# Dominant Modes of Indian Summer Monsoon Variability over Homogeneous Rainfall Regions

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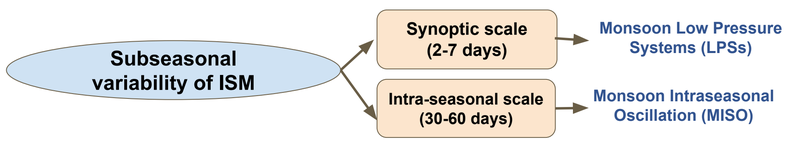
## Introduction

ISM exhibits significant variability on various spatial and temporal scales; the temporal scales of variability typically range from sub-seasonal to interdecadal scale




★ Regional studies of the ISM rainfall are vital for several purposes in agriculture and water management. Where those provide significant contributions to the Indian economy.

★ ISM domain can be divided into multiple sub-domains based on the homogeneity of rainfall distribution.

★ The processes driving spatial and temporal variabilities of ISM can be different for these sub-domains

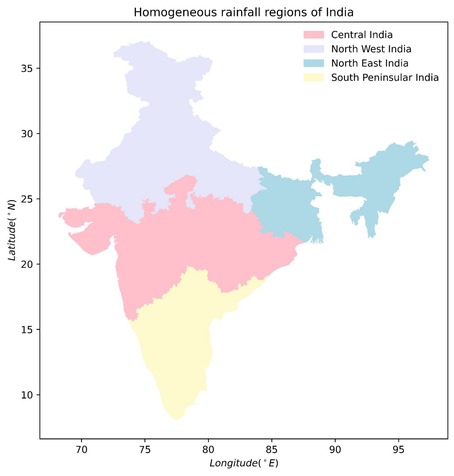



***Figure 1.*** *IMD defined homogeneous rainfall regions of India used for the study*

## Background

- The daily variability in ISM rainfall is linked to a hierarchy of quasi-periodic oscillations, with periodicities of 2–7, 10–20, and 30–60 days.
- Changes in the frequency of these quasi-periodic oscillations can lead to a deficit or excess seasonal rainfall conditions
- Their are contradictory studies on the role of subseasonal processes in causing changes in the seasonal rainfall

### Research gap

★ The dominant periodicities over the ISM homogeneous rainfall regions is not yet explored, past studies only focusing the monsoon core zone or smaller spatial domains of ISM

★ A multivariable approach could have validate the identified dominant periodicities

## Data and Methodology

IMD daily gridded (1°x 1°) rainfall data from 1950 to 2022 during June - September months

Daily values of air temperature, specific humidity, zonal and meridional wind (0.25°x 0.25°) ECMWF Reanalysis v5 (ERA5) data at 850 hPa pressure level

★ **Spectral analysis,** using Fast Fourier Transform (FFT), converts signals into its spectral components and thereby provides frequency information of the signal

★ **Wavelet analysis,** using Continuous Wavelet Transform (CWT) to determine both the dominant time scales of variability and its variation with time

★ **Cross spectral analysis,** using FFT on cross correlation function of two signals, the similarities present in two signals frequency domain will be emphasised

## Results

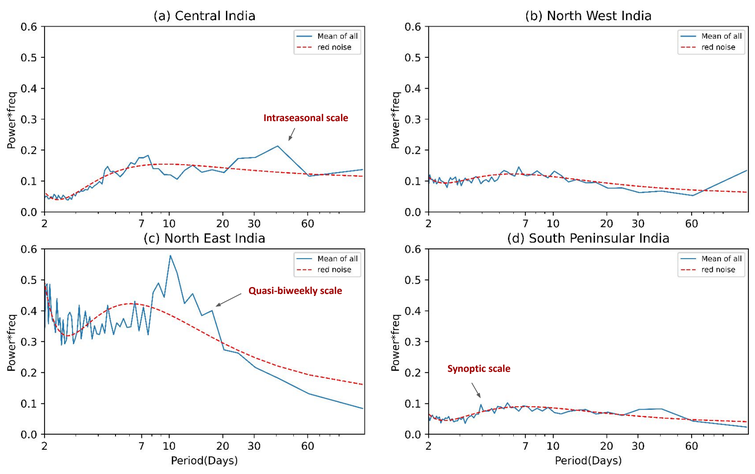



***Figure 2.*** *The domain averaged power spectra of summer monsoon rainfall(blue solid line) during 1950-2022. Red dashed line represents the red noise*

