

Atmos. Meas. Tech. Discuss., author comment AC1  
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## Reply on RC1

Sarah A. Strode et al.

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Author comment on "SAGE III/ISS ozone and NO<sub>2</sub> validation using diurnal scaling factors"  
by Sarah A. Strode et al., Atmos. Meas. Tech. Discuss.,  
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### Response to Reviewer 1 Comments

Strode et al. developed in their study a global set of NO<sub>2</sub> and O<sub>3</sub> diurnal scaling factors accounting for the diurnal variability of NO<sub>2</sub> and O<sub>3</sub> concentrations in the atmosphere. The scaling factors were generated by using a 4D global atmospheric chemistry model, and are publicly available in dependence of solar zenith angle, latitude, and altitude. This work is relevant since the authors close a gap, which up to now do not allow an accurate comparison of different measurements (satellite vs satellite or satellite vs ground-based) of NO<sub>2</sub> and O<sub>3</sub> taken at different times of the day. The authors show, that the utilization of these scaling factors for comparisons (SAGE III/ISS, OSIRIS; MLS, OMPS and ACE-FTS) tremendously reduce the difference between the compared NO<sub>2</sub> and O<sub>3</sub> concentrations. Furthermore, Strode et al. could show that the interannual variability of NO<sub>2</sub> scaling factors is very likely to be correlated to the quasi-biennial oscillation (QBO). I recommend this paper to be published in Atmospheric Measurement Techniques, after the following minor points of criticism will have been addressed.

### **We thank the Referee for the thoughtful comments and respond to individual points below.**

General remarks:

- Consistently use NO<sub>2</sub> and O<sub>3</sub> OR nitrogen oxide and ozone. I would recommend to firstly mention nitrogen oxide (NO<sub>2</sub>) and ozone (O<sub>3</sub>) and the switch to only NO<sub>2</sub> and O<sub>3</sub>.

### **We now use NO<sub>2</sub> and O<sub>3</sub> throughout the text except in the initial mention and in instrument names.**

- For a better readability use consistent order of discussed trace gas in section 1, section 2.1.1, section 2.3 and figure 1. FIRST NO<sub>2</sub> and SECOND O<sub>3</sub>.

**We re-organized the text in the second and third paragraphs of Section 1 to discuss NO<sub>2</sub> and the O<sub>3</sub>. We reworded and moved the sentence about NO<sub>2</sub> bias before the ozone bias discussion in Section 2.1.1. We retain the order of Section 2.3 (now 2.2.2) and figure 1 because the larger relative impact of dynamics for the O<sub>3</sub> diurnal cycle is important for motivating this discussion.**

- Change the order of instruments in section 2.1 to be consistent with the order of

mention later in the manuscript: SAGE, OSIRIS, ACE-FTS, MLS, OMPS LP

**We now use the suggested order.**

- Please revise the reference section regarding missing doi or page numbers.

**We added the doi links.**

Specific remarks:

- Title: Capitalize "Using".

**Done**

- Line 41 – 54: Please mention the order of magnitude for both the NO<sub>2</sub> and O<sub>3</sub> diurnal variation/photochemistry to get an idea of the difference of both species.

**We add the following to the NO<sub>2</sub> discussion: "Using PRATMO, Dubé et al. (2021) showed a diurnal range exceeding a factor of 3 for NO<sub>2</sub> at the equator at 30 km." and we add to the O<sub>3</sub> discussion: "Frith et al (2020) found the O<sub>3</sub> diurnal cycle exceeds 15% in the upper stratosphere near the edge of the polar day."**

- Section 2: Underline difference between experimental data collection and simulation by using 2 sub-sections "2.1 Instruments and observation" and "2.2 Simulation and scaling factors" instead of 2.1-2.3. 2.2 can then be split up into "GEOS Model Simulation" and "Scaling Factor Calculation".

**We combined sections 2.2 and 2.3 into subsections of "2.2 Simulation and scaling factors" as suggested.**

- Section 2.1: Better indicate whether the description regards O<sub>3</sub>, NO<sub>2</sub> or both, especially for the used retrievals.

**We already state "NO<sub>2</sub>" or "O<sub>3</sub>" when discussing specie-specific retrievals.**

- Line 151 – 169: Is the dynamical tendency of NO<sub>2</sub> neglected in the analysis due to the dominance of the chemistry? This is not clear here.

**We now clarify: "Our scaling factors for NO<sub>2</sub> also include both chemical and dynamical effects, but for NO<sub>2</sub>, the chemical tendency is dominant throughout the profile (Fig. 1d-f)."**

- Line 188 – 191: For me the method is not clear here. Do you just take the best fitting data to compare model and observation and not the SZA=90° data? Is this admissible in this context? The "real" 90° value is unknown, isn't it? Please clarify.

**We take the data from the grid box at the observation latitude within 8 grid boxes longitudinally of the observed longitude whose SZA best matches that of the occultation measurements (90°). Thus we are selecting the best fitting SZA, not the best fitting data. We think this is reasonable since we are using the model to define scaling factors relative to SZA, so it is important to validate the model for the observed SZA. To clarify this, we now state "then finding the grid box whose SZA best matches the SAGE III/ISS SZA (±90°)..."**

- Line 221 – 230: Shift complete paragraph into the introduction or shorten it.

**We prefer to keep this paragraph in place since it provides the background for the results presented in this section.**

- Line 237: "the O<sub>3</sub>peak" instead of "the peak O<sub>3</sub>".

**We made this change.**

- Line 248: Change the section title. The result part already starts in section 3 with the model validation. Maybe "Data evaluation"

**We prefer to keep the section title as "Results" since this section includes the main results of our study.**

- Section 4.1.2: define the parameter "sunrise scale diff" as used in the figures.

**We now clarify in the caption of Fig. 6b: "percent difference from climatology in the sunrise scaling factors (denoted "sunrise scale diff" in the axis labels)"**

- Line 319: Change "SAGE III/ISS sunrise (SR) and sunset (SS) NO<sub>2</sub>and OSIRIS and ACE320 FTS observations" to "SAGE III/ISS sunrise (SR) and sunset (SS) and OSIRIS and ACE320 FTS NO<sub>2</sub>observations".

**Changed**

- Line 365 – 381: It would be helpful to note the difference in magnitude of the scale factors when comparing O<sub>3</sub>and NO<sub>2</sub>.

**We added: "We note that the y-axis range of Fig. 9 covers a smaller range of values than that of Fig. 4, which showed NO<sub>2</sub> scale factors."**

- Figure 8: Colors of legend and data are not the same.

**We modified the figure so that the mean values, whose colors match the legend, are visible above the errorbars.**

- Figure 9: Suggest to use a wider y-axis-range.

**We selected this axis range in order to show sufficient detail in the figure. As noted above, we now point out that this y-axis range is smaller than that of Fig. 4.**

- Figure S4: Mention that the shown data is NO<sub>2</sub>

**We added this information to the caption.**

- Figure S5: SZA=60 à SZA=60° (unit missing)

**We added the degree sign.**