Spatial extent of concurrent extremes over India and its teleconnection to climate indices

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Abstract

Concurrent temperature and precipitation extremes during Indian summer monsoon generally have signicant effects on agriculture, society and ecosystems. Due to climate change, frequency and spatial extent of concurrent extremes have changed, and there is a need to advance our understanding in this domain. Quantication of individual extremes (temperature and precipitation) during the summer monsoon season and its teleconnections to climate indices have been studied comprehensively. But, less attention is devoted to the quantication of concurrent extremes and its teleconnections to climate indices. In this study, concurrent extremes (dry/hot and wet/cold) based on mean monthly temperature and total monthly precipitation during the Indian summer season from 1951 to 2019 over the Indian mainland are investigated. Next, the study uses wavelet coherence analysis to unravel the teleconnections of the spatial extent of concurrent extremes to climate indices (Nino 3.4, WEIO SST and SEEIO SST). Results show that the frequency of wet/hot concurrent extremes has increased signicantly, while the frequency of wet/cold concurrent has decreased for the time window 1985 to 2019 relative to 1951-1984. Also, a statistically signicant increase (decrease) in the spatial extent exists in concurrent dry/hot (wet/cold) extremes during the July, August and September months. The ndings of this study could advance our understanding of changes in concurrent extremes during the Indian summer monsoon due to climate change.

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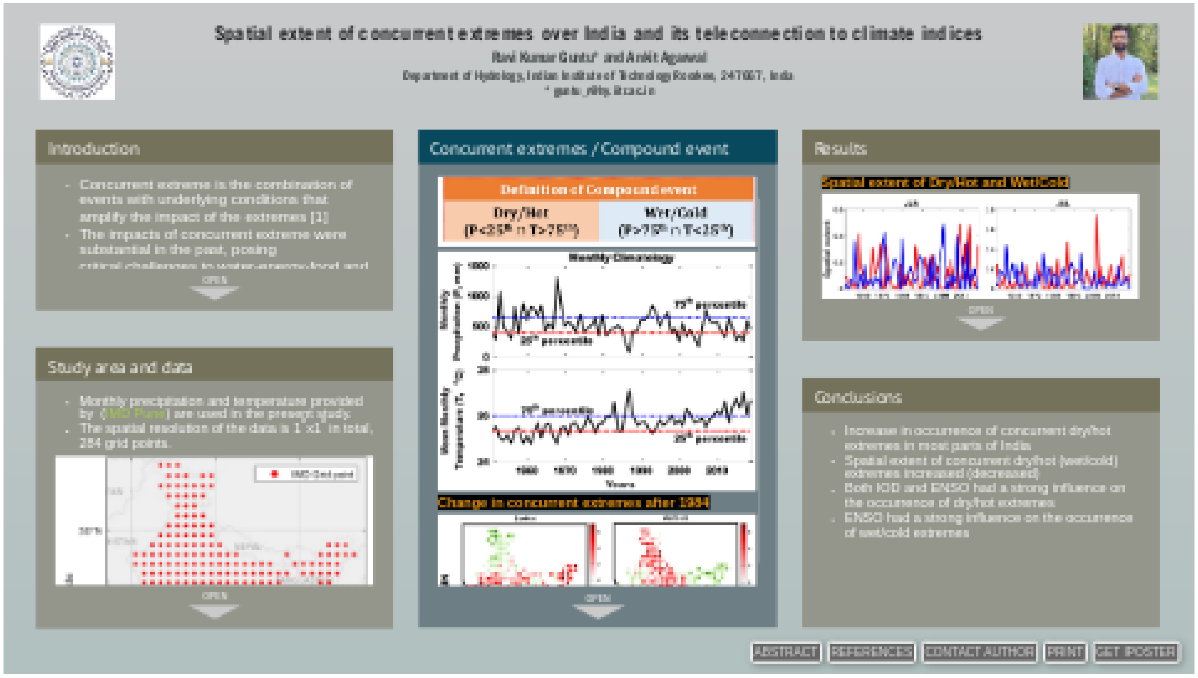

