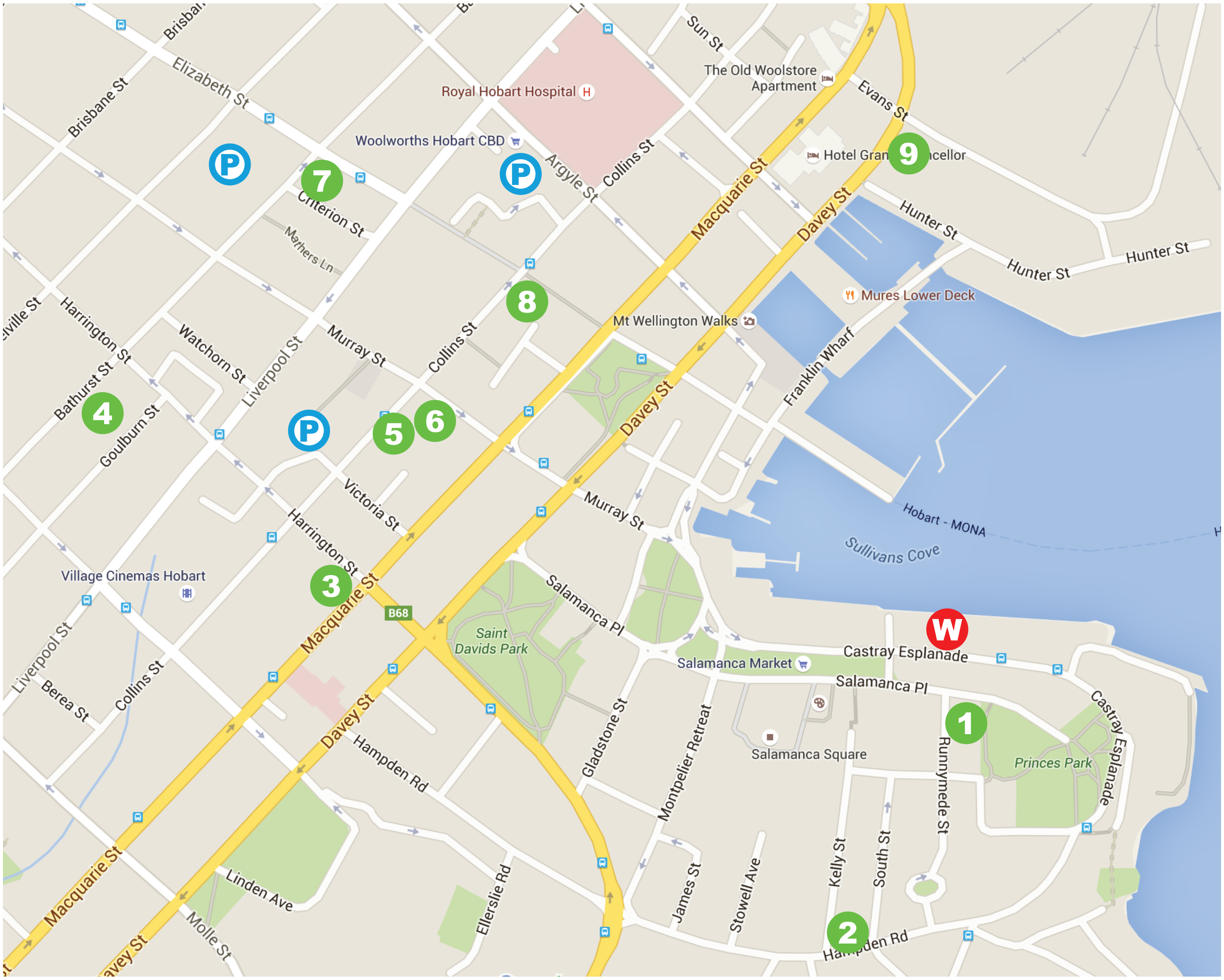
2016 ROMS Asia-Pacific Workshop

Hobart, Tasmania
Australia
October 17 - 20, 2016

Organized by: Hernan G. Arango, John L. Wilkin, Andrew M. Moore, David Gwyther, Ben Galton-Fenzi, and Andreas Klocker

Getting to the Workshop

The conference will be held at the Institute for Marine and Antarctic Studies building on the Hobart Waterfront, 20 Castray Esplanade, Hobart, Tasmania 7000. The main entrance to IMAS is on the west end of the building and signs will be posted to guide you to the meeting room.



Walking:

The map above shows the IMAS building (W), hotels (#), and all day parking structures (P), and will help you find a walking route to the workshop. All hotels and parking structures marked on the map are less than a 25-minute walk from the workshop. The hotel names for the numbered circles are listed on the next page.

Bus:

Many of the Metro Tasmania bus stops are marked ( ) on the map above. We suggest using the Metro Tasmania Trip Planner (metrotas.com.au/planner/) using “IMAS, Hobart, TAS” for the “To” field.

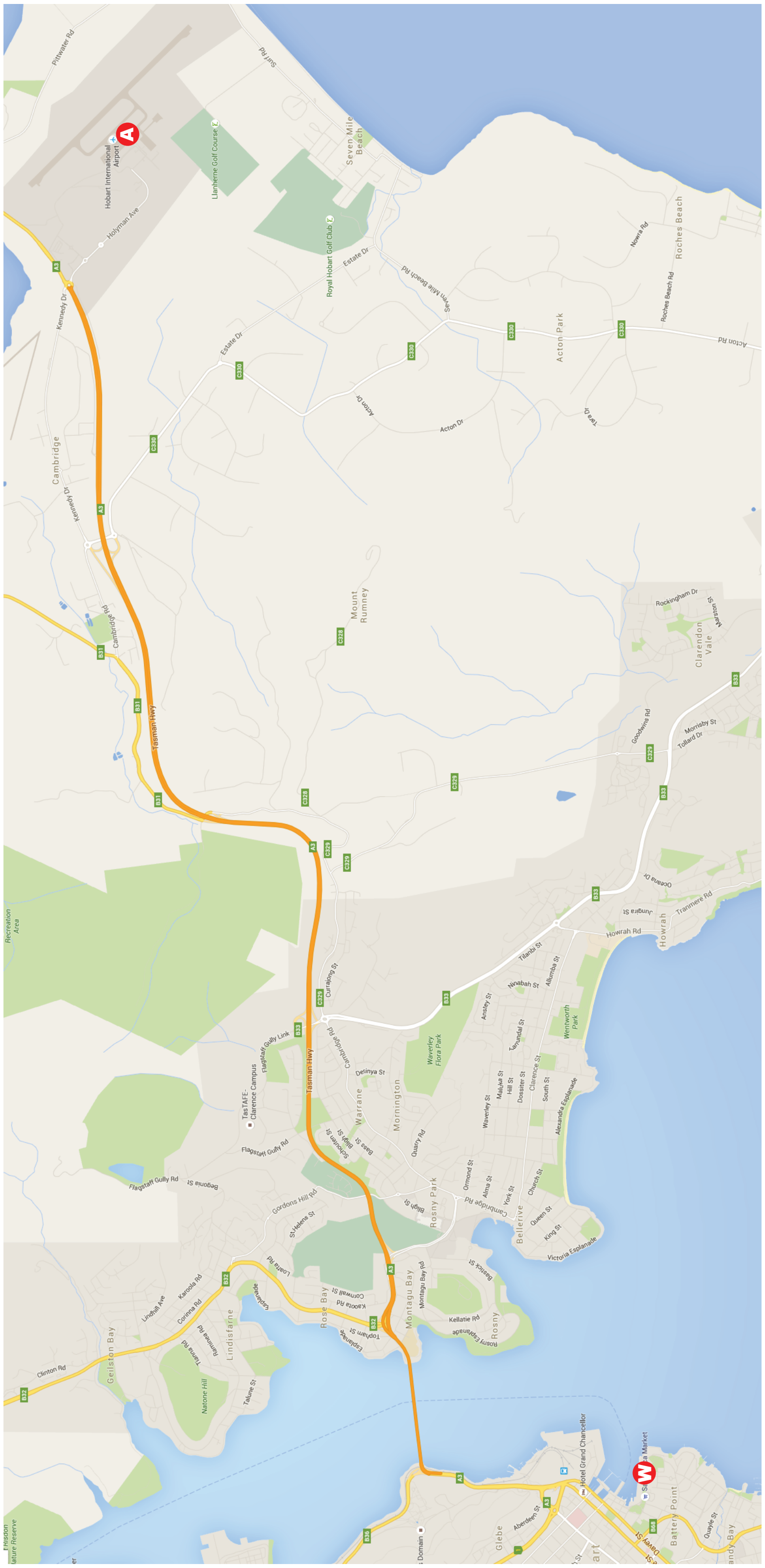
Taxi:

There are several taxi companies operating in Hobart, so consult the front desk staff at your hotel. Give the driver the address **20 Castray Esplanade** and/or tell them it is the IMAS waterfront building and they will have no trouble getting you to the workshop.

Hobart Hotels

1. Lenna Of Hobart Hotel
2. Prince of Wales Hotel
3. Travelodge Hobart
4. Best Western Hobart
5. RACV/RACT Hobart Apartment Hotel
6. Hadley's Orient Hotel
7. Quality Hobart Midcity Hotel
8. Quest Savoy
9. Zero Davey Boutique Apartments

Getting to Hobart



Even though it is designated an international airport, all flights to Hobart International Airport (HBA) will arrive via the Australian mainland (e.g. Sydney, Melbourne, Brisbane). Taxis, rental cars, and busses are all available from the terminal.

We recommend the Redline Airporter bus because of its price and convenience. Every arrival at Hobart Airport is met by a shuttle bus and taxis that will take passengers into Hobart city. The Tasmanian Redline Airporter bus will take you into Hobart city and drop you at your hotel for 18 AUD.

The map above shows the airport (A) and workshop (W) locations. It takes about 20 minutes to get from the airport to the city of Hobart. Your actual travel time will vary depending on the location of your hotel and the mode of transportation.

