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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ice water content vertical profiles of high-level clouds: classification and impact on radiative fluxes" *by* A. G. Feofilov et al.

Anonymous Referee #3

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Review of:

Ice water content vertical profiles of high-level clouds: classification and impact on radiative fluxes by A.G. Feofilov et al.

This manuscript describes radiative effects of ice clouds on a global basis. The authors take up the challenge to connect different satellite dataset (Lidar, Radar, Radiance) as well as meteorological fields to investigate vertical profiles of ice water content (IWC) and connect their shape to changes in radiative fluxes. They found a minor impact of IWC profile shape on the global radiative budget. The results of these study are very helpful for reducing the uncertainties in cloud radiative forcing estimates and also for nadir satellite retrievals. The presentation of the manuscript is excellent and nicely to

read. It is well organized and the analysis and results are clearly structured and communicated. For these reasons, I recommend publication in ACP. The authors may want to consider the following comments/questions in preparing the final/revised version.

1 Specific comments/questions:

- p 16329 l. 11-13: In this paragraph you state that CALIPSO measure also thin clouds. For example in a paper by Davis et al. 2010 it is shown that CALIPSO miss a significant fraction of sub-visible cirrus clouds (OD < 0.03) in the CALIPSO L2 cloud product. Especially in the tropics a large amount of sub-visible cirrus clouds occur, which have a radiative impact. Parts of these clouds and their IWC profiles are most likely not included in your analysis. I would suggest to write a short sentence, where you state that CALIPSO could underestimate sub-visible clouds and cite e.g. Davis or other.

- p.16332 l. 3-7 and Table 2: In this paragraph you describe the amount of selected data. In the later analysis you use latitudinal averages of different ice cloud variables. Therefore the question, if there is any latitudinal dependence on the data coverage with some poorly covered regions ? Can you please comment on this.

- p. 16337 l. 4: Cirrus formation mechanism are not only by in-situ formation and anvil cirrus. Warm conveyor belts (with relative slow updraft) can also produce completely frozen ice clouds from the mixed phase regime in the cirrus altitude range (e.g. Spichtinger et al. 2005). Maybe you add an "e.g." in the bracket or list more formations mechanism.

- p. 16337 l. 11-12: You used the best fit of the four shapes for the ice water profiles in your analysis. Could all observed profiles assigned clearly to one profile or are there some shapes which are not or hardly be represented by your set of the four shapes ?

-p. 16338 l. 18-25: Aggregation in cirrus plays only a role in warm cirrus or completely frozen mixed phase clouds at T > -40 °C (see Kienast-Sjogren et al. 2013). I would explain the lower triangle in downdraft regions in another way. The top of cirrus clouds is mostly know as cirrus formation region with small ice crystals. In case of a downdraft the whole cloud becomes sub-saturated and the small ice crystals at the top sublimate much faster than the lower parts with larger crystals increasing the amount of lower triangle cases. In addition, i don't like the explanation with the wash out of particles in a large updraft. In large updrafts homogeneous freezing is triggered and a lot of small ice crystals appear (see Kärcher et al. 2002) within the whole cloud. Because the whole cloud consists of small particles which need more time to grow to larger sizes, the probability to find upper and lower triangles profiles is reduced.

-p. 16339 l. 18: In this paragraph you describe the common understanding of ice nucleation. The general understanding of the term "ice nuclei" means insoluble particles which triggers heterogeneous freezing. For homogeneous freezing, predominantly happens at temperature below -40°C, supercooled water droplets are responsible for ice formation. There i would recommend to avoid using the word "ice nuclei".

-p. 16339 l. 19: Clustering (see comment above) happens only in warm cirrus. In in-situ cirrus the number concentrations are usually not high enough to cluster ice particles. In this case the ice crystals grow only by water uptake in super-saturation regions to sizes were they start to sediment.

2 Technical comments:

- p. 16336 l. 21-22: From Figure 6a i cannot confirm the kab=1.1 value for IWP < 10 gm-2. For me it looks more like 1.2 for IWP < 10 gm-2 or 1.1 for IWP < 2 gm-2 . I suggest to correct the number in the text.

- Table A1: The acronym LWC (liquid water content) is missing in the table.

- Figure 2: Maybe add the location of each profile in the header.

3 References:

Davis, S., et al.: In situ and lidar observations of tropopause subvisible cirrus clouds during TC4, J. Geophys. Res., 115, D00J17, doi:10.1029/2009JD013093, 2010.

Kärcher, B., and Lohmann, U.: A parameterization of cirrus cloud formation: Homogenous freezing of supercooled aerosols, J. Geophys. Res., 107(D2), doi:10.1029/2001JD000470, 2002.

Kienast-Sjögren, E., Spichtinger, P., and Gierens, K.: Formulation and test of an ice aggregation scheme for two-moment bulk microphysics schemes, Atmos. Chem. Phys., 13, 9021-9037, doi:10.5194/acp-13-9021-2013, 2013.

Spichtinger, P., Gierens, K., and Wernli, H.: A case study on the formation and evolution of ice supersaturation in the vicinity of a warm conveyor belt's outflow region, Atmos. Chem. Phys., 5, 973-987, doi:10.5194/acp-5-973-2005, 2005.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 16325, 2015.