CHAPTER II

WEATHER AND CLIMATE

I. *Introduction*

INDIA HAS A GREAT DIVERSITY of climates with many striking contrasts of meteorological conditions. The diversity is perhaps greater here than in any other area of similar size in the world. For instance, Assam in the east and Rājasthān in the west present extremes of dampness and dryness, a contrast sharper than that between England and Egypt. The contrast between Punjab in the north and Kerala in the south is equally pronounced; Punjab has continental climate, fierce summer heat alternating with winter cold, sometimes down to the freezing point, while Kerala has tropical maritime climate with almost unvarying warmth and uniformly moist air.

In the Thar desert the average rainfall is less than 13 cm. in a year, while at Cherrapunji it is as much as 1,080 cm. In the rainy season, places like Simla in the Himālayas get clouded for days on end, the air saturated with moisture, while in the dry hot months the air may occasionally be almost completely devoid of moisture.

Many of the weather systems which make up the climate of this vast region are largely dependent on conditions outside its geographic limits. For instance, the cold weather rain and snowfall in India are intimately connected with shallow low-pressure systems which originate in the upper levels of the atmosphere to the north-west of India—even as far away as the Eastern Mediterranean region; and the distribution of rainfall in the summer monsoon season depends largely on conditions in East Africa, Irān, Central Asia and Tibet, as also upon the pressure and temperature conditions in Southern Asia, the Indian Ocean and the China seas.

Meteorological observations

The recording of meteorological observation in India started towards the end of the 18th century, during the East India Company's time. Well-equipped meteorological observing stations were established at Madras (1796), Simla (1840) and Bombay (1841), and on the Nīlgiri (1847). In 1874-75 arrangements were made for organized work of observation over the whole of India, by the establishment

of a Meteorological Department under the Central Government, amalgamating a number of Provincial meteorological organizations which existed till then. This enabled the adoption of uniform methods and systematic discussion of the facts recorded over a period of time. The organization was enlarged and improved upon from time to time; sixty to eighty years of records can be obtained in the archives of the Indian Meteorological Department. The number of observation centres in 1961 was over 400.

A significant development was the introduction, in the twenties of the present century, of measurement of wind directions and speeds at various heights above the surface by means of pilot balloons; along with it came measurement of upper air temperatures and humidity by means of recording meteorographs sent up with big balloons. The number of upper-air stations was increased gradually and improved techniques including radio methods came into use during and after World War II. Air services across the country brought about rapid expansion of the meteorological network and modernization of techniques. Climatological data for the country as a whole, adequate both in amount and quality, are now available.

Chains of observatories have also been built in most of the countries in South Asia. International agreements have made it possible to exchange data between different countries. A study of the meteorology of the Indian subcontinent has to be based on the data collected not only within the country, but also from outside.

2. *Climatic Regions*

The broad picture of the climate of a region is determined by its geographical situation. Physiographical features of the region, however, strongly affect the ultimate pattern of its climate and bring about variations in different areas.

The monsoons

In the context of India's geographical situation, the most important feature of its climate is the alternation of seasons known as the monsoons. As a matter of fact, much of the region lying within the Tropics and comprising the great continent of Asia to the north and the vast oceans to the south, and within this the Indian subcontinent in particular makes a very good example of a monsoon area. During the winter third of the year, the general air flow over India is from

land to sea, and then over the Indian seas as the north-east monsoon. The winds are from continental sources and therefore mainly dry. In the summer months there is a complete reversal of the winds which flow from sea to land as the south-west monsoon This is a season of high humidity, much cloud and frequent rain. Between these monsoons lie two transitional periods—the hot weather and the season of retreating south-west monsoon. However, the physical features of a country have a great influence on its climate, and this is well illustrated in the case of the Indian subcontinent.

Physical features

India is separated from the rest of Asia by high mountains. Broadly speaking, the country consists of a peninsula to the south of the Tropic of Cancer (or latitude 23½° N.), jutting well out into the Indian Ocean, and of a broad low alluvial plain to the north. The Peninsula comprises a plateau of comparatively low elevation, flanked near its western edge by the fairly high hills of the Western Ghāts from which the land slopes eastwards. A ridge, the Eastern Ghāts, lower in height and more broken than the Western Ghāts, forms the eastern boundary of the plateau. To the north of the Peninsula is the low plateau of Central India gradually sloping down to the broad lowland plain formed by the valleys of the Indus, Ganga and Brahmaputra. To the north of this extensive plain is the high barrier of the Himālayan mountains rising to an average height of 6·5 km.; and farther north is the Tibetan plateau with an average elevation of 3 km.

These physiographical features decide the climate of different areas in the country. The areas of very heavy rainfall are to the windward side of the Western Ghāts, the hills of Assam, and the Himālayan barrier; and these are the watersheds giving rise to the major river systems of the Indus, Ganga and Brahmaputra. Elsewhere, in the plateau of the Peninsula and the Ganga plains, the effects of orography are less marked and the rainfall is moderate. Southern Punjab and Western Rājasthān constitute the driest part.

It is possible to demarcate five regions with more or less similar broad patterns of climate and weather :

(1) North-west India, comprising West Rājasthān, Punjab and Kashmīr.
(2) Central India, which includes East Rājasth n, Gujarāt, the northern divisions of Madhya Pradesh, Uttar Pradesh and Bihār.
(3) North-east India, comprising West Bengal, Orissa and Assam.

(4) The plateau region comprising the southern divisions of Madhya Pradesh and the Deccan plateau.
(5) The Peninsula consisting of coastal lands and plains.

3. *Seasons and their Duration*

The Indian subcontinent presents a striking variety of meteorological conditions characteristic of the Tropics as well as the temperate zone. Tropical heat, high humidity, heavy and frequent rain, and fierce cyclonic storms prevail during part of the year, in some regions; in the remaining period the weather in some areas is marked by equable temperatures and moderate precipitation in association with shallow storms—conditions resembling those of South-eastern Europe and the Mediterranean regions.

The north-east and the south-west monsoons are the principal features in the meteorology of India. The Asiatic land-mass extending northwards from near the Equator modifies the pressure distribution and air movement over the Indian Ocean, the Arabian Sea and the Bay of Bengal. A permanent global air movement is converted into the periodic air movement of the monsoons. During the winter months the land-mass comprising Central and South Asia is cooler by as much as 8°-14° C than the Pacific and the Atlantic Ocean areas in the same latitudes, while in summer the land-mass is form 5°- 8° C warmer than the sea surface. These differences in temperature form the basis of the monsoons. The point will be considered later in detail.

Between the two principal monsoon seasons are two transitional periods—the hot weather before the advent of the south-west monsoon and the retreating south-west monsoon season. The year may be conveniently divided into the following four principal seasons :

(1) Cold weather season, December-February.
(2) Hot weather season, March-May.
(3) South-west monsoon season, June-September.
(4) Retreating south-west monsoon season, October-November.

In October, clear weather sets in over North-west India and by December this extends over the whole of the country, except in the extreme south-east of the Peninsula where the retreating south-west monsoon continues to give some rain. The cold weather season starts early in December. At the beginning of January, when the

Cold weather cloud land

temperatures in Asia are at their lowest, the north-east monsoon is fully established over the Indian land and sea areas. A belt of high pressure extends from the Western Mediterranean through Central Asia up to North-east China. Clear skies, fine weather, light northerly winds, low humidity and temperature, and large day-time variations of temperature are the normal features of the weather in India from December to February. The settled conditions are broken at intervals by shallow cyclonic depressions travelling eastwards across Irān and Northern India, and often into China. These western disturbances are similar in type to the depressions of European latitudes, though they are usually less intense. The precipitation associated with the passage of these disturbances is generally small in amount, but is very important for winter crops in North-west India. Some of the western disturbances during their eastward passage give light rain over the whole of Northern India; others confine their activity to the extreme north and give moderate to heavy rain in the Punjab plains and heavy snow-fall in Kashmīr and the higher Himālayas. The disturbances are accompanied by clouding and rise of temperature in front of them, while in their rear dry clear weather prevails with stronger westerly to north-westerly winds bringing a spell of colder weather. The fall of temperature in the rear of the disturbances may be considerable, giving rise to pronounced cold waves. For the season, as a whole, rainfall is greatest in the north-west and decreases towards the south and east; the temperature is lower in the north-west than in the east and south.

The average winter conditions over India are illustrated in Map II for January, a typical cold weather month.

March to May is usually a period of continuous and rapid rise of temperature and fall of barometric pressure in North India.

Hot weather

At the same time, there is a decrease of temperature in the Southern Indian Ocean and adjacent land areas of Africa and Australia along with a rise in air pressure and intensification of the southern high-pressure area (anticyclone). A steady transference northward of the area of greatest heat, along with a similar transfer of the equatorial belt of low air pressure, takes place. In March the highest day temperatures of about 38° C occur in the Deccan plateau, while in April temperatures of 38°- 43° C are found in Gujarāt and Madhya Pradesh. In May, the highest temperatures occur in Northern India, particularly in the desert regions of the north-west, where the maximum may be over 48° C. The area of lowest air pressure also lies over North-west India with a trough stretching from there to the Chota Nāgpur plateau. Around this trough a local

circulation of air sets in during this period of rising temperature and decreasing air pressure. This circulation is very significant, since it causes indraughts from the adjacent seas of southerly winds across the West Bengal coast and north-westerly winds across the Bombay coast. Violent local storms often form in regions where deep humid winds from the sea meet hot dry land winds. These storms are accompanied by violent winds, torrential rain and hail; they sometimes attain tornadic intensity and are very destructive, especially in West Bengal. They are called Nor'westers because the accompanying squalls usually come from the north-west, and they are known in Bengal as *Kālbaiśākhī*, i.e., "calamity of the month of *Baiśākh*". In the drier parts of North-west India dust-storms are of common occurrence during this season.

The normal distribution of meteorological elements during the hot weather is depicted in Map III for April, the representative month of the season.

It is obvious that cold weather in India is determined mainly by conditions on the Asian continent, while hot weather is more dependent on local conditions within the country.

South-west monsoon

During the south-west monsoon, weather in India is mainly decided by conditions in the oceanic area to the south.

In consequence of the rapid rise of temperature in May over the Asian mainland, the air pressure decreases in that area. At the end of May, the Asian high-pressure region is replaced by a fairly deep low-pressure area extending from Sudan in Africa to West Rājasthān and thence to West Bengal. The air circulation in the Indian area and the neighbouring seas becomes more and more vigorous. This goes on until, almost abruptly, the south-east trade winds from the south of the Equator, having had a long journey over the ocean, extend northwards into the Bay of Bengal and the Arabian Sea. They are caught up in the air circulation over India and deflected inland as south-westerly winds. Almost the whole of the country is then quickly overrun by this cool and humid air, known as the "South-west Monsoon".

Normally, the south-west monsoon bursts on the Kerala coast during the first five days of June. Slowly it extends northwards and by the end of the month it is usually established over most of the Indian area. In the first half of the wet season, June and July, the south-west monsoon current covers the whole of the sub-continent; and this is in a way the most important season of the year for most of the area. The agricultural prosperity of the land depends to a large extent on the amount and distribution of rainfall during these two months.

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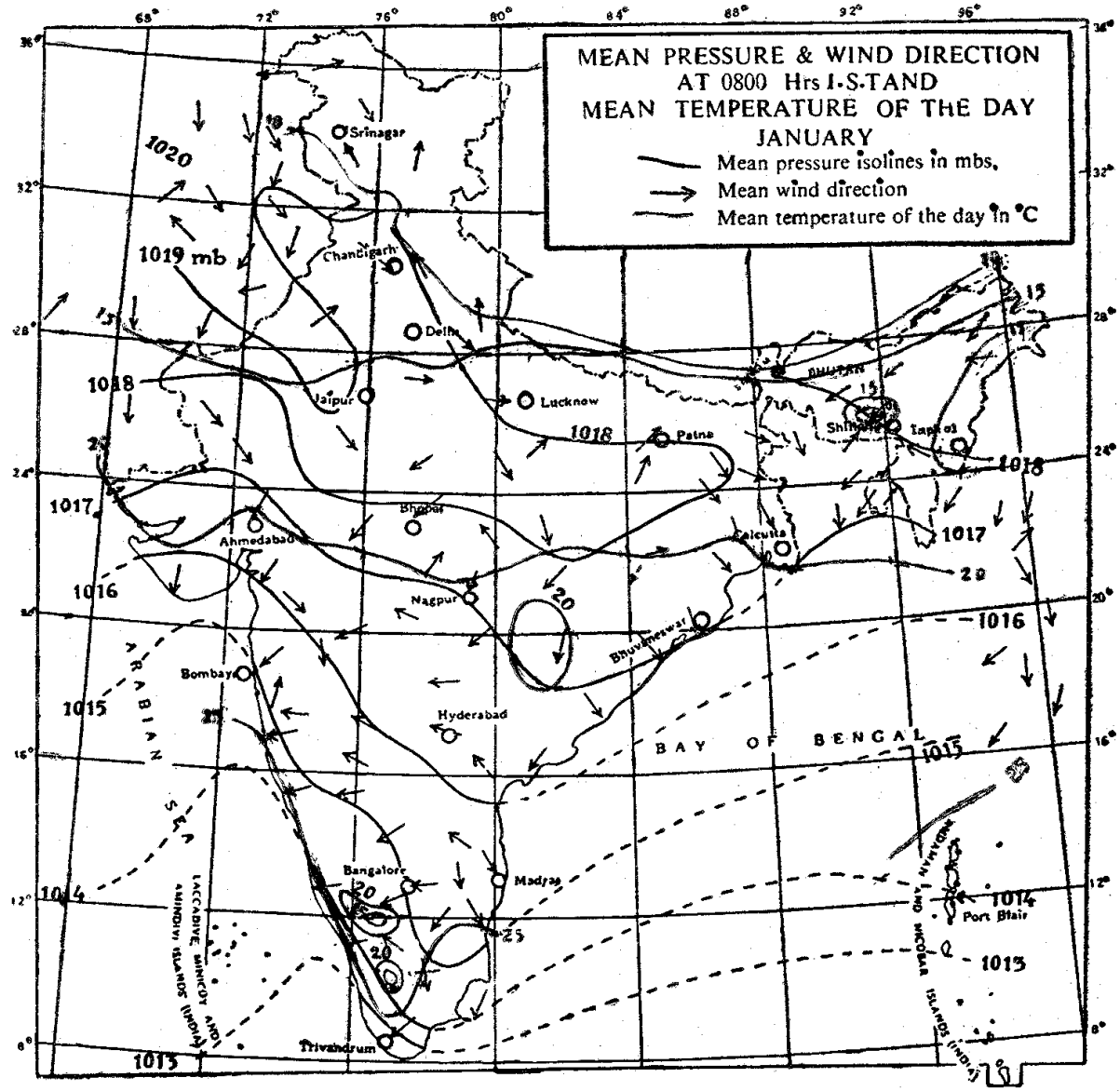

METEOROLOGICAL MAP II

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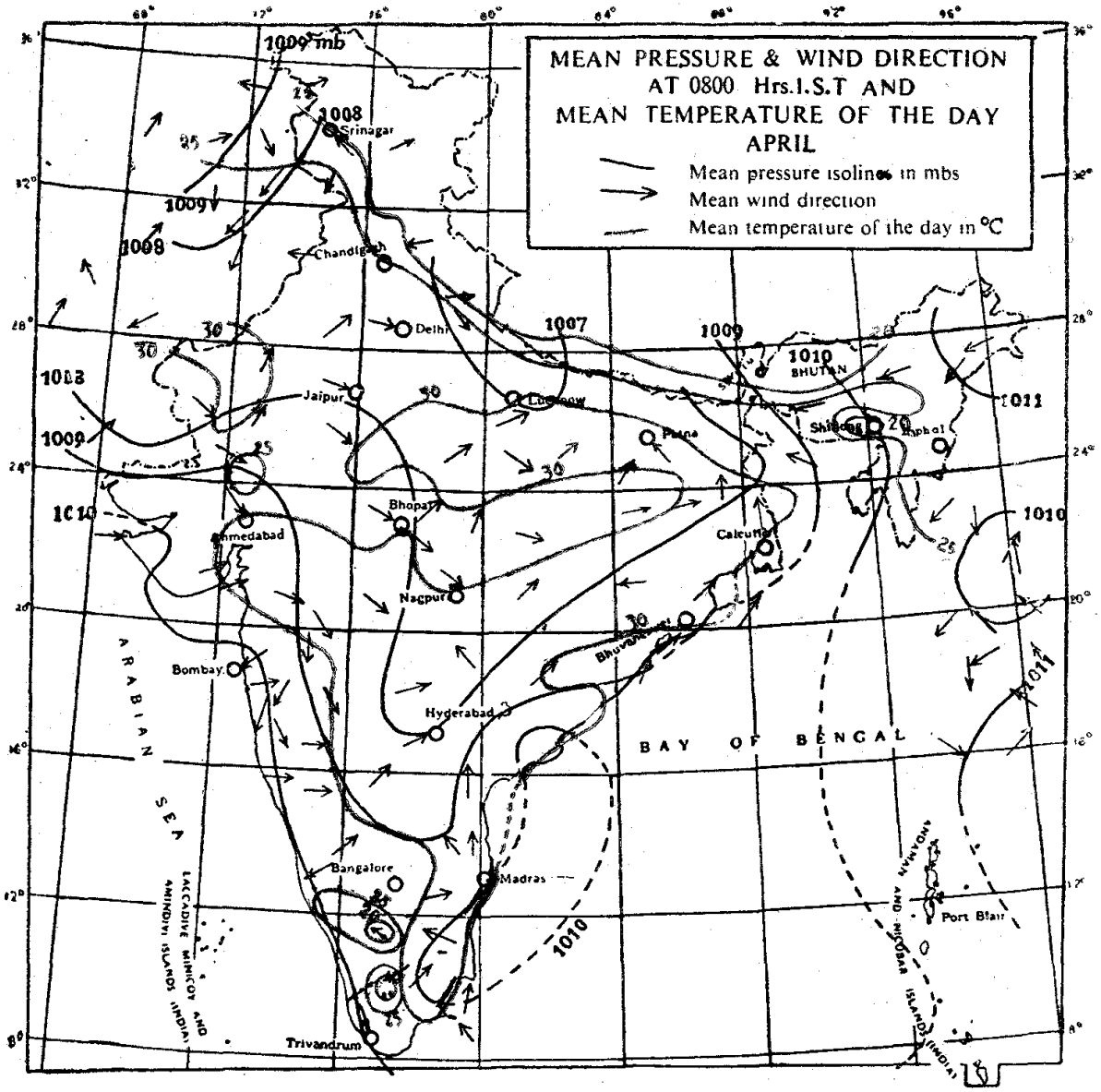

METEOROLOGICAL MAP III

The orographical features of India have a pronounced effect on the flow of monsoon winds over the country and the distribution of rainfall. The Himālayan mountains to the north and their spurs to the north-east constitute two closed sides of a box, as it were. Through the other two open sides of this box, to the south and west, the monsoon current streams in. The monsoon wind in the south Bay of Bengal is mainly directed towards the Burma coast; a part of this air stream also advances northwards and is then deflected by the Arakan hills westwards up the Ganga plains. The result is that at the head of the Bay of Bengal the mean direction of the monsoon winds is more from south-east and south than from south-west. The advancing monsoon winds cross the coast of deltaic Bengal and almost immediately come under the influence of the Assam hills and the eastern ranges of the Himālayas. As they pass into the box formed by the Assam and Chittagong hills they become subject to a vigorous ascensional movement and pour out a great deal of rain on the southern face of the Assam hills. This area has probably the heaviest rainfall in the world. The rest of the monsoon current is deflected westwards by the high barrier of the Himālayan ranges, the lower southern slopes of which receive almost daily rain along the whole region from Sikkim to Kashmīr.

