Review of Solar FTIR measurements of NOx vertical distributions: Part 2) Experiment-based scaling factors describing the diurnal increase of stratospheric NO2 and NO

This paper discusses the creation of diurnal scaling factors for NOx based on NO and NO2 partial columns measured at Zugspitze, Germany. Diurnal scaling factors are needed when comparing NOx from instruments that do not measure at the same local solar time. These observational scale factors are useful for validating the model-based scale factors that are typically used.

Some suggestions about word choice

- Title: calling it a 'diurnal increase of NO2 and NO' is not exactly correct. As you say (e.g. abstract line 19-20), NO does not increase throughout the whole day. It might be better to use a word like "change" or "variation".
- Line 47: Define what is meant by "NO2 diurnal increasing rate". I am also not sure about the choice of the word "diurnal" throughout this paper. I think of diurnal as referring to a 24-hour period, rather than only the hours with daylight. Maybe it would be better to say the "daytime NO2 increase"?

Questions & Comments

- Line 33: The phrase "NOx is a product of industry and traffic in the troposphere" is not clear. Are you referring to aircraft emissions? Or emissions at the surface?
- All figures: it would be useful to include local solar time, in addition to SZA, on the x-axis, so that it is easy to see what time of day the SZA corresponds to in each month.
- Choice of normalization SZA:
    - Does the minimum SZA on the 15th of each month correspond to LST=12:00? Typically, one needs to scale observations from multiple instruments to a common LST or SZA, so it is a bit confusing to represent results that are normalized to a different SZA in each month.
    - I understand that a normalization SZA must be chosen for the purposes of this study and comparing with a model. But what would be useful for a user of the data is the ability to scale NO2 measurements at one LST to NO2 measurements at another LST (both LSTs chosen by the user). Thus, it makes more sense to either provide scale factors normalized to every single SZA bin, or to just provide the binned and filtered data as a function of SZA without any normalization so that the normalization SZA can be chosen based on the application.
- What does the blue arrow represent in Figure S1?
- Have you considered how the scale factors change on a time scale smaller than months? In Figure S1 there is more NO2 in the second half of April than in the first half. Is the scale factor significantly different for each half of the month? Would it help with your "boundary value problem" to look at scale factors in e.g. 10 day bins? Dube et al (2022) use model scale factors calculated for each day of the year, while Brohede et al (2007) considered model scale factors

averaged over 2-week periods. It would be interesting to know how important the time binning is- your results suggest that averaging over a full month is not ideal but perhaps averaging over two weeks is adequate, and there is no need to have different scale factors for each day of the year.

Brohede, S. M., Haley, C. S., McLinden, C. A., Sioris, C. E., Murtagh, D. P., Petelina, S. V., ... & Gordley, L. L. (2007). Validation of Odin/OSIRIS stratospheric NO2 profiles. Journal of Geophysical Research: Atmospheres, 112(D7).

Dubé, K., Zawada, D., Bourassa, A., Degenstein, D., Randel, W., Flittner, D., ... & Walker, K. (2022). An improved OSIRIS NO2 profile retrieval in the UTLS and intercomparison with ACE-FTS and SAGE III/ISS. Atmospheric Measurement Techniques Discussions, 2022, 1-22.

- A related question is if the scale factors change over time. Is there enough to data to determine if there is a trend in the scale factors? It would be very interesting if there is a trend as that would suggest some change in NOy chemistry. It is also important for knowing if climatological scale factors are adequate, or if it would be necessary to have scale factors for every year, in addition to every month.
- Discussion of bias between observations and model: Your main explanation for the difference is that the stratospheric partial column is not independent of the tropospheric column. Is there a reason that this would cause the observed structure in the bias (greater bias in the morning)? More discussion should be included about possible issues with the model near sunrise.

<u>Writing edits:</u>

General:

- Some inconsistency with using the roman numeral ‘I’ and the number ‘1’ to refer to the first paper.
- Inconsistent use of “boundary value problem” and “boundary layer problem”
- Would be good to check the grammar again. I pointed out several things below, but this is not a comprehensive list.

Line 17: Change ‘beside’ to ‘apart from’

Line 19: pluralize ‘experiment”

Line 24: remove comma between ‘we show’ and ‘that’

Line 45: “to face” -> “for dealing with”

Line 47: add comma after ‘high precision’

Line 55: Should ‘received’ be ‘retrieved’?

Lines 68, 77: “close(d) this lack” -> “close(d) this gap”

Line 71: comma between ‘aerosol’ and ‘radiation’?

Line 92: remove “used”

Line 96: change ‘is’ to ‘has’

Line 105: “not existing” -> “without observations”

Line 121: “in analogy” -> “analogous”

Line 123, 136: “at month 15th” –> “on the 15th day of each month,”

Line 128: “follows every month a linear diurnal trend” -> “increases linearly throughout the day in each month”

Line 134: remove comma after ‘both’

Line 151: add a comma before ‘as’, remove word ‘before’

Line 175: What is meant by “the whole season”?

Line 182: missing table number

Line 222: remove ‘recently’ (or add word ‘calculated’ after ‘recently’)