Climatological transboundary circulation and outflow of atmospheric monsoonal compositions over Bangladesh

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Presented By
DR. MD FIROZ KHAN

Air Pollution Hot Spot: Bangladesh

- Air pollution is a global issue, and Bangladesh is one of the most affected countries, facing severe air quality problems.
- The country has been grappling with air pollution for over a decade, resulting in a crisis where millions of people are exposed to harmful pollutants.
- Bangladesh's air pollution has had a significant impact on both the economy and public health.
- According to Siddiqui et al., air pollution in Bangladesh has led to a considerable percentage of deaths and disabilities, with an estimated economic cost of USD 192 million.
- The health consequences of air pollution in Bangladesh are severe, encompassing respiratory diseases, cancer, and cardiovascular diseases.
- The World Bank recently reported that air pollution is responsible for approximately 20% or 88K of premature deaths in Bangladesh.

“Air Pollution!

Is this a new ‘silent spring’ for the people in South Asia

Transboundary Air Pollution Outflow on Bangladesh

China

Indo-Gangetic Plain

India

Nepal

Bangladesh

Bay Of Bengal

Lets Have A Look At Few Factors Influencing Air Pollution in Bangladesh

Fig 1: Black carbon retrieved from AOD at 550 nm over 2015-2021

- Analysis of Black carbon from AOD at 550 nm reveals smog production trends in Bangladesh (2015-2021).
- Smog levels are relatively low in November, December, and January.
- Significant increase in smog levels observed in February and March.
- Black carbon smog peak diminishes notably in April and May.
- Smog virtually disappears during June to August.
- Gradual emergence of smog spots observed from September to October.

