Winter and summer time size segregated distribution of aerosols and optical properties over a site in North-western India

Swagata Payra [1]*

Pramod Kumar[2], Sunita Verma[1], and Divya Prakash[1]

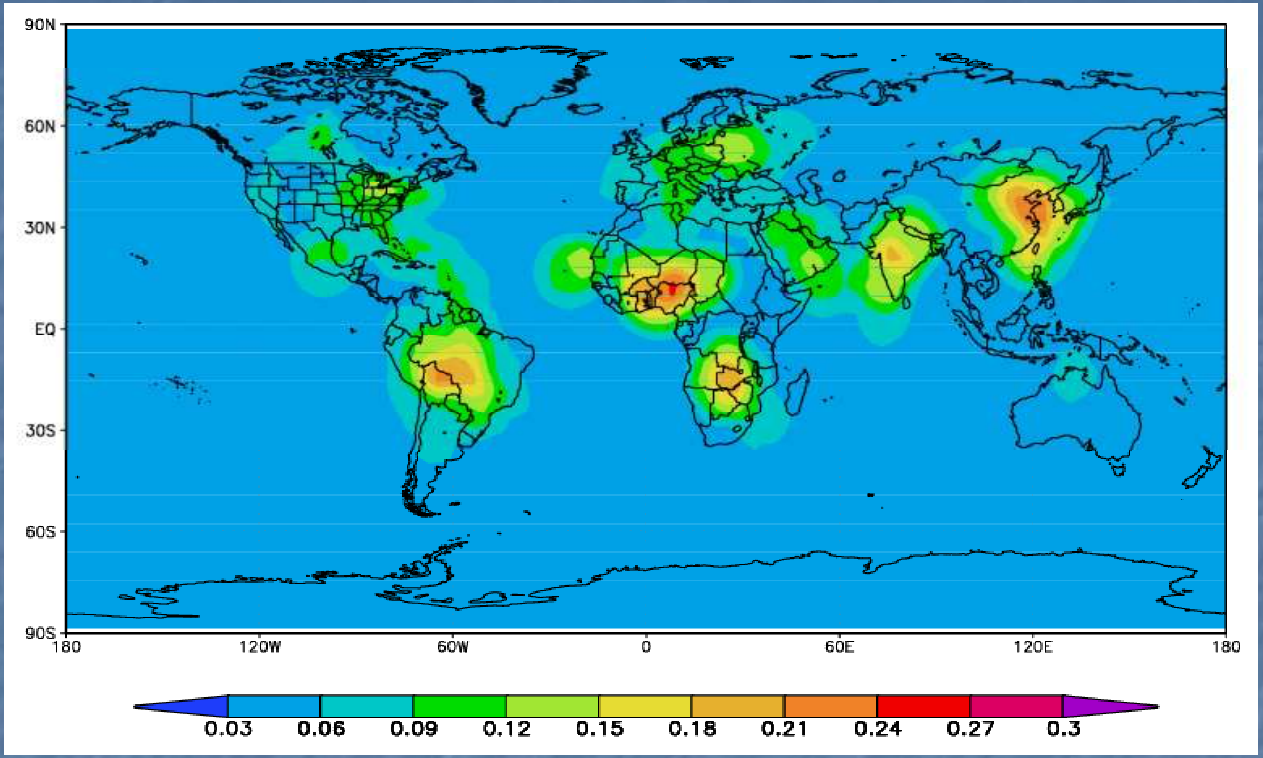
[1]Birla Institute of Technology, Mesra Extension Centre Jaipur
27 Malviya Industrial Area, Jaipur – 302 017 Rajasthan, INDIA

[2] Clarkson University, Potsdam, NY, USA

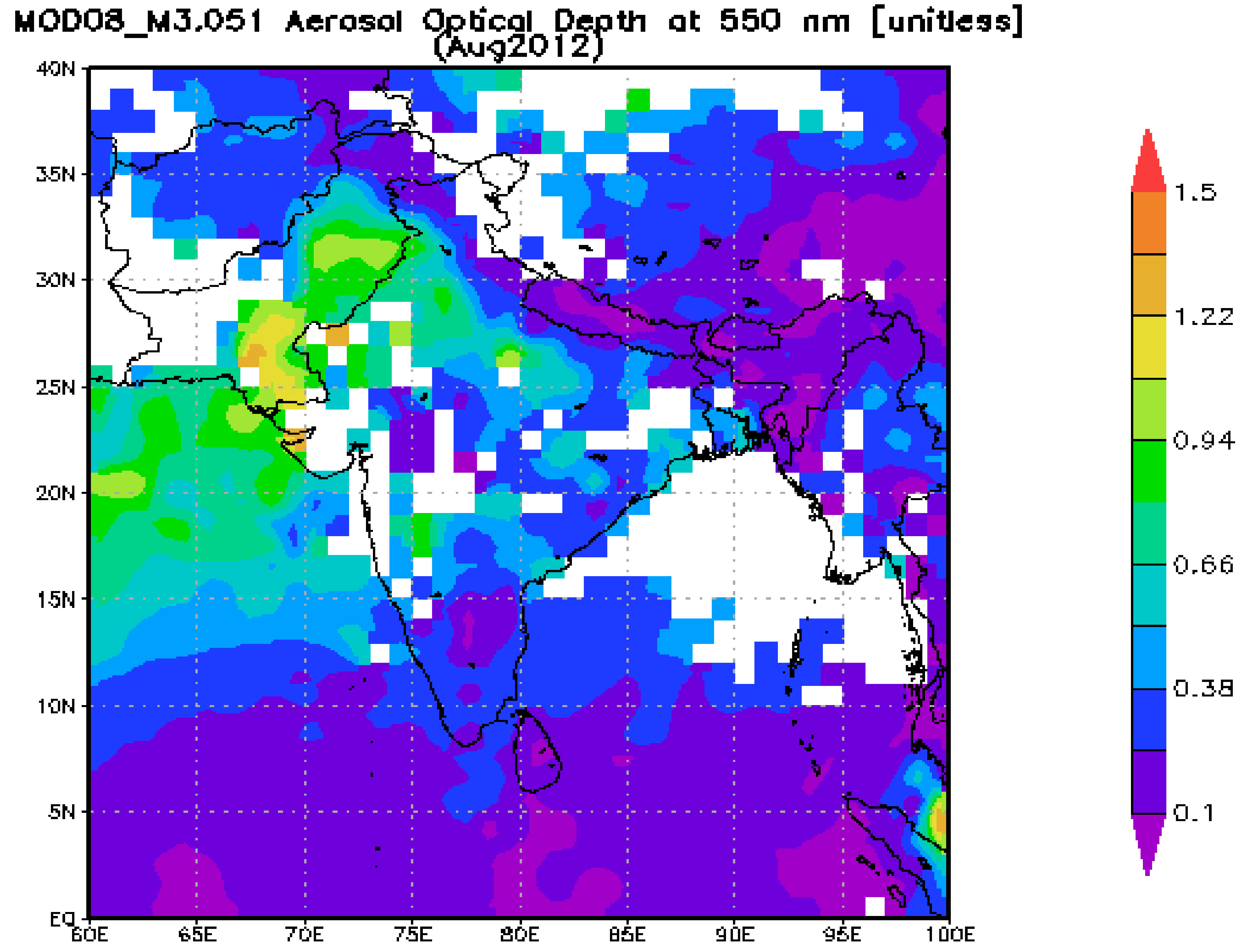
spayra@bitmsera.ac.in

Backgrounds

Global distribution of AOD (670nm) Interpolated out of the AERONET Sun/sky radiometer



- Aerosol effects are more regional than global.
- Latest IPCC (4th Assessment) report shows that understanding of aerosol improved (from low to low-med level).
- One of the good contribution is increased in-situ measurements.
- There are much interest in calculation of the Aerosol Optical Depth (AOD) across the globe on regional basis and reduction of its uncertainty.



MOD08_M3.051 Aerosol Optical Depth at 550 nm [unitless]
(Aug2012)
40N
35N
30N
25N
20N
15N
10N
5N
EQ
60E
65E
70E
75E
80E
85E
90E
95E
100E
1.5
1.22
0.94
0.66
0.38
0.1

Why Aerosols measurement is important

- **High temporal and spatial variability**

Atmospheric aerosols are inherently **very variable in space and time**, which complicates their characterisation and monitoring.

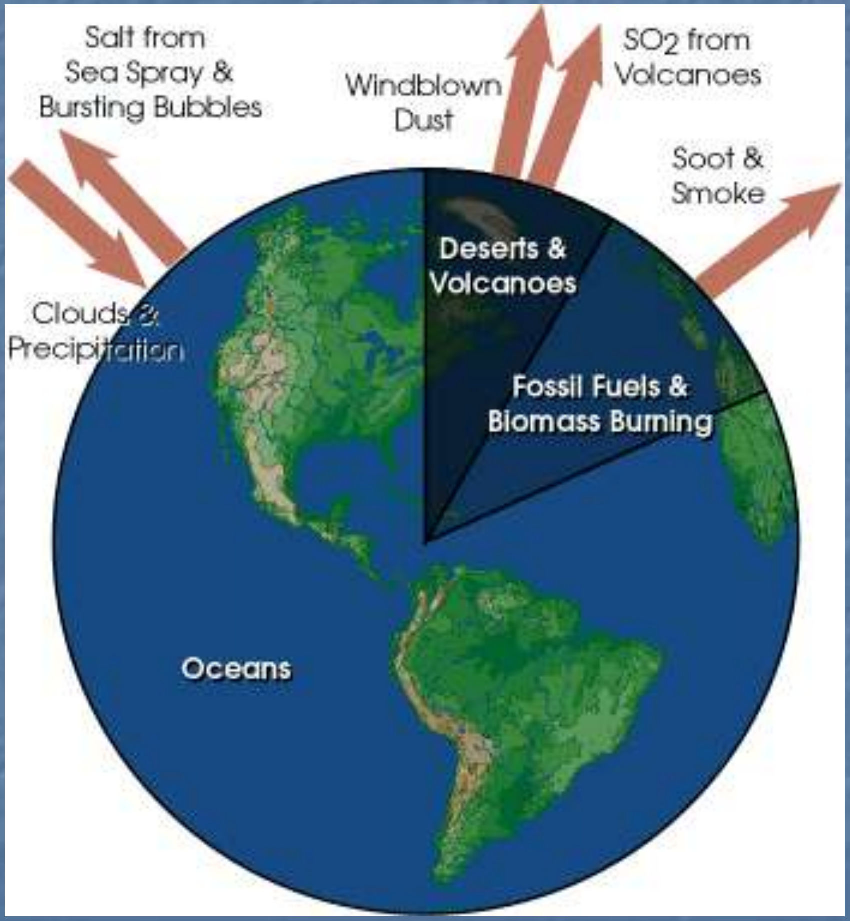
Due to heterogeneous nature, the impact of aerosols on climate must be understood and quantified on a much finer regional scale rather than just a global-average basis.

