A National Oceanographic Partnership Program Award

Planning for a National Community Sediment Transport Model

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Long-term goals

The long-term goal of our research is to improve our understanding and ability to predict the transport, transformation, and fate of sediment and particle-bound nutrients and contaminants. The specific goal of the community modeling effort is to produce advanced numerical models of coastal sediment transport that are scientifically sound, expertly coded, well tested, and suitable for use in both research and practical applications. This effort will also produce model infrastructure, including a system for managing model development, testing, documentation, and distribution; development of model test cases; development and distribution of modeling tools (pre- and post-processing software, for example); and a forum for exchange of scientific and technical information related to coastal sediment transport modeling.

Objectives

The objective of this NOPP-funded project has been to plan the development and maintenance of a national Community Sediment Transport Model (CSTM), to be supported (in part) as a modeling "node" under NOPP. We have been funded to continue and broaden the on-going discussion on building a CSTM model, to identify partnerships in sediment transport modeling, to establish a structure for evaluation of sediment transport models, and to evaluate new and existing models.

Approach and work plan

Our ability to predict the transport and long-term fate of particles in the ocean is essential in addressing a variety of issues related to commerce, defense, and the quality of the marine environment. For example, remediation of contaminated sediments, siting of sewage outfalls, evaluation of past and future disposal sites, burial of mines or archaeological artifacts, transport and fate of biological particles, and evaluation of the impacts of coastal development all require an understanding of the transport and fate of sediment under varying hydrodynamic, physical, and biological conditions. Numerical models can provide a framework within which to synthesize our understanding of sediment transport processes in complex systems. They are also useful as a test bed for emerging sediment-transport algorithms, and to provide realistic settings for biological and geochemical models. To fully realize the power of numerical modeling in

coastal environments, sediment transport models need to be linked directly to hydrodynamic circulation models. Although researchers from academia and private industry are actively pursuing this goal, there is no community sediment transport model for the coastal oceanographic environment. Developing a publicly available, well-tested, and widely accepted model would greatly benefit the ocean research and management communities and the nation.

Community models are freely available computer codes that often include contributions from many researchers and, ideally, are widely tested and applied. Models such ModFLOW, MM5, CCM, and POM have been instrumental in advancing groundwater hydrology, regional meteorology, climate modeling, and physical oceanography, respectively. The value of community-developed models has become widely recognized, as evidenced by the increasing number of community-modeling efforts in their formative stages. Some of these are in closely related fields, such as stratigraphic simulation (Geological Society of America, 2000), and nearshore sediment transport (see Kirby, 1999).

The ideal modeling system would implement peer-reviewed, process-based algorithms for circulation, sediment transport, and processes related to pollution, diagenesis, eutrophication, and turbidity. The models should be modern, well documented, practical to modify or expand, and suitable for advanced computers. They should also be in the public domain and actively supported by an institution or user group. Our vision is to develop such models through a collaborative process involving scientists from government agencies, academic institutions, and industry. The models should be tested and refined by comparing it with select historical data sets and new, critical field measurements. The modeling system will then be available to address sediment-transport issues raised by a wide range of applied and fundamental scientific inquiries.

The creation of a viable CSTM will require several steps to foster, encourage, and sustain involvement by the wide community of sediment transport researchers and model users (Sherwood et al., 2000). The first stage is a modest planning and organizing effort to explore the range of needs and to bring together prospective participants. Based on the planning effort, the second stage will be a larger program where one (or more) CSTM(s) is (are) developed, each by a core group. The model(s) can then be applied and tested by other groups in a variety of case studies. Feedback and development will be rapid and efficient in this stage if there is an open exchange among a critical mass of researchers for continuous peer review, quality control, requirements design, and code development. At the end of this concerted effort, the CSTM will be in active use by many groups, academic, government and industry, with wide avenues of communication established. Finally, the third stage is the transition of the model to a sustainable home that would keep the model up to date, disseminate new versions and continue the discussions and occasional meetings which will maintain and nurture the CSTM over the long-term.

A successful community model will require significant basic research, substantial infrastructure support, well-designed validation experiments, and input from a broad community of specialists. NOPP is ideally suited to nurture this project.

Our approach for advancing this project has been to involve the community by conducting test cases with existing models and by providing diverse forums for exchange of ideas and planning. The specific tasks we proposed were as follows.

- Task 1. Establish a conceptual framework for sediment transport model development
- Task 2. Enhance and maintain community model web site
- Task 3. Sponsor special session and Town Meeting at AGU/ASLO Ocean Sciences Meeting
- Task 4. Host Planning Workshop to write NOPP proposal for FY2003

Key individuals in our research include partner investigators in industry, academia, and government. These are Alan F. Blumberg and Parmeshwar L. Shrestha (HydroQual, Inc.), John Hamrick (TetraTech, Inc.), Hernan Arango and Scott M. Glenn (Rutgers University), Courtney K. Harris (Virginia Institute of Marine Science; VIMS), Thomas F. Gross (NOAA, National Ocean Service), Bradford P. Butman (U.S. Geological Survey), and Richard P. Signell (NATO/SACLANTC). Important contributions to model development and testing were made by John C. Warner, a Mendenhall Post-Doctoral Fellow at the U.S. Geological Survey.

