



Atmospheric stagnation over India and its effect on PM_{2.5}

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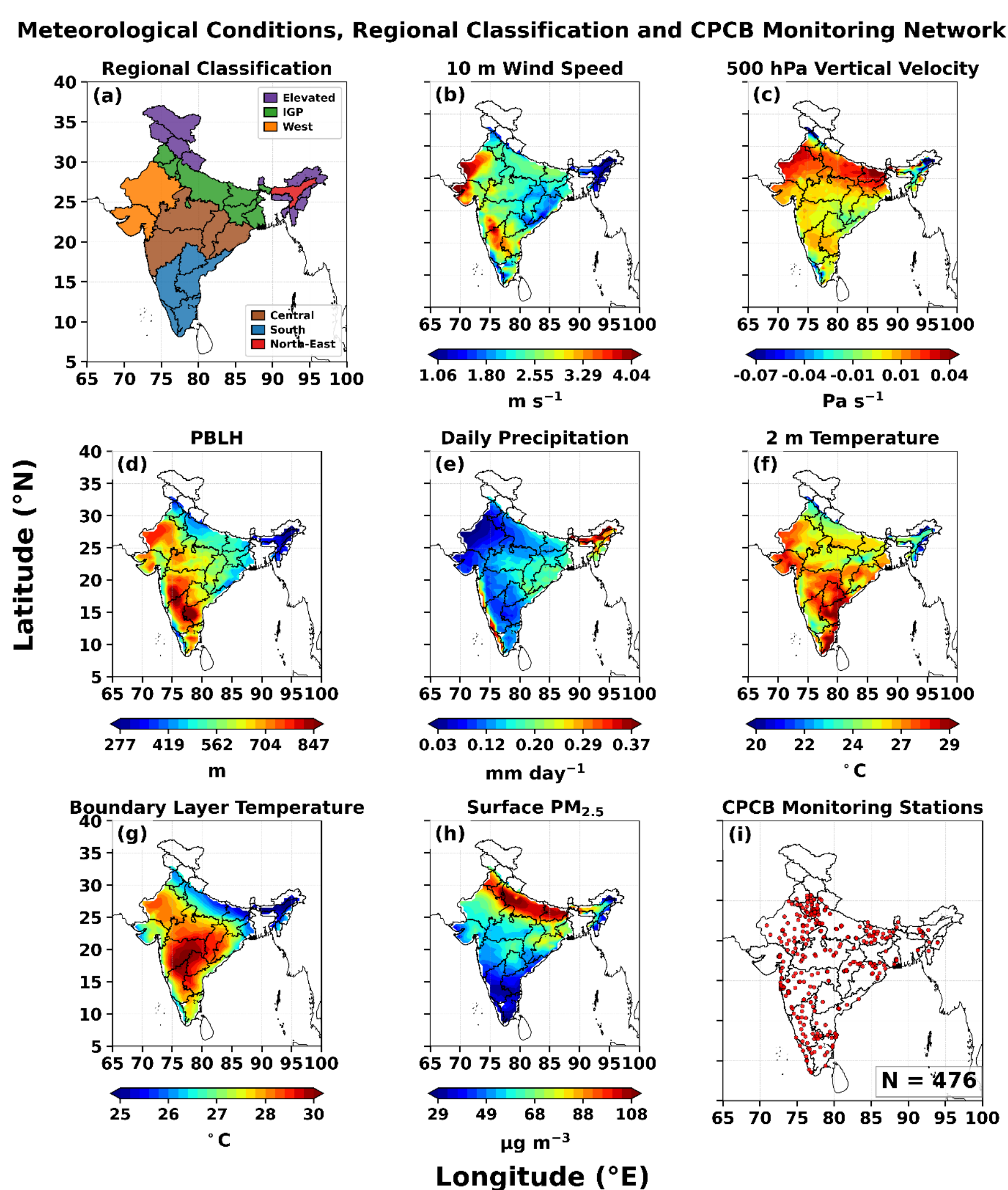
Introduction