- **To improve global emissions inventories and identify the long-term trends using existing information**

Surface Networks expansion is required at the national and International scale for a continuous development and evaluation of emission inventories of aerosol particles

This will help study the atmospheric processes, to broaden the database of detailed aerosol chemical, physical, optical and radiative characteristics, to validate remote-sensing retrieval products, and to evaluate chemistry transport models.

Aerosol Types and Origin



- Aerosol particles larger than about 1 mm in size are produced by windblown dust and sea salt from sea spray and bursting bubbles
- Aerosols smaller than 1 µm are mostly formed by condensation processes such as conversion of sulfur dioxide (SO2) gas (released from volcanic eruptions) to sulfate particles and by formation of soot and smoke during burning processes.
- After formation, the aerosols are mixed and transported by atmospheric motions and are primarily removed by cloud and precipitation processes.

Why Aerosols is important to understand the Weather, specially for Indian Monsoon

The influence of absorbing aerosols over these monsoon-dominated regions has been shown to alter long-term rainfall patterns [Menon et al., 2002].

- **Dimming Effect**

Through general circulation model (GCM) simulations, it has been shown that aerosol-induced surface dimming over the Indian Ocean results in less evaporation from the ocean surface, thereby reducing moisture inflow into South Asia which in turn causes weakening of the monsoon rainfall [Ramanathan et al., 2005].

- **Elevated Heat Pump**

On the other hand, Lau et al., [2008] and Lau and Kim, [2006] have recently proposed the Elevated Heat Pump (EHP) hypothesis, suggesting that desert dust, mixed with soot aerosols over northern India and the foothills of the Himalayas, may cause enhanced heating in the middle/upper troposphere may further lead to the strengthening of the temperature gradient, thus resulting in the advancement of the monsoon rainfall in early summer. .

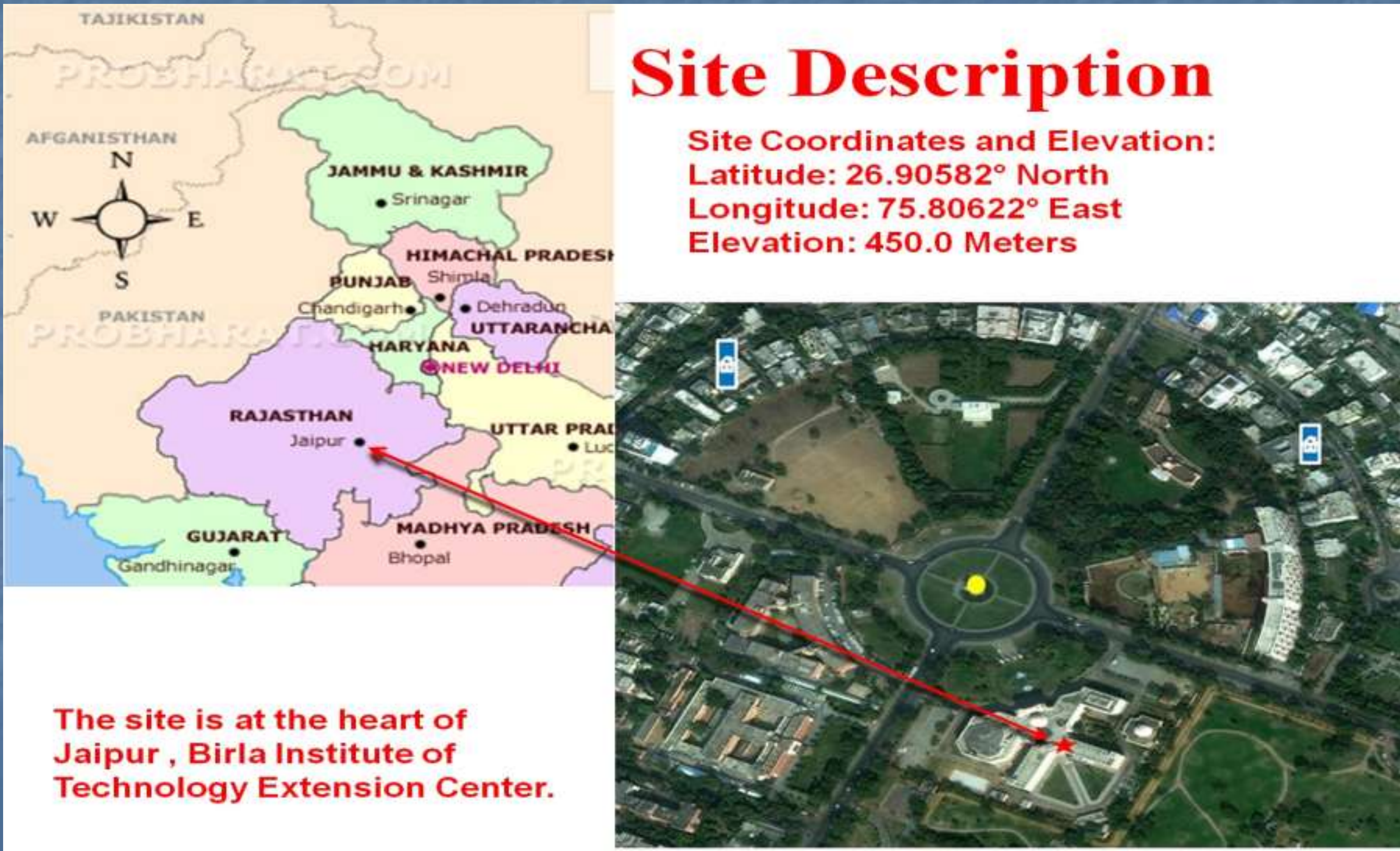
Objectives

The primary objectives for this research effort are

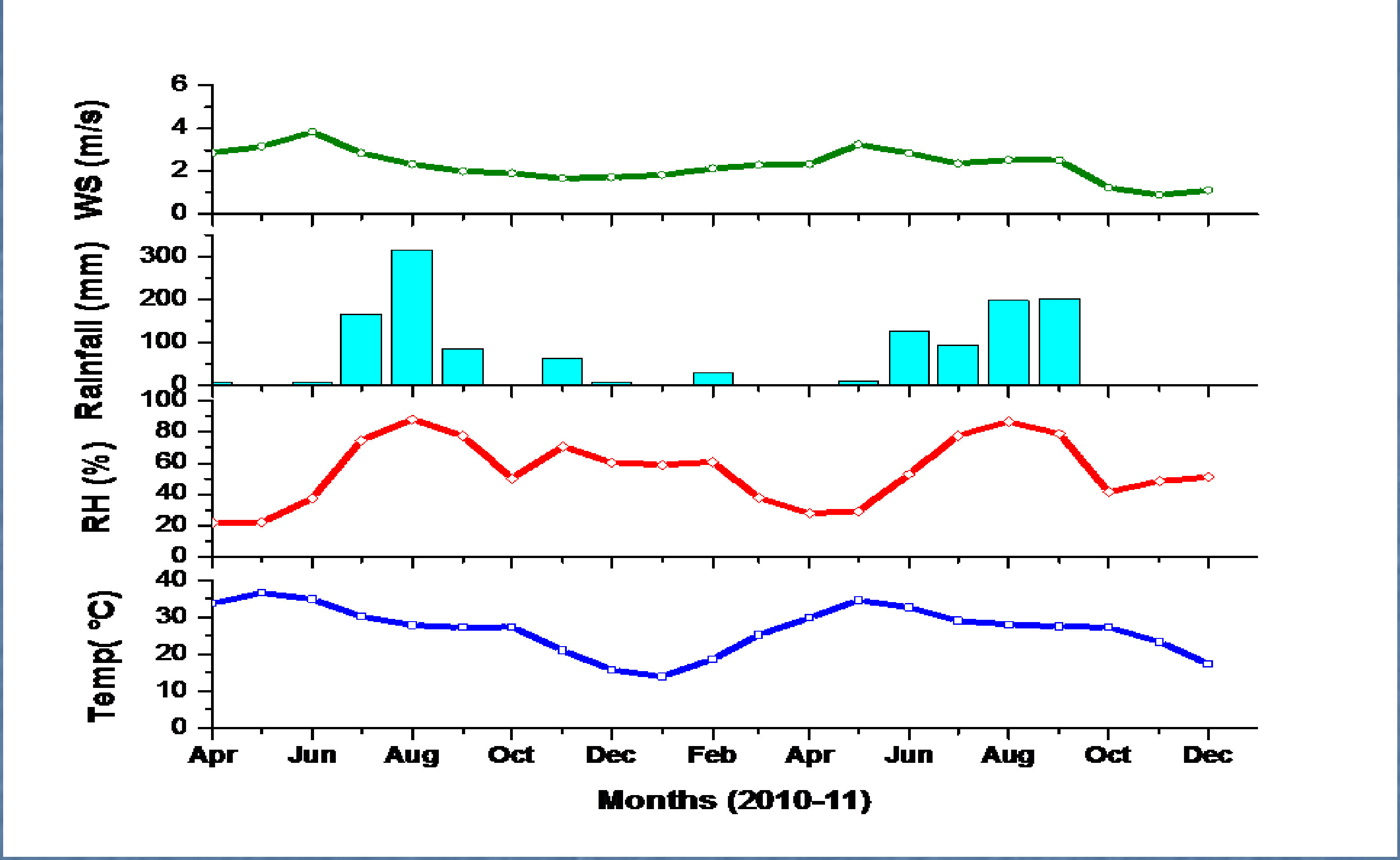
- To characterize the aerosol properties during winter/summer seasons over Jaipur, North-Western India.

- Investigate the origin and transport of tropospheric aerosols using Back trajectories and PSCF analysis.

