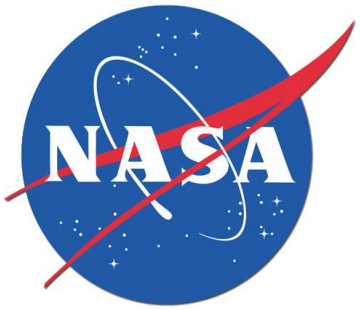

National Aeronautics and Space Administration
Langley Research Center

# SAGE III/ISS Level 2 Aerosol Auxiliary Product

## Readme

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# Contents

# 1 Introduction

The development of this SAGE III/ISS Level 2 aerosol auxiliary data product follows methods used in developing a cloud-free aerosol product for the Global Space-based Stratospheric Aerosol Climatology (GloSSAC), in which SAGE III/ISS data plays a crucial role alongside other space-based measurements (Thomason et al., 2018; Kovilakam et al., 2020). While SAGE III/ISS aerosol data were incorporated into GloSSAC version 2.0 for the post-2017 dataset using a basic extinction ratio-based cloud screening technique (Kovilakam et al., 2020), it was noticed that the simple cloud filtering used in GloSSAC version 2.0 needed a revision as this was removing enhanced aerosols from the data, particularly in the lower stratosphere. Therefore, we developed a revised cloud identification technique that can categorize aerosols and clouds even during and following a perturbed event such as a volcanic eruption/PyroCb event (Kovilakam et al., 2023). In the revised method, we describe the SAGE III Operational Aerosol Type Classification Method (SOATCM), which is based on a method originally developed by Thomason and Vernier (2013) (hereafter TV13). Addressing the challenge of discriminating aerosols and clouds from SAGE-like measurements, particularly during and after perturbing events, is important, as large aerosols can be misclassified as clouds, especially near the tropopause. This concern was previously highlighted by TV13, leading to the application of the TV13 technique exclusively for the background stratosphere. Considering the occurrence of numerous volcanic eruptions and PyroCb events post-2017, it is vital to accurately classify aerosols and clouds in the aftermath of such events. While the detailed description of the SOATCM for aerosol and cloud classification is outlined in Kovilakam et al. (2023), we introduce additional screening techniques employed in developing the Level 2 aerosol auxiliary product, including a re-evaluation of the Level 2 tropopause height.

# 2 Methods

As previously mentioned, a detailed description of the methods used in the aerosol cloud categorization algorithm is available in Kovilakam et al. (2023). In addition to the methods listed in Section 3 of Kovilakam et al. (2023), we have introduced another screening process. The screening relies on the count of negative extinction values and positive extinction values with an error exceeding 50%. If the number of negative and positive extinction values with an error greater than 50% exceeds a third of the total number of extinction data points between the tropopause and 25 km altitude, the respective profile is discarded and labeled as "Transmission Anomaly". Consequently, in the Level 2 aerosol auxiliary data, several profiles might be absent when compared to the Level 2 data. After applying this screening, the algorithm proceeds as described in Kovilakam et al. (2023). It is therefore recommended that interested users read Kovilakam et al. (2023) for a detailed description of the methodology employed.

Additionally, tropopause height is revisited for the Level 2 aerosol auxiliary product. An accurate tropopause height is essential for the SOATCM method, prompting a comparison between tropopause heights determined using the WMO method (e.g., BMO, 1992; Randel et al., 2000) and those reported in the Level 2 data. The higher of the two values is then adopted as the tropopause height for that event. Thus, some instances may show differences in tropopause altitude between the Level 2 aerosol auxiliary and Level 2 data.

# 3 File-Naming Convention

A monthly NetCDF file is generated, encompassing event by event measurements from Level 2, along with aerosol extinction coefficient flags. The Level 2 aerosol auxiliary product uses a simple file naming convention: SAGE3ISS_aer_L2_aux_vxx.x_YYYYMMDD-YYYYMMDD, where vxx.x denotes version number and YYYYMMDD represents the year, month, and day.

# 4 Data Products

Although not all data products from Level 2 are included in Level 2 aerosol auxiliary product, our focus is primarily on providing aerosol-related data in this Level 2 aerosol auxiliary product. Table 1 outlines the variables present in the Level 2 aerosol auxiliary product. For the Level 2 aerosol auxiliary data, we create monthly NetCDF files containing data on a per-profile basis, accompanied by associated flags. Table 1 also presents the flags used in the Level 3 aerosol auxiliary product. Each variable is linked with coordinate names and dimensions. The coordinates include "time", "alt", and "wav"respectively. While the "time"coordinate comprises time of each event in "YYYY-MM-DDTHH:MM:SS" format, "alt"signifies altitude in kilometers, and "wav"represents measurement wavelengths in nanometers ( see Table 2). A detailed description of listed variables is provided below.

