



## Monsoon 2021, a series of extreme weather events

The Monsoon season in 2021 has been a roller coaster ride. Weather models went haywire, making it the most pulsating season so far. While both the onset and withdrawal months made thumping beginning and end respectively, core monsoon months of July and August, failed miserably. This unpredictability is making weather forecasting an increasing challenge and meteorologists believe that it will continue to be so amidst changing weather dynamics.

It would not be wrong to term Monsoon 2021 as the season of extremes. Right from extremely deficient rainfall to extremely surplus rainfall across the country. The deficit rainfall pockets such as West Madhya Pradesh, East Rajasthan, and Marathwada and Vidarbha regions of Maharashtra are all surplus, while the rainiest pockets like Kerala, Odisha and north-eastern pockets of the country struggled to meet their average rainfall quota. According to [an analysis by Council for Energy, Environment and Water \(CEEW\)](#), more than 75% of Indian districts are exposed to extreme climate events. Subsequently, over 40% have experienced climatic disruptions such as a shift from being flood-prone to being drought-prone, or vice-versa.

Southwest Monsoon 2021 has come to an end with normal rainfall to the tune of 99% of the long period average (LPA). However, rainfall distribution has been completely erratic. This pattern has once again reaffirmed **the climate change impact on Indian Summer Monsoon rainfall**. We bring you a brief list of erratic Monsoon patterns this season.

### Monthly Monsoon performance

June: The onset month made a thumping start around the near normal date. The progress as well as performance of Monsoon 2021 was steady through the initial two phases of the Southern Peninsula and East & Northeast India. However, Monsoon stalled thereafter just before entering the third phase of Northwest India. The month ended with surplus rainfall to the tune of 110% of LPA. The dry spell consumed the surplus of June during the last week itself.

July: The month started on a deficit note and the first 10 days of the month saw the performance of Monsoon deteriorating further. As of July 11, the countrywide rainfall was deficit by 8%. Although last week saw some revival, the month ended with a deficit of 93%.

|                 |                   |  |     |
|-----------------|-------------------|--|-----|
| All India       | June to September | Normal (96-104% of LPA)<br>101± 4 of LPA | 99  |
| Northwest India | June to September | Normal (92-108% of LPA)                  | 96  |
| Central India   | June to September | Above Normal (>106% of LPA)              | 104 |
| Northeast India | June to September | Below Normal (<95% of LPA)               | 88  |
| South Peninsula | June to September | Normal (93-107% of LPA)                  | 111 |

**Image Courtesy: IMD**

August: With 24% deficit rainfall, August 2021 made history as the worst performance this Monsoon. While it has been the sixth driest August since 1901, it is the first since 2009 which was a drought year, courtesy of El Nino. The reason can be attributed to absence of the Monsoon weather systems, which then kept the Monsoon trough north of its normal position, bringing torrential rains across the hilly states of Himachal Pradesh, Uttarakhand and foothills of Himalayas like East Uttar Pradesh and Bihar. Also, these Monsoon systems keep activating the semi-permanent off-shore trough along the West Coast. However, in the absence of these weather systems the trough remained weakened. [Indian Ocean Dipole \(IOD\)](#) too remained negative for most of the month. Following figure shows the number of low pressure areas formed during the season. **Image Courtesy: IMD**

| Category | CS | DD | D | WML | L | Total LPS systems | Total PLS Days | Long period Average of Total no of LPS /Days |    |
|----------|----|----|---|-----|---|-------------------|----------------|--|----|
| June*    | 0  | 0  | 0 | 0   | 2 | 2                 | 8              | 3  | 11 |
| July     | 0  | 0  | 0 | 2   | 2 | 4                 | 12             | 3  | 14 |
| August   | 0  | 0  | 0 | 0   | 2 | 2                 | 13             | 4  | 17 |
| Sept.    | 1  | 1  | 0 | 2   | 1 | 5                 | 29             | 3  | 15 |
| Total    | 1  | 1  | 0 | 4   | 7 | 13                | 62             | 13   | 57 |

*“Barring a few days, the countrywide cumulative rain deficiency on a daily basis has been 30%-40%. Prolonged dry spells from August 4-25 had pushed the country towards drought-like*

conditions. Usually, we see four low pressure areas during the month, but 2021 saw just two of them which were also feeble ones. Besides this, typhoon activity in the Pacific Ocean was also less, whose remnants usually travel across the Bay of Bengal and gain strength,” said G P Sharma, President- Meteorology and Climate Change, Skymet Weather.

Following are the key factors responsible for deficient rainfall in August:

- **Negative Indian Ocean Dipole unfavorable for Indian monsoon prevailed**
- **Absence of formation of monsoon depression. Normally two monsoon depression forms in the month of August.**
- **Less number of low pressure area formed over Bay of Bengal. Two against 4 formed during (16-18 & 28-30 Aug.)**
- **Unfavorable MJO conditions over Indian Ocean: During most of the days MJO was in the phase 8, 1 and 2 which are unfavorable for monsoon rainfall activity.**
- **Less West Pacific Typhoon activity. Remnants of westward moving typhoons help to form LPS over Bay of Bengal.**

**Image Courtesy: IMD**

September: The withdrawal month saw what can be termed as a miraculous recovery of Monsoon across India. This can be attributed to the formation of five low pressure areas, resulting in heavy downpour. Usually, recovering from a deficit as large as 24% on August 31 is next to impossible. In 2009, August was deficit by 26%, followed by the rain deficiency of 19% in September. However, it has been a completely opposite scenario in September 2021. As of September 29, the countrywide cumulative rainfall stands at 874.6 mm against the normal of 880.6 mm, which is 99% of the LPA (Long period average) from June to September.

