Aerial measurements of Elevated Pollution Layers during Indian Monsoons

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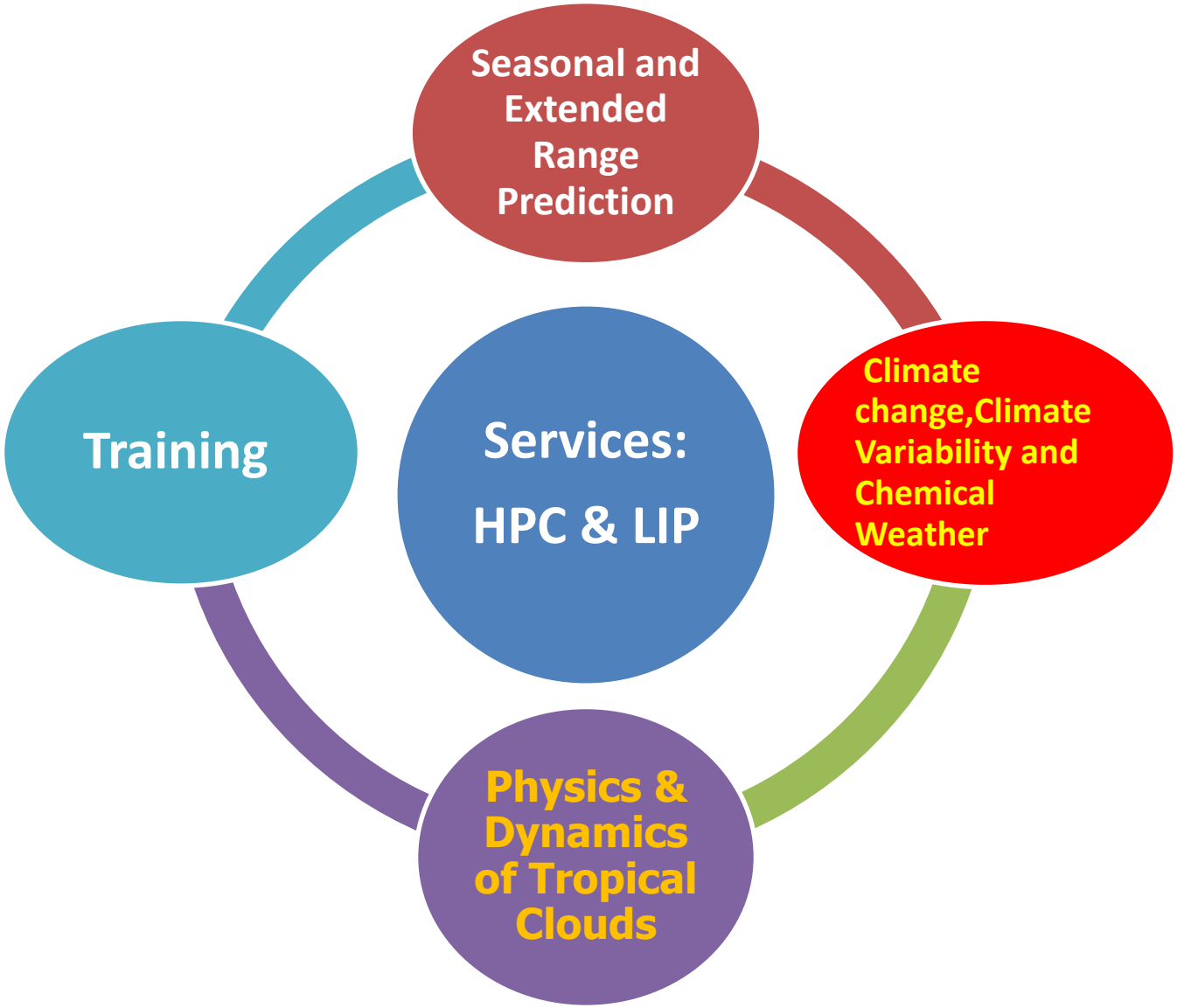
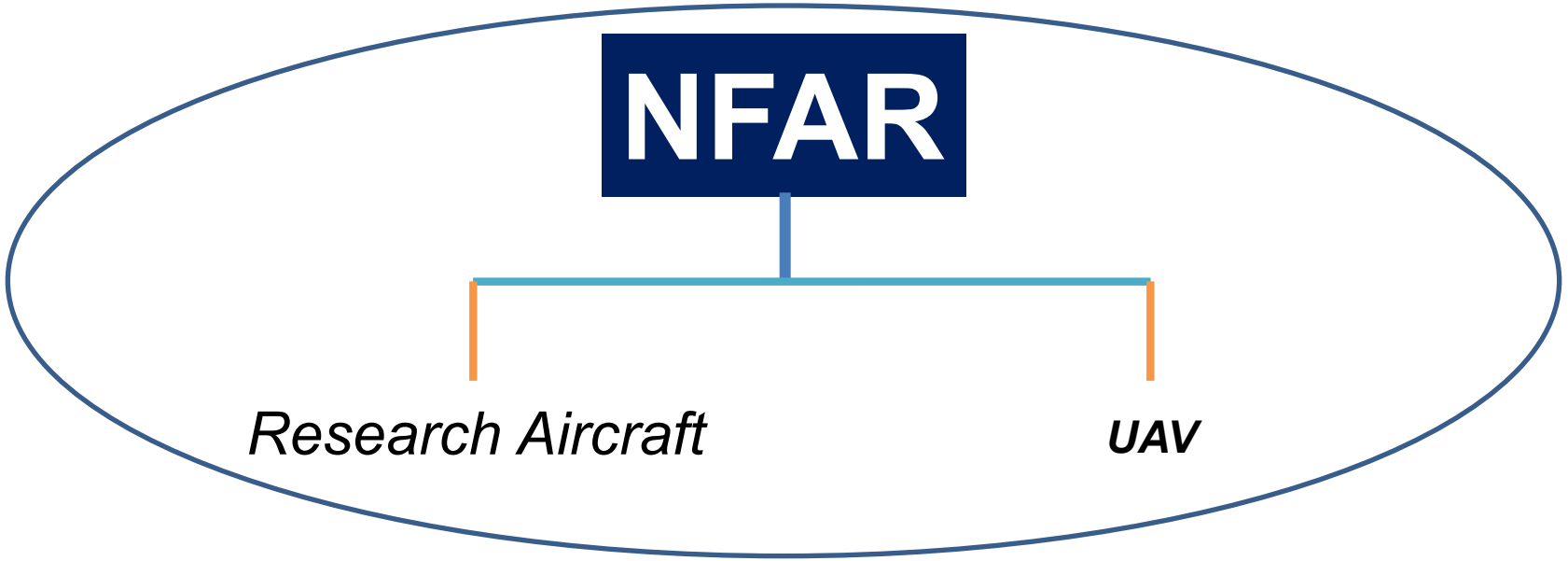
Science Projects at IITM

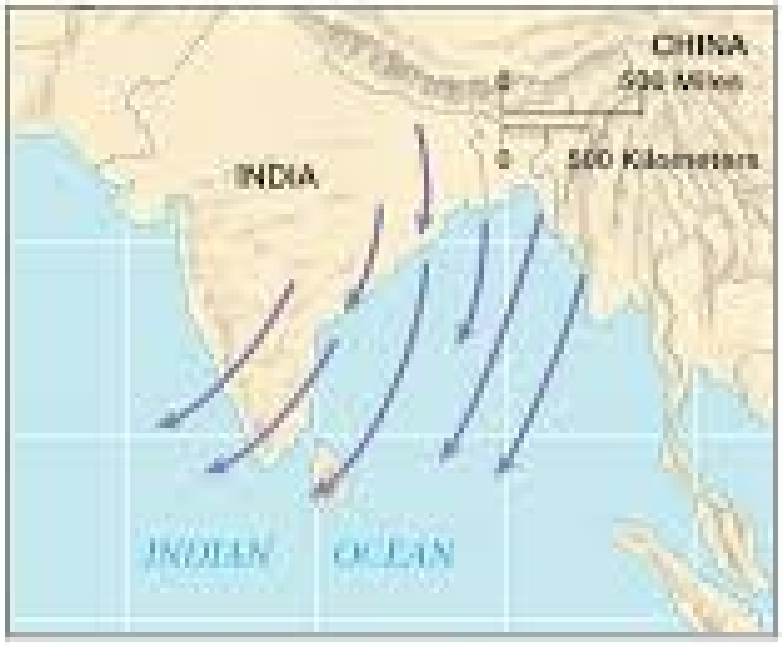




- ***Indian Institute of Tropical Meteorology, Pune***
  Ministry of Earth Sciences (MoES)
  Govt. of India

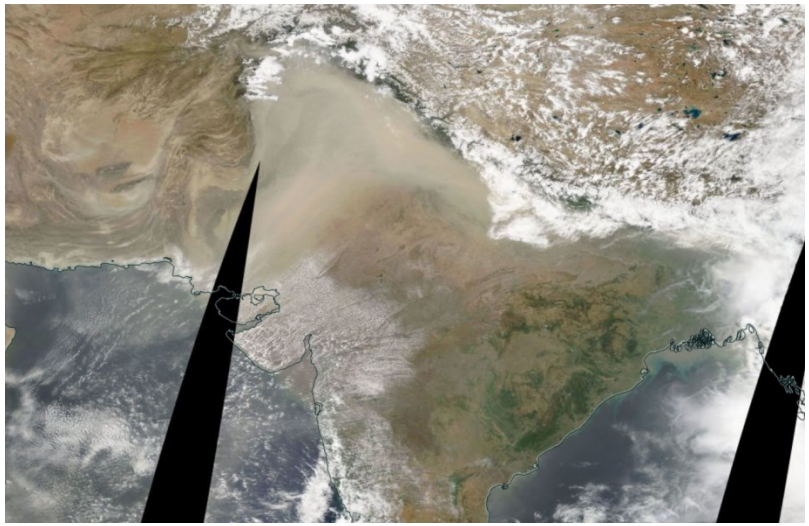
Capability of research aircraft

Summer

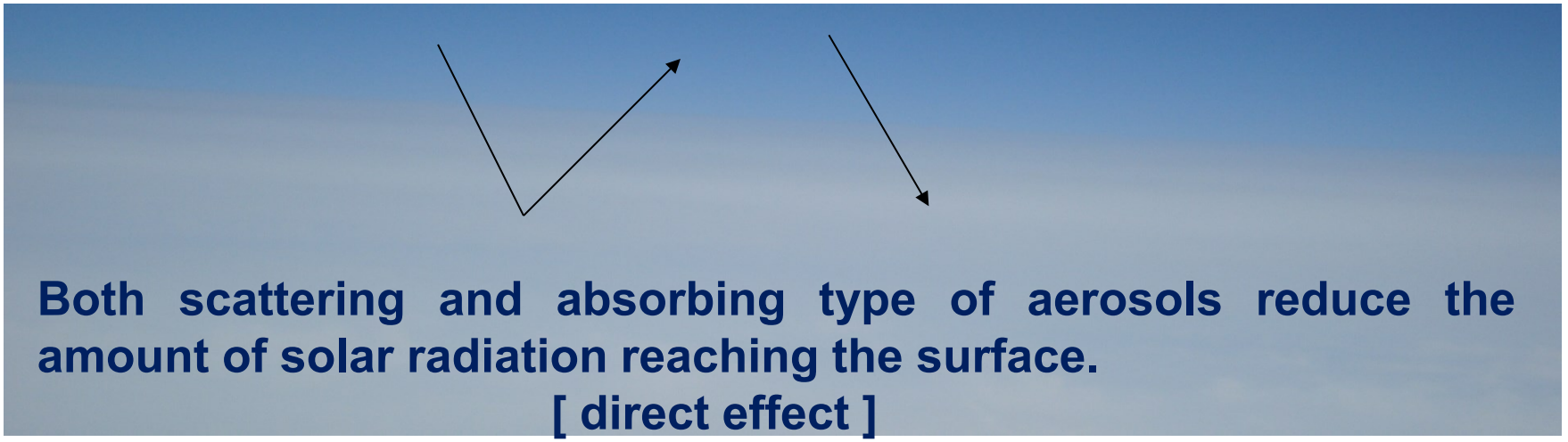


Winter

India experiences
Pre-monsoon - MAM
SW monsoon - Jun-Sept
NE monsoon - Oct-Nov
Long range transport

