

Review of “Time varying changes in the simulated structure of the Brewer Dobson circulation”

By C. Garfinkel et al.

Recommendation: accept after minor revision

This is a useful paper that shows that inferences about changes in the BDC derived from a state of the art numerical model are consistent with recent estimates based on observations of trace species. Further, the study is able to attribute changes in the BDC to various factors (SST, GHG, ODS, volcanoes) by comparing simulations that include one or more of these forcing factors. A few minor suggestions for changes and clarifications are detailed below.

Specific Comments (by page and line number):

(1, 20) “BDC has been deduced from ... average time for air parcel...”: The BDC is not deduced from AoA (that is, AoA does not measure the vector circulation (v^*, w^*); instead, it is a proxy for the strength of the BDC, which, furthermore, needs careful interpretation.

(1, 22) “differences”: It is not clear how one establishes "differences" between a scalar field (AoA) and a vector field (the BDC). See previous comment.

(2, 14) “pronounced aging”: I think this over-states the findings. For example, Engel et al.'s trend estimate is not significantly different from zero.

(2, 17) “aging of the NH”: It might be better to write “increasing age of air in the NH”. Certainly, the mid-stratosphere of the NH is not getting older (except insofar as the Earth and all of us upon it are getting older.)

(3, 11) “aging of the mid-latitude NH”: Better: “aging of air in the mid-latitude NH”.

(3, 20) “GEOSCCM”: Does the model reproduce the QBO? Timing between the QBO and the seasonal cycle can introduce substantial low-frequency, stochastic variability in AoA. This is not relevant to long-term climate change but should be noted, especially if it is present in the model, since low-frequency variability could be misinterpreted as a trend in short records.

(4, 21) “interannual and decadal variability in SST”: Are you saying that you used the

smoothed version of SST in your simulations? This is not clear; and it is not a trivial point, as such stochastic, low-frequency variability will add “noise” to the time series and make it difficult to say much about trends over short periods of time (25 years or less, in my experience.)

(7, 26) “statistically significant”: In general, it would be useful to quote the 2-sigma values every time a trend in AoA is quoted. That way one can get a quick idea of the 95% significance of any trends mentioned. I understand why you may not want to clutter the contour plots by, for example, shading significant regions, but it is easy enough in the text to quote a trend number ± 2 -sd.

(7,28) simulate \rightarrow simulates

(10, 2) “follows ozone depletion”: It is plausible that ozone is responsible for BDC changes in the SH mid-stratosphere. But what about the NH, where ozone changes are minuscule compared to the SH, but where AoA also flattens out after 1990? (cf. Figs. 4a and 4c). This explanation seems incomplete to me.

(10, 24) “the same forcings”: Isn't this trivially true? After all, AoA is a proxy for the strength of the circulation. Perhaps you had something more profound in mind, but I do not know what.

(15, 1) “impossible to directly measure changes”: It is not clear what this means. If you mean that (v^* , w^*) (and, therefore, changes in the BDC) cannot be measured, that is correct. But the diabatic BDC can be obtained from the thermodynamic + continuity equations, and given “good enough” data for a “sufficiently long” period, it should also be possible to detect trends in the BDC. I would think this is probably a more precise, and less ambiguous method than looking at trace gases.

(15, 19) “aging trend noted in observations”: Garcia et al. (2011) have discussed why AoA trends derived from trace species may be misrepresented, even when the trends are corrected for growth rate, so one has to take these trends with a grain (or two) of salt.

(15, 26) “extreme caution”: Trends over 10 years are not very useful. They can be formally computed, but they are more likely to be influenced by stochastic variability than by any real long-term forcing. (In this regard, please clarify whether you used observed SST or smoothed observed SST to drive the model.)

I was going to suggest that you delete this section, but I think it actually serves a

useful purpose in illustrating how these trends can be “all over the place”, especially above ~70 hPa. Even in the shallow branch, the results are not very consistent among the 3 simulations shown in Fig. 8. So, a useful message from the present exercise is that one should not base any conclusions on the long-term behavior of the BDC on 10-year trends.

(16, 24) “fraught with danger”: This is a bit too dramatic. I would think that inferring trends in the BDC from AoA trends derived from observations is even more ambiguous—yet we do it all the time!

(16, 32) “Pinatubo”: Better: “the eruption of Mt. Pinatubo”. The volcano itself would be irrelevant, and unknown to most of us, had it not erupted.

(17, 12) “only applies over long periods”: This is a very useful point, which we often lose sight of, and I am happy to see it emphasized and illustrated by the results presented here.