Using Ensembles to Diagnose the Tropical Cyclone–Extratropical Flow Interaction Associated with Recurving Typhoon Malakas (2010)

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The extratropical flow response to a recurving tropical cyclone is highly sensitive to the interaction between the tropical cyclone and the extratropical flow pattern into which it is moving. In late September 2010, recurving and transitioning Typhoon Malakas interacted strongly with the North Pacific jet stream. This tropical cyclone–extratropical flow interaction resulted in the amplification and dispersion of a Rossby wave train across the North Pacific to North America. As the Rossby wave train traversed North America, it established a high-amplitude ridge–trough pattern over North America that was associated with record-breaking heat in western North America and flooding rains in portions of eastern North America.

It is hypothesized that the downstream extratropical flow response to Typhoon Malakas, and thus the occurrence of extreme weather over North America, is sensitive to the strength of the tropical cyclone–extratropical flow interaction. To evaluate this hypothesis, the main modes of extratropical flow variability surrounding the recurvature of Typhoon Malakas are identified by applying an empirical orthogonal function–fuzzy clustering analysis (Harr et al. 2008; Anwender et al. 2008) to ensemble prediction system forecasts of potential temperature on the dynamic tropopause. The 46-member ensemble prediction system is generated from a high-resolution WRF simulation that incorporates the technique of vortex initialization based on ensemble Kalman filter data assimilation (Wu et al. 2012). All available data obtained during the field campaign "Impacts of Typhoons on the Ocean in the Pacific" (ITOP) are continuously assimilated, allowing for model output that is consistent with observations.

Next, the strength of the tropical cyclone–extratropical flow interaction associated with each of the main modes of extratropical flow variability in the ensemble forecasts is objectively determined based on the advection of negative potential vorticity by the divergent outflow of the tropical cyclone (Archambault et al. 2013). Finally, the downstream extratropical flow response to the recurvature of Typhoon Malakas is evaluated in the context of the mean strength of the tropical cyclone–extratropical flow interaction for each of the main modes of extratropical flow variability.