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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Influence of heterogeneous freezing on the microphysical and radiative properties of orographic cirrus clouds" *by* H. Joos et al.

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Anonymous Referee #2

Review of 'Influence of heterogeneous freezing on the microphysical and radiative properties of orographic cirrus clouds' by Joos et al. The study examines the competition between heterogeneous and homogeneous ice formation during the evolution of an orographic wave cloud. The subsequent effects on the radiative impact of the cloud are explored.

I found the paper interesting and it would be publishable once the following points have

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been addressed.

1. The study, and the results given, are very specific to the dynamic and environmental profiles employed. It would be useful to discuss the wider relevance of these results in terms of their application to different situations e.g. stronger or weaker orographic forcing, different wavelengths etc.

-The dependence of the simulated ICNB, IWP and optical depth on the dynamical and thermodynamical environment has been tested in Joos et al. (2009), ACP for simulations with homogeneous freezing only. The main finding was that the optical depth strongly depends on the temperature inside the ISSR because for our setup, RHi was set to constant values at the beginning of each simulation, implying that higher temperatures lead to more water vapour. Furthermore we showed that the vertical wave phase in which the cloud forms (thus, the vertical velocity which occurs in the ISSR) strongly influences the properties of the cloud. A decrease in the vertical velocity due to a shift of the position of the ISSR to a lower height can lead to a decreased optical depth although the temperature and thus the available water vapour is much higher at this lower position. However, the dynamical forcing strongly influences the cooling rate and subsequently determines the ICNC and optical depth. As these effects have been investigated in Joos et al. (2009) we do not mention those in this paper.

In particular, the IN concentrations considered are much smaller than the ice concentration formed through homogeneous freezing. Although probably not realistic it is interesting to consider the situation where the IN concentration starts to approach the concentrations of ice due to homogeneous freezing. Does the behaviour of IWP, optical thickness and cloud forcing still change monotonically or is there a turning point in the behaviour. It would be good to know where the monotonicity breaks down.

-Thank you for this interesting suggestion. In order to investigate whether the monotonicity breaks down, we performed additional simulations with 100,150, 200 and 300 IN L-1 for the reference temperature profile and 6-12 local time. We added Figures

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and the explanation in the Appendix A. See also Figure (12,13). If the IN concentration becomes larger than 50 l−1, the ICNB, IWP and optical depth start to increase again. In the simulations with more than 50 IN l −1 the homogeneous freezing is strongly weakened or even totally supressed for simulations 200 IN and 300 IN. However, the high IN concentration in these simulations leads to an increase in the heterogeneously frozen ice crystals (ICNB) and thus IWP and optical depth increase. Additionally, one main difference compared to HOM is the fact that a cloud forms also at the windward side of the mountain. Thus, ICNC at the windward side of the mountain is increased compared to HOM whereas the ICNC above the mountain top is strongly decreased because homogeneous freezing is strongly weakened/supressed. Thus, the monotonicity breaks down if the IN exceed a value between 50 and 100 l-1. The SCF, LCF and NCF show the same behaviour (see Figure 13). In the simulations with more than 50IN l-1, the absolute values of SCF and LCF start to increase again. This behaviour equals the one for the optical depth. Again, the increase from 50IN to 300IN is less pronounced than the decrease from HOM to 50IN. For the 300IN simulation, the same mean optical depth as in 5IN is simulated. However, the NCF does not show the same value in these two simulations. This is caused by the different distribution of the ice crystals in the luv and above the mountain. In front of the mountain, the NCF is more negative in 300IN compared to HOM whereas it is less negative above the mountain top. This reflects the distribution of ICNB and IWP in these two simulations.

2. The proof reading of the paper needs to be improved. Some values are missing (eg xx p18087 line3). Some sentences were difficult to understand e.g. between l5-10 p18085.

-We inserted the missing value and restructured the text and figures and added additional information (see fig. 3,4 and 7).

3. The discussion seems much too detailed in terms of the methodology. I felt that i was re-reading earlier parts of the paper rather than just being reminded of the methodology. This could be summarised better.

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-We restructured the summary and now emphasize the most important findings.

4. Figure 1 is difficult to read. Figure 1 is taken from an earlier publication. Therefore we decided not to change it.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 18069, 2013.