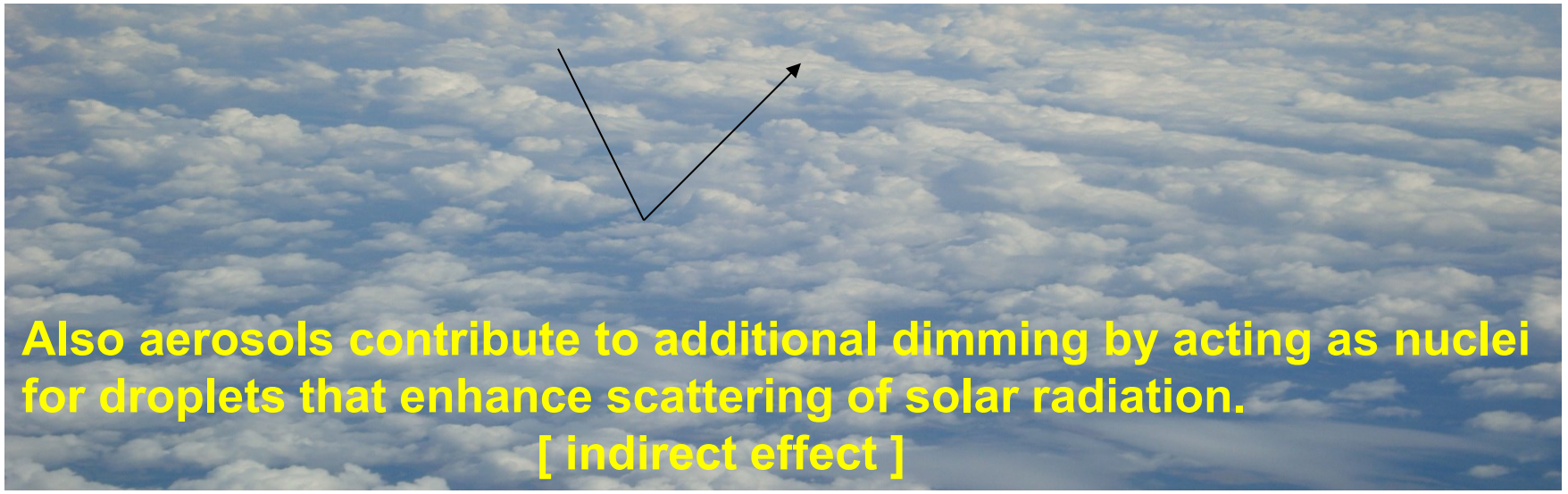


Pollutants and clouds are the two controlling factors



Both scattering and absorbing type of aerosols reduce the amount of solar radiation reaching the surface.

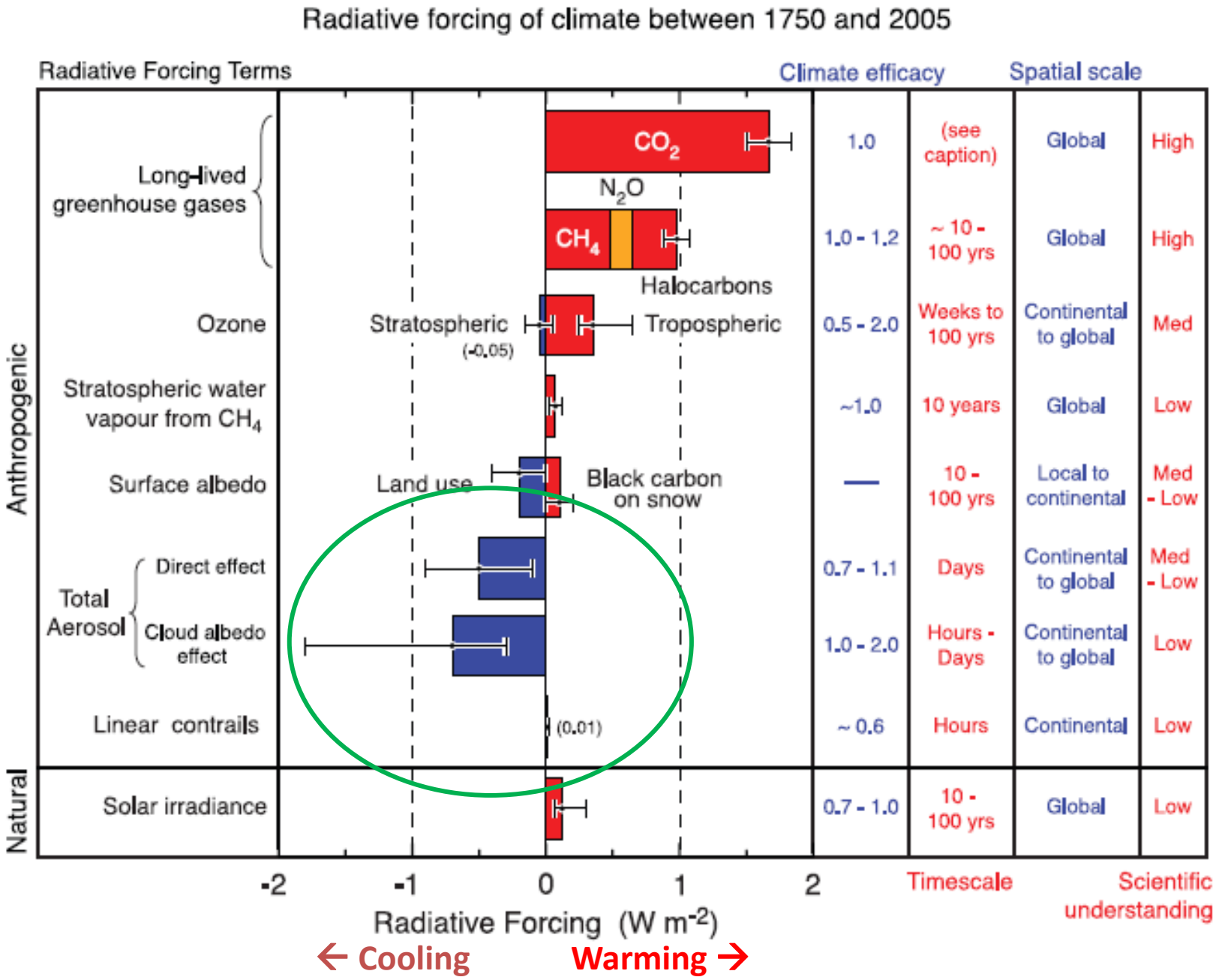
[direct effect]

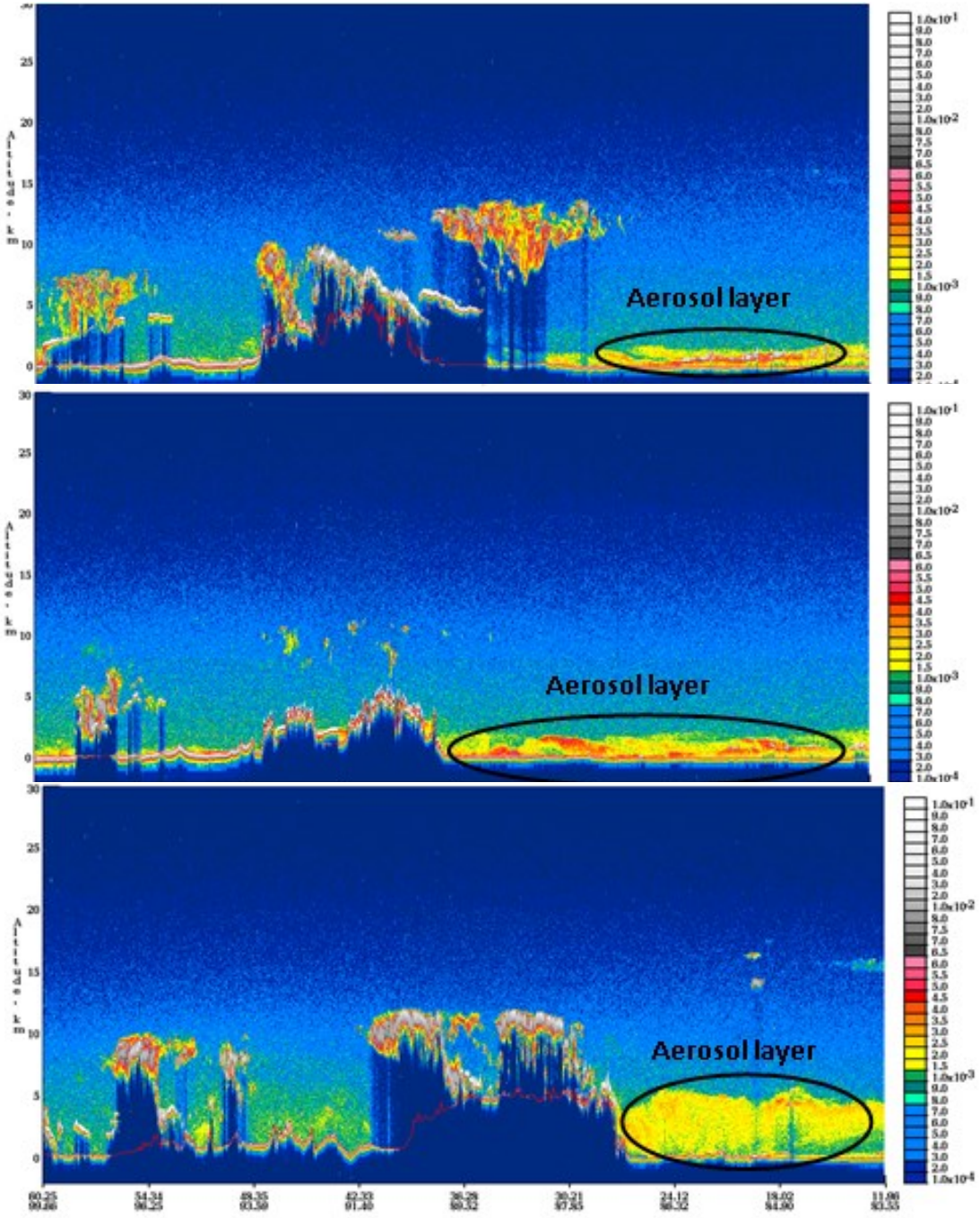


Also aerosols contribute to additional dimming by acting as nuclei for droplets that enhance scattering of solar radiation.

