


Institut de recherche pour le développement

## Sciences de la mer

# Océanographie physique

Rapports scientifiques et techniques N°7

**FEVRIER 2013**

## Summary of the

# 10th ICSHMO

International Conference on Southern Hemisphere Meteorology and Oceanography

# Nouméa (New Caledonia) 23rd to 27th April 2013

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*Agir avec le Sud*
*Acting with the South*

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Summary of the 10th International Conference on Southern Hemisphere Meteorology and Oceanography (10ICSH-MO), held in Nouméa (New Caledonia) from 23rd to 27th April 2013. Nouméa : IRD, février 2013. (Sciences de la Mer. Océanographie Physique. Rapports Scientifiques et Techniques ; No. 7).

HYDROLOGIE MARINE ; CIRCULATION OCEANIQUE ; INTERACTION OCEAN ATMOSPHERE ; CLIMAT ; VARIABILITE ; PREVISION CLIMATIQUE ; CONFERENCE

Imprimé par le service ISC
Centre IRD de Nouméa
Février 2013

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1 LOC: Local Organizing Committee
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**Summary of the 10th International Conference on Southern Hemisphere Meteorology and Oceanography (10ICSHMO)**

Since its advent in 1983, the ICSHMO conferences have provided a unique contribution to ocean and atmosphere sciences that are specific to the Southern Hemisphere. The objective of the 2012 conference held in Noumea, New Caledonia from 23-27 April 2012, the 10th of the series, was to provide an interdisciplinary forum for presentations of our current state of knowledge, as well as motivating new research and applications within the variety of disciplines related to weather and climate of the ocean and atmosphere. This was also the first ICSHMO conference conducted in a Pacific Island state, and the first one conducted in a French Territory. Attendees were welcomed by the President of Government of New Caledonia, and the hosts from MeteoFrance and the, Institut de Recherche pour le Développement (IRD), and American Meteorological Society did a fabulous job, and the venue at the Tjibaou provided an excellent venue that combined the best of a modern facility along with a great recognition of the indigenous traditions of New Caledonia and the region.

In that regard, the 10ICSHMO was a great success; with over 325 attendees from countries across the southern hemisphere, as well as many key attendees from the boreal half of the planet, the 10ICSHMO held a total of 17 sessions covering the breadth of oceanic and atmospheric science with paper and poster presentations ranging from tropical cyclones, ocean observations, climate variability and the South Pacific Convergence Zone; to special sessions on data rescue and management, and climate change and related science work in developing nations in the Pacific Islands region. The conference benefitted from an extremely diverse set of attendees that including academics, scientists from large national agencies, and most encouraging young scientists and students, and up and coming scientists from developing nations. The papers and posters were of extremely high quality, but even more vital was the great exchange of information that took place in the hallways, buses to and from the hotels, and social events. There was a real feeling of (as the Hawaiians would say) of O'hana (or family) that ran through the conference. This was highlighted by a wonderful presentation by Dr. David Karoly from Melbourne University who gave a historical overview of the ICSHMO from its beginnings in 1983 (David by the way is the only person to have attended all 10 ICSHMO conferences to date).

Attendees are already looking forward to the 11th ICSHMO (venue still to be determined). In summary, the conference was a great success, a great amount of good scientific and technical information was exchanged, and from the conversations that were going on and the interactions between senior scientists and students, the fields of oceanography and meteorology (particularly in the developing nations of the Pacific Islands) are in good hands.

## Named session in honour of Pedro L. Silva Dias

Chair: Alice Grimm (grimm@fisica.ufpr.br)

The 10th ICSHMO honoured with a special session Pedro L. Silva Dias, from Brazil. He is a renowned expert on the role of tropical heat sources, with a wide variety of climate variability and change studies in South America, and currently serves as Director of the National Laboratory for Scientific Computing in Brazil.

After the introduction by Dr. Alice Grimm, Dr. Pedro L. Silva Dias talked about the theory and observations of multiscaling characteristics of the South American Monsoon System (SAMS). He described the major features of the SAMS and its important heat sources with regional and remote influences and with significant diurnal, synoptic, intraseasonal, decadal or multi-decadal variability. Theoretical results on the role of heat sources in tropical South America were reviewed, including the role of vertical shear, diurnal variation, determination of the subsidence areas induced by the Amazon and SACZ heat sources, remote influences of the SAMS heat sources and energy transfer from the diurnal to very long time scales based on multiscaling models.

## Named session in honour of Johann Lutjeharms

Chair: Arne Biastoch (abiastoch@geomar.de)

Johann R. E. Lutjeharms was honoured with a special session during the 10th ICSHMO. He was one of Africa's leading marine scientists and most-known expert on the Agulhas Current. He passed away on Wednesday, 8 June 2011.

Dr. Arne Biastoch gave the summary “On the Role of the Agulhas System in Ocean Circulation and Climate”, in which he reviewed the current knowledge of the oceanic circulation south of Africa. The water exchange between the Indian and Atlantic oceans, the “Agulhas leakage”, acts as a key process in the global thermohaline circulation. It serves both as an important backbone of the Atlantic meridional overturning circulation (AMOC) and as a modulator of global climate and climate change. Recent studies suggest an increase in Agulhas leakage due to atmospheric changes. Owing to the strong nonlinearity of the flow, it is dominated by meso- to interannual timescales, which hinders the observational detectability of decadal and long-term changes. Numerical models offer an alternative approach to investigate the mechanisms for changes and consequences on the large-scale circulation.

**Session 01:**
**Monsoon Systems in the Southern Hemisphere**

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Matthew Wheeler (m.wheeler@bom.gov.au)

This session promoted discussion on issues relevant to the understanding of Southern Hemisphere monsoon systems and their variability. In his invited presentation, Hugo Berbery presented a review of the regional and large scale features of the South American monsoon system (SAMS). The ability of the CAM3.5 model to represent the large scale mechanisms of its interannual modulation by large scale SST modes of the Pacific and Atlantic Oceans was discussed. Although idealized simulations with permanent SST anomalies were analyzed, the results may be promising in the context of seasonal dynamical forecasts.

The invited presentation of Gerald Meehl showed that the interdecadal Pacific oscillation (IPO) can modulate Indo-Pacific connections and the biennial tendency in the Indo-Pacific climate system. Several reasons can be responsible for the reduction (increase) of this tendency during positive (negative) IPO: latitudinal extent of Pacific trade winds and cold tongue; differences between SST of Pacific and Indian oceans affecting the trade winds and coupling strength; shifts of Walker Circulation; and intensity of Indian Ocean SST variability. Global coupled climate model simulations illustrate the mechanisms.

The interdecadal variability of the South American monsoon was addressed in one oral and one poster presentation, stressing modes of variability, connection with Atlantic and Pacific modes of SST variability, timescales, and its significant influence on the frequency of extreme precipitation events. The interannual variability of the northern Australian monsoon rainfall was analyzed and the skill of many climate models in simulating the associated atmospheric circulation patterns was assessed. According to one presentation, models that tend to simulate realistic patterns of rainfall and their corresponding circulation patterns show increases in rainfall under anthropogenic climate change conditions and also indicate that wet years become wetter and dry years become drier under these conditions.

