Frequently Asked Questions (FAQ)

ENSO, IOD and its Impact on Indian Summer Monsoon Rainfall

1. What is the El Niño–Southern Oscillation (ENSO)?

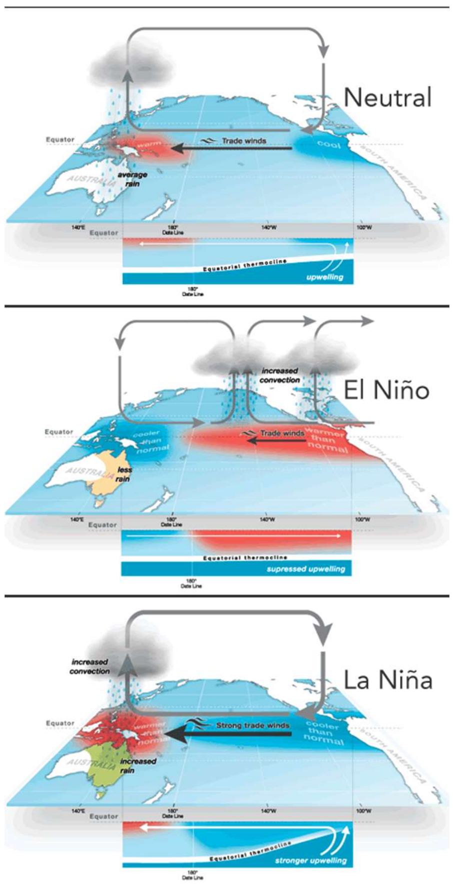
The El Niño–Southern Oscillation (ENSO) is a naturally occurring climate phenomenon resulting from interactions between the tropical Pacific Ocean and the atmosphere. ENSO is one of the most important sources of year-to-year climate variability worldwide and significantly influences rainfall, temperature, and extreme weather in many regions, including India.

ENSO has three phases:

El Niño: Unusually warm sea surface temperatures over the central and eastern equatorial Pacific Ocean.

La Niña: Unusually cool sea surface temperatures over the same region.

ENSO-neutral: Sea surface temperatures remain close to their long-term average.



Schematic diagram representing neutral ENSO conditions (top panel), El Niño conditions (middle panel), and La Niña conditions (bottom panel)

2. How often do El Niño and La Niña occur?

ENSO events typically develop every 2 to 7 years. They usually begin during boreal spring, strengthen through the year, and reach peak intensity during November to February. El Niño events generally last 9–18 months, whereas La Niña events can persist for up to two or three years.

3. Why is ENSO important for India?

ENSO is one of the primary drivers of year to year climate variability over India. It influences:

1. Indian Summer Monsoon Rainfall (June–September)
2. Northeast Monsoon Rainfall (October–December)
3. Temperature extremes
4. Agriculture
5. Water resources
6. Hydropower generation
7. Energy demand

Because nearly half of India's agriculture remains rain-fed, monitoring ENSO is crucial for seasonal climate prediction and disaster preparedness.