Hobart attractions:

1. **Mt. Wellington:** This mountain (1250m) towers over Hobart city and provides spectacular views. There are also lovely temperate rainforest walking trails as you head up the mountain. There is a good sealed road to the top, though it can be walked (on trails) or ridden (on trails/road). There is a tour company that will drive you to the top, and there is a company that will drive you to the top and take you on a guided mountain bike ride back down to the bottom (http://www.mtwellingtondescent.com.au/).

2. **MONA:** The Museum of Old and New Art is Australia's largest private art gallery, with objects from the private collection of an eccentric Tasmanian gambling millionaire. It is well worth spending a day here – any less and it will be somewhat overwhelming. There is a ferry (and a bus as well) that leaves from the Brooke Street Pier on the Hobart Waterfront and takes you out to the Museum (http://www.mona.net.au/).

3. **Bonorong Wildlife Park:** Australian animal sanctuary, including the endangered Tassie Devil. Bonorong is not a zoo and aims to get healthy animals back to the wild. This attraction requires a car (1 hour drive north), or alternatively, there are several tour companies that offer trips here (http://bonorong.com.au/).

4. **Royal Tasmanian Botanical Gardens:** Australia's second oldest botanical gardens features a native Tasmanian section, botanical discovery centre, botanical shop, and sub-Antarctic plant house. The Royal Tasmanian Botanical Gardens is home to a magnificent collection of conifers and cool temperate trees, many dating from the 19th century, as well as extensive gardens that embrace the flora of the Southern Hemisphere (http://gardens.rtbg.tas.gov.au/).

5. **Bruny Island Boat Cruise:** Bruny Island Cruises is an award-winning 3 Hour Wilderness Cruise exploring the rugged coastline of Bruny Island in southern Tasmania. Cruise alongside some of Australia's highest sea cliffs, beneath towering crags and drift up close to listen to the awesome "Breathing Rock." Enter deep sea caves, pass through the narrow gap between the coast and "The Monument" and feel the power of nature at the point where the Tasman Sea meets the might of the Southern Ocean. This cruise also departs from the Brooke Street Pier on the Hobart Waterfront (https://www.brunycruises.com.au/).

6. **Salamanca Market:** Salamanca Market is one of Australia's most loved outdoor markets and can be found every Saturday morning, along the historic Salamanca Place, next to the Hobart waterfront. It's a destination that's hard to beat and is absolutely free to enjoy. The market has an eclectic mix of over 300 stallholders, showcasing the best that Tasmania has to offer. You will find delicious food, artisan jewellery, fine Tasmanian handcrafted timbers, handmade clothing, as well as vintage collectables, pottery, plants and flowers. Definitely worth grabbing a coffee and checking out (http://www.hobartcity.com.au/Hobart/Salamanca_Market).

7. **Tasmania Museum and Art Gallery:** Located on Hobart's historic waterfront, the Tasmanian Museum and Art Gallery (TMAG) has recently undergone a spectacular $30 million redevelopment. The second oldest museum in Australia, TMAG has its origins in the collections of the country's oldest scientific society, the Royal Society of Tasmania, which was established in 1843. Visitors can now experience more of this unique site than ever before, including a fascinating range of nationally significant archaeological material, some of which has been hidden for over 150 years (http://www.tmag.tas.gov.au/).

Hobart Tourist Attractions

Participants

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PROGRAM

Ocean Circulation Modeling

---------- Monday, October 17, 2016 AM ----------

08:00-08:45 Registration

08:45-09:00 Welcome and Logistics

Chairperson: Hernan G. Arango

09:00-09:30 (30 min) Ruoying He, North Carolina State U., USA
Gulf Stream variability and a triggering mechanism of its large meander in the South Atlantic Bight

09:30-10:00 (30 min) John L. Wilkin, Rutgers University, USA
Velocity and sea level anomaly wavenumber spectra in the coastal ocean: Observations from HF-radar and altimetry compared with nested high-resolution models

10:00-10:30 (30 min) Cristian Salas, INPESCA/UdeC, Chile
Spatio-temporal dynamics of the subtropical front in the southeastern Pacific: a modeling approach

10:30-11:00 Break (30 min)

Chairperson: John L. Wilkin

11:00-11:30 (30 min) Mark Hadfield, NIWA, New Zealand
The mean flow through Cook Strait, New Zealand, is 0.4 Sv

11:30-12:00 (30 min) Moritz Wandres, UWA, Australia
The influence of the offshore current regime on shelf and nearshore wave climate in southwest Australia

12:00-12:30 (30 min) Ivica Janekovic, UWA, Australia
Real-time/hindcast modelling system for Central Western Australia

12:30-14:30 Lunch and Posters Session

---------- Monday, October 17, 2016 PM ----------

Chairperson: Ruoying He

14:30-15:00 (30 min) Ryan Holmes, UNSW, Australia
Interactions Between Kelvin waves and Tropical Instability Waves in the Equatorial Pacific Ocean and their Implications for SST Variability

15:00-15:30 (30 min) Stefan Jendersie, Otago University, New Zealand
How competing seasonal processes control the Ross Sea dynamics

15:30-16:00 (30 min) Weifeng “Gordon” Zhang, WHOI, USA
The Dispersal of Polynya Dense Water on a Shallow Sloping Shelf

16:00-16:30 Break/Group Picture (30 min)

Chairperson: Mark Hadfield

16:30-17:00 (30 min) Wilma Huneke, UTAS-IMAS, Australia
Heat transport across the Antarctic Slope and its impact on ice shelf melting

17:00-17:30 (30 min) Eva Cougnon, UTAS-IMAS & CSIRO, Australia
Sustained basal mass loss after the 2010 calving event of the Mertz Glacier

PROGRAM

Ice/Ocean Modeling

---------- Tuesday, October 18, 2016 AM ----------

Chairperson: David Gwyther

08:30-09:30 (60 min) Kate Hedstrom, IMS-UAF, USA
Tales of two sea-ice models

09:30-10:00 (30 min) Ben Galton-Fenzi, AAD, ACE-CRC, UTAS, AU
A TEOS-10 compliant version of ROMS for polar applications

10:00-10:30 Break (30 min)

Chairperson: Andreas Klocker

10:30-11:00 (30 min) Michael Dinniman, Old Dominion U., USA
Transport pathways and consequences for Antarctic ice shelf basal meltwater

11:00-11:30 (30 min) Kaitlin Alexander, CCRC (UNSW), ARCCSS, ACE CRC, Australia
Simulating ice-shelf/ocean/sea-ice interaction in a circumpolar Antarctic domain

11:30-12:00 (30 min) Lenneke Jong, UTAS, Australia
Coupled ice sheet-ocean modelling using FISOC

12:00-14:00 Lunch and Posters Session

---------- Tuesday, October 18, 2016 PM ----------

Chairperson: Kate Hedstrom

14:00-14:30 (30 min) David Gwyther, AGP, UTAS, Australia
Modelling regional ice shelf/ocean interaction with ROMS

14:30-15:00 (30 min) Helen Macdonald, NIWA, New Zealand
Modelling of Ice-Shelf Cavity and Biogeochemical Dynamics in the Ross Sea

15:00-15:30 Break (30 min)

Chairperson: Ben Galton-Fenzi

15:30-16:30 (60 min) Andrew Stewart, UC Los Angeles, USA
Eddy mixing and transport at the Antarctic margins

16:30-17:00 (30 min) Petra Heil, AAD, Australia
Sea-ice modelling: Recent advances and challenges

18:00-22:45 Reception: Peppermint Bay Cruise and Dinner

PROGRAM

Data Assimilation

--------- Wednesday, October 19, 2016 AM ---------

Chairperson: Hernan G. Arango

08:30-10:00 (90 min) Andrew M. Moore, UC Santa Cruz, USA

4D-Var Tutorial I

- Overview of ROMS 4D-Var
- Adjoint Sensitivity
- Obs. Impacts - Analysis and Forecast Cycle
- Other Adjoint-based Algorithms

10:00-10:30 Break (30 min)

10:30-12:00 (90 min) Andrew M. Moore, UC Santa Cruz, USA

4D-Var Tutorial II

- Practical Implementation of Observation Impacts and Adjoint Sensitivity
- Array Modes

12:00-14:00 Lunch and Posters Session

--------- Wednesday, October 19, 2016 PM ---------

Chairperson: Ivica Janekovic

14:00-14:30 (30 min) Andrew M. Moore, UC Santa Cruz, USA
Observation Impacts on Resolved Climate Variability in the California Current System

14:30-15:00 (30 min) Colette Kerry, UNSW, Australia
Predicting Transport in the East Australian Current: Observation Impact from a regional reanalysis

15:00-15:30 (30 min) Frank Colberg, Bureau of Meteorology, Australia
Hydrodynamic models of the Great Barrier Reef

15:30-16:00 Break (30 min)

Chairperson: Andrew M. Moore

16:00-16:30 (30 min) Pavel Sakov, Bureau of Meteorology, Australia
Regional ROMS/EnKF forecasting system for GBR

16:30-17:00 (30 min) Paul Sandery, Bureau of Meteorology, Australia
Ocean forecasting and reanalysis using ROMS with ensemble data assimilation

17:00-17:30 (30 min) Arya Paul, INCOIS, India
Local Ensemble Transform Kalman Filter for ROMS in Indian Ocean

PROGRAM

Numerical Modeling

---------- Thursday, October 20, 2016 AM ----------

Chairperson: Michael Dinniman

08:30-09:30 (60 min) Hernan G. Arango, Rutgers University, USA
ROMS Algorithms: Nesting and Coupling

09:30-10:00 (30 min) Kial Stewart, ANU, Australia
Vertical resolution in ocean models

10:00-10:30 Break (30 min)

Chairperson: John L. Wilkin

10:30-11:00 (30 min) Gary Brassington, R&D, BoM, Australia
Third-order upwinding with limiters for flooding estuaries

11:00-11:30 (30 min) Robin Robertson, UNSW @ ADFA, Australia
Surface Mixing in ROMS

