

## Potential PhD topics:

### 1. What ocean do Lagrangian observing platforms (e.g., Argo and drifting buoys) observe ?

In the mid- and high-latitudes the ocean circulation is composed largely of eddies and fronts. In isolation an ocean eddy is relatively stable being in quasi-geostrophic balance and retaining a closed material surface around its core water mass. It is only through the disruption or destruction of this balance through eddy- interactions that an exchange in mass with its environment takes place. Only at these times is it possible for a Lagrangian observing platform to enter or exit the eddy circulation. This poses many interesting questions such as how frequently do these platforms observe eddies and what are the implications for constructing climatologies of the ocean and ocean forecasting. This research would make use of state of the art high resolution ocean models, analysis of altimetry and the in situ Argo and drifting buoy observations available at the Bureau of Meteorology and the global ocean observing system.

**2. Characterisation of ocean forecast errors from an ocean forecasting system.** A state-of-the-art prediction system makes several assumptions about the errors of the observing system, the ocean models, the atmospheric forcing and data assimilation methodology. Correctly modelling and estimating these errors and validating or improving these assumptions is critical to further improving performance. This project will focus on the available database of forecast innovations and increments from the BLUElink ocean prediction system and determine the systematic bias as well as the statistical distribution. Specific methods will then be developed to deconstruct and attribute error to different components of the system as well as hypothesis testing.

**3. Helen Beggs leads the GHRSSST Tropical Warm Pool Diurnal Variability (TWP+) Project** which aims to quantify diurnal warming of the surface ocean over the Tropical Warm Pool to the north of Australia and to validate and compare various diurnal variation models over this region.

The **International Group for High Resolution Sea Surface Temperature (GHRSSST) TWP+ data set** would be a great resource for any PhD student with a background in either physical oceanography, air-sea heat exchange, marine meteorology and/or satellite oceanography. Further information on the TWP+ Project can be found at <https://www.ghrsst.org/ghrsst-science/science-team-groups/dv-wg/twp/> .

The **GHRSSST Workshop on Tropical Warm Pool and High Latitude SST Issues** (Melbourne, 5-9 March 2012) would be an excellent opportunity for a new PhD student to choose a TWP+ related research project that matches their interests and abilities. The workshop will focus on presentations relating to initial research for the TWP+ Project and using the TWP+ data set during the three working days of the GHRSSST workshop. Further information on the GHRSSST Workshop can be found at <https://www.ghrsst.org/ghrsst-science/Meetings-and-workshops/workshop-on-tropical-warm-pool-and-high-latitude-issues/> <<https://www.ghrsst.org/ghrsst-science/Meetings-and-workshops/workshop-on-tropical-warm-pool-and-high-latitude-issues/>> including a draft agenda which lists the current TWP+ research activities.

### 4. Impact of East Australian Current observations Tasman Sea eddies in an ocean model

#### **Introduction**

Can observations of the East Australian Current using a HF ocean surface radar improve model forecast skill of meso-scale eddies in the Tasman Sea?

The study will use observations at Coffs Harbour (30S, 153E) which extend approximately 100 km east across the East Australian Current (EAC) and perform assimilation impact studies on a domain encompassing upstream of Coffs Harbour, the EAC separation (at approximately Smoky Cape, 31 S), and the Tasman front (across to New Zealand), with a particular emphasis on meso-scale eddies.

### **OSR observations**

The HF OSR measures surface currents in the top few tens of centimetres of the ocean, on a few km resolution with a range of around 100km over 10 minute time scales. The OSR is part of the IMOS ACORN facility and is planned to commence operation in February 2012. Routine data delivery could be expected by mid 2012. Observations show the EAC is largely barotropic, so OSR should be representative of the depth-integrated current.

### **The Ocean Model CLAM? Assimilation**

The HF OSR provides currents in regions where the two radars overlap (and the subtended angles of the ray are greater than ~20). Outside of this region there is another equally extensive area where there is only one useful current vector component resolved. While not suited to visual interpretation, single current vector components can be assimilated into ocean models.

The model already assimilates altimetry, SST and temperature and salinity profiles, so any skill improvement will be in excess of this. The assimilation of HF OSR observations may also be useful in the situation where altimetry is degraded (due to loss of satellites or other problems). It would be useful to quantify the impact of assimilating OSR currents in the absence (or reduction) of altimetry.

Possible candidate data-sets for skill evaluation are feature tracking, surface drifters (these are probably drogued to a few metres depth), or synTS. The first two sources will probably generate sparse data-sets. Maybe the evaluation will be achieved by looking at the increments in SSH?

### **Links to other Work**

We have previously looked at the impact of observations on models using the error estimates in the data assimilation system (Oke *et al.*, 2009). It would be instructive to see how data withholding experiments compare to the observation network design study tool.

Oke, P. R., Sakov, P. & Schulz, E.W., 2009, A comparison of shelf observation platforms for assimilation in an eddy-resolving ocean model, *Dynamics of Atmospheres and Oceans*, 48, 121-142, doi:10.1016/j.dynatmoce.2009.04.002.

## **5. Predictive mapping of seabed cover, benthic habitats, benthic biodiversity using multibeam bathymetry and backscatter data**

Coastal marine benthic environment, which is dreadfully under-studied, has significant economic and conservation values. Sustainable management of this marine ecosystem requires high quality physical and biological datasets on the benthic environment and scientific evidence on the interactions between these physical and the biological variables. Modern multibeam sonar systems, with different sonar frequencies, are capable of accurately mapping large area of seabed from water depth of a few metres to thousands metres. They can provide high-resolution and near-complete coverage of bathymetry and acoustic backscatter data for mapping seabed substrata, benthic habitats and benthic biota.

