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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Middle atmosphere response to different descriptions of the 11-yr solar cycle in spectral irradiance in a chemistry-climate model" *by* W. H. Swartz et al.

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RE: "Middle Atmosphere Response to Different Descriptions of the 11-Yr Solar Cycle in Spectral Irradiance in a Chemistry-Climate Model by W. H. Swartz, R. S. Stolarski, L. D. Oman, E. L. Fleming, and C. H. Jackman

This is a useful addition to the recent series of model studies investigating the effect of SORCE measurements of solar spectral irradiance (SSI) on stratospheric chemistry and radiative heating. Results generally agree with previous simulations in showing a negative ozone response to increased solar UV flux in the uppermost stratosphere and lower mesosphere when using the SORCE measurements whereas the modeled

response is positive when using the NRL SSI variation. The SORCE-derived negative ozone response near the stratopause is inconsistent with observational evidence over the last few solar cycles but the NRL-derived ozone response profile also differs significantly from the observations (Figure 4). The SORCE-derived temperature response in the upper stratosphere is much larger than the NRL-derived response (Figure 7). The modeled ozone response profile using either SSI variation is further broken down into contributions from wavelengths greater than or less than 242 nm, representing ozone production and destruction as well as the wavelength regimes measured by the SIM and SOLSTICE instruments on SORCE (Figure 9). The authors conclude that a chemical transport model with coupled chemistry is needed to simulate accurately the temperature response. They also correctly caution against using a chemistry climate model output in comparison with uncertain observations as a way to validate the SORCE SSI measurements. Publication is recommended after revision in response to the following relatively minor comments.

Specific Comments:

1. The modeled ozone response using the NRL SSI variation (solid curves in Figures 2 and 4) has a relatively weak lower stratospheric maximum in comparison with observations and with most of the simulations studied by Austin et al. (2008). The altitude-latitude cross section shown in Figure 5a does have a secondary lower stratospheric signal but it is weak and confined only to the tropics within 10 or 15 degrees of the equator. Is there an explanation for why the GEOS CCM signal in the lower stratosphere is relatively weak? The model is apparently being forced at its lower boundary using observed SSTs so there should be a significant positive response in the lower stratosphere due to feedbacks from the troposphere-ocean response. One possible reason is that only time slice simulations are performed here while all simulations considered by Austin et al. were transient simulations. Time slice simulations might not fully account for different troposphere-ocean feedbacks under solar maximum and minimum

conditions since the latter are effectively averaged over the whole simulation. Also, the GEOS CCM does not have a QBO if I understand correctly. But this may be less of a factor since Austin et al. found little difference in results for models with and without QBOs.

Requested author revision: Please note the relatively weak lower stratospheric ozone response compared to Austin et al. and provide some possible explanations. This could be done when discussing Figure 2 (top of p. 7051) and/or when discussing Figure 4 (p. 7052). It might also be mentioned in the section that describes the model (section 4.1; see comment 3 below).

2. There is a recent paper by J. Lean and M. DeLand (How does the Sun's spectrum vary? J. of Climate, in press, available online at http://journals.ametsoc.org/page/eors). This paper argues that there are undetected instrument sensitivity drifts in the SORCE SIM data and that these data may therefore not be appropriate for simulations of climate and atmospheric change. This paper should be mentioned and discussed in section 2 (p. 7044-7045).

3. In the description of the GEOS CCM (section 4.1), there is no mention of the QBO and whether a QBO is included in the model (either modeled or forced). Also, it is only stated that time-slice experiments are performed. There should be some discussion of the relative merits of time-slice versus transient experiments in simulating the solar cycle response, especially that in the lower stratosphere. Although time-slice experiments are much more economical, the troposphere-ocean feedbacks on the lower stratospheric response may be simulated incompletely or not at all even for a model that is forced at its lower boundary using observations. Some assessment should be made of whether this simplification would affect only the lower stratosphere or whether there could be some indirect effects at higher altitudes.

4. P. 7053, lines 14-22. Although it is true that the column ozone record is long and

relatively unambiguous (especially the satellite record, which has nearly complete coverage at latitudes less than 60 degrees), most of the ozone column is in the lower stratosphere. As noted above in comments 1 and 3, the lower stratospheric response may not be adequately simulated by the time slice experiments reported here. The maxima in the observed column ozone response at subtropical latitudes (Figure 6) are a clear indication that dynamical processes in the lower stratosphere (coupled to the troposphere-ocean response) are contributing strongly to this response. See L. Hood and B. Soukharev (The lower stratospheric response to 11-year solar forcing: Coupling to the troposphere-ocean response, J. Atmos. Sci., in press; available online at http://journals.ametsoc.org/page/eors). Therefore, the comparisons with model results may not be so appropriate using total ozone. Most conclusions should probably be limited to results in the upper stratosphere, which are dominantly photochemical and radiative in origin.

Minor Corrections:

5. P. 7041, lines 15-25. Mention also the Lean and DeLand paper here.

6. P. 7044, lines 3-20. Is a coupled troposphere and ocean also necessary in the model? Or at least is it necessary to force the model from below using observations of SST and sea ice? This can be mentioned here or deferred to later when the GEOS CCM is discussed, at the authors' discretion.

7. P. 7044, line 23: Goddard Institute for Space Studies

8. P. 7044, line 28: ... and out of phase above when using the SORCE SSI.

9. P. 7046, line 13: The SORCE mission instruments include ... (suggestion)

10. P. 7050, line 21. Please say again here that Figure 2 is calculated assuming the

NRL SSI. It might also be helpful to mention this again in the figure caption to be sure that it is understood by readers.

11. P. 7051, lines 17-21. These statements are certainly true in the upper stratosphere and lower mesosphere but they don't really apply to the lower stratosphere, which is affected by dynamical feedbacks from the troposphere-ocean response. Please add an appropriate phrase to clarify this. Also, please replace the dash with a semicolon in line 20.

12. P. 7052, lines 1-2. Suggest rewriting as: ... most of the middle and upper stratosphere and lower mesosphere.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 7039, 2012.