as a mechanism to modulate the background state in which ENSO operates.

Submission ID: 134
Presenting Author: Wenju Cai*
Session Time: MONDAY 10:45-12:15

4

Model biases in the tropical Indo-Pacific climate and projected change in climate extremes

CAI Wenju[1]; WANG Guojian[2]; SANTOSO Agus[3]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) University of New South Wales

Tropical Indo-Pacific climate variability, such as the El Nino-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) affect extreme weathers, agriculture, and ecosystem worldwide. The frequency of extreme El Nino, extreme La Nina and extreme positive IOD has been projected to increase. Simulation of these modes of variability and the underlying mean climate has been plagued by biases, including overly large amplitude of the IOD and a Pacific cold tongue that extends too far west into the west Pacific. With a potential to under confidence in the projected change, such biases also motivate discussion on measures for reducing uncertainties, including using an “emergent” constraint to select models, even to correct projections. Here we show use of such measures must be treated with caution. Firstly, it must be underpinned by a physical process that also operates without climate change, such that, for example, if a bias contributes to a projected increase in extreme El Nino frequency, models with a greater bias should generate a greater frequency of extreme El Nino events in the present-day climate. Secondly, considerations must be given to the possibility that there might be multiple constraints, some of which might have opposing influence on the projection. Finally, using a constraint to directly correct projected changes is not advisable because the corrected changes are not dynamically consistent and therefore could introduce new uncetainties.

S3.3a Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 239
Presenting Author: Asha Vijayeta*
Session Time: MONDAY 10:45-12:15

5

ENSO-dynamics in CMIP5 simulations in the framework of the linear recharge oscillator model

VIJAYETA Asha[*1]*

1) Monash University

ENSO-dynamics in CMIP5 simulations show a wide spread of uncertainties in ENSO statistics. In this study we use the concept of the linear recharge oscillator model to diagnose the ENSO-dynamics in all CMIP5 model simulations. The parameters allow to quantify damping, growth rate, coupling to thermocline, sensitivity to wind and heat forcings , and allow to separate atmospheric from oceanic processes. Our results illustrates that the ENSO-dynamics and their diversity within the CMIP5ensemble can be well represented with the linear recharge oscillator model diagnostics. The results illustrate that individual processes show larger biases to observation and spread within the model than simple large-scale statistics such as SST standard deviation.

Submission ID: 299
Presenting Author: Luis Icochea*
Session Time: MONDAY 10:45-12:15

6

Relationship between Oceanographic conditions in Southwest Pacific and Peruvian Coast during El Niño Event 2014-2016

ICOCHEA Luis[1]; KOBAYASHI Masato[2]; ROSALES Gandy[3]*

1) La Molina National Agrarian University (Universidad Nacional Agraria La Molina); 2) Yokohama College of Commerce of Japan; 3) Servicio Nacional de Meteorología e Hidrología (SENAMHI)

Perhaps the most extreme oceanographic changes are observed near Peruvian Coast during El Niño Event like as were observed during 82-83,97-98 and will be observed at the end of 2015-begin of 2016. This event have a mechanism that involucres the southwest and the southeast Eq. Pacific Ocean. Will be showed the analysis of data carried out by our laboratory of the faculty of fisheries Universidad Nacional Agraria La Molina. These will be compared with the data registered in the West Pacific, also the biological response of the most abundant marine sp, that let us to make close approximation of the conditions that will occur in the end of El Niño. Methods: Subsurface temperatures(1), dynamic heights(2), wind velocity and currentmeters data from operative buoys of NOAA during El Niño was used. We compared daily and monthly variations in the west-east. Surface (every 15 min in 10 pts) and subsurface temperature, salinity and oxygen data measured along Peruvian Coast in order to detect the effect of Kelvin waves. Results: Was observed differences of the oceanographic parameters during El Niño, however the mechanisms of the occurrence of such events are very similar. (1) and (2) positive anomalies were detected first to the west and after many months the anomalies moved and increased to the east, winds reversal helped the water mass movement, anomalies in the west became negative. Kelvin waves were detected to travel through along the thermocline, arrived along Peruvian Coast and produced a downwelling of the thermocline. In the west the thermocline upwells. Upper layer temperature increase more than 10°C in Peru during more than 2 months. Anchovy schoolfish deepens and migrated to the south and to the coast during El Niño. Demersal species like Peruvian hake and conger eel migrated more than 200 miles south of their traditional distribution area. Conclusions: The occurrence of strong El Niño is very similar, and it could be used to predict the arrive of the warm waters to Peruvian Coast.

S3.3b General Atmospheric Processes

Submission ID: 190
Presenting Authors: Christian Febre*
Session Time: MONDAY 14:30-15:30

1

The Bjerknes's Mechanism application for monitoring the ENSO phases

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1) National Service of Meteorology and Hydrology; 2) National Service of Meteorology and Hydrology; 3) Concepcion University

The El Niño-Southern Oscillation phenomenon has become familiar around the world because substantial weather anomalies often occur during periods of an extreme "ENSO-state". To characterize the nature of El Niño-Southern Oscillation (ENSO), sea surface temperature (SST) and sea level pressure (SLP) anomalies in different regions of the Pacific have been used. An optimal characterization of both distinct character and the evolution of each EL Niño or La Niña event requires at least two variables: (i) SST anomalies in the Pacific basin (ASSTP), and (ii) SLP anomalies expressed as the calculation of the standard normalized Equatorial Southern Oscillation Index (EqSOI), which is given by the difference between the area-average monthly sea level pressure in an area of the eastern equatorial Pacific (80°W - 130°W, 5°N-5°S) and an area over Indonesia (90°E - 140°E, 5°N - 5°S). NCEP/NCAR Reanalysis and ERSST.V4 data were used.

Temporal correlation of three-month running averaged EqSOI and ASSTP showed strong inverse correlation in Niño 3.4 region ($r \leq -0.7$), which indicated a high relationship on interannual timescales of equatorial pressure balance, trade winds and oceanic heat fluxes. To study warm and cold phases of the ENSO cycle (El Niño and La Niña) we analyzed these variables in a dispersion diagram where the equatorial atmospheric-oceanic coupling is shown clearly. Finally, using different statistics we determined thresholds to identify "ENSO-states". To reinforce the study, atmospheric and oceanic patterns have also been evaluated.

S3.3b Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 227
Presenting Author: Shayne McGregor*
Session Time: MONDAY 14:30-15:30

2

Projected changes in the Indonesian Throughflow linked to the deep overturning circulation

SEN GUPTA Alexander[1]; MCGREGOR Shayne[2]; VAN SEBILLE Erik[3]; SANTOSO Agus[4]; BROWN Jaclyn[5]; GANACHAUD Alexandre[6]*

1) University of New South Wales; 2) Monash; 3) Imperial College London; 4) University of New South Wales; 5) CSIRO; 6) Institut de Recherche pour le Developpement

The Indonesian Throughflow (ITF) has an important impact on the mass, heat and freshwater budget of the global oceans. It also plays an important role in modulating both regional and global climate, making the understanding of future ITF changes of considerable importance. The ITF transport changes on a range of timescales, with much of the variability explained by variations in local or regional surface winds.

Using the CMIP5 suite of coupled climate models we examine the response of the ITF and the wider Pacific circulation under a business as usual RCP85 emissions scenario. In particular, we examine the processes giving rise to the projected changes in the models. Substantial and consistent changes are projected by the models, including a ~20% decrease in ITF, a large intensification of East Australia Current extension and asymmetric changes in the low latitude western boundary currents. While projected changes in the winds clearly drive most of the Pacific circulation changes, the ITF reduction cannot be explained by wind changes. Instead, this reduction result from a slowdown of the Pacific overturning circulation and upwelling of water from the deep to upper ocean.

Submission ID: 247
Presenting Author: Takanori Horii*
Session Time: MONDAY 14:30-15:30

3

Low salinity signal on the high salinity subsurface water during negative Indian Ocean Dipole

HORII Takanori[1]; CAI Wenju[2]; SATO Kanako[3]; ANDO Kentaro[4]*

1) CSIRO Oceans and Atmospheric Flagship; 2) CSIRO Oceans and Atmospheric Flagship; 3) Japan Agency for Marine-Earth Science and Technology (JAMSTEC); 4) Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

The Indian Ocean Dipole (IOD) is a seasonal to interannual ocean-atmosphere phenomenon occurring in the tropical Indian Ocean. During the negative phase of the IOD (nIOD), the eastern Indian Ocean is characterized by warmer sea surface temperature, enhanced atmospheric convection, and high-salinity anomalies advected from the west. In this study, we investigated ocean temperature and salinity data in the south eastern Indian Ocean to understand a possible role of the salinity variation on the development of nIOD. We used ocean temperature and salinity data from Argo floats and mooring buoy. We also used satellite SST and precipitation data from the Tropical Rainfall Measuring Mission satellite. During the development phase of the 2010 nIOD (July-September), eastward surface currents induced by westerly wind anomalies produced high salinity anomalies in the central-eastern equatorial Indian Ocean. Observation data also showed relatively low salinity signal around 0-10m depth together with relatively shallow mixed layer in the south-eastern Indian Ocean. Our analysis indicated that the low salinity signal was associated with enhanced local precipitation that eventually formed vertical salinity gradient on the high salinity anomalies. The upper-layer stratification due to the salinity variation could affect ocean-atmosphere interaction during the nIOD by changing the mixed layer depth. A possible contribution of the salinity variation to the mixed layer heat balance and hence an effect on SST will be discussed.

Submission ID: 71
Presenting Author: Benjamin Ng*
Session Time: MONDAY 14:30-15:30

4

Thermocline bias influencing IOD projections

NG Benjamin[1]; CAI Wenju[2]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere

A prominent feature of the Indian Ocean Dipole (IOD) is its positive skewness, where positive phases tend to be stronger in amplitude than the opposite negative phase. These positive IOD events are associated with devastating floods over parts of East Africa and India whilst Australia and Indonesia experience drier than normal conditions. The impacts from these extreme weather events have the potential to displace millions of peoples, affect sensitive ecosystems, and reduce agricultural productivity. Under increasing greenhouse gases, climate models project a weakening of the positive IOD skewness but their simulation of present-day skewness is too weak. Here we show that this bias in IOD modelling is related to the simulation of the thermocline in the eastern equatorial Indian Ocean. Improving the ability of models in simulating a deeper thermocline may lead to stronger present-day simulated skewness and a reduction under climate change that is larger than projected.

S3.3c Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 317
Presenting Author: Hamish Ramsay*
Session Time: MONDAY 16:00-17:00

1

The interannual variability of Australian region tropical cyclones, ENSO, and Indian Ocean subtropical dipole

RAMSAY Hamish[1]; RICHMAN Michael[2]; LESLIE Lance[3]*

1) Monash University; 2) University of Oklahoma; 3) University of Oklahoma

Australian region tropical cyclones (TCs) for 1970—2013 were analysed for seasonal predictability. A pool of six sea surface temperature anomaly (SSTA) regions is found to correlate strongly with TC count (TCC). Three are well-known: Niño 3.4, Niño 4 and the Indian Ocean Dipole (IOD). The three additional regions identified are the subtropical South Pacific Ocean (STSPO), the South Indian Ocean (STSIO) and a region north of Australia (Local). Three-month averaged SSTA from January-February-March (JFM) to September-October-November (SON) are the TCC predictors. Both individual and pairs of autoregressive (AR) three-month periods were used for both linear regression (LR) and support vector regression (SVR) methods. LR gave moderate to high correlations (>0.6), starting from JJA, thereby providing a skillful predictability lead-time of 2 months prior to TC season start (November 1). SVR and AR-SVR double the lead-time with correlations >0.6, beginning with AMJ. SVR methods were superior to LR from JJA to SON, with average R2 increasing by 16.4%, mean-absolute-error (MAE) decreasing by 23.1% and root-mean-square-error (RMSE) decreasing by 15.1%. SVR selects STSIO from MAM through SON, highlighting the Indian Ocean SSTA contribution. The Pacific Ocean contribution (STSPO, Niño 3.4 and/or Niño 4) is selected by SVR for AMJ—JAS; thereafter, Local replaces STSPO. Predictor temporal stability was investigated using moving window correlations. Predictors having moderate to high skill ranged from 4 years (STSPO) to 16 years (STSIO). After 1999—2000, the IOD emerged, following a weakening ENSO-TCC relationship, thereby demonstrating the necessity of retaining all six predictors. Composites of SSTA for MAM through ASO validate the spatial correspondence and evolution of predictor regions.

S3.3c Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 245
Presenting Author: Kevin Tory*
Session Time: MONDAY 16:00-17:00

2

Regional variations in the rate tropical depressions become tropical cyclones

TORY Kevin[*1]*

1) Bureau of Meteorology

Projected changes in future tropical cyclone (TC) formation are almost entirely dependent on climate models. Understanding projections requires knowledge of the changing climatic conditions that support TC formation in these models and in the real world. In this study we attempt to identify the differences in necessary climatic conditions between early and late stages of TC development, as a means to better understand why TC formation rates change in future climate projections. The early and late development stages are defined, respectively, as the formation of a tropical depression (TD), and the further intensification to TC.

The Okubo-Weiss-Zeta-Parameter (OWZP) TC detection algorithm is adapted to identify a tropical depression (TD) proxy. Applied to 34 years of ERA-Interim reanalysis data, the proportion of these TDs that do not become TCs (TD failure rate) is examined. Large variations in TD failure rate were found between, and within, the major TC ocean basins. For example,TD failure rates are generally larger at higher latitudes. A striking regional difference is present in the southern hemisphere poleward of 15°, where about 50% of TDs fail in the South Pacific Ocean, compared to 30% in the South Indian Ocean. These variations are mostly due to differences in climatic conditions that can be summarised by two sets of threshold values. The first set defines where the TD-proxies form, and the second set in conjunction with the first roughly defines where the majority of proxy TDs become TCs.

The results suggest that the proxy TDs form in favourable thermodynamic environments, but the further development to a TC requires more specific favourable conditions that allow the juvenile TD vortex to intensify. The results highlight the increasing importance of in-situ energy extraction from the sea surface, and the vulnerability of the vortex to shear as it becomes reliant on this energy source.

Submission ID: 273
Presenting Author: Sarah Perry*
Session Time: MONDAY 16:00-17:00

3

Unifying the numerical model and proxy-reconstruction views of ENSOs response to climate change

PERRY Sarah[1]; MCGREGOR Shayne[2]; ENGLAND Matthew[3]; SEN GUPTA Alexander[4]*

1) University of New South Wales; 2) Monash University; 3) University of New South Wales; 4) University of New South Wales

The El Niño-Southern Oscillation (ENSO) is the dominant mode of inter-annual climate variability affecting climate globally. ENSO-driven variability has far-reaching impacts, modulating temperature and rainfall and contributing to instances of extreme weather. Climate change has the potential to alter ENSO, subsequently altering ENSO driven impacts, effecting ecosystems and human activity around the world. How ENSO will evolve under future warming is currently uncertain. Proxy reconstructions of ENSO derived from multiple sources show that ENSO variability has been increasing since the late 1800s, while different climate models show increases, decreases, or little change in the variability of ENSO sea surface temperature anomalies (SSTAs) under future warming. However, the models also suggest that the effects of ENSO in the tropical Pacific are becoming enhanced under future warming, suggesting that the impacts of ENSO driven variability will increase.

We use temperature and precipitation data from 21 CMIP5 models to show that ENSO teleconnections are being amplified and dampened at different regions. These changes are occurring globally, including outside of the tropical Pacific. These results suggest that at regions where the ENSO teleconnection is amplified, future warming will exacerbate the ENSO-driven response for that location. This implies that future proxy reconstructions from these areas, and potentially past reconstructions, will suggest and increase in ENSO variance, because proxies capture the effects of ENSO (i.e., increases in rainfall or temperature), rather than changes in SSTAs. The impact of these changes on future proxy reconstructions will be assessed through model pseudo-proxy analysis, in which ENSO variability will be reconstructed from the model temperature and precipitation CMIP5 data from a number of teleconnected locations around the world.

S3.3c Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 156
Presenting Author: Keith Potts*
Session Time: MONDAY 16:00-17:00

4

El Nino, from 1870 to 2014, and other Atmospheric Circulation Forcing by Extreme Apparitions of the Eight Annual, Continental Scale, Aerosol Plumes in the satellite era which Point to a Possible Cause for the Current Californian Drought

POTTS Keith[*1]

1) Kyna Keju Pty Ltd

The lead up science conference to COP21 in July in Paris identified aerosols as the next great challenge for climate research.

Seven continental scale aerosol plumes now exist in the same season each year whilst the East Asian Plume is visible all year. The aerosol optical depth of all the plumes varies hugely with studies showing the surface radiative forcing of the SE Asian Plume (SEAP) as -150W/m^2 and -286W/m^2/AOD.

I show that the natural and anthropogenic SEAP is the sole cause of all El Nino events. The SEAP creates an El Nino by absorbing solar radiation at the top of the plume which heats the upper atmosphere and cools the surface. This creates a temperature inversion compared to periods without the plume and reduces convection. With reduced convection in SE Asia the Trade Winds blowing across the Pacific relax as their exit into the Hadley and Walker Cells is constrained and the reduced Trade Wind speed causes the Sea Surface Temperature (SST) to rise in the central tropical Pacific Ocean as there is a strong negative correlation between wind speed and SST. The warmer SST in the central Pacific creates convection in the region which further reduces the Trade Wind speed and causes the Walker Cell to reverse — a classic El Nino.

I will then show how the South American, West African, Middle East and SEAP plumes create drought in the Amazon, Spain, Darfur and Australia.

All these effects are created by the plumes reducing convection in the region of the plume which forces the regional Hadley Cells into anomalous positions thereby creating persistent high pressure cells in the mid latitudes. This perturbs the mid latitude storm tracks and creates persistent high and low pressure systems around the World at those latitudes giving rise to extreme events by causing the winds to blow persistently from one direction.

Finally I will suggest which plumes may be causing the high pressure ridge in the NE Pacific which is causing the current severe drought in California.

Submission ID: 162
Presenting Author: Nicholas Tyrrell*
Session Time: TUESDAY 09:45-10:30

1

Elements of the continental amplification of an ENSO-like oceanic forcing

TYRRELL Nicholas[1]; DOMMENGET Dietmar[2]*

1) Monash University; 2) Monash University

On seasonal and longer timescales tropical oceans surface temperature anomalies can force land surface temperature anomalies, communicated via an atmospheric bridge. The dryness of the land surface compared to the oceans makes it more sensitive to an atmospheric forcing, resulting in ocean temperature anomalies becoming amplified over land. On near global scales it would appear that the magnitude of the amplification of the ocean temperature anomalies over land is related to the dryness of land, as measured by the soil moisture. Implying that a drier surface would lead to increased amplification. However, on regional scales the land surface temperature response is not correlated with the dryness of the land.

In this study we use the Globally Resolved Energy Balance (GREB) model to deconstruct the regional land surface temperature response to an ocean forcing. We start with a Pacemaker run from the ACCESS AGCM. This run is forced with a canonical ENSO pattern in the tropical Pacific, oscillating with a period of four years, and a responsive slab ocean outside the tropical Pacific. With this model setup the magnitude of the land surface response is similar to that seen in observations and coupled models (CGCMs), and it is possible to take composites of a number of variables at the peak of the ocean forcing. The GREB model allows the circulation, cloud cover, soil moisture and SSTs to be assigned as boundary conditions. By taking composites of these variables from the ACCESS model and applying them to the GREB model individually and in combination, we can build the response pattern and determine the regional importance of the various mechanisms that allow the ocean to influence land surface temperatures.

Submission ID: 345
Presenting Author: Stuart Browning*
Session Time: TUESDAY 09:45-10:30

2

Tropical forcing of Southern Annular Mode asymmetry over the past millennium

BROWNING Stuart[1]; GOODWIN Ian[2]*

1) Marine Climate Risk Group Department of Environmental Sciences Macquarie University; 2) Marine Climate Risk Group Department of Environmental Sciences Macquarie University

Tasman Sea subtropical storms develop explosively when tropical and extratropical air masses collide. Ideal conditions for these interactions occur when anomalously warm Indo-Pacific sea surface temperatures force asymmetry in the negative phase (-ve) of the Southern Annular Mode (SAM). Observational evidence suggests this alignment of major climate drivers occurs relatively infrequently, with El Niño (La Niña) more commonly coupled to SAM-ve (+ve). Consequently our perception of risk, developed over the past 30-40 years, suggests extreme subtropical storms are also relatively infrequent with an expected multidecadal return period. However, the observational record is too short to effectively examine multidecadal variability. Although the Twentieth Century Reanalysis extends back to 1851, observational data scarcity means it is largely unconstrained in the Southern Hemisphere prior to ~1900.

In this study we use a recently developed paleoclimate based reanalysis (PaleoR) to examine multidecadal variability in tropical-extratropical teleconnections over the past millennium. PaleoR spans the past 1200 years and is analogous to modern reanalysis products but constrained by paleoclimate data instead of meteorological observations. When evaluated over the past millennium we find multidecadal to centennial scale persistence in a wide range of mean state configurations. Persistent SAM+ve during the Medieval Climate Anomaly was coupled to mostly El Niño from 1000-1150 CE and then mostly La Niña/La Niña Modoki from 1150-1260 CE. Persistent SAM-ve during the Little Ice Age was coupled to mostly El Niño from 1270-1600 CE and then mostly La Niña from 1600-1900 CE. The combination of La Niña/La Niña Modoki coupled to SAM-ve during 1600-1900 appears to be associated with the most extreme storm periods in the Tasman Sea. Therefore, perceptions of risk based on just the past ~30 years underestimate the full range of natural variability.

S3.3d Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 301
Presenting Author: Andréa Taschetto*
Session Time: TUESDAY 09:45-10:30

3

How did ocean warming affect Australian rainfall extremes during the 2010/11 La Niña event?

UMMENHOFER Caroline[1]; SEN GUPTA Alexander[2]; ENGLAND Matthew[3]; TASCHETTO Andréa[4]; BRIGGS Peter[5]; RAUPACH Michael[6]*

1) Woods Hole Oceanographic Institution; 2) University of New South Wales; 3) University of New South Wales; 4) University of New South Wales; 5) CSIRO Oceans & Atmosphere; 6) Australian National University

Droughts and floods are expected to become more frequent with an intensifying hydrological cycle in a warming world. Extreme rainfall conditions in Australia during the 2010/11 La Niña resulted in devastating floods claiming 35 lives and billions of dollars in damages, and far-reaching impacts on global climate, including a significant drop in global sea level anomalies and record terrestrial carbon uptake. Northeast Australian 2010/11 rainfall was amplified by 84% over average conditions, unusual even for a strong La Niña event, and soil moisture conditions were unprecedented since 1950.

Here we demonstrate that the warmer background state increased the likelihood of the extreme rainfall response in Australia. Using atmospheric general circulation model experiments with 2010/11 ocean conditions with and without long-term warming, we identify the mechanisms that increase the likelihood of extreme rainfall: additional ocean warming enhanced onshore moisture transport onto Australia and ascent and precipitation over the northeast. Our results highlight the role of long-term ocean warming for modifying rain-producing atmospheric circulation conditions, increasing the likelihood of extreme precipitation for Australia during future La Niña events.

Submission ID: 89
Presenting Author: Bertrand Timbal*
Session Time: TUESDAY 11:00-12:30

1

South-Eastern Australia rainfall projections: do we understand the uncertainties?

TIMBAL Bertrand[1]*

1) Bureau of Meteorology

South-Eastern Australia (SEA) has experienced reduced rainfall in the last 30 years compared to the historical record since the 1860s. This reduction has been in the cool part of the year from April to October while the rest of the year has experienced a small increase. This on-going pattern has had consequences for water management, agriculture and the natural environment. There is great interest in the future of SEA rainfall, and whether this decline will continue. However, there are still many uncertainties relating to projections of SEA rainfall, both in our understanding of the processes involved and of the representation of these processes in our main tool for making projections, climate models. In the latest set of global climate model simulations, CMIP5, there is a high level of model agreement on a continuing rainfall decline in SEA, but there are notable model deficiencies and biases to account for and the range of results from individual models is large. Here we take a critical look at the drivers of rainfall change in SEA, their simulation in models and possible changes to these drivers in future. We focus on important drivers of change at inter-annual timescales such as remote drivers in the Pacific and Indian Ocean, and also contributions to long-term trends such as changes to the mean atmospheric circulation. We evaluate what we know with confidence, what we are still unsure of and what we still need to know to make useful future projections of SEA rainfall. This work will help develop confidence in the range of future SEA rainfall projections under plausible future climates in order to help stakeholders navigate the space of uncertainties attached to the projections.

Submission ID: 97
Presenting Author: Eun-Pa Lim*
Session Time: TUESDAY 11:00-12:30

2

Inter-decadal variations in the linkages between ENSO, the IOD and south-eastern Australian springtime rainfall in the past 30 years

*LIM Eun-Pa**[1]

1) Bureau of Meteorology

Inter-decadal variations of the relation between El Niño and the Southern Oscillation (ENSO) and the Indian Ocean Dipole mode (IOD) are investigated and related to changes in the predictability of the IOD and south-eastern Australian (SEA) rainfall in austral spring. The study uses observational records for 1951-2014 and retrospective seasonal forecasts from the Australian Bureau of Meteorology's seasonal forecast system, POAMA for 1985-2014. The strength of the co-variation of ENSO and the IOD and the amplitude of the IOD are observed to vary in phase inter-decadally with the amplitude of ENSO. However, the strength of the teleconnection of ENSO and the IOD to SEA rainfall is observed to vary out-of-phase with the amplitudes of ENSO and the IOD and the co-variability of ENSO and IOD. These changes in the ENSO-IOD co-variability, the amplitudes of ENSO and the IOD, and the teleconnections of ENSO and the IOD to SEA rainfall are highly coherent in the last 35 years. Consequently, since 2000 when ENSO and the IOD amplitudes reduced and the ENSO-IOD co-variability was relatively low, predictability and prediction skill of the IOD were low. However, as the teleconnections of ENSO and the IOD to SEA rainfall were strong, predictability and prediction skill of SEA rainfall was high. A possible cause of the increased strength of the teleconnection of the IOD and ENSO to SEA rainfall during this epoch of low IOD/ENSO variability and co-variability is a change in the zonal variation of rainfall anomalies in the tropical Indo-Pacific during ENSO/IOD.

Submission ID: 122
Presenting Author: Christine Chung*
Session Time: TUESDAY 11:00-12:30

3

The non-linear impact of El Niño, La Niña and the Southern Oscillation on seasonal and regional Australian precipitation

CHUNG Christine[1]; POWER Scott[2]*

1) Bureau of Meteorology; 2) Bureau of Meteorology

The relationship between El Niño Southern Oscillation (ENSO) indices and precipitation (P) in some parts of Australia has previously been shown to be non-linear on annual and seasonal time scales. Here we examine the relationship between P and the Southern Oscillation Index (SOI) at all Australian locations and in all seasons. We show that in many Australian regions, there is more-than-expected (based on a linear relationship) P when the SOI is strongly positive (SOI>15), but less-than-expected drying when the SOI is strongly negative (SOI<-15). Statistically significant non-linearities are found over eastern Australia during DJF and MAM, and northern Australia during SON, when regressing P against concurrent seasonal SOI. JJA is the only season in which the P-SOI relationship is linear over the whole country. Systematic eastward shifts in P patterns explain non-linearities over northern Australia, but do not explain non-linearities southward of approximately 20°S. Links between daily data and seasonal non-linearity will be described.

S3.3e Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales

Submission ID: 211
Presenting Author: Hanh Nguyen*
Session Time: TUESDAY 11:00-12:30

4

Regionalization of the Hadley Circulation and implications for Australian rainfall

NGUYEN Hanh[1]; HENDON Harry[2]; LIM Eun-Pa[3]; MALONEY Eric[4]; BOSCHAT Ghyslaine[5]; TIMBAL Bertrand[6]; LUCAS Chris[7]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Colorado State University; 5) University of Melbourne; 6) Bureau of Meteorology; 7) Bureau of Meteorology

The Hadley Circulation (HC) in the Southern Hemisphere is decomposed into three sectors defined by the equatorial heat sources of Europe-Africa, Asia-Pacific and the Americas. A regional HC is defined by a streamfunction derived from the divergent component of the meridional winds. We show that most of the Southern Hemisphere HC expansion from the late 1970s is due to the expanded local HC in the Asia-Pacific sector, evident in the annual and seasonal means. This expansion is associated with a La Niña-like state in the tropical Pacific. An expanded Southern Hemisphere HC both in the zonal mean and in the Australian sector is associated with a poleward expansion of the tropical wet zone that occurs primarily in the warm seasons, as well as with the positive phase of the Southern Annular Mode. However, we find that the variation of the edge of the regional HC does not strongly affect that of the intensity of the local subtropical ridge (STR) over the Australian sector. Variations in the intensity and position of the STR that are strongly associated with southeastern Australian dry conditions appear as a remote response to tropical diabatic heating associated with the Indian Ocean Dipole (IOD) in austral winter and spring. The dry conditions over southeastern Australia are therefore unlikely to be driven by the expansion of the HC but more likely to be due to a positive phase of the IOD.

Submission ID: 251
Presenting Author: Peter van Rensch*
Session Time: TUESDAY 11:00-12:30

5

The influence of local sea surface temperatures on southeast Australian rainfall during the 1982-83 and 1997-98 El Niño events

VAN RENSCH Peter[1]; GALLANT Ailie[2]; CAI Wenju[3]; NICHOLLS Neville[4]*

1) CSIRO; 2) Monash University; 3) CSIRO; 4) Monash University

The impact that the 1997-98 El Niño event had on September-November (SON) 1997 rainfall in southeast Australia (SEA) was not in line with expectations. This event saw near average SON rainfall in SEA whereas typically other El Niño events, such as the similar 1982-83 El Niño, brought less than average rainfall. Until recently, the evidence suggested that the rainfall received in 1997 was simply due to random atmospheric processes, however, a more recent study suggested that this rainfall disparity could be attributed to local SST forcing. Van Rensch et al. (2015) found evidence that the sea surface temperatures (SSTs) to the north and northeast of Australia contributed to the SEA SON rainfall during both 1982 and 1997 events. During 1982, cool SSTs to the north and northeast of Australia appears to have increased the chance of a rainfall deficit in SEA. Conversely, in 1997 the north and northeast SSTs were only marginally cooler than average. AMIP simulations forced by observed SSTs suggest these SST anomalies tempered the expected rainfall deficit in SEA associated with the El Niño (van Rensch et al., 2015).

This current work explores the results of the previous study using the ACCESS 1.3 atmosphere model forced with prescribed SSTs. Through isolating the contributions of different regions of SST during the 1982 and 1997 events, we confirm which regions were most important for rainfall during these years. A discussion on the atmospheric processes associated with these teleconnections will also be provided.

Reference:

van Rensch, Peter, Ailie J. E. Gallant, Wenju Cai, Neville Nicholls, 2015: Evidence of local sea surface temperatures overriding the southeast Australian rainfall response to the 1997-98 El Niño. Geophys. Res. Lett. In press.

Submission ID: 330
Presenting Author: Simon Grainger*
Session Time: TUESDAY 11:00-12:30

6

Teleconnections and the role of external forcing in Australian regional rainfall variability

GRAINGER Simon[1]; FREDERIKSEN Carsten[2]; KOCIUBA Greg[3]*

1) Climate Information Services Bureau of Meteorology; 2) Research and Development Bureau of Meteorology; 3) Research and Development Bureau of Meteorology

The seasonal mean of Australian rainfall can be considered to consist of an externally-forced climate “signal”, and “noise” related to internal variability. In the global climate system, the externally-forced component is related to changing radiative forcing, most notably the response to changing greenhouse gas concentrations. In contrast, the internal variability is related to hemispheric-scale processes with teleconnections to the Australian climate; for example the El Niño Southern Oscillation (ENSO), the Southern Annular Mode (SAM), the Australian monsoon and the Madden Julian Oscillation (MJO).

The interannual co-variability between the atmospheric circulation and Australian rainfall for both the externally-forced and internal components is investigated in a multi-model ensemble (MME) of 11 Coupled atmosphere-ocean General Circulation Models (CGCMs) from the Coupled Model Intercomparison Project Phase 5 (CMIP5) dataset. This is done for four Australian regions, where the rainfall co-variability with 500 hPa geopotential height exhibits coherent large-scale structures.

Here, we focus on results from two regions and seasons where the observed rainfall has had prolonged, statistically significant trends. For both the northwest of Australia in summer, and southwest in winter, the CMIP5 MME reproduces well the leading observed mode of total co-variability. Furthermore, the CMIP5 MME has an externally-forced mode in these seasons in which the regional rainfall loading pattern matches the pattern of the observed rainfall trends. The coupled circulation loadings are consistent with the atmospheric responses to historical changes in radiative forcing. In both cases, the externally-forced mode is projected to continue, with increased magnitude under the increased greenhouse gas concentrations of the CMIP5 RCP8.5 experiment. The structure and magnitude of this externally-forced mode will be contrasted with the leading internal modes of co-variability.

Submission ID: 15
Presenting Author: Mia Gross*
Session Time: MONDAY 10:45-12:15

1

The representation of health-relevant heatwave characteristics in a Regional Climate Model ensemble

GROSS Mia[1]; ALEXANDER Lisa[2]; MACADAM Ian[3]; GREEN Donna[4]; EVANS Jason[5]*

1) University of New South Wales; 2) University of New South Wales; 3) University of New South Wales and UK Met Office; 4) University of New South Wales; 5) University of New South Wales

Heatwaves have been linked to increased rates of human mortality and morbidity. Due to these adverse health impacts, it is essential to understand how these extreme events might change in the future. Health impacts studies and adaptation planning benefit from having this information at a local scale. While Global Climate Models can provide continental-scale projections of future changes in these events, Regional Climate Models, such as those used in the New South Wales/Australian Capital Territory Regional Climate Modelling (NARCliM) project, provide simulations at a finer scale more appropriate for regional assessments. This paper uses the NARCliM simulations for New South Wales and the Australian Capital Territory to investigate the ability of a Regional Climate Model ensemble to represent heatwave characteristics through the Excess Heat Factor, an index believed to be relevant to human health. Both uncorrected and bias-corrected model output was evaluated against observationally-derived heatwave characteristics for the period 1990-2009. The effect of bias-correction on future changes in heatwave characteristics was also assessed. Overall, while the simulations were able to provide a good representation of the recent climate, bias-corrected simulations did not greatly change model output. Some regions were more affected than others, with bias-correction being most beneficial for coastal regions. We emphasise that these results may not apply to all indices measuring extreme heat and we demonstrate that results for a fixed-threshold index are substantially affected when bias-correction is applied. While supporting bias-correction, this study demonstrates that bias-corrected climate model output is not necessarily required when evaluating a relative measure such as the Excess Heat Factor.

Submission ID: 109
Presenting Author: Clem Davis*
Session Time: MONDAY 10:45-12:15

2

Observed trends in temperature and rainfall over Northern Australia 1911-2013 and the implications on project development and human health

DAVIS Clem[*1]*

1) The Australian National University

Comparisons of the trends in temperature and rainfall between the periods 1911-1940 and 1984-2013 will be presented. These comparisons show that there has been an increase in temperatures and rainfall over the region for the latter period. This analysis finds that temperatures in the coastal locations are increasing at a greater rate than inland locations while rainfall is increasing in the western part of the region. The increases in the seasonal trends of temperatures are also reflected in both the increasing trends in the daily extremes and in the numbers of heat events that have been observed.

There is considerable political and financial pressure to expand development projects and the population in this region, which is already at the upper end of human thermo-tolerance. The implications of these increases on the viability of any planned developments and on attracting people to the region on a more permanent basis will be presented. These implications highlight the need to include risk management decisions to address these issues from the start of the planning process.

Submission ID: 111
Presenting Author: Liz Hanna*
Session Time: MONDAY 10:45-12:15

3

Warming in Tropical Climates — Implications for Health and Productivity

HANNA Liz[1]; DAVIS Clem[2]*

1) Australian National University; 2) Australian National University

The hot monsoonal climate of northern Australia is one of extremes. Coupled with the relentless annual build-up season of increasing heat and humidity Australia's northern climate degrades the wellbeing and functional capacity of human populations. Past development ambitions across Northern Australia have been beset with failures, largely attributed to the difficult tropical climate. Human thermoregulatory boundaries mean that acclimatisation to heat and humidity have a natural upper limit, beyond which continued exercise, such as working, becomes increasingly uncomfortable, and potentially lethal.

The ANU "Working in the Heat" study findings are presented. Novel in its approach, this study measured on-site occupational heat exposures and identified the exposure - health and productivity relationships. This paper applies that relationship to the 1911-2014 trends in warming and rainfall variation across northern Australia, and as per the Davis — Hanna abstract/ AMOS paper, to identify the health and productivity burden of Australia's existing tropical climate.

The region experiences high turnover as people find the benefits of tropical living are outweighed by the discomfort. Staff turnover results in loss of expertise, high workloads for residual staff, and grief. Physical and mental health ramifications of heat exposures are broad, and often serious. Issues of isolation and social problems of substance abuse and domestic and other violence are seasonally related to climate extremes, and they spill over into the workplace. Climate model projections suggest this social, health and productivity burden will exacerbate.

The recent Government White Paper on Developing Northern Australia outlines a strategy to quadruple the population across Northern Australia, with a growth rate double the national average. This strategy ignores the regional climate challenges past, present and future. This paper demonstrates the serious risks in ignoring climate in policy formulation.

Submission ID: 233
Presenting Author: Maryam Navi*
Session Time: MONDAY 10:45-12:15

4

Using environmental health indicators to identify populations vulnerable to climate change

NAVI Maryam[1]*

1) University of Adelaide

Climate change will exacerbate existing health problems in people vulnerable to present day climatic conditions. Environmental indicators are used to routinely monitor the state of climate, however indicators to measure and track the impact on health and identify areas for intervention have not been developed in Australia. Data for use as indicators needs to be readily available, reliable and able to show trends over long periods of time. This study investigates the potential use and validity of evidence- based health indicators of climate change and their use in identifying vulnerable populations.

We conducted a review of Australian literature relevant to climate change health impacts and used the Driving force-Pressure—State-Exposure-Effect-Action framework specific to the development of environmental health indicators. The framework was modified to include potential indicators of human vulnerability.

The bulk of the literature relates to health related impacts of extreme heat, changes in the incidence of climate-sensitive infectious diseases, and health outcomes associated with climate-change related air pollution (e.g. PM, ozone and pollen loads). The results suggest that the most robust environmental health indicators of climate change in the Australian context relate to the incidence of climate sensitive infectious diseases, and heat-related morbidities and mortalities. Risk factors that increase vulnerability to heat include older age, living alone, low socioeconomic status and having existing chronic diseases. People geographically more vulnerable to climate change will be those in low income neighbourhoods, warmer areas and coastal regions. The identification of environmental health indicators of climate change is important for policymakers and climate change adaptation strategies.

Submission ID: 358
Presenting Author: Mark Stafford-Smith*
Session Time: WEDNESDAY 13:45-15:30

1

Future Earth: Earth system science for solutions, from local to global scales

STAFFORD-SMITH Mark[1]*

1) CSIRO

Future Earth is a global platform for international research collaboration on global environmental change and sustainable development that aims to fulfil the commitment of the research community at Rio+20 to play its part in contributing to a more nimble global innovation system in the face of increasing rates of global change. It is focused on eight major societal challenges, in which both fundamental and applied earth system sciences have a critical contribution to make. It also has a solutions orientation, emphasises principles of co-design, and is addressing the challenges of integrating across scales in ways related to the theme of this conference. The platform has frankly taken a while to construct, but this presentation will outline how it is now active, and the ways in which the research community can engage with it.

S3.5a Future Earth: Science for Solutions to Global Problems

Submission ID: 352
Presenting Author: Will Steffen*
Session Time: WEDNESDAY 13:45-15:30

2

The Anthropocene: Humanity meets the Earth System

STEFFEN Will[*1]*

1) Australian National University

In 2000 atmospheric chemist Paul Crutzen proposed that the Earth had entered the Anthropocene, a new geological epoch that is driven not by the great forces of nature but by human activity. Over the past 15 years the concept of the Anthropocene has grown to mean many things to many people, well beyond its original scientific basis. However, debates over its scientific origins still abound, with the International Commission on Stratigraphy set to make a judgment next year on the original Crutzen hypothesis. This talk will focus on the scientific case, based on Earth System science, for confirming that the Earth is indeed now in a new geological epoch of human making. A wide range of evidence from many features of the Earth System will be presented, with an emphasis on changes in the climate system.

S3.5a Future Earth: Science for Solutions to Global Problems

Submission ID: 220
Presenting Author: Malte Meinshausen*
Session Time: WEDNESDAY 13:45-15:30

3

Three gaps to bridge for a safer climate

*MEINSHAUSEN Malte**[1]

1) Australian-German Climate & Energy College, The University of Melbourne

Warming of global average surface temperatures by 2°C relative to pre-industrial levels will go together with pervasive and multi-facetted impacts. Sea level rise is one of them. Given multi-meter commitments of sea level rise at 2°C warming, that level can hardly be considered 'safe' — although that ultimately depends on value judgements. Yet, a likely chance of staying below 2°C is currently the international communities' agreement under the UNFCCC. Thus, there is a large 'target gap'. Measuring Cancun emission reduction pledges for 2020 and the post-2020 targets that parties negotiated at the Paris COP21 meeting against trajectories and carbon budgets that would be consistent with the 2°C target, reveals a second gap, the so-called 'emission gap'. And thirdly, in order to achieve the proposed emission targets, many countries, including Australia, have arguably not the policies in place yet (or any more) to reach those targets. Hence, there is a 'policy & implementation gap'. Lastly, as re-percussion of the previous three gaps, there is a fourth one: the 'adaptation gap', given that adaptation policies are insufficient (and arguably will in many cases always remain insufficient) to soften the impacts of climate change.

This talk will shed light in particular on the second gap, the emission gap, by quantifying the negotiation outcome from COP21 in Paris. The examination will benchmark the outcome against global cumulative carbon emission budgets as well as least-cost mitigation scenarios in line with 1.5°C, 2°C and other warming levels and against different likelihoods of achieving those. In addition, -recognising the value judgements embedded in any consideration of 'fair' emission shares at national levels — some national targets will be examined more closely from different viewpoints of what 'comparable efforts' are in light of the global mitigation challenge.

Submission ID: 270
Presenting Author: Andrew Lenton*
Session Time: WEDNESDAY 13:45-15:30

4

Insights into climate intervention (geoengineering): results from GeoMIP and CDRMIP

LENTON Andrew[*1]*

1) CSIRO Oceans and Atmosphere

Continued anthropogenic greenhouse gas emissions are changing the climate threatening "severe, pervasive and irreversible" impacts. Inadequate emissions reduction is resulting in increased attention on Climate Intervention (CI) — deliberate interventions to counter climate change that seek to either modify the Earth's radiation budget - Solar Radiation Management, or remove the primary greenhouse gas from the atmosphere — Carbon Dioxide Removal (CDR). To explore the efficacy, risks, feedbacks and challenges of different types of proposed CI a number international efforts are underway that bring together a number modelling groups in a common framework: The Geoengineering Model Intercomparision Project (GeoMIP) focussed on Solar Radiation Management, and the Carbon Dioxide Removal Model Intercomparison Project (CDRMIP). In this talk I will introduce each of these projects, their goals and some of the results from each. I will then focus on my research in each of the projects focussing on exploring and quantifying the carbon-cycle response in the land and ocean to different proposed CI.

S3.5a Future Earth: Science for Solutions to Global Problems

Submission ID: 197
Presenting Author: Greg Holland*
Session Time: WEDNESDAY 13:45-15:30

5

Planning for and responding to weather and climate extremes

HOLLAND Greg[*1]; BRUYERE Cindy[2]; BUCKLEY Bruce[3]; CHAN Peter[4]; DONE James[5]; DYER Andrew[6]; LEPLASTRIER Mark[7]; TINGLEY Martin[8]; TYE Mari[9]*

1) NCAR; 2) NCAR; 3) Insurance Australia Group; 4) Insurance Australia Group; 5) NCAR; 6) Insurance Australia Group; 7) Insurance Australia Group; 8) Insurance Australia Group; 9) NCAR

Understanding and predictions of high-impact weather and climate extremes continues to improve, and a variety of innovative approaches are being developed to downscale this information to the local level. However, a major limitation remains in the lack of readily-available tools that can utilise this information to provide robust, well-communicated predictions and advice in support of resilient decision-making. Here we report on collaborative program to develop and support such tools: the Engineering for Climate Extremes Partnership (ECEP).

ECEP brings scientists and practitioners together in a collaborative environment to both specify and support priority basic research and the development of tools for use in community-planning and adaptation assessments. The tools are contained within the Global Risk, Resilience, and Impacts Toolbox (GRRIT), which is bring maintained and supported by NCAR in a similar manner to our weather and climate models. This work also acknowledges that all systems will fail at some level and we have adopted the concept of 'graceful failure' as a key research and development feature.

This presentation will outline the overall ECEP and GRRIT approach. Specific application of tropical cyclone modules described in separate presentations by Bruyere et al and Tingley et al will be demonstrated, including application of a secondary module that directly assesses hurricane impact potential from meteorological information.

Submission ID: 187
Presenting Author: Cindy Bruyere*
Session Time: WEDNESDAY 13:45-15:30

6

Hybrid real-idealized tropical cyclones as a new loss tool

BRUYERE Cindy[*1]; HOLLAND Greg[2]; BUCKLEY Bruce[3]; CHAN Peter[4]; LEPLASTRIER Mark[5]; TINGLEY Martin[6]; DYER Andrew[7]*

1) National Center for Atmospheric Research; 2) National Center for Atmospheric Research; 3) Insurance Australia Group Limited; 4) Insurance Australia Group Limited; 5) Insurance Australia Group Limited; 6) Insurance Australia Group Limited; 7) Insurance Australia Group Limited

Damages caused by Tropical Cyclones are amongst the highest associated with natural disasters. Tropical cyclone related wind (and associated storm surge) and precipitation damage is responsible for the largest portion of financial and material losses. From a reinsurance, management and building code perspective, it is therefore essential to assess the associated long-term risks. Traditionally, this long-term risk assessment is done through a 2-tier approach: 1) assessing wind and precipitation probabilities from historical meteorological observations, and 2) feeding these data into loss or impact models.

The shortcoming with this approach is the lack of an accurate and long historical record and the potential effects of climate change or long-term variability. Synthetic tropical cyclone tracks have traditionally been used to fill in the sparse available data. These have proven to be a useful and effective tool, but they lack information on important processes (e.g. interactions with complex terrain) and miss the combined effects of storm-surge and rainfall-flooding.

Here we describe the development of a new hybrid modeling capability based on the WRF hurricane model that has been designed through industry and (re)insurance collaboration to supplement the traditional statistical-synthetic approaches. The use of the system will be demonstrated using Townsville and Cairns as example locations.

Submission ID: 295
Presenting Author: Michael Grose*
Session Time: WEDNESDAY 13:45-15:30

7

The past and the future of national climate projections in Australia

GROSE Michael[1]; WHETTON Penny[2]; HENNESSY Kevin[3]*

1) CSIRO; 2) CSIRO; 3) CSIRO

Climate projections go beyond the usual remit of scientific research, and represent a nexus of science, policy and decision-making motivated by a strong societal need. While grounded in scientific research, projections are fundamentally a communication concern, as credible information must mesh with decision-making frameworks of next and end users of the information. Several generations of national projections from CSIRO and later with the Bureau of Meteorology have grown in scope and sophistication over time. The projection releases have faced several perennial issues of climate projections and several tensions. In future there will be a desire for updated information products for reasons of credibility and saliency. Greater credibility from new scientific understanding that could lead to better decision making would be highly valued. Similarly, greater salience through enhanced communication methods would also be highly valued, including improvements in combining and conveying information and tailoring of information for specific decision frameworks. Also there will also always be a desire to understand messages from new data sources such as CMIP5 and CORDEX, and the synthesis of these various data sources. Here we reflect on the practice of national climate projections in Australia in the past and consider options and scope for future product

Submission ID: 287
Presenting Author: Helen Cleugh*
Session Time: WEDNESDAY 16:30-17:30

1

Earth system and climate change science for a productive and resilient Australia

CLEUGH Helen[*1]*

1) CSIRO

The Australian government's National Environmental Science Programme (NESP) was launched in 2014 with the goal of providing the environmental research needed to inform Australian decision makers; with a focus on biodiversity and climate. The Earth Systems and Climate Change Hub is a national partnership, bringing together the world-leading capability in multi-disciplinary Earth system science and modelling to provide the information needed to support a productive and resilient Australia. The Earth Systems and Climate Change Hub was established in 2015, and will begin research delivery in 2016. This presentation will provide an overview of the Hub's research priorities, goals and outcomes; along with the overarching research plan. With a strong outcome-focus, commitment to significant stakeholder engagement, and links to the other five NESP Hubs (Threatened Species, Clean Air and Urban Landscapes, Marine Biodiversity, Tropical Water Quality and Northern Australia Resources), the Hub provides an opportunity to ensure that environmental decision and policy-making is informed by the best available climate science. As the name of this session suggests however, the solutions to most global change challenges requires real Earth system science, that includes human systems and therefore economic and social science. Taking this step will require the Hub to develop synergies and partnerships with other research programs and activities, as will be described in this presentation.

Submission ID: 75
Presenting Author: Aurora Bell*
Session Time: WEDNESDAY 13:45-15:30

1

Uncertainty and unpredictability in radar rainfall nowcasting - why does it matter?

BELL Aurora[1]; COOPER Shaun[2]; CURTIS Mark[3]; SEED Alan[4]*

1) Australian Bureau of Meteorology; 2) Environment and Research Division, Bureau of Meteorology; 3) Environment and Research Division, Bureau of Meteorology, Melbourne; 4) Environment and Research Division, Bureau of Meteorology, Melbourne

The Bureau of Meteorology has developed the next generation radar rainfall estimation and nowcasting system which will be implemented by June 2016. The system, named Rainfields3, processes data from 55 radars across Australia and the performance has been improved by including the real-time dynamic analysis of the radar estimation error in the product suite.

The total error in a nowcast of rainfall is the combination of the measurement error of the radar rainfall field and the unpredictability of the changes in the observed field after the time of the observation. The initial measure of the radar rainfall generates the uncertainty and the forecast method used at nowcast scale, in this case the field advection, generates the unpredictability. The rainfall field evolves during the forecast period and there is a scale dependency of the skill of the advection method. The limits imposed by the predictability of the atmospheric state at the mesoscale challenges the forecasters to understand when and how they can add value in the nowcasting process. Understanding the predictability of the current situation will enable the forecaster to evaluate the likely skill of the nowcasts and subsequently communicate their degree of trust in the forecast to end users. Rainfields3 is the first operational nowcasting system in the world that evaluates the uncertainty and the unpredictability in real-time and generates an ensemble that reflects the current total error in the rainfall forecasts.

This presentation will exemplify how the Rainfields3 product suite can assist in the forecast process to evaluate the practical predictability of rainfall through several case studies.

Submission ID: 137
Presenting Author: Alan Seed*
Session Time: WEDNESDAY 13:45-15:30

2

Rainfields3: The next generation radar rainfall estimation and nowcasting system

SEED Alan[1]; CURTIS Mark[2]*

1) Bureau of Meteorology; 2) Bureau of Meteorology

The Bureau of Meteorology has been operating Rainfields, a real-time radar rainfall estimation and nowcasting system, since 2006. The algorithms and system architecture of Rainfields were upgraded as part of the Strategic Radar Enhancement Project, and Rainfields3 is now on track for operational deployment. Major changes to the system architecture enables Rainfields3 to process data from 55 of the weather radars in the Australian radar network and some 10 000 products an hour are generated.

New algorithms for the quality control of radar reflectivity and radial velocity data have been implemented and quality controlled radar data are now available for forecasters and other end-user systems. The radar observes radar reflectivity at some height above the ground and these observations need to be extrapolated onto the surface before the rainfall intensity at the ground can be estimated. Rainfields3 has been enhanced to use numerical weather prediction forecasts of the height of the wet bulb freezing level and real-time estimates of the vertical profile of reflectivity to estimate both surface reflectivity and the extrapolation error. The algorithm used to adjust the radar accumulations against observed rain gauge data has been expanded so as to account for the spatial distribution of the adjustment factor. A real-time data base of gauge data and the radar rainfall estimate at the gauge location is maintained so that Rainfields3 learns the local biases automatically and is able to account for them.

This talk will highlight the improved algorithms that are used in Rainfields3 and provide examples of the performance through case studies.