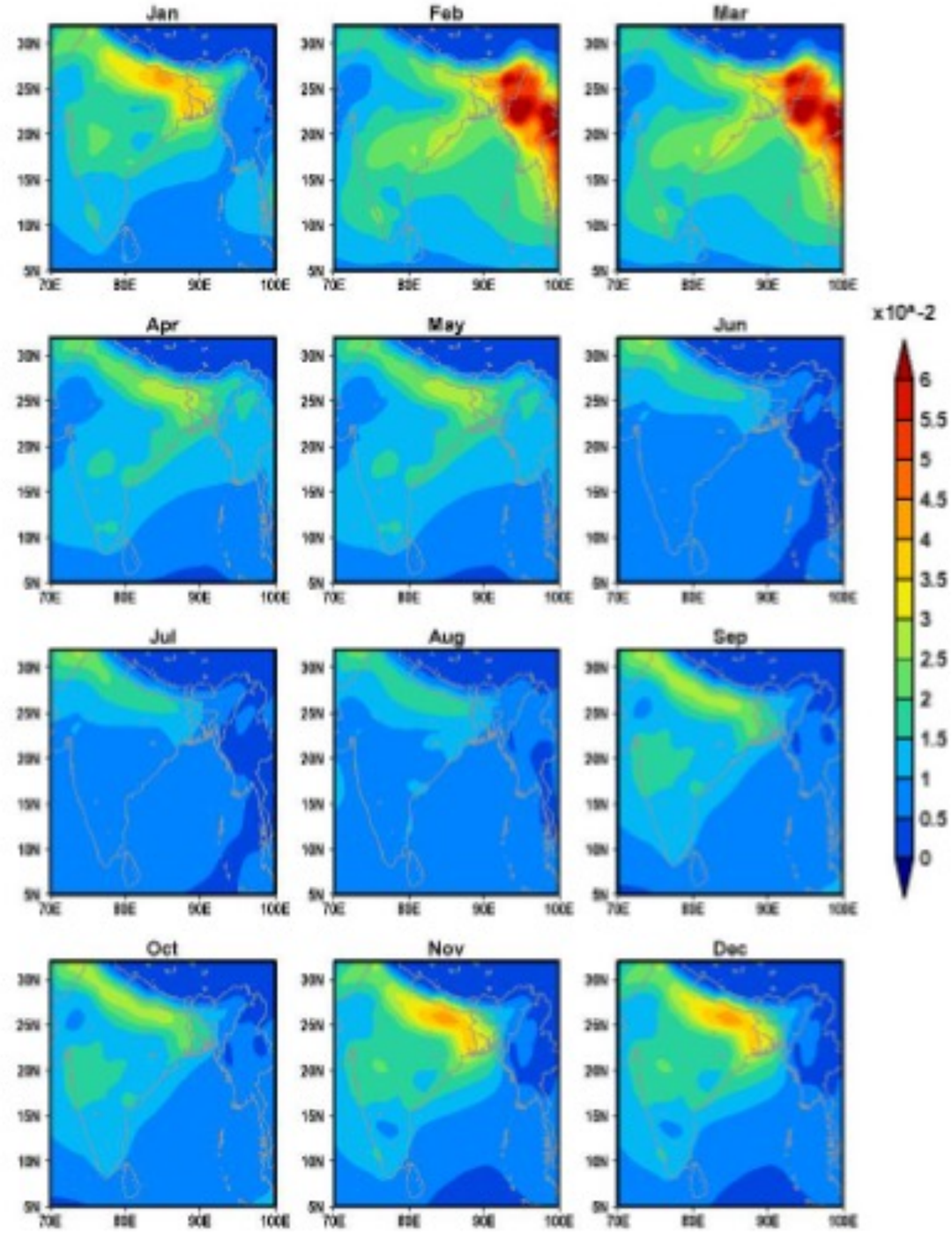


Fig 2: Long term CO variation from 2015 to 2021.

- Long-term CO variation analysis in Bangladesh shows high CO concentrations from November to March.
- CO concentration in February and March is relatively lower compared to November, December, and January.
- April experiences a sharp decline in CO content, resulting in minimal to no CO presence in June and July.
- Similar CO concentrations observed in April and May.
- CO presence resurfaces to some extent in September and October, followed by a renewed increase.

