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Interactive comment on “Accounting for the effects of Sastrugi in the CERES Clear-Sky Antarctic shortwave ADMs” by J. Corbett and W. Su

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We thank the reviewer for taking the time to review our paper and provide useful feedback. Our responses are provided below in blue.

Major Comments: 1. This study appears to be a part of a recently published paper by the same (first two) authors: Su, W., Corbett, J., Eitzen, Z., and Liang, L.: Next-generation angular distribution models for top-of-atmosphere radiative flux calculation from the CERES instruments: methodology, Atmos. Meas. Tech., 8, 611–632, 2015.

Author response: We recognise that there is overlap between this paper and Su et al

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(2015). The Su et al (2015) paper provides a brief description of the new ADMs for all scene types, thus did not go into details to describe the methodology used to develop the clear-sky sastrugi ADMs over the Antarctic. As the method discussed in this paper is new (to our knowledge this type of approach of using statistical relationships between MISR cameras to create ADMs has never been used before), we felt it warranted further explanation than could be provided in the Su et al paper.

2. The study doesn't seem to offer new additional results that are significant compared to Su et al., 2015 paper. For example, Fig. 3 and 5 are reproduced from Figure 12 (Su et al. 2015). The only results that seem unique /interesting are shown in Figure 9 (and may be 8). Unfortunately, all the other figures need to be justified as new/important. Shouldn't Figure 1/diagram be a part of the methodology paper/Su et al. 2015? Why is this study restricted to only one polar region (Antarctic)? A logical extension should have been testing all the ADMS described in Su et al. paper, not just the Antarctic scenes.

Author response: The Su et al (2015) paper briefly describes the methodology and provides one result as justification. This paper provides further details on the development process and includes more extensive validation approaches. Figures 2, 4, 7, 8, 9, 10 are new (figures 3, 5, and 6 contain new elements, figure 1 is a fairly standard viewing geometry diagram with the addition of sastrugi angles) and contain information relevant to developing and evaluating the performance of the new ADMs. This paper also focuses on one very specific issue that was found to affect ADMs – namely sastrugi. For sastrugi to affect flux estimates, and for us to be able to detect and correct the effect, they have to be long-lived and significant over large areas. This really only occurs in Antarctica – we could not find evidence of sastrugi affecting flux retrievals over Greenland, and sastrugi over sea ice and seasonal snow would be too short-lived and variable to see an effect. The tests we perform to validate the sastrugi ADMs and compare them to previous ADMs are only relevant to sastrugi (e.g. nadir vs off nadir flux bias and along-track consistency). These tests would not be useful in evaluating

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cloud ADMs for example because they are not long-lived enough to get views from multiple directions. Furthermore, the suite of tests used to evaluate the ADMs globally is not precise enough to pick up a subtle local effect such as sastrugi (see Loeb et al. 2007 and Loeb et al. 2006 for examples of tests). The global validation will be addressed in Part 2 of Su et al. Due to the specific nature of the problem we are trying to account for and the tests we use to evaluate the effect, we feel this can only be done properly in a dedicated paper.

3. If sastrugi height is about 1 m, how important are these dune-like features from a satellite altitude as a function of sensor spatial resolution?

Author response: The effect sastrugi will have on the BRDF will depend on the fraction of the sensor field-of-view covered by sastrugi, and the consistency of their orientation. A high-resolution sensor will be affected by the sastrugi, if their fraction is high enough and the orientation is consistent enough. This is shown in Kuchiki et al (2011) for the MODIS instrument. For a sensor with a larger footprint such as CERES (20km at nadir) the fraction and orientation is still important. However, as the fraction and orientation are likely to be less consistent over a larger area the magnitude of the effect is likely to be dampened somewhat compared to the higher-resolution instruments. There is still an effect though, as demonstrated in Corbett et al (2012) and in this paper.

4. Figure 2, shows MISR near-infrared reflectance over clear-sky Antarctica for different relative azimuthal angles (raa). The green line is not correct since MISR doesn't scan in the principal plane $raa=0$. Additionally, the plots show that MISR is looking both forward and back in the same relative azimuthal plane; this doesn't seem correct. The red curve is not labeled/identified in the legend. Can the authors explain the reflectance values >1 ?

Author response: Figure 2 shows the mean near-infrared radiances as a function of the sun-sastrugi azimuth angle. i.e the difference between solar azimuth and our estimate of the sastrugi angle based upon the MERRA wind directions. The relative azimuth

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of the MISR instrument here is generally between 330–340 degrees (for the forward cameras) and 150–160 degrees (for the aft cameras). Thus it is possible for MISR to view a sastrugi azimuth between 0–30 degrees (green line is not constrained by relative azimuth). MISR has 9 cameras that are fixed at certain viewing zenith angles and look along the satellite track. For a given MISR pixel in the middle of the MISR swath the forward and aft cameras will generally view the pixel from the same relative azimuth plane (i.e. 180 degrees apart). As you go to the edge of the MISR swath the relative azimuth will change somewhat, especially for the cameras with viewing zeniths closer to nadir. For this study we used the SSFM dataset, which averages the MISR pixels over the CERES footprint when the CERES instrument is in along-track scanning mode. This means the pixels we average are close to the center of the track and will be in the same relative azimuth plane. The distribution of relative azimuths by camera for the data included in figure 2 is shown in Figure 1.