Longer timescales were also highlighted. One presentation described long term variations in the northwestern Australian monsoon, back to 6,500 years, from wet to intermittent/failure conditions, probably due to positive feedback processes triggered by ENSO and its variability. A new forecast scheme of the wet season onset in North Australia was presented, using forecasts from the Predictive Ocean-Atmosphere Model for Australia (POAMA) from 1st July, 1st August, or 1st September. The skill of the hindcasts exceeds the 70% correct level over about 1/3 of the region, and is generally better than that obtained by a previous scheme using the SOI as a predictor.

Several aspects were covered in the poster presentations: prediction of monsoon precipitation; ENSO impacts on monsoon rainfall; monsoon related circulation; and relationships between interdecadal modulation of monsoon and frequency of extreme rainfall events.

**Session 02:**
**Tropical cyclones: past, present, and future**

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The study of tropical cyclones (TCs) continues to be an active area of research for both the southwest Pacific and south Indian Ocean basins, and the great amount of work going on was reflected in the diverse array of presentations and posters that were part of Session 02. The two presentation sessions were split between a focus on more operational considerations in the first half, and a more research focused emphasis in the second half, and this was emphasized by the invited speakers that kicked off each portion of the session.

In the first half, Steve Ready from New Zealand Metservice stepped people through the operational history of TC monitoring and forecasting over the past 30 years or so, and demonstrated the great strides that have been made not only as a result of satellite coverage, but also of improved communications amongst the monitoring centers in the Pacific. From the presentations that ensued, these great strides were confirmed. For example, the progress made via the WMO-sponsored Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project (SWFDDP) in providing improved forecasting tools to national meteorological services across the Pacific will result in better warnings for persons across the region. There has also been an increase in the scope and quality of TC seasonal outlooks, highlighted in discussions related to use of a new dynamically coupled model employed by the Australia Bureau of Meteorology, as well as from a combined group from the National Institutes of Water and Atmosphere and the University of Auckland in New Zealand that have developed a robust outlook method based on seasonal analogs employing the Coupled ENSO Index (CEI) and the technique of Gergis and Fowler (2005)., Continuing this theme, the newly updated South Pacific Enhanced Archive of Tropical Cyclones (SPEArTC) of Diamond, et al (2011) was presented. On a more localized level, work at the University of the South Pacific also described a better analysis of TC tracks and looked at the effects of ENSO on interannual variability of TCs in and around Fiji. Finally, since TCs also have a great impact on the marine environments of the region, a presentation by L'Institut de recherche pour le développement (IRD) in New Caledonia, focused on the impacts of TCs and their impacts on marine ecosystems

The second half of the session began with the invited talk by Kevin Walsh of the University of Melbourne, followed by several contributed talks focusing on the research and modelling aspects of TCs. Kevin pointed out that for the Southern Hemisphere, like in the Northern Hemisphere, both theory and model simulations indicate that there will be increases in the intensities of the most intense TCs in a warmer world. Where the Southern Hemisphere differs from the Northern Hemisphere, however, is that almost all climate models predict substantial decreases in total TC numbers there. The talk went on to consider the issue of whether these decreases in total numbers will be large enough to ensure less frequent intense TCs in this hemisphere.

Given that the spatial resolution of both global climate models (GCM) and regional climate models (RCM) are relatively coarse, the issue of downscaling approaches used to investigate potential changes in the intensity of TCs in a warmer, future climate is a key area of study. As such, results from downscaling studies of Australian region TCs using the CSIRO Cubic-Conformal Atmospheric Model (CCAM) and the Regional Atmospheric Modeling Scheme (RAMS) were presented. As a follow-on to that a presentation on the use of the NOAA

Geophysical Fluid Dynamics Laboratory High Resolution Atmospheric Model (HIRAM) version 2.1 (run on a cubed sphere grid - C180) was shown to simulate hurricane statistics consistent with observations (Zhao et al., 2009, 2010). Analyses were shown to have been conducted on 20 model years (240 'summer' months) to obtain a variety of cyclone statistics, focusing on the spatial and temporal variability of cyclogenesis. The model generated about 250 TCs (near surface winds > 17m/s) per year, with approximately 60-65% reaching full TC strength (winds > 33m/s). This method was able to be employed in order to better characterize the large-scale environment coincident with cyclogenesis.

Another regionally-based modeling activity that was presented uses the Genesis Potential Index (GPI) (Emanuel and Nolan, 2004) coupled with the and direct detection of TC-like vortices (Walsh et al, 2004). The analyses from the models were compared with the NCEP and ERA40 reanalysis data for the current climate. The resultant analysis was then extended to study changes in TC frequencies for the future climate of 2090 assuming the IPCC A2 scenario. Additionally, individual components of the GPI index were studied from a climate change perspective to extend our understanding of the models' responses to climate change.

Two final presentations investigated some historical data reanalysis. An analysis was done to re-adjust the tracks in line with the Dvorak method to re-estimate TC intensities, and from there a comparison was made between the best track from Joint Typhoon Warning Center (JTWC) and the new track reanalyzed that showed a track and intensity errors. While many studies have examined the specific situations of the tropical northern Atlantic, where African Easterly Waves play an important role in cyclogenesis, and north-western Pacific, where easterly waves, monsoonal trough and MJO modulate the activity. However, much less is known concerning storm formation in the southern hemisphere, and a study concerning the analysis of cyclogenetic evolution of named storms in the south-western Indian ocean during 1998-99 to 2009-10 seasons, from ECMWF reanalyses and Meteosat-7 images were presented.

**Session 03:**
**Other severe weather systems: MCS, cut off lows**

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This session was meant to cover all aspects of severe weather systems occurring in the Southern Hemisphere with the exception of tropical cyclones, having a special focus on Mesoscale Convective Systems (MCS) and Cut off low (COL). Such weather systems are among the most severe that affect any areas of the Southern Hemisphere and are responsible for some of the most catastrophic events in terms of their precipitation rate, especially during warm months. The parallel session C started on the morning of the April 26th and finished in the afternoon.

Tercio Ambrizzi from the University of São Paulo, Brazil presented the invited talk. He presented a review of the main dynamic-climatic features of cyclone development over three main regions with higher cyclogenesis frequency: near south/southeast coasts of Brazil, over the Uruguayan and extreme southern Brazilian coasts, and near the southeastern coast of Argentina. In particular he made a review of the following topics: 1) cyclogenesis climatological studies over the South Atlantic Ocean, 2) projections of the cyclones for future climate scenarios, and 3) mechanisms contributing to cyclogenesis in the region. His presentation was important to open the discussion about the importance of the cyclones for the weather and climate over South America. The following oral presentations in the morning covered my regions of the South Hemisphere and were related to the precipitation of diurnal cycle over Tropical South America, anticyclone blocking in Southern Australia, energetics, development and predictability of cut-off cyclones over Southern South America and the Southern Hemisphere in general.

