S5P Mission Performance Centre
UV Aerosol Index [L2__AER_AI] Readme

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

1 Summary

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

Product Identifier: **L2__AER_AI**

Example filename:

S5P_NRTI_L2__AER_AI_20180708T234321_20180708T234821_03812_01_010002_20180709T012327.nc

S5P_OFFL_L2__AER_AI_20180803T040210_20180803T054340_04168_01_010100_20180809T032826.nc

The OFFL data product has the following Digital Object Identifier (DOI): **http://doi.org/10.5270/S5P-0wafvaf**

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_index_340_380` and `aerosol_index_354_388` which gives the UVAI calculated for two different wavelength pairs. As a user guideline for the data quality a qa_value is given. In order to avoid the effects of sun glint it is recommended to only use those pixels with a `qa_value` above 0.8.

Independent validation by MPC Cal/Val experts and the Sentinel-5 Precursor Validation Team (S5PVT) concludes that the NRTI and OFFL UVAI are in good overall agreement with similar satellite data products from OMI and OMPS. A bias of just under 1 UVAI index point was found as compared to OMI and OMPS that is within the ESA mission requirements (see Table 1). However, due to ongoing wavelength dependent degradation in the diffuser affecting Band 3, the bias is slightly larger than 1 UVAI index point (See Section 4). The compliance to these requirements will be reassessed once the Level1b data is updated later this year. The standard deviation of the TROPOMI UVAI is similar as for the OMPS LER product. Thus it is concluded that the TROPOMI product is within the limit for the random requirement of 0.1 UVAI units.

The data product requirements are listed in the S5P Calibration and Validation Plan [RD01]

Parameter	Data product	Vertical Resolution	Bias	Random
Aerosol	Aerosol type	Total column	~1 AAI	<0.1 AAI

Table 1: Mission data requirements for the UVAI product, extracted from [RD01]

2 Processing baseline description

Table 2 contains the history of the UVAI processor versions.

Processor Version	In operation starting from	In operation until
01.00.02	NRTI: orbit 3745, 2018-07-04	Initial version
01.00.02	OFFL: orbit 3661, 2018-06-28	Initial version
01.01.00	NRTI: orbit 3947, 2018-07-18	Orbit 5333, 2018-10-24
01.01.00	OFFL: orbit 3848, 2018-07-11	Orbit 5235, 2018-10-17
01.02.00	NRTI: orbit 5336, 2018-10-24	Orbit 5929, 2018-12-05
01.02.00	OFFL: Orbit 5236, 2018-10-17	Orbit 5832, 2018-11-28
01.02.02	NRTI: orbit 5932, 2018-12-05	Current version
01.02.02	OFFL: orbit 5833, 2018-11-28	Current version

Table 2: History of UVAI processor versions

3 Product Quality

3.1 Recommendations for data usage

In order to avoid misinterpretation of the data quality and to avoid the effects of sun glint, it is recommended to only use those TROPOMI pixels associated with a qa_value above 0.8.

The variables `aerosol_index_340_380_precision` and `aerosol_index_354_388_precision` can also be used to diagnose the quality of the UVAI. These are new data product fields and are under evaluation.

For further details, data users are encouraged to read the Product User Manual (PUM) and Algorithm Theoretical Basis Document (ATBD) 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 key validation results obtained as a part of the S5P Mission Performance Centre (MPC) and by the S5P Validation Team (S5PVT). It contains preliminary results reported at the S5P First Public Release Validation Workshop (ESA/ESRIN, June 25-26, 2018). Individual contributions to the workshop are available in https://nikal.eventsair.com/QuickEventWebsitePortal/sentinel-5p-first-product-release-workshop/sentinel-5p.

Conclusions presented here are based on a series of comparisons with other satellite-based aerosol index data from OMI and OMPS. Focus was placed on several case studies for different known aerosol sources. The conclusions summarized hereafter need to be confirmed by a larger amount of co-locations, and extended over a full year of data, hence, a full cycle of key influence quantities, in order to enable detection and quantification of potential patterns, dependences, seasonal cycles and longer term features.