4. How does El Niño affect the Indian Summer Monsoon?

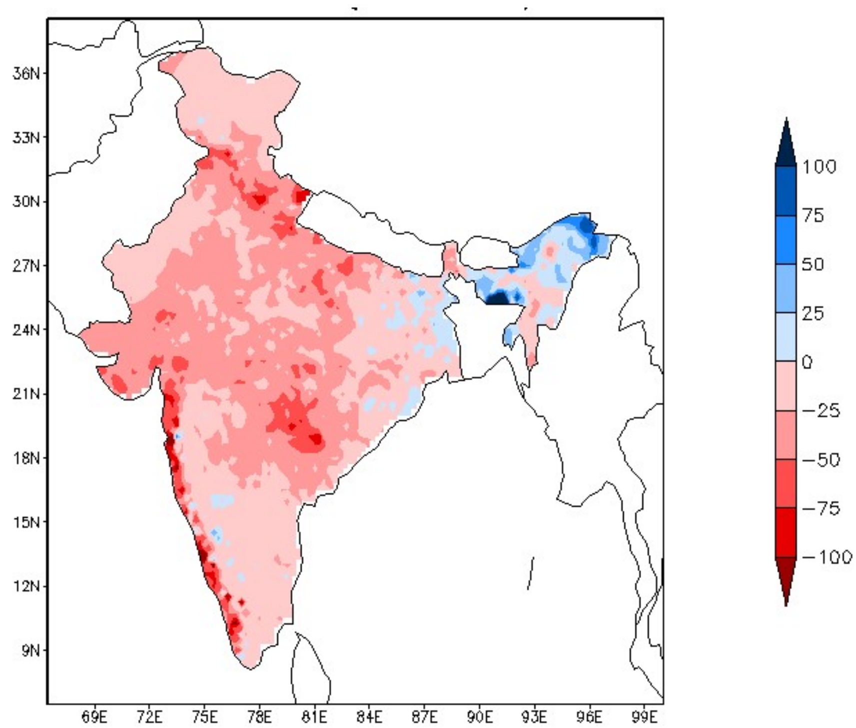
El Niño generally suppresses the Indian summer monsoon by weakening the large-scale atmospheric circulation responsible for transporting moisture toward the Indian subcontinent.

Typical impacts include:

1. Below-normal monsoon rainfall
2. Increased frequency of dry spells
3. Higher temperatures and heatwaves
4. Reduced reservoir inflows
5. Lower agricultural productivity

Historically, many major drought years in India (such as 1982, 1987, 2002, 2009, and 2015) occurred during El Niño events.

However, not every El Niño results in drought, and the severity depends on other climate drivers such as Indian Ocean Dipole, Atlantic Zonal Mode etc .



The figure shows the composite Rainfall anomaly during El Nino years

5. Does every El Niño cause drought in India?

No.

Although El Niño increases the probability of below-normal rainfall, the relationship is not deterministic. Indian monsoon rainfall is also influenced by:

1. Indian Ocean Dipole (IOD)
2. Madden–Julian Oscillation (MJO)
3. Eurasian snow cover
4. North Atlantic and Arctic variability
5. Intraseasonal oscillations
6. Atlantic Zonal Mode/Atlantic Nino

For example, a positive Indian Ocean Dipole can partially offset the drying influence of El Niño. Similarly a cold phase of Atlantic Zonal Mode partially offset the drying influence of El Niño over Indian subcontinent.

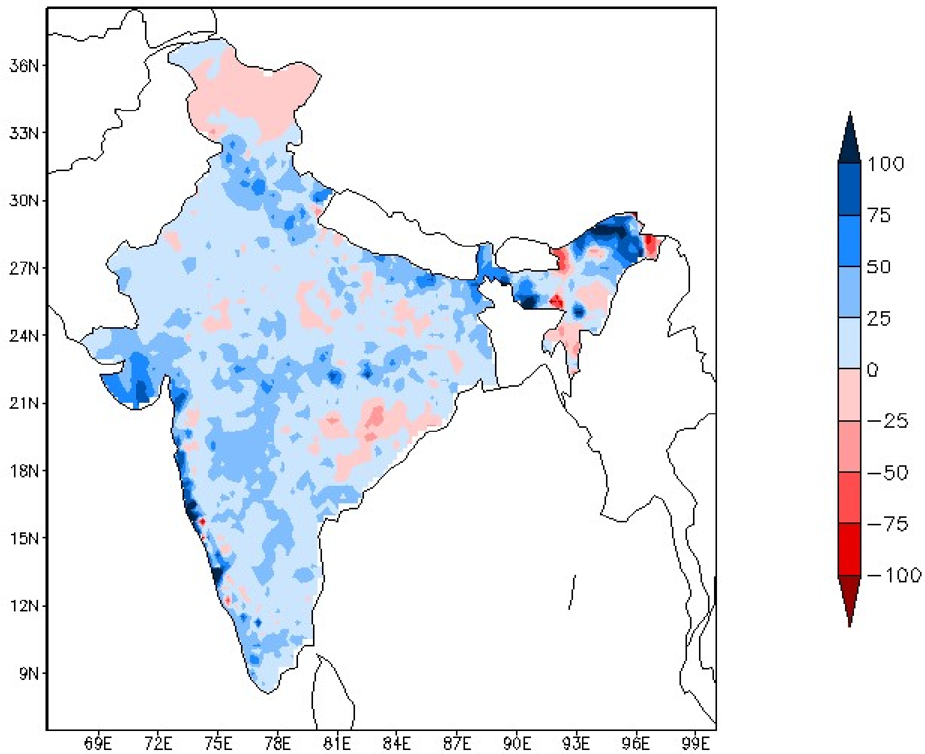
6. How does La Niña affect the Indian Summer Monsoon?

