# Evolving ENSO teleconnections and the rising influence of extreme events on northeast monsoon rainfall

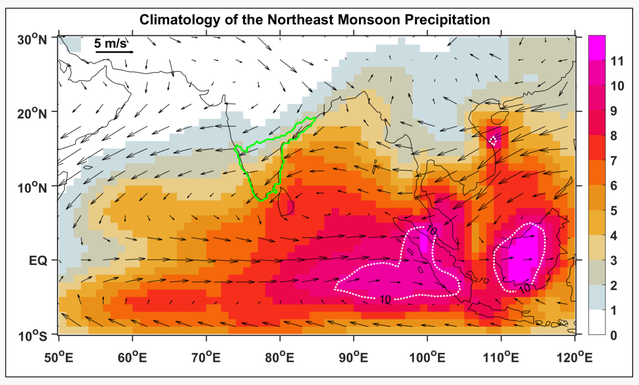
Suneeth K V[1]* and Prasanth A Pillai[1]

[1]Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Dr Homi Bhaba Road, Pashan, Pune, India

IWM-8

## Introduction

The northeast monsoon plays a crucial role in shaping rainfall patterns over southern peninsular India. While it contributes only about 11% of the total annual rainfall over the Indian landmass, its significance is far greater for the southern peninsular India, which receives 30-60% of its yearly precipitation during this season. The interannual variability of northeast monsoon rainfall (NEMR) is approximately 25%, directly impacting agriculture and water resources in the region. Despite its importance, NEMR has received comparatively less attention than the Indian summer monsoon, which has been extensively studied. Given its critical role in sustaining livelihoods and water availability, a deeper understanding of NEMR dynamics and improved forecasting capabilities are essential.




Climatology of Northeast Monsoon Precipitation using GPCP data (1981-2020). Northeast monsoon region over Indian peninsula is marked by green contour.

## Data

### Model data [1981-2020]

- North American Multi-Model Ensemble (NMME) models [1°x1°]

### Precipitation data

- Global Precipitation Climatology Project (GPCP) [2.5°x2.5°, 1981-2022]
- India Meteorological Department (IMD) gridded rainfall data [0.25°x0.25°, 1901-2022]

### SST data [1901-2022]

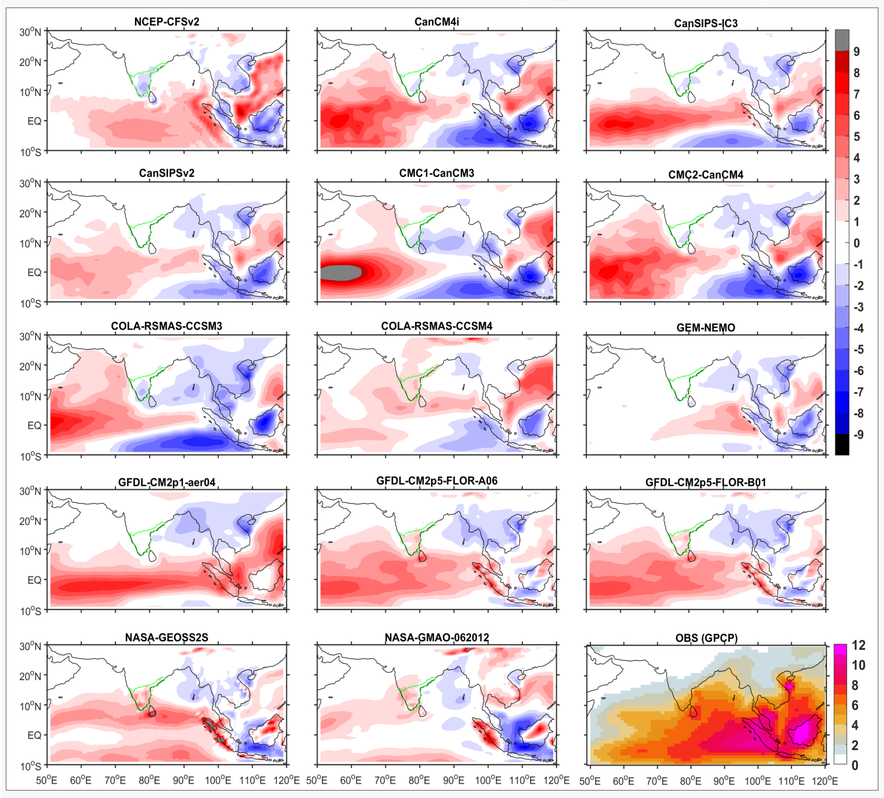
- Hadley Centre Global Sea Ice and Sea Surface Temperature (HadISST) [1°x1°]

