Aerosol Products from TOMS

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Outline

Physical Basis
Aerosol Products
Validation
Algorithm Improvements

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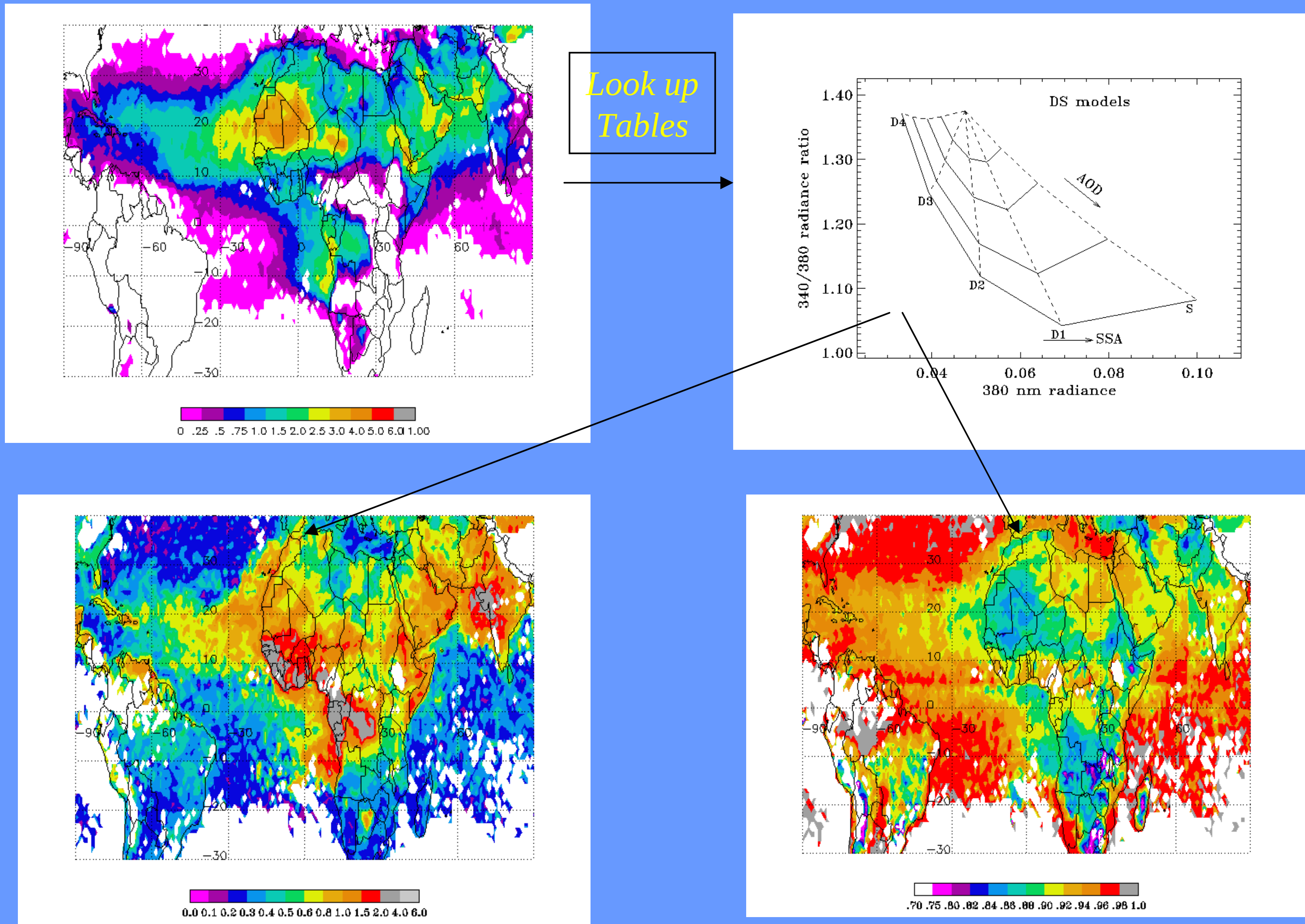
TOMS Aerosol Algorithm

Aerosol Index

Two-parameter Inversion Procedure



Optical Depth

Single Scattering Albedo

Physical Basis of TOMS aerosol retrieval approach

Neglecting particle multiple scattering effects, the upwelling reflectance as measured by a satellite, is approximately given by

$$I \approx \frac{\omega_0 P(\Theta)\pi F_0}{4\pi} \frac{\mu_0}{\mu_o + \mu}[1 - e^{-\tau(1/\mu + 1/\mu_0)}] + [I_s + I_0]e^{-(1-\omega_0)\tau(1/\mu+1/\mu_0)}$$

Aerosol single scattering contribution

Attenuation of Rayleigh and surface components by aerosol absorption

Since I_0 depends on pressure, then

$$I \approx \frac{\omega_0 P(\Theta)\pi F_0}{4\pi} \frac{\mu_0}{\mu_0 + \mu}[1 - e^{-\tau(1/\mu + 1/\mu_0)}] + [\frac{(p_s - p_a)I_0}{p_s} + I_s]e^{-(1-w_0)\tau(1/\mu+1/\mu_0)} + \frac{p_a}{p_s} I_0$$

p_s and p_a are surface and aerosol layer height pressure levels

The net aerosol contribution to the measured reflectance is

$$I_{aer} \approx \frac{\omega_0 P(\Theta)\pi F_0}{4\pi} \frac{\mu_0}{\mu_0 + \mu}[1 - e^{-\tau(1/\mu + 1/\mu_0)}] + [\frac{(p_s - p_a)I_0}{p_s} + I_s][e^{-(1-w_0)\tau(1/\mu+1/\mu_0)} - 1]$$

