Quantifying the contribution of Long-Range Transport to Particulate Matter (PM) loading at a suburban site in the North-Western Indo-Gangetic Basin

THE SECOND WORKSHOP ON
ATMOSPHERIC COMPOSITION AND THE ASIAN SUMMER MONSOON (ACAM)

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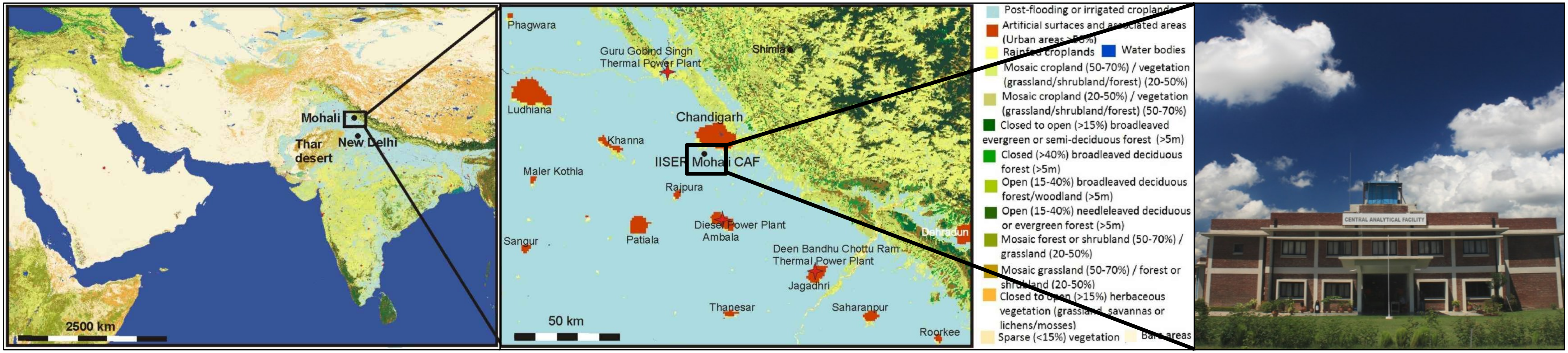
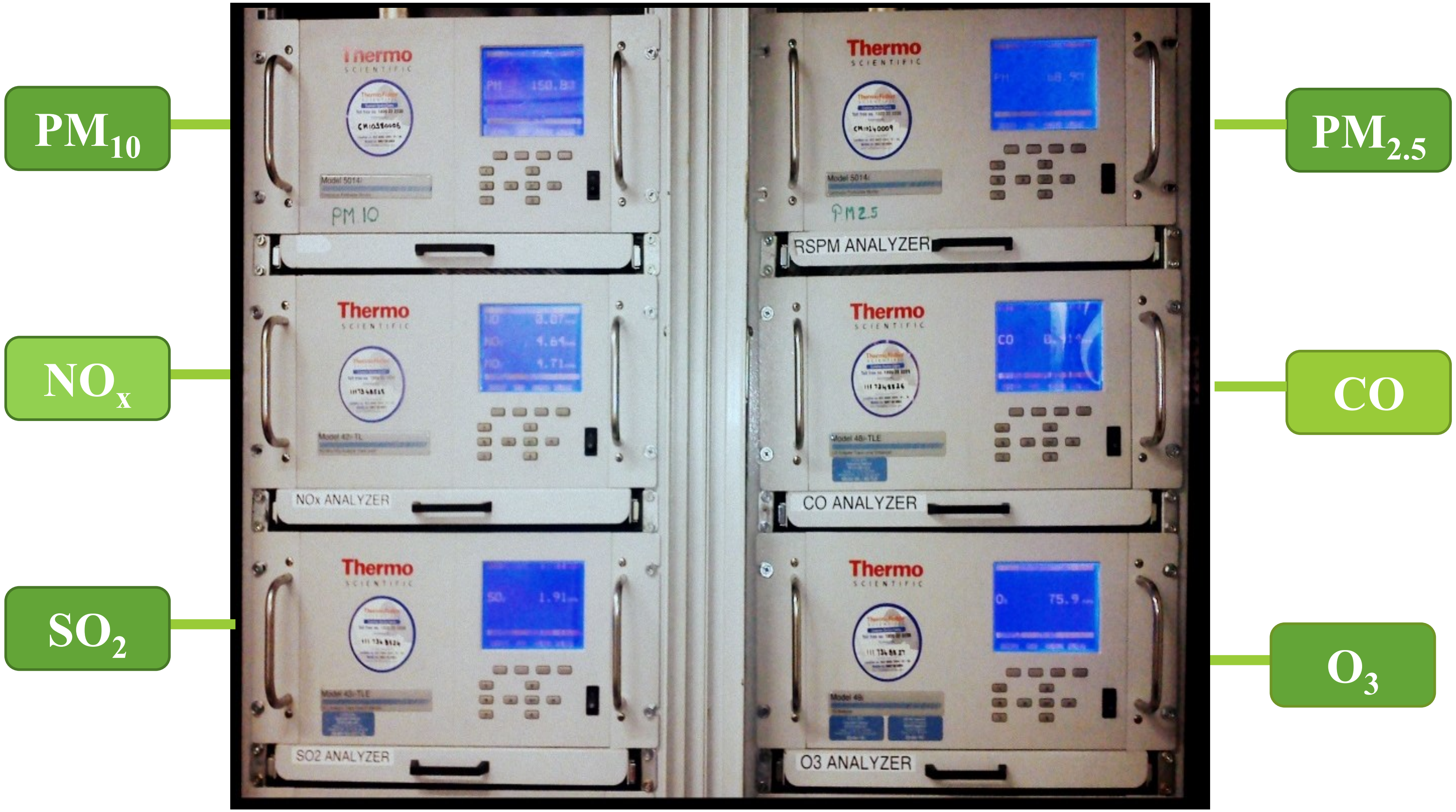
INDIA

Site Location



Facilities



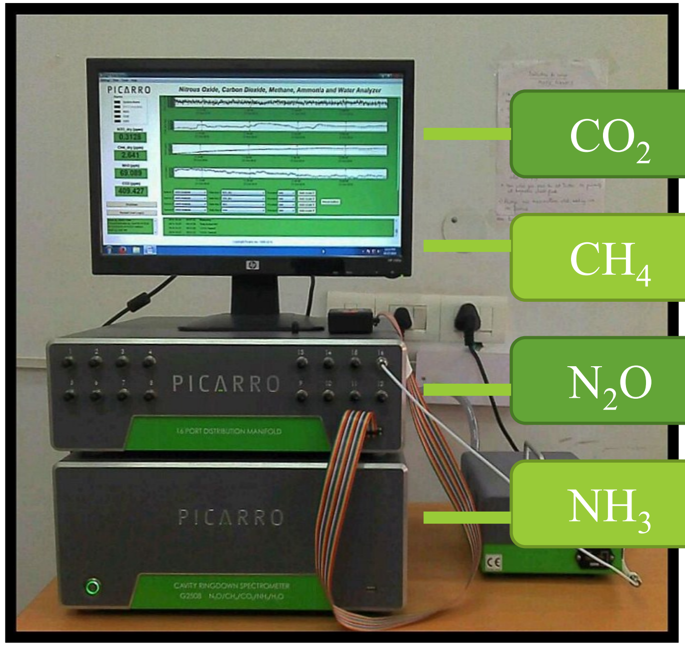
Sinha et al *, Chemical composition of pre-monsoon air in the Indo-Gangetic Plain measured using a new air quality facility and PTR-MS: high surface ozone and strong influence of biomass burning,, Atmos. Chem. Phys., 14, 5921–5941, 2014*

Facilities

Proton Transfer Reaction Mass Spectrometer (PTR-MS)

VOCs

Cavity Ring Down Spectrometer



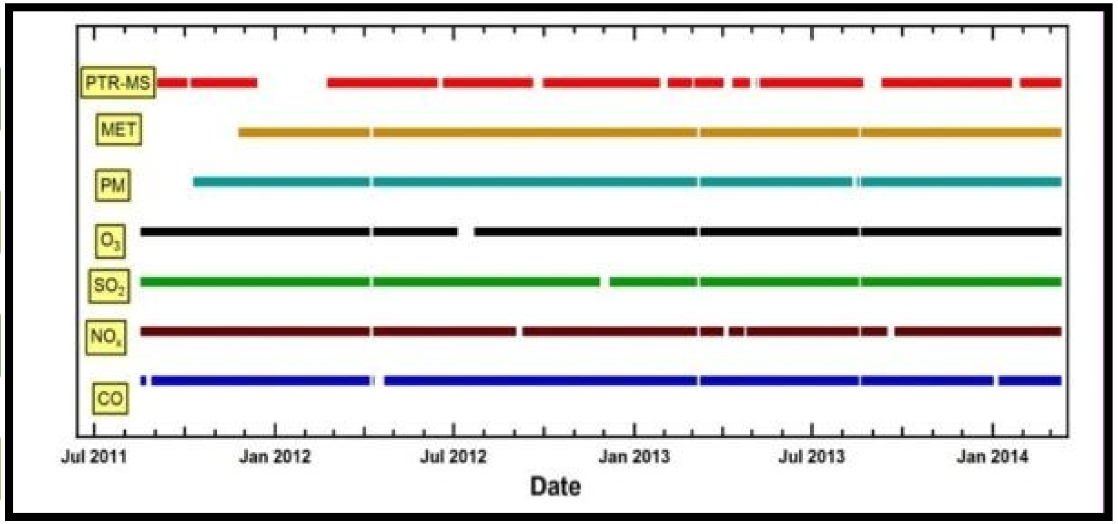
CO_2

CH_4

N_2O

NH_3

Status of Analyzers and Availability of Data from the IISER Mohali, Air Quality Station*



*(Image from Sinha et al., 2014. Data available till date)

