

Retrieval, Inter-comparison, and Validation of Above-cloud Aerosol Optical Depth from A-train Sensors

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Validation of A-train Sensors

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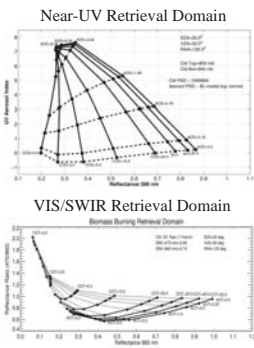
Abstract

Absorbing aerosols produced from biomass burning and dust outbreaks are often found to overlay lower level cloud decks and pose greater potentials of exerting positive radiative effects (warming) whose magnitude directly depends on the aerosol loading above cloud, optical properties of clouds and aerosols, and cloud fraction. Recent development of a 'color ratio' (CR) algorithm applied to observations made by the Aura/OMI and Aqua/MODIS constitutes a major breakthrough and has provided unprecedented maps of above-cloud aerosol optical depth (ACAOD). The CR technique employs reflectance measurements at TOA in two channels (354 and 388 nm for OMI; 470 and 860 nm for MODIS) to retrieve ACAOD in near-UV and visible regions and aerosol-corrected cloud optical depth, simultaneously. An inter-satellite comparison of ACAOD retrieved from NASA's A-train sensors reveals a good level of agreement between the passive sensors over the homogeneous cloud fields.

Direct measurements of ACA such as carried out by the NASA Ames Airborne Tracking Sunphotometer (AATS) and Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR) can be of immense help in validating ACA retrievals. We validate the ACA optical depth retrieved using the CR method applied to the MODIS cloudy-sky reflectance against the airborne AATS and 4STAR measurements. A thorough search of the historic AATS-4STAR database collected during different field campaigns revealed five events where biomass burning, dust, and wildfire-emitted aerosols were found to overlay lower level cloud decks observed during SAFARI-2000, ACE-ASIA 2001, and SEAC4RS-2013, respectively. The co-located satellite-airborne measurements revealed a good agreement (RMSE less than 0.1 for AOD at 500 nm) with most matchups falling within the estimated uncertainties in the MODIS retrievals. An extensive validation of satellite-based ACA retrievals requires equivalent field measurements particularly over the regions where ACA are often observed from satellites, i.e., south-eastern Atlantic Ocean, tropical Atlantic Ocean, northern Arabian Sea, South-East and North-East Asia.

The Color Ratio Algorithm

- The presence of absorbing aerosols above cloud decks reduces the amount of upwelling ultraviolet (UV), visible (VIS), and shortwave infrared radiation reaching the top of atmosphere and produces a strong color ratio effect in the spectral reflectance measurements. This is often referred to as "cloud darkening"—an effect caused by the spectral aerosol absorption.
- The CR technique employs reflectance measurements at TOA in two channels (354 and 388 nm for OMI; 470 and 860 nm for MODIS) to retrieve above-cloud AOD in near-UV and visible regions and aerosol-corrected cloud optical depth, simultaneously.

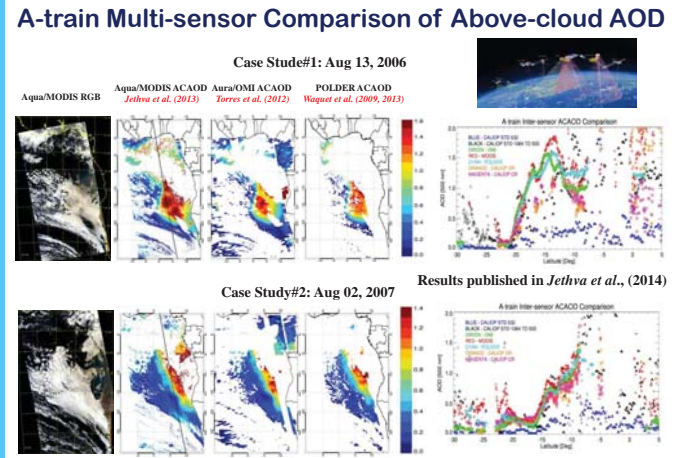
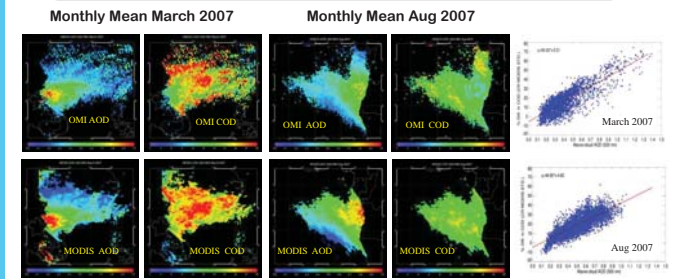
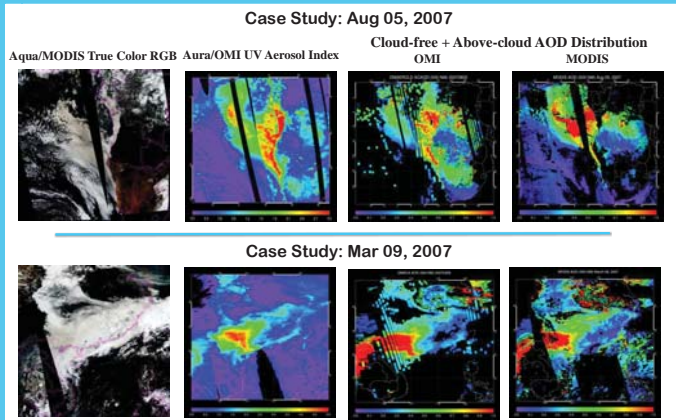


