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Multiple mesoscale airstreams within regions of strong winds in extratropical cyclone Friedhelm

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The jet across the North Atlantic was exceptionally strong throughout December 2011. During the period with strongest baroclinicity a succession of fast-moving storms crossed the UK. Cyclone Friedhelm, which hit Scotland on 8 December 2011, was the most severe of these storms. The structure of this storm, and the location of the strongest winds, led to speculation that it contained a sting jet. This is a mesoscale descending airstream that can cause strong near-surface winds in the dry slot of cyclones, a region not usually associated with strong winds.
In this contribution we present a detailed analysis of the material origin of air masses constituting regions of strong low-level winds near the cloud head tip in cyclone Friedhelm. The analysis consisted of numerical simulations using the operational Met Office weather forecast model supplemented by tracer diagnostics and trajectory analysis. The analysis is supported by observations from the FAAM research aircraft which flew through the cyclone during the second DIAMET (DIAbatic influences on Mesoscale structures in ExTratropical storms) field campaign - the first research flight through a sting-jet storm to the authors' knowledge. Both dropsonde and in-situ observations are available, the latter including the chemical species CO and ozone.
We show that the mesoscale structure in the region of the cloud head tip is very complex and highly transient due to the interaction of multiple airstreams converging into that region. Based on airstream properties (e.g. relative humidity and equivalent potential temperature) and behaviour (e.g. vertical motion), the identified airstreams were classified into two categories: cold conveyor belts and sting jets. The distinction between these airstreams was confirmed using CO and ozone observations. Furthermore, it is shown that the evolution of each identified airstream category is consistent with the type of instability the constituting airstreams encounter as they travel around the cyclone's centre.