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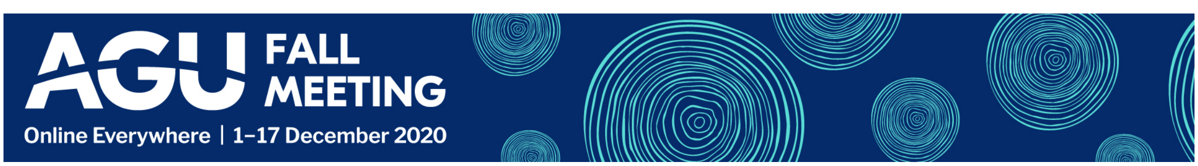
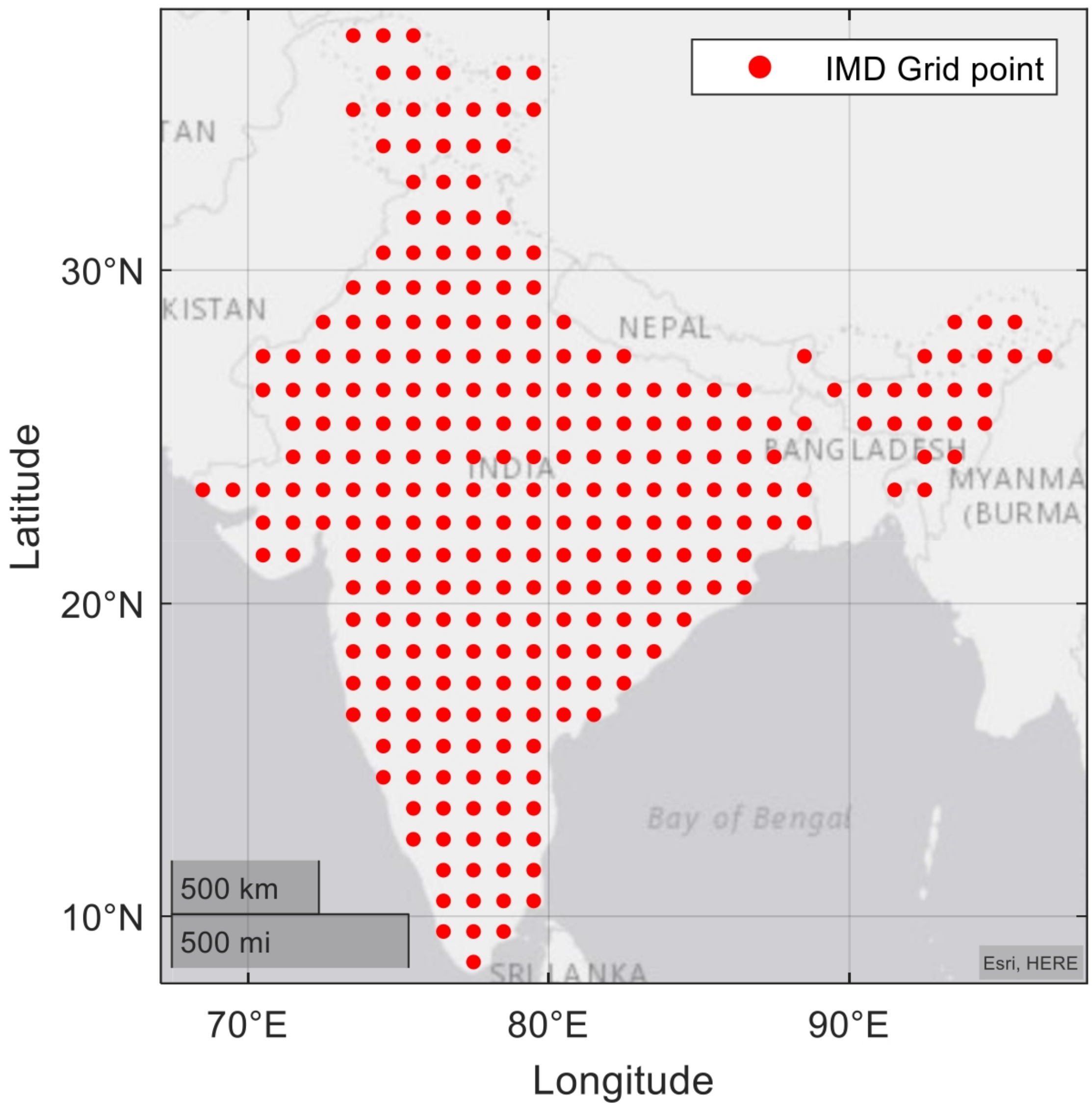