Submission ID: 105
Presenting Author: Philip Riley*
Session Time: WEDNESDAY 13:45-15:30

3

Probabilistic rainfall forecasts from a Poor Man's Ensemble of numerical weather prediction models

RILEY Philip[1]; GRIFFITHS Deryn[2]; WEYMOUTH Gary[3]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology

Probability of Precipitation (PoP) forecasts have been produced for several years by the Australian Bureau of Meteorology's Gridded Operational Consensus Forecasting System (GOCF). PoP forecasts are derived using rainfall forecasts from a Poor Man's Ensemble of Numerical Weather Prediction output from a number of international centres. The current operational system computes the forecast probability of rainfall from the ensemble mean rainfall amount, using an adaptation of the method of Sloughter et al., 2007. Reports from forecast users during 2014 and 2015 highlighted some biases in the predictions. Further investigation showed that the biases could be substantially reduced, and a significant improvement made to overall forecast skill, by including the fraction of ensemble members forecasting rainfall as a predictor of rainfall probability. A new system including this innovation has been developed and tested.

The PoP forecasts are created using empirically derived equations, calibrated by comparing ensemble mean forecast rainfall amount, and the fraction of ensemble members predicting rain, with the observed frequency of rainfall. This paper describes the new forecasting method and illustrates the improvements in the performance of the system using a case study investigation and verification statistics for different areas of Australia, seasons and forecast lead times.

Submission ID: 161
Presenting Author: Deryn Griffiths*
Session Time: WEDNESDAY 13:45-15:30

4

Measuring the stability of sequences of forecasts

GRIFFITHS Deryn[1]; FOLEY Michael[2]; IOANNOU Ioanna[3]; LEEUWENBURG Tennessee[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology

The degree to which a forecast changes from one issue time to the next is an interesting aspect of a forecast system. Weather forecasters report that they are reluctant to change forecasts if they judge there is a risk of it being changed back again as they consider that such instability detracts from the message delivered.

To measure this aspect of forecasts, we have developed a “Flip-Flop Index” based on the sum of sequential differences compared to the difference of the most extreme forecasts within the sequence. The index has been designed with probabilistic forecasts in mind, but can be equally well applied to deterministic forecasts. It has the benefit of a simple definition and not penalizing a sequence of forecasts with a trend. The lack of penalty of a trend is particularly important in assessing probabilistic forecasts which may be expected to become more confident with shorter lead-time. This index will be used to complement metrics assessing the skill of forecasts, as a more stable sequence of forecasts may be of lower quality by other measures.

The Flip-Flop Index will be described and briefly compared to similar indices presented in the literature (Ehret 2010, Ruth et al. 2009, Zsoter et al. 2009).

We will present some preliminary results comparing the stability of sequences of forecasts at shorter and longer lead-times. Forecasts of chance of rain will be considered, from an automated source and from the official Bureau of Meteorology forecasts prepared with human input.

References:

Ehret, U. 2010, Convergence Index: a new performance measure for the temporal stability of operational rainfall forecasts, Meteorologische Zeitschrift 19, 441 — 451.

Ruth, D.P., Glahn, B., Dagostaro, V. and Gilbert, K. 2009, The Performance of MOS in the Digital Age, Weather and Forecasting 24, 504 — 519.

Zsoter E., Buizza, R. and Richardson, D. 2009, “Jumpiness” of the ECMWF and Met Office EPS Control and Ensemble-Mean Forecasts, Monthly Weather Review 137, 3823 – 3836.

Submission ID: 193
Presenting Author: Sally Lavender*
Session Time: WEDNESDAY 13:45-15:30

5

Australian heat low events: A climatology

LAVENDER Sally[1]*

1) CSIRO Oceans and Atmosphere

Heat lows are a persistent feature over northern Australia during summer. Until now, there have been no studies analysing individual Australian heat low events on a multi-decadal timescale. A climatology of Australian heat lows is presented based on an automated detection scheme applied to 35 years of ERA-Interim reanalysis data. Australian heat lows occur most frequently over the northwest of the continent and exhibit a pronounced seasonal cycle in both their frequency and intensity. A composite heat low based on all heat low detections enables the three-dimensional structure of the heat lows to be analysed. The shallow nature of the heat low is clearly evident, and the structure is consistent with heat low observations in other regions of the globe. The similarity between the results presented here and the results of previous modelling studies as well as possible links between Australian heat lows and local weather will be discussed.

Submission ID: 285
Presenting Author: Duncan Ackerley*
Session Time: WEDNESDAY 13:45-15:30

6

Nocturnal rainfall over north-west Australia: When models get it right

ACKERLEY Duncan[*1]*

1) Monash University

Past work has shown that a large proportion of precipitation over north-west Australia occurs overnight. This is counterintuitive given that solar heating has diminished and therefore the forcing mechanism for convection also. Nevertheless, it is known that the nocturnal heat low circulation re-organises overnight, which results in areas of strong convergence. To first order, it appears that the precipitation is associated directly with the convergence; however, convergence alone does not result in rainfall if there is no moisture. Nocturnal rainfall therefore appears to be associated with convergence across a 'dry line' on the boundary between the dry heat low and moist air advected into north-west Australia by a synoptic-scale tropical feature (e.g. a monsoon low). This presentation shows a case study of such an event that occurred in January 2010 and brought 20% of the seasonal rainfall (December-February 2009-10). During the event, >60% of the precipitation fell between 2000 and 0800 local time. Interestingly, such processes also occur in General Circulation Models (GCMs) over central Australia. A second case study from a simulation of the Australian Community Climate and Earth System Simulator 1.0 (ACCESS1.0) is also presented and the physical processes leading to nocturnal rainfall are also shown. The similarity between the GCM and the real-world case study suggests that this is something that is represented well. Moreover, given that other GCMs display a similar preference for nocturnal precipitation over north-west Australia, it is likely that they are also capturing the same processes.

Submission ID: 229
Presenting Author: Evan Weller*
Session Time: WEDNESDAY 13:45-15:30

7

Capturing convergence lines in the tropics and associated rainfall

WELLER Evan[*1]*

1) Monash Univerity

Precipitation is often organized along coherent lines of low-level convergence. Mesoscale convergence lines produced by the diurnal cycle of continental heating and cooling are thought to play an important role in the initiation and organisation of clouds and convection in the tropics. Such structures include fronts, sea breezes, gravity waves, dry lines, inhomogeneous surfaces. At longer time and spaces scales, individual convergence lines are organized into larger structures such as the Intertropical Convergence Zone and South Pacific Convergence Zone. However, the connection between convergence and convection is poor in global models, and poor representation of convection is the source of many model biases in the tropics. As such, properly simulating the initiation of convection in both climate and numerical weather prediction models remains a problem.

Here, we examine this long standing problem in meteorology - the role of convergence lines (and convergence more generally) in the initiation of convection and to better understand the deficiencies in the parameterizations necessary for climate and seasonal scale projections. As a first step in diagnosing the root cause of these problems as well as a means of better understanding the organisation of convection, an objective method has been developed for identifying convergence lines in re-analysis and model data. The method is applied here to the ERA-Interim reanalysis of difference resolutions with the aim to move to an assessment of climate model output. The frequency and rainfall associated with these convergence lines is quantified, including an attempt to examine the diurnal variation of both convergence lines and the rainfall.

S4.1b General Atmospheric Processes

Submission ID: 284
Presenting Author: Duncan Ackerley*
Session Time: THURSDAY 13:45-15:45

1

Idealised AGCM experiments with prescribed land surface temperatures

ACKERLEY Duncan[*1]*

1) Monash University

General Circulation Models (GCMs) are routinely used to represent the global climate of the last thirty years with prescribed sea surface temperatures (SSTs). These types of simulations are commonly referred to as AMIP runs. While the SSTs are prescribed, the land surface temperatures are not and they are allowed to vary; however, there is no reason why the land surface temperatures cannot also be prescribed in order to run idealised experiments of the global climate. This presentation shows how a low-resolution (N48) version of the Australian Community Climate and Earth System Simulator (ACCESS) has been developed with prescribed land surface temperatures (for example, how the diurnal cycle was taken into consideration). Moreover, the results of some initial 'proof-of-concept' simulations are presented to highlight the use of this new version of ACCESS in idealised experiments. These simulations include strong heating of the Amazon, Maritime Continent and Australia, which result in circulation changes that are consistent with theoretical studies. It is hoped that this model will provide a useful tool to the research community in addition to the suite of ACCESS models already available.

Submission ID: 176
Presenting Author: Ghyslaine Boschat*
Session Time: THURSDAY 13:45-15:45

2

On the relative role of eddies and mean meridional circulations in the global energy balance of the atmosphere

BOSCHAT Ghyslaine[1]; SIMMONDS Ian[2]*

1) University of Melbourne; 2) University of Melbourne

The atmosphere and the ocean play a critical role in the Earth energy balance by transporting energy from the equator to the poles. In the atmosphere, this net meridional energy transport is the sum of many atmospheric processes occurring on very different scales in space and time: in the tropics most of the energy is transported poleward by the Hadley circulation, whereas eddies become the principal agency of heat transport in mid and higher latitudes. However these synoptic systems interact in a quite complex manner with the Hadley circulation to ensure a 'seamless' energy transfer.

The aim of this study is to perform a detailed and updated analysis of the meridional heat transports by the atmosphere and determine the relative role of the Hadley circulation and eddy activity in this energy redistribution. Using 6 hourly ERA-Interim data from 1979 to 2014, we examine the spatial contrasts in the transport of sensible heat, latent heat and potential energy components, and diagnose how these may have been changing on seasonal to inter-annual timescales. These contributions are further partitioned into mean circulations and (stationary and transient) eddy activities, to explore the complementary variations occurring between baroclinic synoptic systems and mean tropical cells.

Finally, this "unifying conceptual framework" provides new insights into the variability and trends of the Hadley circulation, which help us better understand the factors controlling the behavior of the cell both in the present climate and under a global warming scenario.

Submission ID: 142
Presenting Author: Laura O'Brien*
Session Time: THURSDAY 13:45-15:45

3

The lifecycle of transient Rossby waves in the Southern Hemisphere

O'BRIEN Laura[1]; REEDER Michael[2]*

1) Monash University; 2) Monash University

Transient Rossby waves propagating eastward across the Indian ocean have been linked to important weather events in Australia. Heat waves (Parker et al, 2014), fire weather (Reeder et al, 2015) in and the monsoon onset (Berry and Reeder, 2015) are preceded by a Rossby wave of this type. In this study the most common propagating waves in the South- ern hemisphere are identified through statistical and dynamical analysis. The generation, growth and subsequent attenuation of these waves are diagnosed by examining the role of various variables including, wave activity flux and the divergent outflow associated with weather events. Their interaction with the jet stream, how they refract and, their influence on regional weather is also presented.

References:

Parker, T. J., G. J. Berry, M. J. Reeder, 2014: The structure and evolution of heat waves in Southeastern Australia, J. Clim., 27, 5768-5785.

Reeder, M. J., T. Spengler, R. Musgrave, 2015: Rossby waves, extreme fronts, and wildfires in Southeastern Australia, Geophys. Res. Letters, accepted.

Berry, G. J., M. J. Reeder, 2015: The dynamics of Australian monsoon bursts, J. Atmos. Sci., accepted.

S4.1b General Atmospheric Processes

Submission ID: 195
Presenting Author: Jennifer Catto*
Session Time: THURSDAY 13:45-15:45

4

Objective classification of Southern Hemisphere extratropical cyclones

CATTO Jennifer[*1]*

1) Monash University

There is a wide variety of flavours of extratropical cyclones in the Southern Hemisphere, with differing structures and lifecycles. Previous studies have classified these manually using upper level flow features or satellite data. In order to be able to evaluate climate models and understand how extratropical cyclones might change in the future, we need to be able to use an automated method to classify cyclones.

Extratropical cyclones have been identified in the Southern Hemisphere from the ERA-Interim reanalysis dataset with a commonly used identification and tracking algorithm that employs 850hPa relative vorticity. A clustering method applied to large-scale fields from ERA-Interim at the time of cyclone genesis (when the cyclone is first identified), has been used to objectively classify these cyclones in the Southern Hemisphere. This simple method is able to separate the cyclones into classes with quite different development mechanisms and lifecycle characteristics. Some of the classes seem to coincide with previous manual classifications on shorter timescales, showing their utility for climate model evaluation and climate change studies.

Submission ID: 88
Presenting Author: Jeffrey Kepert*
Session Time: THURSDAY 13:45-15:45

5

Time and space scales in the tropical cyclone boundary layer

KEPERT Jeffrey[*1]*

1) Bureau of Meteorology

It is often convenient to assume that the boundary layer is in equilibrium with the forcing conditions, which typically consist of the characteristics of the underlying surface and the flow immediately outside of the boundary layer. Assuming that the boundary layer is "slaved" to the adjacent free flow and the surface in this manner enables simplifications that can be useful in developing theory and understanding, and so forth. Dimensional arguments suggest that the tropical cyclone boundary layer adjusts to changes in its forcing faster than the cyclone evolves, supporting such an assumption. Those arguments can be extended to show that the boundary layer only responds to features in the forcing larger than a certain scale; that is, that the boundary layer dynamics contain an implicit low-pass filter.

This talk will begin by using a time-dependent boundary-layer model to confirm the dimensional arguments, and to more thoroughly characterise the spatial filtering. The low-pass filtering property is shown to affect the radius at which the eyewall updraft forms, with implications for tropical cyclone intensification. It also affects the efficiency of a recently proposed positive feedback mechanism for secondary eyewall formation (SEF) in tropical cyclones, and thereby enables a prediction of which region of the storm is most favourable for SEF.

Submission ID: 160
Presenting Author: Thomas Kloetzke*
Session Time: THURSDAY 13:45-15:45

6

Near-surface turbulent wind characteristics measured during Tropical Cyclones Ita (2014) and Nathan (2015)

KLOETZKE Thomas[1]; MASON Matthew[2]; KRUPAR III Richard[3]*

1) University of Queensland School of Civil Engineering; 2) University of Queensland School of Civil Engineering; 3) University of Queensland School of Civil Engineering

Surface Weather Information Relay and Logging Network (SWIRLnet) weather stations (Henderson et al. 2013) were deployed to measure near-surface wind conditions during the landfall phase of Tropical Cyclones (TCs) Ita and Nathan. High frequency (10 Hz) measurements of wind speed and direction were made at an elevation of 3 m using six tower locations in a variety of surface terrain conditions. The purpose of these deployments was to capture high fidelity wind data from within populated areas that would allow wind speeds experienced by those communities to be quantified. Additionally, these data were collected so that turbulent wind statistics from within the very near-surface region of landfalling TCs could be characterised.

Collating tower wind data for both landfall events, turbulent wind statistics were computed using the SWIRLnet mean and gust wind speed data. Mean wind speed and turbulence intensity bins were used to group the following turbulent wind statistics: gust factor, peak factor, and integral length scale for both longitudinal and lateral wind components. These statistics were then compared with traditional Gaussian and non-Gaussian turbulent boundary layer theory, as well as, existing field measurements made at higher levels within the surface layer.

Results show that gust and peak factors are largely independent of wind speed when 10-minute mean values exceed 6-8 m/s. For these data, a linear relationship between gust factors and turbulence intensity was found to exist. In addition, analysis of integral length scales show smaller values (dependent on turbulence intensity) than those reported for higher elevations in the surface layer. This conceptually adheres to the notion that turbulent eddies reduce in size as they get closer to the earth's surface.

Reference:

Henderson, D., M. Mason, and J. Ginger, SWIRLnet: portable anemometer network for wind speed measurements of land-falling tropical cyclones, The 12th Americas Conference on Wind Engineering, USA, 2013.

Submission ID: 325
Presenting Author: Cristian Febre*
Session Time: THURSDAY 13:45-15:45

7

Physical mechanisms associated to the formation of convection over the equatorial west coast during strong El Niño events

QUISPE Nelson[1]; FEBRE Cristian[2]; ITA Tania[3]*

1) National Service of Meteorology and Hydrology (SENAMHI); 2) National Service of Meteorology and Hydrology; 3) National Service of Meteorology and Hydrology (SENAMHI)

This work assessed the relationship between extreme rainfall episodes and synoptic patterns related with southward North-West wind flows at lower troposphere from Caribbean and Central America areas over the equatorial west coast of South America (EWCSA) during the strongest El Niño events (82-83/97-98).

The EWCSA considered a substantial network of in-situ observations to select extreme events based on daily accumulative precipitation using upper quartiles (95th percentile) of the data available for station data. High resolution (0.75°) ERA-Interim (ECWMF) Reanalysis is used here to present main atmospheric patterns for synoptic time scales focused near the equatorial eastern Pacific.

The results show that high regimen of precipitation values (100mm/day) recorded at the EWCSA were triggered by inflows of northwest winds gradually channeled to the shore driving low-level cyclonic vortices (LLCV), around the Guayaquil Gulf, retreating following erratic storms trajectories to the west, northwest or southeast inducing vorticity advection and generating explosive convection along the EWCSA. The LLCV formation is analyzed by the vorticity equation and high thermodynamic energy of Central America linked to the Caribbean low-level jet (CALLJ) produced by high atmospheric instability due seawater heating, strong low-level convergence and strong humidity advection flux from the north hemisphere to the EWCSA.

Submission ID: 181
Presenting Author: Martin Bergemann*
Session Time: THURSDAY 09:45-10:30

1

What is unique about convection in the coastal tropics?

BERGEMANN Martin[1]; JAKOB Christian[2]; LANE Todd[3]*

1) Monash University; 2) Monash University; 3) University of Melbourne

Rainfall in coastal areas of the tropics is often shaped by the presence of circulations directly associated with the topography, such as land-sea and/or mountain-valley breezes. In many regions the coastally-affected rainfall constitutes more than half of the overall rainfall received. Weather and climate models with parametrized convection produce large errors in rainfall in tropical coastal regions, most commonly underestimating rainfall over land and overestimating it over the ocean.

Building on an algorithm to objectively identify rainfall that is associated with land-sea interaction we investigate whether the relationship between rainfall in coastal regions and the large-scale atmosphere differs from that over the open ocean or over continental inland areas. Here we combine 3-hourly satellite estimates of rainfall with estimates of the large-scale atmospheric state from reanalyses data.

We find that when grouped by rainfall intensity, medium-intensity coastal rainfall in the tropics occurs in more stable conditions and drier atmospheres and is associated with less large-scale convergence than its open-ocean and inland counterparts. Overall, the dependence of the amount of rainfall on the large-scale state is significantly weaker when the rainfall is coastally influenced.

To get possible explanations for this behavior we investigate the characteristics of precipitating convection in high temporal and spatial resolution radar data around the Darwin region. During times when the rainfall is mainly associated with coastal land-sea interactions the precipitating clouds tend to be deeper and larger compared to their counterparts that are not related to coastal processes.

Our findings indicate that the representation of convection in weather and climate models must cater for the special character of the large-to-small scale relationship near coasts rather than rely on a common set of rules across the globe.

Submission ID: 113
Presenting Author: Abhnil Prasad*
Session Time: THURSDAY 09:45-10:30

2

Assessment of simulated roll clouds associated with low-level convergence

PRASAD Abhnil[1]; SHERWOOD Steven[2]*

1) Climate Change Research Centre, University of New South Wales; 2) Climate Change Research Centre, University of New South Wales

Convective initiation often takes place when features such as fronts and/or rolls collide, merge or otherwise meet. Rolls indicate boundary layer convergence and may initiate thunderstorms. These are often seen in satellite and radar imagery prior to the onset of deep convection. However, links between convergence driven rolls and convection are poor in global models. The poor representation of convection is the source of many model biases, especially over the Maritime Continent in the Tropics. We simulate low-level convergence lines over northeastern Australia using the Weather Research and Forecasting (WRF) Model (version 3.7.1). The simulations are events from September-October 2002 driven by sea breeze circulations. Cloud lines associated with bore-waves that form along the low-level convergence lines are thoroughly investigated in this study with comparisons from satellite and surface observations. Initial simulations for a series of cloud lines observed on 4th October, 2002 over the Gulf of Carpentaria showed greater agreement in the timing and propagation of the disturbance and the low-level convergence, however the cloud lines or streets of roll clouds were not properly captured by the model. Comparisons with 9 ground-based sites showed significant biases in relative humidity. Results from a number of WRF simulations with different microphysics, cumulus and planetary boundary layer schemes, resolution and boundary conditions will also be discussed.

Submission ID: 297
Presenting Author: Claire Vincent*
Session Time: THURSDAY 09:45-10:30

3

Simulated diabatic heating and far off-shore precipitation in the Maritime Continent

VINCENT Claire[1]; LANE Todd[2]*

1) School of Earth Sciences and ARC Centre of Excellence for Climate System Science The University of Melbourne; 2) School of Earth Sciences and ARC Centre of Excellence for Climate System Science The University of Melbourne

The Maritime Continent is one of the rainiest places on the planet, and plays an important role in global heat and moisture circulations. However, due to the complex topography of the region, the spatial and temporal precipitation patterns are controlled not only by large scale variability such as the Madden Julian Oscillation (MJO), but by mesoscale processes including land/sea breezes, mountain/valley winds and gravity waves generated by the deep, diurnally oscillation heat source over the islands. These processes, while crucial to the aggregate climatology of the region, will not necessarily be resolved in a typical climate model.

In this work, we ran convection-permitting simulations over the whole Maritime Continent region using the Weather Research and Forecasting model for 10 Austral summer seasons. The simulations are shown to capture the main physical processes controlling the diurnal cycle and offshore propagation of precipitation, despite a wet bias and errors in the timing of precipitation over the land.

We used the simulations to examine the relationship between the diabatic heating associated with deep convection over the land and the incidence of diurnally varying, far-offshore precipitation. Results from the 10 Austral summer seasons were composited to study the changes in diabatic heating and far-offshore precipitation with the passage of the MJO.

Submission ID: 201
Presenting Author: Dominik Krug*
Session Time: THURSDAY 11:00-12:30

1

Interface-based entrainment analysis applied to a temporally evolving turbulent plume

KRUG Dominik[1]; CHUNG Daniel[2]; PHILIP Jimmy[3]*

1) University of Melbourne; 2) University of Melbourne; 3) University of Melbourne

We present a new local view of the entrainment process in turbulent self similar flows that was recently introduced in a study on gravity currents (Krug et al. 2015). The concept of the new approach is to express the entrained mass flux in terms of quantities related to the turbulent/non-turbulent interface (TNTI) defined as an enstrophy isosurface. Specifically, these quantities are the local propagation velocity of the TNTI relative to the fluid, an amplification factor due to the convoluted shape of the interface and a factor related to the self-similar structure of the flow. The new framework allows us to trace back changes in the entrainment rate (e.g. due to buoyancy in a plume or a stable stratification in gravity currents) to changes in the physical mechanisms responsible for the entrainment. Thus the new approach provides the means to identify features of the flow that are most relevant in setting the entrainment rate thereby providing valuable insight for improved modeling approaches.

In our presentation, we showcase the new approach by applying it to a direct numerical simulation of the Navier-Stokes equations in a temporally evolving turbulent plume. As part of our analysis we demonstrate that estimates for the entrainment parameter obtained using the local TNTI-based approach are in good agreement with conventional global entrainment metrics that are derived from an integral analysis using an energy-based framework or simply the spreading rate of the flow. This leads us to understand the physical mechanism of entrainment in plumes at the most detailed level directly related to the governing equations of motion. In the final part of the work we will elucidate the aforementioned contributions in more detail.

Reference:

D. Krug, M. Holzner, B. Lüthi, M. Wolf, W. Kinzelbach and A. Tsinober (2015). The turbulent/non-turbulent interface in an inclined dense gravity current. Journal of Fluid Mechanics, 765, pp 303-324 doi:10.1017/jfm.2014.738.

Submission ID: 123
Presenting Author: Charmaine Franklin*
Session Time: THURSDAY 11:00-12:30

2

Impact of cloud microphysics on the phase composition of a tropical mesoscale convective system

FRANKLIN Charmaine[*1]; PROTAT Alain[2]*

1) CSIRO; 2) Bureau of Meteorology

Simulations of tropical convection from an operational numerical weather prediction model are evaluated, with the focus on the model's ability to simulate the observed high ice water contents associated with the outflow of deep convection, and to investigate the modelled processes that control the phase composition of tropical convective clouds.

It is shown that the growth of ice is less dependent on vertical velocity than liquid, with the control on liquid water content being the updraft strength due to stronger updrafts having minimal entrainment and higher supersaturations. Larger liquid water contents are produced when cloud droplet number concentrations are increased or when a parameterisation of heterogeneous freezing of rain is included. These changes reduce the efficiency of the warm rain processes generating greater supercooled liquid water. Including an ice splintering parameterisation also increases the supercooled liquid water content by increasing the vapour deposition on ice, which in turn generates greater latent heating, stronger updrafts and supersaturations. The control on ice water content in the model is the ice sizes and available liquid water, with the larger ice particles growing more efficiently via accretion and riming. Limiting or excluding graupel produces larger ice water contents due to more ice mass contained in slow falling snow particles. This results in longer in-cloud residence times and more efficient removal of liquid water.

It is demonstrated that entrainment in the mixed-phase regions of updrafts is most sensitive to the turbulence formulation in the model. Greater mixing of environmental air into cloudy updrafts produces more detrainment and the generation of a larger stratiform area. Above these levels in the purely ice region of the updrafts, the entrainment and buoyancy of air parcels is controlled by the ice particle sizes, demonstrating the importance of the microphysical processes on the convective dynamics.

S4.2b Clouds and Convective-Scale Processes

Submission ID: 27
Presenting Author: Matthew Igel*
Session Time: THURSDAY 11:00-12:30

3

The nature and magnitude of hydrometeor frictional heating in convective clouds

IGEL Matthew[1]; IGEL Adele[2]*

1) University of Miami; 2) Colorado State University

As hydrometeors fall from or through a cloud, they reach a terminal velocity due to friction with the air through which they settle. This friction has previously been shown to result in significant vertically-integrated turbulent dissipation. But the nature and vertical profile of this dissipation remains unclear. Here, its energetic origin is discussed. For the first time, it is shown explicitly that the energy dissipated originates from hydrometeor potential energy unrecovered during settling. By assuming that hydrometeor kinetic energy is insignificant, it can be shown that the frictional dissipation heats the interstitial air. The magnitude of this heating is then analyzed in a cloud resolving model simulation of a tropical, deep convective cloud. It is shown that locally, heating from hydrometeor friction can reach ~40 K hr^{-1}. The heating is not uniform throughout the cloud, and this asymmetry results in local gradients in heating that act to stabilize the convective environment. It is shown that hydrometeor frictional dissipation is easily parameterizable in a variety of model types, and that it is important to convective clouds.

Submission ID: 319
Presenting Author: Robyn Schofield*
Session Time: THURSDAY 11:00-12:30

4

Implications of WRF simulated and radar mass fluxes for biogenic trace-gas delivery

SCHOFIELD Robyn[1]; FREY Wiebke[2]; KUMAR Vickal[3]; PROTAT Alain[4]; HASSIM Muhammad[5]; LANE Todd[6]*

1) University of Melbourne; 2) University of Manchester; 3) Bureau of Meteorology; 4) Bureau of Meteorology; 5) Centre for Climate Research Singapore; 6) University of Melbourne

The delivery of biogenic halocarbons from the boundary layer to the stratosphere is relevant for stratospheric ozone depletion. Unlike long-lived chlorofluorocarbons and halons, these oceanic halocarbons are short-lived (days to a few months), and while of natural origin their emissions are increasing due to increases in aquaculture. The tropical western pacific is of crucial importance in determining very short lived substance delivery from the surface to the stratosphere via rapid convective processes [Salawitch, 2006; Hossaini et al., 2015]. Mass fluxes simulated by the Weather Research and Forecasting (WRF) for Stratospheric-Climate Links with Emphasis on the Upper Troposphere and Lower Stratosphere (SCOUT-O3) and Tropical Warm Pool International Cloud Experiment (TWP-ICE) campaigns (November 2005 and January - February 2006 respectively). The SCOUT-O3 campaign occurred before the main monsoon period, and experienced biomass burning conditions [Frey et al., 2015]. Two 5-day simulation periods during TWP-ICE are examined, during break and monsoon conditions respectively [Hassim et al., 2014]. These two case studies are combined with long-term radar estimates of mass fluxes. Combining these simulated and observational radar mass flux estimates with emission inventories produces estimates of biogenic bromine delivery to the stratosphere for the Darwin region.

References:

Frey, W., et al., (2015), ACP, 15(11), 6467—6486, doi:10.5194/acp-15-6467-2015.

Hassim, M. E. E., T. P. Lane, and P. T. May (2014), JGR.

Hossaini, R., et al., (2015), Nature Geosci, 8(3), 186—190.

Salawitch, R. J. et al (2006), Atmospheric chemistry: Biogenic bromine, Nature, 439(7074), 275—277.

Submission ID: 221
Presenting Author: Rachel Badlan*
Session Time: THURSDAY 11:00-12:30

5

A comparison of the dynamics of tropical convective systems using WRF and Doppler radar

BADLAN Rachel[*1]*

1) University of Melbourne

Tropical convective clouds are crucial for the redistribution of heat, moisture and momentum in the atmosphere. These convective systems can form various regimes, from disorganised cumuli to mesoscale convective systems. The forecasting and numerical weather prediction of these systems has proven to be difficult. The tropical mesoscale convective systems are affected by factors such as the environmental wind shear, pressure gradients, and the strength of the density current - in turn they influence the development and regime of the clouds, as well as the larger-scale flow due to the type of momentum transport they induce. The maritime continent is especially notorious and provides a challenge when forecasting convection due to its unique configuration of land and sea and their interactions. To date, a monsoon break period during the TWP-ICE campaign in 2006, has been investigated using the WRF model, as 3D observational wind fields have not been available.

This work aims to use a unique dataset from the Bureau of Meteorology radar located in Darwin, which encompass the maritime continent to the north. This dataset has been created using the observed horizontal wind components and derived vertical wind. The WRF model simulations represent upshear-tilted, trailing stratiform systems for all mature stages convective systems, however analysis of the Doppler radar dataset has revealed an atypical system with mirror-image mesoscale circulations. Two factors can affect the orientation of this tilt; the direction and strength of the low-level wind shear, and the vorticity generated by the cold pool. This research investigates why the WRF model is failing to reproduce such a system.

Submission ID: 265
Presenting Author: Bronwyn Dolman*
Session Time: THURSDAY 11:00-12:30

6

Near real-time rainfall retrievals from the new Adelaide Airport instrument cluster

DOLMAN Bronwyn[*1]; REID Iain[2]*

1) ATRAD Pty Ltd; 2) ATRAD Pty Ltd

Wind profiling radars (WPR), particularly those operating near 50 MHz, are capable of retrieving rainfall information in the vertical column above the instrument. The rainfall drop size distribution (DSD) can be retrieved through a de-convolution process, and the rainfall integral parameters such as rain rate and liquid water content can then be calculated. The vertical evolution of rainfall in the descent from cloud to ground can be studied, and examination of all data in collaboration gives insight into the micro physical processes dictating rainfall events. This information can then be used observationally both as a single entity and in collaboration with other instruments, and in numerical weather prediction models.

Retrieving rainfall information typically involves extensive manual effort. Recent work on quality control has allowed this process to become more automated, and progress towards near real-time retrievals. This allows the WPR to act as a rain gauge, but in addition to rain-rate, can provide information on the microphysics throughout the vertical column, and the wind field. The Australian Government Bureau of Meteorology has recently installed a network of WPRs across Australia, where this technique can potentially be employed.

ATRAD in collaboration with the University of Adelaide are developing an instrument cluster at Adelaide Airport. The cluster will consist of a 55 MHz WPR, prototype 449 MHz UHF WPR, precipitation radar, backscatter ceilometer, disdrometer and all sky infrared camera. This site is ideal for rainfall studies as it is within the scanning footprint of the Weather Watch radar, thus allowing intercomparisons.

The new instrument cluster will be discussed, with particular emphasis on progress towards real time WPR rainfall retrievals, and how data from the cluster can be used collaboratively to further our understanding of rainfall processes, and potentially contribute to paramaterisation schemes.

Submission ID: 244
Presenting Author: Lawrie Rikus*
Session Time: THURSDAY 13:45-15:45

1

Synthetic satellite imagery and weather prediction

RIKUS Lawrie[1]; SUN Zhian[2]*

1) Bureau of Meteorology; 2) Bureau of Meteorology

Synthetic satellite imagery generated from the real time model fields in combination with a radiative transfer code comparable to the model's radiation scheme is routinely produced for all of the Bureau of Meteorology's operational NWP forecasts as an experimental product. This imagery is useful because it integrates a significant amount of information about the model atmospheric state at each time as a single image and is readily comparable with the real imagery. Thus it can provide weather forecasters, trained to assess synoptic situations using satellite imagery, with a readily accessible assessment of the current model forecasts. It can also serve as a model evaluation tool; discrepancies between the real and synthetic imagery can point to problems in the model, not just in positions of synoptic features but also cloud properties and its interaction with radiation.

The evaluation of model forecasts using synthetic imagery has some limitations. Since the synthetic imagery is a convolution of model cloud microphysical properties, spatial distribution and optical properties, quantitative assessment of the model's parameterization schemes requires an unraveling process. Some extra diagnostic information can be gained by using more satellite channels but this can be limited by some of the assumptions in the model parameterization schemes which can preclude the representation of some features, e.g. fixed droplet/crystal sizes will prevent the model imagery from representing effects due to very small or very large sizes.

The synthetic satellite imagery has been used to qualitatively assess cloud positions and structures in tropical cyclone and mesoscale NWP forecasts, e.g. the cloud structures in forecast loops of the operational Australian model ACCESS-R show a remarkable correspondence with the real MTSAT imagery in the mid-latitudes but show systematic differences in the tropics.

Submission ID: 180
Presenting Author: Christian Jakob*
Session Time: THURSDAY 13:45-15:45

2

A new framework for cumulus parametrization - Ideas, observations and first results

JAKOB Christian[1]; PETERS Karsten[2]; MOEBIS Benjamin[3]*

1) Monash University; 2) Max-Planck Institute for Meteorology; 3) Monash University

Most cumulus parameterizations used in weather and climate models are build on the assumption that there is a unique small scale response to each possible large scale state. Nevertheless observations show a significant variability in cumulus activity for a given large scale state, especially with smaller domain size. This variability can be parameterized using Markov chains conditioned on the large-scale state to predict convective area fractions at cloud base.

We present a new framework for cumulus paramtrization based on the use of the Markov chain model. The framework adopts a high-resolution grid (O(1km)) embedded in a climate model. For each climate model grid-point, the state of convection at each high-resolution grid-point is predicted using the statistical model. The so-derived sub-grid scale information can then be used in determining the characteristics and effects of convection in the climate model grid cell. We will demonstrate that the model can in principle account for many observed features of convection that conventional models fail to predict, such as the state of organization of convection. The use of the framework across multiple model resolutions will also be discussed.

In a first implementation of the framework, mid-tropospheric humidity and vertical velocity are used to predict the fraction of the grid-box covered by deep convection. A comparison with radar observations shows considerable skill of the statistical model in reproducing the observed behavior of both mean and variability of deep convective area fraction. Together with simple assumptions on density and vertical velocity at cloud base the new framework is used as a closure assumption in an existing convection parametrization. First results indicate significant improvements in the simulation of tropical variability, including but not limited to the MJO without deteriorating the mean climate.

S4.2c Clouds and Convective-Scale Processes

Submission ID: 30
Presenting Author: Hongyan Zhu*
Session Time: THURSDAY 13:45-15:45

3

Improving ACCESS-C convection settings

ZHU Hongyan[*1]*

1) Bureau of Meteorology

Using W-based CAPE closure caused a reduction of rainfall forecasts in the Tasmania region due to the fact that the parameterized convection was taking a leading role in reducing the convective instability, and as a result there was no grid-scale convection over the land. W-based CAPE closure is designed to avoid grid point storms in regions of intense convection. To find a common setting which is suitable for both rainfall forecast of the Tropics and the middle latitudes, we choose to use the grid-box dependent CAPE closure, in which the W-based convection setting is only limited to the regions with local intense convection.

With the new CAPE closure setting, the role of the large scale moisture process has been largely increased and the rainfall band is able to propagate inland to the west part of the Tasmania Island.

The new closure can also inhibit the development of grid point storms during intense convection events in the Tropics. For the simulation with vertical velocity bigger than the threshold, the CAPE time scale will be largely reduced to remove the convective instability, and the intensity of convection. This study recommends that the modified grid-box dependent CAPE closure, which includes the vertical velocity threshold, is suitable for the 4km resolution ACCESS-C model.

Submission ID: 269
Presenting Author: Nidhi Nishant*
Session Time: THURSDAY 13:45-15:45

4

Radiative driving of shallow return flows from the ITCZ

NISHANT Nidhi[1]; SHERWOOD Steven[2]; GEOFFROY Olivier[3]*

1) UNSW; 2) UNSW; 3) UNSW

The Shallow meridional circulation (SMC) is a low-level meridional return flow which occurs co-jointly with the deep meridional return flows out of the ITCZ. In general, the prime causes hypothesized for the occurrence of an SMC are either the gradients in SST and surface pressure or the radiative cooling in the lower troposphere. This study explores the relative importance of both the causes on the dynamics of the SMC. The Weather Research and Forecasting (WRF) model is used in a 3-D idealised framework to simulate the ITCZ. The structure of the simulated circulation includes an SMC in rough agreement with that observed in the ERA-Interim reanalysis dataset. Radiative cooling associated with the moisture and temperature gradient at the shallow levels, had a significant impact on the SMC. With the change of PBL, cumulus and SW radaition paramerizations, changes in the moisture and temperature field was observed. Gradient in the atmospheric moisture and temperature above the PBL, had a significant effect on the radaitive cooling and thus on the SMC. Experiments done by varying solar insolation, due to the differential heating of the atmopshere atlered the vertical profile of temperature gradient. This was followed by the change in the rate of air temperature cooling, which had a direct impact on the SMC. These experiments explicitly explained the role of radaitive cooling on the SMC, since the SST gradient was not changed. The weak role of surface temperature and pressure on the development of the SMC was observed in the experiment with low SST gradient.The weak SMC of the low SST gradient experiment showed a commensurate reduction in the radiative cooling, indicating that the control of the circulation by SST is mediated by radiative cooling.

Submission ID: 175
Presenting Author: Malcolm King*
Session Time: THURSDAY 13:45-15:45

5

CMIP5 climate model simulations of the interaction between the 5-day wave and convection

KING Malcolm[1]; WHEELER Matthew[2]; LANE Todd[3]*

1) University of Melbourne; 2) Bureau of Meteorology; 3) University of Melbourne

The planetary scale 5-day wave is the gravest symmetric mode of the Rossby-Haurwitz wave with westward propagating zonal wavenumber 1. Despite the wave's barotropic and minimally divergent structure, the wave is known to be connected to significant local precipitation anomalies in the tropics, with precipitation anomalies in phase with wind anomalies near the Andes and in quadrature with wind anomalies near the Gulf of Guinea. However, it is not known how well this connection is represented in climate models.

An analysis of horizontal winds and precipitation from 30 CMIP5 models is performed to determine the performance of the CMIP5 models in replicating the observed characteristics of the 5-day wave-convection relationship. Space-time spectral analysis of these fields show that the relationship between the wave and tropical convection is a common and well-realised feature of the climate models, with realistic coherences between zonal winds and precipitation being observed in the 5-day wave range. The spectral coherence appears at realistic levels even in models where the coherence between zonal wind and precipitation is unrealistic for other convectively-coupled wave-like disturbances, such as equatorial Kelvin waves and the MJO. The models have mixed performance with the geographical location of anomalies with two-thirds showing significant signals over the Gulf of Guinea and half showing significant signals over the Andes, and all models underrepresent the magnitude of anomalies by at least a factor of three. Increasing model resolution improves performance over the tropical Andes but does not seem to affect performance over the Gulf of Guinea.

Submission ID: 165
Presenting Author: Dietmar Dommenget*
Session Time: THURSDAY 13:45-15:45

6

The cloud feedbacks amplification of El Nino

RAEDEL Gaby[1]; MAURITSEN Thorsten[2]; STEVENS Bjorn[3]; DOMMENGET Dietmar[4]; MATEI Daniela[5]; BELLOMO Katinka[6]; CLEMENT Amy[7]*

1) Max Planck Institute for Meteorology; 2) Max Planck Institute for Meteorology; 3) Max Planck Institute for Meteorology; 4) Monash University; 5) Max Planck Institute for Meteorology; 6) Rosenstiel School of Marine and Atmospheric Science; 7) Rosenstiel School of Marine and Atmospheric Science

The El Nino Southern Oscillation (ENSO) is the dominant mode of inter annual variability with major impacts on social and ecological systems through its influence on extreme weather, droughts and floods. The underlying atmospheric physical mechanisms that drive it remains poorly understood. Here we present numerical experiments with an Earth system model and the cloud-feedback locking technique suggesting that atmospheric cloud radiative effects enhance ENSO variability by a factor of two or more. It is argued that cloud-induced heating in the mid and upper troposphere associated with high-clouds over the El Nino region combined with cooling by low-level clouds in the surrounding regions enhances the coupling of the atmospheric circulation to the surface temperature anomalies. Thereby, the positive Bjerknes feedback mechanism is enhanced. Behavior consistent with the proposed mechanism is robustly represented in other global climate models analyzed and in satellite observations.

Submission ID: 84
Presenting Author: Robert Colman*
Session Time: THURSDAY 13:45-15:45

7

Understanding cloud feedbacks in ACCESS and CMIP models

COLMAN Robert[1]; BROWN Josephine[2]; FRANKLIN Charmaine[3]; HANSON Lawson[4]; YE Harvey[5]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) CSIRO; 4) Bureau of Meteorology; 5) Bureau of Meteorology

The range in the value of climate sensitivity estimated by the IPCC has not decreased in 25 years, despite intensive research. This range is responsible for a major source of uncertainty in future climate change projections. While uncertainties arise from all feedbacks, cloud changes provide the greatest single source. Understanding and quantifying the magnitude of individual feedbacks therefore remain top-priority tasks for quantifying projection uncertainty. While current versions of the Australian Community Climate and Earth-System Simulator (ACCESS), in particular, have relatively high climate sensitivity, the reasons for this are not entirely clear. It is therefore important that ACCESS feedbacks are better understood and the individual contributions quantified.

This paper describes the implementation of a feedback analysis package for ACCESS, permitting detailed analysis of the location and type of cloud changes contributing to both the ‘rapid response’ of clouds to CO_2 forcing itself to the temperature related feedbacks. Cloud feedbacks in ACCESS1.3 are shown to arise from a complex range of cloud responses, with strongly varying contributions in both short and long wave. The sensitivity of cloud responses to some key convection and rainfall-linked parameters will also be examined.

Since feedbacks vary so much between models, ACCESS model feedbacks will be put in context with the range of CMIP3 and CMIP5 model cloud feedbacks.

Submission ID: 140
Presenting Author: Lam Hoang*
Session Time: TUESDAY 09:45-10:30

1

The formation of TC Larry and its associated extratropical potential vorticity

HOANG Lam[*1]*

1) Monash University

TC Larry formed from a low pressure system in the eastern Coral Sea (16.4°S, 157.9°E) at 1800 UTC on 17 March 2006. The associated coherent 330 K PV maximum is initially detected in the extratropics 5 days prior to TC Larry formation, while the 315 K coherent PV maximum can be tracked back to the tropics 3 days before. The 350 K isentropic PV maps show that Larry's low-level vorticity was formed after strong Rossby wave breaking event in the north Coral Sea on 12 March. The second RWB event in the north Coral Sea occurred on 14 March and intensified the low-level vorticity before a cold surge (in the lower troposphere) arrived in the region from 15 March. The evolution of local environment quantities following the low-level vorticity maximum reveal the local conditions before the formation of TC Larry: increasing relative vorticity, high relative humidity in lower to middle troposphere with weak shallow wind shear. The ARW-WRF 4-day simulation can simulate the conditions before the formation of TC Larry, although the intensity of the disturbance is stronger than observed.

Submission ID: 272
Presenting Author: Yingjun Chen*
Session Time: TUESDAY 09:45-10:30

2

Some factors that influence the amount and distribution of rain during the landfall of tropical cyclones

CHEN Yingjun[1]; DAVIDSON Noel[2]; EBERT Elizabeth[3]; WALSH Kevin[4]; HUANG Xinmei[5]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) University of Melbourne; 5) Bureau of Meteorology

Speed of movement, intensity, intensity change, vortex size, vertical wind shear and environmental effects have been suggested as important influences on the rainfall distribution during the landfall of Tropical Cyclones (TCs). In this study we analyse three landfall events, Lua, Rusty and Christine, when rainfall differed markedly. Based on TRMM and rain gauge observations we characterize the rainfall in terms of amount and asymmetric distribution. We then validate three skilful, high-resolution forecasts of the events and objectively verify the rainfall forecasts. Defining "interaction" as an exchange of potential vorticity (PV) at midlevels between TCs and their environments, we then describe the varying post-landfall interactions for the three storms.

We illustrate that interactions can create asymmetries in storm structure with associated changes in the rainfall distribution. For Christine, no interaction is evident and post-landfall rain remains focussed around its centre. For Lua, the interaction drained midlevel PV from the circulation and as a result, a large asymmetry in rainfall developed and the storm circulation rapidly dissipated. For Rusty, although drainage was present on its poleward side, the environment was replenishing PV on its equatorward side. This two-way interaction created a rainfall distribution characterised by near-center precipitation, as well as a large asymmetry to the south.

We suggest that differential PV advection during TC-environment interactions influences the ascent field and thus the rainfall amount and distribution. Storm motion appears to also have been an important determinant on the rainfall distribution, but environmental wind shear less so.

Submission ID: 208
Presenting Author: Richard Krupar III*
Session Time: TUESDAY 09:45-10:30

3

Estimating surface wind conditions in U.S. landfalling tropical cyclones using single Doppler radar wind profiles

KRUPAR III Richard[1]; SCHROEDER John[2]*

1) University of Queensland-School of Civil Engineering; 2) Texas Tech University-Atmospheric Science Group

Empirical wind relationships derived from a variety of measurement systems have been used to estimate surface wind conditions in tropical cyclones (TCs) over the ocean. However, a significant data gap exists after landfall. A suitable methodology needs to be developed to adjust tropical cyclone boundary layer (TCBL) lower tropospheric winds over land to their surface magnitude. Weather Surveillance Radar-1988 Doppler (WSR-88D) systems run by the National Weather Service in the U.S. provide continuous coverage of TCs at landfall (barring power loss) and a unique opportunity to fill the data gap that exists over land.

A subset of Velocity Azimuth Display (VAD) wind profiles generated at seven WSR-88D sites between 2000-2012 were paired with seven nearby Automated Surface Observing System (ASOS) 10 m wind measurements. ASOS wind data were averaged over two consecutive overlapping radar volumes and standardized to either open (zo = 0.03 m) or marine (zo = 0.01 m) exposure depending on the upstream fetch. The maximum three-second gust measured over two consecutive overlapping radar volumes was also calculated for ASOS gust measurements collected over the period 2007-2012. Earlier gust data were removed given the averaging time used prior to 2007 was five-seconds.

Using the VAD 0-200 m and 0-500 m layer average wind speeds as candidate predictors for the ASOS 10 m standardized mean and maximum three-second gust wind speeds, respectively, several wind adjustment techniques were evaluated. These include the log and power laws, wind speed ratios, and regression-based techniques. Results from this evaluation show that the mean absolute percentage error was smallest for regression-based methods when used to predict both site-specific ASOS 10 m standardized mean wind speeds and non-site-specific ASOS 10 m maximum three-second gust wind speeds. This finding has direct application for nowcasting, TC wind field modelling, and validating design wind maps used in building codes.

Submission ID: 92
Presenting Author: Xingbao Wang*
Session Time: TUESDAY 11:00-12:15

1

ACCESS-TCX: a newly developed high-resolution NWP system for tropical cyclone prediction

WANG Xingbao[1]; KEPERT Jeffrey[2]; DAVIDSON Noel[3]; XIAO Yi[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology

Tropical cyclones pose a significant risk to safe and efficient operations of the offshore oil and gas industry in Australia's northwest. Improved forecasts offer a significant opportunity to mitigate this risk, and to this end we are developing a new tropical cyclone NWP system. This system builds on our experience with ACCESS-TC, but differs from it in being on a larger and fixed domain instead of relocatable, by running twice-daily instead of only when a cyclone has formed, by having higher resolution (~4 km grid), by forecasting to 5 instead of 3 days, and by including a wave model. The system is called ACCESS-TCX, with the X standing for "extended", and aims to address specific issues around forecast length, TC genesis and wave prediction.

We have tested various ACCESS model configurations for this purpose over both northern Australia and the northwest Pacific Ocean, nested in either the global or regional models. The new system improves the TC intensity forecast, however the tracks at present are slightly worse compared with the coarser resolution model. Our most recent experiments include data assimilation and a TC bogus, and further improve the predicted TC intensity, particularly for strong TC. Case studies and real time runs have shown that the TC forecast accuracy in terms of track and intensity (measured by sea level centre pressure and maximum 10-m wind around the centre) is quite sensitive to model resolution, physics, initial condition (IC) and lateral boundary conditions (LBC). The intensity and track can be significantly changed using different IC and LBC coming from ACCESS-G or ACCESS-R. The forecasts are also sensitive to the model dynamics, with ENDGAME dynamics usually producing a stronger TC than the older New Dynamics. While we have demonstrated that ACCESS-TCX has the potential to provide good TC track and intensity forecasts, further testing is required to determine the best combination of model dynamics, physics, and data assimilation.

S4.3b High-Impact Weather in Research and Operations

Submission ID: 94
Presenting Author: Mohammad Wahiduzzaman*
Session Time: TUESDAY 11:00-12:15

2

A model for the north Indian Ocean tropical cyclone tracks and landfall

WAHIDUZZAMAN Mohammad[1]; OLIVER Eric[2]; WOTHERSPOON Simon[3]; HOLBROOK Neil[4]*

1) Institute for Marine and Antarctic Studies UTAS; 2) Institute for Marine and Antarctic Studies UTAS; 3) Institute for Marine and Antarctic Studies UTAS; 4) Institute for Marine and Antarctic Studies UTAS

Extensive damage and loss of life can be caused by landfalling tropical cyclones. In this study, we develop a seasonal forecasting model of tropical cyclone tracks and landfall for North Indian Ocean (NIO) rim countries based on a Generalized Additive Model (GAM) approach. Using tropical cyclone track observations (1979-2013), from the Joint Typhoon Warning Centre (accessed in the International Best Track Archive Climate Stewardshipversion6), the GAM model is fitted to the observed cyclone track velocities as a smooth function of location in each season. The distribution of genesis points is approximated by kernel density estimation. Trajectories are then simulated from the matrix of genesis points, and an array of stochastic innovations applied at each time step. Three hindcast validation methods are applied. First, leave-one-out cross validation is applied whereby the country of landfall is determined by the majority vote from the simulated tracks. Second, the probability distribution of simulated tracks is evaluated against observed tracks. Third, the distances between observed tracks and simulated tracks are compared and quantified. Overall, our model shows very good cross-validated hindcast skill for most NIO rim countries. For example, the percentage of landfall predictions show only a little difference (1.2 to 7.7%) compared to observations.

Submission ID: 87
Presenting Author: Jeffrey Kepert*
Session Time: TUESDAY 11:00-12:15

3

High-resolution ensemble prediction of an East Coast Low

KEPERT Jeffrey[1]; FAWCETT Robert[2]; CHING Simon[3]; THURSTON William[4]; TORY Kevin[5]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology; 5) Bureau of Meteorology

East coast lows are intense low-pressure systems that form close to the east coast of Australia. A severe east coast low occurred from 20 — 23 April 2015, with the worst impact on 21 April. It was a major flood event for Dungog and Maitland, and caused at least four deaths. Dozens of houses lost their roofs, over 200,000 houses were without power, and 57 schools closed. We have prepared a 24-member high-resolution ensemble simulation of the event by downscaling the prototype ACCESS-GE global ensemble to a 1.3-km grid. The forecast quality is very high, with the 48-hour ensemble-mean rainfall total being an uncannily good match to the operational analysis. The main limitation of the ensemble mean was that it underestimated the highest rainfalls (> 300 mm / 48 hours), but the ensemble did indicate substantial probabilities of such extreme rainfall.In east coast lows, the strongest winds and heaviest rain often occur immediately to the south of small-scale lows that form right on the coast within the overall envelope of the larger-scale system. The ensemble showed considerable spread in the timing, location and amplitude of these features, indicating that although the area around Dungog carried the highest risk, a substantial part of the coast was at risk of significant rain and strong winds. We aim to use ensemble sensitivity analysis to help understand the formation of these features and other aspects of east coast low dynamics.Over the next decade or so, ensemble prediction at these resolutions will progressively become available to operations. The need to interpret, use and communicate the resulting data so as to obtain good value from it will change way forecasters operate, and similarly change the planning and protocols of end users. We plan to use this example of an ensemble prediction of a notable severe weather event to help illustrate the possibilities and promote debate on the shape of future severe weather services.

