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Interactive Comment

Interactive comment on "Ozone variability in the troposphere and the stratosphere from the first six years of IASI observations (2008–2013)" *by* C. Wespes et al.

Anonymous Referee #1

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This is the first review of the paper "Ozone variability in the troposphere and the stratosphere from the first six years of IASI observations (2008-2013)" by C. Wespes et al. The paper is designed to address uncertainties and errors in the daily ozone information separated in four vertical domains, i.e middle/low troposphere (MLT), UTLS, middle/low stratosphere (MLS) and upper stratosphere (US). Paper includes discussion about sensitivity of the measurement to these 4 atmospheric regions, complete with Averaging Kernel and degree of freedom assessment that vary regionally and globally depending on the surface contrast (only daily measurements are considered in the paper). The supplement material is very useful as it provides details to the discussion of the stratospheric ozone contribution into the retrieved tropospheric ozone layer. The simulated ozone fields from the global 3-D chemical transport model (MOZART-4) are smoothed with IASI averaging kernels and then tropospheric ozone is assessed to quantify the errors as function of season and latitude. This approach helps data users with understanding of the quality and information in the IASI retrieved ozone information.

The paper describes the statistical model applied to explain variability in IASI time series and attribute change in ozone data over the 2008-2013 period to the decline of the ozone depleting substance concentrations in the atmosphere. The model is based on the multiple regression method by using several explanatory parameters. The model, geophysical variables and iterative process to select only statistically significant contributors to the model fit (0.05 p-value limit) is described in section 3.

The paper also discusses the use of daily vs. monthly ozone median averages in the trend analysis. This is a less frequently used approach. It has its positive and negative sides for understanding short and long-term variability in time series. The advantage of using daily median ozone values in the upper stratosphere makes sense as there is a physical process that relate Solar flux (SF) and ozone variability on the daily bases, but it cannot be clearly separated in layers below upper stratosphere. It will be good to have discussion on significance of the daily vs monthly SF contribution to the trend analyses for all layers (section 4.3.1 discusses only upper stratosphere layer trends). The paper proposed the use of daily data for separation of the Solar signal from the trend contained in the 6-years long time series, but it is not clear from the text that it improves the model fit in all layers and latitude bands (i.e. residuals). This should be discussed in more details in the paper, including showing results in other than US layers.

One note, the “US” abbreviation for upper stratosphere in the text was confusing to me, as it is typically used for geographical domain of the United States. I would have preferred to have the “UST” abbreviation. “MLS” is also an acronym commonly used for the satellite (Microwave Limb Sounder) ozone data, it therefore it would be better to change it to “MLST”.

The paper is well written and the figures are mostly clear (see comment below for Figure 9). There are few places where the figure captions are not clear (see below). Tables have easy look-up format and also use bold fonts to indicate statistical significance of results. Detailed comments 1) P. 12, lines 260-261. Can you please provide more details on how the correction for the autocorrelation is applied to uncertainties of the fit?

2) P.14, lines 301-303. It is clear from the paper that the IASI has information in the MLT layer, which is between surface and $\sim$ 8 km. On the other hand, IASI sensitivity to ozone variability below 4 km is not clearly discussed. Figure 4 suggests 20-40 % total error of the retrieval at the bottom of each of 3 plots for different latitude bands. Figure 5 shows that about 20-40 % ozone variability is observed in the lowest 4 km, with the exception of tropical region. AKs for 0-4 km altitude likely have large contribution from layers above. Is it possible to discern actual day-to-day ozone variability below 4 km and trend that is above the retrieval noise? The information on the AP contribution in MLT (similar to the Figure 2 discussion) can be discussed in this section to help with the sensitivity assessment. This section needs to expand the discussion on information in the MLT.

3) P.14 lines 314-315. Please clarify the statement “The fact that the patterns are similar in $\sim$10 km mainly reflects the low sensitivity of IASI to that level compared to the others.” This is in regards to Figure 6. It would be good to explain a bit more about the patterns. Otherwise reader is left to guess if it is about seemingly no variability in the tropics (blue color indicates low concentrations), or similarity to results at 20 km, or something else. Figure 5 shows high relative ozone variability at 10 km level, but the range in absolute ozone concentrations might be small.

