Response to Reviews 12/10/2021

Color Coding:

Black: Reviewer

Red: Authors

We thank this Reviewer for very helpful comments.

Comment: There is some displacement in the line numbering of the Reviewers and the submitted version of the manuscript. We have also downloaded the ATM version, but there is still a shift. This made it sometimes difficult to identify the location of the Reviewers comments.

Reviewer # 3

RC3: Comment on amt-2021-289', Anonymous Referee #3, 05 Nov 2021 reply
Review for "Top of the atmosphere reflected shortwave radiative fluxes from GOES-R" by Pinker et al.

This paper described the methodology developed to derive surface and TOA SW radiative flux from ABI onboard GOES-R. It includes the conversion of the narrowband radiance observations from ABI to broadband SW radiances that are needed, and the subsequent conversion of broadband SW radiances to broadband SW fluxes. Authors used the MODTRAN to derive the narrowband-to-broadband regression coefficients first for each of the 6 channels and then used the weighed sum for the final SW broadband reflectance. These broadband radiances were then converted to fluxes using a hybrid ADMs from CERES observations and MODTRAN simulations. Major concerns are:

Reviewer # 3

1. For the narrowband-to-broadband conversion, the best strategy would be to use common channels on ABI and MODIS (VIIRS) and then develop the regressions using CERES Level 2 SSF data where CERES broadband radiances and MODIS (VIIRS) narrowband radiances are collocated. Spectral band difference adjustment factors (Scarino et al., 2016) can be used to account for the SRF differences between ABI and MODIS (VIIRS). I also recommend using the multi-linear regressions instead of the two-step approach used here.

Response

This is an interesting option and could serve as a new future project. It is feasible when the CERES and VIIRS are on the same satellite as is the case for CERES and VIIRS for S-NPP and NOAA-20. However, our approach is feasible for any combination of satellites. This comment highlights the difficulty one faces when preparing for a new instrument, in this case, ABI. Since the period of stabilization with the instrument at hand is relatively long, independent developments are not at stand still. To catch-up with all of them would be possible only as a new effort. We believe that what was done is of interest and opens new possibilities for future investigations. We have initially used multi-linear regression but encountered problems of getting negative radiance values. The approach used ensured that all values were positive.

Many operational algorithms, including the NOAA STAR SRB algorithm, are required to work reasonably well on day one, that is, right after the launch of the satellite. The data needed for the approach the reviewer is suggesting are not available from the new satellite at that time and would need to be collected for a long enough period to include all seasons. So, simulation-based narrow-to-broadband transformations are necessary for the day-one algorithm to work. Having said that, we note that an empirical narrow-to-broadband conversion using coincident and collocated CERES and ABI observations is being developed at NOAA/STAR and the method is briefly mentioned in Laszlo et al. (2020).

Reviewer # 3

2. The CERES ADMs that the authors used in the study is outdated. I believe those ADMs are based on the CERES on TRMM observations, as the justification that you used to calculate theoretical ADMs is because "CERES observations at higher latitudes are under-sample or not existent". The ADMs from Loeb et al. (2005) and Su et al. (2015) are based on Terra and Aqua observations and provide sufficient coverage over high-latitude regions. The methodology that you developed to combine the CERES and theoretical ADMs are thus not necessary.

Response

We have used the CERES ADMs that were mature at the start of the project. Indeed, it would be interesting to do what this Reviewer is proposing and compare the results to what was done under this project. Independent approaches are useful to identify issues with any path one may take.

Still, we were looking for the new ADMs however, unlike the CERES/TRMM SSF Edition 2B ADMs, the more recent CERES Terra/Aqua Edition4 ADMs are not available publicly, at least we could not locate them at the NASA LaRC website https://ceres.larc.nasa.gov/data/angular-distribution-models/.

Reviewer # 3

3. As authors mentioned in this paper, CERES provides TOA SW fluxes, it is not clear from the manuscript why fluxes from ABI are necessary. What are the objectives for deriving fluxes from ABI and what are the potential applications?

