

## ***Interactive comment on “GOMOS O<sub>3</sub>, NO<sub>2</sub>, and NO<sub>3</sub> observations in 2002–2008” by E. Kyrölä et al.***

### **Anonymous Referee #2**

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### **General comments**

The paper describes the GOMOS climatologies of O<sub>3</sub>, NO<sub>2</sub> and NO<sub>3</sub> for low- and middle latitudes, i.e. the polar regions are not covered. The climatology time series (2002–2008) are analyzed in terms of their annual, semi annual, solar and QB components. The NO<sub>3</sub> data is of particular interest since this is the first vertically resolved observations with global coverage! These data sets are highly relevant for future chemistry and dynamics assessments of the stratosphere (and MLT for ozone) which is beyond the scope of this paper.

The analysis in terms of the different time components and the resulting figures: 11, 12, 20 and 26 are sophisticated and provides new information and a good overview of the underlying processes. Furthermore, the paper has a logical structure with an effective and precise language and the figures are generally clear and informative. The

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limitations of the climatologies are also properly discussed and relevant references are cited.

However, some specific issues have to be addressed and a few technical corrections need to be done (see below) before the paper can be accepted.

### **Specific comments**

1. The climatologies are presented in number densities as a function of altitude and latitude which is the natural first choice of quantities for GOMOS observations. Sometimes, however, other quantities such as VMR on a pressure (or potential temperature) vertical grid make more sense and helps interpreting the underlying dynamical and chemical processes. Additionally, these quantities are usually needed for comparisons to outputs from atmospheric models. Since conversions from one quantity to another is non-linear, they have to be done for individual profiles rather than on climatological data which means that they are out of reach for the end-data user. Hence, I strongly recommend the authors to provide the GOMOS climatologies with other quantities as well. The paper is a bit figure-heavy so there is no room for additional figures (unless they are particularly interesting) but the features of the climatologies for the other quantities should at least be commented and the data put on the GOMOS website.
2. The general features of the climatologies and their components are well described in the paper but there is a lack of discussion of the deviating data. What could, for example, be the reason for the large residuals of the fitted O<sub>3</sub> time series (Fig 9) in some years and what are the sporadic high values of NO<sub>2</sub> in the equator belt at around 20 km (Fig 15). Is it only observational noise/bias or something real? Deviating results may be the door to new scientific findings and should not be ignored.
3. The diurnal influence is studied through a few simulations with a chemical box-

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model for the three latitude belts. I agree that, WITHIN THE BELTS, the diurnal influence on the GOMOS measurements are small (a few percent at the most) which does not justify any correction. But when you compare DIFFERENT LATITUDE (BELTS), the diurnal effect could be significant. What is approximately the maximum diurnal influence difference between latitude 0 and 50? If this is large, figure 13, 21 and 27 would be hard to interpret (since latitudinal variation is mixed up with diurnal variation) and you should consider scaling the climatology data to the same local time using the chemical box model.

4. To avoid a large effect from outliers, the authors have chosen the median operator. This is probably a wise decision but the actual distributions should be looked at to be able to say this? Are there outliers and do the data follow a normal distribution? For low concentrations data are probably more likely to be log-normally distributed. If so, are the median operator valid? Please comment on this in the text. Also the "variance" of the median operator (sections 2, line 15 and onwards) is not common knowledge. Explain the terms in more depth or give a reference.
5. What additional filtering have been done to the data other than the selection of stars for  $O_3$ ? What does *flagged* data points (P2174,L4) mean? Also, is there a lower limit for the number of profiles within an altitude/latitude/time box for when a statistical analysis is not computed? Figure 1 says something about a two-measurements limit for plotting, does this hold for monthly/daily medians as well? This is crucial information for being able to reproduce the study and must be provided.
6. The difference between *time series*, *monthly means* and *daily means* is a bit unclear. Please be more consistent with the terminology.
7. In section 2, the results from previous validation studies of  $O_3$ ,  $NO_2$  and  $NO_3$  are presented very differently. For  $O_3$ , results from the studies are given but neither

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for  $NO_2$  nor  $O_3$ . Please give the same type of information for all the species. Maybe present the results in a table?

