

Author's response letter

We thank all three referees for valuable comments that have helped us to improve the quality of the manuscript. We provide point to point answers to all comments and questions. The original referee comments are in italics.

Answers to Dr. Sioris:

"The authors have included an illustration of a spectral fit which strengthens this paper."

Yes, we agree. Thank you for your suggestion.

"My main remaining question is whether it is fair to compare profiles at SZA=95° to nighttime ones. I would recommend SZA>97° (or more) is necessary based on Figure 1 of McLinden and Haley. But then this begs the question of whether the statistics are affected (e.g. <20 collocations for Fig. 5?)."

We now rejected from the analysis the SAGE III data points where SZA <107, so now the screening is the same for both instruments. Now the number of collocations are 36 and 115 instead of 42 and 148. Now the median structures of the Fig. 5 and Fig. 6 are even more similar and they both show small positive bias of some 10 %. Fig. 1 changed a little bit (since now there are less SAGE III observations). Fig. 7: For latitude band 90S-60S we now selected only one month (October), because after the screening there are only 6 SAGE III profiles.

"I suggest writing "nitrogen trioxide" into title or abstract."

Done.

"...in tropics..." -> "...in the tropics..."

Done.

"...extremely quickly destroys NO3..." -> "...destroys NO3 extremely quickly..."

Done.

"...only nighttime..." -> "...only during nighttime..."

Done.

"...the vertical structures of..." -> "...their vertical distributions in..."

Done.

"...chemical data..." -> "a chemical data..."

Done.

"In the study of Marchand et al. (2004)" -> "In the study of Marchand et al. (2004),"

Done.

“In our understanding...” -> “To our knowledge, ...” Hopefully, a literature search has been completed by the authors.

Done.

“I assume that the spectral fitting window covers almost the entire spectral range (~250-~680 nm) of the UV/visible band.”

Yes, this is true. In Figure we wanted to emphasize the NO₃ spectral features. We now write: “The GOMOS spectral fitting window is from 248 nm to 690 nm, but in Fig. 1 we have concentrated on area where the NO₃ absorption features are located.”

“It is not clear whether “sampling resolution” refers to the sampling of tangent heights or the increment of the altitude grid in the radiative transfer model.”

The GOMOS retrieval is done in the "tangent height grid", so it is the same thing. We now write: “sampling resolution (which corresponds to both tangent height resolution and the vertical grid of the product)”.

“poleward of 60 degrees latitude” -> “in polar regions ($|\text{latitude}| > 60^\circ$)”. I assume you mean both hemispheres.

Yes, we mean both hemispheres. Done.

“...gas species line of sight concentrations...” -> “...line-of-sight column densities of gas species...”

Done.

“...5, 28, 9...” -> “...5, 28, and 9...”

Done.

“...in time...” -> “...during a time...”

Done.

“...148 matches.” -> “...148 matches instead of 42”.

Done.

x-axis for Figure 7: “NO₃ local density in cm³...” -> “NO₃ local density in cm³...”

Done. We made similar corrections to other figures as well.

“...slightly deviating towards the poles...” -> “slightly deviating at northern high latitudes”

We now write “slightly deviating at high latitudes”.

Answers to referee #1:

“The content and the layout are adequate, but there are numerous grammatical errors and before being accepted this paper needs to be edited for grammar by a co-author or colleague.”

This has been done and found typos etc. are now fixed.

“Page 1498, line 7: “Shows agreement” – quantify this”

We prefer not to give e.g. some percentages, because the spatial and temporal sampling of GOMOS and SAGE III observations are so different. We have now opened the “shows agreement” and now write:

“The study of zonal median profiles shows that the climatologies calculated from GOMOS and SAGE III profiles are comparable and represent the same features in all latitude bands. No clear systematic differences are observed. The median profiles are closest in the tropics and slightly deviating at high latitudes.”

“Page 1498, line 12: “. . .controls the level of nitrogen oxides.” – NO₃ does not “control” the levels of NO_x; if anything it is the opposite with NO_x, O₃, and temperature controlling it.”

We now write: “It is chemically coupled to”.

“Page 1499, line 1: “reverse Reaction (R3) is an additional source . . .” – this is a sink of NO₃.”

We now write: “The thermal decomposition of N₂O₅ (R3) is an additional source of NO₃ (Marchand et al., 2004).”

“Page 1499, line 15: what is SAGE III? You defined it in the abstract, but you should also do so at the first occurrence in the main text; likewise with GOMOS”

Done.

“Page 1500, line 3: GOMOS should be defined earlier”

Done.

“Page 1500, line 9: define “somewhat smaller”

We now write “about 200-300” instead of “somewhat smaller”.

“Page 1501, line 7: Add a reference specific to SAGE III and the lunar occultation technique”

The best specific reference for the lunar occultation technique is the SAGE III ATBD. We have now re-written the paragraph as:

“SAGE III continued the heritage of SAGE I (1979–1981) and SAGE II (1984–2005) by measuring ozone, nitrogen dioxide, water vapor, and aerosol extinctions by solar occultation technique (McCormick et al., 1989) and additionally performed new nocturnal measurements of ozone, NO₂,

and NO₃ using lunar occultation technique (SAGE III ATBD Team, 2002).”

