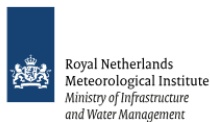




# S5P Mission Performance Centre UV Aerosol Index [L2\_\_AER\_LH] Readme



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<sup>1</sup> The S5PVT AO project summaries can be found at <https://earth.esa.int/web/guest/pi-community/search-results-and-projects/mission>

## CHANGE LOG

Reason for change	Issue	Revision	Date
Cloud mask is based on VIIRS ECM product (instead for VICMO) since OFFL orbit 12432 (see section 4.2)	1	2	11/03/2020

# 1 Summary

This is the Product Readme file (PRF) for the Copernicus Sentinel 5 Precursor Tropospheric Monitoring Instrument (S5P/TROPOMI) Aerosol Layer Height (L2\_\_AER\_LH) Level 2 product and is applicable for both the Near Real-Time (NRTI) and Offline (OFFL) timeliness data products.

A change in the Copernicus Sentinel 5P operations scenario increasing the spatial resolution from 7.0 km to 5.5 km along track for all measurements, became operational starting from 6 August 2019, orbit 9388.

Product Identifier: **L2\_\_AER\_LH**

Example filename:

**S5P\_OFFL\_L2\_\_AER\_LH\_20190404T042423\_20190404T060554\_07630\_01\_010300\_20190410T062552.nc**

**S5P\_NRTI\_L2\_\_AER\_LH\_20190703T122410\_20190703T122910\_08911\_01\_010302\_20190703T130917.nc**

The OFFL data product has the following Digital Object Identifier (DOI): <http://doi.org/10.5270/S5P-i7aj4qr>

The Readme file describes the current processing baseline, product and quality limitations, and product availability status. More information on this data product is available from the Sentinel product webpage:

<https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-5p/products-algorithms>,

and from the TROPOMI product webpage <http://www.tropomi.eu/data-products>.

The data file contains the `aerosol_mid_pressure` and `aerosol_mid_height` which provide the air pressure at the center of the aerosol layer and the height at the center of the aerosol layer relative to the geoid, respectively. The aerosol layer mid pressure is computed for pixels that are relatively cloud-free and have an UVAI greater than 0. As a user guideline, it is recommended to use only those pixels that have an UVAI larger than 1, and contain no sunglint. The flags `sun_glint_warning` and `AAI_warning` are available to filter those ALH pixels that are possibly sunglint contaminated and have a low aerosol load. In general, the data quality is indicated by a `qa_value`. Pixels with a `qa_value` below 0.5 are not recommended for use.

The TROPOMI L2\_\_AER\_LH product is a new product, with little heritage. Aerosol vertical profile products exist from other satellite instruments, e.g. active measurements from Calip on board CALIPSO, and multi-angle measurements from MISR on board Terra.

First preliminary validation efforts by Sentinel-5 Precursor (S5p) Mission Performance Centre (MPC) Cal/Val experts and the S5p Validation Team (S5PVT) show that the ALH is stable and shows good overall agreement with Calip retrievals, with Calip generally retrieving higher ALH than TROPOMI for ocean scenes. The bias can be up to a few hundred meters, but this is still under investigation. Over land, TROPOMI ALH becomes unreliable for increasing surface albedo. The target uncertainty requirements for ALH are defined in the S5p Calibration and Validation Plan [RD01] and summarized in Table 1. The compliance to these requirements is under investigation.

Parameter	Data product	Vertical Resolution	Bias	Random
ALH	Aerosol Layer Height	Total column	<100hPa (1 Km)	<50hPa

Table 1: ALH data product requirements extracted from the S5p Calibration and Validation Plan [RD01]

## 2 Processing baseline description

Table 2 contains the history of the ALH processor versions. Note that the processor version for ALH is changing when there is a change to any of the products belonging to the NL-L2 processor suite (NO2, CO, CH4, AI, ALH, O3 PR) even if the change is not affecting the ALH product.

Processor Version	In operation starting from	In operation until	Relevant Improvements
01.03.02	NRT: orbit 10171, 2019-09-30 OFFL: orbit 8815, 2019-06-26	Current version	No changes with respect to previous version
01.03.01	RPRO: orbit 2818, 2018-04-30 OFFL: orbit 7907, 2019-04-23	Orbit 7424, 2019-03-20 Orbit 8814, 2019-06-26	No changes with respect to previous version
01.03.00	OFFL: orbit 7425, 2019-03-20	Orbit 7906, 2019-04-23	Initial version

Table 2: History of ALH processor versions

## 3 Product Quality

### 3.1 Recommendations for data usage

The ALH is very sensitive to cloud contamination. However, aerosols and clouds can be difficult to distinguish, and ALH is computed for all FRESCO effective cloud fractions smaller than 0.05. Cloud masks are available from FRESCO and VIIRS, and are strongly recommended to filter for residual clouds. A sunglint mask is also available to screen sunglint regions, which are not filtered beforehand. These and other sources of uncertainties are indicated with the `qa_value`. Use of pixels with a `qa_value` below 0.5 is not recommended.