- Atmospheric stagnation (AS) refers to specific meteorological conditions conducive to pollutant buildup in the lower troposphere
- Weak surface winds lead to reduced horizontal dispersion
- Stable atmospheric stratification during temperature inversions leads to limited vertical mixing
- Lack of precipitation hinders wet deposition
- Shallow atmospheric boundary layer (ABL) depth limits the available volume for pollutant dilution
- PM_{2.5} concentrations found to increase by 40-60% during stagnation events across multiple regions in China (Liao *et al* 2018; Wang *et al* 2018)
- In Europe, winter PM₁₀ anomalies under stagnant conditions average 17-19 µg m⁻³ (~60% of mean values; Garrido-Perez *et al*, 2021)
- We present a new empirical methodology for Atmospheric Stagnation Index (ASI) calculation over India using meteorological parameters
- We present ASI spatial and temporal variability and a new method to capture PM_{2.5} variability associated with ASI

Data & Methodology

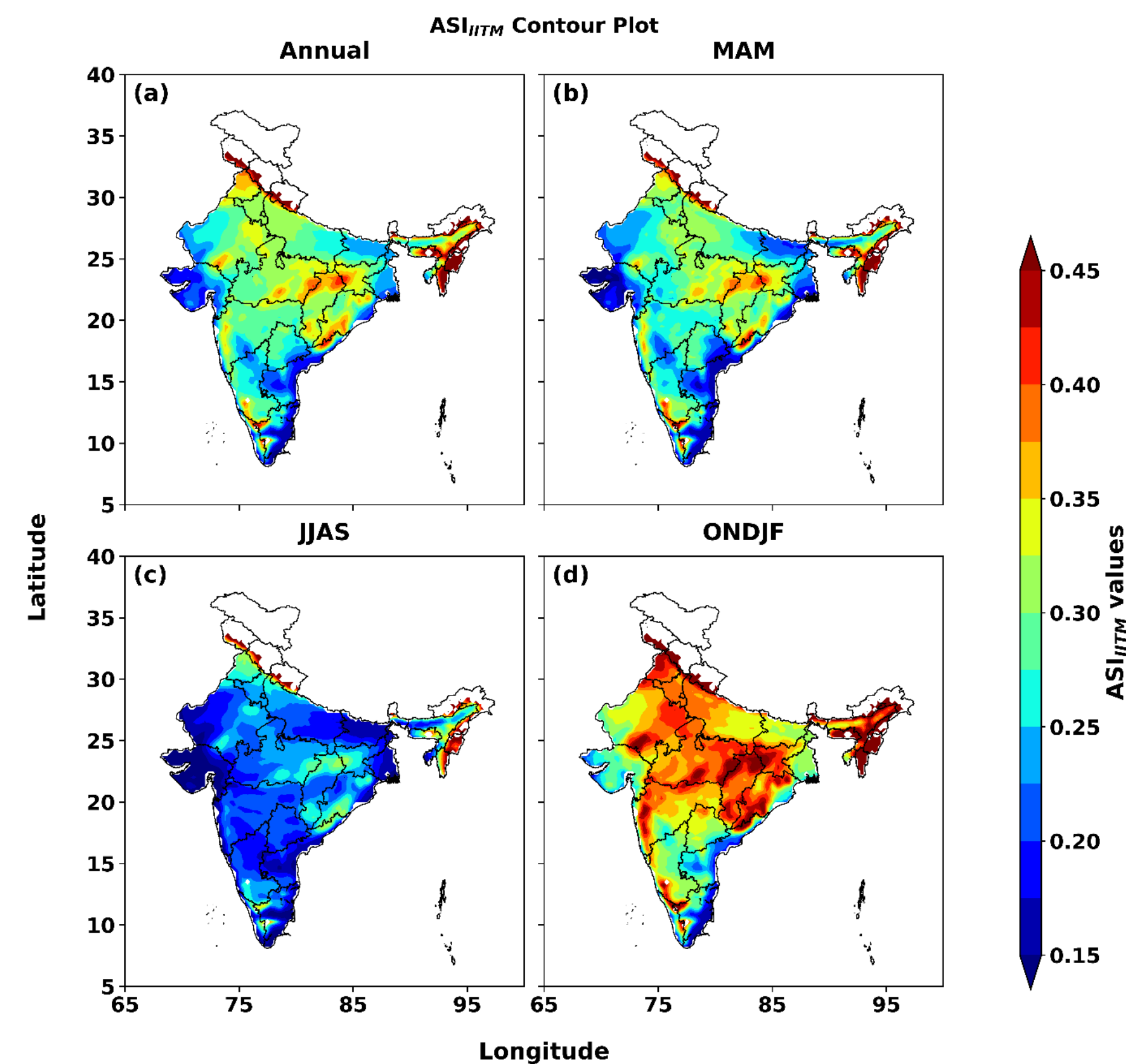
- We define our ASI or ASI_{IITM} as the following:
$$ASI_{IITM} = P_V \times P_{TI} \times P_S \times PBL_{coeff} \times P_W$$
 - P_V is the horizontal ventilation component
 - P_{TI} is the temperature inversion component
 - P_S is the subsidence component
 - PBL_{coeff} is the component associated with PBLH
 - P_W is the wet scavenging component related to precipitation
- ERA5 reanalysis product for meteorological variables
- ECMWF forecast product for meteorological variables
- MERRA2 reanalysis product for PM_{2.5} reanalysis
- CPCB station data for PM_{2.5} observations