INTRODUCTION

- Concurrent extreme is the combination of events with underlying conditions that amplify the impact of the extremes [1]
- The impacts of concurrent extreme were substantial in the past, posing critical challenges to water-energy-food and their nexus [2]
- Knowledge on the interrelationships between concurrent extremes and dominant modes of climate variability is scarce and need to be investigated in this domain [3]

STUDY AREA AND DATA

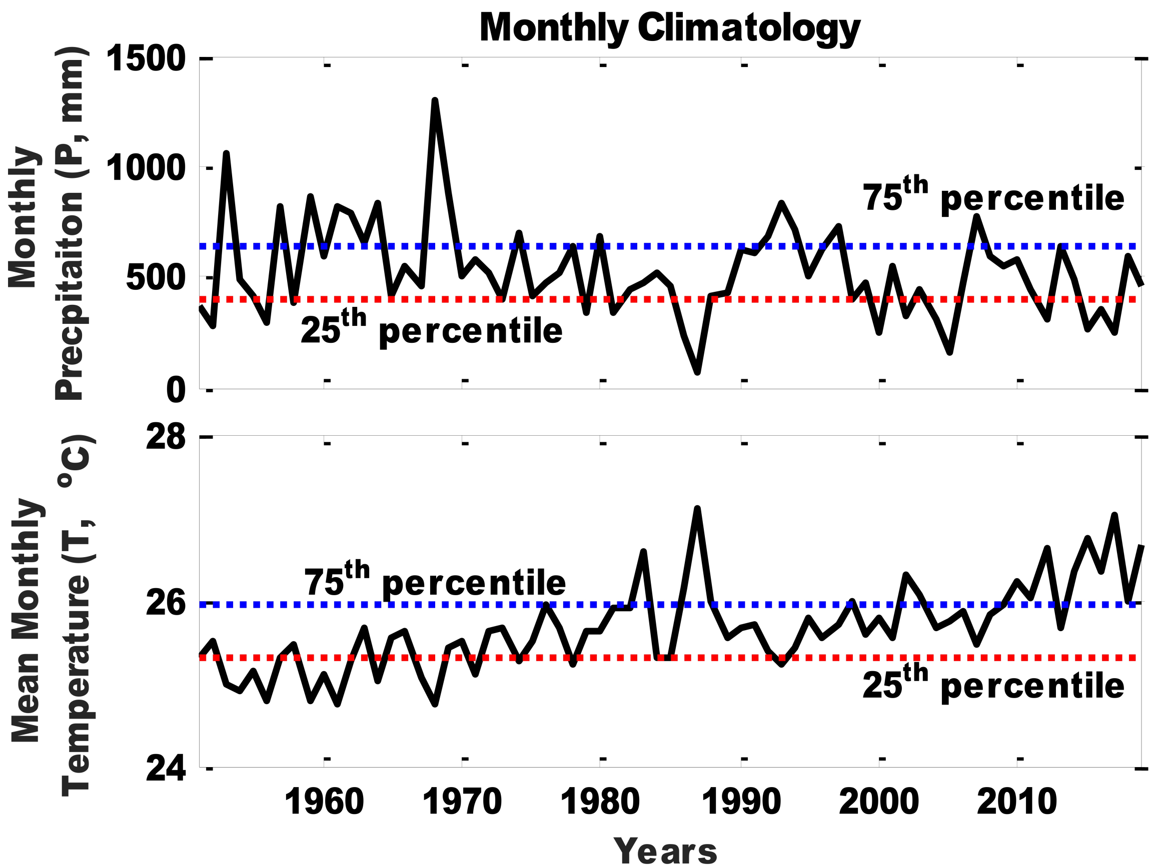
- Monthly precipitation and temperature provided by (IMD Pune (http://www.imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html)) are used in the present study.
- The spatial resolution of the data is 1°x1° in total, 284 grid points.



