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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Middle atmospheric ozone, nitrogen dioxide, and nitrogen trioxide in 2002–2011: SD-WACCM simulations compared to GOMOS observations" *by* Erkki Kyrölä et al.

Anonymous Referee #2

Received and published: 30 January 2018

This is a very interesting paper that highlights how comparing satellite measurements and model output can start to help us better understand the middle atmosphere. It is generally well written, however there are a few sections that need some revision for better clarity (listed below). One general concern is that the descriptions of the results are often vague and not quantified. This needs to be addressed before publication, and the list below also includes instances where this is the case. After all the relatively minor concerns listed below are appropriately addressed, I would recommend the paper for publication.

Figures 1, 8, and 15 really should have a third panel that shows all the relative differ-

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ence profiles (especially 8 and 15).

NOTE: line numbers aren't accurate in the pdf version that I have, so hopefully that's the case with the authors' version as well and this will all make sense!

P1 Throughout the abstract, many value judgements are made (e.g. reasonable agreement, high correlation, etc.) without quantifying the values. Please backup these claims with the exact values that you have measured.

Line 15 – unclear what is meant by "the validity region"

P2 Lines 5-6 – please briefly explain how these references are examples of improving understanding of accuracy.

Line 14 – Smith et al. 2013 (doi:10.1002/jgrd.50445) would be an excellent ref to include as well.

Lines 14-16 – Mention of validation and comparison studies should include references.

Line 22 – "see" on its own tends to imply a full list, something like "e.g." or "see for example" would be more appropriate

Line 24 – should mention this is at all altitudes.

Line 26 – change to "to the lower thermosphere"

Line 32 – Does this mean that ion chemistry is included? Or just (non ion) chemistry within the D region? Please specify in the text.

P3 Lines 1-5 – tends to be vague. Terms "reasonable agreement," "compares well," and "found to be similar" need specific quantified values in order to back up these judgements. Same with "good" on line 11.

Line 11 – What is meant by brightest?

Line 16 – "mesosphere and" can be deleted

Line 17 – “comparison” should be “comparisons”

Line 27 – “Sec. the” should be “Sec. 3 the”

P4 Lines 1-2 – should be “this approach has”

Line 6 – “in detail” is not needed

Line 7 – “those” is not necessary

Line 12 – should be something more like “there is an ozone-specific flag that screens out stars. . .”

Line 14 – should be “outliers” and “stratosphere”

Lines 14-15 – I assume you’re not setting the flags to zero, rather you’re only using profiles where flag values are zero.

Line 27 – do you mean “within $\pm$3%” ?

Line 30 – do you mean “within $\pm$4%” ?

P5 5th line (labelled l38) – could reiterate that this is nighttime profiles being compared.

Line 9 – Sheese et al. 2016 (doi:10.5194/amt-9-5781-2016) is the more recent ACE-FTS NOy validation reference and should be added. Seems to show GOMOS $\sim$0-10% higher between 23-30 km, $\sim$25% higher at 30-45 km (although seems ACE-FTS has low bias of $\sim$10% in this region).

Line 25 – what kind of observations?

P6 Line 16 – delete “a”

Line 19 – would be good to add here how many collocated profiles there are

P7 Eqn 2 – could change to “100%”

Line 6 – “WACCM” should be “GOMOS”

Line 10 – ". . .processes while keeping reasonable. . ."

Line 11 – is it the Pearson correlation coefficient?

Line 12 – What is meant by "averages over number of"?

Lines 13-14 – The equation doesn't make it clear exactly how the data is being filteredâĂŤplease rephrase for clarity. Is this method done using all data at a given altitude? Is it done in latitude bins? Also, in atmospheric datasets where the data is very often neither Gaussian nor uni-modal, using the MAD as a filter can often lead to filtering out a lot of inlying data with the outlying data. If you haven't already, please check that this method isn't "over-filtering" your data, and if everything is okay it would be good to specify that this check was done and how much data is filtered out using this method.

P8 Figure 1 – It would be nice if both figures had the same y-axis labels

Caption – Please specify in caption that these are Aug-Sept profiles

Discussion of Figure 1 – It would be worth noting that both GOMOS and WACCM are exhibiting the tertiary peak and are in good agreement in both height ($\sim$68 km, which actually seems a bit low for the tertiary peak, see Degenstein et al 2005, doi:10.1016/j.jastp.2005.06.019) and concentration.

