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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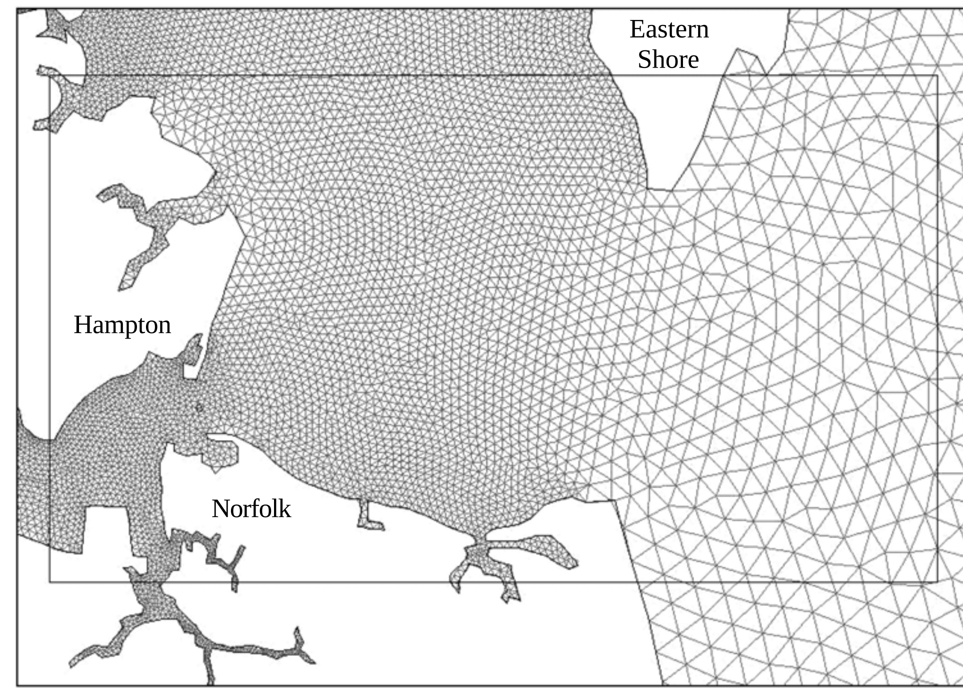

The UnTRIM model's high-resolution, unstructured grid can closely approximate the convoluted shoreline of Chesapeake Bay and its tributaries.

The Crest

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to breed and plant disease-resistant strains of the native oyster *Crassostrea virginica*, and to monitor industry trials of the non-native oyster *C. ariakensis*.

"These efforts are important to overall Bay oyster-restoration activities," notes Jasinski. "Our new presence here will help us develop stronger partnerships and work more strategically with key players in Maryland and Virginia."

NCBO funding also supports ChesMMAP (the Chesapeake Bay Multispecies Monitoring and Assessment Program) and FEMAP (the Fishery Ecosystem Monitoring and Assessment Program), two VIMS programs aimed at providing resource managers with data and tools to assess and manage Chesapeake Bay's fisheries in a sustainable, ecosystem-based manner.

VIMS researchers also rely on NCBO funding to help study and restore Bay grasses, advise shoreline management agencies, develop the next generation of coastal observing systems, and study invasive species.

Jasinksi notes that NOAA-funded projects often generate time-sensitive data and deliverables that federal and state managers need for decision-making. "Being on-the-ground in Virginia will allow us much greater collaboration and oversight on lower Bay projects," says Jasinski. "We'll be able to be much more responsive, both to grant recipients and to managers that need the data and tools."

"Instead of just a funding source, we'd like people to see us as a partner," adds Bahner. "We'd like to establish a cooperative research program so that NOAA and VIMS staff could work more closely together on research projects."

As an example of increased collaboration, Bahner cites a plan to deploy the NCBO vessel R/V *Bay Commitment* in parallel with VIMS' ChesMMAP vessel the R/V *Bay Eagle*. That would help tie the ChesMMAP fisheries data into the bathymetric and habitat data provided by the *Bay Commitment*'s high-tech sonar systems.

The Virginia Office currently comprises three staff members. Jasinski will serve as a liaison between VIMS, other Virginia agencies, and NOAA. Habitat Restoration Specialist Walter Priest, who is funded through the NOAA Restoration Center, will act as statewide liaison to NOAA's community-based restoration program and develop expertise in lower Bay restoration activities to complement staff in Annapolis. A Geographic Information System (GIS) Analyst will develop GIS and web-based management tools.

The final staffing level for the office is open. "Our goal is simply to get effective people to help in Virginia," says Bahner. He is currently working to encourage other NOAA offices to take advantage of the Virginia office by relocating or funding additional staff.

Ms. Jasinski's move to VIMS marks a return to her alma mater, where she earned a M.A. degree in 1992 with advisor Dr. Carl Hershner, studying the effect of sea-level rise on tidal wetlands in Gloucester County. "It's good to be back in Virginia and continue to work on Bay restoration," she says.

The move is also one that benefits the Chesapeake Bay Program (CBP). Ms. Jasinski's husband, Dave Jasinski, is an analyst for CBP and the University of Maryland. A recognized expert on Chesapeake Bay water-quality status and trends, Mr. Jasinski is also now located at VIMS. The relocation allows him to also work more closely with several VIMS scientists and engage them on water-quality issues.

NOAA's new Chesapeake Bay Office at VIMS, with a focus on research, complements NOAA's long-term relationship with Nauticus in Norfolk. The Nauticus office, headed by Jim Dixon and Michelle Fox, will continue to serve as NOAA's education and outreach center for the lower Bay.

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model tested by Wang and Shen, equaled or exceeded SLOSH's performance during the modeling tests. Moreover, says Shen, the newer models have much greater potential for further development.

A key to the newer models' potential is their much higher resolution. UnTRIM, for example, can perform its calculations within a framework of grid cells that are as small as 30 meters square. By comparison, the smallest cells in the SLOSH model (which was originally designed for relatively smooth coastlines) are on the order of 1 square kilometer.

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 to 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 real-time 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