Tropical Cyclone Interactions with Troughs of Different Widths

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We investigate the evolution of tropical cyclones (TCs) as they interact with troughs with different horizontal scales in idealized WRF model experiments. The initial model state consists of a narrow, medium, or wide trough embedded in a zonal jet. An initial, weak TC vortex is placed to the east of the trough at three different distances to vary the initial, deep-layer vertical wind shear (7, 10, or 12.5 m s⁻¹). The resulting nine experiments are run for 72 hours.

Tropical cyclone intensity shows a mixed relationship to initial trough width and vertical wind shear. In all the experiments, substantial modification of the trough by the divergent outflow of the TC results in rapid reduction of the vertical wind shear over the inner core of the TC, allowing the TCs to realign and intensify. In terms of the maximum, azimuthally-averaged wind speed at 72 hours, there is no clear relationship to the initial trough width and vertical wind shear. On the other hand, a lower minimum central pressure is associated with a wider initial trough, indicating that TCs interacting with wider troughs tend to be larger in size.

The differences in TC size come about from multiple processes that nonlinearly feedback on increasing TC size. Upper-level divergence is initially favored at the inflection point of the trough, where there is a transition from subgeostrophic to supergeostrophic flow. Due to the vertical wind shear, a large area of downshear convection forms, and the associated divergent outflow sharpens the potential vorticity (PV) gradient west of the TC, deforms the trough, and builds an anticyclonically curved jet streak to the north of the TC. The forcing for ascent closely follows this sharp PV gradient into the entrance region of the jet streak, anchoring the convective shield. The large area of diabatic heating associated with this convective shield expands the TC circulation, resulting in greater outer vortex surface fluxes, more convection, and a larger wind field.