Atmos. Chem. Phys. Discuss., 15, C7756–C7760, 2015
www.atmos-chem-phys-discuss.net/15/C7756/2015/

Atmospheric Chemistry and Physics
Open Access
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.

A. G. Feofilov et al.

artem.feofilov@lmd.polytechnique.fr

Received and published: 8 October 2015

We thank the reviewer for his/her analysis and helpful suggestions.

Below, we provide point-by-point answers to each of the comments/questions. We mark the reviewers' comments/questions and the authors comments/responses by "**RC:**" and "**AC:**", respectively.

1. Specific comments/questions

RC: 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.

AC: We agree with this comment. However, since we use a joint colocated database, the filtering is done using the "logical AND" condition, so if any of the contributors (AIRS, DARDAR, CALIPSO, GEOPROF) does not mark the scene as a cloud, it is excluded from the consideration. In this dataset, AIRS is known to be less sensitive to thin cirrus than CALIPSO, so the filtering of aforementioned sub-visible cirrus clouds is automatic. The properties and statistics of a joint colocated product are discussed in Sect. 3.1. As the reader knows by the end of the paper, all radiative effects related to IWC vertical profile are negligible for thin clouds, and there is no need for additional discussion on cloud filtering, so we have modified only the text of the paragraph and added the reference to Davis et al., 2010.

RC: 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?

AC: Since the instruments share the same orbit and the geometry of the observations does not change, the coverage does not change with latitude, either (except for the very poles). However, filtering out the clear sky scenes and sub-visible cirrus clouds leads to changes in latitudinal coverage of the product we analyze. It becomes modulated by the cloud cover and the detection threshold, and the joint effect is roughly equal to IWP modulation (areas with large IWP are picked up more often than the dry ones). Still, the number of cases under consideration for each latitude remains large (on the order of hundreds per month per 1-degree belt) and the observed picture remains representative.

RC: 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.

AC: We opted to add "e.g.", thanks for pointing this out.

RC: 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?

AC: This is a good point. The closest shape selection algorithm always makes its choice based on the r.m.s. of the deviation between the model IWC profile and the real one, and for the sake of simplicity we do not provide the analysis of the goodness-of-fit for the cloud types w.r.t. their IWP or geometrical thickness. Indeed, some of the DARDAR shapes show a zig-zag-like structure like the one in Fig. 2a or Fig. 5d and it's obvious that fitting these profiles with a model one will give worse r.m.s. of the deviation than, for example, that of Fig. 5e. Still, all IWC profiles fit well into one of the 4 patterns: increasing top-to-base, increasing base-to-top, constant, or "high middle fading to the edges". As one can see in the Table 4, other shapes we tested are linearly dependent with one of 4 shapes and introducing wave-like profiles is impossible due to their variety.

RC: -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.

AC: Thanks for a very reasonable suggestion – we have made it the first explanation and left the one given by us as a second one, accompanied by a reference to (Kienast-Sjogren et al. 2013). As for the updrafts, we have updated the text in accordance with the mechanism suggested in the comment.

RC: -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".

AC: We agree with this comment. On the other hand, one should not exclude the heterogeneous mechanism from this description, so we have specified the conditions for heterogeneous freezing in the text.

RC: 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.

AC: We have replaced the word "clustering" with "growing".

2. Technical comments

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

AC: This is correct. We have modified the text and included both IWP limits.

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

AC: Fixed, thanks.

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

AC: We have added the latitude / longitude values to figure caption. All examples correspond to tropical latitudes and the selection was done solely on the closeness to even numbers (10, 30, 100, 300 g/m^2) for illustration purposes.

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