3.2.2 Validation approach

S5P/TROPOMI L2__AER_AI UVAI data are verified via comparison to the aerosol indices obtained from other satellite instruments including OMI and OMPS. Both OMI and OMPS have similar afternoon overpass times as compared to TROPOMI and with OMI the same wavelength pair (354/388 nm) can be compared. A series of case studies (Table 3) was selected to cover the types of aerosol plumes we expect to detect with TROPOMI UV Aerosol Index (UVAI) including biomass burning smoke, desert dust, and volcanic aerosol sources.

Date	Type of case	TROPOMI orbit	OMI orbit	OMPS
2017-11-10	Desert dust and small Sub-Saharan fire plumes	00398	70864	31285
2017-11-27	Volcanic eruption, Bali	00636	71108	31523
2017-12-13	Large biomass burning fires, California	00858	71350	31745
2018-03-31	Long-range transport of large desert dust plumes	2397, 2398	72916, 72917	33284, 33285

Table 3: Case studies for analysis of aerosol types

3.2.3 Validation results

Overall, the quality of the initial L2__AER_AI data product appears to comply with the primary mission requirement of UVAI bias within ~1 UVAI.

An independent team at NASA-Goddard carried out satellite-based intercomparisons with TROPOMI and OMPS data and together with the MPC analyses, the following conclusions can be drawn:

- **Bias:** the systematic difference between S5P/TROPOMI and other instruments measuring aerosol index is just within 1 AAI, where TROPOMI values are lower than both OMI and OMPS. Comparison from the case studies listed in Table 3 resulted in a mean bias of -0.8990 with OMPS (TROPOMI UVAI 354/388 – OMPS LER AI 340/378.5).
- **Random error:** The standard deviation of the TROPOMI UVAI is similar as for the OMPS LER product (see Figure 1). Thus it is concluded that the TROPOMI product is within the limit for the random requirement of 0.1 UVAI units. Note that the standard deviation of the OMPS Mie product is systematically smaller due to the more realistic assumptions about clouds and surface reflectance.
- **Dependence on influence quantities:** There is a slight cross-track dependence of -0.25 (West – East side of TROPOMI swath), which is related to the use of the LER model. It should be noted that this cross-track dependence decreases with increasing UVAI values.
- **Geographical patterns:** In general, spatial agreement for aerosol plume shape is very good (see example on Figure 1) however, larger differences are observed for clouded pixels owing to differences in the LER approach of OMI and TROPOMI as compared to OMPS. Large negative values are found over clouds as the TROPOMI UVAI employs the traditional LER approach.

