

Response to Reviewer – ‘Ozone and water vapor variability in the polar middle atmosphere observed with ground-based microwave radiometers’ by Guochun Shi et al.

We thank the Reviewer for his/her positive feedback and valuable comments. Here we address the comments of the Reviewer, with his/her comments in black and our responses indicated in blue.

Review

The revised paper (version 2) is much improved and largely addresses my comments on the initial submission. In their response, the authors have addressed my three major comments satisfactorily, although the ozone and water vapor VMR profile uncertainties from the MWR measurements need to be stated in the paper (see minor comments below). I have several further minor comments and suggestions for improved clarity and trust that other grammatical and typographical errors will be picked up and corrected at the typesetting stage if the manuscript is approved for publication.

In conclusion, I recommend a further, minor revision before the paper is considered further for publication in *egosphere*.

Minor comments

Abstract

- Lines 3–4. The sentence ending ‘, we analyze the interannual behavior and differences of ozone and water vapor and compile climatologies of both trace gases that describe the annual variation of ozone and water vapor at polar latitudes’ could be more succinctly written e.g., ‘, we analyze the interannual behavior and differences of ozone and water vapor and compile climatologies describing the annual variation of both trace gases at polar latitudes’.

Changed the sentence as follows:

we analyze the interannual behavior and differences of ozone and water vapor and compile climatologies describing the annual variation of both trace gases at polar latitudes.

Line 8. ‘MIAWARA-C shows the best agreement with Aura-MLS on average within 5%’. It should be made clear that the average 5% agreement is between MIAWARA-C and Aura-MLS water vapor VMR values.

Changed the sentence as follows:

The average 5% agreement is between MIAWARA-C and Aura-MLS VMR values.

- Line 15. ‘05 May to 20 Jun 2015, ...’ should be ‘05 May to 20 Jun in 2015, ...’.

Added ‘in ’ in this sentence.

1 Introduction

- Lines 49–50. ‘The quasi-biennial oscillation (QBO) implicit meridional circulation mechanism (Garfinkel et al., 2012) and play an important role...’ doesn’t make sense and needs to be rewritten.

Changed the sentence as follows:

The stratospheric quasi-biennial oscillation (QBO) modulates the Northern Hemisphere wintertime stratospheric polar vortex, resulting in its weakening and shifting (Garfinkel et al., 2012; Zhang et al., 2019).

- Line 78. ‘Laser Absorption Spectrometers’ should probably be all lowercase i.e., ‘laser absorption spectrometers’.

Changed the sentence as follows:

Precise water vapor measurements above the troposphere can also be collected by in-situ balloon-borne sensors such as laser absorption spectrometers (Graf et al., 2021)

- Lines 79–83. The sentences ‘The ground-based microwave radiometer (MWR) allows a continuous observation under all weather conditions with a time resolution of the order of hours except during rain. It is specially designed for measuring ozone and water vapor which is valuable as it complements satellite measurements, is relatively easy to maintain, and has a long lifetime which ensures a long and continuous time series covering several decades, and is operated from different locations and measured autonomously on a campaign basis (Scheiben et al., 2013, 2014). Ground-based microwave radiometry...’ could be better written e.g., ‘Ground-based microwave radiometers (MWRs) allow continuous observations under all weather conditions with time resolution of the order of hours except during rain. MWRs measuring ozone and water vapor are valuable as they complement satellite measurements, are relatively easy to maintain, have long lifetimes which ensure long and continuous time series covering several decades, and can be operated from different locations with measurements performed autonomously on a campaign basis (Scheiben et al., 2013, 2014). Ground-based microwave radiometry...’

Changed the sentence as follows:

Ground-based microwave radiometers (MWRs) allow continuous observations under all weather conditions with time resolution of the order of hours except during rain. MWRs measuring ozone and water vapor are valuable as they complement satellite measurements, are relatively easy to maintain, have long lifetimes which ensure long and continuous time series covering several decades, and can be operated from different locations with measurements performed autonomously on a campaign basis (Scheiben et al., 2013, 2014).

2.1 GROMOS-C

- The GROMOS-C ozone VMR uncertainties need to be stated in this section.

Added this sentence in 134 line as follows:

The averaging kernels (AVKs) of GROMOS-C together with its measurement response and errors are shown in Appendix A (Fig. A1). In the lower stratosphere the errors are below 0.3 ppmv and reach above the stratopause values up to 0.4 ppmv. More details about the uncertainty and the AVKs can be found in Fernández et al. (2015).