S4.3b High-Impact Weather in Research and Operations

Submission ID: 215
Presenting Author: Chris Lucas*
Session Time: TUESDAY 11:00-12:15

4

Improvements in the detection and prediction of volcanic ash for aviation

LUCAS Chris[1]; ZIDIKHERI Meelis[2]; DARE Richard[3]; POTTS Rod[4]; MANICKHAM Mey[5]; WAIN Alan[6]; MAJEWSKI Leon[7]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology; 5) Bureau of Meteorology; 6) Bureau of Meteorology; 7) Bureau of Meteorology

The detection and prediction of volcanic ash in the atmosphere is a significant service provided by the Bureau of Meteorology's Darwin Volcanic Ash Advisory Centre (VAAC) to support the aviation industry. The VAAC primarily uses satellite data to monitor eruptions and the presence of ash, along with the HYSPLIT dispersion model for near-term predictions of its movement. High-quality forecasts of ash require estimates of its initial position and extent, accurate Numerical Weather Prediction (NWP) model data and an adequate representation of relevant physical processes within the dispersion model. This presentation highlights work that addresses all three of these areas that has been underway within the Bureau.

For observations, the Volcanic Cloud Analysis Toolkit (VOLCAT) developed by NOAA/NESDIS has been implemented. The algorithm uses multi-spectral satellite imagery to automatically identify and make quantitative estimate of ash cloud properties like height and mass loading. Four case studies of recent high-impact eruptions have been used to validate the algorithm, finding that it performs equivalently to earlier remote-sensing based ash detection techniques, but with some limitations to the quantitative retrievals.

There are many facets to the modelling work. Inverse modelling techniques using satellite ash detections have been developed to better identify the top and bottom heights of the ash cloud. These techniques can be applied to other properties as well. The dispersion model physical processes have been improved, with a new sedimentation algorithm developed, and an evaluation of the wet and dry deposition processes. The use of an ensemble-based ash dispersion modelling scheme to account for uncertainties in the NWP model and the source term have also been investigated.

Work to further improve the guidance available to the VAAC and the aviation industry is underway to exploit the new Himawari-8 satellite and improvements to the Bureau's NWP models.

Submission ID: 231
Presenting Author: Harald Richter*
Session Time: TUESDAY 11:00-12:15

5

The sensitivity of calibrated thunderstorm probabilities to the choice of the calibration period and domain

RICHTER Harald[1]*

1) Research & Development Branch, Bureau of Meteorology

"Calibrated Thunder" is an ensemble-based thunderstorm probability forecast approach first introduced at the Storm Prediction Center in the U.S. about a decade ago. It utilizes two predictors for electrified convection, the Cloud Physics Thunder Parameter (CPTP) and total model precipitation. The system has been run in research mode at the Bureau of Meteorology in Australia for well over a year off the operational five member ACCESS-R12 lag ensemble with ~12.5 km grid spacing. It has produced calibrated thunderstorm probabilities in 3-hourly increments across Australia for a range of lead times out to 48 hours.

This study explores how the quality of Calibrated Thunder varies with the choice of the calibration data period and data domain. Such exploration provides information on whether the advantage of seasonal similarity of a shorter calibration period is negated by the smaller training sample size. We also explore the benefits of calibrating forecast thunder probabilities in the tropics with exclusively tropical historic data, as opposed to data from all of Australia. The ground truth data used for all sensitivity tests are the Global Position and Tracking Systems (GPATS) lightning observations.

Submission ID: 203
Presenting Author: Badrinath Nagarajan*
Session Time: TUESDAY 14:30-15:30

1

A robust fine scale hail hazard prediction using the WRF model

NAGARAJAN Badrinath[1]; TREINISH Lloyd[2]; CIPRIANI James[3]; CALUSINSKI Jeffrey[4]*

1) IBM Research Melbourne; 2) IBM Research Yorktown USA; 3) IBM Research Yorktown USA; 4) IBM S & D Chicago USA

Real time hail hazard prediction capability significantly helps property insurers in their mitigation and recovery efforts. A hail prediction system composed of data assimilation and a modified Weather Research and Forecasting (WRF) model is presented. Several severe storms occurred during the spring of 2012 and 2015 that caused significant hail damage to property over Oklahoma (OK) and Texas (TX). The storms occurred in a weak synoptic scale environment. The study investigates the feasibility and use of a 12-24 h fine horizontal resolution hail swath forecast to estimate the impact of hail to property.

Hindcast of the hail storms are performed at 250-500 m horizontal resolution with a triply nested WRF model with the National Severe Storms Laboratory (NSSL) double moment microphysics scheme. To mimic an operational forecasting environment, the lateral boundary and initial conditions for the WRF model are provided by the 12-km North American Mesoscale and the 13-km Rapid Refresh model forecast data and are enhanced with a three-dimensional variational (3-DVar) assimilation procedure.

The accumulated surface precipitation is reasonable compared to observations. The probability of detection (POD) and probability of false detection (POFD) of hail computed from the hindcast hail swath data for runs with 3-DVar out performs runs without 3-DVar assimilation. For POD, increasing the horizontal resolution for OK storms is less beneficial compared to TX storms. The longer forecast lead time for the OK storms may cause large spatial and structural errors leading to smaller POD scores. The initialization of the fine mesh domains later than the coarse domain yields a significantly high POD and low POFD for all the storms while reducing computational cost. Overall, the higher horizontal resolution coupled with a lead time of about 12-24 h with a modified WRF model provides a robust hail prediction system that produces hail hazard information for property damage models.

Submission ID: 114
Presenting Author: Surendra Rauniyar*
Session Time: TUESDAY 14:30-15:30

2

Analysis of the 27 November 2014 Brisbane hailstorm using Dual-Doppler and dual-polarization radars

RAUNIYAR Surendra[1]; PROTAT Alain[2]*

1) Bureau of Meteorology; 2) Bureau of Meteorology

The South-East Queensland region experiences over 200 thunderstorms a year. On 27 November 2014, a devastating supercell storm hit the Brisbane region, producing torrential rain, destructive wind speeds, 6000 lightning strikes, and widespread hail resulting in damage costs over $1.2 billion. Improving the warning lead time for such events is therefore a priority and should be driven by fundamental research on thunderstorms using advanced radars and high-resolution numerical modeling.

The CP2 research-grade dual-polarization radar and the Mt Stapylton operational weather radar fully sampled the Brisbane supercell storm. In this study our aim is to analyse these radar observations in order to show how operational dual-polarization radars and a denser radar network allowing for dual-Doppler 3D wind retrievals could be used operationally to improve the warning lead time of such catastrophic events and assist with post-event mitigation. Particular attention will be given to the early detection of the hail core and of the downdrafts associated with the descent of the hail core, conducive to low-level gust winds. To do so, the temporal evolution of the high-resolution 3D wind reconstruction (1 km horizontal resolution) and the CP2 classification of hydrometeor type (including hail and rain/hail mixture) are analysed during the storm life cycle, allowing for a comprehensive characterization of the dynamical and microphysical processes involved in the rapid intensification of this supercell.

Submission ID: 291
Presenting Author: Kevin Cheung*
Session Time: TUESDAY 14:30-15:30

3

Simulating the Sydney hailstorm on 9 December 2007 using WRF

MCBURNEY Benjamin[1]; CHEUNG Kevin[2]; MAGILL Christina[3]*

1) Macquarie University; 2) Macquarie University; 3) Risk Frontiers Natural Hazards Research Centre Macquarie University

Sydney is one of the most hail prone capital cities in Australia, with a number of damaging hailstorms occurring over the last thirty years. In this study, a high-resolution numerical simulation of a giant hailstorm event over the Sydney Metropolitan Region was performed in order to assess advancements in Numerical Weather Prediction (NWP) models for such local-scale hazardous weather. The 9th of December, 2007 hailstorm event (3.00pm-4.30pm EDT) was selected as it has not been studied in details. The storm devastated western and northern suburbs, causing AUD$470 million dollars in damage and produced unofficial reports of hailstones up to 11cm in diameter. The storm was simulated using version 3.6.1 of the Weather Research and Forecasting (WRF) Model developed by the US National Center for Atmospheric Research, which was fed by 1-degree latitude/longitude Final Analysis data from the Global Forecast System (GFS) as initial and boundary conditions. Sensitivity tests on the cloud microphysics schemes as well as radiation options were performed to decipher their impacts on the simulated hailstorm. Microphysics options that included hail as one of their hydrometeors (versus those with graupel only) reproduced the hailstorm significantly better than those that did not. In particular, the Goddard microphysics scheme coupled with the Goddard shortwave radiation scheme simulated synoptic patterns leading up to the event well, and the hailstorm track, precipitation, convection and ice density most accurately. However, the simulated storm arrived approximately 1.5 hours earlier than the actual event. Other microphysics options such as the WRF Double-Moment 6-class scheme with hail, and the Thompson, Field, Rasmussen and Hall microphysics scheme also generated encouraging results. Further study on applying the WRF data assimilation system to assimilate radiosonde data from the Sydney airport, which is available twice each day (at 6am EDT and 3pm EDT), will be conducted.

S4.3d High-Impact Weather in Research and Operations

Submission ID: 228
Presenting Author: Jussi Toivanen*
Session Time: TUESDAY 16:30-17:30

1

Simulations of Black Saturday bush fires with the ACCESS model

TOIVANEN Jussi[1]; REEDER Michael[2]; LANE Todd[3]; ENGEL Chermelle[4]; DAVIES Laura[5]*

1) Monash University; 2) Monash University; 3) University of Melbourne; 4) University of Melbourne; 5) University of Tasmania

I describe the numerical atmosphere coupled fire propagation modelthat has been developed in the School of Earth, Atmosphere andEnvironment at Monash University, and present simulation results forlarge Australian bush fires. Our fire spread model runs as a submodelinside the ACCESS model. It uses a level set method to describe themoving fire front and a subgrid scale model for sensible heat andmoisture flux generation. The model has been designed to be easy to use bypeople who are already familiar with the ACCESS model.

The two-way atmosphere coupled bushfire simulation models, like ours,simulate the motion of the land surface fire and the motions of theatmosphere at the same time. The land surface fire affects theatmospheric motions near it through its heat and moisture fluxes andthe atmosphere in turn affects the fire propagation through thelow-level wind, air temperature and humidity. Coupling the fire modeland atmospheric model in this way can improve the realism of the firesimulation by creating a physically realistic feedback loop betweenthe motions of the fire and the atmosphere.

To make our fire simulations as realistic as possible we use finegrained dead vegetation fuel data and accurate orography. Our maininterest are the 2007 Black Saturday bushfires, especially the KilmoreEast fire. The goal is to understand how the fire propagation dependson the available fuel, land topography and atmospheric conditions andhow the fire affects the state of the atmosphere. From modellingpoint of view it is also interesting to compare the outcomes of thefully two-way atmosphere coupled fire propagation models and simplerone way coupled models (where the fire fluxes are discarded) andassess how important the full atmospheric coupling is for the firepropagation models.

Submission ID: 146
Presenting Author: David Kinniburgh*
Session Time: TUESDAY 16:30-17:30

2

Modified fire behaviour in a coupled fire-atmosphere model

KINNIBURGH David[1]*

1) Monash University

The interactions between a bushfire and the surrounding atmospheric environment play a crucial role in the bushfire's behaviour. Energy released from the fire modifies the structure of the surrounding environment, causing fire behaviour to differ than what would be predicted by only considering the far-field atmospheric conditions. This fire-induced flow is the major source of uncertainty in predicting bushfire behaviour. In recent years, numerical coupled fire-atmosphere models have been developed to investigate the effect fire-induced flow has on fire behaviour. Atmospheric features such as cold fronts and undular bores, also affect bushfire behaviour predictability through sudden changes in wind speed, wind direction and changes in the thermodynamic properties of the atmosphere. The current research couples a fire spread model to the atmospheric model, CM1. The fire spread model utilises the McArthur empirical rate of spread formula. The dynamic variables required by the formula are calculated within CM1 and then communicated to the fire spread model to evolve the fire perimeter. The mass of burning fuel is calculated from the change in the burning area over the timestep and then used to calculate the surface sensible and latent heat fluxes produced by the fire. The flux values are communicated back to CM1 to represent the addition of heat and moisture from a parameterised fire. CM1 integrates the atmospheric variables in response to the addition of heat and moisture, yielding a coupled fire-atmosphere system.

Results will be presented from coupled fire-atmosphere simulations that compare a fire's response to a passage of a gravity current in a neutral atmosphere, and an undular bore propagating on the surface of a stable layer to their respective control experiments to demonstrate the effect these atmospheric phenomena have on fire behaviour.

Submission ID: 254
Presenting Author: Nicholas McCarthy*
Session Time: TUESDAY 16:30-17:30

3

Three dimensional radar analyses of Australian pyro-convective bushfires using Turret Tracking

MCCARTHY Nicholas[1]; YEO Claire[2]; MCGOWAN Hamish[3]*

1) University of Queensland; 2) Bureau of Meteorology; 3) University of Queensland

The study of convective bushfire plumes is critical to fire spread models and has direct impacts on operational wildfire management. One of the significant knowledge gaps contained within this is the role of temperature and wind profile on plume formation, structure and evolution. Weather Radar has been demonstrated as a highly effective tool in analysing plume structure and evolution, but very little research has combined this analysis with simultaneous measurement of atmospheric stability, wind shear and moisture. This research aimed to identify key indicators of intense pyro-convections by means of weather radar data analysis and develop understanding of the role of vertical temperature and wind profiles in intensive pyro-convective plume development using 8 confirmed large pyro-convection events that occurred between 2000 and 2015. It was found that the tracking of thermal pulsing (turrets) of bushfire convective plumes using radar contains significant and previously unrealized potential for rapid analysis the evolution of pyro-convection and is an effective technique of summarizing the complex data. In investigating stability and shear conditions, it was found that parcel calculations and other estimations from radiosonde and model soundings (CAPE, CIN and 0-6 Shear Magnitude) will not consistently capture the true convective potential of the environmental atmosphere in the absence of knowledge about the heat and moisture release from the bushfire. The on-going investigations of the University of Queensland Climate Research Group working with the Bureau of Meteorology, Queensland Fire and Emergency Services and New South Wales Rural Fire Service will be using a field methodology employing portable radar and radiosonde systems at live bushfires to fill this gap in knowledge of heat and moisture release from the fire.

Submission ID: 307
Presenting Author: Daniel Pazmino*
Session Time: TUESDAY 16:30-17:30

4

Differences between bushfires and heatwaves weather patterns in Victoria, Australia

PAZMINO Daniel[1]; KAROLY David[2]; PEZZA Alexandre[3]*

1) University of Melbourne; 2) University of Melbourne; 3) Greater Wellington Regional Council New Zealand

Bushfires and heatwaves are dangerous natural hazards in Australia. They are usually considered associated events because much above-average air temperature anomalies characterize them both. However, they differ in several other climatological aspects. The aim of this study is to compare the weather patterns associated with these events in Victoria, Australia. Daily and seasonal anomaly composites of climate variables were produced for the period 1961-2011. A daily analysis revealed that only 12.5% of bushfires were associated with heatwaves. A humid Australia characterizes heatwaves while bushfires exhibit the opposite pattern. On an inter-annual basis, these events cannot be explained by tropical dynamics. These results were obtained using weather station as well as reanalysis data. This study is important since any attempt to forecast these events benefits from a better understanding of their fundamental differences.

S4.3e High-Impact Weather in Research and Operations

Submission ID: 69
Presenting Author: Acacia Pepler*
Session Time: WEDNESDAY 09:45-10:30

1

Does the East Australian Current influence East Coast Lows?

PEPLER Acacia[1]; ALEXANDER Lisa[2]; DI LUCA Alejandro[3]; EVANS Jason[4]*

1) UNSW CCRC/ARCCSS; 2) UNSW CCRC/ARCCSS; 3) UNSW CCRC/ARCCSS; 4) UNSW CCRC/ARCCSS

Cyclones that form or intensify rapidly off Australia's east coast, known as East Coast Lows (ECLs), are one of the main causes of freshwater flooding and severe weather along the eastern seaboard. The presence of the warm East Australian Current (EAC) is widely thought to play an important role in the frequency, seasonality, and impacts of ECLs. However, the nature and strength of this relationship remains poorly understood.

To quantify this relationship, an ensemble of regional climate model simulations were performed over Australia using the Weather Research and Forecasting model, with 10 km resolution in the Tasman Sea and over the adjacent mainland. Several sets of simulations were performed for the period 2007-2008, which includes a number of major ECLs of different synoptic subtypes, using sea surface temperature datasets of different spatial resolutions, as well as fields where the EAC was completely removed. This enables a detailed assessment of the influence of sea surface temperatures on the frequency and characteristics of ECLs and coastal severe weather.

Submission ID: 53
Presenting Author: Mitchell Black*
Session Time: WEDNESDAY 09:45-10:30

2

Distinguishing natural and anthropogenic influences on extreme fire danger in Australia

BLACK Mitchell[1]; KAROLY David[2]; ALEXANDER Lisa[3]; LANE Todd[4]*

1) School of Earth Sciences and ARC Centre of Excellence for Climate System Science University of Melbourne; 2) School of Earth Sciences and ARC Centre of Excellence for Climate System Science University of Melbourne; 3) Climate Change Research Centre and ARC Centre of Excellence for Climate System Science University of New South Wales; 4) School of Earth Sciences and ARC Centre of Excellence for Climate System Science University of Melbourne

In the aftermath of the recent wildfires in Australia the scientific community was faced with the challenge of quantifying the event's link to different causal factors, including human-induced climate change. While there are a number of recorded attribution studies for temperature and precipitation-related events, no such study exists for fire weather.

This study investigates how the likelihood of extreme fire weather in Australia has been changed due to the competing influences of human-induced climate change and modes of inter-annual climate variability. Our analysis benefits from the use of the recently launched Weather@Home Australia-New Zealand distributed computing citizen science project to generate very large ensembles of regional climate model simulations over Australia. The likelihood of extreme fire weather is examined for different phases of the El Niño Southern Oscillation under present climate conditions and climate conditions with no human influences.

Submission ID: 263
Presenting Author: Mitchell Black*
Session Time: WEDNESDAY 09:45-10:30

3

Weather@Home Australia-New Zealand: an overview of recent event attribution studies

BLACK Mitchell[1]; KAROLY David[2]; KING Andrew[3]*

1) School of Earth Sciences and ARC Centre of Excellence for Climate System Science University of Melbourne; 2) School of Earth Sciences and ARC Centre of Excellence for Climate System Science University of Melbourne; 3) School of Earth Sciences and ARC Centre of Excellence for Climate System Science University of Melbourne

Event attribution studies seek to quantify the role of human and natural influences on specific weather and climate-related events. These studies typically require very large ensembles of climate model simulations to calculate how a particular climate driver has changed the likelihood of an event occurring. While such large ensembles are beyond the capability of conventional supercomputing resources, they may be achieved through the aggregated computing power of distributed computing projects.

Launched in 2014, the Weather@Home Australia-New Zealand (ANZ) project runs a moderate-resolution global atmospheric model (HadAM3P) with an embedded regional model (HadRM3P) on personal computers volunteered by the general public. To date, Weather@Home ANZ has generated tens of thousands of model simulations for two distinct climate scenarios: the world as it is and a counterfactual world without anthropogenic greenhouse gas emissions. Any difference in the likelihood of an event between these two scenarios is attributed to anthropogenic forcing.

This presentation provides an overview of the Weather@Home ANZ project and summarises a number of recent event attribution studies undertaken using this modeling framework, including Australia's first real-time event attribution study.

Submission ID: 310
Presenting Author: Savin Chand*
Session Time: WEDNESDAY 11:00-12:30

1

Tropical cyclones in a warming climate and ENSO

CHAND Savin[1]*

1) Federation University Australia

The impact of climate change on tropical cyclone activity is a topic of considerable scientific and socio-economic importance. Despite several modelling efforts, it remains uncertain how regional-scale development of tropical cyclones will respond to a warming climate. One of the main factors that modulate regional variability in tropical cyclone activity is the El Niño Southern Oscillation (ENSO) phenomenon. Here we present state-of-the-art climate modelling evidence of robust changes in ENSO-driven variability in tropical cyclone frequency by the late twenty-first century in response to greenhouse warming, particularly around the Pacific where impact of ENSO is substantial.

Submission ID: 192
Presenting Author: Sally Lavender*
Session Time: WEDNESDAY 11:00-12:30

2

Refining Australian region tropical cyclone projections

LAVENDER Sally[*1]; RAFTER Tony[2]; TORY Kevin[3]; YE Harvey[4]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) Bureau of Meteorology; 4) Bureau of Meteorology

Decision-makers require high quality projections of future tropical cyclone (TC) behaviour, especially coastally impacting TCs. However, the latest international TC projection studies provide contradictory results on changes in TC activity, with some showing increases and others decreases in TC numbers both globally and in the Australian region. As a consequence our confidence in projections has been set back. It is now clearer than ever that the scientific community must investigate why there are these differences. In order to progress we require a greater understanding of the processes controlling TCs in both observations and models to improve confidence in projections.

This presentation will provide an overview of work being undertaken to improve our current understanding of TCs in the Australian region. Results based on a detailed analysis of TC formation environments and track characteristics will be presented, with an emphasis on Australian landfalling TCs. A subset of CMIP5 models with realistic TC climatologies and processes has been selected, which will enable the production of better informed TC projections for the Australian region. It is hoped that this will lead to reduced uncertainty and greater confidence in TC projections, which would have the potential to greatly benefit environmental, social and economic risk assessment and adaptation planning.

Submission ID: 278
Presenting Author: Tony Rafter*
Session Time: WEDNESDAY 11:00-12:30

3

High resolution climate simulations of extreme rainfall

RAFTER Tony[1]; ABBS Deborah[2]; LAVENDER Sally[3]; NGUYEN Kim[4]; THATCHER Marcus[5]*

1) CSIRO Oceans & Atmosphere; 2) (Former) CSIRO Oceans & Atmosphere; 3) CSIRO Oceans & Atmosphere; 4) CSIRO Oceans & Atmosphere; 5) CSIRO Oceans & Atmosphere

Extreme rainfall events represent one of the most destructive natural hazards experienced in Australia and globally, through their contribution to flooding and the resultant risk to human lives and of damage and destruction to natural and man-made environments.

The ability of high resolution convection-permitting (of the order of 5km or finer) or convection-resolving models (1km or less) to represent the atmospheric processes resulting in extreme rainfall is key to our understanding of these phenomena, and to our confidence in producing meaningful projections of extreme rainfall under future climate change scenarios. While the actual processes of extreme rainfall occur at very fine scales, these processes are influenced by large scale and long term atmospheric phenomena, from the large mesoscale environment to climate drivers such as ENSO, IOD and IPO. As such, we need to perform long term climate simulations that account for long term climate processes as well as resolve short term extreme weather in order to develop a realistic representation of the extreme rainfall climatology.

We report on our progress utilising the CSIRO Cubic Conformal Atmospheric Model (CCAM) to advance the representation of rainfall extremes at 2km spatial resolution over regions covering Sydney, New South Wales and Brisbane, Queensland. We use the ERA Interim reanalysis data set as the climate forcing in order to enable comparisons between our modelling results and the Australian Water Availability Project (AWAP) data set, with particular emphasis on the tail of the rainfall distribution. The simulation results for the period 1980 to 2014 suggest that CCAM can produce a plausible simulation of the probability distribution of rainfall for the regions investigated. We characterise the simulated extreme rainfall using statistical analysis methods including extreme value analysis. The ability to use simulations for regional climate projections of extreme rainfall will also be discussed.

Submission ID: 267
Presenting Author: Peter Gibson*
Session Time: WEDNESDAY 11:00-12:30

4

A closer look at the mechanisms behind recent observed trends in Australian heat waves

GIBSON Peter[1]; PERKINS-KIRKPATRICK Sarah[2]; ALEXANDER Lisa[3]; PITMAN Andrew[4]*

1) Climate Change Research Centre University of New South Wales & ARC Centre of Excellence for Climate System Science; 2) Climate Change Research Centre University of New South Wales & ARC Centre of Excellence for Climate System Science; 3) Climate Change Research Centre University of New South Wales & ARC Centre of Excellence for Climate System Science; 4) Climate Change Research Centre University of New South Wales & ARC Centre of Excellence for Climate System Science

For the latter half of the 20th century, significant positive trends in the number, intensity and duration of heat waves have been observed for many parts of Australia. Concern has been raised that if these trends are to continue or increase in future climates, the associated negative effects on human health, society and economy could be severe. This presentation will discuss some of the possible mechanisms behind the changing nature of heat waves in recent past and future climates. Using a circulation-typing framework to diagnose possible observed changes in atmospheric circulation, dynamical versus thermodynamical contributions to recent heat wave trends are assessed across Australia. Insights from this processes-based understanding will be used to more closely scrutinize simulated heat waves in state-of-the-art coupled climate model simulations, and subsequently inform which models should provide the most reliable projections of heat waves into the future.

Submission ID: 342
Presenting Author: Elisabeth Vogel*
Session Time: WEDNESDAY 11:00-12:30

5

Quantifying the impact of meteorological extreme events on global agricultural Yields

VOGEL Elisabeth[1]; ALEXANDER Lisa[2]; DONAT Markus[3]; FRIELER Katja[4]; KAROLY David[5]; MEINSHAUSEN Malte[6]; RAY Deepak[7]*

1) Climate Change Research Centre University of New South Wales; 2) Climate Change Research Centre University of New South Wales; 3) Potsdam Institute for Climate Impact Research; 4) School of Earth Sciences University of Melbourne; 5) School of Earth Sciences University of Melbourne; 6) Institute on the Environment University of Minnesota; 7) School of Earth Sciences University of Melbourne

The frequency and/or intensity of different types of weather extreme events is predicted to increase in a number of regions across the globe under climate change (IPCC, 2012). The global food system is particularly affected due to its dependence on climatic conditions for agricultural production and its increasing global connectedness (GFSP, 2015; Puma et al., 2015). Extreme events, such as droughts, heavy rainfall and temperature extremes can adversely impact crop production with implications for the livelihoods and food security of a large fraction of the world population, particularly in developing countries. To improve the resilience of the agricultural sector to extreme weather events and to increase crop yields in a changing climate, it is critical to better understand the impact of extreme events on the world's crop yields in the past and present.This presentation will summarise first results of our study, which aims at quantifying the impact of meteorological extreme events on crop yields at the global scale by combining detailed crop yield time series at subnational scales with data on past meteorological and hydrological conditions and occurrences of weather extremes. By building empirical models that link weather and hydrological conditions during the growing season to crop yields using a combination of statistical and machine learning methods, we quantified the contribution of meteorological and extreme event indicators to yield anomalies and assessed the spatial patterns of significant impacts on crop yields.

References:

GFSP, 2015. Extreme Weather and Resilience of the Global Food System. Final Project Report from the UK-US Taskforce on Extreme Weather and Global Food System Resilience.

The Global Food Security programme, UK.IPCC, 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York.

Puma, M.J., Bose, S., Chon, S.Y., Cook, B.I., 2015. Assessing the evolving fragility of the global food system. Environ. Res. Lett. 10, 024007. doi:10.1088/1748-9326/10/2/024007.

S4.3f High-Impact Weather in Research and Operations

Submission ID: 359
Presenting Author: John McBride*
Session Time: WEDNESDAY 11:00-12:30

6

On the nature of drought in the ITCZ maritime continent

MCBRIDE John[*1]*

1) Emeritus Scientist, Bureau of Meteorology

This paper analyses a number of long-term rainfall data sets from Singapore, located close to the equator in the western maritime continent. Defining drought in terms of cumulative rainfall distributions below threshold percentages of climatology, the following questions are addressed a) whether a high rainfall regime under the influence of the ITCZ experiences drought; b) whether there is any climate-change signature in the observed rainfall distribution; c) whether the recent extreme low rainfall event in January-March 2014 can be attributed to climate change.

The major findings are:

- There is no signal in the observed record consistent with the climate change signature of increased extremes, that is with higher percentiles increasing in value and lower percentiles decreasing in value
- The existence of long-term (12 month) drought is dominated by multi-decadal variations, or rainfall epochs of approximately 30 years in length
- The recent dry epochs and wet epochs experienced different seasonal distributions, inferring a possible shift in the location of the ITCZ between epochs
- The case study of the 2014 event revealed it was caused by an extreme of the ITCZ location (McBride et al., 2015)

Proposed follow-up work would be to obtain long series data from surrounding countries to determine the spatial structure of the 30-year dry and wet epochs; and to further examine the hypothesis that these events are related to long-term shifts in ITCZ location.

Reference:

McBride, J.L., S. Sahany, M.E.E. Hassim, C. M. Nguyen, S-Y Lim, R. Rahmat, W-K Cheong. 2015. The 2014 record dry spell at Singapore: An Intertropical Convergence Zone (ITCZ) drought. *Bulletin of the American Meteorological Society*, Bulletin of the American Meteorological Society, **96**(12):S126 - S130.

Submission ID: 51
Presenting Author: Andrew Prata*
Session Time: WEDNESDAY 13:45-15:30

1

Satellite observations of stratospheric volcanic aerosols in the Southern Hemisphere extra-tropics

PRATA Andrew[1]; SIEMS Steven[2]*

1) Monash University; 2) Monash University

Large volcanic eruptions can affect global temperatures over seasonal-to-decadal time scales, which motivates the need for a better understanding of the radiative forcing of stratospheric volcanic aerosols. In order to better constrain radiative transfer calculations, observations of volcanic aerosol profiles are needed. The Cloud-Aerosol Lidar with Orthogonal Polarisation (CALIOP) is well suited for studying atmospheric aerosols, especially in the Southern Hemisphere extra-tropics; where ground-based observations are often scarce. In this research, ash and SO2 detections from the Atmospheric Infrared Sounder (AIRS) are combined with CALIOP lidar observations to identify and quantify optical and geometrical properties of stratospheric volcanic aerosol layers. This technique is applied to the recent Chilean eruptions of Puyehue-Cordón Caulle (June, 2011) and Calbuco (April/May, 2015). These eruptions both injected volcanic aerosols into the stratosphere, which were then dispersed throughout the Southern Hemisphere extra-tropics. Due to the widespread nature of these eruptions, frequent CALIOP observations were possible. This allowed for numerous measurements of the two-way particulate transmittance (at 532 nm), which could then be used to retrieve volcanic aerosol extinction-to-backscatter ratios (lidar ratios) for both eruption case studies. These observations highlight the importance of satellite observation in the Southern Hemisphere and also provide new insights into the dynamical, optical and geometrical evolution of stratospheric volcanic aerosols.

S4.4a Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics

Submission ID: 202
Presenting Author: Matthew Woodhouse*
Session Time: WEDNESDAY 13:45-15:30

2

Marine secondary organic aerosol in the Southern Ocean

WOODHOUSE Matthew[1]; LAWSON Sarah[2]; LUHAR Ashok[3]; KEYWOOD Melita[4]; HARVEY Mike[5]*

1) CSIRO; 2) CSIRO; 3) CSIRO; 4) CSIRO; 5) NIWA

Marine aerosol is traditionally thought to be dominated by sea-salt and sulphate derived from dimethyl-sulphide. However, recent studies suggest a significant contribution from both primary and secondary organic aerosol sources. Organic aerosol therefore has the ability to influence marine clouds, with implications for the radiative budget. Furthermore, organic aerosol may form part of a climate feedback linking marine biology with clouds and radiation, analogous to the long-standing CLAW hypothesis.

Here, we use the ACCESS-UKCA global composition-climate model to simulate observations of marine aerosol taken during the Surface Ocean Aerosol Production (SOAP) cruise in the highly productive Chatham Rise region of the Southern Ocean in February 2012. ACCESS-UKCA includes the detailed microphysical aerosol scheme GLOMAP-mode, which represents both aerosol mass and number. Within ACCESS-UKCA, GLOMAP-mode is coupled to the radiation scheme via clouds (the indirect effect) and directly by scattering short-wave radiation.

By comparing ACCESS-UKCA simulations with observations from the SOAP cruise, we assess the contribution secondary organic aerosol makes to aerosol number and mass in the Chatham Rise region and also within the larger context of the Southern Ocean. Improving the representation of marine aerosol by quantifying the role of organic aerosol will help to address the short-wave radiation and warm surface biases exhibited by many current climate models.

Submission ID: 213
Presenting Author: Melita Keywood*
Session Time: WEDNESDAY 13:45-15:30

3

Shipboard measurements of aerosol and trace gas composition over the southern ocean

SELLECK Paul[1]; KEYWOOD Melita[2]; RISTOVSKI Zoran[3]; LAWSON Sarah[4]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) Queensland University of Technology; 4) CSIRO Oceans and Atmosphere

Aerosols have direct effects on the climate by scattering and absorbing light or indirectly by modifying cloud properties. Clouds over the Southern Ocean (SO) are poorly simulated in global climate models and present-day reanalysis products resulting in large radiation biases for the SO. The processes that influence cloud–forming aerosol properties in the remote marine atmosphere such as the SO are poorly understood and the atmosphere over the SO is one of the most poorly studied regions on the globe due primarily to the harsh conditions and remote location.

We present atmospheric aerosol and trace gas observations from the trial voyage of Australia's new research vessel, the RV Investigator, down to the ice edge of Antarctica in the Southern Ocean (65°S), in summer 2015. A wide variety of atmospheric measurements were made, including organic trace gases, aerosol chemical composition, aerosol size distribution, and microphysical and optical properties. Here we present measurements of sub-micron aerosol chemical composition made using a time of flight Aerosol Chemical Speciation Monitor (ToF-ACSM) and aerosol size distribution using a SMPS. We also show measurements of organic aerosol precursor gases including dimethyl sulfide (DMS), measured using a PTR-MS, glyoxal and methyl glyoxal, measured using 2,4-dinitrophenylhydrazine (2,4-DNPH) cartridges and UHPLC-DAD-MS. We explore the contribution of the gas-phase precursors to observed aerosol composition over the Southern Ocean.

Submission ID: 315
Presenting Author: Luke Cravigan*
Session Time: WEDNESDAY 13:45-15:30

4

Contribution of remote marine aerosol species to cloud condensation nuclei over the Southern Ocean

CRAVIGAN Luke[1]; RISTOVSKI Zoran[2]; ALROE Joel[3]; MALLET Marc[4]; MILJEVIC Branka[5]; KEYWOOD Melita[6]; SELLECK Paul[7]; WARD Jason[8]; MOLLOY Suzie[9]*

1) Queensland University of Technology; 2) Queensland University of Technology; 3) Queensland University of Technology; 4) Queensland University of Technology; 5) Queensland University of Technology; 6) CSIRO Ocean and Atmosphere Flagship; 7) CSIRO Ocean and Atmosphere Flagship; 8) CSIRO Ocean and Atmosphere Flagship; 9) CSIRO Ocean and Atmosphere Flagship

Uncertainty in aerosol cloud interactions is likely to contribute to the known biases in modelled low to mid level clouds over the Southern Ocean (1). Observations of aerosol composition and processing are required to explain the limitations of current aerosol models. Remote marine aerosol composition and CCN observations are scarce over the Southern Ocean (2).

In this presentation aerosol composition, volatility, water uptake and CCN measurements over the Southern Ocean will be discussed. Sub-micron aerosol composition was examined using Aerosol Mass Spectrometry and Aitken mode composition was inferred from aerosol volatility and hygroscopicity. These measurements were taken in January and February 2015 during the Cold Water Trials of the RV-Investigator (CSIRO, Hobart) and in March 2015 at the Cape Grim Baseline Air Pollution Station.

Non-sea salt (nss) sulfates consistently dominate remote marine aerosol concentrations at peak CCN sizes (<200 nm). These particles form via atmospheric processing of dimethyl sulfide (DMS), which is emitted from phytoplankton. This work highlights the importance of nss sulfate formation and atmospheric processing to remote marine CCN concentrations. Sub-200 nm sea- spray aerosols (SSA) are more transient than nss sulfates, yet can significantly enhance CCN concentrations (2). The size dependent organic enrichment of SSA remains uncertain and has implications for SSA emissions schemes. These observations, and further like it, are key to refining model representation of CCN and cloud formation over the Southern Ocean.

References:

1. Huang Y, Siems ST, Manton MJ, Thompson G (2014) An Evaluation of WRF Simulations of Clouds over the Southern Ocean with A-Train Observations. Mon Wea Rev 142(2):647—667.

2. Cravigan LT, Ristovski Z, Modini RL, Keywood MD, Gras JL (2015) Observation of sea-salt fraction in sub-100 nm diameter particles at Cape Grim. J Geophys Res Atmos:2014JD022601.

Submission ID: 320
Presenting Author: Rosemary Fedele*
Session Time: WEDNESDAY 13:45-15:30

5

Australian aerosol and Cloud Condensation Nuclei (CCN)

FEDELE Rosemary[1]; KEYWOOD Melita[2]; PORTER Nichola[3]; HUGHES Jeff[4]*

1) RMIT; 2) CSIRO; 3) RMIT; 4) RMIT

Atmospheric aerosol particles indirect radiative effects (or the effects aerosols have on clouds) are currently the largest uncertainty in the IPCC report estimate of anthropogenic induced climate change. Cloud droplets form in the atmosphere by the condensation of water vapour onto aerosol particles. The subset of atmospheric aerosol particles that are able to uptake water vapour, at a given water vapour supersaturation, and form into cloud droplets are Cloud Condensation Nuclei (CCN).

There is a specific need to understand the processes involved with aerosol indirect effects and climate change in general on Australian regional aerosols such as dust emissions, bushfire emissions, Southern Ocean natural aerosol production, terrestrial biogenic aerosol and aerosol precursor emissions, transport and removal processes. A better understanding of aerosol effects is essential in order to reconcile modeled and observed climate variability and climate change.

To this aim, intensive ground-based measurements of ambient aerosols including CCN were made at three locations across Australia; a tropical site located at Gunn Point in the Northern Territory, an urban site located in a suburb approximately 22 km to the west of Sydney in New South Wales and a marine site located at the Cape Grim Baseline Monitoring Station located on the northwest tip of Tasmania.

The program included determination of aerosol microphysical and chemical properties, as well as measurement of volatile organic compounds and criteria pollutants. A CCN counter measured the size resolved CCN number concentration for CCN between 0.75 and 10 micrometers, over a range of supersaturations.

The influence of important aerosol sources and processes to the Australian continent such as biomass burning, urban vehicle emissions, secondary formation and marine sources on CCN formation and regulation will be discussed in this presentation.

This work was supported by the Australian Climate Change Science Program.

S4.4a Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics

Submission ID: 73
Presenting Author: Cacilia Ewenz*
Session Time: WEDNESDAY 13:45-15:30

6

Airborne survey of ultrafine particles over Eastern Australia

JUNKERMANN Wolfgang[1]; EWENZ Cacilia[*2]; HACKER Jorg[3]*

1) Karlsruhe Institute of Technology; 2) AIrborne Research Australia / Flinders University; 3) AIrborne Research Australia / Flinders University

Ultrafine particles (UFP), particles of sizes less than 100nm, exhibit a significant effect on rainfall and radiation in the atmosphere through aerosol cloud interactions. However, these particles are not directly measured with current remote sensing techniques, because they are too small to be visible and only accessible by in-situ techniques (Junkermann and Hacker, 2015).

Cloud and rain droplet size distributions depend on the number of cloud condensation nuclei (CCN). UFP can act as CCN and hence increase the number of cloud droplets but at the same time decrease the size of the droplets, leading to less or delayed rain droplet development (Rosenfeld, 2000). Well documented rainfall trends and only little land use change over the last 40 years as well as 80 years of reference rainfall data since 1890 made the coastal area a unique location for a study of emission changes from coal burning possibly leading to cloud / rainfall modifications.

Airborne in-situ measurements in Eastern Australia in plumes of coal-fired power stations and over hundreds of kilometres downwind from the source display the source strength of individual major sources of ultrafine aerosols and their importance to the overall UFP budget. The remote outback of Queensland in contrast shows a low concentration background otherwise with natural and biogenic sources from the GBR, and from forest fires.

Comparison of the current study to observations in the 1970s showing changes of aerosol sources and typical concentration levels over Australia (Bigg and Turvey, 1978) present evidence that the UFP/CCN originating from the coal burning power stations commissioned since 1968 can be related to the observed regional rainfall trends in Eastern Australia. Combined with HYSPLIT back trajectory calculations indicate that the past as well as the recent UFP / CCN distributions are strongly affected by long range transport from power stations. Primary emissions from coal-fired power stations were clearly identified as a major source of UFP.

References:

Rosenfeld, D. 2000: Suppression of rain and snow by urban and industrial air pollution. Science. 287, 1793-1796.

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S4.4a Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics

Submission ID: 130
Presenting Author: Yi Huang*
Session Time: WEDNESDAY 13:45-15:30

7

What is the role of sea surface temperature in modulating cloud and precipitation properties over the Southern Ocean?

HUANG Yi[1]; SIEMS Steven[2]; MANTON Michael[3]; ROSENFELD Daniel[4]; MARCHAND Roger[5]; MCFARQUHAR Greg[6]; PROTAT Alain[7]*

1) Monash University; 2) Monash University; 3) Monash University; 4) Hebrew University; 5) University of Washington; 6) University of Illinois; 7) Australian Bureau of Meteorology

This study employs 4-year spatiotemporally collocated A-Train satellite observations to investigate cloud and precipitation characteristics in relation to the underlying properties of the Southern Ocean (SO).

Results show that liquid-phase cloud properties strongly correlate with the sea surface temperature (SST). In summer, ubiquitous supercooled liquid water (SLW) is observed over SSTs < ~ 4°C. Cloud-top temperature (CTT) and cloud effective radius of liquid-phase clouds generally decrease for colder SSTs, whereas the opposite trend is shown for cloud optical thickness and liquid water path. Notable geographical differences are also present, with cloud particle size (droplet number concentration) over South Atlantic Ocean being inherently smaller (larger) than that over South Indian Ocean and South Pacific Ocean. Using a novel joint SST-CTT histogram, two distinct liquid-phase cloud types are discovered over the SO, where the retrieved particle size appears to increase with decreasing CTT over warmer water (SSTs > ~ 7°C), while the opposite trend is present over colder water. A comparison with the Northern Hemisphere (NH) counterparts suggests the critical role of SST in driving the large inter-hemisphere contrast in the liquid-phase cloud properties, where SSTs < ~ 4°C (and potential changes in aerosol properties associated with SSTs) are rarely observed in the NH storm-track regions year round.

Our study also suggests that precipitation, which inserts profound influence on cloud properties, remains poorly observed over the SO using the current spaceborne observations. Large uncertainties in precipitation properties are associated with the ubiquitous boundary layer clouds within the lowest kilometer of the atmosphere.

S4.4b Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics

Submission ID: 60
Presenting Author: Alain Protat*
Session Time: WEDNESDAY 16:30-17:30

1

Southern Ocean Cloud — Radiation interactions and their representation in the Australian regional forecast model as revealed by RV Investigator observations

PROTAT Alain[1]; SCHULZ Eric[2]; SUN Zhian[3]; XIAO Yi[4]; KEYWOOD Melita[5]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology; 5) CSIRO

The Southern Ocean (SO) is a region of great importance to global and Australian climate and weather. Climate models are challenged by uncertainties and biases in the simulation of SO clouds, aerosols, and surface fluxes. These biases produce large errors on the surface radiation budget and affect the location of sub-tropical jets, the simulation of anthropogenic indirect aerosol effects on climate, and the simulated global cloud feedbacks and carbon–cycle feedbacks on climate change. These model challenges can be traced to poor physical understanding of these processes. This lack of physical understanding can in turn be attributed to the unavailability of state-of-the-art observations of clouds, aerosols, precipitation, radiation and the air–sea interface, hindering our capability to conduct process studies.

In March 2015, we collected cloud, aerosol, and surface radiation observations over the Southern Ocean as part of a sea trial of the Marine National Facility Research Vessel Investigator. In this talk we will describe the observations collected, the statistical cloud and radiative properties derived from those observations (cloud frequency of occurrence, cloud fraction) and we will compare these statistical cloud and radiation properties to those simulated by the Australian regional weather forecast model (ACCESS). Results show that the frequency of low clouds is underestimated and that of mid-level and high clouds is largely overestimated. Implications in terms of surface radiation budget errors will be quantified and discussed.

S4.4b Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics

Submission ID: 119
Presenting Author: Steven Siems*
Session Time: WEDNESDAY 16:30-17:30

2

Observations of high droplet number concentrations in Southern Ocean boundary layer clouds

CHUBB Thomas[1]; HUANG Yi[2]; JENSEN Jorgen[3]; CAMPOS Teresa[4]; SIEMS Steven[5]; MANTON Michael[6]*

1) Monash University; 2) Monash University; 3) UCAR; 4) UCAR; 5) Monash University; 6) Monash University

Data from the standard cloud physics payload during the NSF/NCAR High-performance Instrumented Airborne Platform for Environmental Research (HIAPER) Pole-to-Pole Observations (HIPPO) campaigns provide a snapshot of unusual wintertime microphysical conditions in the boundary layer over the Southern Ocean. On 29 June 2011, the HIAPER sampled the boundary layer in a region of pre-frontal warm air advection between 58S and 48S to the south of Tasmania. Cloud droplet number concentrations were consistent with climatological values in the northernmost profiles but were exceptionally high for wintertime in the Southern Ocean at 100-200/cc in the southernmost profiles. Sub-micron (0.06<D25m/s) were most likely responsible for production of sea spray aerosol which influenced the microphysical properties of the boundary layer clouds. The smaller size and higher number concentration of cloud droplets is inferred to increase the albedo of these clouds, and these conditions occur regularly, and are expected to increase in frequency, over windy parts of the Southern Ocean.

S4.4b Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics

Submission ID: 128
Presenting Author: Steven Siems*
Session Time: WEDNESDAY 16:30-17:30

3

In-situ observations of “warm ice” over the Southern Ocean

SIEMS Steven[1]; HUANG Yi[2]; CHUBB Thomas[3]; MANTON Michael[4]*

1) Monash University; 2) Monash University; 3) Monash University; 4) Monash University

The prevalence of supercooled liquid water (SLW) recorded by satellite observations down to -40°C has been found to be a remarkable feature over the remote Southern Ocean (SO). The underrepresentation of SLW in climate models is hypothesized to be a major contributor to the large simulated radiative bias in this region.An effort has been made to better understand the microphysics of clouds over this measurement-sparse area. In-situ observations of the thermodynamic phase, cloud droplet number concentration and effective radius are presented for flights under a variety of synoptic conditions off the coast of Tasmania. Further, we detail a wintertime research flight during which shallow (~2500) convective clouds were observed within in a post-frontal environment. The cloud-top temperature was ~ -6° C. The thermodynamics phase of these clouds varied from primarily glaciated to mixed phase to supercooled liquid water. Ice particles were observed at relatively warm temperatures (~-5°C) within and below cloud. The formation of “warm ice” is exceptional given the pristine environment where ice nuclei are considered to be lacking.The general synoptic condition of this case was rather common with a relatively strong southwesterly winds (15-20 m/s) observed at sampling levels. Analyses of back trajectories indicate no obvious history of continental influence on aerosol transport, suggesting a potential oceanic source of ice nuclei. In-situ measurements are combined with the coincident A-Train satellite observations and numerical modeling to further examine the cloud properties, which help understand the formation of warm ice over the Southern Ocean.

S4.5a Systematic Errors in Weather and Climate Models: Analysis and Solutions

Submission ID: 125
Presenting Author: Charmaine Franklin*
Session Time: MONDAY 10:45-12:15

1

Improving the simulation of clouds and precipitation in ACCESS

FRANKLIN Charmaine[*1]*

1) CSIRO

In this presentation numerous model developments will be described that improve the simulation of clouds and precipitation in ACCESS from the tropics to the Southern Ocean, and across spatial and temporal scales from climate to convection permitting simulations. Examples include:

Climate and numerical weather prediction models underestimate cloud condensate over the Southern Ocean. Evaluation using satellite simulators has shown that ACCESS produces too much drizzle. New warm rain parameterisations improve the representation of cloud processes in the model, reducing drizzle, increasing cloud water and generating more accurate shortwave cloud radiative effects. The new parameterisations also have a positive effect in the tropics, increasing condensate and cloud top heights in shallow convective regimes, suggesting an improvement in boundary layer depth.

Compared to observations convection permitting simulations of tropical convection produce stronger updrafts, larger reflectivities and underestimate stratiform area. Including a heterogeneous rain freezing parameterisation in ACCESS and using different ice size distributions shows better agreement with observations. Using different turbulent mixing parameterisations has shown that entrainment in the mixed-phase regions of updrafts is most sensitive to the turbulence formulation. Greater mixing of environmental air into updrafts produces more detrainment and the generation of a larger stratiform area.

The poor simulation of precipitation in the Maritime Continent is a long standing problem. While it has been shown that changing individual components of convection, cloud and microphysics schemes can have some benefit, the combination of several of these changes has been demonstrated to increase the ubiquitous underestimation of midlevel cloud in the tropics. This work illustrates the challenges of model development where interactions between developments can produce better results than the individual components alone.

S4.5a Systematic Errors in Weather and Climate Models: Analysis and Solutions

Submission ID: 216
Presenting Author: Hanh Nguyen*
Session Time: MONDAY 10:45-12:15

2

Sensitivity of the ACCESS regional forecast model statistical rainfall properties to resolution

NGUYEN Hanh[1]; PROTAT Alain[2]; WHIMPEY Michael[3]; RIKUS Lawrie[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology

The representation of the statistical rainfall properties over Darwin is assessed in four versions of the ACCESS forecast model against the dual-polarization CPOL radar observation. Previous results from ACCESS-A show that while the model reproduces the accumulated daily rainfall reasonably well albeit tending to slightly overestimate it, the mean rain rate is too weak, compensated by too large a frequency of occurrence. In terms of intensity the model tends to perform better in the wet than dry regimes, especially during the active monsoon regime, where most of the precipitation occurs. Probability distribution functions of hourly rain rates reveal that while there are very little differences amongst regimes, marked discrepancies are found between model and observations. The model overestimates light rain rates, underestimates moderate to heavy rain rates and produces spurious very heavy rain rates associated with grid point storms. The evaluation of the diurnal cycle of rainfall properties also reveals a general underestimate of rain rates compensated by an overestimated rain frequency over the whole cycle, resulting in overestimated amplitude and poor timing of the diurnal peak. In all regimes, the overestimate of total domain daily rainfall and rain frequency is found to be due to an overestimate of low rain rates produced by the model convective scheme while the underestimate of mean rain rate is due to an underestimate of high rain rates and high rain rates frequency by the model convective scheme.

Comparing different horizontal resolutions (40, 12, 4 and 1.5km) of ACCESS, we show that when convection is parameterized, there is a marked land-sea contrast error where there is too much rain over the ocean which abruptly stops when it reaches the coastlines. This land-sea contrast disappears when the convection parameterization is turned off (in the C2 version) allowing the model to develop convection explicitly, but rain peaks are generally too strong.

Submission ID: 246
Presenting Author: Siobhan O'Farrell*
Session Time: MONDAY 10:45-12:15

3

Ozone simulations with the ACCESS model: Response in the stratosphere over Antarctica

O'FARRELL Siobhan[1]; KLEKOCIUK Andrew[2]; FRENCH John[3]; KNIGHT Calum[4]; WOODHOUSE Matthew[5]*

1) CSIRO Ocean and Atmosphere; 2) Australian Antractic Division and ACE CRC; 3) Australian Antarctic Division and ACE CRC; 4) IMAS University of Tasmania; 5) CSIRO Ocean and Atmosphere

We have performed a set of ensemble simulations looking at the ozone response in ACCESS1-0 and ACCESS1-3 models and here summarise several different responses between the ensemble averages.

We tested the ozone response by doing “No-Oz” perturbation runs where the monthly ozone distribution is held at 1960 levels and the other trace gases and aerosols follow the standard historical scenario. The ozone distribution used is the standard CMIP5 pattern which is zonally averaged above 50hPa and in this UM implementation has been zonally averaged at all levels.

