

Spatial Variability of Aerosol - Cloud Interactions over Indo - Gangetic Basin (IGB)

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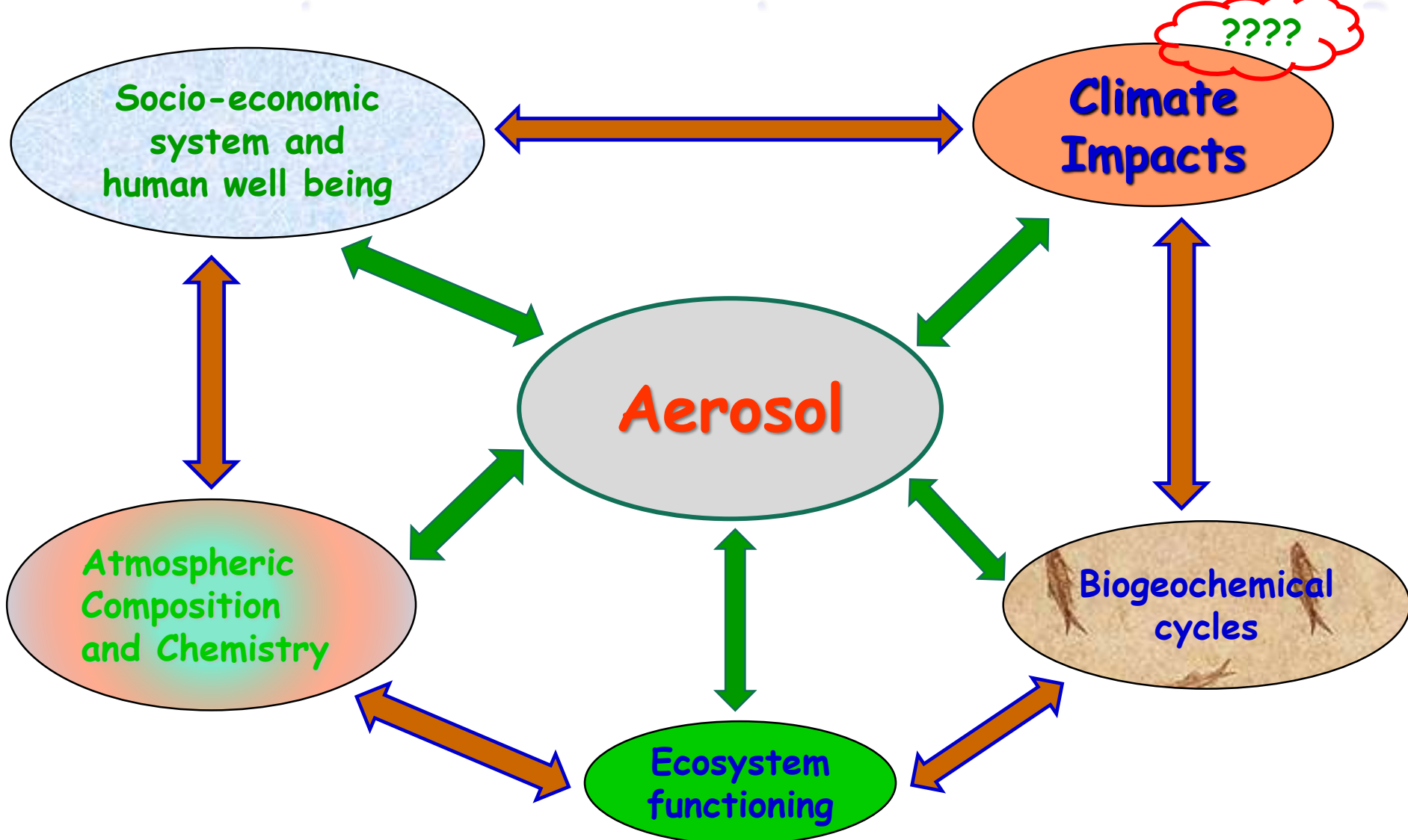
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Thanks to ...

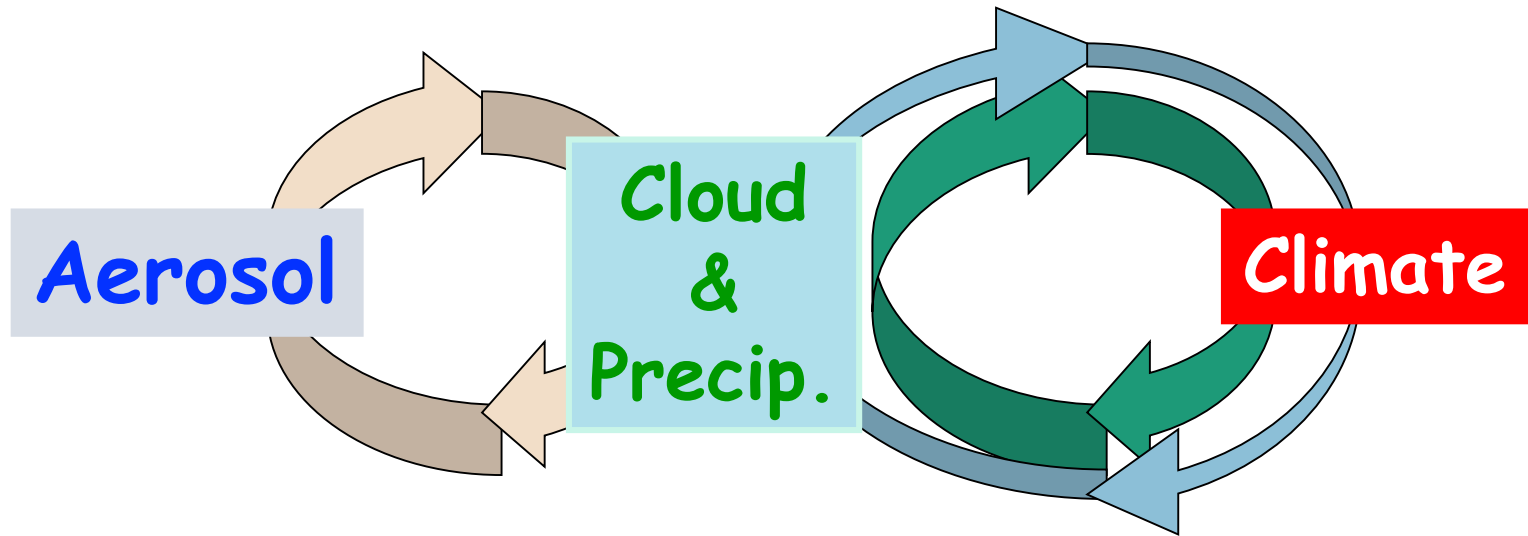
- Prof. S. Ramachandran (Physical Research Laboratory, Ahmedabad)
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- Prof. T. Shibata, Nagoya University, Japan
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Aerosol Impacts on Earth system and Human Being

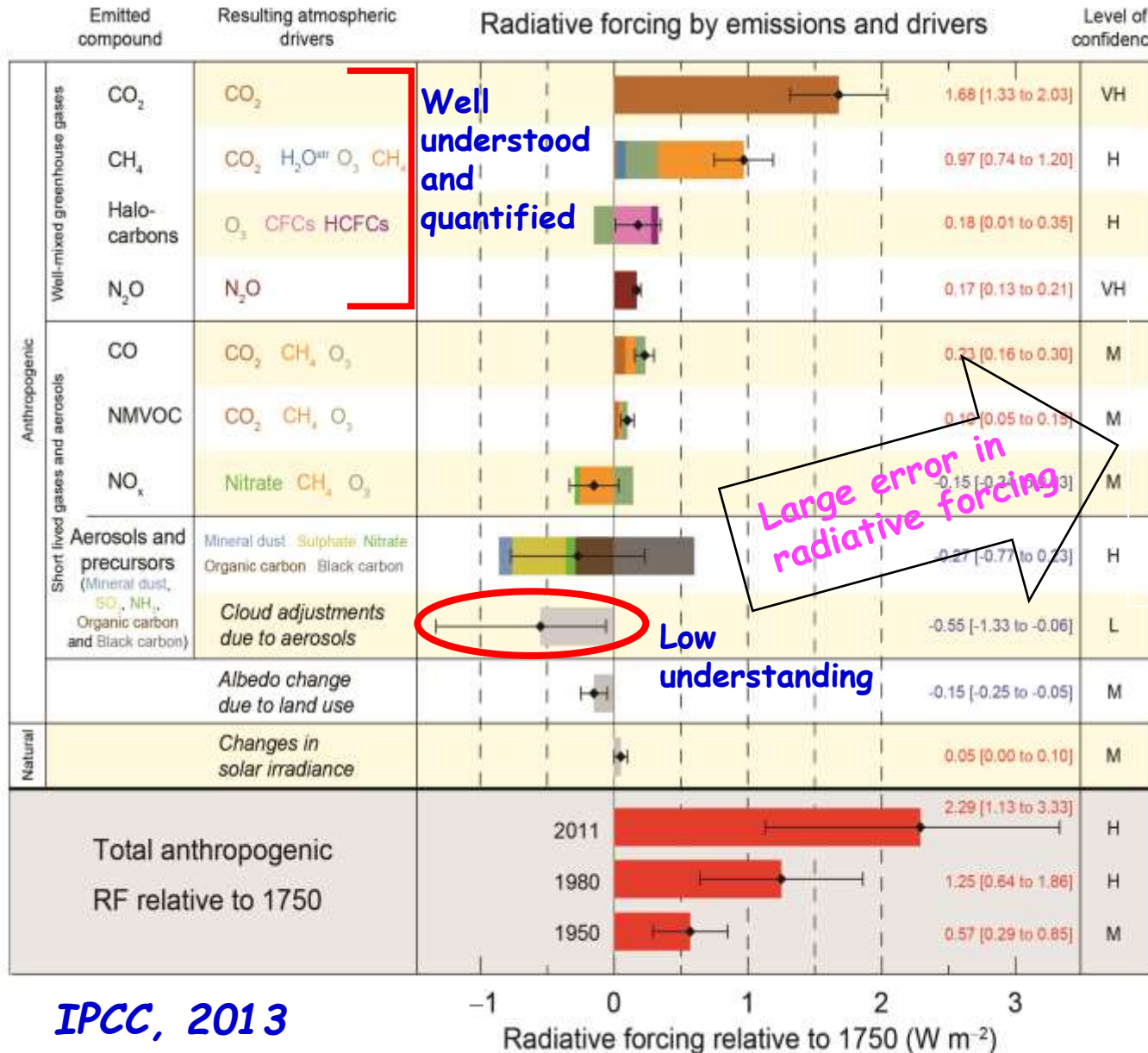


Climate Impact of Atmospheric Aerosol

1. **Direct Effect** : Absorption (**dust**) and scattering (**sulphates**) of solar radiation by aerosols.
2. **Indirect Effect**: Effects of aerosol on cloud properties.
3. **Semi Direct Effect**: Evaporation of the cloud, cloud burn off.



