Coupled Wave-Circulation-Sedimentation Dynamics

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In the realm of coastal modeling, state-of-the-art models have advanced such that the nonlinear feedback between different physical processes such as surface waves, marine currents, and sediments can no longer be ignored, but must be considered as a coupled system. Such a system is demonstrated by coupling numerical models representing coastal wave, circulation, and sedimentation dynamics via the Model Coupling Environmental Library, MCEL. Coupling involves sharing the following quantities: surface wave radiation stress gradients, wave orbital velocities, currents, and sea surface heights. Such coupling captures important nonlinear processes such as the impact of sea level variations on wave breaking location, the wave/current blocking of currents/waves, the effect of wave-current interaction in the marine boundary layer on sediment resuspension, and sediment transport under a variable current field. Specifically, the wave module is comprised of the shelf-scale wave generation and transformation model, SWAN.

Coastal circulation and sea level changes are represented by the shallow water hydrodynamics of the Advanced Circulation model (ADCIRC) and sedimentation processes are simulated by the Littoral Sedimentation and Optics Model (LSOM). MCEL is the distributed framework designed to facilitate model coupling. The coupled system is applied in two diverse geographic regions, the Mississippi Bight and the Arabian Gulf. Relevant observations are utilized for validation of each model component. Furthermore, modeled dynamics are evaluated for sensitivity to the dimensionality of the current field and the frequency of coupling.