NCSU - DIETRICH
DHS Coastal Resilience Center
Research Project Work Plan Template
Years 4 - 5
[July 1, 2018 – June 30, 2019 / July 1, 2019 – June 30, 2020]

1. **Project Title**.

   Improving the Efficiency of Flooding Predictions via Adaptive Mesh Resolution

2. **Principal Investigator**.

   Joel Casey Dietrich, Assistant Professor, North Carolina State University

3. **Other Research Participants/Partners**.

   Clint Dawson, Professor, The University of Texas at Austin

4. **Short Project 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 this project, we will improve the performance and accuracy of a widely-used, predictive model for coastal flooding. Its representation of the coastal environment will adapt during the storm, to better utilize the computing resources and ultimately provide a faster prediction.

5. **Abstract**.

   Storm-induced waves and flooding can be predicted using computational models such as the ADCIRC modeling system, which has been used by DHS and its constituent agencies for mapping of floodplain flood risk and forecasting of storm surge and inundation. This modeling system uses an *unstructured mesh*, which is a highly-flexible, multi-scale representation of the coastal region. A mesh is created by discretizing the computational domain into connected triangular elements of varying sizes, to represent complex coastal features, barrier islands, and internal barriers, and to allow for gradation of the mesh to increase feature detail from the deep ocean, onto the continental shelf, into estuaries and marshes, and over coastal floodplains. In addition to the mesh, data such as bathymetric depth and bottom roughness must be overlaid on each element, thus creating a “model” of the domain. This modeling system has been shown to be efficient in parallel computing environments. However, it is implemented on static meshes and with a static parallelization, and thus it does not evolve as a storm approaches and inundates a coastal region. This implementation can be inefficient when large portions of the mesh remain dry during the simulation.

   In this project, we will optimize the parallel implementation of ADCIRC by using a large-scale adaptivity, in which a mesh will be refined by incorporating entire portions of another, higher-resolution mesh. Instead of subdividing an individual element, we will increase resolution by adding elements from a pre-existing mesh that has been well-validated. Such meshes have been and are being developed by us and by partners within the CRC. This procedure will leverage the existing suites of meshes for the same geographic region. The adapted mesh will be rebalanced among the computational cores so that geographic regions with increased resolution will not be concentrated on a disproportionally-small number of cores, and so that the time spent on inactive regions is minimized. These technologies will decrease the computational cost and better utilize the available resources.

This project will develop technologies to improve the efficiency of ADCIRC simulations, thus allowing for more model runs in ensemble-based design applications, and for faster simulations in time-sensitive applications such as operational forecasting. These outcomes will increase the accuracy of flood risk products used in building design and the establishment of flood insurance rates, and thus lessen the impact of a disaster. These outcomes will also improve the communication and understanding of potential hazards.