Assessment of surface air pollutants over the Indian Summer Monsoon region: Linkage to their characteristics in the upper atmosphere

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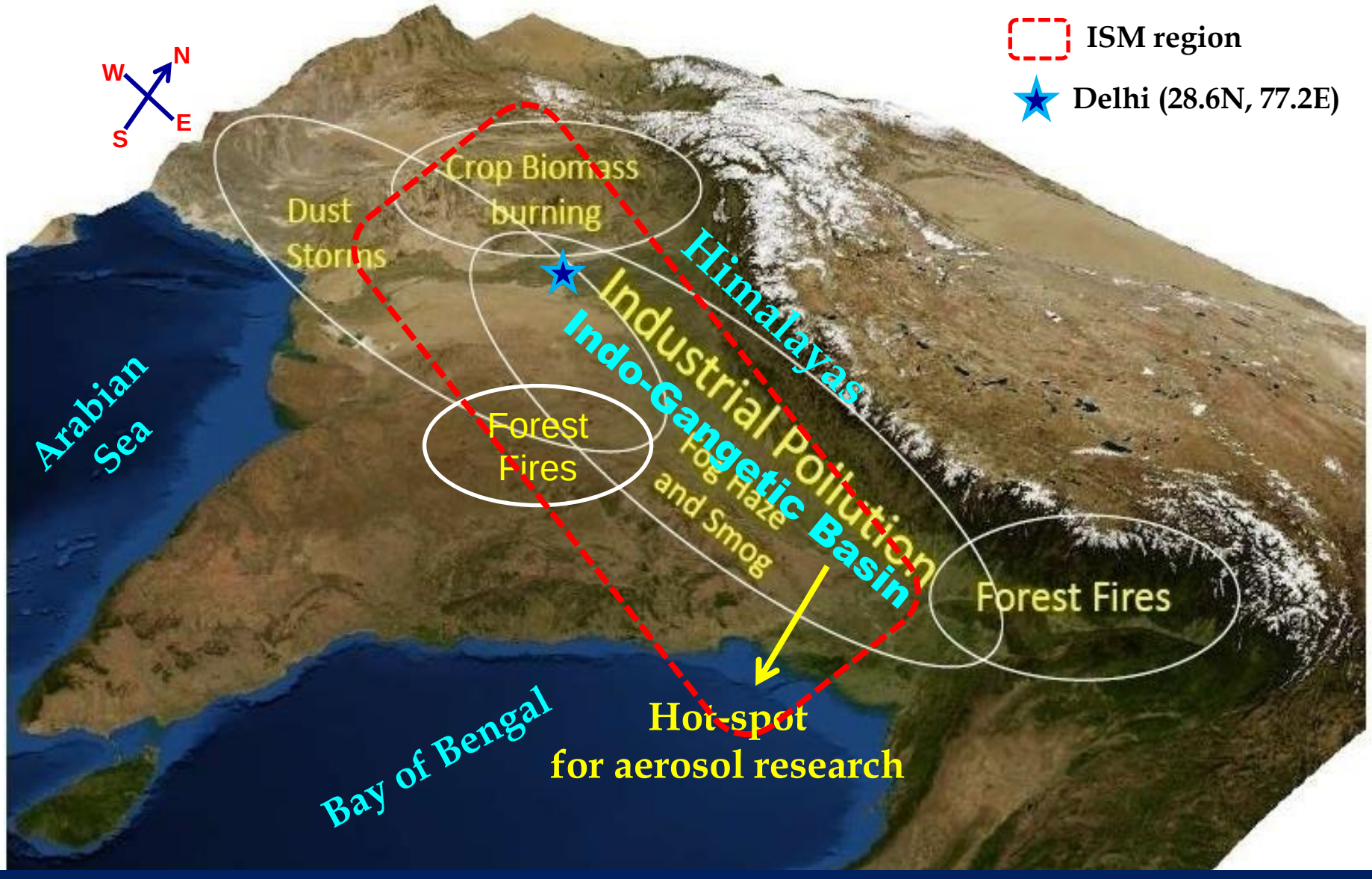
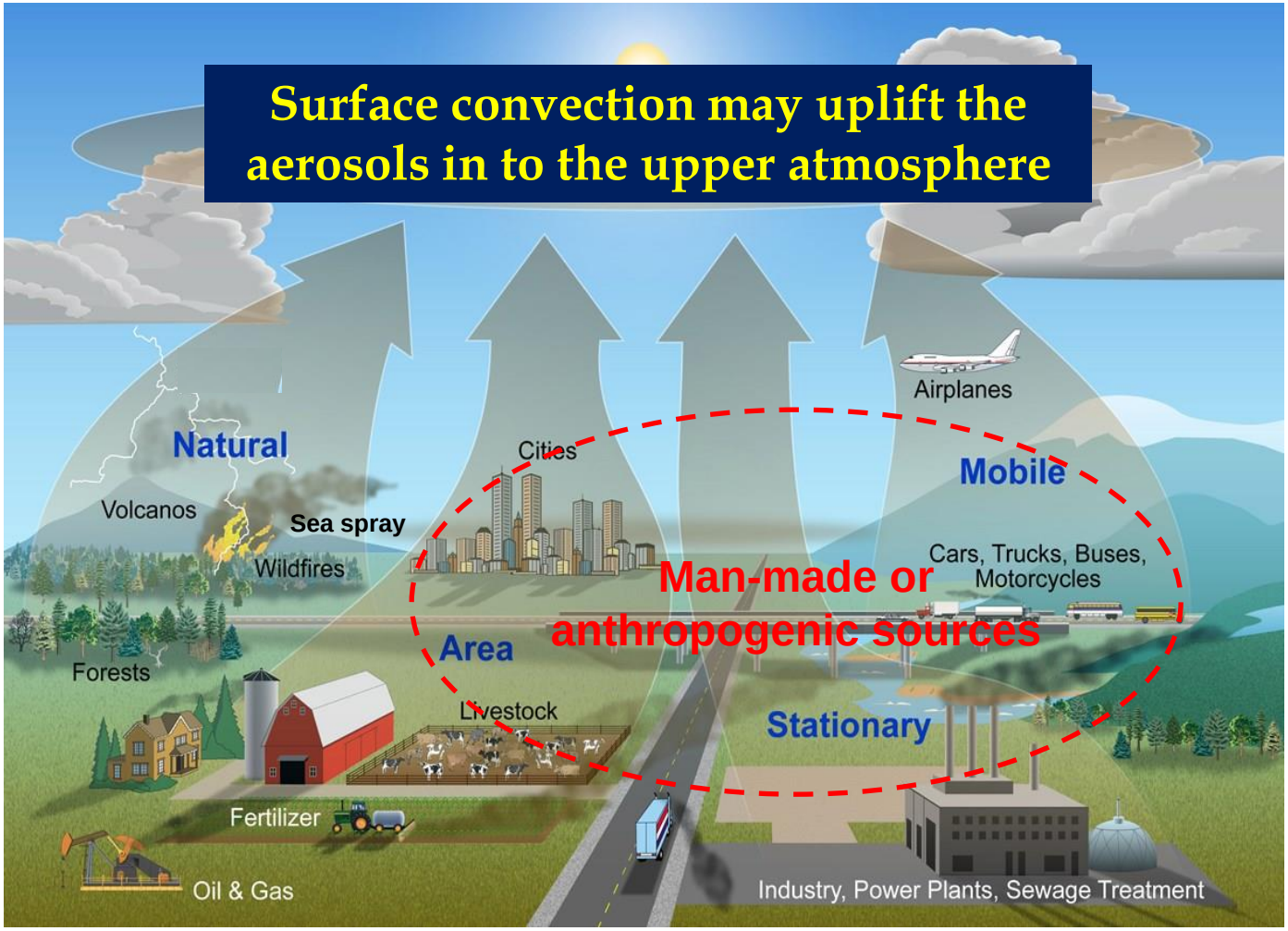
Complex nature of aerosols and large heterogeneity in aerosol loading



Deep convection activity associated with monsoon trough (an elongated zone of low pressure region) occurs frequently over the region during summer monsoon period. It may play an important role in uplifting the boundary layer aerosols up to the higher altitudes.