11:30-12:00 (30 min) EMS Wijeratne, UWA, Australia
ozROMS - a high resolution 16 year re-analysis product for Australian and Indonesian Seas

12:00-14:00 Lunch and Posters Session

---------- Thursday, October 20, 2016 AM ----------

Chairperson: Weifeng "Gordon" Zhang

14:00-14:30 (30 min) Roger Proctor, IMOS, Australia
MARVL: Marine Virtual Laboratory

14:30-15:00 (30 min) Fangfang Kuang, TIO, SOA, China
The cold water source and the role of tides on Guangdong Coastal Upwelling in summer: a numerical model study

15:00-15:30 (30 min) Xiaohui Liu, SIO, China
An application of ROMS model to the East China Sea: On the Kuroshio intrusion northeast of Taiwan

15:30-16:00 Break (30 min)

Chairperson: Frank Colberg

16:00-16:30 (30 min) David Robertson, Rutgers University, USA
ROMS Cyber Infrastructure

16:30-17:30 (60 min) **Open Discussion**

17:30 **Adjourn**

PROGRAM

Posters

1. Hadfield, Mark, NIWA, New Zealand
   The NIWA NZ shelf seas hindcast

2. Jendersie, Stefan, Otago University, New Zealand
   How competing seasonal processes control the Ross Sea dynamics

3. Kumar, Rajesh, New York University, United Arab Emirates
   Coupling ROMS-CICE for Polar COAWST model

4. Li, Junde, The second Institute of Oceanography, China
   A new dipole index of the salinity anomalies of the tropical Indian Ocean

5. Lim, Hak Soo, KIOST, South Korea
   Simulation of wave-induced current considering wave-tide interaction

6. Rocha, Carlos, UNSW, Australia
   Towards biogeochemical modelling of the East Australian Current system

7. Soutelino, Rafael, MetOcean Solutions, New Zealand
   Transient inner shelf response to upwelling favourable winds relaxation off Rio de Janeiro, Brazil

8. Tang, Cheng, Yantai Inst. of Coastal Zone Research, China
   Risk of surface sediment erosion in the Bohai Sea, North Yellow Sea and its indication to tidal sand ridge occurrence

9. Wan, Xiaofang, TIO-SAO, China
   Seasonal variation features of the hydrodynamic environment in the western Taiwan Strait

10. Zhang, Zhaoru, Shanghai Jiao Tong University, China
    A numerical study of circulations in the Bransfield Strait, Antarctica

Talk Abstracts

Simulating ice-shelf/ocean/sea-ice interaction in a circumpolar Antarctic domain

Kaitlin Alexander[1, 2, 3], **Ben Galton-Fenzi**[3], **Katrin Meissner**[1, 2], **Matthew England**[1, 2], **Tore Hattermann**[4,5], and **Jens Debernard**[6]

1. Climate Change Research Centre, University of New South Wales
2. ARC Centre of Excellence for Climate System Science
3. Antarctic Climate & Ecosystems Cooperative Research Centre
4. Alfred Wegener Institute, Bremerhaven, Germany

Given the desire for Antarctic ROMS simulations to include a coupled sea ice model as well as ice shelf thermodynamics, I have collaborated with the MetROMS development team who have recently coupled ROMS with CICE using the MCT coupler. I have adapted this new modelling system to Antarctic simulations by merging in the ice shelf thermodynamics routines of Ben Galton-Fenzi, developing a quarter-degree circumpolar Antarctic domain with a northern boundary of 30S, and configuring appropriate surface forcing and boundary conditions. In this presentation I will discuss the choices I made and the process I took to develop this new configuration, as well as share the results of historical simulations (1992-2005) both with and without tides. In particular I will compare simulated ice shelf melt rates and sea ice extent with available observations, and discuss possible sources of biases in these variables.

ROMS Algorithms: Nesting and Coupling

Hernan G. Arango
Rutgers, The State University of New Jersey, USA

An overview of recent and ongoing ROMS developments will be presented. Lately, there have been a lot of inquires by users about ROMS nesting capabilities. The fully working nesting algorithms were released to the community in September 2015. Both one-way and two-way options work seamlessly and are very stable and robust in idealized and realistic applications. We have very successful applications in various dynamically complex regions around the world. Examples of complex nesting application for the U.S. East Coast in the vicinity of the Gulf Stream will be presented.

The ROMS multi model coupling interface is currently being updated to ESMF, version 7. We are implementing the Unified Operation Prediction (NUOPC) layer to enhance interoperability with other modeling systems. The NUOPC layer is a simplified infrastructure on top of the ESMF library that provides conventions and templates to facilitate the easy coupling between Earth System Models (ESMs).

Third-order upwinding with limiters for flooding estuaries

Gary Brassington
Research and Development, Bureau of Meteorology, Australia

Implementation of limiters for ROMS to prevent undershooting of unphysical salinity values for flooding estuaries. An alternative to MPDATA. We'll compare the accuracy and cost of the two schemes for flooding estuaries discharging into the Great Barrier Reef lagoon.

Hydrodynamic models of the Great Barrier Reef

Frank Colberg, **Gary Brassington**, **Paul Sandery**, and **Pavel Sakov**
Bureau of Meteorology, Australia

The Australian Bureau of Meteorology (BoM) is in the process of developing an operational coastal ocean forecasting system for the greater Great Barrier Reef region. As part of this endeavour, 4km and 500m resolution coastal ocean models of 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).

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.

Sustained basal mass loss after the 2010 calving event of the Mertz Glacier

Eva A. Cougnon[1], **Ben K. Galton-Fenzi**[2, 3], **Steve R. Rintoul**[3, 4], **Guy D. Williams**[1], **John R. Hunter**[3], **Alex D. Fraser**[3], and **Benoit Legrésy**[4]

1. Institute for Marine and Antarctic Studies, University of Tasmania, Australia
2. Australian Antarctic Division, Australia
3. Antarctic Climate & Ecosystems Cooperative Research Centre, University of Tasmania, Australia
4. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Given the importance of the overturning circulation to global climate, there is a need to improve our understanding of Antarctic Bottom Water (AABW) formation and its sensitivity to change. Understanding what is driving changes in AABW properties requires focusing on the key formation regions. The intense production of sea ice in the Mertz Glacier (MG) Polynya (MGP) system drives Dense Shelf Water (DSW) formation, the precursor to AABW. Two simulations are run to investigate the impact of the calving of the MG in 2010. An 89% increase in area-averaged ice shelf basal melting and an 80% decrease of DSW export from the Adélie depression are simulated after the calving event. This study demonstrates the sensitivity of Antarctic ocean-cryosphere interactions to episodic changes to the local icescape (ice shelves, icebergs and sea ice), finding that ice shelf basal melting and DSW formation in the MGP region are dramatically impacted by the MG calving.

Transport pathways and consequences for Antarctic ice shelf basal meltwater

Michael Dinniman, **John Klinck**
Old Dominion University, Norfolk, Virginia, USA

Laurie Padman
Earth and Space Research, Corvallis, Oregon, USA

Oceanic melting of the base of the floating Antarctic ice shelves is the dominant cause of mass loss for the Antarctic ice sheet. Beyond the direct effects of melting on ice sheet mass balance, the flux of basal meltwater into the coastal ocean has been proposed to impact important climate processes such as Antarctic Bottom Water (AABW) formation and the delivery of the limiting micronutrient dissolved iron to the euphotic zone in the extremely productive coastal Antarctic waters.

We study generation of, and subsequent pathways for, basal meltwater with a circum-Antarctic ocean/sea-ice/ice shelf ROMS model. Eight independent simulated tracers are used to examine regional differences in the spread of meltwater. Separate tracer release simulations were performed to study seasonal changes in meltwater fluxes. The results confirm the previously reported idea that transport of meltwater from the Amundsen ice shelves to the Ross Sea is significant, especially with respect to possible changes in AABW formation. Meltwater from ice shelves in the Amundsen and Bellingshausen seas is readily transported into the wider Southern Ocean due to the proximity of the Antarctic Circumpolar Current to the continental shelf. Much of the meltwater reaching the summer coastal polynyas over certain areas of the continental shelf is from non-local sources and there is a strong seasonal variability in the meltwater production. Both of these factors will need to be accounted for in trying to assess the impact of ice shelf melt on phytoplankton nutrient supply.

A TEOS-10 compliant version of ROMS for polar applications

Ben Galton-Fenzi
AAD, ACE-CRC, UTAS, Australia

In this presentation I will discuss the TEOS-10 and its impact on modelling seaice and polar applications. The new equation of state for seawater, TEOS-10, is based on a Gibbs function formulation from which all thermodynamic properties of seawater (density, enthalpy, entropy sound speed, etc.) can be derived in a thermodynamically consistent manner. A significant change compared with past practice is that TEOS-10 uses Absolute Salinity (mass fraction of salt in seawater) as opposed to Practical Salinity to describe the salt content of seawater. Ocean salinities now have units of g/kg. A new TEOS-10 compliant equation of state has been implemented in ROMS.

Investigating the effects of a summer storm on the North Sea stratification using a regional coupled ocean-atmosphere model

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The influence of a summer storm event in 2007 on the North Sea and its effects on the ocean stratification are investigated using a newly set up regional coupled ocean (Regional Ocean Modeling System, ROMS)-atmosphere (Weather Research & Forecasting model, WRF) modeling system, based on the Coupled-Ocean-Atmosphere-Wave-Sediment Transport Modeling (COAWST) System. An analysis of Potential Energy Anomaly (PEA) and its temporal development reveals that the loss of stratification due to the storm event is dominated by vertical mixing in almost the entire North Sea. For specific regions, however, a considerable contribution of depth-mean straining is observed. Vertical mixing is highly correlated with wind induced surface stresses. However, peak mixing values are only observed in combination with incoming flood currents. Depending on the phase between winds and tides, the loss of stratification differs strongly over the North Sea. To study the effects of interactive ocean-atmosphere exchange, a fully coupled simulation is compared with two uncoupled ones for the same vertical mixing parameters to identify the impact of the forcing data resolution as well as SST feedback. While the resulting new mixed layer depth after the storm event in the uncoupled simulation with lower-resolution forcing data can still be located in the euphotic zone, the coupled simulation is capable of mixing almost the entire water column and the vertical mixing without SST feedback is strongly amplified. These differences may have notable implications for ecosystem modeling since it could determine the development of new phytoplankton blooms after the storm and for sediment modeling in terms of sediment mobilization. An investigation of restratification after the extreme event illustrates the persistent effect of this summer storm.

