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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ice phase in altocumulus clouds over Leipzig: remote sensing observations and detailed modelling" *by* M. Simmel et al.

Anonymous Referee #1

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General coments

The authors study two altocumulus cloud case studies that were observed over Germany via ground-based remote sensing. The cases were selected to represent the warmest possible ice formation and more typically cold ice formation within altocumulus. The authors apply an axisymmetric 1D model with spectral microphysics. The model is initialized with observed or model-derived thermodynamic profiles. Varying assumptions are made regarding prescribed vertical motions, aerosol and ice nucleus properties, and ice habit. Generally little work has been done on altocumulus microphysics, but that which has been done requires more review in the introduction and conclusions to motivate this work and to place the results into context. The approach is generally sound, but not enough details are provided to allow the work to be repro-

duced. The observations should be shown and described more completely. Overall, this work merits publication after revisions to the manuscript that can readily address specific comments below.

Specific comments (page/line number if relevant)

1. The scientific questions to be addressed are not adequately stated. Ice nucleation is discussed in the very short introduction, but no questions are targeted for this study. This is perhaps related to the problem that the authors provide no background on altocumulus. Has any study simulated such clouds before? Why did the authors choose to use a model? Why this model with elaborate microphysics but simple dynamics? Has any literature drawn conclusions about altocumulus relevant to this study? Does this study produce conclusions that are consistent with past literature? References should include Fleishauer et al. (JGR 59:1779, 2002), for instance.

2. The observations that motivated the selection of these cases, and which are relied upon, are not adequately shown and their uncertainty properties are not described. Figure 1b makes a good start at showing case 1 cloud conditions, but other case 1 figures are truncated in time. Please show all five of the following fields between 23:45 and 0:40 for case 1 (providing important context for the narrow 20-minute window used for the study) and for case 2: lidar backscatter, radar reflectivity, retrieved IWC, retrieved LWC, retrieved vertical wind. Only the first is shown for the full time range for case 1. LWC is never shown now. Also please report the stated or estimated uncertainty properties of IWC, LWC and vertical wind speed. Are there no clear-air vertical wind retrievals from the Doppler lidar? Please explain why the vertical wind speeds shown in Figure 2 appear as they do for lidar. Finally, please show plots of the initial soundings used, including RHI and RH.

3. The authors acknowledge that the specification of vertical winds is a controlling parameter, but they do not discuss the general nature of these winds, which seems to be important to understanding the relationship of the model setup to the large-scale

conditions. Is the mean vertical wind described large-scale in nature whereas the stochastic components are turbulence? I would expect the updrafts and downdrafts within altocumulus to be driven by cloud-top cooling rather than large-scale winds. In the case that cloud-top cooling-driven turbulence is driving mixing between downdrafts and updrafts, I would expect it to drive the supply of IN. However, the authors state that the mean wind is driving the supply of IN. Does that mean that large-scale convergence is driving the supply of IN to updrafts and downdrafts whereas turbulence does not play a role in the supply of IN?

4. The model vertical resolution is 25 m, but what is the size of the inner and outer cylinder? How was it decided how large to make the inner and outer cylindrical coordinates? Are results sensitive to the specification of cylinder relative size? Is the inner cylinder considered to be the whole 20-min cloud observed (both updrafts and downdrafts) whereas the outer cylinder is the air surrounding the cloud? If so, how much air surrounding the cylinder? Or is the cylinder specified to be an updraft element size, similar to deep convection studies?

5. Aggregation and riming are neglected? Please provide some literature support for why that would be appropriate or otherwise explain.

6. (1581/21) M1 and M6 both have lower free troposphere aerosol. Why did you choose M6 for case 1 and M1 for case 2? How did you apportion 1e5/kg aerosol among the three modes?

7. (1586/6, 1578/4) DeMott et al. (2010) did not analyze measurements colder than –9 C, to my knowledge. Did you extrapolate their relationship to colder temperatures? If so, how did you decide at what temperature to stop extrapolating when approaching 0 C?

8. (1579/2) Because the relationships in Mitchell et al. (1996) and past literature have been derived from observations over limited size ranges, it is not uncommon to use more than one relationship to represent columns of various sizes (e.g., Sölch et

al. QJRMS 136:2074, 2010, table AII). Please provide sufficient information re exactly which relationships you used and over what size ranges for this work to be reproduced.

9. (1575/5) Could preconditioned ice nuclei be nucleated as warm as -1 degrees C or some other temperature limit? Please explain mechanistically how preconditioning could introduce ice nuclei relevant in this study, with reference to literature and relevant temperature range.

10. (1576/30) IWC is shown to 2000 m in Figure 1, which apparently is warmer than 0 C according to the text, which states that IWC extends to only 3000 m. Please clarify.

11. What is the model time step used?

12. (1582/22) It is stated that "ice forms primarily at cloud base". Does this mean that ice is primarily nucleated at cloud base? Cloud base is warmer than cloud top, so I would expect more rapid nucleation at cloud top. Please explain.

Techical corrections

1 (1576/3). Please define TROPOS.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 1573, 2015.