



AERONET Aerosol Measurements in Latin America and the Caribbean (LAC)

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Key Aerosol Sources

Wind driven dust from
deserts and arid land

Sea salt from wind and
wave action

Emissions from urban and
industrial sources (e.g.,
fossil fuel combustion)

Smoke from biomass
burning (e.g., forests,
shrubs, grass)

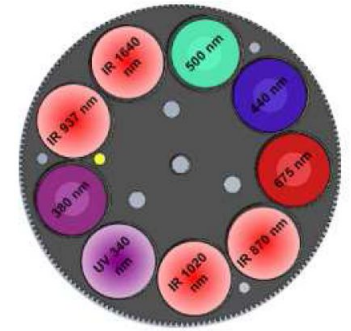
Volcanic eruptions and
biogenic sources



Photo credits (top to bottom): Daniel Jamen Bryant; Dee Golden; Kenn W. Kiser; Daniel Yara; Jane M. Sawyer; Rick Hoblitt/USGS; center: AERONET

Aerosol Robotic Network (AERONET)

<http://aeronet.gsfc.nasa.gov>



- Aerosol Remote Sensing Using Sun/Sky Scanning Radiometers
 - Measure light intensity from UV to Vis to NIR (8-10 wavelengths)
 - Aerosol Optical Depth (Direct Sun or Direct Moon)
 - Inferred Aerosol Properties (Direct Sun and Sky Radiances)
- Widely Used by the Aerosol Community
 - Aerosol Characterization and Climatology
 - Satellite and Model Evaluation
 - Model Assimilation
 - Synergism with other Earth Science data sets

V3 AOD Data Quality Levels

Level 1.0 – Minimally screened

Level 1.5 – Cloud Screened & Quality Controlled

Level 2.0 – Quality assured

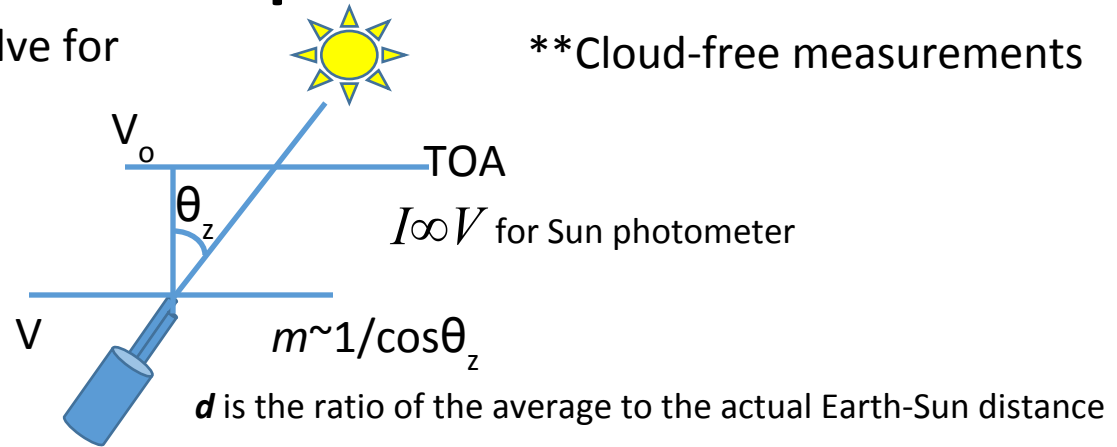


Cieliebaud Sun/Sky Radiometer

Aerosol Optical Depth

From Beer-Lambert-Bouguer Law, solve for the optical depth or $\tau(\lambda)_{\text{Total}}$:

$$\tau(\lambda)_{\text{Total}} = \frac{d^2}{m} \ln \left(\frac{V_o(\lambda)}{V(\lambda)} \right)$$



Determine Aerosol Optical Depth (AOD) :

$$\tau(\lambda)_{\text{Aerosol}} = \tau(\lambda)_{\text{Total}} - \tau(\lambda)_{\text{Rayleigh}} - \tau(\lambda)_{\text{H}_2\text{O}} - \tau(\lambda)_{\text{O}_3} - \tau(\lambda)_{\text{NO}_2} - \tau(\lambda)_{\text{CO}_2} - \tau(\lambda)_{\text{CH}_4}$$

Field Instrument AOD Uncertainty = **± 0.01 (Vis-NIR) to ± 0.02 (UV)**

Reference instruments calibrated by Langley technique have AOD uncertainty ± 0.003 to ± 0.007

Approximate aerosol size:

Ångstrom Exponent

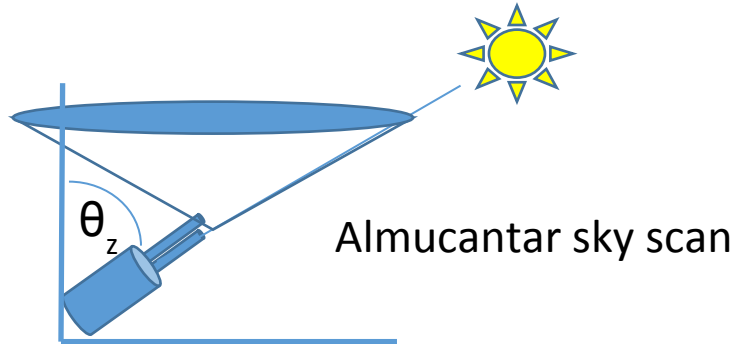
$$\alpha = - \frac{\ln(\tau(\lambda))}{\ln(\lambda)}$$

Fine mode fraction of AOD

$$\eta(\lambda) = \frac{\tau_f(\lambda)}{\tau_f(\lambda) + \tau_c(\lambda)}$$

Aerosol Characteristics

Almucantar inversion [Dubovik and King, 2000; Dubovik et al., 2000, 2002, 2006]:



