Validation of the Absorbing Aerosol Height (AAH) product from GOME-2 using CALIOP data

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1 Introduction

The Absorbing Aerosol Height (AAH) is a new GOME-2 product for aerosol detection developed within the Atmospheric Composition Satellite Application Facility (AC-SAF). It uses the Absorbing Aerosol Index (AAI) and derives the actual height of the absorbing aerosol layer in the O2-A band using the Fast Retrieval Scheme for Cloud Observables (FRESCO) algorithm (Tilstra et al. 2010). This AAH product could be used to monitor volcanic eruptions globally and to provide the height of the ash layers (e.g. within the framework of aviation safety).
To determine the quality of the AAH, a new quantitative validation exercise has been done, using the extracted height from the different aerosol layers from CALIOP and comparing this to the AAH from GOME-2. The results from different case studies will be presented.

2 Method

- Download CALIOP Vertical Feature Mask data (version 4.10) from NASA Langley Research Center Atmospheric Science Data Center
- Retrieve aerosol type(s) and layer height from CALIOP
- Retrieve AAH from GOME-2 for AAI>4 cases
- Compare CALIOP layer height with AAH for points located within 100km distance

3 Some validation results

3.1 Case 1: Calbuco eruption

- On 23/04/2015, the ash plume rose higher than 15km and drifted N, NE, and E.

Fig. 1 shows the aerosol layers detected by CALIOP and GOME-2 for 23/04/2015 (left) and 24/04/2015 (right).

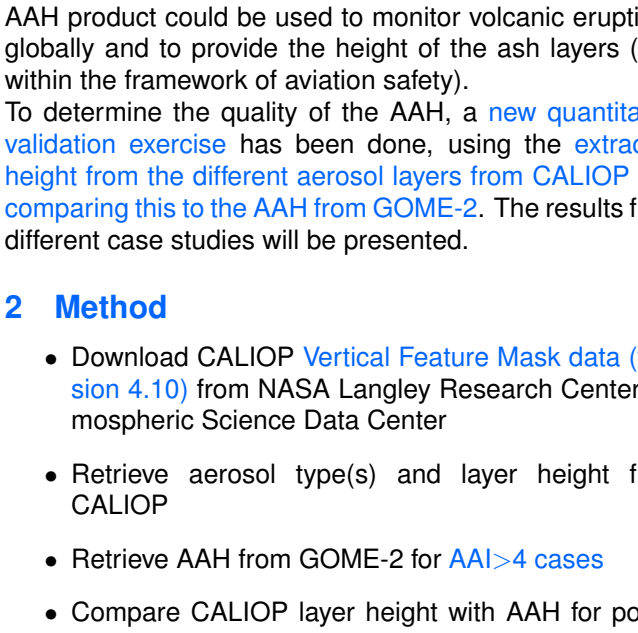

Figure 1. The figures on top show the location of the volcano (in red) and the GOME-2 (in green) and CALIOP (in blue) overpasses for 23/04/2015 (left) and 24/04/2015 (right). The figures in the middle show the differences between the aerosol layer height observed by CALIOP and the corresponding AAH observed by GOME-2 for different aerosol types as observed by CALIOP in function of the distance between GOME-2 and CALIOP. The bottom figures show the minimum and maximum aerosol layer height detected by CALIOP and the AAH from GOME-2.

On 23/04/2015, CALIOP detected volcanic ash between 13-18.5km altitude and stratospheric elevated smoke between 15.5-17km altitude. The AAH of GOME-2 was lower (between 10.5-14.5km) and thus underestimated the altitude of the volcanic layers. It needs to be mentioned that the AAH can never be higher than 15km as a result of using the FRESCO algorithm.

On 24/04/2015, CALIOP detected several aerosol species: dust and polluted dust between 0.2-5.5km; volcanic ash between 13-17.5km; sulfate and stratospheric elevated smoke between 14.5-15km. The AAH of GOME-2 was between 1.8-4.8km and seemed to follow the height of the dust layer instead of the volcanic layer.

3.2 Case 2: Puyehue eruption

- On 05/06/2011, the ash plume rose to 10.7-12.2 km and drifted ESE over the coast of Argentina and into the Atlantic Ocean.

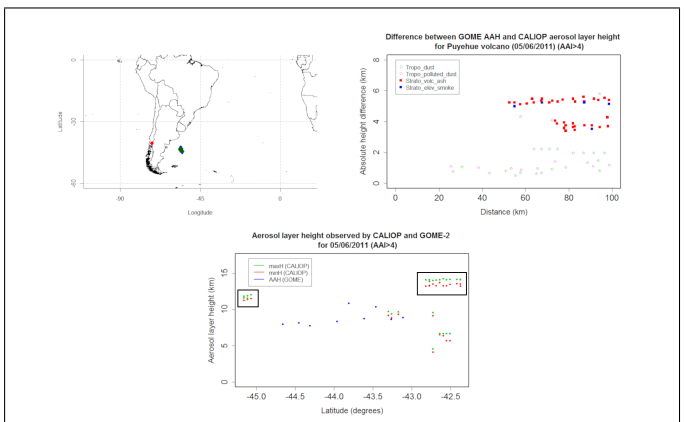

Figure 2. The figure shows the location of the volcano (in red) and the GOME-2 (in green) and CALIOP (in blue) overpasses for 05/06/2011 (top left). The top right plot shows the differences between the aerosol layer height observed by CALIOP and the corresponding AAH observed by GOME-2 for different aerosol types as observed by CALIOP in function of the distance between GOME-2 and CALIOP. The bottom plot shows the minimum and maximum aerosol layer height detected by CALIOP and the AAH from GOME-2. The volcanic ash layer is indicated by the boxes.

