# Understanding El Nino & Indian Summer Monsoon

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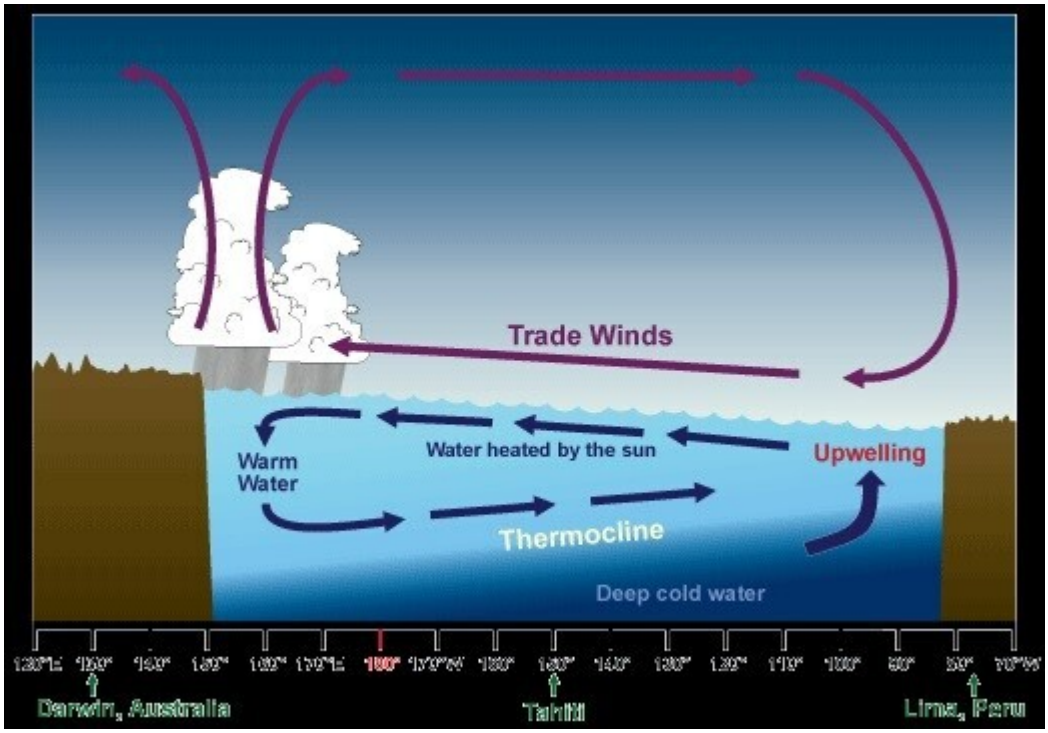
## El Nino – Talk of the town

*There is a buzz around the media and among the weather enthusiastic that as El Nino is likely to gradually increase and which will adversely affect the performance of southwest monsoon during 2023.*

*To understand the severity and actual facts , lets first understand the normal wind pattern over the globe and then what are the changes that develop El Nino and La Nina weather events over tropical pacific ocean.*

*Afterwards, we will look into the yearwise El Nino / La Nina / Neutral events and monsoon performance during southwest monsoon season over India during 1950 to 2021*




Normal Atmospheric Circulation

# Understanding ElNino & Indian Summer Monsoon

The movement of air across the surface of the Earth is called wind and the movement is caused by the difference in air pressure. The wind moves from high pressure area to low pressure area. Due to differential heating of the surface of the Earth, there are permanent high and low pressure zones and wind follows the permanent pattern over the surface of the earth. These are called prevailing winds or planetary winds. There are three types of prevailing winds- Polar easterlies, westerlies and trade winds or tropical easterlies.

Trade winds are defined as the wind that flows towards the equator from northeast direction in the Northern hemisphere or from the southeast direction in the Southern hemisphere. These winds are known for their consistency in speed and direction.

**In normal condition,** the trade winds blow to the west along the equator from South America towards Asia in the tropical Pacific Ocean. These strong winds push the warm surface water towards westward. The sea surface temperature is about 8 deg. C higher in the western Pacific than the waters off South America.