Global Radiative Forcing



Well understood and quantified

Large error in radiative forcing

Low understanding

“Cloud radiative forcing shows strong cooling effect at top of the atmosphere”

- ❖ Spatial-temporal variation
- ❖ Inadequate knowledge about aerosol-cloud interaction (Model Sensitivity)



Addresses

Observations & Numerical Modeling Tools

Instruments used for the present study

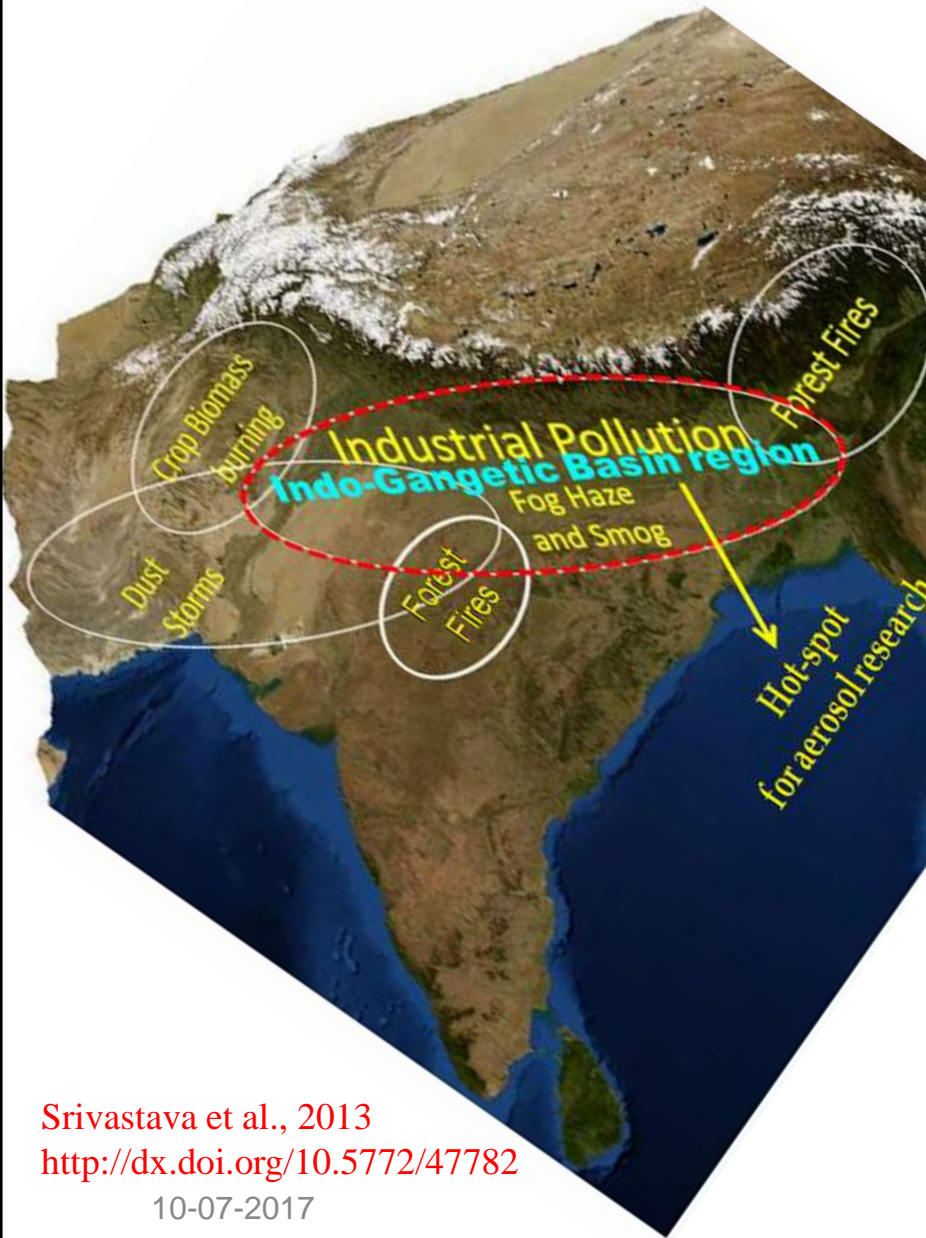
Moderate Resolution Imaging Spectro-radiometer (MODIS) :

- ✓ 36 Spectral band from 0.4 μm to 14.4 μm
- ✓ At 470, 550 and 660 nm over land and 470, 550, 660, 865, 1200, 1600 and 2100 nm over ocean.
- ✓ Daily level 3, version 6.0 AOD, and cloud parameters data are used
- ✓ Spatial resolution of $1^\circ \times 1^\circ$ (<http://modis.gsfc.nasa.gov/>).

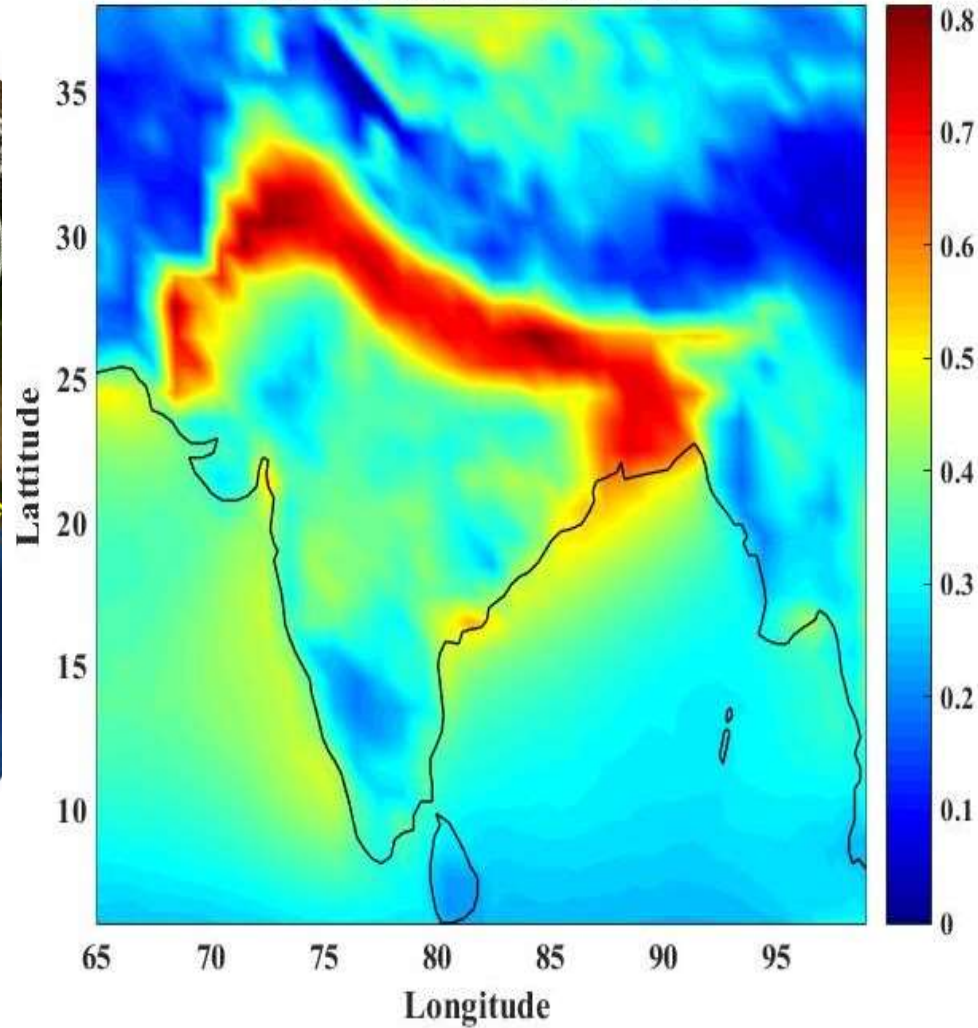
Tropical Rainfall Measurement Mission (TRMM) :

- ✓ Daily TRMM_B342_Daily_v7 rainfall data
- ✓ Very high spatial resolution of $0.25^\circ \times 0.25^\circ$.

Why Indo-Gangetic Basin ?



