

## Reply to Reviewer 2

We thank the Reviewer for the careful reading and evaluation of the manuscript and the good comments which helped to further improve the paper. In the following, we address all comments and questions raised (Reviewer's comments in italics). Text changes in the manuscript are highlighted in color (except minor wording changes).

### General comments:

*This paper examines changes in the stratospheric circulation via CLaMS simulations forced by different reanalysis products, free running model output from CCM1 runs and satellite observations of N<sub>2</sub>O. This wealth of information is used to elucidate the hemispheric asymmetry in the stratospheric circulation variability over recent decades and put these changes in context of the long-term changes expected due to ozone recovery and climate change. The results are generally consistent with previous studies but this study brings more detail and explanation of the circulation asymmetry than has been done before. The methods of analysis are clearly explained, the figures show the features well and the conclusions are fully justified. I recommend publication of this paper in its current form with consideration of the minor comments listed below.*

Thanks for this positive evaluation of the manuscript!

### Specific comments:

Lines 1-3: *The first sentence of the abstract is a bit awkward. Perhaps, 'The stratospheric Brewer-Dobson circulation (BDC) has been found to have weakened in the NH relative to the SH in recent decades, despite ozone recovery over this period that would be expected to cause the opposite trend, inducing substantial effects on chemical composition'.*

Thanks for pointing to that. We agree that the formulation was not clear (as similarly stated by Reviewer 1) and changed the sentence to: "The expected effect of ozone recovery on the stratospheric Brewer-Dobson circulation (BDC) is a slow-down, strongest in the Southern hemisphere (SH). In contrast, the BDC has been found to weaken more strongly in the Northern hemisphere (NH) relative to the SH in recent decades, inducing substantial effects on chemical composition." To make the abstract fit into the word limit, we made a few more minor wording changes.

Line 37: *maybe add 'increasing' before 'ozone depletion' here since ozone depletion has been ongoing after 2000. It might be helpful to come up with a term to describe the ozone depletion before 2000 since you refer to it again later.*

We added "increased ozone depletion" for clarification.

Line 63: *I think you meant 'BDC decrease' rather than 'increase'.*

Yes indeed - corrected! Thanks for noticing that!

Line 84: *The 'e.g.' seems oddly placed after the reference.*

Corrected.

Line 157: *It looks like both ERA-Interim and ERA5 have mostly positive trends in the SH.*

We agree that the description here was unclear. The text has been clarified to: "In the SH, JRA-55 shows positive trends, while the other reanalysis show different trend patterns with regions of both positive and negative trends."

Line 162: *'extent' instead of 'extend'*

Corrected.

Line 164: *'of' instead of 'for'*

Corrected.

Lines 216-7: *This sentence could use a bit more explanation. When you say a 'strengthening deep BDC branch' and 'weakening meridional circulation' I assume you're referring to just the NH circulation but it's not entirely clear. And the consistency with the age of air trends is maybe not straightforward since there are positive age trends in ERA5 in the NH at all levels above 100 hPa. Positive age trends (plus negative N<sub>2</sub>O trends) and a stronger circulation above 10 hPa don't immediately follow so it would be helpful to at least make reference to the later discussion in Section 4.2.*

We agree that at this point the relation between residual circulation and age of air trends is not straightforward, and clarified the text with a reference to the later section where the relation becomes clear: "Hence, residual circulation meridional velocity and EP-flux divergence changes are consistent, indicating a strengthening deep

BDC branch above about 10 hPa and a weakening meridional circulation below in the NH relative to the SH. These trends are largely consistent with the trends deduced from age of air and  $\text{N}_2\text{O}$ , as will become clear from the discussion in Sect. 4.2.”