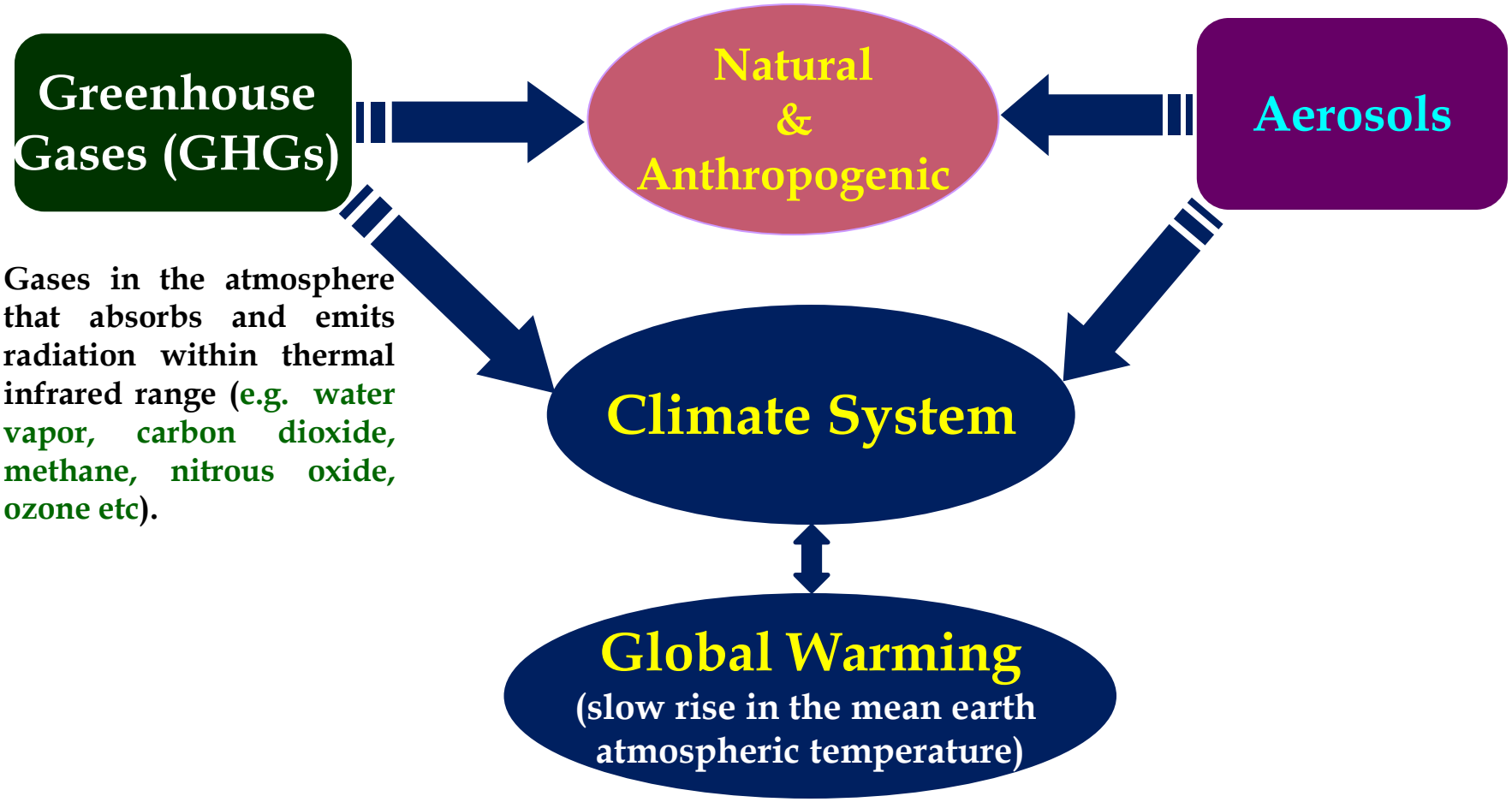
[Courtesy: William K. M. Lau]

Major Sources of Aerosols



On global scale, contribution of natural aerosols are higher as compared to the anthropogenic aerosols, which may not be the case on regional scale (especially near to the densely populated and industrial regions, like IGB).

