AERONET DATA ANALYSIS

ASL720: Project Report

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Introduction:

AErosol RObotic NETwork (AERONET) data has been analyzed over three sites in India.

1. Kanpur, which is one of the largest industrial cities in the Indo-Gangetic basin.

2. Jaipur, which is in the vicinity of the Thar Desert.

3. Pune, which is located at about 100 km from the west coast of India.

Site selection is based on the criteria that we would be able to get contrasting aerosols type at different locations. Pune has been selected as we were not able to get "Level 2.0" data for all the required aerosol parameters for sites over the Indian Ocean.

Aerosol Optical Depth (AOD) values are used to estimate aerosol concentration. And major aerosol types are identified and characterized by their microphysical (particle size) and optical (SSA) properties. The seasonal variability of aerosol parameters is also analyzed along with the possible reasons.

Data:

Data has been taken from site: http://aeronet.gsfc.nasa.gov/
Level 2.0 data is used.

Following parameter values are used:

Year: ***2011***

i. Monthly mean aerosol optical depth (AOD at 500 nm)
ii. Corresponding Angstrom Exponent (AE at 440–870 nm),
iii. Single Scattering Albedo (SSA at 4 wavelengths)
iv. Precipitable Water (The total water vapor in the column derived from the 935nm channel)
v. Fine Mode Fraction (FMF at 500nm)
vi. Size distribution

Fine Mode Fraction:

The fine mode fraction value (ranges from 0 to 1) provides quantitative information on the nature of the size distribution of aerosol particles in the atmosphere. When FMF = 1, it represents pure accumulation mode particles (below 1 μm which are formed due to gas to particle conversion mainly from anthropogenic activities and produce sulfate, black carbon, organic carbon, nitrates, etc.); whereas FMF = 0 represents single coarse mode particles (originating from natural sources such as wind-blown mineral dust and sea salt). Any intermediate FMF value represents a bimodal type particle distribution, where both accumulation and coarse modes can contribute to the total AOD in proportion.

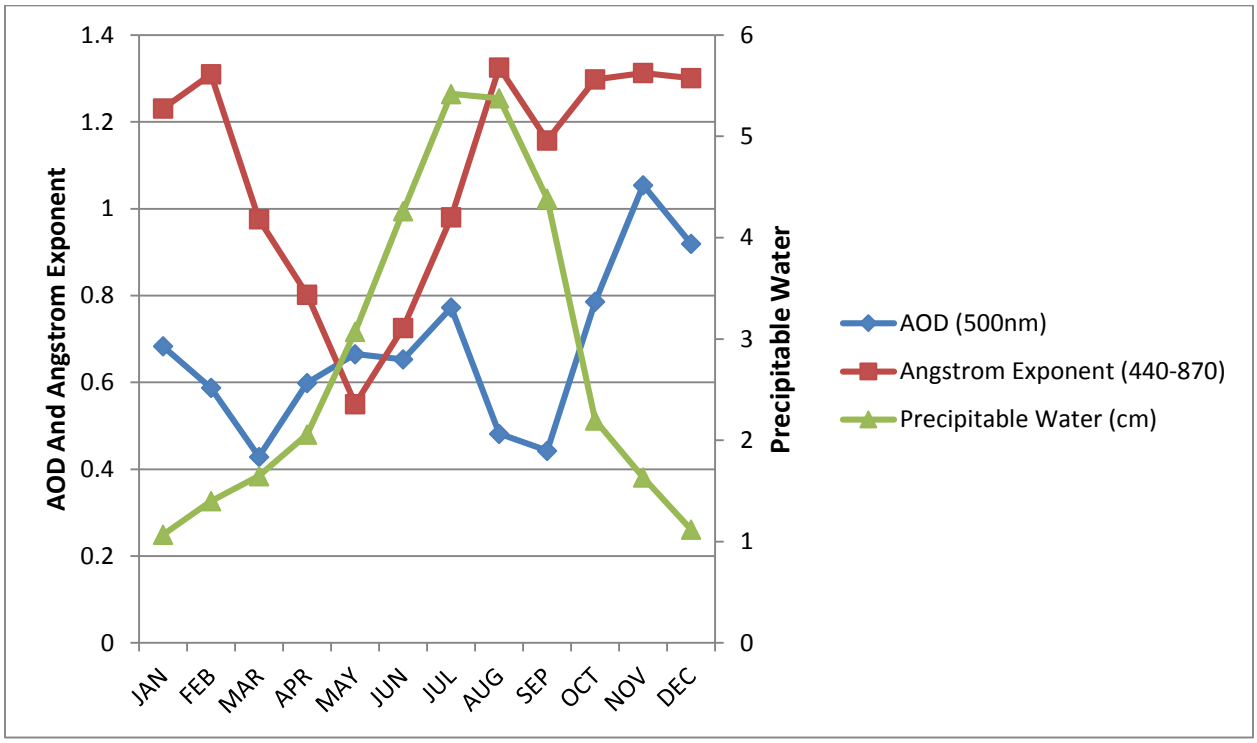
Kanpur

Kanpur is an industrial city situated in the Indo-Gangetic basin. Kanpur is a representative site of the Ganga basin in terms of the weather conditions and atmospheric Seasonal variability.

Why Kanpur?

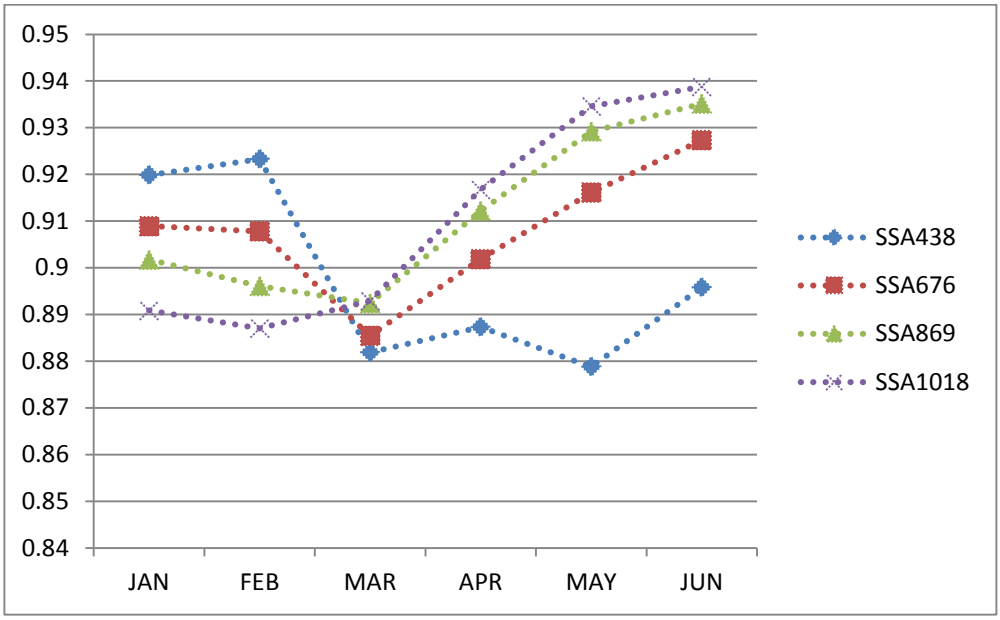
Kanpur represents urban and industrialized area in India. Also, the data for Kanpur is very easily available.