In the afternoon session, the presentations were related to mesoscale convective systems over Southern Brazil and Africa, some discussion about fronts and precipitation and how the climate models represent these weather systems and the last talk discussed the relationship between Southern Hemisphere Cut-off lows and their relationship with Southern Annular Modes and El Niño-Southern Oscillation. Almost all the presentations were followed by at least two questions for the speakers.

In general, the severe weather systems session had a regular number of participants and all presentations were in a high level.

**Session 04:**
**Intraseasonal variability and prediction in the Southern Hemisphere**

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The common ingredient of presentations in this session was the focus on the intraseasonal time scale, that is, the time scale that sits between what is associated with day-to-day weather and seasonal climate variability. Traditionally, a gap has existed in operational forecast services at the intraseasonal time scale, but now intraseasonal prediction is serving to fill this gap (e.g. Fig. 1).

A number of phenomena have been identified as being important on the intraseasonal time scale, and those that were addressed were the Madden Julian Oscillation (MJO), Southern Annular Mode (SAM), blocking, subtropical anticyclones, equatorial waves, and planetary-scale wavetrains. In the invited presentation by Adrian Matthews and colleagues, the audience was treated to an explanation of their theory for dynamical ocean feedback within the MJO. The theory involves MJO forcing of an oceanic Kelvin wave which reflects off Sumatra to reappear as a positive SST anomaly in the western Indian Ocean about 80-100 days later, where it may then force the next “primary” MJO event. Other presentations showed the impact of MJO-associated variations in tropical convection on the weather in locations far removed from the tropics, such as southern South America and southern Africa, through the involvement of Rossby wavetrains.

Physical processes relevant to the intraseasonal time scale were also highlighted. One presentation discussed the role of antecedent soil moisture for intraseasonal variability over southern Africa. Field campaigns that are contributing to the understanding of processes on this time scale include CINDY/DYNAMO, whose field collection phase ran from October 2011 to March 2012, covering a large area of the Indian Ocean, which was the subject of a poster.

Through the increase in understanding on intraseasonal phenomena and processes, significant improvements in intraseasonal prediction have started to occur. An example of this was provided in the invited presentation of Andrew Marshall and colleagues, in which the new multi-week version of the Predictive Ocean-Atmosphere Model for Australia (POAMA) was discussed. The presentation showed that through a combination of the good simulation of rainfall impacts of the MJO, SAM, and blocking, as well as good prediction skill of these phenomena, the skill of predicting total rainfall in weeks 2-4 of the forecast is significant and improved relative to the previous version of the model. In this case the improvement was attributed to the adoption of a coupled ensemble initialization system. However, some inadequacies are still apparent, and the application of forecasts on this time scale for society, industry, and agriculture, remain as important future challenges.

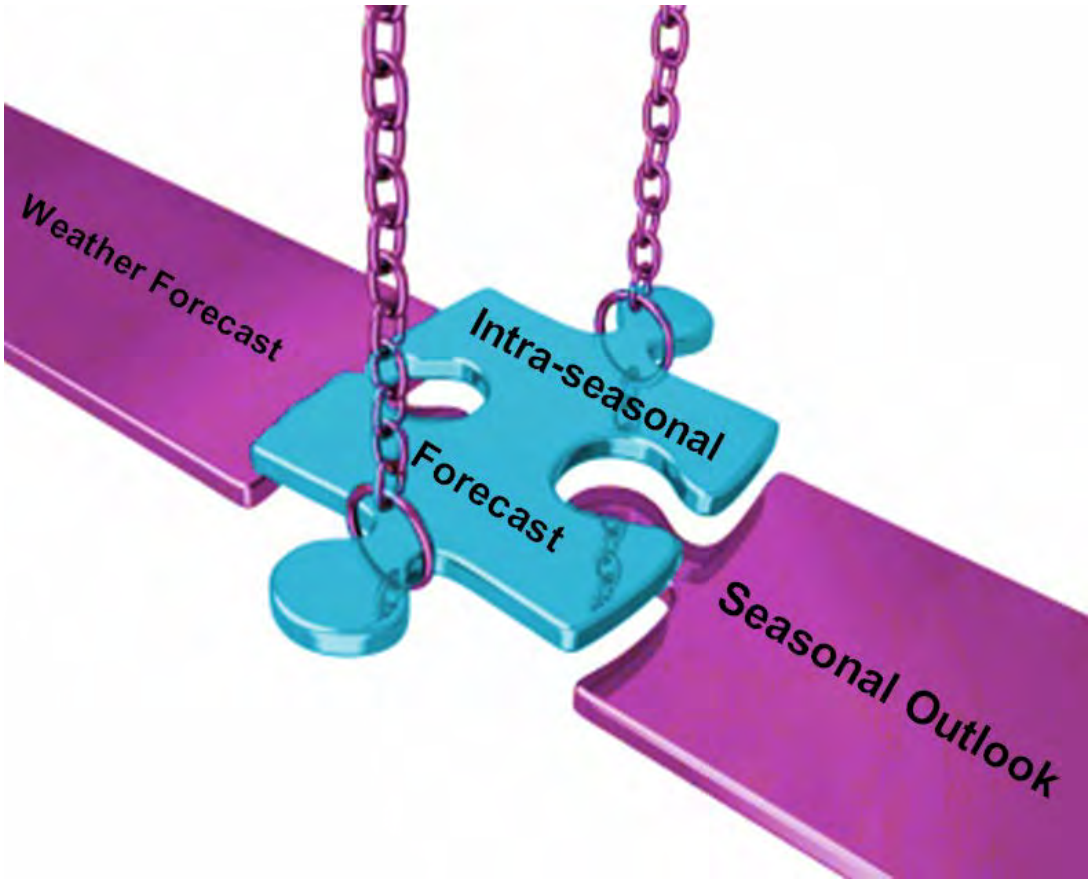


Figure 1: The study of intraseasonal processes and phenomena serves to fill the traditional gap that exists between weather and seasonal climate forecasts (figure presented at the conference in the invited presentation of Andrew Marshall and colleagues).

**Session 05:**
**Interannual climate variability and Southern Hemisphere teleconnections**

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The session addressed many aspects of interannual climate variability and teleconnections research relating to Southern Hemisphere (SH) climatic patterns. Teleconnections propagate the physical influence of climatic phenomena to regions remote from the core physical interactions that define them - such as those transmitting the climatic influence of the core ENSO dynamics in the Indo-Pacific domain to higher latitudes or the impact of extratropical variability associated with the annular modes on the mid-latitudes. Many presentations in the session analyzed the impacts of ENSO, IOD, SAM on regional climate variability all around the SH, e.g., Australia, South Africa, South America and even in Antarctica.

The impact of ENSO on regional SH climate differs with seasonality, magnitude and spatial extent across a range of timescales, depending on the position of maximum warming along the equator being located in the central or eastern Pacific. This teleconnection variability was also implicated in the extreme ocean-atmosphere conditions in the South Pacific in 2009-2010. The role of the SPCZ in modulating the asymmetry of ENSO and the termination of ENSO events was also highlighted. Long-term climate variations recorded by Kauri tree-rings in New Zealand allow reconstruction of an extended record of ENSO activity due to the strong teleconnection of the local climate to the tropical Pacific.

