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The Parameterization of PBL height with Helicity and preliminary Application in Tropical Cyclone Prediction

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Planetary Boundary Layer (PBL) plays an important role in transferring the energy and moisture from ocean to tropical cyclone (TC). Thus, the accuracy of PBL parameterization determines the performance of numerical model on TC prediction to a large extent. Among various components of PBL parameterization, the definition on the height of PBL is the first should be concerned, which determines the vertical scale of PBL and the associated processes of turbulence in different scales. However, up to now, there is lacked consensus on how to define the height of PBL in the TC research community. The PBL heights represented by current numerical models usually exhibits significant difference with TC observation (e.g., Zhang et al., 2011; Storm et al., 2008), leading to the rapid growth of error in TC prediction.

In an effort to narrow the gap between PBL parameterization and reality, this study presents a new parameterization scheme for the definition of PBL height. Instead of using traditional definition for PBL height with Richardson number, which has been verified not appropriate for the strongly sheared structure of TC PBL in recent observation studies, the new scheme employs a dynamical definition based on the conception of helicity. In this sense the spiral structures associated with inflow layer and rolls are expected to be represented in PBL parameterization. By defining the PBL height at each grid point, the new scheme also avoids to assume the symmetric inflow layer that is usually implemented in observational studies. The new scheme is applied to the Yonsei University (YSU) scheme in the Weather Research and Forecasting (WRF) model of US National Center for Atmospheric Research (NCAR) and verified with numerical experiments on TC Morakot (2009), which brought torrential rainfall and disaster to Taiwan and China mainland during landfall. The Morakot case is selected in this study to examine the performance of the new scheme in representing various structures of PBL over land and ocean.

The results of simulations show that, in addition to enhancing the PBL height in the situation of intensive convection, the new scheme also significantly reduces the PBL height and 2m-temperature over land during the night time, a well-known problem for YSU scheme according to previous studies. The activity of PBL processes are modulated due to the improved PBL height, which ultimately leads to the improvement of prediction on TC Morakot.

Key Words: PBL; Parameterization; Numerical Prediction; Tropical Cyclone

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