The variables `aerosol_mid_pressure_precision` and `aerosol_mid_height_precision` can also be further used to diagnose the quality of the ALH.

For further details, data users are encouraged to read the Product User Manual (PUM) [RD03] and Algorithm Theoretical Basis Document (ATBD) [RD02] associated with this data product, available on <https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-5p/products-algorithms>.

### 3.2 Validation results

#### 3.2.1 Status of product validation

This section presents a summary of the preliminary validation results obtained by the development team. Since the ALH is a newly developed algorithm, it has not seen as rigorous testing and validation as other products from TROPOMI with a much longer heritage.

#### 3.2.2 First validation with Caliop

A first validation was performed with operational TROPOMI data from 10 Nov. 2018, shown in Figure 1. In the top panel, the ALH for 10 Nov. 2018 is given. It depicts the situation on the west coast of the US, when severe wild fires scoured the surroundings of Paradise, Ca., and large smoke plumes were visible from VIIRS onboard Suomi/NPP, and TROPOMI. In the bottom panel, the CALIOP 532 nm total attenuated backscatter is shown for the track indicated by the yellow line in the top panel. The TROPOMI ALH values are over plotted for all pixels within 20 km of the CALIPSO track (black/white dots). It shows that the TROPOMI ALH is generally close to the maximum CALIOP total attenuated backscatter for low altitude maxima. Also, overlying cirrus clouds (like between 32° and 34° latitude), affect the ALH, increasing the ALH to somewhere the smoke plume and the cirrus clouds. This underlines the need for a very strict clouds screening, and shows the correct sensitivity of the ALH to scatter layers in the atmosphere.

