Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2020-122-RC2, 2020

Atmospheric Measurement Techniques Discussions
Open Access
EGU

Interactive comment on "Validation of the Sentinel-5 Precursor TROPOMI cloud data with Cloudnet, Aura OMI O_2-O_2, MODIS and Suomi-NPP VIIRS" *by* Steven Compernolle et al.

Anonymous Referee #2

Received and published: 8 August 2020

This paper analyzes properties of clouds derived from TROPOMI measurements and conducts a validation exercise comparing them to retrieval inferred with sensors and algorithms based on different physical approaches.

The objectives, methods used and the results must be considered as provisional, as the described algorithms seem not yet mature enough, as often declared by the authors themselves throughout the presentation of the results.

Many improvements are undergoing and newer reprocessing of the records are to be expected in the near future. As such, the paper documents the ongoing effort to make TROPOMI cloud data reliable.

Printer-friendly version

Discussion paper

The science is sound and the text is well written. However, the paper still needs moderate-to-major revisions. I therefore recommend publication only after my comments are addressed.

I will collapse all my remarks in one general comment below and leave some minor comments later on.

Main general comment

- First and foremost, the present paper is about clouds from TROPOMI. Correction of trace gas retrievals is only one of the many applications.

Even if the Sentinel-4 and Sentinel 5 missions, extending the Sentinel 5P record with the same algorithms, share the obvious goal of monitoring atmospheric composition, cloud research is unfortunately shadowed and left in the background.

Let us immagine a data user who wants to conduct own cloud search using European data sets instead of American data sets, and specifically TROPOMI data. Is he sufficiently informed about the range of applicability of the retrievals for cloud research itself? I do not think so.

Therefore, I find it misleading to begin the introduction by dedicating the entire first paragraph to past missions endeavouring the study of atmospheric constituents only. I understand the logic, but I find it overkill. Clouds are firstly mentioned only at line 19.

This does not mean that the paragraph should be removed, but at the end of the introduction I expect a paragraph of equal importance and length that would enable the reader to judge whether TROPOMI's cloud data can do the job for research objectives as: cloud trends, aerosol-cloud interactions, climatology generation, hydrological cycle, climate extremes, input for aviation safety (is a radiative cloud height, or centroid, of any importance to aviation? No. Cloud top is.).

It looks like that the first comparison of TROPOMI cloud algorithms has been already reported in the TROPOMI S5P Science Verification Report (S5P-SVP). As far as I can judge comparing that outcome with that of this paper, the main conclusions are the same. But some methodological approaches deployed for the S5P-SVP, delivering valuable insights, have not been followed up here (e.g., across-track errors, surface errors as function of low cloud fractions, three-dimensional RT).

So, I invite the authors to elaborate and make explicit the following algorithmic aspects:

- Errors arising from a plane-parallel approximation (neglection of 3D RT). We know that the improved spatial resolution does have an impact on RT. We are not talking about GOME-2 or SCIAMACHY anymore. Please also link your results to those of the MICRU algorithm when talking about cloud fraction.

- Errors arising from the neglection of cloud multi-layeredness. Are the algorithms capable to flag this? Can a data user expect to be able to use TROPOMI data to investigate turbulent atmospheres? Joiner et al. (2010) shows that the fraction of multi-layer cloudy pixels can be up to 50% or more at OMI spatial resolution.

- Vertical inhomogeneity of clouds. To what extent are the presented algorithms capable to follow it? Can they be improved to encapsulate different vertical extinction profiles? Will the algorithms be able to reproduce cloud distributions inferred, e.g., from CloudSAT? Ziemke et al., 2009 show that average cloud extinction profiles for tropical deep convective clouds that peak at different pressures depending in general on the total optical thickness. This implies that the ISCCP diagrams from TROPOMI can not be fully reliable because of the following remark:

- Are the CTH/CH retrievals dependent on COT? This is a matter of great concern for cloud research. This aspect is hastily mentioned by the authors only once, but it got my attention. this has to be read and understood in connection with bullet (2) by the first reviewer, which I support. Please, elaborate and make explicit.