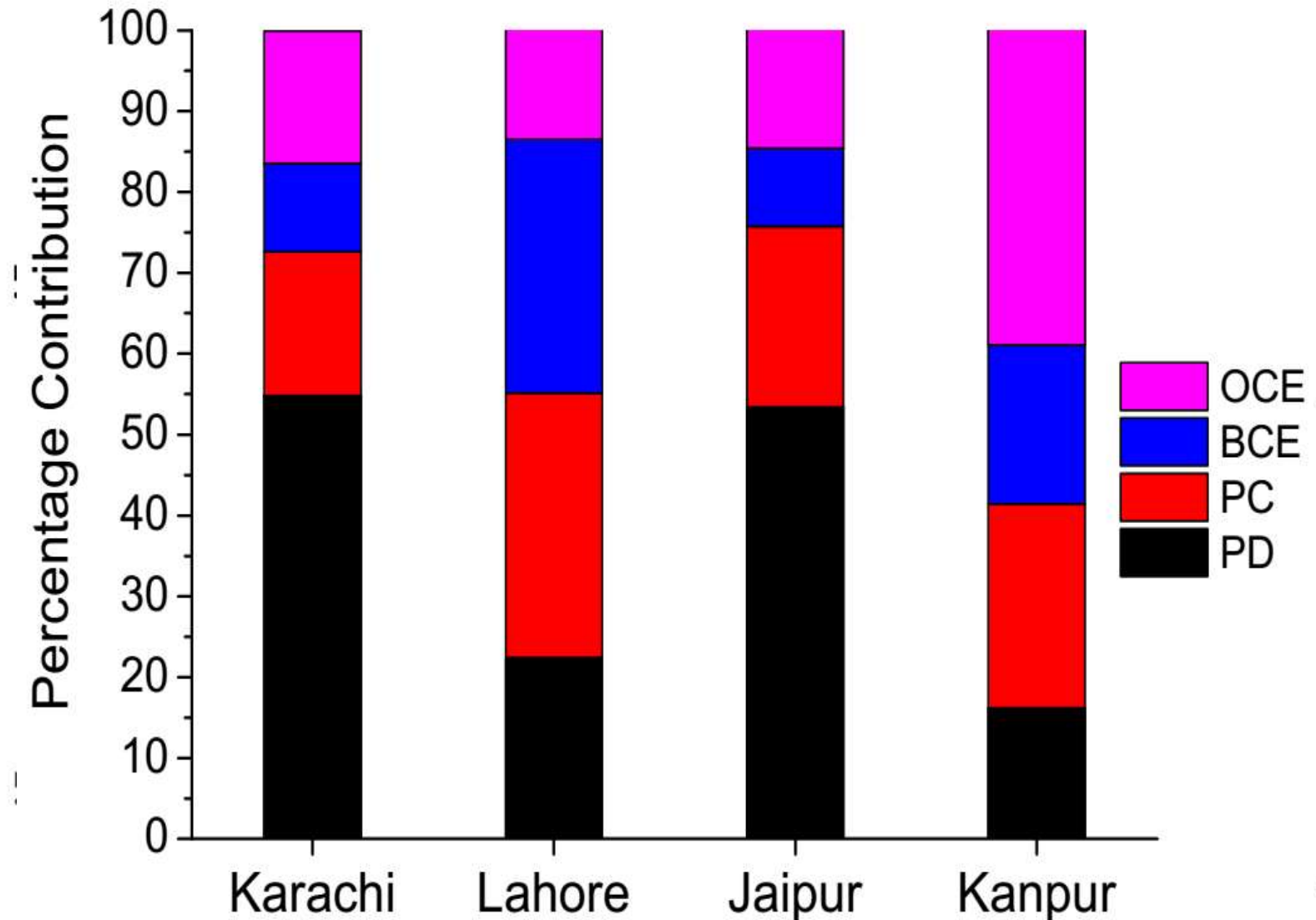
Daily Mean AOD (2001 - 2015)



Srivastava et al., 2013
<http://dx.doi.org/10.5772/47782>

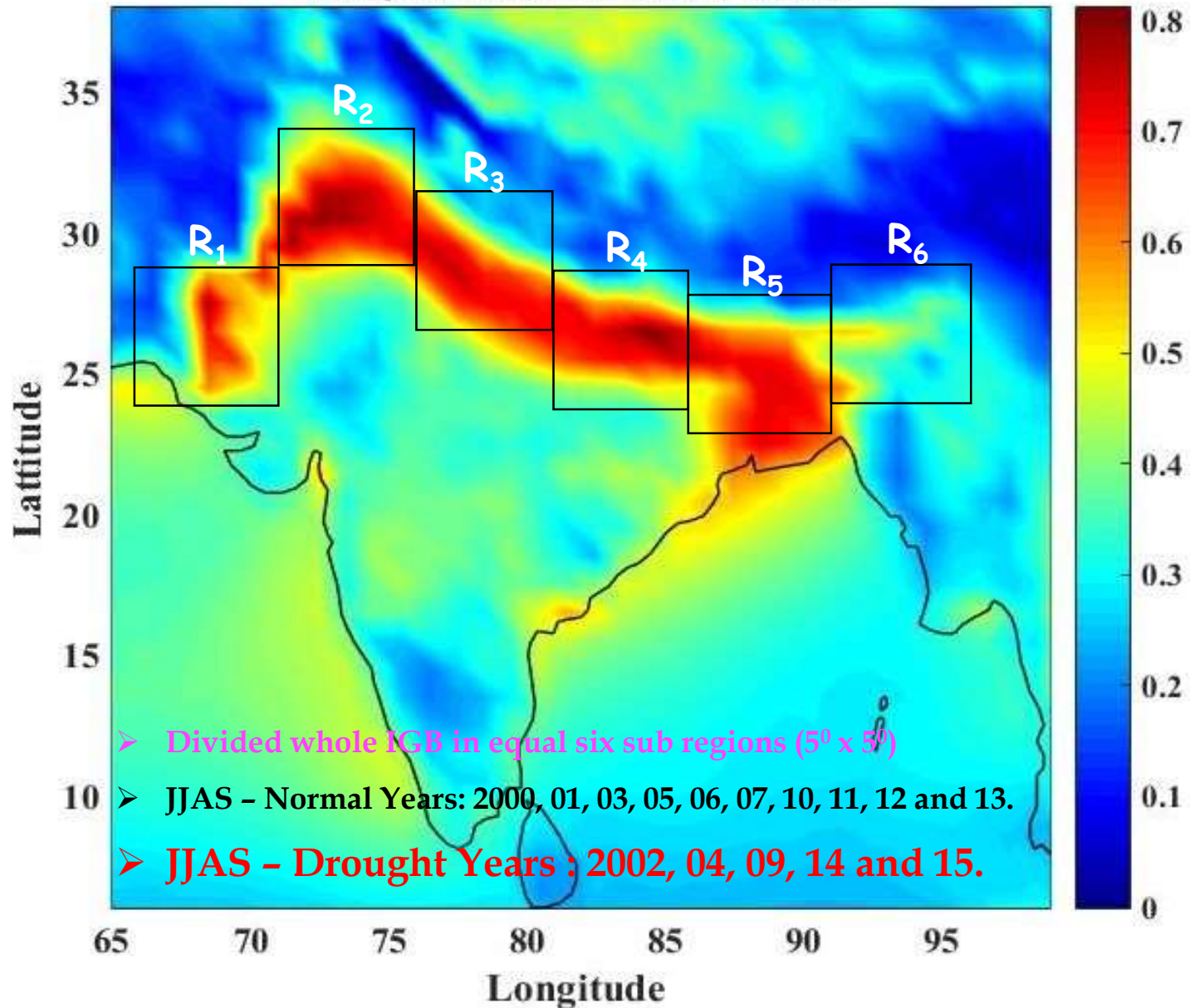
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Heterogeneity in aerosol types and annual their contributions