[indirect effect]

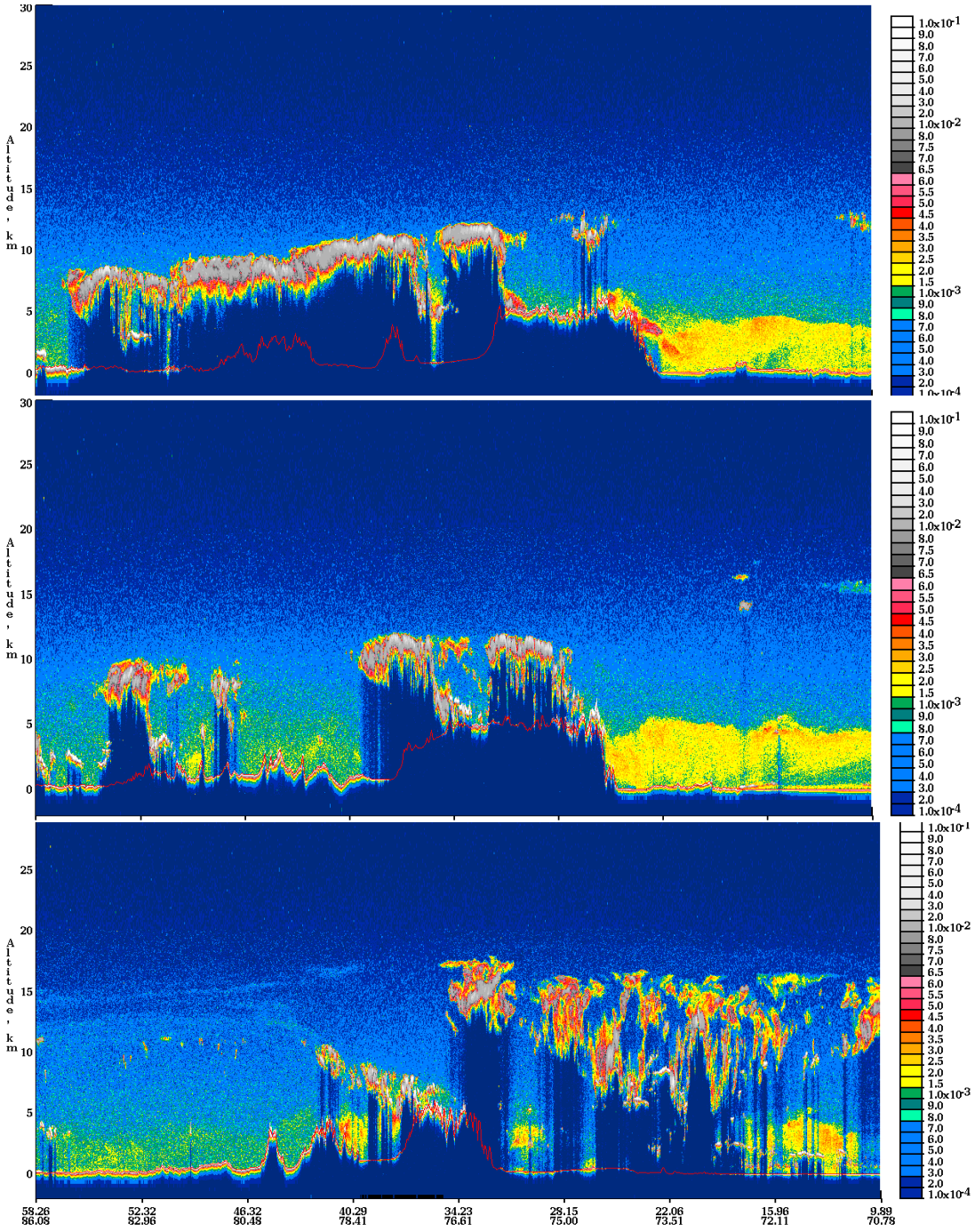
Highly uncertain in terms of climate impact





Over the Indian sub-continent, thick haze is observed almost throughout the year.

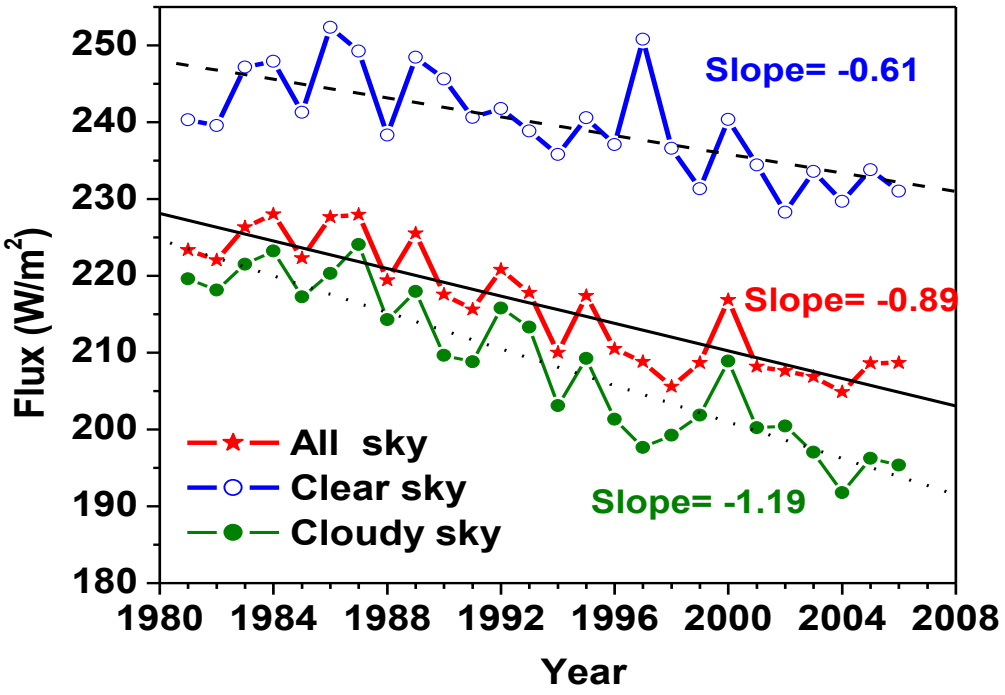
During winter, the maximum aerosol concentration is restricted up to 2 or 3 km due to the presence of low level inversions. While, elevated pollution levels are observed up to 4 to 5 km during pre-monsoon.



While, during monsoon, aerosol distribution is not obtained below deep clouds, which is the limitation of CALIPSO.

Annual mean surface reaching solar radiation

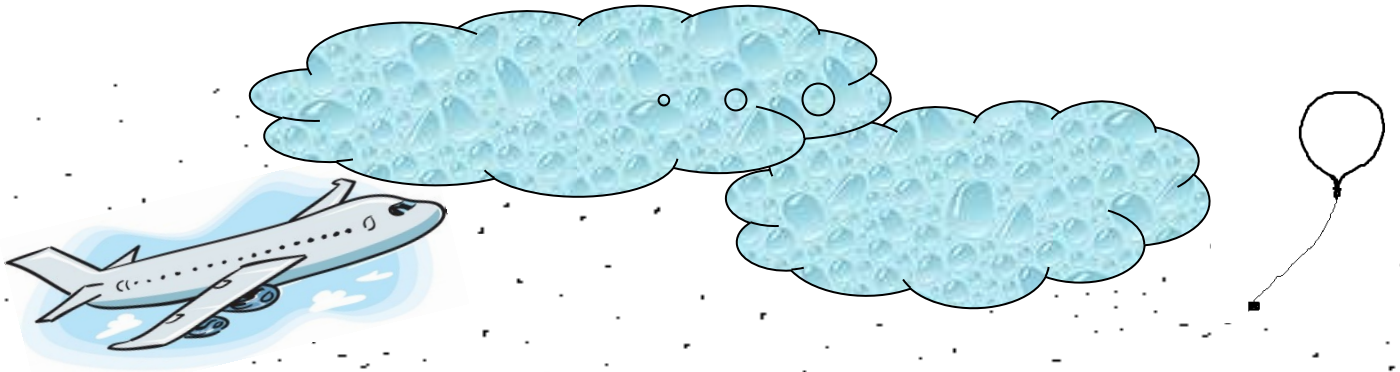
The observed trends for *clear and cloudy sky* days.



Important finding ……

The rate of dimming is found to be twice as large during cloudy conditions *(~12W/m2/decade)* compared to that during clear sky conditions *(~6W/m2/decade).*

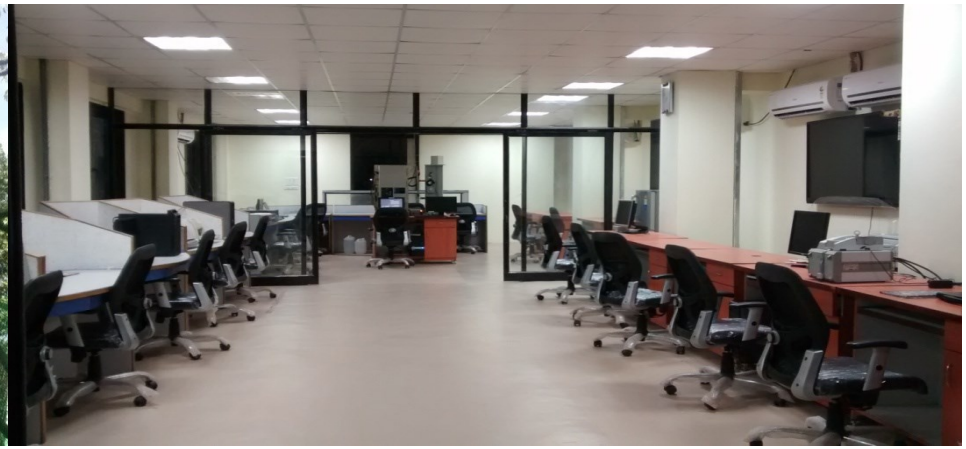
(Padma Kumari & Goswami, GRL 2010)



PBL

Ground Observations

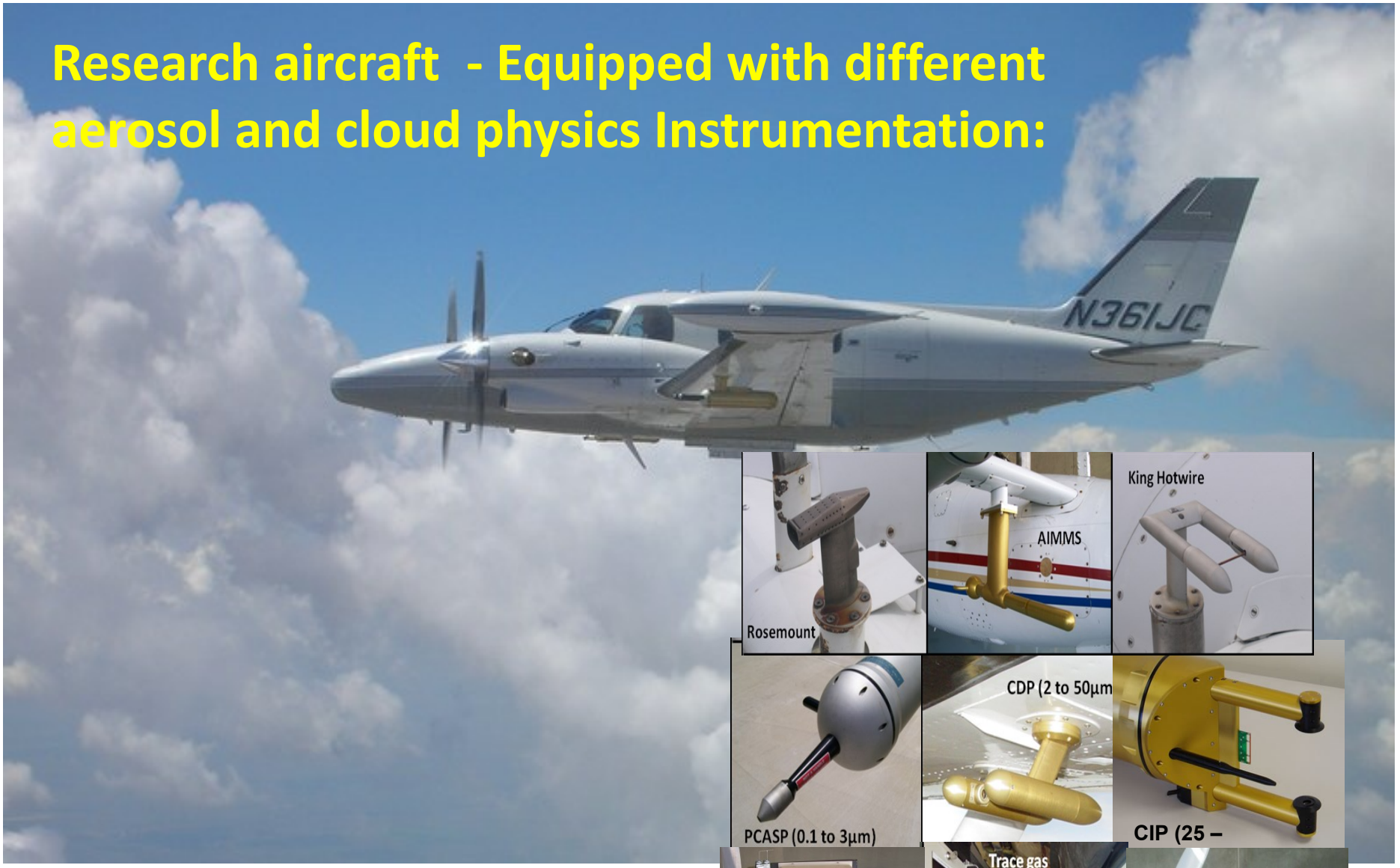
Cloud Physics Laboratory (HACPL), Mahabaleshwar

