Frequently Asked Questions (FAQs) on Monsoon

Q. What is southwest monsoon? What causes the monsoon? Which are the prominent monsoon regions, other than India?

A. The seasonal reversal of winds and the associated rainfall. This word is derived from the Arabic word “Mausim”. The annual oscillation in the apparent position of the Sun between the Tropics of Cancer and Capricorn causes the annual oscillation in the position of the thermal equator (region of maximum heating) on the Earth’s surface. This is associated with the annual oscillation of temperature, pressure, wind, cloudiness, rain etc. This is the cause of the monsoons. On the Earth’s surface, there are asymmetries of land and Ocean. The differential heating of land and Ocean cause variations in the intensity of the annual oscillation of the thermal equator and hence regional variations in the intensity of monsoon. The southwesterly wind flow occurring over most parts of India and Indian Seas gives rise to southwest monsoon over India from June to September.

Q. What is Forecasting?

A. In science, the forecasting means the process of estimation of the value of some variable at some future time. One of the primary functions of the national Weather services is forecast of weather parameters such as rainfall, temperature, wind, humidity etc. over a region averaged over a particular time period. For example forecast of daily rainfall (rainfall averaged over a day).

Q. What is Nowcasting?

A. A weather forecast in which the details about the current weather and forecasts up to a few hours ahead (but less than 24 hours) are given.

Q. What is short range weather forecasting?

A. Short range weather forecasts are weather forecasts valid up to 72 hours ahead. This forecast range is mainly concerned with the weather systems observed in the latest weather charts and also by considering the generation of new systems within the time period.

Q. What are medium range forecasts?

A. These are weather forecasts generally valid for a period of 4 to 10 days (However, up to 7 days in tropics). In this, the average weather conditions and the weather on each day will be prescribed with progressively lesser details and accuracy than that of the short range forecasts.

Q. What is long range forecast?

A. As per the World Meteorological Organization (WMO) definition, long range forecast is defined as the forecast from 30 days’ up to one season’s description of averaged weather parameters. The seasonal forecast comes under long range forecast.

Q. What is extended range forecast?

A. This is the forecast range lies between long range (seasonal) and medium range. Thus, it starts generally from days 10 (however, beyond days 7 in tropics) up to one month.

Q. What are the seasons defined by the India Meteorological Department for the country as a whole?

A. Meteorological seasons over India are:
   Winter Season: January – February
Pre Monsoon Season: March – May
Southwest Monsoon Season: June - September
Post Monsoon Season: October - December

Q. What is maximum temperature?
A. It is the highest temperature attained during a day. It often occurs during the afternoon hours.

Q. What is minimum temperature?
A. It is the lowest temperature recorded which usually occurs during the early morning hours.

Q. What is atmospheric pressure?
A. The pressure of the atmosphere at any point is the weight of the air column which stands vertically above unit area with the point as its centre. For meteorological purposes, atmospheric pressure is usually measured by means of a mercury barometer where the height of the mercury column represents the atmospheric pressure. The pressure is expressed in hPa (Hecta Pascal) which is defined as equal to $10^6$ Newton/m$^2$.

Q. How do we express the quantity of rainfall?
A. Liquid rainfall is expressed as the depth to which it would cover a horizontal projection of the earth’s surface, if there is no loss by evaporation, run–off or infiltration. It is expressed in terms of mm or cm. It is assumed that the amount of precipitation collected in the gauge is representative of a certain area around the point where the measurement is made. The choice of the instrument and the site itself, the form and exposure of the measuring gauge, the prevention of loss of precipitation by evaporation and the effects of wind and splashing are some of the important points to be considered in the correct measurement of precipitation.

Q. What is a thunderstorm?
A. A Thunderstorm is defined as a meteorological phenomenon in which one or more sudden electrical discharges manifested by a flash of light (Lightning) and a sharp rumbling sound (thunder) occurs from a cloud of vertical development.

Q. What is a Dust storm?
A. A Dust storm is an ensemble of particles of dust or sand energetically lifted to great heights by a strong and turbulent wind. Often the surface visibility is reduced to low limits; the qualification for a synoptic report is visibility below 1000 m.

