High-Fidelity Coastal Coupling of WAVEWATCH III and ADCIRC using an ESMF-based framework

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WAVEWATCH III (Tolman et al. 2016) is a leading wind-wave model, which is widely applied in both operational and research environments. Although this model was initially designed for oceanic scales, it has been extended in recent years to unstructured grids for application in nearshore waters. Likewise, the unstructured-mesh ADvanced CIRCulation (ADCIRC, Luettich et al 1992) model has enjoyed broad application both in research and operational arenas. Creating a coupling between these two widely-used models, using a community-based coupling infrastructure is therefore a valuable contribution to a wide range of applications. In this study, we have coupled these two models using the National Unified Operational Prediction Capability (NUOPC) framework, which in turn is based on the Earth Systems Modeling Framework (ESMF). The initial application of this coupled model is the Named Storm Event Model (NSEM), which is a high-fidelity, high-accuracy hindcast system designed to provide estimates of wind and water damage due to landfalling hurricanes in compliance with the United States COASTAL Act of 2012. Within the NUOPC/ESMF framework, each model component is included via an interface called a model cap, which provides the NUOPC driver access to the underlying model variables and model advancing. Such model caps have been developed for ADCIRC and for WAVEWATCH III. The model cap for WAVEWATCH III has been based on a new domain decomposition version of the model, which also features the option to use an implicit numerical scheme for coastal application at a high spatial resolution. The new domain decomposition is computationally efficient and scalable, so that it can be run on a large number of computational nodes. This ESMF-based coupled wave-surge model has been validated for idealized laboratory cases as well as a number of major hurricanes, including Ike, Irma and Sandy. These tests were run on a NOAA operational unstructured mesh featuring 2M nodes, with inundation potential of up to +10 m MSL. The coupled model results show improvements compared to stand-alone runs and validate well against observations, showing clear effects on both the wind-wave and surge fields in the nearshore and overland regions at landfall via dynamic data exchange between models.

References