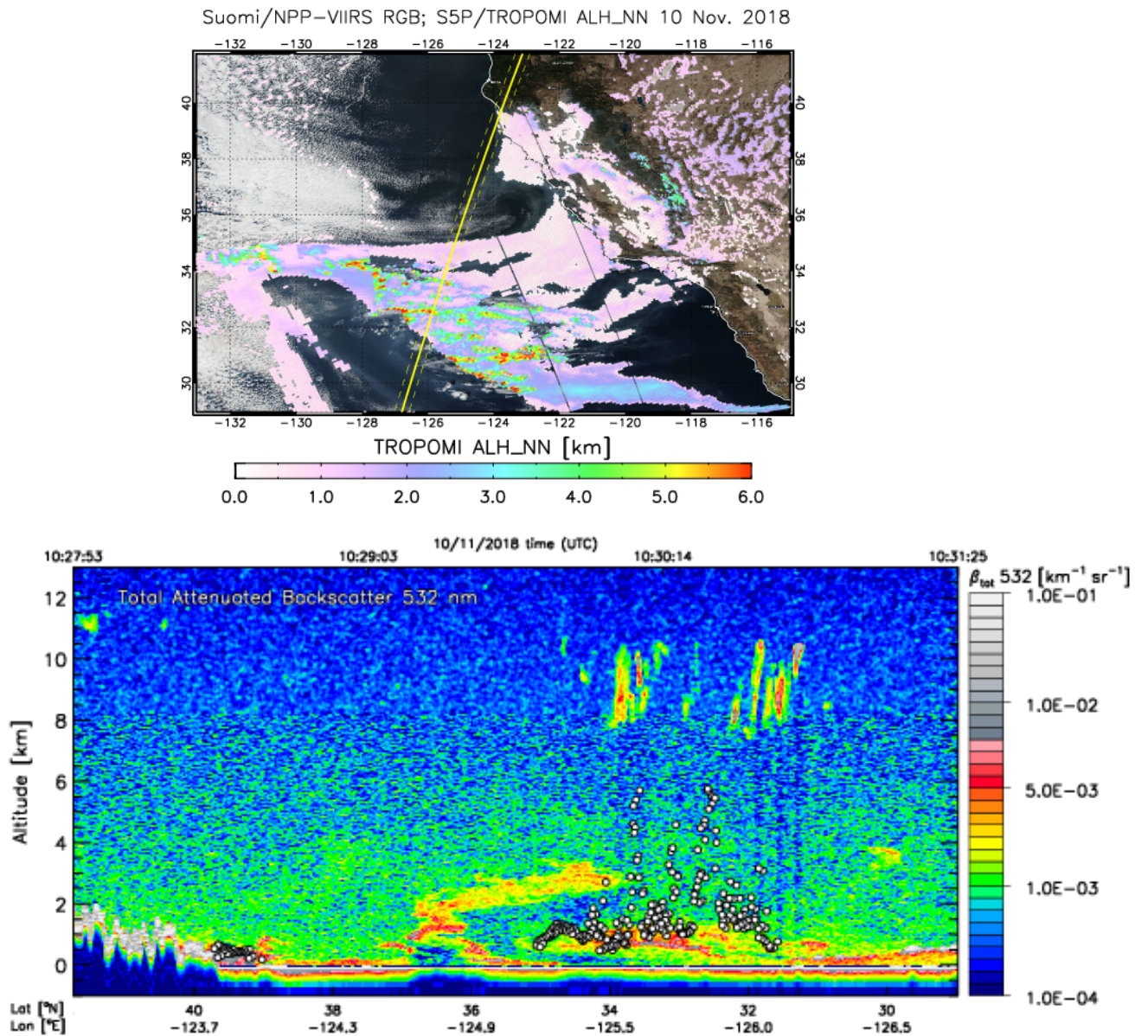


Figure 1: (top) Suomi/NPP VIIRS RGB [D01] on 10 Nov. 2018, overlaid with L2\_AER\_LH. The yellow line depicts the CALIPSO track overpassing that day. The yellow dashed line depicts the 20 km range around the CALIPSO track; (bottom) CALIOP Total attenuated backscatter at 532 nm [D02] on 10 Nov. 2018 for the track shown by the yellow line in the top panel. The TROPOMI L2\_AER\_LH values within 20 km are indicated by black-and-white circles. © Graphics by M. de Graaf (KNMI). Includes modified Copernicus data (2018), processed by KNMI. VIIRS image: © 2013 - 2019 United States Government as represented by the Administrator of the National Aeronautics and Space Administration



## 4 Data Quality Remarks

Currently, the following data quality issues are known and should be kept in mind when looking at the Aerosol Layer Height product and also at preliminary validation results.

### 4.1 Known Data Quality Issues

#### Bias to clouds

As mentioned, the ALH is very sensitive to clouds, and the height will be strongly biased towards the cloud height for partially clouded pixels.

#### High surface albedo

It is known that high surface albedos negatively influence the ALH, biasing the ALH towards the surface. In general, the ALH over (dark) oceans is considered reliable to within the requirement of 1000 m or 100 hPa. Over land, especially bright surfaces, the accuracy may be lower, and the use of the ALH product over bright surfaces like deserts is not advisable.

#### Metadata/Attributes

The spatial resolution of the TROPOMI measurements is improved by bringing the along track ground pixel size from 7.0 to 5.5 Km starting on 6<sup>th</sup> August 2019. Note that, after this operations change, the metadata/Attributes fields related to the spatial resolution, remain **unchanged** (hence not aligned to the improved resolution). These fields are planned to be updated with the activation of Level 2 processors version 02.xx.xx by the second half of 2020.

### 4.2 Data Features

This section describes some characteristics of the data that might seem anomalous, however they are physically correct and not related to any problem.

#### Pixel geolocation around North Pole (feature)

The solar irradiance is measured on a daily basis over the North Pole at a reference azimuth angle to remove seasonal effects on the measurements. To this end, a yaw manoeuvre is executed when the instrument is still in radiance mode, causing possible distortion on the scanlines observed during this manoeuvre (i.e. crossing scanlines, "bow-tie" ground pixel shape instead of rectangular). This occurs at most during the last 26 seconds of radiance measurements in few orbits (7-9 per week). Though this may seem anomalous, it is physically correct, and not related to any problem on the data geolocation.

#### New cloud mask for S-NPP used during OFFL ALH processing

NOAA no longer supports the VIIRS cloud mask (VCM or VICMO) product, which is discontinued (second quarter 2020) in favour of the Enterprise Cloud Mask (ECM). An update to the S5P-NPP L2 processor (to version 01.01.00) has happened (orbit 12432, date 07-03-2020) to ingest the new cloud mask. It should, however, be noted that there are significant differences between the cloud mask fields themselves: E.g. compared to VCM, ECM tends to indicate fewer confidently clear scenes over land, but more over sea. Therefore, values in the cloud/clear counts used to calculate the cloud fraction for the filtering of the OFFL AER\_LH product are now different. Please note that the NRTI AER\_LH does not use this cloud mask and is not affected.

The change in cloud fractions (sign and magnitude) are dependent on the day and location. However, the current thresholds for cloud filtering (which are the same for CH4) do not affect the AER\_LH product, i.e. cloudy scenes are filtered properly. The new cloud mask values available to users are expected to perform better than before and the user is encouraged to use the available cloud masks



to filter for residual clouds. Full assessment of data quality will come after the new processor has been running long enough.

