Indira Gandhi National
Open University
School of Sciences

BGGCT-133
GENERAL CARTOGRAPHY

Block

4

MAP READING AND INTERPRETATION

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BGGCT- 133

GENERAL CARTOGRAPHY

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BLOCK 4: MAP READING AND INTERPRETATION

You will agree with us that the cognitive or soft skill is a very important aspect in any field. Without such skills, it is not possible to read the information in a lucid manner. It plays a vital role to decipher information from a given piece of document precisely. In the subject of geography, it assumes greater importance as it is based on the maps and diagrams, which are being considered as short hand script of a geographer or a cartographer. Such skills also lend an edge to a cartographer as opposed to their counterparts of other knowledge domains. Map reading and interpretation also provides a plethora of information to deal with natural and cultural features of the earth's surface, climatic data and weather maps etc. It is important to learn about how maps are produced, who produces them, what the purposes are and why the maps are created and how maps are utilized etc. by different stakeholders.

With the invention of printing technology in early times, the journey of map making has got both a thrust and a momentum. Now presently, the more faster corresponding levels of development made possible by the ever-growing vistas spanning the dynamic fields of telecommunications, satellite technology, computations and mapping technologies has put this venture into the limelight of everyone. It has entered into the personal lives of everyone evident in the form of Google Maps and GPS devices in our personal mobile which provides diverse kinds of maps of a part of or entire earth in seconds. Hence, it is important to understand the underpinning concepts or fundamentals on mapping techniques, the procedure which are also more or less universally applied in the preparation of these latest maps with some variations and additions. The knowledge of such details is vested in the domain of cartography and geography.

Therefore, we are dealing with the different aspects of map reading and interpretation. You will get a subtle understanding of various aspects of the same after thoroughly reading all the three units of this block.

Unit 11 Topographical Maps:

The study of topographical maps not only provides a fundamental knowledge but also enable us to get an edge over other academic disciplines of knowledge. It provides an accurate and authenticated details dealing with both the physical and cultural details of a part of the earth's surface. This unit will focus on the important aspects of topomaps or toposheets along with the reading skills with the help of conventional symbols and signs to portray host of natural and cultural features.

Unit 12 Representation of Climatic Data:

This unit will highlight the various diagrammatic techniques to represent the climatic data. You will not only explore the diverse diagrams used to ascertain the physiological effects of climate on human beings as well as suitability of places for inhabitation purposes, but also acquire the practical skills to make these diagrams manually.

Unit 13 Weather Maps:

You may agree that weather acts as a common facilitating subject matter to start a discussion either with known accomplices as well as unknown ones. Weather impacts our daily lives in one way or other. This unit will focus on the governing elements, interpretation procedures and characteristic features of seasons along with a brief focus on the science of weather forecasting in India and the world.

We hope that after studying this block, you will be able to better understand the map reading and interpretation skills, techniques of climatic data representation and vital aspects of weather maps in particular.

Our best wishes are always with you in this endeavour.

UNIT 11

TOPOGRAPHICAL MAPS

Structure

11.1 INTRODUCTION

You have read the basic concepts of maps, types and importance of maps, map scales and projections, and various data sources in the previous blocks of this course. In this unit, you will study about the topographical maps. As a learner, you must know the techniques of map interpretation to make an effective map and also its proper utilization. Map interpretation involves a synthesis in which new ideas and facts are built from a set of interrelated details. Undoubtedly, topographical maps are proved to be an important source of the map data. It provides accurate and authentic information with regard to various natural and cultural features of surface of the earth.

In Section 11.2, an overview of the topographical maps is discussed. You will learn the development of topographical maps in India and the different series of

topographical maps published by Survey of India in Section 11.3. You will also learn how to study a topographical map and find out various relief features represented by contour lines from Sections 11.4 and 11.5. Section 11.6 explains you the identification of different physical and cultural features from the Survey of India toposheets.

Expected Learning Outcomes

After studying this unit, you should be able to:

- explain what is a topographical map and the various series of topographical maps;
- depict relief features on topographical maps by using contours;
- study topographical maps; and
- identify the physical and cultural features from a topographical map.

11.2 TOPOGRAPHICAL MAPS

You might have heard the name **'toposheet'** which is also sometimes referred to as a topographical map. A topographical map is an accurate and detailed graphic representation of various physical and cultural features of the earth's surface. It represents three dimensional features of landscape either into flat or two-dimensional features. These maps are often produced at large scale. Topographical map generally contains coordinates grid and graticules which are helpful in determining relative and absolute positions of mapped features. A topographic map characteristically represents the features including,

- **relief:** hills, valleys, slopes, depressions, coastlines and gullies;
- **hydrographic:** lakes, ponds, water tanks, rivers, streams, swamps or mudplats;
- **vegetation:** forest, wooded and cleared areas, orchards and plantations; and
- **cultural:** roads, railways, airports, buildings, rural and urban settlements, names of places and geographic features, administrative boundaries, state and international borders, etc.

