Aerosol Optical Depth (AOD) Measurements from a Newly Established NASA-AERONET Station in Dhaka, Bangladesh

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Overview

- The NASA AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks.
- The program provides a 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.
- NASA has about 400 AERONET stations in all over the World. We have two AERONET stations in Bangladesh.
  - Chemistry Department (MHSB), Dhaka University
  - Island of the Bay of Bengal (Bhola), Bangladesh
- CIMEL Sunphotometer can measure the sun and sky radiances at seven different wavelengths within the visible and near-infra red spectrum (340, 380, 440, 500, 675, 870 to 1020nm).

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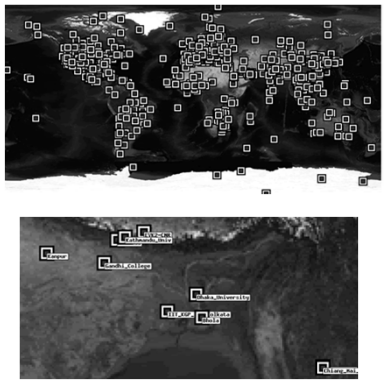
Map of the AERosol RObotic NETwork (AERONET)



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Sunphotometer on the roof of the Chemistry Department (Khondhakar Mukaram Hossain Building), Dhaka University

Sources of air pollutants: Traffic emissions, Industries, Brick kilns, Construction activities, Cooking, and Long range transport, etc.

Latitude: N 23° 43'40", Longitude: E 90°23'52, Elevation: 34.0 meters

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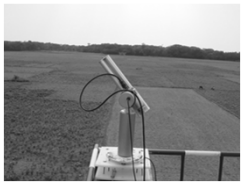
Island of the Bay of Bengal (Bhola) Observatory



- About 1 km far from nearby habitants.
- No industrial and very low traffic emission
- Biomass burning for cooking and agricultural activities, and also long range transport are the main sources of pollution.

Latitude: N 22°10'01", Longitude: E 90°45' 00", Elevation: 10.0 meters

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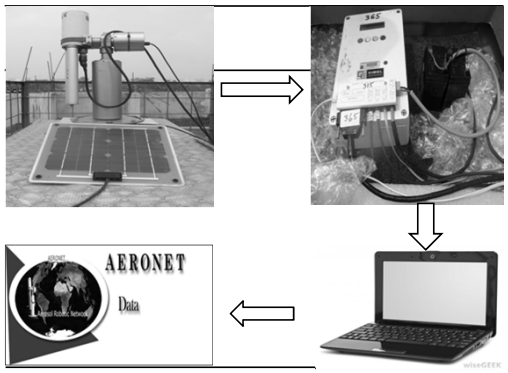

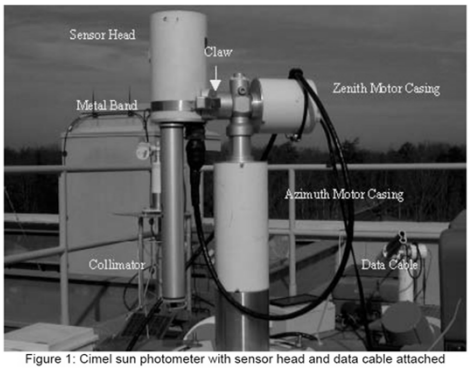

Figure 1: Cimel sun photometer with sensor head and data cable attached

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We need to give input to the Sunphotometer the exact latitude and longitude and also the GMT of the sampling location. Then it starts measuring from sun rise to sunset.

Basically, it measures the intensity of sunlight arriving directly from the Sun. The collimator are directly pointed at the Sun and measure direct sunlight.

Since haze and aerosols block some direct sunlight, a sun-photometer is an ideal instrument for measuring haze.

A hazy sky would read a lower intensity of sunlight and give a lower voltage reading on the Sunphotometer.

A clear blue sky would result in a greater intensity and a higher voltage reading on the sunphotometer.

