Review of “First-time comparison between NO2 vertical columns from GEMS and Pandora measurements” Kim et al 2023

This paper compares NO2 column measurements from the GEMS satellite to NO2 measurements from four Pandora spectrometers in Seosan, South Korea during a three-month period (November 2020-January 2021). The four spectrometers where initially placed at the same site to evaluate their performance relative to one another. The spectrometers were then moved to separate locations near Seosan in December 2020. The effect of cloudiness on the observations was considered. Reasonable agreement between the GEMS and Pandora column NO2 was observed.

This paper fits in the scope of AMT as it presents the first validation of GEMS NO2 measurements. The overall method is fine. Most of my comments are related to clarity as parts of the text were difficult to understand. My other issue is that the manuscript does not have a strong conclusion. Numbers are given for the correlations and RMSE between Pandora and GEMS, but they are not put into context. How does the agreement between GEMS and Pandora NO2 compare to the agreement between other, similar types of measurements? Can you conclude that the GEMS data is of a quality appropriate for use in scientific studies?

Questions & Comments

Line 45: “provides diurnal variations of the NO2 VCD during daytime”

- What exactly do you mean by diurnal variations here? How frequently does the instrument take measurements over a given location?
- It would be useful to provide some information regarding why measurements of the NO2 diurnal cycle are important (ie. NOx chemistry).

Line 56: Does “diurnal NO2 VCD retrievals” mean that the retrievals have some special considerations for diurnal effects, or just that you are doing a retrieval at multiple times throughout the day?

Section 2.2 only discusses the GEMS NO2 data, however the GEMS cloud fraction is also quite important in the analysis. It would be good to discuss the CF retrieval in this section so that later results can be better understood.

Section 2.3 is quite difficult to follow. Please provide more detail on how the reference spectrum was chosen, and on how the spectral fitting was done.

Line 137: What is meant by “differences between the Pandora NO2 retrievals”? Is this referring to differences between measurements from the four Pandora instruments? Or are there multiple versions of the retrieval?

Figure 3: Maybe use different colors, in addition to different symbols, for each Pandora? The figure resolution is quite low so it is difficult to distinguish the shapes.

Line 160: Do you have an idea as to why the NO2 was higher during morning and late afternoon?

Line 161: Why did you choose 0.3 as the threshold value for “cloudiness”? The cloud fraction was also > 0.3 on November 25, but with less spread in the NO2 observations. Do you have a theory as to why? It is also interesting that the measurements only disagree for about an hour near 12:00 on November 13, even though the cloud fraction was >= 0.6 for most of the day.

Line 166-167: What do you mean by “produced least fitting errors”? Why is P1 is considered the reference spectrometer?

Line 200: The text says fig 5 shows daily variations, but the figure caption mentions hourly variations. Which is it? There also is not any discussion of Fig 5. Why is there more spread in the Pandora NO2 compared to the GEMS NO2?

Line 206: You say that there is good agreement between pandora and GEMS at the DM2 site. Is this panel c of fig 6? Because to me it looks like the agreement between Pandora and GEMS is the worst at this site. The GEMS NO2 is biased even lower than the Pandora NO2 at this site, compared to the other 3 sites.

Figure 7: Are these hourly, or daily, values?

Line 224: Is there a missing reference for a study that uses TROPOMI? Or are you comparing Pandora to TROPOMI, in addition to GEMS? Please clarify what is being referred to in this paragraph.

Figure 8: Are you including all data point with CF<0.5, or only those with 0.3<CF<0.5? I think it is the former, in which case it would be useful if the points were colored according to the CF value so that it is easier to distinguish the differences between figures 7, 8, and 9.

Line 255-256: I’m not sure the decreasing bias with increasing CF is physically meaningful… it makes sense for the mean bias to be smaller when there is more spread in the data on either side of the 1:1 line.

Figure 10: What is the CF for the ‘corrected horizontal representativeness’ column?

Minor Edits

In general, I suggest further proofreading as there are many grammatical errors. I have only mentioned some of the issues here.

Sentence line 27-29: wording, change to:

“With a correction for horizontal representativeness in Pandora measurement coverage, correlation coefficients ranging from 0.69 to 0.81 with RMSEs from 3.2 × 1015 molec. cm-2 to 4.9 × 1015 molec. cm-2 were achieved for CF < 0.3, showing better correlation with the correction than without the correction.”

Line 32-33: The way this is currently written is unclear. When you say “plants”, are you referring to N2O emissions from agricultural fertilization? Or biomass burning?

Line 48-49: Sentence is unclear. Maybe the words “by the” on line 49 should be removed?

Line 64-66: Sentence is unclear. Is the AMF more accurate for direct sun DOAS, or for MAXDOAS?

Line 67: Remove “comparison of”

Line 72-73: I do not understand this sentence. Were there two campaigns?

Line 95: manufactured with the same optics and spectrograph?

Line 101-102:

Change to: “The GEMS, a hyperspectral UV-Vis image spectrometer covers a wavelength range of 300–500 nm with a full width at half maximum (FWHM) of about 0.6 nm. GEMS measures atmospheric concentrations of species that affect air quality…”

Line 120-121: Unclear

Line 124: Should refer to Figure 2

Line 130: Is the grey line the difference between the absorption signal and the fit?

Line 149: remove “g” from “AMFg”

Line 183: Change to “comparisons were performed the closet GEMS pixels to each Pandora station”

Line 211: Sentence is unclear.

Line 219: Missing decimal point in 0.45

Line 266-268: Sentence is unclear.