At the surface we found the SAM response was not distinguishable between the historical and the “No-Oz” case for both ACCESS1-0 and ACCESS1-3 in all seasons. We examined the SAM trends at 500hPa and 50hPa to see which of the two models are better able to represent the impact of ozone change during the SON season and looked at how the SAM evolves during the 21st century using the RCP45/RCP85 simulations.

Our study also examines the quasi stationary Rossby waves in the lower stratosphere and their influence on the ozone distribution. The amplitudes of these waves is biased low compared with reanalysis data. There could be a number of causes for this difference, including the vertical resolution of the simulations, the zonal averaging of the ozone distribution, and the representation of surface roughness over Antarctica in ACCESS1-3 which affects gravity wave drag.

We are performing new simulations with ACCESS1-0 using a full 3-D observed ozone field from MERRA reanalysis which is a better match for observations, and which will help answer the second of these issues. We will also look at early runs of ACCESS2 (with 85 vertical levels) where the SST is fixed but the ozone chemistry (within UKCA) is free to evolve and is controlled through the 20th Century and early 21st century by emission levels.

Submission ID: 248
Presenting Author: Ian Watterson*
Session Time: MONDAY 10:45-12:15

4

Evaluating and improving simulated rainfall variability for Northern Australia and Southeast Asia

WATTERSON Ian[1]; THATCHER Marcus[2]; GENG Helen[3]*

1) CSIRO; 2) CSIRO; 3) University of Adelaide

Northern Australia and Southeast Asia is a challenging region for atmospheric models. Monsoons, cyclones and diurnal cycles interact with complex topography and ocean surface variations to produce high rainfall variability. Improved regional modelling will contribute to better infrastructure planning and better adaptation to future climate change. We analyse the distribution of rainfall on both daily and monthly timescales from CMIP5 global models and regional models including CSIRO's CCAM. These are compared with observational products from the Global Precipitation Climatology Centre (GPCC, Germany) and ECMWF -the ERA-Interim Land reanalysis, along with other data sets. Objective skill scores for various gridded statistics and for distribution functions (or PDFs) are evaluated. While most of the models produce fairly realistic rainfall on the larger spatial and longer time scales, there is a wide range of outcomes for both low and high extreme amounts. In particular, the frequency of dry days in these gridded data varies widely, and skill scores for this are not well related to model resolution, or the skill for mean rainfall. However, extreme high rainfall, on grids down to 0.25 degree, can be better simulated by high-resolution models, including new versions of CCAM at both 50 and 10 km resolution. The link between skill in rainfall simulation and that in atmospheric circulation will be examined, along with any implications for the reliability of simulated changes for the coming century.

S4.5a Systematic Errors in Weather and Climate Models: Analysis and Solutions

Submission ID: 236
Presenting Author: Julie Arblaster*
Session Time: MONDAY 10:45-12:15

5

The linearity of Southern Hemisphere extratropical circulation change

*ARBLASTER Julie**[1]

1) Monash University

Detection and attribution is based on the assumption that the impact of natural and anthropogenic forcings on the climate system can be well approximated by linearly adding the effects of individual forcings. This assumption has been validated for global averages and spatial patterns of (mostly) temperature related variables. Modelling groups in CMIP5 undertook these detection and attribution experiments in various ways, some adding each historical forcing to a preindustrial control, others eliminating certain forcings from a historical all-forcing simulation. Many studies have assumed these methods produce similar results, however the available experiments have not allowed this assumption to be tested until now. Here for the first time we compare these two methods of detection and attribution in simulations with the CESM1-CAM5 coupled climate model, with particular application to Southern Hemisphere extratropical circulation change. For example, are the results of a simulation that includes all external forcings but for ozone depletion similar to the results of adding the output of all individual single-forcing experiments but for those driven by ozone changes? Preliminary results suggest that similar evolutions of global temperatures and precipitation are found between the two methods but it remains to be seen how circulation variables and regional scales are impacted. Our experiments enable us to go beyond the global average temperature response and explore different variables at different spatial and temporal scales so to characterize in a systematic fashion where the linearity holds and where it breaks down. The presentation will focus on whether present-day and pre-industrial base states lead to similar impacts of stratospheric ozone depletion on wind and rainfall patterns in the Southern Hemisphere.

S4.5b Systematic Errors in Weather and Climate Models: Analysis and Solutions

Submission ID: 292
Presenting Author: Kevin Cheung*
Session Time: MONDAY 14:30-15:30

1

Simulated surface irradiance in the NARCliM regional downscaling: validation and future projection

CHEUNG Kevin[1]; JI Fei[2]; CHANG Lisa[3]*

1) Macquarie University; 2) Office of Environment and Heritage, NSW Department of Planning and Environment; 3) Office of Environment and Heritage, NSW Department of Planning and Environment

Estimated surface irradiance in the future climate has a lot of practical applications such as the solar energy industry and agriculture. In this study, the simulated surface irradiance during 1950-2009 in the NSW/ACT Regional Climate Modelling (NARCliM) project is evaluated. NARCliM consists of a carefully selected ensemble of models, which include the combination of four global climate models and three configurations of the Weather Research and Forecasting (WRF) regional model (termed R1, R2 and R3). Accurate simulation of surface irradiance mainly depends on that for cloud development and associated radiative processes. Generally, it is found that NARCliM simulations with 50-km horizontal resolution (the domain 1) overestimate irradiance across the Australian continent, especially during spring to summer. The winter simulation is within 10-20% from the observation.

Comparison among the R1-R3 experiments provides hints on the responsible physical processes of the overestimation. Experiments R1 and R2 apply the Kain-Fritsch and Bett-Miller-Janjic cumulus schemes respectively, and they have similar error patterns throughout the seasons. This implies that the differences in cloud development from these two schemes may not be the major factor in modulating the irradiance. On the other hand, experiment R3 applies the CAM radiation physics, which is different from the Dudhia/RRTM package applied in R1/R2. The fact of R3 possessing very different error patterns from R1/R2 suggests that radiation physics is the dominating factor on irradiance. Nevertheless, this dominance of radiation physics may be the result of the general lack of cloud feedbacks to radiation in many weather and climate models. Observations also show that there have been changes in the surface irradiance patterns from the 30-year average between 1950-1979 to the next 30-year average between 1980-2009. The NARCliM simulations roughly capture these changes in patterns but with underestimation of magnitude.

S4.5b Systematic Errors in Weather and Climate Models: Analysis and Solutions

Submission ID: 169
Presenting Author: Khalia Monk*
Session Time: MONDAY 14:30-15:30

2

Optimisation of WRF for regional air quality modelling in NSW

MONK Khalia[1]; SCORGIE Yvonne[2]; MURPHY Clare[3]*

1) University of Wollongong; 2) Office of Environment and Heritage; 3) University of Wollongong

Air pollution is considered to be one of the major environmental risks to human health (Lelieveld et al. 2015). To improve the air quality of a region it is important to have a comprehensive understanding of the composition of pollutants across the local air-shed both spatially and temporally. High quality monitoring networks, such as the one the Office of Environment and Heritage manage across the NSW greater metropolitan region, provide insight into both to real-time and historical air quality for this purpose. However monitoring networks alone are unable to provide spatially-resolved air quality information and projections of future air quality. Regional air quality models can provide this spatially varying information and allow testing of the sensitivity of the air quality to future management and mitigation strategies.

A crucial aspect of regional air quality modelling is the accurate characterisation of local meteorology, which significantly affects emissions of air pollutants, and the transport, chemical transformation and eventual removal of pollutants from the atmosphere. The Weather Research and Forecast model (WRF) is the latest generation mesoscale numerical weather prediction system and can be used to downscale the coarse global ERA-interim reanalysis data for use in regional air quality models. The use of this advanced meteorological model may further improve the ability to predict air quality impacts.

This study aims to optimise WRF for use in NSW regional air quality modelling, ensuring it can reproduce meteorological conditions which significantly influence air quality within the region. Such conditions include the onset and orientation of the sea breeze, drainage flows and peak temperatures. The performance of the model is evaluated for several physic scheme configurations, with the model applied over the Sydney basin down to 1km resolution, and model performance evaluated based on available observational data sets.

Reference:

Lelieveld, J., J. S. Evans, M. Fnais, D. Giannadaki and A. Pozzer (2015). "The contribution of outdoor air pollution sources to premature mortality on a global scale." Nature 525(7569): 367-371.

S4.5b Systematic Errors in Weather and Climate Models: Analysis and Solutions

Submission ID: 143
Presenting Author: Dipayan Choudhury*
Session Time: MONDAY 14:30-15:30

3

Sampling biases in CMIP5 decadal forecasts

CHOUDHURY Dipayan[*1]*

1) UNSW

Information from improved near-term climate predictions (from 1 year to several decades into the future) can help shape decisions for various societal applications, whilst adapting for regional climate change. Following this, several modelling groups have set up decadal retrospective forecast experiments as part of the Phase Five of the Coupled Model Intercomparison Project (CMIP5). Originally, the CMIP5 coordinated decadal predictability experiment involved a series of 10-year hindcasts, initialized every five years starting around 1960. However, recent studies on bias correction, amongst many others, have highlighted the need for additional start dates for a more reliable estimate of the skill of the CMIP5 decadal experiments, leading to annual initializations. This study aims to identify the differences in sea surface temperature (SST) prediction errors between experiments initialized every five years and those initialized every year. The effect of the drift correction method recommended by the CMIP-WGCM-WGSIP Decadal Climate Prediction Panel on the two sets of prediction experiments is also analysed. Our results show that the differences are noticeable for SST predictions over the tropical Pacific, especially for anomaly-initialized models, and less significant for global average SSTs. Considering multi-model ensemble means, the above drift correction leads to spurious trends over the Pacific in case of start dates every five years and negligible improvements compared to raw forecasts for start dates every year. The study also asserts the need to re-analyse any skill assessment over the tropical Pacific using the CMIP-WGCM-WGSIP drift correction method.

Submission ID: 322
Presenting Author: Simon Marsland*
Session Time: MONDAY 14:30-15:30

4

CMIP6: The Coupled Model Intercomparison Project - Phase 6

MARSLAND Simon[1]; HIRST Anthony[2]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere

The World Climate Research Programme Working Group on Coupled Modeling (WGCM) promotes coordination of global climate model experimentation to understand natural climate variability and predictability on decadal to centennial time scales, and predict climate system response to changes in natural and anthropogenic forcing. Since 1995 WGCM and the CMIP Panel have coordinated the Coupled Model Intercomparison Project (CMIP). Analysis of CMIP models underpins the projection of future climate assessed by the Intergovernmental Panel on Climate Change (IPCC), and is of intense scientific and societal interest.

For the IPCC Assessment Report 6 a new phase of model experimentation (CMIP6) is underway. The CMIP6 design focuses on three broad scientific questions: How does the Earth System respond to forcing? What are the origins and consequences of systematic model biases? How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios? The entry level for CMIP6 submission is 5 core experiments: the Atmospheric Model Intercomparison Project (1979-2014); a 500 year pre-industrial control simulation; a 1%/year compounding atmospheric CO_2 increase simulation; a century scale abrupt $4xCO_2$ simulation; and an historical simulation using atmospheric forcings for the period 1850-2014.

Modelling groups are also invited to contribute to a further 21 CMIP6 endorsed Model Intercomparison Projects (MIPs). The MIPs each focus on development and performance of components of the models (atmosphere, land, ocean, cryosphere, chemistry, biogeochemistry, etc.), and the climate system (carbon cycling, decadal predictability, radiative and volcanic forcing, cloud feedbacks, detection and attribution, etc.). A key MIP for future impacts assessment is the ScenarioMIP which focuses on projection of the full climate system under a range of possible future emission scenarios over the coming century. We give an overview of the current status of CMIP6.

Submission ID: 235
Presenting Author: Benjamin Moebis*
Session Time: MONDAY 16:00-17:00

1

The influence of the cloud radiative effect on the double ITCZ bias

MOEBIS Benjamin[1]; STEVENS Bjorn[2]*

1) Monash University; 2) Max Planck Institute for Meteorology

All state of the art global circulation models suffer from the double ITCZ model bias. This bias is one of the most longstanding model errors and it remains unsolved because we do not fully understand the mechanisms and feedbacks that cause the convective organization in the tropics.

Aqua-planet simulations with fixed SST are performed to analyze the convective organization on large scales. A heat and moisture budget analysis and correlations between cloud top height and free tropospheric humidity and thermal stability is used to analyze the convective organization. To test the influence of cloud radiative effects on the double ITCZ bias we either disable cloud-radiation interactions at certain levels in the atmosphere or we apply a prescribed cloud field as input to the radiative transfer calculation.

We show that the ITCZ behavior in the model is strongly influenced by cloud-radiation interactions. In particular, removing the effects of high-level clouds on radiation can lead to a transition from single a to a double ITCZ structure. This can be explained by the overall warming effect that cloud- radiation interactions exert on the active part of the Hadley circulation. This leads to an increased heating gradient between active and suppressed regions driving a stronger Hadley circulation, which in turn significantly affects the moisture distribution. We show that the potential counteracting effect of increased stability through cloud-radiation interaction is muted by the rapid redistribution of heat through gravity waves in the active regions of the Hadley circulation.

Given that upper-level clouds have such a strong influence on the first-order organization of the ITCZ, future research should focus on the link between cumulus convection and anvil properties in the tropics.

S4.5c Systematic Errors in Weather and Climate Models: Analysis and Solutions

Submission ID: 163
Presenting Author: Dietmar Dommenget*
Session Time: MONDAY 16:00-17:00

2

Common model biases reduce CMIP5's ability to simulate the recent Pacific La Niña-like cooling

LUO Jing-Jia[1]; DOMMENGET Dietmar[2]; WANG Gang[3]*

1) Bureau of Meteorology; 2) Monash University; 3) Monash University

Over the recent three decades sea surface temperate (SST) in the eastern equatorial Pacific has decreased, which helps reduce the rate of global warming. However, most CMIP5 model simulations with historical radiative forcing do not reproduce this Pacific La Niña-like cooling. Previous studies suggest that internal climate variations and errors in external radiative forcing may cause the discrepancy between the multi-model ensemble mean and the observation. We illustrate that common biases of current state-of-the-art climate models also contribute to this models-observation discrepancy. Our results reveal that underestimated inter-basin warming contrast across the tropical oceans, overestimated surface net heat flux and underestimated local SST-cloud negative feedback in the equatorial Pacific may favor an unrealistic El Niño-like warming in the models in response to external forcing.

Submission ID: 100
Presenting Author: Olivier Geoffroy*
Session Time: MONDAY 16:00-17:00

3

On the role of convective mixing and turbulence in cloud feedback

GEOFFROY Olivier[1]*

1) CCRC, UNSW

Tropical low clouds radiative feedback is still a leading source of uncertainty for climate change projections. This is a long standing problem, mainly due to the poor representation of subgrid scale processes in climate models and also due to the complex interactions between clouds and large scale circulation. Observational 'emergent constraints' that relate the cloud radiative feedback to some physical properties of the current climate are an important strategy to reduce the uncertainty in climate feedback. However physical processes underlying existing relationships need to be investigated in more detail. Recent studies have highlighted the important role of convective mixing. Here we confirm some common characteristic of the structure of the large scale in relation with the strength of cloud feedback, and show a broader picture of this structure by analysing both CMIP and AMIP simulations. With the use a low resolution climate model, we study how low-level mixing and boundary layer processes impact these features and how they relate to cloud feedback.

Submission ID: 136
Presenting Author: Debbie Hudson*
Session Time: WEDNESDAY 16:30-17:30

1

Forecasting upcoming extreme heat on sub-seasonal timescales

HUDSON Debbie[1]; MARSHALL Andrew[2]; ALVES Oscar[3]; YOUNG Griffith[4]; SHI Li[5]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology; 5) Bureau of Meteorology

There has been an increasing demand in Australia for sub-seasonal forecasts (i.e. beyond a weather forecast and shorter than a season) of extreme events, particularly from the agricultural community. Here we assess the capability of POAMA, the Australian Bureau of Meteorology's subseasonal-seasonal coupled model prediction system, to predict extreme heat and heatwaves over Australia and introduce a number of potential forecast products. We will show that there is significant potential to extend and augment traditional weather forecast warnings for extreme heat events to include guidance on sub-seasonal timescales.We have explored the relationship between sub-seasonal heat extremes and key climate drivers, namely the El Niño Southern Oscillation, Indian Ocean Dipole, Southern Annular Mode, Madden Julian Oscillation and atmospheric blocking, in both the model and observations, and have investigated the forecast skill of extreme heat events during different phases of these drivers using a large set of retrospective forecasts spanning 1981—2010. We will show that there are windows of forecast opportunity related to the state of these drivers, where the skill in predicting extremes over certain regions is increased. This skill is related to how well the model can both predict the driver and simulate the teleconnection between the driver and extreme heat.We have developed a number of trial products for forecasting extreme heat on sub-seasonal timescales (http://poama.bom.gov.au/). These products and the acquired scientific understanding are invaluable for realising the ultimate vision of operational forecasts of extreme heat for users.

Submission ID: 184
Presenting Author: Pandora Hope*
Session Time: WEDNESDAY 16:30-17:30

2

Sensitivity of Australian monthly maximum temperature to antecedent soil moisture

LIM Eun-Pa[1]; HOPE Pandora[2]; SHI Li[3]; HUDSON Debbie[4]; HENDON Harry[5]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology; 5) Bureau of Meteorology

The influence of antecedent soil moisture on subsequent temperature has been established across Australia (Zhang, 2004), but the strength of the association varies by season and region. This association is pertinent for understanding the intensity of heat extremes (Arblaster et al. 2014, Hope et al. 2015) and the influence of soil initialisation on sub-seasonal to seasonal forecast skill (Hirsch et al. 2014, Timbal et al. 2002). In this study we explore the influence of soil initial conditions on the variability of the Australian monthly mean maximum temperature (Tmax) and its impact on the predictive skill of Tmax over the period of 1981-2010. The first part of the study examines the spatial and regional dependence of Tmax on antecedent soil moisture using observations (AWAP). The second part examines the sensitivity of forecast skill for Australian Tmax on the land initial conditions using POAMA, the Bureau of Meteorology's dynamical subseasonal to seasonal climate forecast system. Two sets of 11 member ensemble hindcasts were generated over the period 1981-2010. The control hindcasts were initialised with observed ocean, atmosphere and land conditions on the 1st of each month, while the experimental hindcasts were initialised with the same conditions as the control except with climatological soil conditions. Preliminary results suggest that the influence of the antecedent soil moisture, after removing the influence of ENSO, the IOD and the SAM, explains about 10-40% of monthly Tmax variance in different months and regions in the 30 years of AWAP data. The comparison of the control and experimental hindcasts reveals that the POAMA system skilfully captures monthly spatial variations of the linkage between the antecedent soil moisture and Tmax, and up to 20% of the forecast skill of monthly Tmax stems from realistic soil initial conditions.

S4.6a Sub-Seasonal Variability and Prediction: Bridging the Weather-Climate Interface

Submission ID: 183
Presenting Author: Tess Parker*
Session Time: WEDNESDAY 16:30-17:30

3

Challenges in the prediction of droughts in the United Kingdom on monthly to seasonal timescales

PARKER Tess[1]; WOOLLINGS Tim[2]; WEISHEIMER Antje[3]*

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The current capability to produce skilful, reliable and useful meteorological forecasts of European climate on monthly to seasonal time scales is limited, in particular for precipitation. Increased model resolution and the development of new parameterisations have led to an improvement in the representation of some meteorological drivers of drought in climate models, such as ENSO teleconnections over Europe, anticyclonic blocking, North Atlantic weather regimes, and Northern Hemisphere stationary wave patterns.

Key to the development of skilful monthly to seasonal or longer forecasts is a deeper understanding of the meteorological drivers which may lead to enhanced predictability of drought events in the UK. Recently identified key drivers include North Atlantic sea surface temperatures, stratospheric-tropospheric interactions, and tropical-extratropical interactions such as the impact of the Madden-Julian Oscillation on the North Atlantic Oscillation. The contribution of these drivers to the evolution of individual drought events in the UK is not yet known.

Our research investigates one of the most severe multi-annual drought events in the UK from winter 2009/10 to winter 2011/12. An ensemble of models is used to investigate the sources of forecast error in the short-term prediction of drought. An analysis of blocking events as well as the sensitivity of blocking to atmospheric variables such as mid-tropospheric and stratospheric geopotential height is presented. The role of ENSO, the NAO, Rossby wave breaking, and tropical-extratropical interactions including the MJO and tropical storms will also be discussed

Submission ID: 151
Presenting Author: Eric Oliver*
Session Time: WEDNESDAY 16:30-17:30

4

A reconstruction of Madden—Julian Oscillation variability and global connections from 1905 to 2011

OLIVER Eric[1]; THOMPSON Keith[2]; KLOTZBACH Phillip[3]; JACQUES-COPER Martín[4]*

1) Institute for Marine and Antarctic Studies University of Tasmania; 2) Department of Oceanography Dalhousie University; 3) Department of Atmospheric Science Colorado State University; 4) Oeschger Center for Climate Change Research and Institute of Geography University of Bern

The most widely accepted characterization of the Madden—Julian oscillation (MJO) is the bivariate index developed by Wheeler and Hendon (Monthly Weather Review, 2004). This index relies in part on satellite-based observations of outgoing longwave radiation and thus is not defined for the presatellite era. The MJO is known to have a strong signature in surface pressure, and daily measurements of this variable are available as far back as the late nineteenth century. We present a statistical reconstruction of the Wheeler and Hendon MJO index from 1905 to 2011 based on tropical surface pressures estimated by the twentieth-century reanalysis project. The temporal and spectral properties of the reconstructed index are shown to be consistent with the Wheeler and Hendon index over the common period (1979—2008), as are known links with a number of atmospheric and oceanic variables. The long reconstructed index has been used to examine historical links between the MJO and surface winds and cloud cover over the ocean (1952-2008), extreme precipitation in Australia (1905-2008), Pacific sea levels (1905-2008), global tropical cyclone activity (1905-2011), wintertime air temperature in Alaska (1906-2010), and heatwaves in Patagonia (1957-2010).

Submission ID: 103
Presenting Author: Andrew Marshall*
Session Time: THURSDAY 09:45-10:30

1

On the role of anomalous ocean surface temperatures for promoting the record Madden-Julian Oscillation in March 2015

MARSHALL Andrew[1]; HENDON Harry[2]; WANG Guomin[3]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology

A Madden-Julian Oscillation (MJO) event exhibited record amplification at the beginning of March 2015 as the convective phase traversed an unusually warm central Pacific Ocean. Strong El Nino conditions in the eastern Pacific have subsequently developed through July 2015. This record amplification also resulted in record amplitude of the MJO based on index measurements since 1974. We explore the possible role of the anomalously high ocean surface temperatures in the equatorial central Pacific at the onset of El Niño 2015 for promoting the extraordinary amplification of this MJO event. We conduct a set of forecast sensitivity experiments with the Predictive Ocean Atmosphere Model for Australia and show that the enhanced growth of the MJO was promoted by amplification of the convective anomaly as it encountered the unusually warm central Pacific. Our results indicate a primary role for the anomalous SST at the onset of El Niño 2015 for promoting the intensification of the MJO, and thus support the hypothesis of a two-way interaction whereby initial SST anomalies at the onset of El Niño promote enhanced MJO activity which then leads to enhanced El Niño development.

S4.6b Sub-Seasonal Variability and Prediction: Bridging the Weather-Climate Interface

Submission ID: 348
Presenting Author: Harvey Stern*
Session Time: THURSDAY 09:45-10:30

2

Sub-seasonal variability and prediction: exploring the reliability of forecasts at the weather-climate interface

STERN Harvey[*1]*

1) University of Melbourne, School of Earth Sciences

Several years ago, Stern and Pollock (2011) completed an analysis of the accuracy of the Bureau of Meteorology's seasonal climate outlooks - subsequently updated (Stern and Pollock, 2013). About a year ago, Stern and Davidson (2015) completed an analysis of the accuracy of the accuracy of day-to-day weather forecasts, both official Bureau of Meteorology forecasts and experimental forecasts, out to Day-14. More recently, Stern and Davidson (2016) presented a study of the accuracy of the day-to-day predictions generated by the ECMWF control model out to Day-32. The purpose of the current work is to blend and, where appropriate, update, the aforementioned studies into an exploration of the reliability of forecasts at the weather-climate interface.

References:

Stern H and Pollock J (2011) Verifying the accuracy of two decades of seasonal climate outlooks. 5th International Verification Methods Workshop, 1 - 7 December 2011, Melbourne, Australia [Link: http://www.cawcr.gov.au/publications/technicalreports/CTR_046.pdf].

Stern H and Pollock J (2013) Verifying the accuracy of seasonal climate outlooks - an update. AMOS 19th National Conference, 11-13 February 2013, Melbourne, VIC. [Link: http://www.weather-climate.com/AMOSconf2013_648.pdf].

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Stern H and Davidson N E (2016) On the limits of predictability of day to day weather forecasts for Melbourne Australia. Special Symposium on Seamless Weather and Climate Prediction – Expectations and Limits of Multi-scale Predictability, New Orleans, LA, 10-14 Jan. 2016, Amer. Meteor. Soc. [Link: http://ams.confex.com/ams/96Annual/webprogram/Paper284192.html].

S4.7a Atmospheric Chemistry and Processes

Submission ID: 277
Presenting Author: Paul Krummel*
Session Time: WEDNESDAY 13:45-15:30

1

40 years of atmospheric composition observations and research at Cape Grim, Tasmania — an overview

KRUMMEL Paul[1]; KEYWOOD Melita[2]; FRASER Paul[3]; GALBALLY Ian[4]; STEELE Paul[5]; LAWSON Sarah[6]; VAN DER SCHOOT Marcel[7]; WILSON Stephen[8]; WILLIAMS Alastair[9]; CLELAND Sam[10]*

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In 2016, the Cape Grim station located at the north-west tip of Tasmania, will celebrate 40 years of continuous operation. Commencing operations in 1976, and in its current facilities since 1981, the Baseline Air Pollution Station at Cape Grim is Australia's contribution to international efforts for monitoring the global background atmosphere for trends due to human activities and natural variability. It is one of the three premier stations in the Global Atmosphere Watch (GAW) network of the World Meteorological Organization (WMO). Cape Grim observations thereby contribute very significantly to the GAW programme, and research outputs are published in peer-reviewed international journals of the highest quality, are very frequently cited, and feed into the international/global assessments, for example the IPCC.

Cape Grim's essential purpose has not changed since the program's inception in 1976. National and global concern that human activity is having an impact on the composition of the global (and regional) atmosphere requires that the changes be observed and understood. Initially, this was the main focus, whereas now the data are also used for prediction, to guide development of remedial policies, and to verify the effectiveness of global mitigation actions. The critical, but too often unrecognised role of precise in-situ atmospheric observation programs underpinning our current understanding of atmospheric processes and ability to model future climate, is well summarised in a commentary in Nature, titled "Cinderella science" (Nature 450, p789, 2007).

The Cape Grim station is operated and funded by the Aust. Bureau of Meteorology, with the Cape Grim Science Program jointly supervised by CSIRO, the Bureau of Met., Univ. of Wollongong and ANSTO. This presentation will give an overview of the past and present measurement programs at the station, show some of the iconic long-term datasets, and summarise some of the science highlights and impacts from the past 40 years.

Submission ID: 237
Presenting Author: Katrina Macsween*
Session Time: WEDNESDAY 13:45-15:30

2

Atmospheric Mercury in the Southern Hemisphere and the influence of climate change on mercury air-surface exchange

MACSWEEN Katrina[1]; EDWARDS Grant[2]; HOWARD Dean[3]; MILLLER Matthieu[4]*

1) Macquarie University; 2) Macquarie University; 3) Macquarie University; 4) Macquarie University

The recent UNEP Minamata Convention on Mercury, is a global treaty, signed by 128 countries, including Australia with the mission to protect human health and the environment from the adverse effects of mercury. Since 2011 Cape Grim station has undertaken continuous measurements of atmospheric levels of total gaseous mercury (TGM). As the atmosphere represents the dominant pathway for distribution of mercury globally the Cape Grim atmospheric mercury measurements will play an increasingly important role in the assessment of the impact of the Minimatta treaty. These measurements have already made a significant contribution to the understanding of background levels of TGM in the Southern Hemisphere where it is shown that these levels are significantly lower than previously thought. This finding has significant implications to global mercury modelling and inter-hemispheric transport of atmospheric mercury.

Human activities over the last few centuries has altered both the earth's climate system and added to the global mercury budget. Potential links between climate change and mercury emissions has not been adequately explored. This research aimed to investigate the relationship between climate controls and mercury air-surface exchange and determine the potential implications of these findings with future climate change scenarios. The results show that climate and environmental parameters were the dominate influence for substrate-flux relationships for both background and enriched sites. Based on the differences in in y-intercepts it was calculated that for a 4.4°C increase in temperature there is a 62% increase in flux, approximately 15% for every 1°C change in temperature.

Submission ID: 36
Presenting Author: Ruhi Humphries*
Session Time: WEDNESDAY 13:45-15:30

3

Atmospheric aerosol formation over East Antarctic sea ice — possible Hg catalysed nucleation?

HUMPHRIES Ruhi[*1]*

1) CSIRO Oceans and Atmosphere Business Unit

Aerosol observations above the Southern Ocean and Antarctic sea ice are scarce. Measurements of aerosols and atmospheric composition were made in East Antarctic pack ice on-board the Australian icebreaker Aurora Australis during the spring of 2012. One particle formation event was observed during the 32 days of observations. This event occurred on the only day to exhibit extended periods of global irradiance in excess of 600 W m^{-2}. Within the single air-mass influencing the measurements, number concentrations of particles larger than 3 nm (CN3) reached almost 7700 cm^{-3} within a few hours of clouds clearing, and grew at rates of 5.6 nm h^{-1}. Formation rates of 3 nm particles were in the range of those measured at other Antarctic locations at 0.2—1.1 ± 0.1 cm^{-3} s^{-1}. Our investigations into the nucleation chemistry found that there were insufficient precursor concentrations for known halogen or organic chemistry to explain the nucleation event. Modelling studies utilising known sulfuric acid nucleation schemes could not simultaneously reproduce both particle formation or growth rates. Surprising correlations with Total Gaseous Mercury (TGM) were found that, together with other data, suggest a mercury driven photochemical nucleation mechanism may be responsible for aerosol nucleation. Given the very low vapour pressures of the mercury species involved, this nucleation chemistry is likely only possible where pre-existing aerosol concentrations are low and both TGM concentrations and solar radiation levels are relatively high ($\sim$ 1.5 ng m^{-3} and $\geq$ 600 W m^{-2}, respectively), such as those observed in the Antarctic sea ice boundary layer in this study or in the global free-troposphere, particularly in the Northern Hemisphere.

S4.7a Atmospheric Chemistry and Processes

Submission ID: 274
Presenting Author: Paul Krummel*
Session Time: WEDNESDAY 13:45-15:30

4

The 2015 Antarctic ozone hole, comparison to historical ozone hole metrics and Equivalent Effective Stratospheric Chlorine (EESC)

KRUMMEL Paul[1]; FRASER Paul[2]; KLEKOCIUK Andrew[3]; TULLY Matt[4]; STEELE Paul[5]; DEREK Nada[6]; ETHERIDGE David[7]; TRUDINGER Cathy[8]*

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The 2015 ozone hole only started developing during the third week of August, which is the latest onset of the ozone hole that has been seen since the mid-to-late 1980s. However, record cold stratospheric temperatures and a very stable polar vortex have since seen the 2015 ozone hole become one of the biggest on record, at least in terms of its areal extent (3rd to 4th largest on record). Also, during October the ozone hole set new maximum area records for this time of year.

The development and recovery of the 2015 ozone hole will be shown via a set of metrics based on the Ozone Monitoring Instrument (OMI) on board the Earth Observing Satellite (EOS) Aura, and the OMPS (Ozone Mapping and Profiler Suite) instrument on the Suomi National Polar-orbiting Partnership satellite (Suomi NPP). Other observational results will be shown to complement these satellite data. The 2015 ozone hole metrics will be compared to the historical metrics, and these will be linearly regressed against Equivalent Effective Stratospheric Chlorine (EESC) data that are based entirely on Cape Grim Air Archive, Antarctic firn and AGAGE global measurements of ozone depleting substances (ODS). A brief overview of the EESC calculation method and the trace gas observational data used in the calculation will be given. The year-to-year variability of the ozone hole does not reflect variations in the level of ODSs in the Antarctic stratosphere, which, based on surface observations, have fallen approximately 10% since their peak around 2000, or have fallen by approximately 18% since their peak around 2000 relative to 1980 levels of ODSs. The decadal variations in the ozone hole do reflect the long-term changes of ODSs in the Antarctic stratosphere and the results shown here suggest that ozone hole recovery has commenced, despite the 2015 ozone hole being relatively large.

S4.7a Atmospheric Chemistry and Processes

Submission ID: 40
Presenting Author: Jae Kim*
Session Time: WEDNESDAY 13:45-15:30

5

Evaluation of ozone profile and tropospheric ozone retrievals from GEMS and OMI spectra

KIM Jae[*1]*

1) Busan National University

South Korea is planning to launch the GEMS instrument into the geostationary platform in 2018 to monitor tropospheric air pollutants on an hourly basis over East Asia. The main objective of this study is to evaluate ozone profiles and stratospheric column ozone amounts retrieved from simulated GEMS measurements. Ozone Monitoring Instrument (OMI), which have the spectral range 270—500 nm at spectral resolution of 0.42—0.63 nm, are used to simulate the GEMS radiances. An optimal estimation-based ozone profile algorithm is used to retrieve ozone profiles from simulated GEMS radiances. We compare the retrieval characteristics derived from OMI and GEMS wavelength ranges. This comparison shows that the effect of not using measurements below 300 nm on retrieval characteristics in the troposphere is insignificant. However, the stratospheric ozone information in terms of DFS decreases greatly from OMI to GEMS. The number of the independent pieces of information available from GEMS measurements is estimated to 3 on average in the stratosphere. The difference between OMI and GEMS retrieval characteristics is apparent for retrieving ozone layers above 20 km. We further investigate whether GEMS can resolve the stratospheric ozone variation observed from high vertical resolution EOS Microwave Limb Sounder (MLS). The differences in stratospheric ozone profiles between GEMS and MLS are comparable to those between OMI and MLS below 3 hPa (40 km). At pressure altitudes above 3 hPa, GEMS retrievals show strong influence of a priori and large differences with MLS. The GEMS-MLS differences show negative biases of less than 4% for stratospheric column ozone, while OMI retrievals show similar agreements with MLS. Based on the comparisons, we conclude that GEMS will measure tropospheric ozone and stratospheric ozone with accuracy comparable to that of OMI and ozone profiles with slightly worse performance than that of OMI below 3 hPa.

Submission ID: 258
Presenting Author: Kane Stone*
Session Time: WEDNESDAY 13:45-15:30

6

Revised Dobson Umkehr derived ozone time series from Australian observations

STONE Kane[1]; TULLY Matt[2]; RHODES Steve[3]; SCHOFIELD Robyn[4]*

1) University of Melbourne; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) University of Melbourne

The Dobson Umkehr measurement technique is designed specifically for retrievals of low-resolution ozone profiles, with the highest sensitivity to the stratosphere. This is achieved by measuring at a range of solar zenith angles, typically between 60 and 90 degrees, at a pair (or multiple pairs) of ultra-violet wavelengths.

Dobson Umkehr measurements at Australian sites range from the early 1960s to the present, with a large latitudinal range extending from Darwin (12.5˚S) to Macquarie Island (54.6˚S). Australian observational sites are important, as they not only contain long time series of data, they also lay inside the Southern Hemisphere: a data sparse region of the world. This marks the data as being especially important for trend analysis and model validation. The data are currently available in a post-processed form for algorithms that solely use designated solar zenith angles and a single wavelength pair. However, this is typically a subset of available operational measurements.

Here, we present retrievals of recently digitised measurements from Australian sites. This allows the use of all operational measurements (all solar zenith angles and wavelength pairs) in a newly developed algorithm designed for trend analysis and resolution. We highlight the advantages of using all operational measurements and show newly retrieved time series for Melbourne (1964-1994), Hobart (1967-1992), Macquarie Island (1963-1993), Perth (1969-present), Brisbane (1962-present) and Darwin (1966-1974; 1990-present).

Submission ID: 337
Presenting Author: Steven Utembe*
Session Time: WEDNESDAY 16:30-17:30

1

Simulating Air Pollution in the Latrobe Valley using WRFChem

UTEMBE Steven[1]; SILVER Jeremy[2]; RAYNER Peter[3]*

1) Melbourne University; 2) Melbourne University; 3) Melbourne University

The Latrobe Valley is home to some of Australia's biggest point sources of particulate and gaseous pollutants, with four of Australia's top coal-fired power stations situated in the area. A recent analysis of data from Australia's National Pollutant Inventory (NPI) revealed a 52% increase in PM2.5 emissions from the coal industry in the past five years, compared to an increase of just 14% across all industries in general (EJA, 2015).

Using 2009 and 2014 emissions data from the NPI as input into a regional chemical transport model, the Weather Research and Forecasting Chemistry Model (WRF-Chem, Grell et al, 2005), we will simulate particulate and gaseous concentrations (PM2.5, PM10, O3, NOx, CO and SO2) across a number of sites in the Latrobe Valley and compare the results with observations where available. We will examine pollutant trends across the past 5 years and make some inferences about future concentrations by examining a number of possible future scenarios.

References:

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Submission ID: 159
Presenting Author: Melita Keywood*
Session Time: WEDNESDAY 16:30-17:30

2

Dioxin and furan levels in Australian tropical, marine and urban air

KEYWOOD Melita[1]; POWELL Jennifer[2]; GRAS John[3]; MULLER Johcen[4]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) CSIRO Oceans and Atmosphere; 4) University of Queensland

In 2001 the Australian Government established a National Dioxins Program to understand sources and levels of dioxins, furans and dioxin-like PCBs in the Australian environment. The program included measurement of monthly levels of dioxins and furans in ambient air at a number of sites from 2002 to 2003. Monthly measurements of ambient levels were repeated at a subset of sites as part of a pilot monitoring program to measure persistent organic pollutants in ambient air across Australia from 2011 to 2014. The monitoring program aims to assess the effectiveness of the Stockholm Convention in reducing environmental levels of Persistent Organic Pollutants, by assessing trends in levels in two core media: the atmosphere and humans. We present an analysis of trends in dioxin and furan level in tropical, marine and urban air between 2002/03 and 2012/13.

Submission ID: 76
Presenting Author: Cacilia Ewenz*
Session Time: WEDNESDAY 16:30-17:30

3

Methane and ammonia emissions from feedlots measured using a novel airborne approach

HACKER Jorg[1]; EWENZ Cacilia[2]; LIEFF Wolfgang[3]; NEININGER Bruno[4]; CHEN Deli[5]*

1) AIrborne Research Australia / Flinders University; 2) AIrborne Research Australia / Flinders University; 3) AIrborne Research Australia / Flinders University; 4) ZHAW (Zurich University of Applied Sciences), Switzerland / Metair AG, Switzerland; 5) Faculty of Veterinary and Agricultural Sciences , The University of Melbourne, Victoria, Australia

Agriculture and here especially livestock production is a major source for greenhouse gas emissions. Methane and ammonia emitted from agricultural land are two of the more potent greenhouse gases. The knowledge of their spatial and temporal distribution and concentration is therefore important. Current point measurements, e.g. utilizing flux towers generally lack the information about the individual source, the spatial distribution of the emission over the whole feedlot and emission changes with distance from the source.

The latest technology in concentration measurements of methane and ammonia using Aerodyne Quantum Cascade Laser (QCL) gas analysers and high resolution meteorology measurements integrated into a low and slow flying aircraft was utilised over a feedlot near Charlton in Victoria. The feedlot included cattle pens with around 17,000 cattle at the time of the project.

Various flight pattern were chosen depending on the meteorological conditions like wind speed and direction, which affect the transport of the respective gases. Horizontal transects through the plumes at various heights as well as across the plumes exhibited a clear picture of the overall concentration and distribution of the emitted greenhouse gases. The airborne measurements allowed partitioning of the emissions to individual rows of the feedlot.

Elevated methane levels could be measured close to the source of over 200 ppb above the transect average of about 1700 ppb. Signal to noise ratios were approximately 8 ppb well in the range of ground based measurements. The plume was still visible 25km downwind. Ammonia measurements utilising a similar flight strategy yielded a total flux of $46gs^{-1}$ for the whole feedlot. Individual sources were displayed in transects across the feedlot. The spatial distribution of the gases can be interpreted as effects of the plumes through transport due to horizontal and vertical mixing.

Elevated methane levels were also found which could not be identified as a result of the feedlot but were later found to be from small numbers of cattle in an adjacent paddock. While the study here was concerned with the emissions of a closed feedlot, the latter result displays the ability of the method to estimate greenhouse gas emissions from open grazing with much smaller cattle numbers.

Submission ID: 178
Presenting Author: Jeremy Silver*
Session Time: WEDNESDAY 16:30-17:30

4

Emissions of airborne ryegrass pollen in South Eastern Australia

SILVER Jeremy[1]; RAYNER Peter[2]; NEWBIGIN Ed[3]; DAVIES Janet[4]*

1) University of Melbourne; 2) University of Melbourne; 3) University of Melbourne; 4) Queensland University of Technology

Allergic rhinitis (hay-fever) affects roughly one in six Australians (ABS, 2010), and is an upper airway allergic response to airborne allergens (e.g. pollen, dust, mould spores). Grass pollen is believed to be the most widespread outdoor aeroallergen in Australia (AIHW, 2011), and in South Eastern Australia much of the allergenic burden is attributed to pollen from rye grass (Lolium sp.; Schäppi et al, 1998), a common pasture grass for grazing livestock.

To characterise population exposure, we are developing a modelling framework to simulate emissions and transport of airborne pollen. We have customised a version of the CMAQ Modelling System (Binkowski & Roselle, 2003), a limited-area chemistry-transport model developed by the US EPA. The gas-phase and particulate-phase schemes were replaced by a single particulate type (rye-grass pollen). Emissions are parameterised as a function of land-use, rainfall, growing day, wind speed, humidity, vertical uplift and time of day. Meteorological drivers are produced by the WRF Model (Skamarock et al, 2005).

We compare two simulations from two versions of the emissions module. The first emissions scheme follows other studies, and is based on the product of three terms, respectively representing land-use, flowering and instantaneous-release (e.g. Zhang et al. 2014). The second emissions scheme builds on concepts of availability, production and loss. NWP and transport simulations were run for a Victorian domain, and results are compared with pollen observations from the Melbourne Pollen Count (School of Biosciences, University of Melbourne).

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Submission ID: 304
Presenting Author: Ron Hoeke*
Session Time: THURSDAY 13:45-15:45

1

Impacts of wave energy conversion devices on local wave climate: the AWavEA project

HOEKE Ron[1]; HEMER Mark[2]; CONTARDO Stephanie[3]; SYMONDS Graham[4]; MCINNES Kathleen[5]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) CSIRO Oceans and Atmosphere; 4) CSIRO Oceans and Atmosphere; 5) CSIRO Oceans and Atmosphere

Wave energy is a largely untapped renewable energy resource, despite having arguably the highest energy density among all renewable energies. Unlike wind and solar, wave energy conversion technology is still in its infancy and very little is known about how this technology may impact local wave climate and subsequently affect neighbouring coastal environments, e.g. altering sediment transport, causing shoreline erosion or accretion. In this study, a network of in-situ wave measurement devices have been deployed surrounding the 3 wave energy converters of the Carnegie Wave Energy Limited's Perth Wave Energy Project. This data is being used to develop, calibrate and validate numerical simulations of the project site. Early stage results will be presented and potential simulation strategies for scaling-up the findings to larger arrays of wave energy converters will be discussed. The intended project outcomes are to establish zones of impact defined in terms of changes in local wave energy spectra and to initiate best practice guidelines for the establishment of wave energy conversion sites.

Submission ID: 90
Presenter: Ron Hoeke
Session Time: THURSDAY 13:45-15:45

2

Building a pre-competitive knowledge base to support Australia's wave energy industry

HEMER Mark[1]

1) CSIRO Oceans and Atmosphere

Ocean wave energy provides an abundant resource which could contribute to Australia's future energy mix in a low-carbon world. Several companies, national and international, are looking to exploit this resource. However, there remain considerable knowledge gaps which must be addressed to best support this emerging industry.

To provide the best representation of wave energy resource information, accounting for both spatial and temporal characteristics of the resource, a 34+yr numerical hindcast of wave conditions in the Australian region has been developed. Considerable in situ and remotely sensed data have been collected to support calibration and validation of the hindcast, resulting in a high-quality characterisation of the available wave resource in the Australian domain. Planning for wave energy projects is also subject to other spatial constraints. Spatial information on alternative uses of the marine domain including, for example, fisheries and aquaculture, oil and gas, shipping, navigation and ports, marine parks and reserves, sub-sea cables and infrastructure, shipwrecks and sites of cultural significance, have been compiled to complement the spatial characterisation of resource and support spatial planning of future wave energy projects. Both resource and spatial constraint information are being disseminated via a state-of-the-art portal, designed to meet the needs of all industry stakeholders.

Another aspect currently impeding the industry in Australia is the limited evidence-base of impacts of wave energy extraction on adjacent marine and coastal environments. To build this evidence base, a network of in situ wave measurement devices have been deployed surrounding the 3 wave energy converters of Carnegie Wave Energy Limited's Perth Wave Energy Project. This data is being used to calibrate and validate numerical simulations of the project site. Early stage results will be presented.

S4.8 Renewable Energy and Weather Interactions

Submission ID: 23
Presenting Author: David Batten*
Session Time: THURSDAY 13:45-15:45

3

Bioenergy and biofuels: some climate-related issues

BATTEN David[*1]

1) CSIRO

At the global scale, the economic sectors of energy and transportation are responsible for approximately 40% of all greenhouse gas emissions. Consequently, sources of renewable energy like bioenergy — energy produced from biomass for heat, power and liquid fuels — are the subject of considerable interest and research activity worldwide. Key drivers for bioenergy include: (a) reduction of CO2 emissions by the substitution of bioenergy for fossil energy and fossil fuels; (b) security of energy supplies; and (c) regional development and employment. However, climatic variability resulting from flooding, droughts, and fluctuations in the timing of water availability can have a significant impact on biomass production. To examine the potential impact climatic variability could have on bioenergy derived from biomass, Eaves and Eaves (2007) used historical data to estimate the supply risk of ethanol relative to imported petroleum. By fitting distributions to both annual corn yields and yearly oil imports, they found that variations of oil imports were less than half those of annual corn yields. In other words, corn production was more volatile than oil imports. Most of this increased volatility of corn and ethanol production could be attributed to their dependency on climate. Based on these results, they concluded that displacing gasoline with a first generation biofuel such as ethanol may simply be exchanging geo-political risk with yield risks. We know very little about how climate change will affect the productivity of biomass used for the production of bioenergy and, in turn, how the large-scale production of bioenergy may impact on our climate. Such climate-related impacts must be identified and then incorporated into decisions related to bioenergy production. This paper will focus on the key components of this important feedback loop: (1) How our changing climate might impact on the production of bioenergy (including 2nd and 3rd generation biofuels) (2) In turn, how the widespread production of bioenergy might be expected to affect our climate?

S4.8 Renewable Energy and Weather Interactions

Submission ID: 81
Presenting Author: Pieter de Jong*
Session Time: THURSDAY 13:45-15:45

4

Can wind power supply 75% of the Brazilian Northeast's electricity?

DE JONG Pieter[*1]*

1) Federal University of Bahia

Wind power in the Brazilian Northeast (NE) is expected to contribute 55% of the NE subsystem's electricity supply by 2020. If wind power penetration increase above 65%, it is estimated that the net energy that could be utilised by the NE subsystem would begin to be limited due to diurnal and seasonal wind variability, because higher wind penetrations would result in wind energy curtailment or necessitate exportation to other Brazilian regions (de Jong et al, 2015). The aim of this study is to simulate the NE's net load curve based on the planned rollout of wind farms at various locations in the NE and compare it with the optimal installed capacities at these wind farm locations which would maximise wind penetration. This study uses the Weather Research and Forecasting (WRF) Model to simulate wind speeds across the entire NE region of Brazil. Using a standard power curve for typical wind turbines used in the region, the hourly wind generation is calculated at several locations for all of 2014 and is compared to the observed output data at number of existing wind farms. The correlation of both measured and simulated wind power from wind farms which are substantial geographically spaced is also examined.

Using wind power data derived from the WRF wind speed data, the aggregate hourly wind power and net load for the NE subsystem is calculated based on planned wind farm deployment until 2020. In a second and third scenario it is assumed that the installed wind power capacities at all wind farm locations are entirely flexible. For the second scenario wind power capacities are optimised in order to achieve the maximum wind energy penetration in the NE subsystem with least curtailment. In the third scenario the wind power capacities are optimised to achieve least cost of electricity generation.

Reference:

de Jong P, Kiperstok A, Sánchez A S, Dargaville R, Torres E A. Integrating Large Scale Wind Power into the Electricity Grid in the Northeast of Brazil. Energy 2015; accepted.

Submission ID: 110
Presenting Author: Abhnil Prasad*
Session Time: THURSDAY 13:45-15:45

5

Spatio-temporal synergy between solar and wind energy resources in Australia

PRASAD Abhnil[1]; KAY Merlinde[2]*

1) Climate Change Research Centre University of New South Wales; 2) School of Photovoltaic and Renewable Energy Engineering University of New South Wales

Australia's growing renewable energy industry aims to meet local electricity demands while reducing the dependence on fossil fuels. Solar and wind energy are the two most viable sources of renewable energy resources available. Optimizing both of these resources for the generation of power is crucial. Hybrid solar-wind power generation systems can boost energy production if greater complementary characteristics exist at potential sites. This study uses reduced hourly time averaged diagnostic fields from Modern Era Retrospective Analysis for Research and Applications (MERRA) reanalysis data over Australia from 1979-2014. The boundary layer flux data has been used to construct wind profile at 80 m turbine hub heights. The Wind Power Density (WPD) and surface incident shortwave flux (also available from MERRA surface flux data) were used to assess the feasibility of wind and solar energy, respectively. The complementary characteristics of solar and wind energy were investigated temporally at hourly and daily scales. Hourly anti-correlations in solar and wind energy were significant in northern Australia during morning, central Australia at noon and western Australia in the afternoon. Regions near the eastern, western and southwestern coast dominate the frequency of daily anti-correlations. Further assessment of the complementary characteristics of usable wind (WPD >240 Wm^{-2}) and solar (GHI >0 Wm^{-2}) energy showed potential locations of hybrid wind-solar power generating systems. Wind complemented solar along the western and southern coast, whereas solar complemented wind along the eastern and northern coast. Overall, the synergy between solar and wind energy in Australia is within 30-60% of all days within the period of 1979-2014. The spatio-temporal complementary characteristics of solar and wind energy will also be shown over Australia.

Submission ID: 335
Presenting Author: Surya Karthik Mukkavilli*
Session Time: THURSDAY 13:45-15:45

6

Investigating aerosol climatological biases in solar energy forecasts & towards improved spatiotemporal dust aerosol representations in WRF

MUKKAVILLI Surya Karthik[1]; KAY Merlinde[2]; TAYLOR Robert[3]*

1) University of New South Wales + Commonwealth Scientific & Industrial Research Organisation; 2) UNSW; 3) UNSW

The Lake Eyre basin is the largest source of airborne dust in the Southern Hemisphere. However, despite the magnitude and frequency of dust storms in Australia, uncertainties in numerical weather prediction models remain high over this region for direct normal irradiance predictions. This work characterises the bias metrics from solar forecast simulations over the Australasia Coordinated Regional Climate Downscaling Experiment (CORDEX) domain with the US National Center for Atmospheric Research's (NCAR) mesoscale Weather Research and Forecast (WRF) model. All the shortwave radiative schemes for direct, diffuse and global horizontal irradiance have been analysed in WRF-ARW v3.6 along with a detailed analysis of the Thompson aerosol-aware microphysics scheme in different modes. In particular, this work focuses on extending the current capabilities of the Thompson aerosol-aware microphysics scheme within the solar forecasting context over Australasia CORDEX. The case study of the 2009 Australian dust storm will be used to demonstrate the research and latest developments to reduce the spatiotemporal aerosol uncertainty in WRF with reanalysis sources such as MACC and direct ground observation assimilations from AERONET.

