Tropical Cyclone Stan's Interaction Within a Central American Gyre

By

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Central American gyres (CAGs) are broad (~1000 km diameter) low-level cyclonic circulations that organize over Central America during the tropical cyclone (TC) season. While CAGs have rarely been studied, prior work on similar circulations have been conducted on monsoon depressions (MDs) and monsoon gyres (MGs), which possess spatial scales of 1000 – 2500 km in the west Pacific basin. In these large circulations, multiple vorticity maxima can organize into strips and rotate cyclonically along the outer flank of the larger circulation. Small TCs can develop from these smaller vorticity maxima that remain embedded in the larger circulation. One example of a TC that formed within a CAG is TC Stan (2005). The combination of TC Stan and the CAG were responsible for rainfall > 250 mm (~10 in) over an extensive area of Mexico and Central America, which resulted in > 1000 fatalities. The initial forecast track of TC Stan by the National Hurricane Center (NHC) took the system on a west-northwest heading into mainland Mexico, steered by an anticyclone located over the southeastern US. However, TC Stan deviated towards the southwest after emerging into the Gulf of Mexico and made landfall southeast of Veracruz, Mexico. This presentation is motivated by the unexpected equatorward track deviation of TC Stan, which is hypothesized to have resulted from the barotropic binary interaction of TC Stan's vortex within the larger CAG circulation.

This presentation will investigate TC Stan's interaction within the CAG from a qualitative and quantitative perspective. This presentation first investigates the interaction qualitatively, using vorticity, a point measure of rotation, and circulation, a macroscopic measure of rotation, comparing the climate forecast system reanalysis (CFSR) to the global forecast system (GFS) model forecasts that was available to the NHC during of TC Stan's formation. While the CFSR depicted the development of the CAG and equatorward turn of TC Stan, the GFS forecast failed to develop a CAG and continued to track TC Stan to the west-northwest, similar to the NHC forecast. This presentation also investigates the flow associated with the CAG quantitatively, using piecewise vorticity inversion. Piecewise vorticity inversion is conducted by first removing the TC Stan vortex, and then quantifying the steering flow associated with the CAG versus the flow associated with the exterior environment excluding the CAG. This piecewise partitioning of the flow demonstrates that the equatorward motion of TC Stan is associated with the cyclonic flow of the CAG, and is less impacted by the environmental flow of the anticyclone located over the southeastern US.