Modelling regional ice shelf/ocean interaction with ROMS

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Ice shelves provide buttressing support to the grounded ice sheet of Antarctica. Thinning of the floating ice shelves, through basal melting and ice dynamic processes, can lead to increased discharge of grounded ice into the ocean and a contribution to sea level rise. Thus, understanding the thermodynamic interaction between ice shelves and the Southern Ocean is critical to improving estimates of future sea level change. *In situ* oceanography is logistically difficult; numerical models present an ideal alternative. I will present results from a numerical ocean model (Regional Ocean Modelling System; ROMS) that has been modified to simulate ice/ocean interaction. The performance of ROMS compared to other popular ocean models that include ice/ocean interaction will be discussed. In particular, I will discuss the expected differences in basal melting that result principally from the choice of vertical discretisation of the grid layers. These results suggest high-resolution/terrain-following coordinate models will generally produce lower melt compared to z-coordinate models, because a z-coordinate model with a thicker vertical grid (>20 metres compared to a few metres for a terrain-following model) implicitly assumes stronger vertical mixing. Recommendations from this work should prove useful for ocean modellers simulating surface boundary layer processes with terrain-following or z-coordinate systems.

The mean flow through Cook Strait, New Zealand, is 0.4 Sv

Mark Hadfield and **Craig Stevens**
National Institute of Water and Atmospheric Research (NIWA), New Zealand

Cook Strait is 22 km wide and 210 m deep at its narrowest point and supports large tidal currents (M2 amplitude 6 Sv, peak flow ~ 2 m/s). The conventional wisdom regarding the mean flow is that it is directed from west to east at more than 0.5 Sv. However, based on the first high-quality, long-period ADCP velocity measurements at the Narrows, Stevens (2014) estimated the mean flow to be only 0.25 Sv. A ROMS baroclinic model was set up at 1 km resolution and forced by the 6-hourly surface fluxes and daily Bluelink

oceanic boundary conditions. The model reproduces the measured velocities very well (but only if tidal forcing is included) and generates a mean transport of 0.4 Sv. We conclude that Stevens' estimate of 0.25 Sv is biased low because one of his ADCP sites was influenced by a local eddy generated by tidal rectification. The model shows large (standard deviation ~ 0.7 Sv) wind-driven variations in the subtidal component of flow through the Strait. When strong winds blow from the south, there are incursions of water from the eastern side of the Strait: these are likely to be important in delivering nutrient-rich water into the Strait.

Gulf Stream variability and a triggering mechanism of its large meander in the South Atlantic Bight

Ruoying He and **Xiangming Zeng**
North Carolina State University, USA

The Gulf Stream (GS) variability has an important impact on coastal circulation, shelf ecosystem, and regional weather and climate systems. Here we focus on the variability of the GS south of Cape Hatteras in the South Atlantic Bight (SAB). Statistical analysis on the 21-year satellite altimetry data reveals that the GS path in the SAB has two patterns: weakly and strongly deflected. The strongly deflected pattern is more likely to occur in winter. Over the last two decades, the largest GS offshore meander occurred in November 2009-April 2010. Realistic ocean hindcast simulation and adjoint sensitivity analysis are used to investigate the triggering mechanisms for this extreme event. Our analyses show that a net increase of relative vorticity near the Charleston Bump was generated by strong interaction between increased GS velocity and local bathymetry, pushing the GS further offshore by virtue of conserving the potential vorticity. Quantitative vorticity analysis confirms this finding.

Tales of two sea-ice models

Kate Hedstrom
University of Alaska Fairbanks, Institute of Marine Science, USA

The two sea-ice models available in ROMS will be introduced. These are the single-category Budgell model which has been available for some time on a branch at github. A more recent option is CICE, the community sea-ice model, featuring multi-layer, multi-category thermodynamics and several melt pond schemes. Both use the elastic-viscous-plastic (EVP) rheology by default. New in both models is a landfast ice parameterization (Lemieux, 2015), which adds a large bottom stress to the ice when the estimated keel depth approaches that of the ocean.

Several domains with coupled sea-ice and ocean will be shown with the good, the bad and the ugly one can expect in this business.

Sea-ice modelling: Recent advances and challenges

Petra Heil
Australian Antarctic Division, Australia

Sea ice is a crucial component within the Earth System. Since the beginning of the satellite record in 1979 dramatic change has been observed in Arctic summer sea-ice extent, while these data have shown little change for the Antarctic summer or winter extent. A slight increase in Antarctic winter extent has reverted to close to the long-term normal. Pre-satellite proxies suggest a reduction of Antarctic sea-ice extent between the 1930s and 1970s. Numerical ocean-ice or climate models have been able to simulate the Arctic sea-ice decline, although generally at a rate lower than that observed. Numerical simulations of Antarctic sea ice mostly derive a reduced ice extent, consistent with observed global warming but not congruent with the observed increase in Antarctic winter extent. A number of hypothesis have been suggested to explain this dichotomy. Understanding the drivers for the reduction in Antarctic winter extent observed in 2015 and 2016 is expected to be crucial to improve numerical models of sea ice.

While sea-ice observations still contain some riddles, numerical modelling of sea ice has advanced significantly, nevertheless the community faces many challenges. For example, the inclusion of thermo-halodynamics in sea-ice models allows for an evolving microstructure. Explicit multi-layer snow models coupled to the sea-ice model improve the thermal conductivity of snow provided to the sea-ice model. On the other hand, better presentation of physical processes are needed to improve simulated, for example, ice-thickness distributions, sea-ice deformation, sea-ice volume, density or brine pocket distributions, or surface melt ponding. Some recently developed approaches will be summarized in this presentation.

Interactions Between Kelvin waves and Tropical Instability Waves in the Equatorial Pacific Ocean and their Implications for SST Variability

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3. School of Mathematics and Statistics, University of New South Wales, Australia

Tropical Instability Waves (TIWs) and equatorial Kelvin waves are dominant sources of intraseasonal variability in the equatorial Pacific ocean. Both play important roles in the heat and momentum budgets of the large-scale circulation, and influence the Sea Surface Temperature (SST) and air-sea interactions critical for the El Nino-Southern Oscillation (ENSO). While individually TIWs and Kelvin waves have been well studied, little is known about how they interact, although satellite observations suggest that TIW phase speed and amplitude are modulated by Kelvin waves. Here we examine the influence of Kelvin waves on TIW kinetic energy (TIWKE) using an ensemble set of 1/4-degree ROMS simulations of the equatorial Pacific Ocean. The results suggest that TIWKE can be significantly modified by 60-day Kelvin waves. To leading order, TIWs derive kinetic energy from the meridional shear and available potential energy of the background zonal currents, while losing energy to friction and the radiation of waves. The passage of Kelvin waves disrupts this balance. Downwelling (upwelling) Kelvin waves induce decay (growth) in TIWKE through modifications to the background currents and the TIWs' Reynolds stresses. These modulations in TIWKE affect eddy heat fluxes and the downward radiation of waves, with implications for SST variability and the energetics of abyssal flows in the eastern equatorial Pacific.

I will also briefly discuss future work to couple ROMS to a simple atmospheric model in order to examine the influence of TIWs and TIW-Kelvin wave interactions on SST variability and ENSO.

Heat transport across the Antarctic Slope and its impact on ice shelf melting

Wilma Huneke[1], **Andreas Klocker**[1, 3], **Ben Galton-Fenzi**[2, 3]

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2. Australian Antarctic Division, Australia
3. Antarctic Climate & Ecosystems Cooperative Research Centre, University of Tasmania, Australia

Heat transport across the Antarctic continental slope is crucial for the global overturning circulation, the Antarctic ice sheet stability and the local ecology. The Antarctic Slope Front, which has a nearly circumpolar extent, separates the water on the continental shelf from the deep Southern Ocean. However, the mechanisms that control the meridional exchange of heat content are not fully understood. Using the Regional Ocean Modelling System (ROMS), high resolution idealised experiments are performed in order to investigate physical processes that allow a heat transport across the Antarctic Slope Front.

Real-time/hindcast modelling system for Central Western Australia

Ivica Janekovic
University of Western Australia, Perth, Australia

I will give overview of the real-time WRF-ROMS system for the Central Western Australia (CWA) region developed at UWA. It is based on the WRF-ARW atmospheric model at 10 (for wider) and 2 km (for nested domain) resolutions along with ROMS at ~2.5 km (wide) and 500 m for nested domains. The system is run operationally at UWA providing 5 day forecasts with detail outputs for major ports. Comparing with observations for sea-level, this system is capable of predicting meteo-tsunami events occurring during winter frontal storms. Data from the system is served via an openDAP TDS server and plotted on the web (http://coastaloceanography.org).

The region of CWA is rich with IMOS observations ranging from sea-gliders, CTD & ADCP moorings as well HF radars, along with classical remote sensed SST and SLA observations. IS4D-Var data estimation was applied to the region and some initial results will be presented as well. This region is experiencing important tidal dynamics which are used in all our simulations making the system more complete on one hand, but complicated on other (i.e. data assimilation).