S4.8 Renewable Energy and Weather Interactions

Submission ID: 1
Presenting Author: Roger Dargaville*
Session Time: THURSDAY 13:45-15:45

7

Impact of heatwaves on electricity demand in eastern Australia

*DARGAVILLE Roger**[1]

1) Melbourne Energy Institute, University of Melbourne

It is well known that hot days drive an increase in demand for electricity primarily to run air conditioners to cool homes, offices, shopping centres and industrial locations amongst others. It is less well understood how the demand for electricity varies over the duration of a heatwave. It is commonly assumed that demand increases over the duration of a heatwave, however, a detailed analysis of heatwaves and electricity demand data from the Australian Energy Market Operator suggests that the trend is difficult to detect. One reason is that as well as the temperature effect there is also a diurnal and weekly cycle on electricity demand which often obfuscates the temperature affect.

We have developed a model of electricity demand based on time of day, day of week and temperature and demonstrate that using the instantaneous temperature gives a similar result in simulating demand compared to a more sophisticated measure of effective temperature taking into account overnight lows and previous days maximum temperatures. This suggests that a bulk of the building stock in Australia is poorly insulated and that the demand for air conditioning for a very hot day is independent of whether the hot day occurs as part of a heatwave or not. Also, it demonstrates that the scope for reducing demand for electricity for cooling could be dramatically reduced if better insulation was used as well as other building techniques for improved efficiency.

Submission ID: 242
Presenting Author: Lawrie Rikus*
Session Time: THURSDAY 13:45-15:45

8

A validation of operational NWP forecasts of global, diffuse and direct solar exposure over Australia

RIKUS Lawrie[1]; GREGORY Paul[2]; SUN Zhian[3]; GLOWACKI Tomas[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology

The Bureau of Meteorology's comprehensive set of operational numerical weather prediction (NWP) suite uses the ACCESS system based on the UK Meteorological Office's Unified Model. The suite includes a number of mesoscale models producing twice-daily hourly forecasts over the Australian region. The Australian region 12 km system (ACCESS-R) is the largest of these and uses a 4DVAR assimilation scheme to produce initial conditions for forecasts out to 3 days. Higher resolution city-domain models (ACCESS-C) nested in ACCESS-R provide forecasts out to 36 hours. The models use the same two-stream radiative transfer parameterization which explicitly calculates direct and global solar exposure with the diffuse component determined as the difference between them. The large scale cloud parametrization is a prognostic mixed phase microphysics scheme with a diagnostic ice cloud fraction and the convection parameterization is a massflux based scheme. Aerosols are climatological.

Forecast hourly global, direct and diffuse solar exposure fields from ACCESS-R have been validated against eight high quality measurement sites for the entire 2012 calendar year. Cloud data including cloud amount, cloud type and cloud height recorded at most of the measurement sites by Bureau observers were used to validate relevant aspects of the model's cloud fields. The results show an improvement in global solar radiation forecasts compared to previously published results for the pre-ACCESS system model but forecasts of diffuse and direct exposure still suffer from large biases.

Forecasts from 4 km and 1.5 km resolution ACCESS-C models have been compared with the ACCESS-R results for 2 months. The comparisons provide some insight into the sensitivity to both model resolution and details of the radiative transfer scheme. The 1.5 km models are convection permitting, i.e. they do not have parameterized convection and so provide insight into the role of the parameterized convection in the coarser models.

Submission ID: 224
Presenting Author: Yimin Ma*
Session Time: TUESDAY 16:30-17:30

1

Subgrid orography effect on near surface wind forecasts. Improvements of the predictions with the revised parameterisation in the Bureau's regional operational NWP model

MA Yimin[*1]

1) Bureau of Meteorology

Complex terrain is contained within single grids of global and regional NWP model. This subgrid orography exerts extra drag on the above atmospheric flows in addition to the drag from land surface properties. The subgrid orography effect is not solvable by the governing equations on the grid points for the mean flows in the NWP model, yet has notable influence on the flow over the mountainous regions as well as on their surrounding areas. Parameterisation of the effect in the NWP model remains elusive.

In the UM model the parameterisation scheme is based on neutral atmospheric conditions. We further revise the scheme with stability corrections. With adequate tests using the Bureau's operational regional model, ACCESS-R, we demonstrate that the revised scheme enhances the model performance by improving the near surface wind predictions in terms of both its strength and direction.

Submission ID: 70
Presenting Author: Cacilia Ewenz*
Session Time: TUESDAY 16:30-17:30

2

Meteorological conditions during the Tropical Air-Sea Propagation Study (TAPS)

EWENZ Cacilia[1]; HACKER Jorg[2]; KULESSA Andrew[3]*

1) AIrborne Research Australia / Flinders University; 2) AIrborne Research Australia / Flinders University; 3) AIrborne Research Australia / Flinders University

The Tropical Air-Sea Propagation Study (TAPS) which took place near Lucinda, Queensland during Nov-Dec 2013, concerned the application of numerical weather prediction (NWP) models and radio-wave propagation models to forecasting radio signal coverage in the tropical littoral maritime environment for clear-air conditions. During the study emphasis was placed on obtaining a detailed meteorological data set of the coastal and marine atmospheric boundary layer (MABL). This was achieved by coordinated measurements using a small research aircraft, radiosondes, flux towers and a kitesonde. In the first instance, the data has been applied to the investigation of different turbulence characterisations as well the evaluation of fixed tower and aircraft based turbulent fluxes.

The MABL measurements provided a clear picture of the conditions close to the sea surface. The weather patterns near the jetty exhibited light prevailing, mainly offshore winds. Sea surface temperatures were high with about 29°C at Lucinda jetty. Humidity was very high for the first part of the study and land/sea breeze circulation was evident. During the experiment two large scale transitions to higher pressure occurred, resulting in sustained easterlies and suppressing sea breeze development. High pressure conditions additionally lead to capping inversions above the MABL.

The performance of four NWP models is currently being investigated and results so far show that the synoptic evolution has been captured well by all the models. A detailed investigation of the marine surface layer is also underway and profiles of atmospheric quantities derived from tower flux measurements have been compared to aircraft measurements for different separation distances. The results lend support for the use of Monin-Obukhov similarity theory and also provide insight into the required grid resolutions for NWP models in coastal tropical environments.

Submission ID: 339
Presenting Author: Hamish McGowan*
Session Time: TUESDAY 16:30-17:30

3

Radiation and Energy Flux Transfers under Monsoon conditions over Heron Reef, Southern Great Barrier Reef, Australia

MCGOWAN Hamish[*1]; MACKELLAR Mellissa[2]*

1) Climate Research Group The University of Queensland; 2) Climate Research Group The University of Queensland

Coral reefs cover approximately 2.8 to 6.0 x 105 km^2 of the Earth's tropical and sub-tropical oceans and support the livelihoods of > 500 million people. Their lower thermal capacity compared to the open ocean means that they are subject to more rapid and greater heating (cooling) and higher (lower) sea surface temperatures (SST) than adjacent oceanic sites. Differences in surface roughness and albedo over coral reefs due to modification of waves by the reef rim, shallow waters and underlying benthos affect radiation transfers and exchanges of heat, moisture and trace gases across their air-sea interface. Accordingly, the meteorology of coral reefs is distinct from the adjacent ocean.

In this paper we present results from the measurement of radiation and energy flux exchanges using the eddy covariance method over Heron Reef, a 27 km^2 lagoonal platform reef on the Southern Great Barrier Reef under monsoon conditions. Eddy covariance systems were mounted on pontoons and anchored over the reef ensuring a constant measurement height of 2.2 m above the water surface. Results show mean daily latent heat flux over the reef flat ranged from 52 to 77% of net radiation, while sensible heat flux ranged from 4 to 12% of net radiation with remaining energy going into heating of the reef and overlying water. By comparison, over the deep lagoon, the sum of convective fluxes exceeded mean daily net radiation resulting in a net cooling of the water. The drag coefficient across Heron Reef ranged from 1.5 x 10^{-3} to 2.3 x 10^{-3}. These results highlight the spatial variability in energy exchanges across coral reefs and their very different energy balance compared to the open ocean.

S5.2 Surface-Atmosphere Energetics Through Direct Observation

Submission ID: 280
Presenting Author: Michael Gray*
Session Time: TUESDAY 16:30-17:30

4

Observations of surface-atmosphere energetics over contrasting vegetation types on a sub-tropical sand island

GRAY Michael[1]; MCGOWAN Hamish[2]*

1) University of Queensland; 2) University of Queensland

Subtropical sand islands have received little attention in regards to the measurement of surface-atmosphere exchanges of heat, moisture, and radiation. The eddy covariance method was used to monitor surface-atmosphere energetics over three significant, contrasting, groundwater dependent vegetation types (melaleuca wetland, swamp, pine plantation) on Bribie Island in Southeast Queensland from June 2013 to March 2015.

On a seasonal basis, all three vegetation types showed a similar albedo of 0.11, however, differed in their emission of longwave radiation, with the smaller-sized vegetation in the periodically flooded swamp showing the highest daily maximum values in spring and summer, peaking at 480 Wm^2 and 500 Wm^2 respectively. Daytime emission of longwave radiation was similar for all sites in autumn and winter but at night the swamp had lower minimum values for all seasons (360-415 Wm^2) except for spring when the swamp and melaleuca wetland were similar (daily minimum of approximately 376 Wm^2). The pine plantation had the highest daily minimum value of outgoing longwave radiation (400 Wm^2).

Latent heat flux was largest in the melaleuca wetland in all seasons, ranging between daily maximum values of 140 Wm^2 in winter and 208 Wm^2 in summer. Sensible heat flux was similar for the melaleuca wetland and pine plantation, reaching maximum daily values ranging between approximately 170 Wm^2 in winter and 330 Wm^2 in spring. The swamp was considerably less than the other sites, with daily maximum values between a minimum of 110 Wm^2 in winter and 207 Wm^2 in spring.

When considered on a landscape wide scale, these surface-atmosphere energetics are likely to significantly influence the characteristics of the atmospheric boundary layer, but the extent to which this occurs is as yet unknown. Future work will use these data to initialise the Weather Research and Forecasting (WRF) model and allow an examination of the effect of surface energetics on the local atmosphere.

S5.3a The Land Surface: Processes and Their Interactions with the Atmosphere from Minutes to Millennium

Submission ID: 199
Presenting Author: Ian Harman*
Session Time: TUESDAY 09:45-10:30

1

Edges Matter! A wind tunnel study of the boundary layer and surface exchange over a patchwork landscape

HARMAN Ian[1]; BOHM Margi[2]; POETTE Christopher[3]; FINNIGAN John[4]; GARDINER Barry[5]; HUGHES Dale[6]*

1) CSIRO Oceans and Atmosphere; 2) ANU Research School of Biology; 3) INRA-EPHYSE; 4) CSIRO Oceans and Atmosphere; 5) INRA-EPHYSE; 6) CSIRO Oceans and Atmosphere

The land surface is heterogeneous on many scales - both naturally and through management. This heterogeneity is imprinted onto the atmosphere via surface exchange processes. Thus, Land Surface Models (LSMs) need to represent heterogeneity in land surface characteristics and exchange processes but need to do so at a complexity appropriate to the scales of interest. The current dominant approach in the LSMs within numerical weather prediction and Earth System models is to 'tile' the surface. The land surface is represented as a set of ‘tiles’, each with differing characteristics. The coupling between each of the tiles and the atmosphere is assumed to be in equilibrium (i.e. as if the surface were uniform) and the surface forcing of the atmosphere is then the area-weighted average of the fluxes from the tiles.

In this study we will consider the performance of the tiling methodology through controlled wind tunnel experimentation. Specifically we assess the impact of changes in surface heterogeneity on the area-averaged exchange of momentum and whether this is correctly captured by tiling. We have conducted experiments into the flow and turbulence over 7 canonical surfaces — from uniformly low roughness (grass) to uniformly high roughness (forest) surfaces through five regularly repeating combinations of the two surface types. We illustrate that the total exchange from the patchwork surface comprises three terms; one term is specific to a fragmented landscape and all terms vary significantly with the specific surface configuration. Through theoretical insights, we illustrate how each of the terms depends on the (local) surface characteristics and hence place conditions around when the tiling method can be expected to provide a quantitatively accurate approximation to the actual area-averaged surface exchanges.

Finally, we will outline how these concepts apply to scalar exchange in heterogeneous landscapes and the representation of surface heterogeneity within LSMs.

Submission ID: 204
Presenting Author: Ian Harman*
Session Time: TUESDAY 09:45-10:30

2

Canopy-boundary layer coupling in convectively unstable flows: a tale of interacting instabilities

FINNIGAN John[1]; PATTON Edward[2]; SHAW Roger[3]; HARMAN Ian[4]*

1) CSIRO Oceans and Atmosphere; 2) NCAR-MMM; 3) University of California - Davis; 4) CSIRO Oceans and Atmosphere

The turbulence that couples the flow within and above tall canopies in neutrally stratified conditions predominantly results from a hydrodynamic instability of the inflected mean velocity profile that develops at canopy top. Through a cascade of secondary instabilities, coherent eddies of a characteristic form emerge which are responsible for the majority of the turbulent kinetic energy and transport in the canopy's vicinity.

Above the surface layer, in neutral and weakly unstable flows, large-scale roll-like structures dominate transport through the atmospheric boundary layer (ABL). When buoyant forces become dominant, the rolls transition into Rayleigh-Bernard-like cells spanning the depth of the convectively driven ABL. These modes of motion modulate the near-surface wind and temperature so the surface is alternately subjected to enhanced or reduced wind shear.

We have studied this situation using canopy-resolving large eddy simulation of the full ABL, alongside idealised studies of the instability processes occurring at canopy scale. We show that beneath the strong-shear regions of the ABL-scale structures, the eddies coupling the within and above canopy airspace correspond to those of the inflection point instability. However in regions of low shear, diabatic effects dominate and convective plumes develop. This previously unrecognised means of canopy-atmosphere coupling is the result of a mode of buoyant instability.

The horizontally-averaged transfer of heat and momentum between the canopy and ABL therefore results from two distinct types of coherent eddy, as set by the position relative to the ABL eddies. As the structure of the ABL eddies depends upon the area-averaged heat and momentum transfer from the surface, the three modes of instability are intimately coupled.Finally, we discuss the implications of this fully coupled picture of canopy-ABL turbulent exchange for Land Surface Models and tower-based observational methodologies of turbulent fluxes.

S5.3a The Land Surface: Processes and Their Interactions with the Atmosphere from Minutes to Millennium

Submission ID: 313
Presenting Author: Ned Haughton*
Session Time: TUESDAY 09:45-10:30

3

Empirical Ubermodel: Estimating the maximum information available in met forcings

HAUGHTON Ned[*1]*

1) Climate Change Research Centre

The PLUMBER experiment (Best et al. 2015) showed that a broad cross-section cross-section of Land Surface Models (LSMs) are performing poorly relative to very simplistic benchmark empirical models. A number of hypotheses have been put forward for this poor performance; however, follow-up analysis (Haughton et al. in review) has found none of these provide a satisfactory explanation. Part of the difficulty with analysing this problem is that we have no a priori expectation of how well LSMs should perform. This research attempts to quantify how much information is available in the meteorological forcings and site characteristic data for predicting surface fluxes, as well as to provide one or more best-in-class benchmark empirical models. We do this by analysing the data directly using information theoretic methods, as well as undertaking a broad-based model search to establish a best-performing benchmark, using a similar out-of-sample train and test methodology to that used in Best et al. (2015). We then use these benchmarks to re-analyse the LSMs assessed in Best et al. (2015). While there are some caveats to this kind of empirical modelling (e.g. risks of over fitting, or local minima during fitting), most of these can be mitigated to a satisfactory degree for the purposes of this research.

Submission ID: 120
Presenting Author: Lauren Stevens*
Session Time: TUESDAY 11:00-12:30

1

Towards a CABLE configuration for ACCESS CMIP6 simulations

STEVENS Lauren[1]; SRBINOVSKY Jhan[2]; LAW Rachel[3]; KOWALCZYK Eva[4]; DIX Martin[5]; ZHANG Huqiang[6]; ROFF Greg[7]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) CSIRO Oceans and Atmosphere; 4) CSIRO Oceans and Atmosphere; 5) CSIRO Oceans and Atmosphere; 6) Bureau of Meteorology; 7) Bureau of Meteorology

Exploring configuration choices for the Community Atmosphere-Biosphere Land Exchange (CABLE) model in ACCESS for CMIP5 was limited to meet submission deadlines. Since then there has been ongoing analysis of CABLE's influence on the ACCESS climate focussing on the mean seasonal climate (Kowalczyk et al., 2013) and on extremes (Lorenz et al., 2014). The impact of an alternative stomatal conductance parameterisation has also been assessed (Kala et al., 2015). Lessons learnt from these studies will be applied to the assessment of alternate CABLE configurations for ACCESS CMIP6 simulations. Evaluation will be based on atmosphere-only simulations, using a benchmarking suite to test the impact of alternative parameterisations and parameter values. The aim will be a stable and optimal version of CABLE which can then be applied in the coupled model configuration. This presentation will show climate simulations using ACCESS-CM2 with CABLE and update the community on the progress towards defining the CABLE CMIP6 configuration.

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Submission ID: 48
Presenting Author: Rachel Law*
Session Time: TUESDAY 11:00-12:30

2

Interactions between land carbon, climate, and aerosols in ACCESS-ESM1 historical simulations

LAW Rachel[1]; ZIEHN Tilo[2]; VOHRALIK Peter[3]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere; 3) CSIRO Manufacturing

Earth system models (ESMs) allow the interactions between the carbon cycle, climate and aerosols to be simulated. A recent development for the Australian Community Climate and Earth System Simulator (ACCESS) is the inclusion of the carbon cycle. Land carbon is simulated using the Community Atmosphere Biosphere Land Exchange (CABLE) model including the CASA-CNP biogeochemical module. Ocean carbon is simulated using the World Ocean Model of Biogeochemistry And Trophic-dynamics (WOMBAT). A range of simulations have been undertaken with this model, both with prescribed and simulated atmospheric CO2. Here we focus on an ensemble of three historical simulations spanning 1850-2005. Through this period, the prescribed atmospheric CO2 increases from 285 to 379 ppm, and anthropogenic aerosols also increase. Volcanic eruptions are prescribed by perturbing the stratospheric aerosol optical depth in four latitude bands. These simulations are compared with a further two historical simulations which are run without anthropogenic aerosols.

The ACCESS-ESM1 surface climate, represented by screen level air temperature and precipitation, evolves through the historical period much as earlier ACCESS simulations. Warming from increasing greenhouse gases is offset by cooling from anthropogenic aerosols, with major volcanic eruptions tending to result in cooler and drier conditions for 1-2 years following the eruption. Gross primary production, the total land carbon uptake due to photosynthesis, grows by ~19% over the historical period largely driven by increasing atmospheric CO2. Total respiration also grows, and thus the net land flux to the atmosphere is relatively small, mostly negative (i.e. a carbon sink) and variable. The sink appears to reach maximum uptake around 1960-1995 and then weakens. Major volcanic events result in periods of larger net land carbon uptake. Simulated land carbon fluxes over recent decades are compared with those estimated by the Global Carbon Project.

S5.3b The Land Surface: Processes and Their Interactions with the Atmosphere from Minutes to Millennium

Submission ID: 52
Presenting Author: Tilo Ziehn*
Session Time: TUESDAY 11:00-12:30

3

The global land carbon cycle in ACCESS-ESM1: simulation results for 1850-2100

ZIEHN Tilo[1]; LAW Rachel[2]*

1) CSIRO; 2) CSIRO

Climate models are continuously evolving to include more processes and interactions at higher resolutions and their number has increased rapidly in recent years. A number of institutes worldwide have also been developing earth system models (ESMs), which are able to simulate both, physical and biogeochemical processes through the inclusion of additional components such as the carbon cycle. The Australian Community Climate and Earth System Simulator (ACCESS) has been recently extended to include land and ocean carbon cycle components in its ACCESS-ESM1 version. ACCESS-ESM1 is based on ACCESS-1.4 which uses the Community Atmosphere Biosphere Land Exchange (CABLE) model as its land surface model. The biogeochemistry component of CABLE includes the coupling of carbon, nitrogen and phosphorus cycles. Here we focus on the analysis of the results from ACCESS-ESM1 historical simulations including their validation against independent estimates and future projections using representative concentration pathways (RCPs). Simulations have been run with prescribed historical and future atmospheric CO2 concentrations to see how the exchange of carbon between the atmosphere and land is impacted. The land biosphere takes up carbon over the historical period but releases carbon back to the atmosphere as atmospheric CO2 continues to increase to 2100 and the climate gets warmer. The ACCESS-ESM1 simulations are comparable to those from other ESMs that submitted results to the Coupled Model Intercomparison Project (CMIP5). Model runs have also been completed in which anthropogenic carbon emissions are input to the model and atmospheric CO2 is simulated rather than prescribed. This will allow the positive feedback between the carbon cycle and climate to be quantified.

Submission ID: 145
Presenting Author: Alexander Norton*
Session Time: TUESDAY 11:00-12:30

4

Global estimates of terrestrial gross primary productivity using satellite observations of chlorophyll fluorescence

NORTON Alexander[1]; RAYNER Peter[2]*

1) University of Melbourne; 2) University of Melbourne

The uptake of atmospheric CO2 by terrestrial plants, termed gross primary production (GPP), constitutes a significant uncertainty in the global carbon cycle and subsequently climate prediction(1). This problem is due partly to a lack of useful observations, along with a limited process-understanding of terrestrial carbon-cycling. Recently, a novel satellite observation of plant chlorophyll fluorescence has demonstrated a powerful ability to track changes in GPP(2), a link that that has since been strengthened through ground-based studies(3,4). To utilize these chlorophyll fluorescence observations, we have coupled a land-surface carbon cycle model (BETHY) with a canopy fluorescence model (SCOPE). Then, using a data assimilation system, the fluorescence observations have been used to constrain model parameters, allowing for observation-constrained estimates of GPP globally. We discuss potential implications of these results for improving process-understanding of terrestrial carbon cycling, and plans for combining fluorescence observations and modeling with the more advanced land-surface model CABLE.

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4) Zarco-Tejada et al. (2013) Rem. Sens. Env. 133, pp. 102-115, doi: 10.1016/j.rse.2013.02.003.

Submission ID: 50
Presenting Author: Caitlin Moore*
Session Time: TUESDAY 11:00-12:30

5

The land surface-atmosphere exchange of carbon in Australian tropical savannas

MOORE Caitlin[1]; BERINGER Jason[2]; EVANS Bradley[3]; HUTLEY Lindsay[4]; TAPPER Nigel[5]*

1) Monash University; 2) University of Western Australia; 3) University of Sydney; 4) Charles Darwin University; 5) Monash University

Savannas are one of the most widespread and diverse ecosystems on the planet. They span some 20 % of the global land surface and are a key ecosystem for carbon uptake from the atmosphere. In fact, savannas account for 25 % of gross carbon uptake by terrestrial ecosystems; the second largest terrestrial carbon sink in the world. This makes savannas an important ecosystem in terms of land-atmosphere interactions and in carbon accounting/budgeting.

Despite advances in understanding the savanna contribution to global ecosystem productivity (carbon uptake), many observational studies have only considered savanna productivity from the whole ecosystem and there have been few attempts to separately address the tree and grass components. In addition, there is a paucity of research quantifying seasonal dynamics of tree and grass productivity in detail. This has implications for savanna representation in model analyses.

Savannas experience a strong wet-dry seasonal climate, resulting in strong seasonal productivity dynamics. In the dry season, the trees are the sole contributors to savanna productivity, with the grasses remaining dormant during this rainless period. At the onset of the wet season, the savanna understory flourishes, causing increased savanna productivity and carbon uptake. However, the frequent occurrence of fire in savannas consumes a portion of the carbon stored in vegetation biomass, thus altering the carbon storage potential of these savannas.

Our research therefore focuses on quantifying the seasonal contribution of savanna trees and grasses to overall savanna productivity (carbon uptake) in northern Australia. To do this, we use the eddy covariance technique to record the exchange of carbon between the savanna land surface and the atmosphere over a 24 month period. Research such as this is vital for improving our understanding of the savanna land surface-atmosphere carbon exchange, which thereby facilitates better global carbon budgeting and accounting.

Submission ID: 226
Presenting Author: Ian McHugh*
Session Time: TUESDAY 11:00-12:30

6

Using eddy covariance to quantify the carbon balance at an 'ideal' woodland site: measurements, inferences and uncertainties

MCHUGH Ian[*1]*

1) Monash University

In the past 20 years, eddy covariance has become a widely used technique for quantification of ecosystem / atmosphere exchanges or fluxes of mass (principally carbon and water) and (latent and sensible) energy. The technique uses fast response instrumentation to simultaneously measure relevant vector and scalar quantities, the time-averaged covariances of which are proportional to the flux. However, it has long been recognised that under certain conditions, the turbulent flux measured at a given height is not the only — or even necessarily the dominant - term in the surface mass balance. These conditions pose a particular problem for estimation of long-term carbon budgets, because they occur primarily nocturnally, when respiratory processes generally result in a net efflux of carbon from ecosystems. The corresponding underestimation of this efflux thus results in a concomitant overestimation of carbon uptake over the longer term (i.e. time scales longer than diurnal). Here we report on attempts to either quantify directly or infer indirectly the nocturnal carbon mass balance components at a site which, in the context of over 600 measurement sites globally, is almost ideal from a measurement perspective. We demonstrate that horizontal advection - one of the key nocturnal mechanisms causing the turbulent flux to underestimate the true flux — may result in the loss of up to 50% of carbon respired from the measurement system under certain meteorological conditions. We also demonstrate that ancillary measurements of vertical variations in carbon storage between surface and eddy covariance measurement height are vital for the quantification not only of the nocturnal but also the daytime carbon balance.

Submission ID: 79
Presenting Author: Ying-Ping Wang*
Session Time: TUESDAY 14:30-15:30

1

What is the likely range of transpiration to evapotranspiration ratio of global land biosphere?

WANG Ying-Ping[1]; LI Yue[2]; LU Xingjie[3]; PAK Bernard[4]; ZIEHN Tilo[5]; LI Longhui[6]*

1) CSIRO; 2) Peking University; 3) CSIRO; 4) CSIRO; 5) CSIRO; 6) University of Technology Sydney

A recent study by Jasechko et al. (2013) found that the ratio of transpiration to evapotranspiration of global land biosphere (fT/ET) varied between 80% and 90%, which is much higher than the current estimates by global land models and from observational synthesis (Wang et al. 2014). This study is to address the question what is the most likely range of fT/ET of global land biosphere. We first analysed the values of fT/ET as estimated by ten different ecosystem models from a major international model inter-comparison and eight earth system models from the fifth Coupled Model Intercomparison Project (CMIP5), and found that fT/ET of global land biosphere under present climate condition varied between 40% and 70%. We then used the Australian community land surface model (CABLE) to explore the likely range of fT/ET due to the uncertainties in the stomatal conductance, canopy leaf area index, and representation of soil evaporation and root water uptake over the last three decades. Our results showed that the mean fT/ET of global land biosphere is likely to fall within 40% to 70%, and is unlikely to be greater than 80% globally. Our study supports the results of Wang et al. (2014) and disagrees with the results of Jasechko et al. (2013).

References:

Jasechko, S., Z. D. Sharp, J. J. Gibson, S. J. Birks, Y. Yi, and P. J. Fawcett (2013), Terrestrial water fluxes dominated by transpiration, Nature, 496,347—350, doi:10.1038/nature11983.

Wang, L., S. P. Good, and K. K. Caylor (2014), Global synthesis of vegetation control on evapotranspiration partitioning, Geophys. Res. Lett., 41,6753—6757, doi:10.1002/2014GL061439.

S5.3c The Land Surface: Processes and Their Interactions with the Atmosphere from Minutes to Millennium

Submission ID: 240
Presenting Author: Mark Decker*
Session Time: 14:30-15:30

2

Precipitation and evaporation sensitivity in ACCESS to subgrid scale runoff generation and soil moisture parameterizations

DECKER Mark[1]*

1) University of New South Wales

Newly developed conceptual parameterizations of subgrid-scale soil moisture, runoff generation, and groundwater are implemented into the Community Atmosphere and Biosphere Land Exchange (CABLE) model and testing within version 1.4 of the Australian Community Climate and Earth-System Simulator (ACCESSv1.4) model. ACCESS is evaluated using historical runs with prescribed sea surface temperatures and compared against observations of precipitation, evaporation, temperature, and radiative fluxes. These conceptual parameterizations of heterogeneity have been previously shown to greatly improve offline CABLE performance including mitigating a large positive bias in mean ET, improved seasonality of total water storage, and improved mean runoff at the scales of large river basins. Within the land-atmosphere coupled system, the new parameterizations again reduce the large positive biases in mean ET in the tropics and north of 45oN. In contrast, the changes in mean precipitation exhibit both improvements and regressions at regional scales. The net effect of the changes in evaporation and precipitation result in a substantially improved zonal mean precipitation minus evaporation (P-E) as compared to observations. Overall, the inclusion of subgrid scale heterogeneous processes brings the representation of the hydrological cycle in the ACCESS model in closer agreement to observations and frequently within the observational uncertainty. As a result of the improved representation of the large scale mean P-E over land the new parameterizations lend greater confidence to utilizing ACCESS to explore future trends in P-E over land.

Submission ID: 147
Presenting Author: Vinod Kumar*
Session Time: 14:30-15:30

3

Can NWP soil moisture improve the fire warnings?

KUMAR Vinod[*1]*

1) Bureau of Meteorology

The operational forest fire danger rating system used in Australia contains a component representing fuel availability, which is based on the assumption that the fuel dryness at a given time is affected only by long term and short term drying effects. The long term drying effects are based on cumulative soil moisture deficits, calculated either as the Keetch-Byram Drought Index (KBDI) or the Mount's Soil Dryness Index (MSDI). KBDI and MSDI are essentially empirical water balance models with very simplified formulations. These simplifications may lead to large uncertainties in the estimated soil moisture deficit, especially for dryer environments which are typical of the Australian landscape. With the advancement in the science of measurement — in the form of satellite remote sensing, and in prediction — in the form of physically based land surface models, soil moisture can now be better analysed and predicted. In this study, we compare KBDI and MSDI against the emerging approaches in soil moisture estimation. The land surface model soil moisture dataset used for this study is obtained from the Australian Bureau of Meteorology's operational numerical weather prediction (NWP) system. The remote sensing product used is the ASCAT soil wetness index. Validation of these models are carried out against in situ observations of soil moisture from OzNet and CosmOz networks in Australia. The results indicate that NWP soil moisture has better skills than that from KBDI or MSDI. The average correlations obtained for NWP, KBDI and MSDI over all sites from the two networks are 0.76, 0.64 and 0.74 respectively. ASCAT soil wetness exhibit a site averaged correlation of 0.81 when verified against CosmOz. NWP thus provide the fire community with a more accurate tool for fire danger rating than what they currently have. The relatively high merits of NWP product and its flexibility opens a wide range of possibilities for further development.

Submission ID: 334
Presenting Author: Andrew Coutts*
Session Time: MONDAY 10:45-12:15

1

Reducing city temperatures to save lives and improve liveability: an overview of urban climate research of the Co-operative Research Centre for Water Sensitive Cities

TAPPER Nigel[1]; COUTTS Andrew[2]*

1) Monash University; 2) Monash University

Earlier work by our Monash University group established clear links between human mortality and temperature for all Australian capital cities. The marked threshold response is such that even a small reduction in temperature of 1-2°C in extreme heat events (EHEs) has the potential to save many lives. In the context of the CRC for Water Sensitive Cities, we are asking two fundamental questions that are guiding our five-year research program that began in 2013. 1. How effective are storm water harvesting technologies, tree cover, green infrastructure and water sensitive urban design in improving urban climates at a range of scales? 2. What are the key configurations required to reduce temperatures to save lives under heat wave conditions and to enhance human thermal comfort and liveability? Observational work dominated the first two years of the program, leading to a model identification, building and validation phase in year three and four, that is now transitioning to a final scenario modelling phase. This work has been at a range of spatial scales, from the individual tree/household, to the street, neighbourhood and whole of city scales. This presentation is designed to provide an overview of this work, some of which is presented elsewhere in this session. Overall we believe that approaches using storm water harvesting technologies, tree cover, green infrastructure and water sensitive urban design can provide the cooling necessary to save lives under EHEs.

Submission ID: 249
Presenting Author: Andrew Coutts*
Session Time: MONDAY 10:45-12:15

2

Monitoring and modelling individual trees in the urban landscape

COUTTS Andrew[1]; TAPPER Nigel[2]*

1) Monash University; 2) Monash University

Trees are in integral part of our urban environment, adding to the local amenity and providing a range of ecosystem services including heat mitigation. However, urban trees experience quite different environments from their rural counterparts, including higher air temperatures (from the urban heat island) and high VPD, altered radiation loading, and reduced soil water availability. This can result in higher evaporative demand, which may not be met as a result of limited soil water.

This presentation brings together a number of pieces of research conducted in the CRC for Water Sensitive Cities on individual trees in urban environments and their contribution to urban heat mitigation. This includes monitoring of individual trees in Melbourne suburbs including: whole tree transpiration (Lophostemon Confertus) using sap flow measurements; and leaf scale transpiration (Olea Europaea) using the LI-6400x photosynthesis chamber system. This work highlights the incredibly complex interactions between trees and the built environment, and the resulting water use and transpiration of trees, which influences micro and local scale climates.

This monitoring has also provided a good basis for model validation, and then application. This includes a Single Plant Ecosystem model (MAESPA), which has been used to explore tree responses to urban microclimatic drivers and water availability. Work from a local scale urban climate model (CLM-U) shows the potential for urban vegetation that is well supplied with water (e.g. from rainwater tanks and water sensitive urban design) to promote local scale evapotranspiration, which can have implications for urban heat mitigation.

The key message is that urban trees and urban water need to be strategically managed in unison in order to deliver optimal benefits for heat mitigation and other ecosystem services.

Submission ID: 37
Presenting Author: Asieh Motazedian*
Session Time: MONDAY 10:45-12:15

3

The impact of urban green spaces on urban climate during heat events: A case study on urban green spaces in Melbourne

MOTAZEDIAN Asieh[1]; COUTTS Andrew[2]; TAPPER Nigel[3]*

1) Monash University School of Earth Atmosphere and Environment; 2) Monash University School of Earth Atmosphere and Environment; 3) Monash University School of Earth Atmosphere and Environment

Urban small green spaces are important in reducing the urban heat intensities by reducing the day and night time air (Ta) and mean radiant temperature (Tmrt), and thereby improving human health during hot summer conditions. This study analyses the climatic and bio-climatic impact of a small urban park on its surrounding urban environment in lowering air temperatures and improving human thermal comfort in inner Melbourne, during extreme heat events in summer. On-site measurement campaigns (i.e. fixed weather stations accompanied by transects) were undertaken to identify the cooling capacity of the park and downwind propagation of cooling effects for a representative period in summer 2013-14 (December- March), with a particular focus on air, and mean radiant temperature profiles of the park and its immediate surroundings. On average, the park was found to be cooler than its surrounding built-up area at all times and in all weather conditions. The park's mean maximum cooling reached 1.0°C, and occurred during peak daytime heating (1500h). However, the magnitude of park-induced coolness, the park cool island (PCI) effect, was found to vary from 0.5-3 °C depending on the time of the day, the meteorological conditions, and the local surface features (i.e. SVF, vegetation distribution and irrigation). The results from both fixed weather stations and transects showed that a downwind propagation of cooling effects of the park could also be observed depending on the wind direction that exceeded less than one park-width away from the park. During summer conditions and in peak daytime heating, trees' shading and evapotranspiration in the park could reduce the level of heat stress from strong (UTCI>32°C) in the nearby streets to comfortable (UTCI<26°C) in the park. Results from this study show the importance of small urban parks in mitigating high air temperatures and improving human health especially during hot summer conditions.

Submission ID: 49
Presenting Author: Cho Kwong Charlie Lam*
Session Time: MONDAY 10:45-12:15

4

The irrigation cooling effect within the Royal Botanic Garden Victoria during heatwaves of the 2013 — 2014 summer

LAM Cho Kwong Charlie[1]; GALLANT Ailie[2]; TAPPER Nigel[3]*

1) Monash University; 2) Monash University; 3) Monash University

Urban parks offer opportunities to urban dwellers for respite from urban heat. Park Cool Island (PCI) studies have focused on the urban-park temperature difference, often exploring temperature trends from daily to seasonal scales and rarely for temperate climates. Observational studies can capture the microscale elements of irrigation, which are otherwise difficult to model. Few studies have analysed the impact of irrigation on temperature during heatwaves. Due to unprecedented heatwaves, the Australian summer of 2013/2014 provided a unique opportunity to study this topic. We compared the hourly temperature trends at 1.5 m between irrigated and non-irrigated locations at the Melbourne and Cranbourne Gardens, from December 2013 to March 2014, including during heatwave conditions. Irrigation events at each site were partitioned into before, during and after irrigation scenarios. Further analysis was conducted to compare the irrigation cooling effect between heatwave and non-heatwave days. Our study shows that different landscape characteristics at both gardens affect the magnitude of irrigation cooling. A cooling of 1-2 °C was observed during nocturnal irrigation events, as well as a residual cooling effect for several hours after the irrigation ended in early morning. The irrigation cooling effect also intensified during heatwaves, which confirms previous results from modelling studies. Overall, our study contributes empirical evidence regarding the cooling effect of irrigation in a temperate city at the microclimate scale.

Submission ID: 39
Presenting Author: Kerry Nice*
Session Time: MONDAY 10:45-12:15

5

A micro-climate examination of the temperature moderating potential of increased vegetation and water in urban canyons using VTUF-3D

NICE Kerry[*1]*

1) Monash University

With urban areas facing future longer duration heatwaves and temperature extremes, adaptation strategies are needed. Examining the role that increased tree cover and water availability can have on human thermal comfort (HTC) in urban areas as part of these strategies has been done using observations, but further work requires a modelling tool suited for this task. Sufficient model resolution is needed to resolve variables used to calculate HTC as well as the ability to model the physiological processes of vegetation and their interaction with water. The lack of such a tool has been identified as a research gap in the urban climate area and has impaired our ability to fully examine the use of vegetation and water for improved human thermal comfort.

A new model, VTUF (Vegetated Temperatures Of Urban Facets), addresses this gap by embedding the functionality of the MAESPA tree process model (Duursma & Medlyn 2012), that can model individual trees, vegetation, and soil components, within the TUF-3D (Krayenhoff & Voogt 2007) urban micro-climate model. An innovative tiling approach, allows the new model to account for important vegetative physiological processes and shading effects. It also resolves processes at sufficiently high resolution to calculate HTC and air and surface temperature, humidity, and wind speed across an urban canyon.

Model validations have shown performance improvements of the model and a suitability to use it to examine critical questions relating to the role of vegetation and water in the urban environment. Preliminary scenario modelling of a number of Melbourne streets using VTUF-3D shows UTCI temperature reductions of up to 1-2 degrees C between varying tree cover scenarios and canopy temperature differences of up to 0.5 degree C. Future work includes further model refinement to support increased accuracy, as well as modelling of comprehensive sets of WSUD scenarios (analysing tree numbers, height, leaf area, placement and soil moisture) to provide guidelines for optimizing the HTC impacts of increased urban vegetation.

Submission ID: 11
Presenting Author: Marcus Thatcher*
Session Time: MONDAY 14:30-15:30

1

Developing an urban canopy model for Australian cities

THATCHER Marcus[1]; LIPSON Mathew[2]; KATZFEY Jack[3]; HURLEY Peter[4]*

1) CSIRO Oceans and Atmosphere; 2) UNSW; 3) CSIRO Oceans and Atmosphere; 4) CSIRO Oceans and Atmosphere

This talk describes the development of an urban canyon parameterisation to better represent Australian cities in mesoscale atmospheric models. The urban parameterisation is based on the Town Energy Budget (TEB) model, but with modifications for in-canyon vegetation in suburban areas, better representing turbulent fluxes within the canyon and including air-conditioning to close energy budgets. Off-line simulations show that the urban model is reasonably accurate when predicting near surface temperature, 10m winds, radiation fluxes and turbulent fluxes for Melbourne, although errors in longwave radiation can be improved by better representing urban thermal properties. We also performed in-line simulations from 2000 to 2010 at 1 km resolution using the Conformal Cubic Atmospheric Model (CCAM), where local feedbacks are allowed between the urban parameterisation and the atmospheric model. Specifically we simulate the urban climate of Brisbane and Melbourne as they represent semi-tropical and temperate climate regimes, respectively. We find that the in-line simulations can reproduce many of the characteristics of different Australian urban climates, despite limited information on model parameters for different cities.

Submission ID: 56
Presenting Author: Mathew Lipson*
Session Time: MONDAY 14:30-15:30

2

Improving the representation of heat storage in urban climate models

LIPSON Mathew[1]; THATCHER Marcus[2]; HART Melissa[3]*

1) UNSW Australia; 2) CSIRO; 3) UNSW Australia

Storage heat flux, the net flow of heat into and out of materials within an environment, is regarded as of paramount importance in urban climate studies, and the key process in the genesis of the urban heat island. However, a key conclusion of the first international urban land surface model comparison project suggested that most urban models under-represent storage heat flux (Best and Grimmond, 2015). We introduce an alternative method to parameterise heat conduction through urban materials and compare it with a method commonly used in many urban schemes. We show the new method reduces the error in simulating storage heat flux by comparing it with the exact solution to heat flow in composite materials. We will introduce the new scheme into an established urban climate model, the Australian Town Energy Budget (Thatcher and Hurley, 2012) to evaluate, compare and benchmark its performance against observation and other urban land surface schemes. We also discuss the general challenges of representing urban surfaces in building-averaged schemes, where computational efficiency is key.

References:

Best, M. J., and C. S. B. Grimmond. “Investigation of the Impact of Anthropogenic Heat Flux within an Urban Land Surface Model and PILPS-Urban.” Theoretical and Applied Climatology, July 15, 2015, 1—10. doi:10.1007/s00704-015-1554-3.

Thatcher, Marcus, and Peter Hurley. “Simulating Australian Urban Climate in a Mesoscale Atmospheric Numerical Model.” Boundary-Layer Meteorology 142, no. 1 (January 1, 2012): 149—75. doi:10.1007/s10546-011-9663-8.

S5.4b Urban Climate

Submission ID: 314
Presenting Author: Jason Evans*
Session Time: MONDAY 14:30-15:30

3

Future projections of short time scale precipitation extremes over Sydney

EVANS Jason[1]; ARGÜESO Daniel[2]*

1) University of New South Wales; 2) UNSW

The Weather Research and Forecasting (WRF) model has been used at convection permitting resolution (2km) to simulate the future climate of Sydney with a focus on precipitation extremes at durations from 1 hour to 1 day. Overall, the simulations project temperature increases of 1 to 2K, with larger increases in autumn and winter compared to spring and summer. In terms of precipitation most of the domain is projected to see annual increases of up to 40%. These increases occur mostly in autumn, with little change in summer. Extreme precipitation (higher than 95th percentile) is projected to contribute a larger proportion of this precipitation total.

While the model can reasonably reproduce medium extremes (like the 95th percentile), annual maxima precipitation time-series contains significant over-estimation for much of the area of interest. Given this model limitation, the area averaged Intensity-Frequency-Duration (IFD) curves are simulated reasonably well at large Annual Exceedence Probabilities (AEP) (50%) and show progressively larger errors for smaller AEPs. Future projections show rainfall depths increasing for all durations and AEPs considered here. This future increase is larger for smaller AEPs, but relatively consistent across durations.

S5.4b Urban Climate

Submission ID: 341
Presenting Author: Carlo Agapay Jamandre*
Session Time: MONDAY 14:30-15:30

4

Urban growth within Sydney - effects of urban densification and vertical expansion

JAMANDRE Carlo Agapay[1]; HART Melissa[2]; ARGÜESO Daniel[3]; PITMAN Andrew[4]*

1) Climate Change Research Center UNSW; 2) ARC Centre of Excellence for Climate System Science; 3) Climate Change Research Center UNSW; 4) ARC Centre of Excellence for Climate System Science

New South Wales' urban areas are set to grow to accommodate the 30% increase in population over the next 20 years. This expansion will come in two general forms, internal expansion where structures are projected to be denser, taller, or converted into larger facilities; and external expansion where adjacent non-urban locations will be converted into urban landuse. Mitigation strategies for the projected urban heat island have been mainly focused on adjusting the albedo or materials of roofs. This study will focus on understanding the roles that buildings have on urban climate. The Weather Research and Forecasting model was used to create a diversified representation of Sydney's urban area, classifying Sydney as either low, high, or commercial. Ensemble simulations were produced to examine the effects of higher building densities and heights of low urban areas on climatic variables. Increase in temperatures were linear for both densification and vertical expansion with densification producing more than three times the growth in temperatures. Simulations were performed over Sydney for January 2009 using a 2km spatial resolution with a 61 day spin-up.

S5.4c Urban Climate

Submission ID: 129
Presenting Author: Stephanie Jacobs*
Session Time: MONDAY 16:00-17:00

1

Mitigating the urban heat island and improving human thermal comfort during extreme heat events in Melbourne

JACOBS Stephanie[*1]; GALLANT Ailie[2]; TAPPER Nigel[3]*

1) Monash University; 2) Monash University; 3) Monash University

Heatwaves cause a higher number of Australia-wide fatalities than all other natural disasters combined. In Australia, 90% of the population lives in urban areas, yet urban areas are also warmer than non-urban areas at night due to the Urban Heat Island (UHI) effect. During heatwave conditions, any additional UHI will compound the exposure of the population to heat-stress. This study models UHI mitigation scenarios to estimate the reduction in near surface temperatures in the city, and any concurrent improvements in human thermal comfort, during heatwave events.

We use the Weather Research Forecasting model coupled to a single layer urban canopy model to simulate Melbourne's two hottest recorded heatwaves, January 28-30 2009 and January 14-17 2014. Estimates of heat mitigation strategies are applied: irrigation, vegetation and shading. To represent a theoretical irrigation of the urban surface we increase the top layer of soil moisture to 30%, 60% and 90% of saturation capacity. To represent vegetation, we change a parameter of vegetation fraction from its current measured value to its theoretical maximum in low, medium and high-density areas. A parameter of shading fraction of the surface is also varied alongside vegetation.

Preliminary results will be presented and these highlight the cooling capacity of each mitigation strategy. The nature of the relationship between these mitigation strategies, temperature and human thermal comfort is also investigated.

Submission ID: 173
Presenting Author: Daniel Argüeso*
Session Time: MONDAY 16:00-17:00

2

Urban-enhanced precipitation in the Maritime Continent from a convection permitting model

ARGÜESO Daniel[1]; DI LUCA Alejandro[2]; EVANS Jason[3]*

1) ARC Centre of Excellence for Climate System Science, UNSW; 2) Climate Change Research Centre, UNSW; 3) ARC Centre of Excellence for Climate System Science, UNSW

Urban-enhanced precipitation in the Maritime Continent from a convection permitting modelThis study quantifies the effect of urban areas on precipitation at local scales over the western Maritime Continent using a regional climate model operating at convection permitting spatial resolution. The Weather Research and Forecasting model coupled with an Urban Canopy Model was used to simulate the atmosphere of the region over a 5-year period at 2-km spatial resolution. Two separate simulations with and without urban areas were completed to investigate the influence of cities on rainfall.

We analyze how urban areas modify the annual precipitation, as well as its diurnal cycle, which is a key feature of the Maritime Continent. Our results indicate that major cities intensify precipitation in the late afternoon. As a consequence, they strengthen the diurnal cycle and contribute to a significant increase in rainfall amounts. Examining urban-induced changes in temperature, humidity and wind provide an insight into the mechanisms that drive such effects. We found that the presence of cities modifies the local circulation. They constitute a source of heat at the surface, which destabilizes the atmosphere and brings moisture from the surroundings, especially from the ocean. Urban areas also reduce convective inhibition. Together, these processes increase near-surface moisture flux convergence and favor convective processes leading to an overall increase of precipitation over cities.

Submission ID: 225
Presenting Author: Cassandra Rogers*
Session Time: MONDAY 16:00-17:00

3

Do heatwaves exacerbate the urban heat island in southern Australian cities?

ROGERS Cassandra[1]; GALLANT Ailie[2]; TAPPER Nigel[3]*

1) Monash University; 2) Monash University; 3) Monash University

Individual summer heatwaves in southern Australian cities are capable of causing hundreds of heat related deaths and hospital admissions. The urban heat island (UHI) on the other hand is known to affect urban temperatures year round, particularly at night. While both heatwaves and the UHI are known to increase temperatures in urban areas, the effect of heatwaves on the strength of the UHI has, until now, not been investigated. This research focuses on the effect of summer heatwaves on the UHI in Melbourne, Adelaide, and Perth.

Bureau of Meteorology observational temperature data, from in and around all three cities, were used to determine the magnitude of the UHI during heatwave and non-heatwave conditions. In all three cities, the degree to which heatwaves affected the strength of the UHI varied over the duration of the heatwave, with nighttimes typically experiencing a stronger exacerbation or dampening than the daytime. During heatwaves, nighttime UHIs were found to be hotter than normal in Melbourne and Adelaide, as opposed to Perth which experienced an urban cool island (UCI).

On nights when the UHI is hotter (cooler) than normal in Melbourne and Adelaide (Perth), all cities experience advection of continental air, that is, northerlies in Melbourne and easterlies in Adelaide and Perth. The coastal nature of these cities might have an influence on the UHI strength in some cases. However, these interactions are complex and are likely influenced by the location of urban and rural stations in some cities.

S5.4c Urban Climate

Submission ID: 168
Presenting Author: Melissa Hart*
Session Time: MONDAY 16:00-17:00

4

Linking synoptic circulation patterns to air quality conditions in the Sydney basin

JIANG Ningbo[1]; HART Melissa[2]; DI VIRGILIO Giovanni[3]*

1) NSW Office of Environment and Heritage; 2) ARC Centre of Excellence for Climate System Science UNSW; 3) Climate Change Research Centre UNSW

Ozone and particle pollution remains of concern in Sydney during warm months when levels may exceed Australian standards and lead to high population exposure. While pollutant emissions and chemical transformations can significantly affect air pollution levels in the region, so to can the weather and the inter-annual variability of the regional climate.

Few studies have investigated the relationship between synoptic circulation and air quality in Sydney. Previous studies have focused on the analysis of high pollution episode days or on air pollution conditions across the entire Sydney basin, giving rise to general agreement that pollution episodes are often associated with interactions between synoptic systems and mesoscale processes. Synoptic classification in these studies was performed manually using synoptic charts or through cluster analysis of single-station meteorological data. Given that meteorology/air quality relationships vary by pollutant, location and time, a synoptic climatology derived for one station and pollutant may not be applicable to other locations and pollutants. This is due in part to local orographic effects and spatial variations in emissions.

This study provides a more complete analysis of the effect of synoptic processes on spatial and temporal variations of warm-month ozone and particle pollution in Sydney. A synoptic type catalogue is developed for 2007-2013 using a non-linear map classification method called “self-organising map” from the NCEP/NCAR geopotential height reanalysis for east Australia. Typical synoptic types coinciding with high and low ozone, PM10 and visibility levels are identified and linked to local circulation patterns including drainage flows and sea breezes. The possible mechanisms behind the meteorology/air quality relationships and the effects of bushfires on regional air quality are discussed. This study provides updated, visual insights into how local and synoptic meteorology affects local air quality in tandem.

S6.1a Education and Outreach

Submission ID: NA
Presenting Author: Greg McNamara*
Session Time: WEDNESDAY 09:45-10:30

1

The Australian Earth and Environmental Science Olympiad: An Australian Science Innovations initiative inspiring talented students to think about Earth Systems Science

MCNAMARA Greg[1]; LESUEUR Lillian[2]; NICHOLLS Bronte[3]*

1) Australian Science Innovations, Earth and Environmental Science Olympiad Program Director; 2) Australian Science Innovations, Executive Director; 3) Australian Science Innovations, Earth and Environmental Science Olympiad Program Deputy Director

Joining the well-established Olympiad competitions in biology, chemistry and physics in 2014, the Australian Earth and Environmental Science Olympiad selects and trains talented secondary students in preparation to compete at the International Earth Science Olympiads.

Year 10 and 11 students are invited to test their knowledge of geology, geophysics, meteorology, oceanography, astronomy, and environmental sciences by first sitting a national exam. Those who perform well in the exam are invited to attend an intensive summer school where their theory and practical skills are developed further. Finally, a four-member team is selected to compete at the International Earth Science Olympiad.