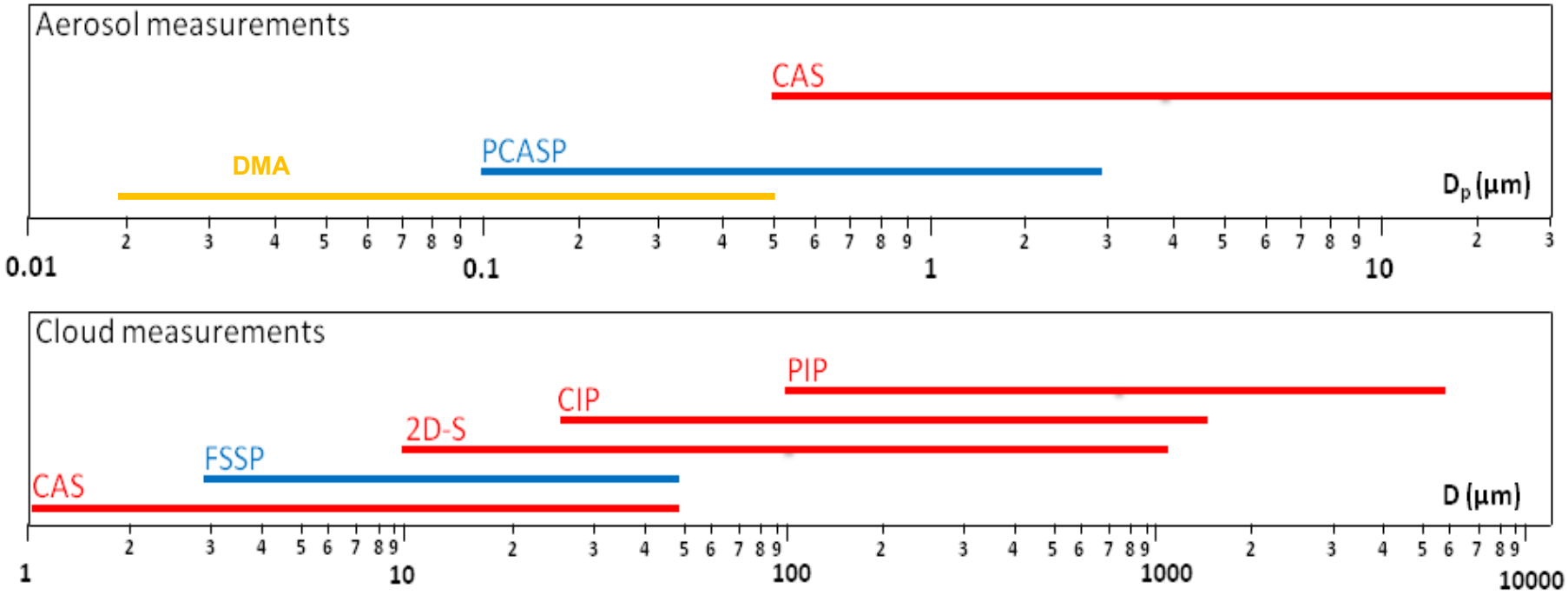


Apart from ground based and satellite measurements, aircraft is proven to be an effective platform for in-situ measurements of atmospheric aerosol over a reasonably large spatial domain.

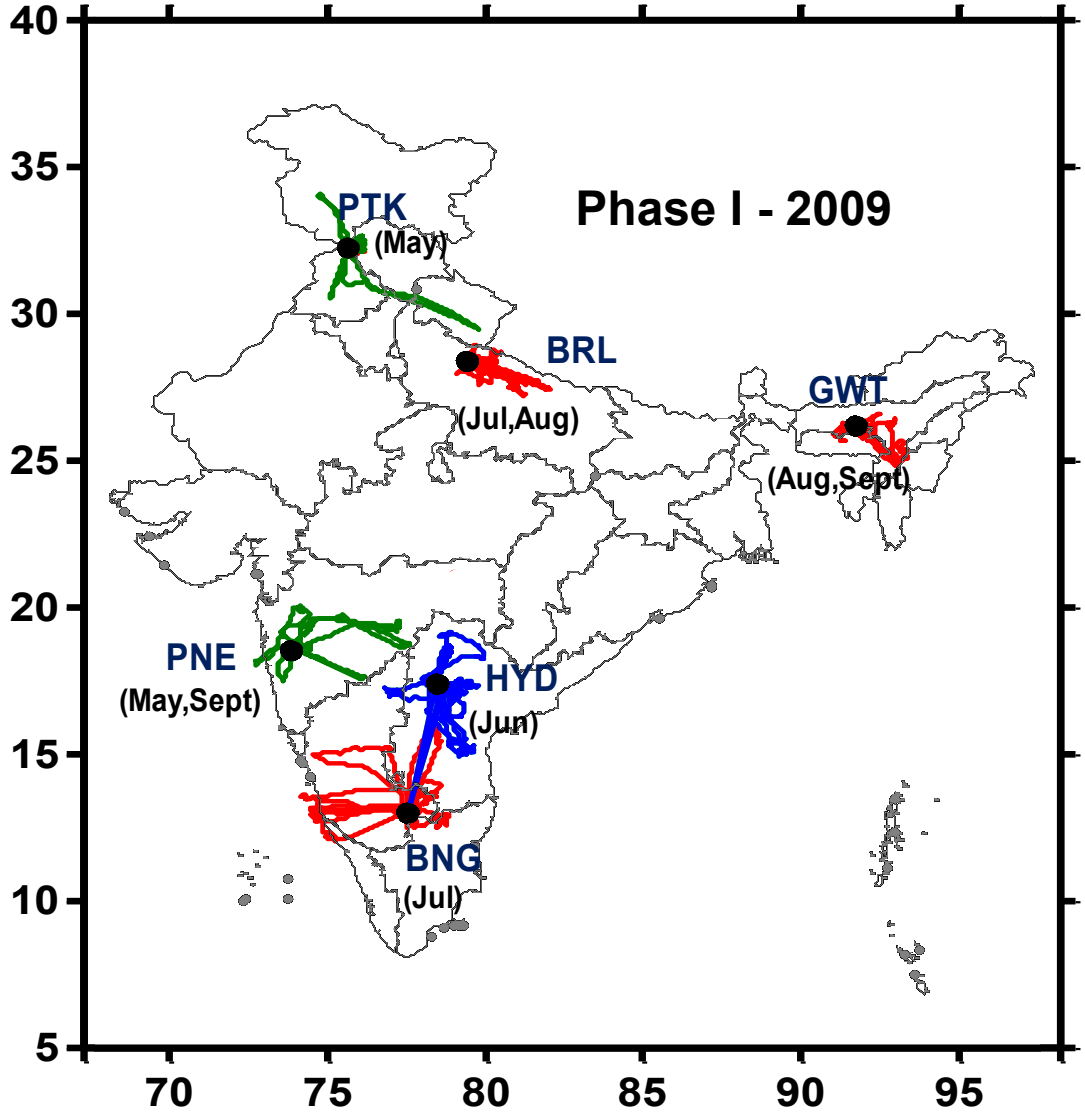
Moreover, aerosol measurements during monsoon are very sparse over India to understand aerosol-cloud interactions. Especially, aerosols in the neighbourhood of clouds are seldom observed by other traditional approaches.

Research aircraft - Equipped with different aerosol and cloud physics Instrumentation:



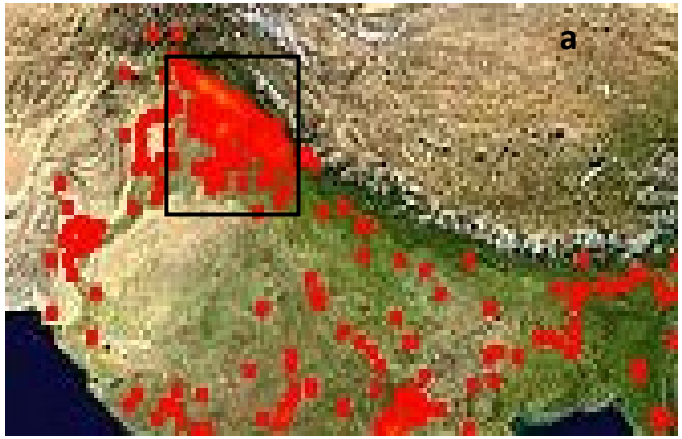


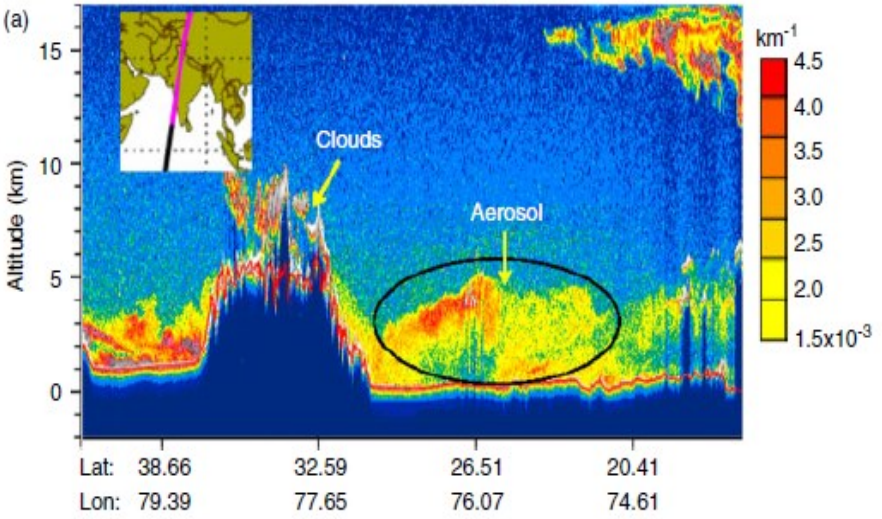
Size range of aerosol and cloud physics probes

