Answer to Referee #2

We thank the Referee for raising a number of important points. We have addressed all the points raised by him/her and have marked blue the relevant corrections in the current version of the paper that have been applied to comply with his/her comments, as well as with those by Referee #1.

According to the Referee's comments, the paper contents and structure have been revised to emphasize the homogeneity of the paper outline and uniqueness of the results obtained. The contents of the abstract and conclusion sections have been largely reformulated to point on the new aspects of the study and main conclusions. Contents of sections 2, 3, and 4 have been rearranged and shortened to improve the reading and understanding of the contents of our paper. We also added details to several paragraphs and 15 new citations (see our Answer to Referee #1) to overall improve the paper contents.

From here below we discuss the "Major and Minor comments" of the Referee. Referee's comments and our answers are marked in the following red and black, respectively. The comments by the Referee that were not answered extensively below have been directly modified in the paper and marked in either blue or italic. Revisions applied to account for comments and suggestions by G. Kopp, J. Fontenla, and M. Haberreiter, which were also mentioned by the Referees, have been marked red in the current version of the paper.

MAJOR COMMENTS:
(1) What "SORCE" are we talking about?

The SORCE mission has two instruments relevant to this work: SOLSTICE (115–310 nm) and SIM (200–2400 nm). There are numerous instances in the manuscript where the authors say "SORCE/SIM" or "SIM" where I think they mean "SORCE" (implicitly meaning SOLSTICE + SIM). "SORCE/SIM" is called out in the Abstract (p. 24559, l. 24). What happened to SOLSTICE? This must be clarified throughout the manuscript. Both instruments imply a larger-than-expected solar cycle variation, not just SIM (e.g., p. 24563, l. 24). There is significant wavelength overlap between these two instruments. Which was used in the various plots and model simulations in the manuscript? It is not always clear. How do SOLSTICE and SIM compare over 200–310 nm, the band responsible for SW heating by ozone and ozone production?

We would like to thank the Referee for his/her comments on the confusion of the use of the term "SORCE/SIM"; we have replaced it in the revised version by "SORCE" where applicable. Moreover, we have added the new Table 3 where the spectral range of each simulation carried out by the models in section 4 is explicitly described, in order to clarify any possible confusion.

Note that the SORCE PIs have been recommending for the last couple years (at least) that the community use SOLSTICE for wavelengths short of 240nm and SIM at longer wavelengths, and this threshold should be moved to even longer wavelengths when the Sun is relatively less active. This recommendation stems from the fact that SIM's SNR is essentially 1 at shorter wavelengths. This is absolutely critical to this discussion. When results in this manuscript report the use of SIM data at wavelengths less than 240 this should be noted explicitly with that caveat (and I frankly question what such results even mean). There are also a number of versions of the SOLSTICE and SIM datasets used in recent papers or now available. SOLSTICE v. 11 (and now 12) released in spring 2012 reduced the magnitude of the inferred solar cycle in SSI by essentially a factor of 2(!) compared to v. 10, so most if not all the previous work cited and the model results presented used a larger solar cycle in this region (if they used the SOLSTICE data at all). Further, SIM data are only publicly available at wavelengths longer than 310 nm (despite the fact that SORCE launched nearly a decade ago), so the source of the SIM SSI needs to be clarified.

We thank the Referee for having raised this issue. We have added information in the text (Table 3, acknowledgements) on the data employed in our study.

The altitude of the change from in-phase and out-of-phase ozone response (with respect to TSI) is discussed on p. 24602, in both the satellite observations and models. This is critically dependent on the selection of SIM vs. SOLSTICE, data version, and wavelength range. This manuscript has to be more precise about what is being presented.

We do hope that with table additions and changes in the text this is clarified.

LESS-MAJOR COMMENTS:

(2) The manuscript reads like three separate papers stitched together, with separate outlines and conclusions in each section. Perhaps the collection of authors is “interdisciplinary,” as stated in the the final conclusions (p. 24609, l. 11–12), but the paper seems more multi-disciplinary than inter-disciplinary. The outlines and conclusions should be consolidated, and I think the bulletized overviews, while fine in a talk, are overkill for an article of this length. The essential conclusions should be reflected in the Abstract.