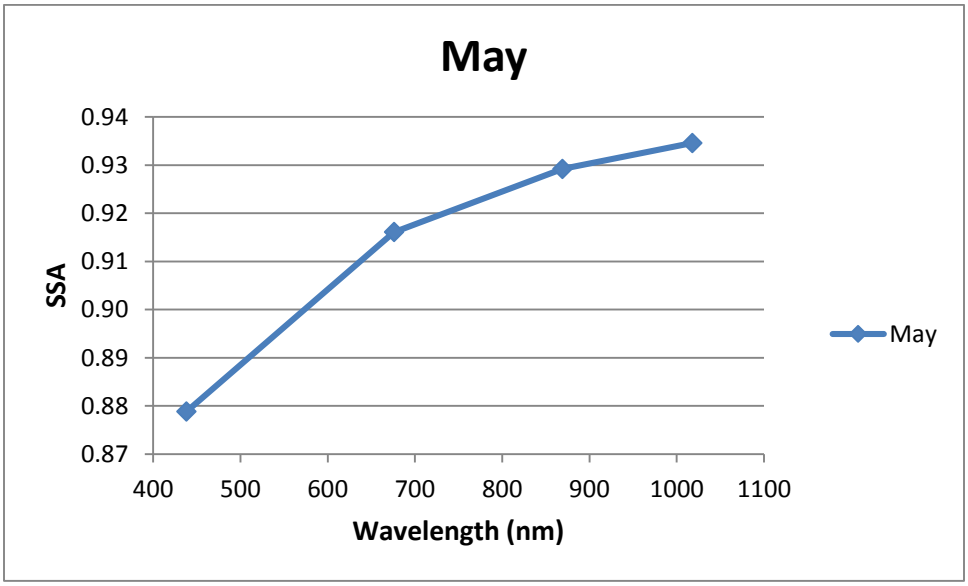
AOD and AE:

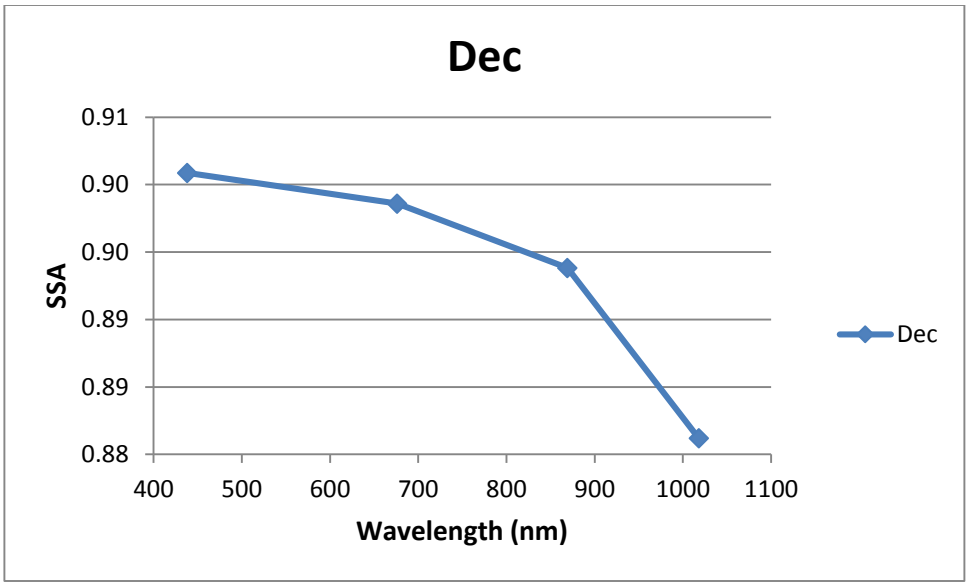


- AOD represents concentration of aerosol.
- Aerosols concentration is high from April to July that is in the summer.
- In monsoon, we see a sudden decline in the aerosol concentration.
- Also, Angstrom Exponent is low during this period, indicating large sizes of aerosols.
- Again, there is an increase in the concentration of aerosols from September to November. Angstrom Exponent is high during this period suggesting fine particles.
- The sudden decline is due to monsoon season. Perceptible water is high, indicating high fall of rain taking more and more particles to the ground. Thus, aerosol concentration decreases.

SSA Plots (for sensitive months)