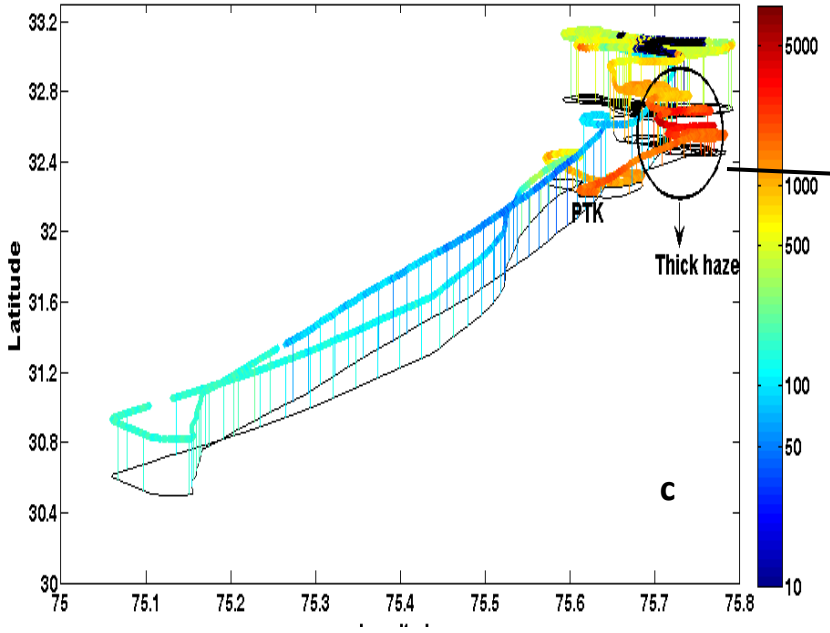


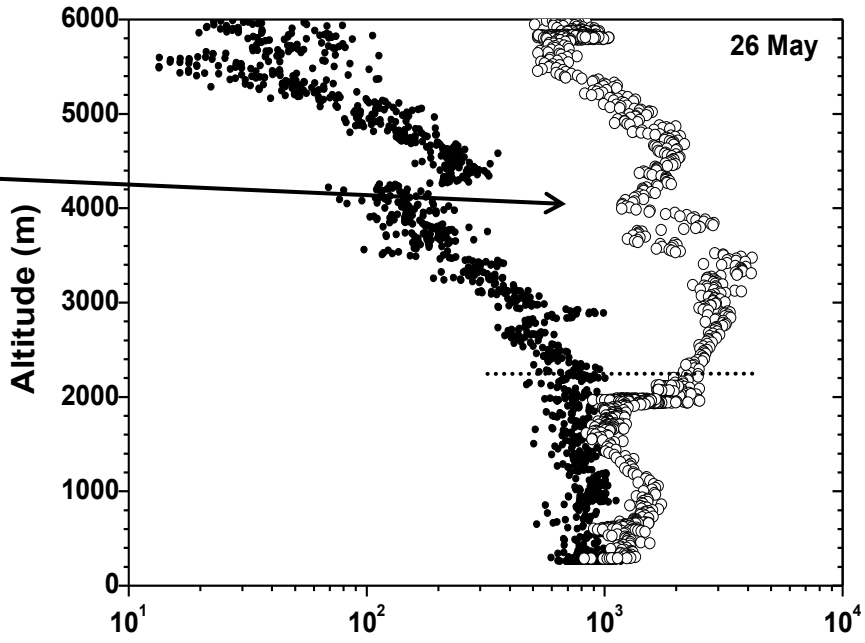
Padma Kumari et al., 2016

High aerosol concentrations near the foot hills of the Himalayas



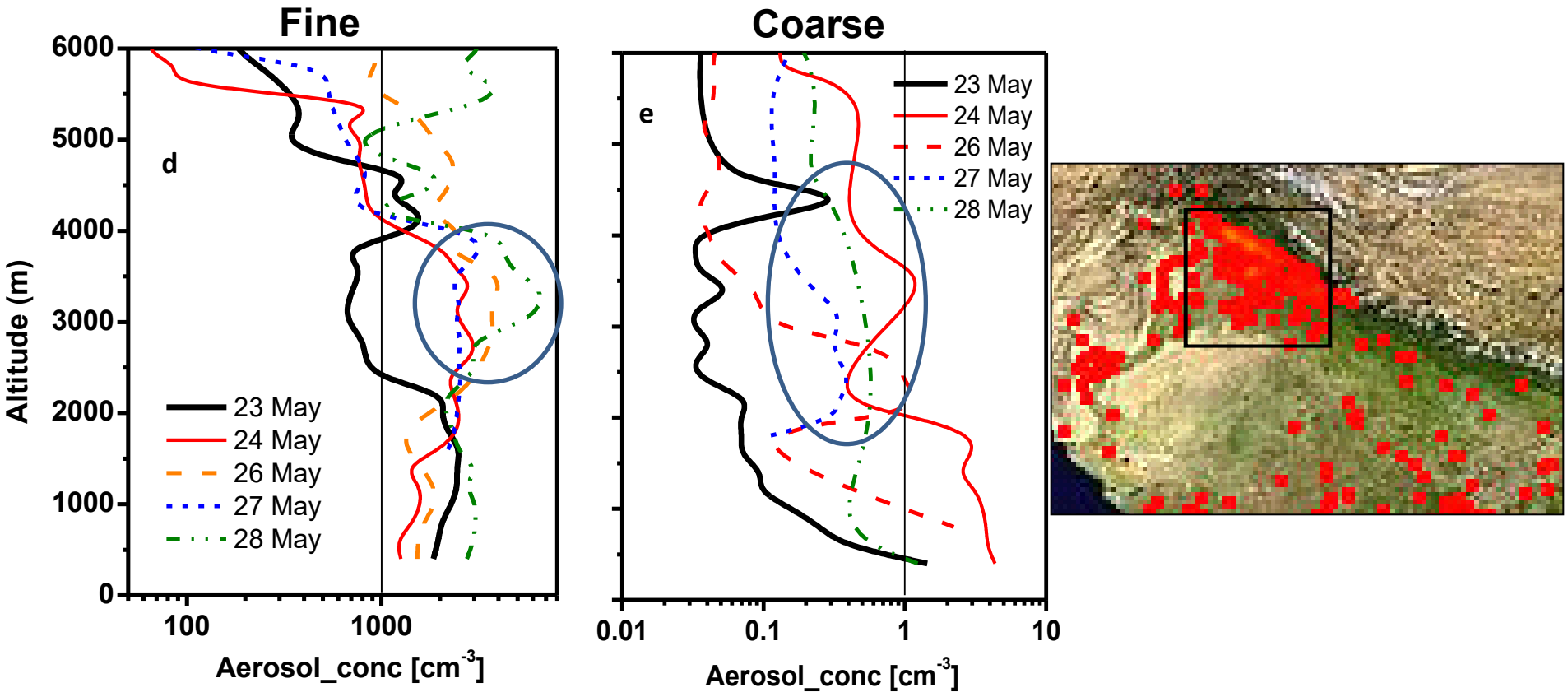






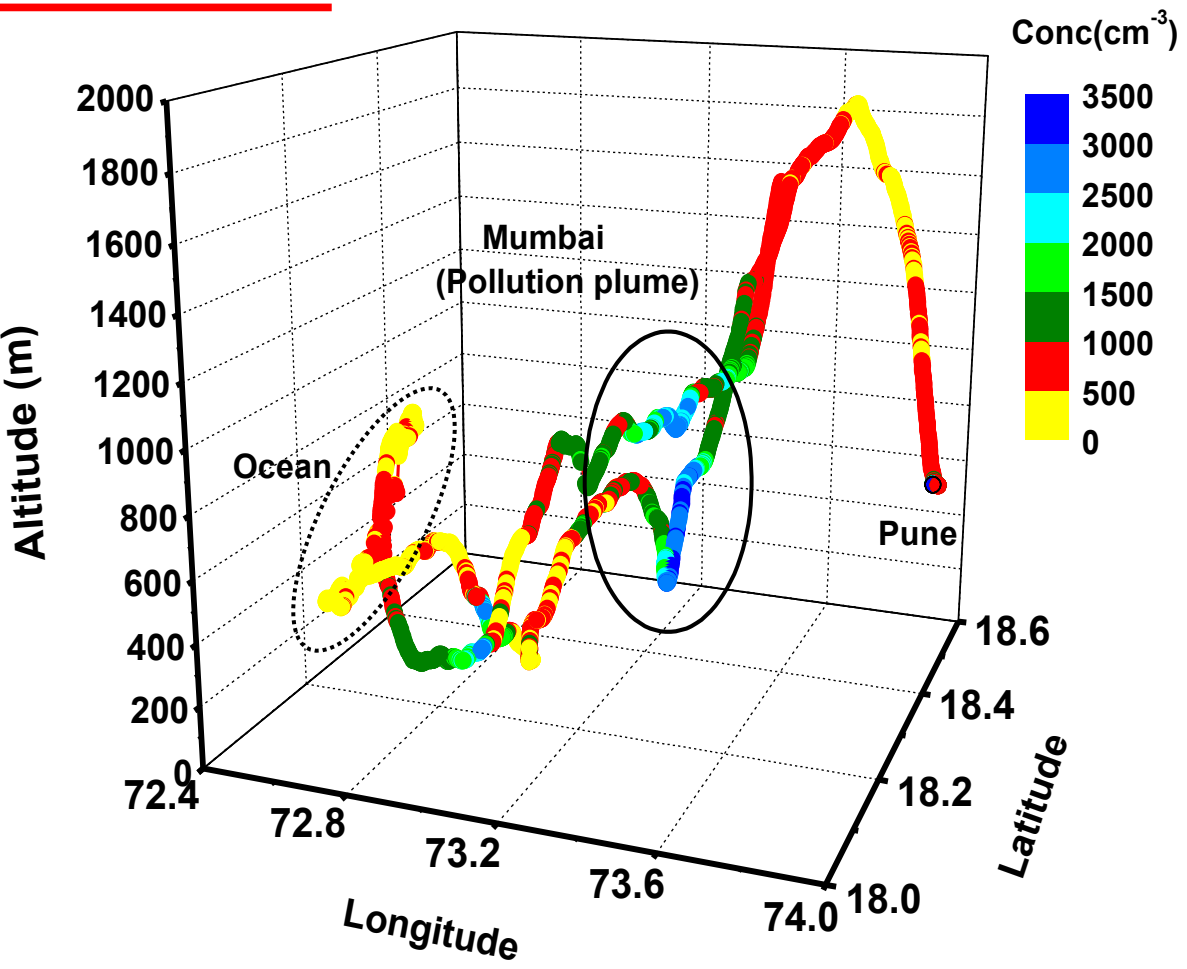
(PadmaKumari et al., QJRMS 2011)

Pathankot (May 23 – 28) fine and coarse mode aerosols



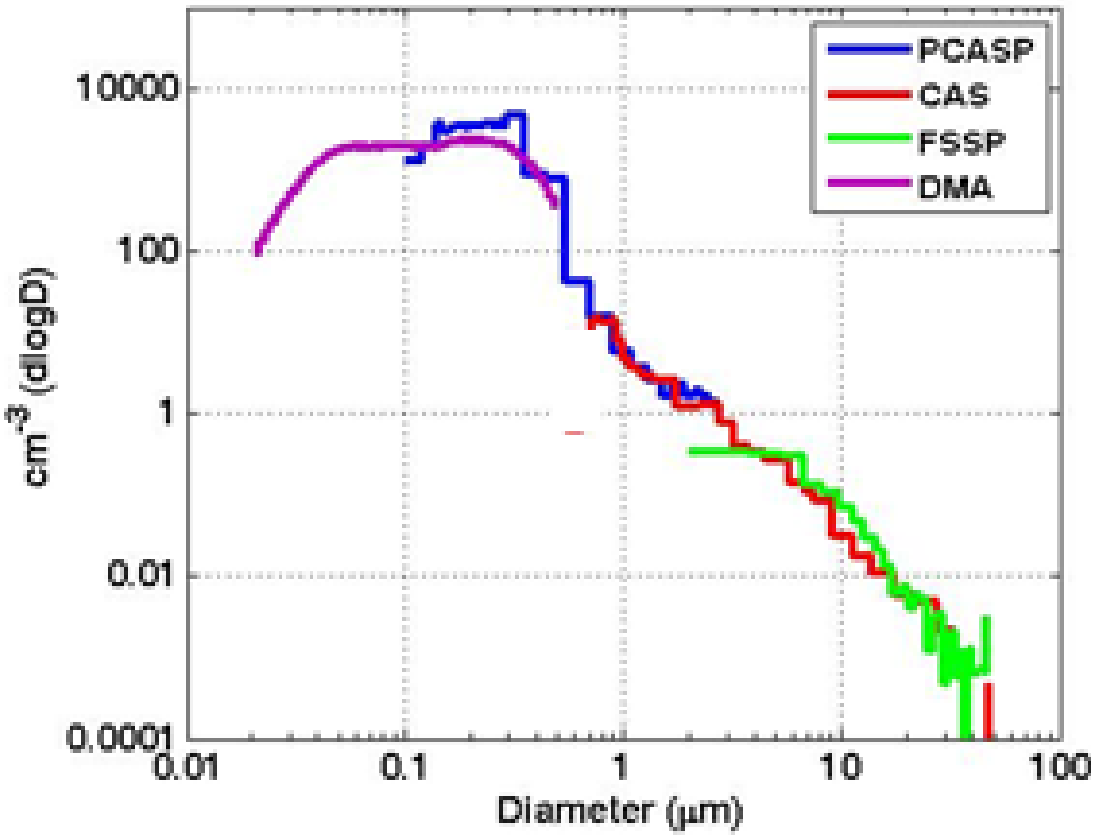
- **Thick haze was observed with elevated aerosol layers up to 4 km with varying concentrations.**
- **Aerosols over this region are well mixed and the vertical distribution is a mixture of both biomass burning and dust aerosols**

