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A NUMERICAL STUDY OF ROTATING CONVECTION DURING TROPICAL CYCLOGENESIS

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Abstract

Idealized numerical model experiments are presented to investigate the convective generation of vertical vorticity in a tropical depression. The calculations are motivated by observations made during the recent PREDICT field experiment to study tropical cyclogenesis, and by a desire to understand the aggregation of vorticity debris produced by deep convection in models of tropical cyclogenesis to form a monopole vortex.

One aim is to isolate and quantify the effects of low to mid level dry air on convective cells that form within a depression and, in particular, on the generation of vertical vorticity in these cells. Another aim is to isolate the effects of a unidirectional boundary layer wind profile on storm structure, especially on vertical vorticity production. A third aim is to isolate the effects of a vortex boundary-layer wind profile on tropical deep convection, focusing especially on the morphology of vertical vorticity that develops.

The growing convective updraughts, that are initiated by a near surface thermal perturbation, amplify locally the ambient rotation at low levels by more than an order of magnitude and this vorticity persists long after the updraught has decayed, supporting the results of an earlier study. The results of calculations with dry air aloft do not support a common perception that the dry air produces stronger downdraughts.

In calculations where the vertical wind shear changes sign at some level near the top of the boundary layer, as occurs in warm-cored disturbances such as tropical depressions or tropical cyclones, it was found that the tilting of horizontal vorticity by a convective updraught leads not only to dipole patterns of vertical vorticity, but also to a reversal in sign of the updraught rotation with height. This feature is quite unlike the structure in a typical middle-latitude `supercell' storm.

These results provide an essential first step to understanding the interaction between deep convective elements in a tropical depression or tropical cyclone.