## Objectives

To study the possible factors contributing to changes in NEMR teleconnections and their influence on the predictability of new-generation seasonal prediction models.

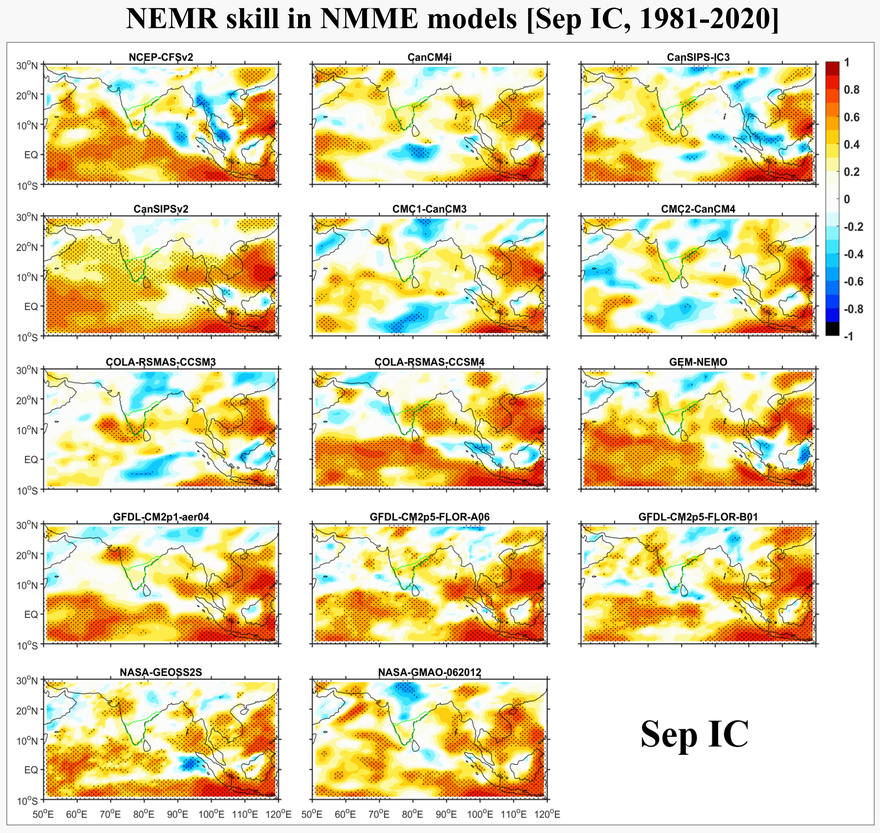
## NEMR: Bias and Skill

### NEMR biases in NMME models [Sep IC, 1981-2020]



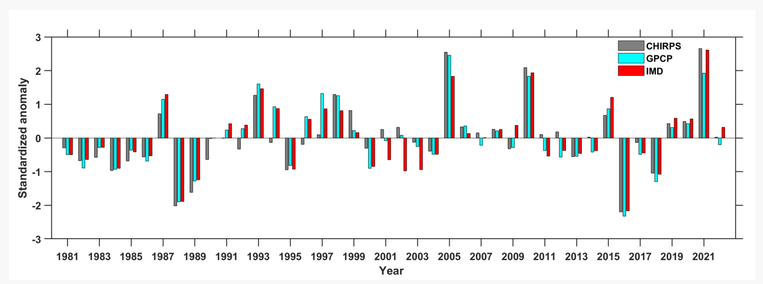

Mean bias in Northeast Monsoon precipitation in NMME models with September Initial conditions.

