Atmos. Chem. Phys. Discuss., 15, C4960–C4963, 2015
www.atmos-chem-phys-discuss.net/15/C4960/2015/

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 #1

Received and published: 16 July 2015

1 General Comments

The paper describes measurement technique and uncertainty estimates for stratospheric ozone profile measurements by the GROMOS microwave radiometer operated at Bern since 1994. Based on a two year overlap period from October 2009 to October 2011, where old and new spectrometer backends were run in parallel, the pre-2010 data are corrected for that spectrometer change.

A multilinear trend analysis is applied to the resulting time series since 1997 (not 1994!). It indicates a significant increasing ozone trend at levels between 10 hPa and

2 hPa, and a significant decreasing ozone trend at levels between 0.6 hPa and 0.06 hPa. These trends are consistent with ozone trends reported in other recent studies. The current paper, thus, adds another piece of evidence for a beginning recovery of the ozone layer in the upper stratosphere (roughly 10 hPa to 1 hPa).

Overall, the paper is solid and generally well written. The Figures are mostly appropriate. However, the paper provides basically no new findings and no really new ideas. It may be acceptable as a documentation of an important long-term dataset, provided that the concerns and suggestions mentioned below have been properly addressed by the authors. I'll leave it up to the editor to then decide if ACP is the right journal, or if AMT or ESSD would be more appropriate.

In some respects, I find the paper disappointing:

- There is no mention, where the data / homogenized time series from the GROMOS spectrometer are available. These data are probably available through the Network for the Detection of Atmospheric Composition, so this should be mentioned. Also it should be made clear which version of the data-set is available there - preferably the newest and most homogeneous version.
- Why is there no time series comparison with the NDACC lidar data from the nearby stations at Hohenpeissenberg and Haute Provence? There is also no comparison with any satellite records, although many satellite ozone records are available, e.g. during the 2009 to 2011 period when the two backend spectrometers were run in parallel.
- The multilinear fit residuals (middle panel in Fig. 6) are almost screaming for a parabolic trend in Eq. 1 (linear and quadratic terms in *t). Why has that not been tried? I think this should really be tested. It would be one "novel" aspect from the paper.*

2 Specific Comments

Pg. 16373, around line 20: I think the most important reference, Newchurch et al., JGR, 2003 is missing here. Please add.

Pg. 16374, line 21: What is meant by harmonic variation? Probably the annual cycle and its harmonics (12 months, 6, 4, 3 and 24 months). Why not say so?

Pg. 16376, line 11: "than" should be replaced by "as"

Pg. 16376, line 13: Is there a "spectrum" missing at the end?

Pg. 16377, lines 13, 14: I do not understand the second part of that sentence? Why does the temperature at 2.5 km "exponentially approach" the surface temperature? Overall temperature at the surface and at 2.5 km will be highly correlated (except for diurnal cycle, or temperature inversion situations). This sentence should be reworded.

Pg. 16379, around line 10: I would argue that 5% difference are not a "small" bias, when you try to analyse 3% per decade trends. As mentioned, I find it disappointing that no other instruments (lidars, satellites) were used as independent references.

Pg. 16380, line 14: Where do the 7.2 and 8.4 months come from? Please mention (e.g. 8.4 and 24 months are the annual modulation sidebands of a 28 month QBO)

Pg. 16380, line 24: Where does the error covariance matrix come from? Are the diagonal elements from your error/ uncerainty considerations in Section 5? Where do the off-diagonal elements come from? Are they from the various lag-auto-correlations of the residuals after the regression? Are they significant? How big is the effect of the off-diagonal elements? Please make this part a lot clearer.

Pg. 16381 1st paragraph: As mentioned, the shape of the residuals in Fig. 6 (middle panel) suggests strongly that a quadratic term should also be included/ tested in Eq. 1.

Pg. 16381, lines 7-8: "Most ... can be explained". Please be more quantitative. What

fraction of the variance is explained? What are typical values for R^2?

Pg. 16382: Eqs. 2 and 3 are not correct. There needs to be a square root taken from $\frac{1}{n-1}\sum$ on the right side.

Pg. 16383, last paragraph: Why are the data from 1994 to 1997 not used? This should be mentioned, and should be explained.

Pg. 16384, line 14: Which studies? The ones below? Please reword/ clarify.

Pg. 16385, line 17 to page 16386, line 10: This discussion has little to do with the presented GROMOS data and is not supported by anything else presented in the paper. As such is speculative and I strongly suggest that it should simply be deleted.

Pg. 16386, lines 11 to 16: What is the explanation for the declining ozone trend in the mesosphere? Please add an explanation.

Pg. 16391, line 6, Typo: temporal

Figure 4: I do not find this plot useful. Mostly it shows repetition of the well known annual cycle. To make this plot useful, it would be much much better to remove the annual cycle and show ozone anomalies, either as ppmv or as % deviation from the annual cycle. Please make a better plot.

Figure 7: I think this Figure could be improved a lot by not comparing apples (=%) and eggs (ppmv and days). The total uncertainty (blue line) should not be shown in ppmv, but also in percent. Then it becomes comparable with the estimated (thermal) observation noise (purple line), and with the observed uncertainty (black line). Instead of time lag (red line) the $1/\sqrt{DGF}$, converted also to % of the ozone profile, should be shown. I would expect that this atmospheric variability part would explain why the observed uncertainty is much larger than the thermal noise at levels between 100 hPa and 10 hPa. These changes would result in a much clearer plot.

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