Response

Development of the NOAA shortwave radiation products (reflected shortwave radiation at TOA and downward shortwave radiation at the surface) was performed in response to a requirement of the NOAA National Weather Service (NWS) for such a product. The Environmental Monitoring Center of NWS requested this product for verifying model-predicted shortwave radiation to improve radiation and land-atmosphere interaction processes (Laszlo et al., 2020).

Specific comments:

Reviewer # 3

1. Line 28, “A satisfactory agreement between the fluxes…” is very vague, including biases and RMS errors will be helpful.

Response

This is mentioned in the Abstract which is limited in length. Such information is provided later in Table 7.

Reviewer # 3

2. CERES ADMs are scene specific, the flowchart in Fig. 2 indicates that cloud phase and cloud optical depth are used for ADM. However, the paper didn’t describe how these cloud properties are derived.

Response

We did not derive these cloud properties. We use the same classification as used in CERES to make the allocation of the ADMs consistent. We believe that it is out of the scope of this paper to describe the monumental work of CERES.

Reviewer # 3

Line 116, “The difference between the two radiances were below 5%”, is the difference for broadband radiances or any specific wavelength?

Response

It was done spectrally for the entire spectrum.

Reviewer # 3

one should avoid using red and green color scheme.

Response

Thanks for pointing this out. We will be careful about it in the future.

Reviewer # 3

3. Line 194, wrong figure number.

Response

Corrected.

Reviewer # 3

4. , it is hard to see the gray lines.

Response

Will attempt to improve.

Reviewer # 3

5. didn't separate the comparison into clear versus cloudy conditions, but authors mentioned on line 244 that "The separate-channel" coefficients work well for predominantly clear sky". I assume authors draw this conclusion based upon the flux magnitude rather than any cloud detection algorithm? Magnitude of TOA SW flux is smaller under clear-sky conditions than under cloudy-sky conditions. Absolute flux differences are not the best way to assess the performance for clear- and cloudy-sky conditions.

Response

In respect to cloud mask, we used the official ABI cloud mask. The other comment of this Reviewer is well taken. We have redone the analysis for clear and cloudy sky and computed biases and RMSE. We have prepared the following new Figure to illustrate it. Indeed, this is a better way to look at the differences. As seen now, difficult to reach a conclusion about performance under clear and cloudy sky. Thank you for this comment.

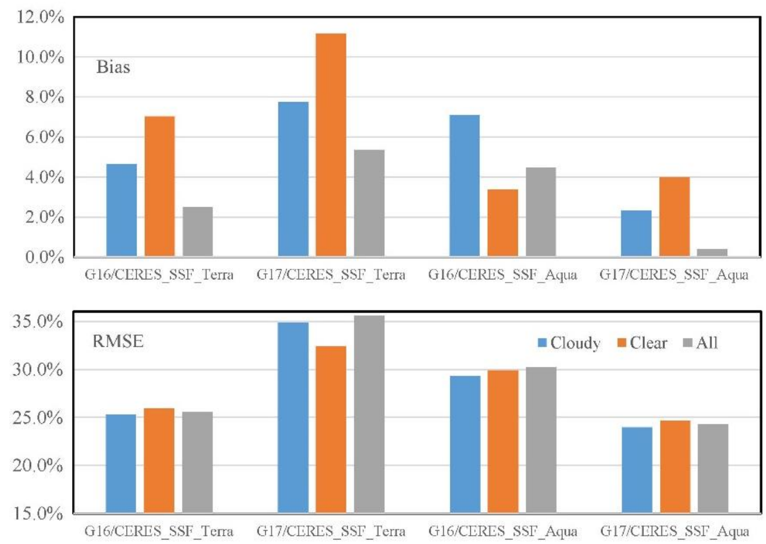


Figure. The relative statistics for Bias and RMSE. The y-axis is percentage. The x-axis are the cases used for comparison. The blue color is for cloudy conditions, the orange is for clear sky and the gray is for the all sky cases.

Reviewer # 3

6. Why using CERES FLASHFLUX for validation? I understand the latency issue, but the data presented in this study are from 2017. Surely higher quality CERES (i.e., SSF) are available now for 2017.

