Tropical Cyclone Intensification under the Influence of Upper-tropospheric Troughs

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Tropical cyclone (TC)–trough interaction remains a significant challenge in TC intensity forecasting. Climatologies of Atlantic TC–trough interactions have found that these events are generally unfavorable for TC intensification, yet some TCs still intensify following an interaction. Four physical processes are hypothesized to affect TC intensity during trough interactions, three favorable and one unfavorable. The three favorable processes are (1) an increase in angular momentum eddy flux convergence (EFC) in the TC outflow layer, (2) an increase in upper-level divergence through the development of an upper-level jet, and (3) superposition between the trough and TC potential vorticity. The unfavorable process is (4) enhanced vertical wind shear from the trough that tilts and ventilates the TC.

Using 35 years of ERA-Interim reanalysis, the authors have previously shown that EFC is a poor predictor of TC intensification during a trough interaction event, especially compared to vertical wind shear. Weak, vertically shallow, and horizontally narrow troughs are most favorable for TC intensification. In addition, satellite observations of infrared brightness temperature indicate that intensifying TC–trough interaction events have convection that deepens and wraps upshear of the TC center. This evolution is associated with reduced vertical wind shear and lower ventilation, which allows the convection to strengthen. The strengthening convection, and its associated divergent outflow, advects low PV toward the trough, slowing its progression and potentially causing the trough to break.

Motivated by these observational and reanalysis results, idealized TC–trough interaction events were simulated using the Weather Research and Forecasting model. A trough within a westerly jet in thermal wind balance was initialized upwind of an idealized TC. The horizontal and vertical scales, and strengths, of the interacting troughs were varied across experiments based on the reanalysis composites: the horizontal scale of the trough (based on a half wavelength value) ranged from ~5–15° of longitude and ~5–20° of latitude, while the vertical extent of the trough varied between 400–250 hPa. Changing the scale and depth of the trough had implications on the shear the TC experiences, the magnitude of the divergent outflow produced, and the time it took for TC convection to erode the approaching trough.

In this presentation, parameters associated with TC–trough interaction events, such as EFC, wind shear, and divergence will be evaluated to investigate their relationship with TC intensity change. Additionally, the evolution of convection, morphology of the trough as it approaches the TC, and PV advection by the irrotational wind will be analyzed, and all modeling results will be compared to the results from the ERA-I reanalysis and satellite observations.