Direct Forcing of Regional Currents by Sea Ice Production

Stefan Jendersie
Sea Ice Group, Otago University, New Zealand

The stability of ice shelves and floating glacier outlets is critical to grounded inland ice sheets in both polar regions. Results from a climatological ice shelf-ocean coupled numerical model (Regional Ocean Modeling System) suggest a new circulation mechanism associated with High Salinity Shelf Water (HSSW) production in the Ross Sea Polynya (RSP, Antarctica) that controls oceanic heat access to the Ross Ice Shelf cavity. Within the RSP the dense water-saturated water column in winter coincides with a seasonal drop in sea surface height (SSH) localised to a convection chimney under the RSP. The SSH gradients of up to 1.5 mm per km are sufficient to generate a barotropic pressure gradient that can counteract the wide scale horizontal baroclinic force and reverse the geostrophic circulation. The effect causes the seasonal occurrence of a strong cyclonic barotropic circulation cell with transports greater than 1Sv. Appearing with the beginning of winter sea ice formation in the RSP it significantly changes the dynamics at the ice shelf front and dominates the regional currents. This is the first reported direct forcing effect of a polynya on the ventilation of an ice shelf cavity. It is yet to be determined whether this is a Ross Sea specific mechanism, or if polynyas have a wider role in protecting ice shelves and glacier outlets and the ice sheets they buttress from future ocean warming.

Coupled ice sheet-ocean modelling using FISOC

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Modelling of ice sheet–ocean interactions is key to understanding the influence of the Southern ocean on the evolution of the Antarctic ice sheet, and to predicting its future behaviour under changing climate conditions. The Framework for Ice Sheet–Ocean Coupling (FISOC) has been developed to provide a flexible platform for performing coupled ice sheet–ocean modelling experiments. We present progress and preliminary results using FISOC to couple the Regional Ocean Modelling System (ROMS) with Elmer/Ice, a full-Stokes ice sheet model.

Predicting Transport in the East Australian Current: Observation Impact from a regional reanalysis

Colette Kerry and **Moninya Roughan**
Coastal and Regional Oceanography Lab, School of Mathematics and Statistics, UNSW, Australia

Brian Powell
Department of Oceanography, School of Ocean and Earth Sciences, University of Hawaii at Manoa, USA

Peter Oke
CSIRO Marine and Atmospheric Research, Australia

Prediction of eddy-rich oceanic regions, such as off southeastern Australia that is dominated by the East Australian Current (EAC), requires the combination of numerical modelling and ocean observations. This is achieved using data assimilation techniques that aim to combine observations with a numerical model in a dynamically consistent way that - in a least-squares sense - provides a better estimate than either alone. Prediction of the EAC transport is of fundamental importance as the current plays a primary role in the transport of heat poleward along the coast of Eastern Australia and sheds eddies that affect weather and biological productivity.

Using the state-of-the-art Regional Ocean Modelling System (ROMS), we have configured a numerical ocean model of the EAC region and combined it with an unprecedented observational data set to generate a high-resolution ocean state estimate over a 2-year period (Jan 2012 - Dec 2013). In addition to the traditional data streams (satellite derived SSH and SST, Argo profiling floats and XBT lines) we exploit newly available observations that were collected as part of Australia's Integrated Marine Observing System (IMOS, www.imos.org.au). These include velocity and hydrographic observations from a deep-water mooring array (the EAC transport array, 27.5°S) and several moorings on the continental shelf, high-frequency (HF) radar observations (at Coffs Harbour, 30.3°S), and ocean gliders. For the assimilation, we use a time-dependent variational scheme (4D-Var) that uses the model physics to compute increments in the initial conditions, boundary and surface forcings such that the difference between the modelled time-evolving flow and the observations is minimised over a time window. In solving this state-estimation problem, we compute the dynamical covariance between the observations and the model that allows us to directly compute the impact of each observation on the circulation estimate.

We investigate the impact of each data stream on estimates of volume and heat transport in the EAC, focussing on 3 shore normal sections 1) off Brisbane, where the EAC is found to be most coherent (27.5°S), 2) off Coffs Harbour, just upstream of the typical EAC separation zone (30.3°S) and 3) off Sydney, downstream of the EAC separation zone (33.9°S). Significantly, we find that the most influential observation platforms are the HF radar off Coffs Harbour and the full depth EAC mooring array, with satellite-derived SSH and SST also having high impact and dominating in the absence of radar and moored observations. Not only do the HF radar observations have high impact on transport estimates at 30.3°S, they also have significant impact both up and downstream of the radar location. Likewise, the impact of the EAC array is far reaching, contributing to transport estimates hundreds of kilometers downstream of its location at 27.5°S, e.g off Coffs Harbour and Sydney.

This work provides new information on the value of specific observation platforms for prediction of the EAC. It represents an important step towards improving our ability to make strategic observations and providing confidence to decision makers as to the continuing investment in Australia's observing system. In future work, we hope to identify optimal observations (types and locations) to improve the impact on predictive skill that could result in measurable socio-economic benefit.

The cold water source and the role of tides on Guangdong Coastal Upwelling in summer: a numerical model study

Fangfang Kuang, **Aijun Pan**, and **Junpeng Zhang**
Third Institute of Oceanography State Oceanic Administration, China

Guangdong coastal upwelling is one of the main seasonal upwelling regimes in the northern South China Sea. Using a nested three-dimensional circulation model based on ROMS, we investigated the cold water source as well as the role of tides on the upwelling system in summer. With the Lagrange tracer experiment, we found that in the region south of the upwelling area, in the bottom layer, in the region where water depth more than 50m water are transported offshore while in the region where water depth less than 50m water move cross-isobath inshore and transported to the upwelling area; in the 60m layer water mainly transported offshore; in the 45m layer in the region of 116°E~116.5°E and in the 30m layer in the region of 115°E~116°E water move cross-isobath inshore and transported to the upwelling area; water above 30m mainly move along-isobath and transported northeast. In conclusion, the shoreward cross-shelf water in the southeast region (about 115°E~116.5°E) above 50m is the main origin of the cold water of Guangdong coastal upwelling system. Numerical experiments with and without tidal forcing showed that tides could weaken the upwelling with enhanced mixing in the bottom layer.

An application of ROMS model to the East China Sea: On the Kuroshio intrusion northeast of Taiwan

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Second Institute of Oceanography, SOA, China

Changming Dong
School of Marine Sciences, Nanjing University of Information Science and Technology, China

A two-level nested ROMS model was setup to investigate the Kuroshio intrusion northeast of Taiwan in the East China Sea. Three configuring skills, including choice of the data of open boundary condition, information transfer between the 2 nested models and the time-frequency of the surface wind forcing, influence the model results greatly. Model results show that the surface intrusion exists onshore of the Kuroshio mainstream in winter, which is coincident with the along-track altimeter and satellite-tracked data. Analysis of the momentum balance from the results of the numerical model suggests that spatial geostrophic adjustment of the Kuroshio, due to loss of the Taiwan Island in support of Kuroshio-fs cross-shelf pressure gradient of the Kuroshio, is the principal mechanism for its on-shelf intrusion northeast of Taiwan. The advection term in the momentum equation plays a major role in the process of the adjustment.

Modelling of Ice-Shelf Cavity and Biogeochemical Dynamics in the Ross Sea

Helen Macdonald, **Stefan Jendersie**, **Erik Behrens**, **David Bowden**, **Graham Rickard**, and **Mike Williams**
National Institute of Water and Atmospheric Research (NIWA), New Zealand

The Ross Sea supports a diverse ecosystem and is one of the least human impacted shelf sea ecosystems in the world. The Ross Sea is interesting from a dynamical point of view as it hosts a large ice-shelf and an associated ice-shelf cavity that affects the flow in the region. For this project a configuration of ROMS has been set up for the Ross Sea region with the dynamics of an ice-shelf cavity added to the base ROMS code. The resultant model can represent the exchange of water mass and properties between the ice-shelf cavity, the deep southern ocean and the vast coastal ocean that sits between the two. A biogeochemical model has also been added to this code to investigate some of the interactions of the flow with the biogeochemical dynamics. The model chosen to simulate biogeochemical processes in the Ross Sea is that of Arrigo *et al.* (2003). This model parameterises important interactions in the Ross Sea including the two main phytoplankton classes, diatoms and P. Antarctica, and the ability to represent growth limitation by iron and NO3. This model has previously been shown to have success for this region, particularly in its ability to capture the temporal and spatial evolution of phytoplankton blooms. Preliminary results from this new model setup are shown. The biogeochemical model reproduces a seasonal cycle of phytoplankton. The model shows two distinct phytoplankton blooms from November to January with a large bloom over the western continental shelf and a smaller bloom over the eastern continental shelf. The effects of the ice-shelf cavity induced changes in circulation on the biology are discussed. In particular, exchanges of biogeochemical tracers between the ice-shelf cavity and the coastal ocean are examined. Together, the ice-shelf cavity and biogeochemical models give us an exciting opportunity to study biogeochemical and ice-shelf cavity processes in the Ross Sea.

Observation Impacts on Resolved Climate Variability in the California Current System

Andrew Moore
University of California Santa Cruz, USA

The impact of the observing system on climate variability resolved by 4D-Var circulation estimates has been computed from a 31 year sequence of historical analyses of the California Current system. The observation impact metrics used are the amplitudes of the leading Principal Oscillation Patterns of the circulation which represent empirical approximations of the leading dynamical modes of variability. In this way, the impact of individual observations and observing systems on the climate variability associated with ENSO, the PDO and the NPGO can be tracked through time over periods spanning decades. Some specific examples will be presented in this talk.

Simulation of coastal undercurrent at southern part of western boundary of Bay of Bengal

Arnab Mukherjee
Indian National Centre for Ocean Information Services (INCOIS), India

Recent ADCP (Acoustic Doppler Current Profilers) measurement at continental slope locations of Cuddalore (southern part of western boundary of Bay of Bengal) showed the presence of coastal undercurrent (CUC). Here, we first showed using ADCP current data that CUC is also present at the continental shelf locations of Cuddalore and later used a high resolution regional ocean model (ROMS) to explore the dynamics of this CUC. Strong CUC is observed during winter (October-December), when alongshore EICC (East India Coastal Current) is directed equatorward down to 60 m and poleward EICC is observed below. CUC is better simulated by ROMS60 (1/12 x 1/12 horizontal resolution ROMS model with 60 sigma vertical levels, 40 levels in the top 200m in the continental slope region) compared to ROMS40 (same horizontal resolution with 40 sigma vertical levels, 23 levels in the top 200 m in the same region). Our model simulation shows that CUC at Cuddalore is due to remotely westward propagated sub-surface Rossby waves from further offshore at interior Bay of Bengal and strong propagation is evident even at 200 m water depth. We also found a significant decrease of thermocline and mixed layer depth in the ROMS60 model compared to ROMS40 model due to sub- surface propagation of Rossby wave.

