

GOES-19 ABI L2+ Aerosol Optical Depth (AOD) and Aerosol Particle Size (APS) Release
Provisional Data Quality
March 12, 2025
Read-Me for Data Users

The GOES-R Peer/Stakeholder Product Validation Review (PS-PVR) for GOES-19 Advanced Baseline Imager (ABI) L2+ Aerosol Optical Depth (AOD) and Aerosol Particle Size (APS) Provisional Maturity was held on March 12, 2025. As a result of this review, the panel chair declared that these products meet the criteria for Provisional maturity.

The ABI L2+ AOD product file includes the total column aerosol optical depth (AOD) 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. 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 μm and AE2: 0.86, 1.61 μm). 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.

- *AOD Measurement range:* -0.05 to +5.00.
- *Ångström exponent Measurement range:* -1.0 to +3.0.
- *Spatial coverage:* Full Disk (FD) and Continental United States (CONUS).
- *Spatial resolution:* The AOD and APS products are provided on a 2-km fixed grid.
- *Retrieval conditions:* Retrieval of AOD, and thus APS, is performed only for clear-sky (cloud-free) pixels. AOD is not retrieved for snow- or ice-covered surfaces, and for water surface in the sun-glint region. Low sun and/or low satellite elevation, measured as air mass larger than 6, reduces the spatial coverage in medium- and high-quality AOD data.
- *Temporal coverage:* The 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. Data over the Full Disk (FD) of the Earth is available every 10 minutes and over the Continental United States (CONUS) region every 5 minutes in operational mode 6. In mode 4, FD observations are taken every 5 minutes, from which the CONUS domain is extracted.
- *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 AE retrievals. GOES-19 ABI AOD and APS were compared to corresponding GOES-16 and -18, S-NPP, NOAA-21 and MODIS products, which showed reasonable consistency with data from those satellites. A limited evaluation of the AOD product with ground-

based sunphotometer measurements indicates that biases are smaller than 0.06, 0.09, and 0.19 respectively for $AOD < 0.04$, $0.04 \leq AOD \leq 0.8$, and $AOD > 0.8$ over land. These values in the medium ($0.04 \leq AOD \leq 0.8$) and high ($AOD > 0.8$) ranges exceed the requirements that are 0.04 and 0.12. The source of this has been identified; update of the GOES-19 spectral surface reflectance relationship will make the AODs compliant in all three ranges. Over water, the biases are about 0.02 for $AOD < 0.4$ and about -0.06 for $AOD \geq 0.4$. 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-19 AE1 value for the period 10/1/2024-1/10/2025 is larger by about 0.06, suggesting aerosol particles smaller than those indicated by AERONET. The GOES-19 AE2 bias is about -0.08. The standard deviation of AE1 and AE2 biases (precision) is about 0.4 and 0.3, respectively.

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 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) Volume 5 (<https://www.ospo.noaa.gov/resources/documents/goes-r.html>). The algorithm used to derive AOD and APS from ABI observations is described in the "EPS Aerosol Optical Depth (AOD) Algorithm Theoretical Basis Document", available on STAR's GOES-R ATBD webpage: https://www.star.nesdis.noaa.gov/goesr/documentation_ATBDs.php.

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 calibration/validation 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-19 ABI AOD and APS products 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.

Known product issues:

1. When reading AOD product data, note that 'AOD', 'AE1', and 'AE2' and their valid ranges are stored as unsigned integers.
2. The AOD algorithm look-up-tables, gas-correction coefficients, spectral surface-reflectance relationships, and internal tests that have not yet been "tuned" to GOES-19.
3. Blocks of missing values can occur randomly in mode 6 and in even larger numbers in mode 4.
4. 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".
5. The PUG Volume 5 v2.5 defines the valid AOD range as [-1, 5] in Table 5.11.1-1. The valid range should be [-0.05, 5].
6. The PUG Volume 5 v2.5 lists, in Table 5.11.1-2, the precision requirement for Aerosol Particle Size over water, as 0.15. To be consistent with the AOD algorithm and product and the requirement for JPSS/VIRS it should be 0.6.
7. The PUG Volume 5 v2.5 lists $LZA \leq 60$ degrees as one of the Performance Conditions in Tables 5.11.1-1 and 5.11.1-2. The current algorithm uses the criteria airmass, such that the $airmass = (1/\cos(SZA) + 1/\cos(LZA)) \leq 6$.

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