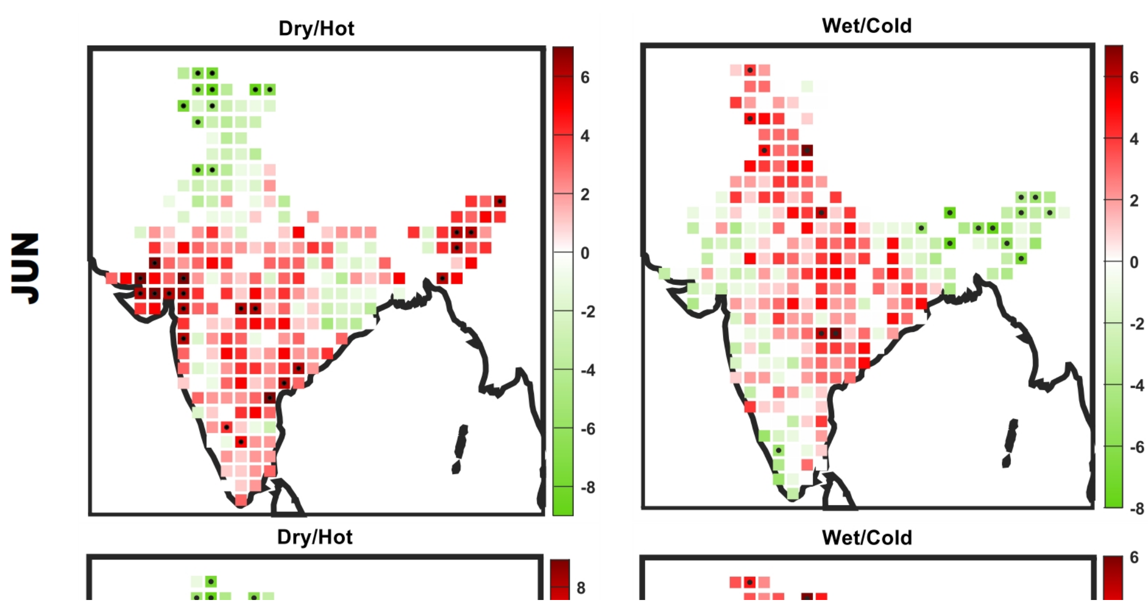
- Duration of study is 69 years (1951–2019)
- The precipitation and temperature datasets have been used in earlier studies [4,5,6,7,8] and are highly reliable
- To quantify the impacts of dominant modes of variability on the spatial extent of concurrent extremes (IOD SST Index (https://psl.noaa.gov/gcos_wgsp/Timeseries/DMI/), Nino 3.4 SST Index (https://www.psl.noaa.gov/data/timeseries/monthly/NINO34/)) are considered.

