Bluelink – an integrator of the Integrated Marine Observing System

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***Abstract*- The intrinsic length- and time-scales of variability in the ocean are too small and short, respectively, for it to be possible to observe the ocean in any truly comprehensive sense. This paper describes the approach being taken by the Bluelink project to combine the strengths of various *in-situ* observing arrays, various types of satellite data, and various types of ocean models, to produce our closest approximation to a truly integrated observing system.**

I. BACKGROUND

The physical properties of the ocean – its temperature, salinity, velocity and pressure vary significantly over distances that are too small, and time intervals too short, for today's observing systems to adequately sample. A range of observing techniques exists for all variables but even in concert, these cannot be claimed to fully sample the variability that exists in the ocean.

The situation is constantly improving, however, and today's ocean observing system is far more complete than it was in the early 20th century, when coastal sea level and ship-based observations provided most of the instrumental record. Significant milestones include the advent of eXpendable BathyThermographs (XBTs) in the 1970s, the Tropical Ocean Global Atmosphere (TOGA) mooring array and satellite observations of the sea surface temperature (SST) in the 1980's, the World Ocean Circulation Experiment (WOCE) in the 1990's and the Argo array of autonomous profiling floats from 2002 to the present. Many of the observing systems developed for WOCE have been continuously renewed, including the satellite altimeters that measure sea level, frequently-sampled lines of full-depth hydrography and satellite-tracked surface drifting buoys.

The systems described above are all focussed primarily on 'blue water' oceanography, and while it is still incomplete in many senses, the system is adequate for sampling much of the variability with length scales greater than about 100km: meso-scale eddies, boundary currents, El-Nino, etc.

Continental shelf waters are far less adequately sampled. It is in recognition of this that several countries, including Australia, have recently grown their coastal observing systems. Australia's Integrated Marine Observing System (IMOS) includes instrumentation of merchant vessels and deployment of moorings, gliders and coastal radars. IMOS will make orders-of-magnitude more observations than have been made previously in Australia, but it is still a very sparse array compared to one that fully samples all Australian coastal waters, or at least, satisfies users' demands for spatial and temporal sampling of the quantities of greatest interest.

The obvious solution to this under-sampling problem is to take the same approach that has been successfully taken with the atmosphere. The weather forecast that we are all very familiar with is generated by assimilating a diverse range of types of observations into a numerical model of the atmosphere. In some places, or at times, for some variables, the density of observations may be high enough to resolve processes that the model can not. For much of the globe, at least for some variables, however, a user's needs are more likely to be satisfied using the output of the atmospheric model than they could be by using the data that was supplied to the model. A good data-assimilating model is the ideal integrator of all the available information - aggregating and interpolating using model physics.

II. BLUELINK - GLOBAL

Bluelink is a partnership of three Australian government agencies (the Royal Australian Navy, the Bureau of Meteorology and the Commonwealth Scientific and Industrial Research Organisation - RAN, BoM and CSIRO respectively) to develop data-assimilating modelling systems for the ocean at a range of scales - global, regional, and littoral-zone.

The global model is run operationally in forecast mode by BoM, presently generating a one-week forecast twice a week [1]. The model has also been run in hindcast mode (for the period from 1992 to the present) a number of times by CSIRO as part of the model development cycle and as an end in itself [2, 3]. The model has spatial resolution of 10km horizontally and 10m vertically in the near-surface waters in the Australasian region. Outside this region and below 250m the resolution becomes gradually coarser but the model does span the entire globe (excluding the Arctic Ocean) to full depth.

A wide variety of data types (principally sea level and temperature from satellites, and *in situ* observations of temperature and salinity by Argo, XBTs, moorings and ships) are assimilated using a multivariate, ensemble optimal interpolation technique, whereby observations of any particular physical variable are projected onto all the model state variables, and not just at the location of the observation. A long (eg, 1992-2008) run of the model without any data assimilation provides an ensemble of intra-seasonal anomalies from which the inter-variable spatial covariance functions, needed for the mapping, are computed as required for the available observations.

The resulting homogeneous, four-dimensional datasets (both the forecasts and the hindcasts) are available on-line via OPeNDAP servers that allow the user to extract whatever subset of the entire dataset they require (see [4]). The salient features of snapshots of the model are the ubiquitous ocean eddies. The model's ability to simulate the boundary currents at the edge of the continental shelf is shown in Fig. 1.

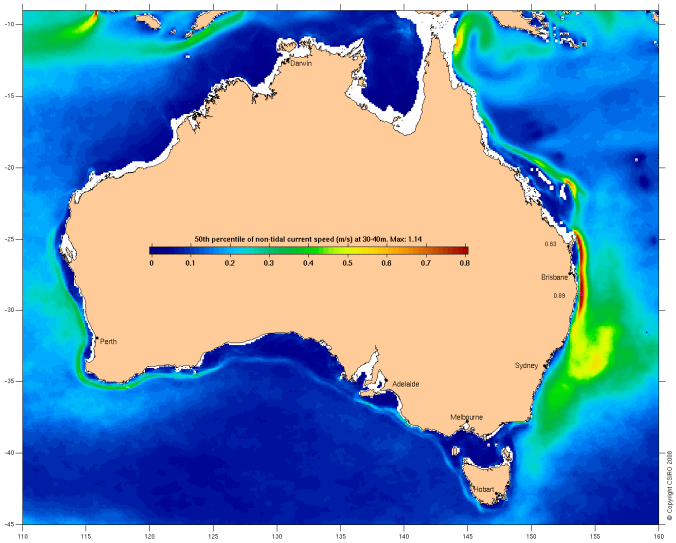

Fig.1 Median of the speed of the ocean currents at 30-40m depth as simulated by the Bluelink global ocean model.

III. BLUELINK - RELOCATABLE

The 10km resolution of the global model is not fine enough for resolving sub-mesoscale features of the flow, or for adequately representing the bathymetry in coastal regions. Another Bluelink system, the Relocatable Ocean Atmosphere Model, has also been developed with an emphasis on making it possible for a user to quickly initiate a run of a finer-resolution (eg 2km) model for an arbitrary model domain. The initial and boundary conditions are taken from the global systems. Tides are also included.

Assimilation of ocean observations into ROAM is also possible but it is presently at a less mature stage than for the global system. The goal is to be able to assimilate all the data that was available to the global system but possibly under-exploited, as well as additional data that was not available for assimilation to the global system. The potential for assimilation of IMOS data into ROAM will be discussed.

IV. APPLICATIONS

The Bluelink systems have been successfully used for several end-user applications. The role of the Bluelink models in the successful searches for the WWII ships HMAS *Sydney* (II) and AHS *Centaur* will be outlined in the presentation as example demonstrations of the model performance on the west and east coasts, respectively.

REFERENCES

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