Review AMT 2021

This paper quantitatively validate the absorbing aerosol height (AAH) product from GOME-2 retrieved by the Fast Retrieval Scheme for Clouds from the Oxygen A band (FRESCO) algorithm for case studies of volcanic eruptions. The topic of this work is useful and provides the guide for the use of GOME-2 AAH product in volcano related research. However, the qualities of both the descriptions of the data and the presentations of results (figures and tables) have to be improved. In fact, previous studies about validation of passive satellite AAH retrieval with lidar observations always used lidar backscattter or aerosol extinction profiles (see references), but only CALIOP VFM product was used in this study. I don't think this is sufficient as a benchmark. If the authors have some specific reasons to use this product, these should be described. The descriptions about the definition of AAH and aerosol profile assumption in FRESCO algorithm are also important to find an appropriate aerosol height benchmark from lidar measurements, but not involved in this study. The detailed comments are as follows.

General comments

1. Before the comparison of GOME-2 AAH and CALIOP data, the authors need to make the definition of GOME-2 AAH clearly, but I cannot find it. What is the aerosol/cloud profile assumption in the GOME-2 retrieval algorithm? For example, in EPIC/DSCOVR ALH retrieval, the aerosol profile is assumed to follow a quasi-Gaussian distribution (Xu et al. 2019, AMT; Xu et al. 2017, GRL), meanwhile in TROPOMI L2 ALH product, a uniform aerosol layer is defined and the middle layer is reported as ALH in the product (http://www.tropomi.eu/sites/default/files/files/publicSentinel-5P-TROPOMI-ATBD-Aerosol-Height.pdf). For different aerosol profile assumptions, the aerosol extinction shows different vertical distribution, which will affect the TOA reflectance oberved by the satellite. On the other hand, the definition of GOME-2 AAH also determines which height should be derived from CALIOP data to do comparison.

2. In fact, in many previous studies, the CALIOP extinction weighted aerosol height was always used as the validation of passive satellite retrieval, such as EPIC and TROPOMI (Xu et al. 2019, AMT; Nanda et al. 2020, AMT). Why did the authors choose the minimum and maximum layer from CALIOP data? How to define this minimum and maximum value? I think the CALIOP aerosol extinction product and backscatter data will be useful. From Fig. 1, the GOME-2 AAH seems not correlated with CALIOP data and indicates its bad agreement with CALIOP data and even meaningless.

3. When the authors did the comparison, was there any quality control method to be used to remove those unconfident AAH retrievals? If not, the invalid retrievals may reduce the correlation between GOME-2 AAH and CALIOP data in Fig.1. In fact, I do not quite understand the "accuracy requirements" in Table 1. More descriptions about the meaning of the numbers in this table is suggested to be added.

4. Most of the figures in this study is not impressive and the figures quality needs to be improved. For example, the data for different aerosol subtypes can be shown as different colored dots in Fig. 1a, so that the readers can easily find which aerosol type has better agreement and which is worse. Or the error in Fig. 4 can be expressed as errorbar instead of dots. The meaning of Fig. 1 and Fig. 4 have some overlaps and the authors should better organize them.

5. Actually, it is difficult to get aerosol type information when retrieve AAH only from O2 A band. Many algorithms only define a fixed aerosol model (optical properties) when retrieve AAH and this assumption will affect the AAH retrieval accuracy. What is the aerosol model used in the GOME-2 AAH retrieval algorithm? This may cause different accuracy when compared with different CALIOP subtypes height. If at one CALIOP footprint, there are several aerosol subtypes at different layers, how to do comparison with GOME-2 AAH?

6. Too many similar figures in Section 3.2. I suggest to re-organize them and provide more information in one figure. If the conclusions are similar for different cases, the figures do not have to be shown again.

Specific comments

1. Line 53-56: What is the relationship between the monitoring of surface thermal anomalies (from MODIS) and gas emissions (from OMPS or S5P) with plume extent detection? Maybe the plume chemical components and remote sensing characteristics could be mentioned here. I suggest to reword these two sentences.

2. I think the UV wavelength pair of GOME-2 AAI product used in the aerosol height retrieval could be mentioned at somewhere in the Introduction or Method, in case the readers are not famililar with this product.

3. Table 1: The meaning of threshold, target and optimal is suggested to be added in the table caption or nearby text.

4. I believe Table 2 is useless in this study.

5. Line 269: What does the "error" mean in Fig. 4? Does it represent the retrieval uncertainty? The authors should make it clear.

6. Figure 7: What does the GOME-2 data in this figure (and other similar figures hereafter) mean the closest pixel data or the mean value for all the pixels within 100 km to CALIOP footprint?

Xu, X., and Coauthors, 2017: Passive remote sensing of altitude and optical depth of dust plumes using the oxygen A and B bands: first results from EPIC/DSCOVR at Lagrange-1 point: Aerosol height retrieval from O2 A B. Geophysical Research Letters, 44. Xu, X., and Coauthors, 2019: Detecting layer height of smoke aerosols over vegetated land and water surfaces via oxygen absorption bands: hourly results from EPIC/DSCOVR in deep space. Atmos. Meas. Tech., 12, 3269-3288. Nanda, S., M. de Graaf, J. P. Veefkind, M. Sneep, M. ter Linden, J. Sun, and P. F. Levelt, 2020: A first comparison of TROPOMI aerosol layer height (ALH) to CALIOP data. Atmos. Meas. Tech., 13, 3043-3059. Sanders, A. F. J., de Haan, J. F., Sneep, M., Apituley, A., Stammes, P., Vieitez, M. O., Tilstra, L. G., Tuinder, O. N. E., Koning, C. E., and Veefkind, J. P.: Evaluation of the operational Aerosol Layer Height retrieval algorithm for Sentinel-5 Precursor: application to O2 A band observations from GOME-2A, Atmos. Meas. Tech., 8, 4947–4977, https://doi.org/10.5194/amt-8-4947-2015, 2015.