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Atmospheric Measurement Techniques Discussions

Interactive comment on "Application of ground-based hyperspectral imaging to retrieve ice crystal shape and fields of cirrus optical thickness" *by* M. Schäfer et al.

Anonymous Referee #1

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This paper reports on ground-based measurements of transmitted radiance from cirrus clouds to derive cirrus optic thickness. The instrument used was a hyperspectral imager covering the wavelength range from the visible (400 nm) to very near-infrared (about 950 nm). However, the analysis was done at a single wavelength that matched a co-located lidar system. Because the sensor employed a 2-d focal plane array and was aimed in a fixed direction, the second dimension of spatial information was acquired through the motion of the cirrus. Attempts we made align the spatial direction of the imager perpendicular to the direction of cirrus advection.

Optical thickness was derived using radiation transfer simulations for a number of scat-

tering angles and four ice crystal habits, using P. Yang scattering models for the different habits. A single particle size (20 microns) was assumed. For some of the cases studied a broad-enough range of scattering angles was covered such that the halo was a good discriminator of habit. For these cases, angular information served as the primary discriminator of habit type and optical thickness could be inferred one the habit was determined. For other cases, when only a limited range of scattering angle was covered, a habit was assumed. Analysis on the sensitivity to this assumption was conducted and presented in the paper, along with sensitivity to surface albedo, cloud altitude and particle size.

I think this is a nice paper. It is short, easy to ready, and both instrumentation and analysis are well-covered. I recommend publication. While I don't have any comments that I would place in the category of "major", I do have a few general comments that I will list first.

1. Although the instrument was hyperspectral, by most versions of that definition (there are several), only a single wavelength was used in the analysis. I think the authors should reconsider the use the word "hyperspectral" in their title. At the very least, they need to point out that the results in this paper do not capitalize on the hyperspectral capabilities of the instrument but that future analyses may better exploit the wavelength dependencies of cloud radiation.

2. The relative lack of sensitivity to particle size is rather surprising but if it is correct, the authors can show this rather simply by comparing the asymmetry parameters for the three particle sizes they analyzed in the simulations. They must be about as close as the relative differences in retrieve tau for those cases. After all, what is retrieved in these cases is tau*(1-g). This is one example where I would prefer to see the authors provide better physical insight into their results. And because they are retrieving something close to tau*(1-g), that explains the potential ambiguities in their results with respect to crystal habit. They have explored only a small subspace of possible crystal habit and the Yang models are only a small sample of possible realizations of ice crys-

tal scattering. In fact it may even be beneficial to present results in units of tau*(1-g), particularly when interpreting parameter sensitivity because it will become immediately apparent to which parameters tau is relatively sensitive (habit) or insensitive (size). A little more physical insight will be very helpful to the general readers of this paper.

3. This is less of a comment than a question: didn't the cloud lidar provide optical thickness information? Of course, habit assumption would be implicit in those retrievals as well. If that data exists, can they be compared with the results here? The lidar appears to have been used more as a ceilometer.

The following comments are minor:

1. p. 1203, l. 7-9. The second sentence in this paragraph, on spatial inhomogeneity, has nothing to do with the first sentence, on crystal orientation. I recommend a reorganization of this paragraph which seems to jump over various topics. Also, the 25% reference needs to be better qualified. I doubt that this represents some upward limit in albedo bias but it may be misinterpreted as such.

2. p. 1204, l. 3-6: The mismatch between remote sensing and in situ measurements probably has very little to do with "enhanced absorption" and almost everything to do with the second part of this sentence, the mismatch in sampling volumes between in situ and remote sensing measurements.

3. p. 1204, l. 13-15. In the last sentence of this paragraph, "These issues may only be solved . . ." I don't think it is explained how these issues may be solved by the two methods listed.

4. p. 1206, l. 26: Should be "tangent"

5. p. 1208, l. 8: need to say "U.S. National Institute . . ."

6. p. 1208, l. 16-17: Instead of "larger" and "smaller" wavelength use "longer" and "shorter".

7. p. 1209: l 21: The spectral range from 400-970 nm covers more than one octave, meaning that the range from 800-970 nm requires order sorting. Actually, it will be required for wavelengths longer than 2*shortest wavelength. Did the detector array include order sorting filters? If not, this comment needs to me moved to the category of "major"! If no order sorting was used, a major correction to the data will be required.

8. p. 1210, l 1: see comment number 6.

9. p. 1210, l 1-14: I think I follow the discussion on wavelength range and smear correction but it was a struggle. I suggest rewriting this paragraph to simply the discussion.

10. p. 1211, l 1-2: for what cases and when do the MODIS size retrievals correspond?

11. p. 1211, l 25-26: It is not explained how the all-sky images provide thickness information. After all, if they do provide this, why do you even need the spectral imager?(!) In other words, this sounds completely qualitative, which I am sure it is, but a little more discussion is warranted.

12. p. 1213, l 13: What is meant by "azimuthal position is rectangular. . ."?? Perpendicular?

13. p. 1213, l 26: halo should not be capitalized.

14. p. 12414, l. 1: Should be "irregular", not "unregular".

15. p. 1216, l 8-11: It is still confusing how MODIS retrievals are implemented. Please explain better here and in comment number 10.

16. p. 1219, l. 20-22: This last sentence in the second to last paragraph is confusing to me. I don't think they can ever remove habit assumption. After all, as I said in the general comments, they are only considering a small subset of possible habits. There will always be residuals between measurement and model. How can they verify they are not habit-dependent? I think it is better to state that angular information provides additional information on habit. That is different than saying it removes all ambiguity of

crystal habit, which this seems to say.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 1201, 2013.