

# Climatology of India

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India is a big tropical country and is famous for its diverse climatic features. India climate can be categorized into six principal subcategories and this has been determined by the Koppen climate classification.

The seasons in India can be broadly categorized into the following:

<b>Name of the season</b>	<b>Tenure</b>
Winter	The months of January and February
Summer	The months of March to May
Monsoon (rainy) season	The months of June to September
A post-monsoon period	The months of October to December

India is home to an extraordinary variety of climatic regions, ranging from tropical in the south to temperate and alpine in the Himalayan north, where elevated regions receive sustained winter snowfall. The nation's climate is strongly influenced by the Himalayas and the Thar Desert. The Himalayas act as a barrier to the frigid katabatic winds flowing down from Central Asia keeping the bulk of the Indian subcontinent warmer than most locations at similar latitudes. As such, land areas in the north of the country have a continental climate with severe summer conditions that alternates with cold winters when temperatures plunge to freezing point. In contrast are the coastal regions of the country, where the warmth is unvarying and the rains are frequent.

The country is influenced by two seasons of rains, accompanied by seasonal reversal of winds from January to July. During the winters, dry and cold air blowing from the northerly latitudes from a north-easterly direction prevails over the Indian region. Consequent to the intense heat of the summer months, the northern Indian landmass becomes hot and draws moist winds over the oceans causing a reversal of the winds over the region which is called the summer or the south-west monsoon. This is most important feature controlling the Indian climate because about 75% of the annual rainfall is received during a short span of four months (June to September). Variability in the onset, withdrawal and quantum of rainfall during the monsoon season has profound impacts on water resources, power generation, agriculture, economics and ecosystems in the country. The variation in climate is perhaps greater than any other area of similar size in the world. There is a large variation in the amounts of rainfall received at different locations. The average annual rainfall is less than 13 cm over the western Rajasthan, while at Mausiram in the Meghalaya has as much as 1141 cm.

The rainfall pattern roughly reflects the different climate regimes of the country, which vary from humid in the northeast (about 180 days rainfall in a year), to arid in Rajasthan (20 days rainfall in a year). So significant is the monsoon season to the Indian climate, that the remaining seasons are often referred relative to the monsoon.

The rainfall over India has large spatial as well as temporal variability. A homogeneous data series has been constructed for the period 1901-2003 based on the uniform network of 1476 stations and analyzed the variability and trends of rainfall. Normal rainfall (in cm) pattern of the country for the four seasons and annual are depicted in Fig 1 and Fig 2 respectively. Normal monsoon rainfall more than 150cm is being observed over most parts of northeast India, Konkan & Goa. Normal monsoon rainfall is more than 400cm over major parts of Meghalaya. Annual rainfall is more than 200 cm over these regions.

For the country as whole, mean monthly rainfall during July (286.5 mm) is highest and contributes about 24.2% of annual rainfall (1182.8 mm). The mean rainfall during August is slightly lower and contributes about 21.2% of annual rainfall. June and September rainfall are almost similar and contribute 13.8% and 14.2% of annual rainfall, respectively. The mean south-west monsoon (June, July, August & September) rainfall (877.2 mm) contributes 74.2% of annual rainfall (1182.8 mm). Contribution of pre-monsoon (March, April & May) rainfall and post-monsoon (October, November & December) rainfall in annual rainfall is mostly the same (11%). Coefficient of variation is higher during the months of November, December, January and February. India is characterized by strong temperature variations in different seasons ranging from mean temperature of about 10°C in winter to about 32 °C in summer season. Details of weather along with associated systems during different seasons are presented as under:

### **Winter Season / Cold Weather Season (January and February)**

India Meteorological Department (IMD) has categorized the months of January and February in winter season. However, December can be included in this season for north-western parts of the country. This season starts in early December associated with clear skies, fine weather, light northerly winds, low humidity and temperatures, and large daytime variations of temperature. The cold air mass extending from the Siberian region has profound influence on the

Indian subcontinent (at least all of the north and most of central India) during these months.