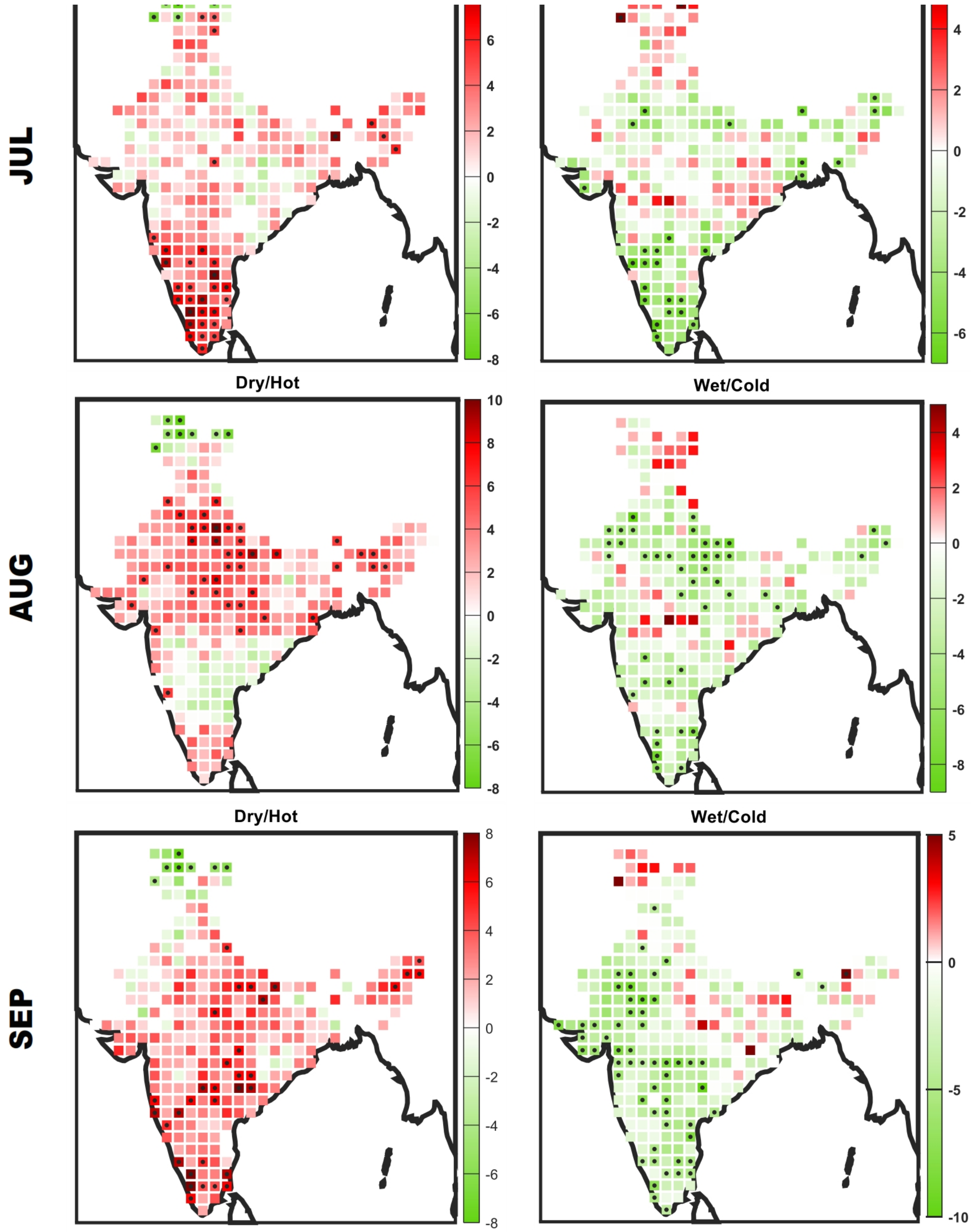
CONCURRENT EXTREMES / COMPOUND EVENT

Definition of Compound event	
Dry/Hot (P<25th ∩ T>75th)	Wet/Cold (P>75th ∩ T<25th)