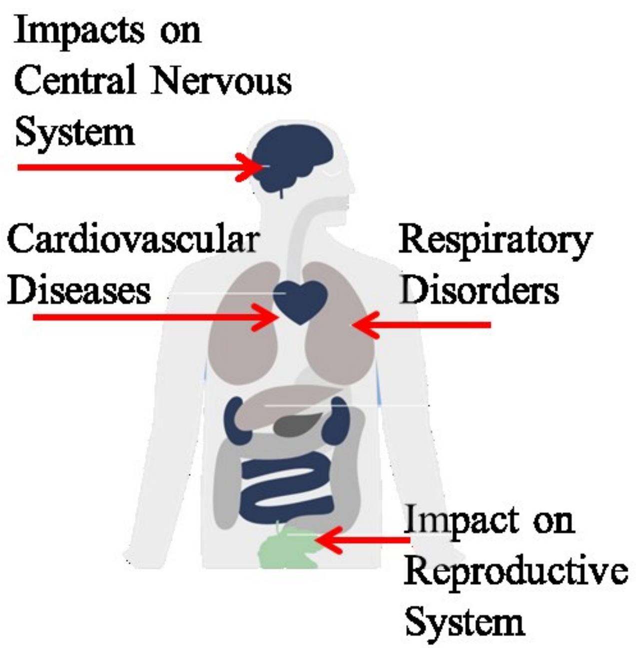
Requests for data are welcome
Please send an e-mail to: vsinha@iisermohali.ac.in

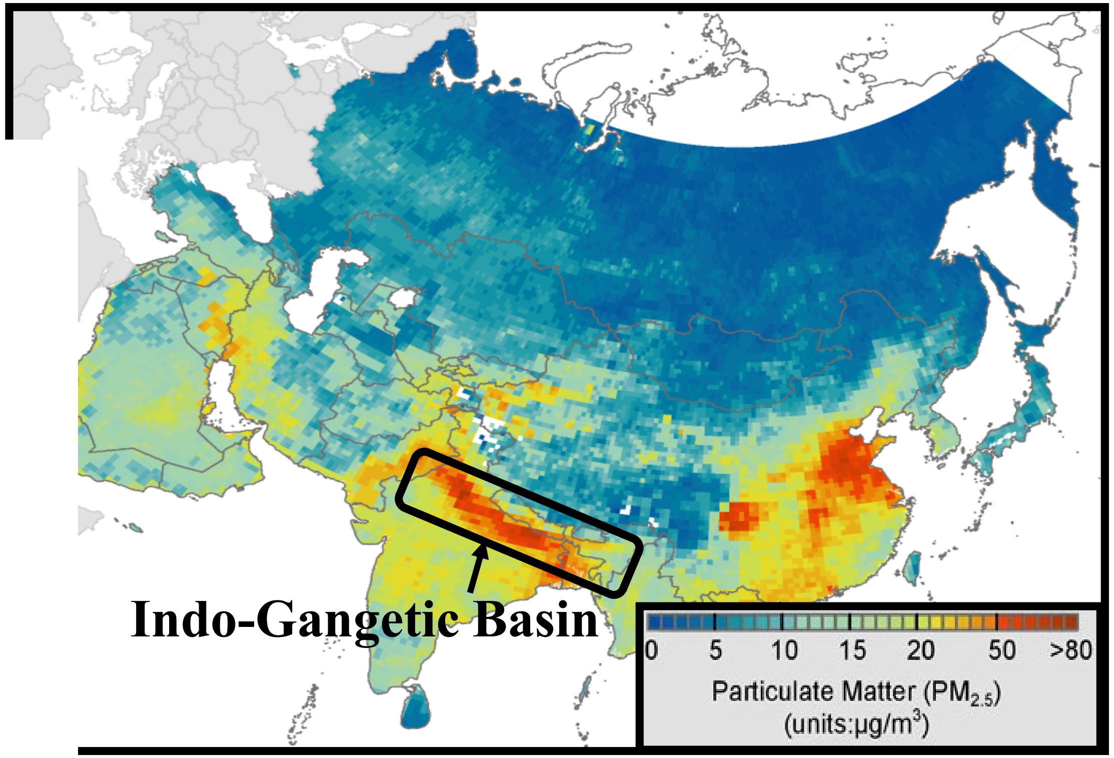
PM_{10} : 100 µg/m^3 (24 hour average)

NAAQS

$PM_{2.5}$: 60 µg/m^3 (24 hour average)

Health Impacts





…obal Annual Average $PM_{2.5}$ Grids from MODIS 2010

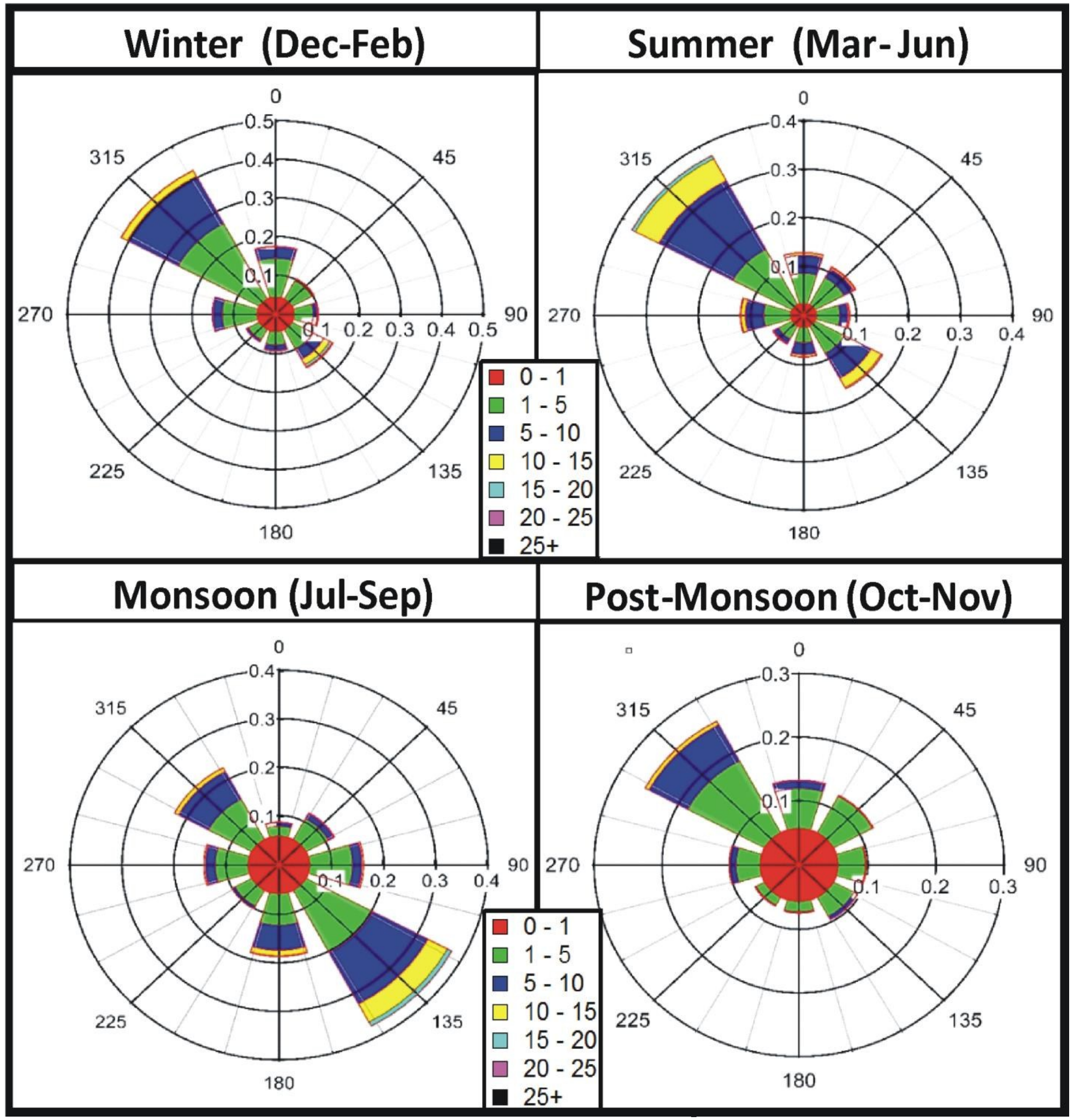
Environmental Impacts

- Direct impacts
- Indirect impacts

Elevated PM Levels

Quantitative Contribution of Long-Range Transport

Number of exceedance events



Winter: 4.5 % / 31.4 %

Summer: 2.5 % / 48.8 %

Monsoon: 5.2 % / 38.7 %

Post-Monsoon: 8.7 % / 19.9 %

Wind-rose plot for the period of August 2011 to June 2013.