Data (visualisation)



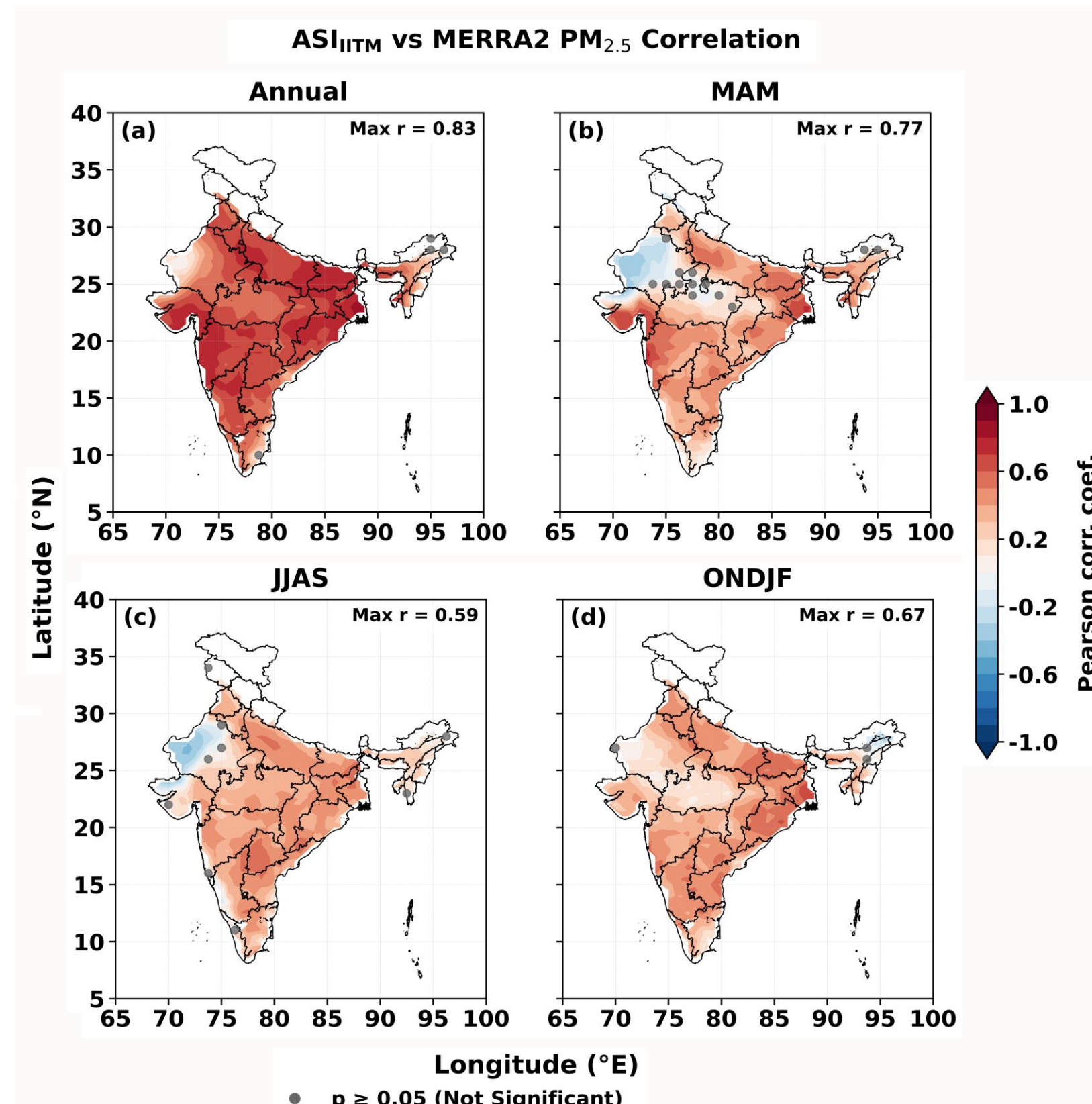
The annual average (a) 10 m wind speed, (b) 500 hPa vertical velocity, (c) planetary boundary layer height, (d) daily precipitation, (e) 2m temperature, (f) temperature at the planetary boundary layer from ERA5 data. Annual daily average MERRA2 PM_{2.5} is shown in subplot g. The coordinates of CPCB monitoring stations are shown in subplot h.