Input Parameters
 TOA reflectance
 OMI: 354 and 388 nm
 MODIS: 470 and 660/860 nm (ocean/land)

A priori:
 Aerosol Model (size distribution, real/imaginary part of refractive indices, aerosol vertical profile, cloud droplet distribution (modified-Gamma), Cloud top/bottom pressure)

RT Model: VLIDORT V2.6

Output Parameters
 Above-cloud AOD
 (at 388 for OMI and at 660/860 nm for MODIS)
 aerosol-corrected COD

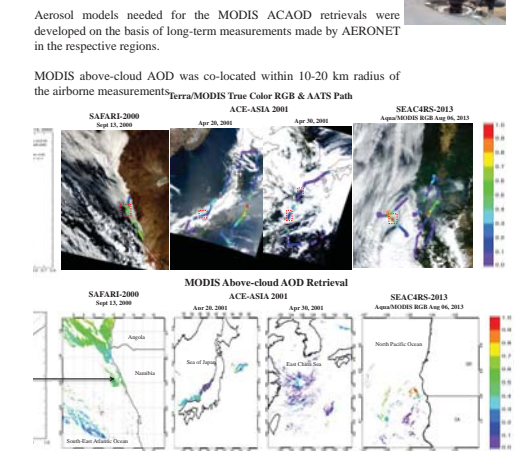


The **Ames Airborne Tracking Atmospheric Research (4STAR)** developed by the NASA AMES research group measures the transmission coefficient in 14 spectral bands (0.3535, 0.3800, 0.4490, 0.4994, 0.5246, 0.6057, 0.6751, 0.7763, 0.8645, 0.9442, 1.0191, 1.2413, 1.5574 μm) and subsequently retrieve the columnar AATS's azimuth and elevation motors controlled by differential sun which locks the detector normal to the solar beam thus provides the transmission. Further information on AATS can be found in Russell et al., 2002; Schmid et al., 2002; Schmalz et al., 2002; Russell et al., 2002; <http://geo.arc.nasa.gov/aats>

AATS/4STAR
 Field campaign participants:
 TARFOX (1996)
 ACE-2
 SAFARI-2000
 ACE-ASIA (2001)
 CLAMS
 SEAC4RS-2013

Validation of Above-cloud AOD

The **Sunphotometer (AATS)** and **Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR)** developed by the NASA AMES research group measures the transmission coefficient in 14 spectral bands (0.3535, 0.3800, 0.4490, 0.4994, 0.5246, 0.6057, 0.6751, 0.7763, 0.8645, 0.9442, 1.0191, 1.2413, 1.5574 μm) and subsequently retrieve the columnar AATS's azimuth and elevation motors controlled by differential sun which locks the detector normal to the solar beam thus provides the transmission. Further information on AATS can be found in Russell et al., 2002; Schmid et al., 2002; Schmalz et al., 2002; Russell et al., 2002; <http://geo.arc.nasa.gov/aats>



- Most satellite-airborne matchups falling within the predicted uncertainties in the above-cloud AOD retrieval (-10% to 50%)
- The co-located COD was found to be either equivalent to the MODIS operational cloud product for lower AODs (ACE-ASIA) or higher by 30-35% for more absorbing aerosol event of SAFARI-2000

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