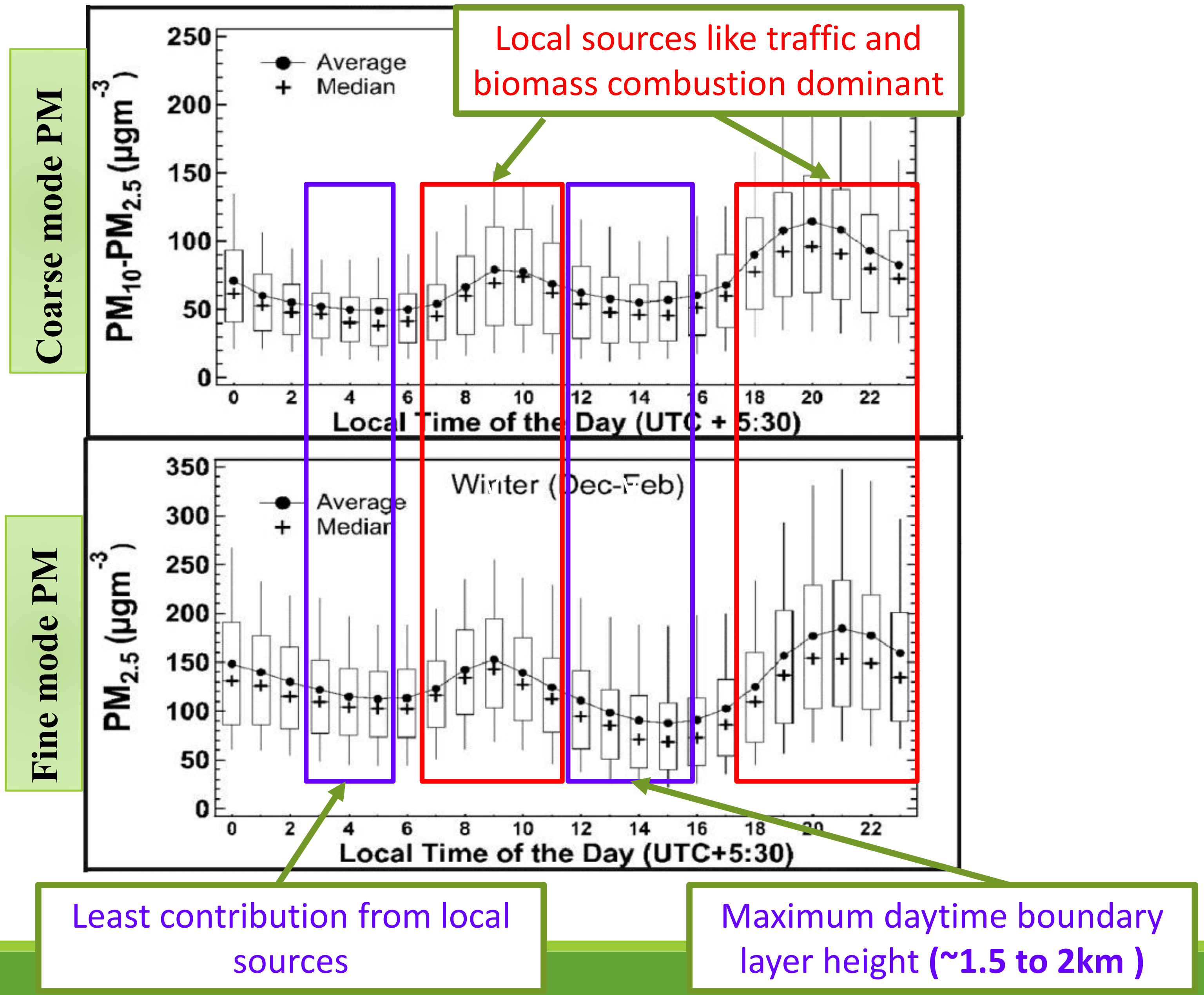
North-west or south-east is the dominant wind direction.

Calm conditions account for < 9% in all seasons.

Rapid transport of air masses occurs frequently.

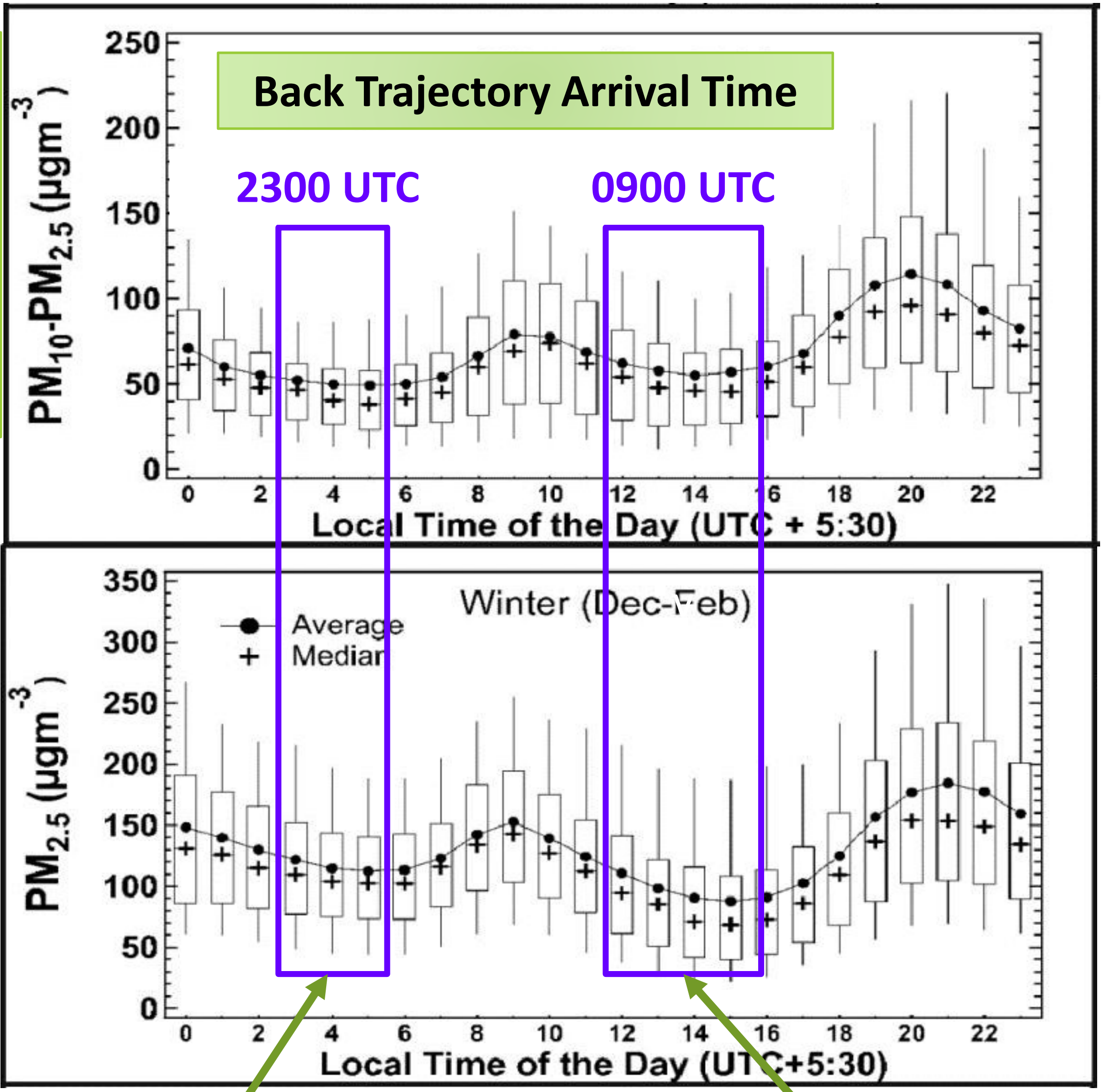
Periods of calm (Wind Speed < $1 ms^{-1}$) **Periods of rapid transport of air masses (Wind Speed > $5 ms^{-1}$)**

Diel Features of Particulate Matter (PM): Winter Season



Coarse mode PM

Fine mode PM



03:00 to 06:00 LT
Least contribution from local sources

12:00 to 16:00 LT
Maximum daytime boundary layer height (~1.5 to 2km)