The monsoon currents of the Arabian Sea branch, as they reach the Bombay coast, are directed from the west-southwest or west to meet the almost continuous hills of the Western Ghāts rising abruptly from the coastal plains to heights of 1 to 2 km. The moist air currents move upwards along the mountains and the forced ascent causes frequent and very heavy rain over the Western Ghāts; heavy rain falls also in the coastal Districts to the west of the Ghāts. Having surmounted the Ghāts the monsoon winds advance over the Deccan plateau and Madhya Pradesh and pass into the Bay of Bengal, meeting the Bay current. Another part of the Arabian Sea branch of the monsoon crosses the coast of Saurāshtra and Kutch and passes over the arid sandy plains of West Rājasthān, giving little rain in these areas until it reaches the Arāvalli hills. The winds then pass on north and north-eastwards and on reaching Eastern Punjab intermingle with the current deflected westwards from the Bay of Bengal. The mixed current is then partly deflected further westwards and partly forced up the southern slopes of the Himālayas. The merging of the two currents occasionally gives moderate to heavy rain in the Western Himālayas, Eastern Punjab and East Rājasthān.

A description of the south-west monsoon cannot be complete without reference to conditions In the south of the Indo-Ganga

plains lying between the fields of direct activity of the Bay of Bengal and the Arabian Sea branches of the monsoon . The air pressure in this area is now lower than in the area immediately to the north or south. This "monsoon trough of low pressure", as it is called, has its axis normally extending from North-west India roughly through Agra, Allahābād and Hazāribāgh into Orissa. Map IV giving the mean meteorological conditions in July illustrates the characteristics of the south-west monsoon season. Cyclonic depressions, which occasionally form in succession during this season at the head of the Bay of Bengal, tend to travel along the axis of this monsoon trough; and during their passage west to north-west they intensify the monsoon currents as well as concentrate the rainfall intheir vicinity. It is mainly from the travel of these depressions along this track that locally heavy rain occurs in the rice-growing Districts in and around Madhya Pradesh.

The monsoon trough, however, does not remain stationary. It moves north or south, sometimes to a considerable extent; and the distribution of rainfall is appreciably affected as the trough moves. Consequently, the monsoon season is by no means a period of continuous rain in any part of the country. There are alternations of bursts of general rain with partial or general breaks. This pulsatory character of the monsoon rainfall is one of the most significant features of the period meteorologically, and also economically in relation to the growth of the crops of the season. Generally speaking, the strength of the monsoon current and the associated rainfall increase from June to July and remain fairly steady in August. The monsoon begins to retreat from Northern India in the second week of September, rainfall decreasing rapidly in the latter half of the month.

October and November are a period of transition leading up to the conditions of dry winter season. The change begins in early October and is usually completed by mid-December. The Arabian branch of the monsoon retreats southwards from Rājasthān, Gujarāt and the Deccan by a series of intermittent actions, while the Bay of Bengal current retreats comparatively steadily down the Ganga plains. The low-pressure conditions prevailing in North India in the monsoon season are obliterated by October. They are transferred to the centre of the Bay of Bengal by the beginning of November, and to the south of the Bay early in December. By the end of December, the belt of low pressure usually passes out of the limits of the Bay of Bengal into the equatorial belt of the Indian Ocean. Similar conditions obtain

Retreating south-west monsoon season

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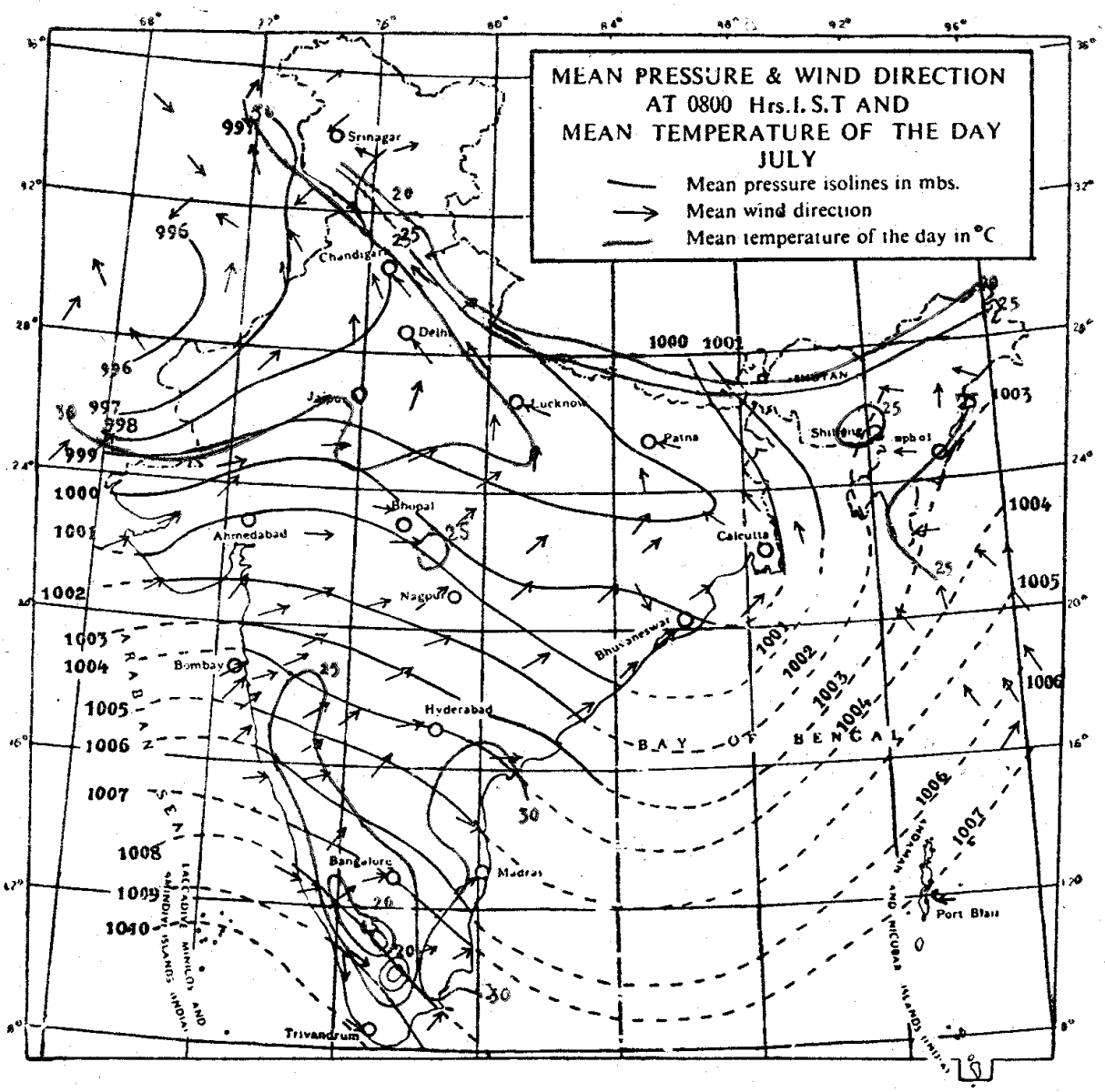

METEOROLOGICAL MAP IV

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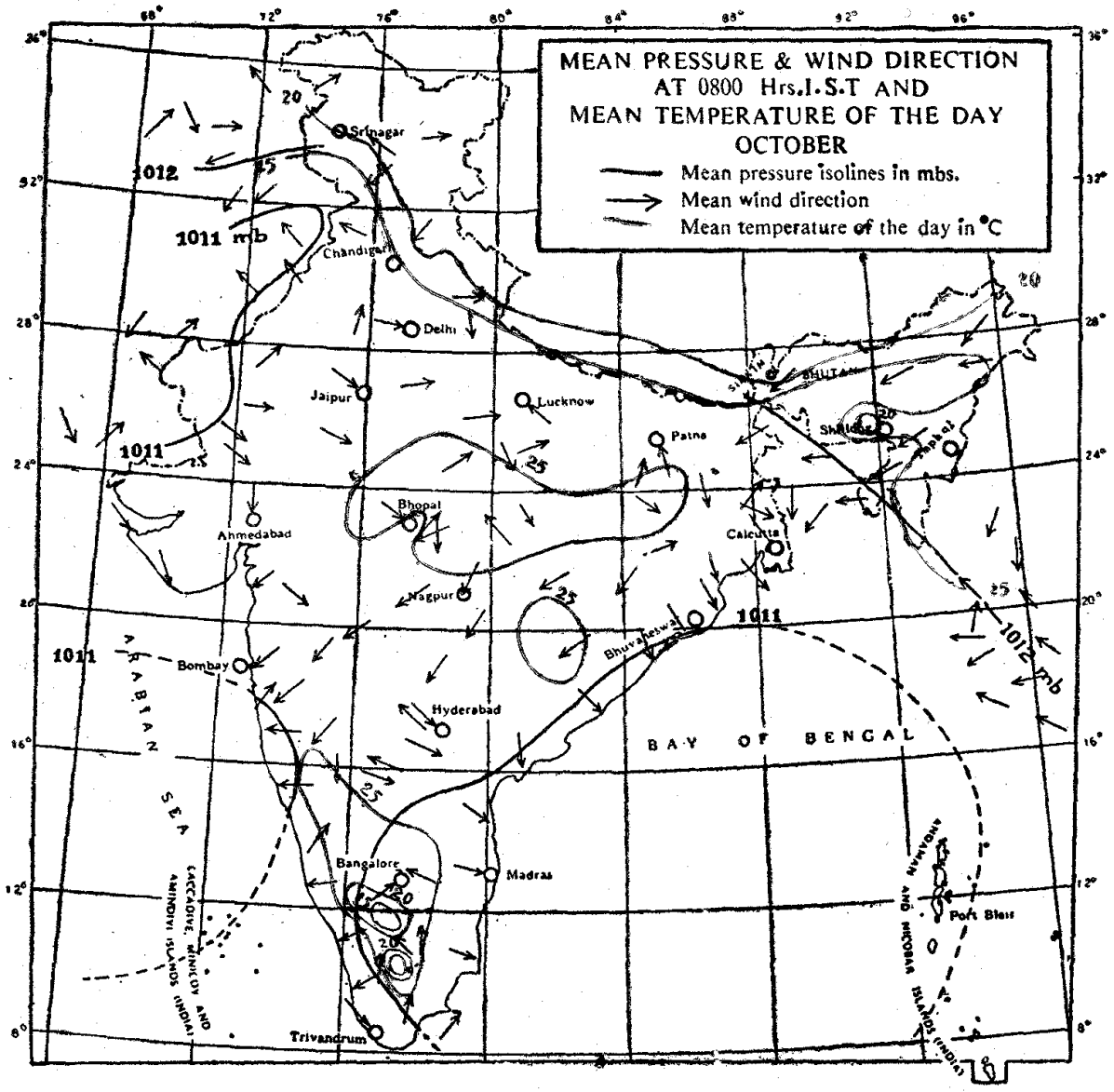


METEOROLOGICAL MAP V

in the Arabian Sea. The general meteorological features of this season are illustrated in Map V.

This season is marked by dry weather in Northern India, but is associated with more or less general rain in the coastal Districts of Madras and over the eastern half of the Peninsula, where October and November are often the rainiest months of the year. These rains are generally known as the north-east monsoon rains. The heaviest and most widespread rainfall at this time of the year occurs during the passage of cyclonic storms. They form in the sea areas adjacent to the Peninsula and advance westwards or north-westwards and sometimes north and north-eastwards. The Bay of Bengal cyclones mostly advance towards the east coast of the Peninsula, while a few strike the Bengal coast or the Arakan coast of Burma. Cyclonic storms are much less frequent in the Arabian Sea than in the Bay of Bengal; in fact, it is often the Bay of Bengal storms that cross the southern Peninsula and emerge into the eastern Arabian Sea where they may reintensify.

The most important feature of this period is thus the gradual withdrawal of the south-west monsoon from the Indian area and the gradual extension of the winds of the dry season from Northern India eastwards and southwards over the entire land and sea areas. The region of transition between these two different air-masses—the "front" between land and sea air—provides the most favourable conditions for the development and growth of cyclonic depressions and their intensification into severe cyclones of the Indian seas.

Usually, before the end of December, the north-east monsoon winds are fully established over the whole region. So the changes in the transitional period of the retreating south-west monsoon are much more gradual than the changes at the start of the monsoon season. The advancing currents move vigorously while the retreating currents are feeble. Rainfall from the decaying current is much less than in the three preceding monsoon months, and is more irregular in distribution. For example, the whole of North-western and Central India and Gujarāt hardly get any rain during this period.

4. *Rainfall*

Of all weather elements, rainfall is by far the most important for a country like India whose economy is largely based on

agricultural enterprise. The timely distribution of monsoon rains is the biggest single factor which determines the country's prosperity. It has been aptly stated that India's prosperity is a gamble in the monsoon rains. The principles behind the physical processes that lead to the formation of clouds and rain may be briefly stated before the seasonal distribution of rainfall in India is surveyed.

Causes of rain

Air always contains a certain amount of water-vapour, the amount varying from time to time and from place to place. The moisture content of any air-mass depends on whether its source is a maritime or continental region and whether it has travelled over sea or dry land. Further, the capacity of air to hold moisture depends on its temperature—the higher the temperature, the greater the capacity to hold water-vapour. When air at a certain temperature has as much water-vapour as it can retain, it is said to be saturated. Very often air is not saturated; then the ratio of the actual amount of water-vapour present, to the amount needed to saturate the air, determines the relative humidity. This relative humidity is usually expressed as a percentage. Air saturated with water-vapour has a relative humidity of 100 per cent; when it contains only half that amount of moisture, its relative humidity is 50 per cent.

When a sample of air which is initially unsaturated is cooled its relative humidity increases; by progressive cooling it can be made to reach a stage when its moisture content will make it saturated with 100 per cent humidity. What happens when this sample of air is cooled further? At a still lower temperature the air needs less moisture to remain saturated; hence, the excess over this amount becomes surplus. The chilled air cannot hold it and it condenses into very tiny water droplets. These float as mist or fog near the ground and as cloud in the upper air. From the cloud stage to the formation of rain the tiny water droplets pass through a complex process. They coalesce into larger water-drops, which the air cannot support in suspension, and come down under the action of gravity as rain.

When air is made to ascend suddenly and rapidly, it cools down at a rate depending upon the amount of water-vapour present in it, or upon its relative humidity. Dry air cools at a rate of nearly 10°C per km. of ascent, but when saturated with water-vapour (with relative humidity 100 per cent) its rate of cooling drops down to about half this rate. As an air-mass, originally unsaturated, is subject to forced rapid ascent, a stage is reached when its temperature falls low enough for the moist air to reach the saturation point; and any further ascent and cooling

of the air is followed by the water-vapour in that air-mass condensing into cloud droplets. If the ascensional movement continues further, and the other conditions favourable for coalescence of the cloud-drops into larger water-drops exist, the result is rain.

The ascent of an air-mass is brought about in several ways. Firstly, there is the heating of the land surface by strong insolation during day-time, as in summer; the air in contact with the hot surface also gets heated, expands and rises up. This process is best exemplified by the formation of clouds in summer afternoons and evenings, and by the marked tendency towards the occurrence of summer thunder-showers in the afternoon and evening at places where the rising air happens to be sufficiently humid.

Secondly, an air current may be forced to rise when it comes across a range of hills as a barrier across the wind flow. As a result of this orographic barrier, the air is forced to ascend up the hill slopes; in that process it is cooled sufficiently to reach the stage of cloud formation, and eventually the rain stage if its moisture content is high enough and its upward flow is maintained. This is well illustrated by the occurrence of heavy orographic rainfall on and near the hill ranges of the Himālayas and the Western Ghāts and the rapid decrease of rainfall as the air passes over the hill crests. After crossing the crest the air may start descending. Some of the most well known wet regions of the world are located near hill slopes.

Thirdly, dynamical causes may force an air current to rise on a large scale. This happens, for instance, within the field of cyclonic storm and near its centre. It is well known that air from all sides flows in towards the inner area of a cyclone, the air streams converging towards the low-pressure centre. This air, accumulating in the inner area of the storm and prevented from escaping horizontally, is subjected to a vigorous ascending movement; and since there is usually enough moisture in this air, a heavy downpour of rain in the inner storm area of the cyclone takes place. The regions along and near the tracks of cyclonic depressions are, in consequence, areas of heavy rainfall.

Brief references have been made in the preceding section to rainfall in India in different seasons. This may now be considered in some detail.

It has already been mentioned that the precipitation of the cold weather period occurs in association with the passage of shallow but extensive low-pressure systems or depressions across Northern India from west to east. On an average, four or five of these western disturbances may be expected each month of

this season to enter India and break the general run of dry clear weather. All these depressions are not equally active so far as their capacity for rain is concerned. Usually, within the fields of these depressions, the condensation takes place in upper air levels at heights above 3 km. from the surface. So, the distribution of precipitation is hardly modified by the terrain except near the mountain ranges of the Himālayas which are sufficiently high to affect air currents above 3 km. and force the winds up the higher mountains on a large scale. The precipitation is accordingly quite large over the higher interior ranges and moderate over the lower outer ranges of the Western Himālayas. It is in this season that the main additions are made to snow accumulations over the Himālayan mountains.

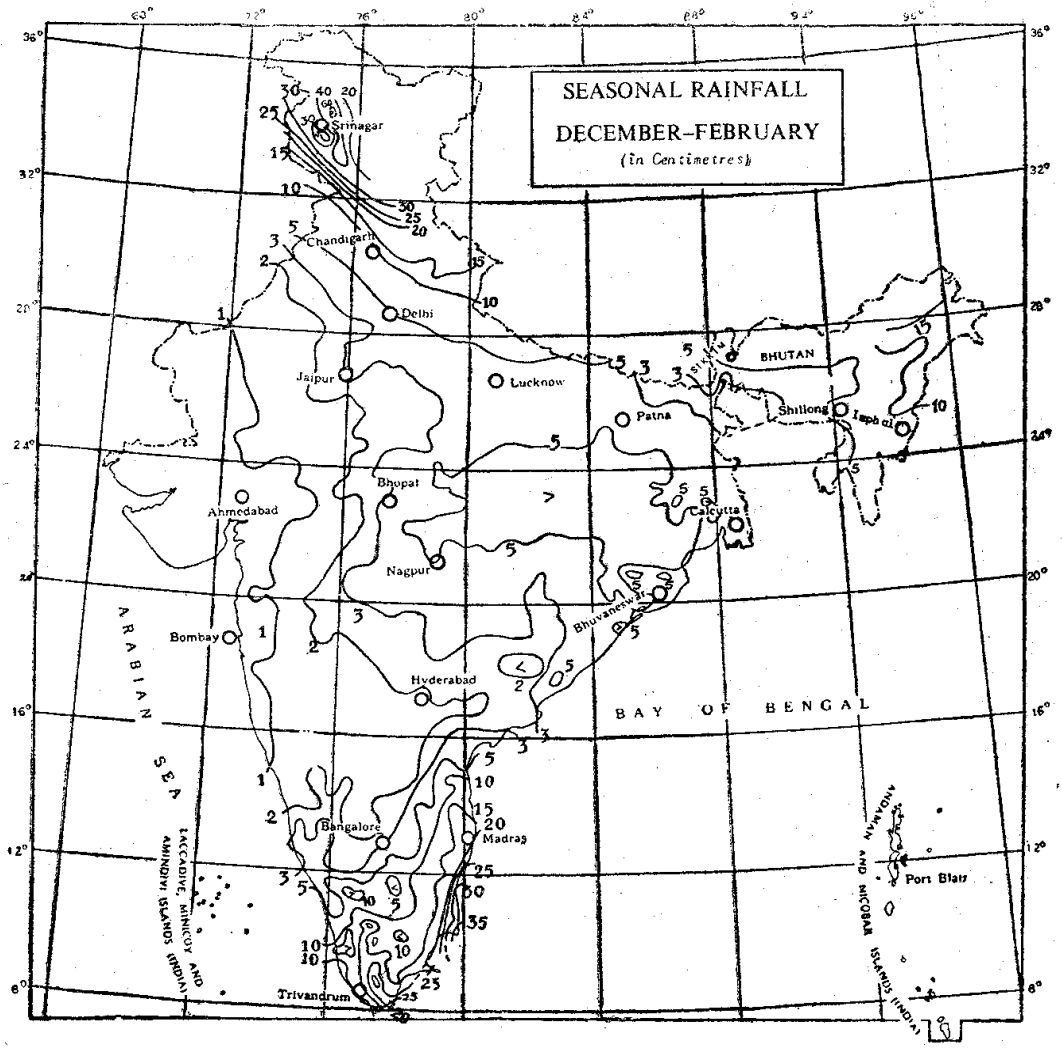
Cold weather rainfall

The precipitation decreases from the submontane Districts of the Himālayas southwards, and also eastwards from Punjab to Bihār. It increases in West Bengal and Assam since, by that time, more moisture-bearing winds are drawn from the north Bay of Bengal into the fields of the travelling depressions. Rainfall is of the order of about 50 mm. in Punjab and Assam and varies from about 18 to 25 mm. elsewhere in Northern India. Occasionally, these western disturbances give rainfall in the central parts of the country as well as in the northern Districts of the Peninsula. Even though the cold weather rainfall in Northern and Central India is small in amount, compared with the rain of the south-west monsoon, it is of great economic importance over most of those areas; upon this rainfall depend the crops of winter such as wheat.