Role of Aerosols in Climate Study

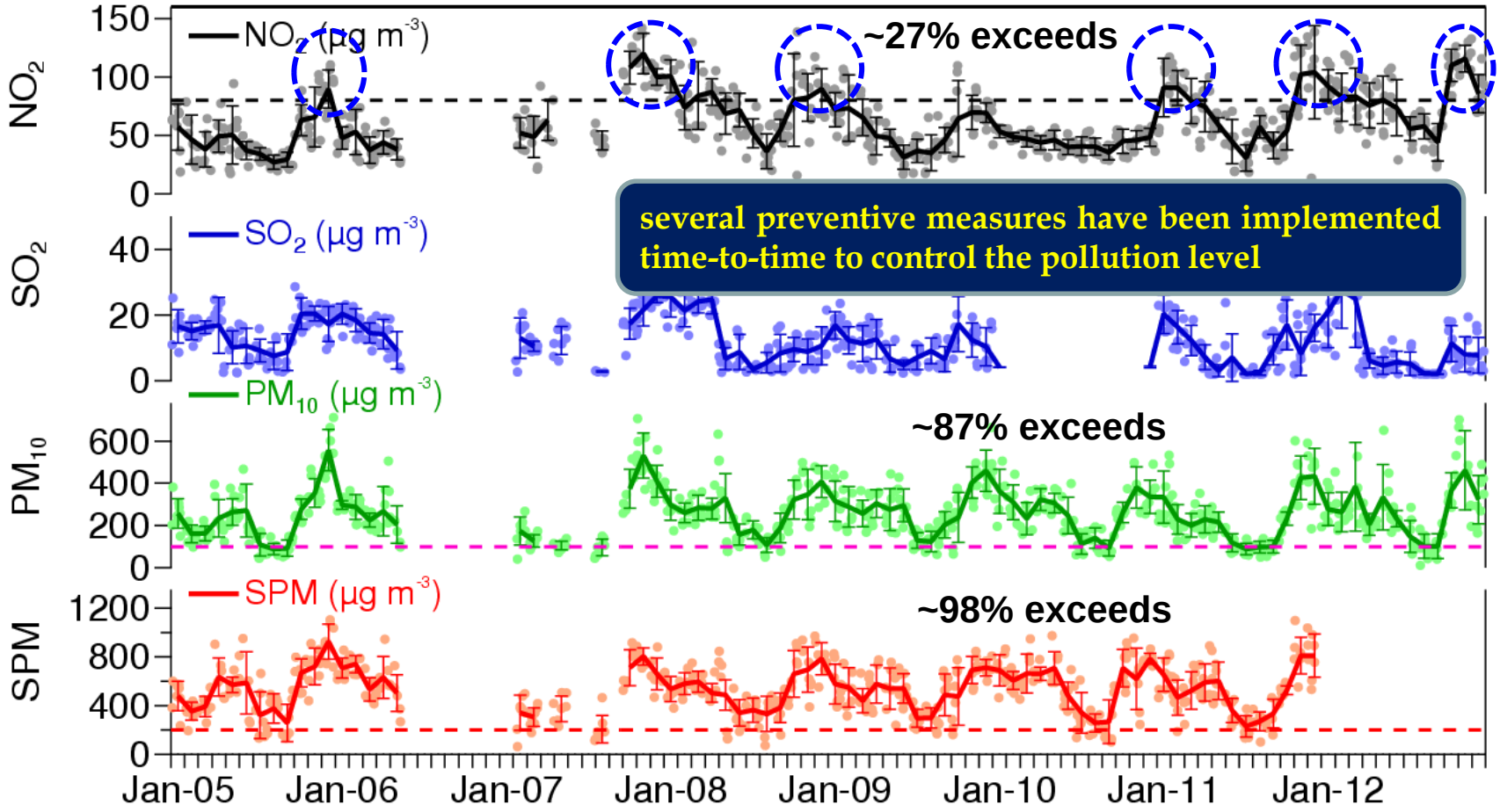


Gases in the atmosphere that absorbs and emits radiation within thermal infrared range (e.g. water vapor, carbon dioxide, methane, nitrous oxide, ozone etc).

leading to consequences such as increase in atmospheric temperature, reduction in glaciers, sea level rise etc, which may affect the water budget on Earth atmosphere (i.e. Hydrological/Water cycle).

Results

Time series analysis of near-surface pollutants at Delhi (2005-2012) [daily (dots) and monthly (solid line)]

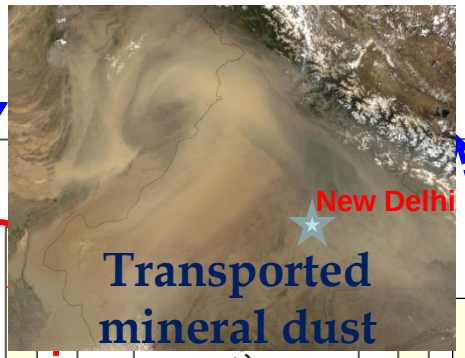


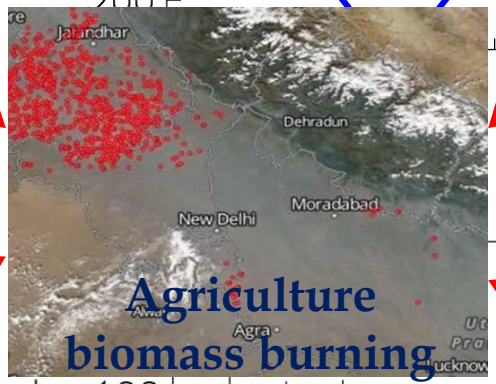
- NO_2 varied from 14-142 μg m^{-3}, with a mean of 62±28 μg m^{-3} [NAAQS=80 μg m^{-3}]
- SO_2 varied from 2-50 μg m^{-3}, with a mean of 15±8 μg m^{-3} [NAAQS=80 μg m^{-3}]
- PM_{10} varied from 30-850 μg m^{-3}, with a mean of 254±134 μg m^{-3} [NAAQS=100 μg m^{-3}]
- SPM varied from 65- 1100 μg m^{-3}, with a mean of 530±213 μg m^{-3} [NAAQS=200 μg m^{-3}]

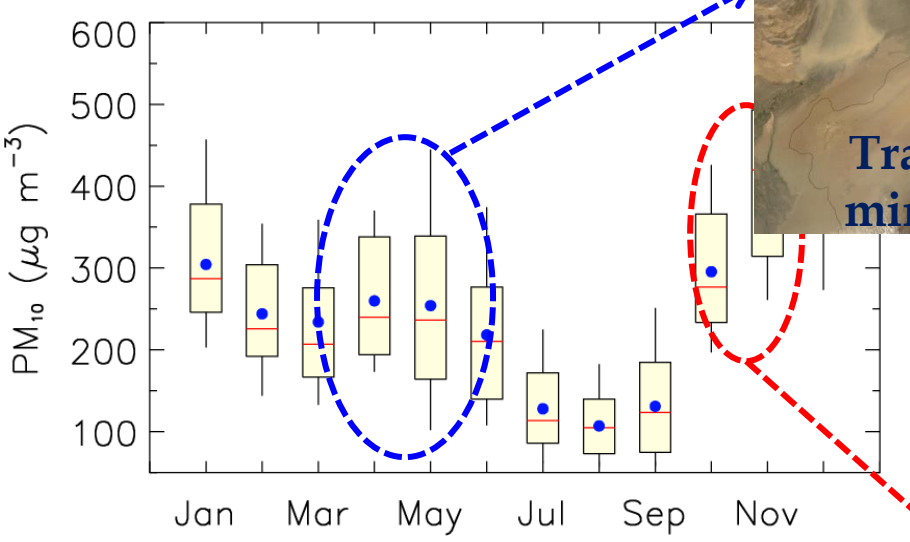
---- NAAQS: National Ambient Air Quality Standard

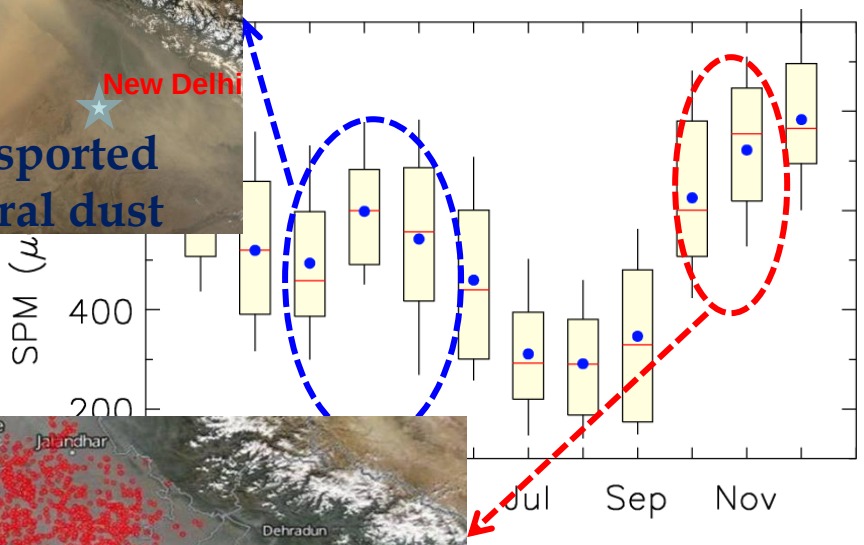
[*Kishore and Srivastava et al., J. Earth Syst. Sci. 2019*]

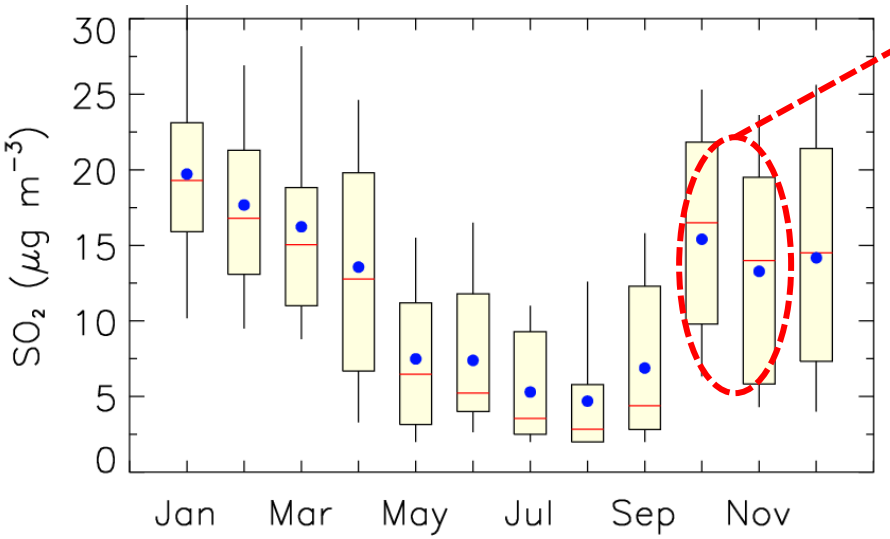
Monthly mean near-surface air pollutants