Computed three day (72h) back trajectories using HYSPLIT_4

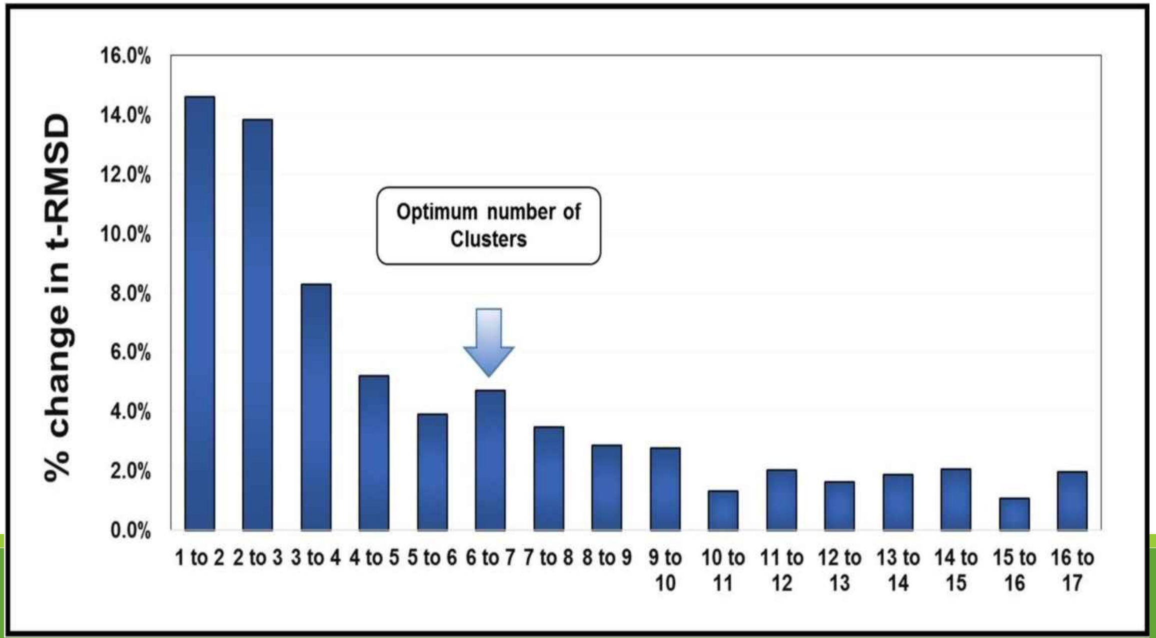
August 2011-June 2013

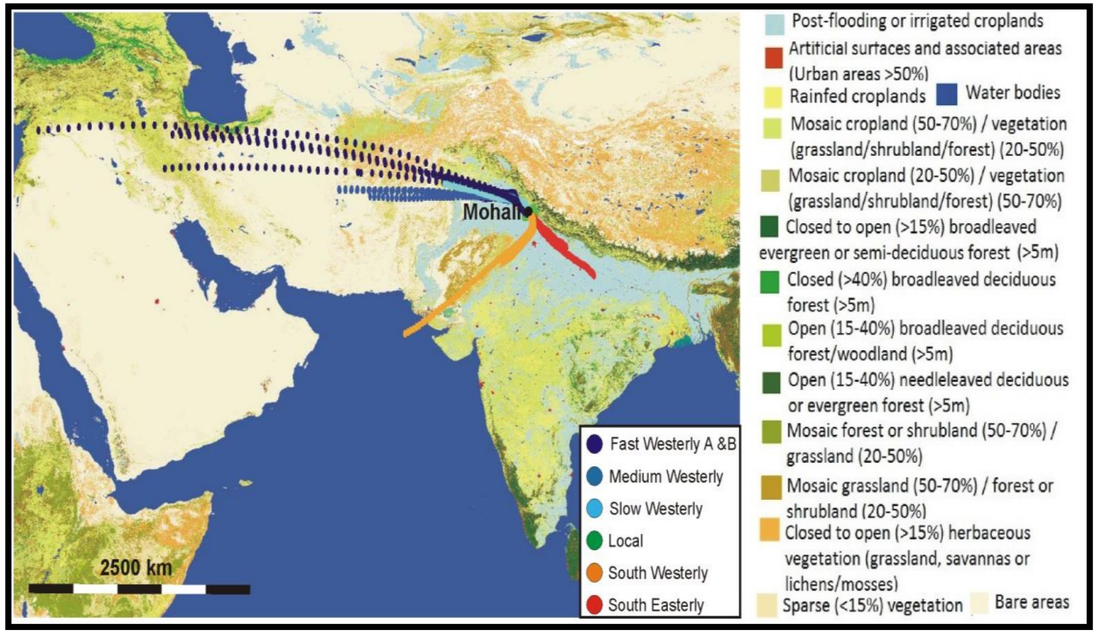
Arrival time 09:00 UTC and 23:00 UTC

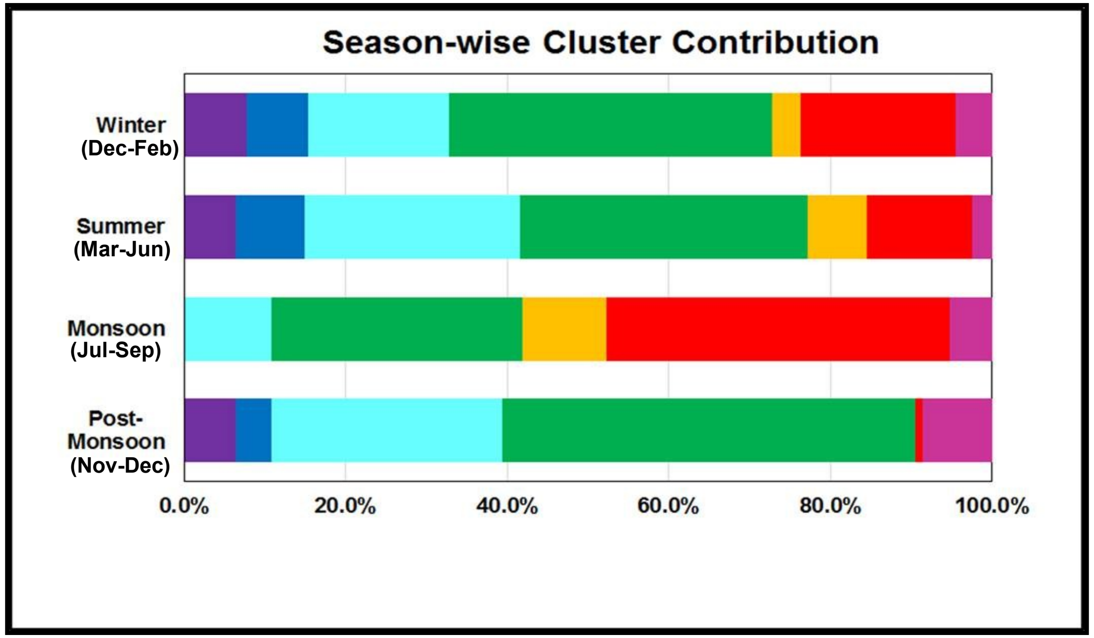
IISER Mohali Atmospheric Chemistry Facility (30.67°N, 76.73°E; 310 m amsl)

Back-Trajectory Cluster Analysis

k-means clustering







Westerly (Fast , Medium, Slow & South-west)

- **Source**: Middle east, Arabia, Afghanistan and Thar desert
- > 35% in winter, summer and post-monsoon

South-Easterly Transport

- Synoptic scale transport: western disturbance in summer and winter
- Bay of Bengal branch of monsoon

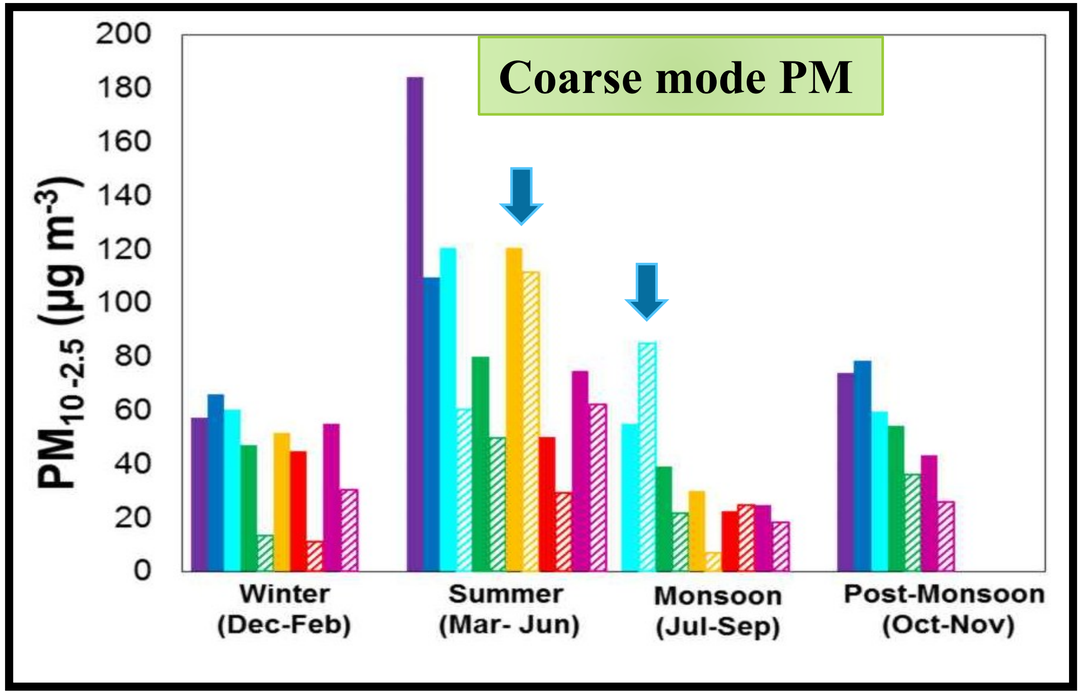
Local

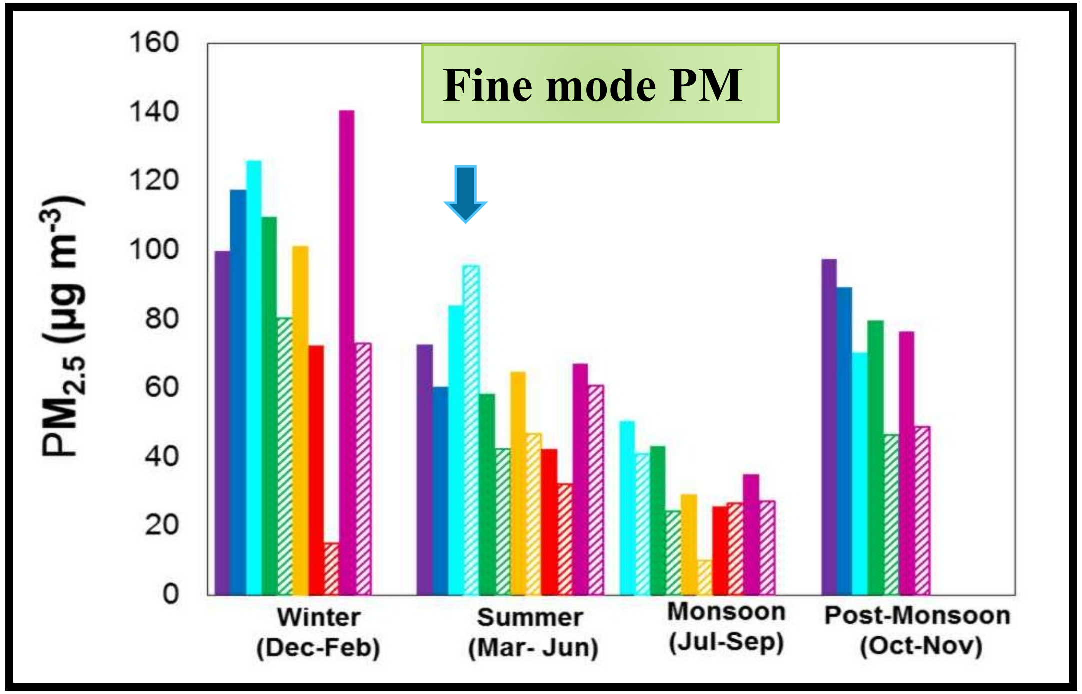
- Synoptic scale transport over NW-IGP
- > 30 % in all seasons
- Represents the regional background

Calm Conditions (WS < 1ms^{-1})

