Analysis of ensemble variability in secondary eyewall formation

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Secondary eyewall formation (SEF) is one of the main, unresolved issues in our understanding of tropical cyclone (TC) dynamics. In recent years, a number of 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 three-dimensional convection permitting) have been used to formulate and test these hypotheses; however, it is unclear whether idealized numerical models are appropriate to study the problem, and convection-permitting simulations are often case studies, preventing any assessment of the generality of their results.

To explore the physical processes responsible for SEF, an ensemble Kalman filter approach is combined with the full physics, NCAR Advanced Hurricane WRF Model to generate forecasts of Hurricane Igor (2010), which underwent a well-documented SEF and eyewall replacement cycle (ERC). Analysis of 72 members of the ensemble shows significant variation in the evolution of Igor: approximately one quarter of the members exhibited at least one ERC with the secondary eyewall initiated at varying times and radii from the center. Ensemble members that undergo ERCs are not the most intense members, though they evolve in weaker vertical wind shear, and exhibit a more uniform moisture distribution relative to the members that do not (Figure 1). The more uniform moisture distribution in the ERC members appears to originate with active outer rainband convection upshear of the center more than 48 h before the ERC is complete and could used as a tool in the forecasting of SEF.

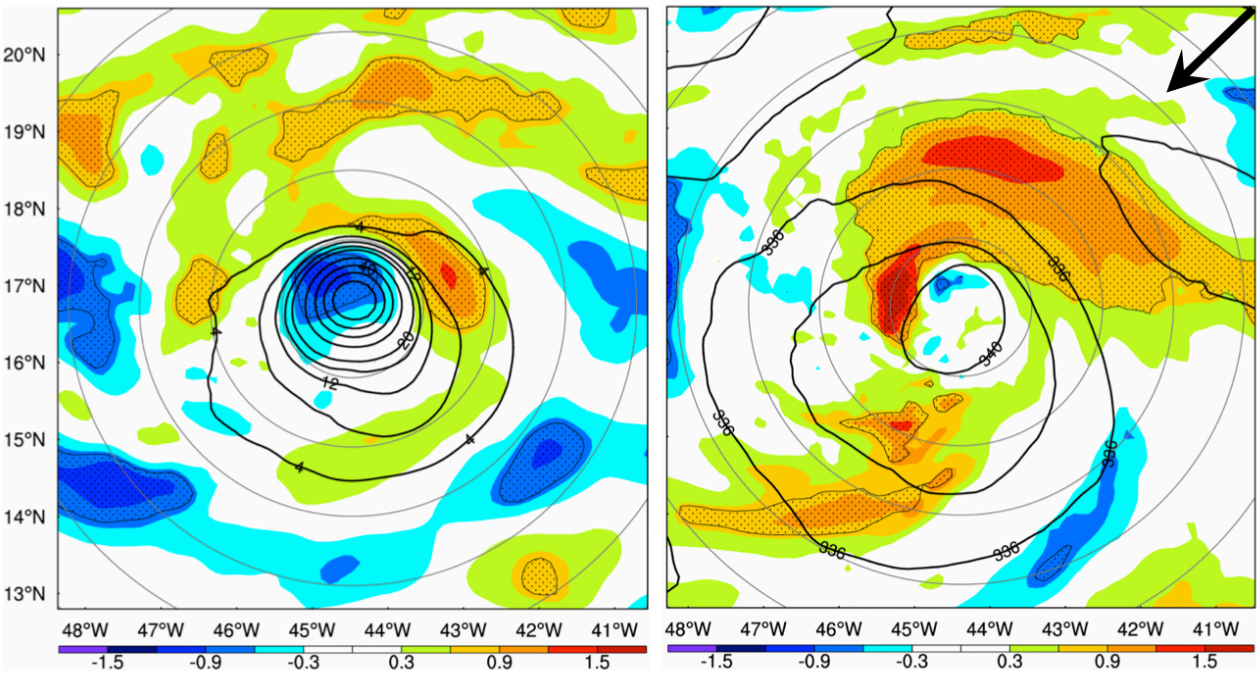

Figure 1. *Storm centered, ensemble mean (black contours) 500-hPa circulation (x 10^{-5} s^{-1}; left) and moist static energy (K; right) 42 h before the ERC is complete. The color shading denotes the standardized difference between the 16 SEF members and the 16 strongest non-SEF members, with the stippling indicating differences that are statistically significant at the 95% confidence level. Range circles (grey) are denoted every 100 km out to 500 km from the center, and the black arrow in the right panel is the vertical wind shear vector.*