### NEMR skill in NMME models [Sep IC, 1981-2020]




Sep IC

NEMR skill in NMME models with September Initial conditions.

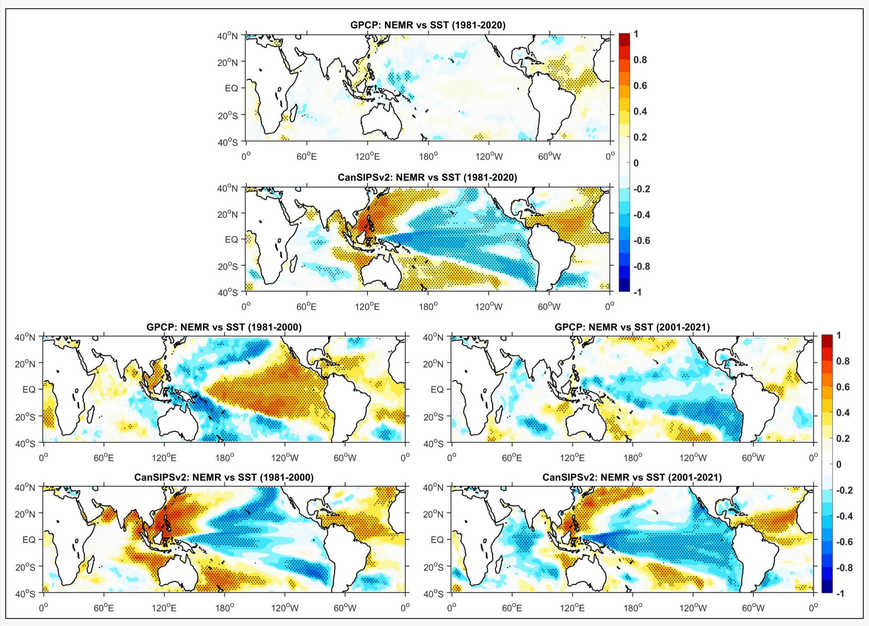



Mean NEMR (southern peninsular India) in different observations.