Change in concurrent extremes after 1984




JUL
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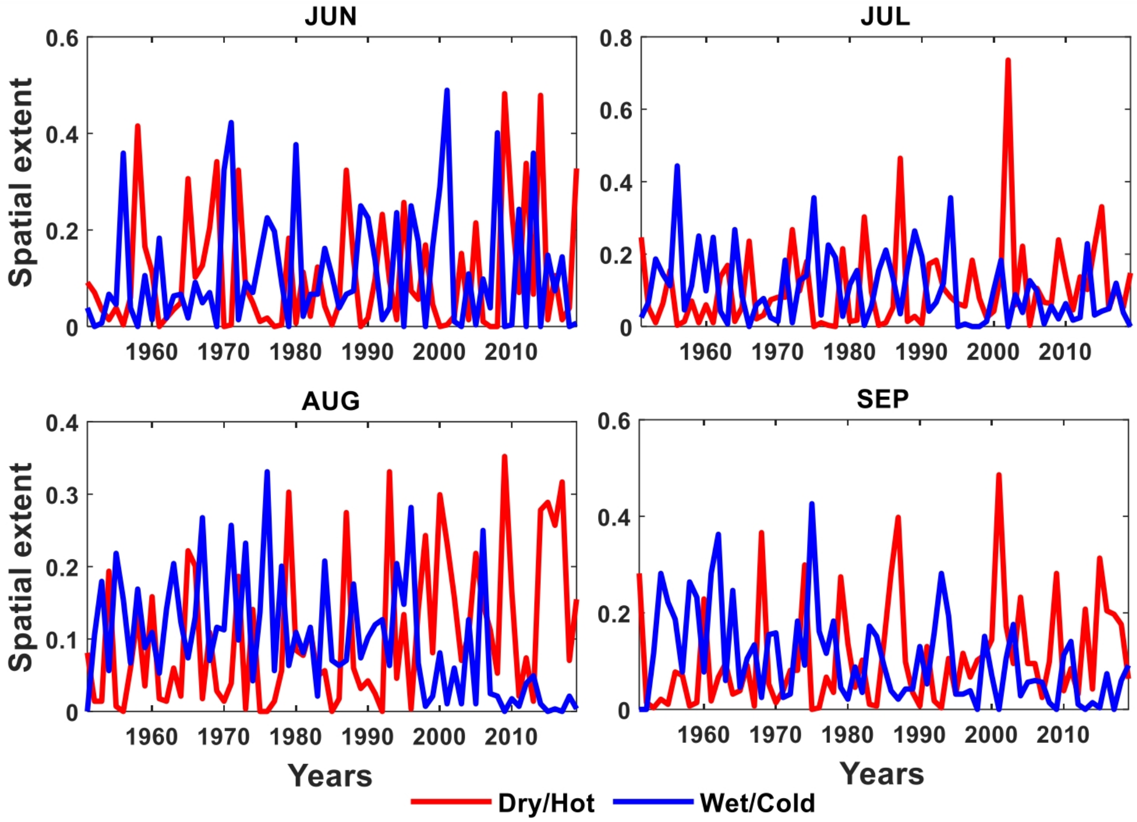
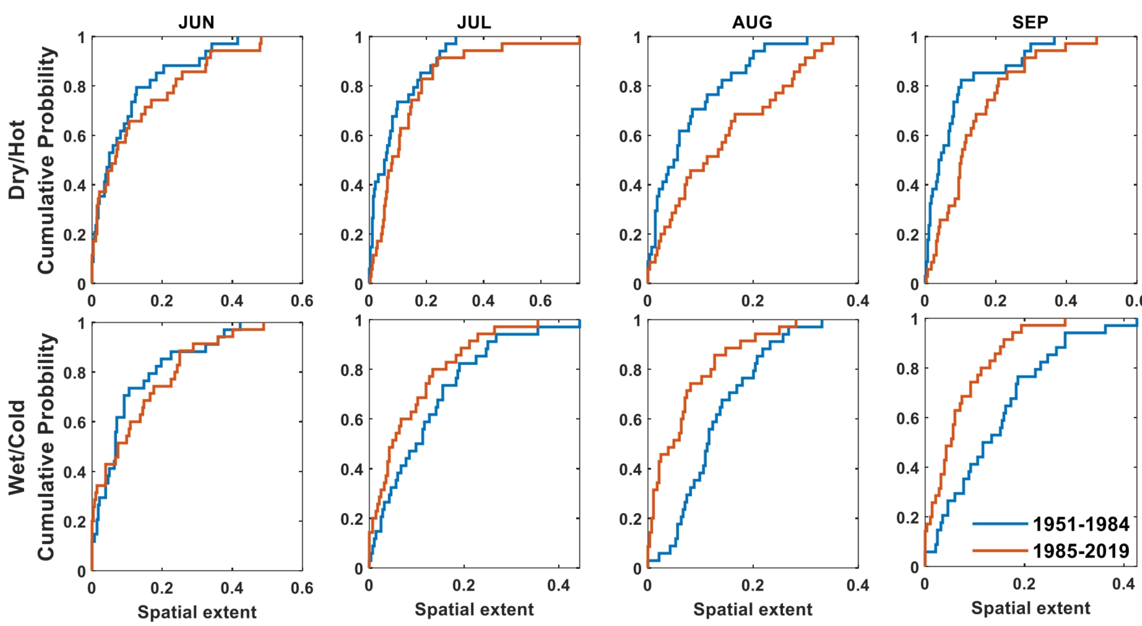
SEP
Dry/Hot
Wet/Cold
Dry/Hot
Wet/Cold