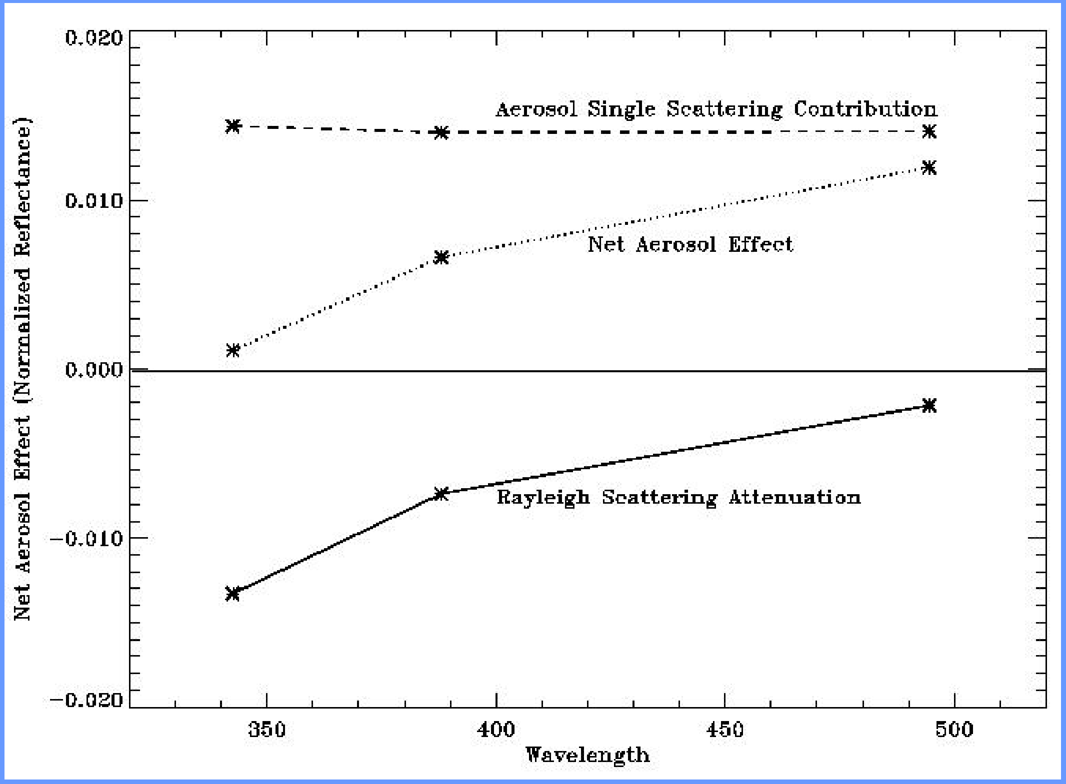
πF_0 Solar flux ω_0 Single scattering albedo τ Aerosol optical depth

μ, μ_0 Cosines of satellite and solar zenith angles $P(\Theta)$ Aerosol scattering phase function

For non-absorbing aerosols the aerosol contribution is just the single scattering component

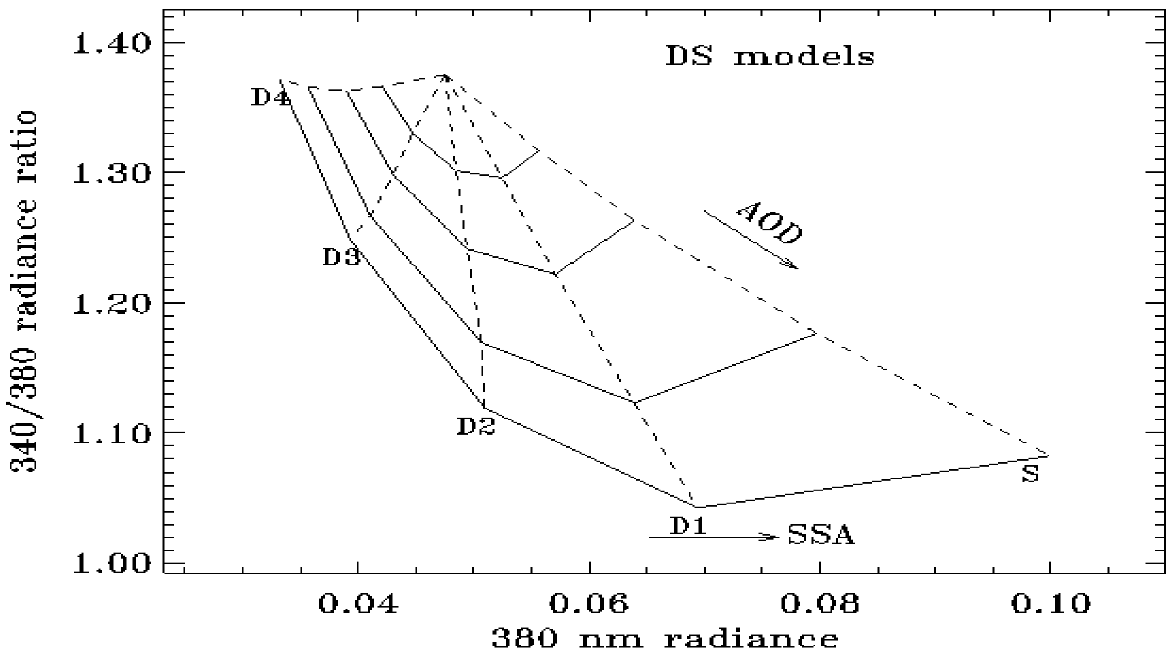
$$I_{aer} \approx \frac{\omega_0 P(\Theta)\pi F_0}{4\pi} \frac{\mu_0}{\mu_0 + \mu} [1 - e^{-\tau(1/\mu + 1/\mu_0)}]$$

For absorbing aerosols, the attenuation of Rayleigh scattering is significant in the UV spectral region.