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The following information can be obtained from Sunphotometer

- Aerosol optical depth (AOD)
- Single scattering albedo (SSA)
- Aerosol particle size distribution
- Contribution of fine and coarse particles
- Water content
- Angstrom parameters
- Brown carbon and black carbon

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Aerosol Optical Depth (AOD)

- Optical depth is defined as the negative natural logarithm of the fraction of radiation that is not scattered or absorbed on a path. It is dimensionless.
- Aerosol optical thickness is the degree to which aerosols prevent the transmission of light by absorption or scattering of light.
- Aerosol optical depth or optical thickness (τ) is defined as the integrated extinction coefficient over a vertical column of unit cross section.
- Extinction coefficient is the fractional depletion of radiance per unit path length (also called attenuation). The optical thickness along the vertical direction is also called normal optical thickness (compared to optical thickness along slant path length).

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Applications of AOD

- ❑ Air Quality
- ❑ Health and environment
- ❑ Climate change
- ❑ Monitoring of sources and sinks of aerosols
- ❑ Satellite data verification
- ❑ Monitoring of the volcanic eruptions and forest fire
- ❑ Radiative transfer model
- ❑ Energy radiation budget

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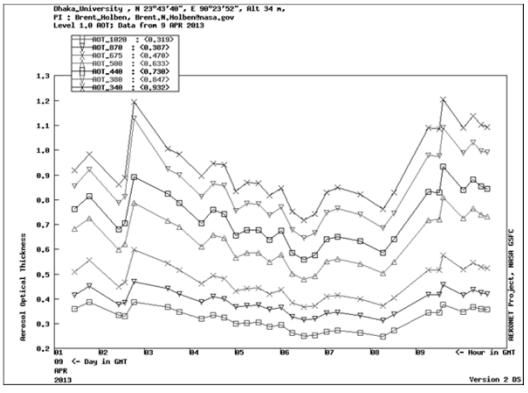
Typical Daily Aerosol Optical Depth (AOD) Variation in Dhaka with Sunphotometer



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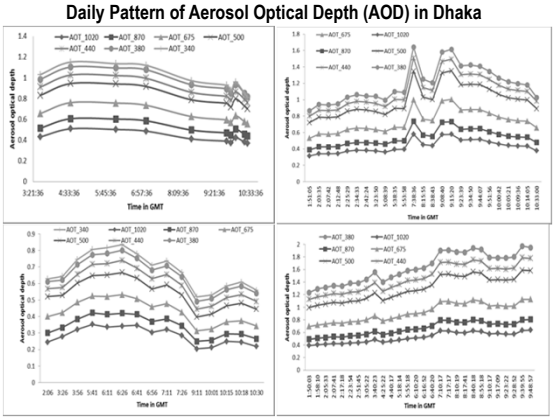
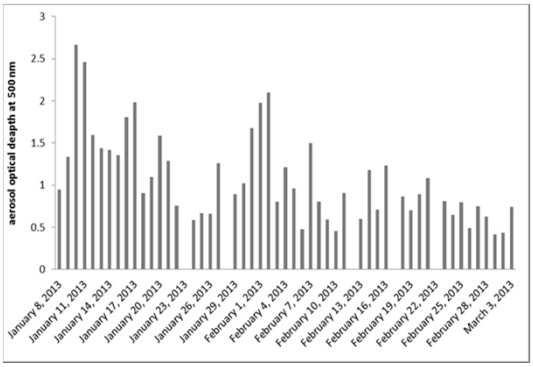
Daily Pattern of Aerosol Optical Depth (AOD) in Dhaka



Variation of AOD at 500 nm in Dhaka, BD



Monthly Average of Aerosol Optical Depth (AOD) at Seven Wavelengths in Dhaka

Wavelength	340	380	440	500	675	870	1020
Jun-12	1.464	1.401	**1.271**	**1.175**	0.947	**0.83**	0.756
Jul-12	0.557	0.534	**0.489**	**0.467**	0.39	**0.362**	0.333
Aug-12	0.579	0.557	**0.518**	**0.487**	0.426	**0.405**	0.381
Sept-12	0.906	0.875	**0.812**	**0.748**	0.625	**0.559**	0.511
Oct-12	0.84	0.798	**0.71**	**0.623**	0.446	**0.336**	0.267
Nov-12	1.021	0.983	**0.885**	**0.78**	0.551	**0.396**	0.309
Dec-12	0.872	0.853	**0.778**	**0.69**	0.496	**0.365**	0.295
Jan-13	1.238	1.21	**1.115**	**1.008**	0.76	**0.572**	0.464
Feb-13	0.905	0.856	**0.757**	**0.659**	0.472	**0.357**	0.287
Mar-13	1.137	1.063	**0.93**	**0.806**	0.571	**0.431**	0.344
Apr-13	1.145	1.061	**0.922**	**0.802**	0.582	**0.462**	0.386
May-13	1.201	1.111	**0.971**	**0.854**	0.635	**0.52**	0.447
Ave	**0.989**	**0.942**	**0.847**	**0.758**	**0.575**	**0.466**	**0.398**