La Niña generally strengthens the monsoon circulation and increases the likelihood of:

1. Above-normal monsoon rainfall
2. More widespread rainfall

3. Increased flood potential
4. Better agricultural conditions

Nevertheless, individual La Niña events differ considerably, and regional rainfall patterns can still vary.



The figure shows the composite rainfall anomaly during La Nina years.

7. Why are some El Niño events stronger than others?

The strength of an El Niño depends on:

1. Magnitude of Pacific Ocean warming
2. Ocean heat content
3. Atmospheric coupling
4. Trade wind anomalies
5. Timing of development
6. Interaction with other climate modes

8. How is the strength of El Niño and La Niña classified?

Operational climate centres usually classify El Niño as weak, moderate, or strong based on the Oceanic Niño Index (ONI) or the Relative Oceanic Niño Index (RONI). There is at present no universally accepted scientific definition of a “super” El Niño.

Positive values indicate El Niño conditions, while negative values indicate La Niña conditions. Larger absolute values correspond to stronger events.

Index Value (°C)	**El Niño Classification**	**La Niña Classification**
0.5 to <1.0	Weak El Niño	Weak La Niña (-0.5 to >-1.0)
1.0 to <1.5	Moderate El Niño	Moderate La Niña (-1.0 to >-1.5)
1.5 to <2.0	Strong El Niño	Strong La Niña (-1.5 to >-2.0)
≥2.0	Very Strong El Niño	Very Strong La Niña (≤-2.0)

These categories provide a convenient way to describe the intensity of ENSO events. However, the climatic impacts over India and other regions depend not only on the strength of the event but also on its spatial pattern, timing, duration, and interactions with other climate drivers such as the Indian Ocean Dipole (IOD), Madden–Julian Oscillation (MJO), and background ocean–atmosphere conditions. Consequently, two ENSO events of similar intensity may produce different impacts on the Indian Summer Monsoon Rainfall.

9. What is the Oceanic Niño Index (ONI)?

The Oceanic Niño Index (ONI) is the most widely used indicator for monitoring ENSO. It is calculated as the 3-month running mean sea surface temperature anomaly over the Niño-3.4 region (5°N–5°S, 170°W–120°W) relative to a long-term climatological average.

Operationally,

ONI ≥ +0.5°C indicates El Niño conditions.

ONI ≤ −0.5°C indicates La Niña conditions.

Persistent anomalies lasting several overlapping seasons are used to declare ENSO events.

10. What is the Relative Oceanic Niño Index (RONI)?

The Relative Oceanic Niño Index (RONI) is an SST-based ENSO index developed to better represent El Niño and La Niña in a warming climate. Unlike the conventional Oceanic Niño Index (ONI), which measures sea surface temperature (SST) anomalies in the Niño-3.4 region relative to a fixed climatological average, RONI measures how warm or cool the Niño-3.4 region is relative to the average temperature of the tropical oceans at the same time.

By removing the influence of widespread tropical ocean warming, RONI better isolates the SST anomalies associated with ENSO itself. This makes it less sensitive to long-term changes in the background climate and provides a more physically consistent measure of ENSO variability under ongoing global warming.

RONI has several practical advantages:

1. It detects the onset and decay of ENSO events more consistently, particularly during weak or transitional events.
2. It shows closer agreement with the Multivariate ENSO Index (MEI), which incorporates both oceanic and atmospheric conditions.
3. It provides a more stable representation of ENSO-related atmospheric circulation and rainfall variability in a changing climate.
4. It requires only sea surface temperature observations, making it simple to calculate while retaining long historical records.