The proposed project would involve intensive field campaigns collecting multibeam data, water column data, sediment samples and biological data. The collaboration with OUC is critical for the collection and analysis of these data. We would provide expertise in the areas of data analysis, modelling and result interpretation.

## **6. Using hyperspectral remotely sensed data for monitoring coastal water quality**

Airborne Hyperspectral Remotely Sensed data has very high spatial and spectral resolutions. It is therefore most suitable for fine-scale and detailed investigation of coastal water quality. The hyperspectral reflectance is jointly influenced by a range of physical and biochemical conditions in the near-surface water. These water quality factors include chlorophyll, phytoplankton, dissolved organic materials, suspended sediments, dissolved oxygen, and surface temperature, etc. The hyperspectral data can thus be used to accurately estimate the concentrations of these water quality parameters and to monitor their seasonal and annual changes.

The proposed project would involve intensive field campaigns collecting hyperspectral data and water quality data at selected seasons. This would be followed by solid data analysis to quantify the relationship of various water quality factors to the reflectance at specific wavebands, which is highly significant and challenging. The collaboration with OUC is critical for the collection and analysis of these data. We would provide expertise in the areas of data processing, modelling and result interpretation.

## 7. Generalised dependence for the ocean sea drag

The sea-drag coefficient is the main property which is employed to parameterise the air-sea interactions in large-scale models, from engineering applications to climate research. Over the last 30 years, however, scatter of the experimental dependences for the sea drag parameterised as a function of wind speed and/or wave age did not improve. The proposed project would intend to develop a generalised parameterisation of the sea drag as a function of multiple environmental forcings, for use in meteorological, climate and ocean engineering applications.

## 8. Coastally trapped wave observations and modelling around Australia

Program Code: 1082

**Supervisors:** A/Prof. Xiao Hua Wang (hua.wang@adfa.edu.au), Dr Ming Feng, CSIRO, A/Prof Moninya Roughan and Dr Andrew Kiss (UNSW)

Australia is surrounded by major ocean boundary currents – with the East Australian Current off the east coast, the Leeuwin Current off the west coast, and the South Australian Current/Flinders Current off the south coast. The Integrated Marine Observing System (IMOS) has set up shelf circulation monitoring systems for the major boundary current systems over the past six years. The observing systems include shelf moorings, gliders, and surface radar systems. The ocean boundary current systems vary on different time scales, such as seasonal and intra-seasonal. The aim of this study is to utilise the IMOS mooring networks and numerical models to understand the coastally trapped wave propagations around Australia, forced by wind anomalies on intra-seasonal and whether time scales, and their interactions with the ocean boundary current systems. The intra-seasonal variability of the ocean boundary currents are important in understanding the extreme events in these systems.

## 9. Remote sensing study on the East Australian Current

Program Code: 1082

**Supervisors:** A/Prof. Xiao Hua Wang (hua.wang@adfa.edu.au) and Dr Zhi Huang, Geoscience Australia

East Australian Current (EAC) is a significant boundary current that flows poleward. On the way, it separates and generates many large and small eddies that cause lots of oceanographic dynamic. It has significant ecological impact on the eastern margin of Australia from about 25S. This PhD project aims to use time-series remotely sensed data to map EAC's spatial structures and investigate the spatial and temporal variability of EAC's characteristics. The remotely sensed data to be used include more than 10 years MODIS SST and Chlorophyll a datasets. We also intend to use satellite altimetry data in combination with the broad scale BlueLink model to help the mapping and validation, especially in the identification of eddies. This PhD project will further develop the techniques used in supervisor's (Huang) similar study on the Leeuwin Current of Western Australian margin (Huang and Feng, 2015). Co-supervisor Wang's expertise in EAC system will be utilised in guiding the design of this study and assessing the results of this study, among others. The successful PhD candidate is expected to have a strong research and analytical skills. Experience and skills in either Remote Sensing or Physical Oceanography field or both are highly desirable.

**These brief research questions are possible projects for research higher degree students under the supervision of A/Prof. Stuart Pearson.**

- What is the Blue Economic Zone and what will its success bring to society, environment and economy? How will it be monitored and evaluated? What does this show about the research needs for China's environmental law, science and management? [with A/Prof Ma Yingjie]
- Why is eco-compensation so popular in China? What does this show about the research needs for China's environmental law, science and management? [with Ma Yingjie]
- How is risk of environmental research, environmental management and environmental policy considered in Australia and China? Current topics for PhDs have related to biofuel policy [with Dong Bo], Antarctica's research program [with Maozeng Jiang] and so what do you think should be studied next?
- Who cares? Using a social science approach, how can the values, attitudes and dreams of Australia and China's young professionals be understood and what scenarios can be plausibly

developed? Environmental research, environmental management and environmental policy considerations of young people in Australia and China. How does this contribute to government research? [with Yantai Institute and NSW Government]

- How widely and how appropriate is applying the Kuznets curve thinking in China a rational Natural Resource Management response? China's rapid development and transition to a eco-civilisation is widely discussed as a stage requiring 'development first and clean-up second'. What is the nature of the evidence used by narrators to justify this and what are the plausible scenarios?