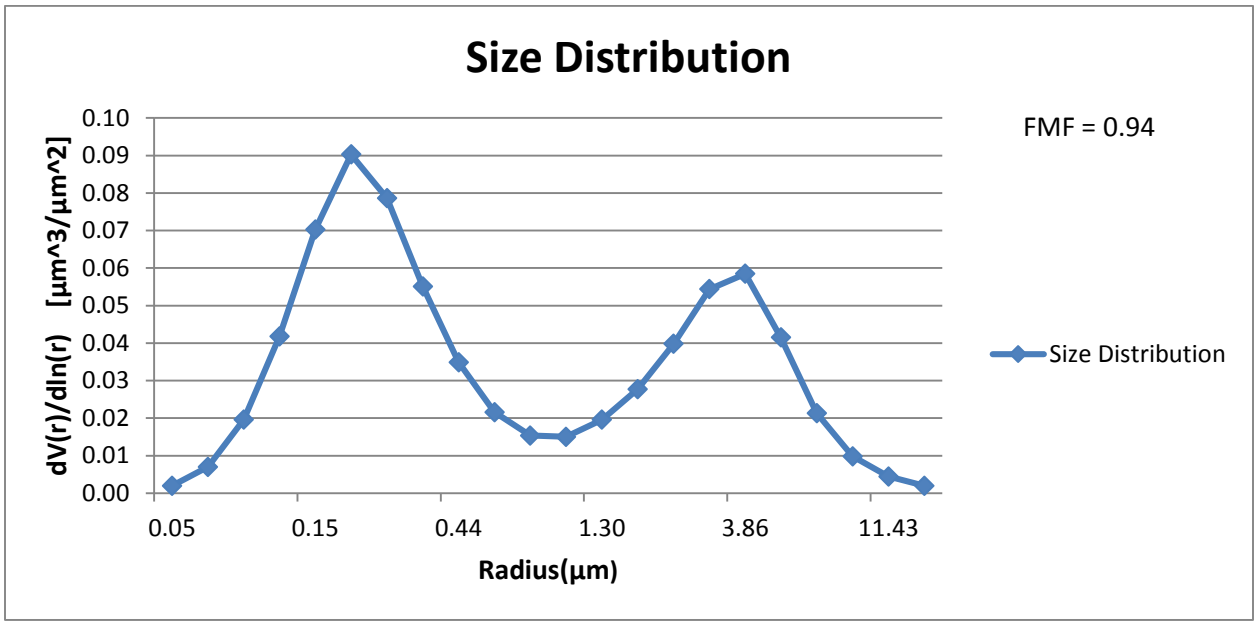




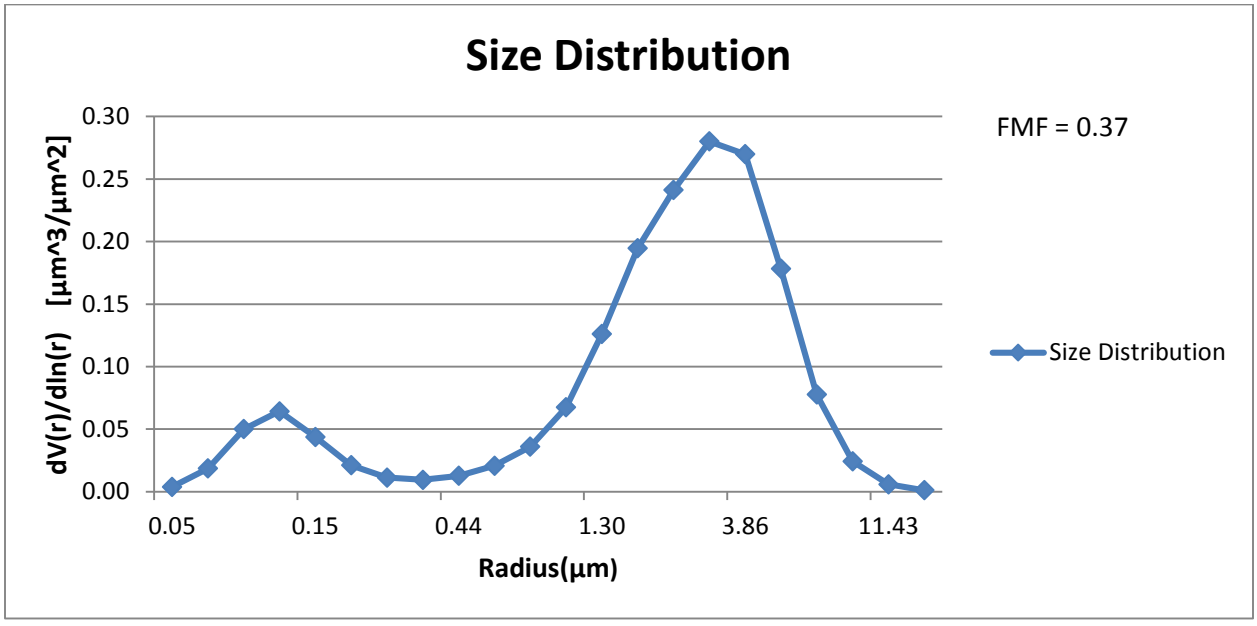
Analysis:

- In May, we see that SSA values are high indicating scattering aerosols are dominating.
- Higher wavelength have higher SSA implies coarser aerosols are dominating.
- In December, SSA values are high indicating scattering aerosols are dominating.
- Higher wavelengths have low SSA values implying finer aerosols are dominating.
- Also, there is a transition period in March which defines the arrival of coarser particles indicated by scattering by the large size particles. This is reasoned by travelling dust particles from Thar Desert.

Size Distribution Plots:



December



May

Aerosol Identification:

- Increase in the AOD from April to July is due to dust particles travelling from Thar Desert to this region. Also, dust is the reason for the large size of aerosols.
- Increase in the AOD from September to November is because of the air mass flowing from north and northwest bringing finer continental aerosols. During this season, northern India have western disturbances, moving from west to east, leading to intense fog and haze in the region.

Jaipur

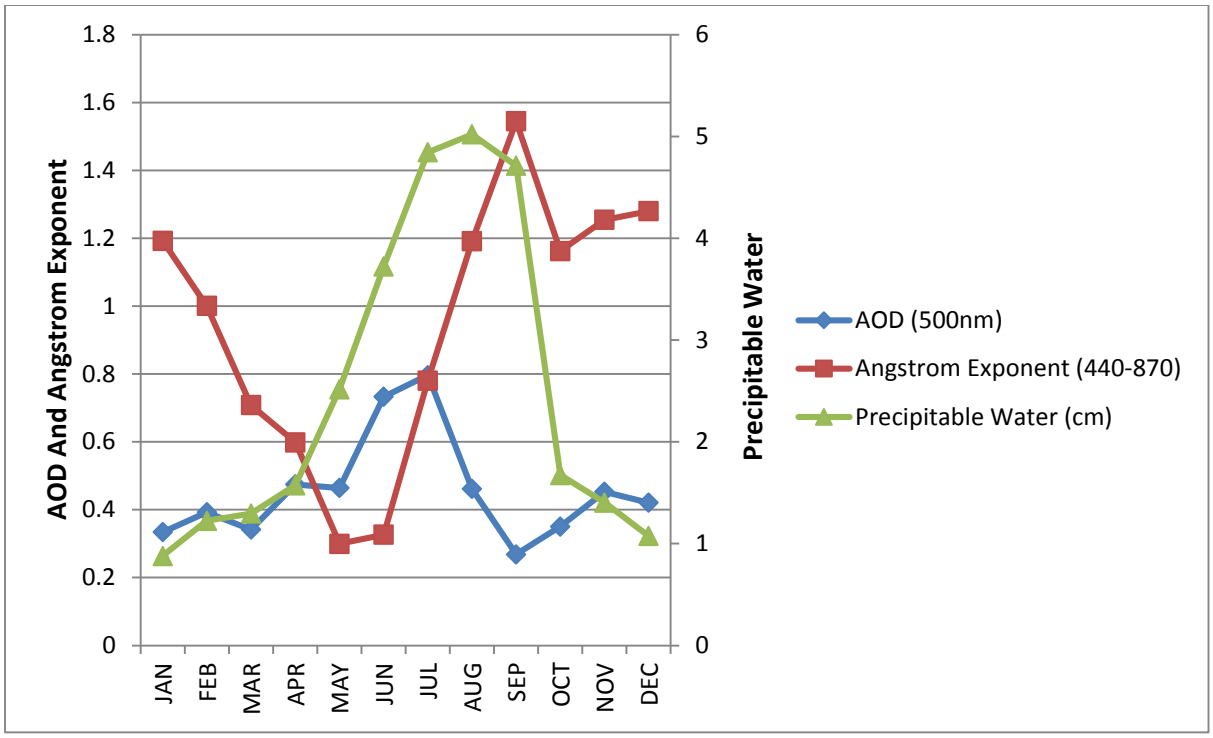
Jaipur, the capital of Rajasthan (desert state) in northwestern India, experiences seasonal dust storms every year due to its location downwind of the Thar Desert.