RESULTS

Spatial extent of Dry/Hot and Wet/Cold

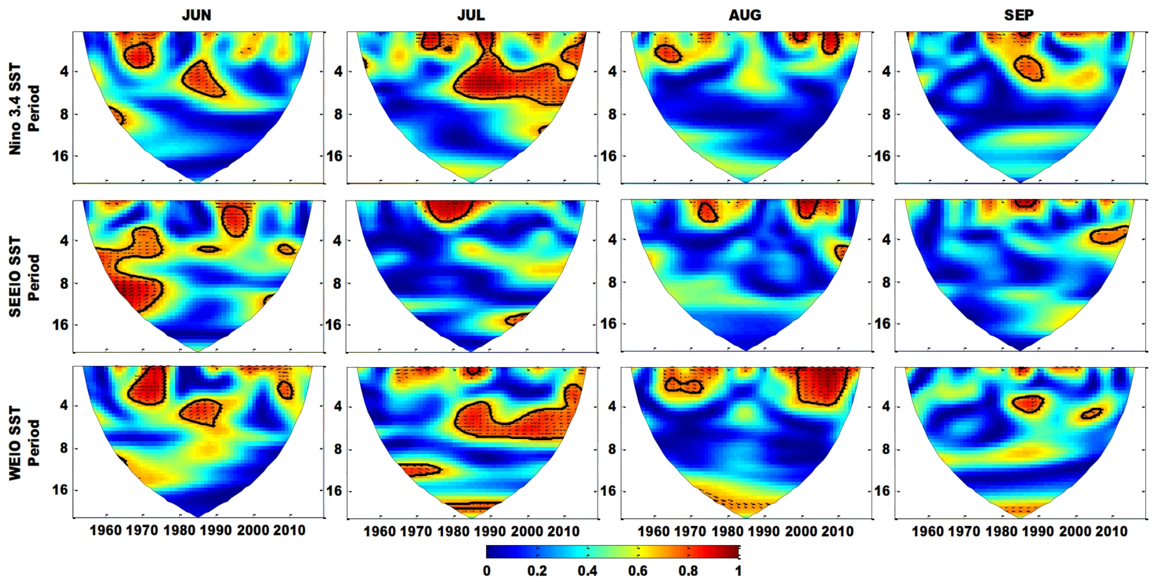


Change in statistical characteristics of spatial extent after 1984

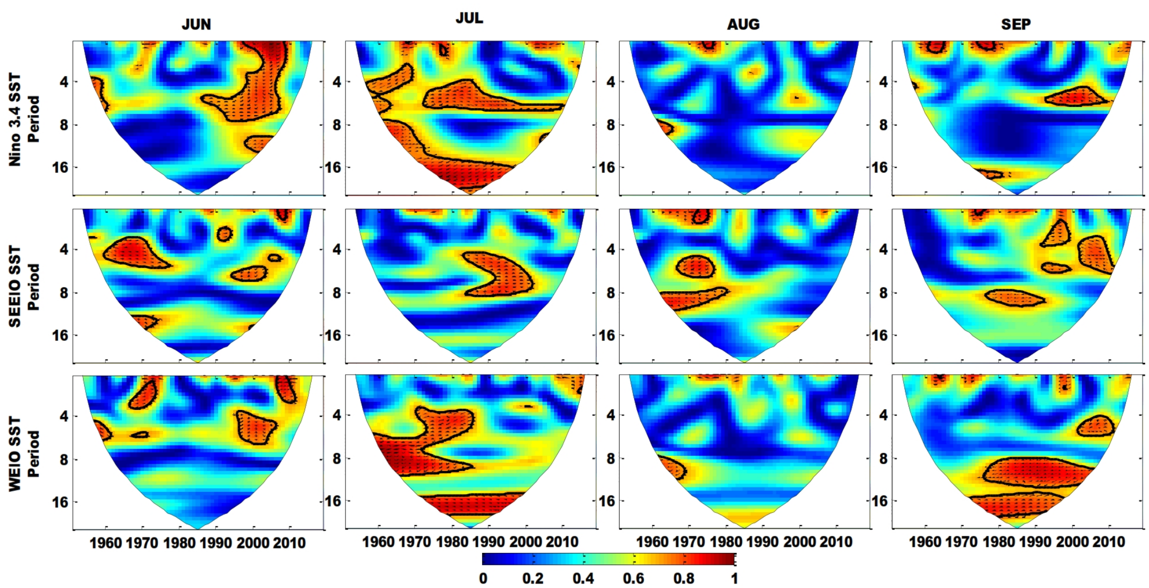


The interrelationship between spatial extent and ENSO and IOD phenomenon

Dry/Hot



Wet/Cold



CONCLUSIONS

- Increase in occurrence of concurrent dry/hot extremes in most parts of India
- Spatial extent of concurrent dry/hot (wet/cold) extremes increased (decreased)
- Both IOD and ENSO had a strong influence on the occurrence of dry/hot extremes
- ENSO had a strong influence on the occurrence of wet/cold extremes

ABSTRACT

Concurrent temperature and precipitation extremes during Indian summer monsoon generally have significant effects on agriculture, society and ecosystems. Due to climate change, frequency and spatial extent of concurrent extremes have changed, and there is a need to advance our understanding in this domain. Quantification of individual extremes (temperature and precipitation) during the summer monsoon season and its teleconnections to climate indices have been studied comprehensively. But, less attention is devoted to the quantification of concurrent extremes and its teleconnections to climate indices. In this study, concurrent extremes (dry/hot and wet/cold) based on mean monthly temperature and total monthly precipitation during the Indian summer season from 1951 to 2019 over the Indian mainland are investigated. Next, the study uses wavelet coherence analysis to unravel the teleconnections of the spatial extent of concurrent extremes to climate indices (Nino 3.4, WEIO SST and SEEIO SST). Results show that the frequency of wet/hot concurrent extremes has increased significantly, while the frequency of wet/cold concurrent has decreased for the time window 1985 to 2019 relative to 1951-1984. Also, a statistically significant increase (decrease) in the spatial extent exists in concurrent dry/hot (wet/cold) extremes during the July, August and September months. The findings of this study could advance our understanding of changes in concurrent extremes during the Indian summer monsoon due to climate change.

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