11. How is the Relative Oceanic Niño Index (RONI) defined?

The Relative Oceanic Niño Index (RONI) is designed to measure ENSO variability after removing the influence of background warming across the tropical oceans. It is derived by first subtracting the tropical mean sea surface temperature (SST) anomaly from the conventional Oceanic Niño Index (ONI), and then applying a scaling factor to preserve the variability of the original ONI.

RONI is defined as:

$$\boxed{\mathrm{RONI} = (\mathrm{ONI} - \mathrm{TropAve}) \times \frac{\sigma_{\mathrm{ONI}}}{\sigma_{(\mathrm{ONI}-\mathrm{TropAve})}}}$$

where:

ONI is the conventional Oceanic Niño Index based on the Niño-3.4 SST anomaly.

TropAve is the mean SST anomaly averaged over the tropical oceans (20°S–20°N).

σ_{ONI} is the standard deviation of the ONI. $\sigma_{(\mathrm{ONI}-\mathrm{TropAve})}$ is the standard deviation of the ONI after subtracting the tropical mean SST anomaly.

The scaling factor,

$$\frac{\sigma_{\mathrm{ONI}}}{\sigma_{(\mathrm{ONI}-\mathrm{TropAve})}},$$

is calculated separately for each calendar month. This scaling restores the variance lost when the tropical mean SST anomaly is removed, ensuring that the RONI retains variability comparable to the original ONI. As a result, the familiar ENSO thresholds (±0.5°C) can continue to be used for operational ENSO monitoring and classification.

12. Why is RONI useful in a warming climate?

As global oceans warm, sea surface temperatures in the Niño-3.4 region also increase, even during neutral conditions.Using a fixed climatological baseline may therefore:

1. Overestimate El Niño intensity,

2. Delay recognition of La Niña termination, or
3. Misrepresent ENSO evolution.

RONI reduces this bias by accounting for simultaneous warming across the tropical oceans, making it particularly useful for monitoring ENSO under climate change.

13. Does RONI replace ONI?

Yes. Several major international meteorological agencies have now adopted the Relative Oceanic Niño Index (RONI) as their primary operational index for monitoring and predicting ENSO. For example:

NOAA's Climate Prediction Center (CPC) officially adopted RONI as its operational ENSO index in February 2026, replacing ONI for ENSO monitoring and prediction. The traditional ONI continues to be published mainly for historical continuity and comparison.

Australia's Bureau of Meteorology (BoM) transitioned to the Relative Niño Index in September 2025, citing its improved representation of ENSO in a warming climate.

RONI has been adopted because it:

1. removes the background warming signal from tropical sea surface temperatures,
2. provides a more physically meaningful measure of ENSO,
3. better represents the atmospheric response associated with ENSO, including tropical rainfall and circulation changes, and
4. allows more consistent comparison of ENSO events across different decades despite long-term ocean warming.

Although ONI remains available for historical reference, RONI is increasingly becoming the international operational standard for ENSO monitoring and seasonal prediction

14. Which ENSO index is more useful for India?

Both ONI and RONI capture the major El Niño and La Niña events and remain useful for monitoring ENSO. However, recent research suggests that RONI provides a more robust representation of the relationship between ENSO and the Indian Summer Monsoon Rainfall (ISMR), particularly under a warming climate.

A recent IMD study (Sabeerali et al., 2026) comparing ONI and RONI for the period 1979–2024 found that:

- RONI explains a larger fraction of the year-to-year variability of Indian summer monsoon rainfall, especially over west-central and southern India.
- RONI shows closer agreement with the Multivariate ENSO Index (MEI) than in ONI in representing the timing of ENSO onset, maturity, and decay, particularly during weaker ENSO events.
- Seasonal forecasts from IMD's Monsoon Mission Coupled Forecasting System (MMCFS) showed higher prediction skill for RONI than for ONI during

the developing, mature, and decaying phases of ENSO, although both indices are affected by the well-known boreal spring predictability barrier.

