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Diabatic modification of potential vorticity in a north Atlantic cyclone

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Heating and cooling due to moist processes in extratropical cyclones introduce local anomalies of potential vorticity (PV). On the mesoscale, diabatically-induced flow anomalies can influence the evolution of mesoscale precipitation structures. If distributed over a large portion of the cyclone, the modified PV can also influence the evolution of the synoptic-scale wave pattern, thus effecting events downstream. The moist processes contributing to modification of PV are typically parameterized in numerical weather prediction models.

The purpose of this paper is to examine the structure and origin of diabatic PV near the level of the tropopause in a north Atlantic cyclone. A mature cyclone with a warm conveyor belt and a tropopause fold that was located northwest of the UK on 20 October 2008 was simulated using the Met Office Unified Model (MetUM) in a global domain (with $\sim$40km horizontal grid spacing in midlatitudes) and in a limited-area domain (with 12 km horizontal grid spacing). A set of Lagrangian PV tracers were integrated online. Each tracer accumulated and advected sources of PV from a specific modelled process (e.g., convection scheme, long-wave radiation, boundary-layer scheme, cloud microphysics). A key finding of this work is that diabatic PV was minimised along the 2 pvu tropopause. A dipole of diabatic PV straddled the tropopause with an increase (decrease) in PV above (beneath) the elevation of the tropopause. The positive diabatic PV above the tropopause was contributed primarily by long-wave radiative cooling, and the negative PV beneath the tropopause was contributed by the convection and large-scale cloud schemes. The practical and theoretical implications of the increased gradient of PV at the tropopause level will be discussed.