Simulation of the Downshear Reformation of a Tropical Cyclone

Leon Nguyen and John Molinari
University at Albany/SUNY

ABSTRACT:

The downshear reformation of Tropical Storm Gabrielle (2001) was simulated at 1-km horizontal resolution using the Weather Research and Forecasting (WRF) model. The environmental shear tilted the initial parent vortex downshear-left and forced azimuthal wavenumber-1 kinematic, thermodynamic, and convective asymmetries. The combination of surface enthalpy fluxes and a lack of penetrative downdrafts right of shear allowed boundary layer moist entropy to increase to a maximum downshear-right. This contributed to convective instability that fueled the downshear convection. Within this convection, an intense mesovortex rapidly developed, with maximum boundary layer relative vorticity reaching $2.2 \times 10^{-2}$ s$^{-1}$. Extreme vortex stretching played a key role in the boundary layer spinup of the mesovortex. Cyclonic vorticity remained maximized in the boundary layer and intensified upward with the growth of the convective plume.

The circulation associated with the mesovortex and adjacent localized cyclonic vorticity anomalies comprised a developing “inner vortex” on the downshear-left (downtilt) periphery of the parent cyclonic circulation. The inner vortex was nearly upright within a parent vortex that was tilted significantly with height. This inner vortex became the dominant vortex of the system, advecting and absorbing the broad, but weaker parent vortex. As this occurred, the TC vortex tilt decreased from 65 km to 20 km within 3 hours. We hypothesize that downshear reformation, resulting from diabatic heating associated with asymmetric convection, can aid the TC’s resistance to shear by reducing vortex tilt and by enabling more diabatic heating to occur near the center, a region known to favor TC intensification.