Q. What are clouds and how they are classified?
A. Clouds are aggregate of very small water droplets, ice crystals, or a mixture of both, with its base above the earth’s surface. A classification is made in level – high, medium, or low – at which the various cloud genera are usually encountered. In temperate regions the approximate limits are high, 5-13 km (16500 – 45000 ft); medium, 2-7 km (6500 – 23000 ft); low, 0-2 km (0 – 6500 ft). The high clouds are Cirrus (Ci), Cirrocumulus (Cc), Cirrostratus (Cs). The medium clouds are Altocumulus (Ac), Altostratus (As) (the latter often extending higher) and Nimbostratus (Ns) (usually extending both higher and lower); The low clouds are Stratocumulus (Sc), Stratus (St), Cumulus (Cu), and Cumulonimbus (Cb).
Q. What are land and sea breezes?

A. Land and Sea Breezes are local winds caused by the unequal diurnal heating and cooling of adjacent land and water surfaces; under the influence of solar radiation by day and radiation to the sky at night, a gradient of pressure near the coast is produced. During the day, the land is warmer than the sea and a breeze, the Sea Breeze, blows onshore; at night and in the early morning the land is cooler than the sea and the land breeze blows off shore.

Q. What are the different methods used for long range forecasting?

A. In general, three approaches are used. These are (i) statistical method (ii) numerical weather prediction or dynamical method and (iii) dynamical cum statistical method.

Q. Who is responsible for issuing operational long range forecast in India? What method is used for the purpose?

A. India Meteorological Department is solely responsible for issuing operational long range forecast for India. The forecasts are prepared at the National Climate Centre of IMD located at Pune. At present, empirical (statistical) methods are used for the preparation of operational long range forecasts.

Q. Which are the countries that use empirical models for long range forecasts?

A. In addition to India, there are several other countries like United States, United Kingdom, Australia, South Africa, Brazil etc., which use empirical methods extensively for long range forecasting. For example, for the long range forecasting of ENSO, many international climate centres use empirical models.

Q. What are the long range forecasts prepared by IMD and when are they issued.

A. IMD issues operational long range forecast for the rainfall during SW Monsoon Season (June-September). These forecasts are issued in two stages. The first stage forecast is issued in mid-April and consists of quantitative forecast for the season (June to September) rainfall over India as a whole. The second stage forecasts issued by the end of June consist of update for the forecast issued in April, a forecast for July rainfall over the country as whole and forecasts for seasonal rainfall over broad rainfall homogeneous regions of India.

IMD also prepares forecasts for winter (Jan- March) precipitation (issued in the end of December) over Northwest India and northeast monsoon (October-December) rainfall over Southern Peninsula (issued in October). However, these forecasts are issued only to the government.

Looking at the potential of numerical models, IMD has also established an experimental prediction system based on General Circulation Model (GCM) in addition to its existing operational forecasting system based on statistical models. For this purpose, IMD uses the seasonal forecasting model (SFM) developed at the Experimental Climate Prediction Centre (ECPC), Scripps Institute of Oceanography, USA. The skill of the numerical model based forecasting system is to be validated for some more years before the same can be used for operational purpose.

Q. What is the accuracy of the long range forecast for monsoon rainfall issued by IMD?

A. The monsoon prediction in our country is being done with reasonable accuracy. The
success rate of IMD forecasts since 1988 has been high. During the last 21 years (1988-2008), IMD forecasts were qualitatively correct in 19 years (i.e. 90% of years). The exception was during years 2002 and 2004 both of which were drought years. However, in some years (1994, 1997, 1999, 2002, 2004 and 2007) the forecast error (difference between actual rainfall and forecast rainfall) was more than 10%. The 2002 drought was due to exceptionally low rainfall during the month of July (46% of long term period) caused by unexpected sudden warming of sea surface over equatorial central Pacific that started in the month of June. It may be mentioned that the exceptionally deficient rainfall of July, 2002 was not predicted by any prediction group in India or abroad. It is not possible to have 100% success for forecasts based on statistical models. The problems with statistical models are inherent in this approach and are being faced by forecaster world wide.

