

General Comments

The manuscript entitled “Pan-Spectral Observing System Simulation Experiments of shortwave Reflectance and Longwave Radiance for Climate Model Evaluation” demonstrates the value of studying the solar shortwave and emitted longwave spectral variability to diagnose climate model performance. This is an excellent presentation of new techniques that can be applied to evaluating climate models and is a valuable addition to the literature. Once the comments I have provided have been address, I believe this manuscript will be a wonderful resource particularly to the modeling community detailing the large amount of information contained in the shortwave and longwave spectral variability of Earth measured from space. I recommend this manuscript for publication, once the comments below have been addressed.

Many of my comments speak to reaching the climate modeling community. There is a lot of discussion of solar reflectance and infrared radiance spectra and how their spectral features illustrate the changes seen in climate models and the differences between models. This is a strength of the manuscript; however, remember that climate modelers may not be accustomed to gleaning information from spectra, such as what is shown in this manuscript. Keeping this in mind, generally describing various areas of the spectrum may not be sufficient for helping the readership follow your descriptions. I suggest making a point to include the numerical wavelength range describing where in the spectrum you are referring and making your description and physical explanations of what is shown in the spectra as specific as possible.

Specific Comments

Abstract

1. Sentence 1 is hard to follow. Can you simplify this? My suggestion is eliminate the word “evolution”. Also, that the feedbacks and forcings are on the climate system is implied: “Top-of-atmosphere spectrally-resolved shortwave reflectances and longwave radiances describe the response of Earth’s surface and atmosphere to feedback processes and human-induced forcings.”
2. Line 5. (Also Introduction, Page 3649, Line 15): “long-duration” – Can you be more specific about how long? Compared to today’s missions, how much longer? Decades? A few years? It will help to contrast weather-specific and climate-specific studies and measurement needs.
3. Lines 5-6: “we have projected 21st century changes described by [CCSM3]” – “Described” sounds qualitative here, and the changes represented in the CCSM3 model are certainly quantitative. Suggestions to replace “described”:
prescribed/illustrated/demonstrated/represented/...
4. Lines 8-9: Make the units of the spectral range and the spectral resolutions the same. “300 nm to 2500 nm and longwave radiance spectra from 2000 to 200 cm^{-1} (5 to 50 μm) at 8 nm and 1 cm^{-1} , respectively.”
5. Line 16: “the spectrum” is too vague. Suggestion: “how climate change alters/impacts Earth’s solar and infrared spectral variability.”

Introduction

1. Line 24: Albedo is not measured directly from space (at least, not in LEO). It would be more accurate to say that albedo is calculated or estimated from measurements of radiance.
2. Page 3649, Lines 5-8: Although your statement about the lack of a formal demonstration of spectral fingerprinting in the shortwave is accurate, you may also want to cite Jin et al 2011. In that study Jin et al 2011 calculated and showed shortwave spectral fingerprints.

- a. Citation: Jin, Z., B. A. Wielicki, C. Loukachine, T. P. Charlock, D. Young, and S. Noël (2011), Spectral kernel approach to study radiative response of climate variables and interannual variability of reflected solar spectrum, *J. Geophys. Res.*, 116, D10113, doi:10.1029/2010JD015228.
3. Page 3649, Lines 11-12: “OSSEs have well-established techniques” – Is it more accurate to say that “OSSEs *are* well-established techniques/tools”? Either way, seems there is a typo here.
4. Page 3649, Line 14: If this doesn’t change the meaning of your statement, insert “weather” between short-term and forecasting, providing a clearer distinction between shorter weather/process-based studies and the longer-term climate studies you are focusing on in this manuscript.
5. Page 3649, Line 16: Again “description” sounds qualitative, and the results provided by climate models are quantitative.
6. Page 3649, Lines 19-20: “allows for an estimation of the value of certain types of remote sensing measurements” – I would suggest a stronger statement here, something like “contributes to the determination of the value of certain types...”
7. Page 3650, Lines 14 – 15: Having read these three studies, it’s obvious to me that each of these studies contributed to *demonstrating* why shortwave spectra are valuable for OSSES, rather than merely *discussing* this point. I would strengthen the statement. In doing so, I do not believe this to be an overstatement of that work.
8. Page 3651, Lines 9-10: Include the wavelength range here. “near-UV (0.3 μm) to the far-infrared (50 μm)”

