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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Interannual-to-decadal variability of the stratosphere during the 20th century: ensemble simulations with a chemistry-climate model" *by* A. M. Fischer et al.

Anonymous Referee #1

Received and published: 1 August 2008

Review of the manuscript "Interannual-to-Decadal Variability of the Stratosphere during the 20th Century: Ensemble Simulations with a Chemistry-Climate Model",

by A. M. Fischer and co-authors.

The manuscript describes an ensemble simulation of the 20th century performed by the chemistry-climate model SOCOL. The ensemble simulation is composed of nine members forced with a complete set of external forcing sources (sea surface temperatures, sea ice changes, land changes, solar variability, emissions of CO2, CO, CH4, NOx, N2O, organic chlorines and bromines, stratospheric aerosols), as well as a quasi-biennial oscillation (QBO). The ensemble simulation is compared for evaluation

with ERA-40 and NCEP re-analyses over the second half of the 20th century, and with radio- and ozone- sondes over the first half of the century. The model results compare quite well with the re-analyses and the observations throughout the century, except for the typical northern high-latitude flaws seen in many such models with a too strong polar vortex and a too low total ozone column. The model also seems to under-evaluate the ozone trend in the southern hemisphere lower stratosphere in the last decades of the century. A descriptive discussion is provided of the chemical and dynamical changes that occurred in the model over the century. In particular, it is shown that no significant trends could be identified either in the ozone or in the dynamics over the first half of the century. The changes identified in the second half of the century are contrasted with the internal variability, as given by the spread of ensemble members. Several dynamical diagnostics are calculated and compared with ERA-40 and NCEP re-analyses: the strength of the sub-tropical jet, the strength of the polar vortex, some statistics on major warmings, the vertical Eliassen-Palm flux component as well as its correlation with the polar temperature.

Overall, I found that the manuscript provides a very good contribution to the field. It has a good standard of model evaluation, utilization and analysis, and offers for the first time to my knowledge a thorough description of stratospheric changes throughout the entire 20th century. The manuscript is also well written and the description of the results is well structured. One weakness of the manuscript, to my opinion, is that it contains little on the dynamical mechanisms that could explain the trends seen in the model. But such an analysis could well fit in another paper. The other weakness concerns the mass fixing procedure. The impact of this procedure on the total ozone column is quite important, but not enough information is provided in the paper to allow the reader to understand it.

Minor comments:

Abstract

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Interactive Comment

P. 14372, l. 19: Replace "large internal model variability" by "large internal variability"

2.1 Model Description

P. 14375, l. 18: Model lid at 0.1hPa or 0.01hPa?

Last para.: Since the mass-fixing-procedure is quite important for the total ozone column, as shown in Fig. 4, it would be good to have more information on it here.

2.2 Boundary conditions

P. 14376, l. 22: Change "Hadely" into "Hadley"

P. 14378, line 14: Replace "why we decided in favor of the GISS" by "why we used the GISS"

2.4 Comparison...

P. 14381, line 5: This should be said earlier, avoid repetition.

P. 14382, line 2: Replace "To address dynamical features, fields of modeled zonal" by "To evaluate the model's dynamics, modeled zonal"

3.1 Analysis of ozone

First para.: I am not convinced by the explanation that the underestimation of the high-latitude maxima in total ozone is due to the mass-fixing problem, since this mass-fixing seems to shift the whole seasonal cycle, rather than to affect the winter time specifically. Also, it seems to me that this is a rather typical problem of chemistry-climate models, which I would suspect may be related to a too weak wave forcing.

P. 14383, line 10: In "back to 1970 with respect to 1979-1999", are you talking about an average over the 1979-1999 period? Please clarify.

P. 14383, line 14: Replace "low-frequency variability of all SOCOL" by "low-frequency variability in all SOCOL"

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P. 14383, line 17: Replace "Yet, the modeled decay seems to be too dominant and too fast." by "Yet, the modeled decay seems to be too fast"

P. 14383, line 27: Replace "Due to the restriction of the ozone...(...), the correction of the violation of mass conservation leads to a ..." by "The restriction of the ozone...(...)leads to a..."

P. 14384, line 7: This mass-fixer has a very important effect on ozone - can you propose an explanation for it?

P. 14384, line 7: Clarify which mass fixer you refer to here (the 40s-40N one?).

P. 14384, line 13: Replace "By and large, the ensemble..." by "The ensemble..."

P. 14384, line 16-17: This sentence seems confusing to me. Considering that observations represent one realization (the true one), their variability should be comparable to one ensemble member. However, Fig. 5 suggests that individual ensemble members have less variability than the observations.

In general: You could consider adding a graph in Fig. 6 which shows the difference between SOCOL 1901-1969 and SOCOL 1970-1999 for instance.

3.2 Analysis of dynamics

P. 14387, line 21: Remove "representing another important factor for the distribution of stratospheric chemical species".

P. 14387, line 24: Replace "modeled temperatures show colder temperatures at northern..." by "modeled temperatures are colder at northern..."

P. 14391, line 9: It would be useful to say what frequency of the model outputs you use to calculate the EP flux? A too low frequency may lead to an overestimated variability in the EP flux. Also, can you say over what time intervals you average the EP flux each year (one month, three months?). In addition, it would have been nice to see the mean residual circulation too.

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P. 14391, line 22: Correct "significane"

4 Conclusion and Outlook

P. 14394, line 25: Model lid at 0.1hPa or 0.01hPa?

Figures and captions:

Fig. 7: I understand that these trends are taken on the whole year following equation 1. Is that true? It could be useful to recall it here or in the text.

Fig. 12: In these graphs, you take as reference (the horizontal bar) the ERA-40, and compare to it the model members. It would be more logical to my opinion to take as reference the model ensemble mean, and discuss whether the ERA-40 can be one realization of this ensemble.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 14371, 2008.