*“The month has performed beyond expectations and such a rebound is quite rare. From extreme failure in August to extreme recovery in September is nothing short of a miracle. The month on its own was able to pull the countrywide rainfall from ‘below normal’ to ‘normal’ category. Oceanic parameters IOD, and [Madden Julian Oscillation \(MJO\)](#) and evolving [La Nina](#) are to be given credit, which aligned all together for the first time to save the falling Monsoon. All*

*these conditions led to the formation of back to back Monsoon low pressure areas,” said G P Sharma.*

Besides this, the Arctic sea-ice loss in summer has also led to late season rainfall extremes. **According to Professor Raghu Murtugudde, an Earth System Scientist at CMNS-Atmospheric & Oceanic Science,** *“Reduced sea-ice in the Arctic during summer, especially over the Kara Sea, leads to high sea-level pressure over Western Europe and Northeastern China, which steer planetary waves southeastward instead of their eastward trajectory. And these waves enter India late in the season to produce circulation anomalies in the upper atmosphere, resulting in heavy rainfall in September. The convergent air is able to feed on the warm Arabian Sea and bring in boatloads of moisture to produce heavy rainfall events in September. This causal link tends to occur late in the season, because the summer sea-ice loss drives a slightly delayed wave response to arrive into India.”*

Following are the key factors responsible for surplus rainfall in September:

- **Sept 2021 had 2nd Highest for 1994-2021(28 years) after 2019(+52%)**
- **Weakening of Negative Indian Ocean Dipole during September**
- **Formation of monsoon depression and one system intensified in to Cyclonic Storm.**
- **Favorable MJO conditions over Indian Ocean: During most of the days MJO was in the phase 3, 4 and 5 which are favorable for monsoon rainfall activity.**
- **More West Pacific Typhoon activity and the Remnants of westward moving typhoons help to form LPS over Bay of Bengal.**

*Image Courtesy: IMD*

#### **Failure of core Monsoon months - Missing link of Atlantic Niño**

As predicted, the country recorded normal Monsoon rains to the tune of 99%. However, the core Monsoon months of July and August failed to perform. Meteorologists have attributed this to the



absence of Monsoon low pressure areas that account for 60 per cent of the seasonal total rainfall. But, what is the reason behind these missing low pressure areas?

*“The erratic evolution of the monsoon through July and August can be attributed to the little brother of the El Niño from the Atlantic. Atlantic Niño’s impact on the monsoon was established in 2014 when an INCOIS led study showed that the number of low-pressure systems is sharply reduced by the Atlantic Niño, leading to deficit monsoons. This season, the sea-surface temperatures over the tropical eastern Atlantic were warmer than normal. The strongest Atlantic Niño event of the past 40 years occurred during June-August. We can blame the significantly fewer low-pressure systems in 2021 on the Atlantic Niño. Monsoon 2021 is a clear example of this missed link,”* added **Professor Raghu Murtugudde**.

### **More rains and more dry days**

The country might have scored the desired number of normal rainfall but it is far away from being a normal one. The rainfall distribution has gone for a toss as we now see the majority of rainfall in just a few days. *“Monsoon 2021 has recorded 874.6 mm against the normal of 880.6 mm. With this, we can say that rains are more but rainy days are still less. There are large gaps between the rainy spells, increasing the dry spells,”* said **Mahesh Palawat, VP- Meteorology and Climate Change, Skymet Weather**.

*“Extreme weather events are the clear cut result of climate change. Frequency of heavy rainy days during the Monsoon has increased and the frequency of light rainy days have decreased,”* said **Mrutyunjay Mohapatra, Director General of Meteorology, India Meteorological Department**.

### **Less number of Monsoon low pressure areas in Bay of Bengal but more inland**

The Bay of Bengal hosts 60% of Monsoon low pressure areas. However, it has been noticed that the intensity as well as the frequency of these weather systems have decreased. The scenario was seen during July and August, which resulted in deficit rainfall. However, there is an increase in the intensity of the lows forming over the land. According to meteorology, the system needs moisture to gain or retain the strength, but there is a drastic decrease in the moisture as the weather system nears the land mass. *“Heating of land has resulted in instability of the atmosphere. This sets in the conducive environment for the low pressure area travelling inland. It does not let the weather system lose its strength. Apart from available Monsoon current, the increased warming of land further fuels in providing moisture to the system, strengthening it further,”* added **Mahesh Palawat**.