To complete the picture of winter rains, the south of the Peninsula must be mentioned. It has been stated earlier that the retreating south-west monsoon current continues to give occasional rain in December in the south of the Peninsula in association with cyclonic storms and depressions from the Bay of Bengal. On the average, one such fairly well developed storm may be expected to strike the east coast of the Peninsula south of Madras and bring heavy rain to the coastal Districts once in three years. The rainfall decreases rapidly inland in amount and frequency, so that it is only about 25 mm. in the Mysore plateau. A few light showers occur in this region in January as well.

The total average precipitation in Northern India is about 250 mm. in the Western Himālayas, diminishing southwards from the Himālayas across the submontane Districts to a smaller amount in the plains. It is only on approaching South-east Madras that the rainfall again increases to over 250 mm. on the south

Coromandel Coast in December, decreasing rapidly inland to only about 25 mm. in the Mysore plateau. The seasonal rainfall distribution and the number of rainy days* is shown in Map VI.



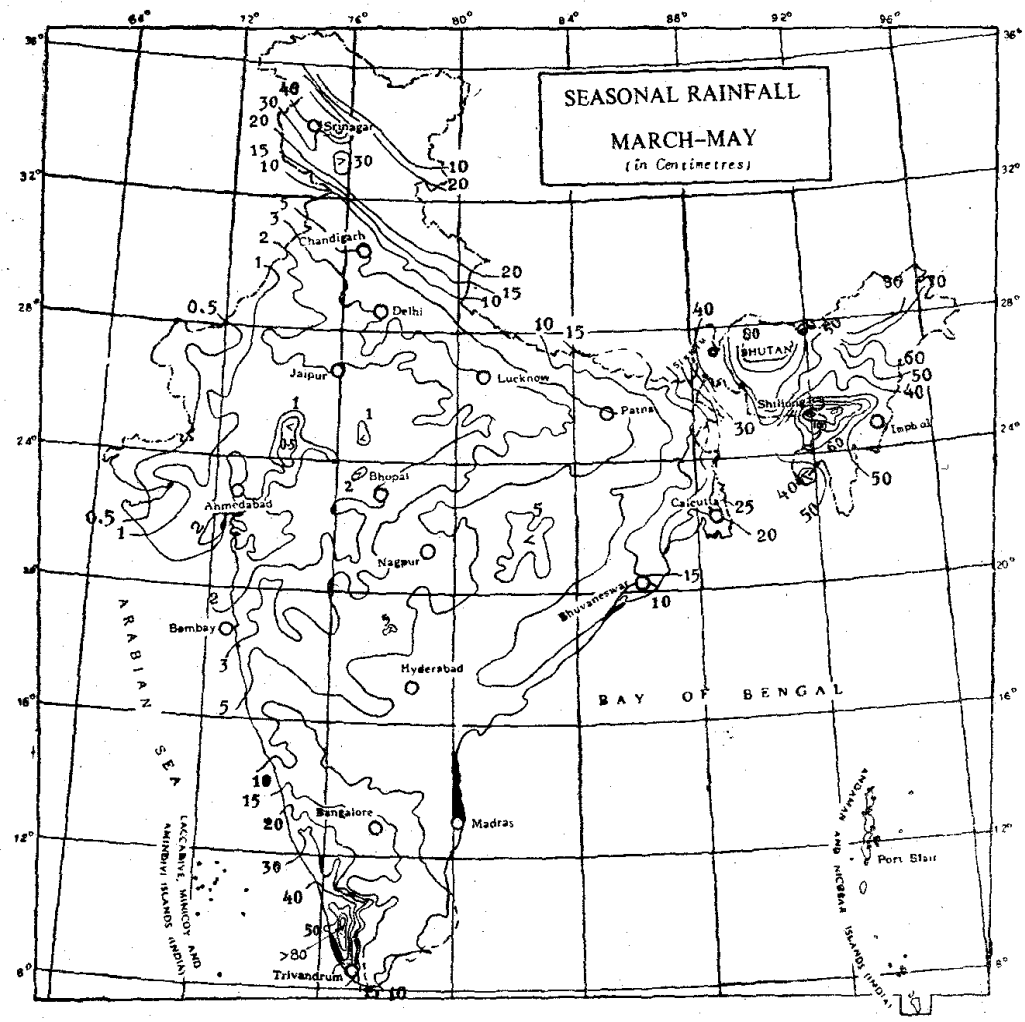
METEOROLOGICAL MAP VI

The distribution of rainfall in the hot weather season is quite different from that of the cold weather, as will be evident from Map VII.

Hot weather rainfall

In the earlier part of the hot weather, in March, western disturbances continue to enter India and occasionally bring rain to parts of North-west India. In their further eastward passage they give rise to thunderstorms, which are sometimes severe and accompanied by hailstorms, in the Ganga plain and in North-east India. As the season advances, thunder-showers occur more frequently and the rainfall becomes heavier. Occasionally, the

*A rainy day is defined as one in which at least 2·5 mm. of rain has been gauged in 24 hours.



METEOROLOGICAL MAP VII

thunder-showers attain great intensity and even tornadic violence, particularly in West Bengal and Assam. In the comparatively drier zone of the interior, the rainfall in the hot weather period is often preceded by dust-storms and is usually small in amount, as for example in Bombay, Berār, Madhya Pradesh, Rājasthān, and the Ganga plain. The rainfall caused by thunderstorms in Assam and West Bengal is larger in amount. Economically, the rainfall of this season is of importance in Assam for its tea crop and in West Bengal for the early spring crop of rice. Over the greater part of the rest of the country, in the plains of the interior of India, the rainfall of this season is of little agricultural value. The thunderstorms may be accompanied by hail which causes damage to crops and orchards.

In the south of the Peninsula, thunderstorm rain occurs chiefly in April and May; the distribution is irregular and the amount averages from 75 to 100 mm. Kerala gets moderate to

large rainfall in May on account of temporary incursions of the south-west monsoon causing widespread thunder-showers on the West Coast. In the north-west of the Peninsula, this is a season of dry winds with little or no rainfall until the end of the season, when temporary and shallow incursions of the monsoon winds give rise to pre-monsoon thunderstorms.

The total rainfall of the period is less than 25 mm. in Rājasthān, Gujarāt, Khāndesh and Madhya Pradesh; and it varies between 50 and 140 mm. in the submontane Districts of Punjab and Uttar Pradesh, in Bihār, West Bengal and Orissa, and over the greater part of the Peninsula. It exceeds 250 mm. in Kerala, while it is over 500 mm. in Assam.

In a way, it is upon the rainfall of the south-west monsoon season that the agriculture of the greater part of India depends

Rainfall of south-west monsoon

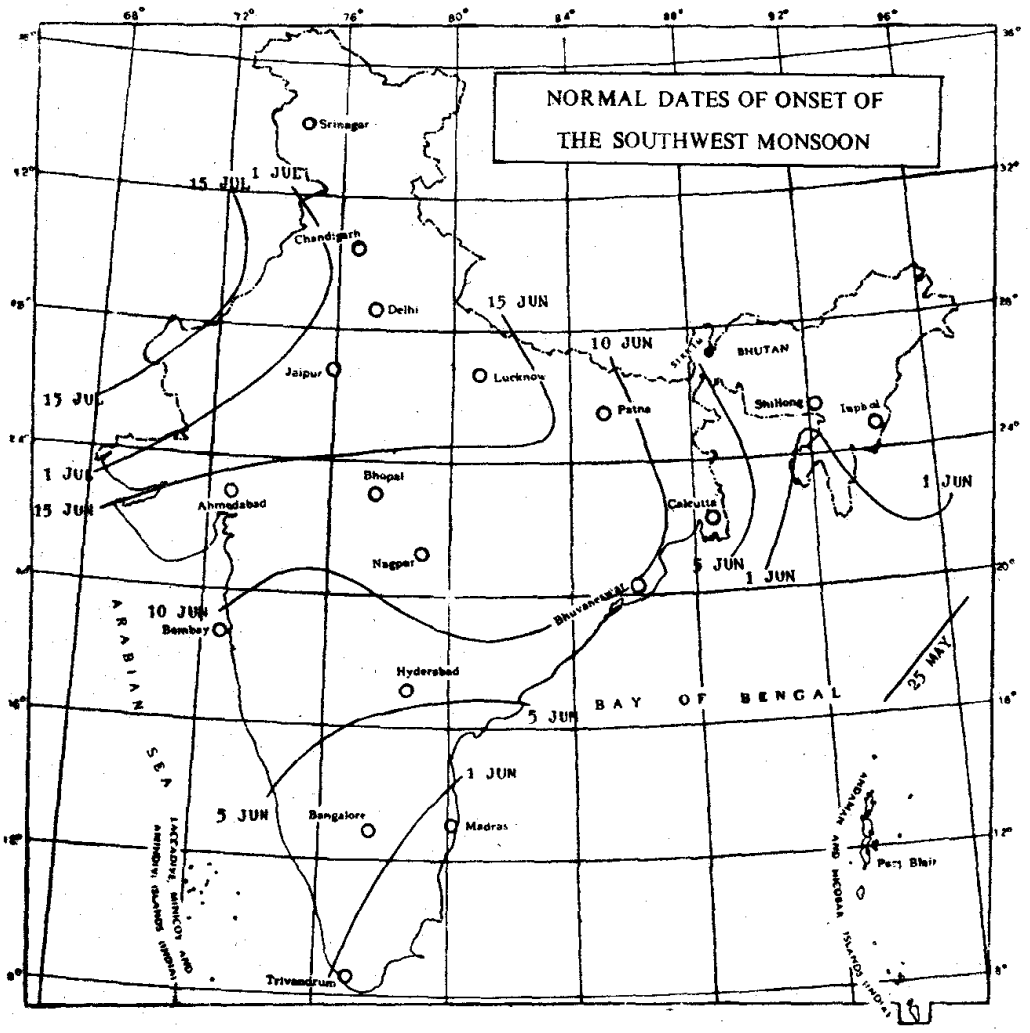
This extensive moist air current from the ocean area, reaching considerable vertical height, is responsible for nearly 90 per cent of the rainfall of the whole year, except in the southern parts of the country.

It has been stated before that towards the end of May, when the weather is at its hottest in India, south-east trade winds in the Indian Ocean advance rapidly northwards across the Equator into the Arabian Sea and the south Bay of Bengal; and in the course of about a fortnight, the monsoon winds establish their sway over the whole of these sea areas. Then the monsoon is very often ushered into the land areas by a cyclonic storm either in the Bay of Bengal or the Arabian Sea.

The monsoon enters the Indian area in two main currents, the Arabian Sea and the Bay of Bengal currents. The former strikes the West Coast, giving heavy rain to the coastal Districts south of Bombay and on the hills of the Western Ghāts. After crossing the Ghāts, the monsoon winds branch into two streams. The southern stream blows across the Peninsula and brings occasional rainfall associated with thundery weather; the northern part crosses the Kāthiāwār coast, gives rain mostly in the coastal Districts, and then blows across Rājasthān, causing precipitation near the Arāvalli hills and the Punjab-Kumaun hills, but very little in the plains of Rājasthān. The Bay of Bengal current also splits into two branches. One advances up the Burma coast; the other, which crosses the West Bengal coast, is directed westwards up the Ganga plain by the deflecting action of the mountains to the east and north of West Bengal.

Normally, the monsoon rainfall extends into Gujarāt and the central parts of the country in the second week of June and into Uttar Pradesh by the middle of June. It is more or less established

over the entire country by the end of the month. Map VIII illustrates the normal dates of the onset of the south-west monsoon and its progressive establishment over different parts of the



METEOROLOGICAL MAP VIII

country. It will be seen from this map that by the first week of july the entire country is overrun by the humid monsoon air and the rainy season is well established in all the regions including the neighbouring sea areas.

During July and August, the humid winds of the south-west monsoon blow more or less steadily over the Indian area and carry rainfall to its farthest limits. The two main factors that determine the activity and strength of the monsoon and largely influence the distribution of rainfall are the position and strength of the trough of low pressure over the Ganga plain and the frequency of depressions from the Bay of Bengal. The trough of low pressure exists throughout the monsoon season, between the westerly winds of the Arabian Sea current and the easterly winds

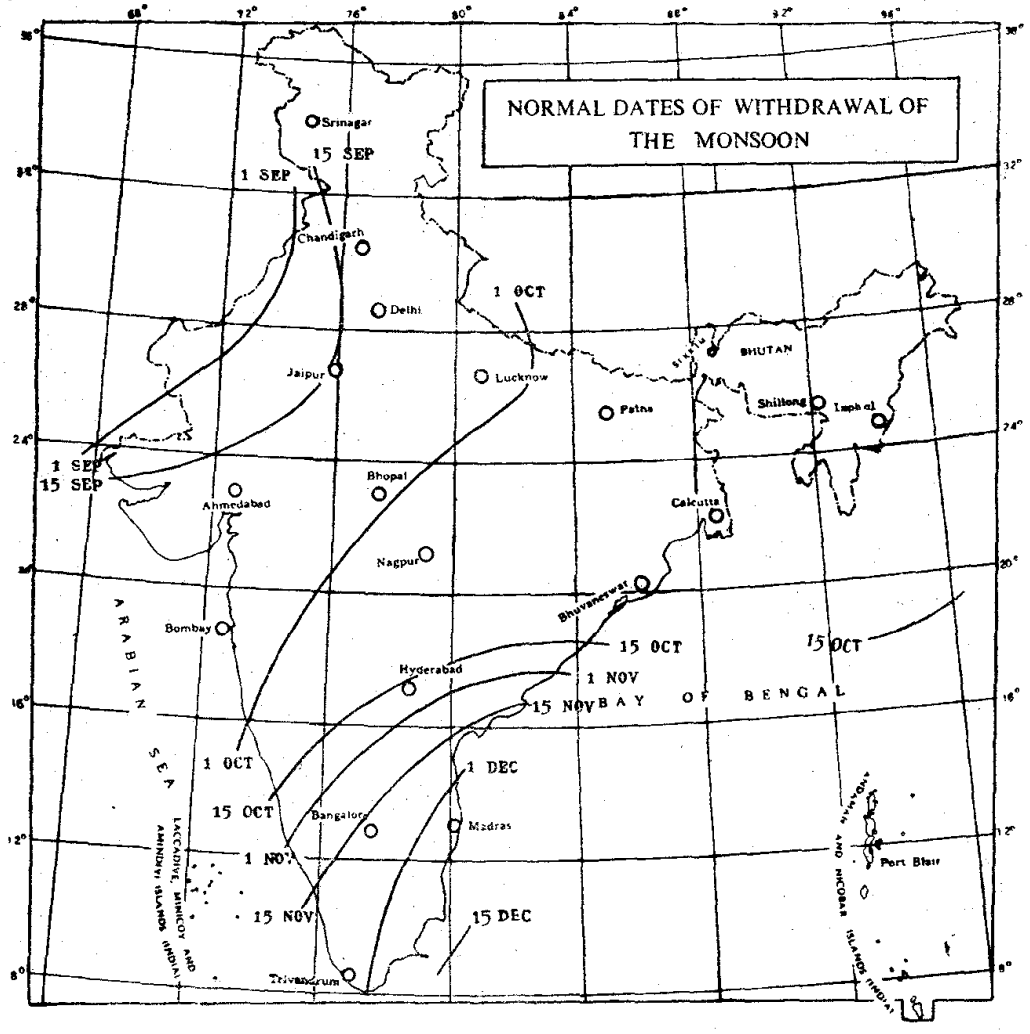
of the deflected Bay of Bengal current. The easternmost end of the trough usually extends into the head of the Bay of Bengal just before the formation of a depression there. At the time these depressions form, there is usually a weakening of the monsoon and decrease of rainfall in West Bengal and Assam. Then, as a fresh pulse of the monsoon advances up the Bay, a depression begins to develop and rainfall increases on the Burma coast. Often, a low-pressure wave from the east across Burma helps the development of these depressions.

Cyclonic depressions

A considerable proportion of the monsoon rainfall over the greater part of India is in association with the movement of cyclonic depressions from the Bay of Bengal. They travel somewhat slowly and often traverse the whole of Northern India. As the depression moves from the head of the Bay of Bengal towards the coast, rainfall extends into Southern or South-eastern Bengal and Lower Assam. With the further movement of the storm westward, the belt of moderate to heavy rainfall extends to Orissa, Chota Nāgpur and Bihār. By the time the storm crosses the Orissa coast and enters Madhya Pradesh, the Arabian Sea current is strengthened and moderate to heavy rain once again extends to Madhya Pradesh and the southern Districts of Uttar Pradesh as well as over the north of the Peninsula. The rainfall may then be carried by the depression into Rājasthān and Gujarāt before it merges in the seasonal low pressure over North-west India. Sometimes the depression curves round and, continuing to move more to the north, eventually breaks up in the submontane regions of Punjab or over Kashmīr. On such occasions, with a strong Arabian Sea branch of the monsoon feeding extra moisture into the storm area, there is very heavy rain in the hill Districts. After the dissipation of a depression the monsoon weakens generally and the rains slacken; but with the next strengthening of the monsoon in the sea and its revival, another depression forms at the head of the Bay of Bengal and as a consequence there is rainfall, somewhat similar to that associated with the depression preceding it. On an average, about eight such cyclonic depressions of moderate to severe intensity pass from the Bay of Bengal into the land area between June and September.

In the absence of these depressions, the distribution of rainfall in this season is strongly influenced by orography and the position of the monsoon trough of low pressure. A more southerly position of the axis of the trough is favourable for the general activity of the monsoon and widespread rainfall occurs over most of the country. On the other hand, a more northerly position of the

trough results in a shift of the rainfall further northward into the foot-hills of the Himālayas. Then there is a decrease in the activity of the Arabian Sea branch of the monsoon, while the Bay branch limits itself to North-east India—Assam in particular. Such a situation is referred to as a "break" in the monsoon. These breaks, when prolonged and associated with continuous heavy rains in the catchment of the Himālayan river systems, cause floods in the rivers while there may be very little rain in the



METEOROLOGICAL MAP IX

plains. Prolonged breaks generally occur in August and September and sometimes in July.