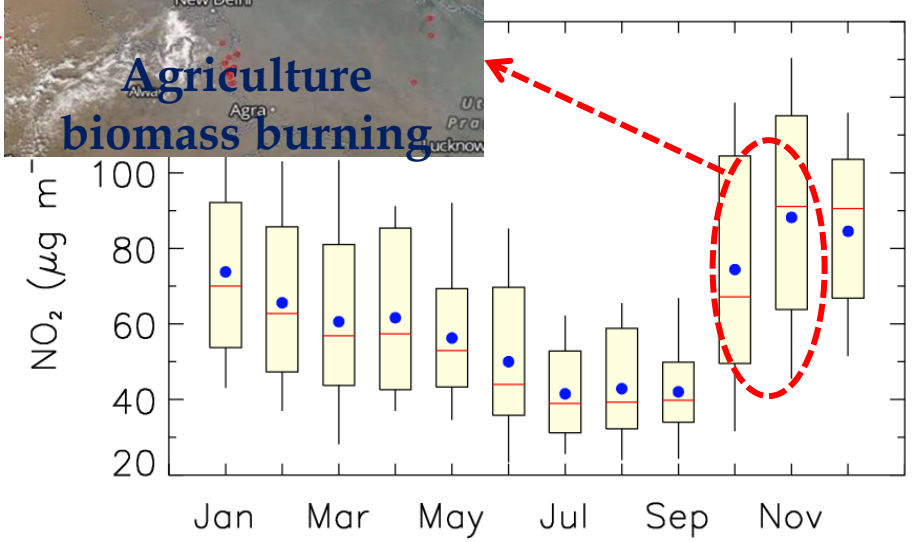






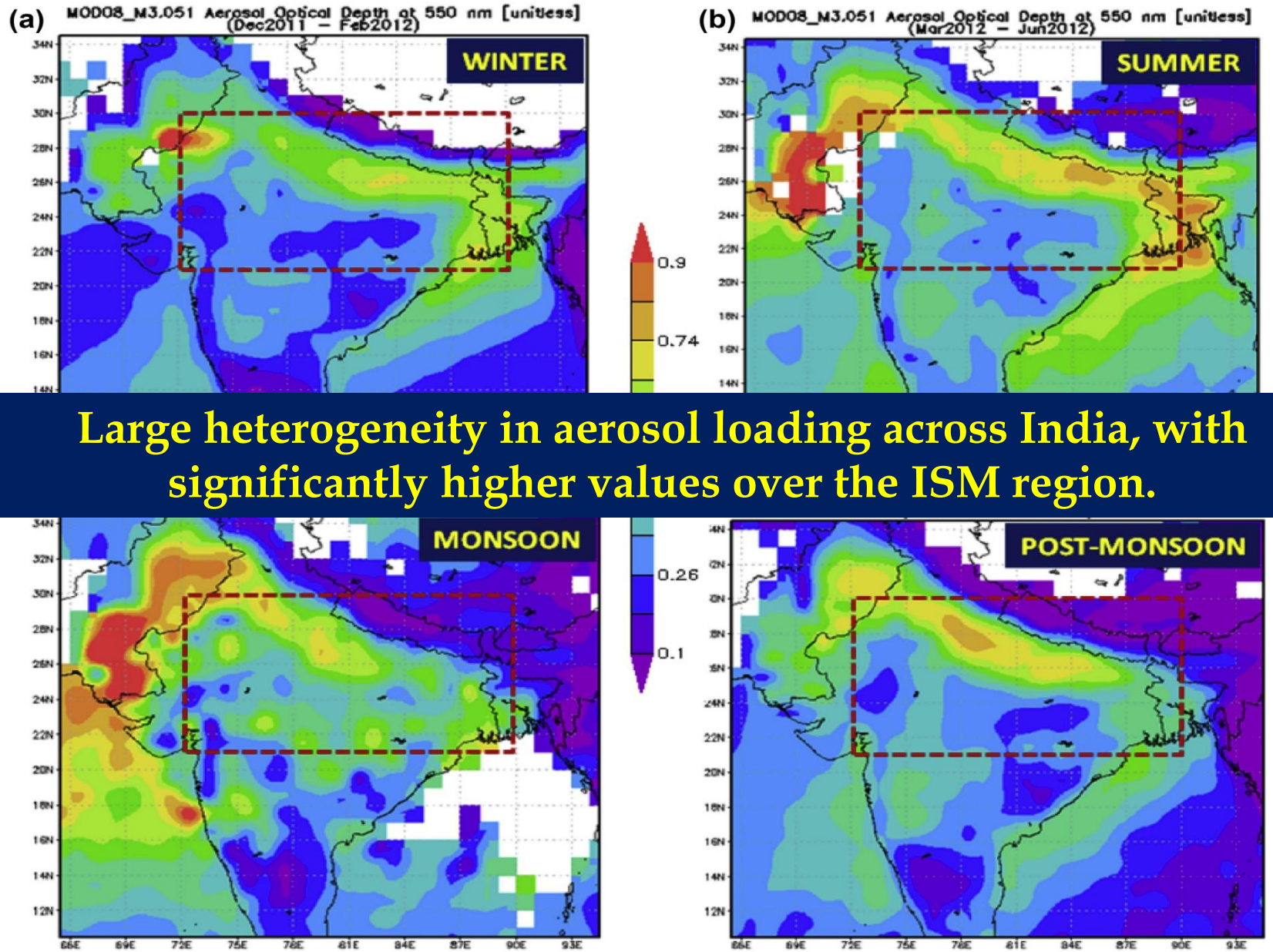






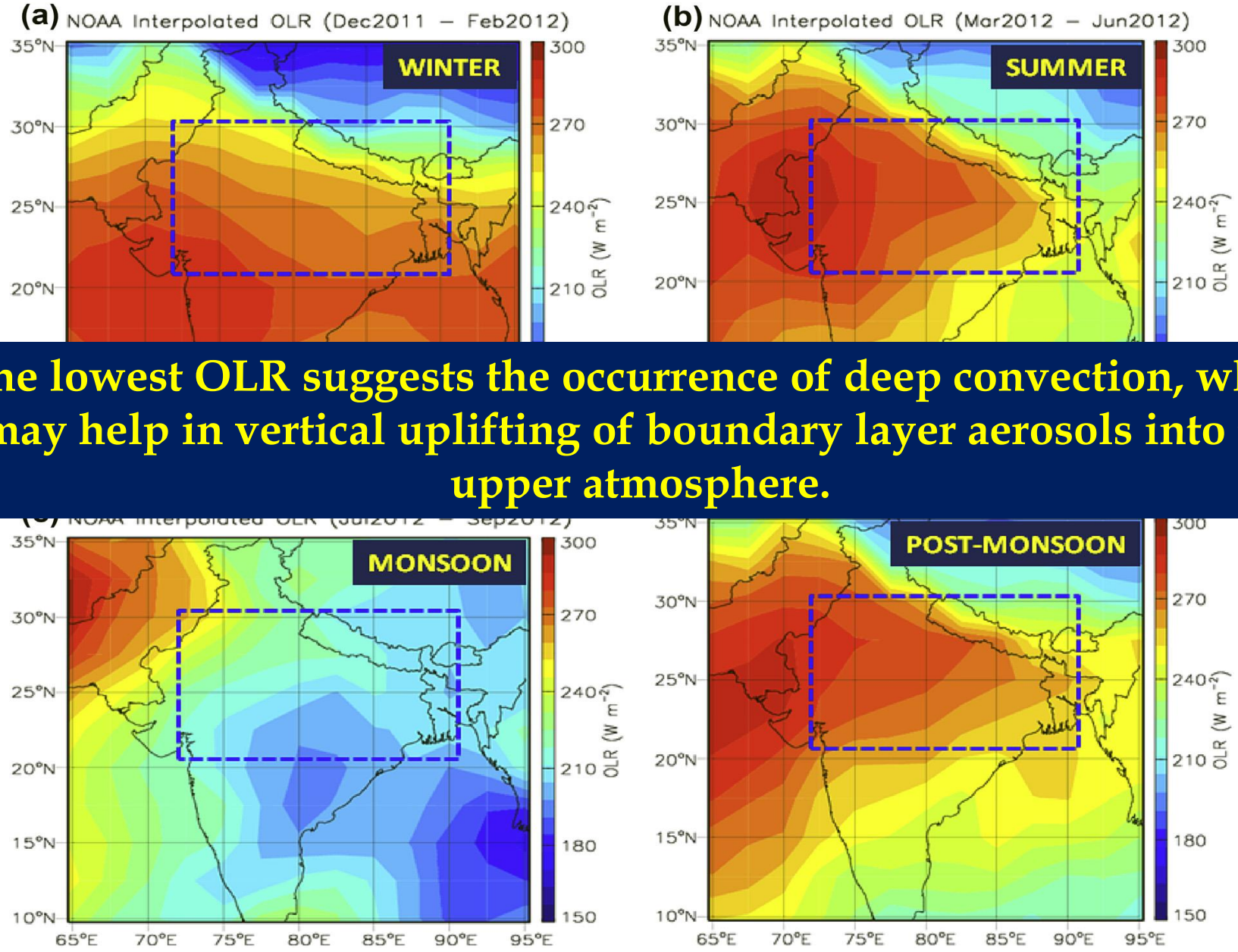
[*Kishore and Srivastava et al., J. Earth Syst. Sci. 2019*]

Seasonal variability of Satellite-derived AOD (from 2011-2012)