Work Completed

All four proposed tasks were successfully completed.

Task 1. We conducted discussions about the needs and best approaches for sediment-transport modeling among the lead and partnering investigators. We convened a meeting at Rutgers University, formulated model test cases, and defined the scope of our modeling efforts this year. One of the products of the project is a draft white paper describing the rational and framework for a community modeling project. Investigators exercised candidate models with test cases.

Task 2. We established a project web site (http://woodshole.er.usgs.gov/project-pages/sediment-transport) that provides background information, test cases with results for some models, and links to source code and related sites.

Task 3. We convened a special session at the AGU/ASLO Ocean Sciences 2002 meeting that featured 40 scientific presentations on “Application and assessment of coastal sediment transport models”. We also hosted an open Town Meeting at Ocean Sciences (see the meeting report at http://woodshole.er.usgs.gov/project-pages/sediment-transport/Town_Meeting.htm).

Task 4. We hosted a workshop in Williamsburg, Virginia to discuss the future of community coastal sediment transport modeling. The three-day meeting was attended by about 50 scientists and engineers from academia, government agencies, and private consulting firms. Results of the workshop were reported in *Eos* (Sherwood et al., 2002). Significant progress was made in defining the need for a community model and in defining the scientific and technical requirements for such a program. Less progress was made in determining how to select specific models or how to manage a community modeling project. The workshop did not develop a NOPP proposal because NOPP had not yet announced funding opportunities for a coastal community modeling project.

In addition to completing the proposed tasks, we have exchanged communication with related projects. Dr. Harris gave an invited presentation at the NSF Margins Source-to-Sink Community

Sediment Modeling Workshop, held in Boulder in February, 2002, titled "NOPP / USGS Coastal Community Sediment-Transport Model". Dr. Sherwood presented status reports at the NOPP Nearshore Annual meeting in Delaware, at WL | Delft Hydraulics Laboratory in The Netherlands in March, at a meeting of the Chesapeake Bay Research Consortium in Annapolis in June, and at HR Wallingford, UK, in October, 2002.

Results

Significant advances in the availability of coastal sediment transport models have occurred during the last two years. As a direct result of this project, algorithms for sediment transport and advanced turbulence models have been implemented in ROMS/TOMS and made available to the community (Fig. 1; Warner et al., 2003), and HydroQual, Inc. has made the source code for Ecomsed public (http://www.hydroqual.com/Hydro/ecomsed/index.htm). Test cases and results have been developed for use by others, and the project has facilitated useful discussions among the modeling community.

