– Three periods could be identified, where the governing microphysical processes are directly influenced by the specific flow conditions in the WCB. In the first period, Pyeongchang is located below the WCB outflow (Fig. 5a). No strong updraughts were present, the precipitation intensity was low and we observed mainly small aggregates and crystals. In the second and third periods, Pyeongchang is located below WCB ascent. A layer with strong vertical wind shear, whose height decreases with time, generates turbulent cells and updraughts. The precipitation intensity peaks between 7 and 10 $\mathrm{mm\,h^{-1}}$ and large rimed aggregates are observed.

This study enabled the investigation of the impact of a large-scale feature, such as a WCB, on the microphysics thanks to the complementarity of atmospheric models, remote-sensing and in situ measurements. It suggests a strong coupling between processes on the synoptic and micro-scales that has to be assessed when evaluating the representation of cloud and precipitation in atmospheric models. While this case study presents a detailed analysis of field measurements, additional investigations with in situ measurements in clouds - characterising the presence of SLW for instance - are needed to further constrain and evaluate the coupling between large-scale dynamical processes and microphysics in models.

Code and data availability. The trajectories were computed with the Lagrangian analysis tool LAGRANTO (Sprenger and Wernli, 2015). We used functions from the Python libraries Py-ART (Helmus and Collis, 2016) and MetPy (May et al., 2008). Other codes and data are available upon request to the corresponding author.

Appendix A: Estimation of the critical vertical velocity

In this appendix we will show details on the estimation of the critical vertical velocity U_z^* needed to form and maintain liquid water in the presence of both ice crystals and snow. Korolev and Mazin (2003) showed that U_z^* can be expressed as a function of pressure, temperature, number concentration and mean size of ice crystals. We use Fig. 10 in Korolev and Mazin (2003), which gives the relation between U_z^* and the product of the number concentration of ice particles N_i and the characteristic size of ice particles r_i for temperature between -35°C and -5°C. Since in our case we have both ice and snow particles, we compute separately N_i and the number concentration of snow particles N_s such that the total number concentration is: $N_{tot} = N_i + N_s$. We also compute the characteristic size of the mixture of ice and snow particles r_{tot}. The expression for N_i is given by Eq. 7.40 of ECMWF (2016):

$$N_i = 100\,exp[12.96\,(e_{sl} - e_{si})/e_{si} - 0.639], \tag{A1}$$

where e_{sl} (e_{si}) is the saturation vapour pressure with respect to liquid (ice). The expression for N_s is given by Eqs. 7.15 to 7.19 in ECMWF (2016). In our case it is simply expressed by:

$$N_s = \Lambda^{-1}\,N_{0s}, \tag{A2}$$

where $N_{0s} = n_{as} = 2 \cdot 10^6$ (Eq. 7.16 and Table 7.1 of ECMWF (2016)) and Λ is given by (Eq. 7.18 of ECMWF 2016):

$$\Lambda = \left(\frac{n_{as} a_s \Gamma(3)}{q_s rho} \right)^{1/(b_s+1-n_{bs})} \tag{A3}$$

$$\Gamma(3) = \int_0^\infty D^2 e^{-D} dD = 2, \tag{A4}$$

where $a_s = 0.069$, $b_s = 2$, $n_{bs} = 0$ are given in Table 7.1 and 7.2 of ECMWF (2016). The expression for r_i can be found by stating that the characteristic volume of an ice particle V_i is:

$$V_i = \frac{\rho q_i}{\rho_i N_i}, \tag{A5}$$

where ρ is the air density, ρ_i the density of ice particles and q_i the mixing ratio of ice. Assuming spherical particles, we can express r_i with:

$$r_i = \left(\frac{3 \rho q_i}{4 \rho_i N_i \pi} \right)^{1/3}, \tag{A6}$$

Since snow particles are spherical in IFS and considered as having the same density as ice, we have $\rho_i = \rho_s$. We define r_{tot} as:

$$r_{tot} = \left(\frac{3 \rho (q_i + q_s)}{4 \rho_i N_{tot} \pi} \right)^{1/3} \tag{A7}$$

Using the values described in Table A1, we find $N_{tot} r_{tot}$ = 1.7 $\mu\mathrm{m}\,\mathrm{cm}^{-3}$, which we can use in Fig. 10 of Korolev and Mazin (2003) to read U_z^* at about -13 $^\circ\mathrm{C}$ and find 0.1 $\mathrm{m}\,\mathrm{s}^{-1}$.

Author contributions. JG and AB designed the experiment. JG operated the instruments, processed and analysed the observational data. AO computed and analysed the WCB trajectories. NJ computed the MASC size distributions. NB computed the radar based hydrometeor classification. JG, AO, EV and AB interpreted the data. JG, with contributions of all authors, prepared the manuscript.

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