Study Location

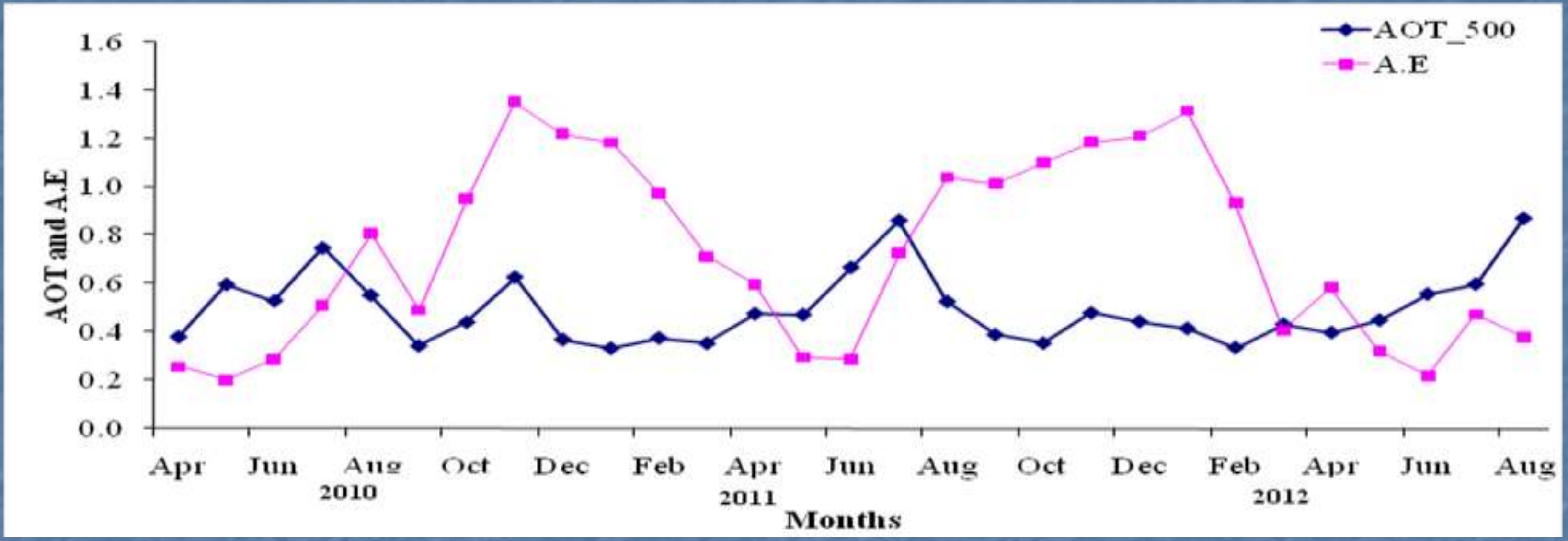


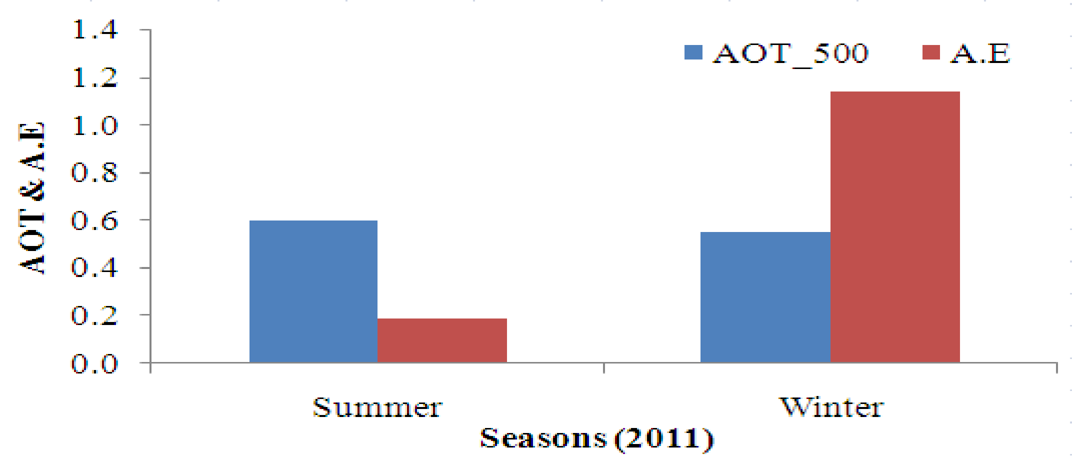
Meteorological Variables



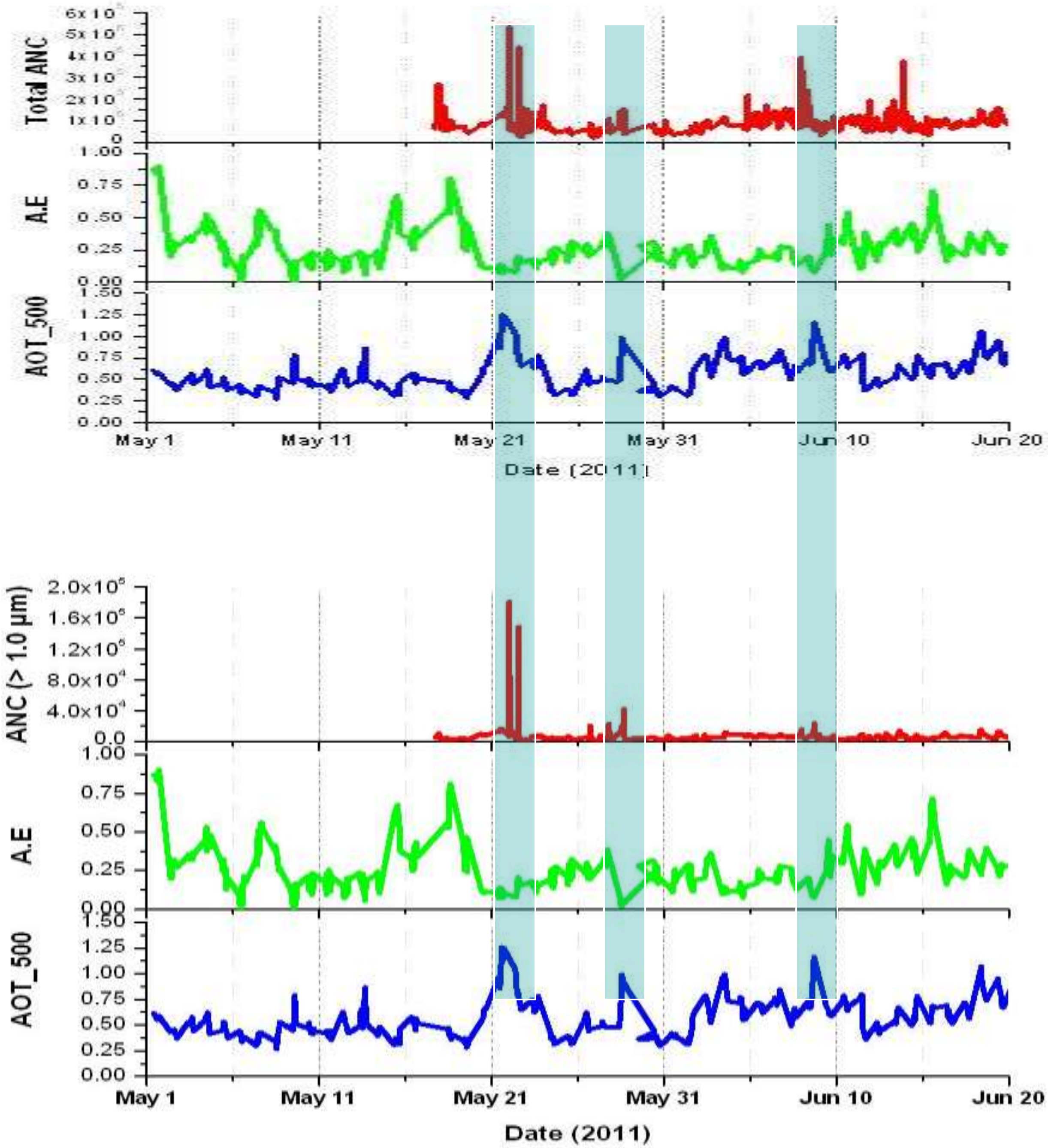
A clear seasonal pattern of weather is seen from the ambient meteorological parameters for the years 2010-11. Wind speed is low in winter gives a stable atmosphere. The maximum temp is in observed in 7th June at 15:00 with 45 degree centigrade but the average temp is high during May (36 C).

Seasonal variation of AOT and A.E since April 2010 till September 2012 over Jaipur





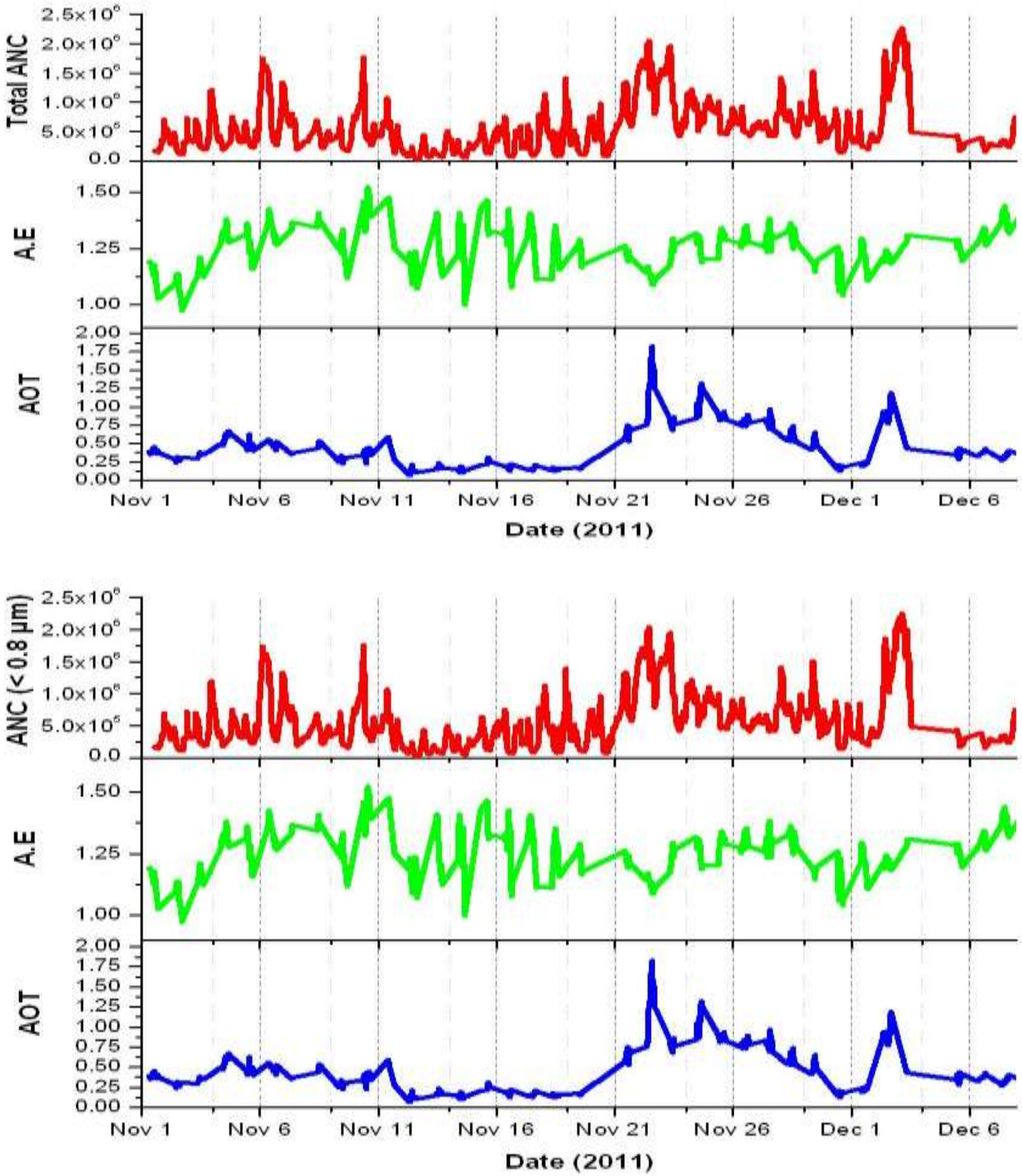
Seasons	AOT	A.E
Summer	0.6018	0.1916
Winter	0.5556	1.1398