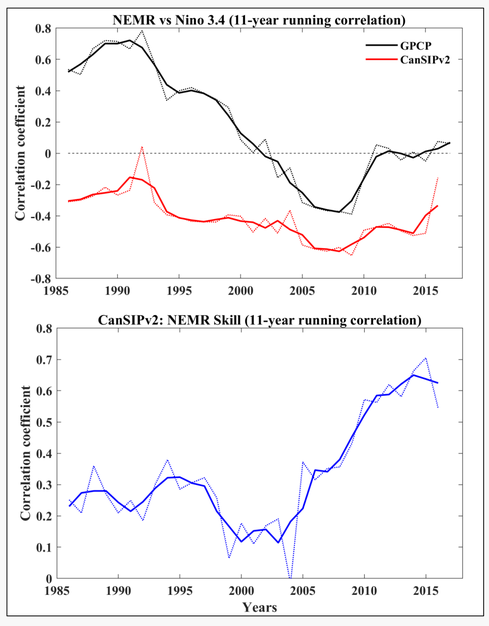
| | GPCP | IMD | CHIRPS | GPCP : Sep IC | | IMD : Sep IC | | CHI : Sep IC | |
|---|---|---|---|---|---|---|---|---|---|
| MODEL | 1981-2020 | | | 1981-2000 | 2001-2020 | 1981-2000 | 2001-2020 | 1981-2000 | 2001-2020 |
| NCEP-CFSv2 | 0.28 | 0.26 | 0.33 | 0.01 | 0.53 | -0.08 | 0.54 | 0.14 | 0.49 |
| CanCM4i | 0.2 | 0.12 | 0.25 | 0.15 | 0.23 | 0.03 | 0.18 | 0.24 | 0.27 |
| CanSIPS-IC3 | 0.22 | 0.15 | 0.28 | 0.13 | 0.3 | 0.02 | 0.24 | 0.18 | 0.36 |
| CanSIPSv2 | 0.37 | 0.33 | 0.4 | 0.32 | 0.4 | 0.24 | 0.39 | 0.42 | 0.38 |
| CMC1-CanCM3 | 0.14 | 0.12 | 0.24 | 0 | 0.27 | -0.02 | 0.23 | 0.17 | 0.31 |
| CMC2-CanCM4 | 0.24 | 0.15 | 0.29 | 0.05 | 0.4 | -0.08 | 0.33 | 0.09 | 0.43 |
| COLA-RSMAS-CCSM3 | 0.2 | 0.16 | 0.29 | -0.16 | 0.47 | -0.25 | 0.45 | -0.06 | 0.51 |
| COLA-RSMAS-CCSM4 | 0.2 | 0.16 | 0.28 | -0.22 | 0.56 | -0.3 | 0.49 | -0.08 | 0.55 |
| GEM-NEMO | 0.37 | 0.38 | 0.37 | 0.4 | 0.36 | 0.38 | 0.38 | 0.47 | 0.3 |
| GFDL-CM2p1-aer04 | 0.13 | 0.12 | 0.19 | -0.04 | 0.26 | -0.14 | 0.29 | 0.05 | 0.29 |
| GFDL-CM2p5-FLOR-A06 | 0.11 | 0.1 | 0.16 | -0.09 | 0.29 | -0.18 | 0.34 | 0.02 | 0.28 |
| GFDL-CM2p5-FLOR-B01 | 0.14 | 0.12 | 0.21 | 0.01 | 0.23 | -0.07 | 0.24 | 0.09 | 0.28 |
| NASA-GEOSS2S | -0.12 | -0.08 | -0.04 | -0.38 | 0.12 | -0.42 | 0.19 | -0.23 | 0.11 |
| NASA-GMAO-062012 | 0.02 | -0.03 | 0.12 | -0.28 | 0.3 | -0.36 | 0.26 | -0.15 | 0.34 |

Mean NEMR (southern peninsular India) skill in NMME models with September Initial conditions.

## Teleconnections

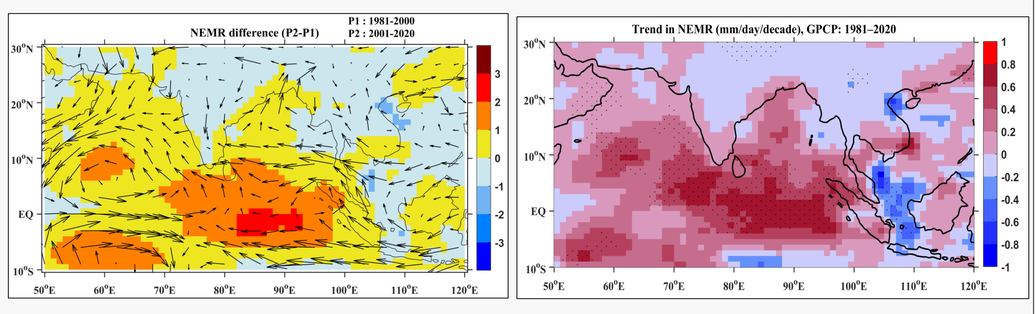



NEMR-SST teleconnection in Observations and Models.