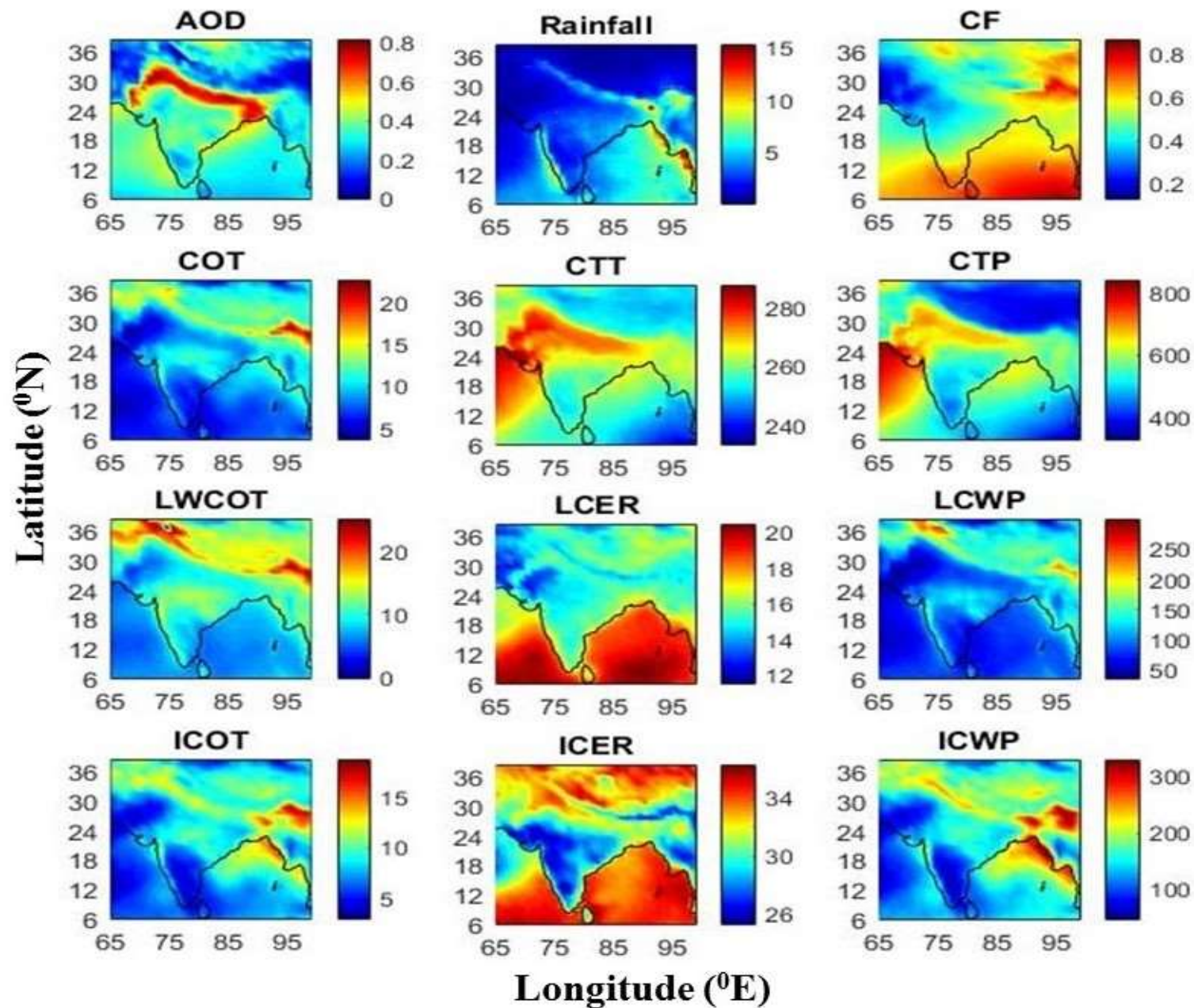


Methodology

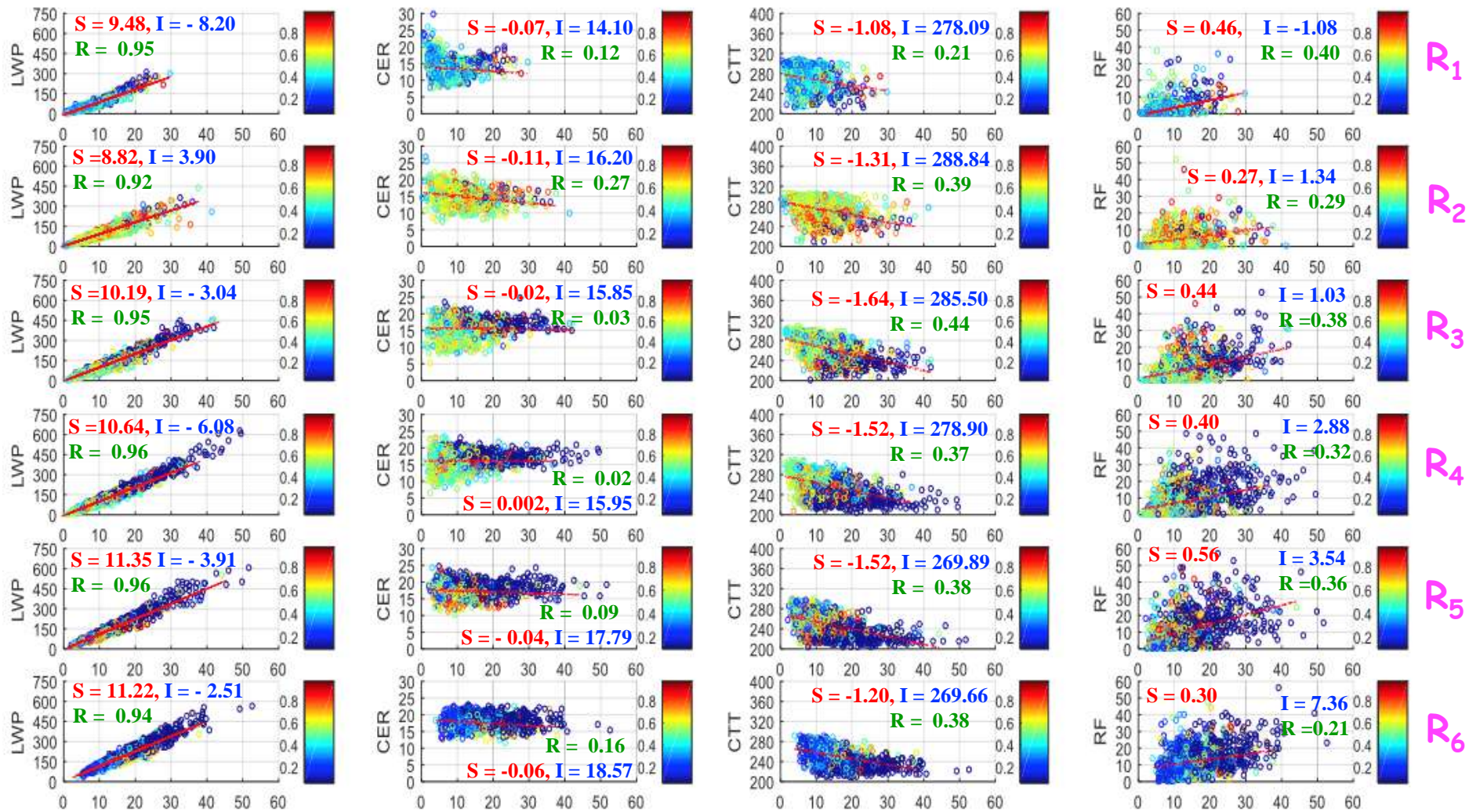
Daily Mean AOD (2001 - 2015)



Preliminary Results and Discussion

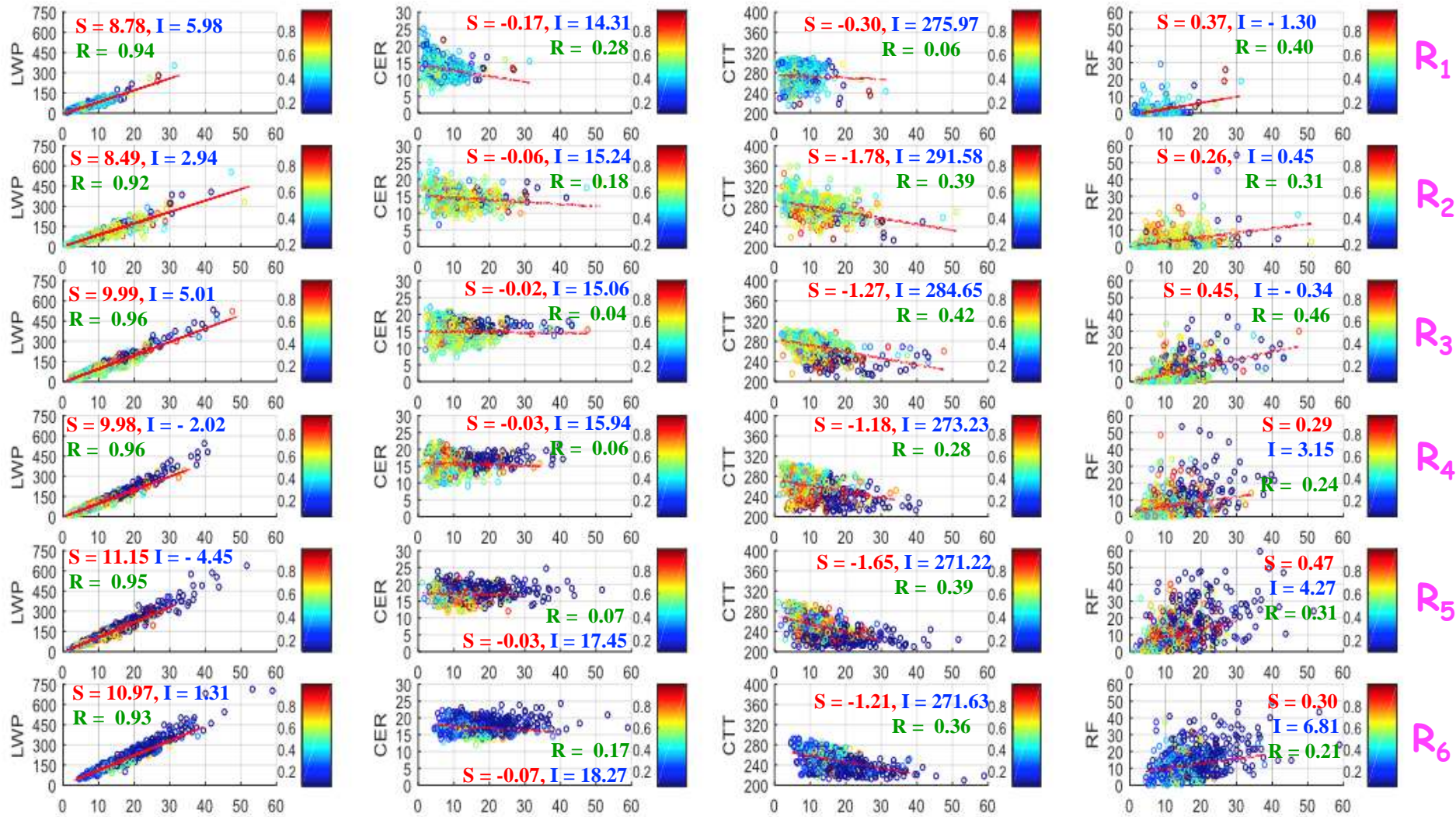


Linear regression analysis of cloud parameters as a function of AOD during Normal Years



Cloud Optical Depth (COD)

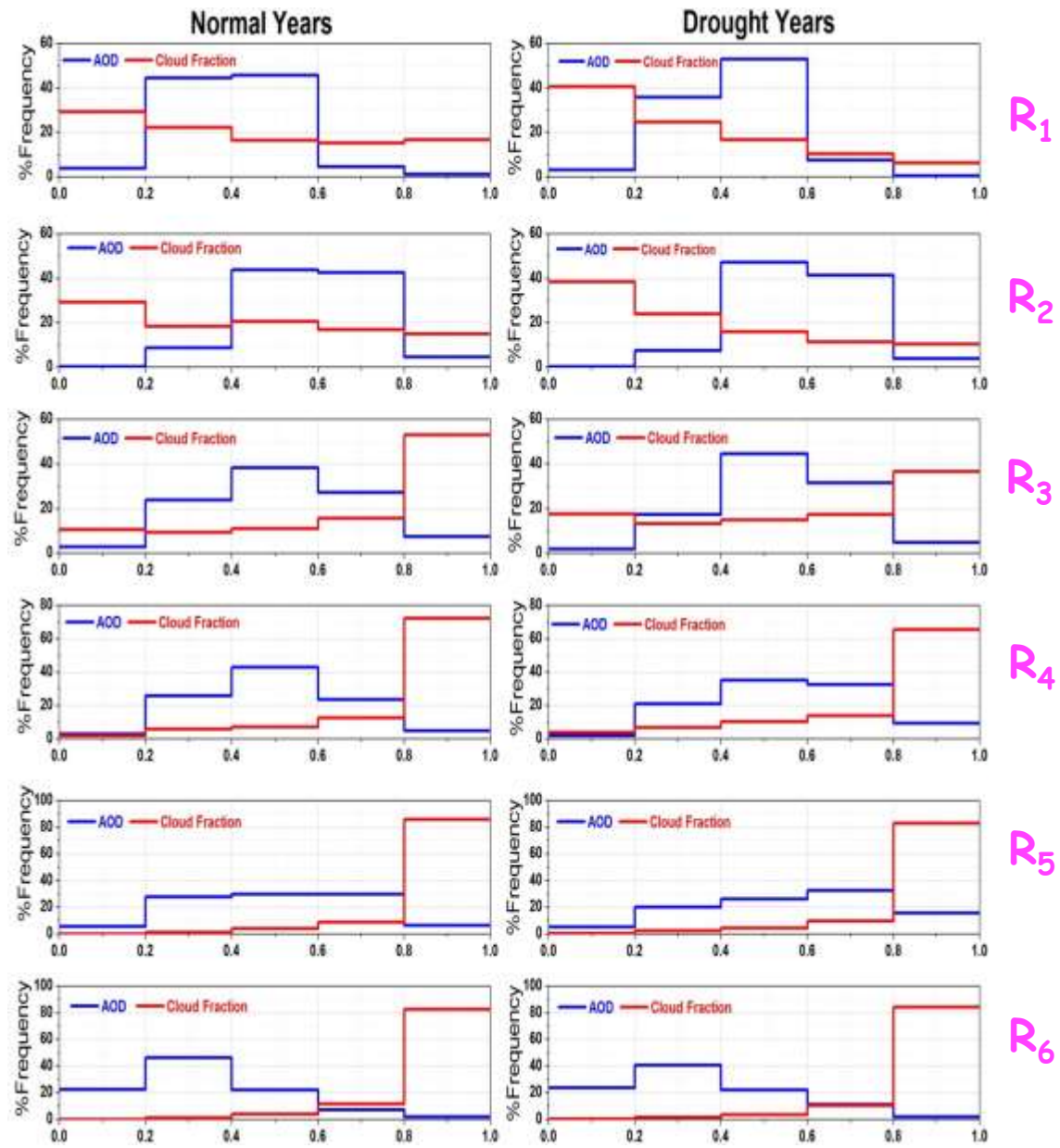
Linear regression analysis of cloud parameters as a function of AOD during Drought Years