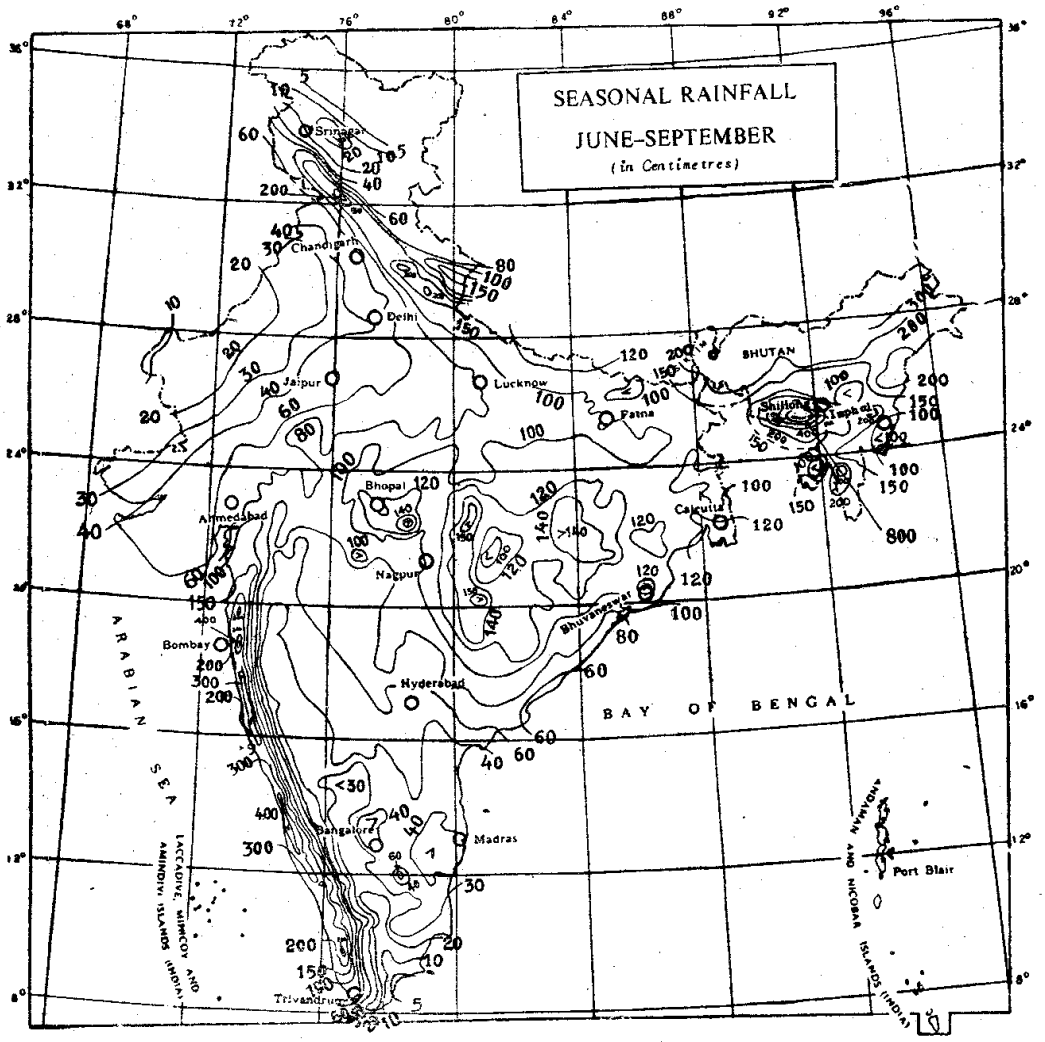
During September occurs the gradual weakening of the monsoon and its withdrawal from North-west India. As the month advances, the monsoon trough of low pressure weakens and extends further south into the Bay of Bengal. The depressions form in more southerly latitudes and after advancing initially westwards into the land area, take a more north-westerly or

northerly course towards the Himālayas where they break up. These cause occasional spells of heavy rain on and near the Punjab-Kumaun hills and in the adjoining plains. In the Deccan plateau the intervals between rainy spells increase in September and the rainfall is usually associated with thunder, conspicuously absent earlier in the monsoon season in the Peninsula. The monsoon withdraws from North-west India by the third week of September and from West Uttar Pradesh, the western divisions of Madhya Pradesh, and Gujarāt by the end of the month. Map IX shows the normal dates of withdrawal of the south-west monsoon from the various parts of the country. There are wide variations in these dates; very often the withdrawal of the monsoon is not as clearly defined as its onset. Anyhow, by the middle of October the monsoon withdraws from over most of the country. The south-eastern coastal part of the Peninsula is an exception.

Map X showing the June-September rainfall distribution illustrates clearly the regions which have heavy precipitation as a consequence of orographic features helping the rapid ascent of monsoon winds. In June, rainfall exceeds 760 mm. along the west coast of the Peninsula, and is between 500 and 760 mm. in and near the Khāsi hills in Assam and in parts of Northern Bengal. It decreases to less than 250 mm. in West Bihār and Orissa and lies between 125 mm. and 250 mm. over most of Uttar Pradesh, Madhya Pradesh and Gujarāt. The average rainfall over the plains of India in June is 201 mm.

In July also, most of the West Coast gets about 760 mm. of rainfall, which increases to between 1,000 mm. and 1,270 mm. on the Ghāts. It falls off rapidly to the east of the Ghāts, being less than 125 mm. over the eastern Districts of the Peninsula south of latitude 16°N. while in the north the precipitation increases again to between 380 mm. and 500 mm. in Assam, the eastern Districts of Bengal, and Madhya Pradesh; it falls off again to less than 125 mm. in West Rājasthān. The distribution of rainsall in August follows the same general pattern as in July, except that the amounts are generally less—500 mm. to 760 mm. on the West Coast; a much smaller area in the central parts of the country receives a rainfall between 380 mm. and 500 mm. in August. The total average rainfall over the plains of India is 284 mm. and 262 mm. in July and August respectively.

The distribution of the September rainfall over the country is similar to that in August, but the amounts are still smaller; the contrast between the rainfall amounts on the windward side of the coastal hills and the interior on the leeward side is less marked. About 500 mm. of rain is received in the Western Ghāts in North



METEOROLOGICAL MAP X

Konkan and 250 mm. to 380 mm. in Assam and Northern Bengal. The rainfall decreases to 250 mm. in parts of South-western Bengal and is between 125 and 250 mm. over most of the country from the Deccan to Uttar Pradesh. In North-west India, to the west of the Ar valli hills in West Rājasthān, the rainfall in September is generally less than 50 mm. The average rainfall over the plains of the country in September is 178 mm.

Rainfall of retreating south-west monsoon

It has been noted already that monsoon rainfall ceases in East Uttar Pradesh early in October. During the subsequent withdrawal of the Bay branch of the monsoon from over Northern India, these moist winds continue to give rain in North-east India until their final retreat from that region by the 10th of the month. About this time the Arabian Sea branch also withdraws from the central parts of the country and the northern areas of the Peninsula, and dry weather sets in over these regions.

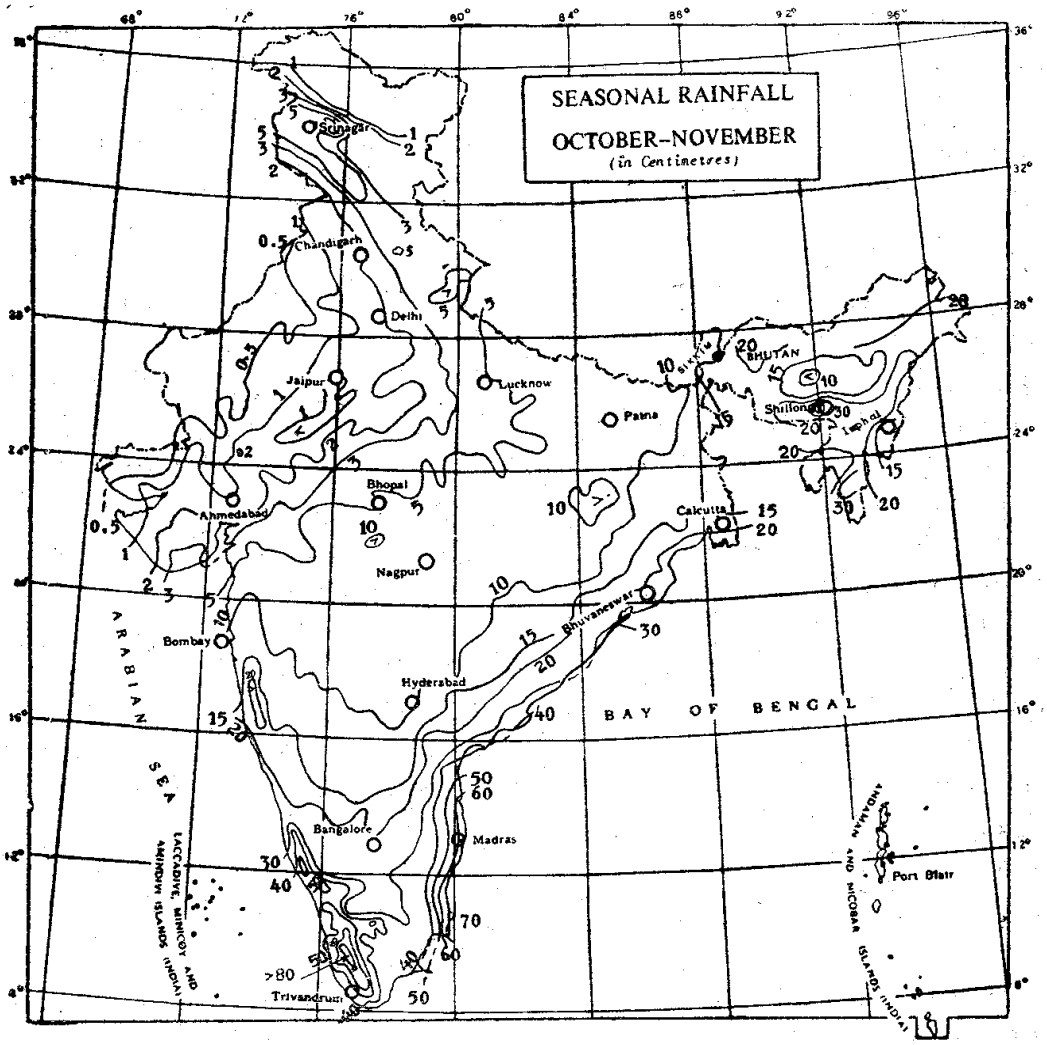
It has been observed already that, by the middle of October, the belt of low pressure which marked the monsoon trough during June to September over the Ganga plains is transferred to the centre of the Bay of Bengal. Under its influence the retreating monsoon current curves round and is directed towards the Peninsula from the north-east; this is sometimes designated as the north-east monsoon. The retreating monsoon winds, now much weaker and shallower, cause occasional showers in the east coast of the Peninsula, the amount of rainfall decreasing from the coast towards the interior. However, during October and November, cyclonic storms form in the Bay of Bengal and carry heavy rainfall along their track. Usually they travel towards the Bengal coast or towards the Burma coast in the earlier part of October; later in the season, they mostly strike the Northern Circārs or the Coromandel Coast and produce very heavy rainfall along the track of the centre of the cyclone. The Deccan and the Tamilnād Districts of Madras receive their rainfall in this season almost solely in association with these storms or depressions, and hence the rainfall distribution is very irregular.

The rainfall in October-November is shown in Map XI. The amount measured in October exceeds, on an average, 250 mm. on the south Coromandel Coast and South Kerala and is somewhat less than 125 mm. over most of the remaining parts of the country. In November the pattern of rainfall distribution is about the same as in October, but the total rainfall is between 250 mm. and 375 mm. on the south Coromandel Coast and less than 25 mm. in the rest of the area in the interior. The rapid decrease of rainfall as one goes from the Madras coast into the interior is a very striking feature of the rainfall distribution in this season. This is due to the heavy rainfall caused by the cyclonic storms as they strike the coastal regions. Rainfall is occasionally very heavy in the Nīlgiri when the cyclonic storms or depressions from the Bay of Bengal advance into the interior Districts of Southern India and break up on the higher ranges.

The Table in Appendix A gives the normal monthly rainfall and normal annual rainfall for the thirty-one meteorological sub-divisions of India.

It is clear from this account that the rainiest season is the south-west monsoon period, June to September, except in South-east Madras where the main rainy season is the October-November period; also, the cold weather rainfall during December and January, though scanty, is of great importance for the wheat crop of Northern India.

The average annual rainfall over the different regions of India is shown in Map I. The effect of the orographical features of the land on rainfall distribution is clearly brought out by the annual as well as the seasonal rainfall maps.



METEOROLOGICAL MAP XI

5. *Rainfall Anomalies—Floods and Droughts*

An important consideration in the rainfall distribution in any region, which is of great significance to agriculture and othe enterprises depending on rain, is the variability of the precipitation received over different parts of the region in specific periods of time. The average annual rainfall in India and its seasonal distribution have been described in the previous section. The amount of precipitation received,however, varies considerably from year to year for the country as a whole; the variations may

be particularly large in certain divisions and Districts in some years.

The average annual rainfall in the plains of India is about 1,070 mm.; its variation from the normal has ranged between −280 mm. in 1899 and +305 mm. in 1917. Variations from the normal in the monsoon rainfall over the country can have four different aspects. Firstly, the beginning of the rains may be considerably delayed or be appreciably early over the whole or parts of the country. Secondly, there can be one or more breaks in the monsoon rains during July and August. Thirdly, the monsoon may withdraw earlier than usual and the rains cease before the due dates, or the rains may persist longer than usual because of a delayed withdrawal of the monsoon. Finally, the rainfall may be heavy and persist longer than usual in one part of the country while avoiding another area, thus bringing about serious anomalies in the distribution of the precipitation.

Long breaks in the monsoon rains or a sudden cessation of the rains during the season can be very harmful to crops and may lead to famine conditions. Some of the interior Districts in North-west India; Gujarāt and the Deccan plateau are particularly liable to occasional drought, the variability of the year's rainfall being as much as 100 per cent or more. Gujarāt is particularly liable to great variability of rainfall, since it is subject to scanty rain in some years and in others to excessive downpours caused by cyclonic storms or depressions moving over the area. Partial or large scale failure of the winter rains causes drought conditions mostly in Punjab and parts of the Ganga plain; but their effect is not so marked on the winter crops because of the irrigation facilities provided in these areas. Deficiency of rain in an area with a heavy average rainfall, as for example in parts of Northern Bengal, rarely affects the staple crops of the area to an extent which could be called crop failure due to drought.

The results of a drought may be scarcity or famine conditions, local or widespread. While such famines were at one time "the bogey of India's administrators," they are no longer regarded as major calamities. This is because the possible effects of a drought are negated by irrigation, the introduction of dry farming systems in areas liable to frequent droughts, and improvements in railway and road transport.

On the other hand, large tracts in naia are liable to receive excessive rainfall and suffer from floods and waterlogging. Heavy downpours brought about by cyclonic storms and depressions from the Bay of Bengal or the Arabian Sea are often responsible for floods. Rainfall from 250 mm. to 500 mm. in one day is

not a rare occurrence; the heaviest recorded in the plains in a period of 24 hours was about 900 mm. at Purnea in North Bihār. This is exceeded only by the proverbially heavy falls at Cherrapunji in the Khāsi-Jaintia hills of Assam where, as has been discussed earlier, the orographic features of the region lead to exceedingly vigorous ascensional movement of the moisture-laden monsoon winds striking against hill slopes. The heaviest rainfall recorded in Cherrapunji is 1,036 mm. over a period of 24 hours. The Table below gives an idea of the heavy downpours which have exceeded 600 mm. in 24 hours.

Table of stations in India which have recorded rainfall of 600 mm. or more in 24 hours

S. No.	Station	Amount (mm.)	Date
1	Cherrapunji	1,036	14-6-1876
2	Jowai (Assam)	1,018	11-9-1877
3	Purnea (Bihār)	889	13-9-1879
4	Nagīna (Uttar Pradesh)	823	18-9-1880
5	Dhāmpur (Uttar Pradesh)	772	18-9-1880
6	Najībābād (Uttar Pradesh)	724	18-9-1880
7	Rewa (Madhya Pradesh)	772	16-6-1882
8	Roha (Mahārāshtra)	630	18-6-1886
9	Jalālpur (Gujarāt)	657	28-7-1891
10	Nenotha (Assam)	693	30-5-1893
11	Cherrapunji	691	11-8-1893
12	Cherrapunji	615	4-9-1897
13	Cherrapunji	639	25-8-1898
14	Cherrapunji	729	10-8-1902
15	Cherrapunji	650	8-7-1903
16	Cherrapunji	615	9-7-1903
17	Cherrapunji	998	12-7-1910
18	Cherrapunji	655	24-7-1910
19	Cherrapunji	851	25-7-1910
20	Cherrapunji	674	28-6-1911
21	Cherrapunji	737	29-6-1911
22	Cherrapunji	644	12-10-1911
23	Cherrapunji	812	25-5-1916
24	Cherrapunji	683	23-8-1932
25	Cherrapunji	925	21-6-1934
26	Cherrapunji	627	23-9-1940
27	Cherrapunji	632	3-9-1951
28	Cherrapunji	823	26-7-1952
29	Cherrapunji	973	11-6-1956

6. *Temperature and Humidity*

Next to rainfall, temperature is perhaps the most important climatic factor in India from the economic point of view. Temperature, along with the amount of water-vapour present in the air, and rainfall virtually determine the character and extent of the principal crops.

Air temperature is measured at all stations under almost similar conditions. Protected from the direct rays of the sun, the thermometer is exposed in louvred boxes of standardized specifications through which the air circulates freely. The bulb of the thermometer is at a standard height of four feet above the ground.

The most important factors which determine the temperature of a place are the sun's altitude, latitude of the place, its elevation, its distance from the sea-coast and the character of prevailing winds, and hence indirectly the amount of cloud and rainfall. During January to May or June the heating of the air by the sun's insolation is greater than the loss of heat by radiation and other causes; hence, air temperature rises more or less steadily with the increasing elevation of the sun. In the rest of the year, the balance is on the other side and temperature steadily decreases from June or July to December.

In most countries July and August are at least as hot as June. But this is modified over the greater part of India by the effects of cloud and rain of the south-west monsoon. The annual variation of temperature is small in the extreme south and increases fairly rapidly northwards. Along the east and west coasts of India the variation of temperature is twice as great in Bombay as in Malabār. It is eight to ten times as much at places in North Deccan and Northern and Central India, and is at its maximum in the most inland parts of the dry Districts.

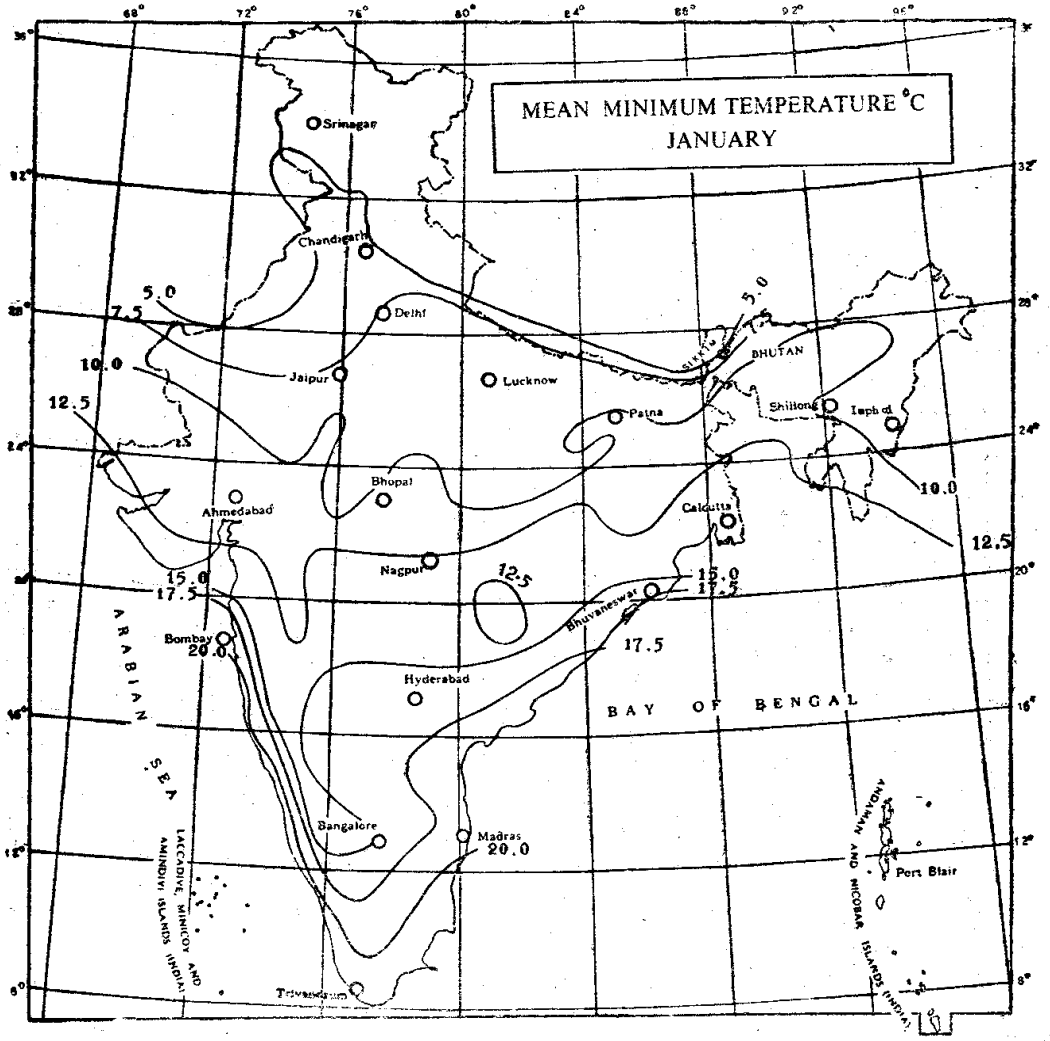
In the cold weather season, from the end of November to February, dry continental winds prevail over the greater part of India; temperature increases from north to south. December and January are the coldest months, the mean maximum temperature ranging from about 29°C in parts of the Peninsula to about 18°C in the north-west, while the mean minimum temperature decreases from about 24°C in the extreme south to below 5°C in the north-west. In the rear of some of the western disturbances in the winter period, cold winds from the Caspian and Turkestn regions pour into India and cause a cold wave to sweep over a major part of Northern India, occasionally invading the northern regions of the Peninsula as well. During these cold waves the temperature

sometimes comes down to as much as 10°C below normal, with several degrees of frost, in the plains of North-west India.