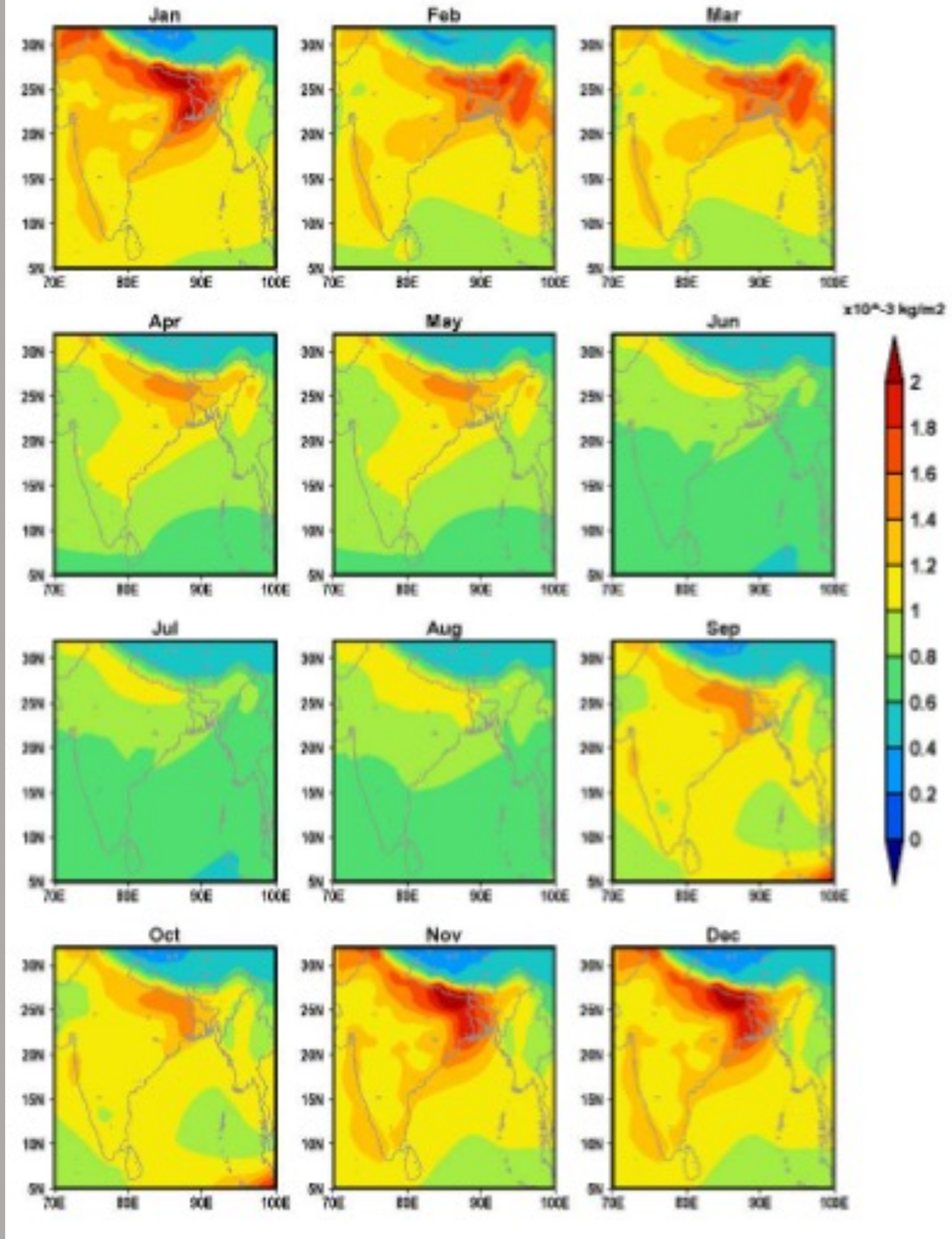


Fig 3: Climatological NO column (kg/m2)

- This figure shows the Climatological NO column (kg/m2) concentration.
- November to January: Bangladesh has low NO levels.
- February to May: Influence of NO emissions from neighboring countries with higher concentrations.
- June to October: Bangladesh experiences high NO concentrations.
- Peak NO levels occur in June, July, and August, surpassing September and October.
- NO concentrations gradually decrease in November.

