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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Variability of the Brewer-Dobson circulation's meridional and vertical branch using Aura/MLS water vapor" *by* T. Flury et al.

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The authors thank the referees for their work and constructive comments on the article. Please find our answers to major comments in the beginning followed by minor comments at the end.

Comment 2.1) I am a bit disappointed since the authors don't succeed to explain the results theoretically. Why is the lower, meridional branch stronger during the QBO West phase (Fig. 12)? Actually I would expect that westerly wind plus Coriolis force would lead to a stronger mixing barrier at 20N. Maybe the authors can provide some physical ar-guments/ideas supporting Fig.12 ? E.g.: Is the increase of easterly wind during the

ascent at the equator due to conservation of angular momentum at the equator?

Answer 2.1) Actually the statement that the meridional branch is stronger during the QBO West (Quasi Biennial Oscillation) phase is only true for altitudes below the maximum westerlies! We took this into account in Fig. 10 where we plotted the zonal wind at 32 hPa and the meridional transport velocity lower down at 100 hPa. In this constellation both are in phase. It is mixing that brings the air out of the tropical pipe thereafter it is the polar and midlatitude wave activity that determines the strength of the meridional pulling i.e. advection. Furthermore, we think that the sketch in Fig. 8 is a good explanation why the meridional velocity is enhanced during the westerly phase of the QBO. We hope that a model will be able to reproduce our results in the future.

Comment 2.2) Figure 3 shows zonal mean H2O at 100 hPa level. I don't think that an air parcel moves on the 100 hPa level from the equator to the pole. The time difference in Figure 3 indicated by the arrows could be to another effect, e.g., vertical phase progression of the water anomaly?

Answer 2.2) We performed the same calculations on the 380K potential temperature level and the results were similar. For this reason we chose to stay in the pressure coordinate system. Obviously there is vertical and horizontal mixing. However, the horizontal gradients of water vapor (H2O) between the Equator and midlatitudes are greater (∼2ppm in January) than the vertical gradient between 15-17 km altitude at midlatitudes, which is our layer of analysis. Thus the amplitude seen in the 100 hPa time series at midlatitudes originates predominantly from horizontal- rather than vertical advection.

Comment 2.3) The role of the troposphere is not discussed though it is known that the QBO and the Brewer-Dobson circulation (BDC) are driven by waves from below. In addition the stratospheric water anomalies (tape recorder) might be connected to meteorological phenomena such as the Asian monsoon.

Answer 2.3) We do not question the mechanisms of the QBO and the BDC. We investigate the interannual variability of the BDC by using H2O as a tracer for transport. The QBO appears to have a significant influence on this transport as documented in the article. But obviously the troposphere has an influence mainly through ENSO (El Niño Southern Oscillation) which we did not consider in this article because the QBO is the main driver of interannual variability in the stratosphere. Whilst the BDC determines the annual cycle in TTL (tropical tropopause layer) water vapor the QBO determines predominantly the interannual variability. The effect of the Asian monsoon on stratospheric water vapor manifests itself by the buildup of a strong anticyclone over the Indian subcontinent from July to October in the UTLS(Upper troposphere lower stratosphere) region. A lot of water vapor is trapped in this anticyclone which, after the breakup of the anticyclone, is mixed with the surrounding air with lower H2O vmr (volume mixing ratio). Thereafter it is transported towards the Arctic and contributes to the BDC water vapor transport as visible in Fig. 3. However, the Asian anticyclone does not influence the tape recorder signal near the Equator which is produced by the seasonal cycle of the tropical tropopause temperature which again is due to the seasonal variation of upwelling induced by the BDC. Nevertheless the exact influence of the troposphere on stratospheric water vapor is a topic of research and will keep us busy interpreting and analyzing the data.

Comment 2.4) In the conclusions the absolute value of the amplitude should be given too.

Answer 2.4)

We will add this number.

Modifications in the manuscript

We will add a more thorough discussion of the different mechanisms that lead to the transport of the water vapor signal (advection vs. mixing/mixing) as pointed out in answer 1.1. (answer to referee 1). We will also leave some room for discussion on the influence of the troposphere on the BDC. However, we will maintain our method of

deriving a measure of the meridional component of the BDC by correlating equatorial and midlatitude zonal mean time series of H2O at 100 hPa and will also stick to our interpretation of the observed anticorrelation of the meridional transport with the vertical transport.

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