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Characterization of the diabatic processes within the warm conveyor belt of a North Atlantic extratropical cyclone observed during NAWDEX

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Extratropical cyclones (ETCs) result from a complex chain of interactions between large-scale dynamic forcings and mesoscale physical processes. Among them, diabatic processes are recognized to be a source of errors on the location and chronology of intense precipitations and strong gusts. These errors come in part from the poor representation of diabatic processes in numerical weather prediction models. This is particularly the case in the Warm Conveyor Belts (WCBs) where diabatic processes are the most significant. WCB is an ascending air mass carrying a significant flow of moisture from the subtropical low levels to the high layers of mid-latitudes. The ascending air releases heat in the middle troposphere, which modifies the atmospheric circulation both in the lower and upper layers.

Here, the diabatic processes are investigated for an ETC observed on October 2, 2016 during NAWDEX (North Atlantic Waveguide and Downstream Impact EXperiment). Two flights of the SAFIRE (Service des Avions Français Instrumentés pour la Recherche en Environnement) Falcon-20 carrying the RASTA (Radar Airborne System Tool for Atmosphere) radar were carried out through the WCB associated to the ETC. A convection-permitting simulation (Δx=2.5 km) was run with the Meso-NH model, in order to resolve explicitly convection within the WCB. The radar reflectivity profiles thus measured as well as the MSG (Meteosat Second Generation) brightness temperatures are well reproduced by the simulation. The budget of water vapor and potential temperature was calculated along the WCB trajectories. This confirms that heating by condensation and by deposition of water vapor on ice crystals dominate in the WCB. As shown by a potential vorticity assessment at the tropopause level, this heating contributes to reinforcing the anticyclonic circulation in the WCB output flow. To further evaluate the representation of diabatic processes and their impact on the ETC development, a coarser simulation in which the deep convection is parameterized (Δx=10 km) was run. It produces less precipitation exceeding 5 mm h-1 below the WCB than the high resolution simulation. The surface winds and the jet stream were also weaker. This study shows the necessity to explicitly represent the diabatic processes in ETCs.