- Local sources
- < 9% in all seasons

Impact of Wet Scavenging on Particulate Matter (PM) Loading





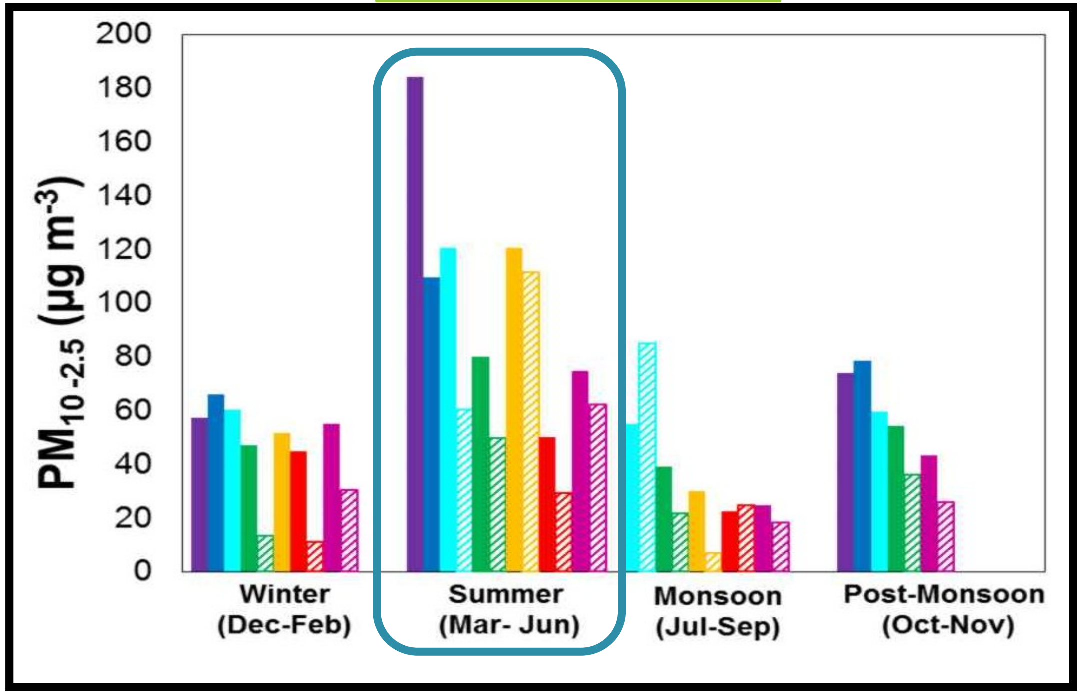
Wet scavenging had a profound impact in lowering the levels of both $PM_{10-2.5}$ and $PM_{2.5}$ for all clusters associated with rain events.

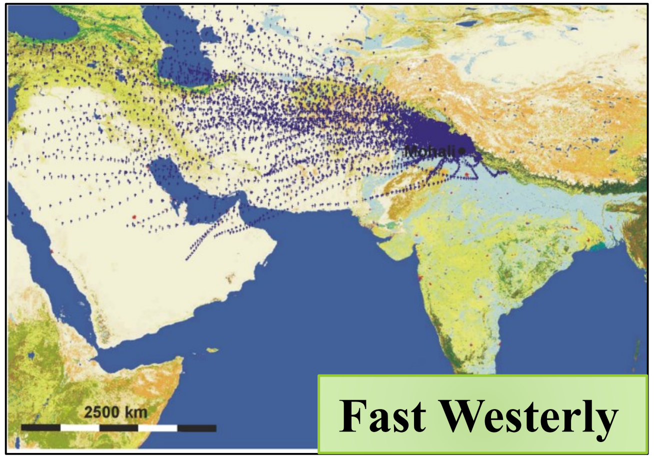
In some cases where convection dust storms accompanied rain event, increase in average cluster loading observed.

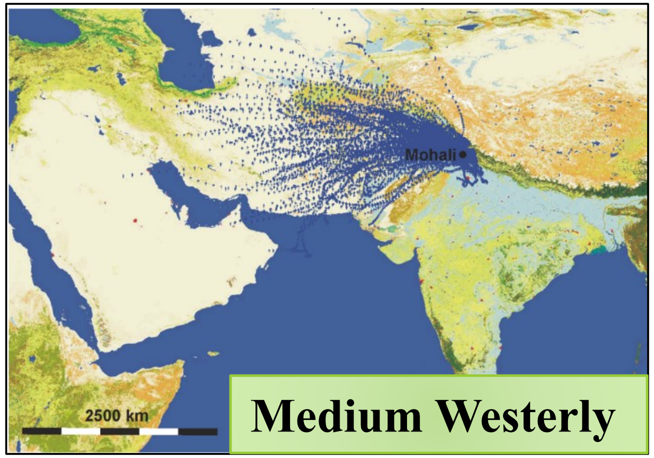
Fast Westerly | Medium Westerly | Slow Westerly | Local | South Westerly | South Easterly | Calm

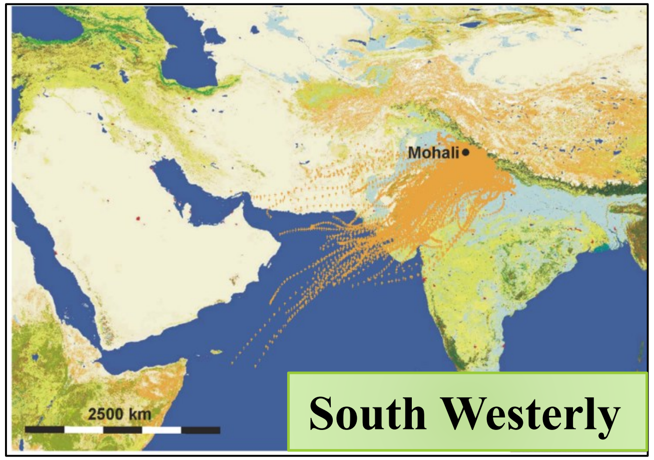
Impact of Air Mass Transport on Particulate Matter (PM) Loading

Coarse mode PM







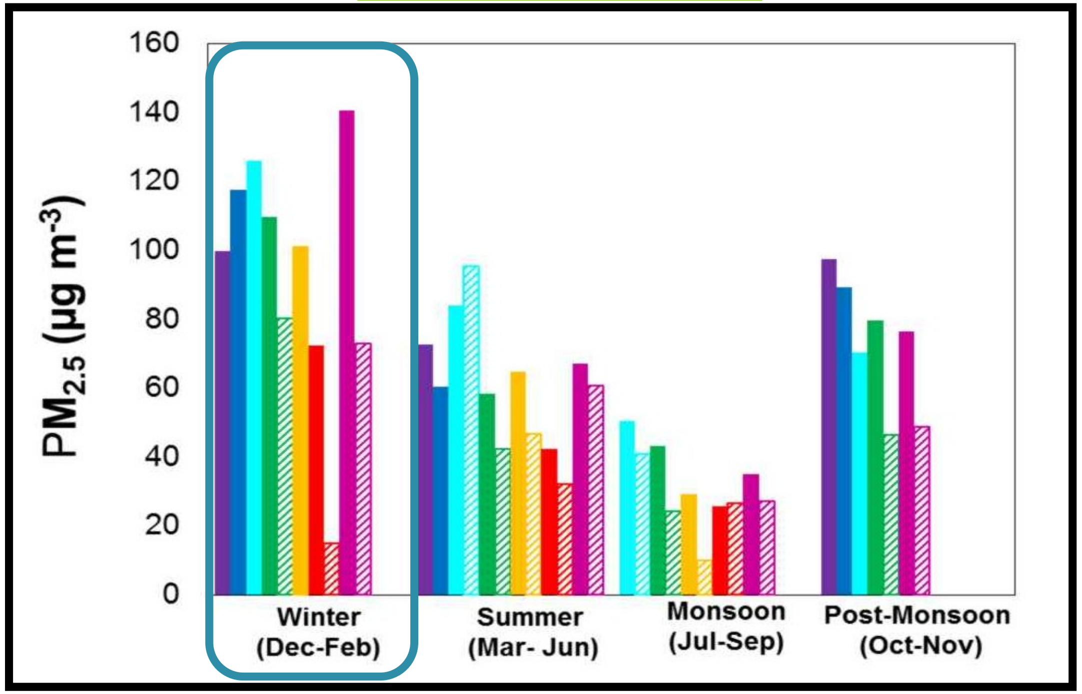


Pawar, H., *Garg, S., Kumar, V., Sachan, H., Arya, R., Sarkar, C., Chandra, B. P., and Sinha, B.: Quantifying the contribution of long-range transport to Particulate Matter (PM) mass loadings at a suburban site in the North-Western Indo Gangetic Plain (IGP), Atmos. Chem. Phys. Discuss., 15, 11409-11464*

■ Fast Westerly ■ Medium Westerly ■ Slow Westerly ■ Local ■ South Westerly ■ South Easterly ■ Calm