Response

We agree with this Reviewer on the need to use the final CERES product. Indeed, that is what was done in all the cases described in the paper. We apologize for the mistake we made in labeling the product. We have been involved in using the FLASHFlux data in preliminary evaluation for such a long time (due to the circumstances of data availability) that we labeled it as Flash Flux and not CERES. We have now prepared a full data base of what was used so the reader can check this point out. Information will be provided how to access this database.

Reviewer # 3

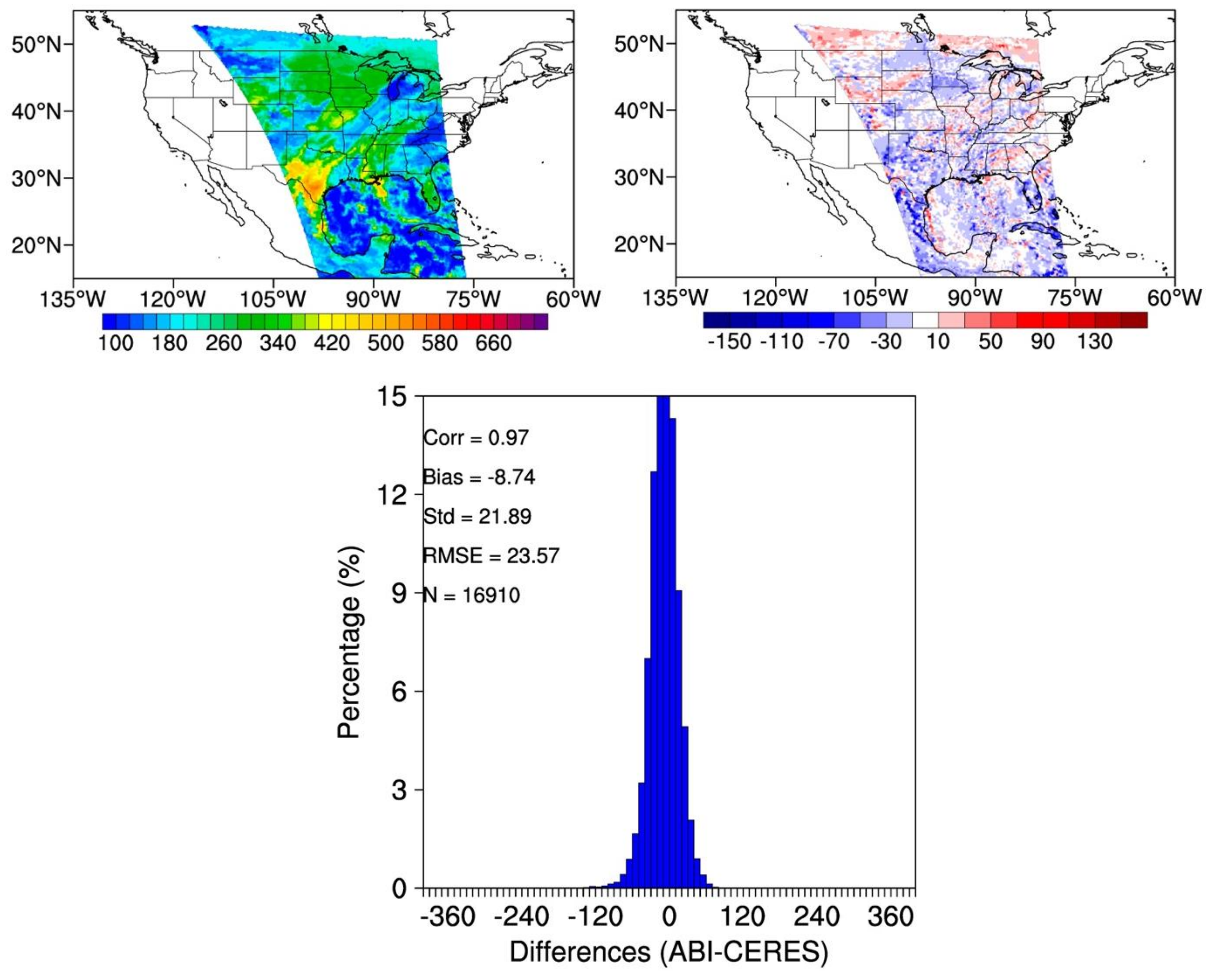
7. CERES data are of much coarse resolution (~20 km) compares to that of ABI (~2 km), the spatial resolution differences will certainly contribute to the biases and RMS. Authors should consider revise the comparison method by averaging the ABI pixels within the CERES footprints weighted by the CERES point-spread function before comparing with the CERES flux.

