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Surface wind, pressure and temperature fields near tornadic and non-tornadic narrow cold-frontal rainbands

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Narrow cold frontal rainbands (NCFRs) occur frequently in the UK and other parts of northwest Europe. At the surface, the passage of an NCFR is often marked by a sharp wind veer, abrupt pressure increase and a rapid temperature decrease. Tornadoes and other instances of localised wind damage sometimes occur in association with meso-gamma-scale vortices (sometimes called misocyclones) that form along the zone of abrupt horizontal wind veer (and associated vertical vorticity) at the leading edge of the NCFR.

Using one-minute-resolution data from a mesoscale network of automatic weather stations, surface pressure, wind and temperature fields in the vicinity of 12 NCFRs (five of which were tornadic) have been investigated. High-resolution surface analyses were obtained by mapping temporal variations in the observed parameters to equivalent spatial variations, using a system velocity determined by analysis of the radar-observed movement of NCFR precipitation segments.

Substantial differences were found in the structure of surface wind and pressure fields close to tornadic and non-tornadic NCFRs. Tornadic NCFRs exhibited a large wind veer (near 90°) and strong pre- and post-frontal winds. These attributes were associated with large vertical vorticity and horizontal convergence across the front. Tornadoes typically occurred where vertical vorticity and horizontal convergence were increasing.

Here, we present surface analyses from selected cases, and draw comparisons between the tornadic and non-tornadic NCFRs. Some Doppler radar observations will be presented, illustrating the development of misocyclones along parts of the NCFR that exhibit strong, and increasing, vertical vorticity stretching. The influence of the stability of the pre-frontal air on the likelihood of tornadoes will also be discussed.