Total Aerosols Number Concentrations (ANC) during Summer in 2011

Correlation	A.E	<0.8 μm	>1.0 μm
AOT_500	-0.46	0.47	0.67

Coarse ANC during Summer in 2011

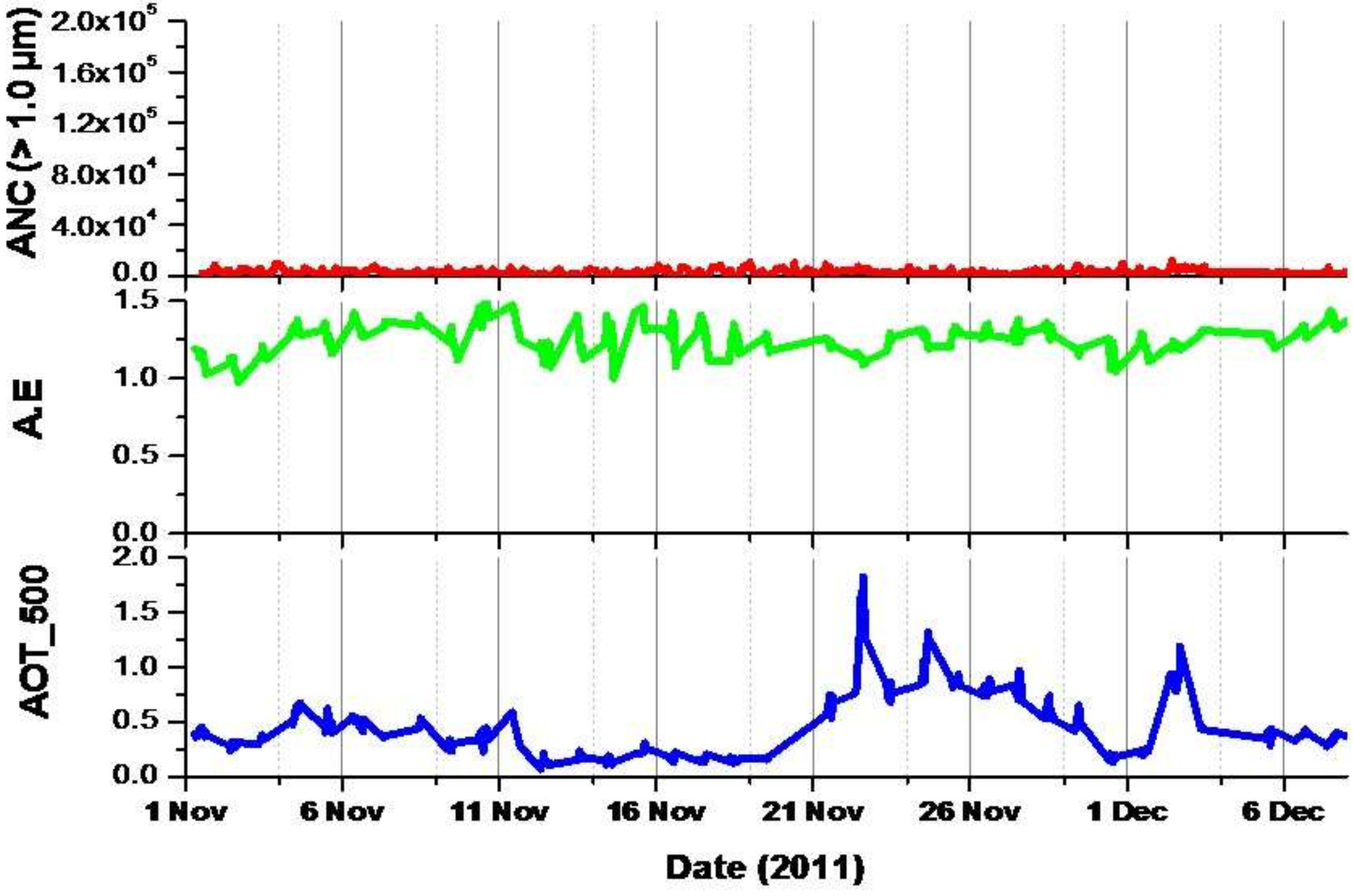


Total ANC in Winter 2011

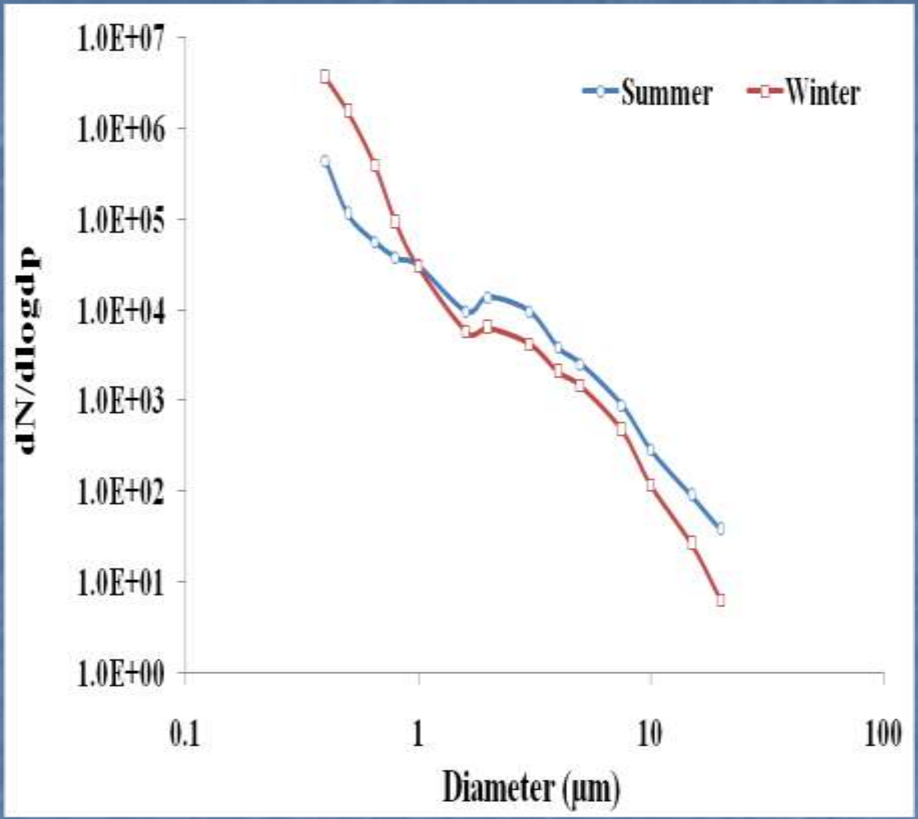
Correlation	A.E	< 0.8 μm	>1.0 μm
AOT_500	0.065	0.536	0.311

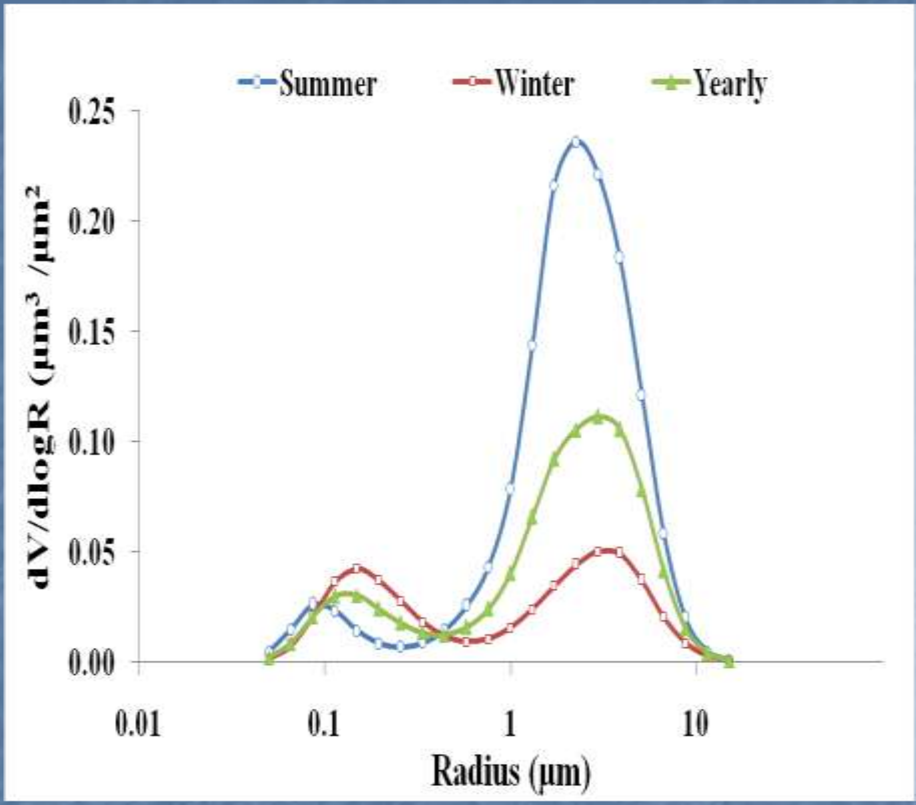
Fine particle

Coarse ANC in Winter 2011



Log-normal distribution of Aerosols Number Conc (ANC) during summer and winter shows the distinct characteristics.





The variation in size distribution of aerosols during two seasons is clearly reflected in the log normal size distribution curves. Particle size less than 0.8 micro meter has key contributor in winter for higher ANC.

