Answer to Referee # 2

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March 15, 2012

Dear Referee, thank you for carefully reading our paper and for your helpful and constructive comments and suggestions. They will help to improve the article. All technical corrections have been applied and will not be discussed below. Reviewer comments are in bold face, replies in italic. All minor comments have been taken into account.

1) P. 32815, L 4: The ozone depletion is mainly due to chemistry only in the upper stratosphere. Approximate pressure level should be mentioned in this context. In fact, Flury et al. (2009) also refer to the ozone depletion caused by transport at lower levels.
We changed the sentence as follows:
[1] investigated ozone depletion and water vapor enhancement at mid-latitudes during the SSW 2008 using trajectory calculations. They showed that the water vapor enhancement was associated with meridional transport while the observed ozone depletion was mainly due to temperature-dependent photochemistry in the upper stratosphere (above 5 hPa) and mainly due to transport of polar air to mid-latitudes in the lower stratosphere (below 5 hPa).

2) P. 32816. Sections 2.1 and 2.2: Uncertainties in the ground based microwave observations and the Aura/MLS data in USLM region of interest should be mentioned.
We added the uncertainties to the text.

3) P. 32819. L16. This sentence needs to be rephrased. Also, for obtaining the H2O along the back trajectories, MLS data are probably averaged over a few scans within the latitude and longitude boundaries of interest. The uncertainties involved may be different from those of zonal averages used elsewhere.
We changed this sentence as follows: For each trajectory point (each altitude and day) the MLS profiles within $\pm 1^\circ$ in latitude, $\pm 10^\circ$ in longitude and ± 0.5 d in time are searched. This search results in one or two profiles per trajectory point. The H_2O VMR values at the altitude closest to the trajectory point are then averaged (if there is more than one profile) and used for the analysis.

4) P. 32822. L17. The zonal mean westerly wind (Figure 4, panel d) shows maxima at 0.1 hPa at 55°N and also at 35°N. Do the authors have any comments?
We now use zonal wind fields of WACCM instead of ECMWF for this plot as there are differences at altitudes above 0.1 hPa between the two data sets. At

altitudes above 0.1 hPa the zonal mean winds of SD-WACCM are regarded as more reliable than those of ECMWF. However, this leads to a slightly different wind distributions in Fig. 4 and the two maxima in panel are not as distinct anymore. We changed the text to:
Approximately four weeks after the SSW the horizontal H_2O gradient at around 60° N has reappeared indicating that the mixing barrier has reformed (panel d shows 10 March). However, the zonal mean zonal westerly wind does not show any distinct maxima indicating that the polar vortex did not recover to its original strength.

5) P. 32823. L 12. Rephrase the sentence. I am assuming that you mean to say 'It is difficult to distinguish between the two effects...'
We changed this sentence to:
Future investigations will be dedicated to the distinction between measurement uncertainty and atmospheric fluctuations as it is very difficult to separate the two effects.

6) P. 32823. L 16. This is not consistent with the figures 6 and 7. Only at 0.3 hPa the H2O decreases throughout March. At higher levels the zonal mean data from MLS in fact shows an increase during March. The statement made here should be consistent with what is shown in Section 6.2.1 (P 32826).
We changed this section to:
In both time series, over Sodankylä and in zonal mean, mesospheric water vapor significantly increases by the end of January in the course of the SSW before it decreases throughout February. The temporal evolution of water vapor at different altitude levels as well as similarities and differences in the two time series, MIAWARA-C's point measurements and MLS's zonal mean, are discussed in Sects. 6.1 and 6.2.

7) P. 32823. L 19. The authors should give more evidence before concluding that ground-based measurements are well suited to study dynamical phenomenon like SSW. The agreement between zonal mean data and ground-based observation shown in Figure 6 is valid for the selected year. But there is no proof that zonal average satellite data will compare well with ground-based information every year. In fact, the authors have mentioned the inter-annual variability in the SSW events (Page 32821). Ground-based data are useful, but by themselves they are not enough to analyze dynamical events like SSW.
You are right. Therefor we changed this sentence to:
Ground based microwave radiometers can be used to study short term dynamical phenomena such as SSWs if their data is complemented with global fields from space borne instruments or models.

8) P. 32824, L 4. The use of the term 'time series' is confusing. Except for the blue line, which represents the time series at Sodankyla based on MIA-C data, the lines represent MLS data interpolated to different locations.
This is true. Therefore we replaced 'time series' by 'data sets'.

9) P. 32824 L 26. The zonal average H2O does not increase by 1 ppmv at 0.1 hPa at the time of max warming (Figure 7, region 2). Even at 0.03 hPa, the zonal average from MLS data shows an increase of about 0.7 ppmv and the peak value occurs around January 30. Such differences between ground-based data and zonal averaged satellite data are to be expected especially during a dynamical event like SSW.
We replaced this sentence by:
At 0.1 and 0.03 hPa the peak value in mesospheric water vapor occurs around 30 January in both times series. It is noteworthy that at the time of the maximum warming in the stratosphere (second vertical line) there is a rapid increase of nearly 1 ppmv at 0.1 and 0.03 hPa over Sodankylä and of approximately 0.5 ppmv at 0.03 hPa in zonal mean.

References

[1] T. Flury, K. Hocke, A. Haefele, N. Kämpfer, and R. Lehmann. Ozone depletion, water vapor increase, and psc generation at midlatitudes by the 2008 major stratospheric warming. *Journal Of Geophysical Research*, 114(D18302):D18302, 2009.