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Tropical Cyclone Structure Change Cycles during Rapid Intensification

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High-resolution simulations of Hurricane Katrina (2005) using TCLAPS show that the modelled vortex vacillates between symmetric and asymmetric phases during periods of rapid intensification. During the Symmetric phase the eye-wall has a high degree of symmetry, comprising relatively uniform elongated convective bands. In this phase the low-level vorticity and equivalent potential temperature fields exhibit a ring-like structure, and the largest intensification rates occur near the radius of maximum tangential wind (RMW). In contrast, the Asymmetric phase is characterised by a highly asymmetric eyewall, having a polygonal form with vortical hot towers (VHTs) located at the vertices. The low-level vorticity and equivalent potential temperature fields have monopole structures with their maxima near the center. In this phase, the largest intensification rates occur inside the RMW. These two phases are very similar to Regimes 1 and 2 respectively found by Kossin and Eastin (2001) using aircraft observations.

Symmetric to Asymmetric transitions are associated with the development of VHTs along the eyewall, resulting from a combination of barotropic and convective instability. These VHTs vigorously mix the air between the eye and eyewall, increasing the vorticity near the vortex center. In conrast, Asymmetric to Symmetric transitions occur as the potential energy available to the convection is consumed and the VHTs weaken. In the process the VHTs become strained in the horizontal and move radially outward as vortex Rossby waves (VRWs). High intensification rates resume near the RMW as result of increased horizontal vorticity fluxes associated with redevelopment of convection in the reduced rapid filamentation zone outside of the weakened VHTs, and through VRW wave-mean flow interactions.