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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impacts of cirrus clouds heterogeneities on TOA thermal infrared radiation" *by* T. Fauchez et al.

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This is a very thorough study on the impact of cloud heterogeneity and associated 3-D radiative transfer effects on TOA IR brightness temperature observation. The topic is important and suitable for ACP. The manuscript is well prepared. There are a few typos in the manuscript, as pointed out by the other reviewer. The most important one is to change "Plan-Parallel" to "plane-Parallel".

I think this paper can be published after some minor revision. On the other hand, I do have several suggestions (listed below) and I think they may help the author to further improve the paper and attract more readers.

1) I'd like really like to see the authors to include 3.7μm band in their analysis. I guess

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this paper is oriented to the IIR instrument, which does not have a 3.7μm band. But the 3.7μm band is commonly used band for cloud property retrievals, e.g., AVHRR, MODIS, VIIRS, SEVIRI, etc. During the day time 3.7μm band radiance contains both solar reflection and thermal emission. The emission component has to be removed before 3.7μm band can be used for cloud droplet size retrieval based on the Nakajima –King method. This so-called emission correction is usually done by relating 3.7μm emission component with the 11μm band observation. Cloud is assumed to be plane-parallel in this step. An interesting and important question would be whether 3-D effect and PPA have different impact on 11 and 3.7 μm bands. The results in Figure 8 seem to suggest that the effect on 3.7μm would be much larger than 11μm band. If so, the results could have significant implications for many instruments using the 3.7μm band. It is why I'd recommend the authors to include an analysis for the 3.7μm band. As far as I know, there is only one previous study [Zhang and Platnick, 2011] (they had a very simple case study see their Figure 15) along this direction.

2) The current tests are done at the 1km resolution (i.e. resolution of IIR). Other instruments have different resolutions. I am wondering what is the scale dependence of the 3-D effect in the IR region. For example, consider two pixels with different size (say 1km vs. 5km), they have the same mean cloud optical thickness (COT) and COT standard deviation. The PPA effect would be the same for these two pixels, but how about the horizontal photon transfer effect? Since the authors used a fractal cloud generator, they are well positioned to answer this question. I will be very delighted to see some theoretical discussions to relate the PPA in the IR region with the, scale-invariant, fractal structure of cloud.

3) A question related to the last point is whether the PPA bias could be corrected, at least at the nadir direction, based on the observed (biased) BT, on the basis of the scale invariant nature of cloud. In other words, if we know the statistics of cloud BT at larger scale, can we infer the sub-pixel level cloud inhomogeneity and furthermore correct the bias BT observation? To be clear, this is a question for the authors to consider. It's up

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13, C11123–C11125, 2014

to them to decide whether to explore in this direction.

4) As hinted by the last paragraph, there may be another paper coming to discuss the implications of the results in this paper for the IIR cirrus cloud retrievals. But the authors should keep in mind that many readers may not follow up. So I think it is a good idea to add some discussions at the end of the paper to talk about the potential implications for remote sensing. In particular, as shown in several recent studies [Marshak et al., 2006; Zhang et al., 2012], solar reflective method is subject to large errors caused by 3-D radiative transfer effects. Note that, the PPA bias can be reduced simply by reducing pixel size, while the 3-D radiative transfer effects are more difficult to control and may even become stronger when pixel size is reduced. The dominance of PPA in the IR BT seems to suggest great potential of IR method for retrieving the small-scale cloud structure, something I think should be discussed.

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Zhang, Z., A. S. Ackerman, G. Feingold, S. Platnick, R. Pincus, and H. Xue (2012), Effects of cloud horizontal inhomogeneity and drizzle on remote sensing of cloud droplet effective radius: Case studies based on large-eddy simulations, J Geophys Res, 117(D19), D19208–, doi:10.1029/2012JD017655.

Zhang, Z., and S. Platnick (2011), An assessment of differences between cloud effective particle radius retrievals for marine water clouds from three MODIS spectral bands, J Geophys Res, 116(D20), D20215, doi:10.1029/2011JD016216.

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