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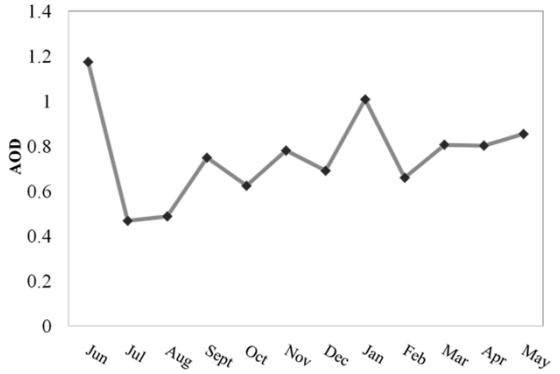
One year monthly Average AOD in Dhaka, BD at 500 nm



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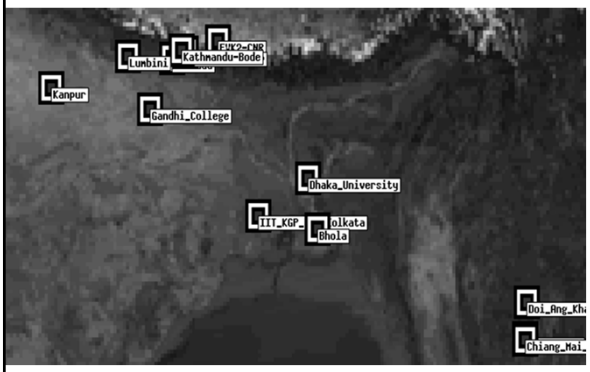

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AOD values at 500 nm for the year of 2012 at Different Locations

	Dhaka	Kanpur	Lahore	Halifax	Hanimadho	Kathmundhu-bode
Jun-12	**1.175**	**0.871**	**0.690**	**0.200**		
Jul-12	**0.467**	**0.866**	**0.682**	**0.188**	**0.441**	
Aug-12	**0.487**	**0.849**	**1.004**	**0.220**	**0.609**	
Sept-12	**0.748**	**0.671**	**1.092**	**0.138**	**1.395**	
Oct-12	**0.623**	**0.771**	**0.549**	**0.138**	**1.913**	
Nov-12	**0.780**	**0.932**	**0.734**	**0.089**		
Dec-12	**0.69**	**0.705**	**0.431**	**0.137**	**0.482**	**0.256**
Jan-13	**1.008**	**0.903**	**0.733**	**0.083**	**0.451**	**0.381**
Feb-13	**0.659**	**0.565**	**0.488**	**0.115**	**0.369**	**0.363**
Mar-13	**0.806**	**0.367**	**0.478**	**0.259**	**0.438**	**0.598**
Apr-13	**0.802**	**0.623**	**0.629**	**0.186**		**0.757**
May-13	**0.854**	**0.679**	**0.629**	**0.117**		**0.565**
average	**0.758**	**0.734**	**0.678**	**0.156**	**0.762**	**0.487**

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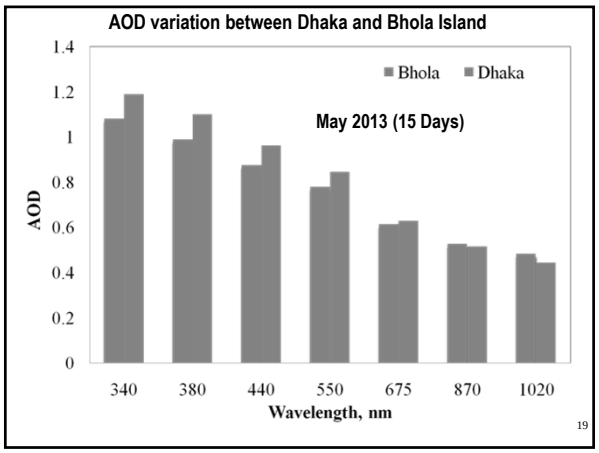