Spatial and Seasonal Distribution of ASI_{IITM}



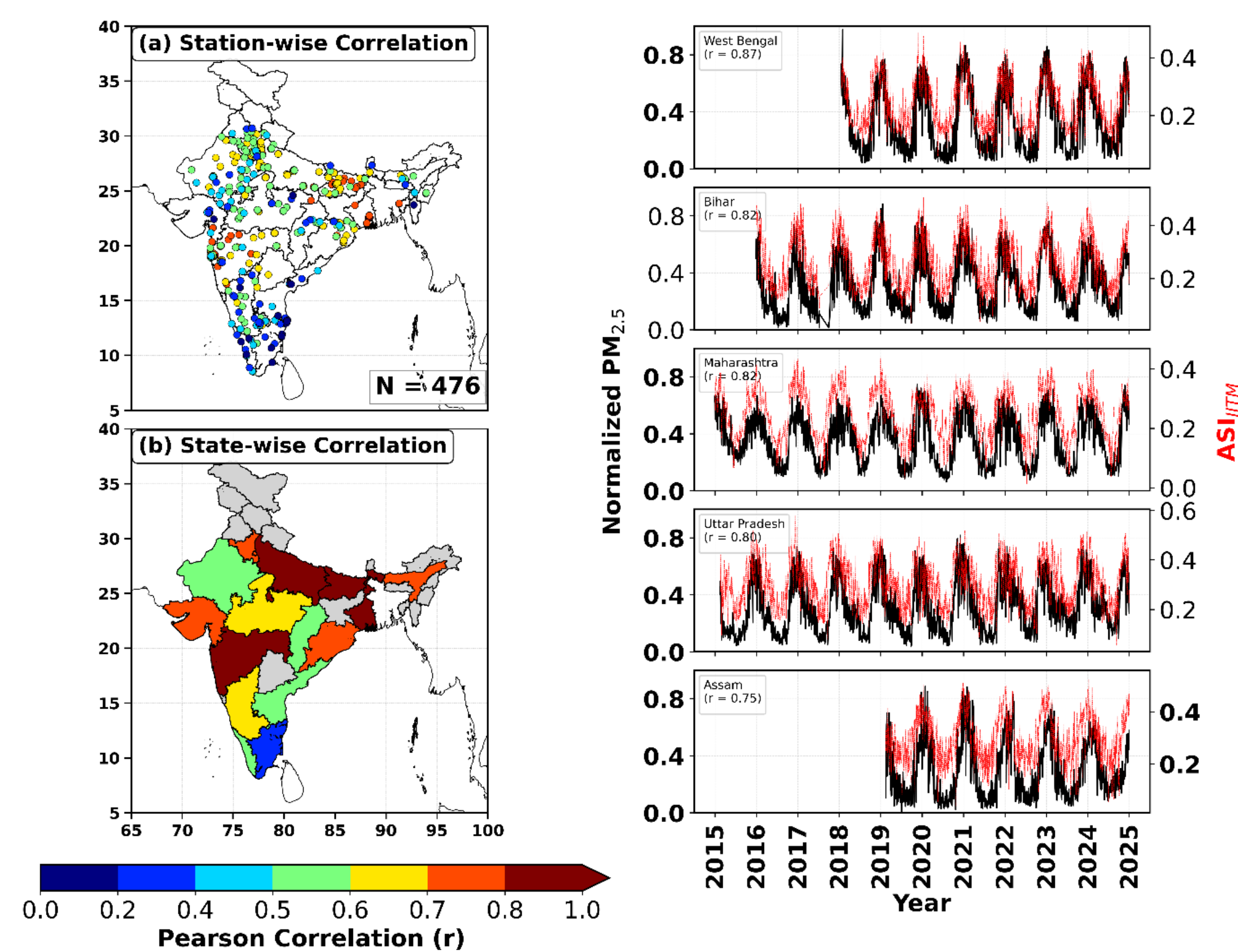
This plot shows the spatial distribution of average ASI_{IITM} over (a) annual, (b) MAM, (c) JJAS and (d) ONDJF time periods. An elevation filter of 1500m was applied to the plot, as elevated regions were found to exhibit extreme ASI_{IITM} values. The lowest and highest ASI_{IITM} values were found during the JJAS and the ONDJF seasons, respectively.