In the hot period, March to May, temperature is highest in the interior where dry land winds prevail; there is a great contrast between the interior and the coastal Districts due to local sea-breezes. With the advance of the hot season, the warmest area slowly shifts from the South and Central Deccan to North-west India, the rise being more marked in the maximum than in the minimum. In March the mean maximum temperature generally exceeds 35°C in the south of the Vindhya range and is over 37°C in parts of the Deccan. In April the mean maximum temperature exceeds 37°C in Northern India over the region stretching from South-west Punjab to Chota Nāgpur, Orissa and the Northern Circārs, and rises above 40°C locally in Madhya Pradesh. The mean maximum temperature in May is over 40°C in most of North-west and Central India. On individual days in May, maximum temperatures exceeding 54°C have been recorded in Western Rājasth n and South-west Punjab. The mean minimum temperature exceeds 21 C over the entire country in May and is higher than 26°C in the eastern half of the Peninsula.

With the arrival of the monsoon rains the maximum temperatures fall rapidly in the north of the Peninsula and the central parts of the country; and with the extension inland of the monsoon in the second half of June and early July, there is a progressive decrease of maximum temperature in North-west India. The season as a whole has almost uniform temperature, varying only slightly in regions of frequent rain. Temperature rises whenever there is a break in the rains; but the hot spell never attains the same intensity as during the earlier hot weather months when the land lies parched under the tropical sun. In the areas which are only occasionally overrun by the monsoon winds, comprising South-west Punjab and North-west Rājasthān, the temperature is at its highest throughout the season but steadily decreases from June to August. In June, the maximum temperatures continue to be as high as in May, being over 40°C in North-west India. At many stations in Uttar Pradesh and Punjab, the highest temperature of the year is recorded in early June. In July, maximum temperatures exceed 37°C only in the Thar desert. In August there is a further general fall of temperature; but with the cessation of the rains in North-west India about the middle of September, temperature rises once more and 40°C or more is recorded again in the area to the west of the Arāvallis.

The clear autumn weather following the termination of the monsoon rains in Northern India is accompanied by a rapid fall of temperature the second half of October—more marked in the minimum an in the maximum. The mean maximum temperature is below 37°C even in North-west India in October, while in November temperatures exceeding 37°C are rare even on individual days in that region. The mean minimum temperature in November is below 10°C in Punjab; and on individual days temperatures below the freezing point may be recorded.



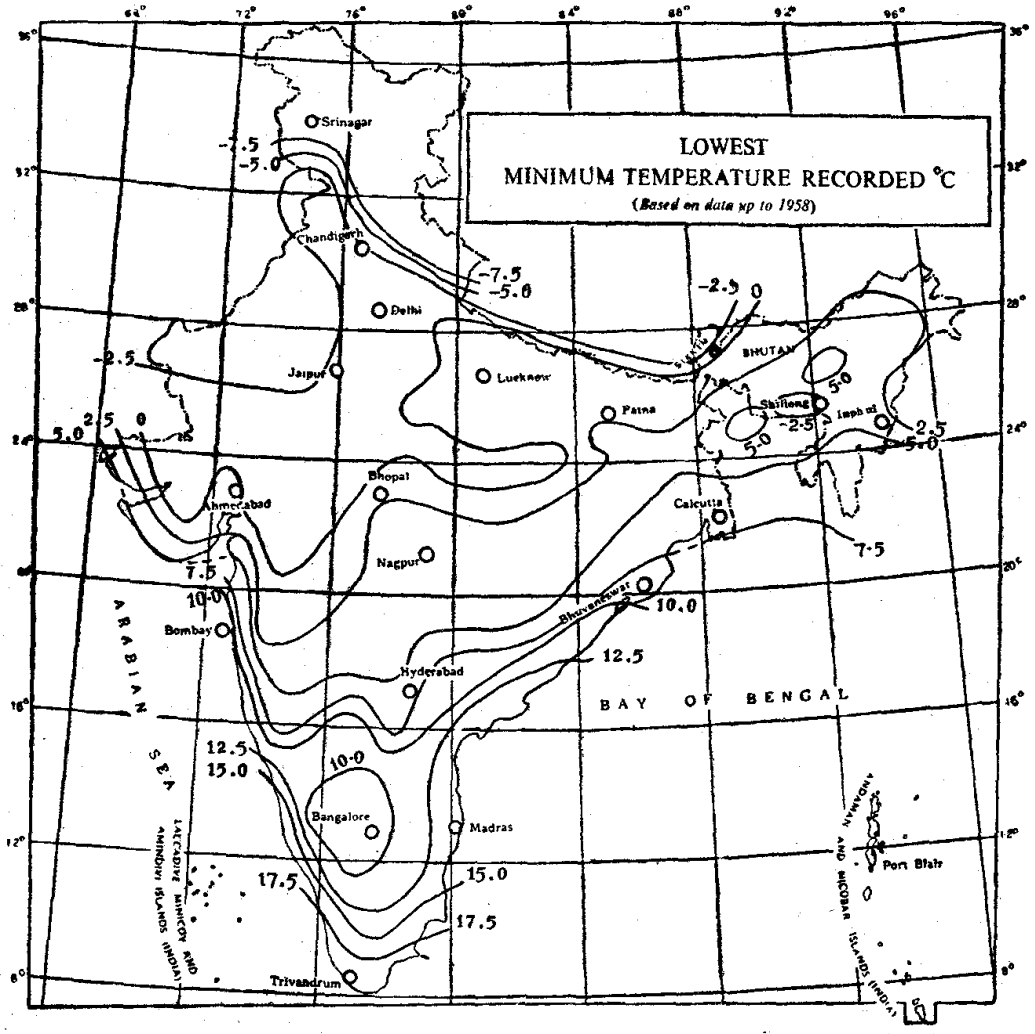
METEOROLOGICAL MAP XII

The distribution of the mean minimum temperature in January and of the lowest minimum recorded in the winter season are shown in Maps XII and XIII respectively, while Maps XIV and XV respectively show the distribution of the mean maximum temperature in May and the highest maximum recorded during the summer season.

In fine, clear weather, temperature changes during the day are strikingly regular in India. The air is coolest shortly before sunrise.

Diurnal range of temperature

As soon as the sun is above the horizon, temperature begins to rise rapidly, the rate slowing down after about 9 a.m. until the highest point is reached in the afternoon. Then the temperature begins to fall, slowly at first and more rapidly thereafter. About sunset the fall is as rapid as the rise in the forenoon. The rate is slower after sunset, but the fall continues steadily until the minimum is reached

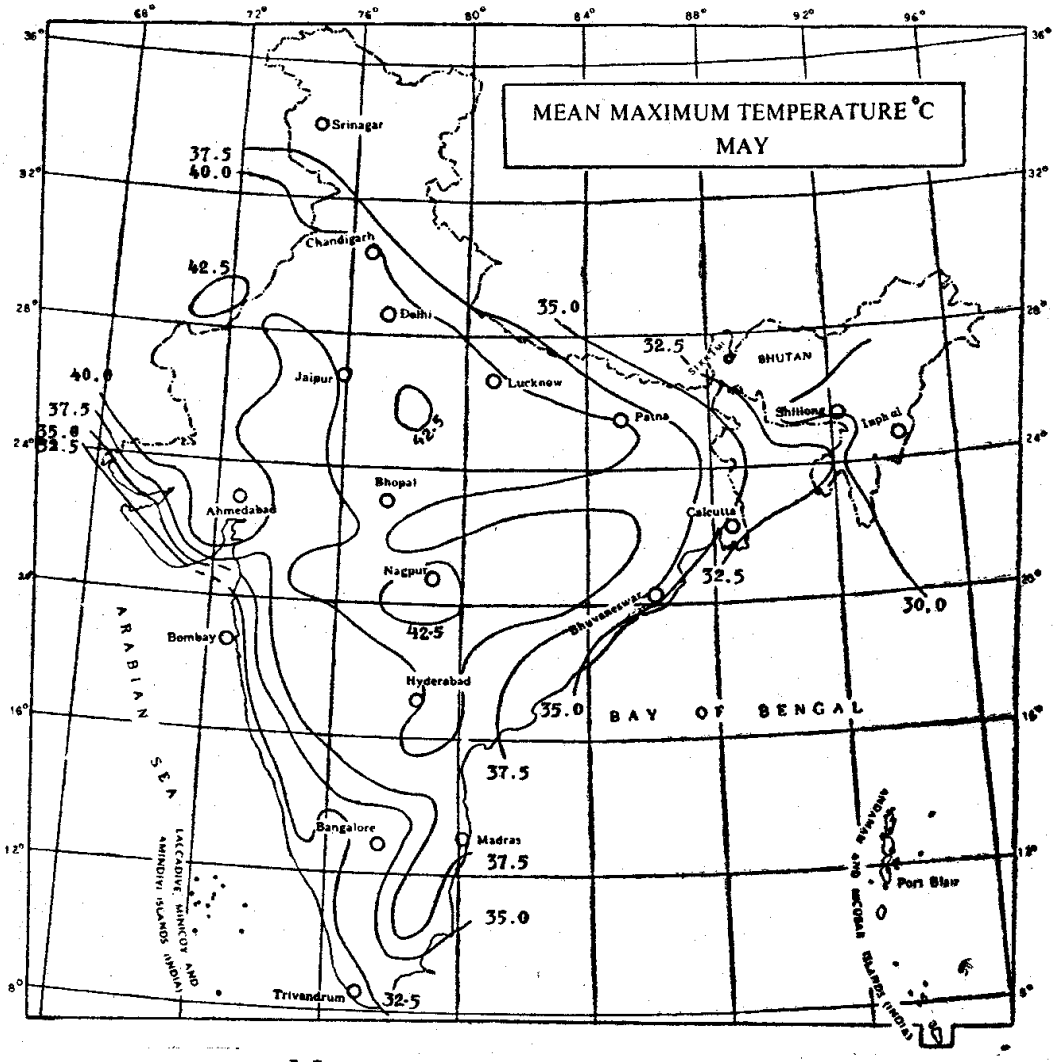


METEOROLOGICAL MAP XIII

a little before sunrise. In coastal regions the rise of temperature during day-time is usually checked with the setting in of sea-breeze shortly aftersh noon.

The range of temperature during the day depends mainly on the humidity of the air and the cloud-coverage of the sky. The range is much greater in the interior of the country, especially

in North-Wast India, than in coastal tracts. As a general rule, the range is greatest in the driest spring months and least in the rainy season. On the mean of the year, the diurnal range is 14°C to 17°C in North-west India, decreasing towards the east and south. The daily range is 8°C to 11°C in North-east India and in the coastal Districts. Throughout the dry tract to the west of the river Yamuna and the Arāvallis the range of temperature is greatest in October and November, when the diurnal variation is not less

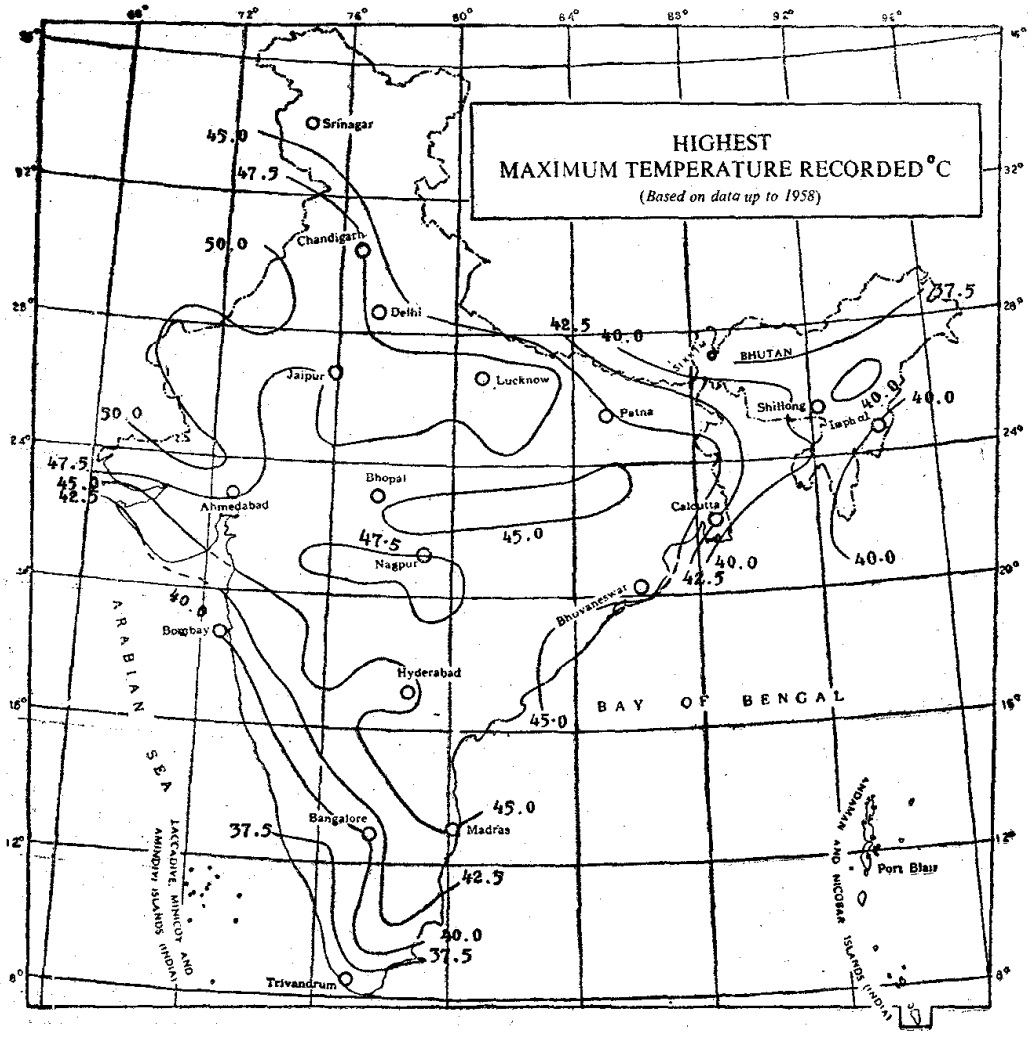


METEOROLOGICAL MAP XIV

than 17°C and increases to 22°C in some places. In the north-west of the Peninsula and the areas adjoining it, the greatest range of 17°C to 19°C occurs in February and March.

In addition to the variety of temperature regions in the plains of India, there is a further variety due to hills. The climate of hill-stations, as health resorts, deserves special attention. These stations are situated along the Himālayas and on the Ghāts in

the Peninsula. Their atmosphere is cooler and damper than that of the neighbouring plains. But while the stations in the North-west Himālayas are subject to great variations of heat and cold, dryness and dampness, those of Southern India are comparatively equable; their fine clear season is shorter than at the northern stations and far less dry. Table in Appendix B gives the temperatures of a few hill-stations as well as selected stations in the plains.



METEOROLOGICAL MAP XV

Humidity

The moisture in the atmosphere is obtained by evaporation of water from the earth's surface and from vegetation. Humidity is greatest where winds of oceanic origin especially from the warmer sea areas predominate; it is the least in places where land winds from a colder region hold sway. Distance from the sea and the character of prevailing winds are the main factors which determine the water-

vapour content of air at any place. Humidity is generally lowest in North-west India, and increases towards the sea in all directions.

In the hot weather season, however, the driest air is to be found in the central parts of the country, while in the south-west monsoon months the region east of the Western Ghāts has the lowest vapour pressure. Further, vapour pressure is the lowest over the country generally in December and January when winds of land origin prevail. Humidity begins to increase with the commencement of oceanic winds on the coast, which increase in strength and extend to the interior regions from March to May. The change from local sea-breezes to moist winds of the south-west monsoon brings about a large and rapid increase of absolute humidity over the whole country. In consequence, the spatial variation of vapour pressure is less in July and August than in any other month. The diurnal variation of vapour pressure is generally small in this season.

In the cold weather months, temperature as well as vapour pressure decrease as one passes from the coastal regions to the interior; the variations in relative humidity are smaller in this season than in the hot weather period. The air is driest in the cold weather season in West Deccan, Gujarāt and South-west Rājasthān, with relative humidity between 40 and 50 per cent.