These winds pile up warm surface water off Asia. The average sea level height is about 1 feet higher at Indonesia than at Peru. Consequently, it makes a deeper warm layer ( about 150 meter) in the western Pacific which pushes the thermocline down whereas thermocline rises ( about 30 meter ) in the eastern Pacific.

However, due to natural climate variability, the normal pattern of atmospheric circulation and precipitation over Equatorial Pacific Ocean has been disrupted. **There are two events namely, El Nino and La Nina.**

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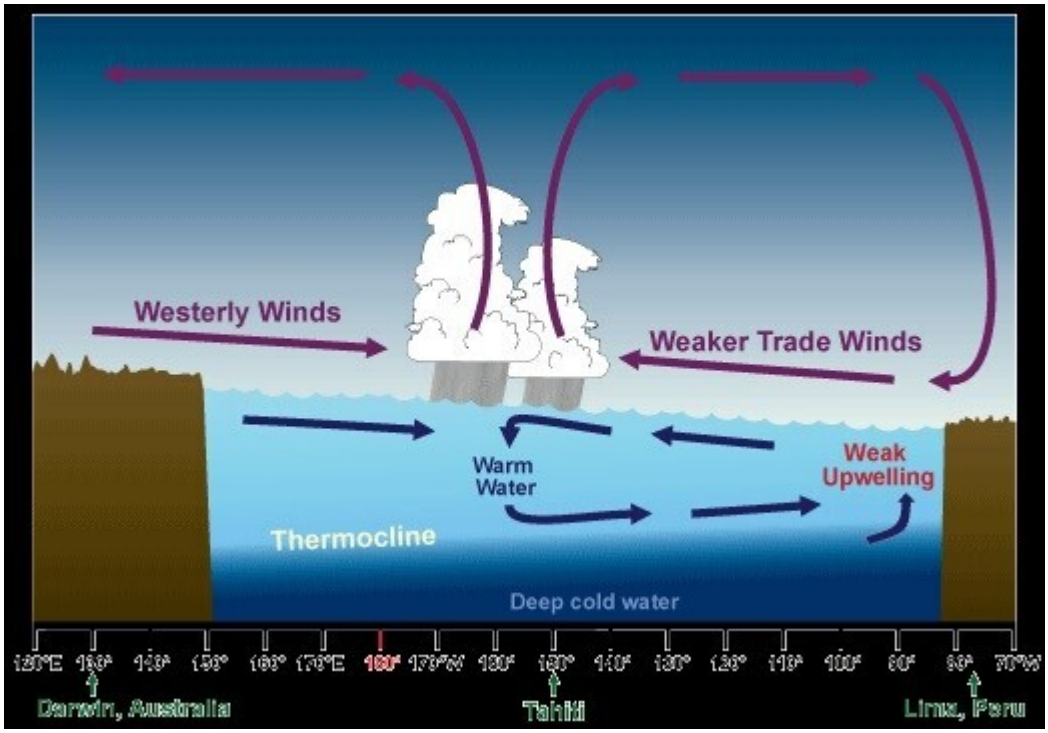


El Nino, meaning “boy child” in Spanish, was first used in the nineteenth century by fishermen in Peru and Ecuador to refer to the unusually warm waters that reduced their catch just before Christmas. During an El Nino event, the trade winds over Pacific Ocean are weaken or reverse, allowing warm water to move eastward towards the coast of South America which results in change in tropical atmospheric circulations.

El Niño is often associated with warm and dry conditions in southern and eastern inland areas of Australia, as well as Indonesia, the Philippines, Malaysia and central Pacific region and wetter than normal conditions are typically observed along the Gulf Coast of the United States, the west coast of tropical South America (Colombia, Ecuador and Peru) and from southern Brazil to central Argentina. Parts of eastern Africa (Kenya, Uganda) also usually receive above-normal rainfall. During the northern hemisphere summer season, the Indian monsoon rainfall generally tends to be less than normal. El Niño is associated with milder winters in north-western Canada and Alaska and drier than normal conditions are typically observed over south-eastern Africa and northern Brazil.