The volume size distribution had two modes; one near 0.3 µm and the other at about 4.5 µm. It also shows that finer particles are less and coarser particles are more during summer

Seasonal heterogeneity in aerosols types over Jaipur, North-western India

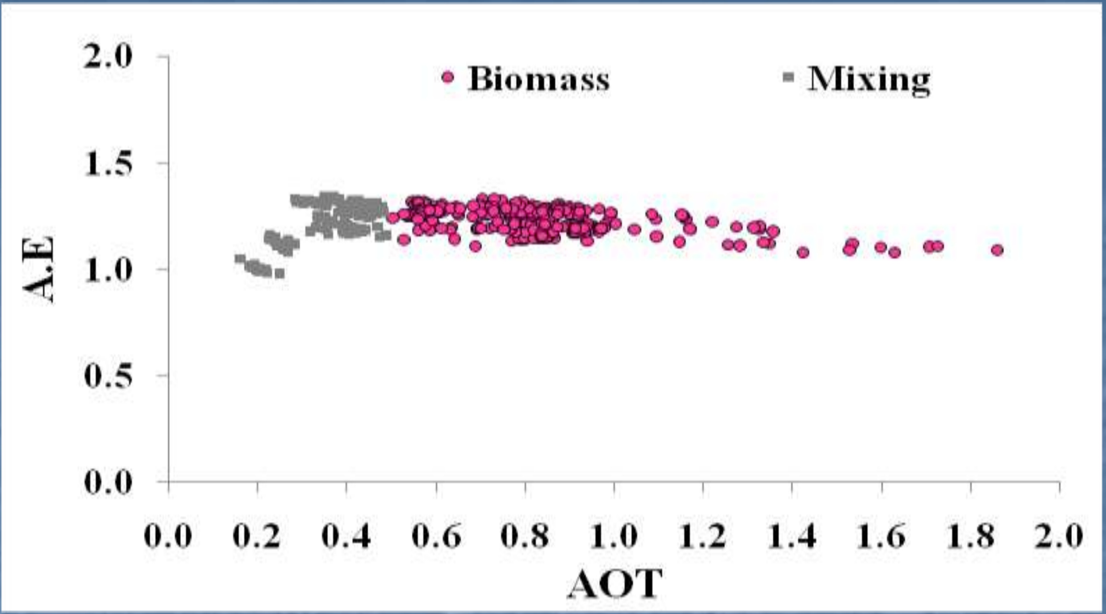
"Aerosol Optical Thickness" is the degree to which aerosols prevent the transmission of light by absorption or scattering of light.

For measurements of optical thickness $\tau\lambda_1$ and $\tau\lambda_2$ taken at two different wavelengths λ_1 and λ_2 respectively, the Angström exponent is given by

$$\alpha = -\frac{\log \frac{\tau\lambda_1}{\tau\lambda_2}}{\log \frac{\lambda_1}{\lambda_2}}$$

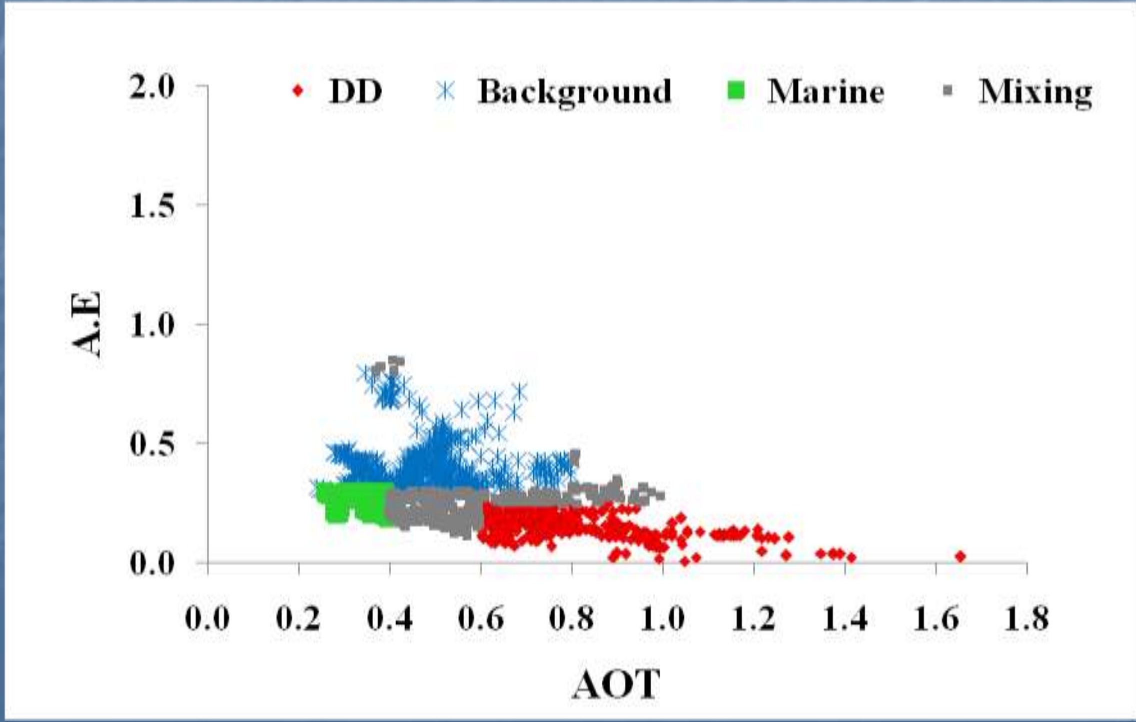
Threshold Values

Aerosol Type	AOT_500	A.E
Desert Dust	> 0.60	< 0.25
Marine	< 0.40	< 0.30
Biomass	> 0.50	> 1.0
Desert Background	< 0.80	0.30< A.E >0.80
Mixed	Remaining	Remaining

