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Comment on amt-2021-158

Anonymous Referee #2

Referee comment on "Glyoxal tropospheric column retrievals from TROPOMI – multi-satellite intercomparison and ground-based validation" by Christophe Lerot et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-158-RC2>, 2021

The manuscript "Glyoxal tropospheric column retrievals from TROPOMI, multi-satellite intercomparisons and ground-based validation" by Lerot et al., presents global glyoxal observations made by the TROPOspheric Monitoring Instrument (TROPOMI). The paper provides the description of the retrieval algorithm, an inter-comparison of glyoxal observations from TROPOMI and other low earth orbit (LEO) satellite retrievals, and validation leveraging a few available MAX-DOAS glyoxal observations. This new retrieval would enable new atmospheric chemistry studies given improved spatial resolution and retrieval noise levels in comparison with retrievals from prior LEO satellites. The paper well written and constitutes a good reference for future studies using TROPOMI glyoxal observations. Its publication its therefore more than justified.

There a few aspects of the retrieval description, the uncertainty calculation and the comparisons with other satellite could benefit from further descriptions and clarification. It would be great if the authors could address the following comments during the discussion before final publication of the manuscript in AMT.

My main concern regarding the different retrieval steps is the assumption of a constant 1×10^{14} molecules/cm² vertical column over the Pacific Ocean as reference for the background correction. This value is based on observations from one group (Sinreich et al., 2010) using an observation methodology similar to the satellite retrieval (DOAS fit) that could be affected by similar biases. At the same time, this results differ from other ocean glyoxal observations (for example Mahajan et al., 2014) reporting smaller columns over the oceans. It would be interesting to provide further discussion about the effect of the background correction in the final reported columns. How much would differ the final columns have the author's decided to use reference columns from chemical transport models or other sources?

Also, to understand the effect of each retrieval step in the final VCDs around the globe it would be beneficial to add a figure showing global values of dSCDs, VCDs, and background corrected VCDs so it is easier to interpret the amount of information present in the final VCDs brought in by each retrieval step.

Other comments and doubts:

The description about the calculation of pseudo-absorbers to account for scene heterogeneity leaves some questions un-answered: (1) what are the criteria defining the two additional cross-sections for scene heterogeneity? (2) What is the effect of using one vs. two extra pseudo cross sections? (3) how is defined the remote region over which the heterogeneity cross sections are calculated?

How many Taylor expansion terms are considered in the derivation of the empirical correction associated with NO₂ slant columns?

Are the MAGRITTE a priori glyoxal vertical profiles computed daily at the satellite over pass time or are they compiled as a monthly climatology as done in most heritage glyoxal satellite retrievals?

How is the interpolation of the background correction matrix done outside the 40°S to 40°N area?

The classification of all AMF uncertainties as systematic is confusing. First, it is important to acknowledge how complicated it can be discriminate systematic and random uncertainties in the AMF calculation and the different sources of uncertainty. The authors should be thank for the efforts they have put in trying to quantify such uncertainties. Said that, given the uncertainties inherent to chemical transport models and surface reflectance climatology, and the representation errors associated with different spatial and temporal resolutions some of the AMF errors have to be necessarily random. Given the mean biases between MAX-DOAS observations and TROPOMI retrievals reported in the manuscript (always $< 0.6 \times 10^{14}$ molecules/cm²) should not the systematic uncertainties reflect this in panel c) of figure 5 with negative values?

During the discussion of uncertainties associated to a priori glyoxal profiles, an effective height uncertainty of 50 hPa is assumed. How is this value obtained?

While the color scale used in figures 7, 8, 9, and 10 produce clean plots they fail to convey complete quantitative information. First, despite glyoxal VCDs ranging between 0 and 1×10^{14} molecules/cm² in most parts of the world the color scheme does not allow appreciating any structure for that given range. Second, what color is assigned for values below 0 and above 6×10^{14} molecules/cm²?

Minor typos and language comments:

Line 56: I think "precursors is" should be "precursors are"

Line 207: "end hence" should most likely be "and hence"

Line 316: "Anthropogenic NMVOCs emissions of are" should be "emissions are" without the "of"

Line 438: "see above section 6.5.1" is meaning "see section 3.3"?