Impact of Air Mass Transport on Particulate Matter (PM) Loading

Fine mode PM



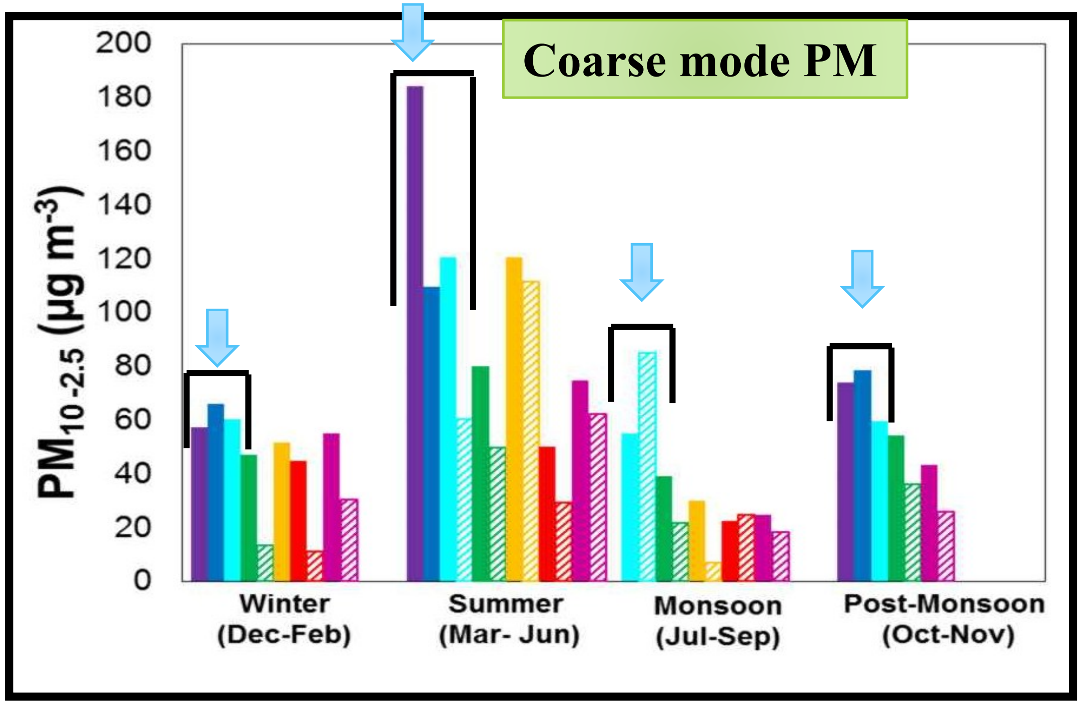
January 20, 2015 20:00 LT

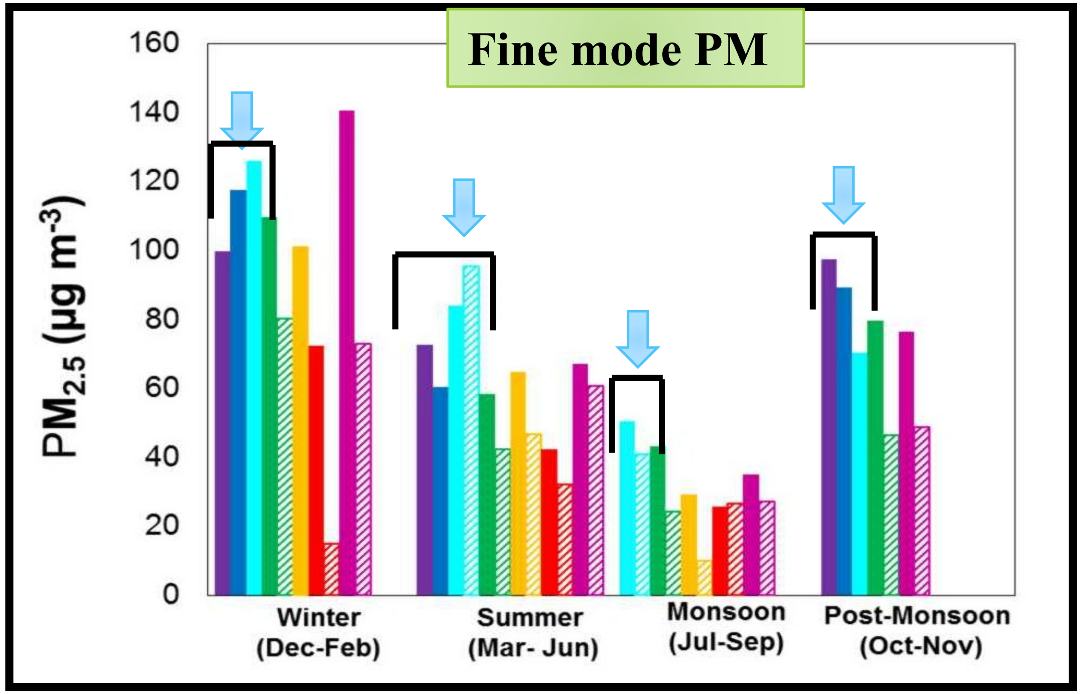
February 1, 2015 18:30 LT

February 7, 2015 19:30 LT

Fast Westerly | Medium Westerly | Slow Westerly | Local | South Westerly | South Easterly | Calm

Impact of Air Mass Transport on Particulate Matter (PM) Loading





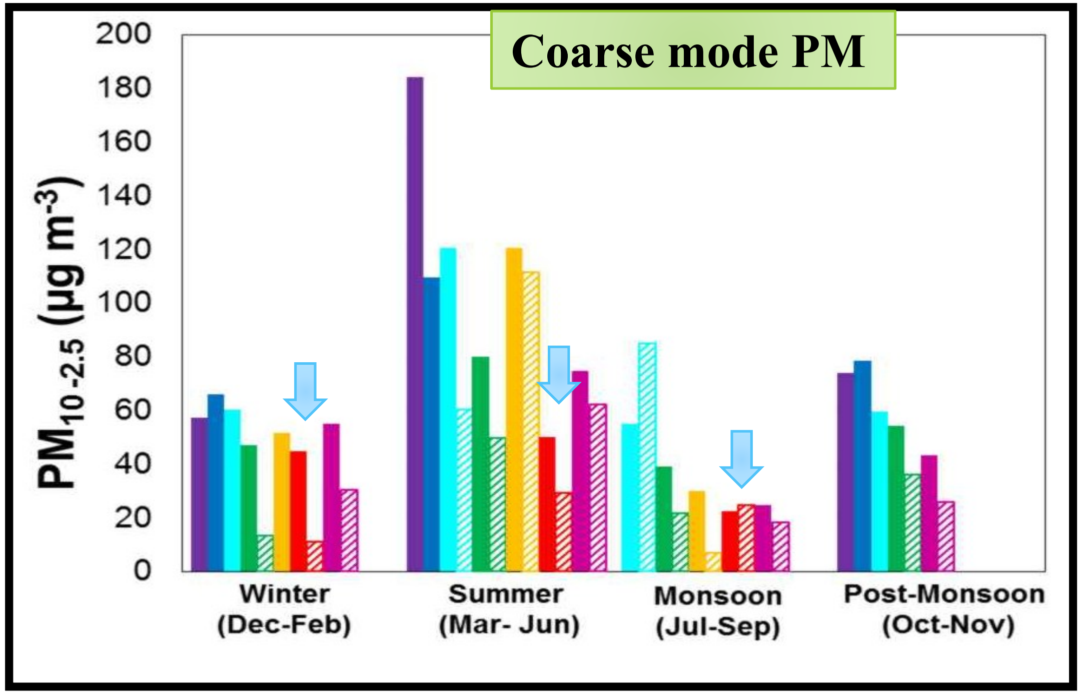
Enhancement (in %) of PM mass loadings above the levels observed for the "**Local**" cluster

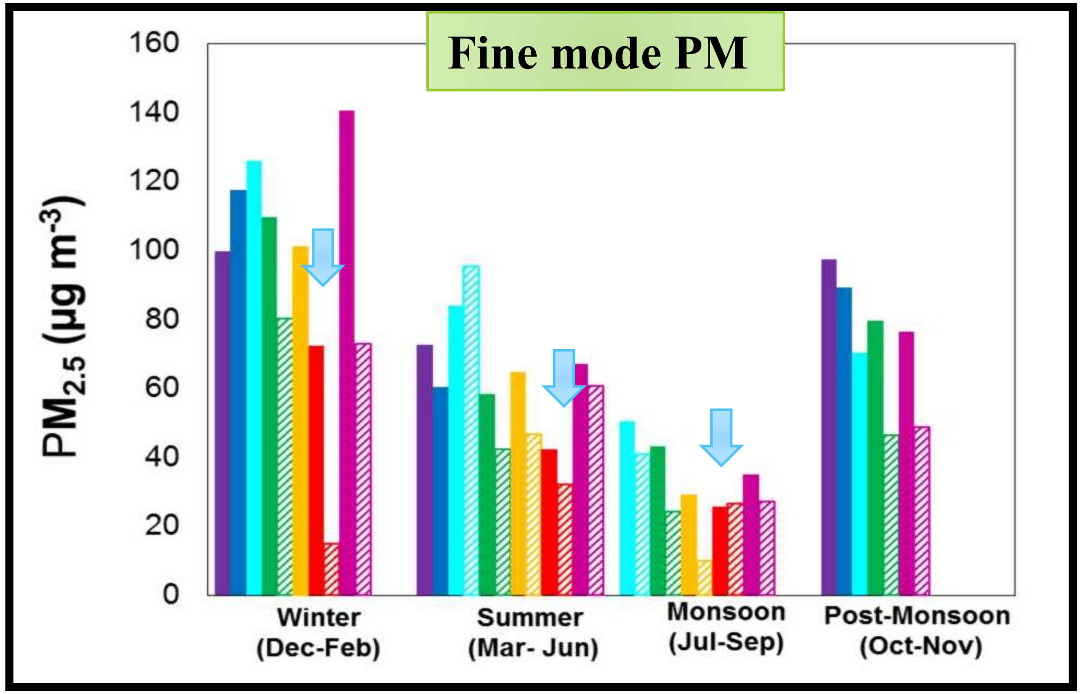
$PM_{10-2.5}$	Fast Westerly	Medium Westerly	Slow Westerly	South Westerly	South Easterly	Calm
Winter	18	28	22	9	Negative	14
Summer	57	27	34	34	Negative	Negative
Monsoon			29	Negative	Negative	Negative
Post-Monsoon	27	31	9			Negative

$PM_{2.5}$	Fast Westerly	Medium Westerly	Slow Westerly	South Westerly	South Easterly	Calm
Winter	Negative	7	13	Negative	Negative	22
Summer	20	4	31	10	Negative	13
Monsoon			15	Negative	Negative	Negative
Post-Monsoon	18	11	Negative			Negative

■ Fast Westerly ■ Medium Westerly ■ Slow Westerly ■ Local ■ South Westerly ■ South Easterly ■ Calm

