

## ***Interactive comment on “Time varying changes in the simulated structure of the Brewer Dobson Circulation” by Chaim I. Garfinkel et al.***

### **Anonymous Referee #1**

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The paper presents an assessment of the trends in stratospheric circulation in model simulations of GEOSCCM, and using specific forcing simulations attributes the trends separately to GHG, ozone depletion and volcanoes. The main points are 1) the model trends are highly sensitive to the period chosen, in particular they change between before and after the late 1980s and 2) the model shows aging trends in the NH for the latter period, in qualitative agreement with observational estimates, which can be attributed to volcanic emissions and the end of ozone depletion. The paper is clearly written, the analysis is very relevant and well-timed and the results are interesting. Nevertheless, the paper would improve if the authors carefully address the following minor comments.

*General comments:*

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1- The choice of the year separating the early and late periods is not clearly explained, and the authors change it throughout the paper somewhat arbitrarily (1988 in Fig. 3, 1992 in other parts). In particular, considering the trends from 1992 makes the starting point right at the peak influence of the Pinatubo eruption (Fig. 5). Since there are no observational trends reported from this year, I do not see the point in taking this year as a reference, besides enhancing the NH mid-stratosphere aging trends.

2- The age of air trends shown in Fig. 3 are quite similar to those reported for the ERA-Interim reanalysis and also consistent with balloon-derived measurements, but only for simulation 3. The other two members give completely different patterns in the mid-stratosphere. Hence, a major point to extract from Fig. 3 is that there is very large inter-member spread, due to the strong interannual variability and the relatively short time series. In his sense, the sentence in the abstract on P1 L5-6 is misleading, as it leads to think that the model is robustly producing positive trends in the NH mid-stratosphere since the late 1980s.

*Specific comments:*

- P1 L 23 – P2 L2: and even there it is not fully true, near the tropopause there is strong isentropic mixing.
- P2 L14-15: “Reanalysis data”: this has only been shown for the ERA-Interim reanalysis, not for others. - P6 L1-2: The reanalysis studies are limited in their initial date because they need to run trajectories for 10 years before they output age of air.
- P6 L9-11: Is this similar to averaging the trends of each member?
- P6 L31-32: Are the trends in the lower stratosphere significant?
- P17 L 9-13: The trends derived from tracer observations are positive from 1975, not just from the late 1980s. This difference between the model and the observations should be mentioned around this part.
- P 9 L27: This is directly shown for sub-seasonal variability in Abalos et al. (2014)

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JAS.

- P10 L3-4: I do not think the ozone depletion impacts only the deep branch of the circulation. For instance Abalos et al. 2015 JGR (Fig. 15) show an impact of ozone depletion in the lower stratosphere BDC in reanalyses, linked to enhanced EP flux propagation and convergence around 50 hPa in DJF. In fact, I do not see a significant difference between the All-forcing curves in the middle and lower stratosphere (Figs. 4c and 4f).

- Fig. 6: Why not show the same latitudinal range and levels as in Fig. 4 for consistency?

- P16 L2-3: This important point in the context of interpreting model trends and comparing them to observations, and could be further emphasized.

P17 L11: (including aging in the mid-latitude mid-stratosphere in the NH): this is only seen in one out of three members (see general comment 1).

- Fig. 8: None of the simulations present an inter-hemispheric dipole in the trends as the observations suggest (e.g. MIPAS). This should be pointed out.

*Technical corrections:*

- P4 L21: has → have

- P7 L28: simulate → simulates

- P7 L 30: relative to the other two?

- P7 L30-31: this sentence is not clear, please rephrase it.

- P8 L 29: GHG gases → GHG

- P9 L20: recover → decrease

- P10 L4 remove “since”

- P15 L2: It is impossible to directly measure → There are no direct measurements

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