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Mechanics and Efficiency of Tropical Cyclone Intensification

by

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While the wind and pressure fields of tropical cyclones are highly axisymmetric, the convection and precipitation which provide the energy source for their development can be highly asymmetric. This is especially true in the early stages of development. The dynamics of vortex intensification from asymmetric heat sources are studied using a linear, three-dimensional, nonhydrostatic model. Asymmetric temperature perturbations to a balanced vortex are shown to go through a two-stage adjustment process. In the first stage, there is a rapid adjustment with gravity wave radiation, producing quasi-balanced vorticity perturbations. In the second stage, these vorticity perturbations are sheared by the symmetric flow, leading to eddy heat and momentum fluxes and changes in structure and intensity of the symmetric vortex.

Changes in intensity of the symmetric vortex are dominated by the response to the projection of the heating onto purely symmetric motions; thus, tropical cyclone intensity change can be accurately estimated from the azimuthally averaged heating. These results are validated for dry dynamics in a nonlinear, fully compressible simulations using the Weather Research and Forecast Model (WRF). As the vortex intensifies, the amount of heat energy from convection which is retained as kinetic energy increases significantly. This is in agreement with previous work by Hack and Schubert (1986) using a balance model, and indicates that a nonlinear feedback is the reason for occasionally observed rapid intensifications of tropical cyclones.