Cloud Optical Depth (COD)

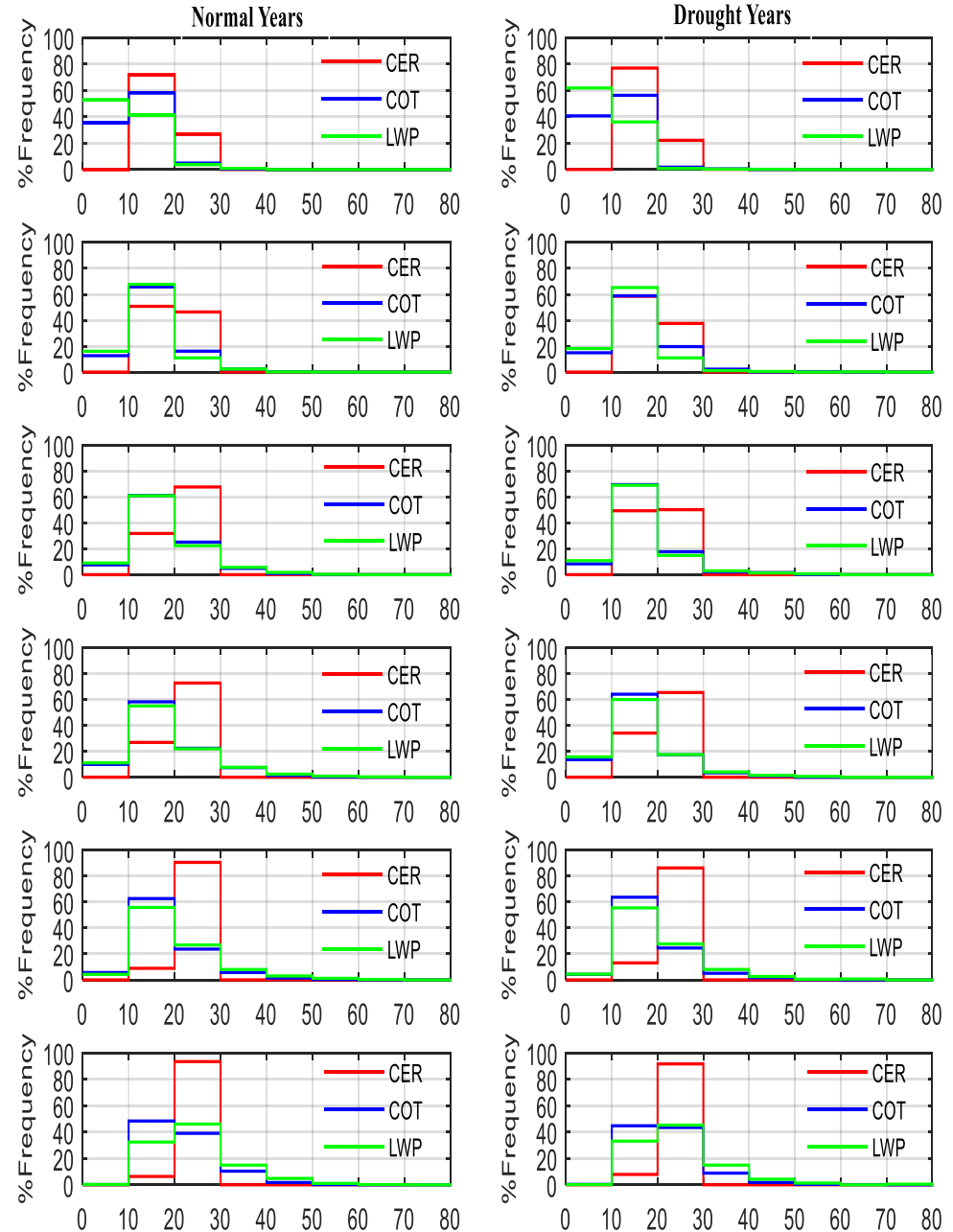
Frequency Distribution of AOD and Cloud Fraction

- ✓ During drought years, AOD decreases for western to eastern IGB (R1 -R4) for lower bins (< 0.4) and increases for higher bins (>0.4)
- ✓ A +ve gradient in cloud fraction is observed during Drought Years, for lower bins from R₁ - R₆ and vice versa for higher bins.
- ✓ A slightly change in higher AOD (>0.6) can have affect the significant contribution of higher cloud fraction (>0.8) .



Frequency Distribution of Cloud Properties

- During drought years, CER decreases for value greater than $20 \mu\text{m}$ (i.e. $\text{CER} > 20 \mu\text{m}$) over R1 to R4 while R5 and R6 have nearly similar value.
- Liquid water path have maximum contribution in the range of $100 - 200 \text{ gm}^{-2}$ except R1 and R6 for both Normal and Drought Years.
- Over R1, LWP decrease for bin $100 - 200 \text{ gm}^{-2}$ while it increases for R3 which may be mainly due to different emission aerosol source.

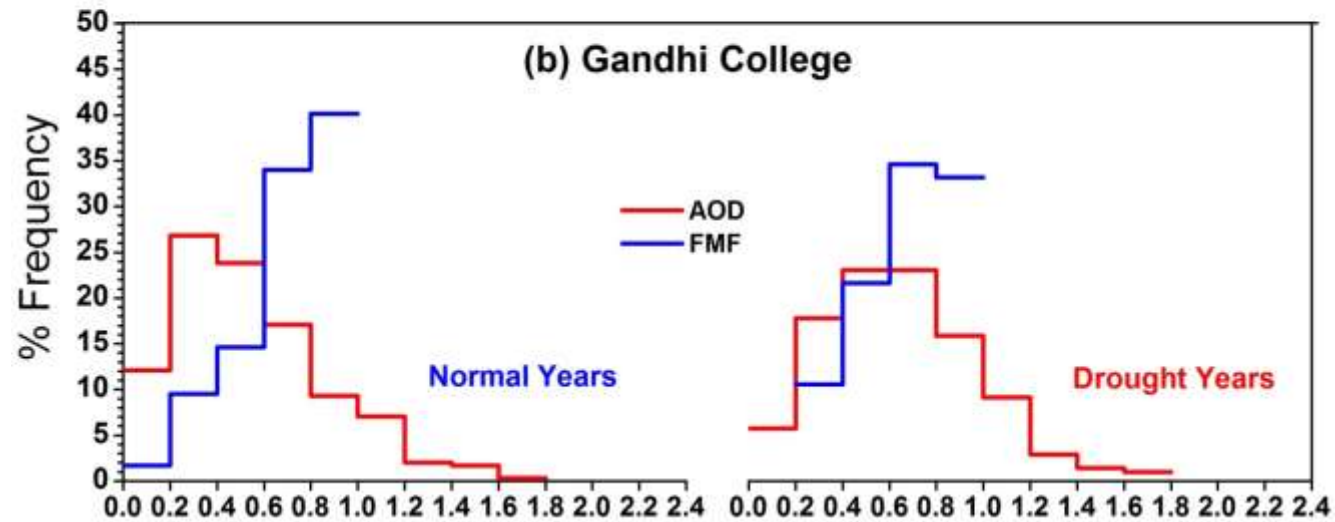
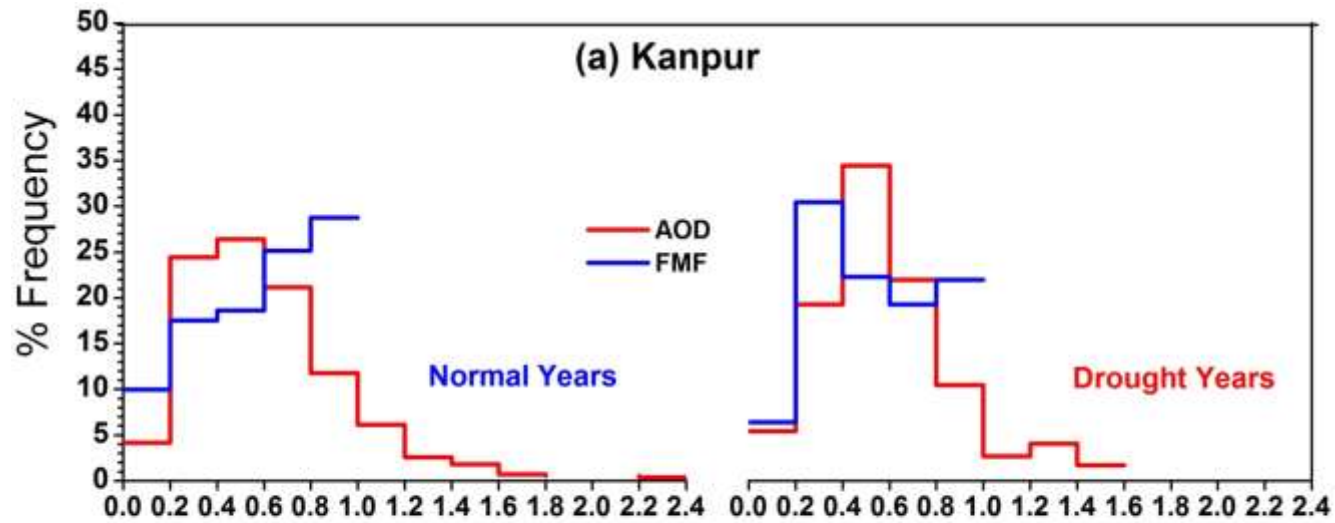


