Impacts of Tropospheric Temperature Structure on the Intensity of Tropical Cyclones

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The change in the intensity of tropical cyclones (TCs) depends on tropospheric temperature conditions. Physical mechanisms on how those conditions affect the TC intensification are still not fully understood. In this study, we investigate the influences of the tropospheric depth and stability on the changes in the intensity and structure of TCs by conducting a series of numerical experiments in which tropospheric lapse rate and tropopause height are systematically changed.
The environmental condition for the development of Typhoon Vera (1959), a worst-class category-5 storm, is regarded as a control in this study. We used the Japanese 55-year Reanalysis at the time of the rapid intensification of this typhoon in order to impose the initial and boundary conditions for the numerical experiments. An axisymmetric non-hydrostatic model, i.e., the Bryan’ s Cloud Model Version 1 (CM1), with the horizontal resolution of 1 km, was used in our experiments. The range of each parameter has been chosen based on the examination of the environmental conditions for typhoons during 1979 and 2014.
It was found that with the increase in temperature lapse rate the maximum intensity of the simulated TC clearly increases. In addition, the maximum intensity also increases when the tropopause height increases but with keeping lapse rate unchanged. In terms of TC structures, the altitude distribution of the vertical wind of TCs was varied by changing the tropospheric temperature structure. The simulated TC under larger-lapse rate conditions or under higher-tropopause conditions generated taller eyewall with deeper convection. It was shown that these conditions lead to an enhanced secondary circulation and hence the increase in the TC intensity. The temperature lapse rate is found to have the most significant impacts on the TC intensity and structure. The increases in tropopause height play a secondary role in the intensification of TCs, but the impacts are smaller than the lapse rate.

Keywords: Tropical cyclone, Numerical experiment, Tropospheric stability , Tropopause height

