Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC1
https://doi.org/10.5194/amt-2021-158-RC1, 2021

Comment on amt-2021-158

Anonymous Referee #1

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-RC1, 2021

Review for manuscript number amt-2021-158 'Glyoxal tropospheric column retrievals from TROPOMI, multi-satellite intercomparison and ground-based validation.'

The manuscript titled '**Glyoxal tropospheric column retrievals from TROPOMI, multi-satellite intercomparison and ground-based validation**' presents a global tropospheric glyoxal product from the new TROPOspheric Monitoring Instrument (TROPOMI) along with a new retrieval algorithm that has been applied to the other satellite-based instruments for an intercomparison. These results are validated with some continental ground-based observations. The manuscript is well structured, albeit lengthy. Overall, it presents a step ahead in creating a high-resolution database for glyoxal, which is currently missing. While certain sections are well detailed and discussed, other parts are glossed over, and selective studies from the past have been used to suggest that the new product is accurate. This is especially of worry over the oceanic region where no validation is presented.

While I do not wish to be negative about the manuscript, which is worthy of publication in AMT after modifications, I hope that the authors can improve on the current draft according to the comments below.

Major comments:

Two major changes are suggested to make the paper easier to read and to highlight the capabilities and shortcomings of the updated retrieval algorithm.

1) A comparison of the different satellite products does not offer much to the current

paper. All the satellite products are generated using essentially the same DOAS settings in the updated BIRA-IASB retrieval algorithm. The high level of consistency is not surprising, considering that the products are analyzed in almost the same way. The small differences that arise because of the physical detectors, footprints, etc., are not unexpected and hence the amount of discussion on this does not seem justified. It makes the paper lengthier than necessary and does not give extra useful information.

2) One of the highlights, which needs to be discussed in more detail, is the high CHOCHO VCDs observed over the ocean. The new product shows high values over the oceans, for which the peak is about half as much as the continental peaks. As the authors have mentioned, this is not explicable by the current known chemistry and sources. Indeed, even in highly productive waters, glyoxal and methylglyoxal are significantly undersaturated, and hence a direct source is not likely (Zhu and Kieber, 2019). Eddy covariance based observations show that the ocean surface is a sink for glyoxal for most of the day (Coburn et al., 2014).

This elevated column over the tropical oceans was reported earlier for satellite observations (Lerot et al., 2010; Vrekoussis et al., 2010) and other older papers using SCHIAMACHY. However, only one group has reported high CHOCHO over one single region in the pacific when using ground-based, or aircraft-based observations (Sinreich et al., 2010) – it has not been seen by others, even in the same region.

The largest collection of ship and land-based observations using data from nine campaigns all over the marine environment have shown that CHOCHO is mostly below the detection limit in the open ocean environment (Mahajan et al., 2014). A pattern of a significant increase in the tropics was not seen. A similar result was also seen by a more recent study by (Behrens et al., 2019) which showed that CHOCHO was mostly below the detection limit with just two days of values just above the detection limit – with the geographical distribution not the same as the new satellite product. Indeed, remote ocean observations from outside the tropical region also show similar glyoxal levels as the tropical regions (Lawson et al., 2015).

Considering this, it would be helpful to have a section about the potential interferences over the ocean:

- What was the effect of the liquid water absorption and vibration Raman infilling of Fraunhofer lines in spectral retrieval over different regions? Are oceanic regions more sensitive than over land?
- How sensitive is the retrieval over the oceans to the chosen background?
- Are there reasons why the retrieval shows significant seasonal changes over the land but not over the ocean?
- Considering the scale of the TropOMI pixels, large lakes could be used as testbeds to check the algorithm's sensitivity to water reflectance-related issues.

Some of these issues, especially related to the liquid water path, can play a big role in false positives over the tropical oceans. A study using OMI has detailed this in the past and should be referred to (Chan Miller et al., 2014) when discussing the retrieval over remote oceans. They were able to correct the elevated retrievals to large degree.

