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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Captured Cirrus Ice Particles in High Definition" *by* Nathan Magee et al.

Anonymous Referee #2

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1 Content

The manuscript is about ice crystal observations with a new balloon borne instrument device. With this instrument the ice crystals are captured during the flight, conserved and analysed with a scanning electron microscope (SEM) in the laboratory. With this technique they found a larger variety of ice crystals shapes and geometries as well as surface roughness.

2 Overall impression and rating

The overall impression of the manuscript is good. The manuscript is mostly easy to understand and to my opinion enough structured. This novel technique of capturing ice crystals and detailed analysis of their surface will enhance the knowledge of which types of crystals and their fine structure can be found in the atmosphere. I really like the detailed SEM pictures of ice crystals and your video is also nice to watch. I agree mostly with the interpretations and I think that the manuscript is a good contribution to the science community. I have some smaller concerns, which should be addressed before publication. For these reasons, I recommend publication in ACP after minor revisions.

3 Specific comments/questions:

- **Sampling characteristic**
  The focus of the manuscript is more on the results of the different balloon soundings, which is of course important to be a publication in ACP. However, I think that there should be a bit more technical information about the sampling characteristic of the instrument, which is important to understand the observations. For example you mentioned that the efficiency of collection is high for particles larger than 50 microns. In Luebke et al. 2016 Figure 10 you find averaged cirrus size distributions of different cloud types which show that a large fraction of ice crystals are also below 50 microns in diameter. If those particles would not enter your sample device you would get only the large crystals which would lead to a distortion of your cloud statistic. Therefore, it would be good if you can provide more information like lower/upper cutoff size, sampling efficiency for different particle sizes, sampling volume, minimum number concentration in Section 2.1.

- **Mapping of microphysical properties to atmospheric conditions**
  As far as I understood the sampling device just samples the crystals from the bottom to the top of a cloud consecutively in one or maximum two sample probes. In case that the number concentration in the cloud is rather low, I can imaging that the mapping of ice crystals found in the sampler to the location and thus to the atmospheric condition (temperature, pressure, humidity) is not really possible. You always find a mixture of particles form the whole cloud column. The other extreme would be a very high number concentration of crystals in the cloud. In this case you see so many crystals on top of each other that you only can see the cloud top in the upper layer of your probe. Than you do not have a full picture of the whole cloud. With this two examples I cannot fully follow the argument of Section 4.1, where you stated to find a large habit heterogeneity within single clouds. You should discuss this point in more detail and maybe also assess which impact do you see your statement of this section due to the sampling.

- **Sampling of different cirrus cloud types**
  At some point in the text (best in Section 2.3) you should mentioned that you focus mostly on thick cirrus layer as they occur typically within frontal systems like warm convenor belts. This is mainly caused by your launch planning/preparation approach and the better predictability of such frontal cirrus clouds. These clouds have typically a large ascent (see e.g. your trajectory with ascent from 5.5 to 11 km in the supplementary material) bringing high amount of moisture into the cirrus altitude. These clouds typically pass through the mixed phase temperature range above -38°C and are referred in the literature as liquid origin cirrus clouds (e.g. Luebke et al. 2016 or Wernli et al. 2016). Ice crystals in these clouds are typically larger in size and show a more complex shape compared to in-situ formed cloud at cirrus altitudes. I suggest to mention these in your text that your results are mostly representative for liquid origin clouds and may not be meaningful for in-situ formed clouds.

- Page 8, lines 220-223: The influence of cloud origin and dynamics on crystal size is in agreement with other studies. Here, I would recommend to cite the paper by Luebke et al. 2016.

- Page 12, lines 351-352: I cannot follow your argumentation that you found sublimated ice crystals at the cloud top due to entrainment. Usually, the cloud top is dominated by nucleation of crystals and there you have the coldest temperatures and highest relative humidity wrt. ice (see e.g. Spichtinger and Gierens 2009). Thus, to find sublimated ice crystals at cloud top seems to unrealistic. At least this argument needs more explanation, citations etc and also discussion with point above.

- Figure 2: What is the large "rock" in the upper left part of the SEM picture. Maybe you can mentioned this also in the text because it is very conspicuous.

4 Technical comments/suggestions:

- **Units in the manuscript**
  In ACP usually all values and their units are given as SI base unit. For example you use the kt for the wind speed which should be given in meters per second (m/s). This unit is also recommended by the World Meteorological Organization for reporting wind speeds. I would recommend to go through the entire manuscript and change all non SI units like miles etc. to appropriate SI unit.

- Page 2, line 43: I suggest to cite also Sourdeval et al. 2018 to have one representative paper of cirrus properties using lidar/radar technique.

- Page 7, line 178: "Hitachi SU5000 is employs a Schottky ", the word "is" is to much.

- Page 7, line 181: Minus is missing at the temperature value. Should be ~-160°C
- Page 10, line 288: Capitalize the "c" --> panel C.
- Page 12, line 334-335: Please use another word than categories, because the reader expect than particles to be sorted in specific categories which is not the case here. It is more like a list of all the findings. You should use e.g. topics or findings.
- Page 13, line 385: "finer than" instead of "finder that"
- Page 14, line 392: I think you mean 500nm instead of 500 microns
- Figure 4: a) No scale, please add a scale here. b)-left and c)-left Scale not readable. b)-right and c)-right Table not readable, please enlarge or skip. Peak classification in the diagramm not readable, please enlarge Peak labels.
- Figure Supl. 1-F (a) and 1-G (a-f): Scale not readable. Can please add the same gray shadow behind the scale as you did in the other pictures.

5 References:

- Luebke, A. E., Afchine, A., Costa, A., Grooß, J.-U., Meyer, J., Rolf, C., Spelten, N., Avallone, L. M., Baumgardner, D., and Krämer, M.: The origin of midlatitude ice clouds and the resulting influence on their microphysical properties, Atmos. Chem. Phys., 16, 5793–5809, https://doi.org/10.5194/acp-16-5793-2016, 2016.
- Sourdeval, O., Gryspeerdt, E., Krämer, M., Goren, T., Delanoë, J., Afchine, A., Hemmer, F., and Quaas, J.: Ice crystal number concentration estimates from

lidar–radar satellite remote sensing – Part 1: Method and evaluation, Atmospheric Chemistry and Physics, 18, 14 327–14 350, doi:10.5194/acp-18-14327-2018, 2018.

- Spichtinger, P. and Gierens, K. M.: Modelling of cirrus clouds – Part 1b: Structuring cirrus clouds by dynamics, Atmos. Chem. Phys., 9, 707–719, https://doi.org/10.5194/acp-9-707-2009, 2009.
- Wernli, H., Boettcher, M., Joos, H., Miltenberger, A. K., and Spichtinger, P. (2016), A trajectoryâĂŘbased classification of ERAâĂŘInterim ice clouds in the region of the North Atlantic storm track, Geophys. Res. Lett., 43, 6657– 6664, doi:10.1002/2016GL068922.

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