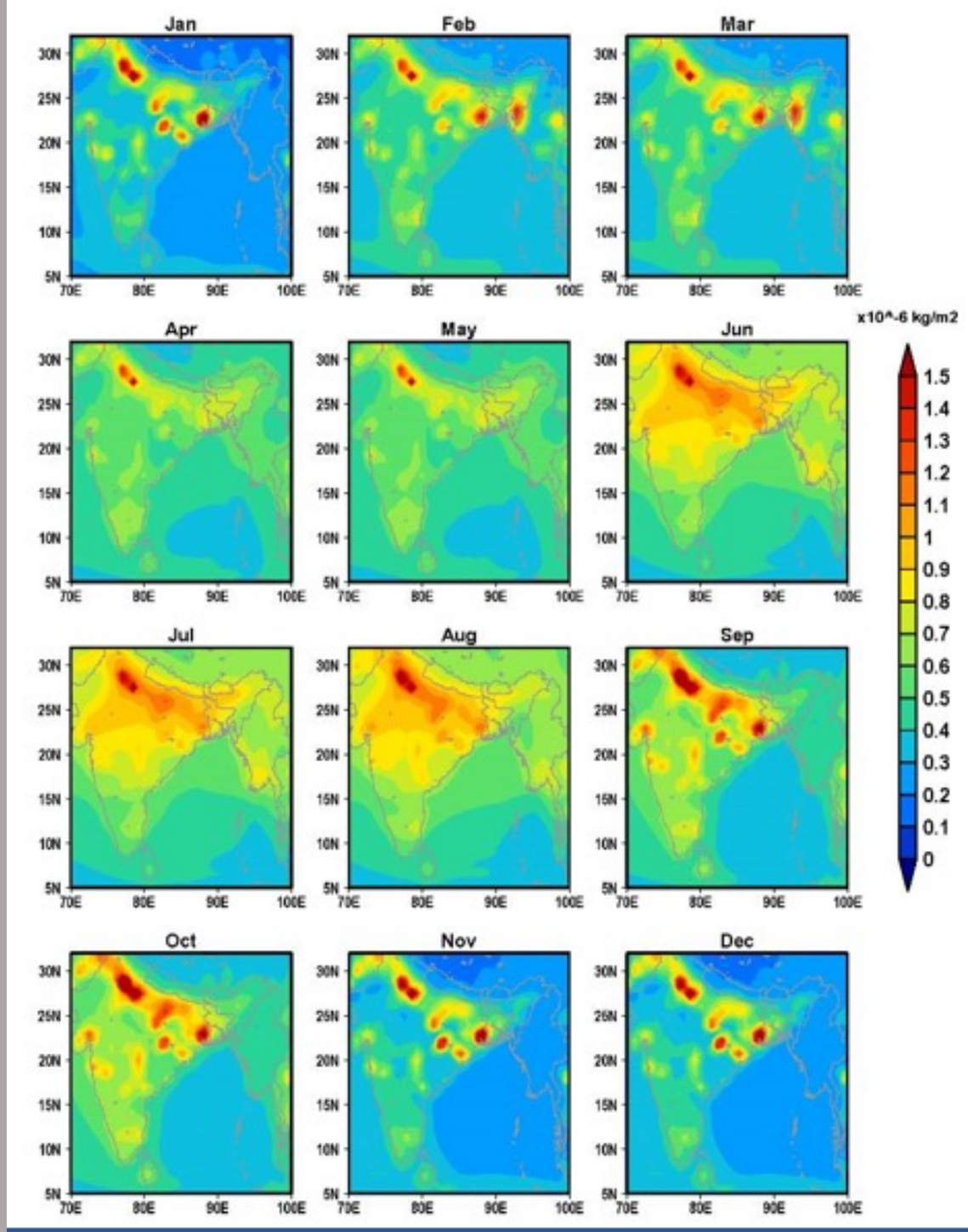


Fig 4: Climatological NO2 column (kg/m2)

- This Figure illustrates the monthly variation of NO2 levels.
- November to January: Relatively low NO2 concentration in Bangladesh.
- Gradual increase in NO2 levels from February to May, with slightly higher concentrations in April and May.
- Elevated NO2 concentrations persist from June to October.
- Peak NO2 levels occur in June, July, and August.
- NO2 concentrations gradually decline in September and October, followed by a gradual decrease in November.