Why Jaipur?

The dust storms are frequent and play a dominant role in climatology of the area. There is enhanced pre-monsoon aerosol loading, comprising mineral dust and other anthropogenic carbonaceous and sulfate components. Therefore aerosol measurements over Jaipur are very important to understand the variability of optical properties in vicinity of dust source region. In addition, information of aerosol optical properties near desert regions is of great importance to ascertain the aerosol scattering/absorbing nature.

Aerosol Optical Properties

During winter, Angstrom exponent was high, indicating presence of fine mode particles. During pre-monsoon season AOD is high and Angstrom exponent is very low, indicating a relatively high ratio of large particles to small particles due to dust loading in this season. During monsoon, AOD decreases as rain brings down aerosol present in the atmosphere. Also due to the same reason, Angstrom exponent decrease during the period as coarser particles are brought down.



The large variation in temperature and scanty rainfall for a prolonged period cause weathering of the soil and the loose dust is picked by the winds as they grow stronger. Dust loading due to Thar Desert leads to relatively higher AOD values in pre-monsoon season than other seasons.

Aerosol Volume Size Distribution

The dominance of the particles with size range >1.5 µm is clearly evident during the pre-monsoon season, which implies that volume concentration in the coarse mode is much higher than that of the fine mode during pre-monsoon seasons over the region. The dust storms lead to large increases in the volume concentration at the coarse mode. As a result, the total particle volume concentration at the coarse mode is increased by 75 % relative to fine mode particles.

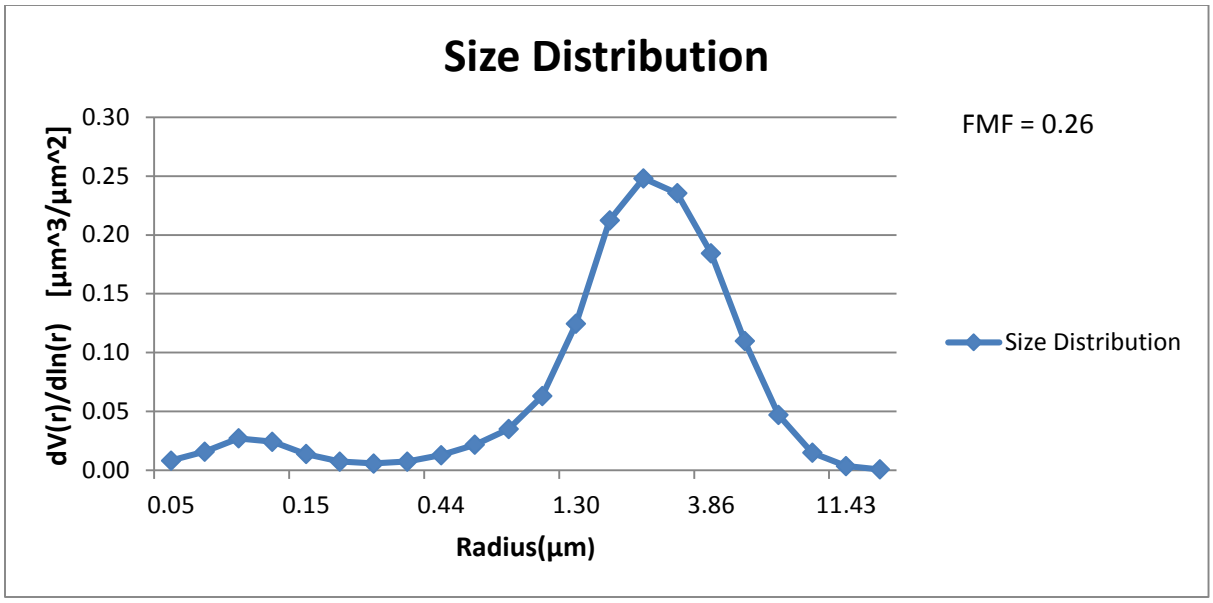


Figure: Volume size distribution in May

In winter, we have finer absorbing aerosols which can due to biomass burning, bio fuel and continental aerosols can also be present in the mixture.

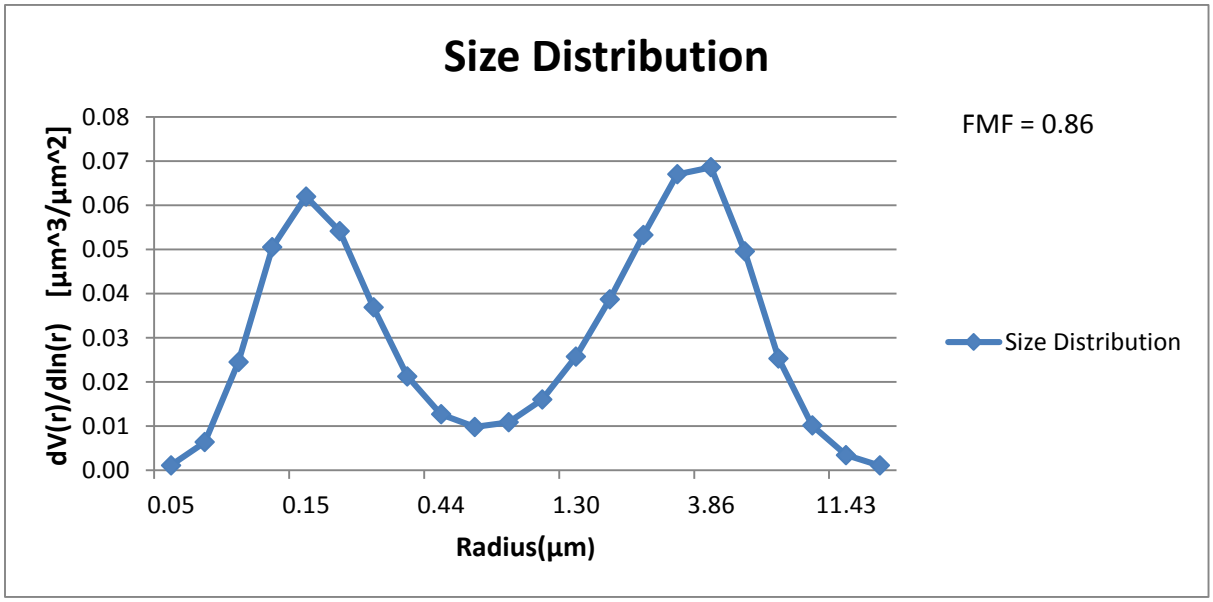
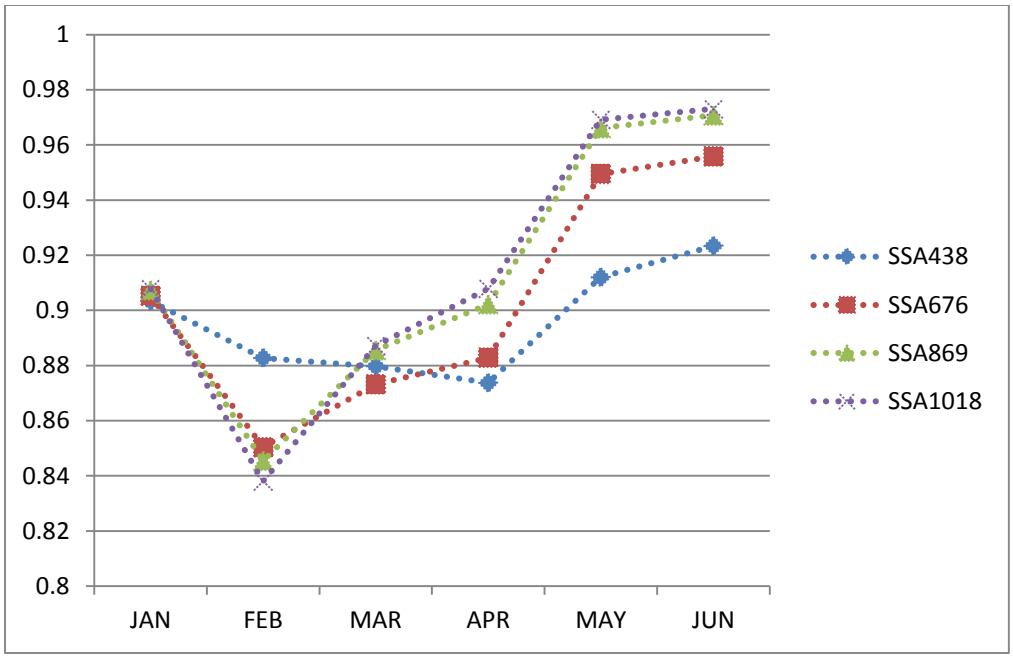