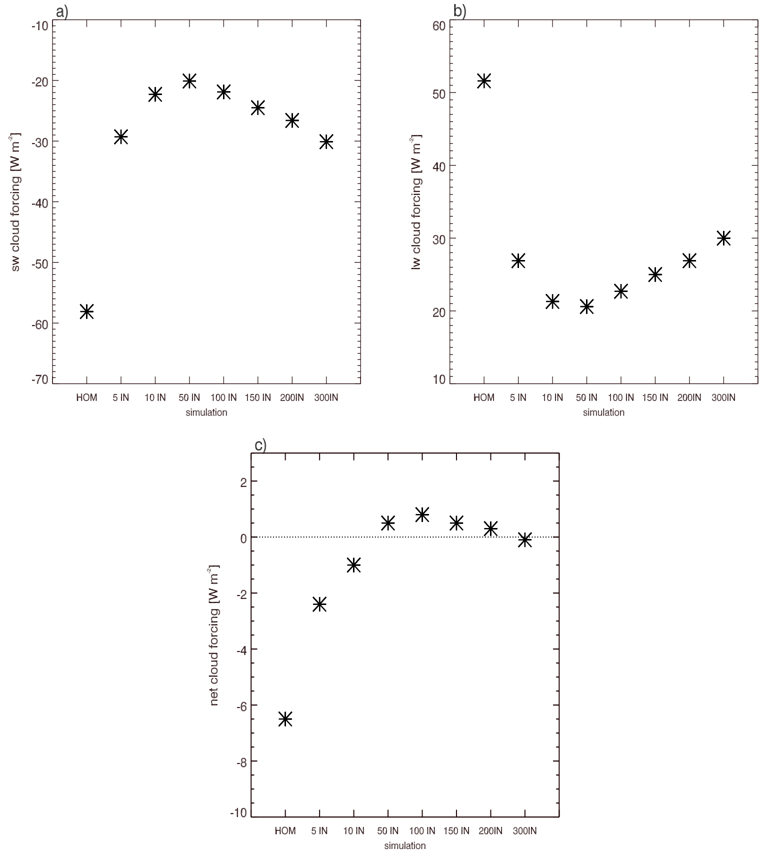

Fig. 1. cloud forcing for simulations with high IN concentration (Fig. 13 in new manuscript)

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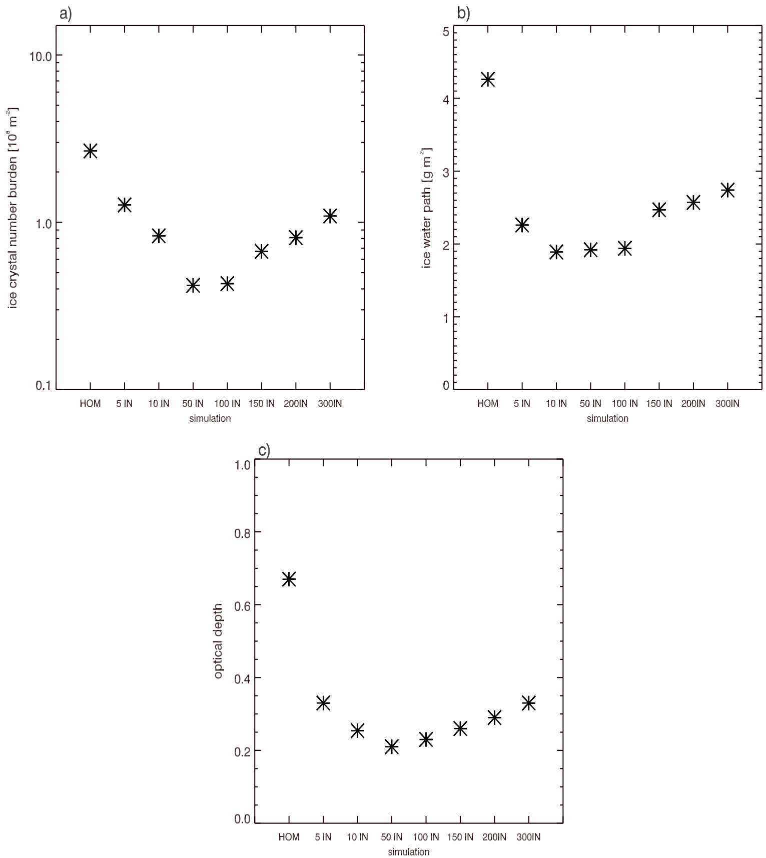

Fig. 2. microphysical properties for simulations with high IN concentration (Fig. 12 in new manuscript)

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