Atmos. Meas. Tech. Discuss., 7, C4366–C4375, 2015
www.atmos-meas-tech-discuss.net/7/C4366/2015/

Atmospheric Measurement Techniques Discussions
Open Access

AMTD
7, C4366–C4375, 2015

Interactive Comment

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

T. Fauchez et al.

t.fauchez@laposte.net

Received and published: 2 January 2015

First of all, we would like to thank the reviewer for his relevant comments and suggestions, which enhance the article quality.
In addition, we improved the English thanks to the help of an English native speaker.

General Comments:

Please find my review of 'Impacts of cloud heterogeneities on cirrus optical

properties retrieved from spatial thermal infrared radiometry' by T. Fauchez et al., MS No.: amt - 2014 - 166. In this work, the authors explore the impact of cloud property heterogeneities on the retrieval of cloud properties from infrared observations available on such instruments as the Imaging Infrared Radiometer (IIR) and MODIS. The authors first generate simulations of cirrus clouds across a range of expected conditions (cloud optical depths, effective diameter, standard deviation of optical depths in cloud subpixels, etc.). They then compare 3-D and plane parallel radiative transfer calculations for these IR wavelengths to infer expected retrieval errors as a function of cloud profile and specific heterogeneities (e.g. variation in optical depth within cloud structure and in cloud microphysical properties). They find that these uncertainties depend upon the specific cloud state and can often be as large or larger than other uncertainty sources inherent to these IR retrieval approaches.

Overall, the paper topic is quite interesting and scientifically relevant to the remote sensing community. As a scientist who has worked frequently with ice cloud retrievals, I have often wondered about the quantitative impacts of 3-D effects on infrared retrieval cloud products. Yet, I had neither time nor tools to explore this topic. Likewise, the basic execution of the study was performed well. I very much appreciated the rigorous manner in which the authors sought to quantify different sources of error across a wide variety of cloud conditions. On the slightly negative side, I found presentation of the paper somewhat confusing at times given all the different test cases and different sources of errors. I also found some odd word choices and sentence constructions that perhaps could be changed for improved reader comprehension. Overall, I would happily recommend that the paper be accepted with only minor revisions. Please find my specific and technical comments below. These should be considered as suggestions and not so much as required changes.

AMTD
7, C4366–C4375, 2015

Specific Comments:

1. My primary concern is with clarity of presentation.

Pg 8778, Line 23. Please list these 'other possible sources of error' here for clarification

Done, we listed in the abstract the 'other possible sources of error' as follow (page 1, lines 19-21):

Cloud horizontal heterogeneity effects are greater than other possible sources of retrieval errors such as those due to cloud vertical heterogeneity impact, surface temperature or atmospheric temperature profile uncertainty and IIR retrieval uncertainty.

Pg 8781, Line 2: Perhaps list these other sources of error for clarification.

We also listed in the introduction the other possible sources of error as follow (page 3, lines 81-83):

Cloud horizontal heterogeneity effects are greater than other possible sources of retrieval errors such as those due to cloud vertical heterogeneity impact, surface temperature or atmospheric temperature profile uncertainty as well as the IIR retrieval uncertainty.

Pg 8785, Line 20: For the description of Split-window and the IIR operational algorithms, it again may be useful to explicitly describe the other sources of

AMTD
7, C4366–C4375, 2015

error. May help for the reader to keep track of which errors you are discussing and how they differ from the impacts of heterogeneities.

Here, the errors discussed are only the algorithm uncertainty. We performed a 1D-retrieval from 1D-simulated radiances to test the retrieval accuracy of the algorithm. We compared then optical thicknesses and ice crystal effective sizes used as inputs for the radiative transfer calculations and those retrieved as outputs. We added changed the paragraph to clarify this point (page 7, lines 215-221):

The uncertainty of the retrieval algorithm was checked by comparing optical properties retrieved from simulated radiances with the optical properties used as input in the radiative transfer. For this we perform a 1D-retrieval from 1D-simulated radiances. The algorithm uncertainties are less than 2 % for effective diameters retrieved with the SWT (test not shown here) and 4 % for effective optical thicknesses retrieved with the algorithm similar to the IIR operational algorithm (test not shown here).