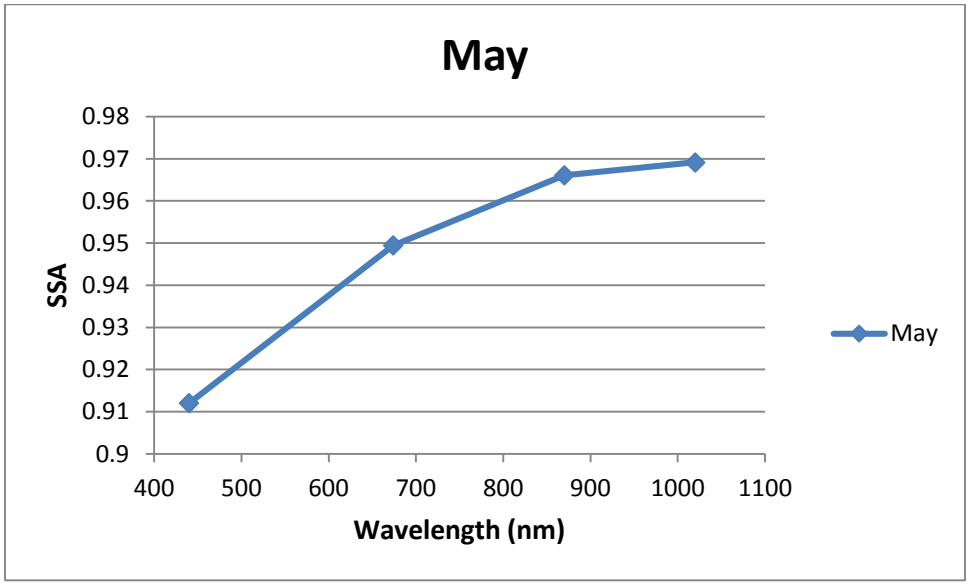
Figure: Volume size distribution in December

Single Scattering Albedo

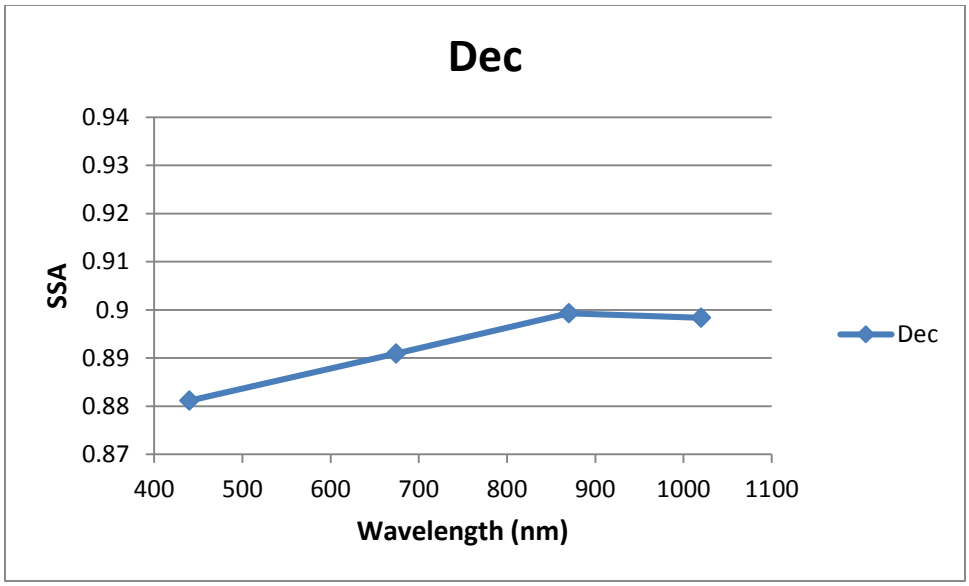
The graph below shows a transition from fine to coarse particles during pre-monsoon period (positive slope of SSA for 1018nm and negative slope for 438nm).



Wavelength dependency of SSA with higher values (>0.95) in the near-infrared range compared to lower values at shorter wavelengths (especially at 440 nm associated with enhanced absorption of iron oxide within dust particulates) indicates the dominance of high dust loading. The average values of SSA at 675–1,020 nm wavelength are found to be 0.968 during May, indicating that the period is dominated largely by the presence of scattering aerosols.



The slope of SSA spectra has been found to be reduced in the non-monsoon season in accordance with the AOD spectrum. SSA is less during this period, indicating dominating presence of absorbing aerosols.



Transport

Back trajectory of transport of dust particles can provide with the possible origin/ sources of dust. Dust storms in the IGP during the pre-monsoon season have been associated with dusts lifted mainly from the Thar Desert and also long-range transport from far western arid regions of the Arabian Peninsula and Oman. A synoptic air mass flowing southwesterly during pre-monsoon season results in frequent dust loading.

