Investigating the factors responsible for secondary eyewall formation in an ensemble of high-resolution hurricane simulations

Kristen L. Corbosiero and Ryan D. Torn
University at Albany, State University of New York, Albany, NY

Secondary eyewall formation (SEF) is one of the main, unresolved research topics in the study of tropical cyclone (TC) dynamics. The phenomenon is a common process of major hurricanes and known to be followed by a series of events (an eyewall replacement cycle) linked to rapid intensity changes. In recent years, a number of competing hypotheses have been proposed for SEF with the most substantive difference among them being the relative roles of internal dynamics and external, environmental forcing. A variety of numerical frameworks (idealized axisymmetric, barotropic, and realistic convection permitting) have been used to support the proposed hypotheses; however, it is unclear whether idealized numerical models are appropriate to study the problem and convection permitting studies often examine just one case, preventing any assessment of the generality of the conclusions.

To explore the physical processes responsible for SEF, a cycling, ensemble Kalman filter (EnKF) approach is combined with the full physics NCAR Advanced Hurricane Weather Research and Forecasting Model to generate ensemble forecasts of Hurricane Igor (2010). This data assimilation system generated a 96 member analysis ensemble every 6 h for a basin-scale 36 km domain, and 12 km nested domain that follow TCs, which are then used to initialize high resolution (1.33 km) forecasts out to 120 h. A preliminary analysis of 48 members of the ensemble shows significant variation in the evolution of Igor. Approximately half the members exhibited at least one eyewall replacement cycle with the secondary eyewall initiated at varying times and radial distances from the center. Preliminary work suggests that ensemble members that undergo eyewall replacement exhibit a more uniform moisture distribution in all quadrants of the TC relative to the members that do not. Future work will explore the differences between ensemble members in the context of vertical wind shear variations, comparison of the inner core vorticity structure and the evolution of eyewall and inner rainband convection.