“Page 1503, line 9: “star number 2” – what is this”

We now write “Alpha Carinae (GOMOS star number 2)”.

“Page 1503, line 17: “3 x 1.4826 x . . .” where does this come from?”

We use this “3 x 1.4826 x”, because for normally distributed data:

- 1.4826 x median absolute deviation is approximately standard deviation (http://en.wikipedia.org/wiki/Median_absolute_deviation), and
- nearly all (99.73%) of the values lie within 3 standard deviations of the mean.

We added a note “This is approximately same as rejecting the data outside 3\sigma limits”.

“Results: Move Figure 4 to section 2.1 since this is where you discuss the spectral fit.”

Done.

“Results: On average are the two instruments seeing the same local time, or is one systematically earlier? (E.g., instrument A measures 1 hour earlier than instrument B). This could explain any systematic differences since NO₃ will be varying through the night.”

When 36 collocations are considered the mean local time difference (GOMOS-SAGEIII) is 18 minutes. When 115 collocations are considered the mean difference is 7 minutes. This is now reported in the paper.

“Results: It would be useful to try and filter coincidences based on large difference in temperatures as NO₃ will be very sensitive to this.”

We have tried to colour code the differences in Fig. 5 and Fig. 6 based on local time and temperature differences, but unfortunately we can not observe any clear pattern. We tried also this kind of filtering, but the structure of the median stays the same.

“Page 1504, line 25: can you speculate on why the agreement might be bettering the tropics?”

We now write: “We expect that the better agreement in the tropics is due to more stable atmospheric conditions and more equal sampling of the instruments.”

“Figure 1, caption: why use different SZA screening criteria for the two instruments (107 vs 100)?”

We now rejected from the analysis the SAGE III data points where SZA <107, so now the screening is the same for both instruments. Now the number of collocations are 36 and 115 instead of 42 and 148. Now the median structures of the Fig. 5 and Fig. 6 are even more similar and they both show small positive bias of some 10 %. Fig. 1 changed a little bit (since now there are less SAGE III observations). Fig. 7: For latitude band 90S-60S we now selected only one month (October), because after the screening there are only 6 SAGE III profiles.

“Page 1499, line 10: “in practice existing only . . .”

Now “in practice existing only during”.

“Page 1500, line 18: “Beside” -> “Besides a”, or equivalent”

Now “Besides a”.

“Page 1500, line 24: fix “with 25-45 km altitude range” and change “with the precision” to “with a precision””

Done.

“Page 1501, line 7: “The instrument” which instrument, SAGE III? Change this to “SAGE III”, likewise on line 8 change “the instrument” to “it””

Done.

“Page 1501, line 17: “Data reduction” – what does this mean?”

We now write:

“Algorithms for altitude registration, refraction, and data binning were derived using techniques similar to the SAGE II (Chu et al., 1989) and SAGE III solar processing (Chu and Veiga, 1998).”

“Page 1502, line 24: “share” is the wrong word, do you mean “possess””

Now “possess”.

“Page 1503, line 12, line 14: Use “The” at the beginning of the sentence, “The black line indicates . . .””

Done.

Answers to referee #3:

“I have a major issue concerning the error analysis. The accuracy of Sage III data is not given and the consistency between the the observed differences and the error budget of both instruments is not discussed. The manuscript cannot be published without this error analysis.”

Thank you, this is an important comment. We now write: “The errors associated with the SAGE III NO₃ observations are provided in the data products and are 20–50 % between 25 km and 45 km.”

We have now compared in Figures 5 and 6 the expected errors of the differences (based on errors reported in the data files) and observed differences. The conclusion is:

“The expected error values of the differences based on the error estimates reported in the data products are consistent with the observed standard deviations between the altitudes 33 km and 42 km. Below 33 km the observed standard deviations are underestimated. We expect that one reason for this is that the reported GOMOS error estimates are too low. In the next processing version (IPF 6.01) the GOMOS error estimates are expected to be improved and slightly higher for NO₃ .”

“The other issue concerns the measurement local time. The local time of GOMOS measurements is not given. It may vary depending on the azimuth of the star and the latitude. NO₃ is decreasing during night due to its conversion in N₂O₅. It is then important to take into account in the comparison the local time difference in even if coincidences have

been limited to local time differences smaller than 2h. It is important to know the average local time difference between the two datasets.”

When 36 collocations are considered the mean local time difference (GOMOS-SAGEIII) is 18 minutes. When 115 collocations are considered the mean difference is 7 minutes. This is now reported in the paper.

The nominal local time for GOMOS is 10pm. We now write:

“GOMOS, nighttime observations are made during the ascending path of ENVISAT and the local time is approximately equal to the local hour of the ascending node, 22:00 LT (Bertaux et al., 2010). GOMOS tangent point local times cover 1.5 h in the equator and 3 h at mid-latitudes (Kyrölä et al., 2010a).”