It was shown that barotropic Rossby wave trains emanating from the Indian Ocean could induce changes to the midlatitude westerlies across southern Australia and thus modulate precipitation. Similarly, South American rainfall anomalies are linked to circulation anomalies set up by tropical SST anomalies in the western Pacific and Indian Oceans and mediated through Rossby wave train dynamics. Blocking in the Australian sector is an important driver of the rainfall variability in that region, with implications for long-term trends. The role of tropical and extratropical surface forcing in the Australian sector is assessed in AGCM simulations for its effect on blocking to better understand model deficiencies. The role that topography, resolution and parameterizations play in improving representations of South American climate, and its teleconnections to the large-scale SH circulation was also explored in AGCM experiments.

Some recommendations arose. It is suggested that studies examining the climate impacts of the SAM across the Southern Hemisphere need to consider the seasonal variations in the SAM structure (asymmetries or circular) as well as varying impacts between its positive and negative polarity in order to adequately describe the underlying relationships. And if it is necessary to study the SAM it is also essential to reduce the uncertainty in air-sea fluxes estimates and air-sea flux representation in ocean models for understanding the observed trends in the Southern Ocean, in particular as they relate to the role of eddies. Some experiments with A-GCM or C-GCM continue to exhibit a significant impact of convective schemes and resolution on the skill of the climate simulations, while the teleconnection patterns in this “numerical world” appear to have second-order impacts on the accuracy of the simulations of temperature and precipitation. A statistical technique that deals with non-linear interactions and avoids linearity assumptions (for example between ENSO and IOD) allows a high level of skill several months in advance for hydrological prediction.

**Session 06:**
**Interdecadal climate variability and Southern Hemisphere impacts**

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Improving our ability to assess the impacts of variations and future changes in climate is crucial. It would enable governments, communities, and businesses to determine strategies to reduce potential negative impacts and to take advantage of opportunities by adapting infrastructure, activities and plans. However, the issue about how much of the regional climate changes is attributable to natural variations and how much is due to anthropogenic activities has not yet been resolved. During recent decades there has been considerable effort in trying to understand the decadal and interdecadal variability of the climate system and very recently climate predictions on decadal timescales are becoming available through multi-model experiments like the WCRP/CMIP5.

The session focused on understanding and attributing SH climate variability on interdecadal time scales in observations and climate models, its regional and local impacts, as well as decadal predictions. The session's two invited talks addressed interdecadal Pacific variability, with modulations in ocean heat uptake affecting long-term global surface warming, changes in the Walker circulation and impact on tropical cyclones. Jerry Meehl (NCAR) reported on the relative roles of forced and inherent decadal variability in the Pacific for the mid-1970s climate shift from climate model simulations: how variations in oceanic heat uptake in the Pacific on decadal timescales can be linked to hiatus periods in observed global surface warming over the past century. Scott Power (BOM) assessed causes of the observed 20$^{th}$ century weakening of the Walker circulation, which coincides with increasingly negative SOI values in recent decades, as well as the impact of such low-frequency variations in tropical Pacific variability on the number of tropical cyclones making landfall in Australia over the past century.

Other topics included how regional climate impacts, such as variations in rainfall, temperature, and streamflow, could be related to changes in the SH large-scale atmospheric circulation and low-frequency ENSO variability and PDO phases. Several studies explored interannual variations and recent observed changes in the meridional circulation over the Australia-New Zealand region, their effect on rainfall, representation in climate model simulations, and attribution.

**Session 07:**
**Climate predictability in the Southern Hemisphere:**

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Demands are increasing for prediction in different time-scale: monthly, seasonal, annual, and up to decadal (near-term climate prediction). Prediction about the shortest climate time scales are already in application while the decadal prediction is a research issue identified in the current IPCC-AR5 experiment.

The presentations confirmed the operational development of the seasonal forecast systems in the Southern Hemisphere: the Pacific Island Countries with the dynamical seasonal prediction system of the Australian Pacific Adaptation Strategy Assistance Program and Brazil or New Caledonia (non-exclusive) with their own system. The downscaling (statistic or dynamic) is a key issue for application to the small territories, but the results show a significant and useful predictability. The climate change in the hindcast (up to 40 years) for seasonal forecast is an issue from a practical point of view and is addressed with preliminary theoretical works. The initial conditions in decadal climate prediction exercises were also pointed out with respect of the lack of observations in the Southern hemisphere and the computational cost: a particle filter approach was proposed as a possible perspective.

**Session 08:**
**Climate change in the Southern Hemisphere**

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The session was organized to exchange and discuss the latest information on climate change in the Southern Hemisphere. This included trends in the physical and biological environment, causes and mechanisms responsible for the observed changes, effects on weather, currents, and ecosystems, the various feedbacks and linkages involved, and prediction of future impacts for projected scenarios of climate change. Forty-eight investigations were presented, 34 as talks and 14 as posters, which made the session one of the biggest of the conference.

Invited speaker Prof. Richard Somerville started by giving an historical perspective of climate change and climate science. He reviewed the advances enabled by the invention of satellites, supercomputers, and climate models, and emphasized the increased understanding of Southern Hemisphere climatology brought about by these advances. Invited speaker Prof. David Karoly reflected on the evolution of climate science during the last 30 years, as seen through the ISCHMO conferences. He pointed out aspects not originally considered, such as ocean-atmosphere interactions, intra-seasonal variability, stratospheric ozone depletion, and climate change, and predicted that the next 30 years will likely witness as many substantial developments with some surprises.

The presentations covered a wide range of topics, but focused mostly on the physical climate and the atmosphere. Relatively few studies addressed issues of ocean circulation and biogeochemistry in a changing climate. Findings were reported on the annual cycle of surface temperature and weather patterns of the Southern hemisphere, climate change and global energetics, atmospheric circulation and Rossby waves in a warming climate, trends in atmospheric fronts, the causes of Australian rainfall variability and climate change in East Africa and Southern America, and the seasonal influence of planetary waves on the Antarctic surface temperature. A variety of climate model simulations and inter-comparisons were presented, including multi-scale forecasts. Other results communicated were: ENSO and freshening trends in the Tropical Pacific; ENSO and precipitation extremes; anthropogenic effects on Agulhas leakage and salinification of the Atlantic; projected ocean acidification in the Western Pacific and potential effects on the health of coral reefs; SAM and phytoplankton diversity in the Southern Ocean; spectral variability of sea-surface height in the Southern Hemisphere; wind-wave predictions under future climate scenarios; the heat content of the upper circumpolar deep water and melting of the West Antarctic ice sheet; and reconstructing the sea-ice volume of the Southern Hemisphere.

**Session 09:**
**Inter-ocean exchanges**

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In the Southern Hemisphere, the Drake Passage, the Agulhas System, the Indonesian Throughflow and the waters south of Australia act as 'choke points' in the global wind-driven and thermohaline circulations. Major international and regional observational and modelling initiatives act to determine and to monitor the amount of inter-ocean exchanges, and detangle potential anthropogenic influence on observed trends from natural multi-decadal variability.