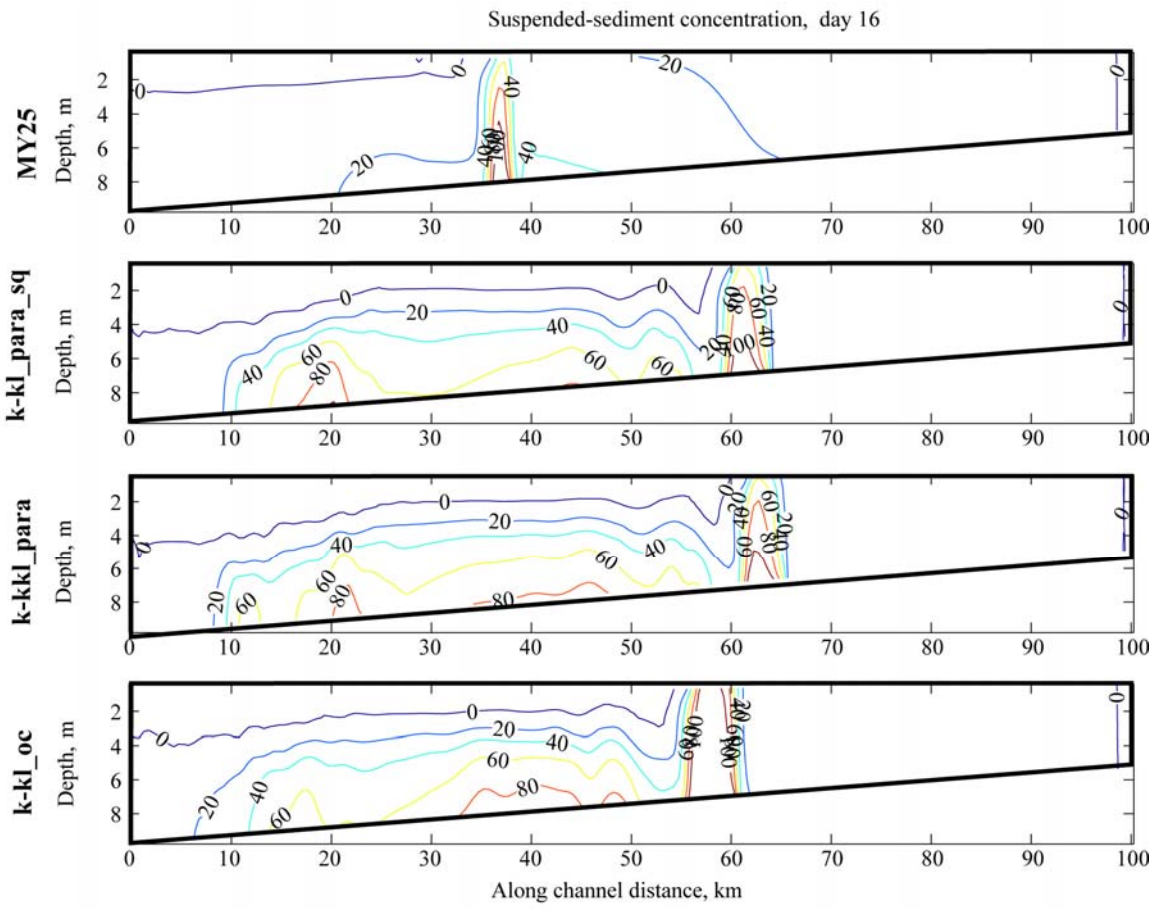

Figure 1. Snapshots of simulated suspended sediment concentration (units of mg/l) at maximum ebb tide from estuary test case simulations with the four turbulence models. The four panels show cross sections of suspended sediment concentrations computed for an idealized estuary. The locus of maximum concentrations varies significantly among the four cases. (See Warner et al., 2003, for details).

This project has heightened community awareness of the advantages of open-source models, and has shifted the standards in modeling excellence towards requiring open source code. Whether this project results in a major NOPP program or not, it has helped to advance numerical modeling of coastal sediment transport by producing a valuable exchange of ideas and stimulating exposure of model source code.

Impact and Applications

National Security

A robust numerical model for transport of contaminants in coastal waters has a role in planning for and responding to threats to coastal populations, resources, and infrastructure. In addition, models that predict oceanographic conditions, including turbidity and bottom stratigraphy, may become useful tactical assets. Community models may be used directly for these purposes, or algorithms developed in the context of community models may be adopted by developers of models used for national security.

Economic Development

Maintenance of navigable waterways is critical to maritime commerce, and numerical models of coastal sediment transport are important tools in planning navigation projects and assessing or mitigating costs associated with development of ports and other coastal commercial facilities.

Quality of Life

Coastal sediment transport models are essential tools for understanding controls on ecosystem health and guiding decisions in coastal resource management. One of the primary benefits of a CSTM is that it can place powerful and well-tested models into the hands of resource managers. The availability of Ecomsed and ROMS/TOMS has already affected research plans in several coastal communities.

Science Education and Communication

Eventually, a user-friendly version of community models will provide science educators and communicators with a tool for demonstrating regional coastal sediment-transport processes.

Transitions

Quality of Life

The USGS has begun to use ROMS/TOMS in research projects related to coastal marine resources, and a widening community of researchers is using open-source models for research on coastal resources.

Consideration for Excellence in Partnering Award

Ocean Sector Diversity: Our partners included industry (consulting firms HydroQual, Inc., and TetraTech, Inc), government agencies (U.S. Geological Survey, NOAA/National Ocean Service), international organizations (NATO/SACTLANC), and academic research institutions, including Rutgers University, Virginia Institute of Marine Science (VIMS), and Woods Hole Oceanographic Institution (WHOI).

Partner Involvement: Effort was widely distributed among the partners. The USGS provided administrative support and hosted the web site. Significant model development was conducted at the USGS and Rutgers, but major contributions of model code and model tests were performed by HydroQual and TetraTech. Researchers at NATO, NOAA, WHOI and VIMS made significant contributions to testing the models in research contexts and played key roles in communicating with the scientific community and leading the public meetings.

Matching Contributions: Significant matches (primarily salary contributions approximately equal to the funding received from NOPP) were provided by the USGS and HydroQual.

Partner Long-Term Commitment: The USGS has committed to a long-term program to support community sediment transport models, in keeping with past examples in other hydrologic and geologic disciplines. This included support of the project at an agency level and support for research, development, and infrastructure support with the Coastal and Marine Geology program. TetraTech plans to continue development and testing of EFDC and hopes to release it publicly in FY2003 or 2004. HydroQual has displayed a long-term commitment to community modeling by placing code for Ecomsed on the Internet and arranging special courses in use of the model. Rutgers University continues to develop advanced ocean models (ROMS/TOMS), and WHOI and VIMS researchers a productive record of research model advancement and application, and will continue those activities.

Success in Project Objectives: The project was very successful in elevating the issue of open-source code for coastal ocean and sediment-transport models, and providing intellectual inertia for community modeling. The proposed tasks were successfully completed, and we expect that the project will continue even if NOPP support is delayed.

Related projects

Related projects include the Nearshore NOPP project (Kirby, 1999; http://chinacat.coastal.udel.edu/~kirby/NOPP/) and the developing NSF Community Sediment Modeling System initiative (Slingerland et al., 2002; http://instaar.colorado.edu/deltaforce/workshop/csm.html). Both of these projects involve process-based sediment transport models in different domains. Also related is the ONR EuroSTRATAFORM project, where results using several coastal sediment-transport models will be compared.

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