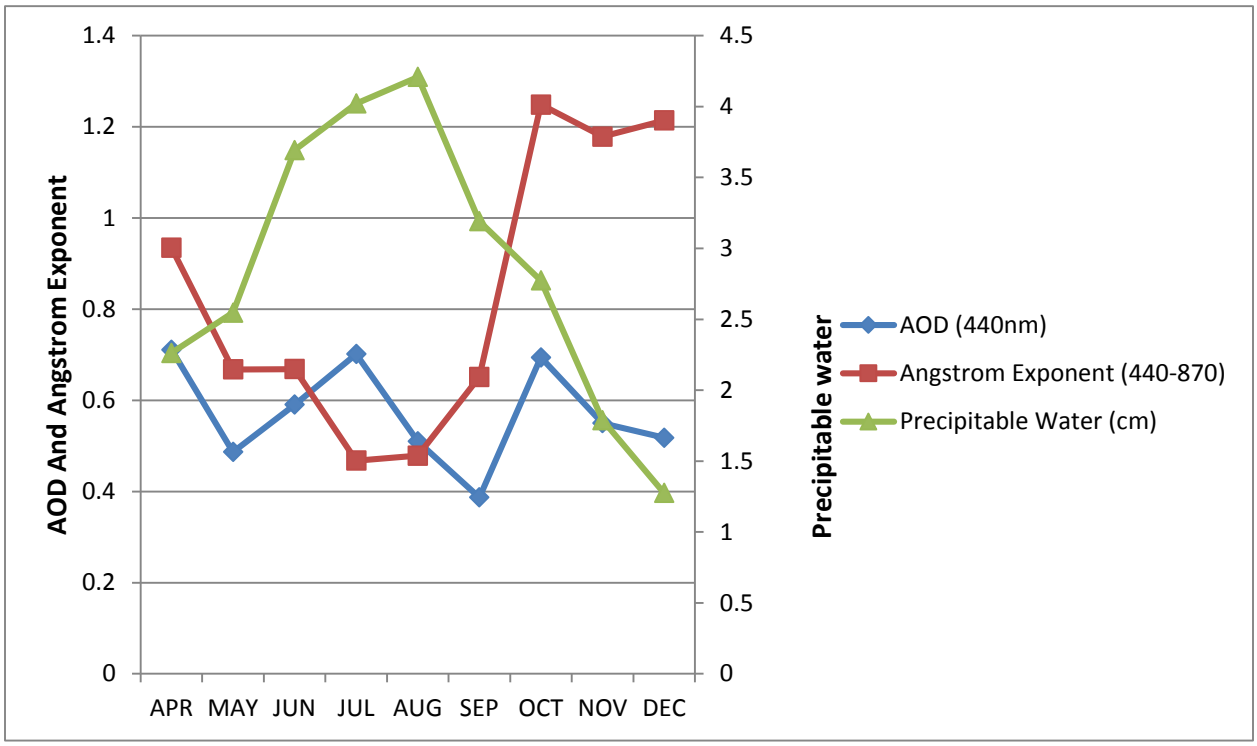
Pune

Pune is located about 100 km from the west coast of India and leeward side of the western ghats. It has tropical wet and dry climate.

Why Pune ?

We selected Pune because it is near to sea and we expected to see maritime aerosols.

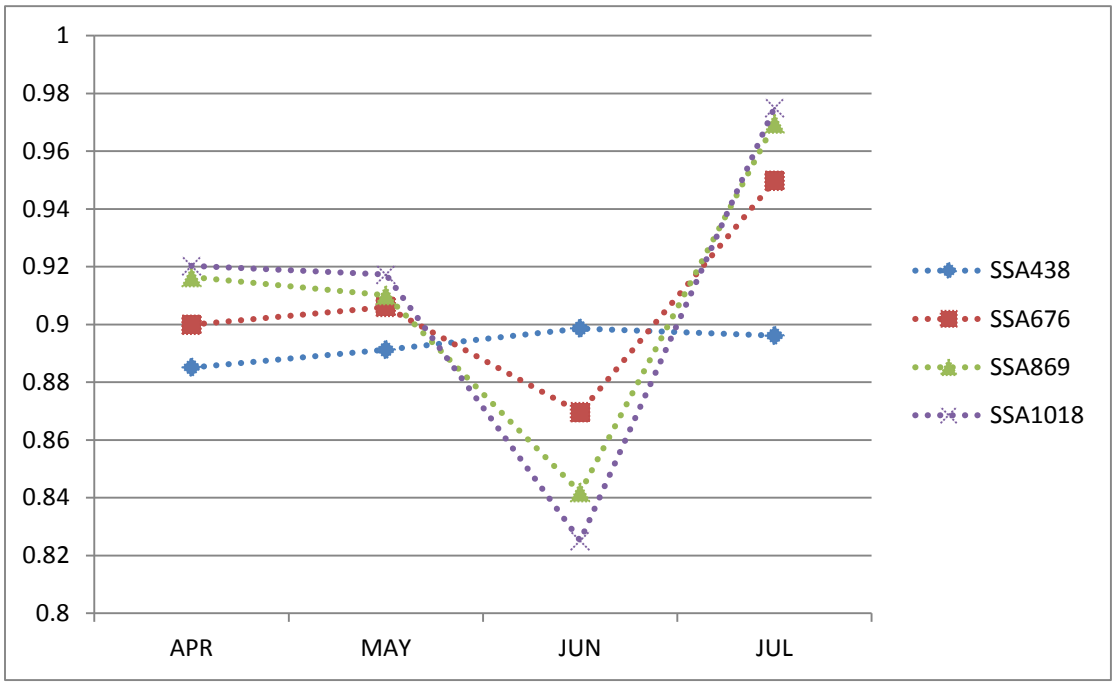
AOD and AE plots:

