Tides and Waves for the National Weather Service River Forecast System
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In addition to the previously reported work with regards to the St. Johns River, the University of Central Florida is cooperating with the Hydrology Laboratory of the NWS Office of Hydrologic Development and the LMRFC (Lower Mississippi River Forecast Center) to develop a two-dimensional storm tide model for the Pascagoula River. The major goals of this research are: 1) To include the Pascagoula River in a modification of an existing modeling domain that incorporates the entire East Coast of the United States, Gulf of Mexico and Caribbean Sea such that astronomic tides and storm surge can be accurately modeled. 2) To develop a shelf-based domain for the Pascagoula River that will produce results comparable to the large-scale domain from Goal 1. This research will result in a model that directly incorporates a full accounting of the hydraulic conditions for flood/river forecasting, especially with regards to flood forecasts and flood forecast mapping in the study area.

The hydrodynamic model employed for calculating tides and surges is ADCIRC-2DDI (ADvanced CIRCulation Model for Shelves, Coasts and Estuaries, Two-Dimensional Depth Integrated). The finite element based model solves the shallow water equations in their full nonlinear form. It can be forced with elevation boundary conditions, flux boundary conditions, and tidal potential terms, all of which result in the full simulation of astronomic tides. In addition, dynamic wind fields for a given hurricane or tropical storm event (e.g. Hurricane Katrina) are converted to spatially variable and time-independent wind surface stresses and incorporated into the ADCIRC-2DDI model along with atmospheric pressure variations to permit the simulation of a storm tide.

The overall work is comprised by the following four tasks: 1) Modification of an existing unstructured, finite element mesh for the WNAT (Western North Atlantic Tidal) model domain by adding the Pascagoula riverine systems to produce a basis model, such that astronomic tides and storm surge can be accurately modeled. 2) Development of a shelf-based model for the Pascagoula River that can produce results comparable to the large-scale domain from Task 1. 3) Verification of a coarse resolution WNAT model which can be employed to provide boundary conditions for the open water locations of a continental shelf-based model. 4) Improvement of the shelf-based model by investigating the influence of estuarine marshes, barrier islands and bottom drag coefficient assignment methodology. Such improvements will provide higher accuracy and more flexibility due to a more complete consideration of the physics.

At present, four tasks have been completed. 1) An inlet-based comprehensive mesh for inbank flow has been produced. 2) A sensitivity analysis based on the inlet-based model is performed to examine the contribution of the western inlet versus the eastern inlet of Pascagoula River. 3) A sensitivity analysis on advection is applied to investigate its influence on the flow velocity and water elevation within the domain. 4) The inlet-based mesh has been incorporated into an existing unstructured, finite element mesh for the WNAT (Western North Atlantic Tidal) model domain.

The following four conclusions are drawn from the work-to-date, which involved astronomic tidal simulations only: 1) The inlet-based model shows good agreement with the historical data. 2) The western inlet of Pascagoula River is more dominate than the eastern inlet; however, it is necessary to include both inlets in the model. 3) Advection plays a significant role in velocity simulation; however, water elevations are insensitive to advection. 4) From an astronomic tidal hydrodynamics point of view, the inlet-based model is not sensitive to the open ocean boundary; however, such performance is not expected during the storm surge simulation. A higher resolution mesh is required in order to accurately predict storm tides generated by hurricanes along the coastal areas.

The following journal publications/manuscripts, dissertations and thesis acknowledge NA04NWS4620013 as a direct result of research performed up to the end of this reporting period.

1. S.C. Hagen, A. Zundel and S. Kojima, "Automatic, Unstructured Mesh Generation for Tidal Calculations in a Large Domain," *International Journal of Computational Fluid Dynamics*, **20 (8)**, 593-608 (2006).
2. Salisbury, M.B. and S.C. Hagen, "The Effect of Tidal Inlets on Open Coast Storm Surge Hydrographs," *Coastal Engineering*, **54 (3)**, 377–391, (2007).
3. Dietsche, D., S.C. Hagen, and P. Bacopoulos, "Storm Surge Simulations for Hurricane Hugo (1989): On the Significance of Inundation Areas," *Journal of Waterways, Port, Coastal, and Ocean Engineering*, **133 (3)**, 183-191 (2007).
4. Parrish, D.M. and S.C. Hagen, "2D, unstructured mesh generation for oceanic and coastal tidal models from a localized truncation error analysis with complex derivatives," *International Journal of Computational Fluid Dynamics*, **21 (7&8)**, 277–296 (August 2007).
5. Funakoshi, Y., S.C. Hagen and P. Bacopoulos, "Coupling of Hydrodynamic and Wave Models: A Case Study for a Hurricane Floyd (1999) Hindcast," *Journal of Waterway, Port, Coastal, and Ocean Engineering*, Revised and resubmitted.
6. Parrish, D.M. and S.C. Hagen, "Incorporating spatially variable bottom stress and Coriolis force into 2D, a posteriori, unstructured mesh generation for nonlinear oceanic and coastal tidal models," *International Journal of Numerical Methods in Fluids*, In Revision.

7. Hagen, S.C., Bacopoulos, P., Funakoshi, Y., A.T. Cox, and V.J. Cardone, “The Role of Meteorological Forcing on the St. Johns River,” *Journal of Hydrometeorology*, In Preparation.
8. Kojima, S., “Optimization of an Unstructured Finite Element Mesh for Tide and Storm Surge Modeling Applications in the Western North Atlantic Ocean,” M.S. Thesis, Department of Civil and Environmental Engineering, University of Central Florida, Orlando (Summer 2005).
9. Salisbury, M.B., “The Effect of Tidal Inlets on Open Coast Storm Surge Hydrographs: A Case Study of Hurricane Ivan (2004),” M.S. Thesis, Department of Civil and Environmental Engineering, University of Central Florida, Orlando (Fall 2005).
10. Funakoshi, Y., “Coupling of Hydrodynamic and Wave Models for Storm Tide Simulations: A Case Study for Hurricane Floyd (1999),” Ph.D. Dissertation, Department of Civil and Environmental Engineering, University of Central Florida, Orlando (Fall 2006).
11. Parrish, D.M., “Target Element Sizes for Finite Element Tidal Models from a Domain-Wide, Localized Truncation Error Analysis Incorporating Bottom Stress and Coriolis Force,” Ph.D. Dissertation, Department of Civil and Environmental Engineering, University of Central Florida, Orlando (Summer 2007).