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Atmospheric Measurement Techniques Discussions

Interactive comment on "Next-generation angular distribution models for top-of-atmosphere radiative flux calculation from the CERES instruments: methodology" *by* W. Su et al.

W. Su et al.

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Dear Referee 1, Thank you for your thoughtful review, please see our response below (in italics).

1. Abstract I suggest re-writing the abstract. The authors provide general description of ADM but they should focus on how the new ADMs are different from old ADMs.

We rewrote the abstract to highlight the most significant differences between the New and Old ADMs.

2. Equation (4) is used to assess the improvement of fluxes. But I only see that it

is used for clear-sky ocean (Fig. 2) and clear-sky land (Fig. 7). Why is it not used for other scene types and cloudy conditions? If this is the metrics used to assess the improvement, it should be used for all scene types.

Equation (4) is used to assess the improvement for all scene types, but we only included the RMS distribution for two scene types due to the length of the paper. We also mentioned that the RMS error is reduced for LW clear-sky ocean/land/desert scenes by using more surface temperature bins on page 8842. To clarify, we have added a sentence in Section 3 indicating that Equation (4) is used for all scene types to assess the performance of the new ADMs.

3. Page 8825 Could you explain why aerosol models of Hess et al. are used? If the authors can use any aerosol models, isn't it beneficial to use the same aerosol model that has been used in the CERES already (e.g. OPAC, Hess et al. 1998)? If one derives aerosol direct radiative effect in two ways, an observational approach used in Loeb and Manalo-Smith (2005) or an theoretical approach that use a radiative transfer model such as used in Su et al. (2013), when the same aerosol model is used, it eliminate one ambiguity that might cause the difference.

The Hess et al (1998) aerosol model is the OPAC model, see reference on page 8850.

4. Page 8839 I do not see how the authors obtain information of sea ice fraction under clouds. In addition, the contribution of sea ice present in the clear-sky portion to the TOA flux is larger the contribution of sea ice under clouds. Therefore, to a first order approximation, the TOA flux is a function of sea ice fraction under clear-sky condition and cloud fraction. If the under cloud sea ice fraction dependence needs to be added, it should be treated differently from the sea ice fraction in the clear sky part. For example, if the cloud fraction is 50the sea ice fraction under the cloudy part is 0 to 502 are not formed in this way. Please provide descriptions of why the authors included the sea ice fraction under clouds in the way described in Table 2 and how it contributes to improve TOA flux.

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We do not directly measure the sea ice fraction under the clouds, we assume that the sea ice fraction under the clear part is representative of the sea ice fraction under the entire footprint. So the "footprint" sea ice fraction = sea ice fraction in clear area of the footprint. While it is true that the anisotropy is mostly dependent on the clear-sky sea ice fraction and cloud fraction, there is an effect on the anisotropy at the TOA from the surface brightness underneath the clouds. This is demonstrated by the dependence of the overcast reflectance on sea ice brightness index in figure 14. By assuming that the clear area sea ice fraction is representative of the total footprint sea ice fraction we have attempted to include this contribution in the anisotropy. We note that this approach should be valid for most of the sea ice footprints. Fractionally sea ice covered footprints will only occur around the edges of the ice, and as a portion of the total footprints this is quite small. This approach also ensures that the use of sea ice brightness index is consistent between clear sky and partly cloudy sky footprints.

5. Page 8845 Could you explain why cloudy sky ADMs for permanent show, sea ice and fresh snow for longwave are constructed separately for terra and aqua?

For most scene types, ADMs were constructed separately for Terra/Aqua, unless we do not have enough angular coverage from one satellite. For the cloudy-sky ADMs, we had plenty of data from both Terra and Aqua to do separate ADMs, and tests using ADMs constructed with combined Terra and Aqua data revealed no significant differences compared to the ADMs constructed for individual satellites. For clear skies, we needed to combine the satellites in order to get enough data for each VZA, so data from both spacecraft were used.

6. Page 8846 The authors separate the effect of ADM improvement from the effect of cloud algorithm difference. But they should mention that, rigorously, the ADM effect is evaluated by constructing old ADMs with new cloud and applied them with new clouds. I understand that the reason for not doing in this way but it should be mentioned. In addition, it is nice if the authors can speculate how the result would be if they chose this approach.