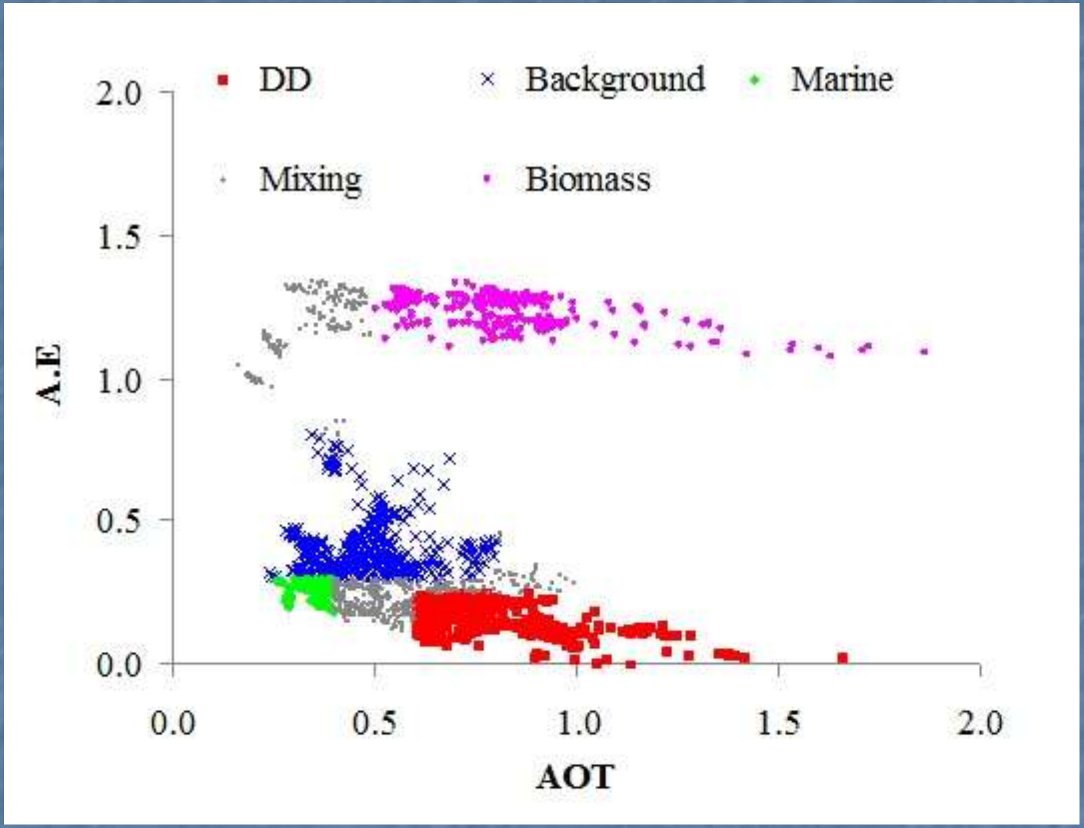


Aerosols Types during Winter

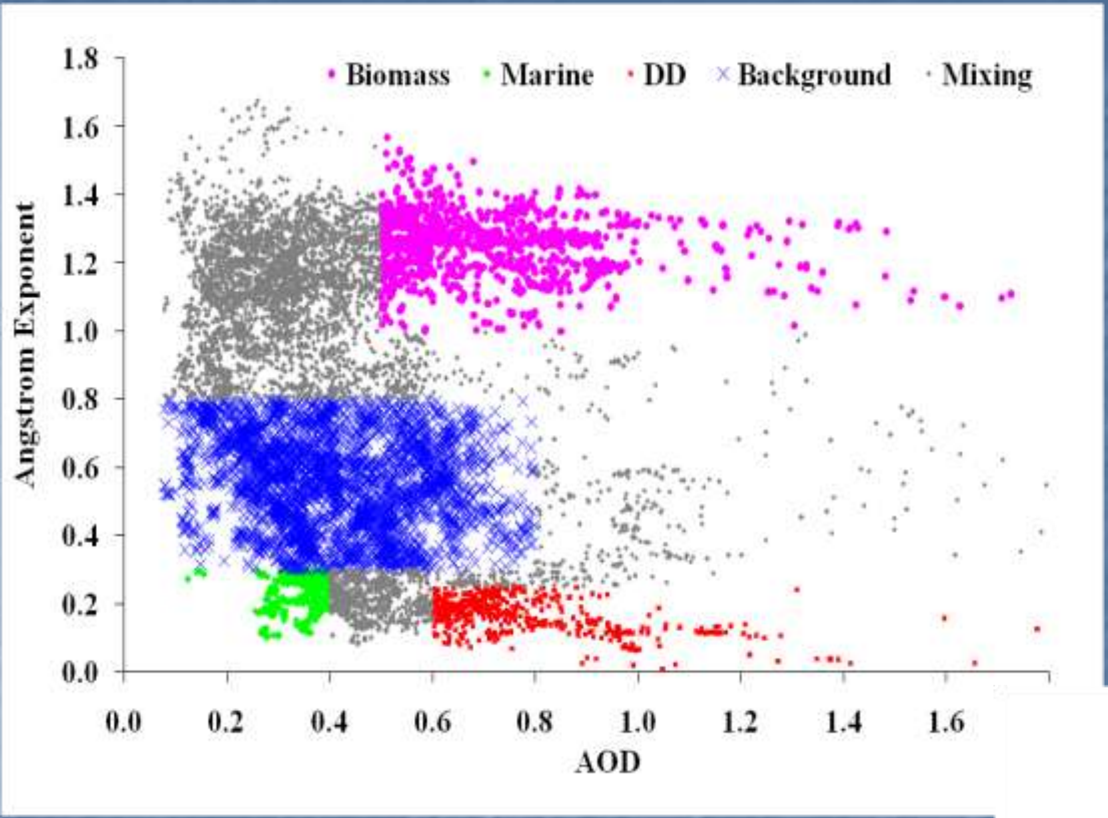
Aerosols Types during summer



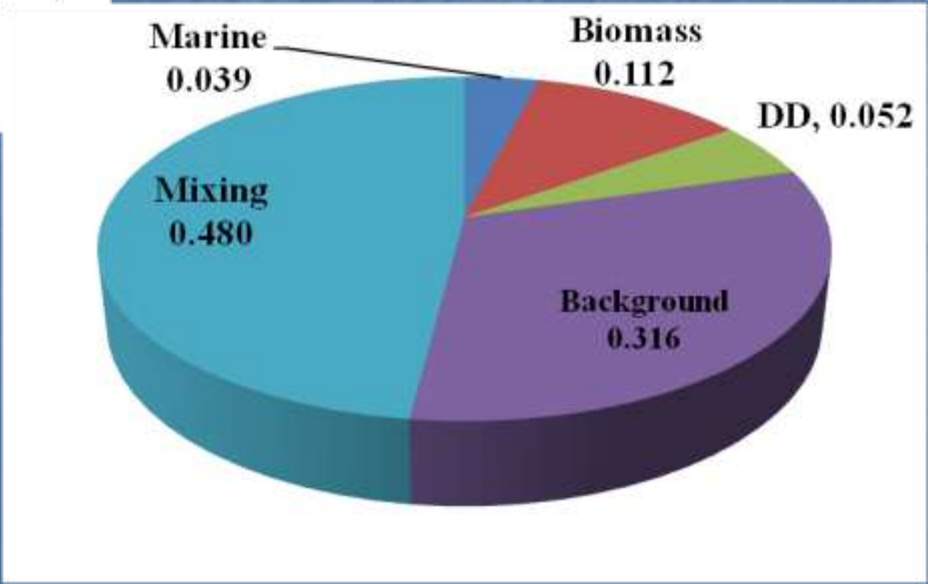
Combination of summer and winter



Annual Classification (year avg)

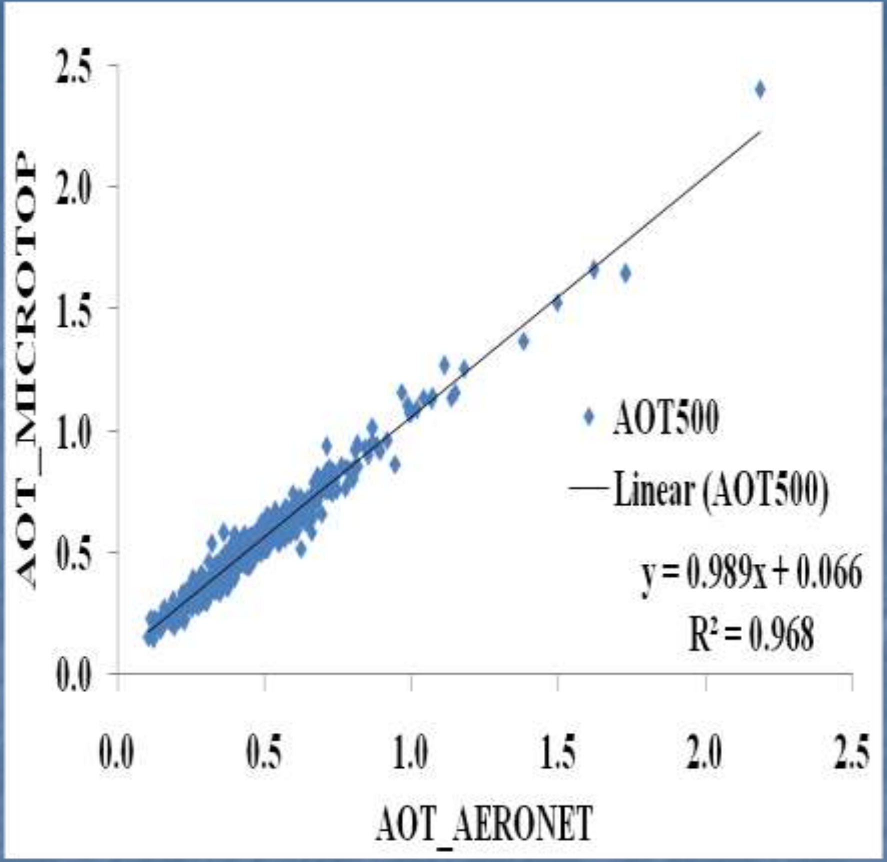


Accepted, Springer, 2012

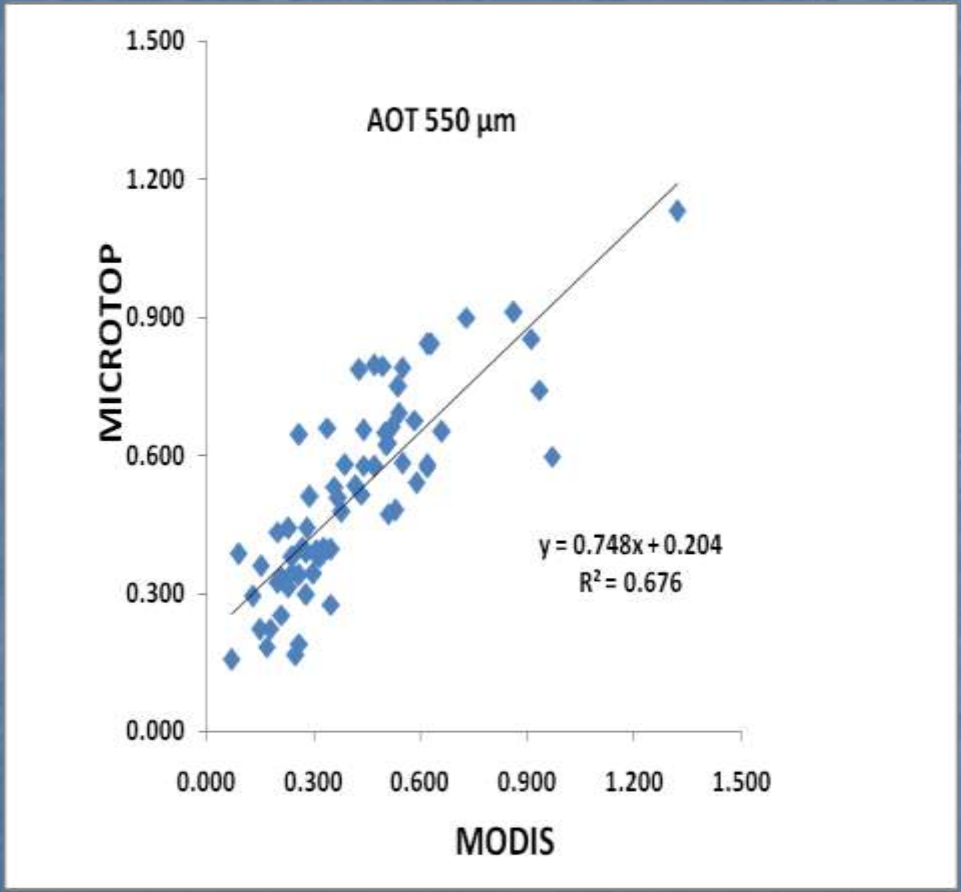


So this is another step that not only AOD, the type (dust storm/biomass) is also classified to understand the radiation budget. Same AOD can be due to scattering / absorption (dust/biomass).

Inter-Comparison
of the AOT
Measurements
over Study Area to Satellite Data
and other primary locations