The relief explained by contour lines are prominent features in any topographical map. The topographical map is different from the planimetric map in which features like roads, buildings, etc. are shown but no contour lines are visible. Whereas, the topographic maps have contours to represent the relief features along with roads, buildings, highways, rivers and so on.

You may know that various countries have established scientific organizations/ institutions/national mapping agencies which produce a topographic map series for their whole country needs at varying scales. One such example is Survey of India (SOI), which publishes topographical maps for Indian territories. Other prominent organizations including United States Geological Survey for United States of America, Royal Survey for United Kingdom, Centre

for Topographic Information of Natural Resources Canada for Canada, Geoscience Australia for Australia, etc. publishes topographical maps on various scales for their country's requierments. If you like to find various series of topographical maps, go through the following web links: ***http:// www.surveyofindia.gov.in/, http://store.usgs.gov, https:// www.ordnancesurvey.co.uk/ http://maps.nrcan.gc.ca.***

A topographical map is generally bounded by the lines of latitude and longitude. Latitudes (North or South), and longitudes (West or East), are marked on the map. These are measured in degrees (°). The latitude (the north-south angular distance), is measured from the equator whereas the longitude (the east-west angular distance) is measured from the prime meridian. The latitude of equator is 0°, and 90°N at the North pole, and 90°S at the South pole. The latitude can be expressed as 28° 38' 41'' N, 33° 51' 54'' S, etc., in the format of degree, minute and seconds. Longitude position is designated as 0° to 180°east, to designate the locations of earth's eastern hemisphere, or 0° to 180° west, for designating the locations of earth's western hemisphere. Hence, it is understood that the longitude ranges from 180° W to 180° E of the prime meridian and are converging towards the poles. The longitude can be shown as 77° 13' 01'' E, 119° 25' 4'' W etc.

Topographical map is generally represented by the ratio scale for example 1:25,000 or fractional scale i.e. 1/25,000. It explains that one unit of the map represents 25,000 same units on the earth's surface. The units may be expressed in various metric units like Inch, Centimetre, and Foot, etc. In this case for example, one inch on the topographical map represents 25,000 inches on the actual ground surface. The common and popular topographical map scales are 1:10,000, 1:25,000, 1:50,000; 1:63,360; 1:100,000; 1:125,000 and 1:250,000. Small scale maps (1:250,000), show lesser details but cover larger area whereas large scale maps (1:10,000), represent greater details as it covers smaller area. A topographical map is printed with verbal scales and/or graphic bar scales. Verbal scales are approximate scales, for example, *one inch is equal to one mile*. While, bar scales show miles, feet, kilometres, and meters etc. You have studied and learnt in detail about the map scales in Unit 3 of Block 1. We hope that you have now understood the important characteristics and usages of a topographical map in general.

You know now that topographical map represents the earth's surface features which existed during the period of survey. Scale explains the details of features of the map. Topomap uses a variety of symbols, generalization, topography and colour to portray different physical and cultural features of the area. You will understand the details of map reading and interpretation procedures of toposheet in the following sections.

SAQ 1

a) What is topographical map?

b) Name any of two prominent organisations that produces topographical maps on various scales.

11.3 DEVELOPMENT OF TOPOGRAPHICAL MAPS IN INDIA

Albrecht Penck, the German Geographer, was first person to propose a map of the entire globe on 1:1,000,000 scale popularly known as the **International Map of the World (IMW),** at the Fifth International Geographical Congress (IGC), held in Berne in 1891. He suggested that "the map must be having a common set of conventional signs so that it will help to create a new cartographic image of the whole globe for resolving complexity of the existing cartographic archive". It was mentioned as "*one common map for one common humanity*". After several discussions, the official mapping agencies of Italy, France, Britain and Germany had started surveying for the preparation of official map series of foreign territories at the million scale. Under the project of IMW, the Survey of India had also commenced a survey to generate new map series on **'India and Adjacent Countries'** at 1:1 million scale in 1904.

Actually, the Survey of India was established long back in 1767. Several British surveyors had worked to map the parts of India on various scales of 1 inch to 1 mile, 1 inch to 2 miles, and 1 inch to 4 miles, etc. Since then, it began to produce various topographical map series under different scales for the nation's requirement from time to time. There were initially two main series of maps namely 'The International Map of the World Series' (IMW Series), and 'India and Adjacent Countries Series' (IAC Series). Recently, the SOI has introduced another map series called 'Open Series Maps' according to the guidelines of National Map Policy, 2005. Survey of India is the only organization which is responsible for publishing and selling of topographical maps of Indian territories. You will now study all the three series of topographical maps.