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We have added the following in the first paragraph under section 7: A more stringent test for the ADM effects on flux would be updating the ADMs developed by Loeb et al. (2005) with the new cloud algorithms. However, the updated ADMs were not available. The ADM effects on flux are expected to be slightly smaller if we had used the updated ADMs than what we presented below.

7. Figure 7 Please indicate that these are for clear-sky land in the caption. I do not understand that why values are not shown over the part of Siberia in C and D but appear in A and B. I would think that valid values should appear in either C or D.

Added 'clear-sky land' in the caption. The reason that part of the Siberia in Fig. 7c and Fig. 7d are missing is because aerosol optical depth retrievals are not available from MODIS team.

8. Figure 10 Could you mention the scene type in the caption?

Added 'clear-sky' in the caption.

9. Figure 11 How does this improvement happening over the South Pole represent other areas over the Antarctica? The South Pole is viewed from one direction but other area over the Antarctica is viewed from different viewing angles and relative azimuth angles. I would think that the South Pole case is an extreme case.

The new sastrugi ADMs reduce the Antarctica wide monthly-mean bias attributed to sastrugi in 2002 by between 25% and 40% depending on the month, and a reduction in the grid-box level bias range from around $\pm 15 W m^{-2}$ to $\pm 5 W m^{-2}$. Briefly, this bias is assessed by calculating the difference in 24-hour equivalent flux estimates for a grid-box from nadir viewing angles and those from all viewing angles. As the nadir viewing angles are less susceptible to the effects of sastrugi than the oblique angles (Warren et al. 1998), the differences between these two estimates are considered to be due to the presence of sastrugi (see section 4 of Corbett et al. 2012 for calculation details. These results and the method are discussed in more detail in Corbett and Su (in prep).

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J. G. Corbett, W. Su, and N. G. Loeb. Observed effects of sastrugi on CERES top-of-atmosphere clear-sky reflected shortwave flux over Antarctica. J. Geophys. Res., 117(D18104):D18104, 2012.

S. Warren, R. Brandt, and P. Hinton. Effect of surface roughness on bidirectional reflectance of Antarctic snow. J. Geophys. Res., 103(E11):25,789–25,807, 1998.

10. Figure 15 It would be better if contours showing populations are used instead of black dots for observed LW radiances.

We modified figure 15 as suggested.

11. Figure 18 I think that these are old minus new, but it should be defined in the caption.

Yes, it is. We modified the caption to make it clear.

12. Figure 19 Why do the daytime and nighttime sample number changes between Ed2SSF and Ed4SSF?

There are a few reasons that the daytime and nighttime sample number changed between Ed2SSF and Ed4SSF. One reason is when we processed Ed2SSF, the MODIS spectral radiances were not available, but it is now available for Ed4SSF processing. Another reason is the Ed2 cloud algorithm failed to process some MODIS granules because of the limitations of the algorithm, while the new improved algorithm can successfully process these MODIS granules.

Below is a list of some minor comments that provide more information to readers who are not familiar with CERES ADMs

14. For the purpose for clarity to those who are not involved in CERES processing, the ADMs currently used should be called as Ed 2 and the new ADMs should be Ed 4 at the beginning of the manuscript.

We have wrestled with the terminology ourselves. We chose not to call them Ed2ADMs

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and Ed4ADMs to avoid confusion as there are no official edition releases of ADMs, they are used for different editions of SSF. For example, the ADMs described in Loeb et al. (2005) were used for Ed2SSF and Ed3SSF. Please understand that we are trying to be as clear as possible while remaining accurate!

15. Loeb et al. (2005) used for the reference of permanent snow, sea ice and fresh snow ADMs. Kato and Loeb (2005), however, present more details of these ADMs. For this reason Kato and Loeb (2005) needs to be used as a reference in addition to Loeb et al. (2005)

The Kato and Loeb (2005) paper was referenced under cloudy sky for fresh snow. We have added this reference in a few more places as necessary.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 8817, 2014.