## Reply to reviewer #2

We thank anonymous reviewer #2 for his/her constructive review that would improve the contents of our paper. The review comments by anonymous reviewer #2 are numbered and repeated below as *in italic letters*, followed by our answers. In the new draft with corrections (supplement file), red, purple, and blue corrections are the revisions suggested by reviewers #1, #2, and #3, respectively. Yellow-marked sentences were also added in response to Short Comment #1 by Dr. Adrian Tuck.

***General comments:***

*(1) The manuscript is well-written and organized. The introduction does a good job of providing an overview. However, I'm curious to know how the study's results compare to other results, e.g., was the amount of depletion typical? Also, the FTIR was installed in March 2007, so why weren't results included from years other than 2007 and 2011? What is the current state of the instrument? Perhaps a comment about ongoing work could be added to the conclusions.*

According to WMO's Scientific Assessment of Ozone Depletion (2018), 2007 is almost in average, and 2011 is a bit larger ozone loss year compared with other recent average years (Chapter 4, Figure 4-6, P. 4.11). Due to the operator's man power problem, operation of FTIR was only done in 2007 and 2011. After short operation of FTIR in 2016, it was now brought back to Japan. This was explicitly explained in the text now.

*(2) In terms of the FTIR retrieval method, why is SFIT2 used, rather than the up-to-date SFIT4? Also, it was helpful to see an example of the averaging kernel, but I'm curious to know what the DOFS were, especially near the altitude of interest.*

When we started the FTIR analysis for Syowa Station several years ago, SFIT4 was not available yet. After a while, SFIT4 became available, but we have already processed all the Syowa FTIR data by SFIT2. We have processed few Syowa spectra by SFIT4 and compared the result with the one by SFIT2. Fundamentally, we have found no major differences between them. Therefore, we decided to use the results processed by SFIT2 in this paper. The information of typical vertical resolution and mean DOFS were now shown in Table 2.

*(3) For the validation, it is hard to draw firm conclusions from the ozone validation using only 14 coincidences. Indeed, these comparisons had notable scatter (e.g., P6L20-28). Why not also add MLS comparisons, especially since MLS is used for HNO3 and HCl measurement validation? Indeed, later in the manuscript, MLS O3 is shown (Fig. 11) with comparisons to the chemistry model.*

We first used MLS data for the ozone validation as well as HCl and $HNO_3$. Later, we used ozonesondes for

validating ozone, because the data quality of ozonesondes is thought to be better than MLS measurements. However, there are less coincidences and altitude coverages are smaller. Now, we will show both ozonesondes and MLS data for validating FTIR ozone data.

***Specific comments:***

*(4) P2L12: Suggest removing "month" or reword "only in the month of September".*

"month" was removed.

*(5) P2L22-25: The sentence grammar should be revised, e.g. the semi-colon.*

";" was replaced with ":"

*(6) P5L34: The list of tangent point altitudes is incomplete in the middle.*

The list of tangent point altitudes was corrected.

*(7) P6L18: Could you elaborate on "slit function"?*

It is a 5 km-wide running mean. The text was modified.

*(8) P7L10: Were the Livesey results covering the same latitudinal range as this study? Was this bias between MLS and HALOE only seen in HCl?*

Livesey et al. (2013) doesn't show any latitudinal information for the comparison with HALOE. For comparison of each species, Livesey et al. (2013) shows good agreement for $H_2O$ and temperature data between MLS and HALOE.

*(9) P7L10: Livesey et al. (2013) not in references. Couldn't locate the study. Please update.*

We added Livesey et al. (2013) in the references.

*(10) P9L30: Remove "later" after Figure 10. Define EL when mentioning equivalent latitude in the Figure 10 caption since it's used in the figure colorbar label.*

The word "later" was removed. Equivalent latitude was already defined in Section 4.1. We modified the description of EL in Figure 10.

*(11) P10L32: Can the satellite coincidences be filtered to ensure similar equivalent latitude to Syowa Station, in addition to the distance/temporal criteria applied?*

Although we set relatively strict collocation criteria (within 300 km radius and +/- 6 hours) for validation, there is a chance that satellite and station are measuring rather different airmasses when Syowa Station was located near the polar vortex edge. In order to check whether such a situation occurs or not, we looked at equivalent latitudes (EL) of measurement locations of MLS and Syowa Station for the collocated coincidence pairs. The result is shown in Figure A (below). As a result, differences of EL are always within 10 degrees in all cases. We now picked up the collocation pairs whose difference in EL are within +/- 5 degrees. The results are shown in Figures B and C (below). As you can see in these figures, the comparison results show almost similar features. Therefore, we concluded that the difference in EL within 10 degrees does not affect the validation results.

