The Design, Calibration, Validation and Application of a Model Nesting Methodology

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Motivated by a need for forecasting the initiation and fate of Harmful Algal Blooms (HABs) on the West Florida Shelf (WFS), a shelf-scale numerical ocean model was nested within a basin-scale model which covered the whole of the Gulf of Mexico. The basin-scale model was based on the Princeton Ocean Model (POM) and the higher resolution, nested model employed Rutgers University's Regional Ocean Modeling System (ROMS). The nested model was forced along the open ocean boundaries with water elevations, baroclinic and barotropic (re-calculated for the nested domain) currents, and temperature/salinity from the basin-scale model. At the ocean surface, both models were forced with COAMPS-based wind stresses and climatological heat fluxes and sea surface temperatures. The nesting calibration was achieved with a series of short 15-day runs and the comparison of water elevation, currents, temperature and salinity fields between the two models for similarity and consistency for a range of open boundary conditions. This exercise showed that for the nesting to be effective, (i) the model bathymetries needed to match along the open ocean boundaries so that the volume transport between the two model domains was consistent, (ii) a special open boundary condition for the normal component of the current needed to be employed without which barotropic waves remained trapped within the nested model domain and caused significant wave reflections, and (iii) the application of a volume conservation criterion to the nested domain was excessively restrictive especially during extreme phenomena such as hurricanes. The nesting validation for the WFS region involved running the coupled set-up for a 6-month period in 2005, which included 5 hurricanes. This ensured that (a) the nested model faithfully reproduced the water elevation, currents, temperature and salinity fields of the basin-scale model and was free of barotropic wave effects and (b) these physical fields were also in good agreement with observed data for 2005.

This model nesting strategy was thereafter employed in two other applications. The first was to model the circulation around Poplar Island, MD which is being restored by the US Army Corps of Engineers; the modeling challenge associated with this application arises from the need to have all the nested model boundaries as open ocean boundaries and the stronger presence of tides relative to the WFS region. In this application, the Poplar Island model was nested within a larger model covering the whole of the Chesapeake Bay and a segment of the coastal shelf, and both models were based on ROMS with the latter system being known as National Ocean Service's Chesapeake Bay Operational Forecast System upgrade (CBOFS2). The second application involved the placing of two ROMS-based nested models within a ROMS circulation model for the Cook Inlet, AK region.. One nest covered the upper region of this model domain (Knik Arm, Chickaloon Bay and Tumagain Arm), and the second nest covered Kachemak Bay both of which are of importance to the navigational marine community. The numerical modeling challenges pertaining to this application arise from the large tidal ranges in the upper Cook Inlet and the extensive expanse of tidal flats and extremely strong tidal currents throughout the region.