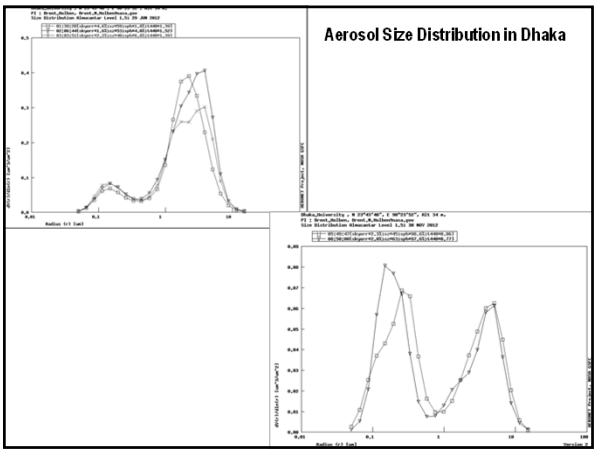

Single Scattering Albedo (SSA)

Definition:

Single scattering albedo is the ratio of scattering optical depth to the total optical depth (scattering+extinction) of the atmosphere. It is a dimensionless quantity and ranges from 0 to 1.

Applications:

- ❑ **Computation of scattering phase function**
- ❑ **Characteristics of the aerosol particles**
- ❑ **Radiative transfer model**
- ❑ **Earth radiation budget study**

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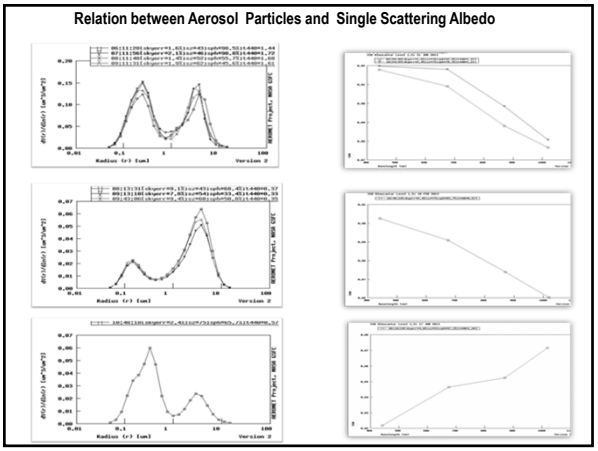
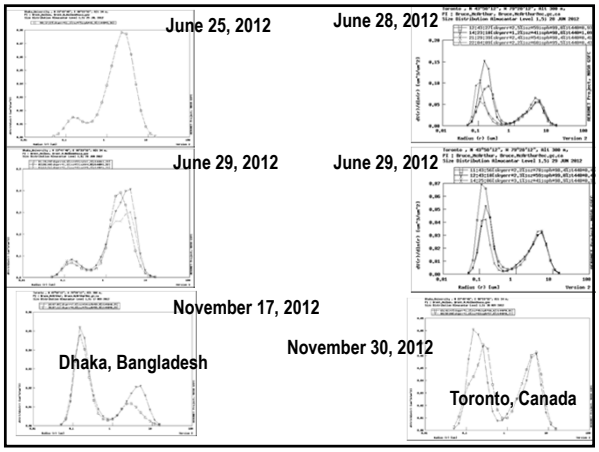
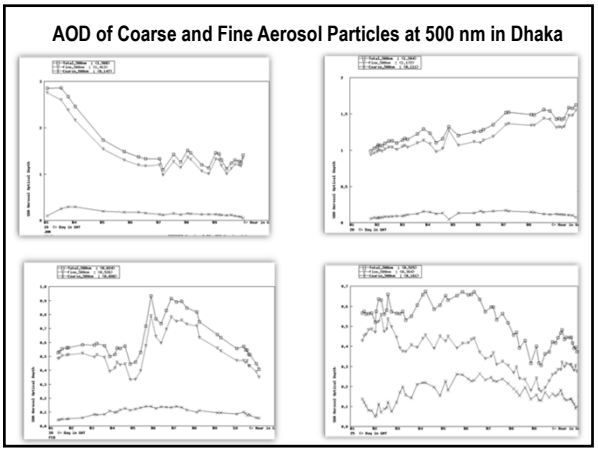
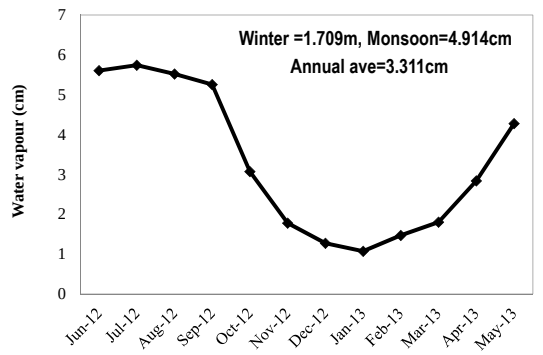