Presentations in this session addressed the influence of the Pacific Ocean on the Indian Ocean, through substantial observational efforts to long-term monitor the detailed flow through the Indonesian passages, by the model-based quantification of Tasman leakage south of Australia and by fast wave responses around Australia on the sea surface height in the Indian Ocean. Agulhas leakage, the interoceanic transfer south of Africa, is subject to substantial increase due to changing wind fields in the Southern Hemisphere. Dedicated model studies aimed to detangle the individual impact of the Indian Ocean Trades and Southern Hemisphere Westerlies on the Agulhas Current system, and consequently the Agulhas leakage. A third important topic was the flow from the Pacific to the Atlantic through the Drake Passage, where multi-national observational efforts called for integrative studies and international coordination.

**Session 10:**
**Ocean observing systems and operational oceanography**

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The last 20 years have provided us with an unprecedented ability to observe, monitor and forecast the oceans. In-situ and remotely sensed ocean observations underpin many research and application areas, including climate research and operational oceanography, covering timescales from days to decades and regions ranging from coastal areas to the global ocean. Furthermore, the advent of oceanic re-analyses at eddy-resolving spatial scales allows the systematic exploration of eddy dynamics in major ocean boundary currents and of shelf-scale upwelling processes. This session invited presentations about the development of the global ocean observing system (GOOS) and about operational ocean forecasting systems, with focus on the Southern Hemisphere.

The presentations focused on recent progress in ocean state and data assimilation and our increasing ability to improve model simulations and predictions on daily to climate time scales by constraining models with observations. CLIVAR (in particular, the Global Synthesis and Observations Panel; http://www.clivar.org/organization/gsop) and the short-term ocean forecasting community (http://www.godae-oceanview.org) have initiated informal collaboration about ocean data assimilation covering short-term, mesoscale ocean forecasting to multi-decadal “reanalysis” for climate applications.

A second focus area of this session was the design, implementation and application of the Southern Ocean Observing System to climate research (SOOS, http://www.scar.org/soos/, also see Fig. 1). The Southern Ocean is changing as indicated by regional warming, decreased salinity in upper and abyssal ocean, basin-wide acidification, regional decreases in sea ice and shifts in ecosystems. Given the connection of the Southern Ocean with all other major oceans there is an increasing need to comprehensively monitor and understand the changes in order to be able to predict future changes, and mitigate impacts. Although many challenges remain, to achieve a sustained global ocean observing system the ocean and climate research community can now draw on these observing networks and oceanic re-analyses to improve our understanding and ultimately our ability to predict daily, to seasonal-to-interannual (e.g., El-Nino/La Nina, IOD, SAM) to multi-decadal changes (e.g., PDO) in the ocean and associated extreme events.

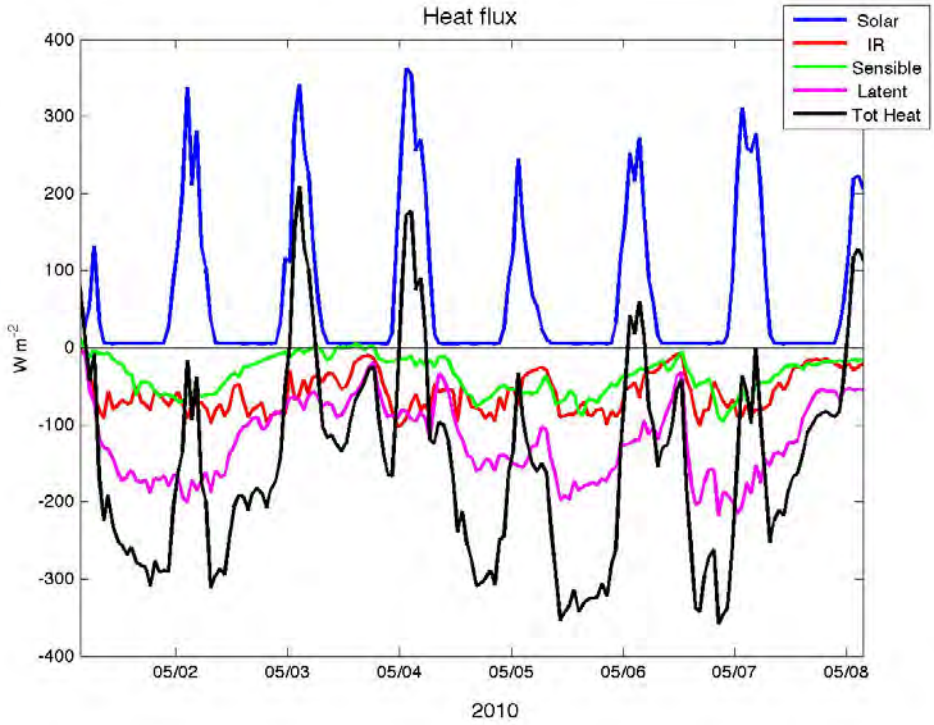


Fig. 1: The Southern Ocean Flux Station (SOFS) is part of the Australian Integrated Marine Observing System and of the international network of OceanSITES Flux Reference Stations measures bulk heat fluxes at the ocean-atmosphere interface in the Southern Ocean (courtesy Eric Schulz, BoM).

**Session 11:**
**Southern Hemisphere Subtropical Convergence Zones: SPCZ, SACZ, SICZ**
**(PACCSAP-sponsored)**

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Ken Takahashi (ktakahashi@geo.igp.gob.pe)

The Pacific-Australia Climate Change Science and Adaptation planning Program (PACCSAP) sponsored a session on the South Pacific Convergence Zone (SPCZ) and other southern hemisphere convergence zones. This session was well-attended and reflected a rapid recent increase in the number of scientists investigating the SPCZ in recent times. Research described the impact of atmospheric Rossby waves and the MJO on the SPCZ (A. Matthews), the vertical structure of diabatic heating in the SPCZ, SACZ and the SICZ (C. Zhang and J. Ling), the inter-relationship between winds and precipitation near the SPCZ in CMIP3 models and the ability of CMIP3 and CMIP5 models to simulate the SPCZ (Jo Brown et al.), the existence and impact of unusual, near-zonal SPCZs in some years (M. Lengaigne et al.) and an increase in their frequency of occurrence in climate models in response to global warming (W. Cai et al.), the impact of bias correcting model SSTs on the simulated SPCZ (M. Widlansky et al.), and the character of the SPCZ and the SACZ during the mid-Holocene (B. Lintner et al.).

**Session 12:**
**Southern Hemisphere Ocean Circulation and Climate**

Rosemary Morrow (Rosemary.Morrow@legos.obs-mip.fr)
Juliet Hermes (Juliet@saeon.ac-za)
Arne Biastoch (abiastoch@ifm-geomar.de)

Invited Speakers:
Matthew England, University of New South Wales, Sydney
Tomoki Tozuka, University of Tokyo

Recent advances in observational systems and realistic models in the Southern Ocean have allowed us to better understand its key role in the hemispheric and global ocean circulation, which in turn impacts on the global carbon cycle and overturning circulation, on regional ecosystems, and on sea level rise. Complex interactions occur between the atmosphere, ocean, cryosphere and marine organisms, which are all evolving over time.