Spatial distribution

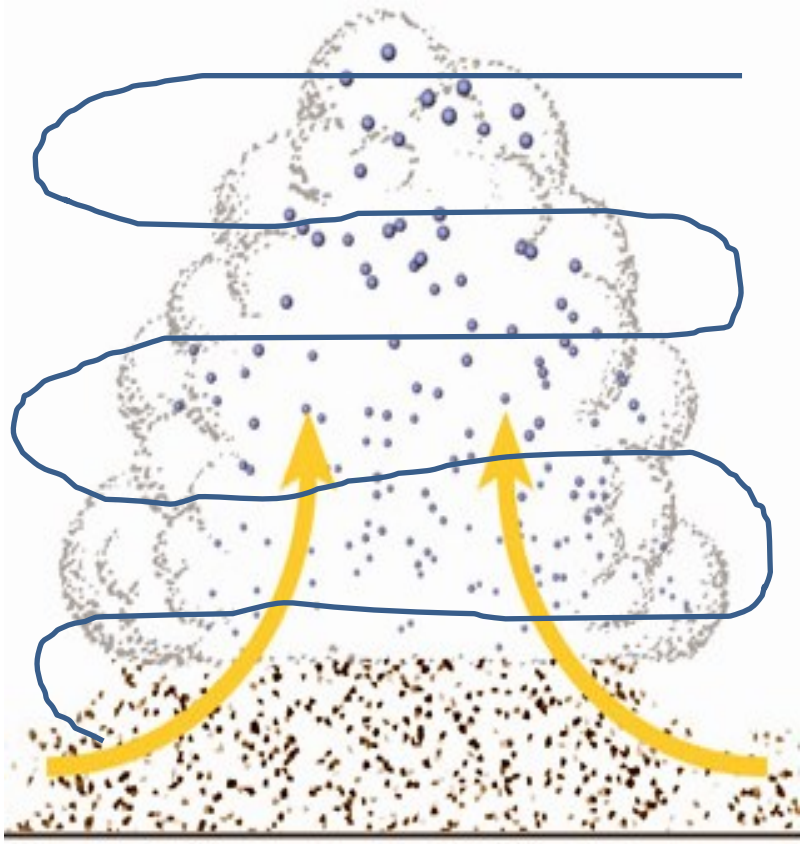


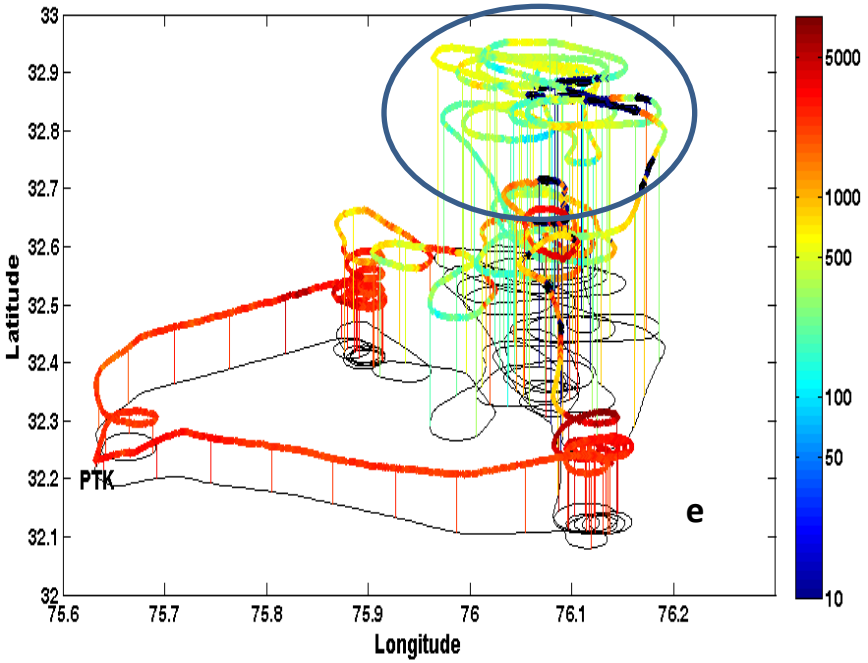
A case study of the aerosol spatial distribution from the base Pune towards the south of Mumbai. As the aircraft passed through the pollution plume over Mumbai, high number concentrations are observed. The west coast is also affected by this pollution.

Size distribution



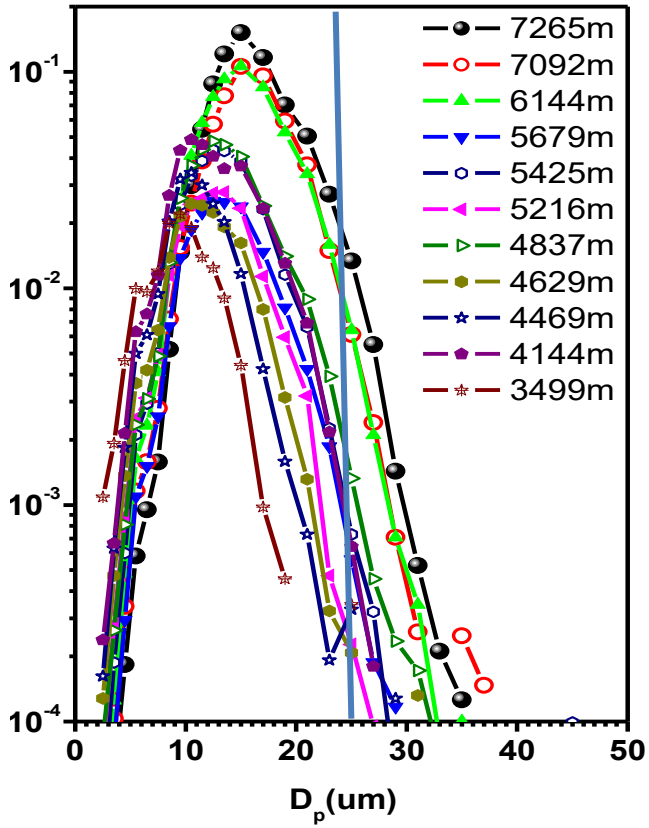
Cloud measurements with aircraft

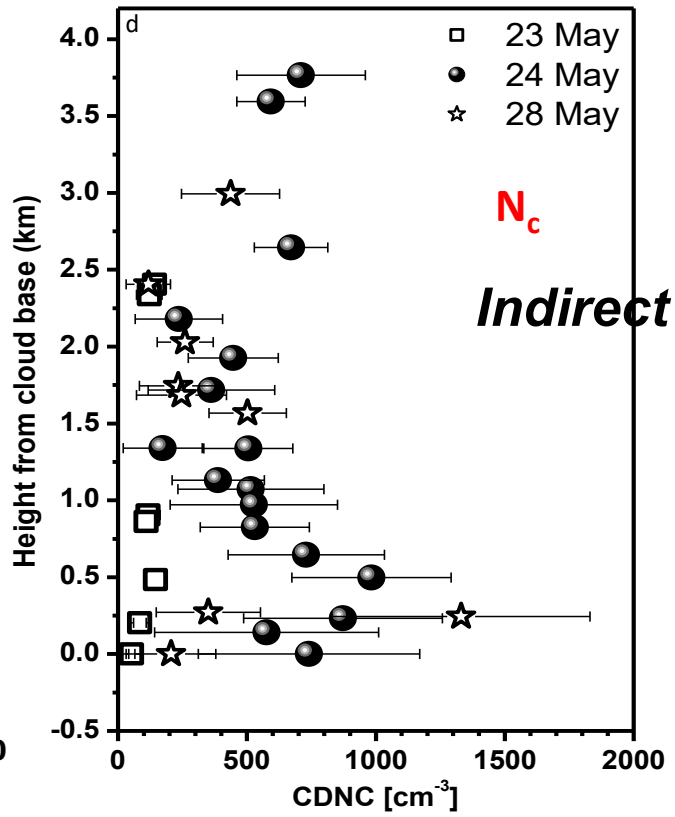




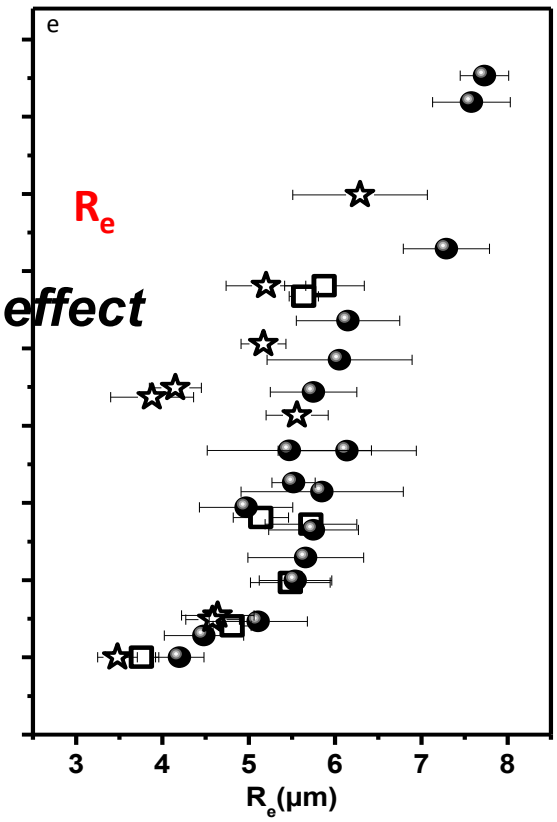
- Number concentration
- Droplet spectra
- Effective radius
- LWC

Effect of Elevated Pollution Layer on cloud microphysics





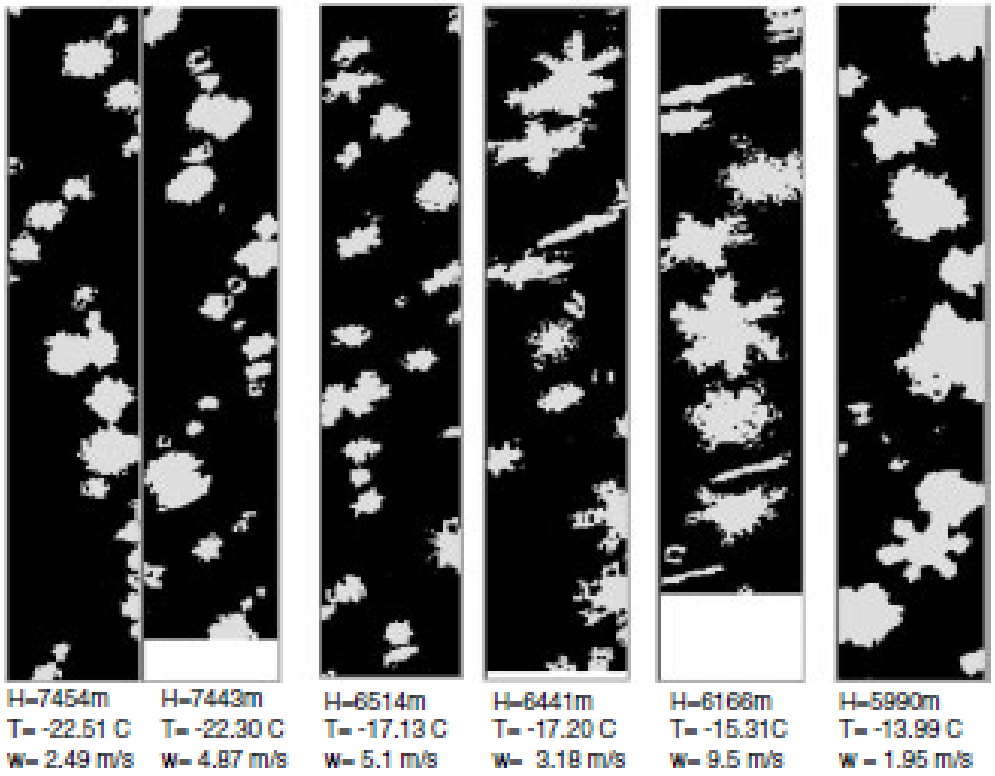
Indirect effect



Pre - monsoon

- Narrow drop size distribution
- Higher droplet number concentrations (200 – 1400 cm^{-3})
- R_e never crossed 8 μm

