

GOES-16 ABI L2+ Aerosol Optical Depth (AOD) and Aerosol Particle Size (APS)  
Full Data Quality  
May 28, 2024  
Read-Me for Data Users

GOES-R Advanced Baseline Imager (ABI) L2+ products will achieve Full Validation maturity by default after two years of Provisional and Operational use with no major anomalies reported (minor product improvements may still be occurring). As a result, GOES-16 Aerosol Optical Depth (AOD) is considered Full Validation maturity as of September 14, 2020.

The ABI L2+ AOD product includes the aerosol optical depth at 550 nm over land and over water. The AOD is a measure of the columnar extinction (scattering + absorption) of radiation by aerosols. It is proportional to the amount (number or mass concentration) of aerosols in an atmospheric column. Starting September 3<sup>rd</sup>, 2020, the AOD product file also includes the Aerosol Particle Size (APS) over water. APS is reported as the Ångström Exponent (AE). It is derived only over water from the aerosol optical depth retrieved in two pairs of the ABI spectral bands, resulting in two values, AE1 and AE2, corresponding to the pairs of ABI bands in the visible and near-infrared spectrum (AE1: 0.47, 0.86  $\mu\text{m}$  and AE2: 0.86, 1.61  $\mu\text{m}$ ). Thus, AE describes the wavelength dependence of aerosol optical depth; it does not provide a value of particle size in units of length, instead it is only a proxy for it. Large/small values of the Ångström Exponent indicate small/large particles, respectively.

The Baseline algorithm used to produce the AOD/APS products was updated to the Enterprise Processing System (EPS) Algorithm, which went into operation at 18:00 UTC for Full Disk and 18:01 UTC for CONUS on February 6, 2024.

- *Measurement range:* AOD: -0.05 to +5.00, APS: -1.0 to +3.0
- *Temporal coverage:* AOD and APS products are produced only during daytime with view and solar zenith angles less than 90 degrees.
- *Refresh:* Temporal resolution of the product depends on the mode ABI operates in. In Mode 6 data over the Full Disk (FD) of the Earth is available every 10 minutes and over the Continental United States (CONUS) region every five minutes. In Mode 4, FD observations are taken every five minutes, from which the CONUS domain is extracted.
- *Spatial resolution:* The AOD and APS products are provided on a 2-km fixed grid.
- *Spatial coverage:* Full Disk (FD) and Continental United States (CONUS). The AOD and APS products are not generated for the Mesoscale domain.

Retrieval of AOD, and thus APS, is performed only for clear-sky (cloud-free) pixels.

The Baseline Algorithm restricts retrievals to dark surfaces and so AOD data is not retrieved for most non-vegetated, sparsely vegetated, desert land surfaces, snow- or ice-covered surfaces, and for water surface in the sun-glint region. The EPS algorithm extends the AOD retrievals over land to bright snow-free surface.

Low sun (solar zenith angle larger than  $80^\circ$  for baseline or  $78.5^\circ$  for EPS) and/or low satellite (satellite zenith angle larger than  $60^\circ$  for baseline or  $78.5^\circ$  for EPS) elevation reduces the spatial coverage in medium- and high-quality AOD data.

- *Quality*: Based on the results of internal tests, which are designed to measure the level of compliance of pixels with algorithm assumptions, four quality levels (no retrieval, low, medium and high) are assigned to the AOD and APS retrievals. An evaluation of the AOD product with ground-based sunphotometer measurements for 01/01/2021 – 12/31/2023 indicates that biases are smaller than 0.06, 0.04 and 0.12 respectively for  $AOD < 0.04$ ,  $0.04 \leq AOD \leq 0.8$  and  $AOD > 0.8$  over land, and smaller than 0.02 for  $AOD < 0.4$  and 0.1 for  $AOD \geq 0.4$  over water. For the above stated ranges of AODs, the standard deviations of biases are less than 0.13, 0.25 and 0.35 over land, and less than 0.15 and 0.23 over water. Relative to the reference AERONET data, the mean GOES-16 AE1 value for the period 01/01/2021 – 12/31/2023 is smaller than 0.3, suggesting aerosol particles larger than those indicated by AERONET. Agreement between GOES-18 and AERONET AE2 values is better; the difference is about 0.1 on average, GOES-16 AE2 being smaller. The standard deviation of AE1 and AE2 biases (precision) is about 0.5.

In general, the high-quality retrievals are recommended for quantitative applications due to their better overall performance; however, the lower quality retrievals also have their merit for qualitative examination of local episodic events due to their greater spatial coverage. The performance is expected to be further improved by updating the spectral land surface relationships and internal test thresholds used in the retrieval algorithm.

The AOD product quality is sensitive to upstream processing, such as the quality of calibration, navigation, cloud mask, snow mask and total precipitable water.