Large heterogeneity in aerosol loading across India, with significantly higher values over the ISM region.

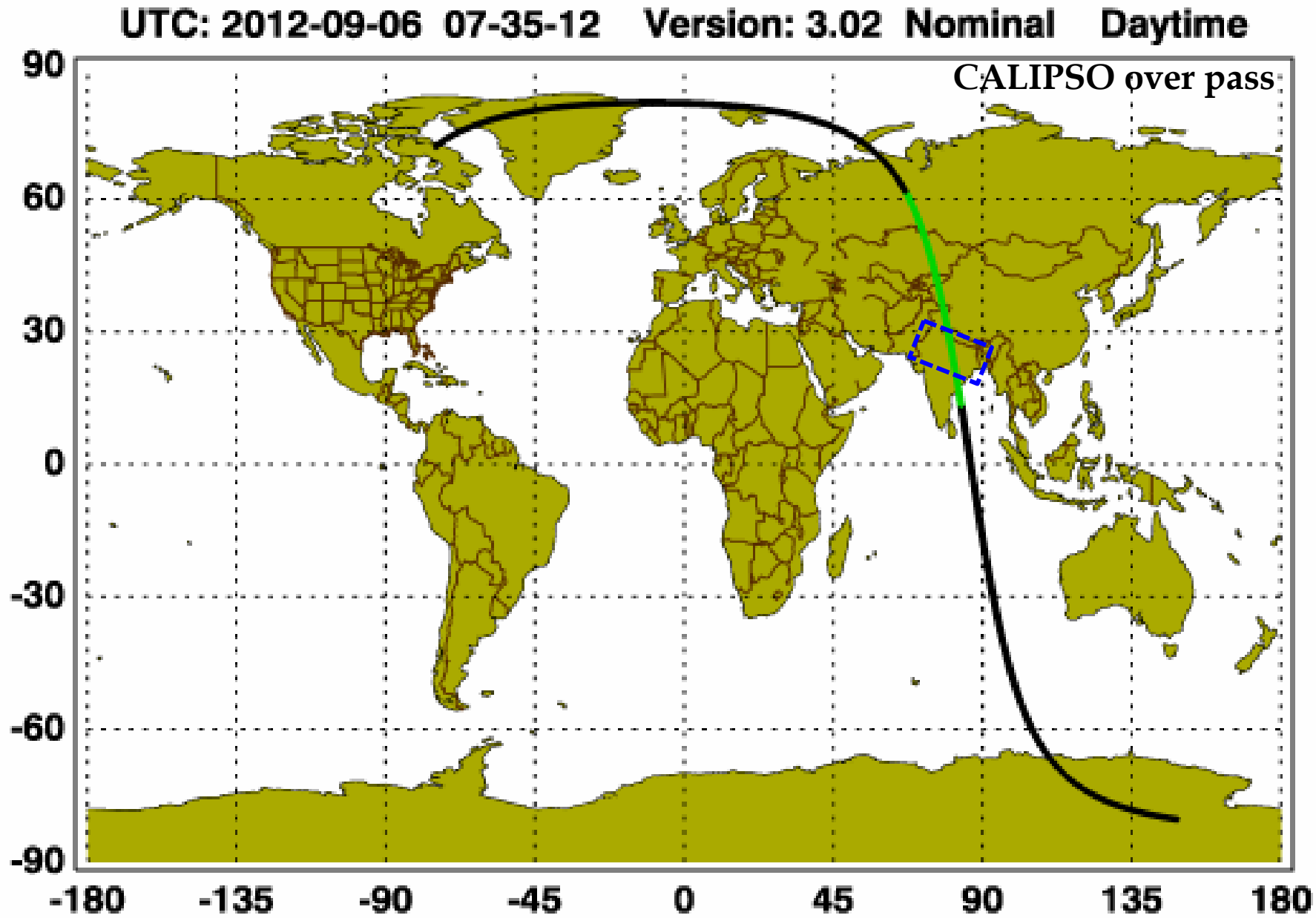
Seasonal variability in Out-going Longwave Radiation (OLR)

