

GOES-16 ABI L2+ Aerosol Optical Depth (AOD) Release
Provisional Data Quality
February 18, 2021 Update
Read-Me for Data Users

The GOES-R Peer Stakeholder - Product Validation Review (PS-PVR) for GOES-16 Advanced Baseline Imager (ABI) L2+ Aerosol Optical Depth (AOD) Provisional Maturity was held on September 14, 2018. As a result of this review, the PS-PVR panel recommended that the ABI AOD product be declared Provisional maturity.

The ABI L2+ AOD product includes the aerosol optical depth at 550 nm over land and over water, associated quality flags, mean, maximum, minimum and standard deviation of 550-nm AOD for the entire domain and in 10-degree latitude bands. 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 4, 2020 the Aerosol Particle Size Parameter (APSP) over water was added to the product file. APSP is reported as the Ångström exponent at two wavelength pairs (0.47, 0.86 μm and 0.86, 1.61 μm) along with the associated quality flags. The Ångström exponent describes the wavelength dependence of AOD. Large/small values of the Ångström exponent indicate small/large particles, respectively.

- *AOD Measurement range:* -0.05 to +5.00.
- *Ångström exponent Measurement range:* -1.0 to +3.0.
- *Spatial resolution:* The AOD product is provided on a 2-km fixed grid.
- *Spatial coverage:* Full Disk (FD) and Continental United States (CONUS). The AOD product is not generated for the Mesoscale domain.

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

Because the current algorithm restricts retrievals to dark surfaces only AOD data is not retrieved for desert, most non-vegetated, sparsely vegetated land surfaces, snow- or ice-covered surfaces, and for water surface in the sun-glint region.

Low sun (solar zenith angle larger than 80°) and/or low satellite (satellite zenith angle larger than 60°) elevation reduces the spatial coverage in medium- and high-quality AOD data.

- *Temporal coverage:* The AOD product is 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. Data over the Full Disk (FD) of the Earth is available every 15 minutes and over the Continental United States (CONUS) region every 5 minutes in operational mode 3. In mode 4, FD observations are taken every 5 minutes, from which the CONUS domain is extracted. On April 2, 2019 the satellite was switched to operate in mode 6 and started taking FD observations every 10 minutes.

- *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 Ångström exponent retrievals. A limited evaluation of the AOD product with ground-based sunphotometer measurements 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, about 0.02 for $AOD < 0.4$ and somewhat larger than 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.

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.

Full description and format of the AOD product is in the Product Definition and User's Guide (PUG) document (<http://www.goes-r.gov/products/docs/PUG-L2+-vol5.pdf>). The algorithm used to derive AOD from ABI observations is described in the "GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document for Suspended Matter/Aerosol Optical and Aerosol Size Parameter" (http://www.goes-r.gov/products/ATBDs/baseline/AAA_AODASP_v2.0_no_color.pdf). Data starting July 25, 2018 meet the Provisional maturity defined below.

Provisional maturity, by definition, means that:

- Validation activities are ongoing and the general research community is now encouraged to participate;
- Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing;
- Incremental product improvements may still be occurring;
- Product performance has been demonstrated through analysis of a small number of independent measurements obtained from select locations, periods, and associated ground truth or field campaign efforts;
- Product analysis is sufficient to establish product performance relative to expectations (Performance Baseline);
- Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community;
- Testing has been fully documented; and
- Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.

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.

Updates since declaration of Provisional Maturity:

Two major updates have been implemented since the GOES-16 ABI AOD product reached Provisional Maturity:

- The Aerosol Particle Size Parameter (APSP) over water has been added to the product file starting September 4, 2020.
- The land spectral surface relationship was updated on October 24, 2020. This is expected to improve the overall performance of AOD retrievals over land and to better capture the true diurnal variation of AOD.

Known product issues:

1. Blocks of missing values occur sometimes and randomly. This decreases spatial coverage.
2. Latitude band percentage metadata are incorrect.
3. Flag to indicate source of total precipitable water (TPW) may be set incorrectly, or occasionally TPW may have incorrect values. Work to fix the issue is underway.
4. The variable "algorithm_dynamic_input_data_container", meant to list names of dynamic input data files required to run the AOD algorithm, is currently not set (null).
5. 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.)
6. 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".
7. The AOD and its valid range and filled value are stored as packed 16-bit unsigned integers in the product files. This may be important when reading data that was generated prior to September 4, 2020 as some software may interpret the data as signed integers. For example, the packed values of AOD valid range [-0.05, 5] may be shown as [0, -6]. To read the correct values users are required to manually convert the AOD and its valid range and fill value attributes to unsigned integers before unscaling. This was fixed on September 4, 2020, and the software should read the AOD and the attributes as unsigned integer correctly. Note that the '_unsigned' attribute has been removed during this fix.

Known PUG issues:

1. The PUG defines the valid AOD range as [-1, 5]. The valid range now 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 values of the data quality flag (DQF) as 0 and 1. Starting April 5, 2018 at 15:15 UTC for Full Disk and 15:07 UTC for CONUS DQF values are 0, 1, 2, and 3.
3. Table 5.10.4 of the PUG lists the spectral AOD and surface reflectance in specific ABI bands, which are recorded in variables "latitude band AOD at specific ABI sensor band ...", "latitude band surface reflectivity at specific ABI sensor band ..." and "AOD at specific ABI sensor band ...", as variables included in the product file. However, starting April 5, 2018 at 15:15 UTC for Full Disk and 15:07 UTC for CONUS these variables are no longer part of the product file.

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