4) P. 21, lines 452-456, statement that “...linear term is not compensated by solar

flax in daily averages" is not completely true, because the SF fitted signal from the model with and without the liner term (blue and orange lines shown in the bottom left panel of Figure 9) are not exactly the same (positive and negative coefficients). Also, the difference between the orange and blue SF signal can be fitted with the linear slope. Besides Figure 8, it will be useful to have a tabulated summary of the variables in the statistical model that were kept after iterative backward selection, and fitting uncertainties for all layers and latitude bands. Otherwise it is hard to get these numbers from the figure. It can be added in the Supplemental materials.

5) Additional Figure 9 comments.

a) The information in the middle panel is not very clear. It is stated that the de-seasonalized IASI ozone data are plotted. Can you please explain the process of deseasonalization for data, such as how the seasonal cycle was derived – from data averages or from the model fit?

b) Whereas the model fit with the linear term included (light blue line) seems to follow the de-seasonalized IASI ozone data (dark blue), the model fit without the linear term (orange) is clearly low-biased from the data (dark blue line). It is not clear how the model fit can be done with the resulting mean offset from the data. Is it possible that the wrong constant term is used to calculate the model time series (orange) for this plot. My understanding of the discussion is that two separate models were used to obtain the data fit: one is with (blue) and another one is without (orange) the linear term. Please make corrections to the text if the single model is used, but the model result is plotted with and without the linear term.

c) On the other hand, in the case of the model fit without the linear term the SF signal contribution to the model fit for monthly mean data is much larger as compared to SF term in the daily data fit model. Is it due to the fact that solar flux seems to increase from 2008 to 2013, and for the analyzed time period seems to be comprise of a liner trend and the day-to-day variability that has significantly increased by 2011?

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6) p.22, lines 486-488. When comparing to the previous publications of the trend analysis, please mention the difference in the time period analyzed. I would replace “in agreement with previous studies” with “comparable to the results published in the previous studies”

7) p. 22,line 497 “change ‘was’ to ‘were’

8) p.23, line 506, change ‘conducting’ to “leading”

9) p.23, line 507-508, add at the end of the sentence “in winter (Table 3)”. Remove the next sentence.

10) P. 23, lines 508-510 add “NH” after “in summer”, and “SH” after “in winter”.

11) P. 23 lines 511-512. The discussion of the effects of the upper stratosphere temperature trends is important for the trend analysis. Can you please comment on the correlations between daily ozone and Solar flux, ozone and temperature, and possibility to discern temperature contribution to ozone variability from Solar flux in upper layers.

12) P.25, lines 553-556. This section discusses the MLT layer (ground-300 hPa). Please clarify what is meant by “As for the upper layers, ...”. It is possible that the subject of the discussion has changed, and then it would be better to have a new paragraph. Also, Tables 2 and 3 show negative trend in the IASI MLT layer , but it is stated here that it is in agreement with increases in ozone found in Arctic (Kivi et al, 2007) following changes in Arctic Oscillation . This statement needs further explanation how the negative ozone trend is related to the Arctic Oscillation during 2008-2013 time period.

Table 3 title has missing information about the second row of trend results. Please add after daily “ (top) and monthly (bottom)”, similar to the title in Table 2.

Supplemental material. The discussion on the tropospheric ozone variability (MLT) is largely concerned with the stratospheric origin of the tropospheric ozone which is tracked by means of the difference between total and ozone tagged by modeled NOx

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tracer (Figures S2 and S3). And this is a wonderful addition to the data analysis. However, the reader would also like to understand the contribution of the stratospheric ozone due to the shape of the AK, which is not discussed at all. It should be possible to assess this retrieval error by using truncated AK (zero weights for stratospheric ozone) for smoothing MOZART -4 profiles and then comparing it to the full IASI AK smoothed profiles.

Figure comments

Figure 1 – add a few minor ticks to the altitude axes

Figure 5 – "1*sigma" – is it correct expression, or it should be defined as sigma/ (median ozone value)*100?

Figure 9. It would be better to separate middle panel into two – for the model fit with and without the linear term. It would then allow for space in the plot to show the residual for both fits separately.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 27575, 2015.