Predicting Tornado Pathlength and Longevity from an Environmental Wind Profile: Theory and Test Cases Using ERA5 Near-Storm Synthetic Proximity Soundings

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Abstract

Conditional forecasts of tornado pathlength and longevity are derived from a proposed kinematical model that simulates the downstream distance a rotating cylindrical pseudo-storm traverses. The proposed model uses a forecast or an observed deep tropospheric sounding as input, and then provides output in the form of numerical tornado pathlength and longevity predictions. Assumptions for this model include that a storm exists in an environment supportive of deep moist surface-based supercellular convection which has developed a cold pool and is accompanied by tornadogenesis. In addition, the model is not valid for two-dimensional thunderstorm modes such as quasi-linear convective systems including bow echoes. Predicted tornado pathlengths and longevities have been tested against over 300 ERA5 near-storm tornado proximity soundings spanning a period from 1950 to 2022 that are valid +/- 1 h and ~31 km from the location of tornadoes. Results from those tests show a robust linear correlation exists between predicted and observed pathlength and longevity, with coefficient of determination values (R^2) >0.9. However, several failure modes were also observed in the vicinity of landfalling tornado-producing tropical cyclones, which yielded predicted pathlengths and longevities that were too large compared to observed values, as well as along pre-existing surface baroclinic boundaries, which occasionally produced tornadoes with longer pathlengths and longevities than was predicted.