Summary

- A negative gradient in aerosol loading is observed from western to eastern IGB.
- A slightly increment in AOD can affect the significant contribution cloud fraction over the region which also show the spatial heterogeneity.
- A strong correlation between cloud optical depth and liquid water path is obtained.
- CER (>20 um) decreases from R1 to R4 suggesting the enhancement in cloud albedo.
- A significant spatial variability in aerosol - cloud interaction is observed over IGB.
- **A further study is needed to understand the influence of aerosol - cloud interaction over IGB on Indian Summer Monsoon.**

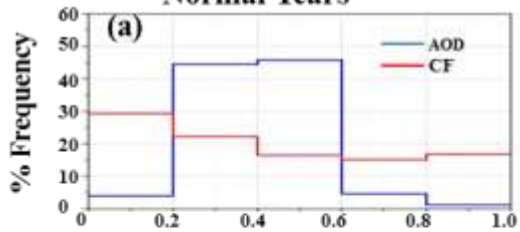
Thank You !!

Suggestions are welcome ...

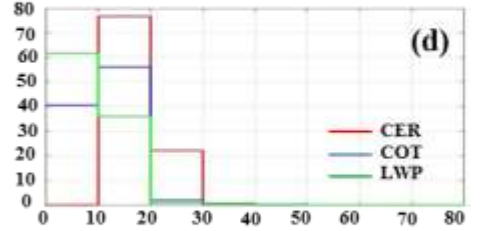
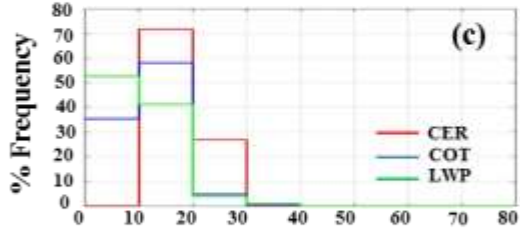
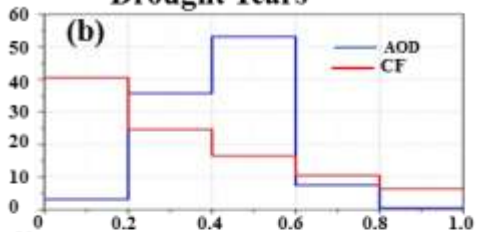


R_1

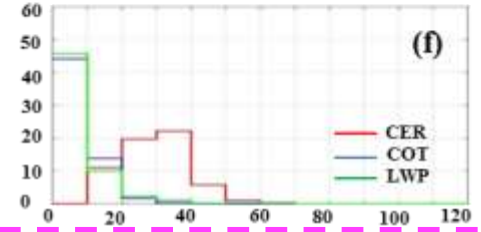
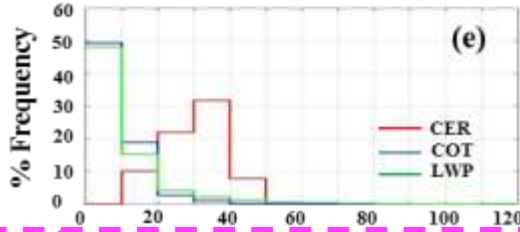
Normal Years



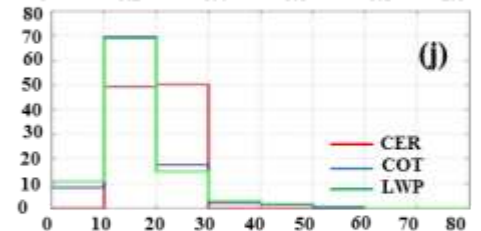
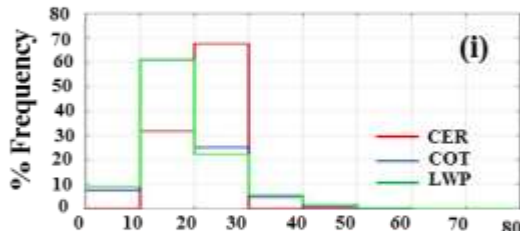
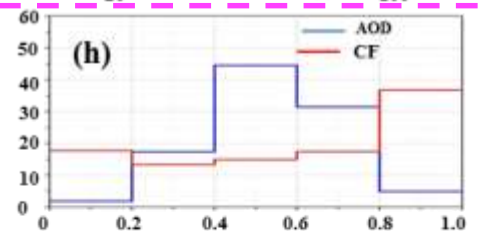
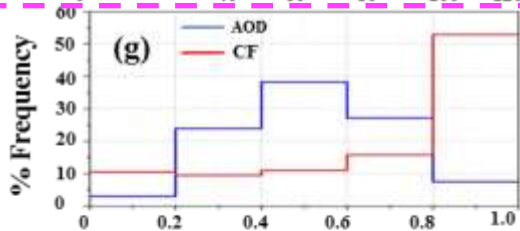
Drought Years



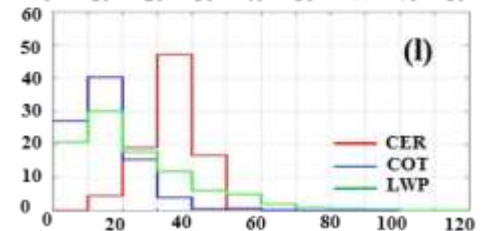
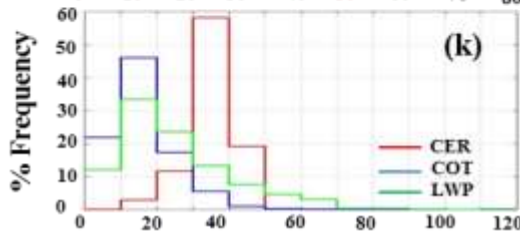
Liquid Phase Cloud