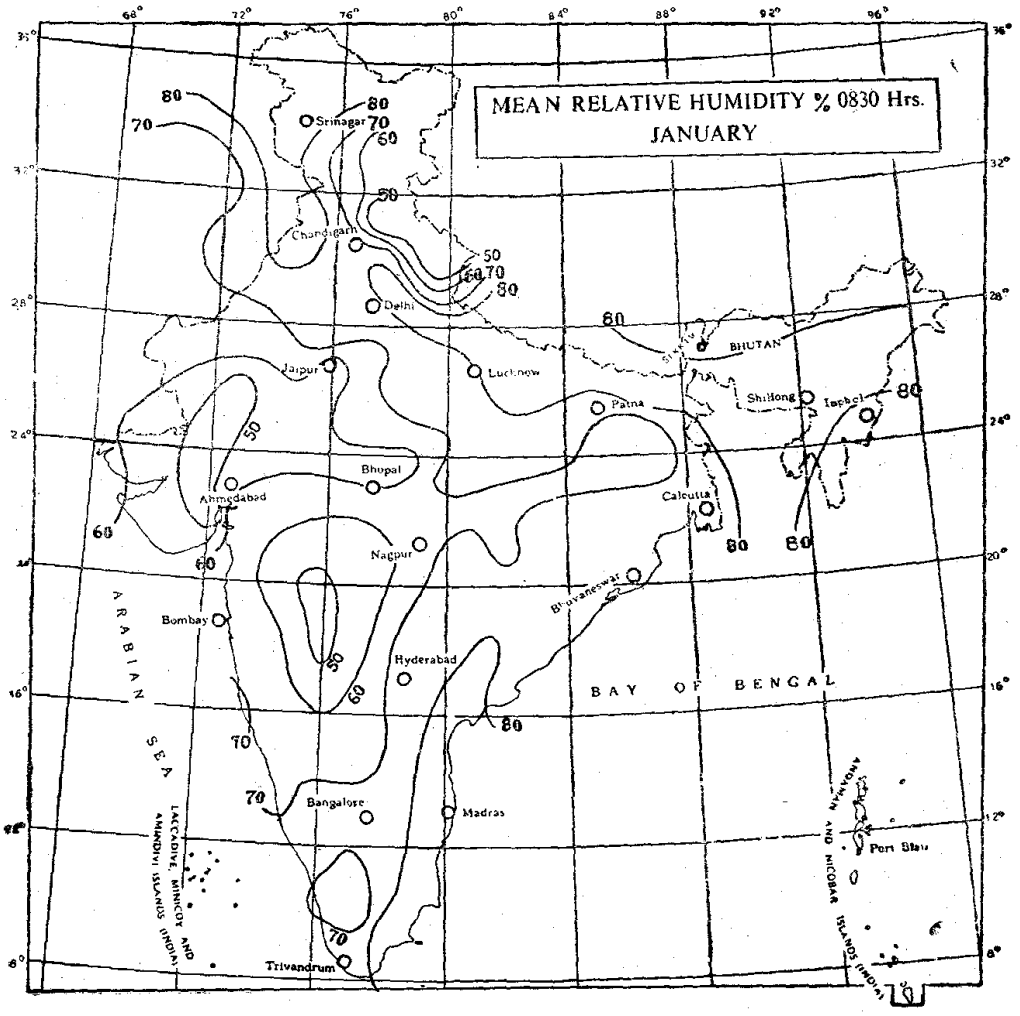
During the hot weather season, the decrease of relative humidity in passing from the coastal areas to the interior Districts is rapid. In this period the air is very dry over the whole of the interior, and particularly in the central parts of the country and the adjacent Deccan plateau, where the mean relative humidity is only about 30 per cent or less. During the hot afternoons of the summer months, relative humidity as low as 5 per cent has been recorded at stations in Upper India, from Punjab to Bihār and sometimes also in the central parts of the country and North Deccan. Such low values are largely the result of a high degree of turbulent motion in the first kilometre or so of the atmosphere; the air near the ground is replaced by originally colder and drier air of the higher levels, heated up partly on account of its descent and partly by contact with the hot land surface.

In the rainy months of the south-west monsoon season, temperature and the amount of water vapour in the air vary only slightly over most of the country. In this period, air is generally very damp and the relative humidity ranges between 80 and 90 per cent over the greater part of India; only in North-west India it falls below 80 per cent.

The distribution of relative humidity in India in January and July is shown in Maps XVI and XVII. The mean annual

humidity is below 50 per cent in the driest parts of the country, the Thar desert and adjoining areas, and is about 80 per cent in the dampest regions in Assam and along most of the coastline.

Clearly, then, a characteristic feature of the climate over most of the country is the large variability of relative humidity. In a spell of very wet rainy weather the air is sometimes saturated, or

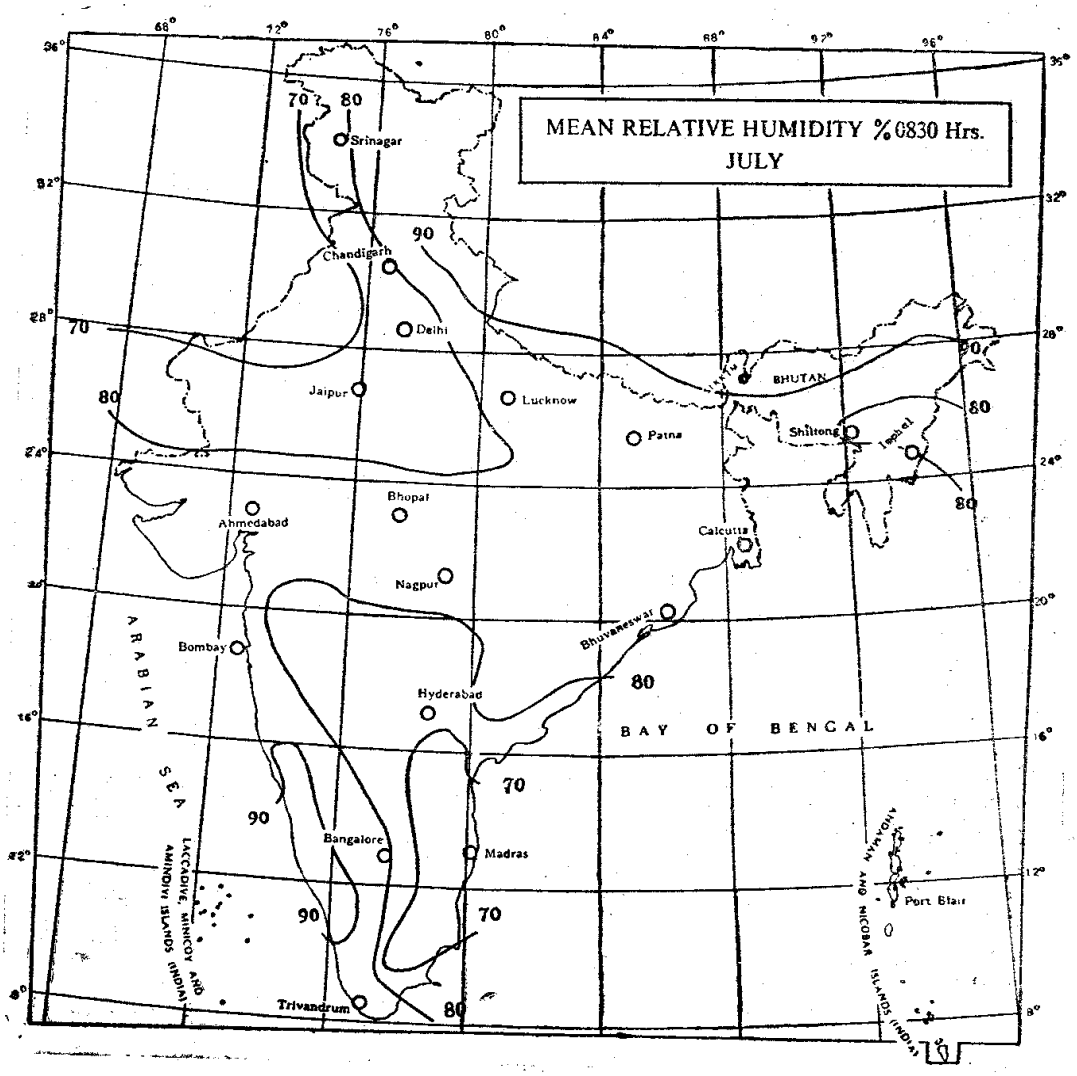


METEOROLOGICAL MAP XVI

has a relative humidity of 95 to 100 per cent; but when hot winds blow, as in April or May in Upper India, relative humidity is often less than 10 per cent. It varies during the day also; the air is dampest in the early dawn and the relative humidity begins to decrease shortly after sunrise. The driest time of the day is the same as that of the highest temperature, and relative humidity increases in the later hours of the afternoon and evening as the temperature falls.

7. *Wind Circulation*

The main features of the principal wind systems of the north-east and south-west monsoon seasons, as also those of the



METEOROLOGICAL MAP XVII

transition months between the two monsoons, have already been described. The account cannot, however, be adequate without a reference to the upper wind circulation over the region. From observations of the upper winds obtained by pilot balloons over the last 35 years or so, and lately by means of radio wind-finding devices, detailed information has been compiled of the monthly mean direction and velocities of upper winds. The general features of the upper-air circulation up to 3 km. during the four principal seasons are briefly indicated here.

During the winter months, the main features of the wind circulation at a height of 0·5 and 1 km. are : (1) the slow drain of cold air from Īrān and Baluchistān towards neighbouring areas in West Pākistān and North-West India, and also along the Himālayas towards the head of the Bay of Bengal; (2) the curving of the North Indian air around the high-pressure area which extends from Gujarāt to Orissa; and (3) an easterly to north-easterly current in the south of the Bay of Bengal and the south of the Peninsula.

Winter Season

The prevailing wind direction at 1 km. is from west to north-west and the mean wind speed 15 to 25 km. per hour in the region from Jodhpur to Calcutta. At levels above 1 km. the mean wind direction in Northern India is also from west to north-west the mean speed increasing with height from 30 to 45 km. per hour. There are two peculiarities of the upper wind distribution in North India during this season. One is the greater tendency of southerly to south-easterly winds to occur in connection with western disturbances in South and East Punjab than at places further south or east; the other is the occurrence of an easterly flow of air from Assam to Northern Bengal down the Brahmaputra valley.

The winds in the south Bay of Bengal and the south of the Peninsula are generally from the east and have a mean speed of about 25 km. per hour at 1 km.; there is not much change of speed with height. As we go northward, north-easterly winds become more and more common on the eastern side of the Peninsula. In the central parts of the country, the wind directions are variable, generally ranging between north-west and north-east in the lower layers with westerlies and north-westerlies becoming more common above 2 km. On the west coast of the Peninsula, to the north of Mangalore, the winds at 1 km. and above become south-east to south.

The main points of difference between wind circulation in the hot season and in the cold season arise from the fact that the anticyclonic high-pressure area over Central India has weakened and is replaced by a cyclonic circulation round a low-pressure area up to 1-km. level. This change, however, takes place without any large alteration in the upper wind circulation above 2 km. The predominant wind directions in Northern India in this season are between west and north-west, but south-westerlies also occur in Rājasthān From Gaya to Calcutta the winds above 2 km. generally blow from a north-westerly direction, but in the lower levels the directions are mostly south or south-west over Bengal. In the Brahmaputra valley the main directions are from the east as well as from the

Hot Weather Season

west, the easterly being more common from the surface up to 1.5 km. while the westerly is more common at 2 and 3-km. levels.

Winds in Gujarāt and the central parts of the country are also mainly from the west and north-west, but are unsteady in the latter region. In the Peninsula the wind direction undergoes a marked change with height. In the first 1 km. the wind is from a northerly direction along the West Coast, and from a southerly to south-westerly direction along the East Coast; the latter extends into the interior of the Peninsula. At 2 km. the winds are mainly from the east and north-east in the South Peninsula, while in the Deccan plateau the direction is often indefinite. At 3 km. the wind direction is generally from north to north-east over the northern half of the Peninsula and north-east to east in the southern half, the only exception being West Deccan, where southerly winds are frequent.

Wind speeds show an increase with height in Uttar Pradesh and Bihār and in the south of the Peninsula. In Uttar Pradesh and Bihār the mean speeds increase from about 25 km. per hour at 1 km. to 40 km. per hour at 3 km. and in the south of the Peninsula, from about 15 km. per hour at 1 km. to 32 km. per hour at 3 km.

So far as wind circulation is concerned, July may be taken as the representative month of the south-west monsoon season.

South-west monsoon season

Normally, by the beginning of this month, the monsoon is established. The wind system is dominated by the low-pressure area over īrān, Baluchistān and Sind, and the low-pressure trough along the Ganga valley. Depressions move more or less regularly in a westerly to north-westerly direction from the head of the Bay of Bengal to West Madhya Pradesh and Gujarāt. Described in general terms, the upper winds are westerly over the whole of the Peninsula, the central parts of the country, and Orissa. But in East Rājasthān, north-easterly winds are also frequent, especially above 1 km. In Punjab the winds are generally from the north-west with occasional changes to south-east.

To the north of the low-pressure trough over the Ganga valley, i.e., over the northern Districts of Uttar Pradesh and Bihār, the winds are generally easterly. In South-west Bengal, south-westerly winds are most common, while in the east and north of this State the main directions are between south and east. The direction of wind in the Brahmaputra valley in Assam depends upon the strength of the monsoon in that area being easterly when the monsoon is weak and westerly when it is strong.

In this season there is great steadiness in wind direction over most of the area. The largest variation occurs in the neighbourhood of the low-pressure trough in the Ganga valley and in South-east Punjab, mainly due to the passage of monsoon depressions over this region.

The mean wind speeds, irrespective of direction, are lowest in Punjab—15 to 25 km. per hour. They are highest in the Peninsula, the mean values ranging from 30 to 70 km. per hour. The maximum speed occurs at about 1.5 km. level.

As the monsoon withdraws from most of the country in October, an anticyclone is established over the regions close to the Himālayas. In the south of the Peninsula and in the south Bay of Bengal, the westerly to south-westerly winds of June to September weaken and become variable in October, while in November north-westerly rain-bearing winds become active.

Retreating south-west monsoon

Over the greater part of the Northern Indian plains, the winds are mainly north-westerly, except that in East Rajasthan northerly to north-easterly winds are also fairly frequent. In Assam and Northern Bengal the easterly valley winds characteristic of winter and early summer blow down the Brahmaputra valley. Over Northern India, the mean speeds irrespective of direction are 15 to 35 km. per hour in the first 2 km. and 30 to 40 km. per hour at 3 km. In the north of the Peninsula, the principal wind direction is from north-west and north, and in the middle and south of the Peninsula from north-east to east. Westerly winds occur sometimes in the extreme south in October. The mean wind speeds are 12 to 25 km. per hour in the north of the Peninsula and 24 to 40 km. per hour in the south.

The seasonal winds as described in this and the previous sections give an idea of the wind circulation from the surface upwards. Variations in these more or less steady features are caused (1) by the daily alternation of land and sea-breezes on and near the coastal belts and (2) by the occasional marked changes in the winds in association with the passage of cyclonic storms, depressions and marked low-pressure areas.

On clear hot days, daily movements of the surface wind take place near the coasts. This is somewhat analogous to the changes of monsoon winds, but of far less strength and extent. Sea-breeze blows from the colder sea to the warm land by day and land-breeze from the cold land to the warmer sea at night. Sea-breeze when well developed, may reach a height of 1 km. or more and extend 50 to 100 km. inland with a velocity of 25 to 35 km. per hour; it usually attains its maximum intensity between 3 and 5 p.m

Land-breeze, on the other hand, seldom extends more than 15 km. seawards and its height and velocity also are correspondingly less.

Land and sea-breezes are most marked along the coastal belts of India during the clear and sunny days of the dry season, particularly on occasions when the pressure-gradient is weak and ill-defined. They are the least pronounced, sometimes even non-existent, during the wet monsoon season when generally cloudy conditions prevent the land surface from heating up at day-time or cooling by radiation at night, and when the steadier and stronger seasonal winds overcome the daily reversal of the conditions over land and sea. On the less rainy east coast of India, however, sea-breeze often sets in even in the monsoon season towards the evenings, with a sudden fall of temperature.

Local variations in seasonal wind circulation are also brought about by somewhat well-defined mountain and valley winds. In hilly and rugged country-side there is an air movement up the valleys during day-time, and a more marked flow of air down the valleys at night; these are particularly well marked at times when the general wind is light or calm. In such instances, the contour of the land plays a very important part. If the valley is long and fairly steep, and particularly if it acts as a drainage channel for a gently sloping wider plateau, the down-flowing mountain wind may assume the speed of a gale.

The pressure systems, cyclonic depressions or storms, which affect the weather over India in different seasons, have already been mentioned. The principal among these are the depressions travelling mainly across Northern India from west to east during the winter season, generally known as the western disturbance: the depressions originating at the head of the Bay of Bengal moving west or north-westwards along the trough of low-pressure over the Ganga plain in the south-west monsoon season, and the cyclones which form in the Bay of Bengal or the Arabian Sea and move inland, causing heavy rain and strong gales during the April-May and October-December transition seasons.

At a time when the general meteorology of India was little known, Henry Piddington laid the foundations of the knowledge of the storms of the Indian seas and introduced the word "cyclone" to designate them. In these storms the air moves in converging spirals in a direction against the hands of a clock. The winds become stronger and fiercer as the centre is approached and reach hurricane force near it. In the innermost central zone of some 15 to 30 km. diameter, known as the "Eye of the cyclone", the wind suddenly falls off to light puffs of air. Beyond the centre the hurricane resumes its force but its direction is now reversed.

It falls off gradually as the centre moves away. Cyclones die down soon after they reach land. But in coastal Districts they may cause great havoc. Lowlying Districts may be hit by destructive storm waves and huge masses of sea-water swept forward. When aided by a high tide, these inundate lowlying land to a depth of 5 to 7 metres.

Cyclones and cyclonic depressions carry their own well-defined wind systems around them, within their fields of influence, and cause temporary but well marked changes in the normal wind circulation over the places they visit in the course of their life-history.

8. *General Summary of India's Climates*

This section summarizes the broad climatological features of the five climatic regions of India for each of the four seasons: winter (December to February), summer (March to May), rainy season (June to September), and autumn (October and November). In this account the term "rainy day" has been used, in accordance with the convention adopted in India, to denote a day in which 2.5 mm. or more of rain is recorded. This summary is supplemented by the Table in Appendix B which gives the temperature and rainfall data for 30 selected stations in the plains of India and simuar data for 10 selected hill-stations and brings out the climatic features of the regions represented by the stations.

North-west India comprising West Rājasthān, Punjab and Kashmīr

Winter :—Western disturbances frequently affect the weather of this region in the cold season. On an average, six disturbances pass eastwards each month, but not all are active. They begin to get active from about the middle of December, remaining for a day or two over Punjab and, sometimes, concentrating there. In front of these disturbances, strong southerly to south-easterly winds with poor visibility blow over the Eastern Punjab hills. These disturbances are sometimes associated with well marked cold fronts; cold waves follow in their wake with strong northerly to north-westerly winds lasting for a day or two and causing frost. The cold waves sometimes extend as far as the northern Districts of the Deccan plateau.

Winter precipitation begins on the mountains in the second half of December and its frequency increases in the Himālayas

and the adjoining plains with the progress of the season. Rain falls only occasionally in Rājasthān. Thunderstorms occur in the later half of the season, mostly in the hills and the adjoining plains. In the southern divisions thunderstorms are less common, but duststorms occur occasionally.

Summer :—This is a season of gusty afternoon winds and convective phenomena like dust-devils, dust-storms and thunderstorms. Western disturbances continue to travel across the region eastwards, the cold fronts in their rear being generally associated with dust-storms or dry thunderstorms. Charged with dust, the atmosphere becomes hazy. Occasionally, in May and June, after extensive dust-storms in the west, the air over East and North Punjab and in Uttar Pradesh becomes charged with fine dust which reduces visibility considerably; this dust-haze often extends to heights of over 3 km.

Rainfall is rare in the plains in April and May. In June it occurs intermittently in West Rājasthān and East and North Punjab, especially near the hills. Kashmīr has more rain in April than in May and June. This is the season of dust-storms and thunderstorms; earlier in the season they are attended with little rain; but the associated rainfall increases as the season advances.

Rainy season :—The monsoon extends to Eastern Punjab in the last week of June or first week of July, the moist winds withdrawing from the region early in September. Dry cloudless weather is succeeded by days of convective clouds, followed again by cloudless skies. In West Rājasthān the rains come in the third or fourth week of June and cause a marked lowering of temperature. This is usually associated with depressions from the head of the Bay of Bengal. In East and North Punjab the rainy season covers the period between the last week of June and mid-September; days of sultry heat are interrupted by cooler days of south-easterly wind and thunder-showers.

The amount as well as frequency of rainfall is greatest on and near the hills. Rainy days in each of the months of July and August average 7 to 8 in Kashmīr and East and North Punjab, and 4 to 5 in West Rājasthān; there is a general decrease in September. Thunderstorms are common in Kashmīr, East and North Punjab, and the neighbourhood of the Arāvalli hills.

Autumn :—This is a season of clear skies with good visibility. Occasionally, western disturbances cause clouding in Kashmīr and the Punjab Himālayas. Rain is scarce. A few days of thunder may be experienced in East and North Punjab and near the Aravalli hills.

Northern Plains comprising Gujarāt, East Rājasthān, Madhya Pradesh, Uttar Pradesh and Bihār.

Winter :—December to February is a season of clear, bright weather interrupted by cloudy spells; these are caused by the passage of western disturbances—six each month on the average—which bring more cloud and rain to West Uttar Pradesh than to the rest of the region. Warm, close weather with southerly winds precedes the disturbances. This is followed by rain in the east and north of the depression; snow-fall occurs on the Himālayas. In the wake of the depressions, pressure rises rapidly and there is clear weather again.

