Dynamics of Semi-Enclosed and Coastal Seas: Numerical Models and Altimetry

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LONG-TERM GOAL

Our long-term goal is to establish and utilize comprehensive, data-assimilative numerical models of semi-enclosed, marginal, and coastal seas of naval interest, in order to obtain a better understanding of the prevailing processes, and to assist in the establishment of a reliable nowcast/forecast capability in these regions at NAVOCEANO. This necessarily requires research into issues related to precision altimetry and its application to naval problems.

OBJECTIVES

Our primary objective is the development of comprehensive ocean circulation models assimilating altimetric, IR (MCSST) and other remotely-sensed (and when feasible in-situ) data. Such data-assimilative models can then be used to study the prevailing processes (through accurate hindcasts) and also to establish predictive (nowcast/forecast) capability of potential use to naval operations. Altimetric data are indispensable to any realistic hindcast/nowcast/forecast capability.

APPROACH

Not unlike the practice in atmospheric research, a better understanding of the circulation, the air-sea exchange, and the prevailing dynamical, physical and biological processes, is best obtained from a suitable combination of dynamics and data. Data assimilation into comprehensive ocean models (coupled and uncoupled) is a key to this. This approach enables realistic estimates of the oceanic state to be made via accurate hindcast/nowcast and short-term forecasts.

Since dynamical factors often overwhelm others in issues related to primary biological productivity and air-sea exchange, it is prudent to get the underlying circulation and its variability right, before attempting to model aspects such as the onset and demise of the spring and fall blooms in regional seas. One promising approach is a data-assimilative dynamical model coupled to a primary productivity model. This is the approach we are taking for the Sea of Japan studies. The availability of NASA SeaWIFS ocean color data is a great aid in calibrating/validating such a coupled model.

For better utilization of precision altimetry (such as the ongoing NASA/CNES TOPEX/Poseidon (T/P) and the upcoming Jason1, and hopefully the US Navy GFO, when it finally starts working) in naval applications, it is imperative that oceanic tides be estimated as accurately as possible. The current NASA-funded global tide models including our own have attained an accuracy of 2-3 cm in deep water regions. However, with Jason1mission objectives in mind, the current push is towards 1 cm accuracy. Also, the NASA models have much larger errors when applied to shallow water areas of interest to the US Navy. Since NASA is not necessarily interested in the littoral, it is up to us, the Navy

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PIs, to come up with a global tidal model uniformly valid in both shallow and deep waters, for use in next generation precision altimetric applications.

WORK COMPLETED

We have assisted and supervised a NASA Fellowship doctoral student Craig Tierney in establishing a near-global tidal model with unprecedented accuracy in shallow water regions of the world (Tierney et al. 1999).

The 1997-98 ENSO event gained much public attention, but most of this was focused on the tropical Pacific. At the same time, the North Indian Ocean (NIO) was undergoing unprecedented warming, the largest observed this century. Like the 1982-83 ENSO,this event caught ceanographers by surprise and there were hardly any in-situ instruments to monitor these anomalous events. Fortunately, the availability of T/P data enables one to hindcast this event. We assisted and supervised another NASA Fellowship student Joseph Lopez in hindcasting this event. The model used has high vertical resolution (38 vertical levels) and $1/2^{o}$ horizontal resolution, and good mixed layer physics, and well-suited to hindcasts and real-time nowcasts of the state of the NIO. It has also been coupled to NOAA ETL/NCAR MM5 regional atmospheric model for monsoon-related studies.

The work on coupling the Sea of Japan dynamical model to a simple 5-box primary productivity model is ongoing. When ready, it will be used to study the onset and progression of the spring bloom in the Sea of Japan (Kantha and Suk 1997). We have been collaborating for years with the South Korean investigators from Korea Research and Development Institute (KORDI) and Seoul National University (SNU) on many aspects of research on Korean Seas including the Sea of Japan (East Sea).

RESULTS

The CU global tidal model has been used to perform studies on tidal modulation of the Earth's rotation, but more importantly, it is now available to NAVOCEANO for use in providing more accurate boundary conditions to their relocatable regional tidal model (http://www-ccar.colorado.edu/~tierney has more details). A paper on baroclinic tides was published in the David Cartwright anniversary issue (Kantha and Tierney 1997) and a review paper on ocean tides (Kantha 1998) will be out in November.

The NIO results can be seen on the North Indian Ocean real time nowcast website - http://www-ccar.colorado.edu/~kantha/nio/nio.html . The model does a good job of depicting the three-dimensional state of the NIO during this anomalous period.

The biological primary productivity model has been tested in 1-D mode, and is now being coupled to the Sea of Japan dynamical model.

IMPACT/APPLICATION

A global tide model accurate in both shallow and deep regions of the global oceans is of importance to naval applications in the littoral, and extension of precision altimetery into shallow waters.

The North Indian Ocean is not only of strategic importance to the US Navy, but its summertime monsoons are crucial to the welfare of nearly half the world population. A better understanding of the oceanic state during the southwest monsoons is therefore quite important.

A better understanding of the primary productivity and hence the optical clarity of Sea of Japan waters is important to naval operations in the region, especially around the subpolar front.

TRANSITIONS

The global tidal model is available for transition to NAVOCEANO.

RELATED PROJECTS

1. Our research on the Sea of Japan is a coordinated effort with the ONR Japan (East) Sea DRI.
2. We have also been working on coupling the NIO dynamical model to a biological primary productivity model under a related DoD AASERT program.
3. We have also been assisting NAVOCEANO in establishing a nowcast/forecast capability for western Pacific marginal seas using a nested model approach that depends on assimilation of altimetric and MCSST data. We continue to assist NAVOCEANO in relocatable tidal models, and real-time nowcast/forecast models of other semi-enclosed seas.
4. We have been collaborating with South Korean investigators on JES DRI and other programs.

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