Assumptions

1. Plane parallel atmosphere
2. Homogenously distributed particles
3. Randomly oriented spheroids
4. Surface characterization
5. Optically effective columnar properties
6. Same refractive index applied to fine and coarse modes of size distribution

Volume Size Distribution ($\mu\text{m}^3/\mu\text{m}^2$)

$$dV(r) / d \ln r$$

Single Scattering Albedo (SSA)

$$\omega_o = \frac{\tau_{scat}}{\tau_{ext}}$$

Estimated SSA
Uncertainty= ± 0.03
for $\text{AOD}_{440\text{nm}} > 0.4$

Further transformations give other parameters:

Absorption AOD

$$\tau_{abs} = \tau_{ext} (1 - \omega_o)$$

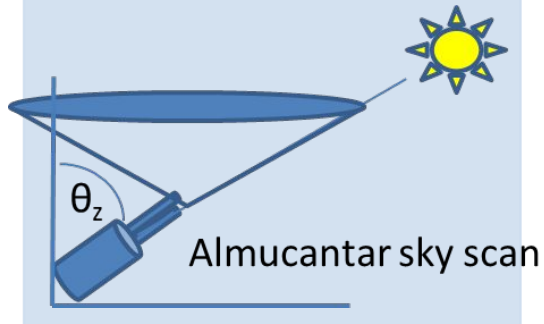
Absorption Ångstrom Exponent (AAE)

$$\alpha_{abs} = - \frac{\ln(\tau_{abs}(\lambda))}{\ln(\lambda)}$$

Standardization

Measurements

- Cimel radiometers
- Direct sun measurements (every 3 to 15 minutes)
- Sky scans performed hourly (e.g., almucantar, principal plane)



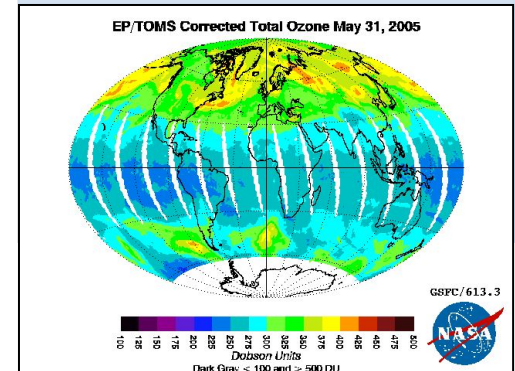
Calibration

- Langley calibration technique for reference instruments
- Calibration transfer from reference to field instruments
- Integrating sphere calibrated by NIST light source for sky measurements



Processing

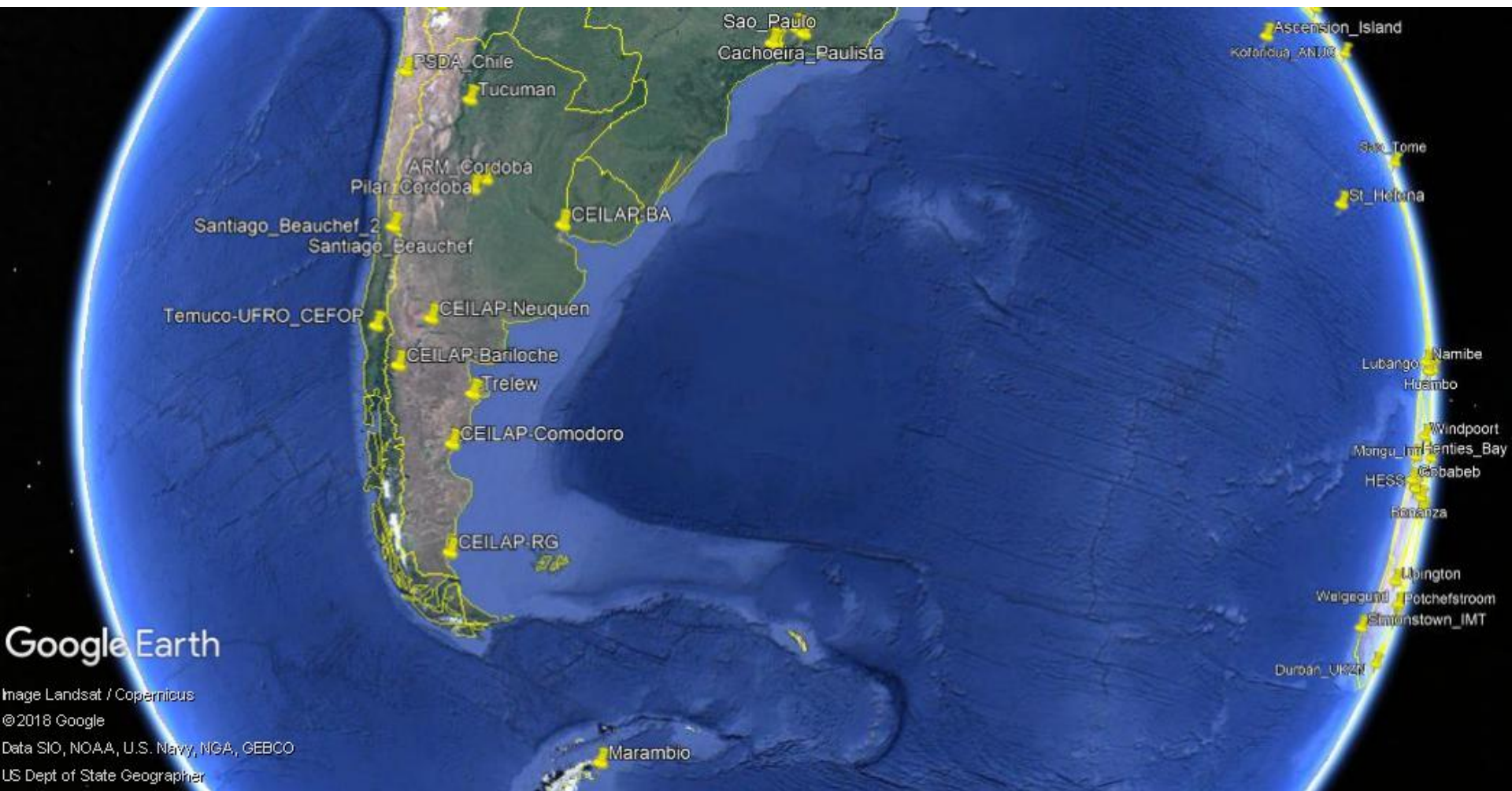
- Known techniques for computing aerosol properties
- Implementing EOS data sets (e.g., NCEP reanalysis fields, OMI NO_2 , TOMS O_3)
- Processed and freely available on web site in near real time



