

Interactive comment on “An Improved Total and Tropospheric NO₂ Column Retrieval for GOME-2” by Song Liu et al.

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This paper describes the many algorithm improvements implemented in a future version (4.9) of GDP used by the EUMETSAT AC-SAF for NO₂ retrieval from GOME-2. Among them, the main improvements are a broader fitting window, 425 – 497 nm (extended from GDP4.8, 425 – 450 nm) and the associated linear intensity offset correction, and the adaptation of STREAM for its stratosphere-troposphere NO₂ separation scheme. Though most (if not all) these improvements have been presented previously in various published works, this paper documents these changes coherently. Additionally, this paper includes tropospheric NO₂ comparison with ground-based MAXDOAS measurements, in an effort to validate the improved algorithm. This paper may be viewed as the algorithm document for GDP4.9, which will be applied to the series of

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GOME-2 instruments for generating a long-term NO₂ record. It is suitable for publication in AMT. There are some clarifications and minor edits needed for acceptance.

Specific Comments:

1. Validation

The validation using MAXDOAS suggests that GPD4.9 agrees better with this independent correlative measurements than GDP4.8, because the bias reductions (shown in Tables 4 and 5) achieved with the newer version GDP. But this overemphasizes the bias reduction. The equally important measure is the standard deviation, which shows little or no improvement. In fact, there are many cases (Tables 4 and 5) that show large standard deviation or lower correlation with MAXDOAS for the new GDP, indicating that the agreement becomes worse with the algorithm changes. One could argue that biases in satellite measurements may be easier to remove, often achieved by offset adjustments. Therefore lower biases likely do not say much about retrieval improvements. Keeping in mind that the coincidence of the ground-based MAXDOAS and GOME-2 may be limited, the agreements (as measured by standard deviation of difference or correlation coefficient) have its limitation as well. I recommend revise section 7, and add some discussions on the agreement based on standard deviation and correlation.

2. Larger Fitting Window

While it is certainly true that the noise level of slant NO₂ column is lower for DOAS retrieval from a larger fitting window in general, there is a downside as well. The key assumption of DOAS approach is that the AMF is (nearly) independent of wavelength. However as the fitting window becomes larger, the spectral dependence of tropospheric AMF becomes more prominent. For instance, the measurement sensitivity (called the box AMF m_l , Eq.8) is $\sim 20\%$ higher at 490 nm than at 425 nm at 1 km above the surface, for a spectral invariant surface reflectivity at 0.1. Closer to the surface at 0.1 km, m_l is $\sim 30\%$ higher at 490 than at 425 nm. Furthermore, surface reflectivity depends on wavelength as well, introducing additional spectral variation in

the tropospheric AMF. This spectral variation in AMF implies that the absorption signal would be 20% to 30% stronger at 490 nm than at 425 nm for the same amount tropospheric NO₂. Considering that many improvements described in the paper are on the order of a few percent, perhaps it is a good idea to discuss how the AMF spectral variation affects the retrieval accuracy. My rough estimate indicates that it may have up to 15% error for the larger fitting window when neglecting the spectral variation.

3. Intensity Offset

* Based on Eq. 1, the offset listed in table 1, should simply be 'a' for GDP4.8, and 'a + b λ' for GDP4.9, not $\ln(1+a)$ and $\ln(1+a+b \lambda)$, respectively.

* Please add in the paper a description of how the parameters 'a' and 'b' are determined.

* The additive intensity offset looks similar to stray light contribution. It would be helpful add some plots to accompany the difference plots in Fig. 1. Specifically, include a map of LER to show the scene reflectivity, and maps of the parameters 'a' and 'b'. If the offset has something to do with stray lights, 'a' would be high for low reflectivity scene, and vice versa, assuming that L1B data are not yet stray-light corrected. In any case, these additional plots would reveal information about L1B, and lend credibility of the intensity-offset correction.

4. Minor edits

* Page 2, line 9: "a strong growth of NO₂ since two decades has caused", 'since two decades' is not clear, revise please.

* Page 2, line 33: "measured GOME-2 (ir)radiances", should be measured GOME-2 radiances, or measured GOME-2 sun-normalized radiances.

* Page 22, line 10: "and photon path", not specific or meaningful here. May be removed.

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