These findings suggest that RONI is better suited for monitoring and predicting ENSO and its influence on the Indian Summer Monsoon in a changing climate. However, ENSO is only one of several factors influencing the Indian monsoon, and phenomena such as the Indian Ocean Dipole (IOD), Atlantic Zonal Mode (AZM), and intraseasonal variability can substantially modify the observed monsoon rainfall in any given year.

15. Can climate change cause El Niño?

No. El Niño and La Niña are naturally occurring climate phenomena driven by ocean–atmosphere interactions in the tropical Pacific.

Current scientific evidence does not clearly show that climate change is increasing the frequency of ENSO events.

However, climate change can amplify the impacts of ENSO because warmer oceans and atmosphere provide more heat and moisture to the climate system, increasing the likelihood of heatwaves and heavy rainfall.

16. How is ENSO monitored?

ENSO is monitored using observations from:

1. Satellites
2. Ocean buoys
3. Research vessels
4. Argo floats
5. Surface meteorological stations
6. Atmospheric observations
7. Climate models

Scientists continuously monitor:

1. Sea surface temperature
2. Ocean heat content
3. Surface winds
4. Air pressure
5. Rainfall
6. Atmospheric circulation

These observations are assimilated into coupled climate models to generate seasonal forecasts.

17. How far in advance can ENSO be predicted?

Modern coupled climate models can often predict ENSO 1–6 months in advance, with the highest forecast skill after the boreal spring "predictability barrier."

Forecast confidence generally increases as the event develops.

18. What other climate factors influence the Indian Summer Monsoon besides ENSO?

Several climate drivers interact with ENSO, including:

1. Indian Ocean Dipole (IOD)
2. Madden–Julian Oscillation (MJO)
3. Eurasian snow cover
4. North Atlantic Oscillation (NAO)
5. Arctic Oscillation (AO)
6. Atlantic ZonalMode

These interactions explain why monsoon rainfall may differ even during similar ENSO events.

19. How does IMD use ENSO information?

The India Meteorological Department (IMD) incorporates ENSO information, along with other global climate drivers, into its dynamical and statistical seasonal prediction systems.

ENSO monitoring supports:

1. Seasonal monsoon outlooks
2. Monthly rainfall forecasts
3. Agricultural advisories
4. Water resource management
5. Disaster preparedness
6. Energy and hydropower planning

20. Where can I obtain official ENSO updates?

Authoritative ENSO information is available from:

1. World Meteorological Organization (WMO)
2. India Meteorological Department (IMD)
3. NOAA Climate Prediction Center (CPC)
4. Bureau of Meteorology (BoM)

These agencies issue regular ENSO outlooks, seasonal climate updates, and regional climate forecasts.

21. How does the India Meteorological Department (IMD) predict ENSO?

The India Meteorological Department (IMD) predicts the evolution of El Niño, La Niña, and ENSO-neutral conditions using its Monsoon Mission Coupled Forecasting System (MMCFS), a state-of-the-art fully coupled ocean–atmosphere seasonal prediction model developed under the Monsoon Mission programme. The model simulates interactions between the atmosphere, ocean, land surface, and sea ice, enabling predictions of tropical Pacific sea surface temperatures and associated atmospheric circulation several months in advance.

MMCFS forecasts are generated using an ensemble of multiple model simulations initialized with the latest observed oceanic and atmospheric conditions. The model predicts the evolution of key ENSO indicators, including the Oceanic Niño Index (ONI).

The predicted ENSO state from MMCFS is one of the major inputs used by IMD in preparing its seasonal outlooks for the Indian Summer Monsoon, Northeast Monsoon, and other climate services. Since ENSO is not the only driver of India's climate variability, IMD also considers other climate factors, such as the Indian Ocean Dipole (IOD), snow cover, and other large-scale ocean–atmosphere conditions when issuing seasonal forecasts.

22. How is an El Niño or La Niña event declared?

An El Niño or La Niña event is declared using a combination of oceanic observations, atmospheric conditions, and climate model forecasts. A single sea surface temperature anomaly is not sufficient to declare an ENSO event.