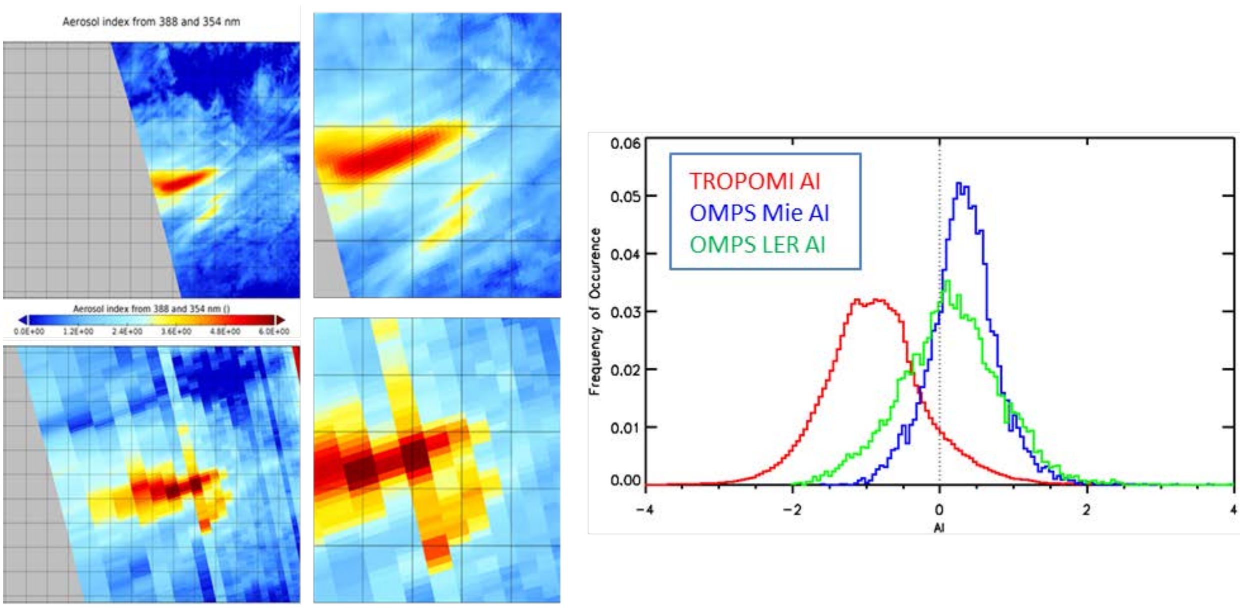

Figure 1: Comparison of TROPOMI UVAI (orbit 00398, all top panels) and OMI OMAERO Aerosol Index UV (orbit 70864, all bottom panels) for Saharan dust (4 panels on left). All plots are for 10 November 2017. Gridlines are 1 x 1 deg. Right panel shows the comparison with OMPS for the same case study.

4 Known Data Quality Issues

Currently, the following data quality issues are known, not covered by the quality flags, and should be kept in mind when looking at the UV Aerosol Index products and also at preliminary validation results.

Bias as compared to other satellite datasets

The reasons for the large negative bias as compared to other satellite-derived aerosol index datasets, need to be further investigated. Small contributors to this bias include difference in the aerosol index due to wavelength pair choice and the difference in how clouds are treated with the LER approach used by TROPOMI. A first step will be to calculate the bias for UVAI values stratified into classes of “high aerosol loading”, “complete or nearly clouded”, and “clear sky”. Part of the systematic bias is probably related to small deviations of the Level 1B input data, see next point.

Wavelength dependent degradation affecting Band 3

It is known that there is wavelength dependent degradation in the diffuser affecting Band 3, where degradation is stronger at shorter wavelengths. This dependence affects the UVAI values by leading to an apparent increase of the reflectance at the shortest wavelength and therefore a decrease of the index. The investigation of this effect is ongoing.

Large negative values for clouds

The large negative values for clouds observed in TROPOMI UVAI data need to be further investigated.

Metadata values exchanged

The global attributes `geospatial_lon_min` and `geospatial_lon_max` values are exchanged; therefore, the user is advised to switch the values for these fields, making note that the `geospatial_lat_min` and `geospatial_lat_max` values are correct. This is an issue traceable to L1b data (version 01.00.00) and is corrected in the following versions of the Level 1B processor.

NRTI data gaps northern hemisphere (solved)

The NRTI data stream shows data gaps over Kazakhstan, southern part of Russia and Canada due to a miss-configuration of the processing facility This issue is solved with the activation of processor version **01.01.00** mid-July 2018 (see section 2).

Orbit numbering in NRTI and OFFL (solved)

Note that NRTI orbit numbers are set with respect to the downlink orbit while OFFL orbit numbers are set with respect to the equator crossing time. This creates an inconsistency between the NRTI and OFFL orbit numbers, which is removed with the activation of processor version **01.02.02** (December 2018.)

5 Algorithm Change Record

For a detailed description of the L2__AER_AI 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.

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.

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 Theroretical Basis Document UV Aerosol Index
source: KNMI; **ref**: S5P-KNMI-L2-0008-RP;
url: https://sentinels.copernicus.eu/documents/247904/2476257/Sentinel-5P-TROPOMI-ATBD-UV-Aerosol-Index

[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

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

(A)AI	(Absorbing) Aerosol Index
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
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
TROPOMI	Tropospheric Monitoring Instrument
UVAI	UV Aerosol Index
VDAF	Validation Data Analysis Facility