ASI_{IITM} vs MERRA-2 PM_{2.5}



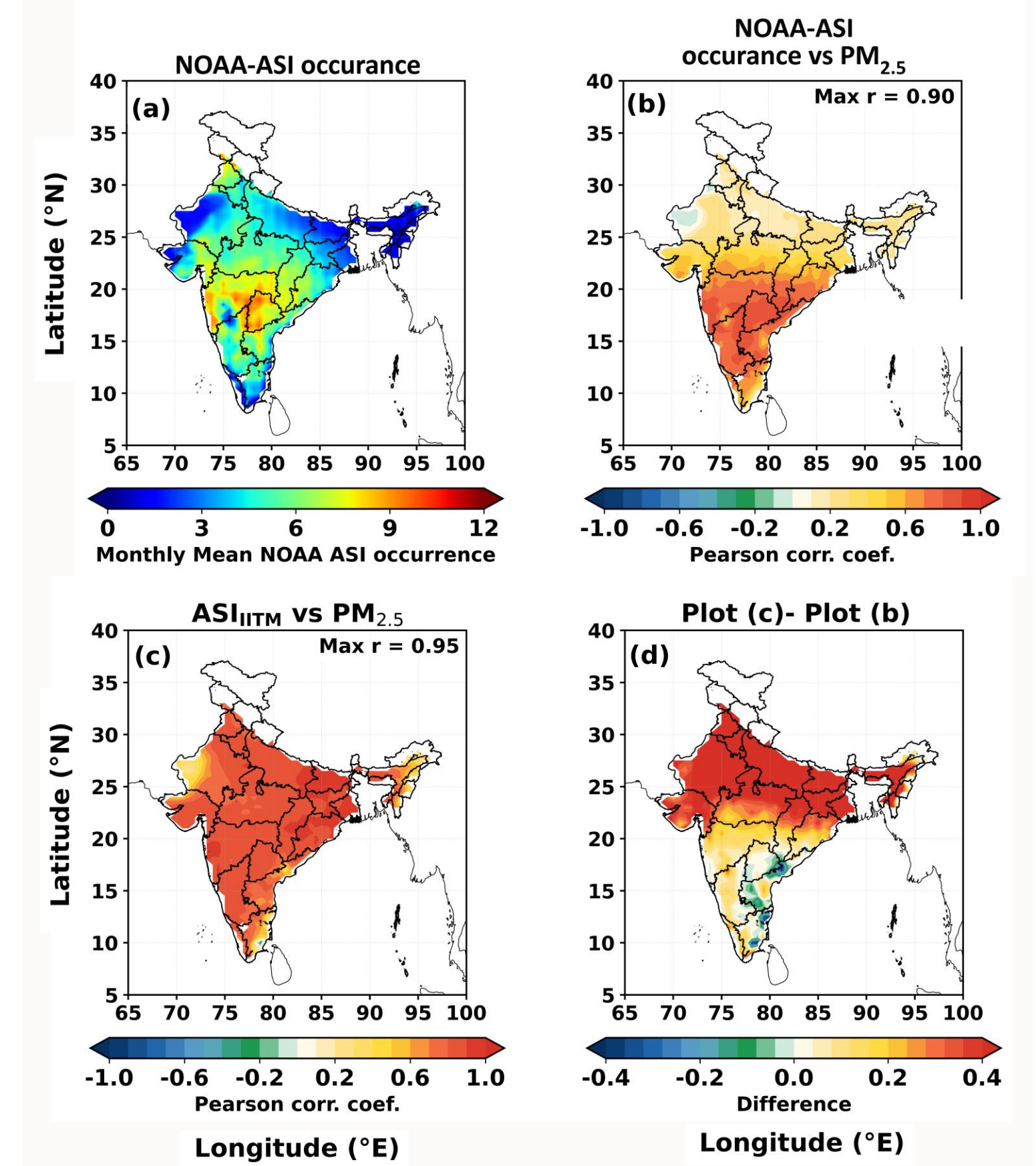
Spatial correlation plot of ASI_{IITM} and MERRA-2 PM_{2.5} product. Subplots (a), (b), (c) and (d) show correlation from the annual, MAM, JJAS and ONDJF periods.

