**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Relationships among Brewer-Dobson circulation, double tropopauses, ozone and stratospheric water vapour" *by* J. M. Castanheira et al.

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<u>Response to the questions of **reviewer # 1**</u>

<u>General comments:</u>

The following changes in the revised paper were performed:

1. Now, we present lagged correlations between -15 months to 15 months for both HALOE-MSL and ERA-I water vapour data. The results are now much more consistent for both the satellite data and reanalyzed data. Because the Brewer-

Dobson circulation is faster in ERA-I, a correlation was not observed for the lag studied in the discussion paper. Another important change in this new version of the paper is that the correlations were calculated for variabilities on interseasonal and interannual time scales. The interdecadal variability was removed as explained in the paper.

2. A new important result is the correlation between DTs and the quasi-geostrophic wave activity. This correlation shows a clear association between DTs and the wave activity in the lower most stratosphere (LMS).

3. We calculated downwelling in several extratropical latitudinal bands in the NH. In general, statistical significant negative correlations between the area covered with DTs and the downwelling strength is found. This was an expected result. However, it does not seem to us that a discussion of the downwelling will add more clarification to the results. Therefore, we decided not discuss the downwelling in this paper.

4. **A copy of the revised manuscript is attached as a supplement file.**

<u>Point by point responses:</u>

P12394, L11: Corrected

P12395, L25: At line 25 of page 12395 we do not refer to any correlation value. We suppose that the reviewer wanted to write line 5 of page 12395 to comment on the correlation value given in Figure 1. In this figure we give the value of the correlation between the original time series and the time series modelled by the multilinear regression (the red curve).

The correlation values mentioned in lines 15-20 are the Pearson correlation values with the individual time series of ENSO and solar flux. The correlation between DTs and QBO |r=0.50| is the correlation coefficient of the multilinear regression of DTs on U30 and U70 (the time series used to represent the QBO).

P12395, L27: We added the observation period for each instrument in the second paragraph of the Data and Method section.

P12395, L28: In the Data and Method section, we give more information on the sources and versions of the data.

P12396, L7: Now, we refer to the t-test explicitly.

P12396, L25: In the Data and Method section we stated explicitly that "Ozone and water vapour were available as (calendar) monthly means. Other variables with hourly resolution were averaged into calendar monthly means. The seasonal cycle of each variable was removed by subtracting the interannual monthly mean from each month."

P12397, L7: We added the observation period for each instrument in the second paragraph of the Data and Method section.

P12397, L27: HIRDLS is sparse along a latitude line due to the separation of orbits but it is not sparse along a longitude line, or along the track of the satellite, since profiles are generated about every 100 km. This feature allows for fine resolution of meridional features such as the DT, the subject of the paper. The DT and ozone data discussed in this section are both from HIRDLS, taken along each orbit, so no co-location is required.

P12398, L8: Yes, three data points are used to find the seasonal cycle of the time series, however, all data between 22-72 degrees latitude (between 180 to 360 profiles before area adjustment) goes into calculating the DT and ozone lamina

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data for each day. Additionally, the DT time series found does compare well to other studies.

"We deseasonalized the time series by first finding the average area for each day of the year and smoothing using a 29-day moving average." If there was no missing days, the used procedure should give the same result as that obtained by smoothing the 3-year time series with a 29-day moving average and then calculating the mean for each calendar day, which is equivalent to calculate the means of three 29-day periods centered in the reference day. Obviously we can get only a crude estimate of the seasonal cycle because we have only 3 years of data. If we perform the correlations separately for each calendar month, the effect of the seasonal cycle will be strongly reduced. We performed these calculations and the correlations obtained for each month leads to the same conclusions as the ones from Figure 4 (Figure 5 of the revised manuscript).

We added a comment about this issue in the revised paper.

P12398, L17: Perhaps the text was not clear enough. We are not separating two kinds of intrusions. When a tropospheric intrusion of tropical tropospheric air moves into the lower extratropical stratosphere, the lower tropical stratosphere may also move polewards. Because the lower tropical stratosphere has a lower ozone mixing ratio than the lower extratropical stratosphere, the poleward displacement of the tropical stratosphere will also contribute to negative anomalies of the total column ozone at the subtropics and midlatitudes.

We rewrote the sentence: "This is consistent with negative anomalies of total column ozone associated with positive anomalies in the area of DTs due to both the northward displacement of *lower stratospheric* tropical air with low ozone mixing ratio and tropospheric intrusions of tropical tropospheric air into the lower extratropical stratosphere."

We just wrote "northward displacement" because in section 3.1 (section 3.2 of

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the revised manuscript) we analyze only ozone and DTs for the Northern Hemisphere.

P12399, L10: We redid the correlations for lags between -14 months to 14 months (please, see the general comments above).

Yes, the correlation with the ERS-I water vapour is higher for small lags.

P12399, L25: The analysis of different lags clarified the results. The correlations for ERA-I water vapour are higher for a lag small than 5 months.

P12401, L11: We rewrote the paragraph. As commented above we did not find useful to introduce the analysis of the downwelling.

P12401, L27: Now we show lagged correlations for lags between -14 months to 14 months. Note that maximum correlation at 82-hPa occurs when the upwelling leads by 3 months.

P12402, L1: We performed the correlation for other lags.

P12402, L17: The analysis of other lags provided more clear results.

P12402: L25: Perhaps this is a signal of the QBO that was not completely subtracted by removing the variability associated with the vertical upwelling.

P12403, L2: The Figures were changed by adding lagged correlations to Figure 6 and combining Figures 11 and 12 while also adding lagged correlations to the plots. Now the results are clearer.

P12404, L15: We analyzed and commented on lags. We introduced also a Figure showing lagged correlations with total column ozone.

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Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/12/C4568/2012/acpd-12-C4568-2012-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 12391, 2012.