- Surface influence. Looking at the S5P-SVP, Figures 13.28 and 13.29, pages 285-286, there is a clear CH-dependency on surface reflectivity and cloud fraction. In the present paper only at P23, bias dependence on surface reflectivity is mentioned. So, I appreciate a similar exercise, where the accuracy of CH is subset after surface reflectivity and cloud fraction. It can be done within a Taylor diagram or by other means, but this interdependency must be made explicit.

- Across-track dependence of cloud retrievals. The authors are encouraged to compare their results with those of Fasnacht et al., 2019. Fasnacht et al., A geometry-dependent surface Lambertian-equivalent reflectivity product for UV-Vis retrievals – Part 2: Evaluation over open ocean, Atmos. Meas. Tech., 12, 6749–6769, 2019.

Minor comments:

P3 L18: "used by FRESCO". There should also be "... and ROCINN"?

P5 L5: "Note that at maximum RCF and CA, sRCF reaches 1.2 rather than 1." Do the authors have an explanation why a CF must exceed the limit of 1? Clearly the value is not physical. So, please, elaborate and make explicit that a CF=1.2 is needed as an ad-hoc correction for surface and/or trace gas retrieval.

P8 L28: "Due to the difference in overpass time between GOME-2 (in the morning) and Sentinel 5 precursor (in the afternoon)" Why is the overpass time a source of discrepancy for the surface albedo climatology? I can understand the difference in footprint size, but not a difference of some hours when building a climatology of an object barely evolving within few hours.

For the spatial resolution, it is not clear to me why the GOME-2 climatology is used and not the MERIS black-sky albedo climatology, which would be a much better choice. Please, elaborate, make explicit and justify.

P13 L2 and ff: Section 4.1.2 S5P FRESCO. I find this section unnecessary in the context of this manuscript. The purpose of the paper is to present a validation and comparison between different cloud products derived from TROPOMI measurements. However, in this section, the inability of FRESCO to discriminate aerosols from clouds is presented. This result, besides not being new (Wang et al, ACP, 2012), is not surprising given the spectral range used by the algorithm which handles cloud and aerosol radiances similarly.

Moreover, the authors swiftly interchange between clouds and aerosols in the narrative and this is inconsistent: line 9 should read "For this new product, the sensitivity to low ___aerosols___ in the low atmosphere is improved" and not "the sensitivity to ___low clouds___ is improved".

This is because based on the very same evidence provided by the authors themselves in the paper you are not retrieving clouds.

So wouldn't it be better to filter out all those pixels that are reasonably aerosol from the data set? I would like to stress that, although one of the possible applications of these data sets is the correction for trace gas retrievals, a cloud data set should serve cloud research too. What if a data user is going to average and assess long-term tendencies or climatology of cloud properties? How much of such missflagged aerosols will be present in the record?

Additionally, please collapse all FRESCO algorithmic details in one section, as pointed out also by the first referee.

References

Joiner, J., Vasilkov, A. P., Bhartia, P. K., Wind, G., Platnick, S., and Menzel, W. P.: Detection of multi-layer and vertically-extended clouds using A-train sensors, Atmos. Meas. Tech., 3, 233–247, 2010.

Wang P, Tuinder ONE, Tilstra LG, De Graaf M, Stammes P (2012) Interpretation of FRESCO cloud retrievals in case of absorbing aerosol events. Atmos Chem Phys 12(19):9057–9077, doi:10.5194/acp-12-9057-2012

Sentinel-5P TROPOMI Science Verification Report, S5P-IUP-L2-ScVR-RP, Issue 2.1", Sect. 13.4-14.4, https://earth.esa.int/documents/247904/2474724/Sentinel-5P-

TROPOMI-Science-Verification-Report, 2015

Ziemke, J. R., Joiner, J., Chandra, S., Bhartia, P. K., Vasilkov, A., Haffner, D. P., Yang,K., Schoeberl, M. R., Froidevaux, L., and Levelt, P. F.: Ozone mixing ratios inside tropical deep convective clouds from OMI satellite measurements, Atmos. Chem. Phys., 9, 573–583, 2009.

Fasnacht et al., A geometry-dependent surface Lambertian-equivalent reflectivity product for UV-Vis retrievals – Part 2: Evaluation over open ocean, Atmos. Meas. Tech., 12, 6749–6769, 2019.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-122, 2020.