Methodology

1. Page 3651, Line 21: “Produce spectral measurements” – The OSSE does not produce spectral measurements; it simulates or emulates them.
2. Page 3651, Lines 25-27: Align the units again. Also, if inverse cm is in parentheses for the wavelength range, have the spectral resolution be in parentheses as well. It helps your reader to not confuse the units.
3. Page 3652, Line 2: After spectral flux, include “spectral irradiance” in parentheses. They are synonymous, and this will help to reach a larger audience.
4. Page 3652, Line 17: I understand why you would cite Feldman et al 2011 here, but I would also suggest other classic texts as a fundamental example (e.g. Hansen and Travis, 1974)
5. Page 3653, Lines 10-14: You mention time-saving radiative transfer methods at the end of the manuscript, but I think it warrants a mention here as well. If you have worked with these time-saving methods and have any idea about how much it reduces this ratio, I recommend including that estimation.

Results

1. Page 3654, Line 10: you mention the longwave fields, but I think you mention them to make the point that they have not been validated as the shortwave fields have been. Say that explicitly at the end of this sentence.
2. Page 3654, Line 17: Your description of what is shown in this figure doesn’t match what you show in the figure. In the text you need to say that we’re looking at a distribution of *differences* between the OSSE and CCSM3 radiation code OLR and albedo. “show a comparison” doesn’t do that sufficiently. – However, Figure 1 is a great display of the differences between the two data sets.

3. Page 3654 (Figure 1): What can you say about what the OLR All Sky bias and the other differences mean for the subsequent analysis completed in this study? Do we need to consider those differences as we examine the OSSE results?
4. Page 3655, Line 3: “with good agreement at low solar zenith angles” – From the way this is stated, it sounds like this point is demonstrated in Figures 1c and 1d, which it is not, so please restate.
5. Page 3655, Line 7: I don’t think a common name for the visible (0.3-0.7 μm) is a “window.” The 8-12 μm range in the mid-infrared is indeed commonly referred to as the atmospheric window (i.e. the part of the atmosphere transparent to emitted terrestrial infrared radiation), but not the visible. Please just refer to that region as the “visible” and not as a window. This occurs in other places in the manuscript as well. Please change them all, including the labels in Figure 1. Additionally, the first time you mention the atmospheric window (8-12 μm), you should include a brief definition for your audience.
6. Page 3655, Line 8-9: Here you are talking about differences being of opposite sign. Please indicate to the reader that you are now talking about Figure 2b (I assume that you are). Simply placing it in parentheses after that statement would help.
7. Page 3655, Line 9: Suggested changes for clarity “Additionally, the spectra indicate the role of water vapour absorption in reducing reflectance in the near-infrared overtone water bands...” In my opinion, your inclusion of overtone throughout the manuscript is not value-added and may just be confusing to the reader. If you would like to include it, it would help to include absorption before the word “bands every time you use it. “...producing rich spectral structure...” is not value-added, please delete.
8. Page 3655, Line 23: You refer to the water vapor absorption bands in the near infrared as the overtone bands several times. It may help to label those bands as the overtone absorption bands in Figure 1, if you decide to keep this description in the manuscript. Doesn’t the spectral structure of the wings of the NIR water absorption bands only specifically point to the shortwave forcing due to water vapor absorption, not necessarily other greenhouse gases? The way this is stated in the text, is not clear.
9. Page 3655, Line 25-27: Instead of decreasing/increasing trends, this should be positive/negative trends.
10. Page 3656, Line 3-7: You mention this in the Figure 3 caption, but it will clarify your explanation in the text to also say that you’re discussing the differences between *decadal averages*.
11. Page 3656, Line 11-12: Even though you say “reflectance” instead of “radiance,” indicating that you are referring to the shortwave, it will be clearer if you explicitly say “shortwave reflectance.” Also, change window band to “visible.”
12. Page 3656, Line 11: “Differences” – change to “Decadal differences”
13. Page 3656, Line 13: Consider adding “absorption” before “bands”
14. Page 3656, Line 12-16: “striping feature” isn’t sufficient to explain what the reader is looking at. Do you mean the vertical stripes in the water bands? Or horizontal stripes? Be more specific. It’s a good visual description, but say something about how those stripes indicate a decrease in water vapor absorption between the two decades. Also, you say “movement of low-level stratus clouds” – but to where? To a higher level in the troposphere or to another zonal band? Additionally, do you know where the ITCZ moves based on what we see?
15. Page 3656, Line 20: Does “Changes” refer to an increase or decrease in cloud cover, and can you say why this change leads to the changes in spectral features that you indicate?
16. Page 3656, Line 24: I thought these were decadal averages, not annual.
17. From what I read, you did not talk about the CRE sub-figures at all (Fig 3c and 3f). Include them in your existing discussion, add a discussion about them, or eliminate them. It looks like there