Scatter Plot AOT vs AOT_AERONET

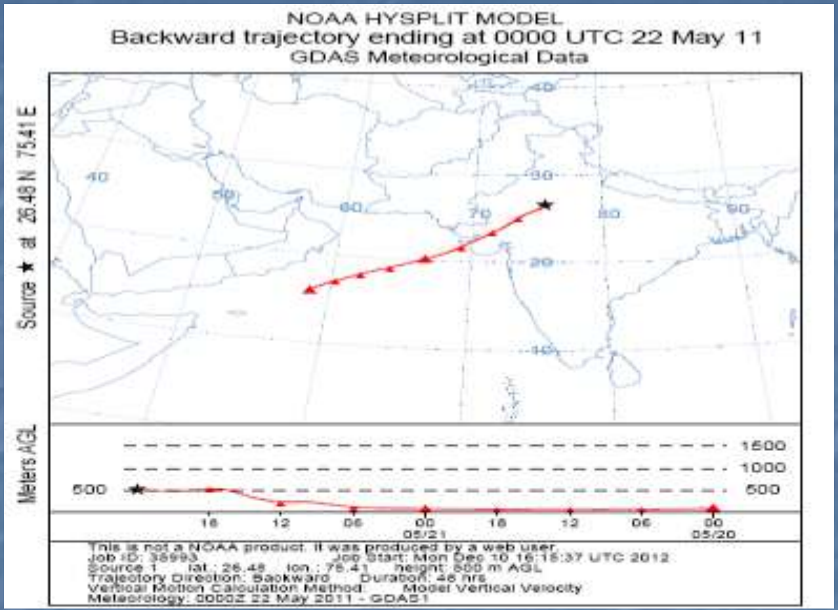


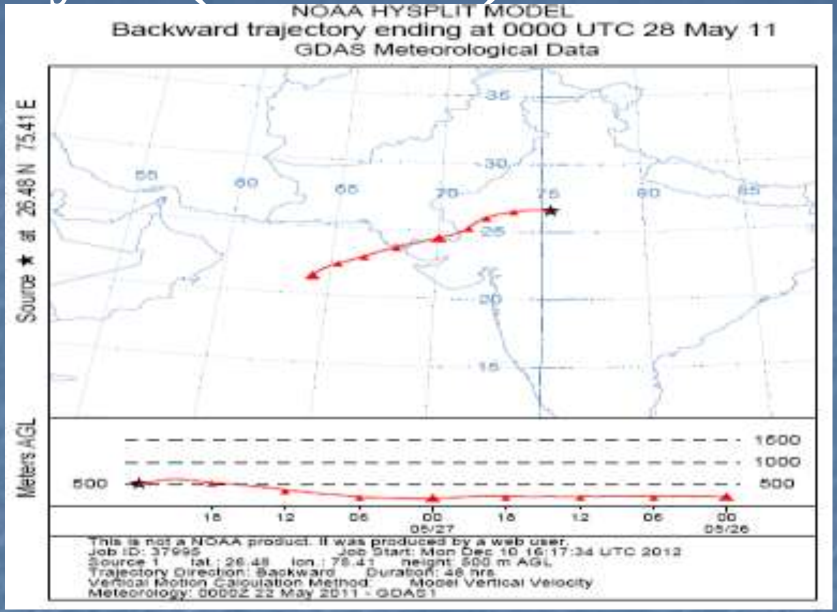
Scatter Plot AOT vs AOT_MODIS

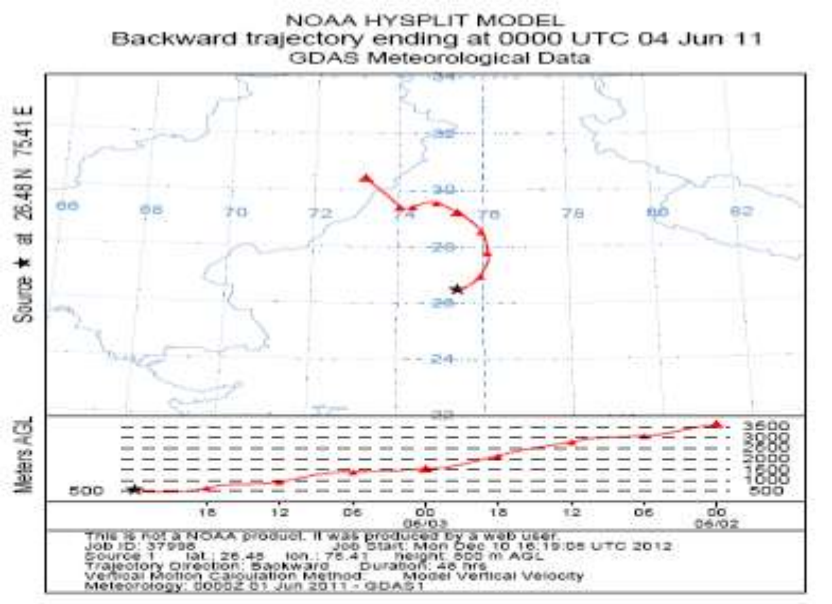
Comparison

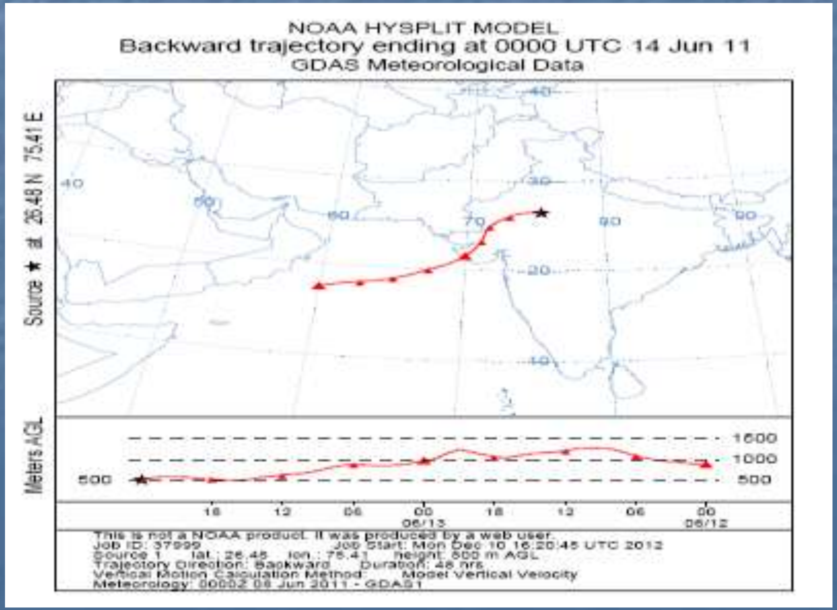
Season (2011)	Locations	Mean aerosol parameters	
		AOD_{500}	$AE_{440-870}$
Summer	Jaipur	0.602	0.192
	Kanpur	0.674	0.556
	Gandhi College	0.628	0.891
Winter	Jaipur	0.556	1.140
	Kanpur	0.786	1.356
	Gandhi College	0.662	1.484

Source/Origin
Back Trajectory analysis (Summer)

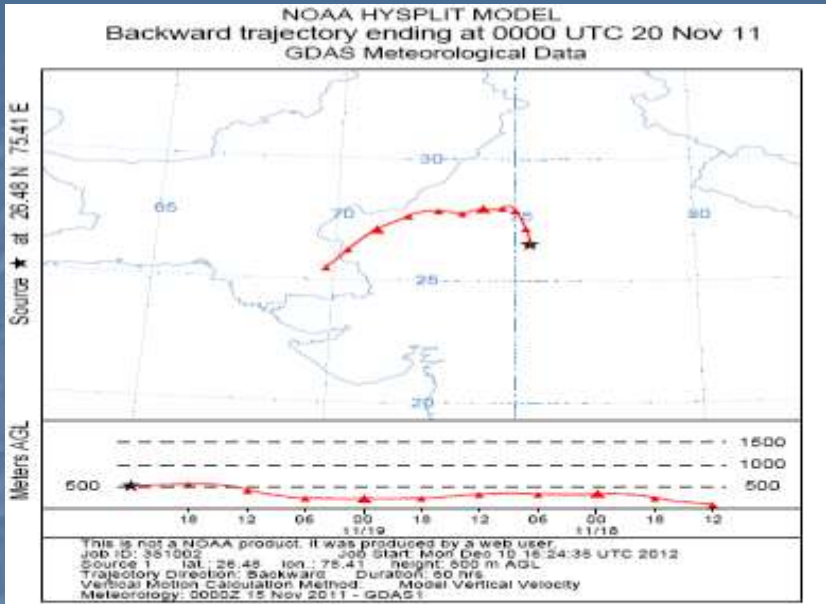


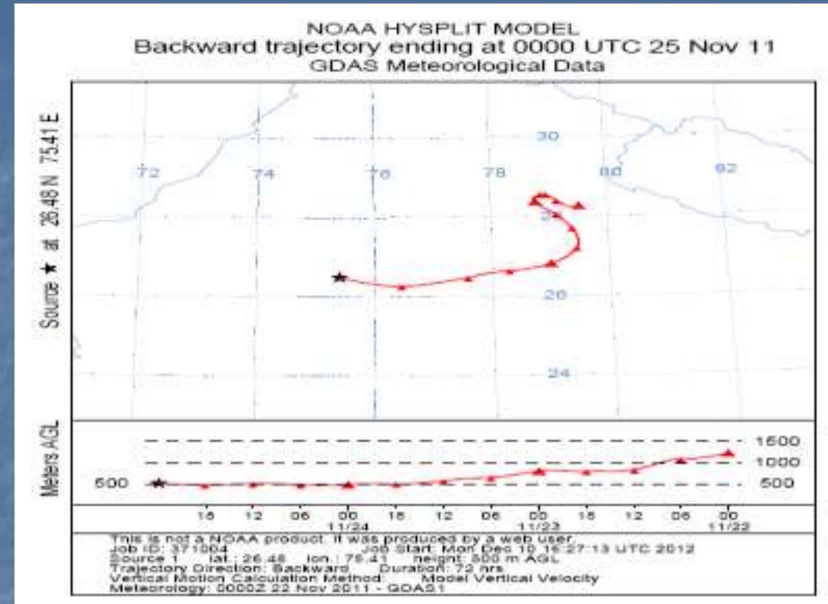


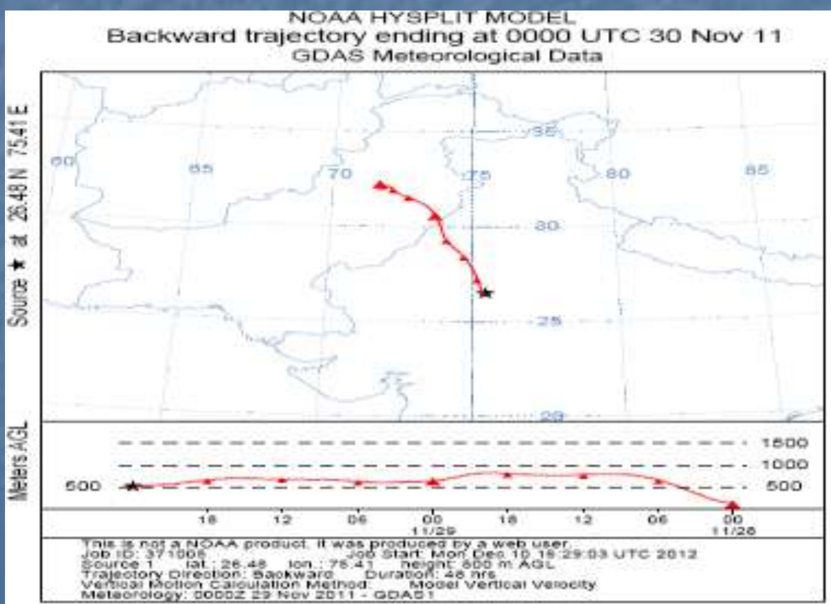


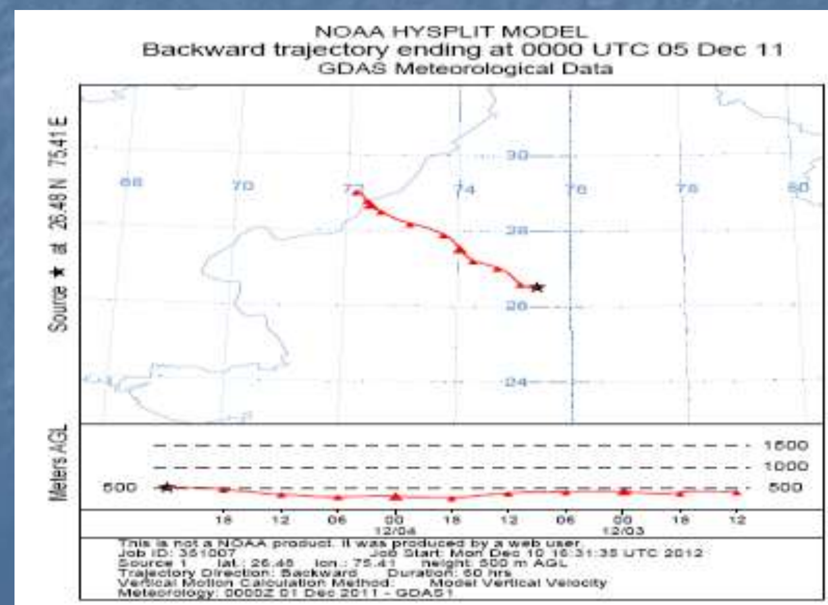


Back Trajectory analysis (Winter)









Contribution

PSCF Analysis

- The key problem with any trajectory is that there is uncertainty with the potential error in position increasing as it progresses backward in time.