The first part of this session presented a number of recent studies which investigated how the surface layer in the Southern Ocean responds to interannual and longer term forcing, including models with increasing resolution. The impact of surface buoyancy fluxes and ocean eddy fluxes on Subantarctic mode water formation was also addressed, and the export of water masses and carbon into the ocean interior. Different papers discussed the response of the Antarctic Circumpolar Current transport to different wind regimes and model resolution. Under increased wind forcing, the more realistic eddy-resolving models had limited transport increases, in agreement with available observations. The detailed upper ocean velocity structure revealed by new ocean observations such as EM-APEX floats gives new insight into Ekman currents and regions of deviations from the equivalent barotropic structure of the circumpolar flow.

At deeper levels, decadal observations of bottom water formation at two sites, in the Weddell Gyre and near Adelie Land, have confirmed the continued warming and freshening of Antarctic Bottom water, with a shift to lighter density classes, so that the volume of the densest water being exported is reduced. The mechanisms governing these changes are also being investigated, but reduced sea ice which allows faster continental glacier melt is contributing.

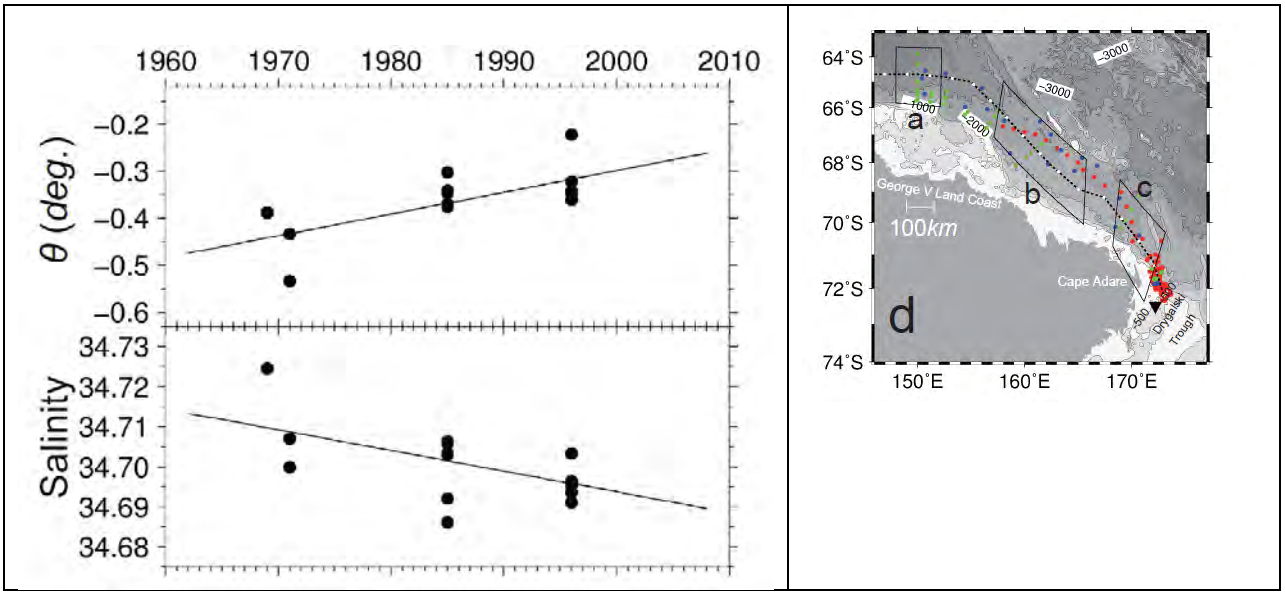


Figure. Decadal warming and freshening of AABW. Potential temperature (upper panel) and salinity (lower panel) averaged over the 100 m thick layer at the bottom vs. year with regression lines from region around 150° E. Profiles located within the box (right) are used here. After Shimada et al. 2011. Ocean Sci. Discuss., 8, 2197–2235, 2011.

**Session 13:**
**Southern Hemisphere Island weather and oceanography: past and future**:

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This session explored the variety of meteorological and oceanographic factors that affect the small, isolated islands in the oceans of the Southern Hemisphere, particularly the Pacific Island states, with an emphasis on the particular challenges that the often geographically isolated communities face in these regions.

One focus was the difficulty in applying climate change simulations to oceanic islands. Although these islands may be large enough to generate their own meteorology and climate that is very different from that over the surrounding ocean, the islands themselves are smaller than the typical grid resolution of a climate model. Hence, islands such as New Caledonia have no representation in climate models, as the model just has ocean there. Hence, downscaling of climate model simulations to the local scale is especially difficult. However, downscaling methods can be applied with care. A next step is to combine downscaled climate model simulations and pathogen models to simulate and predict outbreaks of infectious diseases. Discussion of this approach focussed on dengue fever, which has a clear link with air temperature, and the predictive capability of disease modelling was investigated. Low lying oceanic islands are especially vulnerable to sea level change. This was discussed in the context of long term sea level rise, and variability due to ENSO. In addition the effect of wave breaking raising the sea level just inshore of the surf zone by up to 50 cm can have serious consequences on the many small Pacific islands whose maximum elevation may only be 2-3 m above mean sea level. Coral reefs are globally endangered habitats at risk from climate change, being particularly sensitive to small increases in ocean temperature that can lead to coral bleaching; the energy budget of a reef during a local coral bleaching episode was presented. Finally, many Southern Hemisphere islands are volcanic in origin, and several of these are currently active volcanoes. The often overlooked passive degassing from these volcanoes can be a significant source of sulphate aerosol, with a subsequent contribution to the regional and global radiative balance and forcing of climate change. For example, the passing degassing from Vanuatu is equivalent to over 50% of the (anthropogenic) sulphate aerosol emission from Australia.

**Session 14:**
**From Climate Change Science to Adaptation**:

**Brian Dawson** (briand@spc.int)

The primary purpose of this session was to highlight the importance of linking scientific research to applied on-ground adaptation response action. The session included a range of expert speakers that presented a range of interesting results. One of the key requirements for effective adaptation planning is to reduce the level of uncertainty surrounding future projections of climate change. This is particularly important for longer term-long lived investments such as economic infrastructure.
As observed by several of the speakers overcoming uncertainty associated with long term climate change projections is difficult given our current level of understanding. Recent research has also highlighted that the results of global models can differ from more downscaled models and care needs to be taken in planning adaptation responses on coarse results from global models.

The session involved presentations from nine expert panelists and covered a wide range of topics.
The first presentation, by Johann Bell from SPC, outlined the findings of a major 3 years study that assessed the vulnerability of Pacific fisheries to projected climate change over this century. The vulnerability study highlighted the significant climate change impacts on coastal fisheries, where catches could decline by up to 50% by the end of the century. By comparison the expansion of the warm pool in the central Pacific could result a 20-30% increase in oceanic fisheries catches such as Tuna. This information is of significant relevance to decision makers in terms of long term fisheries policy and catch quota allocations.