Minor comments:

- P:5, L:157-159: Authors have used 435-460 nm wavelength window for the CHOCHO retrieval. Although several groups have used this window, it can be affected by the strong water vapor absorption in this region. Have authors considered introducing a gap in the analysis window for H_2O or tried using a larger window (some studies recommend the 410-460 nm, 400-60 nm, etc.) to check the sensitivity of the retrievals?
- The authors mention that 'There are however two stations (Phimai/Thailand and Pantnagar/India) where the satellite/MAX-DOAS bias is more significant, despite an excellent agreement between the seasonal variations. The origin of this bias is not fully understood, but it is not uncommon to have such biases in UV-Visible satellite retrievals for strongly polluted sites.' – this needs to be explored in more detail – the explanation about high pollution does not check out as the match is better at other polluted stations like Xianghe/China and Mohali/India.
- Line 1274: Reference title is incomplete.
- The authors use 'excellent' at several places – this is very subjective and in most matches are not even 'great' – please reduce the use of superlatives throughout the manuscript.
- The font size in most figures is too small to read without zooming.
- Figure 15: The legends can be moved to the empty panel.
- The ground-based instruments use different DOAS retrieval settings and algorithms. For consistency and standardized validation, should they not be analyzed with the same settings and algorithms?

References:

Behrens, L. K., Hilboll, A., Richter, A., Peters, E., Alvarado, L. M. A., Kalisz Hedegaard, A. B., Wittrock, F., Burrows, J. P. and Vrekoussis, M.: Detection of Outflow of Formaldehyde and Glyoxal from the African continent to the Atlantic Ocean with a MAX-DOAS Instrument, Atmos. Chem. Phys. Discuss., (2), 1–32, doi:10.5194/acp-2018-1286, 2019.

Chan Miller, C., Gonzalez Abad, G., Wang, H., Liu, X., Kurosu, T., Jacob, D. J. and Chance, K.: Glyoxal retrieval from the ozone monitoring instrument, Atmos. Meas. Tech., 7(11), 3891–3907, doi:10.5194/amt-7-3891-2014, 2014.

Coburn, S., Ortega, I., Thalman, R., Blomquist, B., Fairall, C. W. and Volkamer, R.: Measurements of diurnal variations and eddy covariance (EC) fluxes of glyoxal in the tropical marine boundary layer: Description of the Fast LED-CE-DOAS instrument, Atmos. Meas. Tech., 7(10), 3579–3595, doi:10.5194/amt-7-3579-2014, 2014.

Lawson, S. J., Selleck, P. W., Galbally, I. E., Keywood, M. D., Harvey, M. J., Lerot, C., Helmig, D. and Ristovski, Z.: Seasonal in situ observations of glyoxal and methylglyoxal over the temperate oceans of the Southern Hemisphere, Atmos. Chem. Phys., 15(1), 223–240, doi:10.5194/acp-15-223-2015, 2015.

Lerot, C., Stavrakou, T., De Smedt, I., Müller, J.-F. and Van Roozendael, M.: Glyoxal vertical columns from GOME-2 backscattered light measurements and comparisons with a global model, Atmos. Chem. Phys., 10(9), 12059–12072, doi:10.5194/acp-10-12059-2010, 2010.

Mahajan, A. S., Prados-Román, C., Hay, T. D., Lampel, J., Pöhler, D., Großmann, K., Tschritter, J., Frieß, U., Platt, U., Johnston, P., Kreher, K., Wittrock, F., Burrows, J. P., Plane, J. M. C. and Saiz-Lopez, A.: Glyoxal observations in the global marine boundary layer, J. Geophys. Res. Atmos., 119(10), 6160–6169, doi:10.1002/2013JD021388, 2014.

Sinreich, R., Coburn, S., Dix, B. and Volkamer, R.: Ship-based detection of glyoxal over the remote tropical Pacific Ocean, Atmos. Chem. Phys., 10(23), 11359–11371, doi:10.5194/acp-10-11359-2010, 2010.

Vrekoussis, M., Wittrock, F., Richter, A. and Burrows, J. P.: GOME-2 observations of oxygenated VOCsâ□¯: what can we learn from the ratio glyoxal to formaldehyde on a global scale?, Atmos. Chem. Phys., 10, 10145–10160, doi:10.5194/acp-10-10145-2010, 2010.

Zhu, Y. and Kieber, D. J.: Concentrations and Photochemistry of Acetaldehyde, Glyoxal, and Methylglyoxal in the Northwest Atlantic Ocean, Environ. Sci. Technol., 53(16), 9512–9521, doi:10.1021/acs.est.9b01631, 2019.