

Review #3

This paper studies the effects of different footprint sizes and cloud algorithms on the radiative flux calculation from CERES on Suomi-NPP. Quantifying uncertainties from different footprint sizes and cloud algorithms in CERES-NPP is an important issue in calibration.

However, major revision of the text is needed. The sources of uncertainties in these two CERES (CERES-NPP and CERES-Aqua) observations are not fully explained in the text. The collocated radiances themselves already have 1.5%, 0.5%, and 0.1% of intrinsic differences for each channel, respectively. The sampling errors from two different footprint sizes are also embedded in the radiance comparison.

The actual CERES-Aqua and CERES-NPP measured radiances differ, as mentioned above. These comparisons are based upon matched CERES footprints from Aqua and NPP, thus the sample number used here are the same for Aqua and NPP. The footprint size differences can contribute to the radiance differences, but these differences should be random. We believe that the footprint size differences can increase the RMS errors, but the mean radiance differences are mostly resulted from calibration differences between CERES-Aqua and CERES-NPP (page 7). The goal of the simulation designed in this paper is to isolate the effect of footprint size difference on flux inversion without having to unravel the contribution of calibration difference to the flux difference.

This study assumes that CERES-NPP and CERES-Aqua are identical instruments with compatible performance. But one may ask if there were improvements in CERES-NPP instrumentation/electronics or calibration. Possible degradation of CERES-Aqua instrument can be mentioned, if any. Before discussing uncertainties from footprint sizes and cloud algorithms, comprehensive uncertainty analysis of two CERES instruments is necessary to quantify errors from spatial sampling and cloud algorithm differences. I understand that this work is the first step towards identification of the two different CERES observations, but further uncertainty analysis and detailed descriptions are required. The methods to identify the effects of different footprints and cloud algorithms need to be described in detail.

Instrument degradation is indeed an issue if it is not accounted in the calibration. CERES instruments are designed with onboard calibration and instrument degradation is accounted for when the monthly gain factors are derived. We provided some discussion of the instrument gains on page 7. The calibration differences between CERES-Aqua and CERES-NPP are not fully understood yet. The team is working on to understand the differences and eventually place both of them on the same radiometric scale. The focus of the paper is not to address the calibration difference. The simulated CERES-NPP footprints are designed to quantify the flux uncertainty due to footprint size difference and cloud fraction and cloud optical depth differences without having to unravel them from the calibration difference.

1. Introduction: Line 71, Could you provide detailed explanation how two instruments help to construct ADMs that readers can visualize what you described?

One of the CERES instrument is placed in RAP mode, which is designed to maximize the angular coverage for constructing ADMs, while the other one is placed in cross-track mode to provide

daily global coverage. The objective here is to use one instrument to maximize the angular coverage without having to sacrifice the spatial coverage. We rewrote this part in the revised manuscript to make this clear.

2. Introduction: Line 88, “These pixel-level cloud properties are spatially and temporally matched with the CERES footprints ~” ,

What is the spatial and temporal window for scene type matching from MODIS?

The spatial matching is to include all MODIS pixels (1 km) in the CERES footprint (20 km at nadir). The temporal matching is within 20 seconds when CERES is in cross-track mode, and is within 6 minutes when CERES is in RAP mode. We specified these criteria used on page 5.

3. Line 126-128,

“These differences do not show any view zenith angle dependence”.

Figure 1 compares the radiances of SW, daytime LW, and nighttime LW between two CERES measurements, but does not mention view zenith angle difference.

Please explain why these differences do not show any view zenith angle dependence. Daytime LW is derived as the difference between total and SW channels. Nighttime LW is the same quantity with the total radiance because SW radiance is zero during nighttime. How daytime LW difference can be lower than SW difference? Are they offset with bias?

The comparisons shown in Figure 1 include data taken from nadir viewing angles to oblique angles with viewing zenith angle greater than 60 degrees. When we compare the radiances taken at different viewing zenith angle ranges (e.g. <20 degrees, >20 degrees, >40 degrees), the RMS errors of the radiances remain almost the same. This indicates that these differences do not show any viewing zenith angle dependence. We added these discussions in the revised manuscript (page 7).