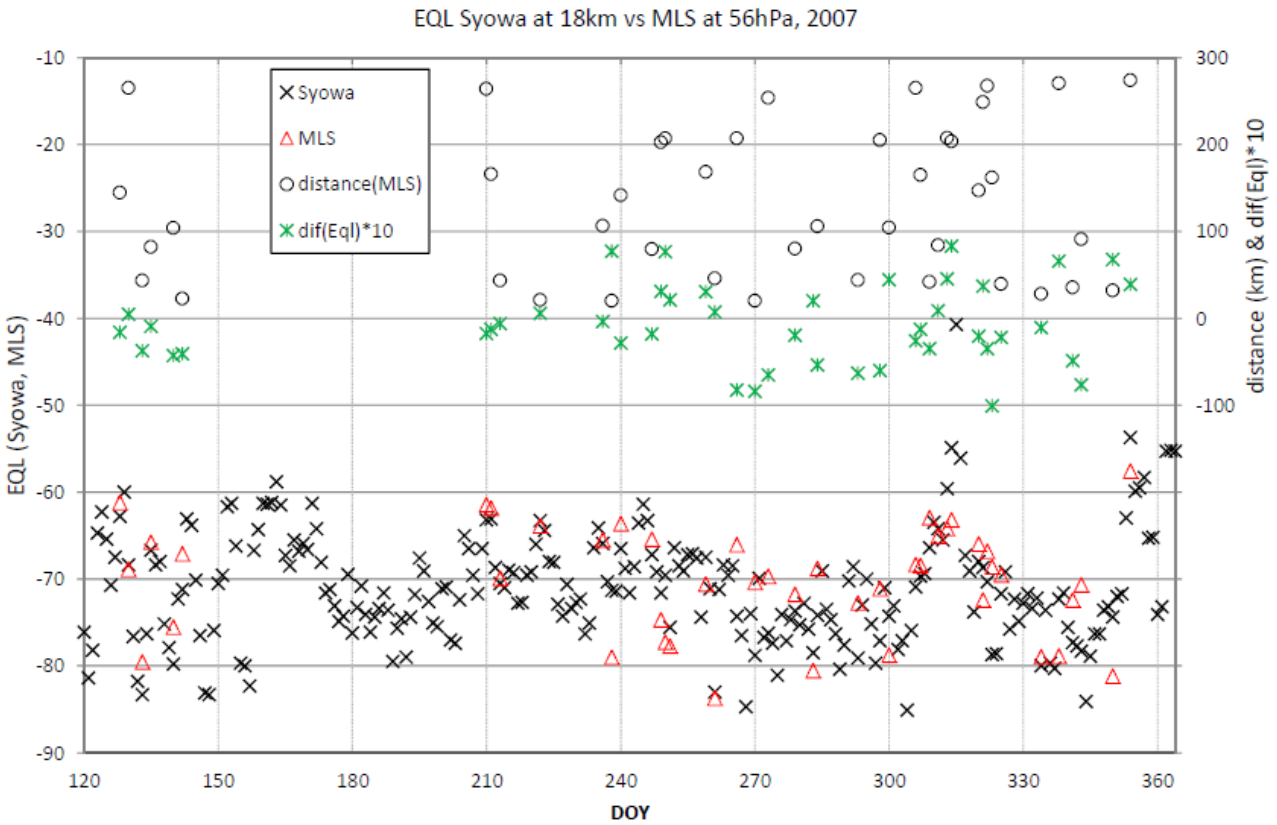


Figure A. Equivalent latitudes (EL) of Syowa Station (black crosses) at 18 km, EL of MLS (red triangle) at 56 hPa, distance between Syowa and MLS measurement locations (black circles), and differences in EL (green crosses) in 2007. Note that the values of differences in EL are multiplied by 10.