Q. What is the difference between weather and climate?

A. Climate, in a narrow sense, can be defined as the average weather conditions for a particular location and period of time. In a wider sense, it is the state of the climate system. Climate can be described in terms of statistical descriptions of the central tendencies and variability of relevant elements such as temperature, precipitation, atmospheric pressure, humidity and winds or through combinations of elements, such as weather types and phenomena that are typical to a location, region or the world for any period of time.

Q. How far ahead can we predict the weather and climate these days?

A. Five-day weather forecast today is generally as reliable as a three-day forecast two decades ago. Outlooks of up to a week, especially in temperate mid-latitude regions are becoming increasingly reliable. Information can be disseminated around the world from one location to another within three hours, while recently understood phenomena such as El Niño Southern Oscillation (ENSO) (El Niño, La Niña and neutral phases) can be forecast up to a year in advance. Seasonal climate predictions can be forecast up to a month, three months or six months ahead although these climate predictions are probabilistic in nature. Such forecasts, often from advanced centres, are made available globally to all nations.

Q. Why are weather forecasts sometimes inaccurate?

A. Air pressure, temperature, mountain ranges, ocean currents and many other factors combine to produce an enormous quantity of interacting variables all of which can alter the weather to a greater or lesser extent. However, greater understanding of the science, plus the use of powerful computer models, continue to improve our ability to make more accurate predictions with longer lead times.

Q. What is the difference between climate change and climate variability?

A. Climate variability is the term used to describe a range of weather conditions that, averaged together, describe the “climate” of a region. In some parts of the world, or in any region for certain time periods or parts of the year, this variability can be weak, i.e. there is not much difference in the conditions within that time period. However, in other places or time periods, conditions can swing across a large range, from freezing to very warm, or from very wet to very dry, thereby exhibiting strong variability. A certain amount of this is understood and accepted by the region’s inhabitants. Occasionally, an event or sequence of events occurs that has never been witnessed or recorded before, such as the exceptional hurricane season in the Atlantic in 2005 (though even that could be part of
natural climate variability). If such a season does not recur within say, the next 30 years, we would look back and call it an exceptional year, but not a harbinger of change. For the scientific community to recognize a change in climate, a shift has to occur, and persist for quite a long time. The Intergovernmental Panel on Climate Change (IPCC) is conducting considerable efforts in trying to determine, for various hydrometeorological hazards (e.g. tropical cyclones and tornadoes) and for related events (e.g. flash floods), whether their occurrence is affected by human-induced climate change. The IPCC Fourth Assessment Report provides evidence that climate change affects the frequency and (or) intensity of some of those events, but further work is under way to refine those findings and prepare a more comprehensive assessment as part of a Special Report to be published in 2011.

Q. What are El Niño and La Niña?

A. El Niño, Spanish for "boy child" (because of the tendency of the phenomenon to arrive around Christmas), is an abnormal warming of water in the Equatorial Pacific Ocean every three to five years and can last up to 18 months. Severe cases of El Niño, as in 1997/98, are responsible for drought, flooding, as well as areas of formation for tropical cyclones and severe winter storms. The 1997/98 El Niño and its associated impacts have been blamed for the deaths of hundreds of people and caused billions of dollars of damage in an estimated 15 countries especially in the Panama Canal region but also as far away as the east coast of Africa. La Niña means "the little girl", the opposite of El Niño, and refers to the abnormal cooling of the ocean temperatures in the same Pacific region.

Q. What are the different Nino regions for measuring El Nino?

A. For the measurement of strength of El Nino or La Nina the Sea Surface Temperature anomalies are measured over eastern and central Pacific Ocean at 4 different regions as depicted below graphically. These four Nino regions are bounded by

- **NINO12**: 0-10S, 80W-90W
- **NINO3**: 5N-5S, 90W-150W
- **NINO4**: 5N-5S, 150W-160E
- **NINO34**: 5N-5S, 120W-170W

Q. What is Southern Oscillation Index (SOI) and ENSO
A. The Southern Oscillation is the atmospheric component of El Niño. It is an oscillation in air pressure between the tropical eastern and the western Pacific Ocean waters. The strength of the Southern Oscillation is measured by the Southern Oscillation Index (SOI). The SOI is computed from fluctuations in the surface air pressure difference between Tahiti (Over Pacific Ocean) and Darwin, (Indian Ocean near Australia). El Niño episodes are associated with negative values of the SOI, meaning that the pressure at Tahiti is relatively low compared to Darwin.

