Adaptive Mesh Refinement for Tropical Cyclone Prediction

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Next generation numerical weather prediction models require a unified approach for simulating across different time and spatial scales. As part of the spatial unification, the global mesh must be capable of simulating both an embedded regional area of interest at higher resolution and other areas of less interest and impact at coarser resolution. The tropical cyclone (TC) is a classic example of a mesoscale weather system that requires high horizontal resolution in its inner-core to resolve the processes responsible for intensity variability and lower resolution in the environment to resolve the processes responsible for its track. Thus, adaptive mesh refinement (AMR) is potentially very useful for TC applications.

TC simulations are conducted in a nonlinear shallow water model based upon a flexible dynamical core using either continuous or discontinuous Galerkin numerical methods (NUMA; Nonhydrostatic Unified Model of Atmosphere). The following experiments are examined, representing idealizations of TC processes in the real atmosphere: (i) a hurricane-like vortex advecting in a background flow, (ii) a dynamically unstable hurricane-like vortex, and (iii) and genesis of TC-like vortices from barotropic instability of a zonal jet. AMR versus non-AMR simulations are conducted for each case, and compared with each other for computational efficiency and accuracy. Moreover, large-level AMR experiments are conducted to demonstrate the utility of finely resolving small-scale features in the TC inner-core responsible for intensity variability.

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