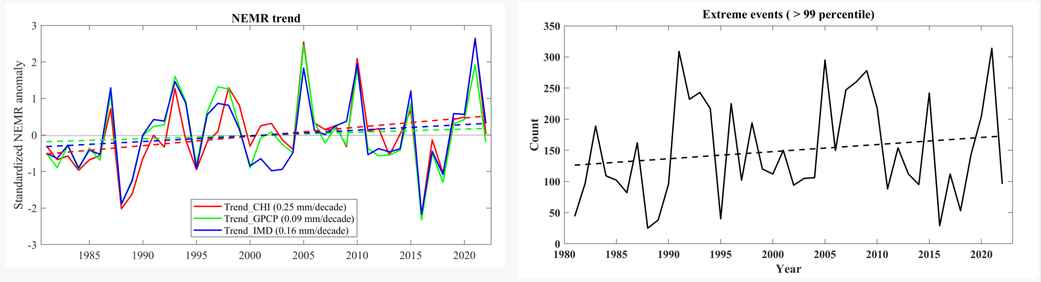



Correlation between Mean NEMR (southern peninsular India) and SST (top); Model Skill (bottom).

## Trends and Extreme events

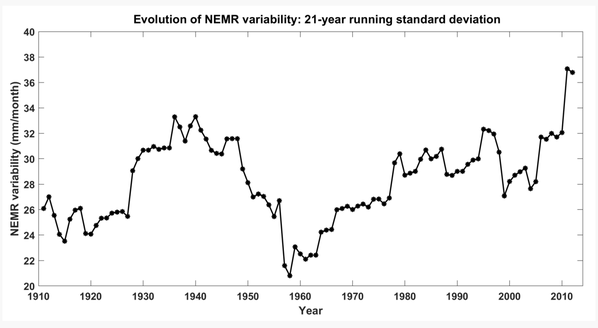


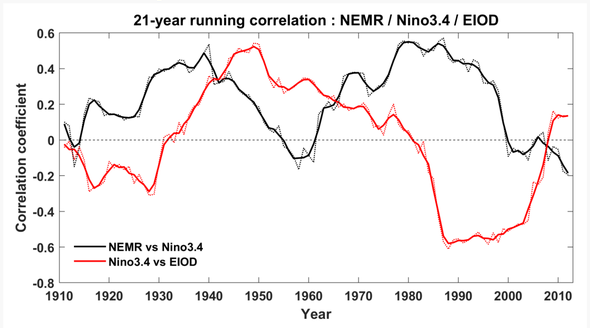

Difference in NEMR (after 2000 vs before 2000) and Trend in NEMR During the 1981–2020.



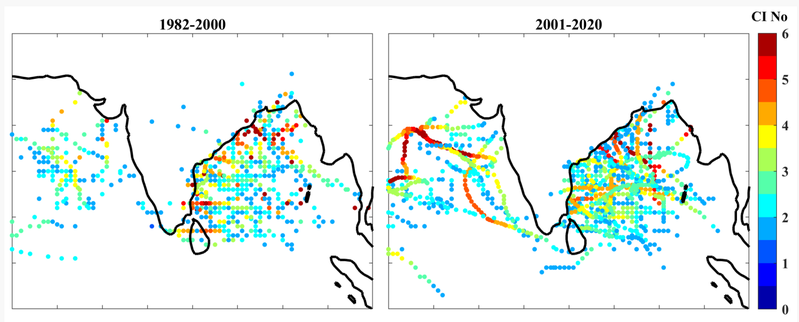

Trend and extreme events in mean NEMR (southern peninsular India) during 1981–2020.

## Decadal variability




Variability of Mean NEMR (southern peninsular India) : Standard Deviation and Its Teleconnection with ENSO and EIOD




Depressions and Cyclone Intensity Numbers (CI No) during 1982–2020 period.

## Summary

- Traditionally, ENSO had a **positive influence** on Northeast Monsoon Rainfall (NEMR), but this connection weakened and even reversed after 2000.
- **NMME models** consistently simulate a **negative ENSO-NEMR relationship**, leading to **low skill** in predicting NEMR.
- The significant increase in extreme rainfall events over the past decade suggests that **extremes** are becoming a **dominant factor** in NEMR variability and predictability.
- The study highlights the **evolving nature of ENSO-NEMR teleconnections**, requiring improved prediction models that account for **decadal variability and extreme events**.