Impact of Different Surface Forcing on Numerical Simulation of Upwelling Features off West Coast of India

Tanuja Nigam, and **Vimlesh Pant**
Centre for Atmospheric Sciences, Indian Institute of Technology Delhi, India

The Arabian Sea (AS), a semi-enclosed basin in northern Indian Ocean, experiences two contrasting surface wind circulations in response to reversal of winds from southwesterly during the summer monsoon (June-September) to northeasterly during winter monsoon (December-February). Wind stress on the sea surface reverses accordingly and affects surface circulation in the AS and alters the thermodynamic structure of upper oceanic layers. During the summer monsoon season, surface Ekman divergence leads to coastal upwelling off the southwest coast of India that brings the colder and nutrient rich subsurface waters to the sea surface, and thereby reduces the sea surface temperature and may increase the biological productivity. Intrusion of this subsurface colder water has a significant impact on the regional weather, such as fog formation and reduction in convection. In this study, coastal upwelling features were simulated using a hydrostatic, free surface, primitive equation ocean model Regional Ocean Modeling System (ROMS) over the domain 70°E-80°E, 5°N-15°N in the AS covering the west coast of India. The model follows sigma coordinate in the vertical. The horizontal and vertical resolutions of model are 0.125° × 0.125° and 40 vertical levels, respectively. During June-September moths, the strong southwest winds blow over the North Indian Ocean (NIO) basin, producing upwelling at the eastern Arabian Sea near Kerala state coastal belt. The model simulations were analyzed for the coastal upwelling off Kerala coast. Model experiments were carried out with two different surface forcing (wind stress and net heat flux) data used widely in the Indian ocean. The ROMS model is forced by European Center for Medium Range Weather Forecast interim re-analysis (ERA-I) and TropFlux data. There is a significant difference (up to 150 Watt/m^2) in the net heat flux of these forcing data sets. Sea surface temperature and sea surface salinity and currents are validated for both the forcing simulations against TRMM Microwave Imager (TMI), Simple Ocean Data Assimilation (SODA) and Ocean Surface Current Analysis Real-time (OSCAR), respectively. Model simulated vertical profiles of temperature and Salinity with ERA-I and TropFlux forcing are validated against SODA data set over the west coast of India. Model results demonstrate that

TropFlux forced simulations are in better agreement with observed data as compare to ERA-I forced simulations.

Local Ensemble Transform Kalman Filter for ROMS in Indian Ocean

Arya Paul and **Siva Reddy**
Indian National Centre for Ocean Information Services (INCOIS), India

Stephen Penny
Dept. of Atmospheric and Oceanic Science, University of Maryland, USA

We have developed and implemented a 56 ensemble member Local Ensemble Transform Kalman Filter (LETKF) for ROMS in the Indian Ocean. It can assimilate in-situ temperature and salinity along with satellite swath data of sea-surface temperature and sea-level anomaly. It has the capability to assimilate sea-surface-salinity as well. We bring in a large enough spread in the ensembles using a 56 member atmospheric forcing from NCEP 20th century Reanalysis. Preliminary results indicate marked improvements in the ocean state.

A Marine Virtual Laboratory: enabling efficient ocean model configuration

Roger Proctor[1], **Peter Oke**[2], **Uwe Rosebrock**[2], **Simon Pigot**[2], **Benedicte Pasquer**[1], **Xaioming Fu**[3]

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3. University of Tasmania, Australia

In pursuit of technical efficiency, the Australian ocean modelling community has developed the Web-based MARine Virtual Laboratory WebMARVL). WebMARVL allows a user to quickly and easily configure an ocean general circulation or wave model through a simple interface, reducing the time to configure a regional model to a few minutes. Through WebMARVL, a user is prompted to define the basic options needed for a model configuration, including the model, run duration, spatial extent, and input data. Once all aspects of the configuration are selected, a series of data extraction, reprocessing, and repackaging services are run, and a "take-away bundle" is prepared for download. Models supported by WebMARVL include three community ocean general circulation models (including ROMS) and two community wave models. The model configuration from the take-away bundle is intended to be a starting point for scientific research and can significantly reduce the time spent on this initial stage of model simulation preparation.

ROMS Cyber Infrastructure

David Robertson and **Hernan G. Arango**
Rutgers, The State University of New Jersey, USA

A quick review of the tools and information available on the ROMS web sites will be presented. We will discuss the current status and capabilities of the ROMS websites. Much work has been done on the nesting documentation in WikiROMS (http://www.myroms.org/wiki). The underlying software of WikiROMS was updated so equations are now delivered in MathML, with fall backs to SVG or PNG images respectively depending on the capabilities of the browser you are using.

The ROMS Matlab repository for model configuration and pre- and post-processing has many new tools needed for the new nesting algorithms. Examples of these tools and the data structures they use will be presented.

Surface Mixing in ROMS

Robin Robertson and **Paul Hartlipp**
University of New South Wales at the Australian Defence Force Academy, Australia

Many vertical mixing parameterizations exist for ROMS and they give widely different results. How well these parameterizations reproduce surface mixing is critical for climate and other applications. Using meteorological and oceanographic data from various locations off Australia, different vertical mixing parameterizations in ROMS were evaluated for their ability to replicate surface mixed layer dynamics. Three different vertical mixing parameterizations were investigated: Nakanishi-Niino, Mellor-Yamada 2.5 level turbulence closure, and the Large-McWilliams-Doney Kpp profile. Nakanishi-Niino performed best for this application using the criteria of the surface mixed layer depth and the structure of the upper ocean temperatures, although the performance of Mellor-Yamada was similar. Additionally, the horizontal and vertical resolution dependencies were investigated.

Regional ROMS/EnKF forecasting system for GBR

Pavel Sakov, **Paul Sandery**, **Frank Colberg**, and **Gary Brassington**
Bureau of Meteorology, Melbourne, Australia

We describe the status, performance and some design aspects of the developed 4-km regional EnKF/ROMS system for the Great Barrier Reef (GBR). The model domain is characterised by a combination of shelf and deep-sea areas, and complicated bottom topography. The model circulation exhibits elements of both chaotic and forced behaviour, as well as bathymetry-locked features. The 96-member EnKF achieves robust performance, with the SST bias correction shown to be an important element of the system. The system achieves very good performance on SST, but can not match a global 0.1-degree MOM-based EnOI system on SLA and subsurface T and S.

Spatio-temporal dynamics of the subtropical front in the southeastern Pacific: a modeling approach

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The spatial dynamics and seasonal and interannual variability of the subtropical front (STF) in the southeastern Pacific is studied through the use of a regional hydrodynamic model. The STF has a direct influence on physical and biological processes that modulate this area (e.g. separated warm and salty subtropical water from colder and fresher subantarctic water, the distribution of pelagic fisheries). We used the Regional Ocean Modelling System (ROMS) AGRIF version. The model domain encompassed between 10 ° N to 47ºS, and from 67ºW to 132ºW with a spatial resolution of 10 km. The study period was from 1994 to 2014 with a daily temporal resolution. The model used atmospheric forcing from NCEP2 and boundary conditions from ECCO. The circulation of water masses and seasonal variability of temperature and salinity variables that characterize the southeastern Pacific were described. The front was bounded spatially through different methodological approaches: meridional variations of sea surface salinity, sea surface temperature gradient, isotherm and isohaline between 0-150 meters. Using Lagrangian drifters, we showed that the average circulation of currents have a predominant surface pattern eastward with a progressive increase in speed from the south of 35°S and west of 80°W to the coast. The model showed a pattern of anticyclonic circulation characteristic of the southeastern Pacific. The model was validated by several approaches including comparison with observed hydrographic data, satellite information of Sea Surface Temperature (SST), Surface Salinity Sea (SSM), Anomaly Sea Level (ANM) and El Niño 3.4. signal. In addition, this model has been coupled with biological models for the study of the dynamics of recruitment of jack mackerel, an important pelagic species.

Ocean forecasting and reanalysis using ROMS with ensemble data assimilation

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Here we describe a 6 year ocean reanalysis and forecast system of the Coral Sea and Great Barrier Reef (GBR) from 2006-2011. The reanalysis is based on a 4 km resolution implementation of the ROMS model and an ensemble data assimilation system. The system assimilates sea-level anomaly from along track altimetry, sea surface temperature from multiple satellite sensors and in-situ temperature and salinity from Argo profiles. Open boundary conditions are taken from the Bluelink reanalysis, and the model is forced with the NCEP Climate Forecast System Reanalysis. Realistic river discharge at the coast is implemented using Bureau of Meteorology hydrological gauge observations. Errors are quantified in terms of forecast innovations. The system is able to capture interesting coastal river flooding and shelf break upwelling events whilst also constraining various mesocale features and boundary currents of the GBR region, such as the northern branch of the East Australian Current, Capricorn Eddy and Papua Gyre.

Eddy mixing and transport at the Antarctic margins

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Ocean processes occurring along the Antarctic continental slope admit shoreward transport of heat toward the continent's marine-terminating glaciers and export newly-formed dense waters from the continental shelf. Recent modeling studies indicate that ocean eddies play a key role in modulating these processes in all sectors of the Antarctic margins. However, due to the computational cost of resolving the small (~20km) scales of Antarctic shelf/slope eddies, previous analyses have been limited to regional models and idealized process studies. In this study we investigate eddy transport and dynamics around the entire Antarctic shelf break using output from recent global ECCO2 simulations run at 1/24th and 1/48th degree horizontal resolutions.

