We thank the reviewer for the thorough reading of the manuscript and the insightful comments, which clearly helped to improve the manuscript. We addressed all points in the revised version as described below. Reviewer comments are in normal font, answers in italics. A summary of the main changes in the revised version is given in the bullet point list here (with more details given in the replies to the specific comments below).

- The title of the manuscript has been revised to more accurately reflect its content, including the requested modifications.
- In response to Reviewer 2's suggestion, we refined the scale-based separation to distinguish between planetary, synoptic-scale, and mesoscale waves. The separation is now presented in sect. 2.2, and discussed with the new Fig. 3 in sect. 3.
- A decomposition into more physical atmospheric wave phenomena was requested by the reviewer 1. In response, the relation between wave scales and physical wave types is discussed at the end of sect. 2.2: planetary waves are associated with quasi-stationary Rossby waves, synoptic-scale waves represent a mixture between Rossby and gravity waves, and mesoscale waves are associated with gravity waves.
- As requested by Reviewer 3, we conducted additional analysis of upwelling trends to examine whether separating the ozone recovery period from the post-ozone recovery period improves the statistical significance of the trends.
- More information from reanalyses other than ERA5 was added to the sect. 3 and 4 of the manuscript as requested by Reviewer 2
- As requested by Reviewer 2 and 3 rewriting and restructuring of several text parts throughout the entire manuscript was done to improve clarity and readability eg. sect. 2.2, sect. 3 and sect. 4.
- The comparison of resampled ERA5 data with original fine resolution ERA5 data was expanded (see Sect. 5), as requested by reviewer 2.

Review for 'a dynamical separation of deep and shallow branches in the stratospheric circulation' by Rasul et al.

This work uses 4 reanalysis data to separate the deep and shallow branch of the Brewer-Dobson circulation, concluded that the shallow branch is mainly driven by wave number smaller than 180, and the deep branch is mainly driven by wave number larger than 180. The past trend over 1980-2017 is also presented. Overall, the analysis of this work is clear, and the paper is well written. I recommend accept this work after a minor revision.

We thank the reviewer for the generally positive evaluation of the manuscript.

Major comment:

The trend that the authors calculated from all reanalysis data over 1980-2017 are not statistically significant. I think this might because over 1980-2017, the Brewer-Dobson circulation could be divided into two eras with an opposite trend: slower during 1980-2000, and faster during 2000-2017 (Polvani et al., 2018, Fu et al, 2019). I suggest that the authors check the trend over the individual time periods.

We thank the reviewer for this very helpful suggestion to divide the trend analysis into periods before and after year 2000, hence influenced by either ozone depletion or ozone recovery, respectively. We carried out the suggested separation of trend calculation into the two periods (see Fig. 1 in this reply letter). However, this separation did not lead to higher statistical significance in the calculated trends (see Fig. 1). The discussion of this result has now been included in Sect. 4.2 of the revised manuscript.

Also, throughout of this paper, there are too much wording like 'maybe', 'appears', which sounds not very scientific and professional, please try to avoid it.

We agree that the text needed improvement. Therefore, we carefully worked on improving the text throughout the entire manuscript and worked on the wording as well as on the structure, in order to enhance the clarity of the presentation.

Specific comments:
Line 31, 'two-way mixing': need citations
Citation Garny et al. (2014) added.

Line 50 'the stratospheric circulation is expected to increase': 'increase' could be misleading, 'strengthen' is better

The word increase was replaced with accelerate as suggested by the reviewer 2.

Line 116 'EP flux': needs a citation here
Citation Andrews (1987) added.

Equation 4: a more detailed calculation method should be described here. Do you calculate the EP flux of each wave number, and then calculate the mean value for wave 1-3, and 4-180? Do you need to perform an inverse Fourier transform from the wavenumber-frequency domain to longitude?

To compute the individual wave contributions, a Fast Fourier Transform (FFT) was applied to each fluctuation component along the longitudinal axis. For example, to obtain $\hat{v}(s)$, the FFT is applied to the zonal array of v', and only the positive wavenumbers are retained. The resulting spectrum $F(s)$ consists of $N/2$ wavenumbers, each representing the contribution of a specific zonal wavenumber, effectively replacing the longitude dimension in the transformed space.

A more detailed description of the Eq. 4 is now present in Sect. 2.2.

Line 133 'nyquist criterion': citation here.
Citations Nyquist (1928) and Shannon (1949) added.

Line 172: DeltaT = 86400s. I think to make the calculation balanced; the unit should be 86400 s/day. And there should be a space between the number and the units. Please also check other numbers in this manuscript.
Fixed.

Figure 1 caption: Is white contour arrows only in figure 1a, and black contour arrows only in figure 1b-c? Why choose to compare different variables?
Different variables are shown in the different panels to enable comparing the residual circulation as well as EP flux vectors.

Line 179 'the wind threshold': is there a relevant citation?
Citation Charney and Drazin (1961) added.

Line 185: this sentence is not Grammarly correct.
Sentence restructured.

Figure 2: green line: you might want to name it 'TEM residual' instead of 'TEM' to avoid possible confusion.
We added a few sentences at the beginning of Sect. 2.2 to clarify what TEM refers to in the figure.

