FINITE ELEMENT MODELING OF COASTAL CIRCULATION

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LONG-TERM GOALS

To develop finite element procedures for nearshore and shelf-scale operations using unstructured grids which can be adapted in a real-time data assimilative manner. Initial application is to the the Yellow Sea, with technology transfer from parallel effort in the Gulf of Maine.

OBJECTIVES

- Develop a realistic circulation model for the Yellow Sea. Processes must include tides and tidal rectification, wind, remote forcing, and baroclinicity.
- Develop a climatological circulation for the Yellow Sea.
- Develop data-assimilative methods for shipboard limited-area nowcasting using the above results as prior estimates.

APPROACH

The work is carried out in collaboration with Dr. Cheryl Ann Blain of NRL. The climatological circulation is computed as in the forerunner Gulf of Maine project. There is a progression from simple diagnostic models to full-physics prognostic models. All calculations are fully 3D.

New software and analytical approaches are tested first in the Gulf of Maine context, where the phenomena are well understood and data is relatively abundant. Beta versions of software are distributed within the Quoddy Users' Group for testing and refinement. Mature models and data products are transferred to NRL.

WORK COMPLETED

A procedure for inversion of shipboard ADCP data was developed and perfected. The software is compatible with the forward simulation models FUNDY (diagnostic) and QUODDY (prognostic).

Observational System Simulation Experiments were performed to evaluate errors incurred in using standard CTD surveys as initial conditions for a limited-area simulation.

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Radiation Boundary Condition previously designed for 2-D FE models was implemented in the operational 3-D model.

Tidal model of the Yellow Sea, initiated in year 1, was completed and results posted on the World Wide Web (see URL in references). Preliminary results employing seasonal winds were also posted.

Climatological data base for the Yellow Sea was acquired from Dr. Cheryl Ann Blain and is being prepared for input to simulations of the climatological mean circulation. There are six bimonthly realizations covering the calendar year.

RESULTS

We are able to produce circulation hindcasts on limited-area area meshes. The procedure presumes a prior estimate for the circulation (e.g. climatology). We use CTD data to describe the hydrographic anomoly relative to climatology. This data is assimilated as Initial Conditions via optimal estimation. ADCP data are then compared with simulations forced with real winds and IC's, and the hindcast error inverted to discover the missing boundary conditions.

Observational System Simulation Experiments reveal some operational rules for the CTD interpretation (Lynch and Naimie 97). The inversion procedure is illustrated in figures 1, 2, and 3 for a typical GLOBEC cruise to Georges Bank (Lynch et al 97).

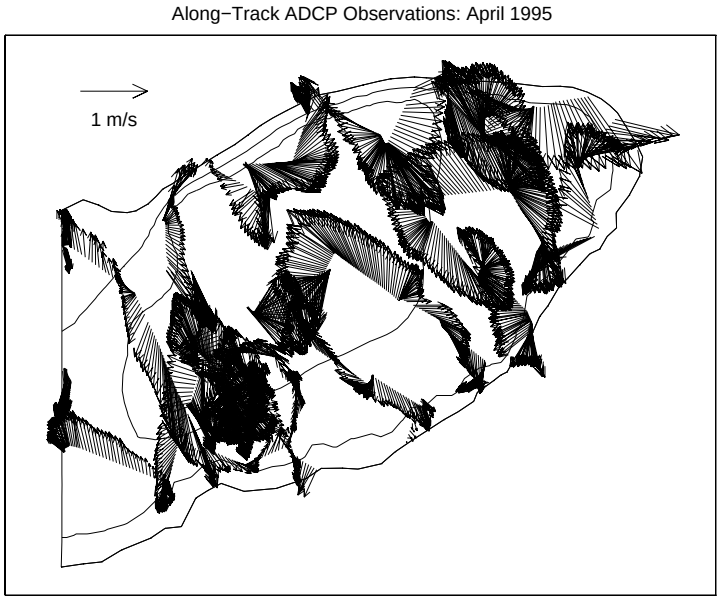

Figure 1: Along-track vertically averaged ADCP observations for EN265.

The Yellow Sea results to date are available on the WWW (Naimie 97). Figure 4 illustrates a representative calculation of the tidally-rectified current.

