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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Trend analysis of the 20 years time series of stratospheric ozone profiles observed by the GROMOS microwave radiometer at Bern" *by* L. Moreira et al.

Anonymous Referee #2

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The study of Moreira et al. (2015) contributes to the important scientific topic of the ozone recovery detection and is therefore relevant for a publication in ACP. The paper is well-structured and clear, except for some points pointed below ("Specific comments"). Therefore, I recommend the publication of this paper in ACP, after these points have been addressed.

Specific comments:

1) Section 1: Introduction

A summary of the historical use of ground-based microwave measurements to detect

ozone trends is missing. Reading the present paper, it seems that no study has been made about this except for the Dumitru et al. (2006) paper. But microwave measurements from several stations have been used in the WMO (2014) report. How the present study fits in this context ? Is it the same methodology that is used for the Bern station in WMO (2014) ? And what about the other stations used in WMO (2014)? Any other publications,. . . ?

2) Section 2.3: Retrieval procedure (p.16376-16378)

I recommend to include more details on the characterization of the ozone profiles obtained with the OEM:

a) OEM requires the use of a priori information, which includes a priori profile (discussed in the paper) but also a priori covariance matrix which is not mentioned in the paper. Can the authors provide this missing information ?

b) The authors provide in the text the vertical resolution in the stratosphere (8-12km) and lower mesosphere (20-25km), but the reader would have a more global picture with the knowledge of the numbers of degrees of freedom for signal and a plot of the averaging kernels as often provided when OEM is used. This would help to interpret Fig.8, underlying the fact that the actual knowledge of the vertical structure of the ozone trends is much less than what a reader could interpret from the trend profile in Fig. 8. Also, for information, how much of the a priori contributes outside of the 20

c) Errors: the smoothing error values (in function of altitude) should also be provided. The link between the errors discussed in this section (2.3) and the uncertainties in Section 5 is not clear. Do I understand well that the error budget provided by OEM (l.9, p.16377) is not used in the "uncertainty analysis" section ?

3) Section 3: Harmonization strategy for the ozone profiles and Fig.3

a) Fig.3 left panel: the authors show the mean of the profiles obtained from the 2 instruments during the same period. And the blue dashed lines are the error on the

FFTS instrument. This error is “the total error from the retrieval along with the error from natural variability of FFTS for this time”: is it relevant to include the error “from natural variability” (note that this error is not very clear in this section and only explained in Sect. 5), since both instruments are measuring at the same time and since therefore the natural variability should be the same in both cases ? Secondly, is it the total error of an individual measurement or the total error on the mean profile (random errors divided by the square root of the number of measurements) which would be more relevant since this plot compares means of profiles ?

b) Fig.3 middle panel: “..presents the mean relative difference profile between data of both spectrometers. . .” It is not clear if it is the difference between the two profiles shown in the left panel (means of the profiles), or if it is the mean of the individual differences between 2 measurements (collocated in time). Please, clarify. The latter is usually used for assessing bias between instruments. Using the former method could lead to wrong bias assessment (e.g. the difference on the 2 means could come from few outliers in one of the 2 data sets means , while the other individual collocated measurements would be in agreement. When the latter method is used, one can conclude if the bias is significant or not looking at the statistical standard deviation of the individual differences. From the figure (middle panel), it gives the impression that the bias is not significant because of the grey dashed lines (error on one single FFTS measurements or on the mean profile ?) being larger than the difference. If this is true, why correcting for a bias if it is not significant ? How looks your Fig. 8 if you do not make the bias correction ? I suggest to plot the mean of the relative differences between individual measurements and the error on that mean (using the standard deviation of the statistics) in Fig.3, middle panel (and right panel), and conclude about the significance of the bias between the 2 instruments.

4) Trend estimation method

a) Choice of the von Clarmann et al. (2010) method: can the authors explain more what is the benefit of using this method compared to the “traditional” one (i.e. without

using a full error covariance matrix) which corrects the trend uncertainties for the autocorrelation in the residuals by using a Cochrane-Orcutt transformation to the model (e.g. in Brunner et al., ACP 2006; Chehade et al., ACP 2014; Coldewey-Egbers GRL, 2014;. . .) or by simply applying a correction in the uncertainty (e.g. Nair et al., ACP, 2013; . . .) ? Does the von Clarmann et al. (2010) method impact also the trends themselves or only the uncertainties on the trends ?

b) It seems that 7 harmonics is much more than what is usually found in the literature (e.g. from 2 to 4 harmonics are found in the references given above). Does it improve significantly the residuals and the coefficient of determination (R^2) to add harmonics ? What was the criteria to choose 7 harmonics ?

c) The ENSO signal in Fig. 6 seems very low: is the parameter “f” (in Eq. 1) significant ? If not why not remove it from the model ?

d) Other proxies (e.g. Northern Atlantic Oscillation; eddy heat flux,..) can also be used in ozone trend studies (Weber et al., ACP, 2011; Frossard et al., ACP, 2013;. . .). Any reason not to include them ? Were they tested and found not significant ?

e) The plot of the residuals (Fig.6) rises a question: do you have an explanation for the observed oscillation in the residuals ?

f) Since the authors provide a trend profile (Fig.8), it could be useful to add the proxies contribution as a function of altitude as well, and to include the information about their significance (as a function of altitude).

5) Uncertainty considerations

a) I don’t understand why in the second type of error (“observation error”), the authors just use the thermal noise error instead of the full random error budget from OEM (thermal noise + smoothing + maybe other random sources).

b) The authors consider a systematic error using validations studies: I would guess that a (constant) systematic error should not impact the trends. Instead, I would investigate

for a possible drift in your time-series by using the validation results. This would enlarge the trend uncertainties.

6) Results and discussion

Any explanation for the negative trend in the lower mesosphere ? You checked your results with other experimental studies: are there available modelling studies that could help you to explain this trend ?

Minor or technical comments:

- p.16372, l.4 (abstract): Provide longitude and latitude of the instrument. Also in p. 16374, l.13.

- p.16372, l.20-22 (abstract): Provide the corresponding approximate altitudes for the trends at 4.36hPa and 02.hPa.

- p.16373, l.4-6: Not clear to me. "...ozone losses were 15-18

- p.16375, l. 5: "And" instead of "An".

- p. 16381, l. 8: the "." is missing at the end.

- p.16381, l.12: "...we have considered 3 different ways to assess the uncertainties": this gives the impression that you will then choose between the 3, while at the end you sum them. So change to something like "We have considered 3 types of errors".

- p.16395, legend Fig3.: "...30 to 0.5 hPa": should be 0.3hPa, according to the text and the green box.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 16371, 2015.