High-Temporal Resolution Observations of Tornadogenesis Using the Atmospheric Imaging Radar

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Scientists have long strived to document the physical processes responsible for some supercells producing tornadoes while other supercells fail to produce tornadoes. Documenting differences in radar signatures between tornadic and nontornadic storms could provide immense benefit to improving operational warnings of tornadoes. While scientific understanding of tornadogenesis has progressed, the mechanisms leading to tornadogenesis or tornadogenesis failure remain difficult to document due to the rapidly evolving processes in tornadic and nontornadic storms. This study uses high-temporal resolution tornado data collected by the Atmospheric Imaging Radar (AIR) to investigate the vertical evolution of rotation during tornadogenesis. The AIR is particularly well suited to observe the vertical evolution of rotation within tornadoes and mesocyclones because it collects simultaneous RHIs, which minimizes horizontal advection and tornado evolution during the radar volume scan.

The primary focus of this study is the 23 May 2016 tornado near Woodward, Oklahoma. This dataset consists of one hour of continuous, 7-s volumetric updates that span the intensification stages of a slow-moving supercell and includes the entire lifecycles of two tornadoes, including tornadogenesis, at 18-20 km in range. Tornadogenesis was observed to occur nearly simultaneously in the vertical and occurred when a low-level vortex became vertically stacked with the low-level and mid-level mesocyclone within the supercell. The first tornado dissipated once the low-level vortex became displaced from the mesocyclone, but a second, longer period of vortex strengthening was observed two minutes following dissipation, leading to the second tornado. Prior tornadogenesis of the first tornado, a strong low-level vortex was observed, but this vortex did not intensify through a deep vertical layer, like what was observed for the first tornado. The Woodward case will be compared to tornadogenesis in a weakly tornadic storm near Grandfield, Oklahoma, on 11 May 2017. Additionally, the behavior of these tornadic storms will be compared to AIR observations of strongly rotating storms that failed to produce tornadoes with the goal of providing differences between tornadic and non-tornadic storms that could potentially be used operationally with the implementation of a rapid-scan radar network in the future.

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