Low atmospheric pressure tends to occur over warm water and high pressure occurs over cold water, in part because deep convection over the warm water acts to transport air. El Niño episodes are defined as sustained warming of the central and eastern tropical Pacific Ocean. This results in a decrease in the strength of the Pacific trade winds, and a reduction in rainfall over eastern and northern Australia.

ENSO is composed of both El Nino and Southern Oscillation. Thus, the oceanic component called El Niño (or La Niña, depending on its phase) and the atmospheric component, the Southern Oscillation.

Q. What is Walker Circulation

The Walker circulation is named after Sir Gilbert Walker, former Director-General of Meteorology in India during the British rule who, in early 20th century, identified a number of relationships between seasonal climate variations in Asia and the Pacific region. He had shown from his many published papers during 1920s and early 1930s that the weather in Djakarta (Indonesia) and Santiago (Chile) was related in such a way that when the pressure was higher than normal at one place it was lower than normal at the other. As these cities are about 15000 km apart it was difficult at that time to visualize a mechanism for the connection between these distant locations. Later it is understood that what Walker had discovered was part of a teleconnection now known as the Southern Oscillation. The Southern Oscillation Index (SOI) gives a simple measure of the strength and phase of the Southern Oscillation, and indicates the state of the Walker circulation.

The easterly trade winds are part of the low-level component of the Walker circulation. Typically, during normal condition the trades bring warm moist air towards the Indonesian region. Here, moving over normally very warm seas, moist air rises to high levels of the atmosphere. The air then travels eastward before sinking over the eastern Pacific Ocean. The rising air is associated with a region of low air pressure, towering cumulonimbus clouds and rain. High pressure and dry conditions accompany the sinking air.

When the Walker circulation enters its El Niño phase, the SOI is strongly negative and when it enters its La Nina Phase, the SOI is strongly positive.

Q. How does the ENSO affect monsoon?

A. In a typical ENSO, the strong easterly winds of the equatorial Pacific weaken, which allows warm eastward-flowing subsurface waters to rise, increasing surface temperatures 1-2°C and sometimes in the central and Eastern Pacific. Along the West coast of South America, El Niño's warm waters persist and deepen, and cold, upwelling, nutrient-rich waters fail to reach surface waters; the resulting warm, nutrient-poor waters devastate coastal fisheries. Heavy rain falls along the South American coast, and heavy rainfall also moves from the western to central Pacific, causing drier than normal conditions in Indonesia and nearby areas including India.
A. The Indian Ocean Dipole (IOD) is a coupled ocean-atmosphere phenomenon in the Indian Ocean. It is normally characterized by anomalous cooling of SST in the south eastern equatorial Indian Ocean and anomalous warming of SST in the western equatorial Indian Ocean. Associated with these changes the normal convection situated over the eastern Indian Ocean warm pool shifts to the west and brings heavy rainfall over the east Africa and severe droughts/forest fires over the Indonesian region.

(Source : JAMSTEC, JAPAN)

Q. What is Madden Julian Oscillation (MJO)? How it influences monsoon activity?

A. The Madden Julian Oscillation (MJO) is one of the most important atmosphere-ocean coupled phenomena in the tropics, which has profound influence on Indian Summer Monsoon. The MJO is the leading mode of tropical intraseasonal climate variability and is characterized by organization on a global spatial scale with a period typically ranging from 30-60 days, which was discovered by Madden and Julian in 1971 in a published paper. It has the following characteristics:

- MJO is a massive weather event consisting of deep convection coupled with atmospheric circulation, moving slowly eastward over the Indian and Pacific Oceans.
- MJO is an equatorial traveling pattern of anomalous rainfall that is planetary in scale.
- Each cycle lasts approximately 30–60 days. Also known as the 30-60 day oscillation, 30-60 day wave, or intraseasonal oscillation (ISO).
- The MJO involves variations in wind, sea surface temperature (SST), cloudiness, and rainfall.
- Based on the place of convective activity the period of MJO is divided into 1-8 phases with each phase roughly last for 7 to 8 days.
Since the MJO is the most important mode of tropical intraseasonal variability with potentially important influences on monsoon activity in the Asian regions on extended range time scale (beyond 7 days to on1 month), the capability of statistical or numerical models in capturing MJO signal is very crucial in capturing the active/break cycle of monsoon.