Water vapour in Dhaka, BD



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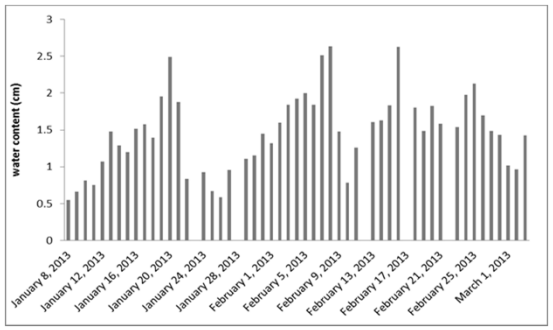
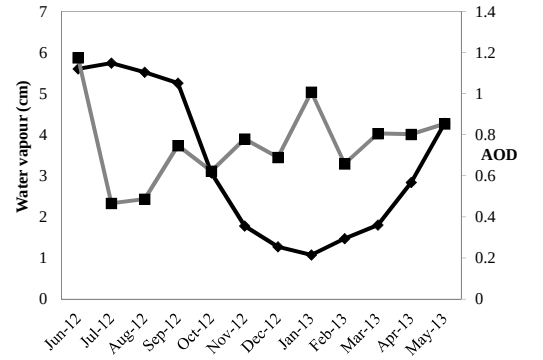
Daily variation of water vapor content (cm) in Dhaka, BD



Monthly average AOD and Water Vapour (cm)



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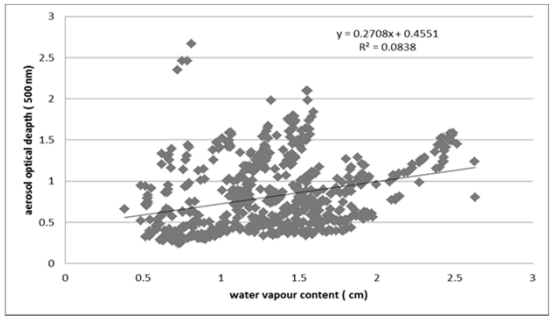
Relationship between water vapor (cm) and AOD (500 nm) in Dhaka, BD



Angstrom exponent

Ångström exponent is an exponent in a formula that is usually used to describe the dependency of the aerosol optical thickness or aerosol extinction coefficient on wavelength. The spectral dependence of the aerosol optical thickness depending on particle size distribution is given by

$$\frac{\tau_\lambda}{\tau_{\lambda 0}} = \left(\frac{\lambda}{\lambda_0}\right)^{-\alpha}$$

Where, T_λ is the optical thickness at wavelength λ, and $T_{\lambda o}$ is the optical thickness at the reference wavelength λ_o.

For measurements of optical thickness $T_{\lambda 1}$ and $T_{\lambda 2}$ at two different wavelengths λ_1 and λ_2 respective ponent is given by

$$\alpha = -\frac{\log \frac{\tau_{\lambda 1}}{\tau_{\lambda 2}}}{\log \frac{\lambda_1}{\lambda_2}}$$

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- The Ångström exponent is inversely related to the average size of the particles in the aerosol: the smaller the particles, the larger the exponent.
- Ångström exponent is a useful quantity to assess the particle size of atmospheric aerosols/clouds, and the wavelength dependence of the aerosol/cloud optical properties.
- This exponent is now routinely estimated by analysing radiation measurements acquired on earth observatory through AERONET.