➔ The dominant scales present over the four regions are the synoptic(2-7d), quasi-biweekly(10-20d),& ISO(25-90d) scales, with characteristic changes in its power

➔ The red noise spectra gives the significance of the observed rainfall spectra

- The CI, NWI, and SPIN wavelet spectral characteristics are significantly consistent with the power spectral analysis
- Significant inconsistency in the wavelet characteristics is observed over NEI with respect to the power spectra
- Over SPIN the presence of ISO activity is very limited with 95% significance during the period of study

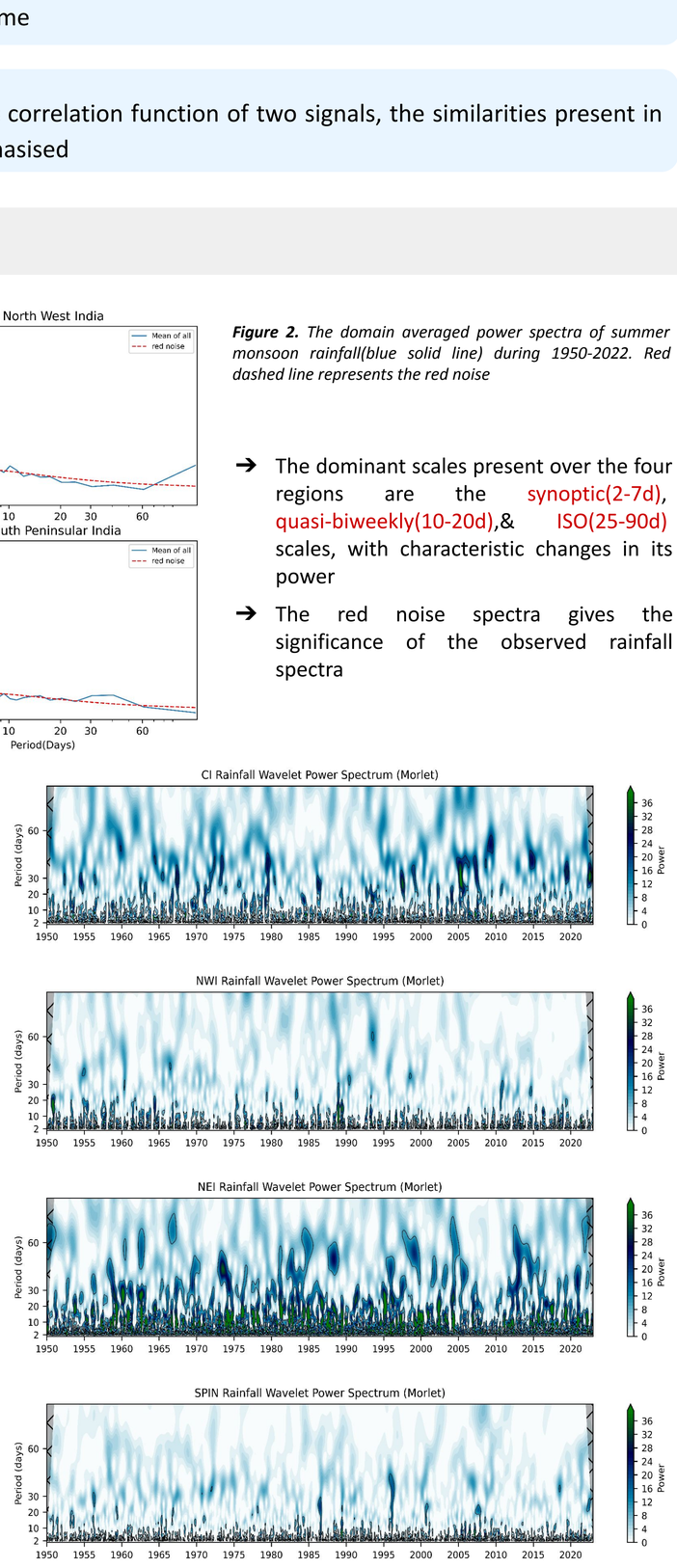



***Figure 4****. The domain averaged wavelet spectra of summer monsoon rainfall from 1950-2022. Black contours shows 95% significance*