ASI_{IITM} vs CPCB PM_{2.5}



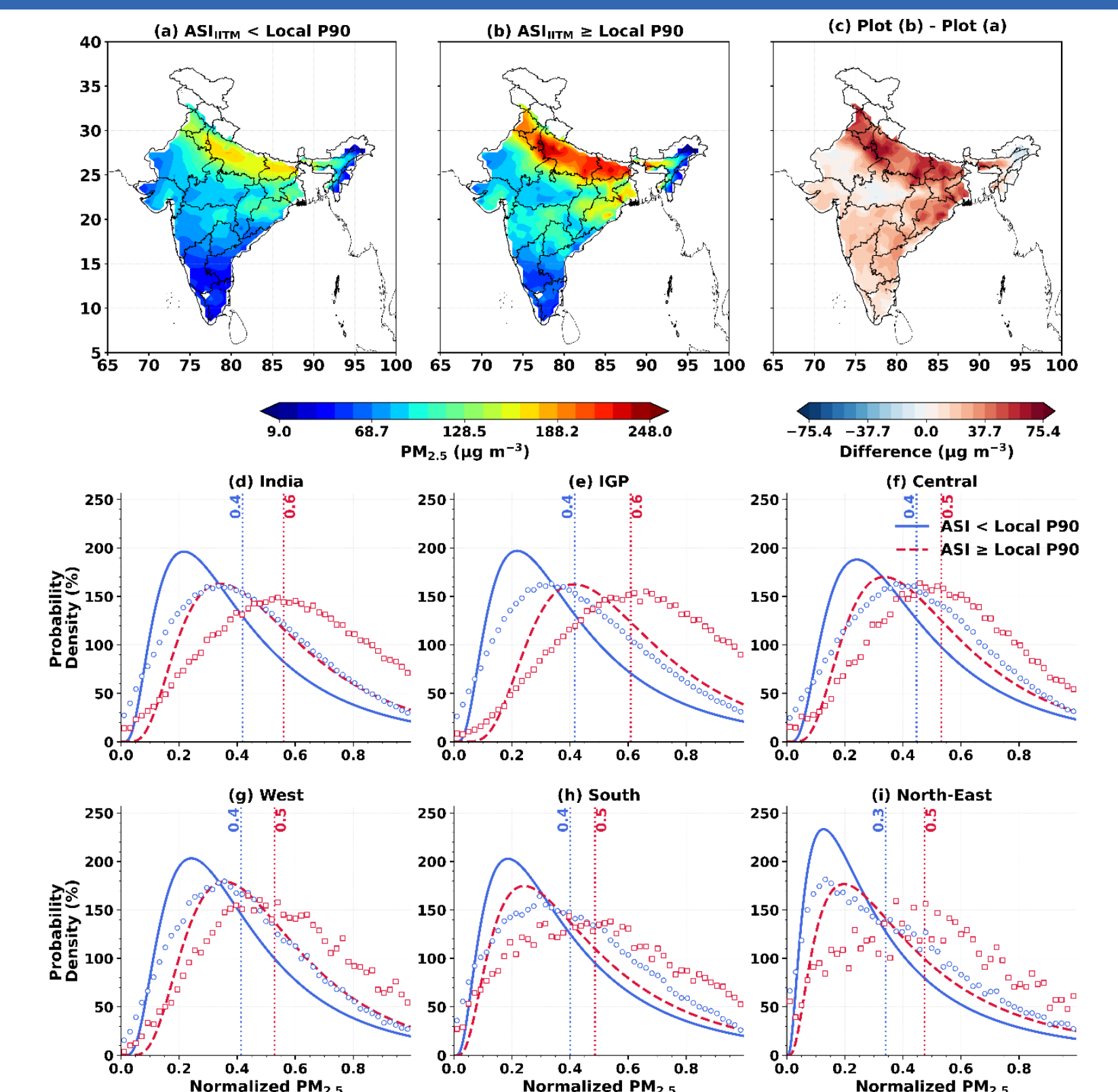
Subplot (a) shows station-wise correlation with ASI_{IITM} and CPCB PM_{2.5} observations. The different colours show the binned $R_{Pearson}$ levels. Subplot (b) shows the average state-wise correlation between ASI_{IITM} and CPCB PM_{2.5} observations. Subplots (c), (d), (e), (f) and (g) show timeseries of average ASI_{IITM} and normalised CPCB PM_{2.5} observations from five different states.

