

Interactive comment on “Ice water content of arctic, midlatitude, and tropical cirrus – Part 2: Extension of the database and new statistical analysis” by A. E. Luebke et al.

Anonymous Referee #2

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General Comments

This study collects and introduces a relatively large amount of observational data on ice water content (IWC) in cirrus from different geographical regions. An analysis of the IWC as a function of temperature and PDF variability of IWC in different temperature bins is also conducted. This dataset is certainly very useful for the model evaluation and thus worth being published in Atmos. Chem. Phys. The analysis is also a good attempt to understand the mechanisms of cirrus cloud formation. The manuscript is in general well written. However, there are several weaknesses in the paper that need to be improved, which are documented in my general and specific comments below.

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1. One conclusion of this study is that the IWC is determined by ice crystal number (Ni). This conclusion is reached by comparing the correlation of PDFs of IWC and Ni. However, this is not convincing. IWC is determined by the ice crystal growth from vapor deposition in cirrus. At higher temperatures with larger saturation vapor pressure, IWC tends to be large. Ice crystal radius (Ri) is certainly determined by the growth process. This may be the reason why IWC has a good correlation with Ri (Liou et al., 2008). In comparison, Ni is determined by the ice nucleation and influenced by the ice aggregation. The correlation between PDFs of IWC and Ni seen in this study may be because the analysis in this study did not separate different geographical regions. The lower peaks of PDFs of IWC and Ni are corresponding to the TTL (having both lower Ni and IWC), while the higher peaks are from other regions (having both higher Ni and IWC). Thus more solid analysis may be needed to warrant the conclusion.
2. This authors claim the lower peak of PDF of IWC is caused by the heterogeneous nucleation while the higher peak is by the homogeneous nucleation, and refers Spichtinger and Kramer (2012). However, from Spichtinger and Kramer (2012) it was suggested that the lower peak is produced from the homogeneous and a mixing of homogeneous/heterogeneous nucleation under the very slow large-scale motions superimposed with high frequency short wave. The dominant role of heterogeneous nucleation mechanism for TTL cirrus is still not concluded.
3. The description in section 2.1.3 for FISH and CLH analysis methods, e.g., equations (1) and (2) is not clear. This will be further noted in my specific comments below.
4. Some discussion in conclusion section on how the data collected in this study can be used for climate models will be valuable.

Specific Comments

1. P29445, L7, “owing to the number and ...”. It is unclear here what you mean for “number”?

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2. P29446, L14, "and measured variability is not considered". Variability of what?
3. P29446, L17, "to create these models". Here "models" should be "parameterizations".
4. P29448, L19, "Sect. 2.3" should be "Sect. 2.1.3".
5. P29449, L17-19. I don't understand how "water vapor saturation mixing ratio" can be used to determine IWC since it is not always saturated to ice in cirrus (i.e., it can be either super- or subsaturation with respect to ice).
6. P29450-29451. The description is unclear to me, e.g., equations 1 and 2. What is "enhancement factor" in the last line of P29450? If eIWC is the value calculated by subtracting H₂O_{gas} from H₂O_{enh}, will H₂O_{gas,adj} = H₂O_{gas} by inserting eIWC into equation 1?
7. Table 1. It will be good to add "latitude coverage" from Figure 3 and "temperature or altitude coverage" from Figure 4 in Table 1 for each field campaign.
8. P29455, section 3.1. It will be helpful to add some discussion on the Schiller et al. dataset. Is the dataset contained in this study (Table 1) completely different from Schiller dataset? Or are there some data in common?
9. P29456, L20, "additional variables to explain it". Which additional variables?
10. P29456, L28-29, do you mean that you only sample in situ cirrus, not anvil cirrus?
11. P29458, L16 and 24. "cirrus formation mechanisms". It would be good to add some details on the formation mechanisms here.
12. P29459. What is "y" in Equation 4?
13. P29461, L16. "relationship is also seen in this comparison". I am not able to see this relationship.

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