The mean air temperatures increase from north to south up to 17°N, the decrease being sharp as one moves northwards in the north-western parts of the country. The mean temperatures vary from 14 °C to 27°C during January. The mean daily minimum temperatures range from 22 °C in the extreme south, to 10 °C in the northern plains and 6 °C in Punjab. The rains during this season generally occur over the western Himalayas, the extreme north-eastern parts, Tamil Nadu and Kerala. Western disturbances and associated trough in westerlies are main rain bearing system in northern and eastern parts of the country.

#### Aviation weather hazards

Poor visibility is the main aviation hazard during the season, especially over N India. Fog, mist & haze are common all over the country in the morning and evening hours. Smoke from industries and automobiles causes reduction in visibility. Low level inversion further favours reduction in visibility. Conditions become most favourable for radiation fog after the passage of a WD, over NW India, Uttar Pradesh, Bihar, Central India, N Bengal and Assam (particularly S banks of Brahmaputra river). Sometimes the fog prolongs, disrupting air traffic adversely, especially over polluted airfields like Palam (Delhi) On Such occasions, there may be little improvement in visibility to 1000-2000m during noon, but it may again deteriorate in the evening and night. Such conditions sometimes may last for a few days. Advection fog occurs over costal areas and where large water bodies are present. The fog generally lifts by 1000-1100 hr IST.

CAT is experienced over NE India and in the vicinity of STJ. Mountain waves are also common during this period over high terrain over N & E India. Icing – During the season the freezing level lowers. Hence ice accretion may be experienced at lower levels.

#### **Pre-monsoon season/ summer season/ Hot weather season/ Thunderstorm season (March, April and May)**

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The temperatures start to increase all over the country in March and by April, the interior parts of the peninsula record mean daily temperatures of 30-35 °C. Central Indian land mass becomes hot with daytime maximum temperatures reaching about 40°C at many locations. Many stations in Gujarat, North

Maharashtra, Rajasthan and North Madhya Pradesh exhibit high day-time and low night-time temperatures during this season. The range of the daytime maximum and night-time minimum temperatures is found more than 15 °C at many stations in these States. Maximum temperatures rise sharply exceeding 45 °C by the end of May and early June resulting in harsh summers in the north and north-west regions of the country. However, weather remains mild in coastal areas of the country owing to the influence of land and sea breezes.

The season is characterized by cyclonic storms, which are intense low pressure systems over hundreds to thousands of kilometers associated with surface winds more than 33 knots over the Indian seas viz. Bay of Bengal and the Arabian Sea. These systems generally move towards a north-westerly direction and some of them recurve to northerly or northeasterly path. Storms forming over the Bay of Bengal are more frequent than the ones originating over the Arabian Sea. On an average, frequency of these storms is about 2.3 per year.

Weather over land areas is influenced by thunderstorms associated with rain and sometimes with hail in this season. Local severe storms or violent thunderstorms associated with strong winds and rain; lasting for short durations occur over the eastern and north eastern parts over Bihar, West Bengal, and Assam. They are called norwesters or “Kal Baisakhis” as generally approach a station from the northwesterly direction. Thunderstorms are also observed over central India extending to Kerala along wind-discontinuity lines. Hot and dry winds accompanied with dust winds (“andhis”) blow frequently over the plains of north-west India.

#### Aviation weather hazards

TS & DS Activity – Violent TS are common during this season with their attendant hazards. DS are common over Rajasthan and NW India. Norwesters affect eastern part of the country. Line squall type of development is also reported by the aircrew. Poor visibility due to widespread dust haze is experienced over entire N India. Dust haze may extend to 7-8km aloft.

Dust raising winds – Strong surface winds of 30-50kts may be experienced between 0900-1700hrs IST. The visibility may reduce to a few hundred meters.

This is the most hazardous season for flying. The main aviation weather hazards are TS/TD, Dust Haze, Squall, High temperatures, Dust Raising Winds, Norwesters, Andhi etc.

