DIETRICH – NCSU
DAWSON – UT-Austin
DHS Coastal Resilience Center
Year 6 ADCIRC Project Workplan
[July 1, 2020 – June 30, 2021]

1. **Title**.

   Improving the Efficiency of Flooding Predictions via Adaptive Mesh Resolution

2. **Principal Investigator**.

   Joel Casey Dietrich, Associate Professor, North Carolina State University

3. **Other Participants/Partners**.

   Clint Dawson, Professor, The University of Texas at Austin

4. **Short Description**.

   Coastal communities rely on predictions of flooding caused by storms. Computational models are essential for making these predictions, but a typical prediction can require hundreds or even thousands of computational cores in a supercomputer and several hours of wall-clock time. In our ongoing project, we have improved the performance and accuracy of a widely-used, predictive model for coastal flooding. In this Year 6, we will complete the transition of these technologies to benefit real-time flood forecasting and the larger model community.

5. **Abstract**.

   In our ongoing project, we have developed three related technologies to improve the performance and accuracy of the ADvanced CIRCulation (ADCIRC) model, which is used widely for predictions of coastal flooding due to hurricanes and other storms. These three technologies are:

   1. *Adcirpolate*. This code enables the 'switching' of ADCIRC simulations between meshes, without the need to restart from scratch. ADCIRC uses an unstructured *mesh* to represent the coastal environment at varying resolutions, typically down to 10-20m. The highest-resolution meshes are tied to specific regions (typically a single state coastline) and can be expensive to use for computations, and thus they are used in forecasting only when a storm is expected to impact that region. Previously, when a forecaster wanted to use a high-resolution, state-specific mesh, s/he had to spin up the computations from scratch, which is wasteful as a storm is approaching. Now with *Adcirpolate*, the forecaster can take the results from the last advisory on any mesh, 'switch' them onto a higher-resolution mesh, and then continue with the next advisory. This will save time and enable flexibility for real-time forecasting.

   2. *ADCIRC+DLB*. These additions to the ADCIRC source code allow for dynamic load balancing (DLB) – the better sharing of the computational workload among the CPUs. This was collaborative work with colleagues at the Univ of Notre Dame. To run efficiently on a supercomputer, the ADCIRC mesh is distributed among the CPUs, each of which is responsible for computations on a small part of the overall

domain. Previously, the mesh was distributed only once, and each sub-mesh was roughly equal in size. This was wasteful because the workload was not distributed evenly – some CPUs were working hard to compute on a sub-mesh in the ocean, while other CPUs were idle because their sub-mesh was in a dry floodplain. Now with *ADCIRC+DLB*, the workload is distributed evenly among the CPUs, and it is redistributed as the simulation progresses. The CPUs are used smartly. We have shown speed-ups of more than 30 percent, without any reduction in accuracy.

3. *Kalpana*. This visualization script was extended to allow for the downscaling of ADCIRC flood guidance onto higher-resolution DEMs. The maximum water levels are interpolated from the ADCIRC model resolution (typically 100-200m in coastal areas) onto a higher-resolution DEM (typically 10-15m, but this can be set by the user), and then extrapolated to intersect the ground surface. Now the forecast flood guidance can be provided at higher resolution to end users, so they can combine with other datasets to estimate damages during and after a storm. We ran this script in real-time during the past several hurricane seasons, and we shared guidance with partners at NC Emergency Management and FEMA.

These project technologies are mature, and we have shown they improve the performance of ADCIRC. However, they are not yet included in the operational workflow of the ADCIRC Prediction System (APS). With support during Year 6, we will work with the principal APS developers/operators to transition the technologies so they can be useful in real-time.