For an El Niño declaration, the following conditions should be satisfied:

1. Oceanic condition

The Relative Oceanic Niño Index (RONI) over the Niño-3.4 region (5°N–5°S, 170°W–120°W) is at least +0.5°C.

2. Persistence

The positive anomaly has persisted or is expected to persist for several overlapping three-month seasons (e.g., MJJ, JJA, JAS, ASO), based on observations and dynamical model forecasts.

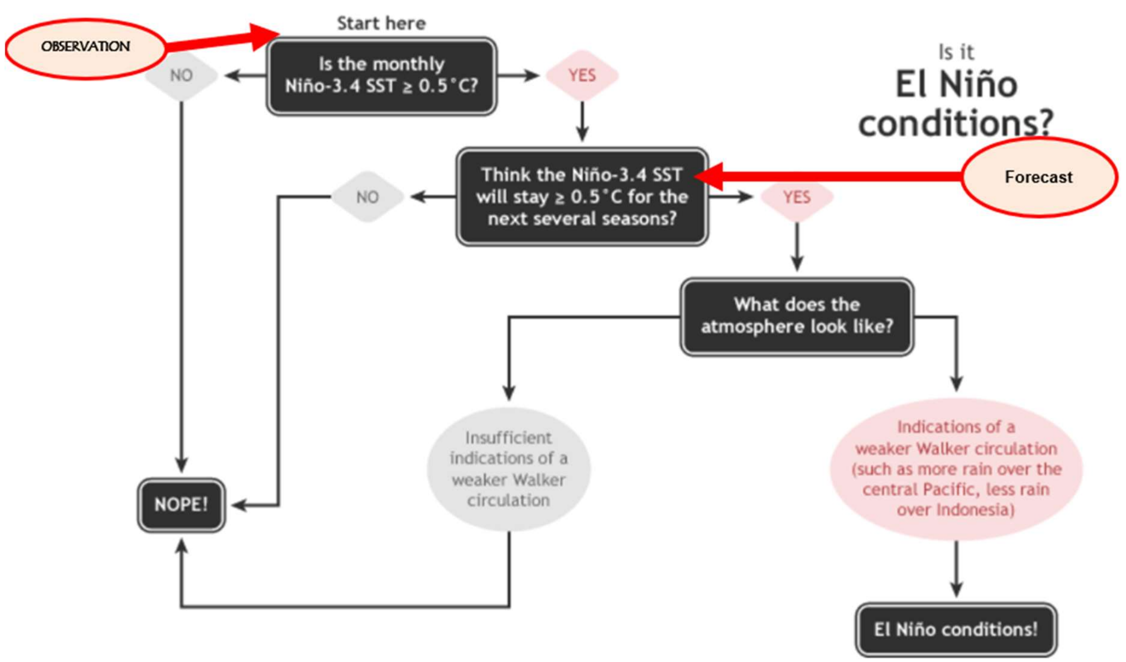
3. Atmospheric response

At least one of the following atmospheric changes, characteristic of El Niño, should also be present:

- Weaker-than-normal easterly trade winds over the equatorial Pacific.
- Reduced convection (cloudiness and rainfall) over Indonesia, accompanied by higher-than-normal surface pressure.
- Enhanced convection (cloudiness and rainfall) over the central or eastern equatorial Pacific, accompanied by lower-than-normal surface pressure.

Only when both the ocean and atmosphere exhibit a sustained and coupled El Niño signal is an El Niño event formally declared.

A La Niña event is declared using the same coupled ocean–atmosphere approach, but with anomalies of the opposite sign. A La Niña event is declared only when the oceanic cooling and the associated atmospheric circulation changes are sustained and consistent with each other.



Summary of NOAA decision process in determining El Niño conditions. NOAA Climate.gov drawing by Glen Becker and Fiona Martin.

Schematic diagram illustrating how El Niño and La Niña events are declared

23. What are the previous El Nino years and associated rainfall during monsoon season?

The table below lists all El Niño years during 1951–2025 along with the corresponding Indian Summer Monsoon Rainfall (ISMR).