are some good points you can make about them. You cannot, however, assume that your reader will understand how they help you make your case about the value of the shortwave and longwave all sky and clear sky OSSE output.

18. Page 3657, Line 6-7: "Difference trends" then "trend differences" makes this description unclear. Do you mean that you calculated the trends in each model's albedo and OLR and then took the differences or calculated the differences first and then calculated the trends from those differences? Your description could lead the reader either way...don't give them the room to guess.
19. Page 3657, Line 9: This may be answered when you address the previous comment: I don't know if by "sign of trends is reversed" really means that or if you mean that the differences in the trends changes sign.
20. Page 3657, Line 14-15: From the way the first sentence of this paragraph reads, it sounds like you only use shortwave reflectance for climate sensitivity (which is fine if that is true, but I don't think it has to be). Also, the shortwave response is "larger" than what?
21. Page 3657, Line 18: Insert "longwave" between "hyperspectral" and "simulations" for clarity.
22. Page 3657, Line 19-23: These validations were done for both models and you found the same result? Also, was the bias found for both OLR and albedo for both clear-sky and all-sky? Just asking for clarification because it isn't clearly stated. Make sure this is clear for your reader.
23. Throughout the discussions of Figures 3 and 4, guide the reader to the specific subfigures better by including Figure 3x or 4x in parentheses, when you can.
24. Page 3658, Line 5-7: This is a great summary of the purpose of the analysis presented in this study. Well stated. The last sentence of the section is an excellent wrap up of the bigger picture as well.

Discussion

1. Page 3658, Line 27: "Earth's spectrum" – again, too vague. Specify that you are referring to solar and infrared spectral variability.
2. Page 3660, Line 29: "the pan-spectral instrumentation" – this makes it sound like there is one instrument being designed to measure across the shortwave and infrared, whereas, at least in the case of CLARREO, the plan is to have two instruments located on the same satellite that cover each spectral range .

Figures

1. Figure 1: Please edit the description to better explain the sub-figures. This isn't a scatterplot; it's a histogram of the differences between the two radiation code calculations. Did you select 2099 for any particular reason? If not and it's just an example, that's fine. If so, that would be good to state. The labels on the figures to point out spectral features are helpful, but try to make them bigger, if possible.
2. Figure 2: Although it's mentioned in the text, also specify that the trends in Figure 2b are between 2000 and 2050. Also, did you deseasonalized the reflectance and radiance before calculating these trends? Were the decadal averages used? Or the annual or monthly averages? Although the units are per decade, it is unclear how these trends were calculated. Please specify. (Also for Figure 4g and f).

Technical Corrections

1. Page 3652, Line 22: There needs to be a semi-colon after the word OSSE. Also should "are" be "of"?
2. Page 3656, Line 12: Delete "covering" – your point is made well without it.

3. Page 3658, Line 4: Typo – Did you mean “from models”? You could also say “from a model-based hyperspectral simulator.”