ATS/CIRA Colloquium

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The Roles of Wind-Induced Surface Heat Exchange in Secondary Eyewall Formation and Rapid Intensification of Tropical Cyclones

Hosted by Michael Bell

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ATS room 101

This study examines the roles of surface heat fluxes, particularly in relation to the wind-induced surface heat exchange (WISHE) mechanism, in the (i) secondary eyewall formation (SEF) and (ii) rapid intensification (RI) of tropical cyclones.

(i) To examine the sensitivity of SEF to the WISHE mechanism, the surface wind used for the calculation of surface heat fluxes is capped at several designated values and at different radial intervals. When the heat fluxes are moderately suppressed around and outside the SEF region observed in the control experiment, sensitivity experiments show that the formation of the outer eyewall is delayed, and the intensity of both eyewalls is weaker. When the heat fluxes are strongly suppressed in the same region, SEF does not occur. In contrast, suppressing the surface heat fluxes in the storm's inner-core region has limited effect on the evolution of the outer eyewall. This study provides important physical insight into SEF, indicating that the WISHE mechanism plays a crucial role in SEF.

(ii) Sensitivity experiments with capped surface fluxes and reduced WISHE exhibit delayed RI and weaker peak intensity, while WISHE could affect the evolutions of TC both before and after the onset of RI. Before RI, more WISHE leads to faster increase of θe in the lower levels, resulting in the eruption and the axisymmetrization of the convection (especially in the lower levels). In addition, TCs in experiments with more WISHE reach a certain strength earlier, before the onset of RI. During the RI period, more surface heat fluxes cause more efficient intensification in a TC, leading to a stronger peak intensity, more significant and deeper warm core in TC center, and the axisymmetrization of convection in the higher levels. In both stages, different levels of WISHE alter the thermodynamic environment and convective-scale processes. With WISHE, a consequent development in the convective activity is identified, resulting in a stronger secondary circulation and increased diabatic heating. Within the inner-core region, deeper inflow increases the transport of angular momentum from the outer radii, leading to faster spin-up of the tangential circulation. In all, the important role of the WISHE feedback in RI, both during the pre-RI stage and during the RI period, is highlighted.

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