Ice Phase Cloud

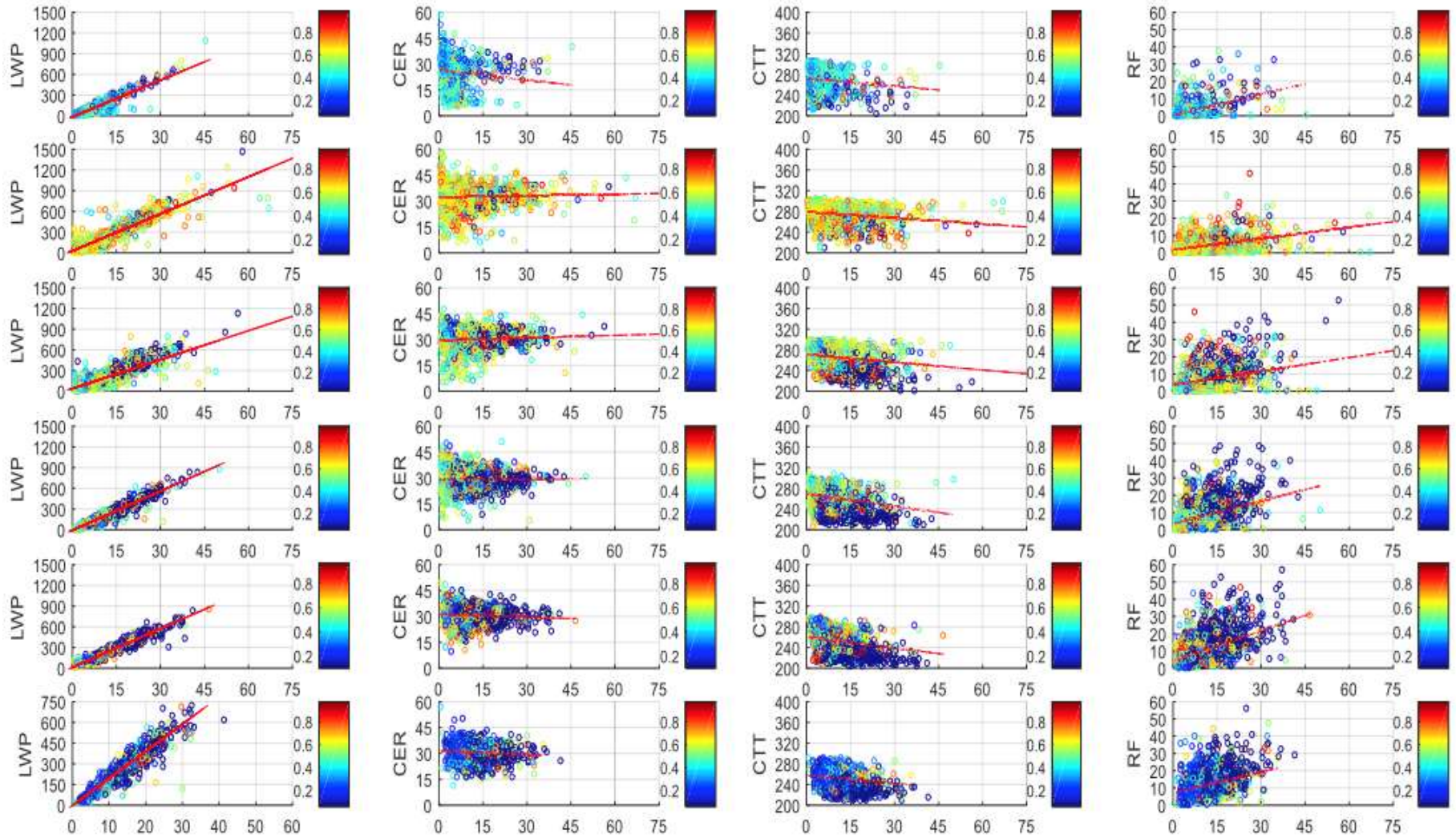
 R_3 

Liquid Phase Cloud



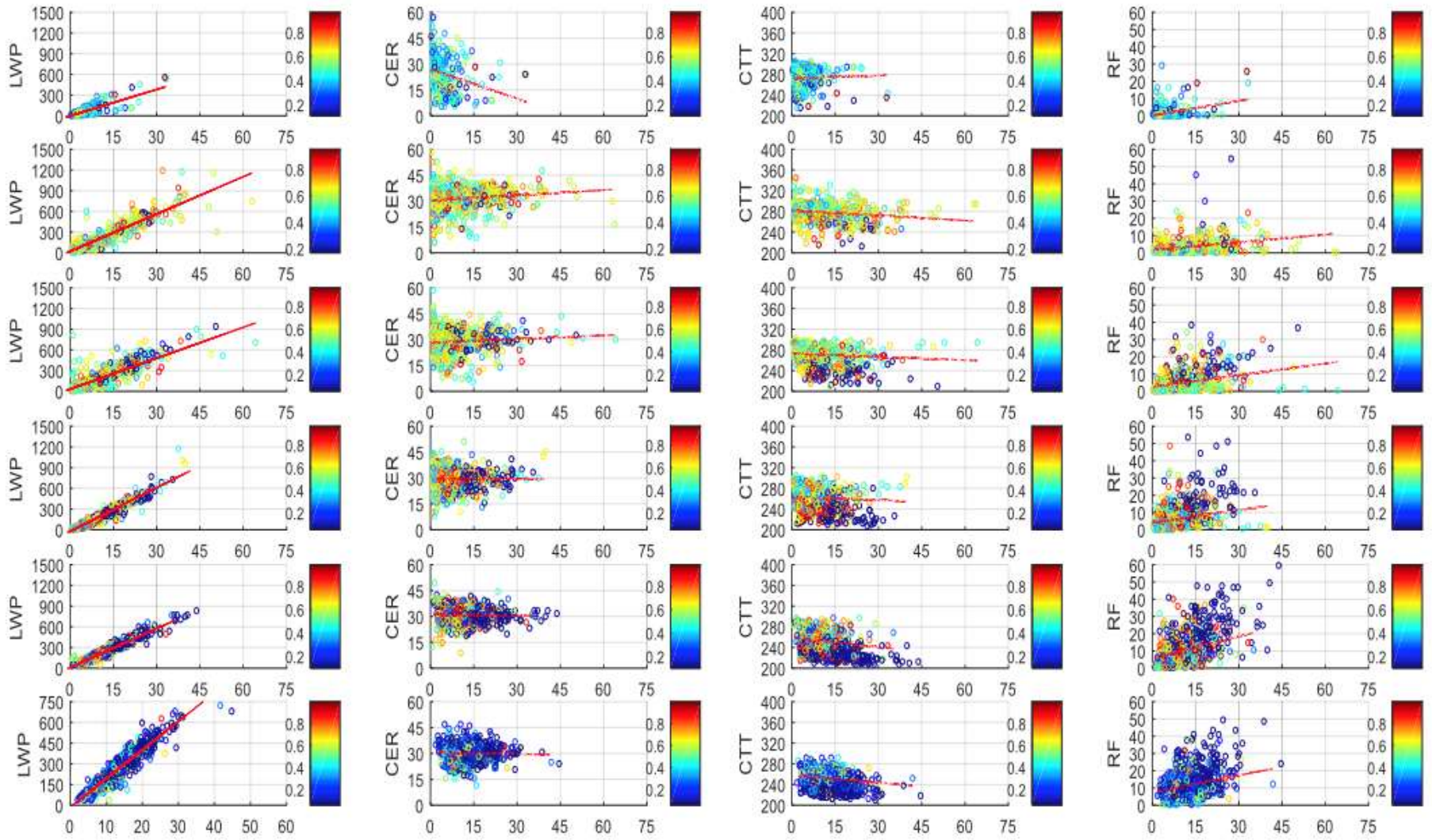
Ice Phase Cloud

Linear regression analysis of cloud parameters as a function of AOD during Normal Years (for Ice Phase Cloud)



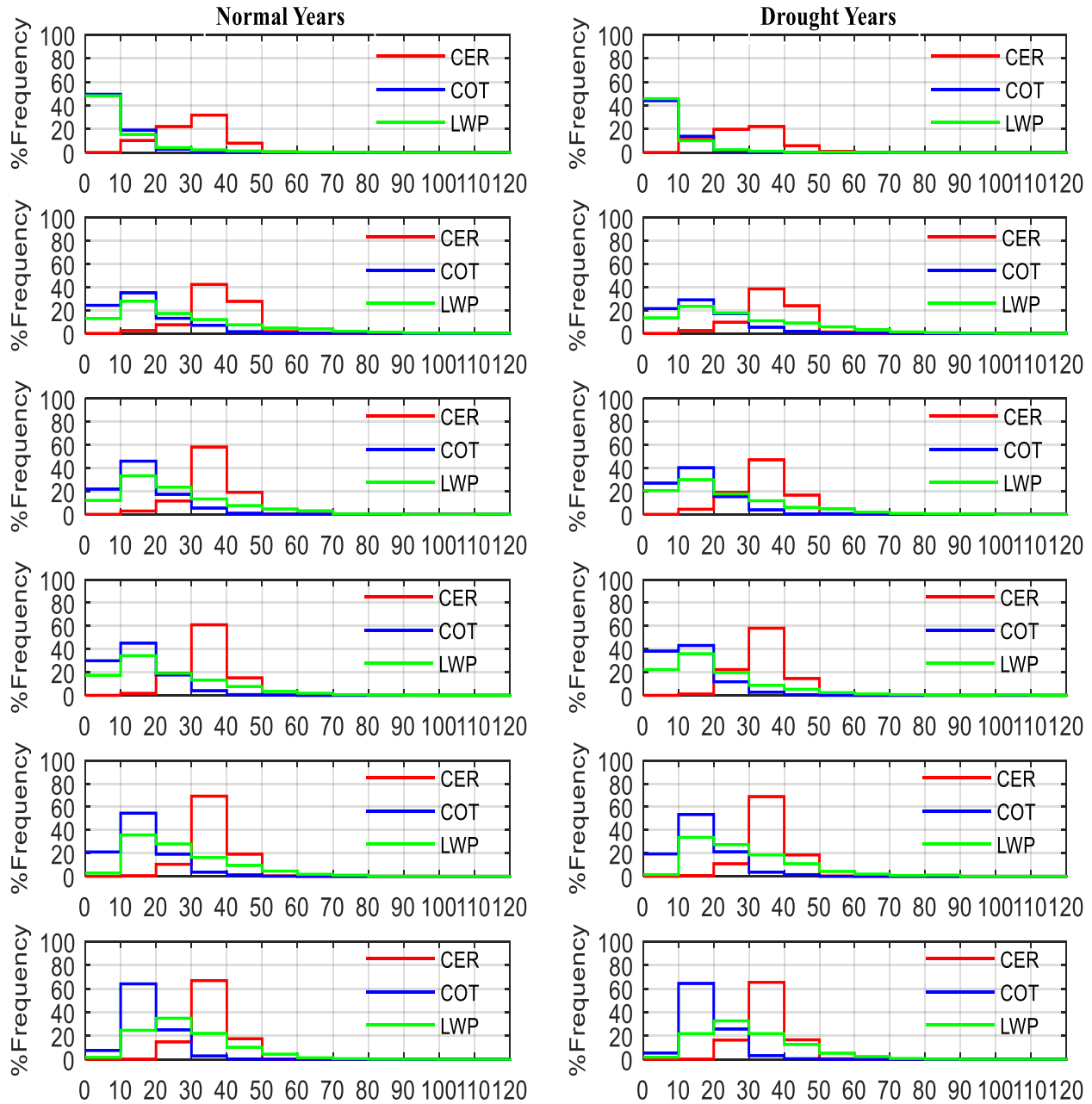
Cloud Optical Depth (COD)

Linear regression analysis of cloud parameters as a function of AOD during Drought Years (for Ice Phase Cloud)



Cloud Optical Depth (COD)

