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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The relationship between tropospheric wave forcing and tropical lower stratospheric water vapor" *by* S. Dhomse et al.

Anonymous Referee #2

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Summary

The paper presents a relationship between water vapor in the tropical lower stratosphere and the strength of the Brewer-Dobson-Circulation (BDC). The analysis is based on different satellite water vapor observations (HALOE and SAGE II in the tropical lower stratosphere, POAM III in northern mid to high latitudes) and eddy heat flux calculations as a measure of the planetary wave driving. The results show an anti-correlation between tropical lower stratospheric water vapor and the strength of the BDC (low/high stratospheric water vapor related to strong/weak BDC). The sudden decrease in lower stratospheric water vapor after 2000 is in agreement with increasing planetary wave forcing and a strengthening of the BDC which contributed to a cooling

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Interactive Discussion
Discussion Paper

of about 0.7 K in the tropical lower stratosphere.

General comments

The variability of stratospheric water vapor as well as the mechanisms responsible for the observed variability are a topic of intense research for several years and there are still a lot of uncertainties. Particularly the sudden decrease in lower stratospheric water vapor after the year 2001 raised a lot of questions, since water vapor soundings in the 1980s and 1990s indicated a continuous increase in stratospheric water vapor. The topic and methodology of the present study are certainly appropriate for ACP. However, I think the paper needs further revision and clarification before it would be suitable for publication.

My major concern is that a similar study discussing the water vapor decrease after 2001 and the link to the BDC was published in JGR by Randel et al. (2006). As far as I understand Randel et al. (2006) come to the same conclusion that the water vapor decrease after 2001 is related to a strengthening of the BDC. Does the present study provide any new scientific insights? Both studies are based on nearly the same data (HALOE, POAM, NCEP), the present study additionally uses SAGE water vapor instead of the Boulder balloon soundings. I miss a clear discussion of the current results with the study of Randel et al. (2006), differences, agreements, new insights.

The correlation analysis (Fig. 2) shows a clear anti-correlation between tropical lower stratospheric water vapor and the eddy heat flux which is a measure of the strength of the BDC. However, I have some doubts whether this result is in agreement with the presented regression analysis of tropical lower stratospheric temperatures. The regression analysis performed in Section 3 (Fig. 4) indicates a cooling of about 0.7 K

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in the tropical lower stratosphere (70 hPa) due to a strengthening of the BDC. The authors used the 70 hPa level for their regression analysis, which is already slightly above the TTL. The NCEP data indicate a clear cooling between 100 and 70 hPa (unfortunately only two pressure levels are available), but the regression analysis shows a minor contribution from the BDC changes to the temperature changes in 100 hPa (also stated by the authors p 9571). Seidel et al. (2001, JGR) showed that the tropical cold point tropopause is located between 90 and 100 hPa. Therefore, I wonder whether the 70 hPa-temperatures are representative for the processes in the TTL. Since stratospheric water vapor in controlled by tropical tropopause temperatures, I suggest to perform a similar regression analysis using tropical cold point temperatures, e.g. the times series presented in Randel et al. (2006, Fig. 4).

Furthermore, in the abstract the authors state that a decrease in planetary wave activity in the mid-nineties might be responsible for increasing stratospheric water vapor. Again, it would be interesting whether there is a relationship between strength of BDC and tropical cold point temperatures. Otherwise, this statement seems to be in disagreement with the observed decrease in tropical tropopause temperatures (Seidel et al., 2001; Zhou et al, 2001, JGR).

The regression analysis performed in this study quantifies the contribution of the BDC strengthening to the cooling in the tropical lower stratosphere, but not to the water vapor decrease. Fueglistaler and Haynes (2005, JGR) found the empirical relationship that temperature changes of ± 1 K near the cold point correspond to water vapor anomalies of ± 0.5 ppmv. Assuming a linear relation the cooling of 0.7 K presented in the current study would correspond to a water vapor decrease of approximately 0.35 ppmv, which seems to be in agreement with the water vapor anomalies shown in Figure 3. I suggest to perform a regression analysis for tropical lower stratospheric water vapor in order to quantify the contribution of the BDC changes directly.

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Specific comments

The manuscript is clearly written, the figures are well prepared. I have just a few minor comments:

- p 9565, l 3: “heterogeneous”
- p 9565, l 9: “homogeneous”, “heterogeneous”
- p 9566, l 13: How is the eddy heat flux calculated? Which data are used? Overall, I recommend to add a section describing the analyzed observational data, reanalyses data and applied methods.
- p 9566, l 17 / Fig. 1: In Figure 1 WV reaches minimum in March/April, not in January/February. This might be related to the large altitude range of the shown WV measurements.
- p 9566, l 24: Ascending motion controls the amount of air entering the stratosphere. The WV content of the air masses is controlled by TTL temperatures.
- p 9567, l 20 / Fig. 2: How large is the anti-correlation between WV and eddy heat flux using northern hemispheric heat flux values only? I would expect that tropical upwelling during September-February is dominated by northern wintertime wave activity. At least, tropical tropopause temperatures are lowest during northern winter.
- p 9567, l 20: HALOE: black solid symbols, SAGE: orange light symbols (according to Fig. 2)

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- Fig. 2: Why are POAM data not included in the correlation calculation? From Figure 3, I would expect a similar correlation between POAM and the eddy heat flux, applying a certain time lag.
- p 9568, l 2: Are the given correlation coefficients statistically significant?
- p 9568, l 17: "H_20", "0"(=zero) should be "O"
- p 9568, l 23: How are the WV anomalies calculated? Did you subtract a climatological mean annual cycle?
- p 9578, Fig. 3: caption: POAM data indicated by the red line, not by a dashed line.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 9563, 2006.