Southwest monsoon Rainfall during El Niño years					
YEAR	JUN	JUL	AUG	SEP	JJAS
1951	-3.1	-11.0	-13.2	-26.6	-13.2
1953	-1.8	14.5	17.6	6.2	10.7
1957	-6.6	9.0	7.1	-21.6	-0.5
1958	-26.1	12.6	26.2	37.6	14.0
1963	1.0	-8.4	24.6	-1.5	4.4
1965	-30.1	-4.0	-24.6	-22.5	-18.6
1972	-26.2	-27.2	-13.8	-23.2	-22.3
1982	-17.4	-17.8	8.3	-24.9	-11.4
1987	-21.1	-21.5	-4.6	-10.3	-14.3
1991	11.1	-1.2	2.0	-19.1	-1.4
1997	3.8	1.5	3.2	-10.2	0.2
2002	2.3	-50.6	-4.4	-19.0	-20.9
2004	0.6	-13.4	-0.8	-26.6	-9.6
2009	-47.1	1.9	-24.1	-15.2	-18.3
2015	14.0	-14.4	-21.6	-22.6	-12.7
2023	-7.49	12.84	-36.09	13.12	-5.32

24. What are the previous La Nina years and associated rainfall during monsoon season?

The Table below provide the previous La Nina years and associated rainfall during monsoon season

Southwest monsoon Rainfall during La Niña years					
YEAR	JUN	JUL	AUG	SEP	JJAS
1954	-14.6	4.8	-9.5	47.0	5.1
1955	5.7	-16.7	26.2	29.8	9.1
1956	26.6	29.5	2.3	-1.4	15.0
1964	6.2	22.5	7.2	18.8	14.2
1970	30.6	-10.4	25.0	27.8	15.2
1971	38.4	-4.4	5.3	-11.9	5.1
1973	-9.6	-0.7	22.6	9.4	6.4
1974	-25.7	0.0	-9.3	-14.5	-10.4
1975	5.7	9.8	13.2	35.0	14.9
1985	-6.3	3.4	-8.2	-9.9	-4.4
1988	-4.6	34.3	17.7	30.1	21.2
1995	-16.5	14.2	4.8	7.3	4.3
1998	-2.2	0.7	-2.4	20.8	3.1
1999	3.3	-5.1	-12.9	11.3	-2.6
2000	12.0	-4.2	-11.6	-19.1	-6.2
2007	20.9	5.0	1.6	27.0	11.3
2010	-14.5	6.7	7.2	17.9	5.0
2011	10.8	-11.6	13.3	14.1	4.9
2016	-10.7	10.0	-6.0	1.1	-0.3
2020	18.5	-8.3	28.8	6.1	10.5
2021	10.30	-5.00	-23.80	36.60	0.40
2022	-7.92	16.66	3.58	8.02	6.47

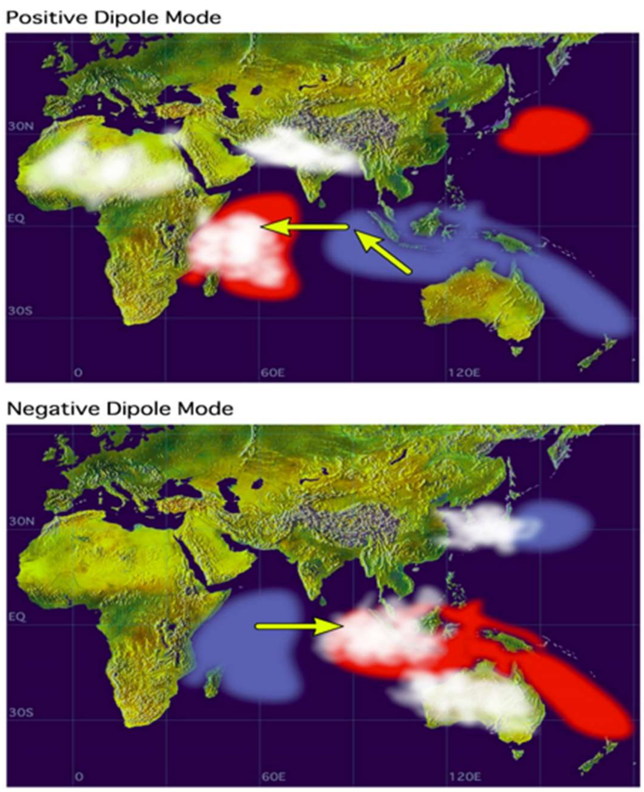
25. What is the Indian Ocean Dipole (IOD)?