## Results

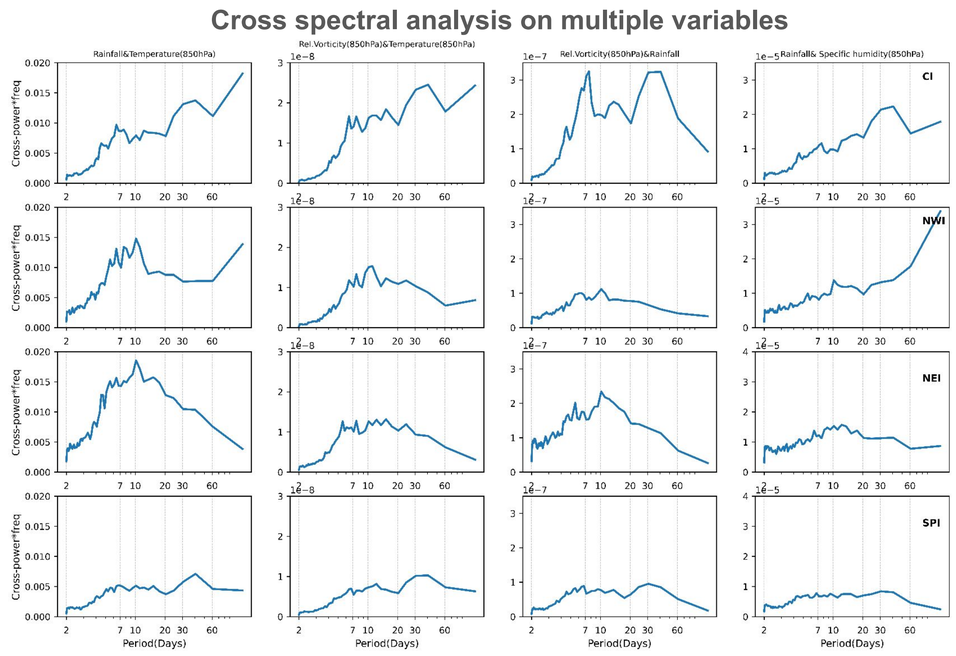



***Figure 4.*** *Domain averaged cross power times frequency along periods*

➔ The cross spectral peaks represents the mutual resonance of variables

➔ The periods of cross spectral peaks coincides with the dominant periods identified in the rainfall spectral analysis

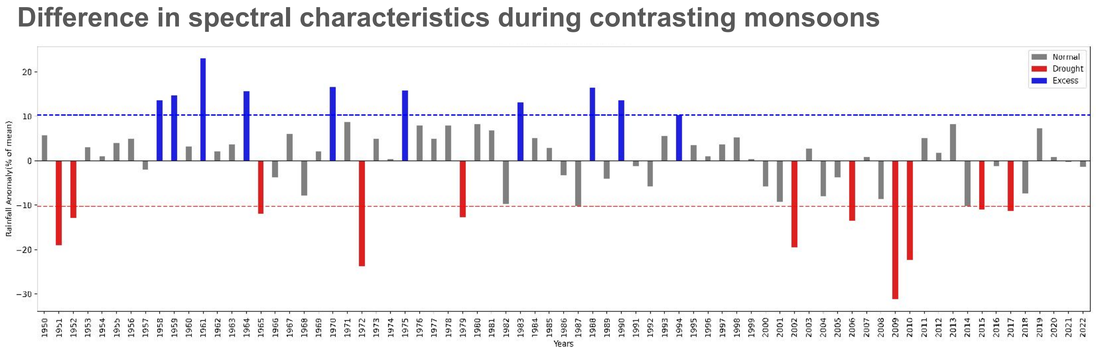



***Figure 5.*** *All India summer monsoon rainfall departure (%) from 1950 to 2022. 10 excess (blue) and 11 deficit (red) years found during the study period*