TOMS Aerosol Products

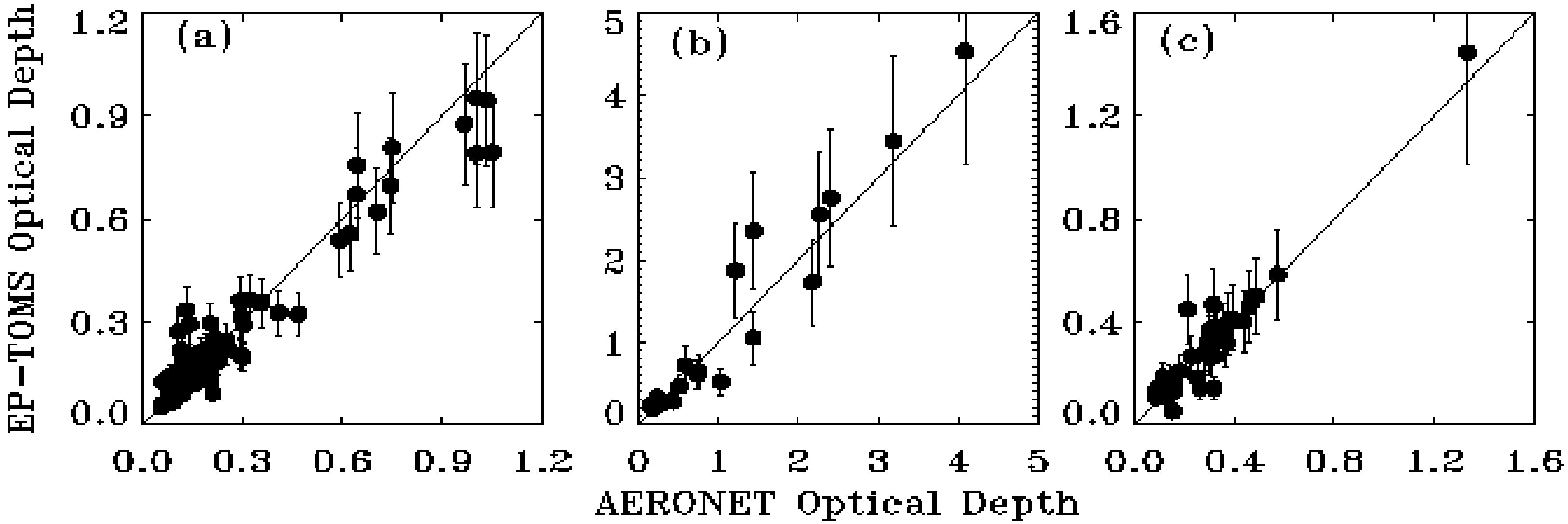
Near UV Retrieval Approach



A set of measurements at the two near-UV channels are associated with a set of values aerosol optical depth and single scattering albedo.

Validation of EP-TOMS retrievals of Aerosol Optical Depth

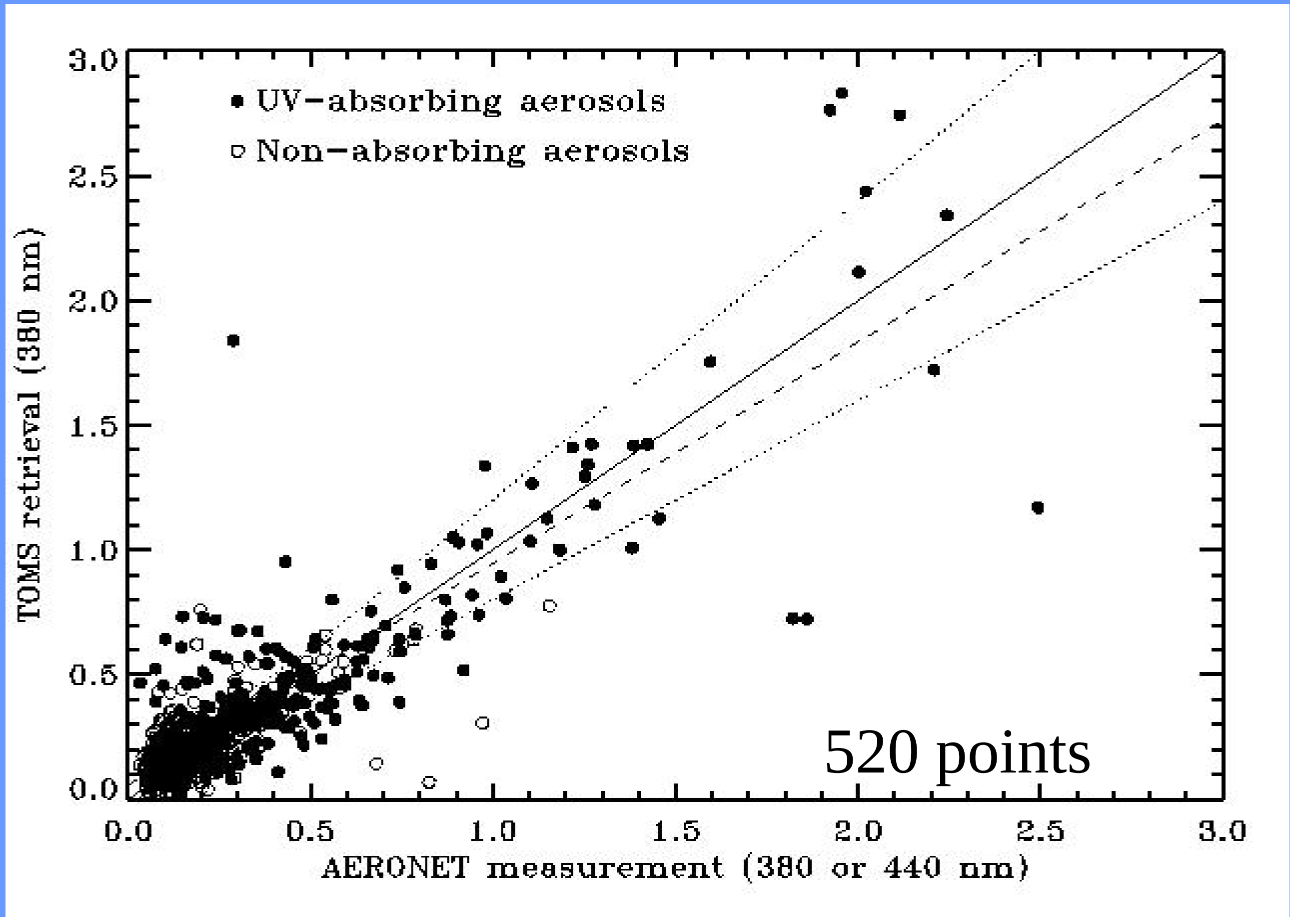
Comparison to AERONET measurements



Non-absorbing aerosols GSFC, 1998 (380 nm)	Smoke aerosols Altafloresta, Brazil 1999 (380 nm)	Saharan Dust Banizombou 1997 (440 nm)