We use energy and vorticity budgets to characterize the eddy-mean flow interaction in the Antarctic Slope Current (ASC). We find that a distinct dynamical regime arises in which the core of the ASC flows at almost exactly the same speed as the overlying sea ice, producing vanishing surface momentum and energy forcing that must be accommodated by lateral eddy momentum and energy fluxes. This balance breaks down where the ASC encounters less steep stretches of the continental slope, setting up "hot spots" of enhanced shoreward heat transport.

Vertical resolution in ocean models

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Spatial resolution is an area of necessary compromise for ocean models. There are enormous and obvious benefits to resolving the smallest dynamical scales, but the computational costs are prohibitive, requiring a cost-benefit compromise at some effective resolution lengthscale. For the horizontal resolution, this decision can be guided by the Rossby radius of deformation, and is supported by numerous sensitivity studies investigating the horizontal resolutions required to resolve specific ocean dynamics. There is no such guide for vertical resolution, and thus it is not obvious that a given vertical grid is able to adequately support the resolution capabilities of a given horizontal grid. Indeed, given that the bulk of vertical processes are parameterised in ocean models, it is not immediately clear what dynamics an ocean vertical grid is supposed to resolve. Here, we argue that the primary purpose of the vertical grid is to resolve the vertical structure of the horizontal flows. We present a method that uses hydrography to estimate the vertical complexity of the horizontal velocity fields. These findings guide the construction of a vertical grid that will not undermine the resolution capabilities of the horizontal grid. These vertical resolution requirements are presented in terms of both z- and sigma-coordinates.

The influence of the offshore current regime on shelf and nearshore wave climate in southwest Australia

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The assessment of global and regional wave energy resources is generally done using model based calculations without taking into consideration wave-current interactions, particularly major offshore current systems. The southwest Western Australian (SWWA) wave climate is dominated by extratropical storms in the Southern Ocean (SO) that generate waves with an average significant wave height of 2m and a mean wave period of 8.8s on the SWWA inner shelf. During frequent storms in winter, much larger wave heights can be experienced. While the tidal range on the SWWA shelf is relatively small (<0.5m), the current regime is dominated by the Leeuwin Current (LC), a strong (current velocities >2m/s) and narrow poleward-flowing surface current that carries warm, low salinity water along the SWWA shelf edge. The strength of the LC varies seasonally and is strongest in the austral winter due to weakened southerly winds. The LC features a meso-scale eddy field of anticyclonic eddies that spin up from the current and propagate away from the coast.

The influence of the offshore current regime on surface gravity waves was examined by developing a COAWST (Coupled Ocean-Atmosphere-Wave-Sediment Transport) model of the SWWA shelf area. COAWST comprises the three dimensional, free surface, terrain-following hydrodynamics model ROMS (Regional Ocean Modelling System) and the third generation wave model SWAN (Simulating WAves Nearshore). Different "states" of the LC were simulated (weaker LC, stronger LC, meandering LC, and various states of the eddy fields) and the coupled model was compared to an uncoupled model of SWAN, which simulated a scenario in the absence of a background current field. It was shown that the LC has a significant impact on the SWWA shelf and nearshore wave climate. Currents opposing the incident wave direction led to increased wave heights of >12%. Furthermore, variations in wave direction of >5%, and a change of ~5% in peak period were observed. Depending on the "state" of the LC, an uncoupled wave model under- or over-predicts the SWWA wave climate. It is therefore important to consider the offshore current regime when estimating the shelf and nearshore wave climate.

ozROMS - a high resolution 16 year re-analysis product for Australian and Indonesian Seas

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The ozROMS model has been configured to include the entire Australian continental shelf and slope together with the adjacent deep ocean using Regional Ocean Modelling System and now includes the oceans around Australia and the Indonesian Archipelago (92° to 180°W, -49°S to 8°N) at a resolution of 3-4 km. Hindcast simulations over a 16 year period (January 2000 to December 2015) were completed with forcing which included atmospheric, sea level (tides and longer term changes) and open boundary forcing of temperature and salinity. The model outputs have been saved and are available through the UWA OPeNDAP Server (http://130.95.29.56:8080/thredds/catalog.html). The model has been validated using IMOS mooring arrays: ITF, Kimberley, Pilbara and EAC, regional tide gauges and satellite imagery.

Australia is surrounded by surface and sub-surface boundary currents that contribute to poleward heat and mass transport and inter-ocean water exchange. Here, the Indonesian Through Flow (ITF) and Tasman Outflow (TO) play a dominant role in the heat and salt exchange between the Pacific and Indian oceans. Estimates of ITF and TO are uncertain due to strong inter-annual variability (e.g. ENSO and the Asian monsoon variability). As an application of the ozROMS model reanalysis output present ITF and TO fluxes (volume, heat and salt) using ozROMS outputs and recent observational data to a strong connectivity between ITF and TO. The subsurface flows, predicted by ozROMS, in the Timor Passage and Lombok Strait, revealed that they originate from both equatorial and south equatorial currents in the Pacific Ocean. Idealized simulations indicated that the volume transport of the ITF is sensitive to the strength of the equatorial current in the Pacific Ocean. The South Equatorial Current (SEC) in the Pacific Ocean impinges on the eastern continental shelf slope of Australia to feed the East Australian Current (EAC). The EAC extension flows along the eastern coast of Tasmania contributing to the Tasman outflow. The volume flux from the TO contributed to the Flinders Current (FC) along the southern shelves. The FC flows as both a subsurface current underneath the Leeuwin Current (LC) and a surface current further offshore. The FC is linked to the northwards flowing Leeuwin Undercurrent (LU) to the north-west of Australia.

Velocity and sea level anomaly wavenumber spectra in the coastal ocean: Observations from HF-radar and altimetry compared with nested high-resolution models

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A CODAR HF-radar network has been observing surface currents in the Mid Atlantic Bight (MAB) continental shelf ocean for several years. CODAR observes the component of velocity along a radial view direction from a single antenna, geo-located by range and azimuth. Vector velocity is computed by combining radials observed by multiple sites. The concave geometry of the MAB coastline enables us to select radial view transects that are substantially along or across isobaths, and compute wavenumber spectra for both along-shelf and across-shelf components of velocity. Comparing radial view spectra to vector component spectra reveals that the optimal interpolation vector combiner significantly damps energy for wavenumbers exceeding 0.03 km^{-1}.

We further computed SSHA wavenumber spectra using coastal altimeter data from CryoSat-2 for ensembles of tracks in the same region that were predominantly across- or along-shelf. While CODAR-derived velocity spectra exhibit power law dependence close to $k^{-5/3}$ down to the limit of resolution, the SSHA spectra are somewhat steeper.

Wavenumber spectra from these observations are compared to results from ROMS simulations with increasing resolution achieved by 2-way synchronous nesting (for two and three levels of nested grids) in the environs of the NSF OOI Pioneer Coastal Array. Modeled and observed spectral shapes generally agree well, but with comparable energy levels not achieved until model horizontal grid resolution approaches ~700 m.

The results have implications for specifying observational error and error-of-representation in data-assimilative modeling systems that exploit CODAR and altimeter observations in the coastal ocean.

The Dispersal of Polynya Dense Water on a Shallow Sloping Shelf

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This study examines the dispersal of the dense water formed in an idealized coastal polynya on a sloping shelf in the absence of ambient circulation and stratification. Both numerical and laboratory experiments reveal two separate bottom dispersal pathways of the dense water: i) an offshore plume moving downslope into deeper ambient water and ii) a coastal current flowing in the direction of Kelvin Wave propagation. The gravitational force drives the initial down-slope drainage of the dense water, which then turns to right under the influence of the Coriolis force and forms the offshore pathway; The dense water coastal current is generated by the along-shelf baroclinic pressure gradient, which is balanced by the bottom drag in the far field. Scales of the speeds of the offshore and coastal plumes are obtained from momentum balances and verified by numerical and laboratory sensitivity experiments. The numerical simulations suggest that $<25\%$ of the dense water enters the coastal current, and the percentage depends highly on the ratio of the velocities of the offshore and coastal plumes. This makes the velocity ratio potentially useful for observational studies to assess the amount of dense water formed in coastal polynyas.

Poster Abstracts

The NIWA NZ shelf seas hindcast

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A ROMS domain spanning the continental shelf around New Zealand has been set up and a prototype hindcast at 5 km resoution has been generated for the years 2008–2014. Lateral boundary data was taken from the HYCOM global model and the surface stresses were from a NIWA 12 km local atmospheric model. We plan to produce a similar product at 2.5 km resolution and are considering other hindcast periods and other sources of boundary and surface data. The model reproduces the observed seasonal and spatial variation in temperature and salinity reasonably well. In some areas currents on the continental shelf are reproduced very well, in others not so much. We plan to use the model output for studies of marine transport and to provide boundary data for smaller-scale models.

How competing seasonal processes control the Ross Sea dynamics

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Over the Ross Sea continental shelf results from an application of the Regional Ocean Modeling System (ROMS) identified a system of three anticyclonic and one cyclonic circulation cells that facilitate the water mass transports in the interior, including the ice shelf cavity. The main control of the cell's dynamics are the horizontal differences in density that drive three mechanisms: baroclinic pressure gradients, gravity driven bottom flows and barotropic pressure gradients through sea surface height gradients. Circumpolar Deep Water (CDW), sourced from the Antarctic Slope Current (ASC), sits next to northward-flowing High Salinity Shelf Water (HSSW) and other dense Shelf Water. CDW resupply events seem triggered by a zonal shift of the ASC on the order of ~10 km that occurs at different times along the shelf break. The second, atmospherically driven mechanism to strengthen density gradients is HSSW production through intense winter sea ice formation in the polynyas of the south-western Ross Sea. The third mechanism to enhance local horizontal differences in density is Ice Shelf Water (ISW) supplied by melting at the ice shelf base. The timing of ISW occurrence is not synchronized with the atmosphere but with the seasonality of warm water inflow to the cavity which in turn is controlled by a number of other processes. The model predicts phase lags of up to 1.5 years between heat import events to the cavity and the subsequent ISW pulse to leave the cavity. Thus the seasonality of flow dynamics in the Ross Sea is a superposition of the ASC variability, the atmospheric cycle, and the heat import signal to the cavity.