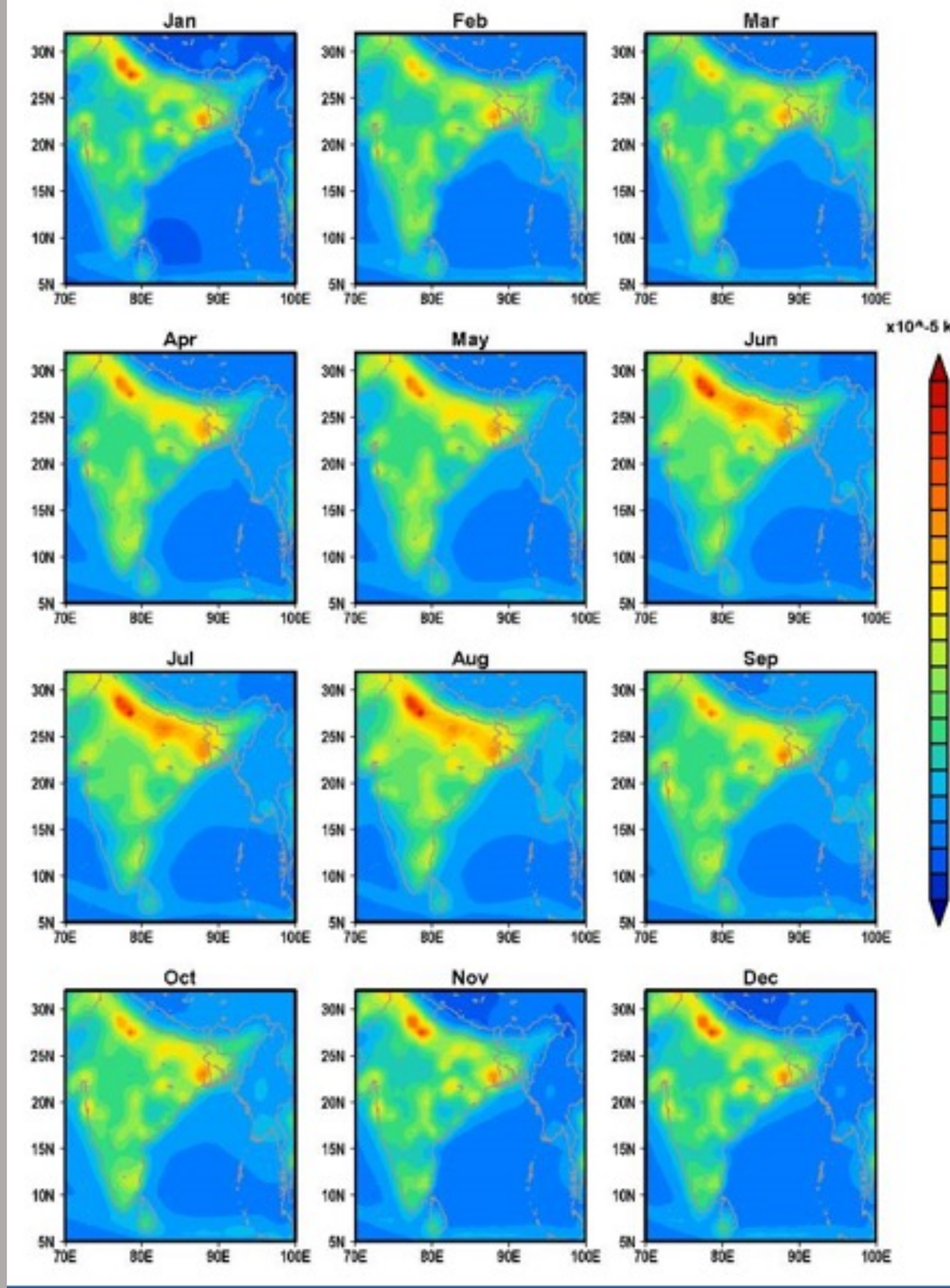
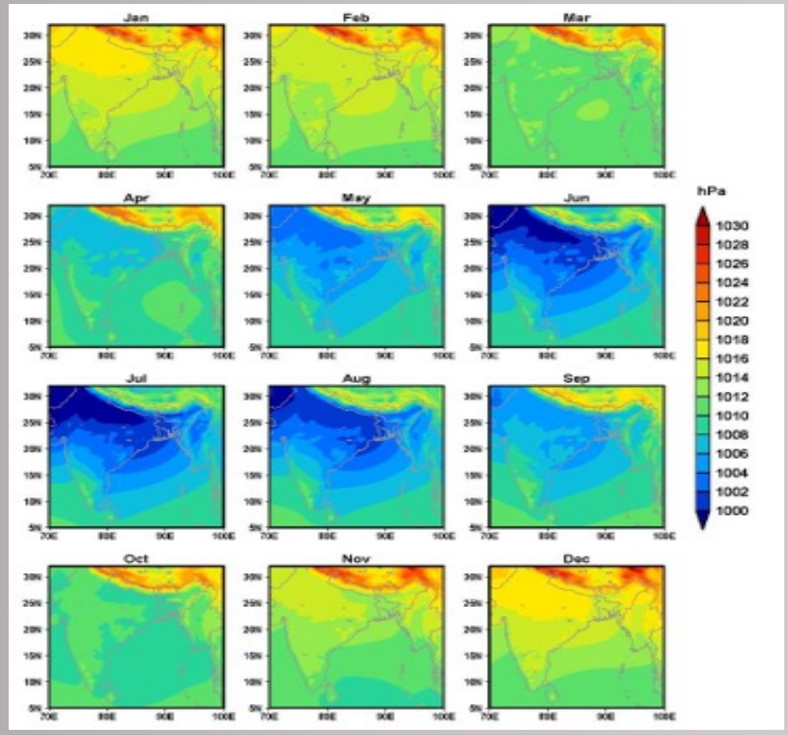
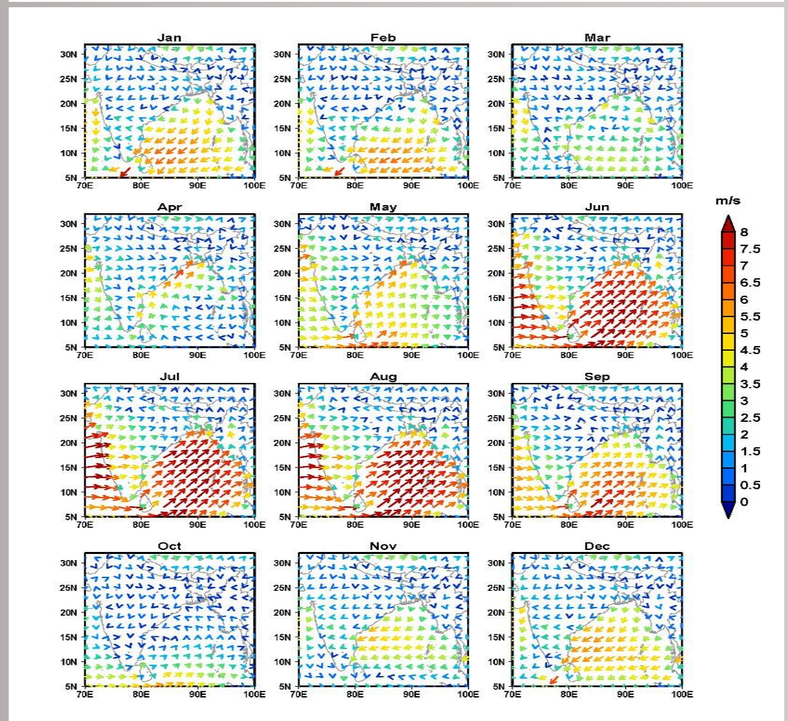


