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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sensitivities of Lagrangian modeling of mid-latitude cirrus clouds to trajectory data quality" *by* E. Kienast-Sjögren et al.

Anonymous Referee #1

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This work examines the uncertainties of Lagrangian parcel modelling of cirrus clouds to the details of model configuration (resolution, small-scale temperature fluctuations, initial water vapour content, and nucleation mechanism). The analyses are carefully done and scientifically sound. The manuscript contributes to progress in cirrus cloud modelling, and it is suitable for ACP. I recommend publication of the manuscript, subject to revisions.

In general, the manuscript is difficult to read. For instance, the abstract provides too many technical details and does not clearly highlight the main results, which are (based on my understanding):

- The model calculations are sensitive to the temperature fluctuations, upstream specific humidity, and nucleation mechanism, and the uncertainties associated with these factors are highly non-linearly linked.
- High resolution is required in order to account for the small-scale (high-frequency) temperature fluctuations.

I suggest the authors to rewrite the abstract to communicate these points more effectively to the readers. In addition, although the main results (as stated above) are important, they are not especially new (I expect these results before reading the manuscript). Also, I am concerned that some of the model results may not be robust, i.e. very specific to the particular cloud studied here. Thus, the additional case (currently in the appendix) is helpful. Having these two cases, the authors could focus the discussions on the results that are robust (or not robust), and by doing so clarify the main conclusions of the paper.

Please see my specific comments below:

- Page 7538, line 15: "ice nuclei number density" is not quite correct. The simulations were carried out with homogeneous nucleation only, and with both homogeneous and heterogeneous nucleation with varying ice nuclei number densities. In section 2.3, please provide the number density of solution droplets used for the calculation of homogeneous nucleation.
- Section 2.2.1: It would be very useful to carry out a simulation of the cloud in the Eulerian domain using the COSMO model. The Lagrangian parcel calculations are subject to additional uncertainties (treatment of shear and particle sedimentation) and thus would greatly benefit from the comparison with the cloud simulation in the Eulerian domain.
- Page 7543, lines 11–13: Please state the vertical resolution in the cloud layer.

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Given the thickness of the cloud (1.5 km), please comment whether such vertical resolution is sufficient.

- I suggest referencing Spichtinger and Krämer (2013) and Dinh et al. (2015). These papers have discussed specifically how small-scale, high-frequency temperature fluctuations affect ice nucleation, and thus are particularly relevant here. Also, the high sensitivity of ice number density to the initial water vapour content of air parcels has been studied in Dinh et al. (2015, see their section 5.3).

- The radiative-dynamical effects (see e.g. Dinh et al., 2010; Schmidt and Garrett, 2013), which have not been considered here, could explain why the current model calculation underestimates the cloud extinction, especially at the cloud top in the active case (figure 14). Indeed, the radiative heating rate could be quite significant in the active case. The radiatively induced updrafts and water vapour flux convergence could help to maintain the cloud, and produce a higher cloud top and cloud thickness (see Dinh et al., 2010, their figure 7). Such features would be consistent with the lidar measurements in figure 14.

References

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