The paper contents and structure have been revised to emphasize the homogeneity of the discussion in the various sections and uniqueness of the results obtained. The contents of the abstract and conclusion sections have been largely reformulated to point on the new aspects of the study and main conclusions. The bulletized overviews were removed from all the sections. However, we suggest their use in the conclusions. In our opinion, itemization helps to highlight the main topics of the paper and clearly explain the main results obtained.

(3) There is an excessive use of section references in the text: “see Sect. 2.3” “see previous section.” It really makes for a choppy read, on top of all the outlines and conclusion bullets.

We have deleted most, if not all, these cross references.

(4) The next-generation SSI instrument (TSIS) referred to on (p. 24562, l. 17) should be named and/or referenced.

The sentence has been moved to sect. 2.4 to comply with comment by Referee #1, and changed as follows:

“…the next generation SIM instrument built for the NOAA/NASA Total Solar Irradiance Sensor (TSIS) mission (Cahalan et al., 2012) includes many design improvements for reducing noise and improving in-flight gegradation tracking. The TSIS/SIM instrument is currently…”

(5) The manuscript talks of the precision goals of both SOLSTICE and SIM (p. 24568, l. 25; p. 24569, l. 15–17). What has actually been achieved would be more useful at this point.

We thank the Referee for having raised this issue. The "goal" wording for SORCE and SIM was removed from the manuscript as that is also what the co-authors who are also part of the SORCE team believe has been achieved. The submitted version of the manuscript stated already the long-term precision value achieved for SOLSTICE. As the SIM long-term precision values have not yet been validated due to lack of other overlapping precision measurements, we modified the discussion in our text for more accurate words. The following changes have been applied in the section:

From "... and goal of precision ..." to "... and measurement precision ..."

From "It aims to achieve ..." to "It achieves..."

From “On longer time scales the stability is lower (see Sect. 3.4), increasing with time, ..“ to “On longer time scales the stability could be lower, increasing with time…”

(6) p. 24570 sounds like a workshop report (it is). Why the meeting was held, what it concentrated on, new methods being developed, etc., are not particularly useful in the context of a review article. (What would help move this work forward is publication of the new degradation models and revised datasets.)

We would like to point out that the instrument teams are working towards applying new degradation models and thus providing revised datasets. Such results are expected out in 2013, along with publication of these new results are being planned. The whole paragraph was changed as follows:

"These discrepancies with prior cycle observations and with *SSI* models have inspired new analyses and collaborations aimed at a better understanding of the potential sources of instrument degradation that might have affected SORCE instruments and previous instruments as well. The studies have been concentrated on SSI instrument observations, capabilities, and estimated spectral irradiance uncertainties, methods of correcting for degradation, and refinement of estimated uncertainties. It has been understood that all detectors and optics suffer some degradation in space, largely due to exposure to solar light, and also due to hydrocarbon contamination that dominates below 400 nm. Accordingly, new models of degradation based on total dose, rather than just exposure time, are being developed for the SORCE and other instruments. Revised data sets are expected out in 2013. Besides, degradation trends have also been analyzed by considering the expected invariance of SSI over the solar cycle minimum. The latter method has been developed by Woods (2012) and applied to data during last solar cycle minimum (2008–2009) to estimate possible degradation trends for SORCE/SIM and SORCE/SOLSTICE. It consists of identifying near-identical solar activity levels on both sides of the minimum to derive corrections for instrument degradation. This analysis showed good agreement of the variability from moderate solar activity level to minimum level from various measurements and models, from 120 nm to 300 nm for solar cycles 21 through 24. However, as the method has about 30% uncertainty in variability due to the assumptions about selecting times of similar irradiance levels, the results may not be as accurate as those derived from analyses based on instrument degradation alone."

(7) The first paragraph of p. 24571 sounds like an advertisement for TSIS. The fact that it was undergoing calibration at LASP at the time this manuscript was written is not useful information. Future missions would more appropriately be mentioned in the final conclusions.

The following sentence has been added at the end of the TSIS paragraph (sect. 2.4 now):

" Nevertheless, even without any overlap in time, the next generation measurements will help to better understand the performance of previous instruments and SSI solar cycle variation."

(8) ". . .may be smaller by half based upon new calibration corrections" (p. 24577, l. 4–5). Are we really talking about SIM, or SOLSTICE? In either case, there is no reference. I assume you are referring to the discussion on p. 24570. Again, that work needs to be published or described in more detail here.

See reply to comment #6.