The international competition consists of theory and practical exams plus the International Team Field Investigation where teams of students from different countries work together to solve real life environmental problems.

In this presentation we will outline the basis of Australian Science Innovation's adoption of an Australian Earth and Environmental Science Olympiad program, the value of the program to gifted and talented students and highlight the successful involvement of Australian students in the International Earth Science Olympiad to date.

We will also discuss the impact the program is having on students and whether the exam, the summer school or the international competition influence student’s decisions with respect to subject choices at senior high school level and university.

This Inspiring Australia initiative is supported by the Australian Government through the Department of Industry partnership with Australian Science Innovations. As the Peak Council of geoscientists in Australia, the Australian Geoscience Council also supports the Australian Earth and Environmental Science Olympiad.

S6.1a Education and Outreach

Submission ID: NA
Presenting Author: Kyi Muller*
Session Time: WEDNESDAY 09:45-10:30

2

Curious minds – STEM for girls

MULLER Kyi[1,2]; LESUEUR Lillian[1]; CLAPPER Mike[2]*

1) Australian Science Innovations; 2) Australian Mathematics Trust

The economic challenges in Australia's workforce are significant as we move into a period where 44% of current Australian jobs are at risk of being affected by computerisation and technology over the next 20 years. Price Waterhouse Coopers' latest document on the state of Science, Technology, Engineering and Maths (STEM) in Australia suggests that there is a degree of urgency in the implementation of the STEM agenda. This was also reflected in the key objective of the position paper submitted by the Office of the Chief Scientist in 2013, which states the need to fully utilise Australia's capacity in STEM to secure social, cultural and economic prosperity. The Australian Government Department of Education and Training through the Restoring the Focus on STEM program and the Department of the Prime Minister and Cabinet have responded to this challenge by funding a girls in STEM initiative called Curious Minds, which is being delivered by Australian Science Innovations and the Australian Maths Trust. One of the key agendas of this program is to engage high-achieving girls from rural or regional areas, indigenous students as well as those whose access to extension and enrichment may be limited. This program involves a three-day summer camp where students are intensively engaged in lectures, excursions and laboratory work. In addition to academic enrichment, a key component of the summer camp is to assign students to a mentor who will work with them during the following six months. Students return for a debrief at the end of the 6 months in a winter camp and further lectures and careers support. This program therefore provides not only an academically rigorous experience, but continuity of support for students as well as a career-focused approach. This is vital if the uptake of STEM subjects in secondary and tertiary education is to be increased in the future.

References:

Office of the Chief Scientist (2013) *Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach*. Australian Government, Canberra.

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S6.1a Education and Outreach

Submission ID: 116
Presenting Author: Sally Ip*
Session Time: WEDNESDAY 09:45-10:30
Poster: Session 2, Poster #68

3

Scientists and Mathematicians in Schools (SMiS)

IP Sally[*1]*

1) CSIRO Education and Outreach

Scientists, Mathematicians and ICT in Schools is a national program that creates and supports on-going partnerships between primary or secondary school teachers and science, technology, engineering, and mathematics (STEM) professionals. Partnerships are flexible and it is up to the skilled volunteer and teacher to negotiate how often they would like to collaborate and the ways they work most effectively together. SMiS encourages participation across various fields of STEM, including the sciences related to weather and climate. These partnerships bring the practice of real world STEM to students, allow students to interact with a 'real scientist' and gain a deeper understanding of the role of STEM in our society and the types of careers available. This presentation brings together relevant partnership examples from across Australia to illustrate the benefits of SMiS for teachers, STEM professionals and students.

Submission ID: 31
Presenting Author: Simon Torok*
Session Time: WEDNESDAY 11:00-12:30

1

Communicating climate change to a young audience

TOROK Simon[*1]; HOLPER Paul[1]*

1) Scientell Pty Ltd

Writing for young people to reach them outside the classroom is a way to engage them with science. Non-fiction writing for young people has seen a surge over recent decades, with more than 60,000 English-language children's books in print globally, and publishers launching younger versions of their science magazines, including Scientific American and National Geographic.

Despite, or because of, increasing media coverage and teaching of climate change in schools, there has been a negative impact on the mood of young people and their hopes for the future. While surveys of Australians consistently found people consider climate change is happening and the majority consider that human activities play a role (Leviston et al., 2013), a survey in 2007 of 600 young people aged 10 to 14 in Australia found pessimism about the environment. In the survey of young people, 45% were nervous about the future impact of climate change (Tucci et al, 2007). More recent surveys (e.g. Mission Australia, 2014) have noted the economy as more worrying for young people.

If the objective of raising awareness of climate change is to influence behavioural change and avoid dangerous changes to the climate system, then have climate communicators failed? Brulle et al. (2012) suggest that knowledge of climate science has little direct influence on public opinion on climate change in the United States. What works and what doesn't work when writing for a young audience? What tools do we have to increase understanding? And importantly, how can we tailor communication to influence behaviour change?

Drawing on experience as authors of popular science books for young people, writers of science text books for high school students, and experience editing science magazines, we will set out our view of what grabs the attention of young people – particularly when communicating complicated, controversial and sometimes grim news to young people while maintaining elements of education and entertainment.

S6.1b Education and Outreach

Submission ID: 33
Presenting Author: Paul Holper*
Session Time: WEDNESDAY 11:00-12:30

2

Storming the classrooms: making climate science hot again

HOLPER Paul[1]; TOROK Simon[1]*

1) Scientell Pty Ltd

There is a marked decline in the number of secondary school students pursuing maths and science. A study commissioned by Australia's Chief Scientist (Goodrum, Druhan & Abbs, 2011) concluded that all the main high school sciences have experienced continued and dramatic declines.

Coincidently, science finds itself under attack from vested interests and pseudoscience. For more than 20 years, climate science has been at the frontline of this battle. It's little surprise that 'climate deniers', cherry pickers and lobby groups are having an impact: there is a lot at stake.

Associated with the decline in students pursuing science at secondary and tertiary level is a shortage of teachers, especially in primary schools, with science and mathematics qualifications. Many Australian primary schools teachers have no science training and view the subject with fear.

Science agencies today have a focus on reaching industry and other funding agencies, lowering the priority of activities such as education that do not directly bring in funding. For example, CSIRO has reduced their schools education programs, while the Bureau of Meteorology has ceased its active schools program.

The climate and science community need to do much more to ensure sound science is part of children's learning.

As authors of more than 20 books on science and climate change targeting young people, and deep experience in education, curriculum and communication, the authors will describe the way in which climate science fits (just) in the national curriculum, and describe their vision and ideas for exciting, engaging and scientifically accurate educational tools and resources.

Reference:

Goodrum, D., Druhan, A., & Abbs, J. (2011). The Status and Quality of Year 11 and 12 Science in Australian Schools. Canberra, ACT: Australian Academy of Science.

Submission ID: 12
Presenting Author: Sophie Lewis*
Session Time: WEDNESDAY 11:00-12:30

Poster: Session 2, Poster #69

3

Can public perceptions of Australian climate extremes be reconciled with the statistics of climate change?

LEWIS Sophie[*1]*

1) The Australian National University

A new Australia-wide average spring temperature record was set in 2013, and again in 2014. This was a period of extended extreme heat. These extremes have been investigated scientifically. However, popular perceptions of extreme climate events often refute the results of scientific analyses. Instead, these understandings posit that new temperature records are purely an artefact of natural variability and the longer the period of observations, the greater possibility of extreme events.

In this study, I investigate various aspects of this mental model of climate change and extremes informed primarily by personal perceptions using evidence of the physical climate system (e.g. climate observations and model output). Using these tools, I show that the characteristics of these recent spring temperature extremes are irreconcilable with the personal perception-based understanding of climate variability, which is epistomised by the public comments of recent Prime Minister Tony Abbott.

This study does not attempt to redress misconceptions about climate change and extremes. Rather, I explicitly examine elements of perception-based understandings of recently observed extremes with the tools used in making quantitative scientific attribution statements.

Submission ID: 167
Presenting Author: Charles Nelson*
Session Time: WEDNESDAY 11:00-12:30

Poster: Session 2, Poster #74

4

Temporal and spatial variation in belief in climate change in Australia

NELSON Charles[*1]*

1) Foreseechange Pty Ltd

The general public's level of belief in climate change has varied substantially over time and also varies by location in Australia. Analysis of these variations enables us to draw conclusions about the factors which have influenced changes in belief. In conjunction with other data, this analysis provides guidance on strategies to influence the level of belief and to propose actions which are less susceptible to opposition based on arguments that human activity is not influencing the climate.

The primary data set analysed is based on annual surveys conducted by Foreseechange since 2005, which contain a measure of the level of belief that the climate is changing. This data set enables analysis over time and also, due to the large aggregate sample size, permits analysis by small area (in this case Commonwealth Electorate Districts).

Time series data concerning the level of support for generic action on climate change, collected by the Lowy Institute, is also analysed and is shown to be strongly correlated with the Foreseechange measure of belief that the climate is changing. Thus, communications which lift the general level of belief in climate change can be expected to increase support for action.

Data from a range of other sources, both from Australia and the USA, is drawn on as further evidence and to enrich the insights and conclusions.

Data concerning support for some specific actions to reduce carbon dioxide emissions are also analysed and this provides a basis for strategy which is resilient to attack by deniers of climate change.

Submission ID: 44
Presenting Author: Leanne Armand*
Session Time: WEDNESDAY 11:00-12:30

Poster: Session 2, Poster #70

5

Beyond Next Wave: A national postgraduate at sea training initiative on the RV Investigator

ARMAND Leanne[*1]*

1) Macquarie University

In 2014, a major transformation of the Australian marine science setting occurred with the commissioning of the marine national facility, RV Investigator. The ship, a new actor in the national educational landscape, catalysed a collaborative response from university and stakeholder groups forming the Strategic Marine Alliance Research, Teaching and Training initiative (Armand et al. 2015). This team's aim is focused on building a national curriculum in alignment with current developments in higher education postgraduate learning. The long-term outcomes are firmly focussed on a rise in Australian marine student qualifications, scientific outputs and reputations, increased use of national scientific infrastructure, and providing a platform for generational, institutional and industry knowledge transfer and collaboration. This presentation will outline the current development of the program inclusive of the current surveying of student interest and external stakeholder needs for marine science graduates; the future steps in securing government learning and teaching funding and external sponsorship for student mobility; and the 3 year trial program commencing from mid 2017.

Reference:

Armand, L., Coleman, R., Coffin, M., Bose, N., Suthers, I., Bruce, E., Baker, E., Gladstone, W., Ellwood, M. and Holmes, S. (2015) Strategic Marine Alliance Research, Teaching and Training(SMART2): A national Master-level at sea training initiative. Pp. 42. Dept. of Biological Sciences, Faculty of Science and Engineering, Macquarie University: North Ryde. http://hdl.handle.net/1959.14/346971.

S6.1b Education and Outreach

Submission ID: 354
Presenting Author: Michael Box*
Session Time: WEDNESDAY 11:00-12:30

6

Physics of radiation and climate: from proposal to publication

BOX Michael[1]; BOX Gail[2]*

1) University of New South Wales; 2) University of New South Wales

In early 2012 we were approached by an editor from Taylor and Francis, about our possible participation in a 'project' to write a new high level book on the Physics of Climate Change. After an exchange of emails, a phone conversation, and much head scratching, we ended up agreeing to write the book between us. Perhaps the primary reason for agreeing is that we had several chapters 'semi-prepared' in the form of old lecture notes. Foolishly, perhaps, we assumed that the rest of the chapters would come together just as easily! In the end it took ~5 person-years.

In this presentation I will outline the trials and tribulations of writing a book at this level (~honours year/beginning graduate level), the challenges and the joys.

Submission ID: 101
Presenting Author: Jatin Kala*
Session Time: WEDNESDAY 11:00-12:30

Poster: Session 2, Poster #73

7

Using STELLA software to teach systems thinking as applied to earth systems science within a post-graduate University course

KALA Jatin[*1]

1) Murdoch University

Given the increasing relevance of future climate change to society, there is an increasing demand to teach concepts of earth systems science at Universities, to a wide range of students, coming from a range of backgrounds, enrolled in a variety of courses across different faculties. Additionally, the "systems-thinking" approach is being increasingly favoured as a useful paradigm in developing solutions to issues such as those posed by future climate change (Richmond 2013). STELLA modelling software (http://www.iseesystems.com/softwares/Education/StellaSoftware.aspx) is a tool designed to teach "systems-thinking" by providing an intuitive, icon-based graphical interface that simplifies model building. Students do not require any prior knowledge of computer programming and do not need to have prior extensive knowledge of calculus, but only basic algebra. Using "stocks", "flows", and "converters", students are able to build spatially implicit models of various aspects of the earth system, such as the hydrological cycle, nutrient cycles, etc. In this talk, I will reflect on my use of STELLA software to teach a post-graduate course in earth systems science at Murdoch University, Perth, Western Australia.

Reference:

Richmond, B. (2013) An introduction to systems thinking. Isee systems, 165 pages.

Submission ID: 351
Presenting Author: John Clarke*
Session Time: WEDNESDAY 11:00-12:30

Poster: Session 2, Poster #72

8

Datasets for impact assessment: The Climate Change in Australia web-tools

CLARKE John[1]; ERWIN Tim[2]; HEADY Craig[3]; BECKETT Duan[4]; BEDIN Tim[5]; WEBB Leanne[6]; GERBING Chris[7]; WILSON Louise[8]; HENNESSY Kevin[9]*

1) CSIRO Oceans & Atmosphere Flagship; 2) CSIRO Oceans & Atmosphere Flagship; 3) CSIRO Oceans & Atmosphere Flagship; 4) Bureau of Meteorology; 5) CSIRO Oceans & Atmosphere Flagship; 6) CSIRO Oceans & Atmosphere Flagship; 7) CSIRO Communications; 8) CSIRO Oceans & Atmosphere Flagship; 9) CSIRO Oceans & Atmosphere Flagship

The Climate Change in Australia website (http://www.climatechangeinaustralia.gov.au) is the key means of disseminating the latest climate projections for Australia from CSIRO and the Bureau of Meteorology. It was launched in April 2015 and so far has attracted more than 110,000 unique users, over 650 of whom have registered to access Advanced features.

The projections can be explored via web-tools which were developed with a strong user focus by drawing on 1) feedback from users of the 2007 version of the website, 2) use cases collected from extensive interviews with natural resource managers, 3) feedback from the project's User Panel, and 4) experience from the UK Climate Impacts Program (UKCIP).

The tools provide visualisation and/or download access to more than 20TB of climate projections data in a variety formats in order to meet the needs of stakeholders. The data are available at a range of scales from regional averages to 5km gridded changes to gridded daily time-series. Application-ready data are available as future daily, monthly, seasonal and annual time-series from a pre-selected sub-set of models that collectively capture the range of changes across Australia.

In this presentation, we demonstrate a sample of the web-tools and detail some of the high-resolution application-ready datasets along with their strengths and weaknesses.

Submission ID: 166
Presenting Author: Dietmar Dommenget*
Session Time: WEDNESDAY 11:00-12:30

9

The Monash Simple Climate Model for interactive teaching about climate, climate models and climate change

DOMMENGET Dietmar[1]*

1) Monash University

The Monash Simple Climate Model (MSCM) allows students and the general public to explore the physical simulation of the climate system with a real global climate model. Despite its simplicity the model simulates the climate response to external forcings, such as doubling of the CO2 concentrations realistically (similar to state of the art climate models). The MSCM web-interface allows you to study the results of more than a ~2000 different model experiments in an interactive way. You can take the climate apart, see how it responses to different climate change scenarios, provides a number of fun problems/puzzles and it allows you to study a number of educational tutorials about the climate, climate models and climate change. By switching OFF/ON physical processes you can deconstruct the climate and learn how all the different processes interact to generate the observed climate and how the processes interact to generate the IPCC predicted climate change for anthropogenic CO2 increase. The presentation will introduce the MSCM interfaces and show some examples of what can be done with it. This will aim at teachers and other educators in public outreach. It will also be starting point to develop a program in high school teaching and for professional development of teachers to work with the MSCM.

Submission ID: 54
Presenting Author: Mitchell Black*
Session Time: WEDNESDAY 11:00-12:30

Poster: Session 2, Poster #71

10

Climateprediction.net: join the world's largest climate experiment

BLACK Mitchell[1]; KAROLY David[2]*

1) School of Earth Sciences and ARC Centre of Excellence for Climate System Science, University of Melbourne, Australia; 2) School of Earth Sciences and ARC Centre of Excellence for Climate System Science, University of Melbourne, Australia

You've heard of climate change, but what does that actually mean for the weather in the region where you live? Could it be that you are going to see an increase in the number of damaging weather events? Or could the weather actually be getting nicer? The climateprediction.net weather@home experiment hopes to answer these questions, with your help. Climateprediction.net, supported by the Nuffield Foundation, has put together Science, Maths and Geography teaching materials based on the project. The educational support that is offered includes materials for school curriculum and specialised online learning courses. All the school curriculum material can be found on the website: www.climateprediction.net/education.

Lightning Lectures – General Session
S3.1 General Climatology – Lightning Lecture

Submission ID: 24
Presenting Author: Blair Trewin*
Session Time: TUESDAY 12:15-12:30

Poster: Session 1, Poster #15

1

1922-1938: Australia's forgotten drought

TREWIN Blair[1]; BETTIO Lynette[2]; EVANS Alex[3]; TIHEMA Tamika[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology

Long-term droughts, extending over a period of several years or more, have been a recurrent feature of Australia's climate, with the Federation Drought (1895-1903), the World War 2 Drought (1937-1945) and the Millennium Drought (1997-2009) as well-known examples.

The period from 1922 to 1938 lacks the profile of the aforementioned events despite sustained rainfall deficits over a length of time unmatched in the Australian instrumental climatic record. It was a period marked by a lack of El Niño or La Niña activity, with no moderate or strong events of either sign.

South Australian area-averaged rainfall was below the 1961-1990 normal in all 17 years from 1922 to 1938, with many individual locations reporting ten or more consecutive years of below-normal rainfall. Over western Queensland, annual rainfall totals comparable to those of the 2012-2015 drought were sustained over a decade or more.

It was the driest 17-year period on record over a large area of the eastern interior of Australia, covering most of northeast South Australia, the western third of Queensland, adjacent border areas of the Northern Territory, and the far northwest of New South Wales, with scattered areas of records also evident to the east and south of this region as far as central Queensland and the Eyre Peninsula. The most extreme rainfall deficits were in relatively sparsely populated regions. Few cropping areas had rainfall for the period in the lowest decile, except in northern New South Wales and the northern and western agricultural areas of South Australia, and the major coastal cities were largely unaffected.

A feature of the period, as with the Millennium Drought, was the lack of sustained heavy rainfall. The percentage of Australia with annual rainfall in the highest decile did not reach its climatological mean of 10 per cent in any of the 17 years, and Birdsville (where such events occur about once in four years on average) did not have a month in which rainfall reached 100 millimetres.

S3.1 General Climatology – Lightning Lecture

Submission ID: 196
Presenting Author: Jennifer Catto*
Session Time: TUESDAY 12:15-12:30

Poster: Session 1, Poster #8

2

The effect of increased tropical sea surface temperatures on frontal precipitation

CATTO Jennifer[1]; SINCLAIR Victoria[2]*

1) Monash University; 2) University of Helsinki

Fronts are hugely important for precipitation in the midlatitudes. A warming climate may influence the precipitation associated with fronts in different ways. Increasing sea surface temperatures in the tropics may act to increase the moisture available for frontal precipitation in the midlatitudes leading to increased precipitation. We have used two models — ACCESS and Open IFS — and performed two simulations using each: one with climatological sea surface temperatures, and one with tropical sea surface temperatures increased by 1 degree (decreasing via a sine function to climatology at 30 degrees North and South). Fronts have been identified using an objective identification method, and linked to the precipitation. The changes in frontal precipitation have been investigated by using a regime decomposition method. This allows us to determine the relative importance of the thermodynamic versus dynamic response to tropical heating.

S3.2 Past Climate Reconstruction and Modelling – Lightning Lecture

Submission ID: 80
Presenting Author: Kathryn Allen*
Session Time: TUESDAY 12:15-12:30

Poster: Session 1, Poster #20

3

Three 292-year winter dam inflow reconstructions for Tasmania, southeastern Australia

ALLEN Kathryn[1]; NICHOLS Scott[2]; EVANS Robert[3]; ALLIE Stuart[4]; CARSON Greg[5]; LING Fiona[6]; COOK Ed[7]; BAKER Patrick[8]*

1) University of Melbourne; 2) University of Melbourne; 3) Silviscan Pty Ltd; 4) Hydro Tasmania; 5) Hydro Tasmania; 6) Entura; 7) Lamont-Doherty Observatory; 8) University of Melbourne

Changes in in seasonal precipitation, and the seasonal distribution of precipitation, have been projected for southeastern Australia. However, in order to better contexturalise past changes, long seasonal hydroclimatic records extending back before the arrival of the First Fleet in 1788 are required. Here we present the first cool-season (July — August) hydroclimatic reconstructions for western Tasmania, southeastern Australia. Recent July-August conditions are well within the natural variability for the past ~ 300 years. Overall, wettest winters occurred prior to1850 while driest winters have occurred since 1850. Relatively low inflow periods occurred around 1860, the early 1900s and 1970, while relatively high inflows occurred in the 1770s and 1810s. Highest inflows to all three catchments occurred in 1816. These winter reconstructions complement a previous warm season (December — January) hydrological reconstruction for the same region and confirm that conditions in one season have not necessarily reflected conditions in the other over the past ~ 300 years. The difference between these seasonal reconstructions illustrates the value of obtaining reconstructions of regional hydroclimatic variability for individual seasons, if at all possible. Superposed epoch analysis suggests that PC1 of the July-August inflow reconstructions may contain a volcanic eruption signature.

S3.5 Future Earth: Science for Solutions to Global Problems – Lightning Lecture

Submission ID: 205
Presenting Author: Martin Tingley*
Session Time: TUESDAY 12:15-12:30

Poster: Session 1, Poster #32

4

Tropical cyclone wind profiles: analytic models, numerical simulations, and the role of topography

TINGLEY Martin[*1]; BRUYERE Cindy[2]; BUCKLEY Bruce[3]; HOLLAND Greg[4]; CHAN Peter[5]; DYER Andrew[6]; LEPLASTRIER Mark[7]*

1) Insurance Australia Group; 2) NCAR; 3) Insurance Australia Group; 4) NCAR; 5) Insurance Australia Group; 6) Insurance Australia Group; 7) Insurance Australia Group

Analytic wind profiles are frequently used to model wind swaths from tropical cyclone tracks, often linked with boundary-layer models to account for translational speed and friction. Applications include risk assessments from vendor catastrophe models (e.g., AIR and RMS) used by the (re)insurance industry, and near real-time damage estimations for land falling cyclones. These analytic profile models do not account for localized wind effects, including those caused by topography and roughness, that are well-understood from first-principles and evident in post-cyclone damage surveys.

Here we quantify differences between wind fields estimated from cyclone track data in conjunction with standard analytic wind profile and boundary layer models, and wind fields from synthetic storms produced by NCAR's current implementation of WRF, optimised for simulation of tropical cyclones in the Queensland region of Australia. We focus on an ensemble of synthetic storms that make landfall near the cyclone-prone city of Townsville, in north Queensland. The storms feature different genesis locations, steering flow speeds, intensities, underlying sea surface temperatures, and grid resolutions of either 12, 4, or 1.33km.

Differences between the wind fields estimated using the different modelling resolutions, and between the wind fields from the synthetic storms and those estimates from analytic wind profiles, confirm the importance of topography in determining local-scale features of the wind field. A regression model is developed that predicts the high-resolution, synthetic wind field from the analytic wind profile and geographic variables including elevation, slope, and slope aspect. The performance of the statistical predictions is assessed using out-of-sample synthetic storms. These results provide a computationally efficient recipe for improving upon analytic predictions of wind profiles, and are immediately relevant to risk and impact assessment in cyclone-prone regions.

S4.1 General Atmospheric Processes – Lightning Lecture

Submission ID: 238
Presenting Author: Robert Warren*
Session Time: TUESDAY 12:15-12:30

Poster: Session 2, Poster #36

5

Correcting radar calibration errors using TRMM

WARREN Robert[1]; PROTAT Alain[2]; SIEMS Steven[3]; RAMSAY Hamish[4]*

1) Monash University; 2) Bureau of Meteorology; 3) Monash University; 4) Monash University

Quantitative applications of weather radar data, such as precipitation estimation, require a well-calibrated radar system. However, due to time and financial constraints, thorough calibration tests and adjustments can be made only infrequently (once or twice a year) in most operational radar networks. In addition, hardware replacements and other maintenance activities can lead to undesirable changes in radar calibration. These issues give rise to errors which vary in time, both slowly, due to degradation of the radar system components, and rapidly, when the radar is recalibrated (deliberately or otherwise). Correction of these errors requires a coincident "truth" measurement to compare against. Previous work has demonstrated that measurements from the precipitation radar on board the Tropical Rainfall Measurement Mission (TRMM) satellite are suitable for this purpose. In this study, an existing method for comparing TRMM and ground-based radar measurements is used to quantify and correct historical calibration errors for four radars around Brisbane. Here, an overview of the method will be presented, together with results demonstrating the impact of the corrections on radar products such as accumulated rainfall. Future work will extend the analysis to other radars in the Australian network and explore the use of the Global Precipitation Mission (GPM) satellite for ongoing calibration checks to aid real-time radar applications such as severe storm and flood warnings.

Submission ID: 338
Presenting Author: Chermelle Engel*
Session Time: TUESDAY 12:15-12:30

Poster: Session 2, Poster #41

6

133-m high resolution ACCESS simulation of Black Saturday using the ENDGame dynamical core and ECWMF reanalysis initial conditions

ENGEL Chermelle[1]; LANE Todd[2]*

1) The University of Melbourne; 2) The University of Melbourne

In July 2014 the United Kingdom Meteorological Office changed the dynamical core of their Unified Model from New Dynamics to ENDGame. The change was then propagated to the Australian ACCESS model. In this poster we describe a one way nested 133-m ACCESS run (using the ENDGame dynamical core) on the day of the Black Saturday fires, using a ECMWF reanalysis as the initial conditions. We compare this run to that published earlier using the New Dynamics dynamical core and Unified Model version 7.5 initial conditions. Discussed are meteorological aspects of the runs and the importance of their initial conditions.

S5.2 Surface-Atmosphere Energetics Through Direct Observation – Lightning Lecture

Submission ID: 281
Presenting Author: Michael Gray*
Session Time: TUESDAY 12:15-12:30

Poster: Session 2, Poster #62

8

WRF simulations of the sub-tropical boundary layer in Southeast Queensland, initialised by observed surface-atmosphere energetics

GRAY Michael[1]; MCGOWAN Hamish[2]*

1) University of Queensland; 2) University of Queensland

Anecdotally, the sand islands off the coast of Southeast Queensland (SEQ) have sufficient influence on the local atmosphere to enhance convection in their immediate area, thereby influencing cloud, wind field dynamics and precipitation, but this has yet to be quantified. Therefore, the extent of the influence of the islands on the general atmosphere of the region, and consequently the impacts of changes in land use such as urban sprawl or establishment of large pine plantations on local and regional meteorology, are unknown.

Observational data of surface-atmosphere energetics, collected from three eddy-covariance units run over contrasting, vegetation types on Bribie Island for a time period of over 20 months from mid-2013 to early-2015, have been used to initialise the surface-layer boundary conditions in simulations of the local atmosphere using the Weather Research and Forecasting (WRF) model. Model output is compared to precipitation data from a network of rain gauges and automatic weather stations.

S5.4 Urban Climate – Lightning Lecture

Submission ID: 28
Presenting Author: Sarah Chapman*
Session Time: TUESDAY 12:15-12:30

Poster: Session 2, Poster #66

9

The impact of urbanization and climate change on urban temperatures and heat stress: A systematic review

CHAPMAN Sarah[*1]*

1) University of Queensland

Urban areas are where most of the world's population will be exposed to climate change. Given this, it is crucial to understand how climate change will affect the urban environment. The urban heat island (UHI) is one of the most extensively studied urban climate modifications, and recent research has found that it may change with a changing climate. The UHI is also strongly affected by urban form. As the urban footprint expands and increases in density, the effect of the UHI is likely to increase. We conducted a systematic review to identify how the UHI effect will change in the future due to climate change and urbanization. Of 1283 research articles that met the search criteria, 44 met the criteria for relevance. To be relevant, an article needed to include 1) the impact of urbanization or climate change on the urban heat island, and not the other way around, 2) a measure a change in the urban heat island intensity, and 3) it had to look at more than just historical changes in the urban heat island. Only four of these articles considered the interaction of the UHI and climate change, and only five articles considered the impact of increased heat stress on urban populations. The results of this review reveal a lack of studies that focus on the combined impact of urban growth and climate change on the future urban climate, with little research extended to the analysis of heat stress. Heat stress did not always respond the same as temperature. In humid regions, heat stress indices increased more than temperature. In some areas where urban and rural areas experienced the same temperature increase, urban areas still experienced a larger increase in the frequency of high-heat stress nights. This was attributed to the higher present-day temperatures in urban areas. The differing response of heat stress and temperature, particularly in humid regions, highlights the importance of considering heat stress specifically when examining health impacts.

Submission ID: 35
Presenting Author: Jessica Benthuysen*
Session Time: MONDAY 16:00-17:00

Poster: Session 1, Poster #2

1

Freshening events and hypersaline conditions in the Central Great Barrier Reef

BENTHUYSEN Jessica[1]; TONIN Hemerson[2]; HERZFELD Michael[3]*

1) Australian Institute of Marine Science; 2) Australian Institute of Marine Science; 3) CSIRO

In the Central Great Barrier Reef (GBR), seasonal changes in near-shore salinity are largely driven by rainfall and freshwater outflow from rivers. During the monsoonal wet season, river runoff leads to near-surface freshening, which can extend offshore and throughout the water column. During the dry season, evaporation over precipitation can cause near-shore waters to become hypersaline, a condition when coastal waters are more saline than oceanic waters. In recent years, rainfall extremes have occurred over Queensland. December 2010 was the wettest recorded month for Queensland, coinciding with a record high Southern Oscillation Index and a strong La Niña. In contrast, from spring 2014 through autumn 2015, rainfall over coastal regions along the Central GBR was very low to low from fraction of seasonal averages and included sites with record lowest autumn total rainfall. During these time periods, the changes in salinity are examined in CTD (conductivity-temperature-depth) cross-shelf transects and mid-shelf mooring data from the Yongala national reference station supported by the Integrated Marine Observing System. The CTD transects include periods when the near-shore waters are hypersaline early in the wet season and more fresh near the coast afterward. These observations are complemented by underway sampling from the RV Cape Ferguson, with hypersaline waters recorded in Cleveland Bay and Bowling Green Bay near Townsville. The mid-shelf mooring captures seasonal variations in salinity and the extreme near-surface freshening from the 2010-2011 Burdekin River fresh water plume. Numerical experiments using a state-of-the-art, regional hydrodynamic model are applied to determine how the river plumes impacted waters in the Central GBR during this anomalous wet season. Solutions with and without river outflow are contrasted to determine their impact on the shelf water's salinity field and circulation.

Submission ID: 258
Presenting Author: Ningning Zhang*
Session Time: MONDAY 16:00-17:00

Poster: Session 1, Poster #4

2

Seasonal and interannual variations of mixed layer salinity in the southeast tropical Indian Ocean

ZHANG Ningning[*1]

1) CSIRO, Perth

In this study, seasonal and interannual variations of the mixed layer salinity (MLS) in the southeast tropical Indian Ocean (SETIO) are analyzed using historical datasets and data-assimilating ocean model outputs. On the seasonal cycle, the MLS in the SETIO becomes fresher in austral winter and saltier in austral summer. Between the Java coast and the South Equatorial Current (12°S), the annual cycle of MLS closely follows the variation of air-sea freshwater flux. Between 12°S and the northwest coast of Australia, advection associated with the Indonesian throughflow (ITF) decreases the MLS by 0.2 psu in austral autumn; whereas excess evaporation over precipitation in spring increases the MLS. Off the west coast of Australia, the annual cycle of the MLS is less than 0.1 psu, and is largely associated with the variation of the Leeuwin Current (LC). Interannual variations of the MLS in the region are strongly influenced by ENSO cycle such that El Niño (La Niña) events are typically associated with saltier (fresher) MLS. Composite and budget analyses reveal that interannual variation in precipitations drives the MLS anomalies off the Java coast; whereas anomalous meridional currents mainly contribute to the salinity variation off the west coast of Australia. Between 12°S and the northwest coast of Australia, the MLS variations are influenced by both local precipitations and the ITF transport anomalies, so that enhanced local precipitations have substantial contributions to the drastic freshening of the Indonesian-Australian Basin/South Equatorial Current during the extended La Niña events in 1999-2001 and 2010-2012.

Submission ID: 64
Presenting Author: Rosalie Schultz*
Session Time: MONDAY 10:45-12:15

Poster: Session 1, Poster #29

1

Opportunities for northern Australian Indigenous land management practices to mitigate climate change and improve health

SCHULTZ Rosalie[1]; GREEN Donna[2]*

1) Climate Change Research Centre; 2) Centre for Climate Change Research

Opportunities for Australia to mitigate climate change include reducing emissions and storage of greenhouse gases. In the Northern Territory (NT), burning of savannah grasslands contributes approximately 25% of carbon emissions. This represents a significant opportunity for emissions reductions. Much of the area burnt is on Indigenous land, which makes up 50% of NT's land area.

A literature review was undertaken of Indigenous land management practices in northern Australia, and their impacts on carbon emissions, biodiversity and people's health. Literature was identified from diverse disciplines including anthropology, biomedicine, climate science, economics, environmental science, politics and sociology.

Indigenous land management practices include controlled burning of savannah grasslands, with an emphasis on burning early in the dry season. This creates a mosaic of patches burnt at different intervals. The controlled burning pattern enhances ecosystem integrity and reduces carbon emissions, compared with recent natural burning that can cover vast regions and typically occurs later in the dry season. Indigenous burning practices had ceased until recently, leading to much more extensive fires every year. This risks lives and property, reduces biodiversity and increases carbon emissions.

Transdisciplinary literature in this area shows that re-introduction of traditional burning and other land management practices under leadership of Indigenous people has multiple benefits. Indigenous people re-establish their authority and expertise, re-engage with their traditional country, benefit from carbon abatement funding, and improve their health and well-being. Combining Indigenous customary knowledge with scientific expertise, monitoring and equipment presents an opportunity for northern Australians to collaborate in sustainable development.

Submission ID: 185
Presenting Author: James Goldie*
Session Time: MONDAY 10:45-12:15

Poster: Session 1, Poster #27

2

Comparison of heat stress index fit to Sydney hospital admissions

GOLDIE James[*1]*

1) ARC Centre of Excellence for Climate System Science

Efforts to understand how human heat stress is affected by climate are hampered by a lack of consensus on the best way to model heat stress in an epidemiological context.

For this project, twelve years of Sydney hospital admission records for selected cardiovascular, respiratory and renal conditions were used to build a set of epidemiological models distinguished by their use of various heat stress indices. The indices used included heat-humidity indices, heatwave indices and direct aggregates of observable variables. The Akaike Information Criterion, a measure of goodness-of-fit, was calculated for each epidemiological model to determine which heat stress index provides the best fit to Sydney health data.

The analysis showed that daily temperature measures, which are popular among epidemiologists and easily understood by the public, are the poorest predictors of hospital admission counts. In contrast, Excess Heat Factor—a heatwave measure used operationally by the Bureau of Meteorology—is the best predictor, providing a better to Sydney admissions than daily weather data, heat-humidity indices and other heatwave indices. All heatwave indices outperformed other indices.

This success suggests that Excess Heat Factor may be a more suitable index for heat alerts and other heat-health policies than the indices used today.

S4.4 Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics – Lightning Lecture

Submission ID: 82
Presenting Author: Jennifer Fletcher*
Session Time: WEDNESDAY 13:45-15:30

Poster: Session 2, Poster #44

1

Cold air outbreaks' influence on Antarctic sea ice

FLETCHER Jennifer[1]; JAKOB Christian[2]*

1) Monash University; 2) Monash University

We examine a simple and important mechanism for month-to-month variability in sea ice growth and melt: cold air outbreaks. A robust correlation occurs between the frequency of occurrence of cold air outbreaks and the growth and melt of Antarctic sea ice. It is not surprising that sea ice makes cold air outbreaks possible, but we find that cold air outbreaks themselves strongly influence the growth rate of sea ice in turn.

Analysis of terms contributing to the sea surface temperature tendency indicates that this relationship is primarily due to heat loss from the ocean to the atmosphere through surface fluxes. On the short timescales over which cold air outbreaks occur, Ekman dynamics are insufficient to explain the subsequent sea ice growth.

We also find that the seasonal relationship between cold air outbreaks and the Southern Annular Mode (SAM) exhibits a similar pattern as that between the SAM and sea ice. Because the SAM varies on short (days to weeks) time scales as well as longer ones, this suggests that cold air outbreaks play a role in modulating the observed relationship between the SAM and sea ice, while Ekman transport likely dominates on longer timescales.

S4.7 Atmospheric Chemistry and Processes – Lightning Lecture

Submission ID: 303
Presenting Author: Jenny Fisher*
Session Time: WEDNESDAY 13:45-15:30

Poster: Session 2, Poster #51

1

Intercontinental and interhemispheric influences on Southern Hemisphere tropospheric composition

FISHER Jenny[1]; PATON-WALSH Clare[2]; ROULSTON Christopher[3]; BUCHHOLZ Rebecca[4]; GRIFFITH David[5]; DEUTSCHER Nicholas[6]; VELAZCO Voltaire[7]; ZENG Guang[8]; POLLARD David[9]; MURRAY Lee[10]; LIESCHKE Kaitlyn[11]*

1) University of Wollongong; 2) University of Wollongong; 3) University of Wollongong; 4) National Center for Atmospheric Research; 5) University of Wollongong; 6) University of Wollongong; 7) University of Wollongong; 8) National Institute of Water and Atmospheric Research; 9) National Institute of Water and Atmospheric Research; 10) Lamont-Doherty Earth Observatory; 11) University of Wollongong

Short-lived trace gas pollutants in the atmosphere play a critical role in regulating atmospheric composition, air quality and climate forcing. The sources of trace gases to the Southern Hemisphere troposphere differ greatly from their better-studied northern counterparts. Over regional to continental scales, much of the Southern Hemisphere is characterised by low anthropogenic emissions, high biogenic emissions, and episodically large influence from biomass burning emissions. In addition to local sources, emissions transported intercontinentally are known to exert a large influence. Meanwhile, the impact of anthropogenic emissions from the Northern Hemisphere is unclear: though large in magnitude, their influence is thought to be dampened by a "transport barrier" at the Intertropical Convergence Zone. Australia is uniquely placed to assess the potential influence of these different sources, with both geographical proximity and a well-established observational network. In this work, we use a combination of satellite data, ground-based measurements and a chemical transport model (GEOS-Chem) to quantify intercontinental and interhemispheric influences on Southern Hemisphere tropospheric composition. The model is constrained by multi-year, ground-based column and surface in situ measurements spanning a latitudinal gradient from 12-45°S. Outside of austral spring, we find diverse contributions to tropospheric composition, including consistent influence from biogenic emissions in South America and Africa and episodic influence from Asian anthropogenic emissions. Using IASI satellite CO observations, we define a chemical equator and show how temporal variability in its position affects interhemispheric influences on composition in tropical Australia. In this talk, these findings will be discussed along with their implications for policy-relevant background pollution amounts in Australia — and possible relevance to other Southern Hemisphere environments.

Submission ID: 126
Presenter: Jenny Fisher
Session Time: WEDNESDAY 13:45-15:30

Poster: Session 2, Poster #52

2

Clean air and urban landscapes — towards a Clean Air Plan for Western Sydney

MURPHY Clare[1]

1) University of Wollongong

The negative health impacts of airborne particulates on urban populations are now well established. Whilst the air quality in Australian cities is generally very good compared to many other parts of the world, Sydney experiences occasional poor air quality events that expose the population to heightened health risks. Health effects are also known to occur at air pollution concentrations that are within national air quality standards, meaning that health benefits can be realised through improving air quality even in regions with relatively low pollution levels. The population within the Sydney basin is predicted to grow by ~ 20% in the next decade, increasing both the local sources of pollution and the population exposed.

The Clean Air and Urban Landscapes hub has formulated a project to address this issue called the Western Air-Shed Particulate Study for Sydney (WASPSS). The project will provide the tools and evidence to develop a Clean Air Plan for Western Sydney. Research activities will be focussed around three main research aims, each with their own subproject:

(1) Extend air quality measurement/monitoring capacity to support improved characterisation of air quality in Western Sydney.
(2) Implement and validate state-of-the-science regional air quality modelling to assess major sources contributing to air pollution in Western Sydney and assess benefits arising from a range of possible mitigation measures.
(3) Evaluate existing methods applied internationally and locally for estimating human exposure to airborne pollutants, and estimate air pollution related exposures and health effects for Western Sydney.

The project will enable policy makers to estimate the benefits of different mitigation strategies to the future air quality in Western Sydney.

S4.7 Atmospheric Chemistry and Processes – Lightning Lecture

Submission ID: 131
Presenting Author: Kaitlyn Lieschke*
Session Time: WEDNESDAY 13:45-15:30

Poster: Session 2, Poster #54

3

Decadal-scale trends and variability in Australian atmospheric composition

LIESCHKE Kaitlyn[1]; FISHER Jenny[2]; MURPHY Clare[3]; JONES Nicholas[4]; GREENSLADE Jesse[5]; JONES Dylan[6]*

1) University of Wollongong; 2) University of Wollongong; 3) University of Wollongong; 4) University of Wollongong; 5) University of Wollongong; 6) University of Toronto

The atmosphere is vital to maintaining a habitable environment on Earth, and understanding its changing composition is important in terms of both air quality and climate. The ground-based solar Fourier Transform Infrared Spectrometer (FTIR) at the University of Wollongong provides a long-term record of atmospheric composition above Wollongong, NSW, Australia. The trends in the trace gases carbon monoxide (CO), hydrogen cyanide (HCN) and formaldehyde (HCHO) were calculated from 1997 to 2011 using these 15 year records and interpreted with simulations from the global atmospheric chemical transport model GEOS-Chem. A significant negative trend was calculated for HCN (-1.5%.yr^{-1}, 95% confidence interval -1.9 to -1.0%.yr^{-1}) of which the largest monthly trends occurred in December and January. This suggested a decrease in local biomass burning. HCN abundance showed an obvious impact from the 1997-98 ENSO event and the trend was not significant when these years were excluded. A significant positive trend was observed in HCHO (+2.1%.yr^{-1}, 95% confidence interval +1.0 to +3.6%.yr^{-1}) for which the largest monthly trends occurred in November and February. This may be caused by a temperature-driven increase in biogenic isoprene emissions. A significant negative trend was calculated for CO (-1.2%.yr^{-1}, 95% confidence interval -1.5 to -0.95%.yr^{-1}) with the largest monthly trend calculated in December and smaller significant trends in all other months. As the abundance of CO should be impacted by the highly seasonal biomass burning and biogenic emissions, the lack of obvious seasonal trends suggests an additional impact from decreasing anthropogenic emissions.

Submission ID: 191
Presenting Author: Matt Tully*
Session Time: WEDNESDAY 13:45-15:30

Poster: Session 2, Poster #55

4

Impact of approximations in the recommended Dobson algorithm on total column ozone measurements at four Australian sites

TULLY Matt[*1]*

1) Bureau of Meteorology

Observations of total column ozone made by the GAW network of Dobson spectrophotometers are processed with a standard algorithm, which uses a crude parameterised value of mean ozone height by latitude, and assumes a constant "effective ozone temperature" for all locations and times of year.

Here, daily ozone and temperature profiles from the MERRA reanalysis (Rienecker et al. 2011) are used to calculate the mean ozone height and effective ozone temperature at four long-standing Australian Dobson sites (Darwin, Brisbane, Melbourne/Airport and Macquarie Island) for each individual day from 1979 to 2014, also making use of the current state-of-the-art ozone cross-sections (Serdyuchenko et al. 2014), and the effect on the calculation of total column ozone investigated.

The effect on the calculated ozone of the annual cycle in temperature ranges from 2.5% at Macquarie Island to 0.5% at Darwin, but day to day variations can be twice this amount. The effect of the seasonal cycle in mean ozone height is negligible at Darwin but increases poleward, reaching 0.6% for measurements made two hours from local noon at Macquarie Island.

These results suggest the standard Dobson algorithm should be updated to incorporate reanalysis data in the ozone retrieval.

References:

Rienecker, M.M., M.J. Suarez, R. Gelaro, R. Todling, J. Bacmeister, E. Liu, M.G. Bosilovich, S.D. Schubert, L. Takacs, G.-K. Kim, S. Bloom, J. Chen, D. Collins, A. Conaty, A. da Silva, et al., MERRA: NASA's Modern-Era Retrospective Analysis for Research and Applications. J. Climate, 24, 3624-3648, doi:10.1175/JCLI-D-11-00015, 2011.

Serdyuchenko, A., Gorshelev, V., Weber, M., Chehade, W., and Burrows, J. P.: High spectral resolution ozone absorption cross-sections — Part 2: Temperature dependence, Atmos. Meas. Tech., 7, 625-636, doi:10.5194/amt-7-625-2014, 2014.

Submission ID: 328
Presenting Author: Sonya Fiddes*
Session Time: WEDNESDAY 13:45-15:30

Poster: Session 2, Poster #50

5

Synoptic weather evolution and climate drivers associated with winter air pollution in New Zealand

FIDDES Sonya[*1]*

1) University of Melbourne

Particulate matter (PM) pollution is a problem for some regional and urban centres across New Zealand during the winter period when solid fuel (wood and coal) fires are used for home heating. These exceedances of safe PM concentration thresholds occur during stable atmospheric conditions, when cool air temperatures and low wind speeds allow for a surface inversion to occur and trap PM. This study examined the relationships between PM and local and large-scale synoptic conditions at daily and seasonal scales. Minimum temperature and wind speed were both negatively correlated with PM during the winter season, whilst the combination of the two can explain 30-54% of variability in average PM10. Synoptic-scale daily composites of high PM days showed the evolution of an anticyclone in the Tasman Sea, with an injection of cool air over New Zealand and persistent south-westerly winds leading to cold and stable conditions on the day of exceedance. Both of these results indicate that there is some potential for predicting days in which atmospheric conditions could favour elevated PM concentrations. Furthermore, at the seasonal scale, weaker westerly winds were found to be associated with winters with higher exceedance days, although the relationship is not straightforward. These characteristics can be associated with other, predictable large-scale climate drivers such as the El Niño-Southern Oscillation, and may aid in identifying years in which a higher risk of PM pollution events exists.

Submission ID: 327
Presenting Author: Alex Holmes*
Session Time: TUESDAY 14:30-15:30

Poster: Session 2, Poster #64

1

Improving fire risk estimation through investigating fire intensity, moisture and temperature anomalies

HOLMES Alex[1]; RÜDIGER Christoph[2]; TAPPER Nigel[3]*

1) Monash University; 2) Monash University; 3) Monash University

Fire risk and fire intensity assessments are increasingly important in countries such as Australia, where extreme conditions are expected to increase in both intensity and frequency. It is postulated that in semi-arid regions such as south-eastern Australia, an increase in the soil moisture deficit will lead to a change in the energy balance (greater sensible heating), thus resulting in a temperature increase. This, coupled with a high fuel load and low vegetation moisture, provides ideal conditions for forest fires and is also likely to determine their intensity. However, there are few studies to date investigating the interaction between soil moisture, temperature, vegetation moisture and fire intensity. This study investigates this relationship in an observation-based dataset and modeled data in south-eastern Australia. A strong relationship between the number of hot days, the preceding soil moisture deficits, as expressed by the standardized precipitation index (SPI) and the antecedent precipitation index (API), and fire radiative power is found in south-eastern Australia.

S2.1 General Ocean Science – Poster

Submission ID: 117
Presenting Author: Prasanth Divakaran*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #1

1. Operational Ocean forecast inter-comparison for the Australian region

DIVAKARAN Prasanth[1]; BRASSINGTON Gary[2]; RYAN Andrew[3]; REGNIER Charly[4]; SPINDLER Todd[5]; MEHRA Avichal[6]; HERNANDEZ Fabrice[7]; GREGORY Smith[8]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) UK Met Office; 4) Mercator Ocean Toulouse France; 5) NOAA/NCEP Washington USA; 6) NOAA/NCEP Washington USA; 7) Institut de Recherche pour le Developpement (IRD) Toulouse France; 8) Environment Canada (EC) Dorvaln Canada

The study compares performance of short-range operational ocean forecasts, using 'observational-space' metrics developed under GODAE OceanView (GOV). This approach of comparing forecasts and observations taking place in observational space is seen as a departure from other diagnostic approaches such as analyzing model trends or innovation statistics. The physical parameters involved in the comparison are sea surface temperature (SST), sub-surface temperature, sub-surface salinity and sea level anomaly (SLA). In-situ drifting buoy SST observations used were obtained from USGODAE, sub-surface conditions were compared to Argo profiles, while SLA was measured by several satellite altimeters courtesy of AVISO. The five forecasting centers involved are Met Office, Australian Bureau of Meteorology, Mercator Ocean, Environment Canada and NOAA/NWS/NCEP. Best-estimate (behind the real-time analysis) and forecasts are inter-compared for the Australian region (0-50°S, 90-180°E) for 2015.

Submission ID: 35
Presenting Author: Jessica Benthuysen*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #2

2. Freshening events and hypersaline conditions in the Central Great Barrier Reef

BENTHUYSEN Jessica[1]; TONIN Hemerson[2]; HERZFELD Michael[3]*

1) Australian Institute of Marine Science; 2) Australian Institute of Marine Science; 3) CSIRO

In the Central Great Barrier Reef (GBR), seasonal changes in near-shore salinity are largely driven by rainfall and freshwater outflow from rivers. During the monsoonal wet season, river runoff leads to near-surface freshening, which can extend offshore and throughout the water column. During the dry season, evaporation over precipitation can cause near-shore waters to become hypersaline, a condition when coastal waters are more saline than oceanic waters. In recent years, rainfall extremes have occurred over Queensland. December 2010 was the wettest recorded month for Queensland, coinciding with a record high Southern Oscillation Index and a strong La Niña. In contrast, from spring 2014 through autumn 2015, rainfall over coastal regions along the Central GBR was very low to low from fraction of seasonal averages and included sites with record lowest autumn total rainfall. During these time periods, the changes in salinity are examined in CTD (conductivity-temperature-depth) cross-shelf transects and mid-shelf mooring data from the Yongala national reference station supported by the Integrated Marine Observing System. The CTD transects include periods when the near-shore waters are hypersaline early in the wet season and more fresh near the coast afterward. These observations are complemented by underway sampling from the RV Cape Ferguson, with hypersaline waters recorded in Cleveland Bay and Bowling Green Bay near Townsville. The mid-shelf mooring captures seasonal variations in salinity and the extreme near-surface freshening from the 2010-2011 Burdekin River fresh water plume. Numerical experiments using a state-of-the-art, regional hydrodynamic model are applied to determine how the river plumes impacted waters in the Central GBR during this anomalous wet season. Solutions with and without river outflow are contrasted to determine their impact on the shelf water's salinity field and circulation.

Submission ID: 323
Presenting Author: Neil Holbrook*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #3

3. Physical underpinnings of marine heat waves: Drivers and global patterns

HOLBROOK Neil[1]; SCANNELL Hillary[2]; BENTHUYSEN Jessica[3]; FENG Ming[4]; SEN GUPTA Alexander[5]; OLIVER Eric[6]; ALEXANDER Lisa[7]; BURROWS Michael[8]; DONAT Marcus[9]; HOBDAY Alistair[10]; MOORE Pippa[11]; PERKINS-KIRKPATRICK Sarah[12]; SMALE Dan[13]; STRAUB Sandra[14]; WERNBERG Thomas[15]*

1) University of Tasmania; 2) University of Washington; 3) Australian Institute of Marine Science; 4) CSIRO; 5) The University of New South Wales; 6) University of Tasmania; 7) The University of New South Wales; 8) Scottish Marine Institute; 9) The University of New South Wales; 10) CSIRO; 11) Aberystwyth University; 12) The University of New South Wales; 13) Marine Biological Association of the United Kingdom; 14) The University of Western Australia; 15) The University of Western Australia

Marine ecosystem health can be adversely affected by frequent, or persistent, extreme ocean temperatures. In particular, marine heatwaves (MHWs) are relatively rare ocean warming events that persist over an extended period of time (days to weeks) and can have devastating consequences for marine species. MHWs have recently occurred off Western Australia (2011), in the northwest Atlantic (2012), and the northeast Pacific (2014). Further, global patterns of MHWs suggest that their magnitude, timing and distribution may be driven by known modes of climate variability. Importantly, drivers represent a combination of both local and remote processes — with the remote, larger-scale processes offering the potential for MHW predictability. However, relative to atmospheric heatwaves over land, little is collectively known about MHWs, and there have been no comprehensive global studies undertaken to identify the physical drivers responsible for MHWs.