8. It is common to include an autocorrelation term in time series fits since the concentration at one month (day) is, to some extent, a function of the previous month/day. The authors should declare why they don't have this term in equation 1. In addition, all the terms in equation need to be clearly defined in the text just after the expression. Right now it is not even clear that  $z$  means altitude...
9. The paper is a bit figure-heavy! Figure 19 and 25 are redundant since that information can be deduced from Fig 18 and 24. I suggest to remove these. Also, why is there not a figure of the  $O_3$  constant factor like for  $NO_2$  (Fig 18) and  $NO_3$  (Fig 24)?
10. There is a confusion with the word *error* which appears multiple times in the paper (e.g P2175, L15). I would prefer the word *uncertainty* or even better *precision*, when referring to the statistical repeatability of a measurement/operator since *error* is not well defined (could mean noise (random) , bias (systematic) or even malfunction).
11. On page 2180 and line 26-27 you conclude that the QBO signal is almost zero in the SH for the second ozone maximum but 17-18% for NH and mid-latitudes. This seems to be an interesting result but is not investigated or discussed further in the paper. If this is a new finding, you should probably highlight it in the Abstract and/or Conclusions ?
12. In the conclusion the authors refer to a website where plots from GOMOS yearly climatologies can be found. Nice user-friendly interface, but why are the climatologies not presented in the monthly-type way like in the paper? Also the VMR plots of  $NO_2$  and  $NO_3$  look really noisy which needs a comment.

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13. The statement in Abstract and elsewhere: *NO<sub>3</sub> distribution is controlled by temperature* is a bit strong. To me, it is not clear that you have shown this by the results from GOMOS in this paper. In any case, NO<sub>3</sub> must at least also be said to be controlled by temperature AND OZONE. You have also found that the relation breaks down at higher altitudes. I recommend a vaguer statement about this or to remove it from Abstract and Conclusions.

#### Technical corrections

- (P2170, L18) Missing word: *...early winter ozone MAXIMA at...*
- (P2170, L19) English: *...which results IN...*
- (P2171, L15) What is meant by *...UV-visible spectral range*, detector 1+2?
- (P2171, L26) English: *...in THE data*
- (P2172, L17) Logic: *negative bias* is not well defined. What data set is higher/lower?
- (P2174,L7) Wording: It does not feel right to say that zonal variations *are ignored*. Please reword.
- (P2179,L17) Word: I have never seen the unit *Dobsons* with a genitive 's' before. I think it should be Dobson UNITS?
- (P2183,L5) English: *..symmetric with RESPECT TO the equator*.
- (P2183,L22) Error: I read the solar term to a maximum of around 30% not 20%...
- (P2184,L6) It is not clear what this *asymmetry* refers to.

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- (P2184,L12) What does this 3.5% variability concern? You are a bit too short here...
- (P2184,L14) Why suddenly southern mid-latitudes when the other species are for northern latitudes?
- (P2184,L22) Word: *iand* should be AND
- (P2185,EQ3) Please explain what  $\rho$ ,  $b_{12}$  and  $b_9$  means in the text below the equation.
- (P2185,L11) Missing word: *...are nearly IN equilibrium*
- (P2187,L3) Missing word: *.. there exist A recent climatology...*

#### Figures:

- (Fig 1) Missing x-axis unit. Should read: *month of year*. Also the latitude unit is missing on the y-axis, should be (*deg*)
- (Fig 2) How can the local hour be above 24?!? Limit the x-axis to 24 for clarity
- (Fig 4) The caption indicates that the x-axis unit is in MONTHS but the tics of the axis is in YEARS (03, 04, 05 and so on) which is confusing. I suggest simply to change the x-label to *Time (years)* and say in the the caption that the figure shows monthly median values. The figure will also look better if the space between the subplots are reduced. The same comments are valid for figures: 5, 6, 7, 15 and 22 .
- (Fig 6) Missing unit of the y-axis. (*deg*)
- (Fig 10) Missing unit of the x-axis. ( $\text{cm}^{-3}$ )

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- (Fig 11) Double *the* in the caption
- (Fig 17) Double *scaled by* in the caption
- (Fig 19) Redundant, can be removed. See comment above
- (Fig 25) Redundant, can be removed. See comment above
- (Fig 27) Missing unit of the y-axis. (deg)

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