Pg 8781, Line 22: The statement that 'Cirrus 3 to 5 are useful' needs more justification. Retrieval uncertainties are highly dependent upon cloud state (size of particles, optical depth, etc.) so it is not clear why conclusions using very small particles would hold for larger, more realistic sized particles.

This remark is indeed relevant. We mean that although cloud heterogeneity effects are probably slightly overestimated due to the too small crystal effective size (heterogeneity effects are larger for small effective sizes) for this cirrus averaged optical thickness. Cirrus 3 to 5 are however useful to understand how heterogeneity effects increases with the optical thickness heterogeneity parameter (σ_τ in Table 1) which increases from 0.7 to 1.1 and 1.5 while other cloud properties kept constant. We add this paragraph to explain why cirrus 3 to 5 are useful to study (page 4, lines 103-108):

Cloud heterogeneity effects are probably slightly overestimated due to the too small crystal effective size (heterogeneity effects are larger for small effective sizes) with respect to the mean cirrus optical thickness. Nevertheless, cirrus cases 3 to 5 are however useful to understand how heterogeneity effects increases with the optical thickness heterogeneity parameter (σ_τ in Table 1) which increases from 0.7 to 1.1 and 1.5 with other cloud properties held constants.

2. Optical property parameterizations, Pg 8782: Do you ever look at the impact of changing ice particle scattering models (Baran vs Yang) for a cloud field constant in all other ways.

That is an interesting comment. We did it. Indeed, if you look at Table 2, you can see that cirrus CII-2 (Baran) and CII 3 (Yang) are almost similar with only slight differences between τ_c and σ_τ.. Figure 9 shows that, for a given σ_τ value, the impact of cirrus heterogeneities on the effective emissivity ($\Delta\varepsilon_{eff}$) and effective optical thickness ($\Delta\tau_{eff}$) is very similar between both cirrus. The optical property model seems thus not have a significant impact in the case of this cirrus.

We explain it in the discussion of Figure 9 page 8790 lines 11 to 26 for comparisons between cirrus CII-1 (Baran), CII-2 (Baran) and CII-3 (Yang):

Figure 9 shows the impact of cirrus heterogeneities on the retrieved effective emissivity $\Delta\varepsilon_{eff}$ and on the effective optical thickness $\Delta\tau_{eff}$ as a function of the standard deviation of the optical thickness $\sigma_{\tau_{1km}}$ for cirrus cases CII-1, CII-2 and CII-3. $\Delta\varepsilon_{eff}$ and $\Delta\tau_{eff}$ are similar for the three cirrus cases, thought some slight differences are evident

AMTD

7, C4366–C4375, 2015

as a function of the wavelength. Indeed, at $8.65\ \mu m$, $\Delta\varepsilon_{eff}$ and $\Delta\tau_{eff}$ are smaller for the CII-3 cirrus case than for the two others cirrus cases. At $10.60\ \mu m$, this difference is close to zero. At $12.05\ \mu m$, $\Delta\varepsilon_{eff}$ and $\Delta\tau_{eff}$ are larger for the CII-3 cirrus than for CII-1 and CII-2 cirrus. This effect is due to the variability of the optical properties for the CII-1 and CII-2 cirrus. Indeed, cirrus case CII-3 contains only aggregate crystals of effective diameter $D_{eff} = 9.95\ \mu m$ resulting from the model of Yang et al. (2001, 2005), while cirrus cases CII-1 and CII-2 contain crystal of various sizes. For CII-3 cirrus, small crystals have a single scattering albedo maximum at $8.65\ \mu m$, leading to a lower PPA bias. At $12.05\ \mu m$, small particles are more absorbing and the PPA bias is larger. For the CII-1 cirrus, corresponding to the cirrus observed during the CIRCLE-2 campaign, the average effective emissivity error is within the limit of the method sensibility (Garnier et al.,2012) of about 0.03 in absolute value.

Or even for pristine habits, e.g. aggregates can not generate halos that we often see in the real-world associated with nighttime cirrus.

That is something that we did not investigated, although that will be very interesting We assumed that the Baran et al. parameterization allows us to study a quite realistic 3D optical property distribution inside the cirrus, independent on the choice of the crystal size or shape.