PadmaKumari et al., QJRMS, 2013



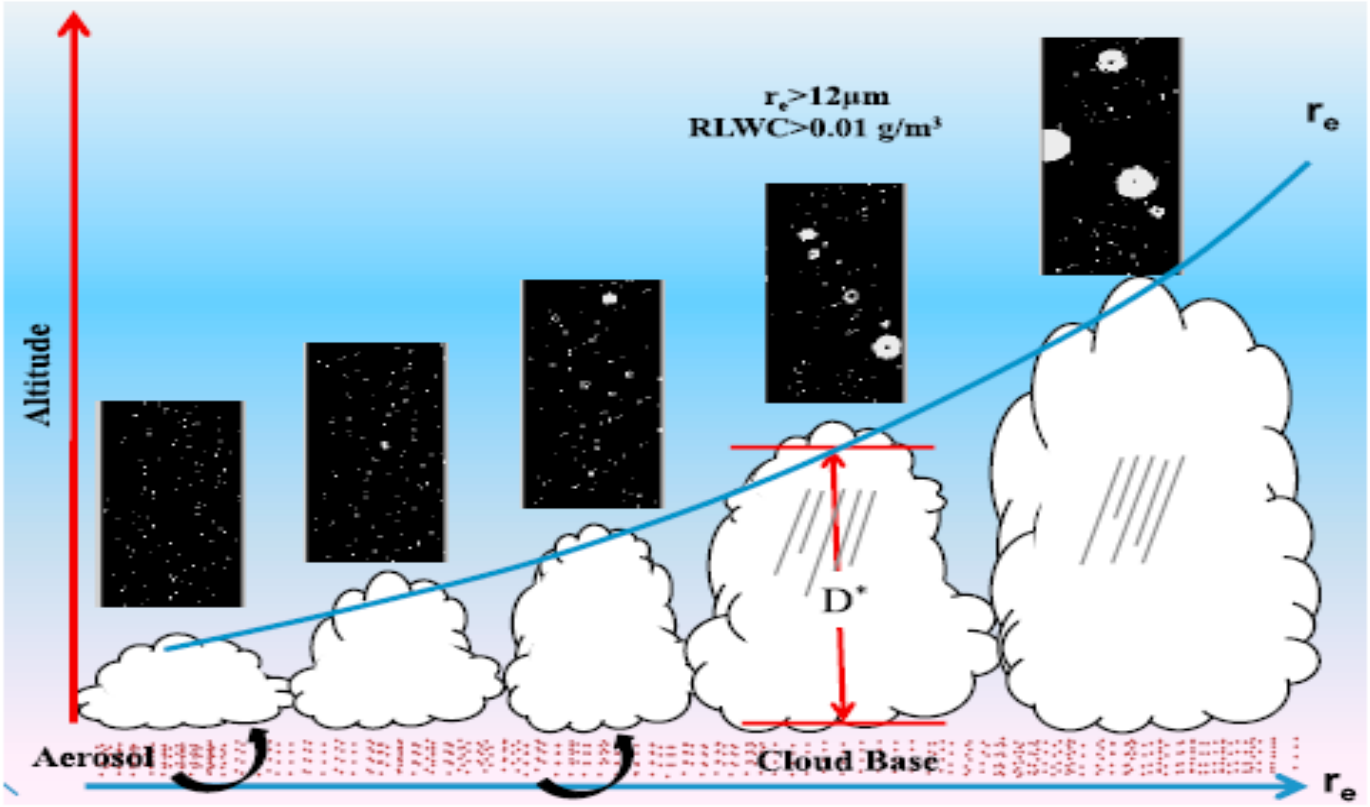
Ice phase is observed above 5 km. Dust aerosol is acting as a potential ice nuclei at temperatures lower than -14 ˚C.

As dust is always present in the atmosphere at high concs during pre-monsoon, could lead to changes in cloud microphysics, which may effect the radiation balance of the earth-atmosphere system.

Padma Kumari et al., QJRMS, 2013

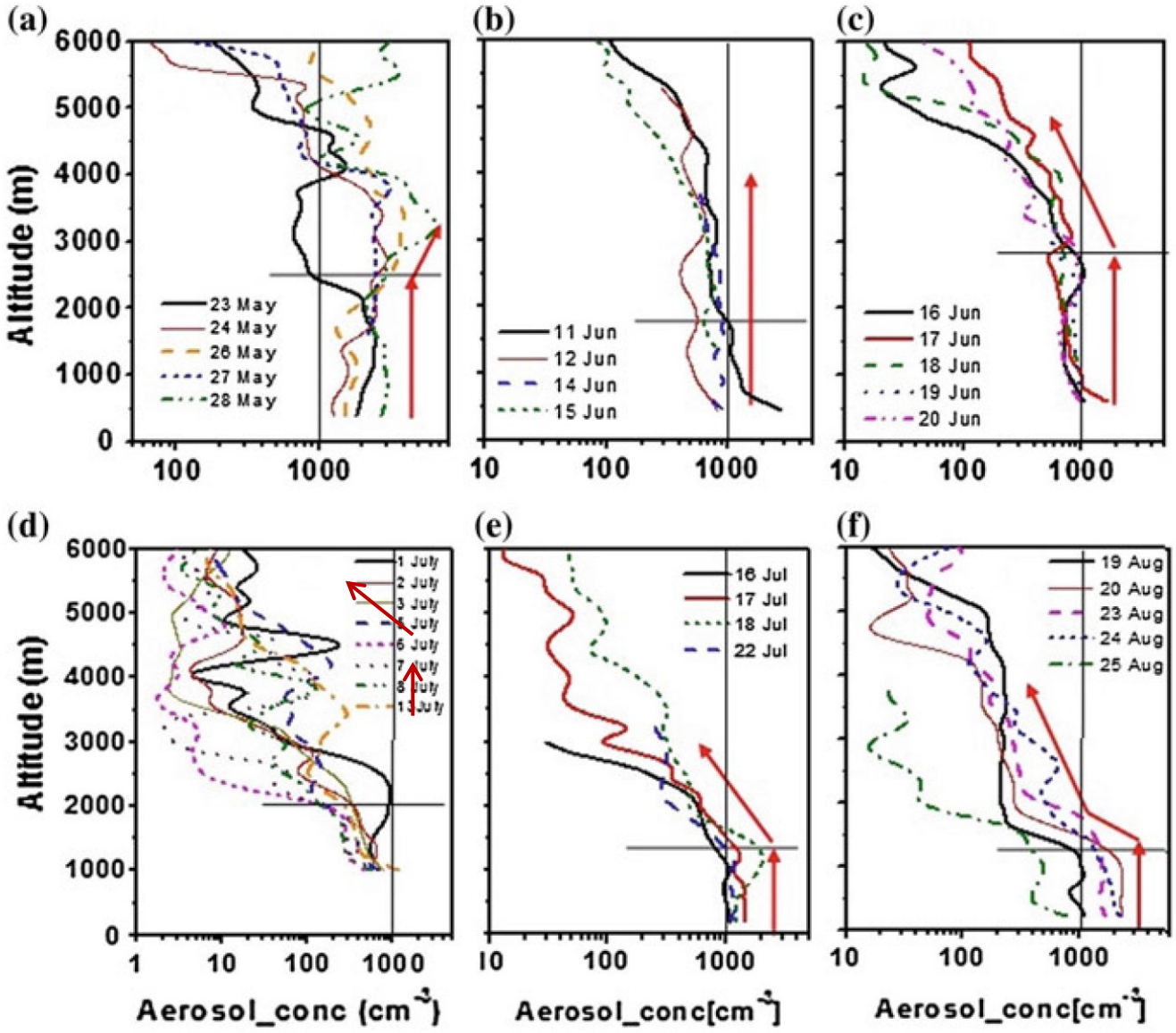
Aerosol - cloud interactions - Indirect effects

Aerosol control on depth of warm rain.



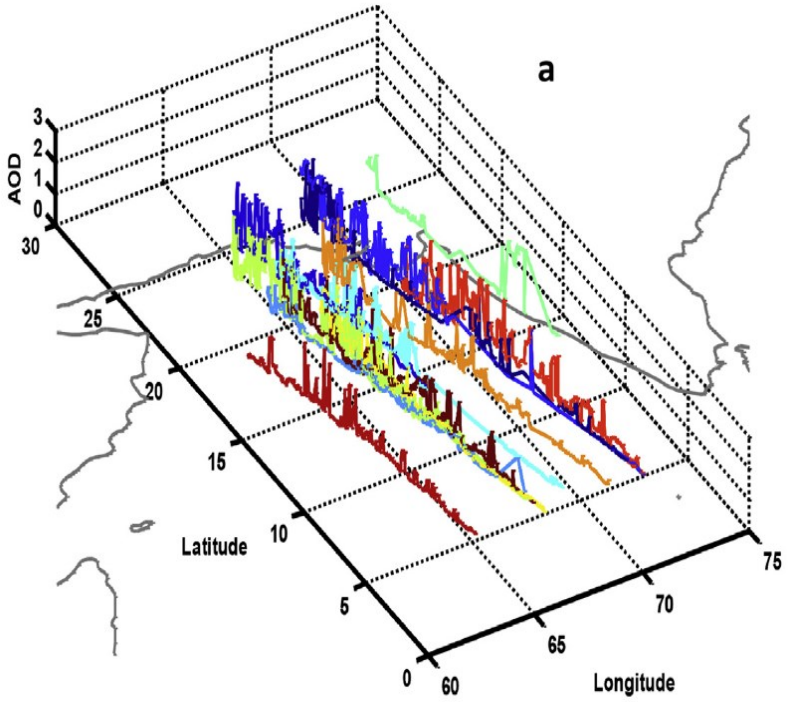
More aerosols → More cloud drops → deeper cloud for onset of rain

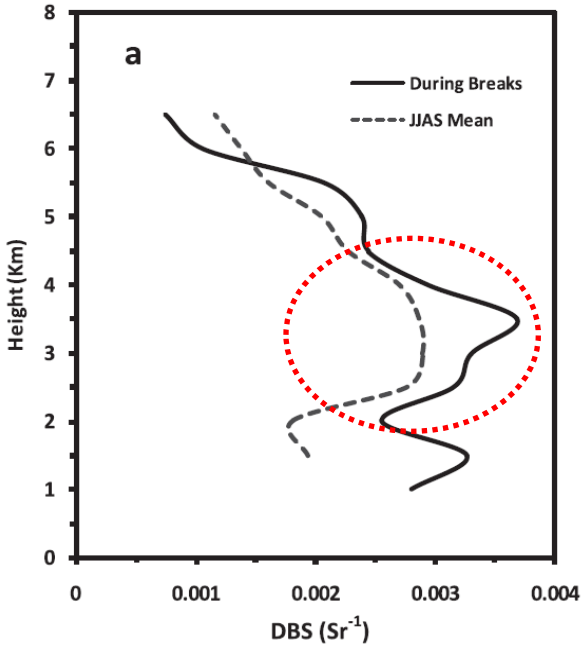
[Mahen et al., JGR 2012]