In this season rain occurs on 4 or 5 days in West Uttar Pradesh and from 1 to 3 days elsewhere. Gujarāt is the driest area and December the driest month. Dust-storms are rare in this season, while thunderstorms occur only on 1 or 2 days in each of the months of January and February, associated with cold fronts in the rear of passing western disturbances.

Summer :—Weather is generally fair with only occasional western disturbances which are more active in the earlier part of the season. This is the time of convective phenomena like dust-storms, thunderstorms and hail. Haze in the atmosphere increases with the advance of the season. Moderate to strong westerly dry land winds prevail, especially in March and April.

Thunderstorms and dust-storms increase in frequency with the progress of the season, their maximum frequency being in West Uttar Pradesh and in the Kumaun hills. Rain falls only on 1 or 2 days in each of the months, the frequency being higher in Bihār.

Rainy season :—The monsoon advances into this region about the third week of June, generally preceded by thunder-storms and dust-storms, particularly in East Rājasthān and West Uttar Pradesh. It withdraws from Gujarāt, Madhya Pradesh and Uttar Pradesh by the third week of September, and from Bihār by the end of that month or early October. The monsoon is most active in this region in July and August, when depressions from the head of the Bay of Bengal travel west or west-north-westwards bringing heavy rain to the central parts of the country and some times to Gujarāt.

In July and August, 10 to 15 rainy days may be experienced, while there are only 5 to 9 days in June and September. Rainfall increases towards the south-east in Gujarāt and East Rājasthān, while in Uttar Pradesh and Bihār plains it increases both towards the Himālayas in the north and the Central Indian hills in the

south. Thunder is heard frequently in July and August, but is usually unaccompanied by strong winds.

Autumn:—After the withdrawal of the monsoon, clear bright weather prevails during the season. Only occasionally, storms from the Bay entering West Bengal cause disturbed weather in South-east Bihār;remanants of storms from the Arabian Sea,which cross the coast north of Bombay, disturb the weather in Gujārat and Madhya Pradesh.

North-east India comprising West Bengal, Orissa and Assam

Winter:—Light, north-easterly winds blow down the Brahmaputra and Cāchār valleys in Assam and light northerly to north-westerly winds over the rest of the region. Weather is occasionally changed by the passage of western disturbances across the region; light rainfall occurs in January and February along the hills, increasing towards North-east Assam.

The number of rainy days increases from December to February. Thunderstorms are rare in December and January and occur only on 1 or 2 days in February, these may occasionally be accompanied by dust-storm or hail.

Summer:—In this season North-east India is under the sway of three air streams—a deep north-westerly current from Uttar Pradesh and Bihār, a shallow southerly stream from the head of the Bay of Bengal over the Orissa and Bengal coasts, and a shallower current of north-easterly to easterly winds from the Brahmaputra valley blowing over the plains of Northern Bengal and Bihār. With the interactions between these air streams, this is a season when marked instability develops in the atmosphere and severe thunderstorms occur extensively, sometimes preceded by dust-raising squalls. Occasionally, in April and May, hot westerly to north-westerly winds blow for a day or two over Southern Bengal.

Rainfall increases both in amount and frequency as the season advances, being generally associated with afternoon or evening thunderstorms and squalls. They are generally more concentrated in the southern Districts of the region and in Upper Assam. Hailstorms occur on 1 to 3 days in the season, especially in Orissa and South-west Bengal and on the Assam hills.

Rainy season:—The monsoon advances into West Bengal in the last week of May or in early June, being usually ushered in by a depression in the Bay of Bengal. Subsequently, a series of these depressions, forming at the head of the Bay and moving inland,

give spells of continuous and moderate to heavy rain generally over the region. The monsoon withdraws from North-east India in the last week of September or the first week of October.

July and August are the rainiest months. Rain is most frequent and heavy on the southern slopes of the Khāsi hills in the north-east corner of Assam and in Northern Bengal. Much of the rainfall in June and September is associated with thunder-clouds, while thundery weather is less frequent in July and August.

Autumn :—After the withdrawal of the monsoon winds, light unsteady winds are experienced by the middle of October. Thereafter in November the winds are north-westerly from the Ganga valley or north-easterly from the Silchar and Brahmaputra valleys. Occasionally in October cyclonic storms from the Bay cross the Bengal coast and bring cloud and rain with them.

There are about 5 to 7 days of rain in this region in October; this goes down to 1 or 2 days in November. The rainfall is more in Southern Bengal and in the north-eastern divisions of the region. Almost all the rain in this season is associated with thunder; Orissa and the hilly Districts of Chota Nāgpur are the most liable to experience thundery weather.

The Plateau Region comprising the Deccan Plateau, Vidarbha and Chota Nāgpur

Winter :—December to February is a season of clear, bright weather in the plateau region of the Indian area. In December, an occasional incursion of the moist easterly winds may cause cloudy skies and light showers in the southern regions of the Deccan plateau, while in January and February western disturbances sometimes cause cloud and rain in the Central Indian plateau and in Chota Nāgpur.

In the northern parts of the region rain may occur on 4 days in the season—mainly in January and February—while in the southern divisions one day of rainfall in December is the average. There are occasional thunderstorms in association with the western disturbances, which may sometimes be accompanied by hail, the number of thunderstorms increasing with the progress of the season.

Summer :—This is a season of increasing temperature and increasing humidity in the central parts of the country. In March the western disturbances take a more northerly track; still, some of them cause cloudy and rainy weather in the central plateau region. Thunderstorm and rain occur in Mysore. Cyclonic

storms from the Bay of Bengal or Arabian Sea cause disturbed weather in the south of the Peninsula.

Rainfall increases as we go eastwards towards Chota Nāgpur and south towards South-west Mysore, which have the greater frequency of thundery days in this region as the season advances.

Rainy season :—From the beginning of the monsoon to the end of August, rainfall decreases as one proceedes eastwards from the Western Ghāts; it decreases from 250-375 cm. to 50-60 cm. within 50 or 60 km. of the crests of the Ghāts. The driest part of the Deccan strip in this season is an area stretching north to south parallel to the Western Ghāts and 80-125 km. east of them, from the foot of the Sātpura hills to almost the foot of the Nilgiri hills. In September the plateau region east of the Western Ghāts gets some heavy thunder-showers in association with dissipating low pressure systems which move westwards across the Peninsula.

The southern divisions of Madhya Pradesh, Vidarbha and Chota Nāgpur form the area of maximum rainfall, with an average of about 115 cm. in 50 rainy days. The Deccan plateau gets 40-50 cm. in 25 to 35 rainy days. In the Mysore plateau the number of days with rain is larger but the amount of rain is smaller. Thunderstorms with dust-raising squalls occur on a few days before the advent of the monsoon; there are 6 to 12 days of thunderstorm in the season in Vidarbha and Chota Nāgpur.

Autumn :—This is a period of transition from the rainy season to winter with rapidly clearing skies in the northern divisions. In the south the retreating monsoon continues to give rain in and around the Mysore plateau in October and to a lesser extent in November. Occasional storms from the Bay of Bengal in November cause stormy weather and widespread rain in the Deccan. Most of the rain in the interior of the Peninsula is accompanied by thunder.

The Peninsula comprising Coastlands and Plains

Winter :—Up to the middle of December the north-east monsoon continues to give rain in the south of the Peninsula. Then the moist winds retreat southwards and the whole region is filled with dry air from the north. Occasionally, in December, cyclonic storms from the south of the Bay of Bengal travel towards the Coromandel Coast causing high winds and locally heavy rain. The rest of the period is a season of clear, bright weather with cool nights and morning mist or fog near the coast and in the valleys.

Rainfall is rare in January and February. Throughout the season there may be 1 or 2 days of thunder in each month in the south of the Peninsula.

Summer:—With a steady increase of temperature and humidity, afternoon thunderstorms become more and more common on the West Coast, especially in Kerala. In the last ten days of May, an advance of the monsoon in Kerala may take place. It is associated with a depression or cyclonic storm, and on rare occasions a storm from the Bay of Bengal causes severe weather with gales and heavy rain near the Coromandel Coast.

Rain is usually associated with thunder and increases with the advance of the season. South Kerala and the neighbouring hills get the maximum rain, the thundery weather of April and May being short-lived local squalls.

Rainy season:—The monsoon begins in Kerala early in June, reaching Bombay during the first week. At the time of the advance of the monsoon, and also when diffuse low-pressure areas from the Bay of Bengal move westwards across the Peninsula in September, the Andhra coast sometimes gets heavy showers. The interior of the Peninsula, especially the south-eastern Districts, gets thunder-showers when the monsoon current is generally weak, and also when weak depressions move westwards across the north of the Peninsula in September.

Rainfall is heavy on the West Coast, increasing to a maximum on the crests of the Western Ghāts and decreasing rapidly on the eastern side. The monsoon rainfall on the western side of the Ghāts is 380-500 cm. while about 70 km. to its east it is only 50-65 cm. on the average. The rainfall on the West Coast decreases rapidly north of Surat and south of Trivandrum, and the south-eastern Districts of the Peninsula get only a few days of rain. When the monsoon is established, thunder is rare on the West Coast; it occurs, however, in Kerala when the monsoon current is weak.

Autumn:—October and November are the cyclone months in the Bay of Bengal and the Arabian Sea. Associated with thes cyclones, October to mid-December is the main rainfall season in South-east Madras.

A few thunder-showers occur on the Konkan coast; elsewhere they are fairly frequent in October and somewhat iess so in November.

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APPENDIX A

SUBDIVISIONAL NORMALS OF RAINFALL IN MM.

(Based on data for the period 1901-1950)

Subdivision	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
ay Islands . . .	48·3	33·0	30·2	67·8	349·5	527·3	378·7	402·1	468·4	286·0	231·7	171·7	2994·5
ssam (including Manipur and Tripura) .	18·4	38·4	81·5	212·6	337·6	484·3	447·4	396·6	317·1	144·1	30·8	8·9	2517·7
Sub-Himālayan West Bengal . . .	9·9	20·4	35·6	118·2	329·1	675·0	683·3	574·5	503·6	157·7	14·8	4·1	3126·2
Gangatic West Bengal .	13·1	25·8	27·1	42·6	108·0	241·2	318·0	318·7	206·6	109·4	21·7	3·1	1435·3
Orissa	14·0	25·9	21·4	35·3	70·8	213·2	351·6	335·6	236·5	131·6	39·9	6·4	1482·2
Bihār Plains . .	21·2	31·3	19·8	19·1	50·8	196·2	357·8	354·0	218·1	83·4	15·7	4·5	1371·9
Bihār Plans . . .	14·4	19·6	10·6	15·8	48·0	172·4	311·4	314·0	225·1	59·4	8·8	3·5	1203·0
Uttar Pradesh, East .	15·8	18·9	8·7	6·8	14·9	100·5	301·6	295·8	191·2	41·6	5·9	6·0	1007·7
Uttar Pradesh, West .	23·9	25·3	13·7	8·6	14·7	94·1	288·7	287·9	168·1	25·6	3·9	9·7	964·2
Punjab (including Delhi and PEPSU) . .	27·1	26·4	20·9	12·0	12·3	47·8	179·1	171·6	101·0	11·2	2·8	12·5	624·7
Himāchal Pradesh. .	Subdivisional normals have not been calculated as there are no plain stations with normals.												
Jammu and Kashmir .	95·7	96·0	108·3	77·6	52·0	55·2	167·1	174·5	75·5	26·1	15·2	51·4	994·6
Rājasthān, West . .	5·4	5·9	4·0	3·4	7·7	28·7	99·3	110·3	40·7	4·4	0·8	2·6	313·2
Rājasthān, East . .	9·0	6·0	4·7	3·2	8·5	68·3	242·8	228·5	112·0	12·2	4·3	4·6	704·1
Madhya Pradesh, West .	13·5	9·7	7·5	4·4	9·4	126·5	349·9	294·6	176·2	29·5	16·8	6·9	1044·9
Madhya Pradesh, East .	18·4	26·0	16·9	15·9	16·8	188·8	429·4	394·9	215·5	58·5	15·2	5·5	1401·8
Gujarāt region . .	2·4	2·0	1.4	2·5	6·7	129·9	399·8	241·5	158·4	23·0	7·6	1·3	976·5
Saurāshtra and Kutch .	1·7	2·4	1·3	2·9	6·4	73·6	205·9	104·2	65·9	12·9	3·9	1·5	482·6
Konkan . . .	2·8	0·8	1·5	5·7	28·9	616·9	1076·1	630·0	373·4	103·3	29·1	3·5	2872·0
Madhya Mahārāshtra .	5·0	2·3	3·4	11·0	24·0	148·3	281·3	178·6	161·6	68·4	31·4	6·1	921·4
Marāthwada . .	5·8	5·9	7·2	8·3	15·9	138·2	170·5	140·1	196·0	48·4	29·1	8·2	773·6
Vidarbha . . .	12·3	18·7	11·3	11·1	12·3	174·8	343·2	257·9	180·8	48·3	21·3	7.5	1099·3
Coastal Andhra Pradesh	10·1	13·6	12·3	24·8	51·0	103·6	152·5	148·4	165·8	188·6	116·5	21·1	1008·3
Telangāna . . .	5·1	15·0	12·3	21·9	22·6	133·4	240·4	189·7	192·9	64·4	24·6	4.0	926·3
Rāyalaseema . .	9·2	5·8	7·1	19·7	50·1	58·2	80·8	95·8	134·0	112·3	83·1	21·7	677·8
Madras State . .	37·0	16·4	22·9	51·0	73·2	61·5	68·6	95·8	106·4	192·8	195·9	86·6	1008·1
Coastal Mysore . .	2·9	1·7	5·4	30·4	108·7	843·6	1100·1	633·9	284·3	175·1	66·2	12·5	3264·8
Interior Mysore, North .	2·9	3·1	6·6	27·7	51·2	88·1	127·3	97·7	127·5	95·1	38·7	9·1	675·0
Interior Mysore, South	4·7	5·3	10·6	49·4	103·0	177·0	311·1	208·8	144·6	150·3	66·6	13·5	1244·9
Kerala . . .	18·8	19·6	46·1	114·9	245·1	667·5	678·4	417·2	240·0	306·2	190·7	51·6	2996·1
Arabian Sea Islands .	31·9	12·1	12·5	38·3	152·4	344·9	275·1	213·3	153·9	160·1	114·5	63·4	1572·4

APPENDIX B

TEMPERATURE AND RAINFALL

ıeter cistern (Hp) in metres above mean sea level as on 1-1-1960.
the average maximum temperature in degrees centigrade.
the average -minimum temperature in degrees centigrade.
nonth gives the average rainfall in millimetres.

JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER			Extreme values (upto 1950)				Years Rainfall (mm.)
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	Highest Max. °C	Date	Lowest Min. °C	Date	
) (21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)	(42)	(43)
3 28·8	23·9	378·7	28·6	23·7	402·1	28·4	23·2	468·4	28·8	23·2	286·0	28·9	23·1	231·7	28·7	22.8	171·5	36·1	8-5-1889	16·7	23-1-1940	2994.5
·5 32·2	25·7	292·9	32·4	25·6	263·7	32·1	24·6	176·3	30·6	21·7	75·7	27·5	16·4	13·5	24·4	11·7	3·6	40·0	25-4-1939	5·0	24-1-1925	1634.2
·3 32·0	25·3	341·4	32·0	25·4	325·4	31·6	24·7	221·0	30·2	21·7	108·5	27·3	16·5	21·8	24·2	12·3	6·9	38·3	18-4-1938	5·6	8-1-1945	1847·2
·8 31·4	25·2	773·9	31·4	25·1	658·9	31·1	24·3	560·6	30·4	21·3	150·1	27·9	16·0	14·2	24·9	11·8	4·3	40·0	11-4-1932	2·2	3-2-1905	3339·1
·1 31·9	25·9	331·2	31·7	25·8	334·0	32·2	25·7	252·7	31·8	23·4	127·3	29·1	17·8	27·2	26·4	13·1	4·1	43·9	1-6-1924	6·7	20-1-1899	1624·8
·9 31·9	25·7	353·1	31·7	25·6	353·6	32·2	25·5	236·5	32·1	23·6	141·7	29·5	18·8	45·2	27·4	14·9	7·1	47·2	6-6-1948	7·8	4-1-1923	1539·3
·7 29·1	22·9	396·7	28·5	22·6	373·1	29·0	22·1	232·4	28·3	18·9	90·4	25·3	13·8	20·3	22·9	10·3	7·1	43·3	22-5-1948	2·8	11-2-1950	1512·7
·5 33·4	25·9	331·0	32·2	25·7	366·5	32·5	25·1	197·1	31·4	21·1	48·8	27·4	13·9	12·9	23·7	9·2	3·6	47·2	12-6-1931	3·9	12-2-1950	1184·9
·0 32·7	26·6	276·1	31·8	26·5	340·4	32·1	26·1	237·7	31·4	22·7	54·6	27·9	16·1	8·9	23·8	11·3	5·3	46·1	12-6-1931	2·2	2-2-1905	1166·4
·8 34·4	26·9	195·6	32·9	26·1	218·2	33·7	24·6	133·9	33·7	18·5	19·6	29·2	11·2	3·3	24·0	7·9	5·8	48·3	2-6-1889	—2·2	16-1-1935	679·0
·3 33·4	26·6	307·6	31·9	25·9	293·1	33·0	24·8	182·	32·4	19·6	40·4	28·6	12·6	8·6	24·3	8·6	7·1	47·8	12-6-1901	1·1	2-2-1905	980·1
·7 33·4	26·5	310·4	32·0	25·8	325·9	32·8	25·2	208·0	32·4	20·1	51·3	28·4	13·2	10·2	24·1	9·1	5·8	47·2	12-6-1901	1·7	2-2-1905	1076·0
·9 33·6	26·4	308·1	32·5	25·9	286·5	33·3	24·7	213·1	33·0	19·2	35·1	28·8	12·3	5·6	24·4	8·5	6·3	48·3	12-6-1901	1·1	3-1-1946	1014·4
·6 35·1	26·9	186·2	33·6	26·1	169·9	33·7	24·3	134·9	33·3	18·5	14·2	28·8	11·4	2·0	23·1	6·8	8·6	47·2	29-5-1944	—0·6	16-1-1935	660·1
·9 35·3	26·2	254·0	34·0	25·6	219·5	34·4	23·3	158·2	33·2	16·7	23·4	27·8	9·9	4·6	22·4	6·6	16·8	47·8	29-5-1944	—1·1	19-1-1947	905·7
·7 35·9	26·7	108·2	33·1	25·0	131·3	34·5	23·8	57·4	35·4	18·7	7·6	31·0	13·2	1·8	26·2	10·2	02·	48·9	25-5-1932	—2·2	31-1-1905	366·0
·6 34·4	25·7	187·5	32·6	24·4	203·7	33·7	22·7	84·8	34·4	18·0	14·2	29·7	11·9	2·3	24·6	8·7	7·6	47·8	25-5-1932	—2·2	1-2-1905	597·9
·3 29·8	23·4	490·7	28·9	22·9	277·6	29·9	22·3	240·0	31·5	18·4	31·7	28·7	12·9	20·6	26·1	9·7	6·3	45·6	22-5-1947	0·6	18-1-1935	1260·2
·5 30·3	23·9	370·8	29·9	23·8	389·1	31·2	23·6	213·1	31·3	21·1	52·3	28·8	15·9	14·5	26·8	12·6	4·1	47·2	29-5-1935	3·9	29-12-1902	1358·8
·0 30·2	23·7	483·4	29·2	23·2	416·6	30·7	22·5	211·3	31·1	17·6	46·5	28·0	11·3	18·8	25·3	8·2	8·4	46·1	2-6-1889	0·0	2-2-1905	1430·7
·0 31·2	24·2	376·2	30·7	23·9	286·3	32·1	23·7	184·7	32·8	20·6	54·6	29·8	16·5	19·8	27·7	14·0	9·9	47·8	20-5-1883	3·9	7-1-1937	1242·2
·3 33·9	25·8	344·2	32·2	24·9	205·5	33·7	24·4	116·8	36·2	22·6	9·4	33·7	18·7	4·3	30·2	15·3	0·8	47·8	27-5-1916	2·2	6-2-1920	782·8
·0 32·8	24·7	248·4	31·6	23·8	125·5	33·1	22·6	84·8	35·4	20·5	14·0	32·8	16·0	3·8	29·4	11·9	1·5	47·8	15-5-1919	—0·6	16-1-1935	594.3
·4 28·1	22·1	168·9	27·6	21·4	96·5	29·2	20·5	130·1	31·9	19·1	76·2	30·3	14·7	30·5	29·4	11·7	4·3	43·3	30-4-1897	1·7	17-1-1935	661·3
·8 29·7	24·8	613·4	29·4	24·5	328·9	29·7	24·3	286·0	31·6	24·2	64·5	31·9	22·5	17·5	30·3	20·4	2·3	39·4	24-3-1945	11·7	15-1-1935	1804·8
·4 30·7	22·6	161·3	30·0	22·3	134·9	30·1	21·9	170·7	31·2	19·8	73.1	29·5	16·5	31·7	28·6	13·6	5·8	44·4	28-5-1935	6·1	8-1-1946	772·2
·8 31·6	26·1	112·0	31·8	26·0	121·2	31·3	25·8	168·1	30·8	24·7	212·1	28·9	22·4	112·8	27·1	19·9	17·3	43·9	1-6-1906	14·4	15-1-1940	954·3
·7 35·7	26·3	86·6	34·9	25·6	113·0	34·4	25·1	119·4	32·2	23·9	305·8	29·7	22·2	350·3	28·9	20·5	139·2	45·0	21-5-1910	13·9	29-1-1905	1285·6
·9 27·4	18·8	111·3	27·4	18·7	136·7	27·7	18·6	163·6	27·6	18·3	153·4	26·3	16·6	61·2	25·7	14·7	13·2	38·9	22-5-1931	7·8	13-1-1884	888·9
·4 29·2	23·2	223·0	29·1	23·3	145·5	29·7	23·3	137·9	30·0	23·4	273·3	30·1	23·1	205·5	30·7	22·4	74·7	35·0	24-3-1950	18·9	18-1-1950	1812·1
·7 24·1	18·1	358·9	24·0	17·8	342·7	23·5	16·5	302·3	21·7	12·7	188·2	18·9	7·8	38·3	16·4	4·4	6·1	30·0	23-4-1939	—2·8	13-2-1950	2253·3
·1 18·8	14·4	792·2	18·8	14·3	643·4	18·2	13·4	445·5	16·7	10·2	142·2	13·3	6·2	24·6	10·4	2·7	6·3	26·7	13-4-1910	—5·0	11-2-1905	3092·4
·9 24·7	19·9	726·2	23·8	19·4	643·9	25·3	18·9	363·2	26·3	14·9	63·3	25·6	10·4	28·2	21·8	7·7	8·6	40·6	23-5-1916	—1·1	16-1-1935	2122·9
·3 20·8	15·8	736·3	20·2	15·6	752·1	19·9	14·2	295·7	18·3	10·9	28·2	15·6	7·3	4·1	12·4	4·1	29·5	34·4	24-5-1949	—6·7	10-2-1950	2327·3
·1 21·5	15·2	416·1	20·1	15·2	419·1	20·1	13·6	182·4	18·0	10·8	33·3	14·7	6·9	10·2	10·5	4·1	27·7	30·6	13-6-1932	—10·6	11-1-1945	1542·2
·1 24·1	19·0	597·4	22·2	18·0	660·4	24·0	18·2	213·4	26·3	17·9	20·6	23·3	14·2	4·3	20·4	11·2	2·8	38·3	9-6-1897	—1·1	31-1-1929	1639·1
·8 18·7	16·8	2546·1	18·8	16·4	1764·3	19·9	15·8	685·8	24·0	16·3	154·4	23·8	15·1	46·5	23·1	13·8	5·3	36·1	3-4-1934	3·9	1-2-1942	6226·3
8·2 16·8	11·2	117·6	17·1	11·1	177·0	17·1	11·1	177·3	16·7	10·7	256·5	16·1	9·7	253·5	16·5	8·4	129·8	27·8	5-5-1923	2·8	7-1-1950	1673·8
6·0 16·6	11·2	201·2	17·1	10·9	147·1	18·1	10·6	138·7	18·1	10·3	202·2	17·6	8·9	157·7	18·3	6·6	48·5	27·2	22-4-1942	—1·7	30-1-1921	1376·2
6·3 20·3	16·8	1129·3	20·7	16·8	682·7	22·0	16·6	307·6	24·0	16·9	199·9	23·9	15·8	81·3	23·8	14·3	22·1	35·0	11-5-1902	8·9	20-2-1936	3265·4

