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Analysis of seemingly unphysical vertical vorticity evolution along simulated outflow trajectories

Andrew Vande Guchte and Johannes Dahl
Texas Tech University, (johannes.dahl@ttu.edu)

It is well documented that air parcels experience baroclinic generation of horizontal vorticity within the downdraft of a supercell thunderstorm. This horizontal vorticity is subsequently tilted into the vertical while the parcels are descending such that there is vertical vorticity present immediately above the surface, which is critical for tornadogenesis. Idealized model simulations with cloud model CM1 have been shown to realize this process. However, in some cases, these simulations depict trajectories that upon exiting the downdraft experience rapid changes in vertical vorticity magnitude and sign while travelling nearly horizontally along the ground without an appreciable variation in altitude. Such vertical vorticity evolution appears dynamically unrealistic and would contradict a large body of literature which argues that downdrafts are necessary for the generation of near-ground vertical vorticity.
In this study, the sensitivity of vertical vorticity evolution along simulated outflow trajectories to the treatment of the lower boundary condition and vertical grid resolution is analyzed. Furthermore, in order to determine the dynamical cause for the evolution of vertical vorticity along these trajectories, the vorticity is decomposed into barotropic and non-barotropic parts by examining the deformation of stencils around the parcels in question.