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Atmospheric Measurement Techniques Discussions

Interactive comment on "A new TROPOMI product for tropospheric NO_2 columns over East Asia with explicit aerosol corrections" *by* Mengyao Liu et al.

Mengyao Liu et al.

liumy_14@pku.edu.cn

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General comments:

1, The main simplification concerns the cloud pressure retrieval, which no longer accounts for aerosols, while an explicit aerosol correction is maintained for the NO2 retrieval itself. The impact of this simplification should be more extensively discussed and accounted for in the error analysis. In addition, the aerosol correction is treated twice in the product (explicit correction for the NO2 retrieval, and implicit correction for the cloud pressure retrieval), which may lead to larger retrieval errors than more simple treatments (e.g. only explicit aerosol correction without cloud, or simple cloud correction including implicit aerosol correction). Therefore, I strongly encourage the authors

to expand their discussion and provide more robust and convincing arguments in support of their approach. I recommend publication of this manuscript only after major revision addressing the aforementioned comments.

Thank you very much for your suggestions. We have added a section (Section 3.3) and additional experiments to test the effect of such issue.

In Line 161-165, we add:"

Two additional cases (Cases 3 and 4) concern the treatment of CP in combination with the choice of aerosols and surface reflectance. Specifically, using the CP data directly from FRESCO-S means that our retrieval algorithm does not perfectly account for the effect of aerosols on clouds. Our retrieval consider the BRDF effects while Lambertian surface is used in deriving the FRESCO-S CP. "

In Line 347-385, we add:"

3.3 Influences of directly using the CP data from FRESCO-S

As we take the CP data directly from the FRESCO-S retrieval rather than re-retrieving CP (as done for CF), two main issues arise. First, the FRESCO-S retrieved CP may be affected by aerosols, thus using such CP data in our explicit aerosol corrections (Case REF) may lead to over-correction of aerosol effects. To estimate the effect of such over-correction on retrieved NO2 VCDs, we employ in an additional sensitivity case (Case 3 in Table 2) a "semi-explicit" aerosol correction approach. This approach explicitly includes aerosols in the calculation of AMF for the clear-sky portion (Mclr) of a pixel (as in Case REF), but excludes aerosols for the cloudy-sky portion (Mcld) of that pixel. Correspondingly, CF is re-calculated on the basis that the radiance at 437.5 nm received by TROPOMI is contributed from the aerosol-contained clear-sky portion and the no-aerosol cloudy-sky portion. Table 3 shows that in July 2018, on a pixel basis, the derived NO2 in Case 3 are larger than those in Case REF, with an average difference increasing from 3.1% at relatively clean situations (NO2 VCDs in Case REF

< 5 $\times$ 10^15 molecu·cm^(-2)) to 11.2% for polluted situations (NO2 VCDs in Case REF $\geq$ 15 $\times$ 10^15 molecu·cm^(-2)). The spatial distributions in Fig. S1a and S1b also show higher NO2 VCDs in Case 3 relative to Case REF. The corresponding increases in CF (Fig. S1c versus S1d) are because in Case 3 the scattering contributions to the radiance from aerosols in the cloudy-sky portion (that would have occurred) are accounted for with higher CFs. The enhanced "shielding effect" of clouds (due to higher CFs) result in lower NO2 AMFs and higher VCDs.

For surface reflectance, Case REF considers the BRDF effect instead of Lambertian Equivalent Reflectivity (LER) which is used in deriving FRESCO-S clouds. This leads to inconsistency between when the CP is derived and when it is used. The LER data used by FRESCO-S are generated at 758 and 772 nm (based on the Global Ozone Monitoring Experiment-2), rather than at the 437.5 nm for the NO2 retrieval. Thus Case 4 adopts the OMI LER data from TM5-MP-DOMINO, a five-year monthly based climatology at 440 nm, and re-calculates CFs and NO2 AMFs with explicit aerosol corrections and FRESCO-S CP (Table 2). Here, the ice-snow flag in the TM5-MP-DOMINO product is used to exclude the possible ice/snow contamination, and only the pixels with blue-sky albedos (derived from the BRDF data in Case REF) less than 0.3 are taken into consideration. The resulting NO2 VCDs in Case 4 are lower than Case REF by 3.7% on pixel-based average for relatively clean situations and by 8.3% for polluted situations (Table 3). Figure S2a and S2b further shows the spatial distributions of the relative and absolute differences in derived monthly mean NO2 VCDs between Case 4 and Case REF. In general, Case 4 leads to lower NO2 VCDs than Case REF because of stronger surface reflectance, as is obvious in the comparison of blue-sky albedo in Case REF and LER albedo in Case 4 (Fig. S2c versus S2d). "

Specific comments:

1, Figure 1: Reflectance at 758nm -> 437.5nm.

Changed.

2, Figures 6-7: these figures can be merged. I suggest to add similar figures where the y-axis use retrieved MAX-DOAS profiles smoothed by satellite averaging kernels. This will remove the error on the satellite retrieval coming from the profile shape uncertainty.

Figure 7 has been merged with Fig. 6.

It is a good suggestion to show the results using retrieved MAX-DOAS profiles smoothed by satellite averaging kernels. However, we do not have MAX-DOAS NO2 profiles at any station.

3, Page 17 line 9: more much -> much more

Changed.

4, SI Table S2: Number of measurements within +/- 0.5h -> Number of measurements within +/- 1h, why?

This phenomenon occurs at Xuzhou. It is because our criterion to ensure weak temporal variability of NO2 within the time window; large variability would suggest very local signals that can contaminate the comparison. Indeed, expanding the sampling (temporal) window leads to much stronger variability at Xuzhou, leading to fewer numbers of valid days (7 days are excluded in Table S2).

In Line 185-187, we stated that "To reduce the influence of local events, we exclude all MAX-DOAS data whose standard deviations within the period exceed 20% of their mean values.". We have added a footnote in Table S2 to explain this issue.

5, SI reference is missing.

Added.

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2019-500/amt-2019-500-AC1-supplement.pdf