3. Along the lines of comment 2, the shape of the ice particles is determined by a ratio of effective diameters as on Pg 8785. Do heterogeneity effects ever result in the selection of different ice crystal shapes and, if so, what is the impact on retrieved cloud properties. Such information might be especially important for a combined scheme exploiting visible and near-IR measurements that are very sensitive to change in crystal habit.

Indeed, ice crystal shapes retrieved from 1D or 3D radiative transfer are not necessary equal. However, due to the weak accuracy on the crystal shape retrieval of the IIR algorithm (10 to 25%), we did not obtain a significant tendency.

4. Pg 8782, Vertical variability. It would seem that the impact of vertical variability would depend heavily upon the vertical profile of real-world clouds.

Here we simulated the cirrus of the CIRCLE-2 airborne campaign using satellite and in-situ data and this cirrus is may be not representative of all possible cirrus vertical structures. We added this paragraph to explain that the effect of the vertical variability could be larger, in particular for old cirrus where the sedimentation process could be strong and increase differences between ice crystals at the cloud top and at the cloud base (page 13, lines 419-424):

Note that effects of the vertical variability are discussed here for the structure of the cirrus observed during the CIRCLE-2 campaign. Effects could be different for other cirrus structure but they are not discussed here. For example, for old cirrus, sedimentation processes could be much larger, increasing differences between the cloud top and base. The impact of the vertical variability on cloud properties retrieved from satellite observations could be thus be larger.

5. Pg 8793: Other Sources of Uncertainty. Have the impacts of water vapor (with associated cloud altitudes) been considered?

That is an interesting question but unfortunately we did not look at to the impacts of water vapor, essentially for time reasons.

AMTD
7, C4366–C4375, 2015

Technical Comments:

I have a few technical comments or suggestions. These generally refer to choices of words or grammar issues that do not seem quite appropriate given my own working understanding of English. Again, make changes at own discretion as sometimes it is not clear what the authors meant (indicated by ???)

Pg 8778, Line 6: 'One' to 'one cloud field'
Done.

Pg 8778, Line 17: Add 'use' or 'assumption' of PPA.
Done.

Pg 8778, Line 23: 'more higher' to 'greater'
Done.

Pg 8778, Line 24: Not sure if 'incertitude' is the correct word here or ever. Maybe just use 'uncertainty'
Done.

Pg 8778, Line 24, 'from' to 'when' ??
Done, thank you, we replace by 'for'

Pg 8778, Line 25, 'superior to' to 'is greater than'
Done.

AMTD
7, C4366–C4375, 2015

Interactive Comment

Pg 8779, Line 10 and 11: ’spatial’ to ’space-Â■based’ ??
Yes, done
Pg 8779, Line 17, ’dedicated’ ???
We removed this word.
Pg 8779, Line 17: ’retrieving’ to ’the retrieval of’
Done.
Pg 8789, Line 29: eliminate ’The’
We can’t find The in Pg 8789 line 29, doesn’t exist. We supposed that it concerns the ’The’ of Pg 8779 line 28 before ’three’. We remove it.

Pg 8782, Line 14: Perhaps use a more scientific expression for ’difficult to handle’
Done, changed by ’difficult to characterize’..

Pg 8786, Lines 7-Â■11. Change the (-) symbol at the beginning of each line to make clear it is not (-) in a mathematical sense
Done, changed by black squares.
Pg 8787, Line 2: change ’PPA’ to ’impact of PPA’ or something similar
Done, changed by ’the impact of the PPA’.
Pg 8787, Line 7: Perhaps the ’tip’ or ’point’ of the red arrow
Done, we added ’tip’ as well as at line 10 for the blue arrow.
Pg 8787, Line 20: ’no’ ???
Changed by ’no linear’ by ’nonlinear’
Pg 8788, Line 3: ’negatives’ to ’negative’
Done.
Pg 8787, Line 4: ’weaker’ to ’smaller’
Assuming that it is page 8788, we replace ’weaker’ by ’smaller’.
Pg 8790, Line 10: ’than’ to ’as’

AMTD
7, C4366–C4375, 2015

Interactive Comment

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

Done.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 8777, 2014.

AMTD

7, C4366–C4375, 2015

Interactive Comment