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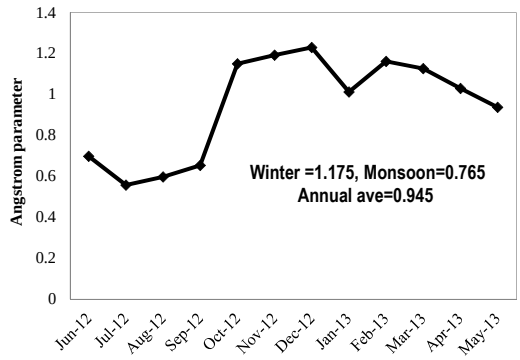
Angstrom Parameter in Dhaka, BD



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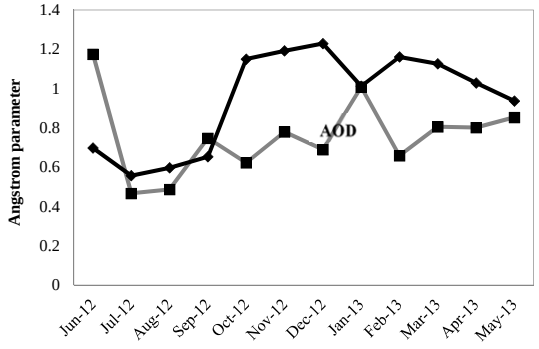
Relation between angstrom exponent and AOD (monthly average)



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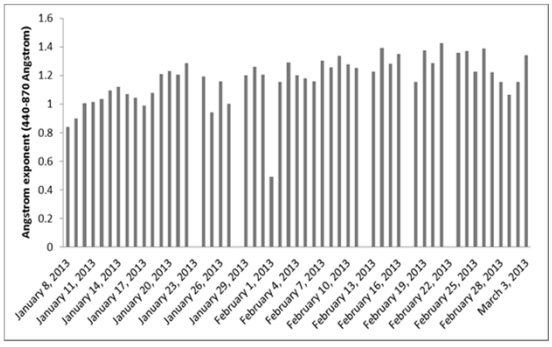
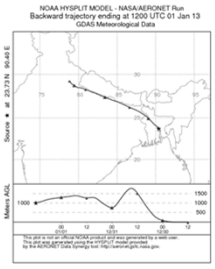
Variation of the Angstrom exponent in Dhaka, BD

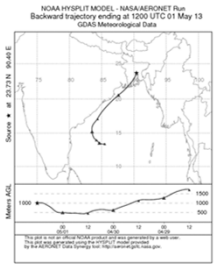


Information Regarding Trans Boundary Pollution from AOD Measurements

AOD at 500nm: 1.223

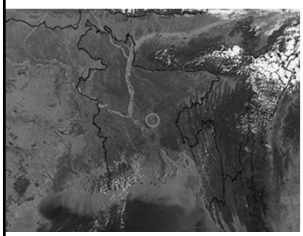


AOD at 500nm: 0.893

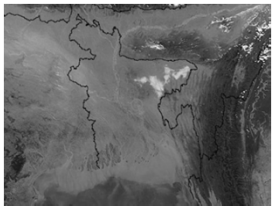


Distinguish between Clear and Hazy day

TERRA-MODIS Pictures



Clear Day
AOD at 500nm on March 19, 2013: 0.522



AOD at 500nm on January 12, 2013: 1.255
Hazy day

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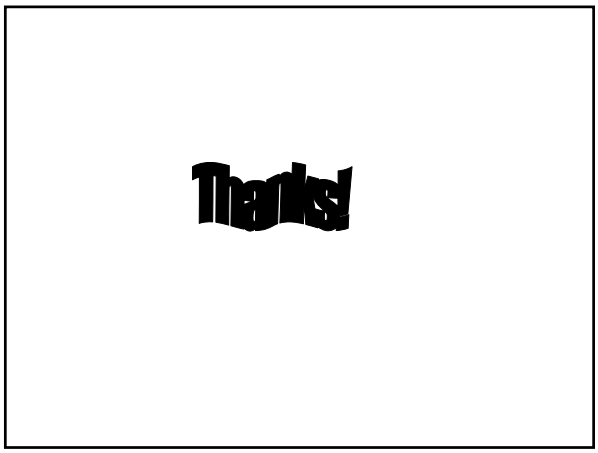
Conclusion

- **Very high AOD values were observed in Dhaka. Dhaka AOD is slightly higher compared than other south Asian locations, but much higher compared to North Armenian site**
- **Bimodal size distributions were observed in most of the cases. Coarse particles are dominating in monsoon months.**
- **Clear and Hazy Day can be distinguish from AOD measurements**
- **AOD measurements showed that Dhaka aerosol has a significant contribution from Trans boundary pollution.**


Thanks!