## **5 Algorithm Change Record**

For a detailed description of the L2\_\_AER\_LH algorithm, please refer to the ATBD [RD02].

## **6 Data Format**

The product is stored as NetCDF4 file. The NetCDF4 file contains both the data and the metadata for the product.

For OFFL data the product is stored as a single file per satellite orbit, for NRTI data the product is stored as multiple files per orbit.

Please note that consecutive data granules of the NRTI product show an overlap of about 12 scan lines.

Details of the data format are provided in the Product User Manual (PUM) [RD03].

### **6.1 Data format changes**

This document describes the first public release of the data product, therefore there are no changes to report.

## 7 Product Availability

All S5P/TROPOMI data are available on the Copernicus Open Data Hub <https://scihub.copernicus.eu>.

More information on this data product and data handling tools are available from the product web page under heading 'Tools': <http://www.tropomi.eu/data-products>.

For further questions regarding S5P/TROPOMI data products please contact [EOSupport@Copernicus.esa.int](mailto:EOSupport@Copernicus.esa.int).

The access and use of any Copernicus Sentinel data available through the Copernicus Sentinel Data Hub is governed by the Legal Notice on the use of Copernicus Sentinel Data and Service Information and is given here:

[https://sentinels.copernicus.eu/documents/247904/690755/Sentinel\\_Data\\_Legal\\_Notice](https://sentinels.copernicus.eu/documents/247904/690755/Sentinel_Data_Legal_Notice).

## 8 References

- [RD01] Sentinel-5 Precursor Calibration and Validation Plan for the Operational Phase  
**source:** ESA; **ref:** ESA-EOPG-CSCOP-PL-0073;  
**url:** <https://sentinel.esa.int/documents/247904/2474724/Sentinel-5P-Calibration-and-Validation-Plan.pdf>
- [RD02] Sentinel-5 precursor/TROPOMI Level 2 Algorithm Theoretical Basis Document of the Aerosol Layer Height  
**source:** KNMI; **ref:** S5P-KNMI-L2-0006-RP;  
**url:** <http://www.tropomi.eu/sites/default/files/files/publicSentinel-5P-TROPOMI-ATBD-Aerosol-Height>
- [RD03] Sentinel-5 precursor/TROPOMI Level 2 Product User Manual O3 Total Column  
**source:** KNMI; **ref:** S5P-KNMI-L2-0026-MA;  
**url:** <https://sentinels.copernicus.eu/documents/247904/2474726/Sentinel-5P-Level-2-Product-User-Manual-Aerosol-Index-product>
- [D01] VIIRS Calibration Support Team (VCST). (2017). VIIRS/NPP Day/Night Band 6-Min L1B Swath SDR- 750m NRT [Data set]. NASA LANCE MODIS at the MODAPS. [https://doi.org/10.5067/viirs/vnp02dnb\\_nrt.001](https://doi.org/10.5067/viirs/vnp02dnb_nrt.001)
- [D02] Winker, D. (2016). CALIPSO LID L1 ValStage1 HDF File - Version 3.40 [Data set]. NASA Langley Atmospheric Science Data Center DAAC. [https://doi.org/10.5067/caliop/calipso/cal\\_lid\\_l1-valstage1-v3-40](https://doi.org/10.5067/caliop/calipso/cal_lid_l1-valstage1-v3-40)

More information on this data product is available from the Sentinel product webpage:

<https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-5p/products-algorithms>,

and from the corresponding TROPOMI product webpage <http://www.tropomi.eu/data-products>.

## Abbreviations and acronyms

ALH	Aerosol Layer Height
ATBD	Algorithm Theoretical Basis Document
BIRA-IASB	Royal Belgian Institute for Space Aeronomy
DLR	German Aerospace Center / Deutsches Zentrum für Luft- und Raumfahrt
DOI	Digital Object Identifier
ECM	Enterprise Cloud Mask
ESA	European Space Agency
ESL	Expert Support Laboratory
KNMI	Royal Netherlands Meteorological Institute / Koninlijk Nederlands Meteorologisch Instituut
LER	Lambertian-Equivalent Reflectivity
MPC	Mission Performance Centre
NASA	National Aeronautics and Space Administration
NRTI	Near Real Time (timeliness of products)
OFFL	Offline (timeliness of products)
OMI	Ozone Monitoring Instrument
OMPS	Ozone Mapper and Profiling Suite
PRF	Product Readme File
PUM	Product User Manual
QWG	Quality Working Group
S5P	Sentinel-5 Precursor
S5PVT	Sentinel-5 Precursor Validation Team
TCCON	Total Carbon Column Observing Network
TROPOMI	Tropospheric Monitoring Instrument
UVAI	UV Aerosol Index
VCM	VIIRS Cloud Mask
VDAF	Validation Data Analysis Facility