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A transition mechanism for the spontaneous axisymmetric intensification of tropical cyclones

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A mechanism for the transition of tropical cyclones (TCs) to the spontaneous rapid intensification (RI) phase is examined using a three?dimensional full?physics model. The rapid intensification phase of the simulated TC is divided into three sub?phases according to the rate of intensifition: I) a slowly intensifying phase, II) a RI phase, and III) an adjustment phase toward the steady state. The evolution of a TC vortex is diagnosed by the energy budget analysis and using a parameter representing the degree of axisymmetric structure of the TC vortex, and the simulated TC is determined to be axisymmetrized 12 h before the onset of RI. It is found that equivalent potential temperature in the lowest layer suddenly increases inside the radius of maximum wind (RMW) after the TC becomes axisymmetric. The forward trajectory analysis revealed that the enhanced convective instability in the TC core region where the eyewall subsequently forms results from the increased inertial stability. Since fluid parcels remain longer inside the RMW owing to the increased inertial stability of the TC core, the parcels obtain more enthalpy from the underlying ocean. As a result, low?level equivalent potential temperature and hence convective available potential energy (CAPE) increase. Under a suitable condition (i.e., large CAPE) for the formation of eyewall, the convergence of the low?level inflow becomes larger owing to the enhanced secondary circulation; this process is considered to be the trigger of RI in agreement with the previous study. As the inertial stability becomes large, the condensation around the TC core effectively enhances the primary circulation as well as CAPE inside the RMW. Thus, the positive feedback works until the TC goes into the RI phase.

Keywords: tropical cyclone