



Persistence of Synchronized Extreme Rainfall in Changing Climates

For Prelims: Persistence of Synchronized Extreme Rainfall in Changing Climates, [Global Warming](#), Indian Summer Monsoon Rainfall (ISMR).

For Mains: Persistence of Synchronized Extreme Rainfall in Changing Climates, Factors Affecting the Rainfall in India.

[Source: TH](#)

Why in News?

Recently, a new study has been published by Advancing Earth and Space Sciences (AGU) titled- ***Geographical Trapping of Synchronous Extremes Amidst Increasing Variability of Indian Summer Monsoon Rainfall***, highlighting that Indian Monsoon has undergone significant alterations due to [Global Warming](#).

- The study investigates **synchronous extreme rainfall events** during the **Indian Summer Monsoon Rainfall (ISMR) from 1901 to 2019**. It highlights the consistent presence of interconnected extreme hubs in Central India, suggesting the geographical concentration of these concurrent events in the region.

How have been the Rainfall Trends in India?

- **Consistent Spatial Concentration:**
 - Despite the rising variability in Indian [Summer Monsoon](#) Rainfall (ISMR) over the past century, synchronous extreme rainfall events **have consistently concentrated within a specific geographical region**, primarily in **Central India (CI) that extends from parts of West Bengal and Odisha to parts of Gujarat and Rajasthan**.
 - This corridor has remained unchanged from 1901 to 2019!
 - This indicates a **stable pattern of synchronized extreme** events despite overall increased variability.
- **Network Cohesiveness:**
 - There is a **persistent network of highly interconnected extreme rainfall hubs** in CI. These hubs exhibit strong local connections, emphasizing a stable synchronization of extreme events in this region over the long term.
- **Correlation with Climatic Patterns:**
 - India's monsoon forecasts rely heavily on its relation to the **El Niño and the La Niña phenomena**, although this relation holds only about 60% of the time.
 - Indian Rainfall events are correlated with [El Niño Southern Oscillations \(ENSO\)](#), with more **synchronization during strong El Niño periods** and less during La Niña conditions.
- **Implications for Predictability:**

- The findings suggest that despite the increasing variability and complexity of ISMR, understanding the persistent nature of extreme rainfall synchronization in CI provides insights crucial for predicting synchronous extremes.
- This knowledge can aid in developing effective adaptation strategies and risk management during the monsoon season.

What are the Implications of the Findings on the Forecast?

▪ Revisiting Stationarity:

- Despite the belief that **stationary elements in climate systems no longer exist** due to global warming, the Indian monsoon's ability to synchronize heavy rain events **challenges this notion**.
- It suggests that certain consistent patterns, such as synchronized extreme rainfall events along specific corridors, **persist even in a changing climate**.

▪ Understanding Corridor Dynamics:

- The **identification of a geographic corridor**, primarily the mountain ranges **along the west coast and across Central India, as the potential trapping zone for synchronized extreme rainfall events** and monsoon depressions provides a crucial insight.
 - This hypothesis would significantly enhance the understanding of how and where these events occur, aiding in more accurate forecasts.

▪ Forecast Improvement:

- The research suggests that improving forecasts of synchronized extreme rainfall events doesn't necessarily require increased model resolution or higher computational costs.
- Instead, **focusing on understanding the dynamics of synchronization within the existing models could lead to more accurate predictions**. This highlights a strategic shift in forecasting approaches.

▪ Risk Reduction Strategies:

- Accurate forecasts of **these large-scale extreme rainfall events are vital for minimizing risks across various sectors** like agriculture, water management, energy, transportation, and public health.
 - The findings offer an **opportunity to refine risk reduction strategies at a smaller scale**, leveraging better forecasts **for preparedness and mitigation**.

▪ Leveraging India's Resources:

- The study **emphasizes India's strong modelling capacity and computational resources**, positioning the country well to exploit this potential for better forecasting.
- It highlights the capacity to delve deeper into understanding synchronization dynamics and optimizing forecasts, potentially minimizing the impacts of extreme rainfall events on various sectors.

What are the Factors Affecting the Indian Monsoon?

▪ Himalayan Mountains:

- The **Himalayas** are a **major factor in the formation of the monsoon winds** in India.
- During the **summer months, the landmass over the Indian subcontinent heats up rapidly**, leading to the formation of a low-pressure system.
 - The Himalayas, which act as a barrier, prevent the cool, dry air from the north from flowing into the region, resulting in a pressure gradient that draws in warm, moist air from the Indian Ocean.

▪ Thar Desert:

- The Thar Desert, also known as the **Great Indian Desert**, is a crucial factor in the formation of monsoon winds in India.
- It **acts as a rain shadow area for the Bay of Bengal branch of the monsoon**, meaning that it receives very little rainfall due to the barrier created by the **Aravalli Mountain range**.
 - Thus, the Arabian branch of the monsoon, which moves parallel to the Thar Desert, also leads to very little rainfall in the nearby regions.
 - **This lack of rainfall can have significant impacts on agriculture and the local economy in the region.**

- The hot and dry air from the desert creates a low-pressure zone in the whole northwest parts of India, which draws in moisture-laden winds from the Indian Ocean, resulting in heavy rainfall during the summer months.

▪ **Indian Ocean:**

- The [Indian Ocean](#) is a significant contributor to the formation of monsoon winds in India.
- The ocean's warm and moist air interacts with the low-pressure system over the Indian subcontinent, resulting in the formation of the monsoon winds.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims:

Q. With reference to 'Indian Ocean Dipole (IOD)' sometimes mentioned in the news while forecasting Indian monsoon, which of the following statements is/are correct? (2017)

1. IOD phenomenon is characterised by a difference in sea surface temperature between tropical Western Indian Ocean and tropical Eastern Pacific Ocean.
2. An IOD phenomenon can influence an El Nino's impact on the monsoon.

Select the correct answer using the code given below:

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Ans: (b)

Exp;

- The Indian Ocean Dipole (IOD) is an atmosphereocean coupled phenomenon in the tropical Indian Ocean (like the El Nino is in the tropical Pacific), characterised by a difference in Sea-Surface Temperatures (SST).
- A 'positive IOD' is associated with cooler than normal sea-surface temperatures in the eastern equatorial Indian Ocean and warmer than normal sea-surface temperatures in the western tropical Indian Ocean.
- The opposite phenomenon is called a 'negative IOD', and is characterised by warmer than normal SSTs in the eastern equatorial Indian Ocean and cooler than normal SSTs in the western tropical Indian Ocean.
- Also known as the Indian Nino, it is an irregular oscillation of sea-surface temperatures in the Indian Ocean in which the western Indian Ocean becomes alternately warmer and colder than the eastern part of the Indian Ocean. Hence, statement 1 is not correct.
- The IOD is one aspect of the general cycle of global climate, interacting with similar phenomena like the El Nino-Southern Oscillation (ENSO) in the Pacific Ocean. An IOD can either aggravate or weaken the impact of El Nino on Indian monsoon. If there is a positive IOD, it can bring good rains to India despite of an El Nino year. Hence, statement 2 is correct.
- Therefore, option (b) is the correct answer

Mains:

Question: How far do you agree that the behaviour of the Indian monsoon has been changing due to humanizing landscape? Discuss. (2015)