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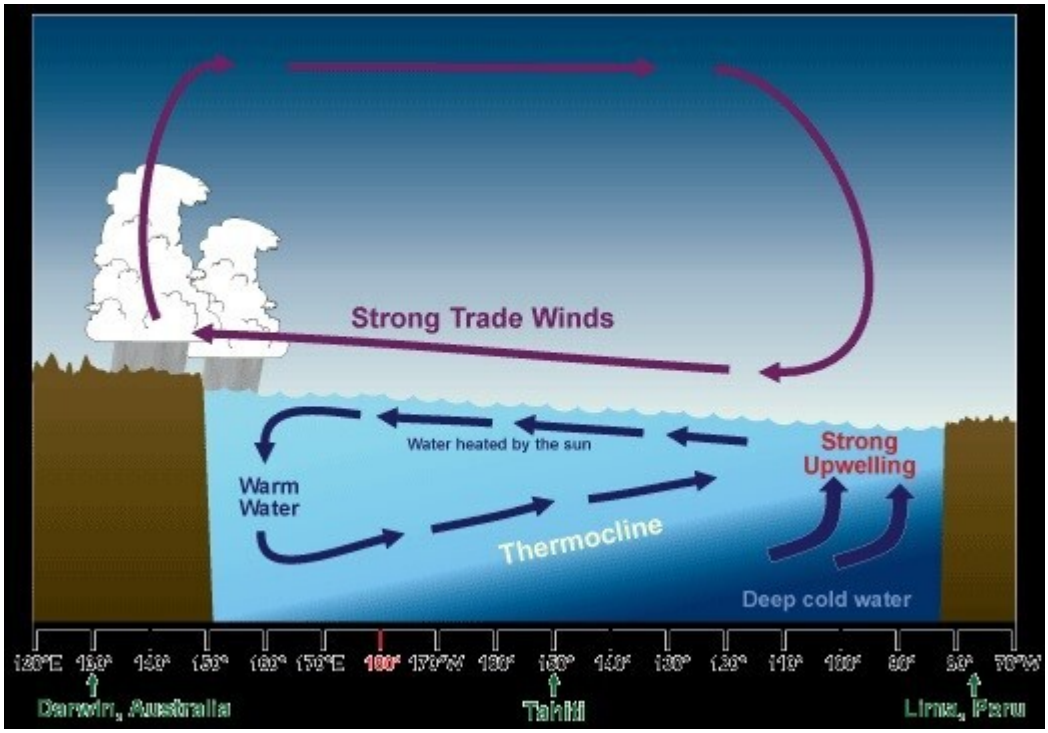



The opposite of El Niño is known as La Niña, which means “little girl”. There are occasions when the trade winds that blow west across the tropical Pacific are stronger than normal. This leads to the large-scale cooling of the ocean surface temperatures and increased upwelling off South America.

In many locations, La Niña cold episodes produces the opposite climate effects to El Niño. La Niña is often associated with wet conditions in eastern Australia, and with heavy rainfall in Indonesia, the Philippines and Thailand. Increased rainfall is also observed in North Eastern Brazil, Colombia and other northern parts of South America and is associated with rainfall deficiency in Uruguay and parts of Argentina. Drier than normal conditions are generally observed along coastal Ecuador and North Western Peru.

**Monitoring of El Nino** :

Monitoring of El Niño and La Niña requires observations from both the atmosphere and oceans. These observations are often summarized in terms of various atmospheric and oceanic indices. Some indices are based the absolute departure, or anomaly, from the long-term average of a variable over a region(s).

