Interactive comment on "Stratospheric O3 changes during 2001–2010: The small role of solar flux variations in a CTM" by S. S. Dhomse et al.

Anonymous Referee #2
Received and published: 28 June 2013

The paper 'Stratospheric O3 changes during 2001 – 2010' investigates the role of spectral solar cycle variations for the variability of stratospheric ozone in the stratosphere and lower mesosphere. A number of specified model simulations are carried out using different models of solar spectral variability for the period 2001 – 2010, and results of these model runs are compared to observations of ozone throughout this period.

The main result appears to be that the observed variability of ozone especially at the tropical stratopause, which is commonly attributed to solar spectral variability in the UV range, can be explained by dynamical changes only. This is a very interesting result (and of course raises the question whether the source of the dynamical change is solar or not). The model experiments appear to be generally very well thought out, and the paper is very well written. However, there is one point which I find should be addressed: the description of the models used, both the solar models as well as SLIMCAT, is insufficient for the discussion of the results. My main objection here is that the wavelength coverage of the SATIRE and NRL-SSI models are not given, and the treatment of the far-UV (Lyman-alpha and Schumann-Runge continuum) regions of the SLIMCAT model, which used to be parameterized to a fixed solar flux, are not discussed. For the discussion of the results, it would be very important to know how the wavelength region 116 – 200nm, and especially Lyman alpha and the Schumann-Runge continuum, are treated; so please, add this information to the model descriptions.

We thank the reviewer for his/her helpful comments. See replies to the reviewer 1. Details about model photolysis scheme have been added in the revised manuscript. Both NRL-SSI and SATIRE-S provide solar fluxes at much higher resolution (1nm) starting from EUV to microwaves. However, the SLIMCAT photolysis scheme only uses 203-spectral windows (WMO, 1985). Solar flux variations associated with Lyman-alpha are included in our simulation. Intense fluxes in Schumann-Runge Continuum are absorbed well above the model lid (0.1hPa), so those variations are not included in our simulations. However, flux variation at the Schumann-Runge Bands and longer wavelengths are included in present simulations.

More specific comments are summarized below.

Specific comments:

Page 12264, lines 15-16: ".. due to changes in stratospheric dynamics". This is conclusion drawn from the model results, and should be marked as such: ".. which are shown to be due to changes in stratospheric dynamics by the model results."

Modified as "which is due to realistic dynamical changes in our simulations."

Page 12267, line 5 – 6: Please give a reference for the vertical resolution of the SABER data.

Done

Page 12267, lines 15-25: What is the wavelength range of the SATIRE-S model?
Page 12267, lines 26 ff: Wavelength range of the NRL-SSI model?

##Corrected as

"The SATIRE-S SSI dataset ranges from 115 nm to 0.16 nm with variable resolution of 1 nm up to 290 nm and 2 nm up to 1000 nm. The NRL-SSI dataset is available from 120.5 nm to 0.1 mm with 1 nm resolution up to 750 nm. Both NRL-SSI and SATIRE-S solar flux data show very similar 11 yr solar cycle variability for wavelengths less than 250 nm. Above 250 nm, SATIRE-S displays larger variability, with twice the change in flux compared to NRL-SSI at 300 nm, increasing to a three-fold larger variation at 370 nm. For most wavelengths between 440 and 1250nm NRL-SSI is more variable than SATIRE-S."

Page 12268, line 10: "32-vertical" ! "32 vertical"

Done.

Page 12268, lines 15 – 17: as far as I know, the photolysis code of the SLIMCAT model has, or used to have, a special parametized treatment of Lyman alpha photolysis for some species (e.g., O2, H2O, CO2, CH4), as well as a parameterization of the O2 photolysis in the Schumann-Runge continuum. As this affects both the ozone productionand the ozone loss rates via HOx production directly, it is important for the discussionof the model results to understand how / if the Lyman alpha and Schumann-Runge parameterizations are varied throughout the solar cycle in the different model runs.
So, it should be explained in Section 3 how Lyman alpha and Schumann Runge O2 photolysis is treated in your model experiments.

Please see reply to main comment and reply to Reviewer 1. (Nb the model has a parameterisation for the SR bands, not SR continuum).

Page 12268, line 16, Figure 1 / page 12269, line 5: In Figure 1, the wavelength range only extends down to 180 nm, while you state that the SLIMCAT range covers wavelength down to 116 nm. Why not show the full wavelength range of the SLIMCAT model in Figure 1, especially as the wavelength range from 116 – 200 nm contains the Schumann-Runge bands, SR continuum, and Lyman-alpha? Should the reason be (as I am led to assume) that the SATIRE-S and NRL-SSI models do not extend to 116 nm, this should be discussed here, as it might lead to an underestimation of the chemical impact of the solar variation in the model experiments.

See reply to reviewer 1. Figure 1 and corresponding caption have been modified in the revised manuscript. We also added a paragraph stating more details of the photolysis scheme. More details about NRL-SSI and SATIRE-S spectral resolution have been added.

Page 12268, description of SLIMCAT model: does the chemistry code of the SLIMCAT model still assume an equilibrium approach for families like Ox and HOx? This might affect the comparison of daytime / nighttime values in Figures 5 and 6 in the upper stratosphere and lower mesosphere, as there, Ox and HOx are not in equilibrium during night-time. However, this would probably only affect the upper 1-2 model levels.

The model integrates an Ox family and assumes equilibrium between O3, O(3P) and O(1D). The HOx species are treated separately but each is assumed to be in steady state (e.g. d[OH]/dt=0). See also reply to reviewer 1 and Figures R1 and R2. We also did a profile by profile comparison with other species from ACE, but we did not find any significant differences between ACE and SLIMCAT at the top levels. Either way, the main focus of this study is to highlight MLS-SABER (and model) differences in the upper stratosphere and the robust positive solar signal in the tropical middle stratosphere during the recent solar cycle.

Page 12269, line 23-25: does the vertical resolution of the SABER experiment (which, admittedly, is quite good) affect the results of the SABER-model intercomparison? i.e.,would it be possible that the comparison of the profile shape improves if the model O3 was reduced to the vertical resolution of SABER?

Yes, SABER vertical resolution is better than MLS or SLIMCAT. However, for direct comparison we decided to use fixed pressure (or MLS) levels, so both SABER and SLIMCAT are interpolated onto MLS pressure levels. Due to different levels in SABER, we think direct comparison would be quite complicated.

Page 12274, line 25: due to internal atmospheric variability, or possibly anthropogenic influences?

Done.

Figure 2: Would it be possible to give an error range of the observations? This might be helpful to determine whether, or where, the observed differences between observations and model results are significant.

We are using monthly mean values, so we think averaging errors is not a good idea. However, in Section 2, we do mention approximate errors in both MLS and SABER retrievals.