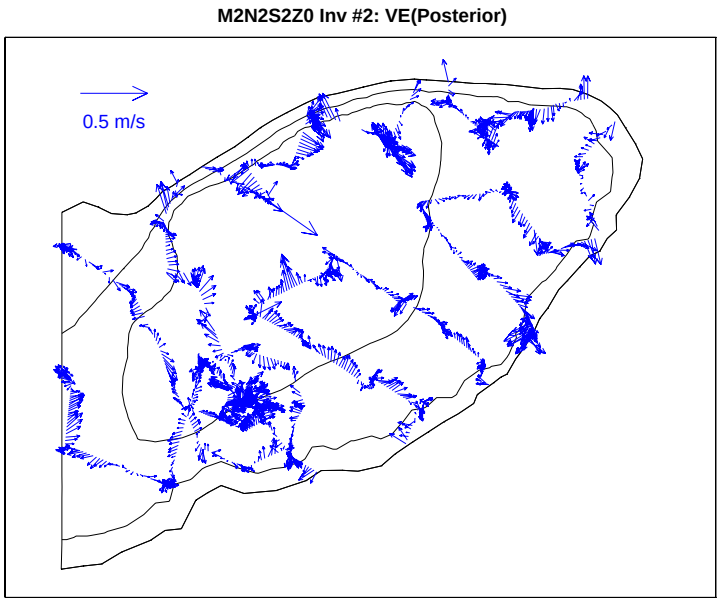

Figure 2: Posterior along-track error after second iteration with {Z0, M2, S2, N2}.

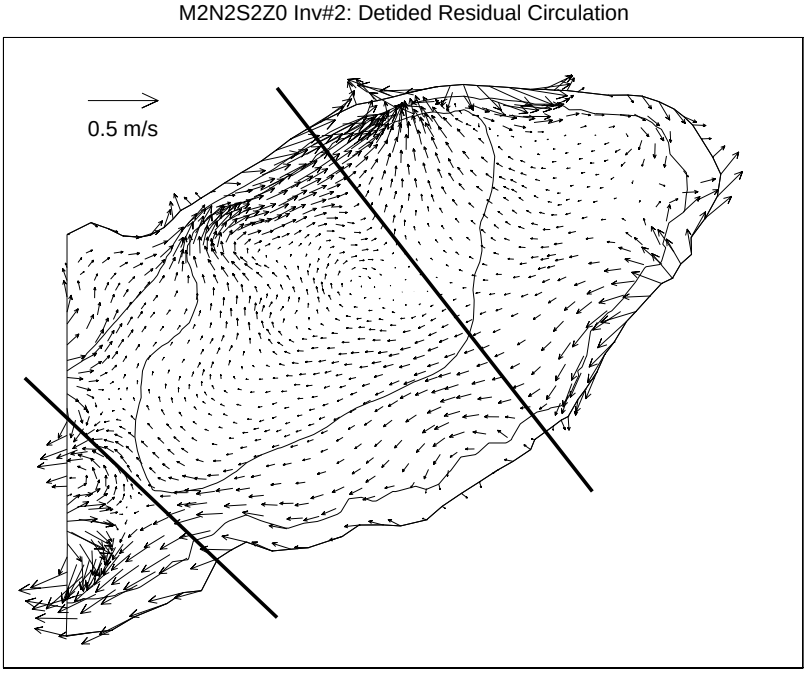

Figure 3: Posterior estimate of Eulerian average velocity: second iteration, {Z0, M2, S2, N2}. The bold lines demark the three zones discussed in the text: the southwest corner where the hindcast is indeterminate; the western portion where the climatology is largely preserved; and the eastern portion where the climatology is fundamentally rearranged.