(9) Table 2 should include information on which SORCE data (SIM vs. SOLSTICE), versions, and wavelength ranges were used in the model calculations, because "When using SORCE/SOLSTICE data the temperature response is approximately half of the SORCE/SIM response indicating the large sensitivity of this model to difference SSI data sets" (p. 24602, l. 3–5). Precisely, and I think that sensitivity has to be true for all models that are computing SW heating correctly.

We have added information in Table 2 and included a new Table (Table 3) in order to show exactly the model spectral and temporal simulation setups. Moreover, we have made additions in the text

discussing the SOCOL model's sensitivity to the spectral forcing with respect to changes in temperature as representative. We would like to emphasize that information summarized in Table 3 was retrieved from peer-reviewed papers, but for MPI-ESM-LR. Therefore, further details on the data set employed can be found in the reference papers, which were mostly co-authored by members of the SORCE team.

(10) Fig. 2: The time period should be spelled out. The reader should not have to search Sects. 2 and 3 to find the time period.

The text has been changed accordingly.

(11) Fig. 7: Please add a legend to the figure (like Fig. 8).

Added, thanks.

MINOR COMMENTS:

(12) It is not necessary to mention soft x-rays in the Abstract; they have no climate relevance.

The text has been changed accordingly.

(13) It is not necessary to capitalize solar spectral irradiance and total solar irradiance in the Introduction (p. 24560, l. 12 and 15).

The text has been changed accordingly.

(14) "Variations of solar UV lead to changes in stratospheric ozone and heating, and hence to indirect amplification. . . ." (p. 24561, l. 3–4). What is meant by indirect amplification should be explained.

The whole sentence has been revised as follows:

"Variations of the solar UV radiation between 120 and 350 nm lead to changes in stratospheric ozone and heating that amplify the effect of the UV radiation in the Earth's atmosphere, possibly also through indirect mechanisms (e.g. the "bottom-down" mechanism, Meehl et al., 2009). Hence, although the UV radiation shortward of 400 nm represents less than 8% of the TSI, its variability may have a significant impact on climate. In contrast, the visible and IR bands, which have the largest contribution to the TSI, small variations over the solar cycle, and no absorption in the atmosphere but in some well-defined IR bands, directly heat the Earth's surface and the lower atmosphere. The large amount of solar flux at the visible and IR bands implies that small flux differences may induce important terrestrial consequences. The impact of the variability of these bands on the Earth's climate is expected to be small, although it may involve amplification mechanisms (e.g. the "bottom-up" mechanism, van Loon et al., 2007)."

(15) Typo: "challe.g." (p. 24564, l. 20).

Revised, thanks.

(16) ". . . raises doubts about the consistency of the observations from SORCE" (p. 24574, l. 8–10). Consistency between SIM and SOLSTICE or SORCE and other measurements?

The sentence was changed as follows:
"….raises doubts about the consistency between SOLSTICE and the other measurements, and also between SIM and the other data."

(17) “Haigh et al. (2010) were first to publish the important implications of the SORCE/SIM data. . . .” (p. 24599, l. 24–26). Actually, Cahalan et al. (2010) published six months earlier, showing the effect on middle atmosphere temperature with the GISS modelE.

We thank the Referee for having drew our attention on this. We have changed the sentence accordingly and added a reference to Cahalan et al. (2010). The new sentence states:

“Cahalan et al. (2010) and Haigh et al. (2010) published first the important implications of the SORCE data for middle atmosphere heating and therefore temperatures. Using simulations from a 2-D radiative-photochemical model Haigh et al. (2010) also presented effects on ozone.”

(18) Typo: “tthe” (p. 24604, l. 3).

Revised, thanks.

(19) Typo: “is is” (p. 24605, l. 11).

Revised, thanks.

(20) “In order to better understand solar-induced climate variability and estimate uncertainties and sensitivities of single climate model responses in a more robust way, coordinated climate model simulations are needed, using a range of SSI estimates which are presented for the first time in a comprehensive way in this paper” (p. 24605, l. 12–16). I personally think effort would be better spent getting the SSI measurements right first. The solar cycle derived from SOLSTICE data has already been revised down significantly. It is quite possible that SIM will also be reduced and be more consistent with previous measurements.

We thank the Referee for having raised this issue. We have reformulated our conclusions and tried to better convey our thoughts and priorities concerning future work in this field.