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Isentropic Slope Tendency as a Diagnostic for the Evolution of Severe Extratropical Cyclones

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The significant economical and societal impact of severe extratropical cyclones asks for quantitative diagnostics to assess their evolution and strength. For Northern Europe, these severe storms appear often as part of a chain of several storms, with the most intense severe storms occurring at the end of the chain. Hence, preceding storms must act to increase the background baroclinity along which the succeeding storms evolve. We will test this paradigm by using the slope of the isentropes as a measure for baroclinity. For a baroclinically growing disturbance, the mean motion of the air parcels is at a lower angle than the slope of the isentropic surfaces. Therefore, a larger slope and baroclinicty indicate a larger potential for disturbances to convert available potential energy to kinetic energy via baroclinic conversion. Our slope diagnostic separately quantifies the diabatic and adiabatic effects on the slope tendency, allowing us to assess the relative importance of diabatic effects on storm evolution.

With our isentropic slope diagnostic, we demonstrate with two extreme cases that individual storms affect the environmental baroclinity. The chosen storms Dagmar and Nina affected the Northern UK and Western Norway in the winters of 2011-2012 and 2014-2015, respectively. A buildup of the isentropic slope and atmospheric jet over the Atlantic by preceding storms is evident during the days before Dagmar develops and reaches Western Norway. We discuss the buildup of the baroclinicity for both cases as well as the relative contributions to its tendency. In addition, we describe the life cycle of these storms in terms of how the storm changes and uses its environment to attain its intensity. We also compare our diagnostic to more traditional measures, such as baroclinic energy conversion, pinpointing advantages and caveats of our method.