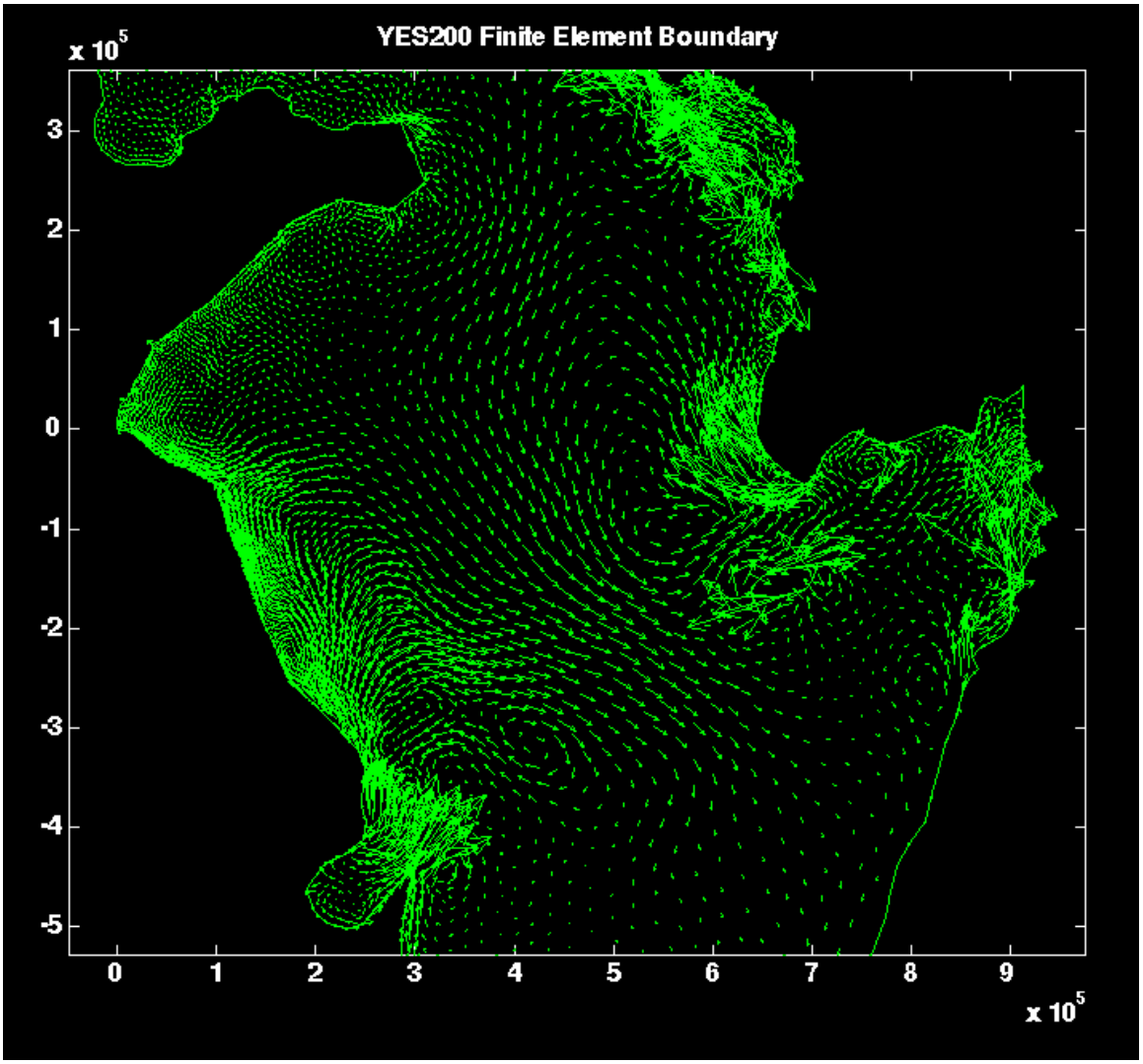

Figure 4: Tidally-rectified currents as computed with the nonlinear 3D QUODDY finite-element model.

IMPACT/APPLICATIONS

The combination of the climatology being developed and the hincasting tools should make a demonstration of ship-based near-real-time nowcasting possible in the near future.

TRANSITIONS

Dr. Cheryl Ann Blain is an active participant on this project. All software developed is available to her and other Navy personnel. The Quoddy Users Group is the vehicle for technical discussions and trial of the software in other applications, ensuring a robust conceptual development and software design.

All methodological advances are prepared for publication in peer-reviewed media.

RELATED PROJECTS

USGLOBEC (NOAA/NSF): Georges Bank has been the training ground for most of the software development prior to this project. This application is still active and due to the large amount of data for this system, it remains a prime target for initial testing of nearly all project ideas.

REFERENCES

Lynch and Naimie 97: "Hydrographic Data Assimilation on Geores Bank", D.R. Lynch and C.E. Naimie. Proc. ASCE Conf on Estuarine and Coastal Modeling, Alexandria, 1997 (in review).

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Naimie 97: http://www-nml.dartouth.edu/ñaimie/YellowSea/visualize/yellow_sea.html