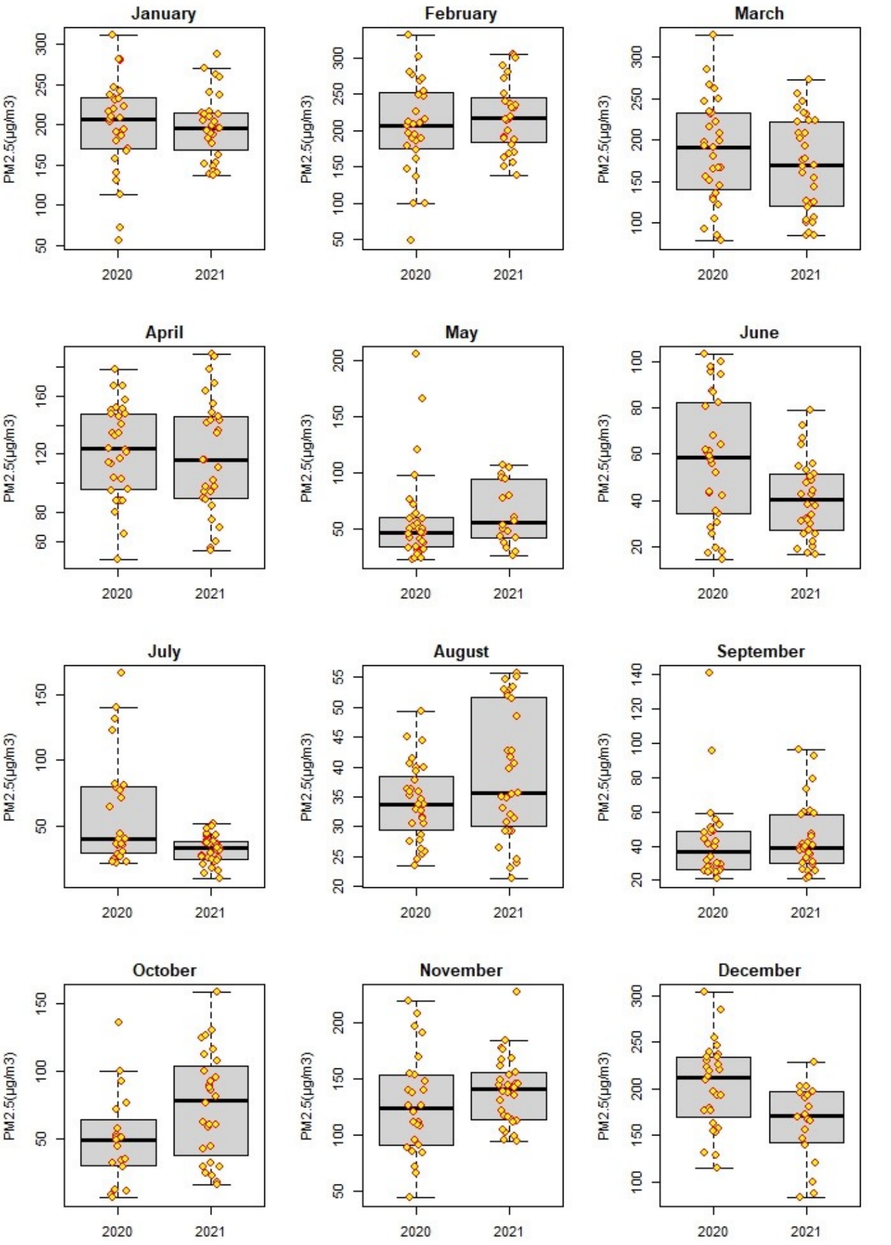
Fig 5: Climatological sea level pressure (hPa) & wind vectors