# Understanding ElNino & Indian Summer Monsoon

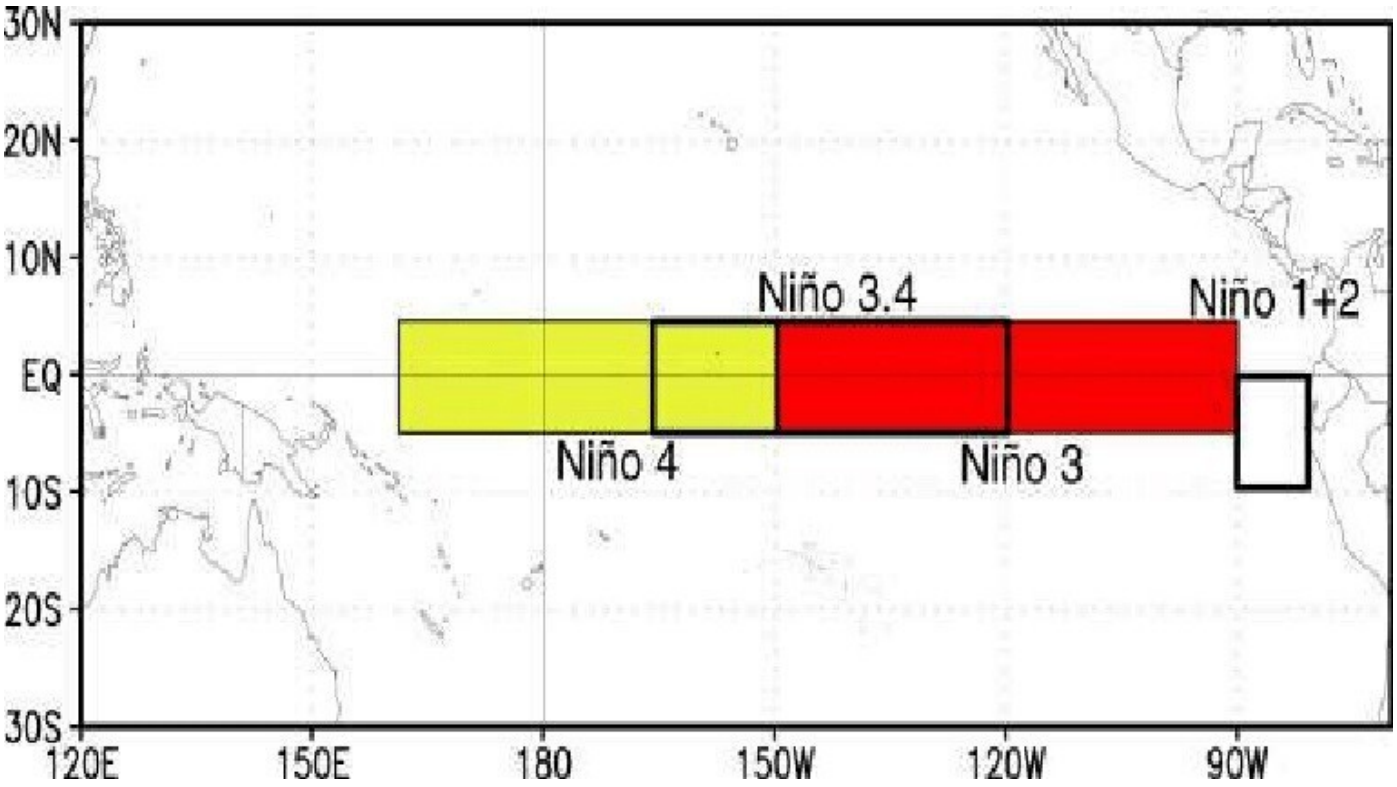
El Nino and the Southern Oscillation, also known as ENSO is a periodic fluctuation in sea surface temperature (El Niño) and the air pressure of the overlying atmosphere (Southern Oscillation) across the equatorial Pacific Ocean.

Sir Gilbert Walker (Director General of Observatories (IMD) 1904-1924) discovered the Southern Oscillation – a large scale fluctuations in sea level pressure between eastern and western tropical Pacific. The Southern Oscillation Index (SOI) is a standardized index based on the observed sea level pressure (SLP) differences between Tahiti and Darwin, Australia. In 1960, Jacob Bjerknes and others realized that the changes in the ocean and the atmosphere were connected. It is found that the tropical ocean affects the atmosphere above it and the atmosphere influences the ocean below it. Prolonged periods of negative (positive) SOI values coincide with abnormally warm (cold) ocean waters across the eastern tropical Pacific typical of El Niño (La Niña) episodes. Thus a hybrid term of ENSO was created.

The Southern Oscillation describes a bimodal variation in sea level barometric pressure between observation stations at Darwin, Australia and Tahiti. It is quantified in the Southern Oscillation Index (SOI), which is a standardized difference between the two barometric pressures. Normally, lower pressure over Darwin and higher pressure over Tahiti encourages a circulation of air from east to west, drawing warm surface water westward and bringing precipitation to Australia and the western Pacific.