Aerosol Robotic Network (AERONET)

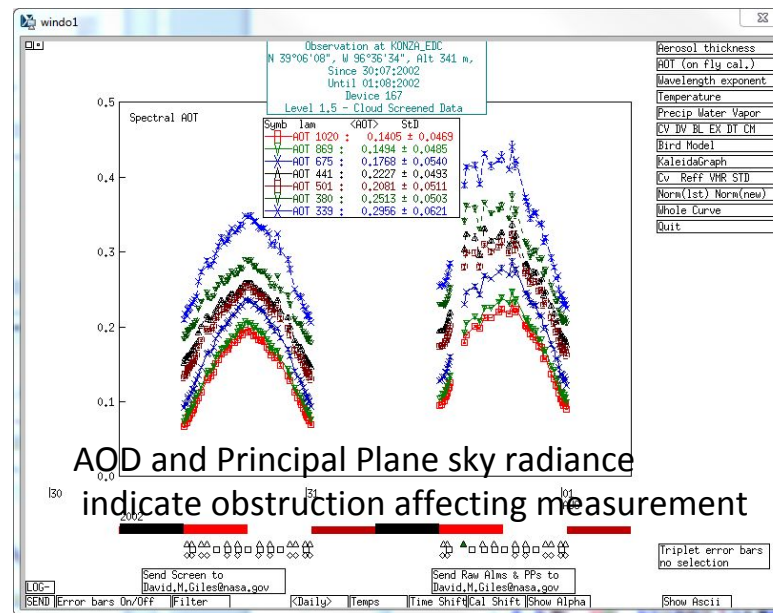
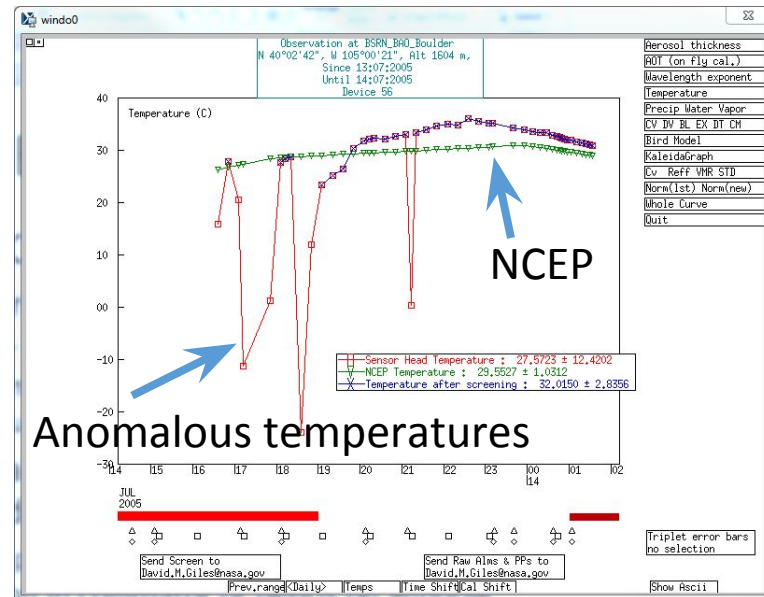


Aerosol Robotic Network (AERONET)



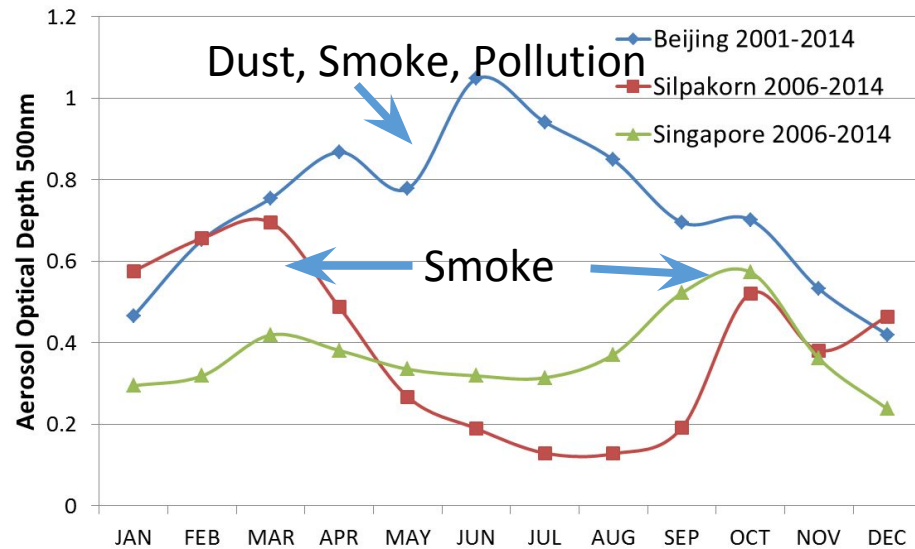
AERONET Version 3: AOD

- **V3 Level 1.0:** Unscreened data (NRT)
 - Applies new temperature characterizations
 - Updated coordinates and elevation
 - Applies NO2 OMI L3 climatology (2004-2013)
 - Applies updated absorption coefficients (Literature/HITRAN)
- **V3 Level 1.5:** Based on Level 1.0 (NRT)
 - Improved cloud screening
 - New quality controls applied
- **V3 Level 2.0:** Based on Level 1.5 with pre- and post-calibration and temperature characterization applied
 - Level 2.0 data quality confirmed during post-field calibration evaluation and released 30 days afterwards to allow for updates to ancillary databases
 - Significantly improves timeliness of Level 2.0 data availability