ertain to Sangner aerodrome site.

‡All values except elevation pertain to the town site (now closed).

MONTHLY TEMPERATURE AND RAINFALL

Column (2) gives the height of the barometer cistern (Hp) in metres above mean sea level as on 1-1-1960.
Column I under each month gives the average maximum temperature in degrees centigrade.
Column II under each month gives the average -minimum temperature in degrees centigrade.
Column III under each month gives the average rainfall in millimetres.

Station	Elevation in metres (Hp)	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEM	
		I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(3
1. Port Blair	79	29·1	22·1	48·3	29·7	21·4	33·0	30·9	22·0	30·2	31·7	23·8	67·8	30·4	23·9	349·5	29·1	23·9	527·3	28·8	23·9	378·7	28·6	23·7	402·1	28·4	23·2	468·4	28·8	23·2	286·0	28·9	23·1	231·7	28·7	22
2. Gauhāti	55	23·8	10·7	9·9	25·8	12·2	25·7	29·9	15·9	53·1	30·8	19·9	148·8	31·0	22·5	253·5	31·6	24·8	317·5	32·2	25·7	292·9	32·4	25·6	263·7	32·1	24·6	176·3	30·6	21·7	75·7	27·5	16·4	13·5	24·4	11
3. Tezpur	79	23·4	11·4	15·0	24·9	13·4	25·9	28·7	16·9	51·1	29·5	19·9	157·	30·4	22·4	268·2	31·4	24·7	304·3	32·0	25·3	341·4	32·0	25·4	325·4	31·6	24·7	221·0	30·2	21·7	108·5	27·3	16·5	21·8	24·2	12
4. Jalpaiguri	83	23·6	10·7	6·9	25·0	12·2	17·0	29·5	15·8	33·3	31·7	20·1	113·8	31·5	22·6	302·3	31·3	24·3	683·8	31·4	25·2	773·9	31·4	25·1	658·9	31·1	24·3	560·6	30·4	21·3	150·1	27·9	16·0	14·2	24·9	14
5. Calcutta(Alipore)	6	26·5	12·7	11·9	28·8	15·3	27·9	33·7	20·6	34·0	35·9	24·3	50·5	35·3	25·5	133·9	33·7	26·1	290·1	31·9	25·9	331·2	31·7	25·8	334·0	32·2	25·7	252·7	31·8	23·4	127·3	29·1	17·8	27·2	26·4	13
6. Cuttack	27	28·4	15·5	11·2	31·2	18·2	27·7	35·9	22·1	21·6	38·3	25·3	30·7	38·6	26·7	80·0	35·4	26·5	230·9	31·9	25·7	353·1	31·7	25·6	353·6	32·2	25·5	236·5	32·1	23·6	141·7	29·5	18·8	45·2	27·4	14
7. Rānchi	655	23·1	10·6	26·7	25·0	12·6	43·9	30·6	17·3	29·0	35·3	21·7	21·8	37·2	24·0	54·6	33·5	24·1	216·7	29·1	22·9	396·7	28·5	22·6	373·1	29·0	22·1	232·4	28·3	18·9	90·4	25·3	13·8	20·3	22·9	10
8. Gaya†	116	23·5	9·6	19·6	26·3	11·6	24·6	33·2	17·3	11·4	38·8	22·6	6·3	40·3	26·6	22·6	37·5	27·4	140·5	33·4	25·9	331·0	32·2	25·7	366·5	32·5	25·1	197·1	31·4	21·1	48·8	27·4	13·9	12·9	23·7	9
9. Patna	53	22·9	10·7	15·5	25·5	12·7	22·1	32·2	18·1	9·4	37·1	23·1	8·4	38·1	25·7	30·0	35·8	26·7	158·0	32·7	26·6	276·1	31·8	26·5	340·4	32·1	26·1	237·7	31·4	22·7	54·6	27·9	16·1	8·9	23·8	11
10. Āgra	169	22·5	7·0	13·2	25·3	9·2	13·5	31·7	14·8	8·4	37·8	21·1	6·6	41·4	26·0	9·1	40·1	28·8	51·8	34·4	26·9	195·6	32·9	26·1	218·2	33·7	24·6	133·9	33·7	18·5	19·6	29·2	11·2	3·3	24·0	7
11. Allahābād	98	23·7	8·6	17·0	26·3	10·7	21·3	33·2	16·3	9·7	39·1	21·6	5·3	41·8	26·8	7·1	39·4	28·4	80·3	33·4	26·6	307·6	31·9	25·9	293·1	33·0	24·8	182·	32·4	19·6	40·4	28·6	12·6	8·6	24·3	8
12. Banaras (Vārānasi)	76	23·4	9·1	21·6	26·3	11·2	23·4	33·2	16·4	11·2	38·7	22·1	5·8	40·9	26·3	13·7	38·4	27·9	88·7	33·4	26·5	310·4	32·0	25·8	325·9	32·8	25·2	208·0	32·4	20·1	51·3	28·4	13·2	10·2	24·1	9
13. Lucknow†	111	23·3	8·4	17·5	25·9	10·8	20·6	32·7	15·9	8·6	38·6	21·6	9·1	40·8	25·7	15·0	37·9	27·6	88·9	33·6	26·4	308·1	32·5	25·9	286·5	33·3	24·7	213·1	33·0	19·2	35·1	28·8	12·3	5·6	24·4	8
14. Delhi	216	21·1	7·3	20·8	24·3	9·4	23·6	30·6	14·8	12·9	37·1	21·4	9·7	41·2	26·7	9·7	40·2	28·7	67·6	35·1	26·9	186·2	33·6	26·1	169·9	33·7	24·3	134·9	33·3	18·5	14·2	28·8	11·4	2·0	23·1	6
15. Ambāla†	272	20·6	6·3	39·4	22·8	8·8	50·8	29·1	13·6	25·7	35·6	19·1	16·3	39·9	24·3	21·1	39·8	27·1	75·9	35·3	26·2	254·0	34·0	25·6	219·5	34·4	23·3	158·2	33·2	16·7	23·4	27·8	9·9	4·6	22·4	6
16. Jodhpur	224	24·5	9·2	5·1	27·1	11·4	6·1	32·7	16·5	2·8	37·7	21·8	3·3	40·9	26·6	9·7	39·8	28·1	30·7	35·9	26·7	108·2	33·1	25·0	131·3	34·5	23·8	57·4	35·4	18·7	7·6	31·0	13·2	1·8	26·2	10
17. Jaipur*	436	22·8	8·3	10·9	25·1	10·4	9·9	31·3	15·1	7·1	36·8	20·7	5·1	40·5	25·2	13·2	39·5	27·0	51·6	34·4	25·7	187·5	32·6	24·4	203·7	33·7	22·7	84·8	34·4	18·0	14·2	29·7	11·9	2·3	24·6	8
18. Bhopāl†	523	26·3	9·9	17·0	28·2	12·6	5·3	32·9	16·6	8·9	37·3	21·8	3·6	40·2	26·1	10·2	36·3	25·3	148·3	29·8	23·4	490·7	28·9	22·9	277·6	29·9	22·3	240·0	31·5	18·4	31·7	28·7	12·9	20·6	26·1	9
19. Raipur	298	27·5	13·3	13·7	29·9	15·7	26·9	35·1	20·1	18·0	39·3	24·7	15·5	41·9	28·0	21·3	36·7	26·3	219·5	30·3	23·9	370·8	29·9	23·8	389·1	31·2	23·6	213·1	31·3	21·1	52·3	28·8	15·9	14·5	26·8	12
20. Jabalpur	393	25·3	9·0	24·4	27·6	10·6	24·4	33·2	14·9	15·5	38·2	20·3	9·9	41·0	25·3	14·5	36·8	26·0	157·0	30·2	23·7	483·4	29·2	23·2	416·6	30·7	22·5	211·3	31·1	17·6	46·5	28·0	11·3	18·8	25·3	8
21. Nāgpur	310	28·7	14·3	11·4	31·2	16·6	23·4	35·9	20·7	16·8	40·3	25·1	16·3	42·7	28·3	20·8	37·6	26·4	222·0	31·2	24·2	376·2	30·7	23·9	286·3	32·1	23·7	184·7	32·8	20·6	54·6	29·8	16·5	19·8	27·7	14
22. Ahmadābād	55	29·3	14·2	2·0	31·1	15·6	1·5	36·1	19·7	1·3	39·9	23·6	1·8	41·6	26·2	9·9	38·8	27·2	85·3	33·9	25·8	344·2	32·2	24·9	205·5	33·7	24·4	116·8	36·2	22·6	9·4	33·7	18·7	4·3	30·2	15
23. Rājkot (Aerodrome)‡	138	28·4	10·6	1·0	30·4	12·5	1·8	35·1	16·8	1·5	38·8	20·9	2·0	40·6	24·2	14·0	37·6	25·8	96·0	32·8	24·7	248·4	31·6	23·8	125·5	33·1	22·6	84·8	35·4	20·5	14·0	32·8	16·0	3·8	29·4	11
24. Poona†	559	30·3	11·7	2·5	32·5	12·8	1·3	36·1	16·5	2·0	38·3	20·2	14·2	37·1	22·4	27·4	31·9	23·1	107·4	28·1	22·1	168·9	27·6	21·4	96·5	29·2	20·5	130·1	31·9	19·1	76·2	30·3	14·7	30·5	29·4	11
25. Bombay (Colaba)†	11	28·4	19·3	4·1	28·4	19·7	2·0	30·1	22·2	1·5	31·7	24·5	1·5	32·8	26·4	18·3	31·4	25·9	464·8	29·7	24·8	613·4	29·4	24·5	328·9	29·7	24·3	286·0	31·6	24·2	64·5	31·9	22·5	17·5	30·3	20
26. Hyderābād (Begumpet)	545	29·4	14·9	8·1	31·9	16·9	11·7	36·0	20·3	12·9	38·1	24·0	25·9	39·6	26·6	28·7	34·8	24·1	107·4	30·7	22·6	161·3	30·0	22·3	134·9	30·1	21·9	170·7	31·2	19·8	73.1	29·5	16·5	31·7	28·6	13
27. Vishākhapatnam	3	27·0	19·6	10·4	28·5	21·3	21·6	30·5	23·7	11·2	31·9	25·8	18·5	33·3	27·6	48·3	33·1	27·2	100·8	31·6	26·1	112·0	31·8	26·0	121·2	31·3	25·8	168·1	30·8	24·7	212·1	28·9	22·4	112·8	27·1	19
28. Madras†	16	29·6	19·5	45·5	31·3	20·2	12·5	33·0	22·4	13·2	35·3	25·6	17·5	38·5	27·6	37·9	37·6	27·3	44·7	35·7	26·3	86·6	34·9	25·6	113·0	34·4	25·1	119·4	32·2	23·9	305·8	29·7	22·2	350·3	28·9	20
29. Bangalore	921	26·8	14·2	7·1	29·7	15·7	8·9	32·3	18·2	10·7	33·6	20·7	44·5	32·9	20·6	107·4	29·1	19·3	70·9	27·4	18·8	111·3	27·4	18·7	136·7	27·7	18·6	163·6	27·6	18·3	153·4	26·3	16·6	61·2	25·7	14
30. Trivandrum	64	31·3	22·2	22·9	31·7	22·9	20·8	32·4	24·2	38·6	32·3	25·1	105·7	31·9	25·3	207·8	29·5	23·7	356·4	29·2	23·2	223·0	29·1	23·3	145·5	29·7	23·3	137·9	30·0	23·4	273·3	30·1	23·1	205·5	30·7	22
Hill-Stations																																				
31. Shillong	1500	15·7	3·8	14·0	16·9	5·7	29·2	21·3	10·4	56·4	23·2	13·8	146·1	23·4	15·1	295·4	23·7	17·3	475·7	24·1	18·1	358·9	24·0	17·8	342·7	23·5	16·5	302·3	21·7	12·7	188·2	18·9	7·8	38·3	16·4	4
32. Darjeeling	2127	8·6	1·9	10·9	9·0	2·6	31·7	13·2	6·2	54·1	16·2	9·3	113·0	17·3	11·4	231·4	18·4	13·7	597·1	18·8	14·4	792·2	18·8	14·3	643·4	18·2	13·4	445·5	16·7	10·2	142·2	13·3	6·2	24·6	10·4	2
33. Pachmarhi†	1075	22·2	8·7	22·1	24·1	10·4	24·6	28·9	15·2	14·7	33·3	20·4	9·7	35·4	23·9	16·5	31·0	22·2	201·9	24·7	19·9	726·2	23·8	19·4	643·9	25·3	18·9	363·2	26·3	14·9	63·3	25·6	10·4	28·2	21·8	7
34. Mussoorie	2042	10·2	2·6	67·1	11·0	3·2	80·5	15·7	6·9	66·0	20·9	11·6	33·8	24·9	15·1	42·7	24·2	16·3	191·3	20·8	15·8	736·3	20·2	15·6	752·1	19·9	14·2	295·7	18·3	10·9	28·2	15·6	7·3	4·1	12·4	4
35. Simla	2202	8·6	1·9	64·8	9·5	2·4	70·1	14·0	6·6	64·0	19·0	10·6	45·7	23·1	14·4	59·7	24·1	15·7	149·1	21·5	15·2	416·1	20·1	15·2	419·1	20·1	13·6	182·4	18·0	10·8	33·3	14·7	6·9	10·2	10·5	4
36. Mount Abu	1195	18·8	10·2	5·3	20·2	11·6	7·4	24·9	16·1	4·3	29·1	20·2	2·8	31·2	21·8	20·3	28·8	20·3	100·1	24·1	19·0	597·4	22·2	18·0	660·4	24·0	18·2	213·1	26·3	17·9	20·6	23·3	14·2	4·3	20·4	11
37. Mahābaleshwar	1382	23·6	13·7	4·6	25·6	14·6	2·8	28·6	17·4	4·6	29·9	18·9	25·1	28·8	18·2	47·0	21·6	17·0	939·8	18·7	16·8	2546·1	18·8	16·4	1764·3	19·9	15·8	685·8	24·0	16·3	154·4	23·8	15·1	46·5	23·1	13
38. Kodaikanal†	2343	16·8	8·1	82·0	17·8	8·6	39·4	19·0	10·1	51·6	20·1	11·7	124·2	20·2	12·6	156·7	18·1	11·8	108·2	16·8	11·2	117·6	17·1	11·1	177·0	17·1	11·1	177·3	16·7	10·7	256·5	16·1	9·7	253·5	16·5	8
39. Ootacamund†	2249	18·8	6·1	35·1	19·7	6·6	12·9	21·1	8·8	32·5	21·9	10·8	85·6	21·3	11·4	158·7	17·8	11·3	156·0	16·6	11·2	201·2	17·1	10·9	147·1	18·1	10·6	138·7	18·1	10·3	202·2	17·6	8·9	157·7	18·3	6
40. Mercara	1152	24·9	14·0	6·1	27·0	14·9	7·6	28·9	16·4	18·8	28·6	17·8	67·8	26·7	18·2	135·9	22·2	17·4	606·3	20·3	16·8	1129·3	20·7	16·8	682·7	22·0	16·6	307·6	24·0	16·9	199·9	23·9	15·8	81·3	23·8	14

NOTE:—For extreme values of temperature, the latest dates of occurrence have been given.

Monthly maximum and minimum temperature values are based on data upto 1940

*Rainfall normals for Jaipur pertain to Sangner aerodrome site.

‡All values except elevation pertain to the