Line 13 – delete "the"

P9 Line 1 – "reaches again 2%" must be a typo. At the secondary peak, the differences clearly much larger.

Fig 2 caption – might want to say "A cell with a dot marks where there are no collocated profiles." Same with Figures 3, 4, 9, 10, 16, and 17.

P10 Line 18 – "in the two cases"

Line 30 – it may be more prudent to something more along the lines of "we have not

been able to identify any potential sources of uncertainty that could lead to such a large error in the GOMOS data"

P11 Figure 5 – At the secondary maximum the WACCM seasonal variation is very difficult to discern and it's not immediately clear that WACCM and GOMOS are in phase. Could this panel have the y-axis on a log scale?

P12 Figures 6 – A legend (maybe on the rhs) would make the plots much easier to read. Same with Figures 7, 11, 12, 18.

Figure 7 – The red and blue is slightly confusing, because the reader will naturally be comparing to Figure 6 where the same colours indicate only Arctic values. Please use two styles of lines that relate better to Figure 6. Same with Figure 12.

Line 34 – "correlation is typically very high,"

Lines 34-35 – I find this sentence somewhat confusing, please rephrase for better clarity.

P13 First paragraph – please include quantification of the differences and correlation for all three panels of Figure 5.

Line 4 (6th line) – "whereas"

Lines 5-12 – Please include quantification of the differences and correlation for all three panels of Figure 6 and 7.

Figure 8 – should include altitude scale to match Fig 1. Same with Figure 15.

P14 First paragraph – are these also Aug-Sept? If so, please mention here and in Fig 8 caption. Same with NO3 results/figure.

Fourth line – "maximum at 5 hPa the difference is within"

Line 9 – "will be discussed"

Line 11 – "is typically 0-10%" and "typically agree within $\pm$5%" as differences do reach

higher values in the respective regions

P15 First paragraph – Please quantify discussion of correlation coefficients

Line 13 – Should start sentence with something like, “As seen in Fig. 13 and 14,. . .”

P16 First line – it’s somewhat confusing that you’re discussing the difference in ppb when figure 13 is in %, please make this consistent (or discuss both % and ppbv). Unless, you’re referring to Fig 14 here, but Fig 14 doesn’t show results for 0.5 hPa. Either way, this section needs to be made clearer (as to what Figures you’re discussing and what they show).

Line 5 – “peak density, $\sim$2hPa”

Line 10 – “is typically inside”

P17 Figure 13 – units are missing on both panels

Last line – “The secret behind” could be something more like “the reason for”

P18 Fifth line – delete “to state”. Also is there a reference for MERRA underestimating temperatures in these regions? If not, please explain why it is plausible (i.e. SSWs).

P20 Figure 18 – middle panel colours are not explained (should they be blue and red?). Would also suggest using different colours for the bottom panel

Line 7 – Do you mean to say that MERRA temperature overestimates are a result WACCM overestimates of NO3? Instead of “consequently” do you mean “likewise”?

Line 10 – “mixing ratio values”

Line 12 – The sentence, “The very high. . . exponential function.” Needs more discussion with quantification.

Figure 20 – I believe that left and right panels are switched (or incorrectly referenced in the caption). Also, I appreciate that all three panels have been plotted on the same scale, but this makes them more difficult to interpret. I recommend having the y-axes

on different scales. I would also highly recommend having the y-axes on a log scale. This would again make the figures and the discussion thereof clearer.

P21 First line – delete “ref.”

P22 It is unclear here what the point of comparing the GOMOS and WACCM NO3/O3 ratio to theoretical calculations is. What does this tell us?

Line 5 – “comparison is done” should be “comparisons are done”

P23 Line 7 – “mesosphere below” should be “mesosphere just below”

Line 16 – what is meant by “to large extent”? When can and can’t it be fitted to exponential function?

Lines 18-19 – I disagree that you’ve shown that you can use NO3 measurements as a proxy for SSWs. How did you show this? This would need more analysis and much more discussion. You would need to start by showing that deviations from the exponential curve only occur during SSWs.

Lines 21-22 – “physics and chemistry.” should be “physics and chemistry is necessary.”

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