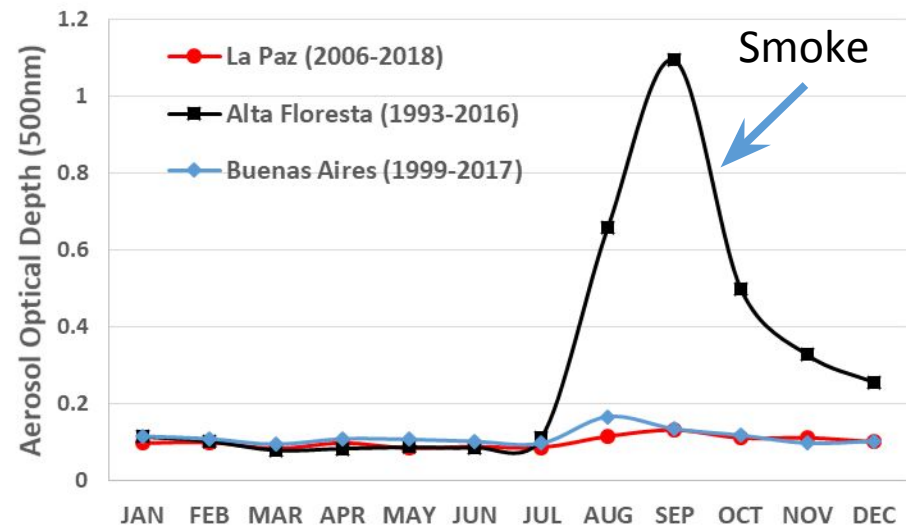


Multi-Annual Monthly Climatology Aerosol Loading

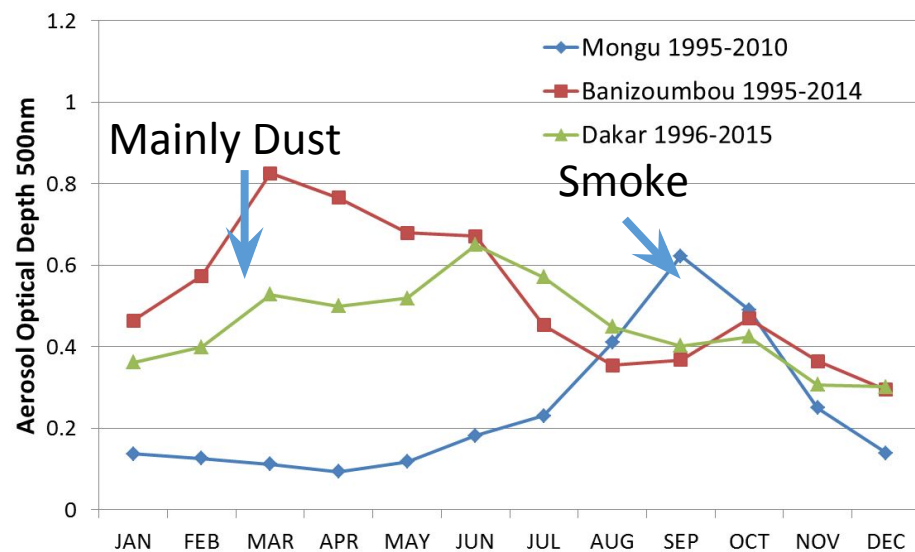
East Asia - Monthly Climatology



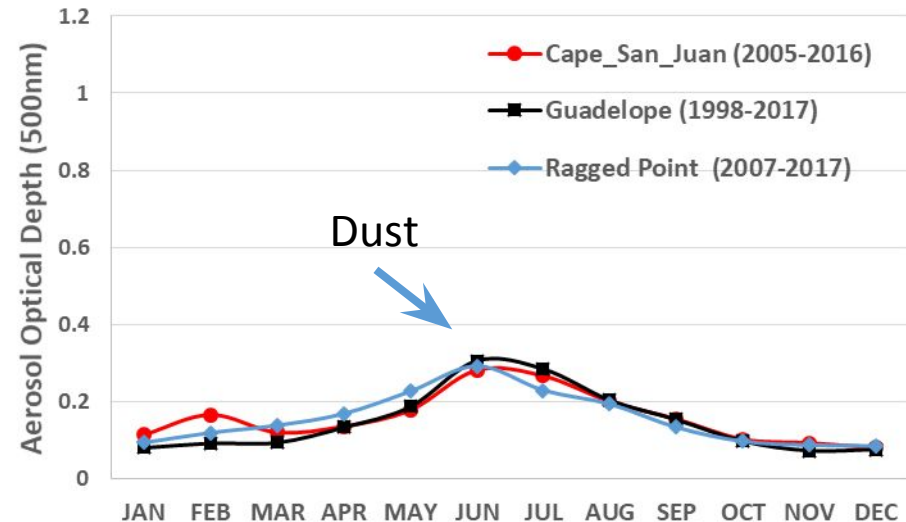
South America - Monthly



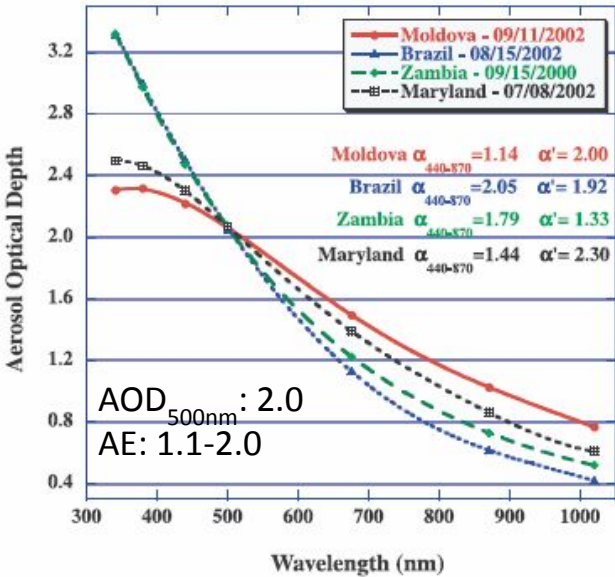
Africa - Monthly Climatology



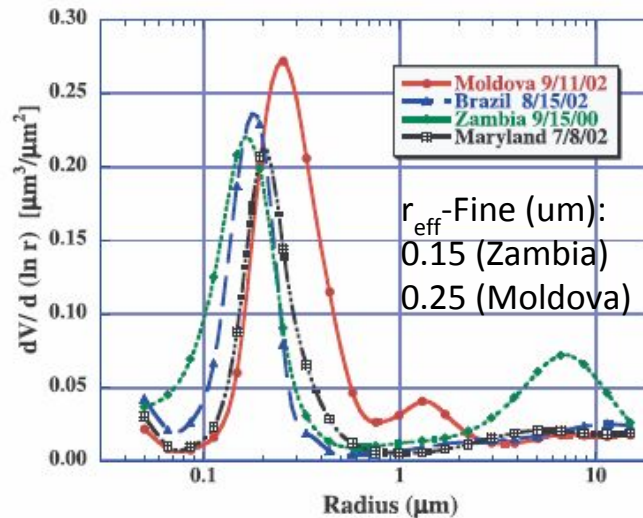