A full description and format of the AOD product is in the Product Definition and User's Guide (PUG) Volume 5: Level 2+ Products, located on OSPO's GOES-R documents webpage:

<https://www.ospo.noaa.gov/Organization/Documents/goes-r.html>. The algorithm used to derive AOD from ABI observations is described in the "EPS Aerosol Optical Depth (AOD) Algorithm Theoretical Basis Document", located on STAR's GOES-R ATBD webpage:

[https://www.star.nesdis.noaa.gov/goesr/documentation\\_ATBDs.php](https://www.star.nesdis.noaa.gov/goesr/documentation_ATBDs.php).

Full maturity, by definition, means that:

- Validation, quality assurance, and anomaly resolution activities are ongoing.
- Incremental product improvements may still be occurring.
- Users are engaged and user feedback is assessed.
- Product performance for all products is defined and documented over a wide range of representative conditions via ongoing ground-truth and validation efforts.
- Products are operationally optimized, as necessary, considering mission parameters of cost, schedule, and technical competence as compared to user expectations.
- All known product anomalies are documented and shared with the user community.
- Product is operational.

Users bear all responsibility for inspecting the data prior to use and for the manner in which the data are utilized. Persons desiring to use the GOES-16 ABI AOD product for any reason, including but not limited to scientific and technical investigations, are encouraged to consult the NOAA algorithm working group (AWG) scientists for feasibility of the planned applications.

Status of the AOD product and any remaining known issues that are being resolved:

1. Blocks of missing values occur sometimes and randomly in Mode 3, and in even larger numbers in Mode 4.
2. The variable "algorithm\_dynamic\_input\_data\_container", meant to list names of dynamic input data files required to run the AOD algorithm, may be set as 'null' for some inputs.
3. In the products generated before Feb 6, 2024, some of the zonal average values stored in variables "lat\_band\_..." are assigned to the wrong latitude bands. This has been corrected in the Enterprise products starting February 6, 2024.
4. Inconsistent units (percent) and valid range (0, 1) in metadata variables "lat\_band\_aod550\_percent...". (Long name indicates values are in percent but actually they are fractions.) This has been corrected in the Enterprise AOD product since February 6, 2024.
5. The long name of variable "aod\_outlier\_pixel\_count" is set as "number of aerosol optical depth at 550 nm pixels over land whose value is outside valid measurement range"; it should read "number of aerosol optical depth at 550 nm pixels over land **and ocean** whose value is outside valid measurement range".

Known PUG v2.4 issues:

1. The PUG defines the valid AOD range as [-1, 5] in Table 5.10.1-1. The valid range should be [-0.05, 5]. This is the value that appears in the product files starting April 5, 2018 at 15:15 UTC for Full Disk and 15:07 UTC for CONUS.
2. The PUG lists the meta data in Table 5.10.6-2 as they are in the Baseline AOD product. Some have been changed in the Enterprise AOD product, including "Sunlint\_angle" (value change from 40 to 36), "Sunlint\_angle\_bounds", "quantitative\_local\_zenith\_angle" (value change from 60 to 78.5), "quantitative\_local\_zenith\_angle\_bounds", "quantitative\_solar\_zenith\_angle" (value change from 80 to 78.5), and "quantitative\_solar\_zenith\_angle\_bounds".
3. The PUG lists all input files in "algorithm\_dynamic\_input\_data\_container" as "null" as they are in Baseline AOD product. Some dynamic input files have been updated in the Enterprise AOD product including "input\_ABI\_L2\_4\_level\_cloud\_mask\_data", "input\_ABI\_L2\_auxiliary\_solar\_azimuth\_angle\_data", "input\_ABI\_L2\_auxiliary\_solar\_zenith\_angle\_data", "input\_ABI\_L2\_auxiliary\_sunlint\_angle\_data", "input\_ABI\_L2\_brightness\_temperature\_band\_15\_2km\_data", "input\_ABI\_L2\_brightness\_temperature\_band\_14\_2km\_data", "input\_ABI\_L2\_cloud\_mask\_data\_quality\_flag\_data", "input\_ABI\_L2\_intermediate\_product\_cloud\_mask\_data\_information\_flag\_data", "input\_ABI\_L2\_intermediate\_product\_cloud\_top\_cloud\_shadow\_flag\_data",

“input\_ABI\_L2\_intermediate\_product\_reflectance\_band\_1\_two\_km\_data”,  
“input\_ABI\_L2\_intermediate\_product\_reflectance\_band\_2\_two\_km\_data”,  
“input\_ABI\_L2\_intermediate\_product\_reflectance\_band\_3\_two\_km\_data”,  
“input\_ABI\_L2\_intermediate\_product\_reflectance\_band\_4\_two\_km\_data”,  
“input\_ABI\_L2\_intermediate\_product\_reflectance\_band\_5\_two\_km\_data”, and  
“input\_ABI\_L2\_intermediate\_product\_reflectance\_band\_6\_two\_km\_data”.

Contact for further information: OSPO User Services at [SPSD.UserServices@noaa.gov](mailto:SPSD.UserServices@noaa.gov)

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