This study synthesises what is known about the climatic drivers and ocean-atmosphere processes that underpin MHW events. Our findings are based on a global meta-analysis of historical MHW events identified in the peer-reviewed literature since 1950, and collating MHW driver information within a framework that unifies our understanding. To achieve this, we classify the characteristic drivers and processes underpinning the identified events across regions and time scales, based on a recently developed hierarchical MHW framework (*), and a confidence assessment of the metainformation. Estimates of intensity and duration of these events were quantified through a unified analysis of the multi-decadal record of global satellite sea surface temperatures, using the MHW definition from the hierarchy — that is, five or more days with temperatures warmer than the 90th percentile, based on a 30-year historical baseline period.

*Hobday et al (2015) A hierarchical approach to defining marine heatwaves. Submitted to Prog Oceanogr.

Submission ID: 258
Presenting Author: Ningning Zhang*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #4

4. Seasonal and interannual variations of mixed layer salinity in the southeast tropical Indian Ocean

ZHANG Ningning[*1]

1) CSIRO, Perth

In this study, seasonal and interannual variations of the mixed layer salinity (MLS) in the southeast tropical Indian Ocean (SETIO) are analyzed using historical datasets and data-assimilating ocean model outputs. On the seasonal cycle, the MLS in the SETIO becomes fresher in austral winter and saltier in austral summer. Between the Java coast and the South Equatorial Current (12°S), the annual cycle of MLS closely follows the variation of air-sea freshwater flux. Between 12°S and the northwest coast of Australia, advection associated with the Indonesian throughflow (ITF) decreases the MLS by 0.2 psu in austral autumn; whereas excess evaporation over precipitation in spring increases the MLS. Off the west coast of Australia, the annual cycle of the MLS is less than 0.1 psu, and is largely associated with the variation of the Leeuwin Current (LC). Interannual variations of the MLS in the region are strongly influenced by ENSO cycle such that El Niño (La Niña) events are typically associated with saltier (fresher) MLS. Composite and budget analyses reveal that interannual variation in precipitations drives the MLS anomalies off the Java coast; whereas anomalous meridional currents mainly contribute to the salinity variation off the west coast of Australia. Between 12°S and the northwest coast of Australia, the MLS variations are influenced by both local precipitations and the ITF transport anomalies, so that enhanced local precipitations have substantial contributions to the drastic freshening of the Indonesian-Australian Basin/South Equatorial Current during the extended La Niña events in 1999-2001 and 2010-2012.

Submission ID: 20
Presenting Author: Qingxiang Liu*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #5

5. Wave climate of the Arctic Ocean as observed by altimeters

LIU Qingxiang[1]; BABANIN Alexander[2]; ZIEGER Stefan[3]*

1) Swinburne University of Technology; Ocean University of China; 2) Swinburne University of Technology; 3) Swinburne University of Technology

The downward trend of the Arctic sea ice is deemed to have been accelerated significantly since the last decade. Not only is the ice cover retreating rapidly, the ice thickness is also severely reduced, featuring a gradual transition from perennial multiyear ice to seasonal first-year ice. In the meantime, an earlier onset of summer melt together with a delay of autumn regrowth is also observed, leading up to an intensified shortening of ice persistence. The extensive loss of the Arctic ice enlarges the open-water area and consequently makes lager basin-scale fetch more possible for wave growth. Combining with the favouring atmospheric conditions, energetic wave events might be expected to emerge more frequently in Arctic marginal ice zone. Moreover, the emerging ocean waves, as a link between the atmospheric boundary layer and the upper ocean mixing layer, play a crucial role in momentum, energy, heat, gas and moisture fluxes exchange, indicating that the air-sea interaction in the Arctic enters a completely new regime. At the very beginning a detailed knowledge of wave climate in the Arctic Ocean is essential to investigate this broad scientific topic. Using observations from a consistent altimeter dataset, we will report the wave climate in the Arctic Ocean over the last two decades (1996-2014) as well as the wind climate over the open water area. As expected, in general wave height in the whole Arctic area shows a positive trend, e.g., for the Chukchi Sea and Beaufort Sea. While, for the Kara Sea and Barents Sea, a multi-year variability is obtained, that is, waves in these area increased slightly in the first decade but decreased in recent years.

S2.3 Advances in Modelling and Prediction of Coastal Oceanographic Processes – Poster

Submission ID: 124
Presenting Author: Qingxiang Liu*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #6

6. Calibration and validation of HY-2 altimeter wave height

LIU Qingxiang[1]; BABANIN Alexander[2]; GUAN Changlong[3]; ZIEGER Stefan[4]*

1) Swinburne University of Technology; 2) Swinburne University of Technology; 3) Ocean University of China; 4) Swinburne University of Technology

Wave height, observed by the altimeter on-board the China satellite HY-2, over the period from 1 October 2011 to 6 December 2014 is evaluated against in situ buoy and other simultaneously operated altimeters. In general, HY-2 altimeter agrees well with buoy, presenting a bias of -0.22 m and a RMSE of 0.30 m. The frequently used linear regression can considerably decrease the RMSE by 33% to 0.2 m. Further comparison with other altimeters, however, reveals two additional features of HY-2 measured waves. Firstly, a noticeable mismatch between HY-2 and other missions is present in high sea state (waves greater than 6 m). Secondly, a jump of HY-2 wave height performance occurring in April 2013 is detected, which is associated with the switch to backup status of HY-2 sensors and the subsequent update of data processing software. Although having been reported by previous studies, so far these two deficiencies have not been paid sufficient attentions. Given this, the duration of HY-2 wave height accounted in this paper is sub-divided into two phases, and a two-branched calibration is proposed for each phase, respectively. These revised calibrations, validated throughout the range 1-9 m, are expected to improve the practical applicability of HY-2 measured waves significantly, especially for studies on extreme weather.

Submission ID: 65
Presenting Author: Peter Baines*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #7

7. The effect of global dynamical factors on the interannual variability of global land-based rainfall

BAINES Peter[1]; HENLEY Benjamin[2]*

1) University of Melbourne; 2) Melbourne University

Rainfall is notoriously variable, even when seasonal means are taken. In part, this may be attributed to the fact that it is influenced by a variety of different dynamical factors. Some of these (such as El Niño/La Niña) are reasonably well known, but others with smaller but significant contributions have received relatively little attention, and these are explored here. We describe a study of the interannual variability of observed rainfall, and the dynamical factors that may influence it. The rainfall data involved cover the period from 1900 to present day, and include that compiled by the Universities of Delaware and East Anglia. Since rainfall is affected by different factors in different seasons, the analysis is seasonal, and a multiple regression analysis based on time series is performed to determine the effects on seasonal rainfall of ten factors that include the following: ENSO, global warming, the quasi-biennial oscillation (QBO), the Atlantic Meridional (or Multi-decadal) Oscillation, the Pacific Decadal Oscillation, the Indian Ocean dipole, the Southern Annular Mode (SAM), the solar cycle and global volcanism. Patterns of influence of these various factors on rainfall are obtained, which are indicative of (mostly, so far poorly understood) dynamical processes associated with these variations. However, a large fraction of the rainfall variance remains random and unpredictable.

Submission ID: 196
Presenting Author: Jennifer Catto*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #8

8. The effect of increased tropical sea surface temperatures on frontal precipitation

CATTO Jennifer[1]; SINCLAIR Victoria[2]*

1) Monash University; 2) University of Helsinki

Fronts are hugely important for precipitation in the midlatitudes. A warming climate may influence the precipitation associated with fronts in different ways. Increasing sea surface temperatures in the tropics may act to increase the moisture available for frontal precipitation in the midlatitudes leading to increased precipitation.

We have used two models — ACCESS and Open IFS — and performed two simulations using each: one with climatological sea surface temperatures, and one with tropical sea surface temperatures increased by 1 degree (decreasing via a sine function to climatology at 30 degrees North and South). Fronts have been identified using an objective identification method, and linked to the precipitation. The changes in frontal precipitation have been investigated by using a regime decomposition method. This allows us to determine the relative importance of the thermodynamic versus dynamic response to tropical heating.

Submission ID: 324
Presenting Author: Steefan Contractor*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #9

9. Application of gridded datasets of observed daily precipitation for the investigation of past rainfall variability over Australia and globally

CONTRACTOR Steefan[*1]*

1) UNSW Australia

Gridded datasets of observed daily precipitation are needed for investigating the variability of rainfall in the past. These datasets are important to validate model output which increases our confidence in future predictions, as well as comparison with palaeoclimate records in order to get a more complete understanding of climate sensitivity. Hence gridded datasets of observed daily precipitation help bridge the gap between the past and the future changes in precipitation; however, uncertainties related to these datasets are large. A case study of Australia is presented in which multiple existing and newly gridded datasets of observed daily precipitation are compared. These datasets include AWAP and six other datasets interpolated from in situ observations, as well as datasets that combine both remote sensed and in situ observations (TRMM 3B42 V7 and GPCP 1DD Version 1.2). We find that all precipitation grids have broadly similar climatologies and annual precipitation maxima, albeit regional differences exist. With regards to the day-to-day variability, our results indicate distinct structural uncertainties between those datasets gridding in situ observations and those datasets deriving precipitation primarily from satellite measurements. Structural uncertainties due to varying interpolation methods also exist albeit they are smaller. Finally substantial uncertainties also exist within precipitation extremes derived from the various datasets compared. We also present considerations for the construction of a global dataset of gridded daily precipitation for a global investigation of past precipitation variability.

Submission ID: 68
Presenting Author: Warwick Grace*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #10

10. Runs of extremes modelled using the stretched exponential distribution

GRACE Warwick[1]*

1) Grace Research

The stretched exponential distribution is shown to model the frequency and duration of runs of extreme days. Extreme days are regarded here as those days when the meteorological variable concerned exceeds an upper threshold, or fails to reach a lower threshold. Thresholds are of any chosen ranking percentile such as 95% for upper thresholds and 5% for lower thresholds, although absolute values such as 35°C or 5°C may be used.

The model requires only two parameters and these parameters are location-specific and independent of percentile of the threshold. The frequency and duration of runs of extreme hot days (heat waves) and runs of extreme cold days (cold spells) are investigated. Using the records of daily maximum and minimum temperatures in Australia and Europe, agreement between model and observations is shown to be good to very good.

Submission ID: 206
Presenting Author: Fan Jia*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #11

11. Global warming attenuates the tropical Atlantic-Pacific teleconnection

JIA Fan[1]*

1) CSIRO

Changes in global sea surface temperature (SST) since the end of last century display a pattern of widespread warming intercepted by cooling in the eastern equatorial Pacific and western coasts of the American continent. Studies have suggested that the cooling in the eastern equatorial Pacific may be partly induced by warming in the North Atlantic. However, it remains unknown how stable this inter-tropical teleconnection will be under global warming. Here we show that the inter-tropical teleconnection from the tropical Atlantic to Pacific weakens substantially as the CO2 concentration increases. This reduced impact is related to the El Niño-like warming of the tropical Pacific mean state, which leads to limited seasonal migration of the Pacific inter-tropical convergence zone (ITCZ) and weakened ocean heat transport. A fast decay of the tropical Atlantic SST anomalies in a warmer climate also contributes to the weakened teleconnection. Our study suggests that as greenhouse warming continues, the trend in the tropical Pacific as well as the development of ENSO will be less frequently interrupted by the Atlantic because of this attenuation. The weakened teleconnection is also supported by CMIP5 models, although only a few of these models can capture this inter-tropical teleconnection.

Submission ID: 312
Presenting Author: David Karoly*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #12

12. Evaluation of projected changes of temperature and rainfall in 2030 for some Australian cities using recent observed changes

KAROLY David[*1]*

1) University of Melbourne

CSIRO has been preparing climate change projections for the 21st century for Australia since 1992, including both short-term projections for temperature and rainfall changes in 2030 and longer term projections for the end of this century. More detailed projections were released by CSIRO and the Bureau of Meteorology in 2007 (CSIRO, 2007), based on the CMIP3 multi-model projections. The most recent climate change projections for Australia were released earlier this year (CSIRO and Bureau of Meteorology, 2015; www.climatechangeinaustralia.gov.au/en/), based on both the CMIP5 and CMIP3 multi-model projections. These reports include very little evaluation of the previous projections against observed climate changes even though two decades have now passed since the original projections and base periods used.

Here, a brief evaluation is presented of the projected climate changes in 2030 for several major cities in southern Australia (CSIRO, 2007; Webb and Hennessy, 2015) against the most recent observed decadal climate changes. This evaluation considers changes in annual mean temperature, the number of days above 35°C and seasonal mean rainfall.

The recent observed decadal changes in several variables, including the number of hot days and the winter rainfall, are at or above the median projected changes for 2030 already. This might be due to inadequate consideration of decadal variability in the projected changes or to underestimation of likely future climate change in these projections.

References:

CSIRO (2007), Climate Change in Australia — Technical Report 2007, CSIRO and Bureau of Meteorology, Australia. 148pp.

CSIRO and Bureau of Meteorology (2015) Climate Change in Australia Projections for Australia's NRM Regions: Technical Report, CSIRO and Bureau of Meteorology, Australia. 216pp.

Webb, L.B. and Hennessy, K. (2015) Climate Change in Australia: Projections for selected Australian cities, CSIRO and Bureau of Meteorology, Australia. 13pp.

Submission ID: 353
Presenting Author: Eun-Pa Lim*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #13

13. Interaction of the past 50 year SST trend and La Niña 2010: Amplification of the Southern Annular Mode and Australian springtime rainfall

LIM Eun-Pa[*1]*

1) Bureau of Meteorology

The tropical Indian, western Pacific and Atlantic Oceans have warmed more rapidly than the eastern Pacific in the past 50 years. The impact of this asymmetric warming trend on the anomalous Southern Hemisphere extratropical circulation and record-high Australian rainfall during the strong La Nina event of austral spring 2010 was investigated using the Australian Bureau of Meteorology coupled model seasonal forecast system (POAMA). In this study, we conducted four different forecast sensitivity experiments by initialising POAMA with 1) the ocean conditions of 1 September 2010 that contained well developed La Nina conditions; 2) the same ocean conditions but from which the temperature was detrended over the period 1960-2010; 3) the ocean conditions consisting of the temperature trend and the climatological conditions of 1 September 2010, and 4) the climatological ocean conditions of 1 September 2010. The results of experimental forecasts for September to November of 2010 highlight a synergistic response to the La Nina SST anomalies and the SST trend. The tropical rainfall anomalies were nonlinearly amplified, thereby promoting a stronger positive excursion of the Southern Annular Mode (SAM), thus enhancing the wet conditions over eastern Australia by upwards of 30%.

Submission ID: 329
Presenting Author: Alyce Sala Tenna*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #14

14. Current and future changes in forest fire danger indices for the southwest of Western Australia

SALA TENNA Alyce[1]; KALA Jatin[2]; ANDRYS Julia[3]; LYONS Thomas[4]*

1) Murdoch University; 2) Murdoch University; 3) Murdoch University; 4) Murdoch University

Bushfires have a significant impact on the southwest of Western Australia from a social, economic and environmental perspective. Therefore it is vital to have an understanding of the current and projected future changes of fire weather and fire danger to adapt an effective bushfire management strategy with climate change. The extent of fire weather changes is dependent on the region and climate, and outputs from regional climate model (RCM) simulations can be useful in gaining knowledge of these future changes. In this study, we will present an evaluation of the ability of the Weather Research and Foresting (WRF) model, a widely adopted RCM, in simulating McArthur's Forest Fire Danger Index (FFDI) (McArthur et al., 1967) in the southwest of Western Australia over the period 1981-2014, at a resolution of 5 km, driven by ERA-Interim re-analysis. Along with the FFDI we will show results of Mount's Soil Dryness Index and Drought Factor (Finkele et al., 2006) calculations to show comparisons against observationally derived products of these operational indices. This work will then be extended to examine current and future changes of the FFDI in the southwest of Western Australia using WRF simulations of current and future climate, driven by 4 different global climate models from the 3rd Coupled Model Intercomparison Project of the International Panel on Climate Change.

References:

Finkele, K., Mills, G.A., Beard, G., and Jones, D.A. (2006). National daily gridded soil moisture deficit and drought factors for use in prediction of Forest Fire Danger Index in Australia (Australian Bureau of Meteorology, Bushfire Cooperative Research Centre).

McArthur, A.G. (Alan G., Forestry, A., and Bureau, T. (1967). Fire behaviour in eucalypts forests (Canberra: Forestry and Timber Bureau).

S3.1 General Climatology – Poster

Submission ID: 24
Presenting Author: Blair Trewin*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #15

15. 1922-1938: Australia's forgotten drought

TREWIN Blair[1]; BETTIO Lynette[2]; EVANS Alex[3]; TIHEMA Tamika[4]*

1) Bureau of Meteorology; 2) Bureau of Meteorology; 3) Bureau of Meteorology; 4) Bureau of Meteorology

Long-term droughts, extending over a period of several years or more, have been a recurrent feature of Australia's climate, with the Federation Drought (1895-1903), the World War 2 Drought (1937-1945) and the Millennium Drought (1997-2009) as well-known examples.

The period from 1922 to 1938 lacks the profile of the aforementioned events despite sustained rainfall deficits over a length of time unmatched in the Australian instrumental climatic record. It was a period marked by a lack of El Niño or La Niña activity, with no moderate or strong events of either sign.

South Australian area-averaged rainfall was below the 1961-1990 normal in all 17 years from 1922 to 1938, with many individual locations reporting ten or more consecutive years of below-normal rainfall. Over western Queensland, annual rainfall totals comparable to those of the 2012-2015 drought were sustained over a decade or more.

It was the driest 17-year period on record over a large area of the eastern interior of Australia, covering most of northeast South Australia, the western third of Queensland, adjacent border areas of the Northern Territory, and the far northwest of New South Wales, with scattered areas of records also evident to the east and south of this region as far as central Queensland and the Eyre Peninsula. The most extreme rainfall deficits were in relatively sparsely populated regions. Few cropping areas had rainfall for the period in the lowest decile, except in northern New South Wales and the northern and western agricultural areas of South Australia, and the major coastal cities were largely unaffected.

A feature of the period, as with the Millennium Drought, was the lack of sustained heavy rainfall. The percentage of Australia with annual rainfall in the highest decile did not reach its climatological mean of 10 per cent in any of the 17 years, and Birdsville (where such events occur about once in four years on average) did not have a month in which rainfall reached 100 millimetres.

Submission ID: 26
Presenting Author: Blair Trewin*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #16

16. On the trends in Australian temperature extremes

FAWCETT Robert[1]; TREWIN Blair[2]*

1) Bureau of Meteorology; 2) Bureau of Meteorology

We compute a range of ETCCDI-inspired indices for summer-months maximum temperatures and winter-months minimum temperatures across the last 50 years (1965/66—2014/15 for summer, 1966—2015 for winter), using the Bureau of Meteorology's ACORN-SAT low-resolution (0.25°) daily maximum and minimum temperature anomaly analyses (base period 1961-1990). To convert these into actual temperatures, we use the Bureau's whole-network monthly temperature analyses to provide 1961-1990 climatological means.

For each season and temperature variable, we compute the seasonal mean, highest and daily values, the highest n-daily value (for which the n consecutive days are at or above this value) for n = 2 to 7, and the corresponding lowest n-daily values. This yields 15 indices covering the most extreme warm and cool spells up to seven days in length, at each grid point. National averages are then computed, providing 50-year time series. These time series, along with their linear trends, provide the basis for the results reported below.

Summer maximum temperatures have been rising at a rate of 0.12°C/decade, but the locally highest summer day temperature has been rising at a much higher rate of 0.17°C/decade, while the locally highest summer two-day temperature has been rising at a marginally lower rate. In contrast the locally lowest summer day temperature has a rather lower trend of 0.07°C/decade.

Winter minimum temperatures have been rising at a rate of 0.11°C/decade (i.e., slightly below the summer maximum temperature rate of 0.12°C/decade), but the locally highest winter night temperature has been rising at a much higher rate of 0.17°C/decade, while the locally highest two-night temperature has been rising a rate of 0.15°C/decade. The locally lowest winter night temperature has been rising at a rate of 0.13°C/decade, slightly more than the mean rate.

Analogous calculations based on the ACORN-SAT anomaly analyses alone yield fairly similar results.

Submission ID: 188
Presenting Author: Karuru Wamahiu*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #17

17. A quantification of the added value of bias correcting global climate models prior to use as boundary conditions for regional climate model simulations over Australia

WAMAHIU Karuru[1]*

1) Murdoch University

Global Climate Models (GCMs) are increasingly being used as boundary conditions to drive Regional Climate Models (RCMs). However, all GMCs suffer from some form of bias, which may impact the RCM simulation severely, especially in the simulation of climate extremes. One approach to overcome this issue is to bias-correct the GCM outputs prior to use in driving the RCM. In this study we investigate the effectiveness of a bias-correction technique proposed by Bruyere et al. (2014) in reducing simulation errors for regional climate simulations over Australia at a 50 km resolution, using the CORDEX-Australia domain. Simulations are carried out using the CCSM4 GCM outputs as input to the Weather Research and Forecasting (WRF) model, widely adopted RCM, over a 10 year period during the historical period. Simulations are carried out with bias-corrected and non bias-corrected CCSM4 outputs and the analysis focus on the representation of both mean and extreme indices of climate.

Reference:

Bruyere, C. L., Done, J. M., Holland G. J., and Fredrick, S. (2014) Bias corrections of global models for regional climate simulations of high-impact weather. Clim. Dyn., 43: 1847-1856.

Submission ID: 357
Presenting Author: Louise Wilson*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #18

18. Projections of regional Australian rainfall extremes from CMIP5 models

WILSON Louise[1]; RAFTER Tony[2]*

1) CSIRO; 2) CSIRO Oceans & Atmosphere Flagship

Extreme rainfall events have a major impact on the Australian environment and society. From a risk assessment and impact planning perspective, knowledge of the potential changes in the magnitude and frequency of these events is extremely valuable.

Here we present mid- and late-21st century projections of daily rainfall extremes from CMIP5 models under emission pathways RCP4.5 and RCP8.5 for regions of Australia. We examine annual maxima of daily rainfall and derive 20-year return levels using extreme value theory, with distribution parameters of a Generalised Extreme Value (GEV) model fitted to data using the method of L-moments.

By late in the 21st century annual maxima and 20-year return levels of one-day rainfall amounts are projected to increase significantly for almost all of the Australian continent. The magnitude of the projected changes are found to be strongly dependent on the emissions pathway providing the climate forcing. Changes also vary spatially with some areas of the continent showing notably larger changes than others.

Further regional differences in our projections are discussed, as are the differences between the climate response of rainfall extremes against that of mean rainfall, with extremes projected to increase even in regions where mean rainfall declines.

Submission ID: 282
Presenting Author: Duncan Ackerley*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #19

19. Evaluating mid-Holocene precipitation over Australasia and the Maritime Continent in climate models

ACKERLEY Duncan[*1]*

1) Monash University

This work presents the initial assessment of model simulations of the mid-Holocene over the Australasian and Maritime Continents (taken from the Paleoclimate Modelling Intercomparison Project, PMIP) in relation to those available data. The mid-Holocene (6 ka) encompasses a period after sea level stabilisation (around 8-7.5 ka) and before the onset of strong ENSO-related variability (post 4 ka). There is some evidence of possibly drier conditions over northern Australia with increased coastal dune activity, along with slightly wetter conditions over Borneo and Papua New Guinea. Weakening of the Southern Hemisphere mid-latitude westerlies (relative to the early Holocene) is also likely to have occurred, as evidenced by drier conditions in Western Tasmania and Victoria. The modelled results from the mid-Holocene simulations indicate that conditions were approximately 1-6% drier over much of continental Australia than at present. There is also evidence of slightly wetter conditions (1-3%) over the northern tip of Australia and parts of Papua New Guinea and Borneo. There are also differences in the seasonal cycle of precipitation and circulation in these models in response to the changes in the orbital parameters in the mid-Holocene relative to present day. The precipitation in the early half of the monsoon season (October, November and December—OND) is typically 10% higher in the mid-Holocene simulations. Conversely, the precipitation is typically more than 10% lower in the late half of the monsoon period (January, February and March—JFM). The increase in OND precipitation and decrease in JFM implies that the monsoon onset and retreat may have been earlier than at present (in response to the insolation forcing), and therefore it is important to assess the changes over the whole monsoon period (October to March) instead of just the summer months (December, January and February).

S3.2 Past Climate Reconstruction and Modelling – Poster

Submission ID: 80
Presenting Author: Kathryn Allen*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #20

20. Three 292-year winter dam inflow reconstructions for Tasmania, southeastern Australia

ALLEN Kathryn[*1]; NICHOLS Scott[2]; EVANS Robert[3]; ALLIE Stuart[4]; CARSON Greg[5]; LING Fiona[6]; COOK Ed[7]; BAKER Patrick[8]*

1) University of Melbourne; 2) University of Melbourne; 3) Silviscan Pty Ltd; 4) Hydro Tasmania; 5) Hydro Tasmania; 6) Entura; 7) Lamont-Doherty Observatory; 8) University of Melbourne

Changes in in seasonal precipitation, and the seasonal distribution of precipitation, have been projected for southeastern Australia. However, in order to better contexturalise past changes, long seasonal hydroclimatic records extending back before the arrival of the First Fleet in 1788 are required. Here we present the first cool-season (July — August) hydroclimatic reconstructions for western Tasmania, southeastern Australia. Recent July-August conditions are well within the natural variability for the past ~ 300 years. Overall, wettest winters occurred prior to1850 while driest winters have occurred since 1850. Relatively low inflow periods occurred around 1860, the early 1900s and 1970, while relatively high inflows occurred in the 1770s and 1810s. Highest inflows to all three catchments occurred in 1816. These winter reconstructions complement a previous warm season (December — January) hydrological reconstruction for the same region and confirm that conditions in one season have not necessarily reflected conditions in the other over the past ~ 300 years. The difference between these seasonal reconstructions illustrates the value of obtaining reconstructions of regional hydroclimatic variability for individual seasons, if at all possible. Superposed epoch analysis suggests that PC1 of the July-August inflow reconstructions may contain a volcanic eruption signature.

Submission ID: NA
Presenting Author: Michael-Shawn Fletcher*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #21

21. Hemisphere-wide fire and hydroclimatic trends over the last 2400 years reveal centennial-scale trends in the Southern Annular Mode

FLETCHER Michael-Shawn[*1]*

1) University of Melbourne

The Southern Hemisphere westerly winds (SWW) are an important component of the global climate system, driving hemispheric-scale trends in climate, terrestrial ecosystem processes and fire activity, oceanic upwelling and biogeochemical cycling, as well as modulating global atmospheric CO2 concentration, dust fluxes and thermoclimate. Currently, the SWW are shifting southward and strengthening over the Southern Ocean in response to stratospheric ozone depletion. This shift is associated with a positive trend in the Southern Annular Mode (SAM), the primary mode of atmospheric variability in the extra-tropics of the Southern Hemisphere, and has the potential to amplify the effects of anthropogenic climate change via degassing of CO2 from the Southern Ocean. This potentiality has serious ramifications across a range of natural systems. Critically, considerable uncertainty exists over how this SAM trend will further impact Southern Hemisphere climates in the coming decades and there is an urgent need for longer-term proxy data on SWW and SAM dynamics. Here we show synchronous trends between sites located within Nothofagus/Podocarpaceae forest in Chile and Tasmania over the past 2400 years. The hydroclimate of both sites is almost entirely dependent on the SWW and we reveal hemisphere-wide centennial-scale SAM-like shifts of the SWW throughout this time. We compare our results with other SWW proxy data and reveal a persistent coupling between SWW dynamics and atmospheric CO2 concentration through the past 2400 years. The pervasiveness of the SWW influence across a range of natural systems highlights the need to account for SWW variability in models that predict the impacts of global climate change.

S3.2 Past Climate Reconstruction and Modelling – Poster

Submission ID: 155
Presenting Author: Ailie Gallant*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #22

22. Can we use 20th Century climate reanalysis products to support Antarctic ice core interpretation?

GALLANT Ailie[1]; DURAN Earl[2]; VANCE Tessa[3]; ROBERTS Jason[4]*

1) School of Earth Atmosphere and Environment, Monash University; 2) University of Tasmania; 3) University of Tasmania; 4) Australian Antarctic Division

Ice cores are useful proxies for interpreting past climate, particularly for those areas where instrumental data are short and/or scarce, such as Antarctica. However, ice core proxies cannot be used in complete isolation and interpretation of proxy data is often complemented by an examination of the climate through instrumental observations or reanalysis data. In Antarctica, much of the instrumental data, including reliable reanalysis data, is limited to the post-satellite era (~post-1978). This poses problems when decadal-to-multidecadal scale features are being examined.

Recently, several reanalysis products have become available that assimilate only surface measurements, thereby extending reanalyses throughout the 20th Century. This extension helps with the interpretation of ice core proxies for decadal-to-multidecadal scale features, but is reliant on the skill of these reanalysis products over Antarctica, which we test here for the first time.

This study examines the skill of one of the newer 20th Century reanalysis data sets, the ERA-20C by comparing it to radiosonde measurements of temperature, geopotential height, wind speed and direction over Antarctic stations from 1957—2010. The radiosonde data provides an independent comparison as only surface measurements have been assimilated into the ERA-20C reanalysis. The results demonstrate variation in skill with meteorological variable, with season and over time, which are attributable to a number of factors.

Submission ID: 234
Presenting Author: Julie Arblaster*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #23

23. Decadal variability in global temperatures and Antarctic sea ice extent

ARBLASTER Julie[*1]*

1) Bureau of Meteorology

A recent slowdown in global temperature rise has prompted many studies on decadal variability in the climate system. After rising rapidly through the 1980s and 1990s, global temperatures showed weaker warming since around 2000. Around the same time a transition was seen in the major mode of decadal variability in the tropical Pacific — the Interdecadal Pacific Oscillation (IPO) — to its negative phase. This produced cooler sea surface temperatures and associated negative overlying rainfall and convective heating anomalies in the equatorial Pacific . This transition of the IPO coincided with an intensification of the Amundson Sea Low near Antarctica and an acceleration of the increasing trend in average Antarctic sea ice extent.

Understanding these observed changes hinges on answering the compelling question of how naturally occurring decadal variability combines with the response to increasing greenhouse gases to produce the time evolution of the climate system. Here we use global coupled climate models to investigate this interplay between internally generated decadal variability and scenarios of anthropogenic climate change. We show that the atmospheric teleconnections from the negative phase of the IPO in these models is characterised by anomalies similar to the observed recent sea level pressure and surface wind changes near Antarctica that are conducive to expanding average Antarctic sea ice extent, particularly in the Ross Sea region in winter. These atmospheric circulation changes are linked to precipitation and convective heating anomalies in the tropical Pacific originating from internally-generated decadal variations of the IPO. Thus the recent accelerated increase in Antarctic sea ice extent has a significant contribution from tropical Pacific decadal climate variability. Based on these results and others, predictions of future changes in global temperatures and Antarctic sea-ice extent are made.

Submission ID: 209
Presenting Author: Andrea Dittus*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #24

24. Investigating the role of sea-surface temperatures in driving temperature and rainfall extremes globally and in Australia

DITTUS Andrea[1]; KAROLY David[2]; LEWIS Sophie[3]; ALEXANDER Lisa[4]*

1) University of Melbourne; 2) University of Melbourne; 3) Australian National University; 4) University of New South Wales

The role of sea-surface temperature (SST) variations and El Niño-Southern Oscillation on temperature and rainfall extremes is investigated, using atmospheric simulations from the Australian Community Climate Earth System Simulator driven by observed SSTs over the period 1960-2013. At the global scale and in Australia, we estimate the fraction of variance explained by SST forcing on different types of extremes such as the hottest day of the year or the number of days above the 90th percentile, extreme 5-day precipitation and other indices of extremes. These simulations contribute to the international Climate of the Twentieth Century project. In this presentation we demonstrate the utility of these atmospheric simulations in gaining a better understanding of how much the variations of climate extremes are due to SST variations or due to chaotic internal variability.

S3.3 Indo-Pacific Variability: Teleconnections and Impacts from Interannual to Centennial Scales – Poster

Submission ID: 200
Presenting Author: Ziguang Li*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #25

25. Dynamics of changing impacts of tropical Indo-Pacific variability on Indian and Australian rainfall

LI Ziguang[*1]

1) CSIRO Oceans and Atmosphere Flagship

A positive Indian Ocean Dipole (IOD) and a warm phase of the El Niño-Southern Southern Oscillation (ENSO) reduce rainfall over the Indian subcontinent and southern Australia. Since 1980s, El Niño's influence has been decreasing, accompanied by a strengthening in the IOD's influence on southern Australia but a reversal in the IOD's influence on the Indian subcontinent. The dynamics are not fully understood. Here we show that a post-1980 weakening in the ENSO-IOD coherence plays a key role. During the pre-1980 high coherence, ENSO's influence dominates the IOD and the rainfall impact. During the post-1980 weak coherence, a positive IOD actually leads to increased Indian rainfall, offsetting the impact from El Niño. The post-1980 weak coherence means that the El Niño's pathway for influencing southern Australia cannot fully operate, and as the positive IOD becomes more independent and more frequent during this period, its influence on southern Australia rainfall strengthens. Possible impacts from greenhouse warming are discussed.

Submission ID: 239
Presenting Author: Asha Vijayeta*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #26

26. ENSO-dynamics in CMIP5 simulations in the framework of the linear recharge oscillator model

VIJAYETA Asha[*1]*

1) Monash University

ENSO-dynamics in CMIP5 simulations show a wide spread of uncertainties in ENSO statistics. In this study we use the concept of the linear recharge oscillator model to diagnose the ENSO-dynamics in all CMIP5 model simulations. The parameters allow to quantify damping, growth rate, coupling to thermocline, sensitivity to wind and heat forcings , and allow to separate atmospheric from oceanic processes. Our results illustrates that the ENSO-dynamics and their diversity within the CMIP5ensemble can be well represented with the linear recharge oscillator model diagnostics. The results illustrate that individual processes show larger biases to observation and spread within the model than simple large-scale statistics such as SST standard deviation.

Submission ID: 185
Presenting Author: James Goldie*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #27

27. Comparison of heat stress index fit to Sydney hospital admissions

GOLDIE James[*1]*

1) ARC Centre of Excellence for Climate System Science

Efforts to understand how human heat stress is affected by climate are hampered by a lack of consensus on the best way to model heat stress in an epidemiological context.

For this project, twelve years of Sydney hospital admission records for selected cardiovascular, respiratory and renal conditions were used to build a set of epidemiological models distinguished by their use of various heat stress indices. The indices used included heat-humidity indices, heatwave indices and direct aggregates of observable variables. The Akaike Information Criterion, a measure of goodness-of-fit, was calculated for each epidemiological model to determine which heat stress index provides the best fit to Sydney health data.

The analysis showed that daily temperature measures, which are popular among epidemiologists and easily understood by the public, are the poorest predictors of hospital admission counts. In contrast, Excess Heat Factor—a heatwave measure used operationally by the Bureau of Meteorology—is the best predictor, providing a better to Sydney admissions than daily weather data, heat-humidity indices and other heatwave indices. All heatwave indices outperformed other indices.

This success suggests that Excess Heat Factor may be a more suitable index for heat alerts and other heat-health policies than the indices used today.

Submission ID: 210
Presenting Author: Marissa Parry*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #28

28. The impact of extreme heat on morbidity in Sydney, Australia: Exploring the Importance of Definitions

PARRY Marissa[*1]*

1) University of New South Wales

Climate change is expected to result in an increase in the number of extremely hot days and warm nights. This is of particular concern for human health as several studies have shown that single days of extreme heat are associated with significant short-term increases in mortality and morbidity. Despite this well-established association, there is no consistent approach to defining a hot day or warm night in public health studies. As a result, previous studies have used a variety of temperature metrics and thresholds to define such days and nights. The importance of adopting a consistent approach to definitions of temperature extremes in public health studies is beginning to emerge with a few studies showing that the choice of definition can substantially affect the association between heat exposure and health outcomes. However, this evidence has primarily emerged from the northern hemisphere, and the importance of defining temperature extremes in the Australian context has received very little attention. Therefore, this study examined whether the definition of a single day of extreme heat can affect the association between heat exposure and morbidity, specifically hospital admissions, in Greater Metropolitan Sydney for the period of 2001-2013. A time-stratified case-crossover study design was used with conditional logistic regression, controlling for the confounding effects of day of the week, public holidays, relative humidity and air pollution. Preliminary results suggest that the definition of a single day of extreme does substantially affect the association between heat exposure and morbidity with the magnitude of most associations altering depending on the temperature metric and threshold used. The importance of developing a consistent approach to temperature extremes is vital to developing appropriate heat-health warning systems to reduce the public health burden from extreme heat.

Submission ID: 64
Presenting Author: Rosalie Schultz*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #29

29. Opportunities for northern Australian Indigenous land management practices to mitigate climate change and improve health

SCHULTZ Rosalie[1]; GREEN Donna[2]*

1) Climate Change Research Centre; 2) Centre for Climate Change Research

Opportunities for Australia to mitigate climate change include reducing emissions and storage of greenhouse gases. In the Northern Territory (NT), burning of savannah grasslands contributes approximately 25% of carbon emissions. This represents a significant opportunity for emissions reductions. Much of the area burnt is on Indigenous land, which makes up 50% of NT's land area.

A literature review was undertaken of Indigenous land management practices in northern Australia, and their impacts on carbon emissions, biodiversity and people's health. Literature was identified from diverse disciplines including anthropology, biomedicine, climate science, economics, environmental science, politics and sociology.

Indigenous land management practices include controlled burning of savannah grasslands, with an emphasis on burning early in the dry season. This creates a mosaic of patches burnt at different intervals. The controlled burning pattern enhances ecosystem integrity and reduces carbon emissions, compared with recent natural burning that can cover vast regions and typically occurs later in the dry season. Indigenous burning practices had ceased until recently, leading to much more extensive fires every year. This risks lives and property, reduces biodiversity and increases carbon emissions.

Transdisciplinary literature in this area shows that re-introduction of traditional burning and other land management practices under leadership of Indigenous people has multiple benefits. Indigenous people re-establish their authority and expertise, re-engage with their traditional country, benefit from carbon abatement funding, and improve their health and well-being. Combining Indigenous customary knowledge with scientific expertise, monitoring and equipment presents an opportunity for northern Australians to collaborate in sustainable development.

Submission ID: 63
Presenting Author: Rosalie Schultz*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #30

30. Differential effects of temperature extremes on hospital admission rates for respiratory disease between Indigenous and non-Indigenous Australians

GREEN Donna[1]; BAMBRICK Hilary[2]; SCHULTZ Rosalie[3]; TAIT Peter[4]; GOLDIE James[5]; WEBB Leanne[6]; ALEXANDER Lisa[7]; PITMAN Andrew[8]*

1) Climate Change Research Centre; 2) Centre for Health Research; 3) Climate Change Research Centre; 4) Public Health Association of Australia; 5) Climate Change Research Centre; 6) Climate Change Reseach Centre; 7) Centre for Climate Change Research; 8) Centre for Climate Change Research

Indigenous Australians suffer considerably worse health than non-Indigenous Australians. This gap may be exacerbated by climate change if temperature extremes have disproportionate adverse effects on Indigenous people. We analysed the effect of temperature extremes on hospital admissions for respiratory diseases, stratified by age, Indigenous status and gender, for people living in two different climates zones in the Northern Territory during the period 1993-2011. We examined admissions for both acute and chronic respiratory diagnoses, controlling for day of the week and seasonality variables. Our analysis showed that: (1) overall, Indigenous hospital admission rates far exceeded non-Indigenous admission rates for acute and chronic respiratory diagnoses, and Top End climate zone admission rates exceeded Central Australia climate zone admission rates; (2) extreme cold and hot temperatures were associated with inconsistent changes in admission rates for acute respiratory disease in Indigenous and non-Indigenous children and older adults; and (3) no response to cold or hot temperature extremes was found for chronic respiratory diagnoses. Extreme hot and cold temperatures have different effects on hospitalisations for respiratory disease between Indigenous and non-Indigenous people; and effects vary between the different climate zones. We did not, however, find that there were differing responses to temperature extremes in the two populations, suggesting that any increased vulnerability to climate change in the Indigenous population of the Northern Territory arises from an increased underlying risk to respiratory disease and an already greater existing disease burden. On-going efforts to support improvements in livelihood and health of Australia's indigenous people are needed. The risks that effects of climate change on health will increase inequity should be addressed.

Submission ID: 322
Presenting Author: Simon Marsland*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #31

31. CMIP6: The Coupled Model Intercomparison Project - Phase 6

MARSLAND Simon[1]; HIRST Anthony[2]*

1) CSIRO Oceans and Atmosphere; 2) CSIRO Oceans and Atmosphere

The World Climate Research Programme Working Group on Coupled Modeling (WGCM) promotes coordination of global climate model experimentation to understand natural climate variability and predictability on decadal to centennial time scales, and predict climate system response to changes in natural and anthropogenic forcing. Since 1995 WGCM and the CMIP Panel have coordinated the Coupled Model Intercomparison Project (CMIP). Analysis of CMIP models underpins the projection of future climate assessed by the Intergovernmental Panel on Climate Change (IPCC), and is of intense scientific and societal interest.

For the IPCC Assessment Report 6 a new phase of model experimentation (CMIP6) is underway. The CMIP6 design focuses on three broad scientific questions: How does the Earth System respond to forcing? What are the origins and consequences of systematic model biases? How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios? The entry level for CMIP6 submission is 5 core experiments: the Atmospheric Model Intercomparison Project (1979-2014); a 500 year pre-industrial control simulation; a 1%/year compounding atmospheric CO_2 increase simulation; a century scale abrupt $4xCO_2$ simulation; and an historical simulation using atmospheric forcings for the period 1850-2014.

Modelling groups are also invited to contribute to a further 21 CMIP6 endorsed Model Intercomparison Projects (MIPs). The MIPs each focus on development and performance of components of the models (atmosphere, land, ocean, cryosphere, chemistry, biogeochemistry, etc.), and the climate system (carbon cycling, decadal predictability, radiative and volcanic forcing, cloud feedbacks, detection and attribution, etc.). A key MIP for future impacts assessment is the ScenarioMIP which focuses on projection of the full climate system under a range of possible future emission scenarios over the coming century. We give an overview of the current status of CMIP6.

Submission ID: 205
Presenting Author: Martin Tingley*
Session: Posters 1
Session Time: TUESDAY 15:30-16:30
Poster #32

32. Tropical cyclone wind profiles: analytic models, numerical simulations, and the role of topography

TINGLEY Martin[*1]; BRUYERE Cindy[2]; BUCKLEY Bruce[3]; HOLLAND Greg[4]; CHAN Peter[5]; DYER Andrew[6]; LEPLASTRIER Mark[7]*

1) Insurance Australia Group; 2) NCAR; 3) Insurance Australia Group; 4) NCAR; 5) Insurance Australia Group; 6) Insurance Australia Group; 7) Insurance Australia Group

Analytic wind profiles are frequently used to model wind swaths from tropical cyclone tracks, often linked with boundary-layer models to account for translational speed and friction. Applications include risk assessments from vendor catastrophe models (e.g., AIR and RMS) used by the (re)insurance industry, and near real-time damage estimations for land falling cyclones. These analytic profile models do not account for localized wind effects, including those caused by topography and roughness, that are well-understood from first-principles and evident in post-cyclone damage surveys.

Here we quantify differences between wind fields estimated from cyclone track data in conjunction with standard analytic wind profile and boundary layer models, and wind fields from synthetic storms produced by NCAR's current implementation of WRF, optimised for simulation of tropical cyclones in the Queensland region of Australia. We focus on an ensemble of synthetic storms that make landfall near the cyclone-prone city of Townsville, in north Queensland. The storms feature different genesis locations, steering flow speeds, intensities, underlying sea surface temperatures, and grid resolutions of either 12, 4, or 1.33km.

Differences between the wind fields estimated using the different modelling resolutions, and between the wind fields from the synthetic storms and those estimates from analytic wind profiles, confirm the importance of topography in determining local-scale features of the wind field. A regression model is developed that predicts the high-resolution, synthetic wind field from the analytic wind profile and geographic variables including elevation, slope, and slope aspect. The performance of the statistical predictions is assessed using out-of-sample synthetic storms. These results provide a computationally efficient recipe for improving upon analytic predictions of wind profiles, and are immediately relevant to risk and impact assessment in cyclone-prone regions.

Submission ID: 133
Presenting Author: Francisco Lang*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #33

33. Understanding the structure of the Southern Ocean atmospheric boundary layer in response to synoptic forcing

LANG Francisco[1]; SIEMS Steven[2]; HUANG Yi[3];* BELUŠIĆ *Danijel[4]; MANTON Michael[5]*

1) Monash University; 2) Monash University; 3) Monash University; 4) Monash University; 5) Monash University

In-situ observations of the thermodynamic structure of atmospheric boundary layer over the Southern Ocean have commonly found that a complex, multi-level structure is present beneath the free troposphere. Russell et al. (1998) coined the term'buffer layer' based on observations from the first Aerosol Characterization Experiment (ACE-1). Hande et al. (2012) examined 16 years of high-resolution soundings from Macquarie Island, finding not only the frequent occurrence of a buffer layer (33.7%), but also the inability of the high resolution reanalysis to produce such a structure (2.2%). Using A-train observations of boundary layer clouds, Huang et al (2015) highlighted that the boundary layer over the Southern Ocean was distinctly shallower than that over the North Atlantic.

In this research we explore the structure of the boundary layer over the Southern Ocean in relation to the synoptic meteorology. Cyclones and fronts identified in the reanalysis are employed to classify the Macquarie Island soundings. Specific focus is paid to the post-frontal boundary layer that has been linked to the large bias observed in the reflected shortwave radiation over the Southern Ocean.

Submission ID: 86
Presenting Author: Damian Murphy*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #34

34. Gravity wave momentum fluxes above and around Macquarie Island using ACCESS modelling

MURPHY Damian[1]; ROFF Greg[2]; SATO Kaoru[3]*

1) Australian Antarctic Division; 2) Bureau of Meteorology, Australia; 3) University of Tokyo

Missing gravity wave drag near 60 degrees south has been proposed as the cause of the common cold bias in modelled southern polar stratospheric temperatures [McLandress et al. 2012]. Potential gravity wave momentum sources around those latitudes, such as jets, fronts and orographic waves generated by small islands, have become a focus of gravity-wave source investigations. Macquarie Island provides opportunities for such gravity wave studies through both the waves it generates as a knife-edge like barrier in a strong oceanic wind flow, and as a site where regular balloon soundings provide observational insight into waves propagating overhead [e.g. Guest et al, 2000].

High resolution (horizontal grid spacing of 1 km) ACCESS model runs, nested within the coarse global ACCESS grid, make it possible to investigate the nature of gravity waves generated in the vicinity of Macquarie Island. Momentum flux measurements are used to identify strong wave events and the character of the waves generated by the candidate mechanisms above is examined. An alternate method for extracting the momentum flux using temporal rather than spatial averaging is also being trialled.

This presentation will describe the methods used for this study and preliminary results.

References:

Guest, F. M.; Reeder, M. J.; Marks, C. J. & Karoly, D. J. Inertia-gravity waves observed in the lower stratosphere over Macquarie Island Journal of the Atmospheric Sciences, 2000, 57, 737-752.

McLandress, C.; Shepherd, T. G.; Polavarapu, S. & Beagley, S. Is missing orographic gravity wave drag near 60deg S the cause of the stratospheric zonal wind biases in chemistry-climate models Journal of the Atmospheric Sciences, 2012, 69, 802-818.

Submission ID: 243
Presenting Author: Lawrie Rikus*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #35

35. Simple climatologies of tropospheric westerly jet streams in nine global reanalyses

RIKUS Lawrie[*1]*

1) Bureau of Meteorology

A simple closed contour object identification scheme has been applied to the zonal mean monthly mean zonal wind fields from nine global reanalysis data sets to identify objects corresponding to westerly jet streams. The results cluster naturally into 6 individual jet streams but only the tropospheric jets (the Subtropical/Polar Front and the Arctic jets) are considered here. The time series of the jet properties from all reanalyses have been decomposed into seasonal means and anomalies, and correlations between variables evaluated, with the aim of identifying robust features which can form the basis of evaluation metrics for climate model simulations of the 20th century.

For the major tropospheric jets, there is substantial agreement between all the reanalyses although the Twentieth Century reanalysis shows some systematic differences from the others, suggesting that the monthly mean tropospheric jets are strongly influenced by properties of the stratospheric jets. Some of the results from the object identification scheme applied to the reanalyses have been used to develop a simple model evaluation score for the zonal mean upper tropospheric jet seasonal cycle which has been applied to a set of CMIP 5 models.

The Arctic jet appears to be associated with the Arctic frontal zone, although it is intermittent in the reanalyses. When it is present its seasonal mean latitude cycle shows a distinct polewards trend from May to November consistently across all reanalyses except the Twentieth Century reanalysis. To attempt to explain this behaviour time series have been generated from a set of longitude section means of the monthly mean zonal wind for each reanalysis. These show the role of the seasonal cycle of both latitude and mean speed in each of the sectors contribute to the zonal mean behaviour.

Submission ID: 238
Presenting Author: Robert Warren*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #36

36. Correcting radar calibration errors using TRMM

WARREN Robert[1]; PROTAT Alain[2]; SIEMS Steven[3]; RAMSAY Hamish[4]*

1) Monash University; 2) Bureau of Meteorology; 3) Monash University; 4) Monash University

Quantitative applications of weather radar data, such as precipitation estimation, require a well-calibrated radar system. However, due to time and financial constraints, thorough calibration tests and adjustments can be made only infrequently (once or twice a year) in most operational radar networks. In addition, hardware replacements and other maintenance activities can lead to undesirable changes in radar calibration. These issues give rise to errors which vary in time, both slowly, due to degradation of the radar system components, and rapidly, when the radar is recalibrated (deliberately or otherwise). Correction of these errors requires a coincident "truth" measurement to compare against. Previous work has demonstrated that measurements from the precipitation radar on board the Tropical Rainfall Measurement Mission (TRMM) satellite are suitable for this purpose. In this study, an existing method for comparing TRMM and ground-based radar measurements is used to quantify and correct historical calibration errors for four radars around Brisbane. Here, an overview of the method will be presented, together with results demonstrating the impact of the corrections on radar products such as accumulated rainfall. Future work will extend the analysis to other radars in the Australian network and explore the use of the Global Precipitation Mission (GPM) satellite for ongoing calibration checks to aid real-time radar applications such as severe storm and flood warnings.

Submission ID: 311
Presenting Author: Anil Deo*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #37

37. Contrasting Tropical Cyclone and non-Tropical Cyclone related Rainfall Drop Size Distribution at Darwin, Australia

DEO Anil[1]*

1) University of Melbourne

In this study the rainfall drop size distribution (DSD) during the passage of seven tropical cyclones (TCs) over Darwin is compared and contrasted with that associated with non-tropical cyclone (non-TC) events using the impact disdrometer data at the Darwin Atmospheric Radiation and Measurement (ARM) site. The disparity of the DSD with respect to rainfall types (between TC and non-TC), distance from TC centre and TC wind speed are also examined. It is shown that TC DSDs are statistically different from the non-TCs, the former encompassing a high concentration of small to moderate drop sizes. The TC mass-weighted mean diameter (Dm) is lower than the non-TC values at all rain rates and also for the different precipitation types (convective, transition and stratiform). TC DSDs vary with distance from TC centre whereby rainfall near the TC centre (< 60 m) comprises relatively higher concentrations of small to moderate drops (< 4 mm) which is strongly evident at small to moderate rain rates (< 30 mm hr^{-1}). With respect to TC wind speed, rainfall tends to have a higher concentration of larger drops at higher wind speeds. Such variations in the DSD have implications for the parameters used in the algorithm that converts radar reflectivity to rainfall rate, as well as the analytical expression (gamma function fitting) used in describing the observed DSD employed in cloud modelling parameterizations.