Caribbean - Monthly



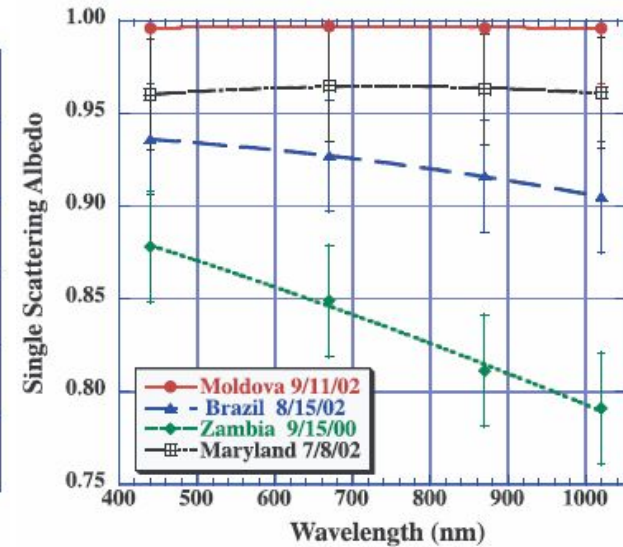
Variations of Biomass Burning Smoke



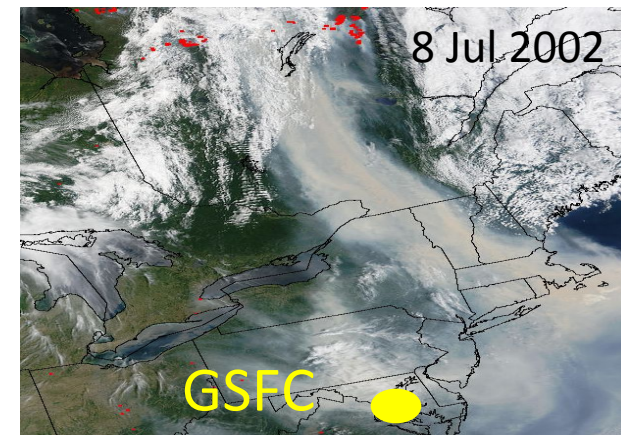
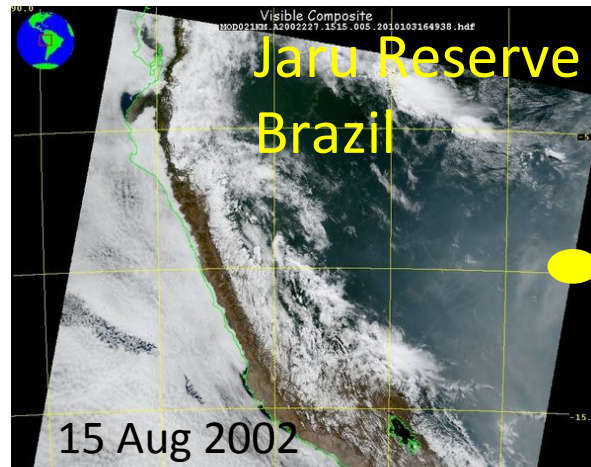
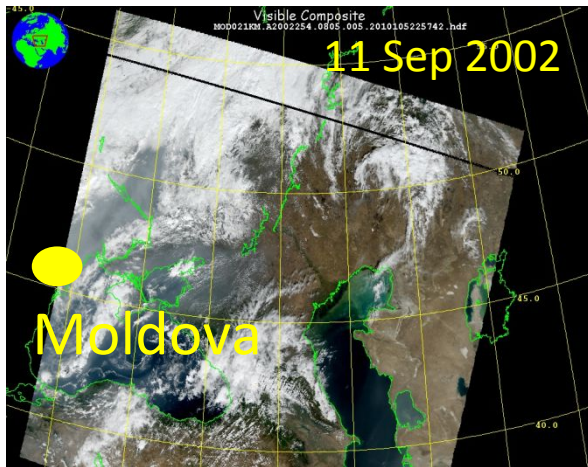
Aerosol optical depth spectra from 340 nm to 1020 nm for the four smoke events studied.