Coupling ROMS-CICE for Polar COAWST model

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A polar version of the COAWST (Coupled Ocean Atmosphere Wave Sediment Transport) model is under development. Polar COAWST is an international effort to develop a high resolution regional model for the polar region. It consist of Polar WRF, ROMS (in future Polar ROMS ?) CICE. Our effort is to couple ROMS with CICE.

A new dipole index of the salinity anomalies of the tropical Indian Ocean

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With the increased interest in studying the sea surface salinity anomaly (SSSA) of the tropical Indian Ocean during the Indian Ocean Dipole (IOD), an index describing the dipole variability of the SSSA has been pursued recently. In this study, we first use a regional ocean model with a high spatial resolution to produce a high-quality salinity simulation during the period from 1982 to 2014, from which the SSSA dipole structure is identified for boreal autumn. On this basis, by further analysing the observed data, we define a dipole index of the SSSA between the central equatorial Indian Ocean (CEIO: 70°E-90°E, 5°S-5°N) and the region off the Sumatra-Java coast (SJC: 100°E-110°E, 13°S-3°S). Compared with previous SSSA dipole indices, this index has advantages in detecting the dipole signals and in characterizing their relationship to the sea surface temperature anomaly (SSTA) dipole variability. Finally, the mechanism of the SSSA dipole is investigated by dynamical diagnosis. It is found that anomalous zonal advection dominates the SSSA in the CEIO region, whereas the SSSA in the SJC region are mainly influenced by the anomalous surface freshwater flux. This SSSA dipole provides a positive feedback to the formation of the IOD events.

Simulation of wave-induced current considering wave-tide interaction

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To prevent the beach erosion and to support the beach restoration project, the Korean government has initiated the development of coastal erosion control technology since 2013. As a part of this project, the waves and currents have been observed for two consecutive years in the nearshore and offshore of the Haeundae beach to understand the coastal process and sediment transport. Haeundae beach is a ~1.6 km long and ~50 m wide sand beach facing the Korea Strait. In this study, a numerical simulation using a wave and current coupled model (ROMS-SWAN) was conducted for determining the wave-induced current during the Typhoon DANAS and seasonal swell waves (Hs : 2.5 m, Tp: 12 s) for better understanding of the coastal process near the surfzone. By comparing the measured and simulated results, we found that cross-shore current during summer is mainly caused by the eddy produced by the wave-induced current near the beach, which in turn, is generated by the strong waves coming from the SSW and S directions. During other seasons, a longshore wave-induced current is produced by the swell waves coming from the E and ESE directions. The wave-induced current simulated by ROMS-SWAN generates longshore current heading west toward Dong-Back Island (the West end of the beach) during all the seasons and eddy current toward Mipo-Port (the East end of the beach) in Summer which is well matched with the observed residual current with AWACs. The wave-current modeling with long-term measurement will be incorporated in a simulation of sediment transport in Haeundae for developing a coastal erosion control system.

Towards biogeochemical modelling of the East Australian Current system

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The East Australian Current (EAC) is the Western Boundary Current (WBC) of the South Pacific subtropical gyre and dominates the large scale flow of the Tasman Sea. It advects warm oligotrophic waters poleward, displacing cooler, generally more productive waters. It generates mesoscale eddies and induces coastal-upwelling. To better understand how this dynamic oceanographic regime exerts its influence on the biogeochemical properties of the EAC System, we have developed a coupled physical-BGC

(ROMS+N2PZD2) model of the region. We strive to achieve a realistic simulation of the basis of the region's marine ecosystem and to assess the spatial and temporal variability of different biogeochemical variables (nitrates, ammonium, phytoplankton and associated chlorophyll concentration, zooplankton, small and large detritus), from synoptic events to seasonal and interannual timescales and encompassing shelf, open ocean, surface and sub-surface. A high demand for this information exists, arising from a range of fields and applications such as scientific research on marine ecosystems, monitoring of seawater quality and decision-making support for marine and coastal management, yet little is known on how the specific dynamics of the EAC system define the region's BGC processes. We have conducted model performance assessments through comparison of chlorophyll-a model outputs with remote sensing products and verified the model's ability to reproduce the expected latitudinal differences in phytoplankton biomass. The accuracy of the simulated mixed layer depth variability and the use of only one trophic compartment for the phytoplankton group have been identified as the main limiting factors. These advances form the foundation for future work where we will explore specific scenarios including the BGC dynamics of cyclonic eddies, coastal entrainment and future climate change.

Transient inner shelf response to upwelling favourable winds relaxation off Rio de Janeiro, Brazil

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We investigate the response of inner shelf dynamics to upwelling-favorable wind relaxation at the Cabo Frio upwelling system. Other studies have shown that when upwelling-favorable winds relax, the prevailing currents often weaken or reverse to form a propagating warm coastal countercurrent (CCC). Evidences of CCC been reported during upwelling-favorable wind events over the Rio de Janeiro continental shelf. We address this problem both by analysing meteorological and oceanographic time series during 2013-2015 and through simplified, process-oriented modelling approach. Along with 2 years of *in situ* measurements, 27 wind relaxation events were detected, from which 8 of them were followed by a CCC setup and rapid increases in SST up to 9°C along the coast. The observed CCC velocities were generally higher than those related to the upwelling coastal jet. The main CCC features suggests that the flow is forced by both barotropic and baroclinic pressure gradients at different time scales. Despite the simplified model setup, numerical solutions provided a good correlation between the occurrence of CCCs events with both temporal and spatial variablity in the wind field. Particularly, the solutions showed that the steady circulation balance sustained by the vigorous NE winds is dismantled as upwelling-favorable winds relax. An alongshore pressure gradient is suggested as the main mechanism to force the CCC. Consequently, free-surface perturbations propagates along the coast and enhance cross-isobath balance, increasing CCC alongshore velocities. Interestingly, complete wind field revarsals doesn't seem mandatory to properly force significant changes in inner shelf flow associated with upwelling dynamics.

Risk of surface sediment erosion in the Bohai Sea, North Yellow Sea and its indication to tidal sand ridge occurrence

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Bottom geomorphological evolution and sediment distribution are under strong control of tidal forcing along China's coast. To quantify and assess the temporal-spatial change of the bottom environment, a risk-based probabilistic concept of erosion is applied and maps of erosion risk are constructed. Sediment data categorized into 5 classes, together with hydrodynamic data in a temporal resolution of one hour and a model time of one month from ROMS output, are used to calculate the potential of erosion of surface sediments in the Bohai Sea and North Yellow Sea. Comparison with results of the tidal ellipse and bottom shear stress from model output shows that the highest risk of erosion is located in the Yalujiang Estuary, West Korea Bay, north of the Bohai Bay and in the surroundings of the Laotieshan channel of Bohai Strait, which may explain the occurrence of tidal sand ridges in the modeling domain.

Seasonal variation features of the hydrodynamic environment in the western Taiwan Strait

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Seasonal variation features of the hydrodynamic environment in the western Taiwan Strait in spring, summer, late autumn and early winter are investigated in detail based on *in situ* Conductivity-Temperature-Depth (CTD) cruise data and the current profiles and the near- seabed temperatures obtained from the Bottom-Mounted Moorings (BMM) during a comprehensive survey conducted by the Chinese Offshore Investigation and Assessment Project from 2006 to 2007. It reveals that the water is vertically well mixed in spring with isotherms and isohalines largely parallel with the coastline. The water temperature and salinity increases southward and in an offshore direction. The coastal current adjacent to Fujian Province is largely barotropic and flows upwind as a northeastward current with the largest current speed (about 0.25 m/s) occuring offshore of Quanzhou. Correspondingly, the less saline (< 32.4) Zhe-Min coastal water is mostly confined within the upper to middle near shore regions north of Quanzhou. By contrast, significant local upwelling features can be identified in the western Taiwan Strait in summer, with three distinct cool(< 25°C) and high saline(> 33.8) near-seabed upwelling centres located offshore of Shantou, Dongshan and Nanri Island, respectively. Meanwhile, the Fujian coastal current flows in accordance with the dominant summertime monsoon with largest amplitude of ~0.40 m/s adjacent to Pingtan and is largely barotropic except for the offshore zone of Shantou, where the current speed at 10 m depth (0.19 m/s) is a bit larger than at 25 m (0.15 m/s). Distribution features of the salinity and temperature agree with each other in late autumn and early winter, increasing in both the southward and offshore directions. During the observation period, the Zhe-Min coastal water emerges offshore of Pingtan Island from the 26th of December and then the whole western strait is dominated by the cold southward Zhe-Min coastal water(< 17°C) after the 15th of Janunary. A weaker residual current south of Xiamen is detected and significant vertical current shear can be identified during the period.

A numerical study of circulations in the Bransfield Strait, Antarctica

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The Bransfield Strait and Gerlache Strait in Antarctica are the spawning and nursery ground of Antarctic Krill, and circulations in this area play an important role in the transport of krill larvae. A numerical model based on ROMS has been developed for this area to simulate the circulation patterns and to reveal the underlying forcing mechanisms. The horizontal resolution of the model is ~800 m in the southern Bransfield Strait and ~1.5 km in the south Scotia Sea. Atmosphere forcing comes from the Climate Forecast System Reanalysis (CFSR). The model is nested in a coarser-resolution model based on ROMS that covers the Drake Passage, the Scotia Sea and the Weddell Sea. The model reproduces the observed circulation system in the Bransfield Strait, including the most important circulation feature–the Bransfield Current, which is a strong, northeastward current along the northern slope of the Bransfield Strait. The model also captures the observed southwestward currents in the southern Bransfield Strait, northeastward currents flowing from the Gerlache Strait into the Bransfield Strait, and southward currents entering the Bransfield Strait from the Boyd Strait. Compared to observational data, the strength of the Bransfield Current is underestimated by the model, which needs to be further improved. In the future, the model will be used to investigate the influence of wind stress (including the wind stress curl), the intrusion of the circumpolar deep water and the Antarctic Slope Current on the circulations in the Bransfield Strait.