

Review:

Seunghwan Seo et al., Diurnal variations of NO₂ tropospheric vertical column density over the Seoul Metropolitan Area from the Geostationary Environment Monitoring Spectrometer (GEMS): seasonal differences and impacts of varying *a priori* NO₂ profile data

Summary:

In this paper, the authors show the diurnal variation in tropospheric NO₂ over Seoul, derived from an analysis of GEMS data. They also compare the results to output from two chemical transport models and conduct a sensitivity study of the GEMS results to *a priori* inputs from the models. The scope of the study is fairly limited, but the methods appear generally sound and the conclusions supported. I do have some questions about the retrieval algorithm used, for example in regard to cloud treatment.

The manuscript is well-written and organized with appropriate references. Needed improvements mostly involve clarification and a more detailed description of the approach. However, these concerns are generally minor, and if addressed, I can recommend the paper for publication.

General comments:

(1) For an overview of the IUP algorithm, only an unpublished study (Richter et al) is cited. Published references are given for some of the details including features fit to the spectra (Ring, NO₂ with temperature correction and other trace gases), a radiative transfer model, LER reflection values, etc. Most of these are fairly standard in DOAS retrievals. The stratosphere-estimation algorithm of Beirle et al. is also cited, but applying this to a GEO satellite is non-trivial. The authors should provide more details of the GEMS NO₂ retrieval used here, including an explanation of the cloud correction/screening.

(2) What is the temporal data domain for the study? Dates are given in figures 5, 6, 7, but elsewhere are GEMS retrievals from all days of each month combined into monthly/hourly means? Was the same done for the model output? What cloud screening was used, if any? For completeness, please also give the year.

(3) I'm confused by the f2 line (yellow) in figure 6. If a fixed NO₂ profile is used, shouldn't the TropVCD in the model be constant by definition? Why are there differences in the afternoon? I'd suggest eliminating the f2 line, unless I'm misunderstanding what it means, in which case some explanation should be added.

Minor comments and suggested corrections:

- (1) Page 2, Lines 10, 17: Please state what the ranges represent.
- (2) Page 4, Line 3: Might be clearer stated as "...NO₂ TropVCD between the WRF-Chem- and TM5-based GEMS datasets..."
- (3) Page 5, Line 18: "...chemistry scheme follows the Regional Atmospheric Chemistry Mechanism ..."
- (4) Page 5, Line 24: "...were combined with..."
- (5) Page 7, Line 7: "...may affect NO₂ TropVCD values for each month."
- (6) Page 7, Line 15: "VCDs from the two GEMS products were similar throughout..."
- (7) Page 7, Line 20: "For all times..."
- (8) Page 8, Line 2: "The differences in GEMS..."
- (9) Page 8, Line 18: "Figure 5 compares the diurnal changes in GEMS NO₂ TropVCD..."
- (10) Page 8, Line 21: "...the two GEMS data products..."
- (11) Page 9, Lines 4-5: Giving a range here is confusing. I suggest "Therefore, NO₂ TropVCDs calculated using WRF-Chem f2 show values up to 16.5% lower before 13:45 KST and up to 4.9% higher..."
- (12) Page 9, Lines 6-8: "Notably, despite the diverse diurnal variations in *a priori* data from TM5 and WRF-Chem v3, the retrieved columns based on these data exhibited similar diurnal patterns..."
- (13) Figure 2: This figure is hard to read because the maps are small. Is it possible to expand them? Also, the label on the color scale is too small to see clearly. It would help to add "WRF-Chem v3 minus TM5" in the figure caption(s).
- (14) Figure 6: Consider omitting the yellow line (f2). See "General comments".