Aerosol volume size distributions retrieved from AERONET measurements



Aerosol single scattering albedo retrieved from AERONET measurements. The error bars show the 0.03 uncertainty (estimated) in retrieved SSA.



AERONET

New Instrumentation/Enhancements

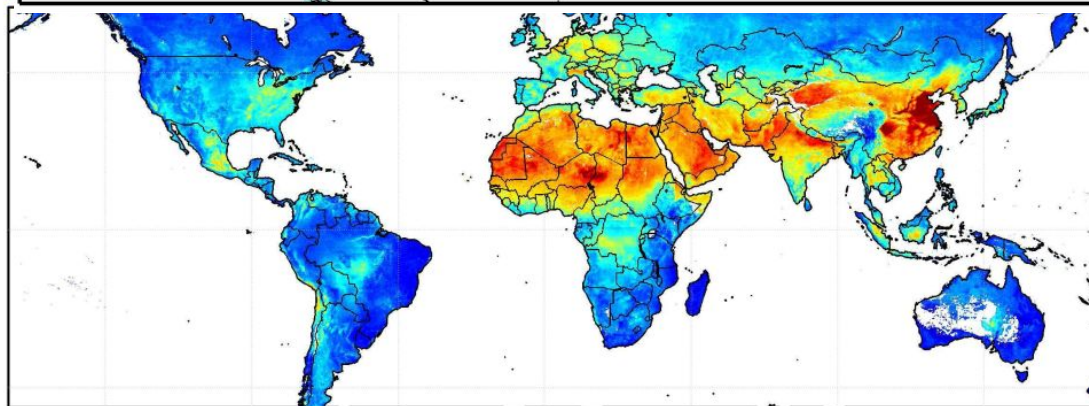
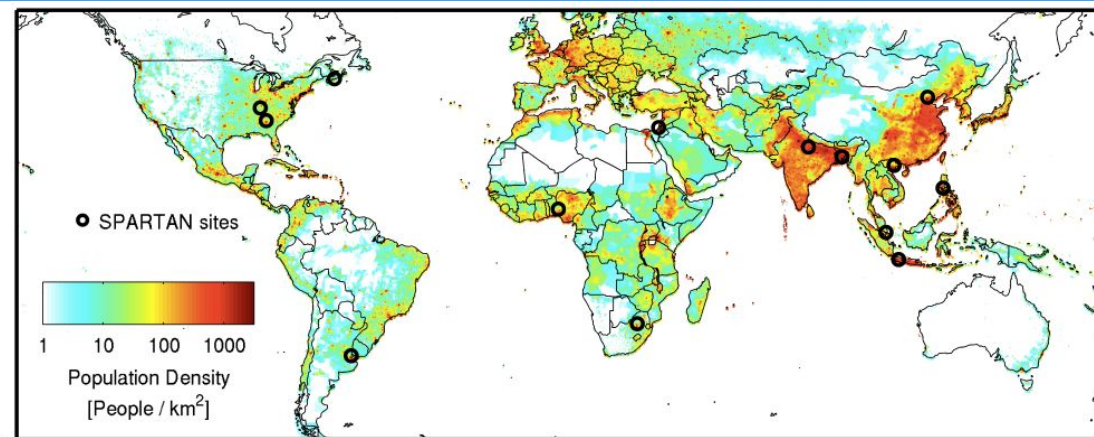
- Improved solar tracking reducing triplet variance
- Greater control over instrument measurement scenarios (e.g., **CCS and Hybrid**)
- **Lunar measurements**
 - 1st to 3rd quarter lunar phase (waxing to waning gibbous)
 - Processing for lunar measurements (e.g., ROLO, Tom Stone)
- Development toward attachment for CO2 measurements (Emily Wilson)
- Synergism with MPLNET, PANDORA, SPARTAN, and in situ measurements