- The solution is to use an ensemble of trajectories so that the analysis will average out these errors and provide an outcome with greater accuracy.

- *The basic concept of the PSCF methods is to use the trajectories to obtain an indication of the residence time (i.e., the time spent in the vicinity of sources) and its relationship to the observed concentrations at the receptor/Jaipur site.*

PSCF Techniques

- If a trajectory endpoint lies in the *ij*th cell, the air parcel assumes to collect in the cell and transports along the trajectory to the monitoring site

- $PSCF_{ij}$ is the conditional probability that an air parcel that passed through the *ij*th cell had a high concentration upon arrival at the monitoring site

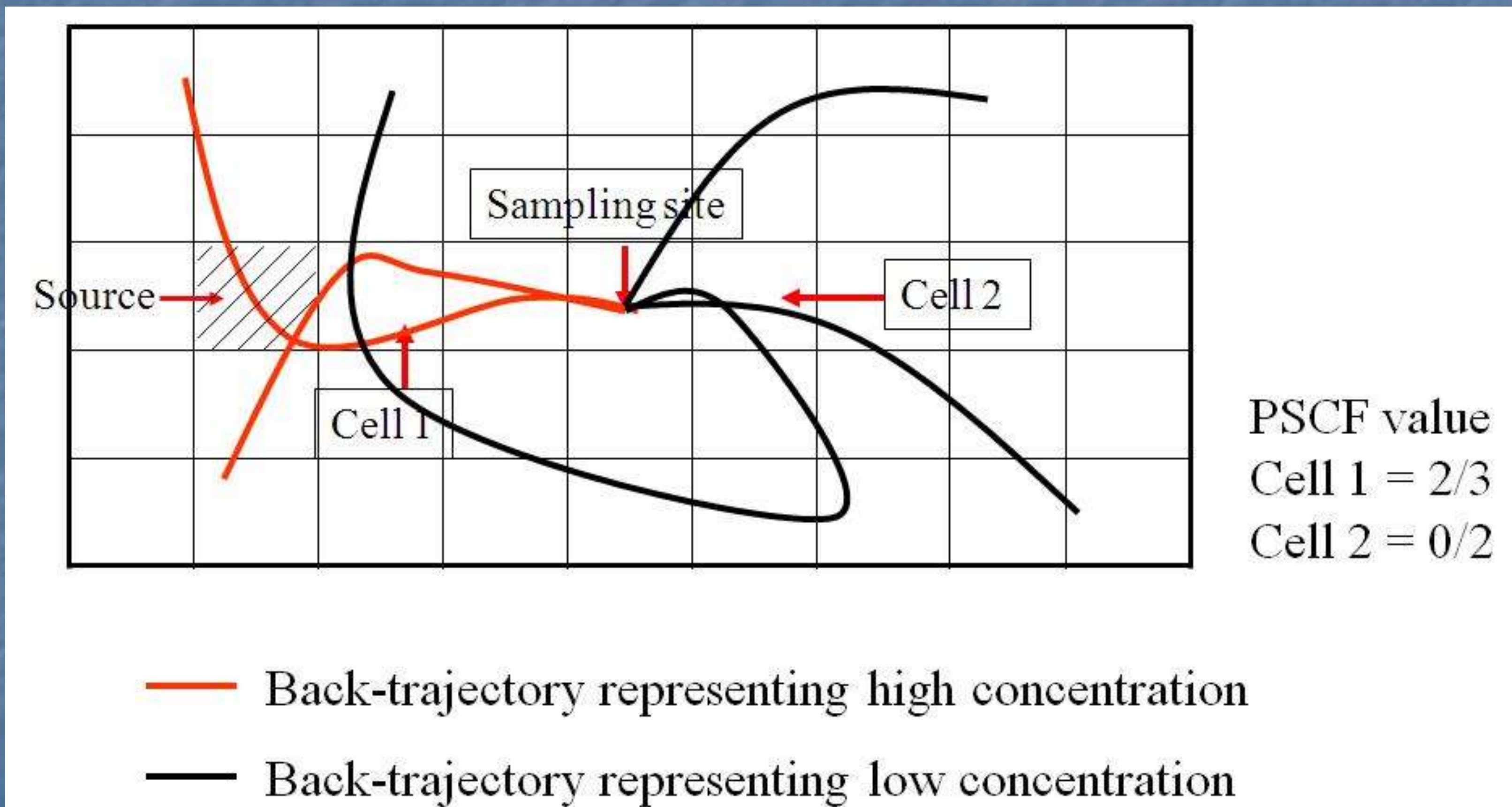
$$PSCF_{ij} = \frac{m_{ij}}{n_{ij}}$$

n_{ij} : total number of end points that fall in the *ij*th cell

m_{ij} : number of end points that exceeded the threshold criterion

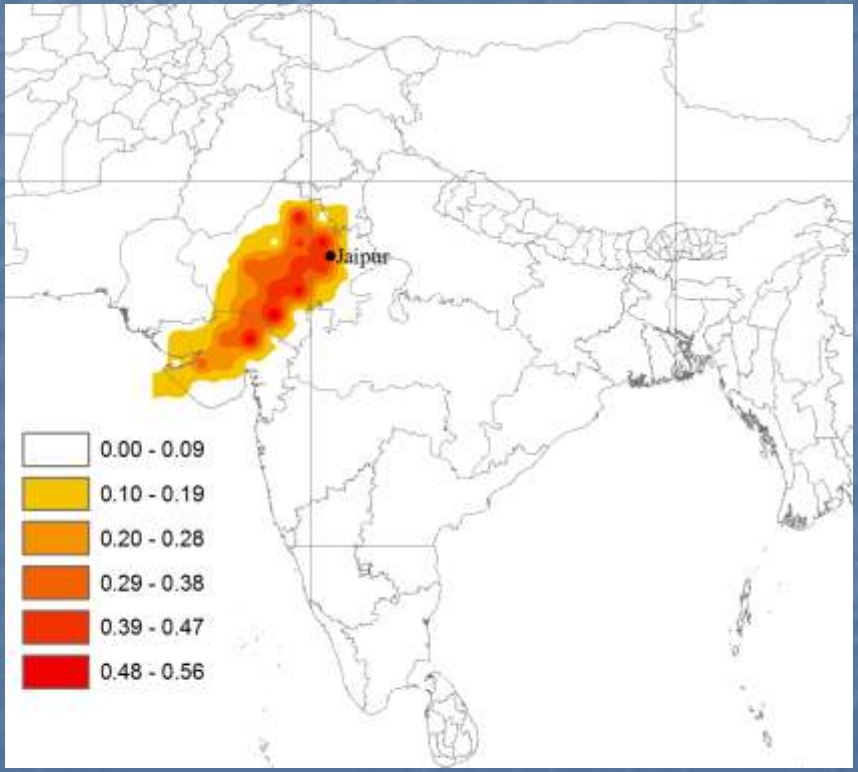
(in this study, average concentration of each species was used for the threshold criterion)

PSCF Techniques

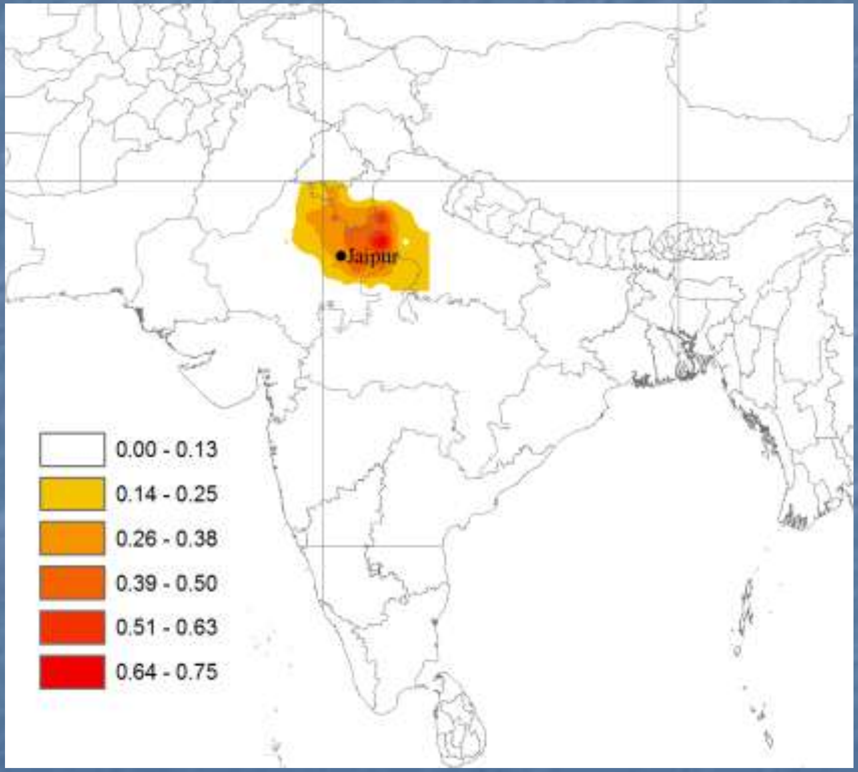


PSCF Analysis

Summer



Winter



Conclusions

- First time new observations on the optical properties of aerosols over Jaipur region during 2011-2012 are initiated and in progress since April, 2011.

- The aerosol properties possesses clear seasonal variability's with maximum aerosol loading associated with mostly coarse particles (AE<0.25) during pre-monsoon season with occurrence of the highest AOD value compared to all other seasons.

- Five different aerosol types have been classified from the relation between AOD_{500} and AE, applying appropriate threshold values. The percentage contribution of each type varies seasonally. In winter, local production contribute to observed. An appreciable biomass burning (BB) type is attributed to both local and transported aerosols.

- The HYSPLIT back trajectory analysis identifies the Thar Desert as the dominant potential source regions in pre-monsoon carrying primarily the coarse mode aerosols.

- On the other hand, during the post-monsoon and winter seasons the main contribution to different aerosol types is from local sources and came from north-west during winter

Acknowledgement

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