## 4.1 Event ID

The Event ID matches that of the Level 2 file. Event ID is a one-dimensional variable (data type "object") in the file, associated with the "time"coordinate.

## 4.2 Input Data Version

The input data product version represents the version of the Level 2 data file. It is a one-dimensional variable (data type "float64") linked to the "time"coordinate.

## 4.3 Latitude

Latitude coincides with the Level 2 file. It is a one-dimensional variable (data type "float64") linked to the "time"coordinate.

## 4.4 Longitude

Longitude mirrors the Level 2 file. It is a one-dimensional variable (data type "float64") linked to the "time"coordinate.

## 4.5 Tropopause Height

The tropopause height is recalculated for Level 2 aerosol auxiliary product, as mentioned in Section 2. Tropopause height is a one-dimensional variable (data type "float64") connected to the "time"coordinate.

## 4.6 Aerosol Extinction Coefficient

Aerosol Extinction Coefficient is identical to the Level 2 data. It is a three-dimensional variable (data type "float64") with "time", "alt", and "wav"coordinates.

## 4.7 Aerosol Extinction Coefficient Uncertainty

The uncertainty in the Aerosol Extinction Coefficient aligns with that of Level 2. It is a three-dimensional variable (data type "float64") with "time", "alt", and "wav"coordinates.

Table 1: Level 2 aerosol auxiliary data products

| Measurement Variable | Longname | Units | Coordinates | Data Type |
|---|---|---|---|---|
| event_id | Event ID | None | (time) | object |
| dp_vers | Input Data Product Version | None | (time) | float64 |
| lat | Latitude | degrees north | (time) | float64 |
| lon | Longitude | degrees east | (time) | float64 |
| trp_hgt | Tropopause Height | km | (time) | float64 |
| ext | Aerosol Extinction Coefficient | $km^{-1}$ | (time, alt, wav) | float64 |
| ext_un | Aerosol Extinction Coefficient Uncertainty | $km^{-1}$ | (time, alt, wav) | float64 |
| flags | Aerosol Extinction Flags | None | (time, alt, wav). | float64 |

Table 2: Level 2 aerosol auxiliary product coordinates

| Coordinate Name | Longname | Units | Data Type |
|---|---|---|---|
| time | time | YYYY-MM-DDTHH:MM:SS | object |
| alt | Altitude | km | float64 |
| wav | Wavelengths | nm | int64 |

### 4.8 Flags

The Level 2 aerosol auxiliary product provides various flags that can be used to categorize aerosol and aerosol-cloud mixtures. The "Flags" variable is a three dimensional variable (data type "float64") associated with "time", "alt" and "wav" coordinates. Table 3 lists the flags associated with Level 2 aerosol auxiliary data and their corresponding meaning. The first flag listed in Table 3 is "Transmission Anomaly" "that occurs in SAGE-like occultation measurements and it is likely that a negative extinction value is reported below a large positive one because of the retrieval assumption of atmospheric homogeneity. Thus, we assign a flag of -1.0 to these values and do not use them for further analyses. Additionally, we introduce the "Unavailable Extinction ratio" flag (Flag = 1). In the context of the Level 2 aerosol auxiliary product, we employ the extinction ratio between 756 and 1544 for classification purposes. This flag signifies an unavailable extinction ratio owing to either missing or negative values in the 756 nm or 1544 nm channels. We classify aerosols as "background (Flag = 2.0)", "perturbed (Flag = 3.0)", and "enhanced (Flag = 4.0)", based on a method described in section 3.3 of Kovilakam et al. (2023). It is important to note that the flag categorization is specifically applied to data ranging from the tropopause to 25 km, as detailed in Kovilakam et al. (2023). Additionally, we classify aerosol/cloud mixture and polar stratospheric clouds. For those who are interested in aerosol only data, we recommend using flags 2.0, 3.0, and 4.0.

Table 3: Flags

| **Flag Name** | **Flag Value** |
|---|---|
| Transmission Anomaly | -1.0 |
| Unavailable Extinction Ratio | 1.0 |
| Background Aerosol | 2.0 |
| Perturbed Aerosol | 3.0 |
| Enhanced Aerosol | 4.0 |
| Aerosol/Cloud Mixture | 5.0 |
| Polar Stratospheric Clouds | 10.0 |

## References


BMO: International Meteorological Vocabulary, WMO, World Meteorological Organization, URL `https://library.wmo.int/records/item/35809-international-meteorological-vocabulary`, 1992.

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