Comparison with previous studies



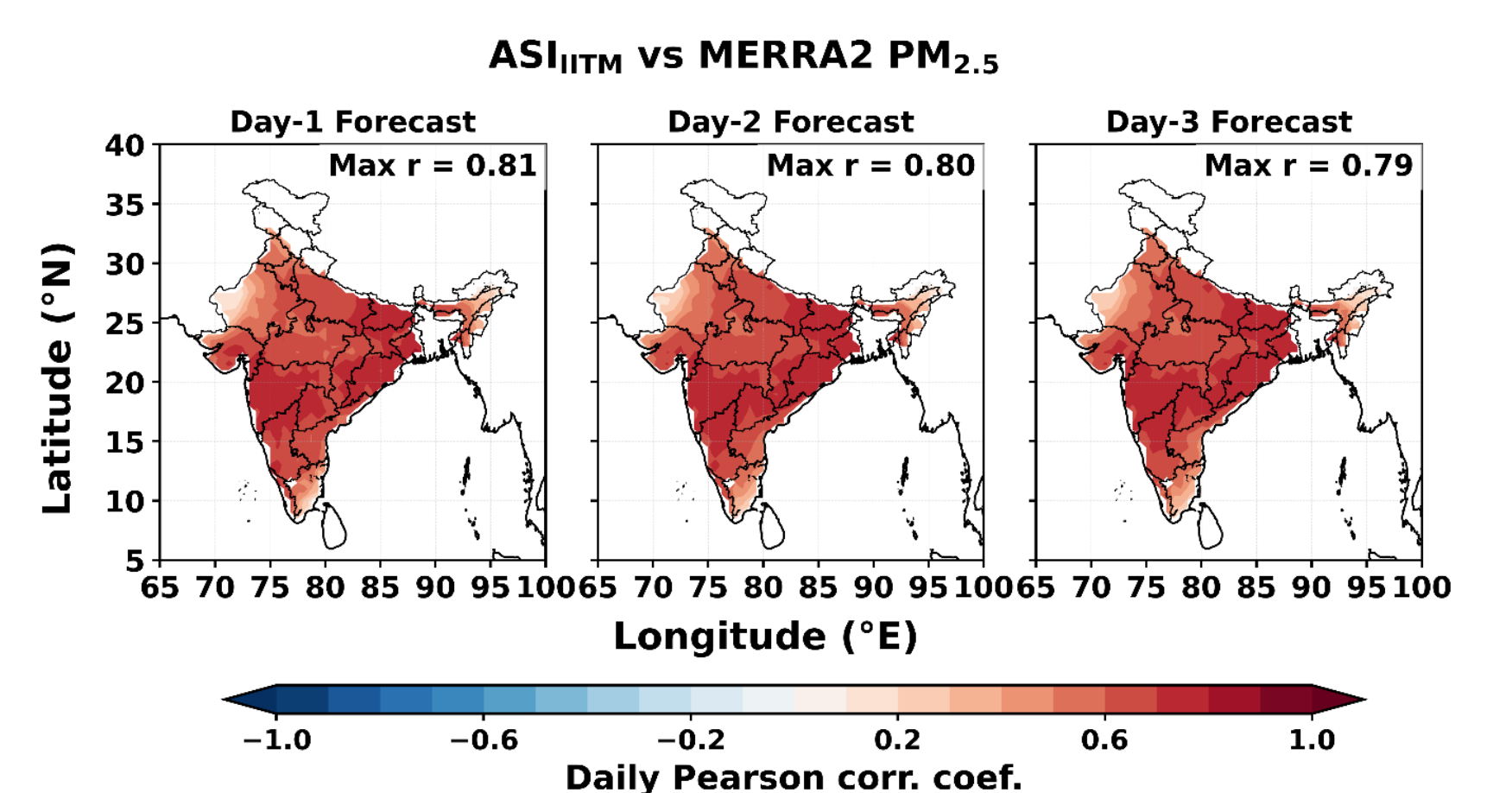
Comparison plot with NOAA-ASI. Subplot (a) shows the average monthly occurrence of NOAA-ASI over India. Subplot (b) shows the correlation between the monthly average NOAA-ASI occurrence and the monthly average MERRA2 PM_{2.5}. Subplot (c) shows the correlation between the monthly average ASI_{IITM} and the monthly average MERRA2 PM_{2.5}. Subplot (d) shows the difference between subplots (c) and (b).

ASI_{IITM} and Extreme PM_{2.5}



Subplots (a) and (b) show average MERRA2 PM_{2.5} levels associated with ASI_{IITM} < P90 and ASI_{IITM} > P90. Subplot (c) shows the difference between subplots (b) and (a). Subplots (d), (e), (f), (g), (h) and (i) show the probability density function for CPCB PM_{2.5} associated with ASI_{IITM} < P90 (blue) and ASI_{IITM} > P90 (red).

ASI_{IITM} vs ECMWF PM_{2.5}



Correlation between ECMWF forecast (1-, 2- and 3- day lead time) and MERRA2 PM_{2.5}

Conclusion

- New ASI_{IITM} shows good correlation with ambient PM_{2.5} over India (better than previous studies)
- High ASI_{IITM} coincide with high PM_{2.5}
- ASI_{IITM} from the meteorological forecast can be used in predicting extreme ambient PM_{2.5}

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