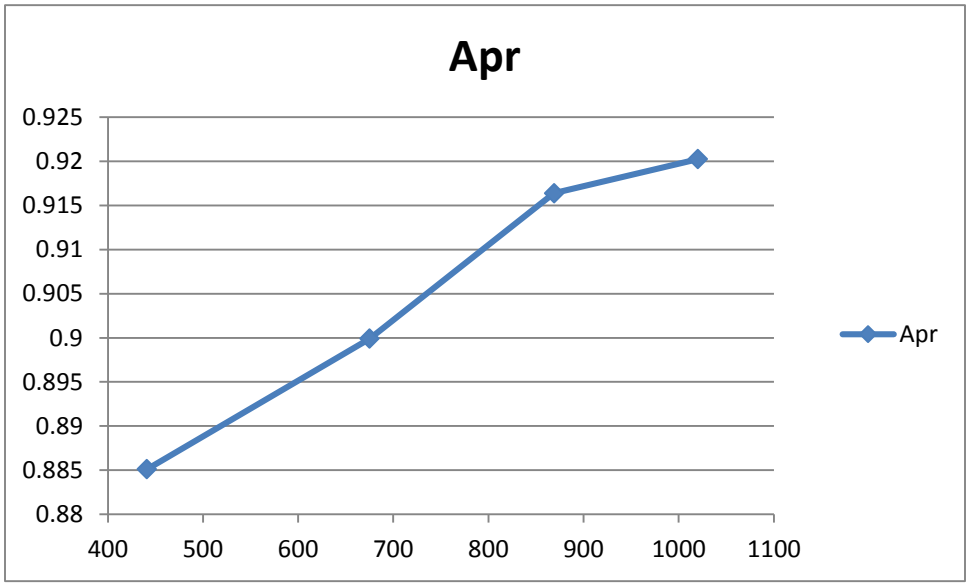


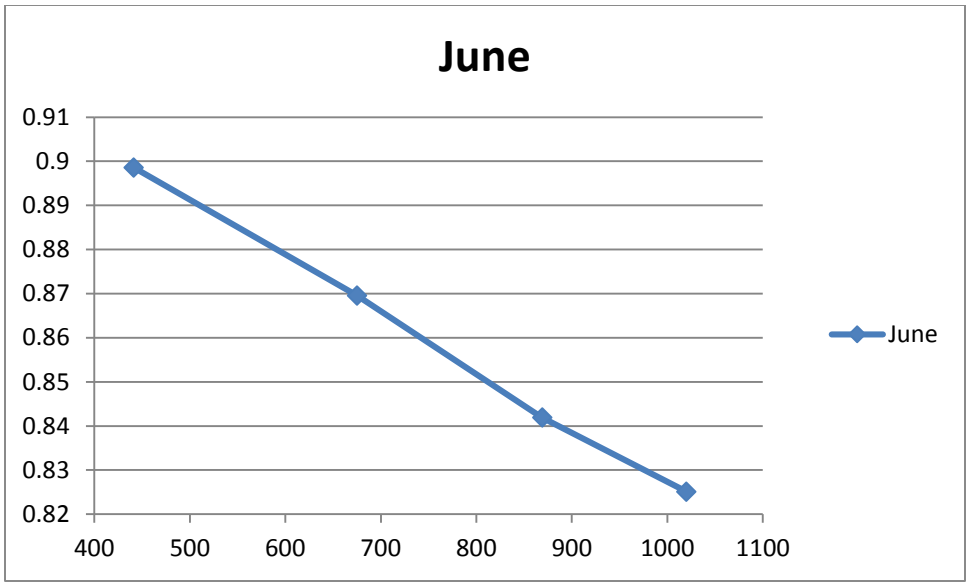
Analysis :

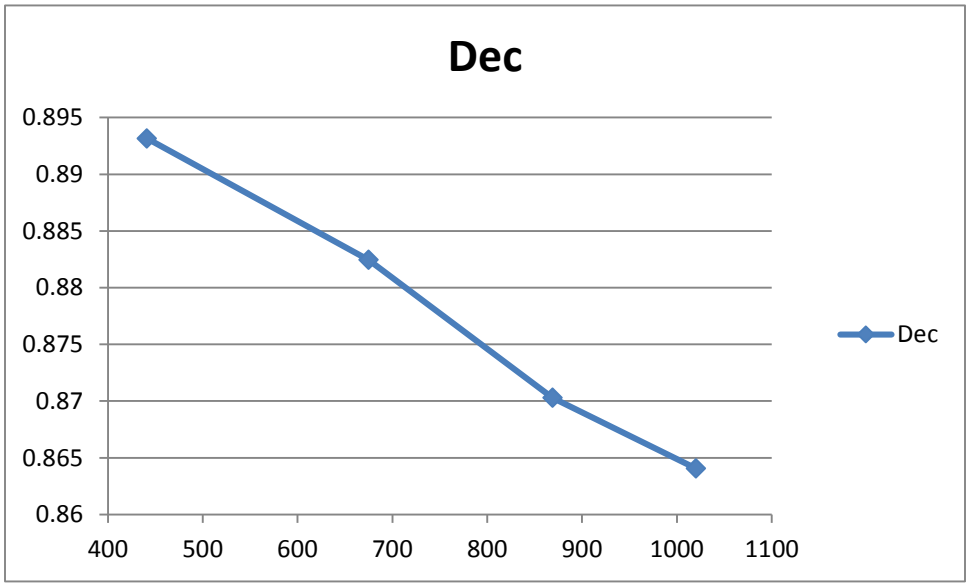
- In winters AE is high implies finer aerosols are dominating.
- In summers AE is small implies coarser aerosols are dominating.
- AOD drastically decreases in monsoon. As rain water brings down the aerosols present in atmosphere, hence we have low concentration of aerosols (lower AOD).
- Finer aerosols dominate during monsoon because coarser aerosols easily come down with water.

SSA plots(for sensitive months):



