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Warm conveyor belts and cloud radiative forcing

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Warm conveyor belts are frequent flow features of extratropical cyclones in the Northern Hemisphere. They originate in the warm sector of cyclones in the boundary layer and strongly ascend within approximately two days to the upper troposphere. Due to their strong ascent, WCBs represent the strongest cloud and precipitation forming airstream in extratropical cyclones. On satellite images they are therefore often represented by extended cloudy areas along the cold front and to the North East of/above the cyclone centre.

The clouds which are associated with this strongly ascending airstreams can be liquid, mixed-phase or ice clouds and they can strongly interact with the longwave and shortwave radiation and thus strongly influence the Earths radiative budget in the extra-tropics (the region where WCBs and cyclones are most frequent). In our study we investigate how much of the cloud radiative forcing (CRF, longwave and shortwave) in the extra-tropical storm track is associated with WCBs.

We identify WCBs with a Lagrangian method, whereas WCB are represented by trajectories that rise at least 600 hPa in 48 h in the vicinity of an extratropical cyclone. For our study we use the existing climatology of WCBs (Madonna et al., 2014) which is based on a 30 year time period (1979 – 2010) of the ERA-Interim dataset. The CRF is then traced along all WCB trajectories during the considered 30 year period. Furthermore 10 – year CRF data from the CERES satellite project are used in order to evaluate the impact of WCBs on the long and shortwave radiation in the extra-tropics.

It can be seen that during the winter months, where WCBs are most frequent, a substantial part of the longwave and shortwave CRF in the storm tracks is connected to WCBs. As WCBs mostly ascend from the south towards the polar regions, they exhibit a negative net cloud forcing (NCF) along the southern part of the associated cloud band whereas in their northern part, the NCFgets positive due to the lack of sunlight in the winter months. The WCBs therefore strongly contribute to the positive NCF in the polar regions of the winter hemispheres.

These results highlight the importance of a correct simulation of WBS. A realistic representation of the frequency of occurrence, location and ascent of WCBs e.g. in global climate models is, besides the correct representation of the cloud's microphysical properties, crucial for a correct calculation of the cloud radiative forcing.