On 05/06/2011, CALIOP detected volcanic ash between 11-14km, stratospheric elevated smoke between 13.5-14km, dust between 5.5-9.5km and polluted dust between 4-9.5km. GOME-2 AAH was between 4-11km. Again, the GOME-2 AAH agreed better with the height of the dust layer.

3.3 Case 3: Hurricane Ophelia

Hurricane Ophelia was responsible for the transport of Saharan dust and smoke from Portuguese wildfires to parts of Europe (e.g. Belgium) over the period from 15 to 17/10/2017.

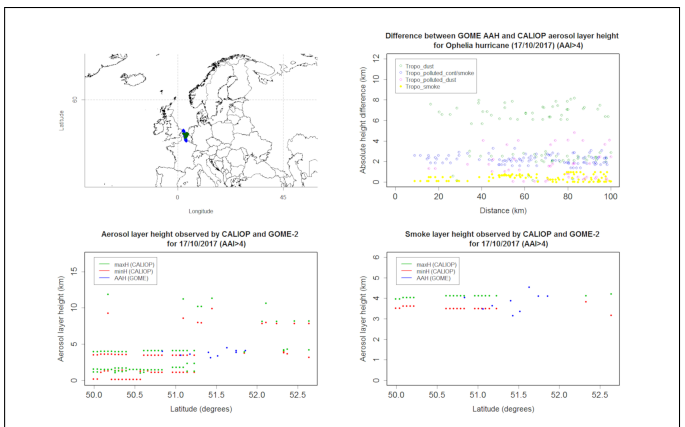

Figure 3. The figure shows the location of the GOME-2 (in green) and CALIOP (in blue) overpasses for 17/10/2017 (top left). The top right plot shows the differences between the aerosol layer height observed by CALIOP and the corresponding AAH observed by GOME-2 for different aerosol types as observed by CALIOP in function of the distance between GOME-2 and CALIOP. The bottom left plot shows the minimum and maximum aerosol layer height detected by CALIOP and the AAH from GOME-2. The smoke layer height is shown in the bottom right plot.

CALIOP observed several aerosol species: dust and polluted dust, polluted continental aerosols and smoke. From fig. 3, it becomes clear that GOME-2 observed the smoke layer and the AAH agreed quite well with the height detected by CALIOP.

3.4 Case 4: West African dust storm

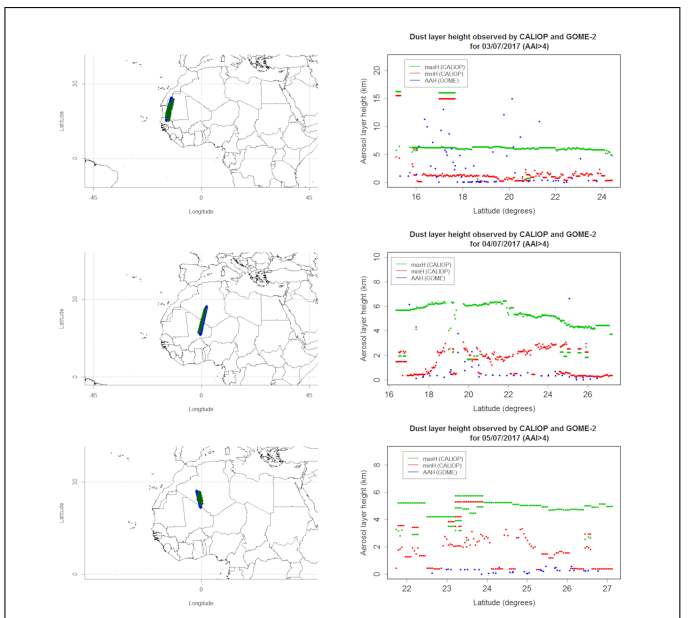

Figure 4. The figure shows the location of the GOME-2 (in green) and CALIOP (in blue) overpasses for 03/07/2017 (top left), 04/07/2017 (middle left) and 05/07/2017 (bottom left). The plots on the right show the height of the dust layer on these days.

A dust storm was present over Western Africa from 3 to 5/07/2017. The dust layers are shown in Fig. 4. Apart from the dust layers, other aerosols were also present. On all days, CALIOP also observed polluted continental aerosols, clean continental aerosols, polluted dust and smoke. Overall, the AAH seemed to follow the minimum CALIOP height of the dust layer, with the exception of a few points.

4 Conclusions/Outlook

The amount of data is often highly limited when only using AAH calculated under conditions with AAI>4.

Finding perfect collocations both in space and time between GOME-2 and CALIOP overpasses is challenging.

For the volcanic case studies, the AAH clearly underestimated the height of the volcanic aerosol layers detected by CALIOP. The fact that GOME-2 AAH is limited at 15km plays a role here.

Also, sometimes GOME-2 seemed to detect other types of aerosols (e.g. dust) instead.

Dispersion modelling will be used in the future to study the bin size of the aerosol layer and to determine the representative scene.

5 References and acknowledgements

- Tilstra et al. (2010), GOME-2 Absorbing Aerosol Index: statistical analysis, comparison to GOME-1 and impact of instrument degradation, in Proceedings of the 2010 EUMETSAT Meteorological Satellite Conference, EUMETSAT P.57, ISBN 978-92-9110-089-7, Cordoba, Spain.

- Information on the studied volcanos was found at: https://volcano.si.edu/
- The CALIOP data were obtained from the NASA Langley Research Center Atmospheric Science Data Center.

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