Researchers Test and Refine Storm-Surge Models

Thanks to the recent upsurge in Atlantic Basin hurricane activity, thousands of property owners along the U.S. East and Gulf coasts have become all too familiar with the term “storm surge.”

VIMS researchers Harry Wang and Jian Shen have just completed the first phase of a collaborative project whose ultimate goal is to help coastal residents and emergency managers better prepare for future storm-surge flooding. Their help comes in the form of computer models that can predict surge levels more accurately.

Wang, Shen, and other members of VIMS’ Estuarine and Coastal Modeling Group were joined in the effort by researchers with the International Hurricane Research Center at Florida International University (FIU).

“Our goal,” says Wang, “was to compare the performance of new and existing storm-surge models to determine which ones have the greatest potential for further development.”

The group tested the National Hurricane Center’s current surge model (called SLOSH for Sea, Lake and Overland Surges from Hurricanes) and several newer models to gauge their strengths and weaknesses. The tests measured the resolution, computing efficiency, and accuracy of each model using hurricanes Andrew, Betsy, Camille, Hugo, and Isabel.

The SLOSH model was originally developed by the National Weather Service more than 20 years ago. Emergency managers use SLOSH to determine which areas must be evacuated for storm surge. SLOSH, together with improved track forecasting, communications, and evacuation routes, has significantly reduced the number of hurricane-related fatalities in the U.S. However, the model’s limitations lead to large uncertainty in its flood predictions.

Newer models, including the high-resolution UnTRIM (Unstructured Tidal Residual Inter-Tidal Mudflat)

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Storm-Surge Models

The newer models also use grid systems that are much more flexible, allowing a closer fit to the convoluted shoreline of an estuary like Chesapeake Bay.

“UnTRIM’s unstructured grid gives us the ability to fit the model grid to the shoreline and resolve the tributaries,” says Shen. “It can accommodate complicated geometry,” adds Wang. UnTRIM’s greater resolution and flexibility allows it to create a virtual Bay made up of 239,541 cells of varying shape.

In simulations using data from Hurricane Isabel, the UnTRIM model’s surge predictions closely matched realtime water-level measurements from various sites in the Bay, including Gloucester Point in the York River and Sewells Point in the James River. “The Isabel simulation captured both the evolution of the surge and its peak distribution,” notes Shen. “It clearly demonstrates the effectiveness of the unstructured-grid model for simulating storm surge.”

Storm-surge models are also benefiting from advances in coastal mapping. Shen and Wang’s collaborators at FIU are leaders in the application of a new airborne mapping technology called LIDAR, for Light Detection And Ranging. Whereas existing coastal maps show topography in intervals of 5 to 10 feet, LIDAR data are routinely accurate to 6 inches.

Incorporating highly detailed LIDAR data within a storm-surge model promises forecasts of unprecedented accuracy. That’s particularly important in flat-lying coastal plains, where even small discrepancies between mapped and actual elevations can result in surge-prediction errors that trigger massive over-evacuations, at an estimated cost of $1 million per mile.

Data from a new generation of ocean-observing systems, like the one being developed at VIMS (see Spring 2004 issue of the CREST), also promise to improve model accuracy. Modelers can use these data both to improve real-time forecasts and to validate and refine their models. “We simply can’t do high-quality modeling without ocean-observing systems,” says Wang. “The accuracy of coastal-flooding predictions is directly related to the accuracy of the model, and that depends greatly on good observational data.”

But the modelers’ greatest challenge, notes Shen, is to bridge the gap between the large-scale wind forces that drive the hurricane at sea, and the small-scale features that control the surge level in any particular spot.

“Hurricanes come from the ocean, but the critical area for surge modeling is the coast and estuary,” says Wang. To perform best, “[the model] needs to simultaneously cover the large area where the storm roams and the details of the local region where people live.”

A related challenge is to better incorporate the atmospheric parameters that drive the hurricane and its surge. This is partly an issue of conflicting data standards that reflects the traditional separation between oceanographers and atmospheric scientists. “We need an ‘industry standard’ for data so we can communicate more freely,” says Wang. Atmospheric data parameters include a hurricane’s winds, central pressure, size, forward speed, and track direction.

Funding for the just-completed model inter-comparison study came from the Federal Emergency Management Agency through a grant to FIU. Wang and Shen are now continuing their efforts with funding from the Navy and NOAA, through a grant from SCOOP (the Southeastern University Research Association, Coastal Observation and Operational Prediction Program).

“The inter-comparison study gave us a new direction for our own modeling research,” says Shen. “We’re excited about the possibilities.”

For more information on the model inter-comparison project, visit http://www.ihrc.fiu.edu/lcr/research/windstorm_simulation/index.htm

VIMS Governor’s School

VIMS, in cooperation with Christopher Newport University, hosted a group of high school students this past summer as part of the Virginia Governor’s School program. The five-week residential program has provided high-achieving Virginia high school students with marine research experiences for 14 years. The program is structured as an apprenticeship in which each student works with a faculty sponsor on an authentic VIMS research project. From L, Molly Turner (West Potomac HS, Alexandria), Residential Assistant Jennifer Scott (Potomac HS, Dumfries, VA), Jenny Geldermann (Chantilly HS, Chantilly), Ian Keene-Babcock (Glencar HS, Salem), and David Gibbs (H-B Woodlawn Alternative Program, Arlington).

Ms. Tumer worked with VIMS graduate student Jill Pelouquin to identify and quantify phytoplankton from the Ross Sea, Antarctica. Ms. Geldermann worked with Dr. Rom Lipcius to examine the role of the blue crab as a keystone predator in salt marshes of Chesapeake Bay. Mr. Keene-Babcock helped Dr. Rochelle Seitz to determine relative survival rates of juvenile blue crabs in habitats with varying predator and prey levels. Mr. Gibbs helped graduate student Todd Gedanke determine the rate of growth of bamboofish via analysis of dissected vertebrae.

VIMS By the Numbers.....

- 436 Active research awards at VIMS during fiscal year 2004
- $54,237,007 Dollar amount of those awards
- 84.2 Percent of VIMS grant awards during fiscal year 2004 that came from federal sources
- 8.7 Percent of VIMS grant awards during fiscal year 2004 that came from private sources
- 7.1 Percent of VIMS grant awards during fiscal year 2004 that came from state sources
- 68 Percent of VIMS grant proposals submitted during fiscal year 2004 that were successfully funded
- 11.9 to 1 Ratio of federal to state grant funding at VIMS in 2004
- 11,540 Number of hatchery-reared juvenile blue crabs released into the York River by VIMS researchers in June (see p. 3)
- $1,000,000 Estimate of dead croaker on the Maryland and Delaware portion of the Eastern Shore during the July 31 weekend (see p. 1)
- $3,400 Dollars raised to fight cancer by VIMS’ Relay for Life team, the Sharks
- 2 Number of intact 1830s wine bottles excavated during archeological work at the site of VIMS new seawater lab, along with white earthenware, tailor’s straight pins, and an English-made clay pipe