The Indian Ocean Dipole (IOD) is a naturally occurring climate phenomenon characterized by differences in sea surface temperatures between the western and eastern equatorial Indian Ocean. Like ENSO, the IOD has three phases: positive, negative, and neutral.

The IOD typically develops during boreal summer, peaks during September–November, and weakens rapidly thereafter. It influences rainfall patterns over the Indian Ocean region, eastern Africa, Australia, and South Asia.

A Positive Indian Ocean Dipole (Positive IOD) occurs when the western equatorial Indian Ocean is warmer than normal and the eastern equatorial Indian Ocean (near Indonesia) is cooler than normal. This temperature contrast strengthens easterly wind anomalies along the equator.

A Negative Indian Ocean Dipole (Negative IOD) occurs when the eastern equatorial Indian Ocean is warmer than normal and the western equatorial Indian Ocean is cooler than normal, which strengthen the westerly wind anomalies along the equator.



Schematic diagram representing positive IOD events (Top panel) and negative IOD events (Bottom panel)

26. How is the Indian Ocean Dipole (IOD) defined?

The Indian Ocean Dipole (IOD) is monitored using the Dipole Mode Index (DMI), which measures the difference in sea surface temperature (SST) anomalies between two regions of the tropical Indian Ocean:

Western Indian Ocean: 50°E–70°E, 10°S–10°N

Eastern Indian Ocean: 90°E–110°E, 10°S–Equator

The DMI is calculated as:

DMI = SST anomaly (Western Indian Ocean) − SST anomaly (Eastern Indian Ocean)

Based on the DMI:

1. Positive IOD: DMI ≥ +0.4°C
2. Negative IOD: DMI ≤ −0.4°C
3. Neutral IOD: −0.4°C < DMI < +0.4°C

For an IOD event to be declared operationally, these thresholds are typically maintained for several consecutive weeks during the boreal summer and autumn.

27. How does the IOD affect the Indian Summer Monsoon?

The IOD can significantly influence the strength of the Indian Summer Monsoon, although its impact varies from year to year.

Positive IOD: Warmer-than-normal waters in the western Indian Ocean and cooler-than-normal waters near Indonesia generally enhance moisture transport toward India and tend to favour above-normal monsoon rainfall.

Negative IOD: Warmer waters near Indonesia and cooler waters in the western Indian Ocean generally suppress convection over the Indian subcontinent and may contribute to below-normal monsoon rainfall.

28. Can the IOD offset the impact of El Niño?

Yes. A positive IOD can partially or, in some cases, substantially offset the weakening influence of El Niño on the Indian Summer Monsoon. For example, some El Niño years with a strong positive IOD have experienced near-normal monsoon rainfall despite the presence of El Niño. For example year 1997 despite being an strong El Nino, Indian Summer Monsoon Rainfall was normal.

Conversely, a negative IOD occurring together with El Niño can further increase the likelihood of below-normal monsoon rainfall.

Therefore, IMD considers both ENSO and IOD while preparing seasonal monsoon forecasts.

29. Why does IMD monitor multiple climate modes?

No single climate phenomenon determines the behaviour of the Indian Summer Monsoon. Seasonal rainfall over India is influenced by the combined effects of several large-scale climate drivers, including:

1. El Niño–Southern Oscillation (ENSO)
2. Indian Ocean Dipole (IOD)
3. Atlantic Zonal Mode (Atlantic Niño)
4. Madden–Julian Oscillation (MJO)
5. Eurasian snow cover
6. Other ocean–atmosphere interactions

The India Meteorological Department (IMD) monitors all these factors to produce reliable seasonal climate outlooks.