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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The effect of solar zenith angle on MODIS cloud optical and microphysical retrievals" *by* D. P. Grosvenor and R. Wood

Anonymous Referee #1

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In my view this is a very strong paper. It addresses an important question, whether the radiative effects of cloud variability cause systematic biases in satellite retrievals of cloud properties at low solar elevations. This question has been addressed in earlier studies; the present manuscript adds the issue of droplet number concentrations and a new methodology. The presentation is clear, though it is on the long side. Therefore I recommend publishing the manuscript, although I recommend making some fairly important revisions first. Please find my specific comments below.

P 335, L 6-9: I share the authors' concern that the variability of 5 km-resolution cloud top temperature product may not be a good indicator of radiatively important small-scale cloud variability. This seems especially important, as it may have led to the puzzling observation that the solar elevation dependence does not increase with cloud

variability (which seems to weaken the variability-hypothesis considered throughout the paper). Therefore my main suggestion for improving the paper is to test different indicators of cloud variability to capture small-scale cloud variability, for example using the variability in 250 m reflectance (e.g., Di Girolamo et al. 2010, Zhang and Platnick 2011) or in 1 km brightness temperature (e.g., Varnai and Marshak 2002). If this wasn't possible, I recommend prominently pointing out this issue as soon as the first puzzling results appear in Figure 11, and mentioning it wherever the findings of Figures 11 and 12 are discussed.

P 334, L 15-16: I fully agree with the authors' statement, and would even guess that 3-D effects absorbing and non-absorbing wavelengths are more likely to have different than identical magnitudes. For example, the relative effects may be larger at absorbing wavelengths, while the absolute effects may be larger at non-absorbing wavelengths. It would help to expand this discussion and include some references. If needed, the assumption and discussion could be expanded to other scenarios (e.g., larger 3-D effects at absorbing or non-absorbing wavelengths).

Appendix D: The paper does a very good job at presenting thorough discussions about a wide range of considerations, but this results in a fairly long article. I believe some shortening would benefit the manuscript. For example it may be sufficient to mention Latin Hypercube Sampling only briefly, as Appendix D concludes that its results were not too different from a simple analysis of mean values.

P 310, L 6-8: The reasoning or wording here is not clear to me, as plane-parallel relationships are based on modeling, not on empirical correlations.

P 319, L 5: It would help to clarify whether the analysis used quality assessment flags included in the MODIS cloud product. (For example the multi-layer cloud flag may help reduce the effects of overlying ice clouds.)

P 326, L 6: A range of 10-20% may sound more realistic. Also, mentioning the reference for this expectation here could help readers even if it was mentioned earlier.

P332, L 17-25: This paragraph appears to combine plane-parallel bias (that is, variability within a 1-D framework) with 3-D issues. It would help to make the wording clear or to change the paragraph heading.

P 332, L 27-29: To make the argument complete, it would help to mention what changes in the width of drop size distributions could cause the solar elevation dependent changes in retrieved re.

P 334, L 13: I suggest changing the wording "observed retrieved values", as it sounds awkward. Also, I suspect some typos or wording mix-ups in this sentence, as 3-D effects cannot cause retrieved values.

P 338, L21 and P 339, L 11-16: While excluding suspicious data (at high solar zenith angles) may be a very good approach for eliminating retrieval biases at high latitudes, it seems worth mentioning that other approaches might also become possible in the future if the biases could be tied to cloud variability (or other factors) in a definite manner. Finally, it may also be worth mentioning whether the findings are relevant only to MODIS or to other datasets as well.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 303, 2014.