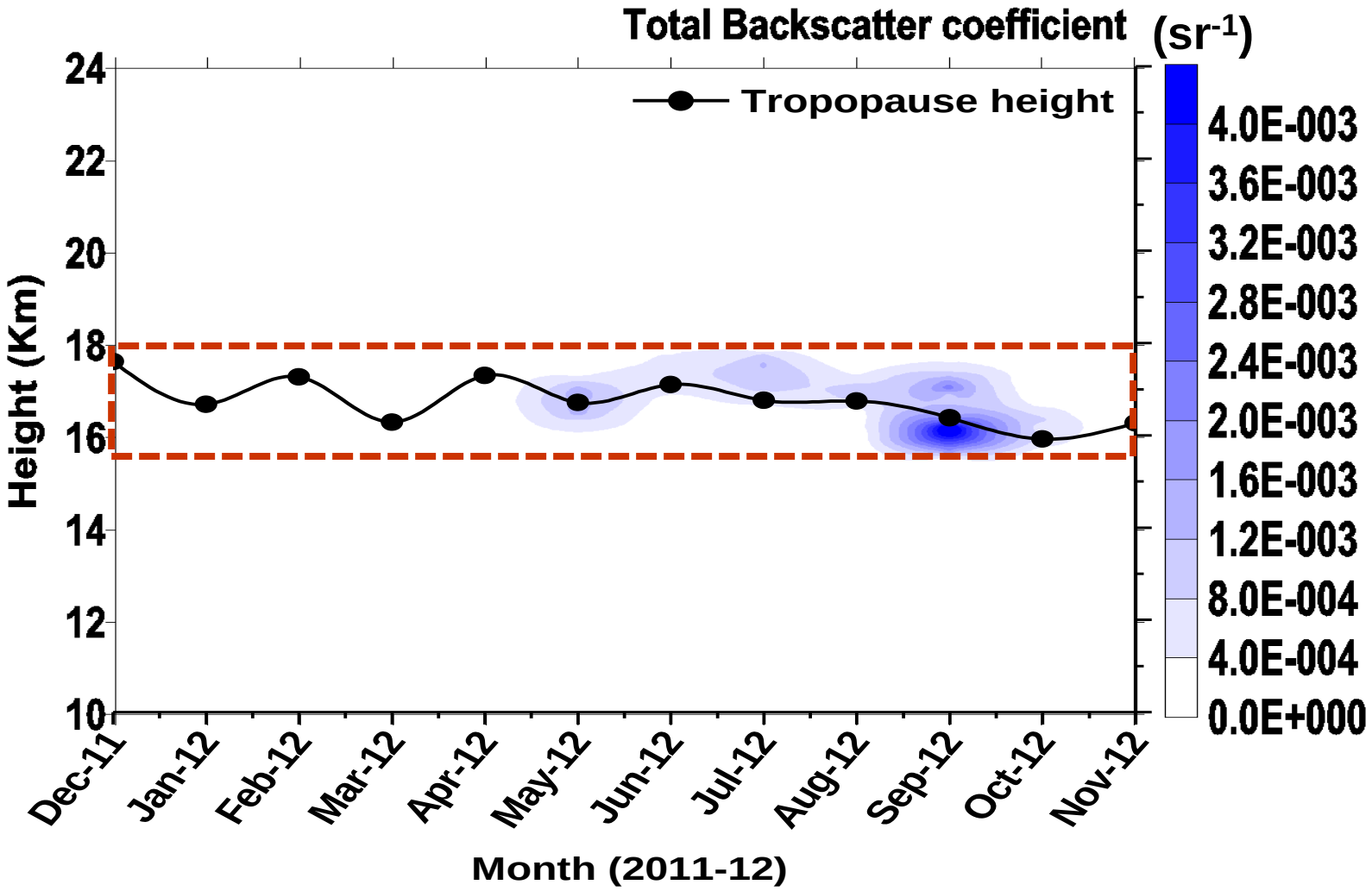


The lowest OLR suggests the occurrence of deep convection, which may help in vertical uplifting of boundary layer aerosols into the upper atmosphere.

OLR: proxy for surface deep convection

Aerosol characteristics in the UTLS and their possible association with boundary layer aerosols over the ISM region

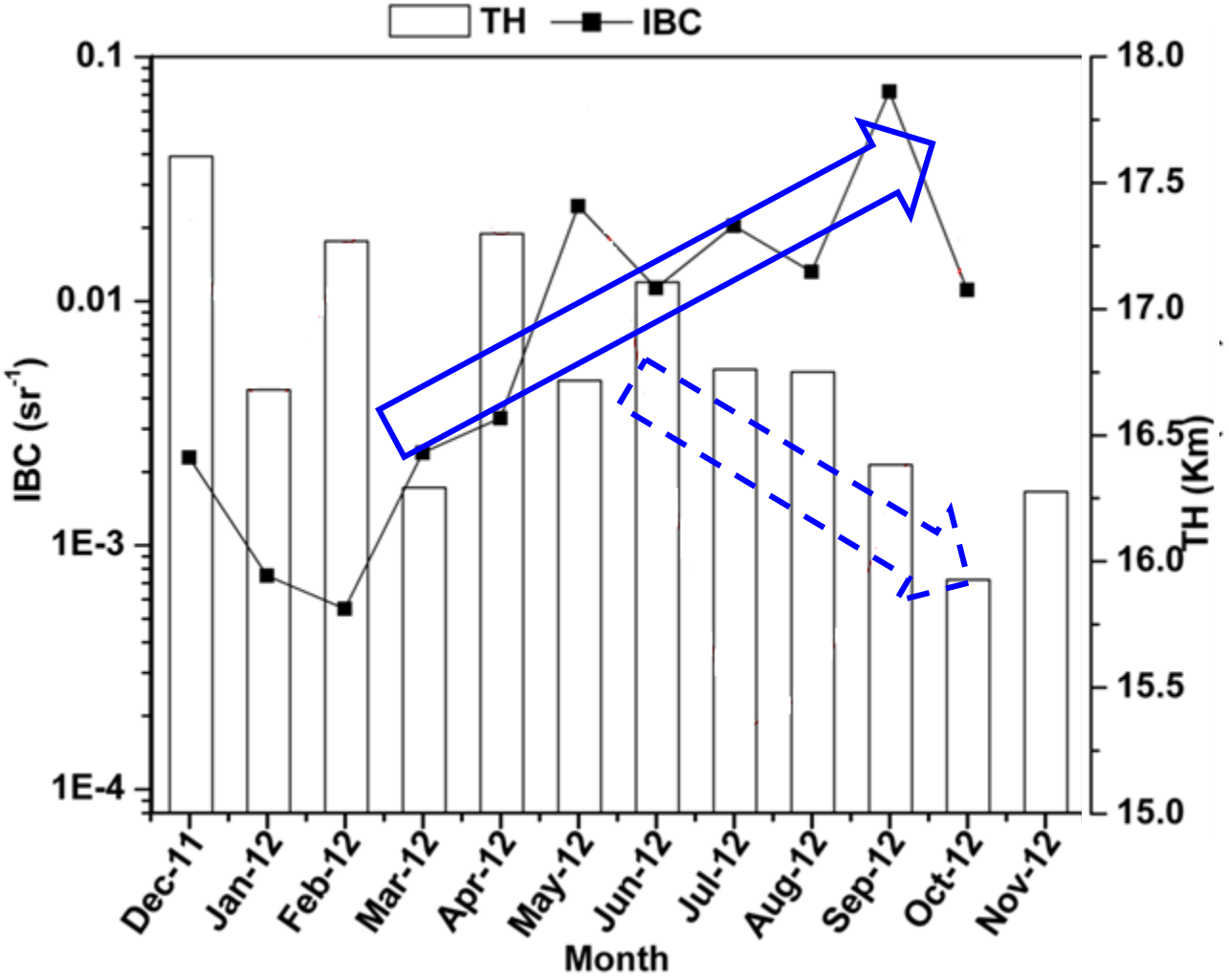




An enhanced aerosol layer was observed between 16-18 km altitudes (in the vicinity of tropical tropopause), with broad layer depth of ~2 km.