Response

For the re-mapping, we adopted the ESMF re-gridding package. The detailed information can be found at:
http://earthsystemmodeling.org/regrid/
For an ideal situation, the ABI high-resolution TOA SW fluxes should be mapped into the CERES footprint for validation as suggested by the Reviewer. However, there are reasons that make it difficult to do so. For example, the case 12/26/2019 UTC 19. There can be more than 18000 pixels in a single swath of the SSF, when constrained to U.S. Different pixels have different times. Neglecting the seconds, there are still more than 30 mins differences (this changes case by case) between the first pixel and the one at the end and this brings up a time matching time issue. But if remapping the SSF to ABI, we can set up a unique time for ABI (ABI is at 5 min intervals) and then constrain the region and the time range of SSF.
Both remapping the ABI to SSF and remapping SSF to the ABI bring up spatial matching errors as recognized by the scientific community. In Figure 10, we show the SSF before re-gridding (Figs 10 (a) & (b)) and after re-gridding (Figs. 10 (c) and (d)). As seen, the fluxes after re-mapping CERES SSF to the ABI resolution resemble well the reverse re-mapping. Another consideration is the computational efficiency of re-mapping the curvilinear tripolar grid to unconstructed grid. For large arrays, it is more efficient to remap the unconstructed grid to the curvilinear tripolar grid.

We have done one case of remapping the ABI to CERES_SSF as suggested, and the edges do improve. There are additional consideration in selecting the direction of re-mapping. This Figure will be put in the Supplements.

Remapping 2-km ABI flux to CERES_SSF scale (20 km)



FigureS1. Top Left: Mean ABI Flux on 12/26/2019 UTC 19:00 from GOES-16 re-gridded to CERES SSF (20km)/Aqua domain; Top Right: Difference between re-gridded ABI Flux and CERES SSF/Aqua; Bottom: frequency distribution of the differences (bottom).

Reviewer # 3

8. Line 256, what "CODC" stands for?

Response

Cloud Optical Depth Conus

Reviewer # 3

9. Line 271, typo.

Response

Corrected.

Reviewer # 3

10. Line 321, authors state that "both estimates of TOA fluxes do no(t) account for seasonality in the land use classification", this is not clear. Do you mean CERES ADMs do not account for land surface seasonality? If so, that is not true. CERES clear-land ADMs are constructed for each calendar month (Loeb et al. 2005, Su et al. 2015).

Response

The simulations do not account for seasonality.

Reviewer # 3

11. Line 376, what do you mean "the order in which these transformations are executed is arbitrary"?

Response

Was reworded.

Reviewer # 3

12. Line 388-389, CERES Ed4 data were release in 2017 or so, not sure what authors mean that "CERES observations are also undergoing adjustment and recalibration". Please clarify.

Response

Was clarified in text. Thanks for the additional references that are now included in our paper.

Scarino et al. (2016), A Web-Based Tool for Calculating Spectral Band Difference Adjustment Factors Derived from SCIAMACHY Hyperspectral Data, IEEE Trans. Geo. Remote Sens., 54, 5, 10.1109/TGRS.2015.2502904.

Su et al. (2015), Next-generation angular distribution models for top-of- atmosphere radiative flux calculation from the CERES instruments: Methodology. Atmos. Meas. Tech., 8:611–632.

Loeb et al. (2005), Angular distribution models for top-of- atmosphere radiative flux estimation from the Clouds and the Earth's Radiant Energy System Instrument on the Terra satellite. part I: Methodology. J. Atmos. Oceanic Technol., 22:338–351.