Improving the Efficiency of Flooding Predictions and Wave Prediction

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SHORT DESCRIPTION

Coastal communities rely on predictions of flooding caused by storms, but these predictions can take hours on even the fastest supercomputers. In our ongoing project, we have improved the efficiency of a widely used, predictive model for coastal flooding. In Year 7, we will continue to refine and transfer technologies to end-users.

ABSTRACT

In our ongoing project, we have developed technologies to improve the efficiency of a widely used, predictive model (ADCIRC) for storm-driven coastal flooding. In Year 6, these technologies have been or are being transitioned to end-users to benefit the real-time forecasting by the ADCIRC Prediction System (APS). However, the technologies and their workflows will benefit from additional investments in the following:

1. *Improvements to and integration of Kalpana with HAZUS*. In previous years, the Kalpana visualization script was extended to include options for downscaling of flood forecast guidance. This downscaling can span between the ADCIRC model resolution (typically 100- 200m in coastal areas) and higher-resolution digital elevation models (DEMs) (typically less than 15m, but this can be set by the user). This downscaling is especially useful for emergency managers and other decision-makers, who want to see flooding guidance at the same scales as critical infrastructure. In Year 7, we will continue to improve Kalpana by upgrading it and its library dependencies to be compatible with Python 3, validating its use near levees and other small hydraulic barriers, and exploring the potential benefits of parallelization. We will also work with end-users to ensure compatibility with Hazus.
2. *Integrate the new wave model into forecast workflow*. In Year 6, we worked with Don Resio on the development of a new wave model, which is based on modified second-generation physics formulations suitable for hurricane events and shown to

be faster computationally than Simulating WAves Nearshore (SWAN) and similar third-generation wave models. This new wave model is still in development, but early tests are promising for its computational efficiency. In Year 7, we will continue to gain familiarity with this wave model, couple it with ADCIRC via the same framework used for coupling with WaveWatch III, and start to transition it to forecasts.

3. *Improvements for Adcirpolate workflow*. In previous years, the Adcirpolate script was developed to allow for the 'switching' of a simulation between meshes, and thus to allow a single storm forecast to continue on a higher-resolution mesh near the projected landfall location. In Year 6, we are transitioning this technology to the workflow for the ADCIRC Prediction System, so it will be useful in this and future hurricane seasons. In Year 7, we will improve the Adcirpolate workflow in two ways:
4. *Develop or revise meshes for the South Atlantic Bight (SAB) and Texas*. The SAB is the offshore waters and coast from Florida through North Carolina. For the SAB, a mesh was developed in previous project years by combining the state-specific component meshes from FEMA flood risk mapping studies, but this combined mesh is too costly for forecast applications. In Year 7, we will develop a new SAB mesh. For Texas, the existing mesh was updated in previous project years to include revisions from USACE ERDC, but these revisions proved to be unstable and/or inaccurate in forecast applications. New Texas meshes are also in development in collaboration between UT Austin and Notre Dame, and we have access to more accurate bathymetric data for Texas through the Texas Water Development Board. In Year 7, we will assess these mesh revisions and test for both accurate input data and stable and validated numerical solutions. These meshes (SAB and Texas) are critical as 'target' meshes for Adcirpolate.
5. *Include wave model(s) in Adcirpolate workflow*. The existing implementation of Adcirpolate was developed for ADCIRC, and it does not include support for a wave model. In Year 7, we will explore the need for switching and hot-starting (continuing a previous simulation) both SWAN and a new wave model (described above). For SWAN, we will first quantify its performance as it is cold-started (as a new simulation), to determine how quickly it can recover to the full storm wave conditions. Then, if necessary, we will update Adcirpolate to switch the SWAN solution to the new mesh. For the new wave model, we will explore what is needed to hot-start (which is not a current capability) and then update Adcirpolate as necessary.
6. *Update ADCIRC with mass-conserving continuity equation*. In prior work, we investigated mass conserving algorithms for the continuity equation in ADCIRC, effectively replacing the Generalized Wave Continuity Equation, which has always been problematic, especially for overland flows and in wetting and drying regions. This involves using different discretization methods, such as finite volume or discontinuous Galerkin (DG) approaches, that have been shown to be mass conserving and suitable for transport equations. The momentum equation is still approximated using standard

continuous Galerkin (CG) methods. We have recently developed a new Python-based strategy for coupling methods (and software), which we have explored for coupling DG and CG codes. We will investigate this approach for coupling DG continuity with CG momentum within the general ADCIRC framework. If this approach works as hoped, it will be incorporated into the ADCIRC Prediction System. will continue to offer the courses that were developed and offered to the students during the preceding 6 years. In addition, we propose to engage students in research projects that will utilize the computers purchased with the DHS grant funds provided to us during year 6. We expect the students, with the faculty's assistance and guidance, to produce posters and possibly papers that may get published or presented later at relevant scholarly academic conferences. Speakers will be invited to our seminar courses. The speakers will be presenting their cutting-edge research expertise and talking about different opportunities in their respective institutions.