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The use of self-organizing maps to characterize the tornadic near-storm environment

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Near-storm environmental characterization of tornadoes typically involves bulk measures of atmospheric parameters; composite indices such as the Significant Tornado Parameter (STP) have been shown to discriminate well between non-tornadic but severe supercells and supercells producing tornadoes rated 2 or higher on the Enhanced Fujita scale.

Traditional studies, however, tend to match each tornado event with a single point proximity sounding, and hence a single value of STP. In this work, we instead examine two-dimensional patterns, using the model-produced [Rapid Update Cycle (RUC) or Rapid Refresh (RAP)] mesoanalysis grids, of parameters surrounding over 15,000 United States tornado events between 2003 and 2015. To do this, we make use of a neural network clustering technique, Self-Organizing Maps (SOMs), to create statistically distinct clusters of these patterns in the environment.

The two-dimensional plots produced by the SOM technique enable the identification and clustering of patterns that can distinguish, for instance, between a typical U.S. Great Plains east-west moisture gradient (dryline) scenario and a scenario dominated by high convective available potential energy to the southwest of the tornado. The importance of the specific positioning of boundaries such as drylines or fronts relative to the position of the tornado provides an important reminder that tornadic activity does not always correlate with a “bullseye” of a given parameter.

Analyzing the statistics of a particular cluster sheds light on the properties of that particular spatial arrangement of atmospheric parameters. Does a given cluster primarily showcase events from the southeastern U.S.? Is probability of detection particularly low? Are quasi-linear convective systems more common? Are tornado outbreak events or high-fatality events more likely?

Answering these questions for each cluster and incorporating the full spatial variability of near-storm atmospheric parameters into our considerations of the tornadic near-storm environment allows for a more nuanced climatology of the tornadic environment that can be applied in situations and locales extending beyond prototypical U.S. Great Plains springtime early-evening events.