Impact of Air Mass Transport on Particulate Matter (PM) Loading





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Monsoon			29	Negative	Negative	Negative
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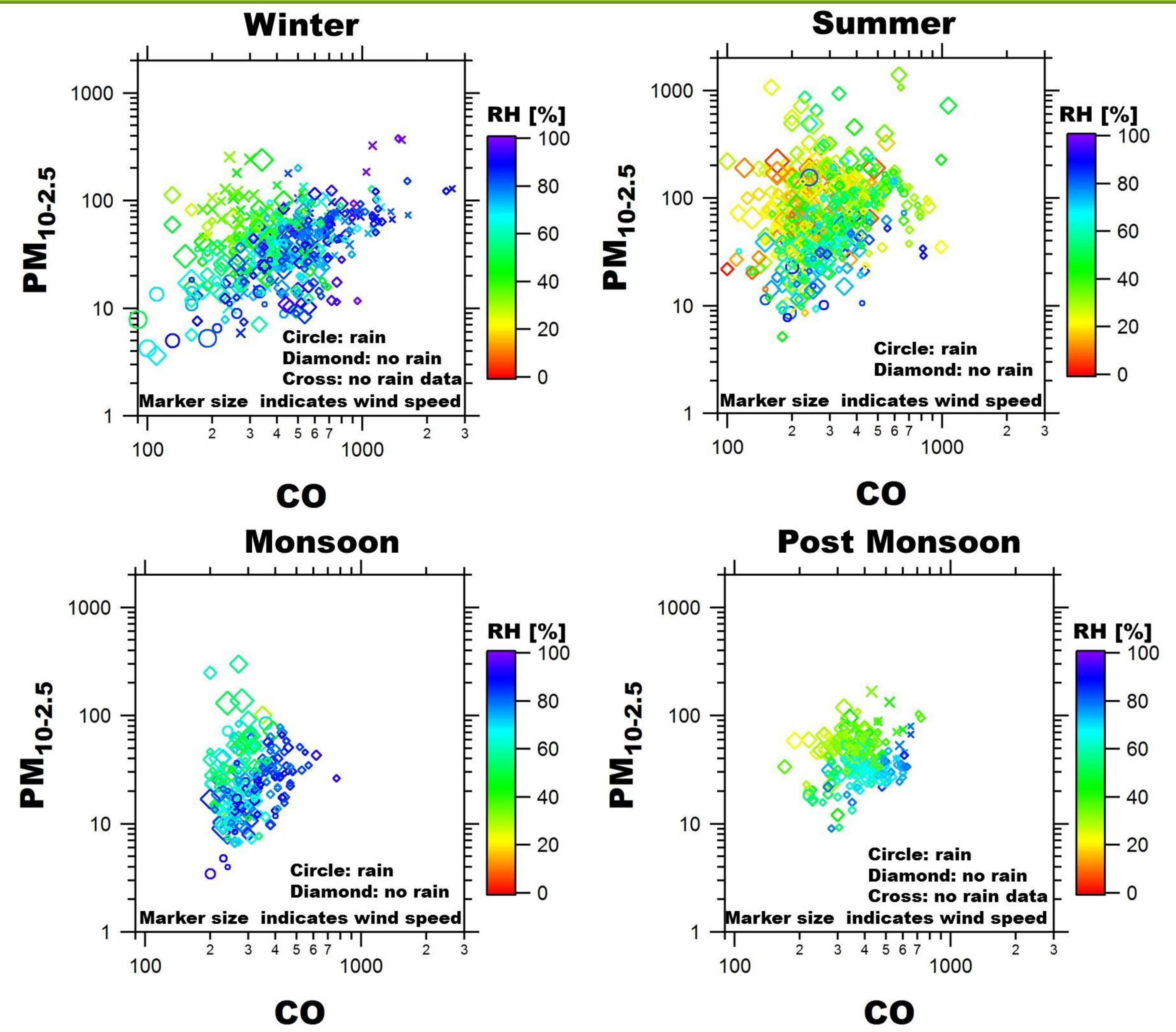
■ Fast Westerly ■ Medium Westerly ■ Slow Westerly ■ Local ■ South Westerly ■ South Easterly ■ Calm

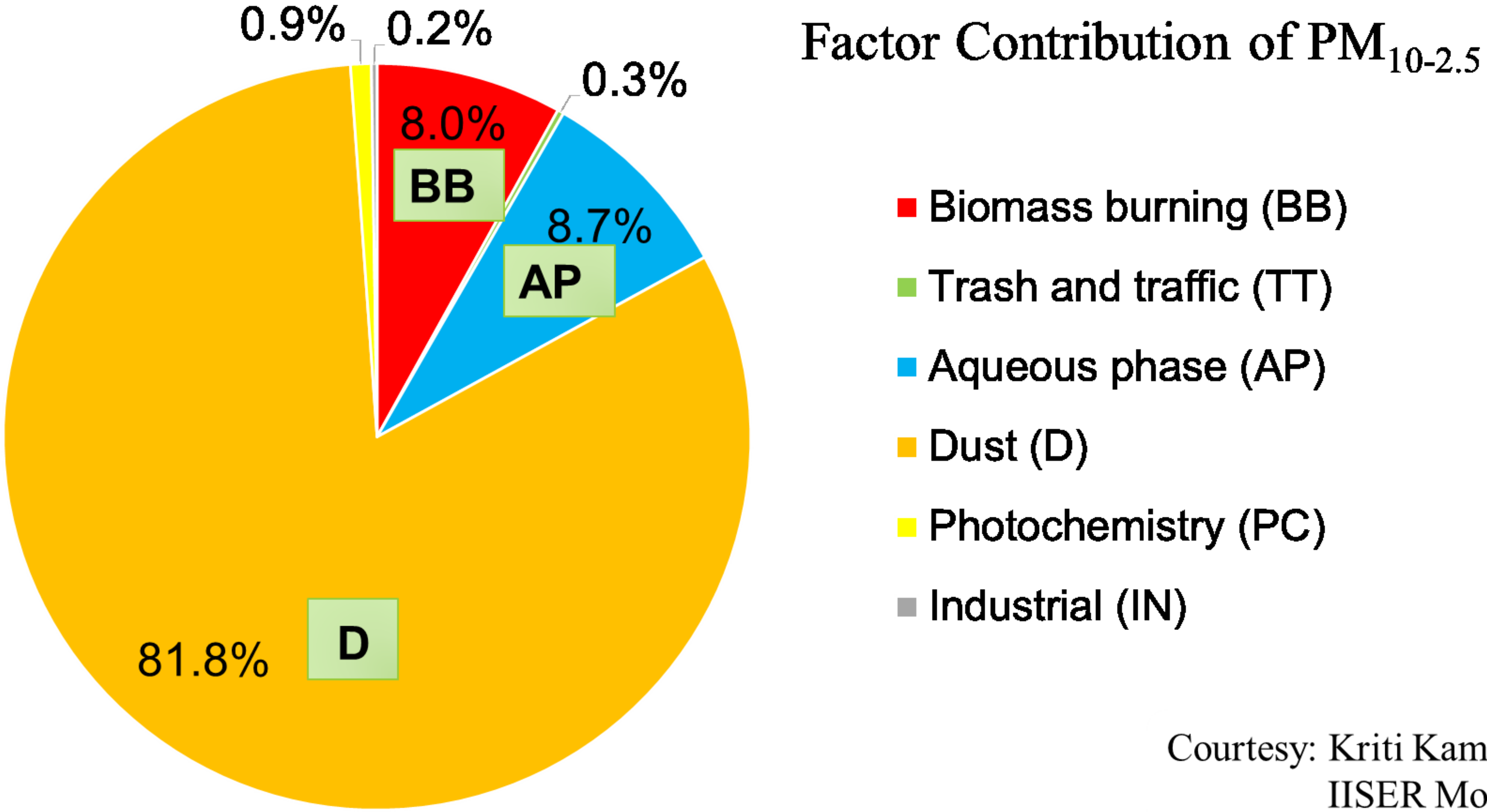
Dependence of coarse mode PM on gas-phase precursors and Met. parameters



At RH > 70%, aqueous phase oxidation of gas-phase precursors, results in high degree of correlation between coarse PM and CO (r = 0.55).

At RH < 50%, locally suspended and transported dust contribute to coarse PM.

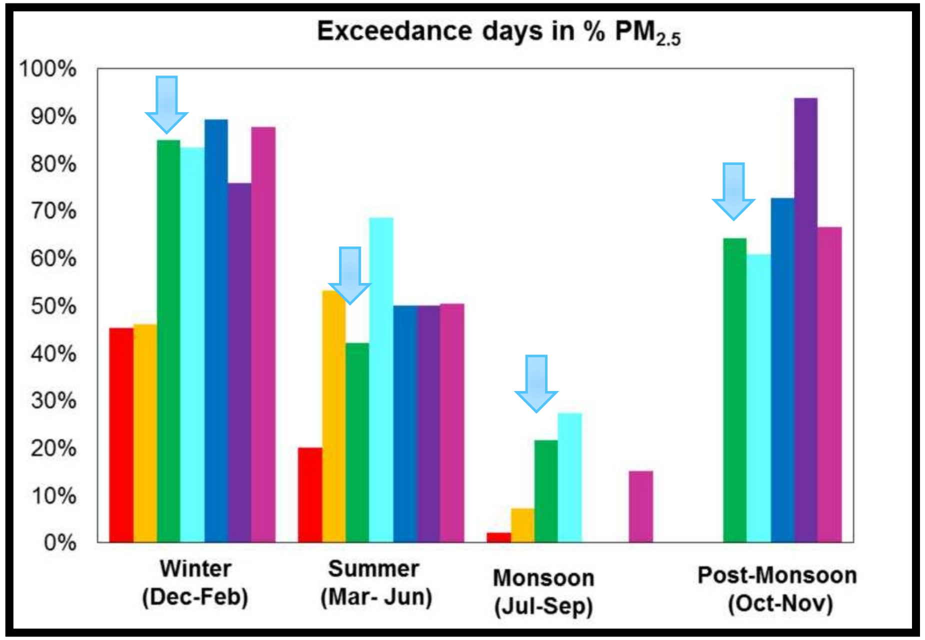
Work In Progress: PMF Model applied to ambient data of Aug 2011- June 2013

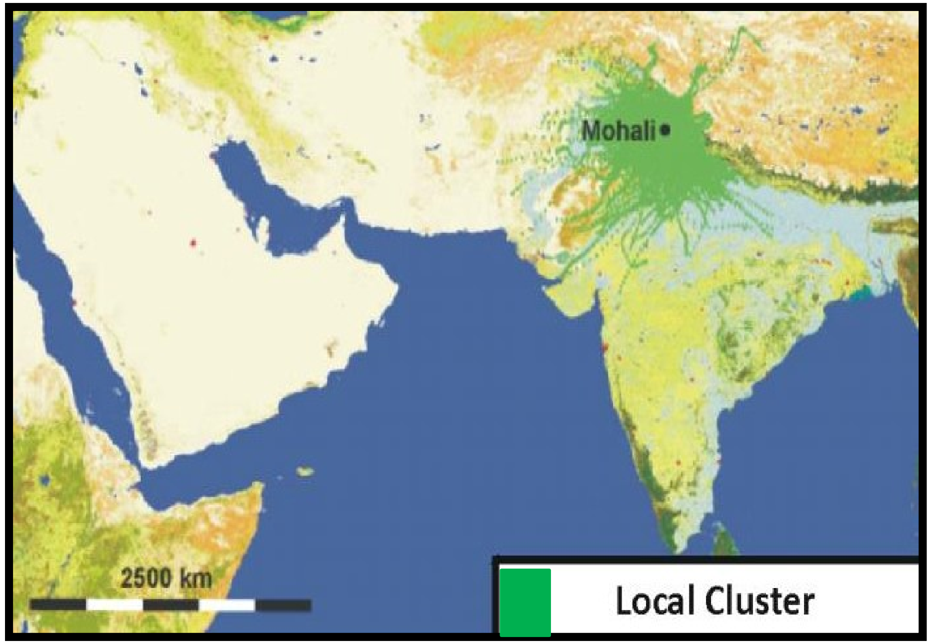


Courtesy: Kriti Kamal Gupta
IISER Mohali

Impact of Air Mass Transport on Particulate Matter (PM) Exceedance Events

24 hour average of $PM_{2.5}$ $> 60\ \mu g/m^3$: **EXCEEDANCE**





Increase in exceedance days due to long range transport varied between a few % to at most 30%

