Microphysics and polarimetric features of snowfall associated with a warm conveyor belt during the ICE-POP 2018 campaign

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A warm conveyor belt (WCB) is a coherent moist airstream rising from the boundary layer to the upper troposphere in one or two days. It originates in the warm sector of an extratropical cyclone and is responsible for most of the precipitation associated to it. While it is relatively well understood how the bulk of the cloud is produced by the WCB, the details of the microphysics governing the growth of precipitation need to be further investigated. We take advantage of the complementarity between atmospheric models, remote sensing and in-situ measurements to study the impact of such a large-scale feature on the microphysics.

In this study we investigate the microphysics of an intense snowfall event associated to a WCB over Korea. The International Collaborative Experiments for Pyeongchang 2018 Olympic and Paralympic winter games (ICE-POP 2018) was a measurement campaign organised by the Korean Meteorological Administration. An X-band Doppler dual-polarisation radar was deployed in Gangneung at sea level. A W-band cloud profiler with a collocated 89 GHz radiometer and a multi-angle snowflake camera (MASC) were installed in PyeongChang at 789 m a.s.l.

On 28 February 2018, 57 mm of equivalent liquid precipitation were measured in 24 hours. It represents 77% of the 2018 winter precipitation in PyeongChang, showing the significance one single event can have on the seasonal precipitation amount in this region. The synoptic situation during this event consisted in a potential vorticity streamer that led to the intensification of an existing surface cyclone. The active warm front associated to this deep low pressure system reached the PyeongChang region at 06 UTC. Doppler radar measurements suggest the presence of a WCB with altitude and speed in good agreement with radio-soundings. Moreover, trajectories based on the Integrated Forecast System (IFS) model from the ECMWF show the presence of a WCB rising from 900 hPa to 300 hPa in 12 h. During the rapid ascent, supercooled liquid water (SLW) is produced inside the WCB with a maximum of 200 mg/kg around 5000 m a.s.l. A hydrometeor classification based on the polarimetric variables suggests that before the arrival of the WCB, the nimbostratus cloud contained mainly ice crystals. When the WCB reaches PyeongChang, we mainly observed aggregates below 4500 m. As the core of SLW passes over the measurement sites at 06 UTC, we observed predominantly rimed particles, consistent with a peak in brightness temperature measured by the radiometer and an increase in the degree of riming of the MASC images. This suggests that SLW produced in the WCB led to an intensification of riming during this period. Vertical profiles of polarimetric variables from 06 to 07 UTC reveal an increase in horizontal reflectivity (ZH) and differential reflectivity (ZDR) from 5500 m to 4500 m altitude. This is a signature of anisotropic growth of crystals by vapour deposition. Below 4500 m (T > -16 ˚C) ZH increases even more, while ZDR decreases abruptly. We interpret it as the onset of aggregation, as snowflakes are getting bigger (increase in ZH) and less oblate (decrease in ZDR). We advocate that updrafts and turbulence generated by the WCB enhances aggregation by increasing the time particles are suspended and the probability of collisions respectively. At 2300 m (T = -7 ˚C) a peak in specific differential phase shift (Kdp) is observed together with a maximum in proportion of rimed particles. We interpret this peak in Kdp as secondary ice generation by the Hallet-Mossop process.

This case study reveals the impact of a strong WCB in the observed snowfall microphysics. Firstly, the SLW produced during the rapid ascent in the WCB led to intense riming and production of secondary ice particles. Secondly, the updrafts and turbulence generated by the WCB enhanced aggregation. This shows the importance of the interactions between large-scale dynamics and microphysics in the considered snowfall event.

Keywords: microphysics, dynamics, dual-polarisation radar, warm conveyor belt, riming, aggregation