### **Northeast India: A perpetual rain deficit pocket**



After the West Coast, Northeast India accounts for the second highest rainfall contributor of the season. However, the situation has changed and the region is now touted as the perpetual rain deficit pocket. In the last decade, East & Northeast India has been recording below normal rainfall, barring 2020 which managed surplus rains. 2021 also seems to follow the same track and the season is most likely to end with rain deficiency.

**Rainfall statistics for East & Northeast India from 2012-2021:**

| Year | Actual Rainfall (in mm) | Departure from normal |
|------|-------------------------|-----------------------|
| 2021 | 1246.2                  | -12%                  |
| 2020 | 1500.3                  | 6%                    |
| 2019 | 1243.8                  | -12%                  |
| 2018 | 1085.5                  | -25%                  |
| 2017 | 1409.0                  | -2%                   |
| 2016 | 1292.0                  | -10%                  |
| 2015 | 1343.4                  | -7%                   |
| 2014 | 1292.8                  | -10%                  |
| 2013 | 1045.5                  | -27                   |
| 2012 | 1305.5                  | -9%                   |

Source: IMD



*“This rainfall consistent deficiency can be attributed to the changing weather patterns. Both the frequency and track of Monsoon systems are responsible. Most of the weather systems forming in the Bay of Bengal do not tend to follow the usual track northwards, instead they move now more often to the east-west track. As a result, the Monsoon trough remains south for most of the time. Also, the wind pattern continues to change from easterly to humid south-westerly. Simultaneously, the frequency of low-pressure areas in the Bay has also come down. Thus, we can say that weather conditions have modified a lot and the result is in front of us,” said G P Sharma.*

### **Withdrawal of Monsoon strikes a hatrick**

Southwest Monsoon 2021 has defied the official withdrawal date and is unlikely to commence anytime soon before October 6-7. With this, it is all set to score a hat trick in the delayed retreat of the Monsoon season after 2019 and 2020. While 2020 saw the process of withdrawal of Monsoon commencing on September 28, it was 2019 which started bidding farewell to Monsoon rains on October 9, making it the most delayed retreat of the monsoon since 1975.

As reiterated above, atmospheric conditions kept the Monsoon current active. IOD and La Nina could be given special mention for letting Monsoon leave the country. *“La Nina has a strong relation with the wetter Monsoon and evolving it may lead to delayed withdrawal of the Monsoon. This is what has been seen this season. A transition from Neutral to La Nina is likely during the winter of 2021-22. In mid-September, sea surface temperatures (SSTs) in the east-central Pacific are about -0.4°C different from the average. Key atmospheric variables are in consonance with neutral conditions. A La Nina watch is ‘on’ for September 2021,” said G P Sharma.*

Earlier, the stipulated withdrawal from extreme West Rajasthan was September 01. However, looking at the changing weather patterns during 1971-2019, this was revised last year and the new date has been fixed at September 17. Withdrawal dates have been shifted by 7-14 days across most parts of the country including the national capital, where the new date is taken as September 25.

*“Unlike onset, we do not have set criteria for the withdrawal of Monsoon but we need to have a visible change in the atmospheric conditions before the announcement of retreat. The rains over the region, by and large, have to cease, followed by the reversal of wind patterns to drier north-westerly. Secondly, a drop in the humidity along with mostly sunny days has become a norm. Rise in the day temperature at least for a week or two, nearly coincides with the 2nd summer for the region,” said GP Sharma.*

### **Cyclone Gulab, third cyclone in Bay of Bay Bengal of the century in September**



Another rare event during the Monsoon 2021 is the formation of a tropical storm in September. Cyclone Gulab had formed in the Bay of Bengal and made landfall near Srikakulam over North Coastal Andhra Pradesh around midnight on September 26. Gulab is the third cyclone of this century to form in September after Cyclone Daye hitting Odisha near Gopalpur on September 21, 2018 and Cyclone Pyaar on September 19, 2005.

The post monsoon Cyclone season spans from October to December for the Indian Seas, both the Bay of Bengal and the Arabian Sea. Accordingly, very few storms form in September, the fag end of the southwest monsoon season as the Monsoon current is very strong and vertical wind shear is very high. Moreover, striking the Andhra Pradesh coastline is further rare, as the storms normally head for the Odisha coast during this time.

## Appendix

- A. **La Niña:** La Niña is an oceanic and atmospheric phenomenon that is the colder counterpart of El Niño, as part of the broader El Niño–Southern Oscillation (ENSO) climate pattern. It is known to give above-normal rains during the Southwest Monsoon. However, it has the capacity to reduce the Northeast Monsoon rains in southern India.
- B. **Indian Ocean Dipole (IOD):** It is defined by the difference in SST (Sea surface temperatures) between the eastern and western tropical Indian Ocean. Positive IOD enhances the rains over the Indian region. In fact, being neutral on the positive also aids the rainfall.
- C. **Madden-Julian Oscillation (MJO):** It is a transitional feature that has a cycle of 40-60 days as it visits the Indian Ocean. Whenever MJO is in Phase 2 and 3 i.e. the Indian Ocean, it enhances the rainfall over the Indian region. Being a transit feature, one cannot ascertain its availability at this point of time.