

Interactive comment on “Impacts of cloud heterogeneities on cirrus optical properties retrieved from spatial thermal infrared radiometry” by T. Fauchez et al.

Anonymous Referee #3

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The paper presents a modelling study of the effect of cloud heterogeneity on retrieval of cirrus cloud optical properties from space-based thermal measurements. This is achieved by comparing full 3-D radiative transfer simulations with 1-D results. The paper highlights the importance of 3D heterogeneity effects.

The paper is at places difficult to read and follow. There are also a few points that need clarification and explanation. Below are suggestions for improvements.

C4094

Specific remarks

- **Page 8777, Title:** Maybe replace “spatial” with “space-based”.
- **Page 8778, lines 23-25:** The last sentence in the abstract is hard to understand. Please clarify and rewrite.
- **Page 8780, lines 19-20:** This paper discuss the IR part of the spectrum. Thus, please give the IR optical depth as well.
- **Page 8781, line 17:** Please describe how the effective diameter is defined for the various ice particle shapes.
- **Page 8782, line 19:** A mono-disperse ice particle size distribution is used. Please discuss how realistic this assumption is and quantify the magnitude of this assumption by comparing with realistic size distributions.
- **Page 8782, line 23:** A Henyey-Greenstein phase function is used as that is what is provided by Yang et al. (2001). It was argued by Yang et al. (2001) that in the IR the asymmetry factor was sufficient and the full phase function was not needed, but no calculations were shown to support this statement. Later Baum et al. (2005a, 2005b) have provided full phase functions for various ice particle shapes. Please discuss, justify and quantify the error/uncertainty associated with the use of the Henyey-Greenstein phase function for highly irregular ice particles when calculating radiances.
- **Page 8782, line 24:** It is stated that the “optical properties are constant over the entire clouds”. Presumably this does not include the optical depth? Please clarify what is meant by “optical properties”.
- **Page 8783, line 4-16:** 3DMCPOL is a Monte Carlo code. As such all the quantities calculated by the code has a statistical uncertainty which depends on the

C4095

number of photons traced and the atmospheric conditions. Please give the number of photons traced and the statistical uncertainty in the calculated quantities. The statistical uncertainty in the calculated quantities should be compared with the noise-equivalent temperature of the IIR-instrument and should be smaller than that.

- **Page 8786, line 1:** Please specify what the “optical and microphysical properties” are.
- **Page 8786, lines 7-8:** The symbols $\varepsilon_{3-D_{eff}}$ and $\varepsilon_{1-D_{eff}}$ are at best very confusing. It is presumed that the $_{eff}$ -label here refers to ε and that here D_{eff} has nothing to do with the effective radius? Why not use for example ε_{eff}^{3D} and ε_{eff}^{1D} ? Also why not use τ_{eff}^{3D} and τ_{eff}^{1D} instead of $\tau_{3-D_{eff}}$ and $\tau_{1-D_{eff}}$? If these are adopted the sentence in lines 14-15 needs to be changed. In any case the above mentioned symbols should be simplified to avoid confusion.
- **Page 8786, lines 15-16:** τ_{1km} is defined here, but it not used anywhere in the error definitions above. May this sentence be omitted?
- **Page 8787, line 2:** On the previous page it is stated that “BT3D $_{1km}$ is larger than BT1D $_{1km}$ ”. This then implies that the PPA bias is smaller than 1. On line 2 it is stated that “The PPA is greater . . .”. Please clarify these two statements. Also it is not the PPA that is greater, it is the PPA bias. Hence change “The PPA” to “The PPA bias”.
- **Page 8789, line 4:** “too large” compared to what?
- **Page 8789, line 15:** Please replace “PPA.” with “PPA bias.”
- **Page 8804, Fig. 1:**
 - Different texts are used for x-labels in plots c) and d). Please make them similar.

C4096

- X-axis and Y-axis are not very informative choices for axes-labelling. Choose something else, for examples x-direction (or east) and y-direction (or north?)?
- Indicate in plots a) and c) for which y-value the vertical cross sections in plots b) and d) are made.
- **Page 8805, Fig. 2:** The plots would benefit from inclusion of near-vertical lines indicating the optical thickness of the ice clouds. For an example of such a plot, albeit for volcanic clouds, see Fig. 2 of Wen and Rose (1994).
- **Page 8806, Fig. 3, lines 5-6 in caption:** The sentence starting with “Heterogeneity effects” is not clear. Maybe rather write: “Using the PPA gives an overestimate of D_{eff} compared to a 3D retrieval.”?
- **Page 8807, Fig. 4, lines 5-6 in caption:** No reference is given for the Jensen inequality, nor is it discussed in the text. May this sentence be omitted?
- **Page 8809 and 8811, Figs. 6 and 8:** R-values are given in the plots. The R-values are not discussed in the text nor the captions and may be omitted.

Technical remarks

Generally the language throughout the manuscript would benefit from a careful read by a native English speaker. At least consider the following:

- **Page 8778, line 22-23:** Please consider replacing “are much higher” with “are larger”.
- **Page 8778, line 24:** Please consider using uncertainty instead of incertitude.

C4097

- **Page 8779, lines 10-11:** Please consider using “space mission” instead of “spatial mission”.
- **Page 8780, line 25:** Please replace “in the same time” with “simultaneously”.
- **Page 8781, line 8:** Please change “generated” to “generate”.
- **Page 8784, line 9:** It is not clear what is meant here. Please rewrite this sentence.
- **Page 8786, lines 7-13:** Replace “on the” with “the” in four places.
- **Page 8787, line 6:** Replace “The Fig. 3” with “Fig. 3”.
- **Page 8787, line 8:** Replace “an homogeneous” with “a homogeneous”.
- **Page 8787, line 20:** Replace “no linear” with “non-linear”.
- **Page 8788, line 4:** Replace “weaker” with “smaller”.
- **Page 8788, line 12:** Replace “Garnier et al. (2012) shown” with “Garnier et al. (2012) have shown”.
- **Page 8788, line 17:** Replace “superior to” with “larger than”.
- **Page 8790, line 10:** Replace “than cirrus” with “as cirrus”.
- **Page 8790, line 14:** Replace “very close” with “similar”.
- **Page 8790, line 23:** Replace “the PPA” with “the PPA bias”.
- **Page 8791, line 27:** What is meant by “in relative”.
- **Page 8794, line 4:** Please replace “discussed on the” with “discussed the”.

C4098

- **Page 8794, line 6:** Please replace “have been focused” with “have focused”.
- **Page 8801, line 7 in caption of Table 1:** Please replace “define” with “defined”.
- **Page 8815, Fig. 12, line 2 in caption:** Please change “assymetry” to “asymmetry”.

References

- Baum, B., Heymsfield, A., Yang, P., and Bedka, S.: Bulk scattering models for the remote sensing of ice clouds. Part 1: Microphysical data and models, *J. of Applied Meteorology*, 44, 1885–1895, 2005a.
- Baum, B., Yang, P., Heymsfield, A., Platnick, S., King, M., Hu, Y.-X., and Bedka, S.: Bulk scattering models for the remote sensing of ice clouds. Part 2: Narrow-band models, *J. of Applied Meteorology*, 44, 1896–1911, 2005b.
- Wen, S. and Rose, W. I.: Retrieval of sizes and total masses of particles in volcanic clouds using AVHRR bands 4 and 5, *J. Geophys. Res.*, 99, 5421–5431, 1994

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C4099