

## **Nonhydrostatic and Hydrostatic Hindcasts and Simulations of Internal Wave Generation in Straits**

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### **LONG-TERM GOALS**

The purpose of this study is to understand the feasibility of forecasting the dynamics of the generation and life cycle of large amplitude internal waves and their impact on the larger scale flow. The forecasting system may include imbedded nonhydrostatic models, subgrid scale models or subgrid scale parameterizations in hydrostatic models. The scope of the dynamics and the resolution which can be included in a forecast system will be explored.

This work will provide the understanding needed to build an operational system to predict the timing, location and intensity of NLIWs as required for tactical planning.

### **OBJECTIVES**

- To investigate the generation, development, propagation and interaction of IWs and NLIWs in straits using nonhydrostatic and hydrostatic models.
- To hindcast these NLIWs using high resolution nonhydrostatic and hydrostatic numerical models with realistic ocean topography and surface forcing and using open boundary conditions provided by the large scale ocean model.

### **APPROACH**

Simulations and hindcasts have been conducted on massively parallel HPC machines. We are developing a system of nested hydrostatic and nonhydrostatic model domains that allows us to achieve the necessary resolution with the correct physics to hindcast submesoscale processes. The system efficiently utilizes data from the NCOM and COAMPS models as forcing and initial conditions for the MITgcm model. The system also allows us to multiply nest the MITgcm model to achieve high resolution hindcasts. We have the capability and the infrastructure to conduct large scale, high resolution numerical experiments on high performance, massively parallel computers.

### **WORK COMPLETED**

Implemented, Tested and Published NEW Open Boundary Conditions for nesting a Nonhydrostatic model in a Hydrostatic model.

# Report Documentation Page

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- Formulated a combined open boundary condition consisting of
  - A Transport Correction Scheme (TCS) for incoming fluxes to conserve volume
  - A Flow Relaxation Scheme (FRS) to match outgoing and incoming fluxes
- Developed and tested methods using hindcasts of the DongSha Plateau in the South China Sea and the Mindoro straits ([Gallacher et al. 2011](#))
- See results, animations, model/data comparison time series and links to [Gallacher et al. 2011](#)) at the web page <http://www7330.nrlssc.navy.mil/7331/IWISE/>

Data is being archived from the NAVO NCOM RELO WPAC forecast model, which includes the SCS area, to hindcast the FY11 IWISE cruise.

We have moved the use of the MIT model into cutting edge research areas involving hindcasts using multiply nested nonhydrostatic domains forced with data from hydrostatic models e.g. ReLO NCOM forecasts and hindcasts and using DBDB2 and higher resolution bathymetries.

- *Nested* hindcasts were conducted in the northern South China Sea using the NRL-MIT model. Hindcasts were conducted in a *hydrostatic* NRL-MIT mesoscale domain at 2 km resolution. This was forced by global NCOM and OSU tides. Data from this domain was used to force a 500m resolution *nonhydrostatic* NRL-MIT submesoscale domain.

## RESULTS

Results from hindcasts compared favorably with buoy measurements (see web page) and remote sensing.

Large discrepancies at the boundaries between the exterior and interior domains are caused by differences in physics (nonhydrostatic versus hydrostatic) and differences in resolution. These differences can cause unrealistic interior solutions with incorrect long term trends, and spurious reflections and perimeter currents at the boundaries.

We have extended and improved two open boundary condition methods which together correct these problems and we have implemented them in the MIT model. This significantly expands the boundary conditions in the MIT model. A paper has been published Ocean Modelling detailing the improved BCs (Gallacher et al., 2011).

## IMPACT/APPLICATIONS

This work will help to determine the importance of and the requirements for nonhydrostatic forecast systems for naval applications. The scales and features which will require nonhydrostatic simulation are being assessed.

## RELATED PROJECTS

The NRL project Autonomous Characterization of Environmentally Induced Non-Acoustic Noise and the Adaptation of Multi-Sensor USW Networks. (6.2, Undersea Warfare) is related to this project because it involves nonhydrostatic modeling of the SW06 experimental area and time and comparison

with measurements taken during SW06. Components of SW06 are funded through the ONR NLIWI DRI.

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Nonhydrostatic Modeling of Nonlinear Internal Waves and Turbulence

## **PUBLICATIONS**

Gallacher, P. C., D. A. Hebert, M. R. Schaferkötter, Nesting a Nonhydrostatic Model in a Hydrostatic Model: The Boundary Interface , *Ocean Modelling*, **40**, 2, 190-198, 2011.