The reason that the daytime LW difference is smaller than that of SW is because the difference of the total channel is slightly smaller than the difference of the SW channel. When the SW radiance is subtracted from the total radiance, the difference in LW is not as large as that of SW.

4. Table 1.

The difference between two cases is largest in SW radiance, but it is less in daytime LW radiance. Authors can explain the reason why the difference in daytime LW radiance, which is derived as the difference between total and SW channels.

As mentioned above, the reason that the daytime LW difference is smaller than that of SW is because the difference of the total channel is slightly smaller than the difference of the SW channel. When the SW radiance is subtracted from the total radiance, the difference in LW is not as large as that of SW. We added some explanation on Page 7.

Line 212-14,

“Polar region cloud fraction differences are mainly because (that) VIIRS lacks the water vapor and CO₂ channels which affect the polar cloud mask algorithm.”

Please explain how lack of those channels cause polar region cloud fraction difference. While VIIRS shows less cloud fraction over northern high latitude

snow regions, it shows more cloud fraction over arctic. If all positive and negative difference is caused by large uncertainty of VIIRS, then more explanations on VIIRS cloud retrieval limitations including usage of different parameterization over snow/ice surfaces and uncertainty caused by this difference should be mentioned.

The CERES cloud working group developed sophisticated cloud detection algorithms using visible and infrared channels of MODIS separately for polar and non-polar regions and for daytime, twilight, and nighttime. However, these detection algorithms have to be modified to apply to the VIIRS observations, as some of the MODIS channels utilized for cloud detection are not available on VIIRS. These modifications include replacing the 2.1 μm MODIS channel with the 1.6 μm VIIRS channel, and replacing detection tests using MODIS 6.7 μm and 13.3 μm channels with VIIRS 3.7 μm and 11 μm channels, and supplement with tests utilizing VIIRS 1.6 μm channel and the brightness temperature differences between 11 μm and 12 μm . These changes mainly affect the cloud detections over the polar regions, and as different tests and thresholds are used for daytime and twilight cloud detections, these changes will also affect different latitude zones differently.

Line 158 are used to derived → are used to derive
Corrected, thank you!

5. Conclusions

299 How these simulations helped to calibrate CERES-NPP observations?

These simulations are not designed to calibrate the CERES-NPP radiance observations. The focus of the paper is to assess the effect of footprint size difference and scene identification difference on flux inversion without having to account for the overpass time difference and calibration difference.

306 How much is the uncertainties of CERES ADMS as appeared in Su et al (2015)?

The biases and RMS errors provided in Su et al. (2015) is for diurnally averaged SW and LW flux. The bias for regional monthly mean TOA SW flux is less than 0.2 Wm^{-2} and the RMSE is less than 1.1 Wm^{-2} . For TOA LW flux, the regional monthly mean bias is less than 0.5 Wm^{-2} and the RMSE is less than 0.8 Wm^{-2} .

314-316 VIIRS and MODIS cloud retrieval algorithms are not consistent. Then it is important to quantify the differences and reflect them to improve the CERESNPP algorithm. Last sentence, “To maintain the consistency of the CERES climate data record, it is thus important to maintain the consistency of cloud retrieval algorithms.” does not help much to solve the problem.

Figure 5 quantify the cloud fraction and cloud optical depth difference between Aqua and NPP. The CERES team developed cloud retrieval algorithm using MODIS observations for over ten years. Because VIIRS lacks some of the channels that were used for MODIS cloud retrieval, to make the cloud retrieval consistent between VIIRS and MODIS, the MODIS and VIIRS retrieval algorithms have to be reevaluated using only channels that are available for both MODIS and VIIRS. This is a grand challenge and will take time to develop the new algorithms and to process

data of more than 30 instrument years. We rewrote this sentence to reflect the need to develop algorithm considering the capabilities of both MODIS and VIIRS.