- The Figure shows climatological sea level pressure (hPa) over the Indo-Gangetic area and the Bay of Bengal.
- November to March: High pressure in northwest region, lower pressure in the Bay of Bengal.
- April to August: Reversal of the trend, with lower pressure in the northwest and higher pressure in the Bay of Bengal.
- September onwards: Progressive reversal, with slightly higher pressure in the northwest and slightly lower pressure in the Bay of Bengal.



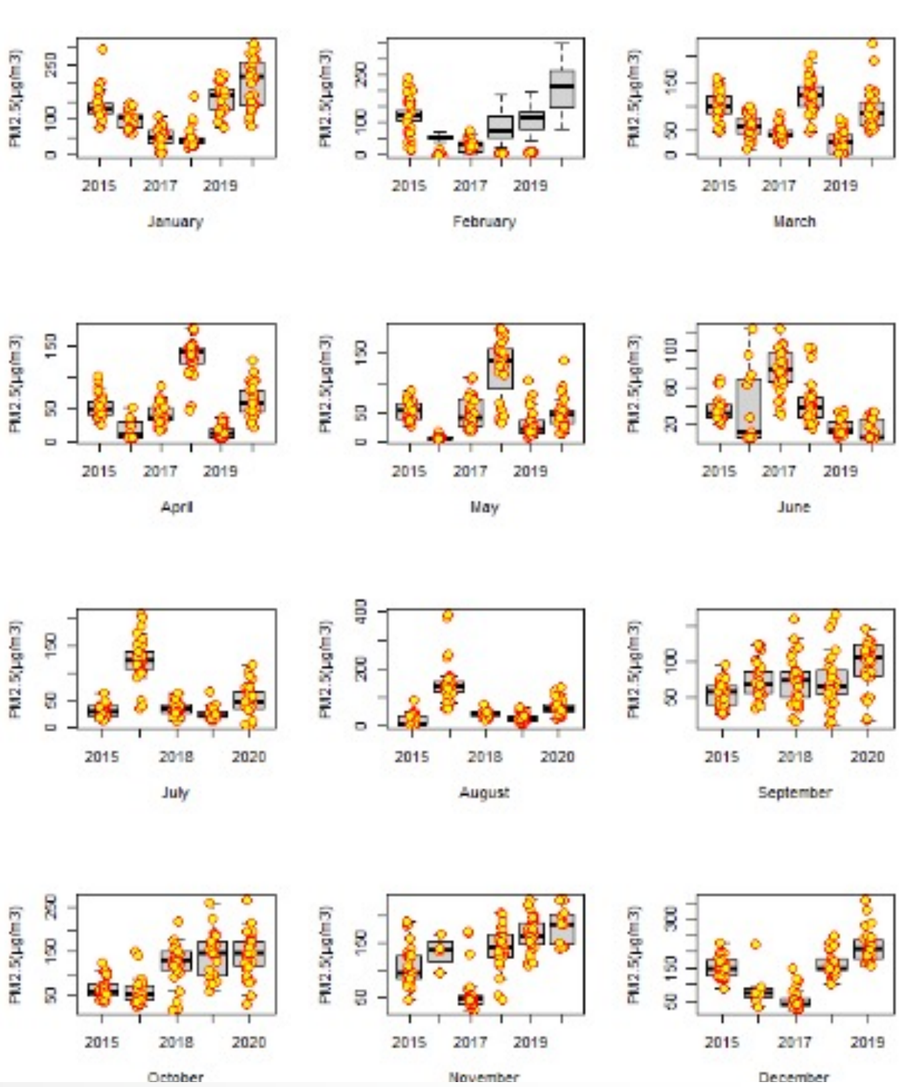


$PM_{2.5}$ variation from 2020 to 2021 in Rangpur



Effect of transboundary air pollution through PM2.5 variation

- **During winter the $PM_{2.5}$ is highest in both Rangpur and Dhaka**
- **Both Local and Regional sources play a role in the variation of $PM_{2.5}$**



$PM_{2.5}$ variation from 2015 to 2021 at Farmgate in Dhaka site.