### **South-west Monsoon/ Summer Monsoon (June, July, August and September)**

The SW monsoon is the most significant feature of the Indian climate. The season is spread over four months, but the actual period at a particular place depends on onset and withdrawal dates. It varies from less than 75 days over West Rajasthan, to more than 120 days over the south-western regions of the country contributing to about 75% of the annual rainfall.

The onset of the SW monsoon normally starts over the Kerala coast, the southern tip of the country by 1 June, advances along the Konkan coast in early June and covers the whole country by middle of July. However, onset occurs about a week earlier over islands in the Bay of Bengal. The monsoon is a special phenomenon exhibiting regularity in onset and distribution within the country, but inter-annual and inter-annual variations are observed. The monsoon is influenced by global and local phenomenon like El Nino, northern hemispheric temperatures, sea surface temperatures, snow cover etc. The monsoonal rainfall oscillates between active spells associated with widespread rains over most parts of the country and breaks with little rainfall activity over the plains and heavy rains across the foothills of the Himalayas. Heavy rainfall in the mountainous catchments under 'break' conditions results flooding over the plains. However, very uncomfortable weather due to high humidity and temperatures is the feature associated with the breaks.

Cyclonic systems of low pressure called 'monsoon depressions' are formed in the Bay of Bengal during this season. These systems generally form in the northern part of the Bay with an average frequency of about two to three per month and move in a northward or north-westward direction, bringing well-distributed rainfall over the central and northern parts of the country. The distribution of rainfall over northern and central India depends on the path followed by these depressions. SW monsoon current becomes feeble and generally starts withdrawing from Rajasthan by 1st September and from north-western parts of India by 15th September. It withdraws from almost all parts of the country by 15th October and is replaced by a northerly continental airflow called North-East

Monsoon. The retreating monsoon winds cause occasional showers along the east coast of Tamil Nadu, but rainfall decreases away from coastal regions.

Flying in monsoon clouds is relatively smooth, as they are stratiform type and visibility is exceptionally good, except in precipitation. Clouds are in different layers and there are clear gaps in between various layers of clouds. Hence one can mostly find a suitable cloud free level for flying, except when affected by a depression.

### **Post-monsoon or Northeast monsoon or Retreating SW Monsoon season (October, November and December)**

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North-East (NE) monsoon or Post-monsoon season is transition season associated with the establishment of the north-easterly wind regime over the Indian subcontinent. Meteorological subdivisions namely Coastal Andhra Pradesh Rayalaseema, Tamil Nadu, Kerala and South Interior Karnataka receive good amount of rainfall accounting for about 35% of their annual total in these months. Many parts of Tamil Nadu and some parts of Andhra Pradesh and Karnataka receive rainfall during this season due to the storms forming in the Bay of Bengal. Large scale losses to life and property occur due to heavy rainfall, strong winds and storm surge in the coastal regions. The day temperatures start falling sharply all over the country. The mean temperatures over north-western parts of the country show decline from about 38°C in October to 28°C in November. Decrease in humidity levels and clear skies over most parts of north and central India after mid-October are characteristics features of this season (NATCOM 2004, IMD 2010).

Maximum cyclonic storms (CS) occur in October over the Bay of Bengal and in November over the Arabian Sea. Severe cyclonic storms are more in November than in October. They usually form near Andaman seas and move towards Tamil Nadu, Andhra and Orissa. The CS normally strike Tamil Nadu coast. Some of them move north and strike West Bengal or Bangladesh coasts. A few of them after crossing over the peninsula emerge over the Arabian Sea, revive, recurve and strike Maharashtra & Gujarat coasts.

Aviation weather hazards

Poor Visibility – Generally visibility is good. However, as the season progresses visibility starts deteriorating near industrial areas during dawn and dusk. After the passage of a WD there may be fog or mist. In the South poor visibility is during precipitation.

Low Clouds – Low clouds, very strong winds, heavy rain and TS activity is experienced during the passage of a CS.

CAT – Clear Air Turbulence may be experienced due to STJ in the north.