Q. How are low pressure system classified in India? What are the differences between low, depression and cyclone?

A. The low-pressure systems over Indian region are classified based on the maximum sustained winds speed associated with the system and the pressure deficit/ number of closed isobars associated with the system. The pressure criteria is used when the system is over land and wind criteria is used, when the system is over the sea. The system is called as low if there is one closed isobar in the interval of 2 hPa. It is called depression, if there are two closed isobars, a deep depression, if there are three closed isobars and cyclone if there are four or more closed isobars. The detailed classifications based on wind criteria are given in the Table below. Considering wind criteria, the system with wind speed of 17-27 knot is called as depression and the low pressure system with maximum sustained 3 minute surface winds between 28-33 knot is called a deep depression. The system with maximum sustained 3 minute surface winds of 34 knot or more is called as cyclone.

<table>
<thead>
<tr>
<th>System</th>
<th>Pressure deficient hPa</th>
<th>Associated wind speed Knot (Kmph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low pressure area</td>
<td>1.0</td>
<td>&lt;17(&lt;32)</td>
</tr>
<tr>
<td>Depression</td>
<td>1.0- 3.0</td>
<td>17-27 (32–50)</td>
</tr>
<tr>
<td>Deep Depression (DD)</td>
<td>3.0 - 4.5</td>
<td>28-33 (51–59)</td>
</tr>
<tr>
<td>Cyclonic Storm (CS)</td>
<td>4.5- 8.5</td>
<td>34-47 (60-90)</td>
</tr>
<tr>
<td>Severe Cyclonic Storm (SCS)</td>
<td>8.5-15.5</td>
<td>48-63 (90-119)</td>
</tr>
<tr>
<td>Very Severe Cyclonic Storm (VSCS)</td>
<td>15.5-65.6</td>
<td>64-119 (119-220)</td>
</tr>
<tr>
<td>Super Cyclonic Storm</td>
<td>&gt;65.6</td>
<td>&gt;119 (&gt;220)</td>
</tr>
</tbody>
</table>

Q. What is Satellite Meteorology?

A. Satellite Meteorology refers to the study of earth's atmosphere and oceans using data obtained from remote sensing devices flown onboard satellites orbiting the earth. Satellite make measurements indirectly by sensing electromagnetic radiations coming from the surfaces below.

Q. Which satellites are being used to monitor the weather of Indian region?

A. Kalpana-1 located at Longitude 74° E and Insat-3A located at 93.5° E both geostationary satellites are being used to monitor the weather of Indian region.

For meteorological observation, INSAT-3A carries a three channel Very High Resolution Radiometer (VHRR) with 2 km resolution in the visible band and 8 km resolution in thermal infrared and water vapour bands. In addition, INSAT-3A carries a Charge Coupled Device (CCD) camera which operates in the visible, near infra Red and short wave infrared bands providing a spatial resolution of 1 km. A Data Relay Transponder (DRT) operating in UHF band is incorporated for real-time hydro meteorological data collection from unattended platforms located on land and river basins. The data is then relayed in extended C-band to a
central location. Kalpana -1 Satellite has a 3- Channel VHRR and DRT similar to INSAT -3A Satellite.

Q. Which products are being derived from operational Indian Geostationary Meteorological Satellites?

A. The following products are being derived from INSAT satellites
   - Outgoing Longwave radiation (OLR)
   - Sea surface temperature (SST)
   - Quantitative precipitation estimate (QPE)
   - Cloud Motion vectors (CMV)
   - Water Vapour Wind (WVV)
   - Cloud Top Temperature (CTT)
   - Visible Channel Image
   - Infrared Channel Image
   - Colour Composite Channel Image
   - Water vapour Channel Image

**Outgoing long wave radiation (OLR)**

Majority of meteorological sensors operate in long wave range of radiation so that:

1. They operate day and night
2. The problem of low albedo is not encountered
3. The earth radiation is maximum and thermal IR and ocean emissive is nearly unity.