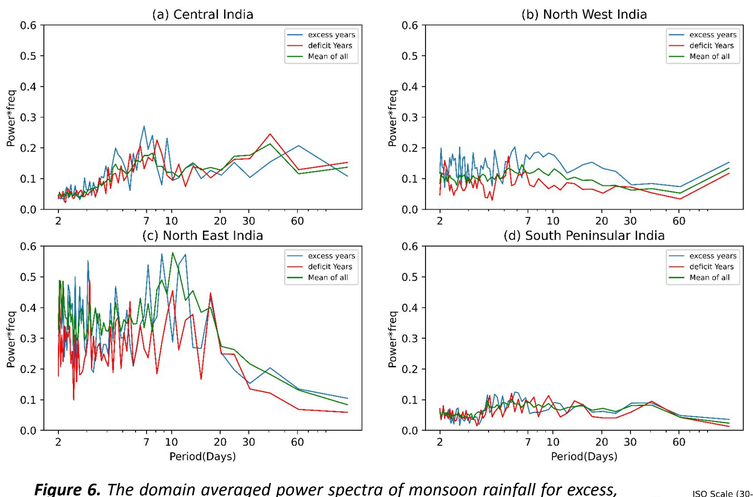



***Figure 6.*** *The domain averaged power spectra of monsoon rainfall for excess, deficit, and normal years during 1950-2022*

➔ Peak shift in dominant ISOs (30-60 day) observed over CI and SPIN

➔ The seasonal rainfall variability during excess and deficit years significantly differ over NWI (p-value = $3x10^{-13}$) and NEI (p-value = 0.0008), meanwhile the significance is less over CI (p-value = 0.4) and SPIN (p-value = 0.49) although the shift in periods observed

- The variance contributed by dominant synoptic scale is much higher compared to other periodicities
- Deficit (excess) years shows lesser (higher) variance on all periodicities
- A less intense dipole kind of pattern in variance is observed over CI in ISO scale

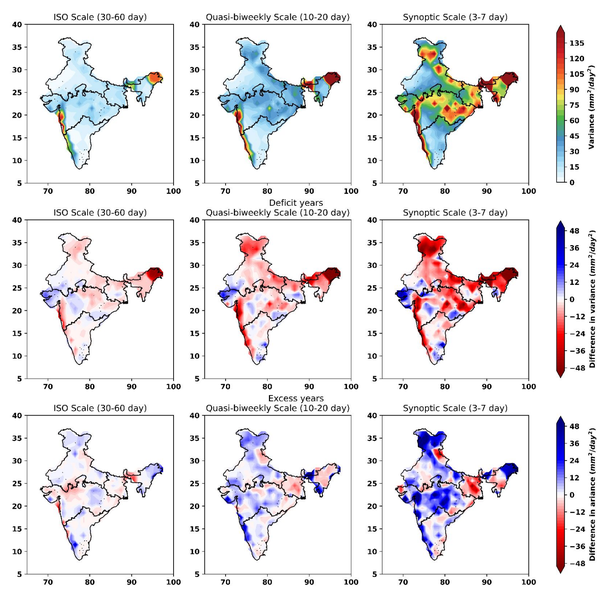



***Figure 7.*** *spatial distribution of variance of bandpass filtered daily rainfall anomalies in dominant periods, mean variance (top panel), difference in variance during deficit (middle panel) and excess (bottom panel) monsoons with respect to the mean variance respectively.*

## Summary

★ The presence of multiple scales with significant variations in its power over the four regions validates the homogeneity of seasonal rainfall

★ over CI and SPIN , synoptic as well as ISO scales are shown to be dominant, both synoptic and quasi-biweekly scales significantly dominate over NEI region, and over NWI only the synoptic scale shows dominance while other scales are weaker

★ We identified differences in periodicities of dominant scales during excess and deficit monsoons

★ The dominant ISO scale is faster in drought years while it is slower in excess monsoons over CI

## References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