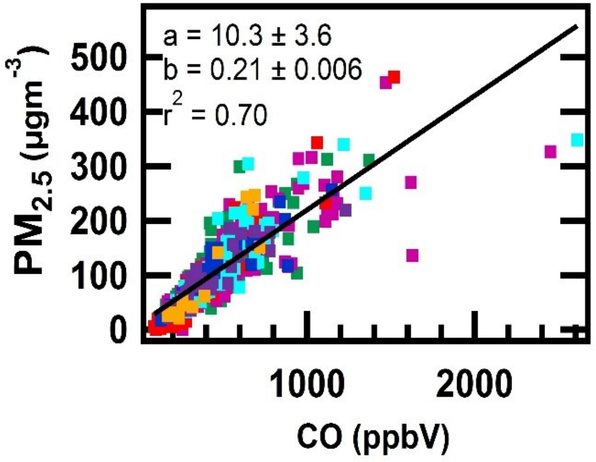
Exceedance days controlled by long range transport to less degree.

Regional Pollution Sources

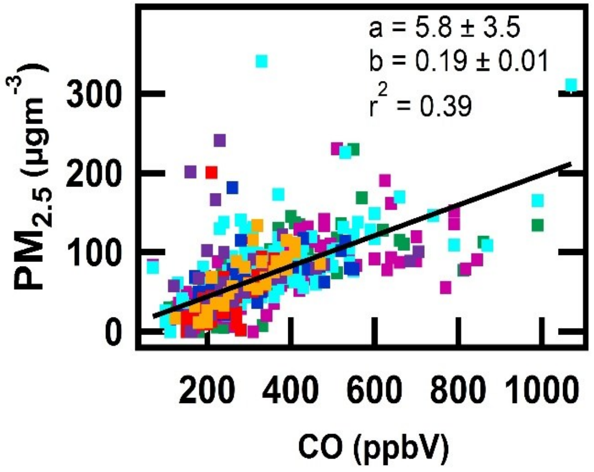
■ Fast Westerly ■ Medium Westerly ■ Slow Westerly ■ Local ■ South Westerly ■ South Easterly ■ Calm

Dominant regional pollution sources contributing to $PM_{2.5}$

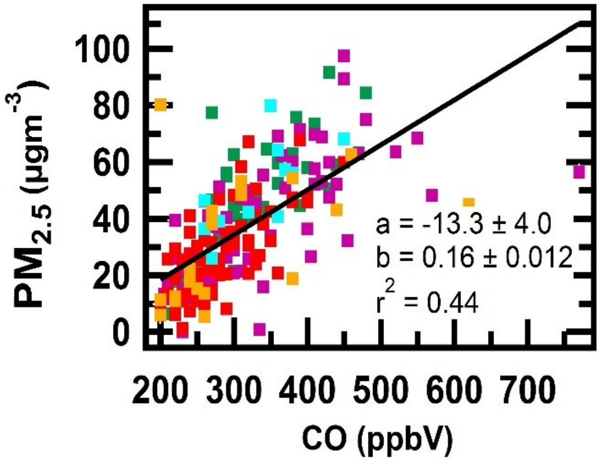
Winter (Dec-Feb)



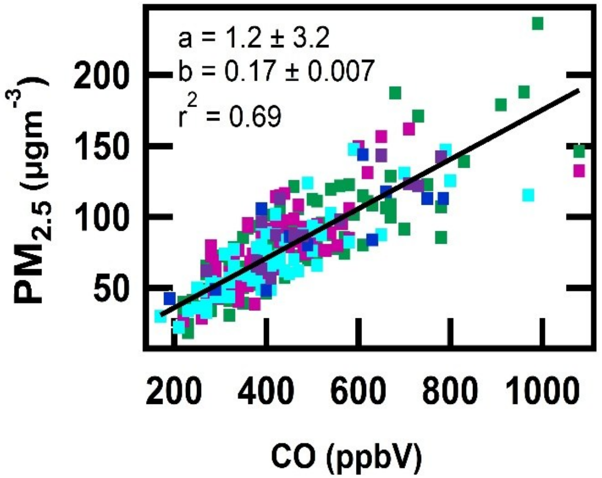
Summer (Mar-Jun)



Monsoon (Jul-Sep)



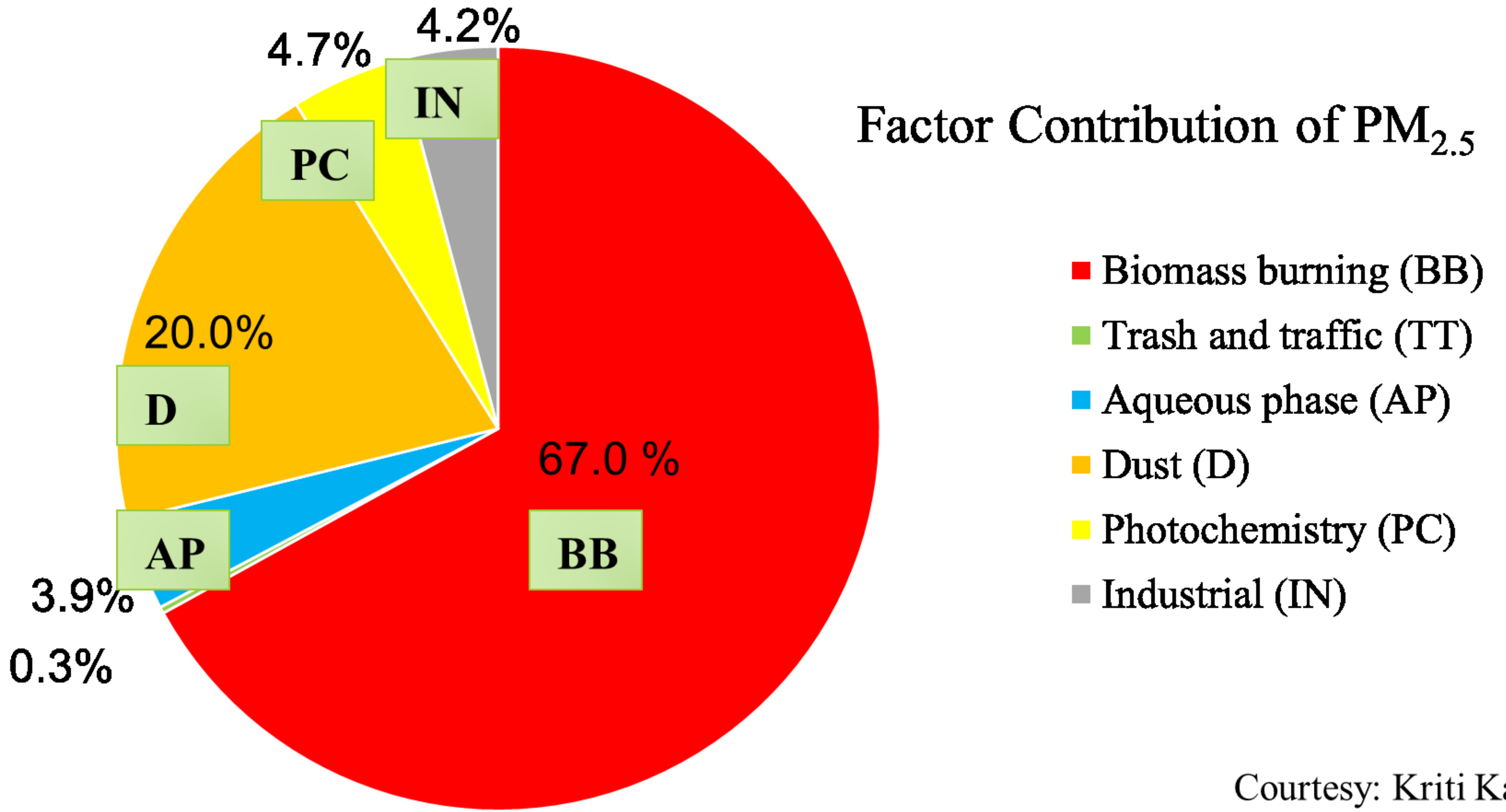
Post-Monsoon (Oct-Nov)



$PM_{2.5}$ mass loadings largely controlled by combustion sources during all seasons.

Regional pollution sources to be targeted in order to bring PM mass loadings in compliance with air quality standards.

Work In Progress: PMF Model applied to ambient data of Aug 2011- June 2013



Courtesy: Kriti Kamal Gupta
IISER Mohali

Conclusion

Long range transport from west leads to significant enhancements in average **coarse (9 to 57%)** and **fine (4% to 31%)** PM loadings in all seasons.

South-easterly air masses were the cleanest and had significantly low loadings of coarse **(-6 to -75%)** and fine **(-38 to -67 %)** PM in all seasons.

High degree of correlation with CO (a combustion tracer) suggests most fine PM originated from **combustion sources.**

To bring PM mass loadings in compliance with NAAQS, **mitigation of regional pollution sources** needs to be given highest priority.

Acknowledgement

- ACAM and all organizers
- ICIMOD
- Ministry of Human Resource Development, India
- DST Inspire Fellowship & IISER Mohali
- Dr. Bärbel Sinha