SPARTAN –Surface Particulate Matter Network

PM_{2.5} and AERONET to relate satellite AOD to ground-level PM_{2.5}

<http://spartan-network.org/>



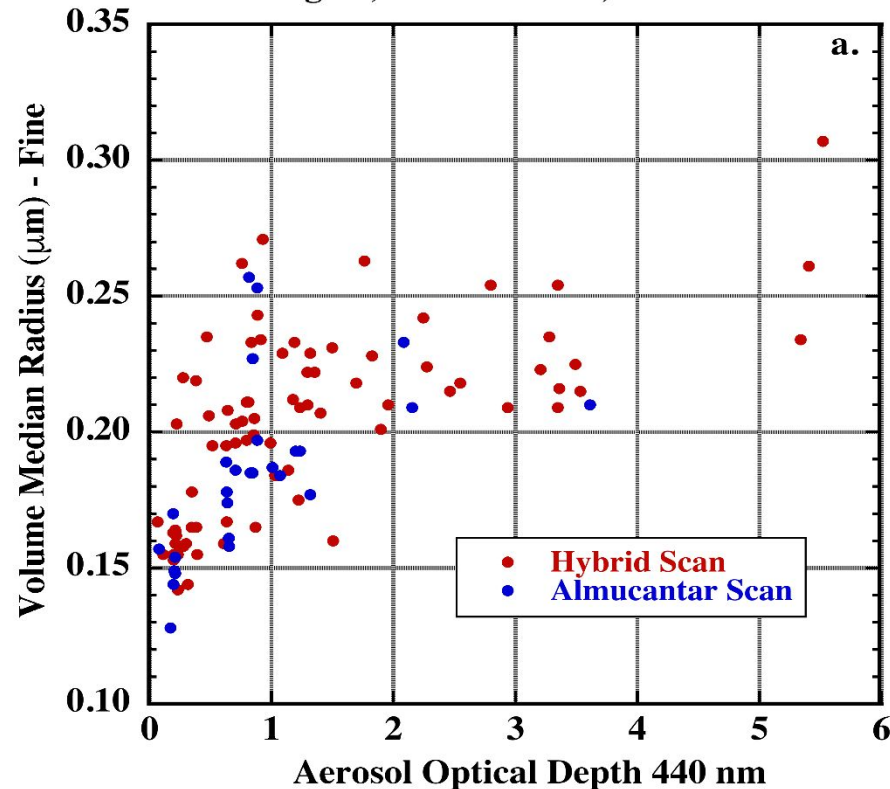
0 5 10 15 20 50 80
Satellite-Derived PM_{2.5} [$\mu\text{g}/\text{m}^3$]



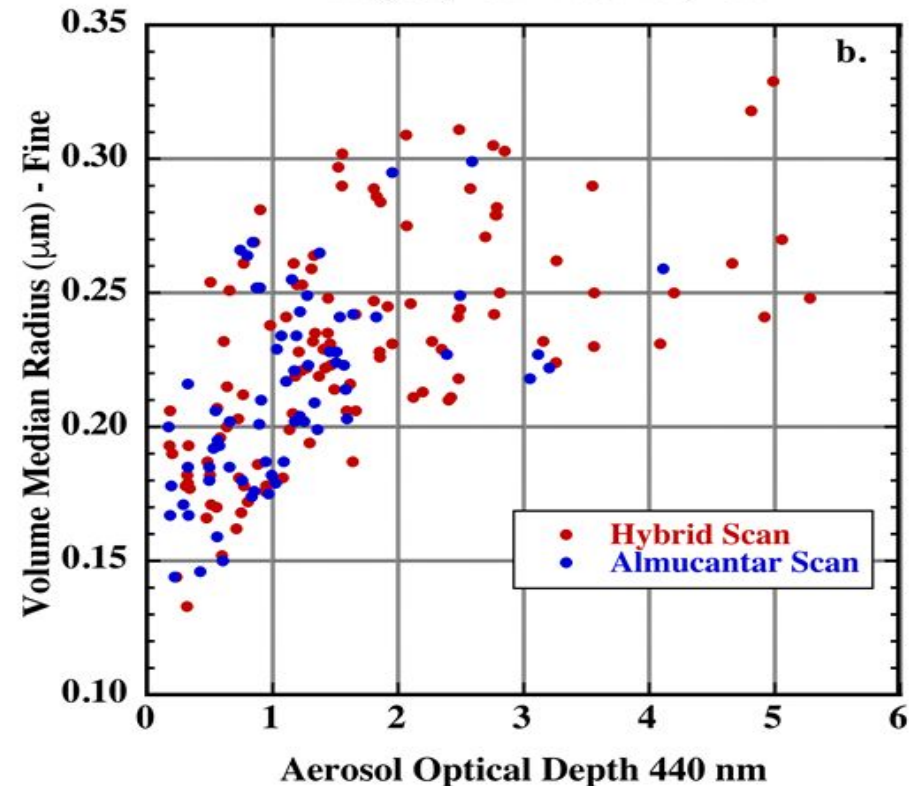
Sun photometer
3-λ nephelometer
Filter sampler-PM_{2.5}, PM₁₀

Hybrid and Almucantar Sky Scan Retrievals

Palangkaraya, Indonesia - Hybrid & Almuc Retrievals
Volume Median Fine Mode Radius
Aug 01, 2012 - Nov 15, 2015



Singapore - Hybrid & Almuc Retrievals
Volume Median Fine Mode Radius
Aug 01, 2012 - Nov 15, 2015

