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Analysis of an Idealized Diabatic Rossby Vortex: A Coherent Structure of the Moist Baroclinic Atmosphere

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The PSU/NCAR mesoscale modeling system (MM5) is used to conduct a number of idealized numerical simulations to confirm recent findings of an alternate growth mechanism in a moist baroclinic environment to that of traditional baroclinic instability. In this alternate growth scenario, disturbance growth depends on the presence of sufficient environmental moisture and baroclinicity. The resulting coherent structure, termed a diabatic Rossby vortex (DRV), grows as a result of an approximate phase-locking and mutual amplification of two diabatically-generated potential vorticity (PV) anomalies: a low-level positive (cyclonic) PV anomaly and a mid-tropospheric negative (anticyclonic) PV anomaly.

The three-dimensional structure of a DRV is found to be qualitatively very similar to that seen in previous two-dimensional model simulations. The most apparent structural discrepancy from the two-dimensional model is the increased strength of the mid-tropospheric negative PV anomaly in the three-dimensional simulations.

A sensitivity study is undertaken to better understand the dependence of the DRV dynamics on some of the more pertinent environmental and perturbation vortex parameters, and to quantify the effect of each parameter. The resulting intensity of a DRV is most sensitive to the magnitude of environmental baroclinicity and moisture content, while the vertical profile of moisture is the most dominant factor in determining the characteristic depth of the DRV. It is also found that the 'size' and 'amplitude' of a precursor perturbation vortex are important factors in determining the track and intensity of the ensuing DRV.