2.2 MIAWARA-C

- The MIAWARA-C water vapour VMR uncertainties need to be stated in this section.

Added this sentence as follows:

The AVKs of MIAWARA-C together with its measurement response and errors are shown in Appendix A (Fig. A2). In the upper stratosphere, the errors are 0.5 ppmv and increase from 0.5 ppmv to 1.5 ppmv in the mesosphere.

- Line 125–126. ‘...orthomode transducer (OMT) placed immediately after the feedhorn. The signal is split into two polarizations by an orthomode transducer directly.’ can be shortened to ‘...orthomode transducer (OMT) located immediately after the feedhorn.’ The second sentence isn’t needed.

Removed the second sentence and changed the sentence as follows:

The incident radiation is split into vertical and horizontal polarisation by an orthomode transducer (OMT) located immediately after the feedhorn.

- Line 129. ‘Every 15 minutes the ambient load is measured for about 2 s and the sky at 60° elevation is measured for about 15 s.’ This suggests only $2\text{ s} + 15\text{ s} = 17\text{ s}$ of measurements are made every 15 minutes. Confirm this is correct or rewrite to clarify the actual measurement times.

Changed the sentence as follows:

The standard measurement cycle of MIAWARA-C is to measure sky East, reference East, sky West, and reference West for about 15 s each. Every 15 minutes the ambient load is measured for about 2 s and the sky at 60° elevation is measured for about 15 s. A tipping curve is performed to determine the sky temperature at 60° elevation. The difference spectra in the east and west directions and the two polarizations are then calibrated separately with the hot and cold measurements close in time.

- Line 134. ‘MIAWAR-C’ should be ‘MIAWARA-C’.

Changed the sentence as follows:

For MIAWARA-C retrievals with a constant time resolution and with a constant noise of 0.014K are performed.

2.3 Aura-MLS

- Line 143. ‘118 GHz and 240 GHz radiometers’ should probably be ‘118 GHz and 240 GHz channels’.

Changed the sentence as follows:

Temperature is derived from radiances measured from the 118 GHz and 240 GHz channels with a vertical resolution between 3 and 6 km.

- Lines 150–151. ‘Profiles for comparison are extracted if the location is within $\pm 1.2^\circ$ latitude and $\pm 6^\circ$ longitude of Ny-Ålesund and the defined virtual conjugate latitude station.’ should be ‘Profiles for comparison are extracted if their location is within $\pm 1.2^\circ$ latitude and $\pm 6^\circ$ longitude of either Ny-Ålesund or the defined virtual conjugate latitude station.’

Changed the sentence as follows:

Profiles for comparison are extracted if their location is within $\pm 1.2^\circ$ latitude and $\pm 6^\circ$ longitude of either Ny-Ålesund or the defined virtual conjugate latitude station.

3.1 Ozone

- Lines 188–189. The sentence ‘The maximum observed and reanalysis ozone VMR in the SH (approximately 5.5 ppmv) is somewhat smaller 1.0 ppmv and later in the hemispheric spring season compared to the maximum occurring in the northern hemisphere’ could be written more clearly e.g., ‘The maximum observed and reanalysis ozone VMR (approximately 5.5 ppmv) in the SH is 1.0 ppmv smaller than the NH maximum and occurs later in the hemispheric spring season’.

Changed the sentence as follows: The maximum observed and reanalysis ozone VMR (approximately 5.5 ppmv) in the SH is 1.0 ppmv smaller than the NH maximum and occurs later in the hemispheric spring season.

4.2 Conjugate latitude station (79° S, 12° E) in the SH

- Line 349. ‘MW’ should be ‘MWR’.

Changed the sentence as follows: It further demonstrates that ozone and water vapor in the NH will continue to be available from ground-based MWR observations, however, the detailed information about the SH winter as shown here for the 'conjugate latitude' will be lost after the end of the last three limb sounders such as Aura-MLS which is still observing.

7 Conclusions

- Line 479. ‘Quasi-Biennial Oscillation’ can probably be abbreviated here to ‘QBO’.

Changed the sentence as follows: However, there is no strong correlation between up- and downwellings in the opposite hemispheres most likely due to dynamic processes such as the QBO or weather patterns which play a role and need to be taken into account.