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Atmospheric Measurement Techniques Discussions

Interactive comment on "A generalized method for discriminating thermodynamic phase and retrieving cloud optical thickness and effective radius using transmitted shortwave radiance spectra" *by* S. E. LeBlanc et al.

Anonymous Referee #2

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Review of the Manuscript by LeBlanc et al. (2014): "A generalized method for discriminating thermodynamic phase and retrieving cloud optical thickness and effective radius using transmitted shortwave radiance spectra", submitted to AMTD.

This is an important paper which I recommend for publication in AMT. It fits very well into the scope of the journal. The analysis is thorough; I didn't find any serious inconsistencies. In particular, a method to retrieve cloud optical thickness tau and effective radius reff from normalized transmitted radiances is introduced and applied to three

measurement cases. The errors of the original data are stringently propagated through the retrieval and the final results are used to reconstruct the original normalized radiance spectra.

I would like to give some general comments for consideration in the revised manuscript version:

(i) In my point of view, the method is not a "generalized method", as implied in the title of the manuscript and the text. What I mean here is that it remains unclear why in particular these 15 parameters, as defined in the manuscript, are chosen for the retrieval. I guess even more than 15 parameters could be proposed; maybe less than 15 would do a similarly good job. The sensitivity of the chosen particular parameters is well introduced; however, this makes the approach not a general one. I would consider the method general if the parameters are determined by an objective algorithm (e.g., principal component analysis, or other procedures) which is not the case here. Therefore, I suggest omitting the term 'general' in the title and the respective text.

(ii) For a mixed-phase cloud the retrieval of tau and reff seems not meaningful. You can clearly decide from the retrieval if there is some ice in the cloud, but there is no way to tell how much. Therefore, if you want to retrieve tau and reff you have to assume the cloud consisting of either liquid water drops, or pure ice only, which both cannot reproduce the mixed phase cloud normalized transmitted radiances.

(iii) I feel the paper is too long, and the number of figures could considerably be reduced (e.g., Figs. 1-3 could be omitted, also Fig. 4 is not crucial for the paper) without much loss of information. Therefore, I ask the authors to shorten their paper.

Detailed comments:

- For the title (and elsewhere in the text), I suggest to change the term 'shortwave' to 'solar'. Short is always relative, solar is much more specific.

- Page 5294, line 21: I guess the 53 W m-2 are annually averaged too.

- Page 5295, line 2-5: I suggest adding the reference Ehrlich et al. (2008) here, which also deals with cloud thermodynamic phase retrievals using spectral reflectivity.

- Page 5295, line 19-21: It could help to explain what 'additional information' means.

- Page 5297, line 13: The terminology used for 'spectral zenith radiance' is not consistent. For example, on Page 5300, line 21-22, it is 'zenith transmittance'. This is a little confusing.

- Page 5297, line 13: I suggest changing 'radiance light collector' to 'optical inlet'.

- Page 5297-5298, line 21-13: Was a calibration performed in the field? It seems the calibration factors were obtained from laboratory measurements, which might change due to disconnection of the optical fibers for the transport to the measurement site.

- Page 5299, line 2-9: The pixel size of the satellite products should be specified.

- Page 5301, line 23-24: Have inherent uncertainties of surface albedo, cloud base altitude/extent, and atmospheric state profiles been considered in the final uncertainty analysis?

- Page 5302-5303, line 25-3: If my understanding is correct, you calculated one LUT for each of the presented three case studies?

- Page 5303, line 11: Please see previous comment on terminology ('cloud-transmitted radiation').

- Page 5303, line 15 and line 16: I suggest changing 'asymmetry parameter' to 'asymmetry factor'.

- Page 5303, line 21: Typo, replace 'Fig. 4' by 'Fig. 5', please reduce the size of the huge axis labels of Fig. 5.

- Page 5304, line 26-27: Why do you use the term 'transmittance' in a way that is inconsistent with common definitions? Call the quantity what it actually represents:

normalized transmitted radiance. The reader gets confused otherwise.

- Page 5305-5306, lines 18-3: This is nice; you might consider a cross-reference to Brückner et al. (2014, submitted to JGR).

- Page 5308, line 27 (and following): The terms in brackets could be avoided (also later in the text), since the detailed definitions are introduced in Table 1.

- Page 5312, line 16: The phase discrimination for mixed-phase clouds is not really clear. It is obvious that only-ice cases can clearly be distinguished. However, how pure liquid water cases can be discerned from mixed-phase clouds? The ice content in mixed-phase clouds cannot be quantified, which does not become clear from the text. There seem to be two ranges of optical thickness (larger and lower 10). For the range of tau > 10, it is possible to determine thermodynamic phase using one single parameter 1, 2, 4, 9, 10, or 13. Which one do you use? For tau < 10 all 15 parameters are required to determine thermodynamic phase. Anyway, this means you have to use the combination of all 15 parameters, since the range of optical thickness is unknown. Is this the main point of the paragraph? In a similar way, what is the resolution of tau and reff used in the model to discriminate whether it is a liquid water or ice cloud? Please elaborate.

- Page 5313, line 15-16: Can a threshold or number in certain parameters be given beyond which the retrieval is still valid? Or is this the predefined value of 0.69?

- Page 5313-5314, line 23-10: While Section 5.1 discusses only the retrieval uncertainties due to measurement errors, there are other uncertainties as well. For example, uncertainties caused by multi-layer clouds or uncertainties of the model input. Therefore, lines 23 to (next page) 10 should be reworded to clarify that while other uncertainties can also occur, this section discusses only those due to measurement uncertainties.

- Page 5315, line 8-19: It makes no sense to compare to reff time series retrieved from the two wavelength method which cannot be used to derive reff.

- Page 5317, line 1-19: ‘Although we have not addressed the applicability of the 15 spectral parameters to mixed phase clouds in this work, we investigate the results of the thermodynamic phase discrimination, and the residual of least squares fit of the retrieval to measured transmittance under conditions of concurrent ice and liquid absorption.’ Then I would suggest to show only the results for the thermodynamic phase. To compare the results for tau and reff from all 3 methods, at least the ice cloud LUT should be used for the slope and 2-wavelength method in the start of case B (as GOES retrieves also ice phase). Using a liquid cloud LUT cannot result in a reliable retrieval (values of reff > 30 μm represents the upper limit of reff in the LUT). Furthermore, I don’t think, that the overall trend is reproduced with all 3 methods.

- Page 5318, line 3-14: I suggest adding a discussion concerning the influence of different ice crystal shapes on the 3 retrieval methods. As reported by several studies, this could have a huge influence on the retrieved cloud parameters.

- Page 5319, line 28: ‘Lastly, The presence’ to ‘Lastly, the presence’

- Fig. 13: The dashed dark green line in case B is very hard to distinguish from the solid colored lines. I suggest changing the color and line style of the presented data.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 5293, 2014.