[*Srivastava et al., Atmos. Environ., 2018*]

The monthly mean variability in tropopause height and IBC

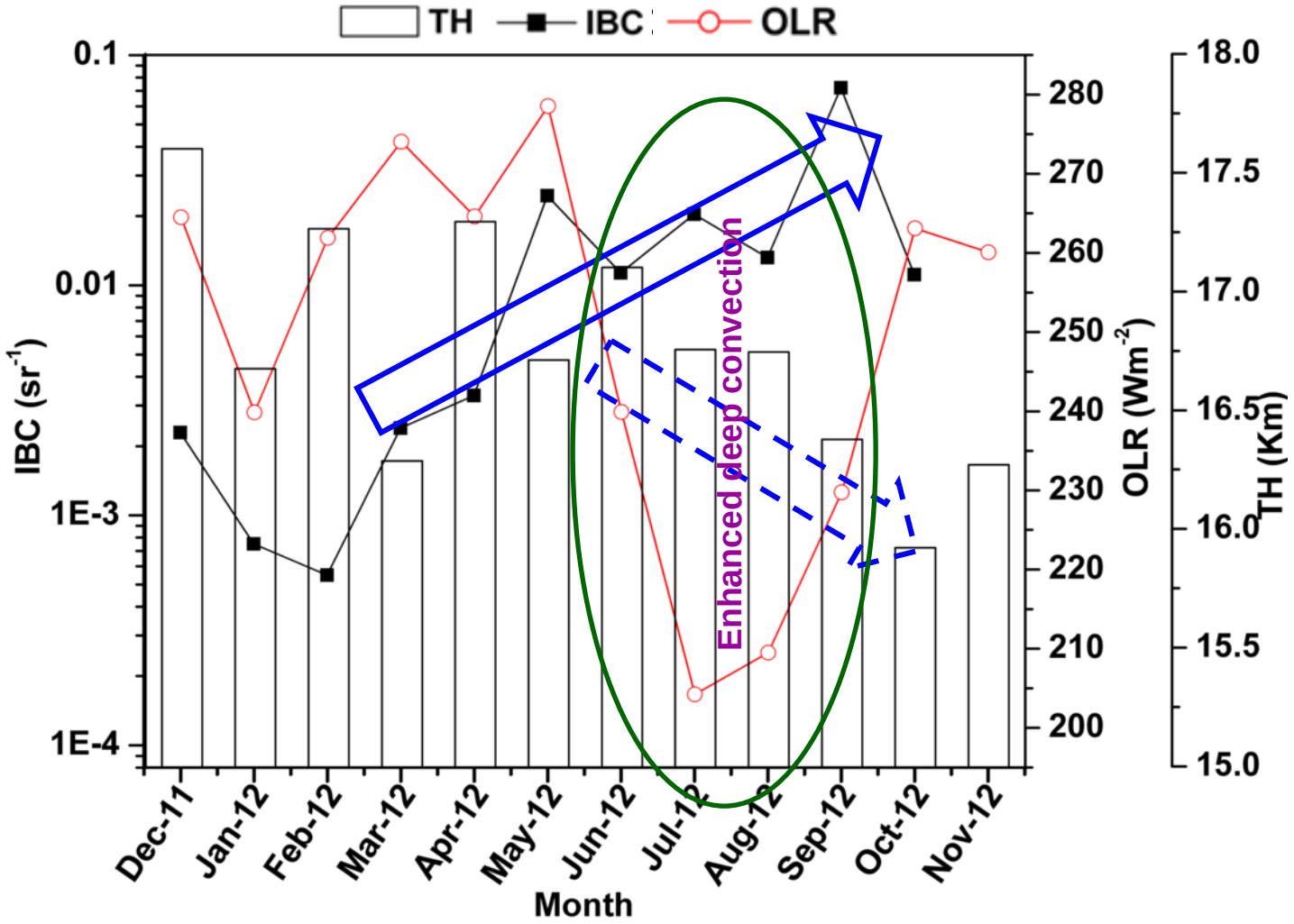


IBC: Integrated Backscatter Coefficient (15-19 km)

Enhancement in aerosol loading in the UTLS region during the summer-monsoon period could probably be due to the convective uplifting of the boundary layer aerosols, which may also affect the stability of tropopause.

[*Srivastava et al., Atmos. Environ., 2018*]

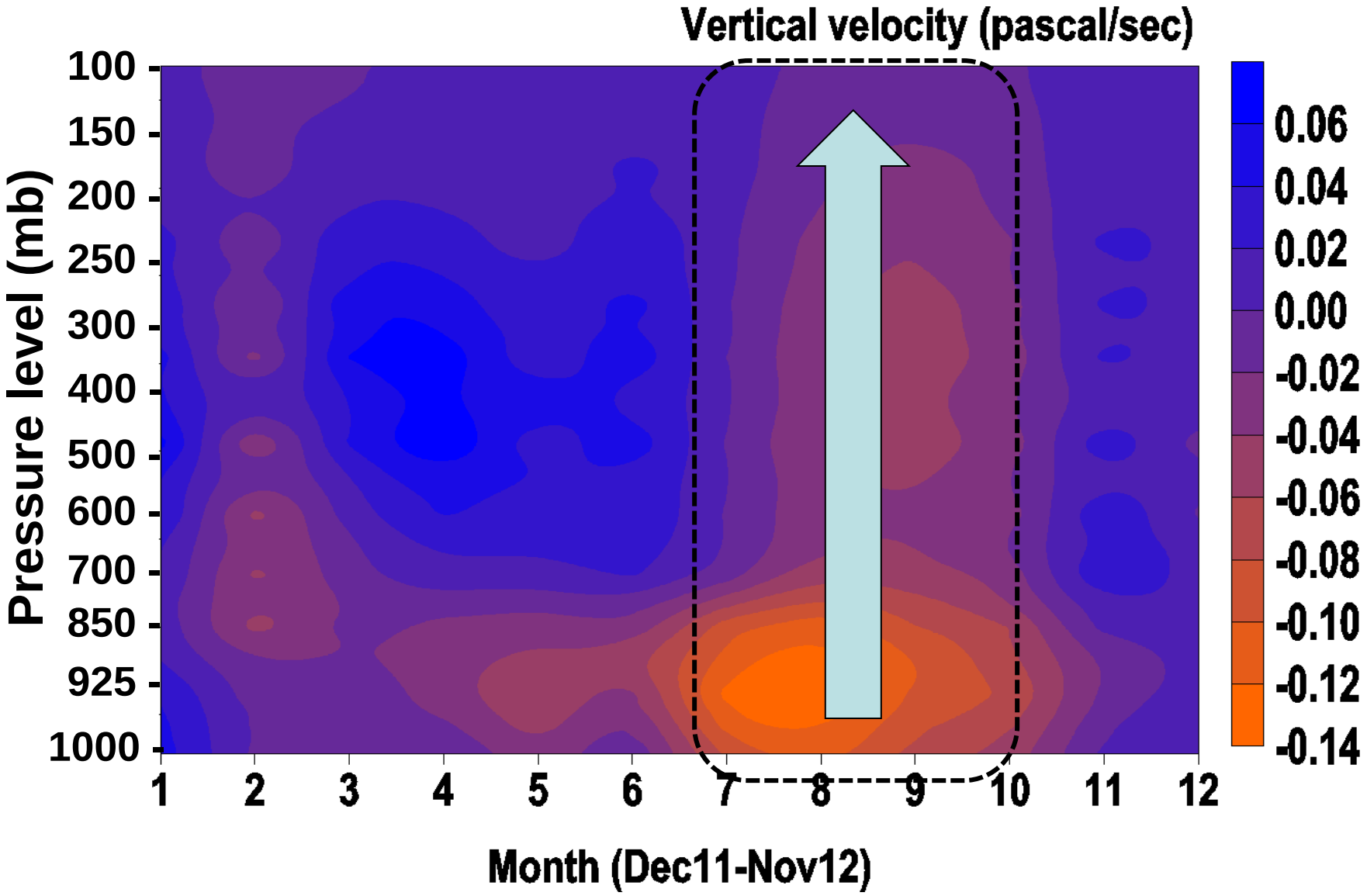
The monthly variability in tropopause height, IBC and OLR



IBC: Integrated Backscatter Coefficient (15-19 km)

OLR: Out-going Long-wave Radiation (proxy for surface deep convection)

The lowest OLR (enhance deep convection), corresponding to an enhancement in IBC during the summer-monsoon period suggests vertical uplifting of boundary layer aerosols into the upper troposphere. [*Srivastava et al., Atmos. Environ., 2018*]



Confirms the probability of vertical transport of boundary layer aerosols up to the upper troposphere region associated with deep convection.