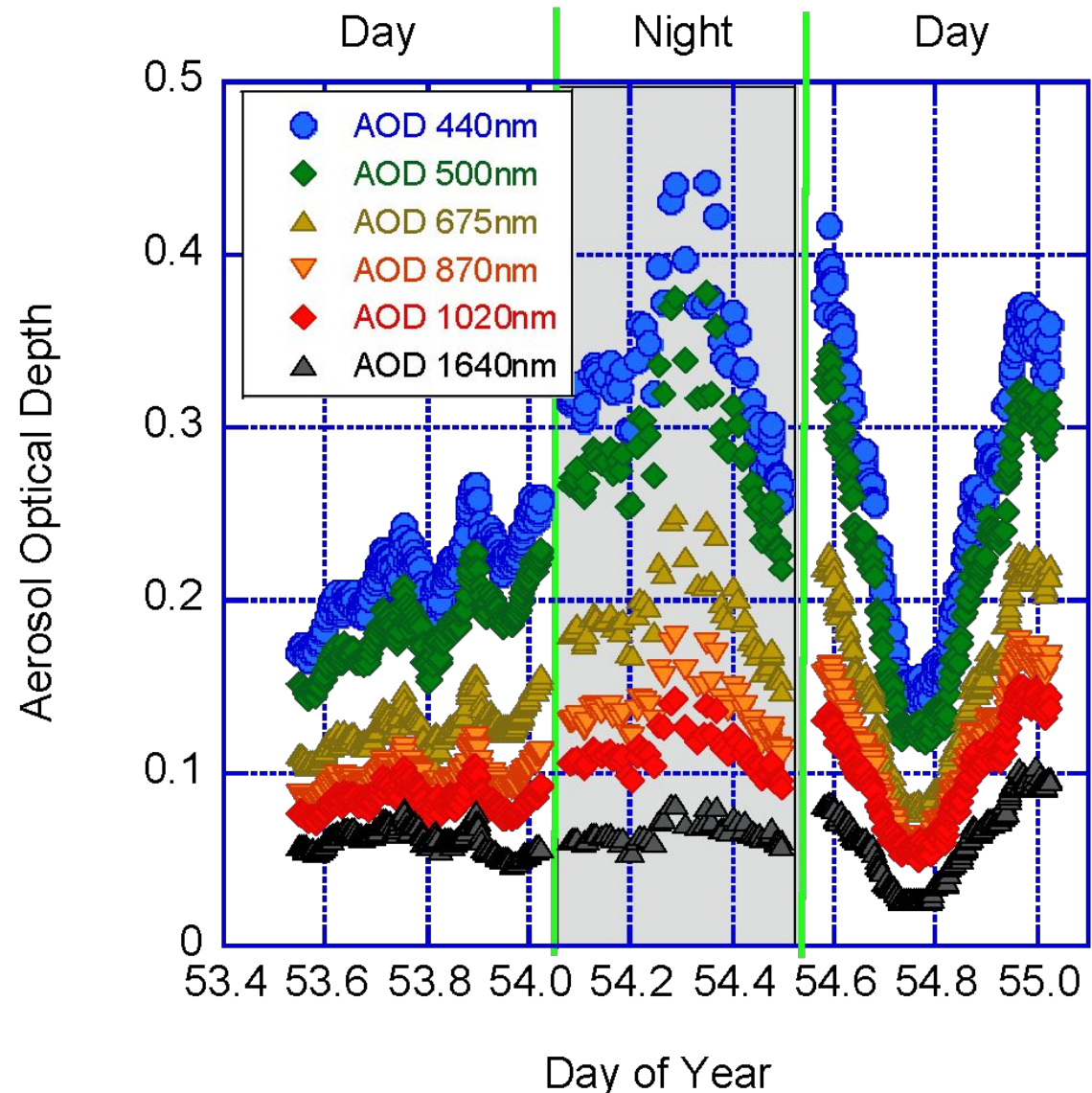


Hybrid Scan results in many more retrievals at AOD > 2 at 440 nm since Hybrid scans can be made at mid-day with low Solar Zenith Angle (SZA). Almucantar scans require SZA > 50 degrees – this results in insufficient signal to measure 440 nm AOD when AOD is very high

Provisional Lunar AOD

Kanpur, India 22–23 February 2016

- Under evaluation
 - Instrument nighttime performance
 - Lunar calibration and corrections
 - Cloud screening and quality controls



AERONET Data Applications

- Aerosol climatology – seasonal variability
- Aerosol Inversions
- Data Synergy (MPLNET)
- Atmospheric correction and evaluation (MODIS, MISR, VIIRS, OMI, ASVRN, etc.)
- Comparison to remote sensing and in situ sensors at the surface and on aircraft (SolRadNet, LARGE, PANDORA)
- Applications to air quality (SPARTAN, IMPROVE)
- Verification of aerosol transport models (GOCART, NAAPS, ICAP, MERRA)
- Utilization of aerosols in numerical weather (NCEP, ECMWF, UKMET)

http://aeronet.gsfc.nasa.gov

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AERONET

AEROSOL ROBOTIC NETWORK



+ AEROSOL OPTICAL DEPTH

+ AEROSOL INVERSIONS

+ SOLAR FLUX

+ OCEAN COLOR

+ MARITIME AEROSOL

Web Site Feature

AERONET Data Synergy Tool - Access Earth Science data sets for AERONET sites

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+ STAFF

+ SYSTEM DESCRIPTION

5 January 2018 - Version 3 Level 2.0 AOD and SDA products are now available.

11 January 2018 - Version 3 Level 1.5 and Level 2.0 Almucltar inversion products are now available

MISSION

The AERONET (AErosol RObotic NETwork) project is a federation of ground-based remote sensing aerosol networks established by [NASA](#) and [PHOTONS](#) (PHOTométrie pour le Traitement Opérationnel de Normalisation Satellitaire; [Univ. of Lille 1](#), [CNES](#), and [CNRS-INSU](#)) and is greatly expanded by networks (e.g., [RIMA](#), [AeroSpan](#), [AEROCAN](#), and [CARsNET](#)) and [collaborators](#) from national agencies, institutes, universities, individual scientists, and partners. Fo more than 25 years, the project has provided long-term, continuous and readily accessible public domain database of aerosol optical, microphysical and radiative properties for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases. The network imposes standardization of [instruments](#), [calibration](#), [processing](#) and [distribution](#).

AERONET collaboration provides globally distributed observations of spectral aerosol optical depth (AOD), inversion products, and precipitable water in diverse aerosol regimes. Version 3 AOD data are computed for three data quality levels: Level 1.0 (unscreened), Level 1.5 (cloud-screened and quality controlled), and Level 2.0 (quality-assured). Inversions, precipitable water, and other AOD-dependent products are derived from these levels and may implement additional quality checks.

The processing algorithms have evolved from Version 1.0 to Version 2.0 and now Version 3.0. The Version 3 databases are available from the AERONET and PHOTONS web sites. Version 2 data may be downloaded from the web site through 2018 and thereafter upon [special request](#). New AERONET products will be released as new measurement techniques and algorithms are adopted and validated by the AERONET research community. The AERONET web site also provides AERONET-related news, a description of research and operational activities, related Earth Science links, and an AERONET staff directory.

+ Read More



NEWS

V3 AOD, SDA,
and inversions