



# CERES Terra Edition4A SSF Aerosol Properties - Accuracy and Validation 3/3/2022



## Introduction

Aerosol optical depths,  $\tau_1$  (SSF-73) and  $\tau_2$  (SSF-74), are being retrieved from calibrated reflectances of bands 1 (0.659  $\mu\text{m}$ ) and 6 (1.640  $\mu\text{m}$ ) of the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the Terra satellite, launched in 1999 using a simplistic AVHRR/VIRS-like single-channel algorithm. The parts of this algorithm unique to the  $\tau$  retrieval are:

- The AVHRR/VIRS-like aerosol retrievals are provided on the Terra SSF for continuity with the past NOAA/AVHRR and TRMM/VIRS analyses and to check the consistency of the simplistic "NOAA" retrievals against more sophisticated MODIS aerosols. These more comprehensive and presumably more accurate MODIS aerosols are also provided on the TERRA SSF (parameters SSF-146 through SSF-160). The user is advised to use the MODIS aerosol product. Note also that the NOAA-like product for Terra has not yet been validated or thoroughly tested.
- From  $\tau_1$  and  $\tau_2$ , the Angstrom exponent is estimated as  $\alpha = -\ln(\tau_1 / \tau_2) / \ln(\lambda_1 / \lambda_2)$ . Note that errors in  $\alpha$  change in inverse proportion to  $\tau$  (Ignatov and Stowe 2000, 2002b).
- Most (but not all) cloud-free conditions are acceptable for aerosol retrieval: weak-cloud (with 3.7  $\mu\text{m}$  albedo <3%), strong-clear, weak-clear, aerosol-clear, glint-clear, and smoke-clear. In addition, all aerosol cases have to pass a 2x2 adjacent pixel uniformity test with MODIS band 1 reflectance:  $R_{1,\text{max}} - R_{1,\text{min}} < 0.3\%$ .
- The independent-channel algorithm uses pre-computed look-up tables from the 6S radiative transfer code to relate cloud-free reflectances of the MODIS bands 1 and 6 to  $\tau$  and illumination/viewing geometry. The atmosphere is considered plane parallel, bounded by a rough ocean surface with wind speed of 1 m/s (Ignatov and Stowe 2002a). This independent-channel algorithm is also used with Advanced Very High Resolution Radiometer (AVHRR) data in NOAA/NESDIS operations and TRMM/VIRS. Consistency checks of aerosol retrievals from AVHRR using this algorithm are reported by Ignatov and Nalli (2002). The calibration and cloud masking algorithms are described in detail in other sections of this quality summary.
- To avoid problems with the spherical atmosphere and specular reflection from the ocean surface, the retrievals are restricted to the following geometrical limits: solar zenith angle less than 70° (we do not recommend using data with sun angle greater than 60°, due to pronounced bias in this range of sun angle as reported by Ignatov and Nalli 2002, and

Ignatov and Stowe 2002a), satellite viewing zenith angle less than 60°, relative azimuth angle between 90 and 180°, and glint angle (angle between reflected ray and specular ray for a flat ocean) greater than 40°.

- The  $\tau_1$  and  $\tau_2$  are retrieved from the mean of the MODIS radiance in the CERES Single Scanner Footprint (SSF). The mean of the MODIS pixel level radiances used to compute the  $\tau$  value is also saved, in addition to many other MODIS and CERES parameters, on the SSF. (See [SSF Collection Guide](#).) This value can be used, with the associated geometrical parameters stored on the SSF, to test improvements to  $\tau$  using other retrieval algorithms.

## Validation Study Results And Data Accuracy

The TERRA SSF Edition1A data have not yet been fully evaluated using self-consistency checks or against AERONET. As a quick preliminary test, the AVHRR/VIRS-like  $\tau_1$ ,  $\tau_2$ , and  $\alpha$  have been compared against MODIS-like  $\tau_1$ ,  $\tau_2$  (SSF-152, and SSF-155, respectively), and the Angstrom exponent derived therefrom using one week of data from 15-21 December, 2000. The results of regression analyses "AVHRR/VIRS like parameter" against "MODIS-like retrievals" are listed below:

MODIS-like retrievals are available over 567,318 CERES footprints. AVHRR/VIRS-like retrievals are available over 733,168 footprints.

$\tau_1$ :  $\tau_1(\text{AVHRR/VIRS-like}) = +0.022 + 0.951 * \tau_1(\text{MODIS-like})$ ; R=0.912; Sig=0.032

$\tau_2$ :  $\tau_2(\text{AVHRR/VIRS-like}) = +0.013 + 0.934 * \tau_2(\text{MODIS-like})$ ; R=0.892; Sig=0.021

(Note the "AVHRR/VIRS-like" and "MODIS-like"  $\tau$  are expected to differ slightly due to slightly different reporting wavelengths. The effect should be small).

$\alpha$ :  $\alpha(\text{AVHRR/VIRS-like}) = +0.29 + 0.504 * \alpha(\text{MODIS-like})$ ; R=0.615; Sig=0.27

Accuracy of  $\alpha$  is known to degrade in inverse proportion to  $\tau$  (Ignatov et al. 1998; Ignatov and Stowe 2002b; Ignatov and Nalli 2002). If the  $\alpha$  - correlation statistics is calculated only for  $\tau_2 > 0.1$ , to exclude the most uncertain  $\alpha$ , then the regression equation improves to become

$\tau_2 > 0.1$ :

$\alpha$ :  $\alpha(\text{AVHRR/VIRS-like}) = +0.23 + 0.580 * \alpha(\text{MODIS-like})$ ; R=0.807; Sig=0.12

## Word of Caution

The actual error of both products (AVHRR/VIRS- and MODIS-like) may be somewhat worse than shown in their comparison statistics, because both products may share similar retrieval errors (e.g. due to residual cloud in the field-of-view). More analyses are needed to better understand and quantify those.

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