Spatiotemporal Impacts of Aerosols on Cloud Properties and Precipitation Patterns in South Asian Monsoon Region: Contrasting High and Low Precipitation Years

Palwasha Khattak[1], Jan Cermak[1,2], Syeda Hira Fatima, and Julia Fuchs[1,2]

[1]Institut für Meteorologie und Klimaforschung – Atmosphärische Spurenstoffe und Fernerkundung (IMK-ASF), Karlsruher Institut für Technologie (KIT)
[2]Institut für Photogrammetrie und Fernerkundung (IPF), Karlsruher Institut für Technologie (KIT)

palwasha.khattak@partner.kit.edu

RESEARCH QUESTIONS

1. To what extent does the influence of aerosols on cloud properties and precipitation patterns differ between high and low monsoon years in the South Asian monsoon region?
2. What are the specific spatiotemporal changes observed in cloud drop effective radius (CDER), Cloud Fraction (CF), Cloud Top Height (CTH), Cloud Top Pressure (CTP), Cloud Top Temperature (CTT), Column Water Vapor (CWV), Ice Water Path (IWP), Liquid Water Path (LWP), and precipitation amounts in response to aerosol variability during contrasting high and low monsoon years?

METHODS

Temporal and Geographical Scope	Analyzed monsoon months (JJAS). Subdivided study regions based on precipitation patterns.
High and Low Precipitation Years	Categorized based on normalized anomaly values for each region individually.
Data Normalization	Normalized precipitation, AOD, & cloud properties to standardized range.
Temporal & Spatial Correlation Analysis	Calculated Pearson correlation AOD & cloud correlations. Identified positive/negative correlation frequency for precipitation years.

DATA SET & STUDY AREA

- Spatial and Temporal Analysis Time Period: 20 years: 2000 - 2020
- Monsoon Months: June, July, August, and September (JJAS)
- AOD & Cloud properties: MODIS/Terra Satellite - MOD08_M3, 1°x1° grid
- Precipitation Data: Global Precipitation Climatology Project (GPCP), 1°x1° grid

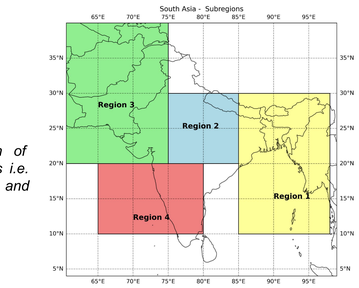

Figure 1: ***Right:*** *The division of South Asia into four sub-regions i.e. Region 1, Region 2, Region 3, and Region 4.*

HIGH & LOW PRECIPITATION YEARS

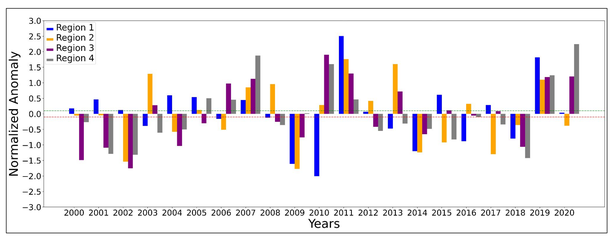

Figure 2: *Time Series analysis of precipitation data for JJAS months of all years, for four sub-regions in South Asia. Each color displays a region (Region 1 = Blue color, Region 2 = Yellow color, Region 3 = Purple color, and Region 4 = Grey color).*

TEMPORAL & SPATIAL CORRELATION

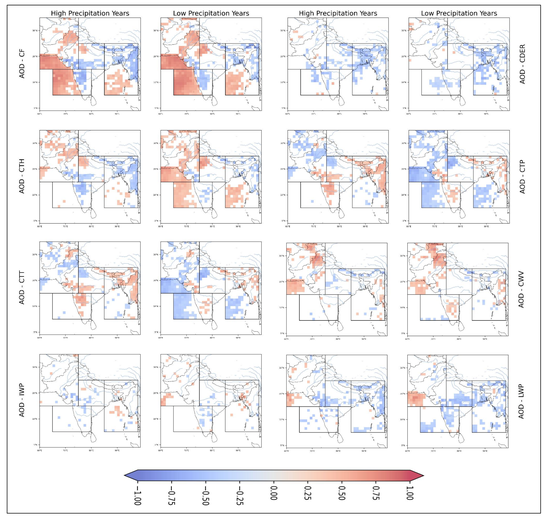

Figure 3. ***Left:*** *Temporal and Spatial correlation analysis during High (first column of each correlation) and Low (second column of each correlation) precipitation years. These results only include the correlations significant at p<0.05. From top left to bottom: AOD-CF, AOD-CTH, AOD-CTT, and AOD-IWP. From top right to bottom: AOD-CDER, AOD-CTP, AOD-CVW, and AOD-LWP.*

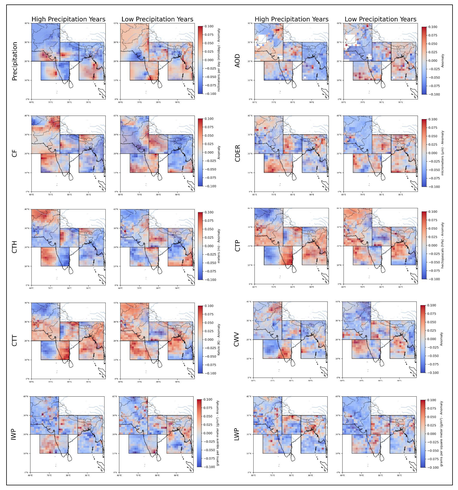

Figure 4. ***Right:*** *Spatial distribution anomalies for the specified four regions of South Asia during High (left) and Low (right) precipitation for JJAS months of all 20 years. From top left to bottom: Precipitation, CF, CTH, CTT, and IWP. From top right to bottom: AOD, CDER, CTP, CWV, and IWP.*

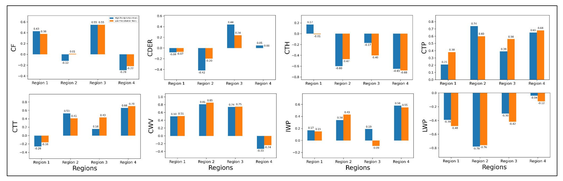

Figure 5. ***left:*** *Bar Plots for AOD and Cloud Property Correlations for Region 1, Region 2, Region 3, and Region 4 during JJAS High and Low Precipitation Years. From top left to right: AOD-CF, AOD-CDER, AOD-CTH, and AOD-CTP. From bottom left to right: AOD-CTT, AOD-CVW, AOD-IWP, and AOD-LWP. Blue color bar represents High precipitation years and Orange color bar represents Low precipitation years in the correlation between AOD and cloud properties for all four regions.*

CONCLUSIONS

- Precipitation anomalies vary across four regions during JJAS months, revealing intriguing relationships with aerosols.
- Discrepancies arise in the AOD-cloud properties relationship, indicating complex aerosol-cloud interactions.
- Temporal and spatial correlations show significant regional variations in the AOD-cloud properties relationship.
- Categorizing years into high and low precipitation categories showed important information, but may overlook seasonal complexities.

REFERENCES

- Patil, N., Dave, P., & Venkataraman, C. (2017). Contrasting influences of aerosols on cloud properties during deficient and abundant monsoon years. Scientific Reports, 7(1), 44996.
- Platnick, S., et al., 2015. MODIS Atmosphere L3 Daily Product. NASA MODIS Adaptive Processing System, Goddard Space Flight Center, USA: http://dx.doi.org/10.5067/MODIS/MOD08_D3.061

Scan for Abstract

SCAN ME