Line 240: 'ERA5 is able to resolve gravity waves better than other reanalysis': need a citation here
citation Hoffman et al. (2019) added.

Line 267: 'we expect a higher..': can you explain more about this sentence?
Figure A2 illustrates a decrease in the upwelling deficit with altitude within the shallow branch region, suggesting that parameterized wave drag contributes substantially to the outflow in this part of the circulation. Since the separation level is defined as the lowest altitude where the outflow driven by planetary waves exceeds that driven by smaller-scale waves, the enhanced contribution of smaller-scale waves—due to the inclusion of parameterized wave drag—is likely to shift the separation level upward. Text in the manuscript is also updated

Figure 6: it will be helpful to include error bars to the mean value?
Error bars are added to the Fig.

320: 'compareed' typo.
Fixed.

429: ‘we find out the deep branch’, the deep branch of the Brewer-Dobson circulation.

Sentence restructured.

References:

Polvani, L. M., Abalos, M., Garcia, R., Kinnison, D., & Randel, W. J. (2018). Significant weakening of Brewer-Dobson circulation trends over the 21st century as a consequence of the Montreal Protocol. *Geophysical Research Letters*, 45, 401–409. https://doi.org/10.1002/201

Fu, Q., Solomon, S., Pahlavan, H. A., & Lin, P. (2019). Observed changes in Brewer–Dobson circulation for 1980–2018. *Environmental Research Letters*, *14* (11), 114026.

Garny, H., Birner, T., Bönisch, H., and Bunzel, F.: The effects of mixing on Age of Air, J. Geophys. Res., 119, https://doi.org/10.1002/2013JD021417, 2014.

Andrews, D. G., Holton, J. R., and Leovy, C. B.: Middle Atmosphere Dynamics, Academic Press, San Diego, USA, 1987.

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Hoffmann, L., Günther, G., Li, D., Stein, O., Wu, X., Griessbach, S., Heng, Y., Konopka, P., Müller, R., Vogel, B., and Wright, J. S.: From ERA-Interim to ERA5: the considerable impact of ECMWF’s next-generation reanalysis on Lagrangian transport simulations, Atmos. Chem. Phys., 19, 3097–3124, https://doi.org/10.5194/acp-19-3097-2019, https://www.atmos-chem-phys.net/19/3097/2019/, 2019.

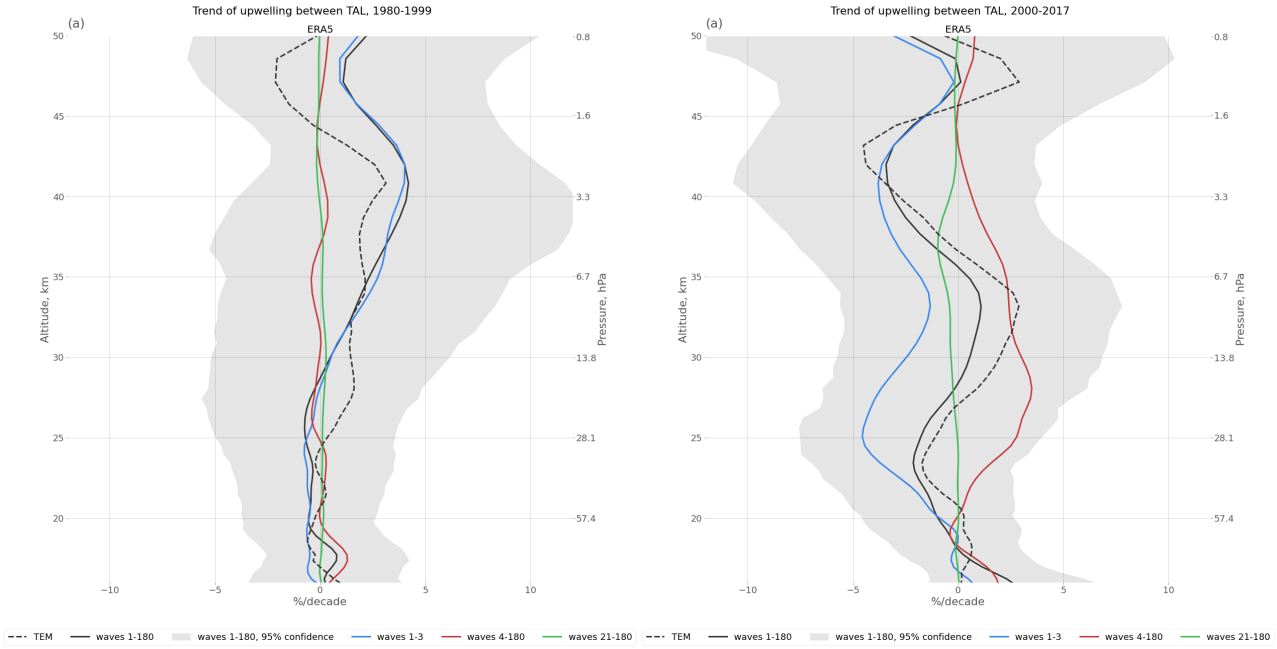

Figure 1: Vertical profiles of upwelling trends constructed from ERA5 data, for periods 1980-1999 (left), and 2000-2017 (right).