Emlyn Jones (CSIRO)

The particle filter: an expensive toy or should we take it more seriously?

Data assimilation methods that are used for operational numerical weather prediction and ocean forecasting must be computationally efficient such that forecast cycles complete within time and computational constraints. Variational (e.g. 4D-Var) and Kalman Filter (e.g. EnKF) methods are efficient but rely on linear and Gaussian approximations to make the assimilation step computationally tractable. The Particle Filter (PF) does not rely on such assumptions, but is computationally expensive to run and to date there are few if any examples of it being used in large geophysical problems. This session will focus on the theory behind the PF and the associated advantages/disadvantages of this assimilation method.

Shane Keating (UNSW)

Stochastic data assimilation methods for satellite observations

Mixing by ocean eddies on scales of 10-50 km plays a key role in biogeochemical processes, frontal dynamics, and tracer transport in the upper ocean. These scales lie at the edge of resolution of current-generation satellites. However, attempts to "fill in the gaps" using contemporary data assimilation approaches such as 4DVAR and Ensemble Kalman Filters are limited by the *curse of dimensionality.* In this talk, I will describe a suite of stochastic data assimilation strategies for deriving "superresolved" satellite observations obtained by combining low-resolution observations with a stochastic parameterization for the unresolved scales. A key feature of these methods is the use of computationally inexpensive stochastic models for the unresolved scales, which can be trained using the observations themselves.

Jeff Kepert (BoM)

4D-VAR for dummies

Four-dimensional variational assimilation is one of the principal reasons for the enormous improvement in NWP forecast skill over the past two decades. While many people know of the value of 4D-Var, far fewer understand how it works, or know what adjoints are and why they are important. For too long, too many have been intimidated by the reputation for formidable mathematics that surrounds it. This fun-filled interactive session will cut through the mystique, present the key elements of the theory and outline the techniques needed to make them work in practice.

Benoit Legresy (CSIRO)

Satellite observations for oceanography

In the past decades satellite observations have led to a revolution in oceanography. While observations at sea are difficult, remote, sparse and heavy to organise, satellites bring observations 24/7 all over the globe. Progress in the satellite techniques has provided a wealth of quality new observations. We will see the range of satellite orbits from geo-stationary to polar available for science applications. The main observations classically used will be presented, including Sea Surface Temperature, Sea Surface Height, Surface Wind and Wave. Recent developments in ocean colour, sea ice mapping, gravimetry and other promising techniques will also be presented as well as future incoming new satellite product possibilities.

John Le Marshall (BoM)

Assimilation of satellite data for numerical weather prediction

Satellite data plays a key role in numerical weather prediction. Data from nearly 50 satellite instruments are required for a state-of-the-art modern global analysis system. Recent experiments have shown that in the southern hemisphere , the accuracy of a no-satellite data 24-hour (one-day) forecasts is the same accuracy, on average, as a 96 hour (four-day) with-satellite data forecast when forecasts were verified against the control (all data used) analysis. The effective use of these satellite data determines the quality of the analysis. Here we will discuss the variety of observations available from satellite, how these observations are assimilated and the beneficial impact of a number of key observation types.

Richard Matear

Application of Parameter Estimation to Marine Biogeochemical Models

Marine biogeochemical (BGC) modelling is a key approach to helping us understand the biochemical processes responsible for the transfer of nutrients and carbon between non –living (inorganic) and living (organic) pools. Quantifying these biochemical processes is essential to understanding carbon cycling in the ocean, the air-sea exchange of carbon, the impact of climate variability and change on marine ecosystems, and the link between ocean physics and ocean biology. Extending the physical modelling to include BGC data assimilation presents an exciting opportunity to expand ocean data assimilation products. However, delivering these new BGC data assimilation products is not a trivial. Here I will focus on the challenges of tackling BGC data assimilation. To help set the context of this discussion I will first briefly review the basic components of the biogeochemical models that could be incorporated into physical data assimilation systems. Second, I will briefly discuss previous BGC data assimilation effort. Finally, I will present how using parameter estimation with data assimilation can improve BGC models. The focus on parameter estimation stems from the large model errors associated with biogeochemical models, the highly uncertain biological parameters, and the strong non-linearity between biogeochemical state variables.

Outline:
1. Briefly review what is biogeochemical modeling.
2. Provide motivation for applying data assimilation methods to biogeochemical models
3. Present several examples of marine biogeochemical data assimilation
4. Discuss challenges for facing BGC parameter estimation with data assimilation
5. Summarize and provide a view on future requirements and future priorities for biogeochemical data assimilation

Terence O'Kane (CSIRO)

Data assimilation in strongly nonlinear systems

Turbulence closures and data assimilation methodologies have a range of similar technical difficulties that must be overcome, of which the most prominent is inhomogeneity or large-scale flow dependence. In order to track regime transitions in an evolving nonlinear system requires the solution of an infinite hierarchy of moment equations; this problem is formally identical to the closure problem that arises in statistical approaches to turbulence. Here we will describe methods based on approximations to successively higher order moments required for strongly nonlinear non-Gaussian systems.

Pavel Sakov (BoM)

A brief perspective on the Ensemble Kalman filter

This talk gives an overview of the EnKF: its formulation, basic concepts, and some practical aspects.

Paul Sandery (BoM)

Introduction to practical mesoscale ocean forecasting.

This session will focus on the practical use of data assimilation in ocean forecasting. We will look at the method of Ensemble Optimal Interpolation, which is straightforward to implement and can be used to help understand many of the features of ensemble data assimilation. We will learn how ocean models can be initialised to remotely sensed satellite altimetry, sea surface temperature and in-situ observations. Students will gain knowledge on how ensembles are generated and the relative roles of model and observation uncertainty in the Kalman gain. We will also take a look at how single observations project into the state vector in a multivariate system and demonstrate the need for multiple observation types and reasonable coverage in order to make meaningful forecasts.

Peter Steinle (BoM)

The use of ensembles in variational assimilation

Atmospheric data assimilation requires the ability to use observations that are only indirectly related to the model-state variables, the use of information from the changes over time at a given location and including both the large and small scale influences at every location within the domain. Variational assimilation has been very successful at most of these and has underpinned much of the recent improvement in numerical weather prediction. However, traditional variational systems still have their limitations. One of the ways to address this is to make better use of information from ensemble systems for a number of purposes, such as:

- Estimation of the background error variance
- Estimation of the background error co-variance
  of complex perturbation and adjoint models

This talk will discuss why this is necessary and how successful the various approaches have been