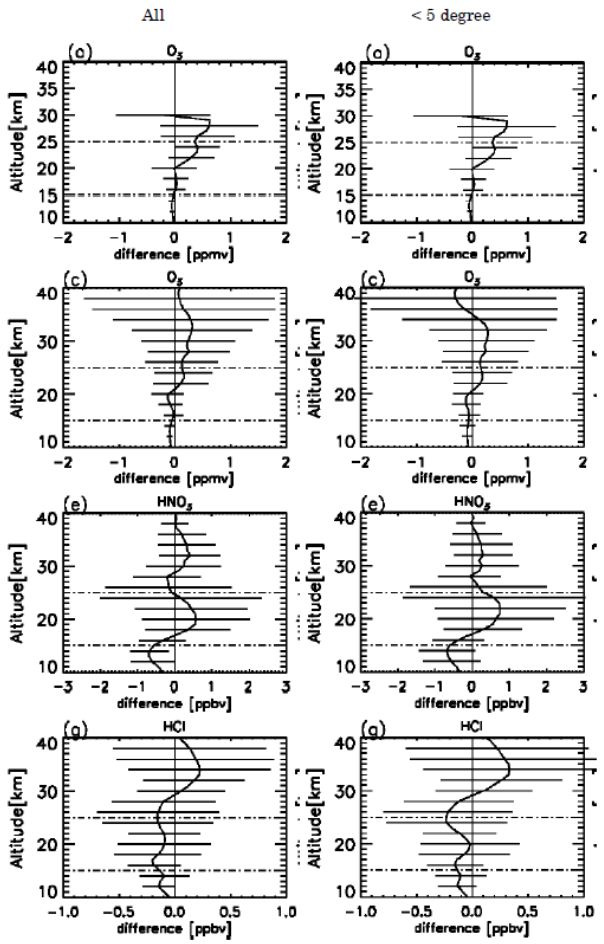


Figure B. Absolute differences with all collocation pairs (left columns) and those for differences in EL < 5 degrees (right columns).

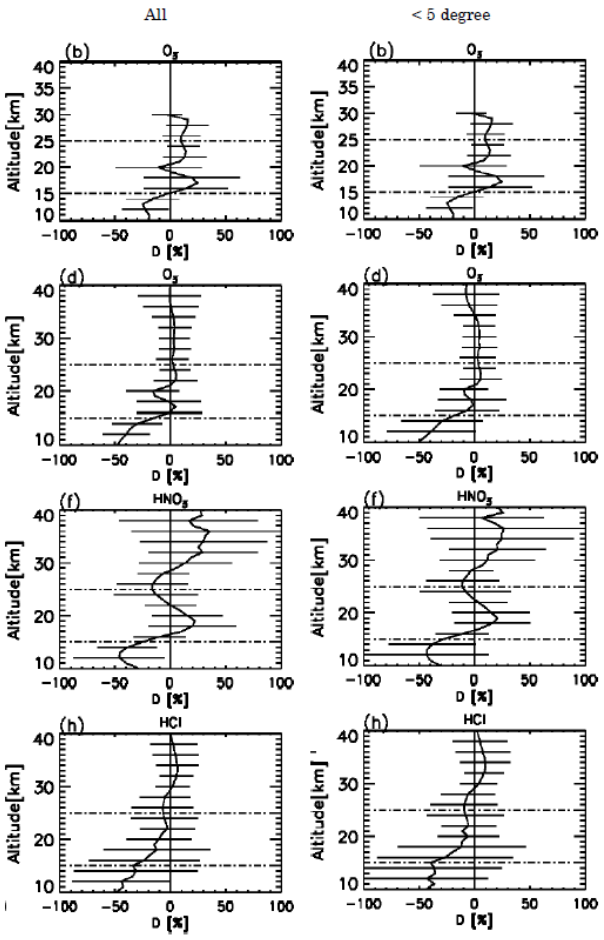


Figure C. Percentage differences with all collocation pairs (left columns) and those for differences in EL < 5 degrees (right columns).

*(12) P11L1: It's preferable to spell the term and then put the acronym in brackets, e.g., Reduced Major Axis (RMA)", which has been done elsewhere in this manuscript.*

It was corrected as suggested.

*(13) P13L27-31: Nice result about the $ClONO_2$ transport.*

Thank you for your comment. However, reviewer #3 required more discussions on $ClONO_2$ transport and continuous loss of HCl at the vortex core. Please refer our replies to reviewer-#3 on this issue.

*(14) P18L29: Misspelled "Livesey" as "Liversey".*

It was corrected to "Livesey".

*(15) Table 3: Suggest adding number of coincidences contributing to the altitudes of interest*

Number of coincidences and typical error values were added in Table 3.

*(16) Fig. 4: Between day 310 and 320, the time spent outside the vortex is a nice illustration of how significant the boundary is for ozone chemistry. Clear support for the criteria used to define these boundaries.*

Thank you for your comment. Now, some description on this issue is added in Section 4.1