Department of Atmospheric Sciences Seminar Announcement

Department of Atmospheric Sciences, S.O.E.S.T., University of Hawai'i at Mānoa
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The Role of Boundary Layer Dynamics in Tropical Cyclone Intensification

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Date: Wednesday, April 4, 2018
Refreshments: 3:00pm at MSB lanai
Free Cookies, Coffee & Tea Provided
(Please Bring Your Own Cup)
Seminar Time: 3:30pm
Location: Marine Sciences Building, MSB 100

Abstract:

In this study, the role of boundary layer dynamics in tropical cyclone (TC) intensification has been examined with the following hypothesis. The boundary layer dynamics has a negative effect on TC intensification by direct surface frictional dissipation, while contributes positively to TC intensification and eyewall contraction by modifying the strength and radial location of eyewall updrafts/convection. This would lead to changes in the radial distribution of gradient wind, and further affect the intensification rate of the storm by modifying the inertial stability in the inner core and the rate of eyewall contraction.

To test the hypothesis and isolate the dynamical and thermodynamic effects of the boundary layer dynamics, three different models with different complexities are used to conduct a series of sensitivity experiments with varying drag coefficient and vortex structure. In part I, results from a simplified framework, which is a height-resolving boundary layer model coupled with a one-layer shallow water equation model above, are discussed in detail. In this coupled system, a mass sink is parameterized by mass flux at the top of the boundary layer to mimic the eyewall heating and thus to allow intensification of the TC vortex and changes in the radial distribution of gradient wind above the boundary layer. Results show that the storm with larger drag coefficient, less strength, larger radius of maximum wind, and higher intensity displays faster eyewall contraction and more rapid intensification.

In part II, results from full-physics model simulations are discussed with the focus on evaluating the relative importance and their combined role of dynamical and thermodynamic effects of boundary layer dynamics due to the presence of surface friction to the simulated TC intensification. It is shown that larger surface friction can enhance the radial inflow and stronger upward motion (Ekman pumping), leading to faster moistening of the inner core, larger and more inward penetrated eyewall updrafts and thus diabatic heating inside the radius of maximum wind (RMW). This largely shortens the initial spin-up of the TC vortex and earlier establishment of the rapid intensification (RI). However, larger surface friction has little effect on the subsequent intensification rate of the simulated storm, suggesting that the positive contribution of the indirect thermodynamic effect by surface friction is largely offset by the negative dynamical effect due to surface frictional dissipation. The results thus strongly suggest that boundary layer dynamics contributes significantly to the onset of RI but has little effect on the subsequent intensification rate.