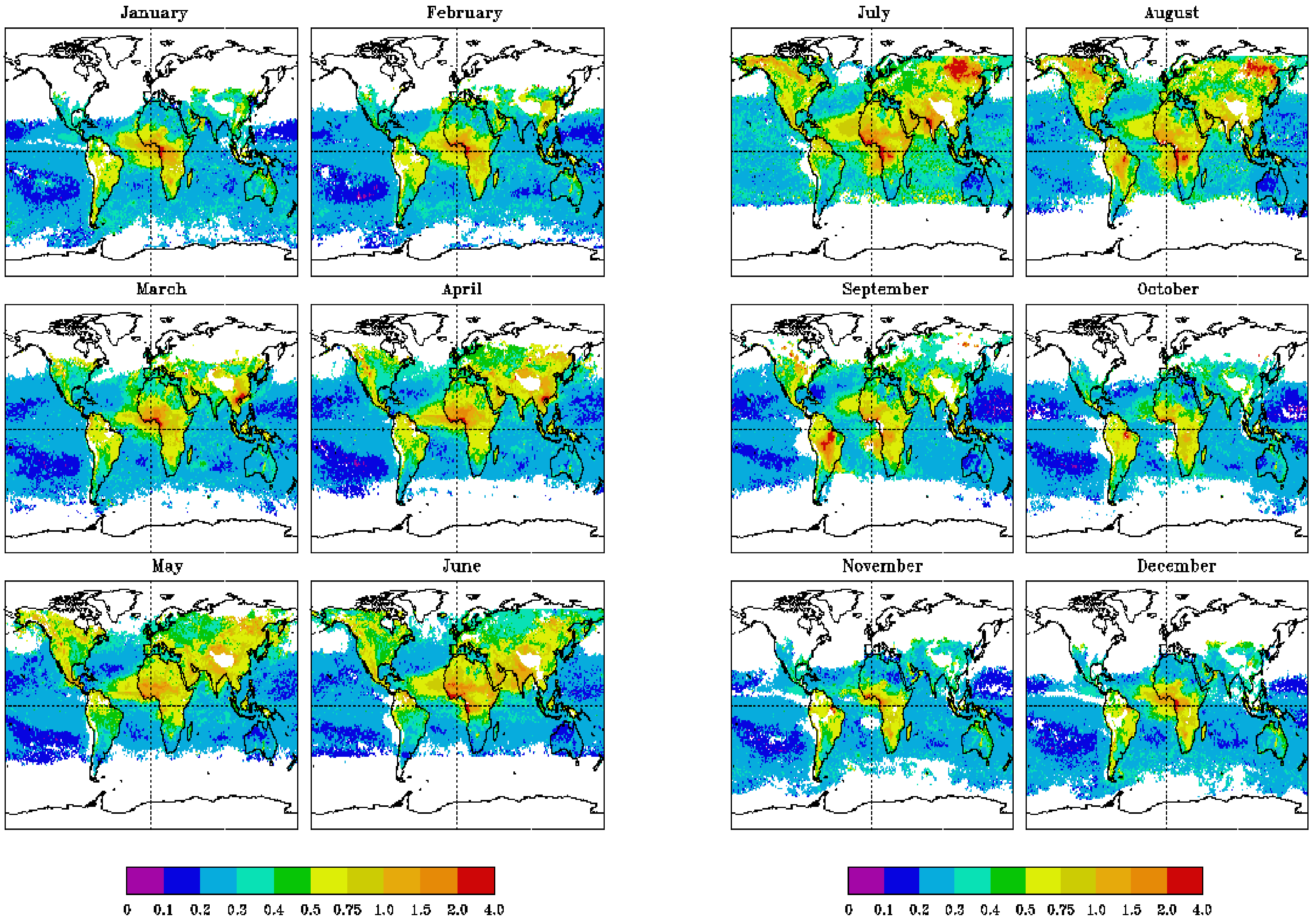
Optical depth validation using AERONET observations

Comparison at six AERONET sites over a three-year period

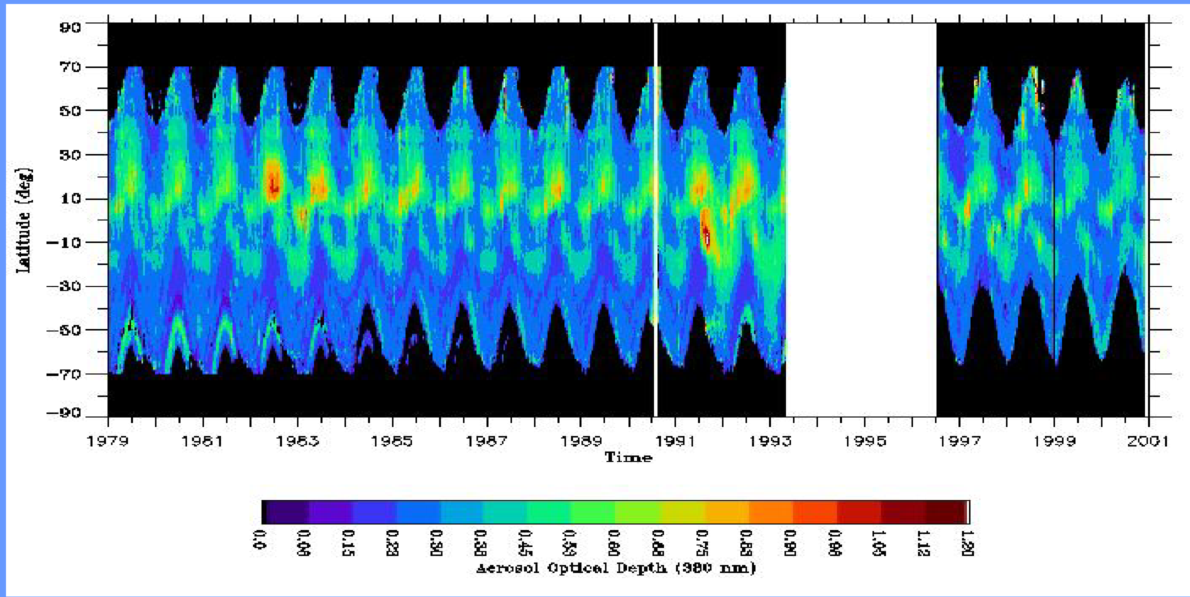


TOMS agrees with AERONET within 30% (or 0.1) in 75% of the comparison points.