When the pressure difference weakens, which is strongly coincidental with El Niño conditions, parts of the western Pacific, such as Australia experience severe drought, while across the ocean, heavy precipitation can bring flooding to the west coast of equatorial South America.

The strengthening and weakening of the trade winds is a function of changes in the pressure gradient of the atmosphere over the tropical Pacific. Ironically, the warming of the sea surface works to decrease the atmospheric pressure above it by transferring more heat to the atmosphere and making it more buoyant. So, in summary, the pressure gradient affects the sea surface temperatures, and the sea surface temperatures affect the pressure gradient. Thus, the two components of ENSO – sea surface temperature and atmospheric pressure are strongly related.




There are several regions of the tropical Pacific Ocean that have been highlighted as being important for monitoring and identifying a developing El Niño or La Niña. Referred to as NINO regions, the most common are shown in the figure below:

- NINO 1+2 (Latitude 0° -10° S, Longitude 80° W -90° W). The region that typically warms first when an El Niño event develops.
- NINO 3 (Latitude 5° S-5° N; Longitude 150° W-90° W). The region of the tropical Pacific that has the largest variability in sea-surface temperature on El Niño time scales.
- NINO3.4 (Latitude 5° S-5° N; Longitude 170° W-120° W). The region that has large variability on El Niño time scales, and that is closer (than NINO3) to the region where changes in local sea-surface temperature are important for shifting the large region of rainfall typically located in the far western Pacific.
- NINO4 (Latitude 5° S-5° N: Longitude 160° E-150° W). The region where changes of sea-surface temperature lead to total values around 27.5° C, which is thought to be an important threshold in producing rainfall

**El Nino and Southwest Monsoon over India**

Monsoon is defined as a seasonally reversing wind system which is characterized by the precipitation. The seasonal reversal of the wind direction brings moisture from the warm waters of the tropical ocean to the Indian continent through southwesterlies. Southwest Monsoon season is considered from June to September but monsoon rains are not experienced everywhere from June to September. There is a gradual progress of southwest monsoon over Indian subcontinent. The Southwest Monsoon season over India contributes over 80% of annual rainfall. The traditional farming in India is totally dependent on monsoon rains. As there is a socio-economic impact of performance of southwest monsoon over India , the forecasting of arrival and strength of monsoon is utmost important.

The weather forecaster analysing and evolving tele connection between performance of southwest monsoon and various global weather systems. El Nino is considered to be one of the influencers on the performance of southwest monsoon. El Nino generally suppresses monsoon rainfall, leading to below average rainfall over large parts of India. This can result in drought like conditions, affecting agriculture, water supply and the overall economy. In contrast, La Niña generally increases monsoon rainfall, leading to above average rainfall over India.

# Understanding ElNino & Indian Summer Monsoon

The data of EL Nino / La Nina events and All India Southwest Monsoon performance during 1950 to 2021 is given below:

| # | First Name | Last Name | Username |
|---|---|---|---|
| 1 | Mark | Otto | @mdo |
| 2 | Jacob | Thornton | @fat |
| 3 | Larry | the Bird | @twitter |

# Understanding ElNino & Indian Summer Monsoon

| Year | All India Southwest Monsoon Performance over Long Period Average ( %) | El Nino / La Nina / Neutral events | Intensity |
|---|---|---|---|
| 1950 | 89 | La Nina | Moderate |
| 1951 | 104 | El Nino | Moderate |
| 1952 | 97 | Neutral | |
| 1953 | 98 | El Nino | Moderate |
| 1954 | 102 | La Nina | Moderate |
| 1955 | 110 | La Nina | Moderate |
| 1956 | 97 | Neutral | |
| 1957 | 103 | El Nino | Moderate |