Submission ID: 318
Presenting Author: Todd Lane*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #38

38. The small-scale structure of mesoscale convective systems: implications for simulation and transport

LANE Todd[*1]*

1) University of Melbourne / ARCCSS

Deep convective systems represent a quintessential example of nonlinear turbulent phenomena. Mature systems are maintained through a combination of moist instabilities, turbulent dissipation, and coherent structures. The convective regions of storms are highly turbulent and recent work has demonstrated that the turbulence can extend throughout the cloudy air as well as in preferred regions outside of clouds. Understanding this small-scale structure has important implications for convective transport in the upper-troposphere / lower-stratosphere, aviation applications, and cloud-resolving model resolution requirements.

In this study a series of large-eddy simulations are used to characterise turbulence within and around idealised squall lines. The highest resolution simulations use 75-m grid spacing in each spatial direction over domains with 8000x1200x334 grid points; 15-member ensemble simulations with 125-m grid spacing over the same areas are also used. The simulations also identify patterns of vertical transport by using online passive tracers. We use the simulations to calculate spatial variation in turbulence characteristics and identify those regions characterized by convective instability, three-dimensional turbulence, and stratified turbulence. The implications of these results for cloud-resolving simulation are also discussed.

Submission ID: 332
Presenting Author: Hamish Ramsay*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #39

39. The effects of overshooting convection on mixing within the tropical tropopause layer in idealised climate states

RAMSAY Hamish[1]; SINGH Martin[2]; SHERWOOD Steven[3]*

1) Monash University; 2) Harvard University; 3) University of New South Wales

A series of cloud-resolving simulations are performed to study the impact of spatial/and or temporal inhomogeneity of tropical deep convection, in particular convective overshoots that penetrate into the tropical tropopause layer, on upper tropospheric/lower stratospheric (UTLS) temperature structure and trends under surface warming. Two sets of simulations are studied: one in which the sea surface temperature (SST) is increased uniformly, and a second in which convective updrafts are intensified periodically by introducing an island-like surface with a fixed-diurnal cycle while the surrounding SST is unchanged. All simulations are run to radiative-convective equilibrium so as to capture the mean-state response at larger time scales. We discuss the implications of our results for the interpretation of observed and modelled trends in the UTLS.

S4.3 High-Impact Weather in Research and Operation – Poster

Submission ID: 360
Presenting Author: Ross Bunn*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #40

40. Australian climatologies of surface-based and elevated thunderstorms

BUNN Ross[1]; RICHTER Harald[2]; RAMSAY Hamish[3]; JAKOB Christian[4]*

1) Monash University; 2) Bureau of Meteorology; 3) Monash University; 4) Monash University

Thunderstorms that source air from above a stable near-surface boundary layer divorced from the effects of diabatic heating are known as elevated thunderstorms (hereafter referred to as ES), as opposed to surface-based storms (SS). These storms can produce heavy rain and snow (Moore et. al. 2003, 1998), damaging winds (Goss et. al. 2006), as well as lightning which can affect aerodromes and cause bushfires. However, forecasting the development and cessation of these storms is a challenge for Australian forecasters where sparse upper-air observational networks hinder effective monitoring of the pre-storm environment. Whilst the majority of US ES occur overnight and in winter (Colman 1990), no Australian climatologies or case studies of ES are available in the literature and the seasonal and diurnal occurrence of Australian ES remain unknown.

The first ES climatology for Australia is presented by seasonal and diurnal event density maps, and contrasted to SS density maps. In creating the climatology, discriminators separating ES from SS environments are applied to six-hourly ECMWF ERA Interim Reanalysis (ERA Interim) data on a 0.75 degree grid with 37 vertical levels. Based on derived parameters from 239 Capital City soundings, ERA Interim Equivalent Potential Temperature (ThetaE) values compare well with observed values, and the performance of ES/SS discriminators based on ThetaE are presented. However, ERA Interim Convective Available Potential Energy (CAPE) values compare poorly to observed values, in contrast to results by Allen and Karoly 2013.

References:

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Colman, B. R., 1990: Thunderstorms above Frontal Surfaces in Environments without Positive CAPE. Part I: A Climatology. Monthly Weather Review, 118, 1103-1122.

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Moore, J. T., A. C. Czarnetzki, and P. S. Market, 1998: Heavy precipitation associated with elevated thunderstorms formed in a convectively unstable layer aloft. Meteorological Applications, 5, 373-384.

Moore, J. T., F. H. Glass, C. E. Graves, S. M. Rochette, and M. J. Singer, 2003: The Environment of Warm-Season Elevated Thunderstorms Associated with Heavy Rainfall over the Central United States. Weather and Forecasting, 18, 861-878.

Submission ID: 338
Presenting Author: Chermelle Engel*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #41

41. 133-m high resolution ACCESS simulation of Black Saturday using the ENDGame dynamical core and ECWMF reanalysis initial conditions

ENGEL Chermelle[1]; LANE Todd[2]*

1) The University of Melbourne; 2) The University of Melbourne

In July 2014 the United Kingdom Meteorological Office changed the dynamical core of their Unified Model from New Dynamics to ENDGame. The change was then propagated to the Australian ACCESS model. In this poster we describe a one way nested 133-m ACCESS run (using the ENDGame dynamical core) on the day of the Black Saturday fires, using a ECMWF reanalysis as the initial conditions. We compare this run to that published earlier using the New Dynamics dynamical core and Unified Model version 7.5 initial conditions. Discussed are meteorological aspects of the runs and the importance of their initial conditions.

S4.4 Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics – Poster

Submission ID: 252
Presenting Author: Jenny Ahn*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #42

42. Aircraft observations of the effect of drizzle on winter-time low altitude clouds over the Southern Ocean

AHN Jenny[*1]*

1) Monash university

Trenberth and Fasullo (2010) identified shortcoming in the representation of clouds as the major source of biases in the short-wave (SW) radiation budget in climate models and reanalysis products over the Southern Ocean (SO), a region that covers ~15% of the Earth's surface. The fractional cover of low-altitude clouds over this region has been reported to be over 80%. Despite this uncertainly, these clouds have been undersampled due to the remote and challenging environment over the SO.

Microphysical properties such as cloud droplets number concentration (CDNC) and effective radius (reff) are necessary to define both the SW scattering and the precipitation of these clouds, yet are poorly understood over the SO. Gultepe and Isaac (2004) and Wood (2012) both note the inherent relationship between precipitation and these parameters. In general precipitating clouds will have a large effective radius and smaller CDNC.

This research examines the sensitivity of the microphysical properties of clouds over the SO to the presence of drizzle/precipitation with new observations, and revisits the earlier research of Boers et al. (1998) from the Southern Ocean Cloud Experiments (SOCEX I & II). Three years (2013~2015) of winter-time in-situ observations made by the Hydro Tasmania aircraft are analysed to examine the variability of the CDNC and reff near Tasmania. As with the observations of Wood (2012), the CDNC and reff are found to vary between drizzling and non-drizzling clouds.

These in-situ observations are employed to MODIS satellite products, where available. A few limited flights were made to directly evaluate A-train observations (CloudSat, Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) and MODIS).

S4.4 Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics – Poster

Submission ID: 158
Presenting Author: Simon Alexander*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #43

43. Clouds and aerosols at Cape Grim observed with lidar

ALEXANDER Simon[*1]*

1) Australian Antarctic Division

The Bureau of Meteorology's UV Raman lidar with polarization capability was located at Cape Grim, Tasmania from May 2013 — May 2014. The data permit characterisation of the seasonal cycle of clouds at the northern extreme of the Southern Ocean. The Southern Ocean has large sea surface temperature biases in climate models, which are believed to be due to incorrect cloud representations in the models which allow an incorrect amount of shortwave radiation to reach the ocean. Surface measurements have not yet been made in this region but are required to provide basic climatological parameters in order to validate models and evaluate satellite retrievals. We will present an overview of our Cape Grim lidar cloud detection algorithm and the climatology of various key parameters including cloud base height and cloud fraction. Using the Raman backscatter channel, we determine the cloud and aerosol backscatter, extinction and optical depth and will illustrate these with reference to co-located surface short-wave and long-wave radiation observations. Lastly, we will illustrate the seasonal variability of various cloud and aerosol parameters.

Submission ID: 82
Presenting Author: Jennifer Fletcher*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #44

44. Cold air outbreaks' influence on Antarctic sea ice

FLETCHER Jennifer[1]; JAKOB Christian[2]*

1) Monash University; 2) Monash University

We examine a simple and important mechanism for month-to-month variability in sea ice growth and melt: cold air outbreaks. A robust correlation occurs between the frequency of occurrence of cold air outbreaks and the growth and melt of Antarctic sea ice. It is not surprising that sea ice makes cold air outbreaks possible, but we find that cold air outbreaks themselves strongly influence the growth rate of sea ice in turn.

Analysis of terms contributing to the sea surface temperature tendency indicates that this relationship is primarily due to heat loss from the ocean to the atmosphere through surface fluxes. On the short timescales over which cold air outbreaks occur, Ekman dynamics are insufficient to explain the subsequent sea ice growth.

We also find that the seasonal relationship between cold air outbreaks and the Southern Annular Mode (SAM) exhibits a similar pattern as that between the SAM and sea ice. Because the SAM varies on short (days to weeks) time scales as well as longer ones, this suggests that cold air outbreaks play a role in modulating the observed relationship between the SAM and sea ice, while Ekman transport likely dominates on longer timescales.

S4.4 Clouds, Aerosol, Radiation and Meteorology in the Southern Hemisphere Extra-Tropics – Poster

Submission ID: 279
Presenting Author: Fahimeh Sarmadi*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #45

45. The impact of atmospheric stability on the spatial distribution of orographic precipitation

SARMADI Fahimeh[1]; CHUBB Thomas[2]; SIEMS Steven[3]; MANTON Michael[4]*

1) The School of Earth Atmosphere and Environment Monash University; 2) The School of Earth Atmosphere and Environment Monash University; 3) The School of Earth Atmosphere and Environment Monash University; 4) The School of Earth Atmosphere and Environment Monash University

The spatial distribution of precipitation in mountainous regions, such as the Snowy Mountain of south-eastern Australia, is of considerable interest because subtleties in the rainfall patterns can have large influences on individual catchment inflows. Resource managers allocate water to a variety of needs such as agriculture, the environment, hydroelectric generation and municipal needs of downstream areas, and better understanding of these rainfall patterns would serve to inform these decisions.

While there has been a general lack of research on orographic precipitation in Australia in comparison to mountainous regions of Europe, North America, and New Zealand, precipitation in the Snowy Mountains has been the subject of some recent studies (e.g., Watson and Lane 2014).

In the current study we present a selection of case studies to characterise the impact of lower atmospheric stability on the spatial distribution of precipitation. We use upwind soundings to estimate a representative Froude number for the precipitation events and analyse the evolution of a number of important variables, including wind speed and direction, moisture fluxes, height of a number of temperature levels, and integrated cloud liquid water amounts. Numerical simulations are performed with the Weather/Research Forecasting numerical model (WRF) to better appreciate the impact of orographic forcing on the spatial distribution of precipitation in the Snowy Mountains.

Future research will employ a model configuration that couples an ice-nuclei module (made available by the Research Applications Laboratory of the US National Center for Atmospheric Research) to the Thompson microphysics scheme.

Key words: Orographic, Numerical simulations, Snowy Mountains

Reference:

Watson, C.D., and T.P. Lane, 2014, Further sensitivities of orographic precipitation to terrain geometry in idealized simulations, J.Atmos.Sci., doi: 10.1175/JAS-D-13-0318.1.

Submission ID: 288
Presenting Author: Robyn Schofield*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #46

46. Potential of dissipating deep convective clouds for subvisible cirrus formation

FREY Wiebke[1]; SCHOFIELD Robyn[2]; PROTAT Alain[3]; BORRMANN Stephan[4]; LANE Todd[5]*

1) University of Melbourne School of Earth Sciences; 2) University of Melbourne School of Earth Sciences; 3) Bureau of Meteorology; 4) Max Planck Institute for Chemistry; 5) University of Melbourne School of Earth Sciences

This case study looks at the dissipating stage of a Hector thunderstorm as observed during the SCOUT-O3 campaign from Darwin, Northern Australia, in November 2015. It combines observations (aircraft and ground-based) with high resolution, cloud resolving modelling and a microphysical box model run along trajectories and stand-alone.

The observations show a vertically extensive, though optically thin, persistent cloud layer after diminishing of the convection at about 11-17km altitude. The microphysical properties of the cloud particles in the upper parts of this cloud layer are similar to those found in subvisible cirrus. The observations show the importance of the dissipating stage of the deep convective storm on the conditions in the tropical tropopause layer by leaving moist air behind. Thus, favourable conditions for very thin or subvisible cirrus which have an effect on the amount of water vapour transported across the tropopause into the stratosphere.

The cloud resolving simulations, performed with the Advanced Research Weather and Research Forecasting (WRF-ARW) model, also shows the persistent cloud layer. Furthermore, passive tracers indicate that air masses in this layer have a convective signature, being uplifted from the boundary layer. However, the microphysical box model, which uses either homogeneous or heterogeneous nucleation, run along forward trajectories fails to form the cloud layer. Sensitivity test are applied to the trajectories in terms of temperature and moisture fluctuations. Furthermore, the WRF model output is passed directly to the microphysical box model and then run stand-alone.

Here, we will show a summary of the observations and the results of the different models, including the sensitivity runs.

Submission ID: 102
Presenting Author: Carol Godwin*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #47

47. An evaluation of planetary boundary-layer and land surface schemes in the Weather Research and Foresting (WRF) model against high resolution atmospheric profiles over contrasting land surfaces

GODWIN Carol[1]; LYONS Thomas[2]; KALA Jatin[3]; ANDRYS Julia[4]*

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The Weather Research and Forecasting (WRF) model is a widely adopted regional atmospheric model used for studies ranging from long-term regional climate simulations to high resolution large-eddy simulations over much shorter time scales. Whilst WRF has been extensively evaluated against surface observations of temperature and precipitation by numerous studies over various parts of the global, the evaluation of the vertical structure of the atmosphere in WRF is not as extensive, due to the limited availability of high-resolution atmospheric profiles at sufficient spatial and temporal resolutions. The BUFEX field campaign in the southwest of Western Australia (Lyons et al. 1993), an observational study of the impacts of land-use change on the atmospheric boundary layer, has completed the collection of high-resolution atmospheric profiles during August 2007 and December 2005, at a 3-hourly frequency and high vertical spatial resolution (5 to 15 m), over two contrasting land surface; native vegetation and agricultural land-use. We will show comparisons of high-resolution WRF simulations (1 km horizontal resolution and up to 40 vertical levels) using different land surface and planetary boundary-layer and surface-layer schemes against the observed atmospheric profiles. The analysis will focus on ability of WRF to simulate the observed differences in boundary-layer properties over the two contrasting land surfaces.

Reference:

Lyons TJ, Schwerdtfeger P, Hacker JM, Foster IJ, Smith RCG, Huang X (1993) Land-atmosphere interactions in a semiarid region: The bunny fence experiment. Bull. Am. Meteorol. Soc., 16:551—558.

Submission ID: 38
Presenting Author: Nadja Herger*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #48

48. Comparison of two Methods to account for Model Interdependency

HERGER Nadja[1]; ABRAMOWITZ Gab[2]; SANDERSON Benjamin[3]; KNUTTI Reto[4]*

1) UNSW Australia; 2) UNSW Australia; 3) NCAR Boulder; 4) ETH Zurich

Multi-model ensembles are commonly used for climate projections and are a key tool to express initial condition, boundary condition, parameter as well as structural uncertainties. However, different research groups share sections of code, literature, parameterisations of their models or even whole model components. Moreover, they share approaches to process representation and data sets for model evaluation. Different model simulations do not represent truly independent estimates which might lead to biases in the ensemble mean and variance, overestimation of sample size and correlations might emerge solely due to model replication. Simple averaging (equal weight for each model) is often not effective, as errors are found to not be random but correlated across models. Internal climate variability and its appropriate definition further complicates this problem. Here we compare and contrast two recent ensemble interpretation frameworks that account for model interdependency, including examining the assumptions made by each of them.

Submission ID: 151
Presenting Author: Eric Oliver*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #49

49. A reconstruction of Madden—Julian Oscillation variability and global connections from 1905 to 2011

OLIVER Eric[1]; THOMPSON Keith[2]; KLOTZBACH Phillip[3]; JACQUES-COPER Martín[4]*

1) Institute for Marine and Antarctic Studies University of Tasmania; 2) Department of Oceanography Dalhousie University; 3) Department of Atmospheric Science Colorado State University; 4) Oeschger Center for Climate Change Research and Institute of Geography University of Bern

The most widely accepted characterization of the Madden—Julian oscillation (MJO) is the bivariate index developed by Wheeler and Hendon (Monthly Weather Review, 2004). This index relies in part on satellite-based observations of outgoing longwave radiation and thus is not defined for the presatellite era. The MJO is known to have a strong signature in surface pressure, and daily measurements of this variable are available as far back as the late nineteenth century. We present a statistical reconstruction of the Wheeler and Hendon MJO index from 1905 to 2011 based on tropical surface pressures estimated by the twentieth-century reanalysis project. The temporal and spectral properties of the reconstructed index are shown to be consistent with the Wheeler and Hendon index over the common period (1979—2008), as are known links with a number of atmospheric and oceanic variables. The long reconstructed index has been used to examine historical links between the MJO and surface winds and cloud cover over the ocean (1952-2008), extreme precipitation in Australia (1905-2008), Pacific sea levels (1905-2008), global tropical cyclone activity (1905-2011), wintertime air temperature in Alaska (1906-2010), and heatwaves in Patagonia (1957-2010).

Submission ID: 328
Presenting Author: Sonya Fiddes*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #50

50. Synoptic weather evolution and climate drivers associated with winter air pollution in New Zealand

FIDDES Sonya[*1]*

1) University of Melbourne

Particulate matter (PM) pollution is a problem for some regional and urban centres across New Zealand during the winter period when solid fuel (wood and coal) fires are used for home heating. These exceedances of safe PM concentration thresholds occur during stable atmospheric conditions, when cool air temperatures and low wind speeds allow for a surface inversion to occur and trap PM. This study examined the relationships between PM and local and large-scale synoptic conditions at daily and seasonal scales. Minimum temperature and wind speed were both negatively correlated with PM during the winter season, whilst the combination of the two can explain 30-54% of variability in average PM10. Synoptic-scale daily composites of high PM days showed the evolution of an anticyclone in the Tasman Sea, with an injection of cool air over New Zealand and persistent south-westerly winds leading to cold and stable conditions on the day of exceedance. Both of these results indicate that there is some potential for predicting days in which atmospheric conditions could favour elevated PM concentrations. Furthermore, at the seasonal scale, weaker westerly winds were found to be associated with winters with higher exceedance days, although the relationship is not straightforward. These characteristics can be associated with other, predictable large-scale climate drivers such as the El Niño-Southern Oscillation, and may aid in identifying years in which a higher risk of PM pollution events exists.

Submission ID: 303
Presenting Author: Jenny Fisher*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #51

51. Intercontinental and interhemispheric influences on Southern Hemisphere tropospheric composition

FISHER Jenny[1]; PATON-WALSH Clare[2]; ROULSTON Christopher[3]; BUCHHOLZ Rebecca[4]; GRIFFITH David[5]; DEUTSCHER Nicholas[6]; VELAZCO Voltaire[7]; ZENG Guang[8]; POLLARD David[9]; MURRAY Lee[10]; LIESCHKE Kaitlyn[11]*

1) University of Wollongong; 2) University of Wollongong; 3) University of Wollongong; 4) National Center for Atmospheric Research; 5) University of Wollongong; 6) University of Wollongong; 7) University of Wollongong; 8) National Institute of Water and Atmospheric Research; 9) National Institute of Water and Atmospheric Research; 10) Lamont-Doherty Earth Observatory; 11) University of Wollongong

Short-lived trace gas pollutants in the atmosphere play a critical role in regulating atmospheric composition, air quality and climate forcing. The sources of trace gases to the Southern Hemisphere troposphere differ greatly from their better-studied northern counterparts. Over regional to continental scales, much of the Southern Hemisphere is characterised by low anthropogenic emissions, high biogenic emissions, and episodically large influence from biomass burning emissions. In addition to local sources, emissions transported intercontinentally are known to exert a large influence. Meanwhile, the impact of anthropogenic emissions from the Northern Hemisphere is unclear: though large in magnitude, their influence is thought to be dampened by a “transport barrier” at the Intertropical Convergence Zone. Australia is uniquely placed to assess the potential influence of these different sources, with both geographical proximity and a well-established observational network. In this work, we use a combination of satellite data, ground-based measurements and a chemical transport model (GEOS-Chem) to quantify intercontinental and interhemispheric influences on Southern Hemisphere tropospheric composition. The model is constrained by multi-year, ground-based column and surface in situ measurements spanning a latitudinal gradient from 12-45°S. Outside of austral spring, we find diverse contributions to tropospheric composition, including consistent influence from biogenic emissions in South America and Africa and episodic influence from Asian anthropogenic emissions. Using IASI satellite CO observations, we define a chemical equator and show how temporal variability in its position affects interhemispheric influences on composition in tropical Australia. In this talk, these findings will be discussed along with their implications for policy-relevant background pollution amounts in Australia — and possible relevance to other Southern Hemisphere environments.

Submission ID: 126
Presenting Author: Jenny Fisher
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #52

52. Clean air and urban landscapes — towards a Clean Air Plan for Western Sydney

MURPHY Clare[1]

1) University of Wollongong

The negative health impacts of airborne particulates on urban populations are now well established. Whilst the air quality in Australian cities is generally very good compared to many other parts of the world, Sydney experiences occasional poor air quality events that expose the population to heightened health risks. Health effects are also known to occur at air pollution concentrations that are within national air quality standards, meaning that health benefits can be realised through improving air quality even in regions with relatively low pollution levels. The population within the Sydney basin is predicted to grow by ~ 20% in the next decade, increasing both the local sources of pollution and the population exposed.

The Clean Air and Urban Landscapes hub has formulated a project to address this issue called the Western Air-Shed Particulate Study for Sydney (WASPSS). The project will provide the tools and evidence to develop a Clean Air Plan for Western Sydney. Research activities will be focussed around three main research aims, each with their own subproject:

(1) Extend air quality measurement/monitoring capacity to support improved characterisation of air quality in Western Sydney.
(2) Implement and validate state-of-the-science regional air quality modelling to assess major sources contributing to air pollution in Western Sydney and assess benefits arising from a range of possible mitigation measures.
(3) Evaluate existing methods applied internationally and locally for estimating human exposure to airborne pollutants, and estimate air pollution related exposures and health effects for Western Sydney.

The project will enable policy makers to estimate the benefits of different mitigation strategies to the future air quality in Western Sydney.

Submission ID: 13
Presenting Author: Kaitlyn Lieschke*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #53

53. Decadal-scale trends in Australian atmospheric composition

LIESCHKE Kaitlyn[1]; FISHER Jenny[2]*

1) University of Wollongong; 2) University of Wollongong

The atmosphere is a dynamic system that allows life as we know it to exist on Earth. Understanding the changing composition of the atmosphere is important in terms of both air quality and climate. The ground-based solar Fourier Transform Infrared Spectrometer (FTIR) at the University of Wollongong provides a long-term record of atmospheric composition above Wollongong, NSW, Australia. Here we present long-term trends in the trace gases carbon monoxide (CO), hydrogen cyanide (HCN) and formaldehyde (HCHO), calculated using these decadal-scale records and interpreted with simulations from the global atmospheric chemical transport model GEOS-Chem. Significant negative trends over the 1997-2011 period were calculated for HCN (-1.47 %/yr, 95 % confidence interval -1.94 to -1.03 %/yr) and CO (-1.23 %/yr, 95 % confidence interval -1.48 to -0.95 %/yr). The trend for HCN was influenced by the 1997-98 ENSO event, and the trend was not significant when these years were excluded. The model was able to reproduce the observed HCN and CO trends with an overlap in the 95 % confidence intervals. A significant positive trend was calculated for observed HCHO (+2.12 %/yr, 95 % confidence interval +1.03 to +3.55 %/yr) but was not seen in the simulation. The largest monthly HCN trends occurred in December and January, suggesting a decrease in local biomass burning sources over this period. For HCHO, the largest monthly trends occurred in November and February, possibly indicating a temperature-driven increase in biogenic emissions leading to increased HCHO production. Observed CO showed the largest monthly trend in December, with smaller trends (all of similar magnitude) in other months. As CO should be influenced by the highly seasonal biomass burning and biogenic trends identified from HCN and HCHO, the lack of strong month-to-month variability in the CO trends suggests an influence from declining anthropogenic emissions as well.

Submission ID: 131
Presenting Author: Kaitlyn Lieschke*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #54

54. Decadal-scale trends and variability in Australian atmospheric composition

LIESCHKE Kaitlyn[1]; FISHER Jenny[2]; MURPHY Clare[3]; JONES Nicholas[4]; GREENSLADE Jesse[5]; JONES Dylan[6]*

1) University of Wollongong; 2) University of Wollongong; 3) University of Wollongong; 4) University of Wollongong; 5) University of Wollongong; 6) University of Toronto

The atmosphere is vital to maintaining a habitable environment on Earth, and understanding its changing composition is important in terms of both air quality and climate. The ground-based solar Fourier Transform Infrared Spectrometer (FTIR) at the University of Wollongong provides a long-term record of atmospheric composition above Wollongong, NSW, Australia. The trends in the trace gases carbon monoxide (CO), hydrogen cyanide (HCN) and formaldehyde (HCHO) were calculated from 1997 to 2011 using these 15 year records and interpreted with simulations from the global atmospheric chemical transport model GEOS-Chem. A significant negative trend was calculated for HCN (-1.5%.yr^{-1}, 95% confidence interval -1.9 to -1.0%.yr^{-1}) of which the largest monthly trends occurred in December and January. This suggested a decrease in local biomass burning. HCN abundance showed an obvious impact from the 1997-98 ENSO event and the trend was not significant when these years were excluded. A significant positive trend was observed in HCHO (+2.1%.yr^{-1}, 95% confidence interval +1.0 to +3.6%.yr^{-1}) for which the largest monthly trends occurred in November and February. This may be caused by a temperature-driven increase in biogenic isoprene emissions. A significant negative trend was calculated for CO (-1.2%.yr^{-1}, 95% confidence interval -1.5 to -0.95%.yr^{-1}) with the largest monthly trend calculated in December and smaller significant trends in all other months. As the abundance of CO should be impacted by the highly seasonal biomass burning and biogenic emissions, the lack of obvious seasonal trends suggests an additional impact from decreasing anthropogenic emissions.

Submission ID: 191
Presenting Author: Matt Tully*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #55

55. Impact of approximations in the recommended Dobson algorithm on total column ozone measurements at four Australian sites

TULLY Matt[1]*

1) Bureau of Meteorology

Observations of total column ozone made by the GAW network of Dobson spectrophotometers are processed with a standard algorithm, which uses a crude parameterised value of mean ozone height by latitude, and assumes a constant "effective ozone temperature" for all locations and times of year.

Here, daily ozone and temperature profiles from the MERRA reanalysis (Rienecker et al. 2011) are used to calculate the mean ozone height and effective ozone temperature at four long-standing Australian Dobson sites (Darwin, Brisbane, Melbourne/Airport and Macquarie Island) for each individual day from 1979 to 2014, also making use of the current state-of-the-art ozone cross-sections (Serdyuchenko et al. 2014), and the effect on the calculation of total column ozone investigated.

The effect on the calculated ozone of the annual cycle in temperature ranges from 2.5% at Macquarie Island to 0.5% at Darwin, but day to day variations can be twice this amount. The effect of the seasonal cycle in mean ozone height is negligible at Darwin but increases poleward, reaching 0.6% for measurements made two hours from local noon at Macquarie Island.

These results suggest the standard Dobson algorithm should be updated to incorporate reanalysis data in the ozone retrieval.

References:

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Submission ID: 343
Presenting Author: Willow Hallgren*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #57

57. Comparing the impact of Canonical and Modoki ENSO events on the wind resource in Australia

HALLGREN Willow[1]; GUNTURU Bhaskar[2]*

1) Griffith University; 2) The Joint Program on the Science and Policy of Global Change MIT

There is an increasing recognition that ENSO has significant impacts on renewable energy resources; Several studies explore the impact of ENSO events on the wind resource in the US and Canada, and on the solar resource in Australia. However, the impact of ENSO on wind resources in Australia has not yet been studied, despite wind being an important and growing contributor to the renewable energy generated in Australia. This study addresses this gap, and compares the impact of Canonical (eastern pacific) and Modoki (central pacific) El Nino and La Nina events on the wind resource in Australia.

We calculated composites of the WPD anomalies for all the days throughout the MERRA timeseries (from Hallgren et al., 2014) corresponding to both canonical and Modoki El Nino and La Nina events were calculated for a region encompassing Australia. Variance of WPD, and the difference in both the frequency and magnitude of both high and low wind events compared to neutral conditions, were also calculated. Our analysis indicates that a Modoki El Nino less adversely affects the mean wind resources in most of southern Australia and QLD compared to a canonical El Nino. Compared to the changes (from neutral conditions) seen during a canonical la nina, we found that the Modoki La Nina coincides with: lower WPD in parts of southern Australia, Tasmania, and QLD; lower variance throughout most of southern and eastern Australia; higher frequency of low wind events in the SE of QLD; and lower magnitude of low wind events in parts of SA, NT and Tasmania. Compared to the changes due to a canonical El Nino, the Modoki El Nino coincides with: higher WPD in the southern half of Australia and most of QLD; higher variance throughout much of the south and east; more frequent, and a higher magnitude for, low wind events in SE Australia; and a smaller magnitude for low wind events in southern SA and southern WA. Since ENSO events can be forecast in advance, our results have considerable implications for managing large-scale generation of wind power in Australia.

Submission ID: 262
Presenting Author: Nick Earl*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #58

58. Weekly cycles in surface temperature in major Australian cities at different times of day

EARL Nick[1]; SIMMONDS Ian[2]; TAPPER Nigel[3]*

1) University of Melbourne; 2) University of Melbourne; 3) University of Monash

One approach to quantifying the impact of human activities on the atmosphere is based on the examination of weekly cycles (WCs). There are no natural atmospheric processes which have a strictly WC, and hence any signal in meteorological parameters varying on such a time-scale can be considered as associated with anthropogenic activities. WCs provide an interesting insight into the role that such activities (e.g., industrial activity and commuting), commonly reduced at weekends, have on the atmosphere in the urban environment. There is much ongoing scientific debate to whether such cycles exist and/or whether the associated signals can be considered to be statistically robust. Here we investigate the WCs of temperature in the major Australian cities and how these cycles vary at different times of day. We use data from surface monitoring stations located in the city centres at eight different times of day (3 hourly 0000-2100), utilising data from the Bureau of Meteorology. We also investigate the extent of the Melbourne urban heat island and examine whether there is a WC present. We introduce a new Monte Carlo approach (which takes into account the reduction of degrees of freedom associated with the autoregressive nature of the time series examined) to quantify the statistical robustness of the long term (1955-2014) signals in the data. We explore the extent to which any signal can be explained by the mechanisms proposed in the literature.

Submission ID: 67
Presenting Author: Warwick Grace*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #59

59. Measurements of the ratio of the components of Turbulence Kinetic Energy in the surface layer

GRACE Warwick[1]; TEPPER Graeme[2]*

1) Grace Research; 2) MicroMeteorology Research & Educational Services

Turbulence Kinetic Energy (TKE) is comprised of the variances of the wind speeds in the horizontal (stream-wise and cross-wind) and the vertical. Measurements of each component were obtained for 15 months from a 10m tower located in the wheat-fields of Western Australia at Ongerup. In particular the relationship of TKEh (Turbulence Kinetic Energy comprised of the horizontal variances) and TKE (comprised of all components) was investigated.

Widely-used relationships that apply for neutral conditions in the surface layer imply that the ratio of TKEh to the TKE is ~ 0.83. Our results show that the ratio on average is 0.85 regardless of stability. Albeit for one site, this is a novel finding and implies that the variance of the vertical wind speed on average equals 0.36TKEh. The results require replication at other sites and other heights above ground level.

The vertical component is an important consideration in estimating dispersion of pollution and of agricultural sprays. However, compared to the horizontal components, the vertical component is difficult and expensive to measure. Therefore the potential practical value of this result is that the vertical component of turbulence may be estimated from TKEh which is cheaper and easier to measure than vertical wind speed variance.

Submission ID: 355
Presenting Author: Jhan Srbinovsky*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #60

60. Coupling CABLE to GA7 for ACCESS-CM2

SRBINOVSKY Jhan[1]*

1) CSIRO

The Australian Community Climate and Earth System Simulator - Coupled Model (ACCESS-CM2) will be the new Australian contribution to the next coupled (C) model inter-comparison project (MIP); CMIP6. It will use the latest atmospheric configuration from the UK Met Office (UKMO), GA7; and with this involves a new process of coupling the Australian land surface model, Community Atmosphere Biosphere Land Exchange model (CABLE) to the Unified Model (UM). This is due in part to the separation of the UM's native land-surface model (MOSES) from the UM code to create the Joint UK Land Environment Simulator (JULES) land-surface model. JULES contains the same scientific code as MOSES but the interfacing to the UM is different and it can be run in standalone mode. This means that the way CABLE was coupled to earlier versions of the UM needs to be re-visited and re-tested via offline (standalone), Atmosphere (A) only AMIP and Transpose-AMIP simulations. We will present some of the difficulties and improvements that we have made to the CABLE interface and compare seasonal means of global surface fields to the previous model submission from CMIP5; specifically ACCESS1.3.

Submission ID: 256
Presenting Author: Shane Bilish*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #61

61. Comprehensive observations of a marginal maritime snowpack

BILISH Shane[1]; CALLOW Nik[2]; MCGOWAN Hamish[3]; MCGRATH Gavan[4]*

1) Snowy Hydro Ltd; 2) The University of Western Australia; 3) The University of Queensland; 4) The University of Western Australia

Runoff from snowmelt in the Snowy Mountains of New South Wales underpins significant renewable energy production, water supply and irrigated agriculture within the Murray-Darling Basin. The Australian snowpack, largely due to the latitude and modest elevation of the region, is warm and highly marginal compared to areas with seasonal snow in other countries. Snowpack longevity and maximum snow depth have decreased in recent decades and the implications of further decline under climate change on snowmelt dynamics and snowpack runoff remain largely unknown. In addition, the very high intra- and inter-annual variability may be a significant constraint on the use of temperature-index models to predict snowmelt in this region, as these models assume that the relative magnitudes of the energy balance components remain constant over time. A greater understanding of the physical processes driving snowmelt in this environment is therefore required.

An extensive range of meteorological and snowpack measurements were made in a small research catchment (Pipers Creek, 1.4 sq. km) in the Snowy Mountains during the 2015 winter season. The objective was to quantify the components of the energy and water balances for the catchment and determine the relative significance of various meteorological events. Estimates of the near-surface energy fluxes were obtained using both eddy covariance and aerodynamic profile methods. Snow surveys were conducted across the catchment from late May until the final melt in October to characterise spatial variability in the accumulation and ablation of the snowpack. Streamflow was measured at a weir at the lower end of the catchment and precipitation was measured nearby using a fenced gauge configured to minimise the effect of wind-induced undercatch. While the study is ongoing for the winter of 2016, preliminary results offer some insight into energy balance controls on snowmelt processes and the implications for snowmelt in this atypical alpine area.

Submission ID: 281
Presenting Author: Michael Gray*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #62

62. WRF simulations of the sub-tropical boundary layer in Southeast Queensland, initialised by observed surface-atmosphere energetics

GRAY Michael[1]; MCGOWAN Hamish[2]*

1) University of Queensland; 2) University of Queensland

Anecdotally, the sand islands off the coast of Southeast Queensland (SEQ) have sufficient influence on the local atmosphere to enhance convection in their immediate area, thereby influencing cloud, wind field dynamics and precipitation, but this has yet to be quantified. Therefore, the extent of the influence of the islands on the general atmosphere of the region, and consequently the impacts of changes in land use such as urban sprawl or establishment of large pine plantations on local and regional meteorology, are unknown.

Observational data of surface-atmosphere energetics, collected from three eddy-covariance units run over contrasting, vegetation types on Bribie Island for a time period of over 20 months from mid-2013 to early-2015, have been used to initialise the surface-layer boundary conditions in simulations of the local atmosphere using the Weather Research and Forecasting (WRF) model. Model output is compared to precipitation data from a network of rain gauges and automatic weather stations.

S5.3 The Land Surface: Processes and Their Interactions with the Atmosphere from Minutes to Millennium – Poster

Submission ID: 271
Presenting Author: Ian Enting*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #63

63. Are climate-to-carbon feedbacks being double-counted?

BODMAN Roger[1]; ENTING Ian[2]*

1) Victoria University; 2) University of Melbourne

The future behaviour of the carbon cycle is a major contributor to uncertainty in temperature projections for the 21st-century. Much of this uncertainty stems from the different processes that modify atmospheric CO2 concentrations, yet these remain difficult to separate out and quantify from the historical record. The principle land surface climate-carbon cycle interactions are the CO2 enhanced growth (atmosphere-to-biosphere feedback or CO2 fertilisation effect) and the temperature dependent feedback effect on plant respiration. Consistency in propagating these uncertainties from the past in to the future is important for simulating climate change driven by greenhouse-gas emissions.

Calibrating a model to fit CO2 enhanced growth alone will also effectively include climate-carbon cycle feedback effects. Using a simple Earth system model, we find that the model's parameters can be calibrated from 20th-century observations allowing for just this CO2 enhanced growth or for both CO2 enhanced growth and the CO2 respiration temperature feedback, with little change in projected temperature outcomes. These results cast doubt on claims the CO2 projections are under-estimates if they fail to include climate-to-CO2 feedbacks explicitly. CO2 projections based on calibrations over the 20th century may implicitly include climate-to-CO2 feedbacks because of the degree of co-linearity between changes in CO2 and temperature as drivers of the two feedback processes.

Submission ID: 327
Presenting Author: Alex Holmes*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #64

64. Improving fire risk estimation through investigating fire intensity, moisture and temperature anomalies

HOLMES Alex[1]; RÜDIGER Christoph[2]; TAPPER Nigel[3]*

1) Monash University; 2) Monash University; 3) Monash University

Fire risk and fire intensity assessments are increasingly important in countries such as Australia, where extreme conditions are expected to increase in both intensity and frequency. It is postulated that in semi-arid regions such as south-eastern Australia, an increase in the soil moisture deficit will lead to a change in the energy balance (greater sensible heating), thus resulting in a temperature increase. This, coupled with a high fuel load and low vegetation moisture, provides ideal conditions for forest fires and is also likely to determine their intensity. However, there are few studies to date investigating the interaction between soil moisture, temperature, vegetation moisture and fire intensity. This study investigates this relationship in an observation-based dataset and modeled data in south-eastern Australia. A strong relationship between the number of hot days, the preceding soil moisture deficits, as expressed by the standardized precipitation index (SPI) and the antecedent precipitation index (API), and fire radiative power is found in south-eastern Australia.

S5.3 The Land Surface: Processes and Their Interactions with the Atmosphere from Minutes to Millennium– Poster

Submission ID: 66
Presenting Author: Shaoxiu Ma*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #65

65. Representing eucalypts in the Community Atmosphere Biosphere Land Exchange model

MA Shaoxiu[1]; PITMAN Andrew[2]; KALA Jatin[3]*

1) Climate Change Research Centre The University of New South Wales; 2) Climate Change Research Centre The University of New South Wales; 3) School of Veterinary and Life Sciences Environmental and Conservation Sciences Murdoch University

Eucalypts are the dominant vegetation type in Australia and vary considerably in height (from low-lying shrubs to trees exceeding 30m) and root depth (shallow to deep rooted). Eucalypts are commonly represented via a single plant functional type (PFT) within most Land Surface Models (LSMs), a type that represents all broadleaf evergreen forest growing globally. This study examines a more realistic representation of eucalypts within the Community Atmosphere Biosphere Land Exchange (CABLE) model, a commonly used LSM within the Australian climate science community. Three different categories of eucalypts are implemented within CABLE and experiments are conducted using CABLE coupled to the Weather Research and Forecasting (WRF) regional climate model to examine if these alternative representations reduce model bias. We show that more realistic representation of eucalypts in CABLE results in an improvement in the simulation of mean and maximum temperatures over Northern Australia in January, including warm temperature extremes likely because the surface energy balance is resolved more appropriately during the day. We find little change in the simulation of minimum temperatures because the more realistic representation of eucalypts has little impact on the night-time surface energy balance. We also find little impact on precipitation.

Submission ID: 28
Presenting Author: Sarah Chapman*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #66

66. The impact of urbanization and climate change on urban temperatures and heat stress: A systematic review

CHAPMAN Sarah[*1]*

1) University of Queensland

Urban areas are where most of the world's population will be exposed to climate change. Given this, it is crucial to understand how climate change will affect the urban environment. The urban heat island (UHI) is one of the most extensively studied urban climate modifications, and recent research has found that it may change with a changing climate. The UHI is also strongly affected by urban form. As the urban footprint expands and increases in density, the effect of the UHI is likely to increase. We conducted a systematic review to identify how the UHI effect will change in the future due to climate change and urbanization. Of 1283 research articles that met the search criteria, 44 met the criteria for relevance. To be relevant, an article needed to include 1) the impact of urbanization or climate change on the urban heat island, and not the other way around, 2) a measure a change in the urban heat island intensity, and 3) it had to look at more than just historical changes in the urban heat island. Only four of these articles considered the interaction of the UHI and climate change, and only five articles considered the impact of increased heat stress on urban populations. The results of this review reveal a lack of studies that focus on the combined impact of urban growth and climate change on the future urban climate, with little research extended to the analysis of heat stress. Heat stress did not always respond the same as temperature. In humid regions, heat stress indices increased more than temperature. In some areas where urban and rural areas experienced the same temperature increase, urban areas still experienced a larger increase in the frequency of high-heat stress nights. This was attributed to the higher present-day temperatures in urban areas. The differing response of heat stress and temperature, particularly in humid regions, highlights the importance of considering heat stress specifically when examining health impacts.

Submission ID: 232
Presenting Author: Giuseppe Oppedisano*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #67

67. Building for the climate - The impact of heat mitigation strategies on thermal comfort in Melbourne's suburbs

OPPEDISANO Giuseppe[*1]

1) Monash University

Urban warmth and increased climatic variability continue to exacerbate challenges posed to the urban environment and heat-related illnesses. Importantly, the implementation of heat mitigation strategies is pivotal to ensuring indoor thermal comfort and energy conservation. DesignBuilder and EnergyPlus software was used to model the comparative microclimatic impact of green infrastructure and building materials upon indoor thermal comfort and energy conservation, whereby the results were extrapolated to show how heat wave resilience could be improved for elderly populations. Urban Green Infrastructure (UGI) implementations including green roofs and walls, tree shadings and off-site factors (local scale implementations including green spaces and increased vegetation cover) were applied in this study in combination with two materials schedules, as constructed and best practice, on two different townhouse sites.

Overall, off-site UGI reduced building cooling loads by a between 5-10 % in heat events exceeding 30 °C. Furthermore, extensive green roofs reduced indoor temperatures by up to 1.9 °C during heat events above 30 °C. In turn indoor thermal comfort marginally improved and energy conservation increased by up to 15 % during peak temperatures. Similarly, implementing green walls on the ground floor of dwellings increased occupant thermal comfort and provided an 8-14 % reduction in cooling demand during extreme heat events. Moreover, tree shadings were used to reduce direct solar gains into the building by approximately 25 % which also supported minor improvements in occupant comfort. In relation to heatwave resilience in vulnerable populations, the implementation of best practice materials with UGI eliminated the risk of heat related discomfort. Consequently, residents can experience a greater degree of liveability within their home given the context of increased building density and the greater propensity for extreme heat events.

Submission ID: 116
Presenting Author: Sally Ip*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #68

68. Scientists and Mathematicians in Schools (SMiS)

IP Sally[1]*

1) CSIRO Education and Outreach

Scientists, Mathematicians and ICT in Schools is a national program that creates and supports on-going partnerships between primary or secondary school teachers and science, technology, engineering, and mathematics (STEM) professionals. Partnerships are flexible and it is up to the skilled volunteer and teacher to negotiate how often they would like to collaborate and the ways they work most effectively together. SMiS encourages participation across various fields of STEM, including the sciences related to weather and climate. These partnerships bring the practice of real world STEM to students, allow students to interact with a 'real scientist' and gain a deeper understanding of the role of STEM in our society and the types of careers available. This presentation brings together relevant partnership examples from across Australia to illustrate the benefits of SMiS for teachers, STEM professionals and students.

S6.1 Education and Outreach – Poster

Submission ID: 12
Presenting Author: Sophie Lewis*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #69

69. Can public perceptions of Australian climate extremes be reconciled with the statistics of climate change?

LEWIS Sophie[*1]*

1) The Australian National University

A new Australia-wide average spring temperature record was set in 2013, and again in 2014. This was a period of extended extreme heat. These extremes have been investigated scientifically. However, popular perceptions of extreme climate events often refute the results of scientific analyses. Instead, these understandings posit that new temperature records are purely an artefact of natural variability and the longer the period of observations, the greater possibility of extreme events.

In this study, I investigate various aspects of this mental model of climate change and extremes informed primarily by personal perceptions using evidence of the physical climate system (e.g. climate observations and model output). Using these tools, I show that the characteristics of these recent spring temperature extremes are irreconcilable with the personal perception-based understanding of climate variability, which is epitomised by the public comments of recent Prime Minister Tony Abbott.

This study does not attempt to redress misconceptions about climate change and extremes. Rather, I explicitly examine elements of perception-based understandings of recently observed extremes with the tools used in making quantitative scientific attribution statements.

Submission ID: 44
Presenting Author: Leanne Armand*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #70

70. Beyond Next Wave: A national postgraduate at sea training initiative on the RV Investigator

ARMAND Leanne[*1]*

1) Macquarie University

In 2014, a major transformation of the Australian marine science setting occurred with the commissioning of the marine national facility, RV Investigator. The ship, a new actor in the national educational landscape, catalysed a collaborative response from university and stakeholder groups forming the Strategic Marine Alliance Research, Teaching and Training initiative (Armand et al. 2015). This team's aim is focused on building a national curriculum in alignment with current developments in higher education postgraduate learning. The long-term outcomes are firmly focussed on a rise in Australian marine student qualifications, scientific outputs and reputations, increased use of national scientific infrastructure, and providing a platform for generational, institutional and industry knowledge transfer and collaboration. This presentation will outline the current development of the program inclusive of the current surveying of student interest and external stakeholder needs for marine science graduates; the future steps in securing government learning and teaching funding and external sponsorship for student mobility; and the 3 year trial program commencing from mid 2017.

Reference:

Armand, L., Coleman, R., Coffin, M., Bose, N., Suthers, I., Bruce, E., Baker, E., Gladstone, W., Ellwood, M. and Holmes, S. (2015) Strategic Marine Alliance Research, Teaching and Training(SMART2): A national Master-level at sea training initiative. Pp. 42. Dept. of Biological Sciences, Faculty of Science and Engineering, Macquarie University: North Ryde. http://hdl.handle.net/1959.14/346971.

Submission ID: 54
Presenting Author: Mitchell Black*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #71

71. Climateprediction.net: join the world's largest climate experiment

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1) School of Earth Sciences and ARC Centre of Excellence for Climate System Science, University of Melbourne, Australia; 2) School of Earth Sciences and ARC Centre of Excellence for Climate System Science, University of Melbourne, Australia

You've heard of climate change, but what does that actually mean for the weather in the region where you live? Could it be that you are going to see an increase in the number of damaging weather events? Or could the weather actually be getting nicer? The climateprediction.net weather@home experiment hopes to answer these questions, with your help. Climateprediction.net, supported by the Nuffield Foundation, has put together Science, Maths and Geography teaching materials based on the project. The educational support that is offered includes materials for school curriculum and specialised online learning courses. All the school curriculum material can be found on the website: www.climateprediction.net/education.

S6.1b Education and Outreach

Submission ID: 351
Presenting Author: John Clarke*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #72

72. Datasets for impact assessment: The Climate Change in Australia web-tools

CLARKE John[1]; ERWIN Tim[2]; HEADY Craig[3]; BECKETT Duan[4]; BEDIN Tim[5]; WEBB Leanne[6]; GERBING Chris[7]; WILSON Louise[8]; HENNESSY Kevin[9]*

1) CSIRO Oceans & Atmosphere Flagship; 2) CSIRO Oceans & Atmosphere Flagship; 3) CSIRO Oceans & Atmosphere Flagship; 4) Bureau of Meteorology; 5) CSIRO Oceans & Atmosphere Flagship; 6) CSIRO Oceans & Atmosphere Flagship; 7) CSIRO Communications; 8) CSIRO Oceans & Atmosphere Flagship; 9) CSIRO Oceans & Atmosphere Flagship

The Climate Change in Australia website (http://www.climatechangeinaustralia.gov.au) is the key means of disseminating the latest climate projections for Australia from CSIRO and the Bureau of Meteorology. It was launched in April 2015 and so far has attracted more than 110,000 unique users, over 650 of whom have registered to access Advanced features.

The projections can be explored via web-tools which were developed with a strong user focus by drawing on 1) feedback from users of the 2007 version of the website, 2) use cases collected from extensive interviews with natural resource managers, 3) feedback from the project's User Panel, and 4) experience from the UK Climate Impacts Program (UKCIP).

The tools provide visualisation and/or download access to more than 20TB of climate projections data in a variety formats in order to meet the needs of stakeholders. The data are available at a range of scales from regional averages to 5km gridded changes to gridded daily time-series. Application-ready data are available as future daily, monthly, seasonal and annual time-series from a pre-selected sub-set of models that collectively capture the range of changes across Australia.

In this presentation, we demonstrate a sample of the web-tools and detail some of the high-resolution application-ready datasets along with their strengths and weaknesses.

Submission ID: 101
Presenting Author: Jatin Kala*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #73

73. Using STELLA software to teach systems thinking as applied to earth systems science within a post-graduate University course

KALA Jatin[*1]*

1) Murdoch University

Given the increasing relevance of future climate change to society, there is an increasing demand to teach concepts of earth systems science at Universities, to a wide range of students, coming from a range of backgrounds, enrolled in a variety of courses across different faculties. Additionally, the "systems-thinking" approach is being increasingly favoured as a useful paradigm in developing solutions to issues such as those posed by future climate change (Richmond 2013). STELLA modelling software (http://www.iseesystems.com/softwares/Education/StellaSoftware.aspx) is a tool designed to teach "systems-thinking" by providing an intuitive, icon-based graphical interface that simplifies model building. Students do not require any prior knowledge of computer programming and do not need to have prior extensive knowledge of calculus, but only basic algebra. Using "stocks", "flows", and "converters", students are able to build spatially implicit models of various aspects of the earth system, such as the hydrological cycle, nutrient cycles, etc. In this talk, I will reflect on my use of STELLA software to teach a post-graduate course in earth systems science at Murdoch University, Perth, Western Australia.

Reference:

Richmond, B. (2013) An introduction to systems thinking. Isee systems, 165 pages.

Submission ID: 167
Presenting Author: Charles Nelson*
Session: Posters 2
Session Time: WEDNESDAY 15:30-16:30
Poster #74

74. Temporal and spatial variation in belief in climate change in Australia

NELSON Charles[1]*

1) Foreseechange Pty Ltd

The general public's level of belief in climate change has varied substantially over time and also varies by location in Australia. Analysis of these variations enables us to draw conclusions about the factors which have influenced changes in belief. In conjunction with other data, this analysis provides guidance on strategies to influence the level of belief and to propose actions which are less susceptible to opposition based on arguments that human activity is not influencing the climate.

The primary data set analysed is based on annual surveys conducted by Foreseechange since 2005, which contain a measure of the level of belief that the climate is changing. This data set enables analysis over time and also, due to the large aggregate sample size, permits analysis by small area (in this case Commonwealth Electorate Districts).

Time series data concerning the level of support for generic action on climate change, collected by the Lowy Institute, is also analysed and is shown to be strongly correlated with the Foreseechange measure of belief that the climate is changing. Thus, communications which lift the general level of belief in climate change can be expected to increase support for action.

Data from a range of other sources, both from Australia and the USA, is drawn on as further evidence and to enrich the insights and conclusions.

Data concerning support for some specific actions to reduce carbon dioxide emissions are also analysed and this provides a basis for strategy which is resilient to attack by deniers of climate change.

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