Response to Reviewer #2

Dear Reviewer,

I appreciate the time you have spent reviewing this manuscript. Your suggestions have helped to improve it. I have responded to each of your comments below. Your comments are italicized, our responses are in normal text, and the edits that will be made in the manuscript text are in bold.

1). *While PCA is very useful tool in finding similarities between various data sets, it is also powerful in identifying differences. The fact that there are significant differences between two sets of eigenvectors derived from OSSE and SCIAMACHY (see figure 4) indicates that the OSSE radiative transfer calculations may have some unrealistic assumptions. The authors have done a good job in handling the spatial and temporal variability of the data to minimize the differences (see figure 2). Some of the differences shown in figure 4 could be due to the cloud properties and surface BRDF used in the radiative transfer calculations. Although the authors have mentioned the possible impact of BRDF as a likely cause for some of the differences in the first eigenvector, a more detailed radiative transfer simulation study is recommended for quantifying the differences in the future. For example, using other sources of high spectral resolution snow BRDFs to calculate the TOA reflectance spectra and compare the results with those obtained using low spectral resolution MODIS snow BRDF. The spectral differences shown in Figure 4 could also be due to the cloud single scattering properties and the number of streams used in the multiple scattering calculations in the OSSE simulations.*

To address this suggestion, we expanded upon the paragraph beginning at Page 28328, Line 18 with the following: In addition to the ideas presented above, there are other ways to improve and expand upon the analysis presented in this study. We focused on the similarities between the observed and simulated data, but it may also be useful to investigate the nature of the differences between the two data sets. **One approach to address the differences in the variability between data sets would be to conduct a radiative transfer simulation study in which specific variables that may be the cause of variability differences were modified. For example, regarding the difference discussed in Sect. 4.2, we could rerun the OSSE using snow BRDFs with a higher spectral resolution than the current MODIS input to evaluate if such a change accounts for the difference observed between the first pair of SCIAMACHY and OSSE eigenvectors.**

A new paragraph would then start with the sentence that currently begins at Page 28328, Line 21.

2). *Page 28320, line 3, "Eq. 7" should be "Eq. 6"?*

Yes. Thank you for catching that. Equation 6 is where we first define the distance. We will make this change.

3). *Page 28324, line 15, “reflectance” should be replaced with “Bidirectional Reflectance Distribution Function (BRDF)”.*

Yes, we will make this edit.

4). *In the conclusion section, there should be some discussions about the effect of using monthly mean CCSM field for OSSE simulation. The gridded monthly mean SCIAMACHY spectra are generated from the average of daily observations, while the OSSE reflectance spectra are computed from monthly mean fields. The monthly mean of daily reflectance spectra are not equivalent to the reflectance spectrum calculated using the monthly mean atmospheric and surface properties due to the non-linear nature of the radiative transfer equation.*

We will add the following bold text to the end of the sentence that starts Page 28322, Line 6: Even with the data resampling, inherent differences between satellite-measured and model-generated reflectance may remain **because of the inherent nonlinearity in the equation of radiative transfer.**

We include a discussion of this point at the end of the first paragraph of the Conclusion section: **In Sect. 4.1, we discuss the differences between the SCIAMACHY and OSSE data sets despite our attempts to align the spectral, spatial, and temporal sampling. Our main objective in this study was to compare the variability of the two data sets, which we did using the intersection of the principal components calculated from the covariance matrices. It is possible that the sampling differences between the two sets of reflectance spectra were manifested as differences in the pairs of principal components, but despite those sampling differences, the spectral shapes of the principal components were qualitatively similar. The test that we proposed in this study to quantitatively compare the variability between two data sets does not rely on the similarity between each pair of spectra, nor does it evaluate the equivalency of the covariance matrices or the resulting principal components. Rather, this test evaluates the similarity of the subspaces that are spanned by some number of principal components. If the two subspaces are found to be statistically similar, we interpret this to mean that the variability of those subspaces is similar as well.**