Apart from the nadir camera, the other cameras all lie in the same relative azimuth plane. The nadir camera shows different values as the azimuth of a nadir pointing camera will change significantly with small deviations from the sub-satellite point. However, the radiance does not change significantly.

The reflectance is defined as $\rho = \pi I / \mu F_0$ where I is the measured radiance, $\mu = \cos(\theta_0)$ and F_0 is the incoming solar in that particular band. We realize that this equation is not actually included in the paper and will be added. Reflectance values will often be greater than one for highly reflective surfaces, especially at higher viewing zenith angles and for low solar zenith angles.

A legend has been added that includes the correct label for the red curve.

5. The finding that “monthly regional biases as large as $\pm 15 \text{ Wm}^{-2}$ in the inverted TOA SW flux” and that “ADMs reduce the monthly regional biases to $\pm 5 \text{ Wm}^{-2}$ and the monthly-mean biases are reduced by up to 50 %” – cited in the abstract and conclusions, are not supported by results. The values cited are neither in the “Results” nor in

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the "Discussion" sections.

Author response: These values come from Figure 8 in the discussion paper. The ± 15 Wm⁻² value comes from Corbett et al 2012. We have modified figure 8 (now figure 9) to include the results from all the months we look at and provide further discussion of this in the results section. We have also changed our comparison between the KL05 and CS15 ADMs to use the 0.5-99.5 percentile results only as this removes the outliers from the comparison. We have changed the abstract and conclusions to reflect this.

Minor comments: 1. pg 382, line 3 - misspelling of "sastrugi" 2. Pg. 389, line 20, weighted-area NOT weighted-are.

Author response: These will be corrected in the paper.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 375, 2015.

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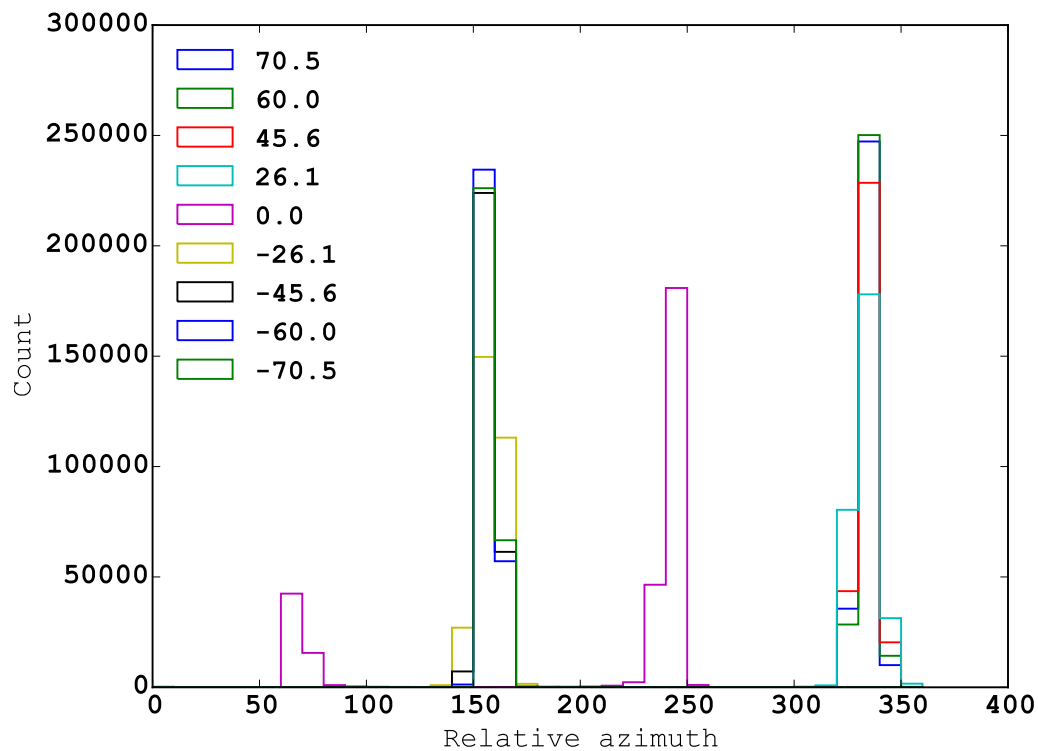
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Fig. 1. Distribution of relative azimuths by camera viewing zenith angle for SSFM footprints over clear-sky Antarctica, when the solar zenith angle is between 65–70 degrees.

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