Frequency Distribution of Ice Phase Cloud Properties



Heterogeneity in aerosol types and annual their contributions

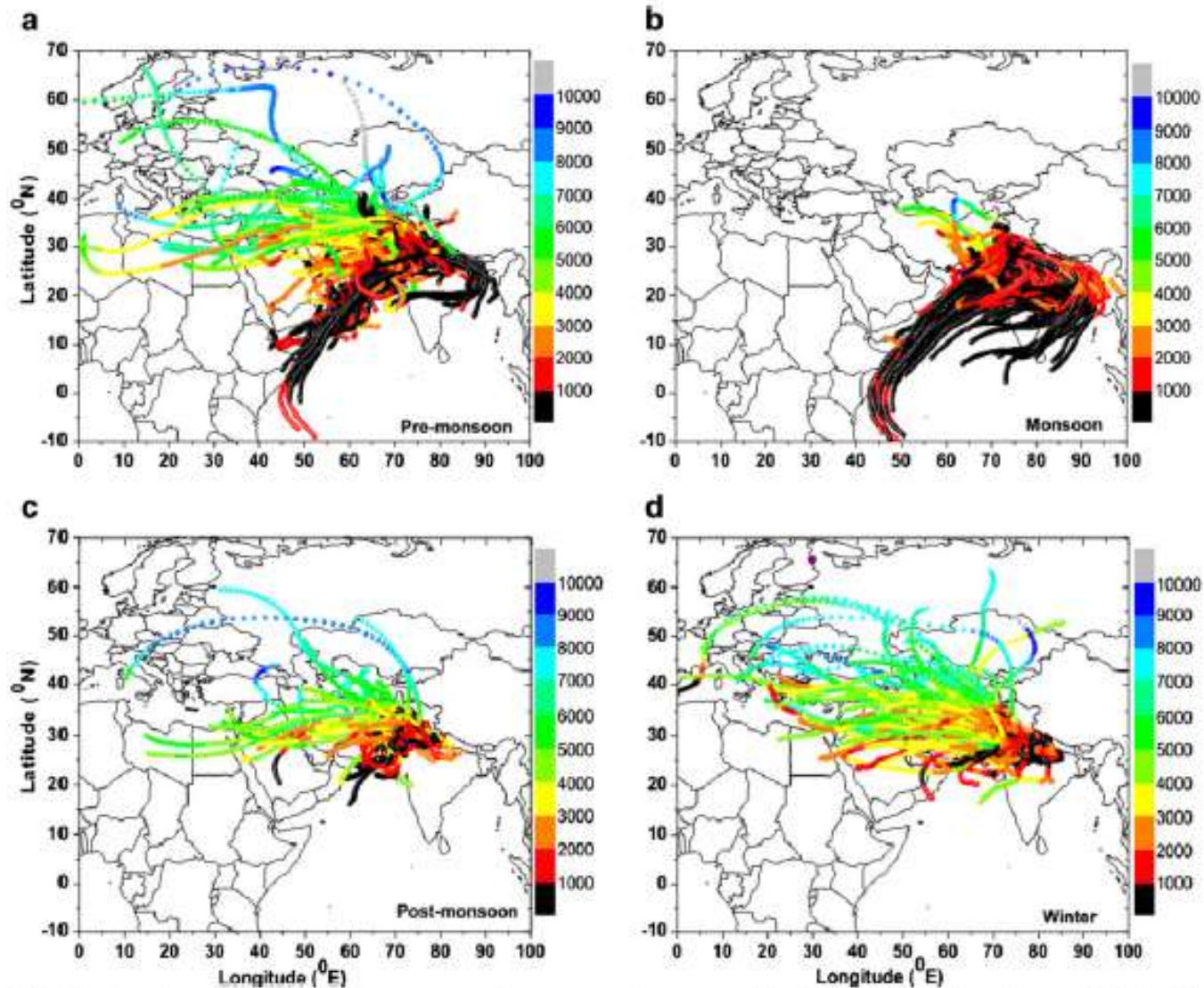


Fig. 8 Five days air mass back trajectories for a pre-monsoon, b monsoon, c post-monsoon, and d winter season. The color scale represent the altitudinal variation of air masses (in meter) during their transportation.

What are Aerosols...??



Dust storm



Industrial emission



sea-salt



Urbanization



Volcanic eruption



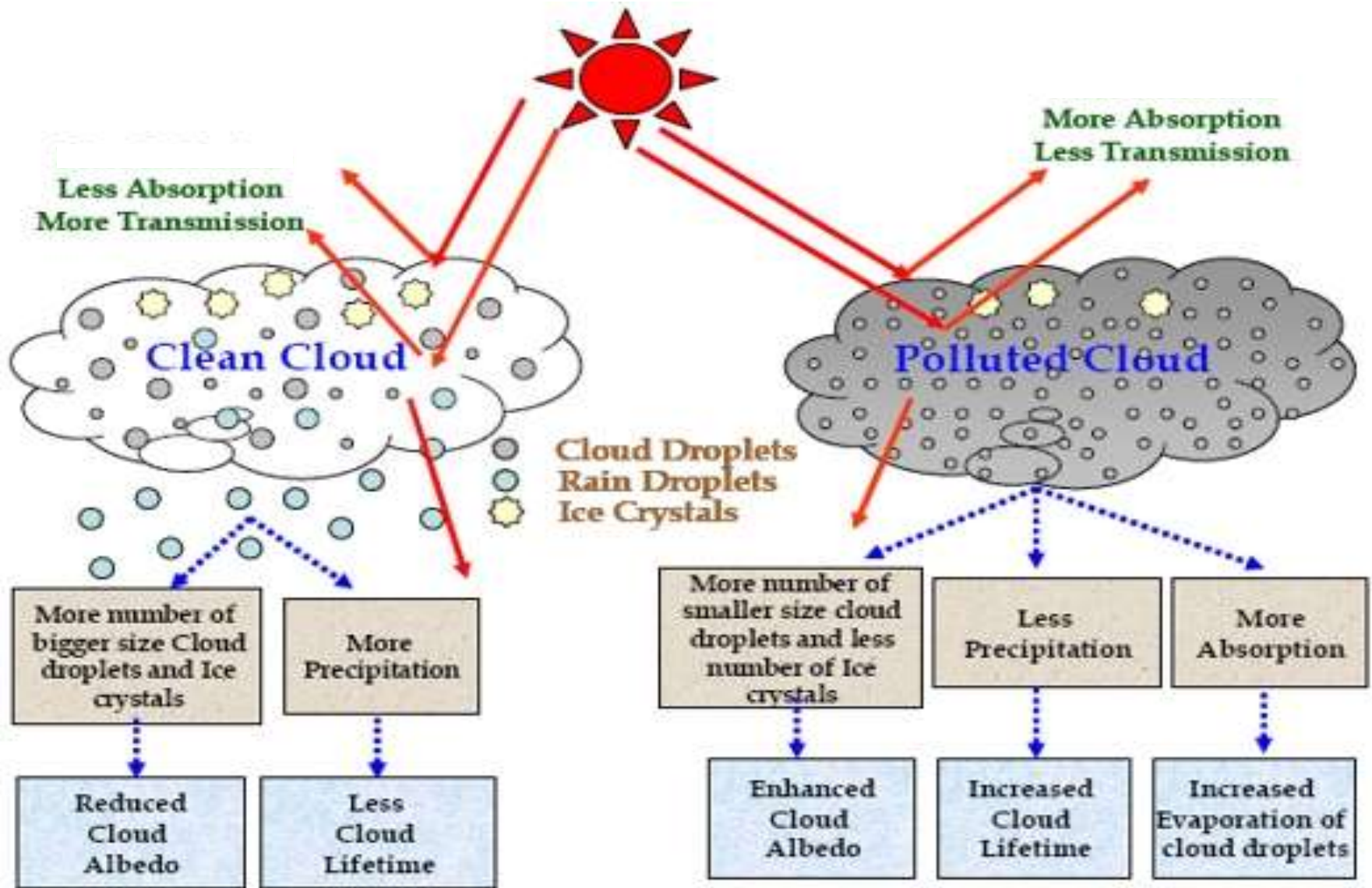
Biomass Burning



Transportation



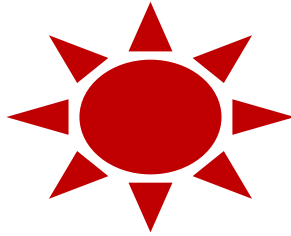
Indirect Effect



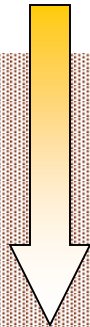
Climate Impact of Atmospheric Aerosol

Direct Effect

Sun



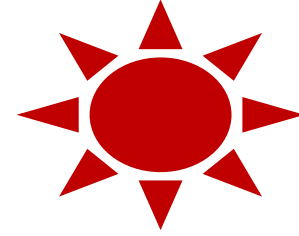
Absorbing aerosols



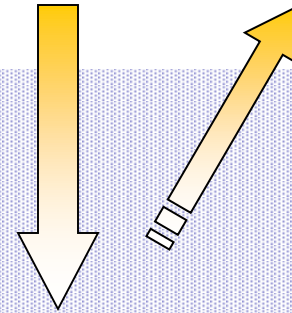
Solar radiation absorbed (Warming)

e.g. Black carbon, mineral dust

Sun



Scattering aerosols

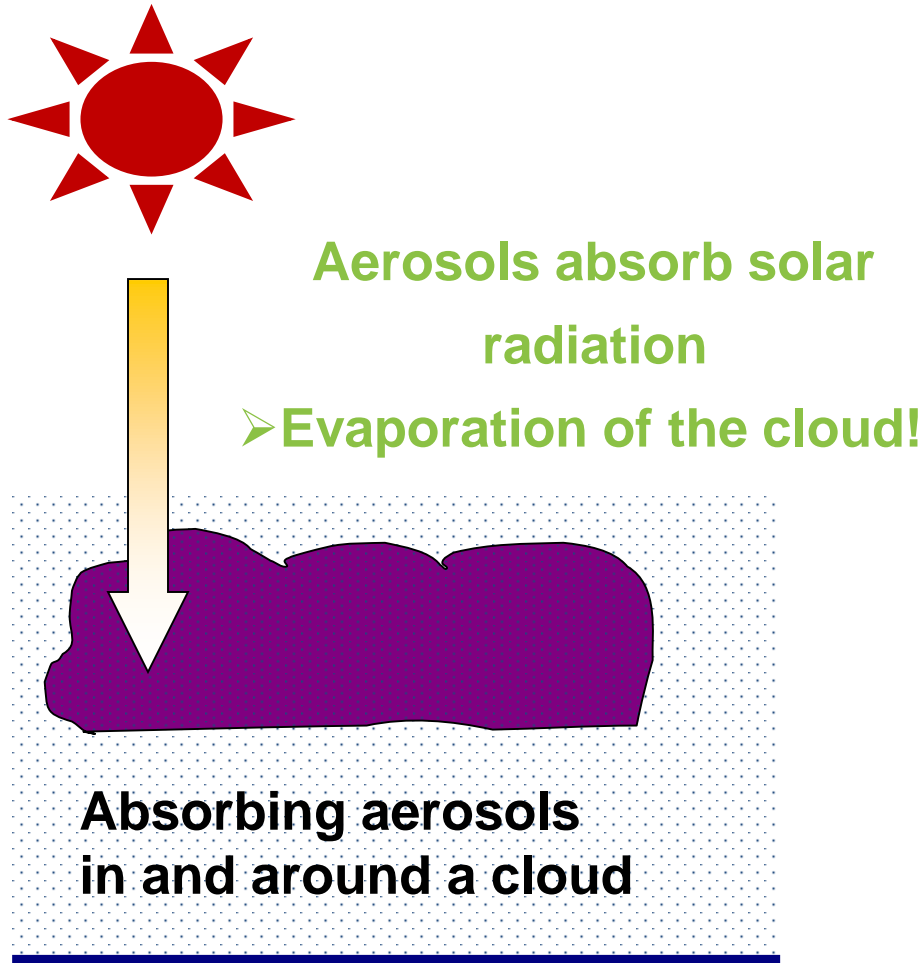


Solar radiation scattered to space (Cooling)

e.g. Sulphates, nitrates, organics

Most aerosols both absorb and scatter!

Semi-direct Effect



- Absorbing aerosols may reduce low cloud cover
- Warm the troposphere.