Keeping the above into mind the outgoing flux of long wave radiation at the top of atmosphere is an important parameter in the earth atmosphere radiation budget. This parameter can be derived by physical/statistical algorithm from the narrow band.

**Sea Surface Temperature (SST):**

As we know oceans are the major storage of heat in the earth climate systems. Sea Surface Temperature (SST) is one of the key controllers of climate variability and acts as a vast thermal reservoir. SST regulates the transfer of long wave radiation to the atmosphere as well as the latent and sensible heat fluxes into the lower atmosphere.

**Quantitative Precipitation Estimate (QPE)**

It is one of the key meteorological parameter. A detailed knowledge of its distribution in space and time is essential for understanding weather & climate. Information about rainfall is of great value in variety of discipline beside being control to human survival scientifically The latent heat released during the process of condensation water into cloud and rain drops is one of the significant energy source responsible for atmospheric heat engine.

Q. What are Image Channels?

A. The satellites typically scan the earth using different wave lengths (channels). Current INSAT geostationary meteorological satellites have 3 channel imager with the following channels:

   i) VISIBLE wavelengths (0.55 - 0.75 um) (reflected solar radiation).
   ii) IR (thermal infra-red) (10.5 - 12.5 um). (emission channel. Each point on the earth emits radiation in proportion to its hotness/coldness. So this channel gives a thermal
iii) WV (water-vapour) (5.7 - 7.1 um). (This is also an emission band. The image shows differences in water vapour absorption in the atmosphere).

**Q. What is the difference between geostationary and polar orbiting satellites?**

**A.** A geostationary satellite is positioned above the Equator and orbits the Earth at the same rotation speed as the Earth itself, making it appear stationary from the point of view of an observer on the Earth’s surface. It flies very high above the surface of the Earth (altitude almost 36000 kilometers), and thus is able to capture the whole Earth disc at once. A polar orbiting satellite circles the Earth at a near-polar inclination, meaning that it always passes almost exactly above the poles. The satellite passes the equator and each latitude at the same local solar time each day, meaning the satellite passes overhead at essentially the same solar time throughout all seasons of the year. The low Earth orbit (800 - 850 kilometers) is much closer to Earth than a geostationary orbit, and thus can see a smaller part of the Earth below than a geostationary satellite, but in finer detail.

**Q. What is GPS?**

**A.** The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit in six orbital planes at an altitude of 20200 Km above the earth surface with an orbital period of 12 hrs by the U.S. Department of Defense. GPS works in any weather conditions, anywhere in the world, 24 hours a day.

**Q. How does GPS receivers determine its 3D position from GPS signal?**

**A.** The GPS receiver compares the time a signal was transmitted by a GPS satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position by triangulation. Precise location of interest to geophysists required correction of position errors due to atmospheric delays.

**Q. What is a radar?**

**A.** Radar is acronym for Radio Detection and Ranging. It uses electro-magnetic waves in microwave region to detect location (range & direction), height (altitude), intensity (in case of weather systems) and movement of moving and non-moving targets.

**Q. What is the working principle of radars?**

**A.** Radars are used for detection of aircrafts, ships, weather systems and a variety of other applications. Our discussion is restricted to weather radars only. Radar transmitter transmits electro-magnetic waves through a directional antenna in any given direction in a focused manner. A part of the transmitted energy is absorbed by the atmosphere. Some of the energy travels further through the atmosphere and a fraction of it is scattered backward by the targets and is received by the radar receiver. The amount of received power depends upon radar parameters like transmitted power, radar wavelength, horizontal and vertical beam widths, atmospheric characteristics etc., In case of weather echoes like clouds it depends on physical state (raindrops, snow, hail etc.) and drop size distribution hydro meteors. The amount of return power provides information about the intensity of weather systems and azimuth and elevation of the antenna gives the location and height of the cloud systems. The time taken in to and fro journey of the electromagnet waves gives the range (or distance from radar) of the targets. Modern day radars, viz., Doppler Weather Radars, employ Doppler principle to provide information about the speed and direction of the moving targets.