[*Srivastava et al., Atmos. Environ., 2018*]

Summary

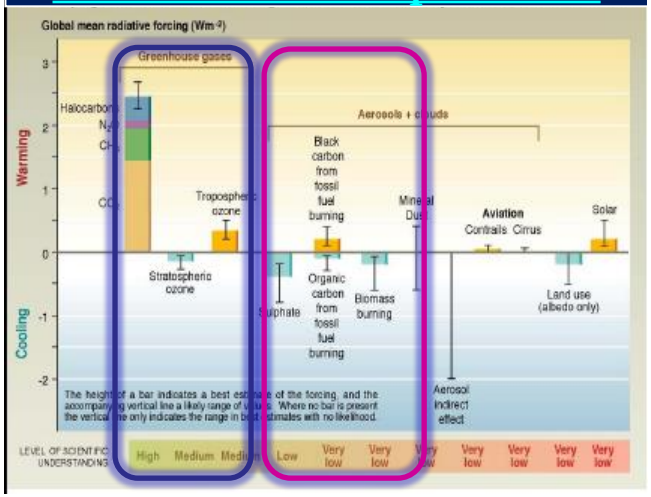
Study suggest that the ISM region has enhanced aerosol loading with different compositions, which has large spatial heterogeneity in their characteristics and found to have significant impact on UTLS aerosol characteristics during deep convection period.

Thank

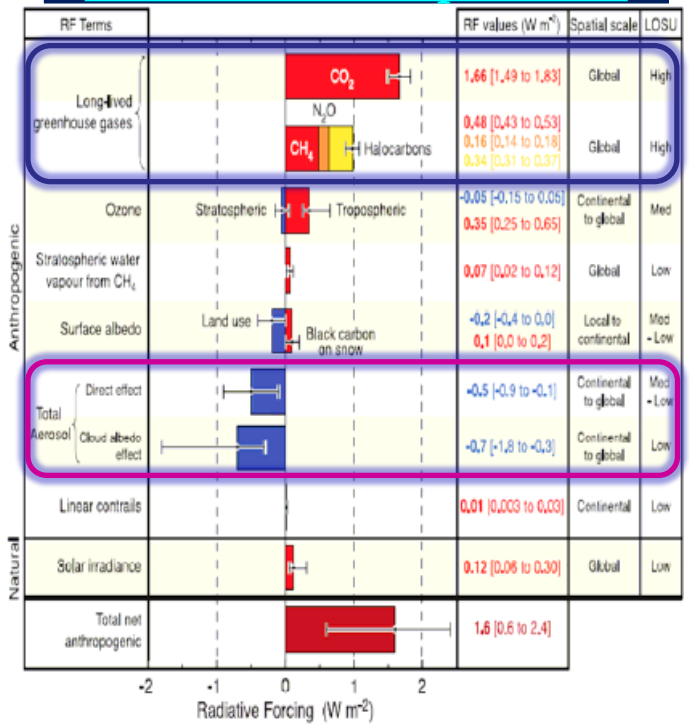
You…

Intergovernmental Panel on Climate Change (IPCC)

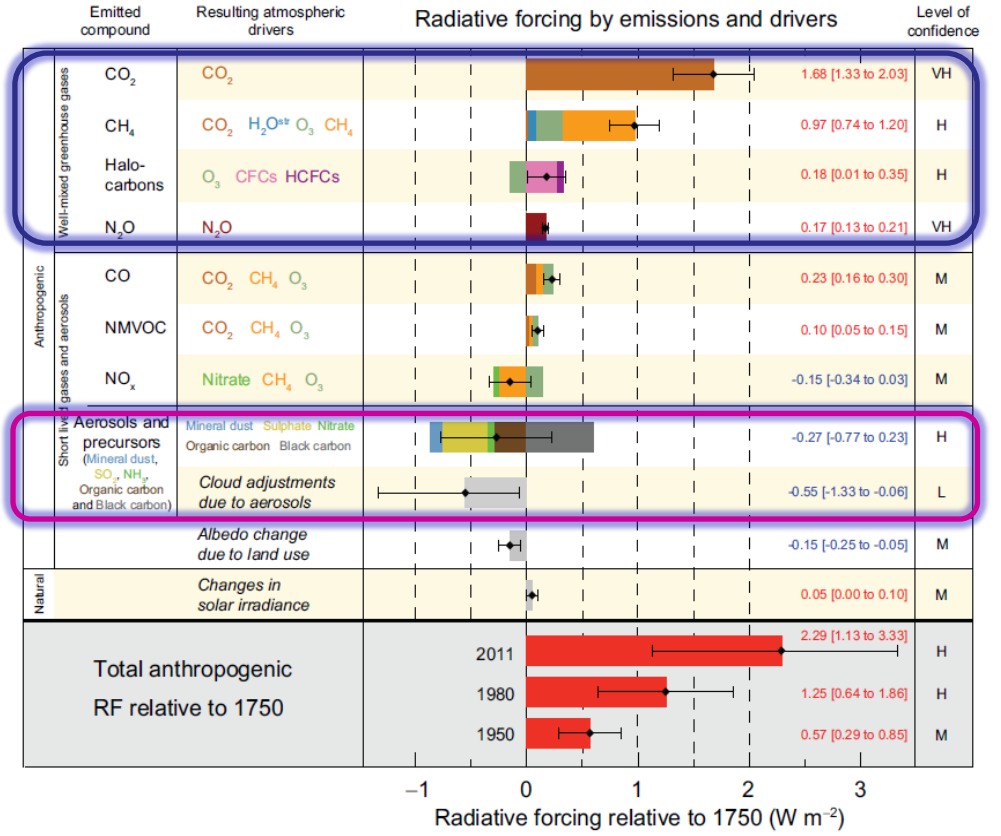
3ed Assessment Report- 2001



4th Assessment Report- 2007



5th Assessment Report- 2013



- **Inadequate measurements of aerosols on regional and global basis and poor understanding on their role in the Earth's radiation budget.**
- **Thus, proper understanding and assessment of aerosols are essential to reduce their uncertainties in direct and indirect climate forcing.**

Aerosols

- **Aerosols (Aero + Sols) are the tiny suspended particulate matters present into the atmosphere in the form of either solid or liquid. Due to their liquid phase, it is also called as hydrosols.**

- **Aerosols are one of the most important and certainly the most visible aspects of air pollution, which lies mostly within the atmospheric boundary layer in the lower troposphere.**

1. **Solid – smoke, fly ash, dust**
2. **Liquid – mist, fog, smog (smoke + fog → Polluted fog)**

Typical size range → 0.001 to 100 µm

- **The effects span of these aerosols are in the areas of health, air quality (acid rain and visibility degradation), radiation, cloud microphysics, ozone depletion and thus the climate change.**

Aerosol Classifications