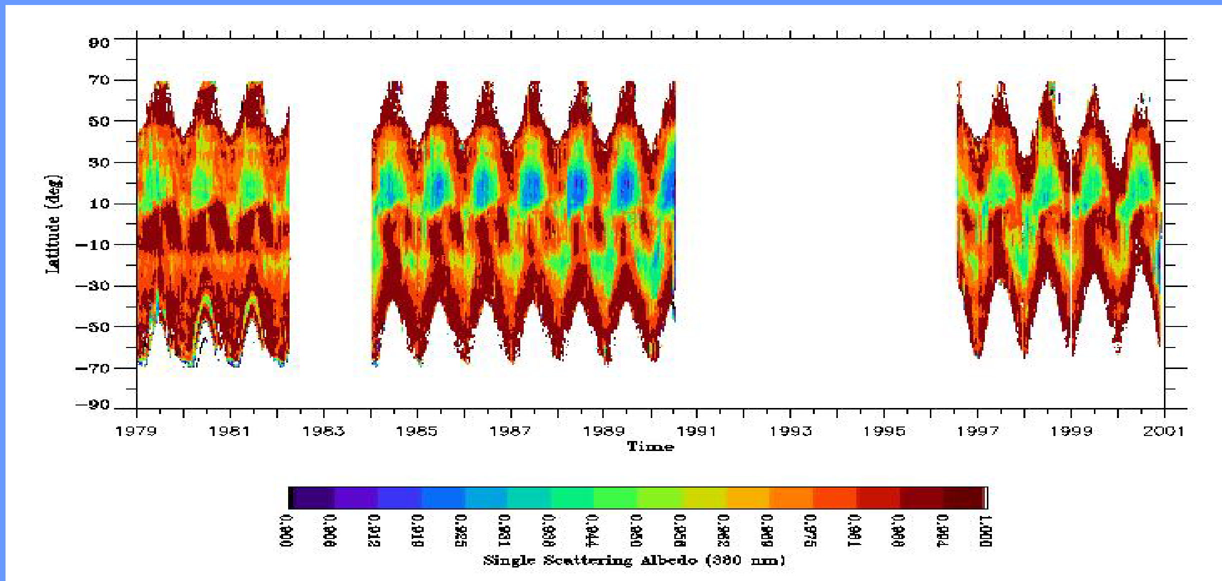
TOMS AOT Climatology (*Torres et al, JAS, 2002*)



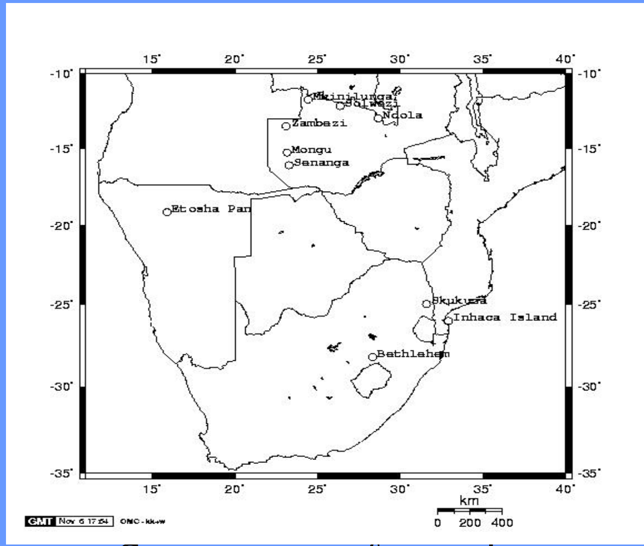
TOMS aerosol optical depth record (*Torres et al, JAS, 2002*)



Single Scattering Albedo



AERONET-TOMS comparison of single scattering albedo during SAFARI 2000 (August-September)



Summary of results

Site	Aeronet (440 nm)	TOMS (380 nm)
Mwinilunga	0.887	0.886
Ndola	0.866	0.880
Senanga	0.878	0.869
Solwezi	0.881	0.882
Zambezi	0.864	0.881

TOMS retrieved single scattering albedo agrees with AERONET results within 0.03

Algorithm Improvement

New Calibration

New Aerosol Models

-Three aerosol types: mineral dust, carbonaceous aerosols, urban-industrial

-Bi-modal particle size distributions based on AERONET's multiyear statistics

Advantages:

-More reliable UV-to-visible conversion of retrieved parameters

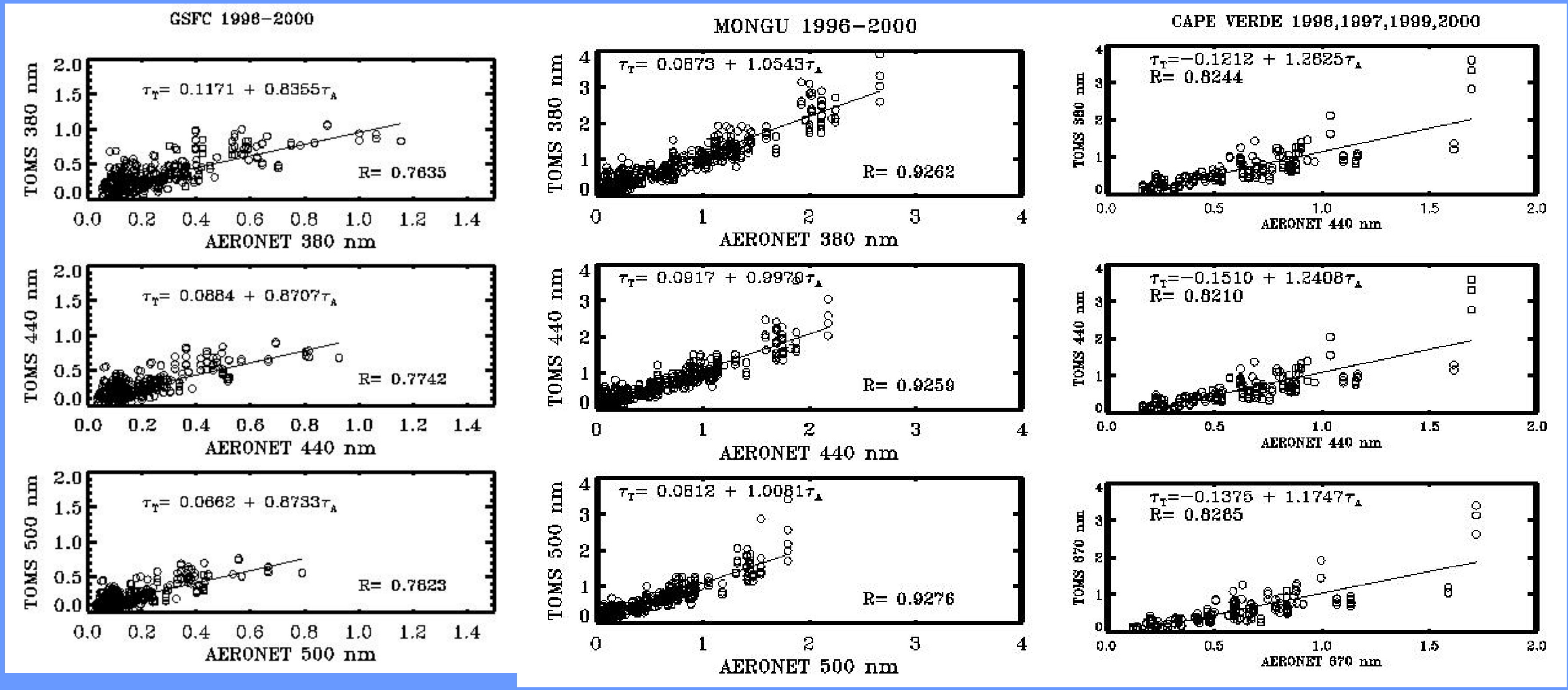
-Consistency with aerosol models used in the OMI aerosol algorithm.

Aerosol data will be reprocessed using the new algorithm

Improvement of TOMS aerosol algorithm

Better wavelength conversion by using new aerosol models based on AERONET statistics

Sulfate *Smoke* *Dust*



Summary

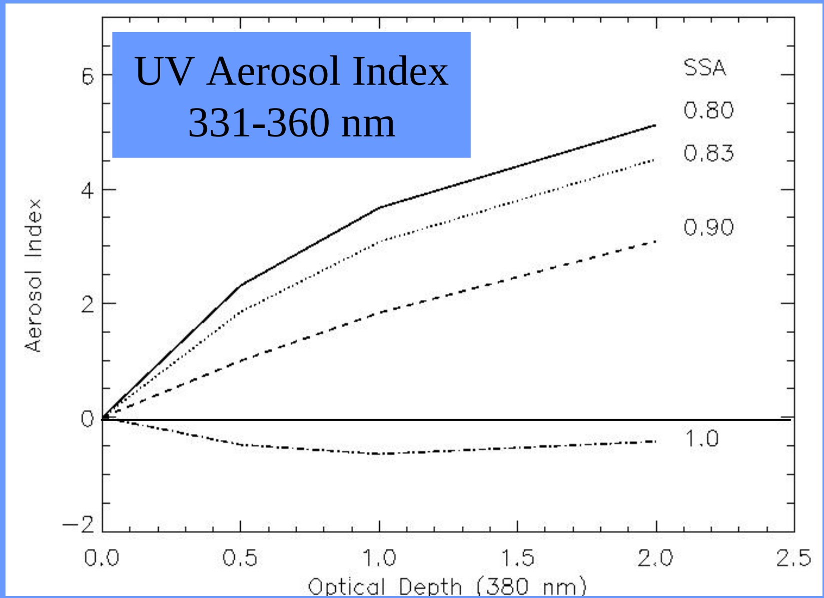
Satellite measurements in the near UV offer two unique advantages:
-Aerosol detection capability over all land surfaces, including deserts.
-High sensitivity to aerosol absorption that allows the retrieval of aerosol single scattering albedo.

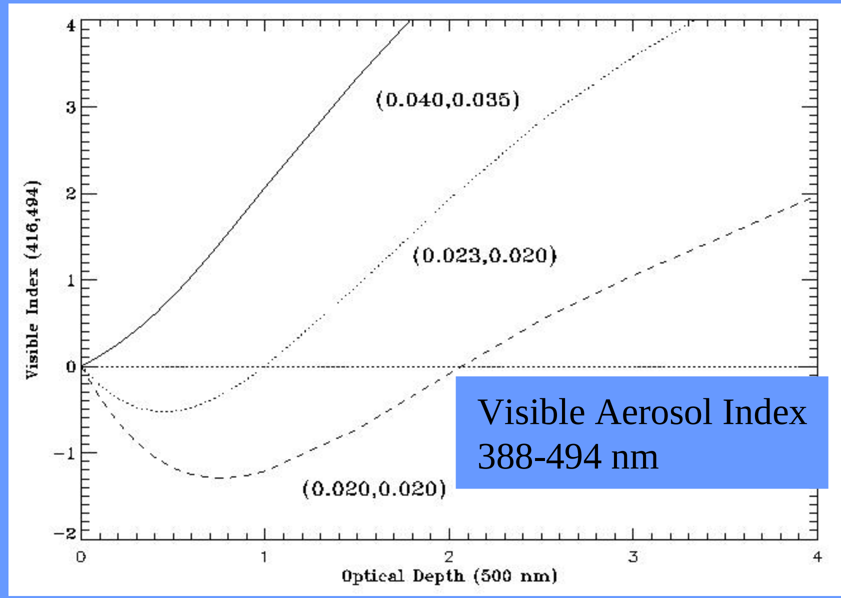
A multi-year aerosol data record from TOMS data has been produced (available at the TOMS website: toms.gsfc.nasa.gov)

Version 2 of the TOMS aerosol record is currently being developed and will be available in the next few months.

