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Tornado Outbreaks from Quasi-Linear Convective Systems in the United Kingdom: Synoptic-Scale Environments and Along-Line Variability

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The United Kingdom (UK) experiences more tornado reports per unit area than any other country. Tornado outbreaks in the UK (classified as days with 3 or more tornadoes) are commonly associated with quasi-linear convective systems (QLCSs), lines of convective storms that often occur along an atmospheric boundaries, such as a cold front.
Tornado reports are taken from the Tornado and Storm Research Organisation (TORRO) database, where 9 tornado outbreaks from QLCSs between 2004–2017 were associated with 58 tornado reports. Of the nine outbreaks, eight can be classified into two synoptic categories, labelled ‘type 1’ and ‘type 2’. Synoptic categories are derived from the location of the parent extratropical cyclone and configuration of the front associated with the QLCS. Environmental differences between the categories are assessed using composites of ERA-Interim reanalysis data at the times available closest to the tornado outbreaks. Significant environmental differences are found between the two types, where type 1 events are characterised by a sharp cross-frontal wind shift and temperature gradient coinciding with a warm pre-frontal air mass and 850hPa low-level jet. Type 2 events exhibit a shallow cross-frontal wind shift, negligible cross-frontal temperature gradient and no pre-frontal low-level jet.
To further assess the environmental conditions of both types of tornado outbreaks, a mesoscale convection-permitting model (WRF) is used to simulate each event. Simulations are tested against reality using precipitation data from the UK Met Office archive and synoptic composites. Of the 8 tornado outbreaks, 7 are simulated to an acceptable degree of accuracy (4 type 1 events and 3 type 2 events). Initial analysis focuses on cross-frontal variables (wind shift, temperature gradient, etc) and 500m absolute vorticity. Preliminary results show 500-m absolute vorticity coinciding with type 1 QLCSs are structured into equally spaced misovortices, each connected by a strand of weaker vorticity. However, broader frontal bands found with type 2 events have a less distinctive vorticity structure exhibiting sporadic isolated misovortices within the frontal band. To investigate this further, the three dimensional structures and surrounding environments of misovortices in type 1 and type 2 events are assessed to determine how current theories of tornadogenesis can be applied.