Jaclyn Brown, from CSIRO Australia, discussed the results of recent modelling under the Pacific Climate Change Science Program, and highlighted the significant biases that occur across the range of models available. Models also often long term and it is hard to clearly determine climate change from natural climate variability over the shorter term, though this is often the time period on which decision makers make planning and policy decisions. It is essential that decision makers be aware of these biases and systematic errors as they can have significant implications in terms of likely future climate change outcomes. Model errors and biases also underscore the level of uncertainty that remains in terms of ascertaining the potential impacts at a smaller scale, especially in the Pacific Island countries.

In a similar vein to the previous paper Matthew Chamberlain identified the coarseness of many global climate models and that they often mask important details about processes at work at the local scale. This is particularly the case for ocean processes and projecting the impacts on marine systems. He emphasized the importance of model downscaling to get higher resolution results that can highlight important processes at work. The experience of the work undertaken in downscaling is especially applicable to the Pacific Island countries due to their very small scale and the inability of models to deliver fine enough detail for adaptation decision making.

Stephen Crimp, CSIRO Australia, presented a very useful paper on the impacts of climate change on Pacific island food security. Recent research work undertaken by CSIRO, in cooperation with the Secretariat of the Pacific Community, indicates that both the yield and nutritional value of Pacific staple crops (such as Taro and Cassava) are likely to fall under higher concentrations of $CO_2$ in the atmosphere. In addition at higher concentrations of $CO_2$ also result in an increase in toxicity in cassava, an important Pacific staple. The result of this work has very important implications for future food security and highlights the need to put in place measures to address these issues over the coming decades.

The importance of improving the predictive capability of fisheries models by introducing environmental conditions data was highlighted by Karen Evans, CSIRO Australia. Often the impact of changes in environmental conditions are dealt with separately in standard fisheries models, which tends to reduce the predictive power of the models. Moving towards integrated models that directly include environmental data, such as changes to key climate variables, will be important in improving model results and their predictive capabilities. However, it was noted that integrating environmental data into existing models can be difficult.

Michel Allenbach, University of New Caledonia, presented a research paper on modeling the impact of climate change on Wallis Island Lagoon. He showed the results of the work and how the dynamics of the lagoon changed under future climate change projections. His work is important in determining how sea level and temperature changes in the outside ocean may influence those within the lagoon. This work is of particular interest to atoll countries and highlights the important role played by the barrier reef systems on atolls.

It is important that the designs of long lived infrastructure assets incorporate the future changes to key climate variables, such as temperature and precipitation regimes, to ensure that they are able to perform to their design levels in the future. In a paper presented by Philip Malsale, Vanuatu Meteorology Department, it was outlined how Vanuatu was using the latest climate change projections to design more climate change resilient infrastructure. This is a clear demonstration of applying science research outputs to practical on ground applications. It also underscores the importance of reducing modelling uncertainty and producing more accurate downscaled results for island countries.

Alex Sen Gupta provided an interesting overview of the potential impacts of climate change on major current systems in the Pacific. In particular ocean temperatures and salinity are expected to increase significantly over the coming century. He also highlighted the potential movement of the Pacific Warm Pool to the east and possibly an increase iron transport through the New Guinea undercurrent. This will have significant repercussions for Pacific fisheries, as was highlighted in an earlier paper.
Finally, Claire Spillman presented a paper on predicting seasonal coral bleaching episodes and how they may change overtime. She highlighted the results of research and that the ability to predict bleaching events has significantly improved in recent

years. As expected the key variable in bleaching events is Sea Surface Temperature (SST) and these are expected to increase over the coming century and result in more frequent and extreme bleaching events.

Overall the session provided some valuable information that can help guide decision makers in responding to future climate change impacts. However, it was also clear that much more needs to be done to reduce model uncertainty and to present the findings of the scientific research in a reasonable user friendly form that non-technical people can easily interpret.

**Session 15:**
**ACRE – Atmospheric Circulation Reconstructions over the Earth**

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Philippe Frayssinet (philippe.frayssinet@meteo.fr)

The international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative (http://www.met-acre.org/) was given the opportunity to hold a Special Session at the 10ICSHMO. This was a chance for ACRE to showcase the extent and scope of both its international and regional activities and objectives. All but one of the seven presentations was from major ACRE partners. There were four posters from this Special Session on display.

The Special Session began with an opening overview of ACRE by the initiative's Project Manager, which encompassed ACRE's objectives to both undertake and facilitate the recovery of historical instrumental surface global weather observations to underpin three dimensional (3D) reanalyses spanning the last 200 years for the needs of climate science and climate applications, educators and students, and citizens worldwide. ACRE links more than 40 projects, institutions, and organisations around the globe and has developed, and is developing, regional foci which will hone its efforts to recover, image, digitise and archive historical instrumental surface terrestrial and marine weather observations in regions with untapped or under-represented data potential.

An invited presentation, shared by two guest speakers, focused on the regional foci of ACRE Pacific with an overview of its data activities across the region, particularly in New Zealand-Southwest Pacific and with Météo-France in both New Caledonia and French Polynesia. Some details were also given of the results of specific studies on tropical cyclones and the South Pacific Convergence Zone (SPCZ) using the 3D global historical weather reconstructions of the ACRE-facilitated 20$^{th}$ Century Reanalysis Project (20CR).

Details were given of historical marine data digitisation linked to ACRE, from 'traditional' keying through to Citizen Science OldWeather projects. Over the last 6 years, this has resulted in the digitisation of a mass of synoptic marine weather observations: 275,000 from English East India Company (1780s-1830s), 1.6 million from Royal Navy (1914-1923) and 1.5 million from Royal Navy (World War 2) ship logbooks. This highlighted the great potential in using Citizen Science to digitise vast amounts of data efficiently.

A major presentation by the manager and leader scientist of 20CR provided a detailed perspective of the status and planned developments moving on from 20CR to both longer and coupled ocean-atmosphere reanalyses. It showed both the need for more digitised synoptic terrestrial and marine weather observations to improve 20CR, and the potential of 20CR and its successors to provide the best, high resolution, high quality 3D baselines of the weather and its variables back over the last 200 years.

Additional data activities and potentials for the Pacific Ocean region (linked to ACRE Chile and ACRE Pacific) were highlighted in two talks, including one by the Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP). This has helped to pave the way for closer ties between ACRE and PACCSAP in the Pacific region.

Finally, details were given of the use of 20CR in examinations of winter sea-ice extent in the Bellingshausen Sea region of Antarctica.