| | | | |
|---|---|---|---|
| 1958 | 103 | Neutral | |
| 1959 | 110 | Neutral | |
| 1960 | 90 | Neutral | |
| 1961 | 104 | Neutral | |
| 1962 | 85 | Neutral | |
| 1963 | 99 | El Nino | Weak |
| 1964 | 100 | La Nina | Moderate |
| 1965 | 96 | El Nino | Moderate |
| 1966 | 87 | Neutral | |
| 1967 | 85 | Neutral | |
| 1968 | 96 | Neutral | |
| 1969 | 109 | El Nino | Weak |
| 1970 | 98 | La Nina | Weak |
| 1971 | 101 | La Nina | Moderate |

| | | | |
|---|---|---|---|
| 1972 | 95 | El Nino | Moderate |
| 1973 | 95 | La Nina | Moderate |
| 1974 | 98 | La Nina | Moderate |
| 1975 | 94 | La Nina | Weak |
| 1976 | 94 | El Nino | Weak |
| 1977 | 98 | El Nino | Moderate |
| 1978 | 96 | Neutral | |
| 1979 | 97 | Neutral | |
| 1980 | 88 | Neutral | |
| 1981 | 98 | Neutral | |
| 1982 | 91 | El Nino | Strong |
| 1983 | 97 | El Nino | Strong |
| 1984 | 102 | La Nina | Weak |

| | | | |
|---|---|---|---|
| 1985 | 102 | La Nina | Weak |
| 1986 | 90 | El Nino | Strong |
| 1987 | 97 | El Nino | Strong |
| 1988 | 103 | La Nina | Weak |
| 1989 | 104 | La Nina | Weak |
| 1990 | 103 | Neutral | |
| 1991 | 98 | El Nino | Moderate |
| 1992 | 102 | El Nino | Moderate |
| 1993 | 102 | Neutral | |
| 1994 | 107 | El Nino | Moderate |
| 1995 | 102 | El Nino | Moderate |
| 1996 | 95 | Neutral | |
| 1997 | 102 | El Nino | Strong |
| 1998 | 106 | El Nino | Strong |

| | | | |
|---|---|---|---|
| 1999 | 102 | La Nina | Strong |
| 2000 | 95 | La Nina | Strong |
| 2001 | 91 | Neutral | |
| 2002 | 96 | Neutral | |
| 2003 | 102 | Neutral | |
| 2004 | 92 | Neutral | |
| 2005 | 87 | El Nino | Weak |
| 2006 | 99 | El Nino | Weak |
| 2007 | 105 | El Nino | Moderate |
| 2008 | 98 | La Nina | Moderate |
| 2009 | 93 | El Nino | Moderate |
| 2010 | 102 | El Nino | Moderate |
| 2011 | 101 | La Nina | Weak |
| 2012 | 92 | La Nina | Weak |

| | | | |
|---|---|---|---|
| 2013 | 106 | Neutral | |
| 2014 | 88 | El Nino | Strong |
| 2015 | 86 | El Nino | Strong |
| 2016 | 97 | El Nino | Strong |
| 2017 | 95 | Neutral | |
| 2018 | 91 | El Nino | Weak |
| 2019 | 110 | Neutral | |
| 2020 | 109 | La Nina | Moderate |
| 2021 | 109 | La Nina | Moderate |

The above data indicates that the relationship of El Nino and deficient rainfall during southwest monsoon season over India is not totally established. The performance of monsoon depends upon the intensity, duration and spatial distribution of sea surface temperature anomalies in the tropical Pacific Ocean. There are different global weather systems which influence rainfall during monsoon season.

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**The present condition of El Nino / La Nina**

Bureau of Meteorology, Australia declared that La Niña has ended in the tropical Pacific Ocean. The El Niño–Southern Oscillation (ENSO) is now neutral (neither La Niña nor El Niño) with oceanic and atmospheric indicators having returned to neutral ENSO levels.

All models (except one statistical model) in the IRI ENSO prediction plume predict SSTs to transition to an ENSO-neutral state during Mar-May, 2023. The likelihood of El Niño remains low during Mar-May (3%), increasing to 20% in Apr-Jun, and 47% in May-Jul, and then becomes the dominant category thereafter with probabilities in the 56-59% range from Jun-Aug to Oct-Dec 2023

Reference :-


1. World Meteorological Organisation
2. National Weather Services ,
3. Columbia Climate School
4. Bureau of Meteorology, Australia
5. National Oceanic and Atmospheric Administration