Aerosol properties in the near UV will continue to be retrieved by the Ozone Monitoring Instrument (OMI) to fly on AURA (2004)

Aerosol type identification in TOMS and OMI algorithms





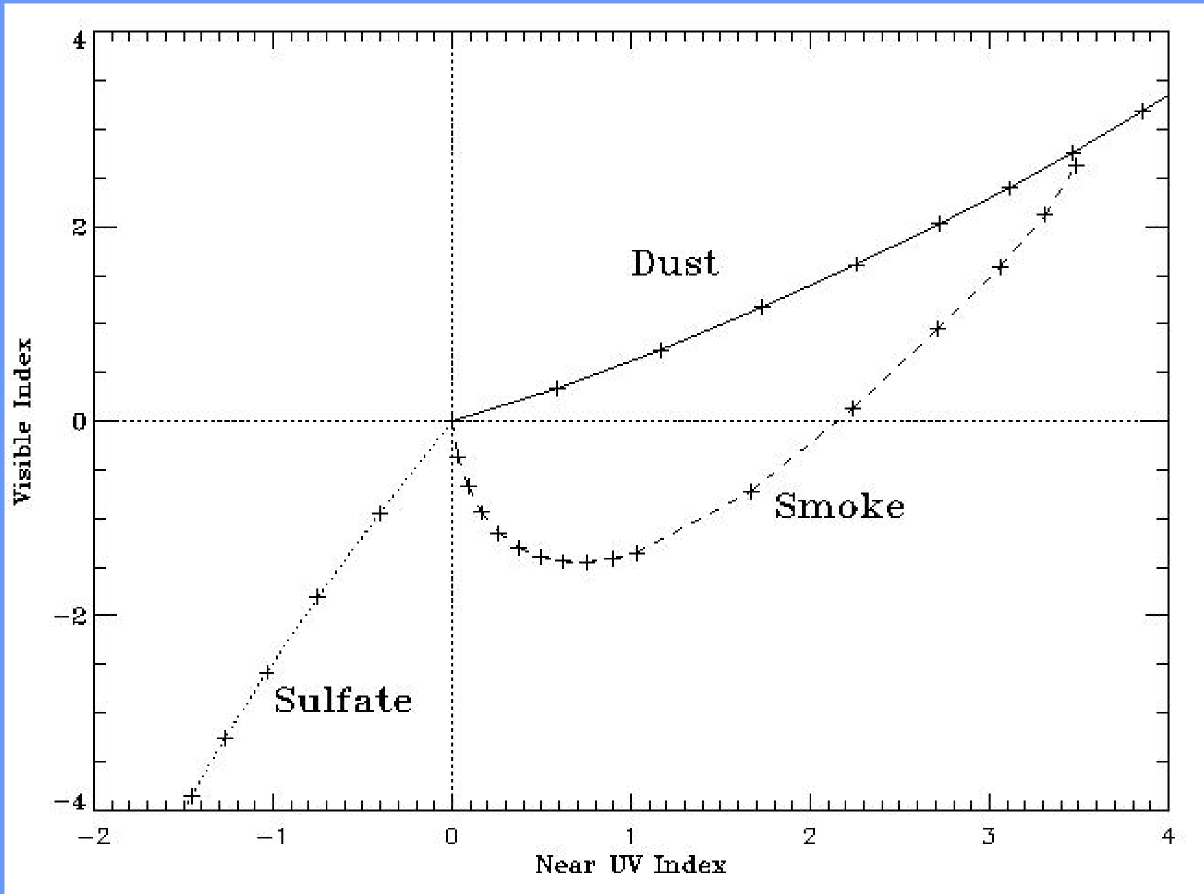
-The UV Aerosol Index separates absorbing from non-absorbing aerosols.

-It does not differentiate between different absorbing aerosol types (smoke, mineral dust, volcanic ash)

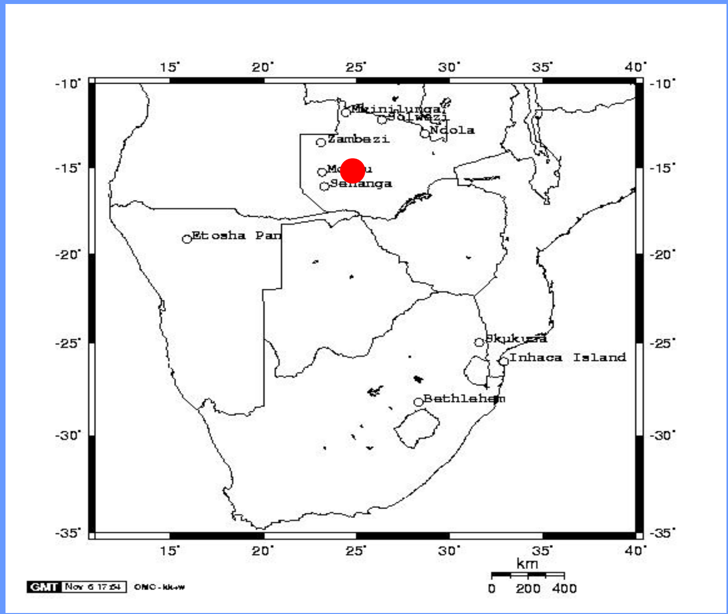
-The visible aerosol index separates colored aerosols from gray aerosols.

