Role of Cumulus Congestus and Shallow Convection in Tropical Cyclone Formation

Zhuo Wang
Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign, Urbana, IL

Abstract

The role of non-deep convection, including cumulus congestus and shallow convection, in tropical cyclone (TC) formation is examined using a high-resolution simulation of Tropical Cyclone Fay (2008). It is found that non-deep convection plays a dominant role in moistening the lower to middle troposphere and in spinning up the near-surface circulation prior to genesis, while deep convection plays a key role in moistening the middle to upper troposphere and in intensifying the cyclonic circulation over a deep layer. The transition from the tropical wave stage to the TC stage is marked by a substantial increase in net condensation and potential vorticity generation by deep convection in the inner wave pouch region, and the contributions of deep convection become dominant after genesis.

This study suggests that TC formation can be regarded as a two-stage process. The first stage is a gradual process of moisture preconditioning and the low-level spinup mostly by non-deep convection. The second stage commences with the rapid development of deep convection in the inner pouch region after the air column is moistened enough, whereupon the concentrated convective heating near the wave pouch center strengthens the transverse circulation and leads to the amplification of the cyclonic circulation over a deep layer. The rapid development of deep convection can be explained by the power-law increase of precipitation rate with column water vapor (CWV) above a critical value of CWV. It is also shown that non-deep convection can effectively drive the low-level convergence and thus provides a direct and simple pathway for the development of the TC proto-vortex near the surface.