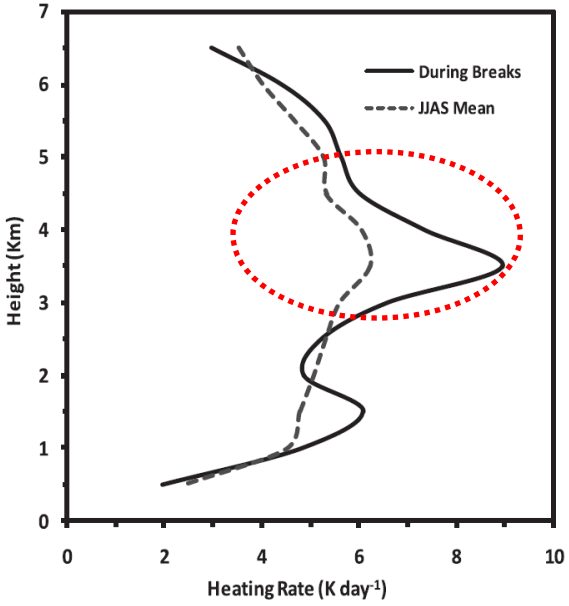
Aerosol gradient and transition from boundary layer to free troposphere during different phases of monsoon

PadmaKumari et al., 2016





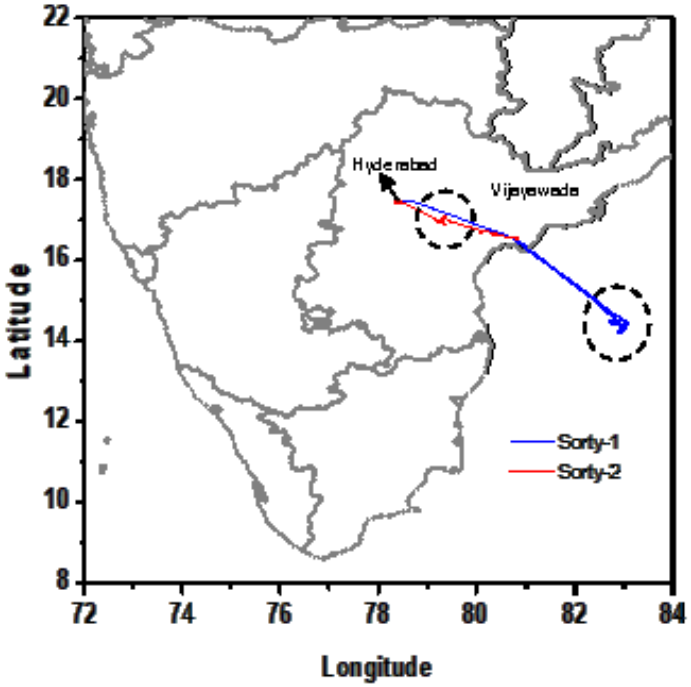
The presence of elevated dust aerosol layer over the AS was observed between 2 and 5 km with maximum frequency of occurrence at 3.5–4 km, which caused a maximum heating of 9 K/Day. This heating is more by 3 K/Day than that observed during JJAS mean. The excess heating could induce significant changes in the existing dynamical/circulation patterns, which in turn can intensify or extend the break situation.

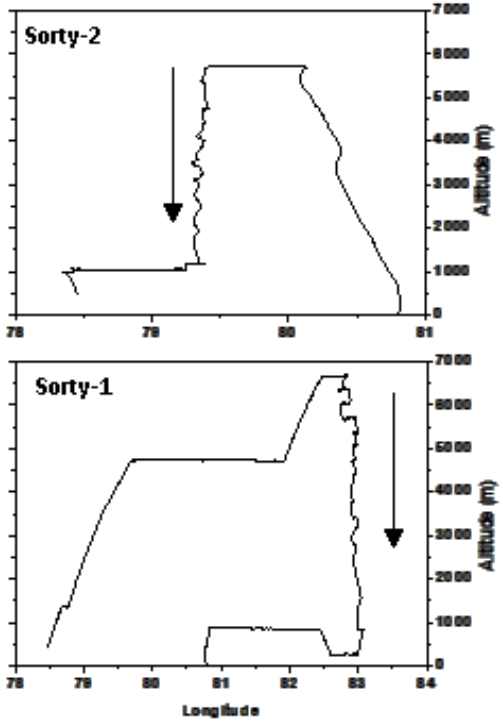


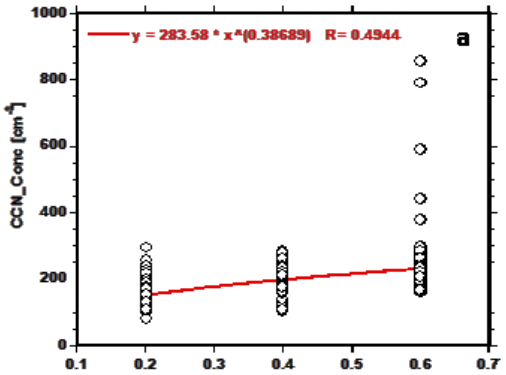
Significant differences are observed in cold and warm cloud microphysics with and without dust aerosols.

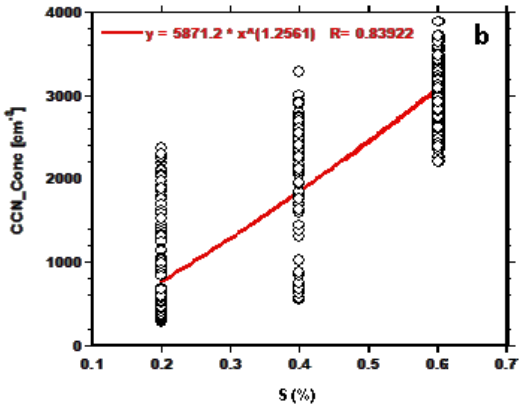
[Harikishan, Padma kumari et al., Atmos Env., 2015]

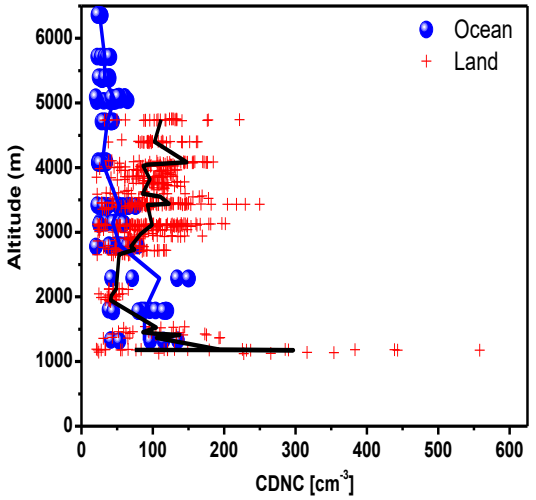
Aerosol & Cloud microphysics over Ocean and Land

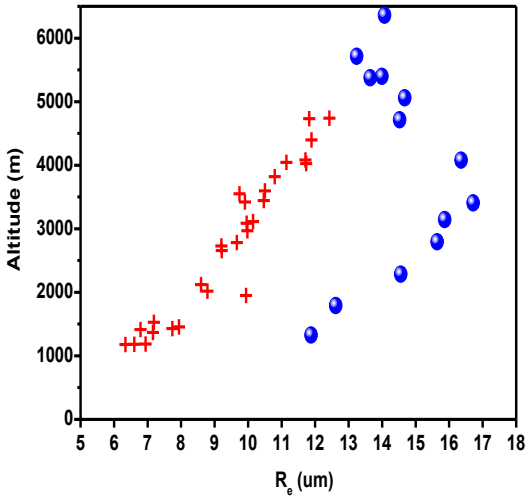






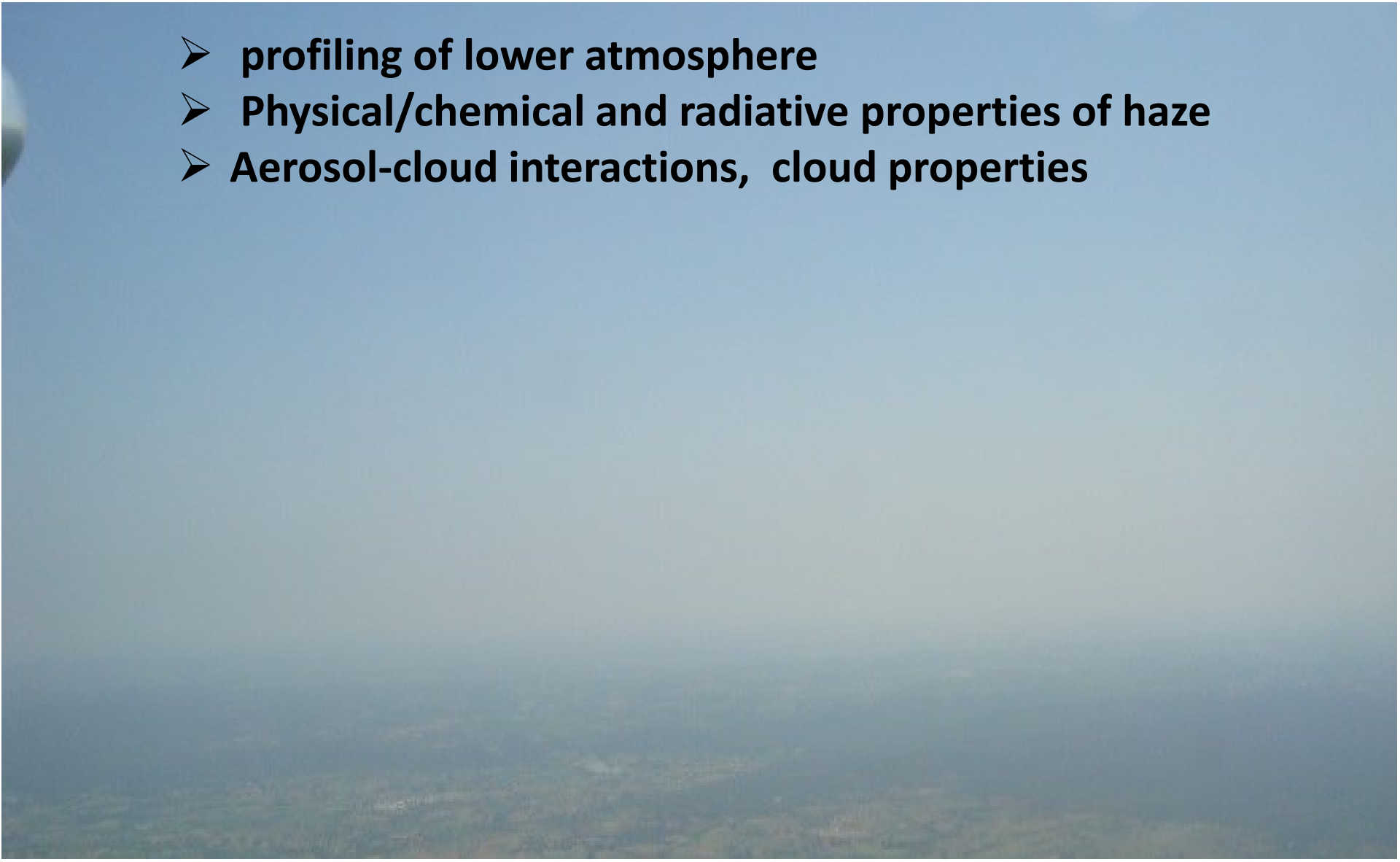






Padma Kumari et al., Atmos. Res., 2017

UAVs



- profiling of lower atmosphere
- Physical/chemical and radiative properties of haze
- Aerosol-cloud interactions, cloud properties

THANK Q

for your kind attention