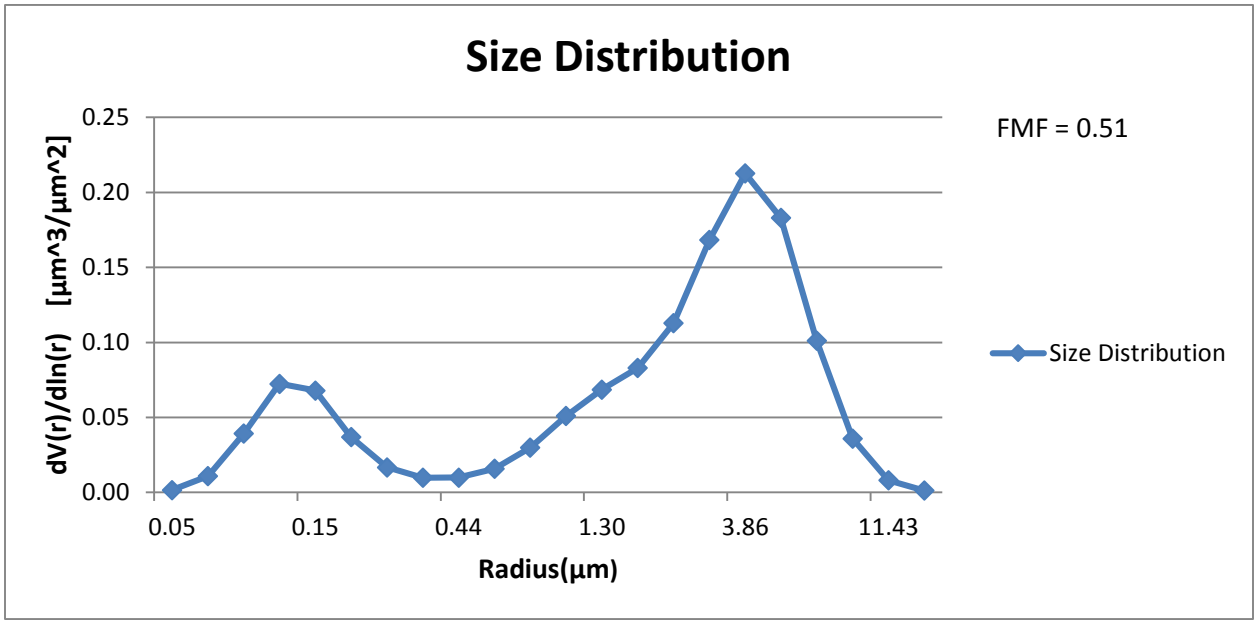




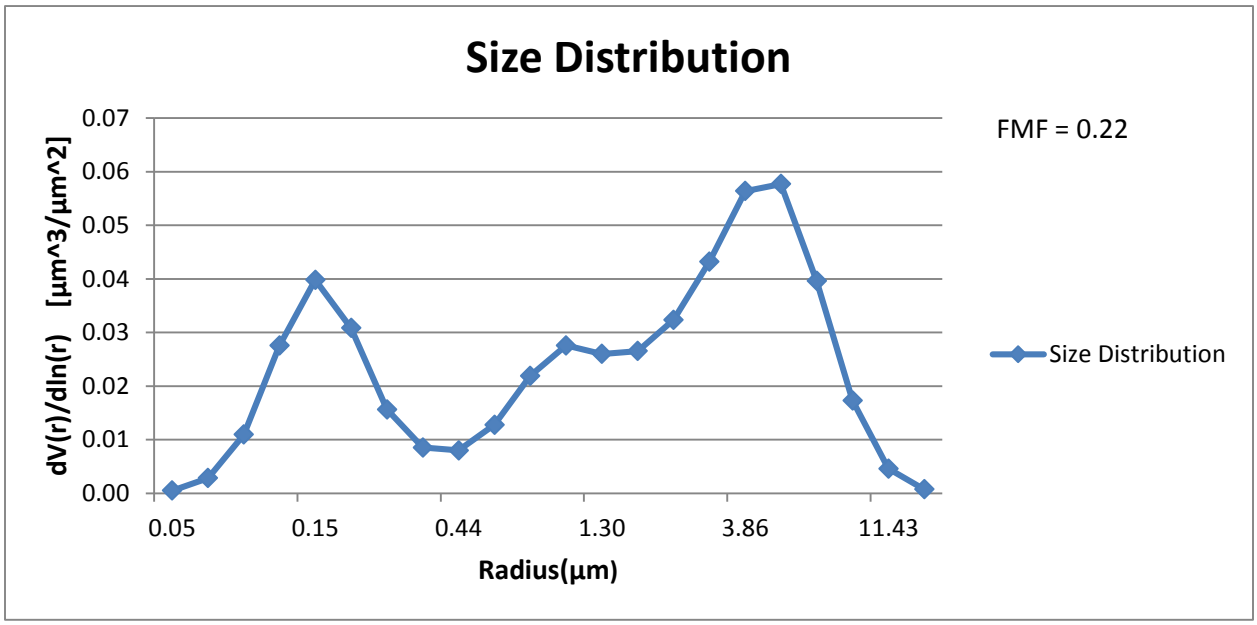


- In summer (April – May) SSA values are low, implies absorbing aerosols are dominating.
- In summer higher wavelength have higher SSA (are scattered more) implies coarser aerosols are dominating.
- After May we have a transition because rain brings down most of the coarser aerosols and hence in June higher wavelength are scattered less compared to lower wavelengths.
- In July suddenly higher wavelengths are scattered more compared to lower wavelengths implies coarser aerosols suddenly dominate.

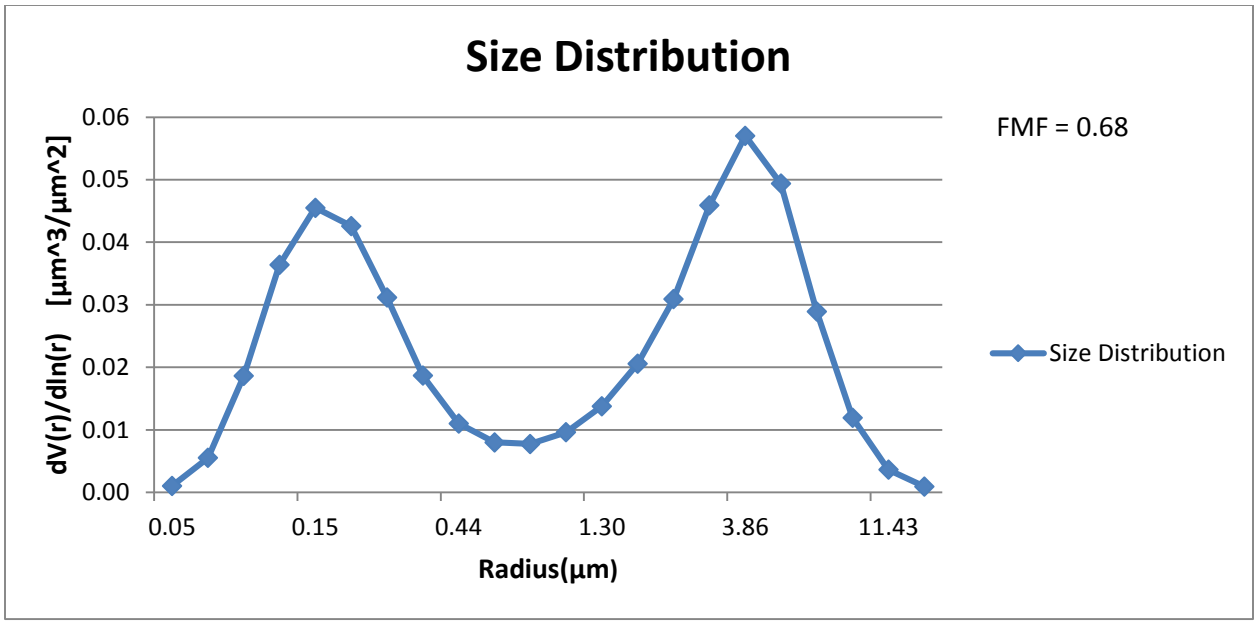
Size distribution graphs :



April



June



December

Aerosol identification :

- In summer, we have abundance of absorbing coarser aerosols such behaviour because of presence of **Dust**, which is due to local activities like urbanization, industrialization and construction activities or wind-blown dust due to strong surface heating.
- In winter, we have a mixture of finer and coarser aerosols which can due to **biomass burning**, bio fuel and continental aerosols can also be present in the mixture.
- During monsoon, we have coarser aerosol, this can be due to **maritime aerosols**. As, Pune is near to coast and during monsoon strong south west winds are blowing from Arabian Sea.

Contribution

Ashwin and Ravi: Data collection and cleaning.

Pulkit and Suman: Plotting the data.

Analysis was done by the whole team together.