Numerical study on the downstream impact of warm conveyor belts in extratropical cyclones

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Warm conveyor belts (WCBs) are important airstreams that occur in extratropical cyclones. Rising from the warm sector's humid boundary layer, they experience a strong ascent and latent heat release by condensational processes until they fan out at upper levels. WCBs ascend through the microphysically active cloud region and they experience characteristic changes in potential vorticity (PV) along their ascent. In most cases WCBs reach upper tropospheric ridges with low PV values where they contribute to the amplification of negative PV anomalies and downstream Rossby waves. The enhancement of upper-level ridges is often the cause for the generation of PV streamers or larger amplitude waves downstream, which then trigger extreme weather and/or the genesis of a new cyclone. Since this important dynamical effect of WCBs is driven mainly by the latent heat release due to phase transitions of water along the flow, WCBs and the downstream flow evolution are potentially sensitive to the moisture content in their inflow. Therefore, analysis errors in the low-level humidity in WCB starting regions (as have been identified with Lidar measurements) can lead to significant NWP forecast errors.

In this study, numerical sensitivity experiments are performed with the global IFS model from the ECMWF for at least two North Atlantic WCBs. The first case occurred during IOP2 of the T-NAWDEX-Falcon field campaign that took place in October 2012. During the campaign, Lagrangian observations in WCBs could be obtained from in-situ aircraft measurements. The second case has been selected because it was poorly predicted by the IFS. For the experiments, an extended model version of the IFS is applied, which allows (1) to separately diagnose the heating rates from the different microphysical processes occurring along the WCB, and (2) to conduct simulations with modified moisture in the inflow of the WCB. Using these novel tools, the contribution of the different microphysical processes to the Lagrangian PV modification and eventually their impact on the downstream upper-level wave structure and development can be quantified.