**Invited speakers**:

**Pene Lefale** (National Institute of Water & Atmosphere (NIWA), Auckland, New Zealand)
**Andrew Lorrey**, (National Institute of Water & Atmosphere (NIWA), Auckland, New Zealand)

**Session 16:**
**Special session: Southwest Pacific Ocean Circulation and Climate Experiment (SPICE)**

Sophie Cravatte (sophie.cravatte@ird.fr)
Alexandre Ganachaud (alexandre.ganachaud@ird.fr)
William Kessler (william.s.kessler@noaa.gov)

SPICE (Southwest Pacific Ocean Circulation and Climate Experiment) is a regionally coordinated experiment. Its goal is to observe, model and understand the role of the Southwest Pacific ocean circulation in the large-scale, low- frequency modulation of climate from the Tasman Sea to the equator, and the generation of local climate signatures whose diagnosis will aid regional sustainable development. This special session was intended to present achieved and expected scientific advances related to this project. Presentations were made on all aspects concerning the Southwest Pacific: the oceanic circulation in the Coral, Solomon and Tasman seas; heat and mass transports; properties and dynamics of the strong boundary currents and jets; water mass transformations and impact on the chlorophyll.

During the last few years, much effort has been put toward monitoring the main currents in the Southwest Pacific. Especially, an integrated approach to monitoring the western boundary currents (WBCs) and coastal currents has been undertaken (XBT lines, Deep Moorings Arrays, ocean gliders, satellite, HF radars). Gliders have been repeatedly deployed to measure the New Guinea Coastal Undercurrent at the entrance of the Solomon Sea. Measurements around New Caledonia during specific cruises and with gliders allowed a better description of the jets and of the East Caledonian Current. A mooring array off Brisbane is currently deployed to monitor the East Australian Current (EAC), as well as slope and shelf moorings to measure the Great Barrier Reef currents north and south of the South Equatorial Current bifurcation. Additionally, other global observational datasets (Argo floats, altimetry data, XBT lines, historical cruises) as well as numerical simulations have been successfully used to describe the mean circulation, as well as its interannual variability linked to the ENSO cycle.

Numerical simulations from different groups are now able to correctly simulate and capture the main details of the circulation: the series of South Equatorial Current (SEC) jets around the large islands of the southwest Pacific, the bifurcation at the Australian coast, the EAC separation and the associated eddy fields. High resolution models (1/36°) which are eddy resolving and submesoscale permitting, are also currently being developed at LEGI (Grenoble, France) and at UCLA (Los Angeles, USA). These will improve the simulation of the WBC, the eddy activity, and topographic effects. An aspect that remains to be developed is high-resolution regional coupled models, to better understand the atmosphere-ocean coupled system behavior.

One of the outstanding results presented during the ICSHMO meeting was the evidence of decadal variability in the subtropical gyre, which impacts the currents in the whole Southwest Pacific. A decadal change in the EAC extension toward Tasmania, opposite in phase to the Tasman Front outflow was seen in different datasets. Associated with these, a significant warming trend and salinity increase and a sea level increase was seen in the Tasman Sea, with impacts on fish species in Tasmania.

Closer to the equator, decadal changes during the last twenty years have also been shown. An equatorward shift of the SEC has been suggested, inducing an increase in the North Vanuatu Jet and a weakening of the North Caledonian Jet. This equatorward shift changes the amount of thermocline waters of tropical versus subtropical origins joining the equatorial band through the

Solomon Sea. Even though it has been suggested that thermocline waters are mixed diapycnally inside and north of the Solomon Sea, such a change of thermocline water origins may induce an increase in the equatorial thermocline salinity and temperature.

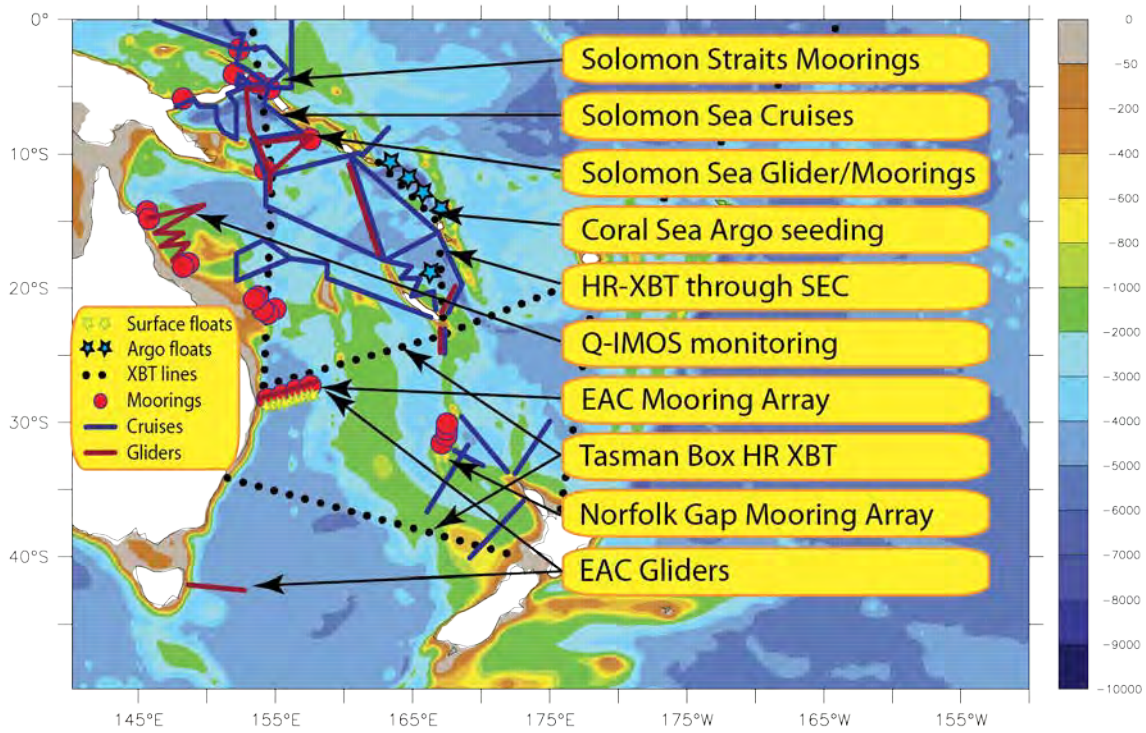


Figure: Ongoing experiments in the Coral Sea. SPICE program also includes ongoing experiments in the Tasman Sea and

**Session 17:**
**Climate change in developing SH island countries (PACCSAP-sponsored)**

Scott Power (S.Power@bom.gov.au)
Brad Murphy (B.Murphy@bom.gov.au)

The Pacific-Australia Climate Change Science and Adaptation planning Program (PACCSAP) sponsored a large delegation of Pacific islanders from many countries to participate in the 10ICSHMO, and specifically in this session. The islanders exhibited posters describing climate and climate change - past and future - in their countries, and gave excellent oral presentations providing regional overviews of climate change. It was the first time many of the islanders had attended an international conference on meteorological and oceanographic research. For nearly all of the islanders it was the first time they had given oral presentations at an international science conference. PACCSAP also hosted a very well-attended session on climate change in island states. An overview of the contents of a major new two volume report on climate change in the Pacific was provided by Scott Power (http://www.cawcr.gov.au/projects/PCCSP/publications.html). The first volume provides a regional overview, while the second volume provides reports tailored for use in 14 Pacific island countries (Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu) and East Timor.