Generalized Additive Model (GAM)

$$\text{Log}[E(y)] = \beta_0 + \beta_1 Z_{CO} + \beta_2 Z_{O3} + \beta_3 Z_{\text{wind speed (WS)}} + \beta_4 Z_{\text{mixing\_height}} + \sum S(\gamma_i, df_i)$$

Where,

$E(y) = PM_{2.5}$ (Response variable)

Z_* = Linear variables (predictors)

γ = Covariates (Trend, Temperature, Humidity)

S = Smoothing function using cubic splines

df = Degree of freedom

Risk Ratio (RR)=$\text{Exp}[\beta_i]$

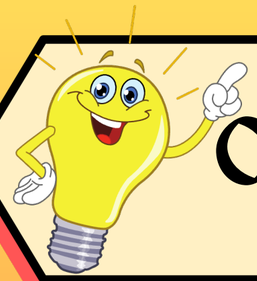
ER =(RR-1)*100, % change in concentration of PM2.5 due to a certain input (e.g. boundary layer height)

Overall	est	se	low	upp	pvalue	RR	lowrr	uprr	ER
~C0	0.2952	0.0169	0.2620	0.3285	0.0000	1.3435	1.2996	1.3888	34.3459
~O3	0.0031	0.0023	-0.0014	0.0077	0.1722	1.0032	0.9986	1.0077	0.3153
~Wind_speed	-0.0417	0.0096	-0.0606	-0.0228	0.0000	0.9592	0.9412	0.9774	-4.0837
~pbl	0.0001	0.0000	0.0000	0.0001	0.0035	1.0001	1.0000	1.0001	0.0077

Winter	est	se	low	upp	pvalue	RR	lowrr	uprr	ER
winter~C0	0.2317	0.0247	0.1833	0.2802	0.0000	1.2608	1.2012	1.3234	26.0802
winter~O3	0.0022	0.0022	-0.0020	0.0065	0.3042	1.0022	0.9980	1.0065	0.2242
winter~Wind_speed	-0.0331	0.0096	-0.0519	-0.0143	0.0006	0.9674	0.9494	0.9858	-3.2574
winter~pbl	0.0001	0.0000	0.0000	0.0002	0.0070	1.0001	1.0000	1.0002	0.0135

Monsoon	est	se	low	upp	pvalue	RR	lowrr	uprr	ER
monsoon~C0	0.2768	0.0468	0.1850	0.3686	0.0000	1.3189	1.2032	1.4457	31.8868
monsoon~O3	-0.0296	0.0156	-0.0601	0.0009	0.0581	0.9709	0.9417	1.0009	-2.9147
monsoon~Wind_speed	0.0685	0.0890	-0.1059	0.2428	0.4419	1.0709	0.8995	1.2749	7.0877
monsoon~pbl	0.0002	0.0001	0.0000	0.0003	0.0231	1.0002	1.0000	1.0003	0.0152

Post-monsoon	est	se	low	upp	pvalue	RR	lowrr	uprr	ER
post_monsoon~C0	0.2668	0.0179	0.2318	0.3018	0.0000	1.3058	1.2609	1.3523	30.5826
post_monsoon~O3	0.0040	0.0023	-0.0005	0.0084	0.0798	1.0040	0.9995	1.0085	0.3990
post_monsoon~Wind_speed	-0.0340	0.0096	-0.0529	-0.0151	0.0004	0.9665	0.9484	0.9850	-3.3463
post_monsoon~pbl	0.0001	0.0000	0.0000	0.0001	0.0354	1.0001	1.0000	1.0001	0.0058



Our Way Forward

- It is imperative to increase community awareness regarding the risks associated with air pollution or carbon footprint.
- Encourage greater utilization of public transportation within the city.
- Adopt carpooling as a regular practice and minimize the frequency of individual car journeys.
- A pressing demand to gradually eliminate Old Fleets.
- Promote Alternative energy resource.
- Establish regional agreements or include the issue of transboundary air pollution in the agendas of organizations such as SAARC and Male Declaration, thereby addressing regional political commitments and mitigating the problem.

Its time to re-incarnate the planet for the Better!

Thank You!

Contact Email: firoz.khan@northsouth.edu / mdfiroz.khan@gmail.com