-It allows the separation of smoke (gray) from mineral dust (colored)

Combined use of UV and Visible Aerosol Indices in the OMI Aerosol Algorithm

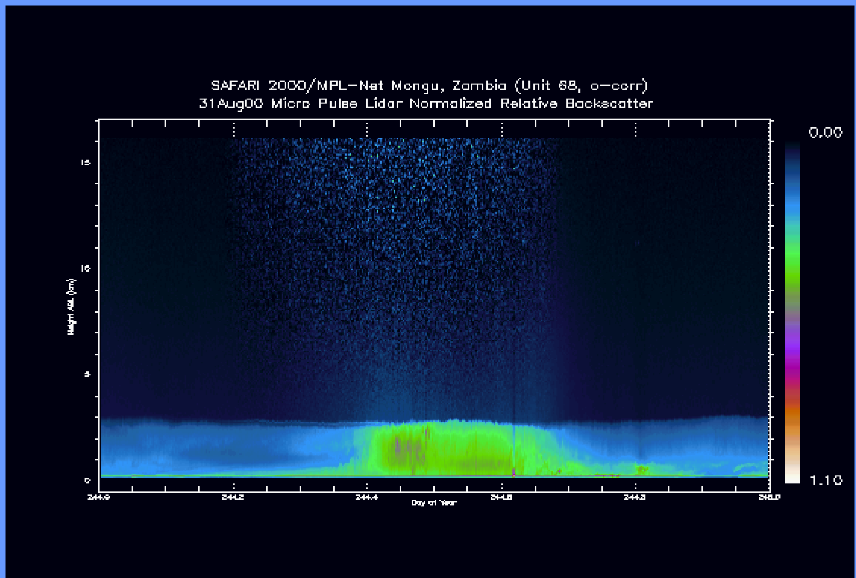


Case Study 1: SAFARI 2000



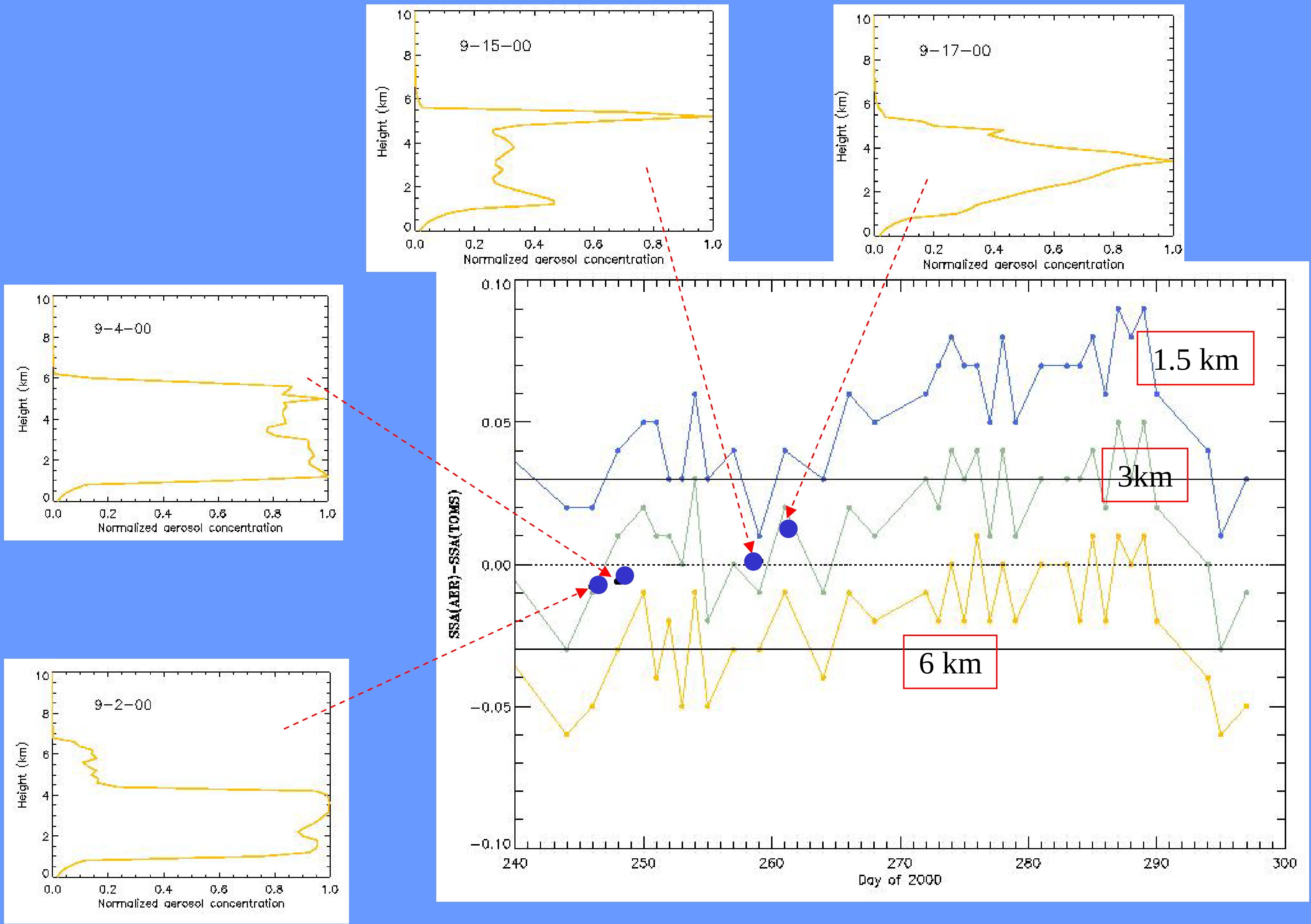
Aerosol Optical Depth and SSA measured by AERONET at Mongu, Zambia

Backscatter profiles by MPLNet



Rare opportunity to test the Algorithm sensitivity to aerosol profile shape and altitude

Impact of aerosol vertical distribution on SSA retrieval



When the actual aerosol profile shape is used in the retrieval, the derived SSA value agrees with AERONET results within 0.01

The use of a single layer distribution yields reasonable results provided that the effective aerosol layer height is correctly prescribed