11.3.1 International Map of the World (IMW) Series

This series is used for international map on 1:1,000,000 or 1:1 million scale. Each sheet consists of 4° of latitude and 6° of longitude. The geographical position of the sheet is defined by two letters and a number. The first letter is N or S depending on whether the sheet is north or south of the equator. Next letter after the N or S indicates latitude of sheet alphabetically with the capital letters in succession of each 4°. Numbering starts from 180° longitude and goes from west to east, the number changes after every 6° longitude. Longitudes are numbered from 1 to 60 where 1 indicates 180°–174° West and the number 60 represens 174°–180° East. Latitudes are assigned by letters as NA (0°- 4° North) to NV (84°- 88° North) or SA (0° - 4° South) to SV (84°- 88° South). The letter Z is used to designate polar regions.

Beyond 60° latitude, the longitudinal span has increased to 12°, and from 76° latitude, it doubles again to 24°. The IMW series maps are confined only upto 1:250,000 scale. The layout of the sheets is shown in Fig. 11.1. Survey of India was published on 1:1,000,000 scale for covering 4° of latitudes and 6° of longitudes under IMW series. At present, any map of the world is not producing under IMW series.

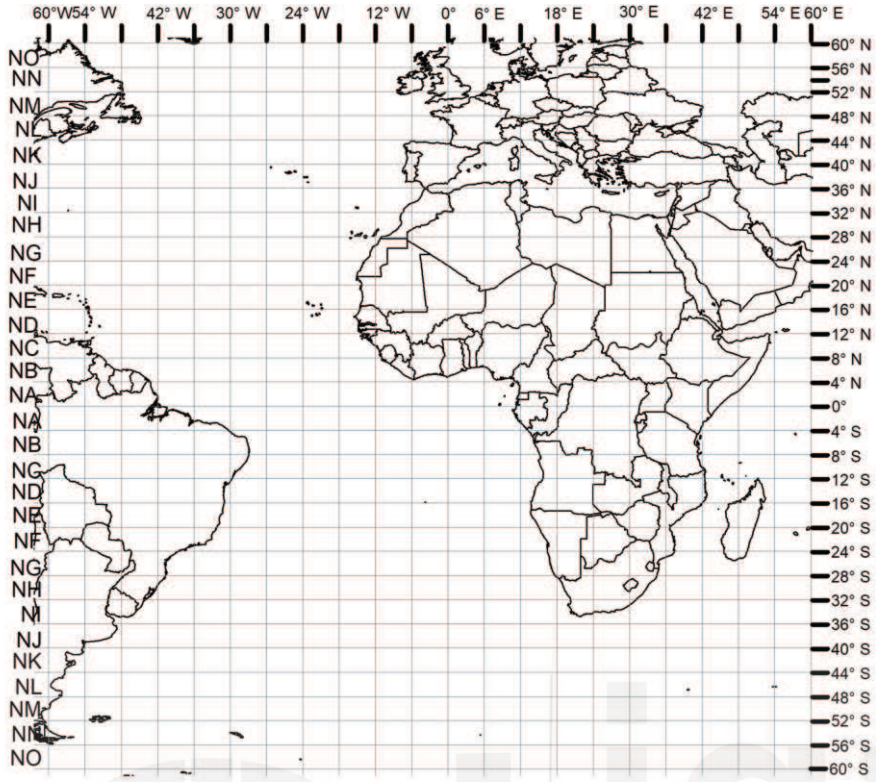


Fig. 11.1: The scheme of International Map of the World series.

11.3.2 India and Adjacent Countries (IAC) Series

You have understood about IMW series maps. Let us now study India and Adjacent Countries (IAC), series maps. IAC series map numbers cover the entire region of India and also adjacent lands of Afghanistan, Tibet, and China which is presented in Fig.11.2. In this series, each map is bounded by 4° latitude and 4° longitude on 1:1,000,000 scale. There are 136 sheets covering India and adjacent countries with the assigned index numbers 1, 2, 3, ...136.

Subsequently, SOI discontinued preparing maps for the adjacent lands of other countries from the year 1937 onwards. However, the layout plan and numbering system of the abandoned IAC series is continued in preparing topographical maps of India. Maps covering only India are a total of 50 index sheets that is numbered from 39 to 88. These 4 x 4 degree sheets are drawn at the scale of 1:1,000,000 (1 inch to 16 miles). These toposheets are called as 1M or 1 Million sheets. Where the sheets are falling in the Sea are not numbered. Some sheets are named after prominent places for example Delhi (Sheet No. 53). These IAC series maps were published in two categories namely Political and Layered editions. Political edition was published with administrative boundaries in colour, and Layered edition has graduated layers of colours to show altitudes.

Further, each 4°× 4° square or 1M sheet is sub-divided into 16 equal parts of 1^0 x 1^0. Each part has been assigned with an alphabet serially as A, B, C, D, E, F, G, H, I, J, K, L, M, N, O and P. Each grid is called by the sheet number followed by an alphabet for example 53B. The sheets drawn on 1:250,000 scale (1 inch to 4 miles), are called as degree sheets or quarter-inch sheets.

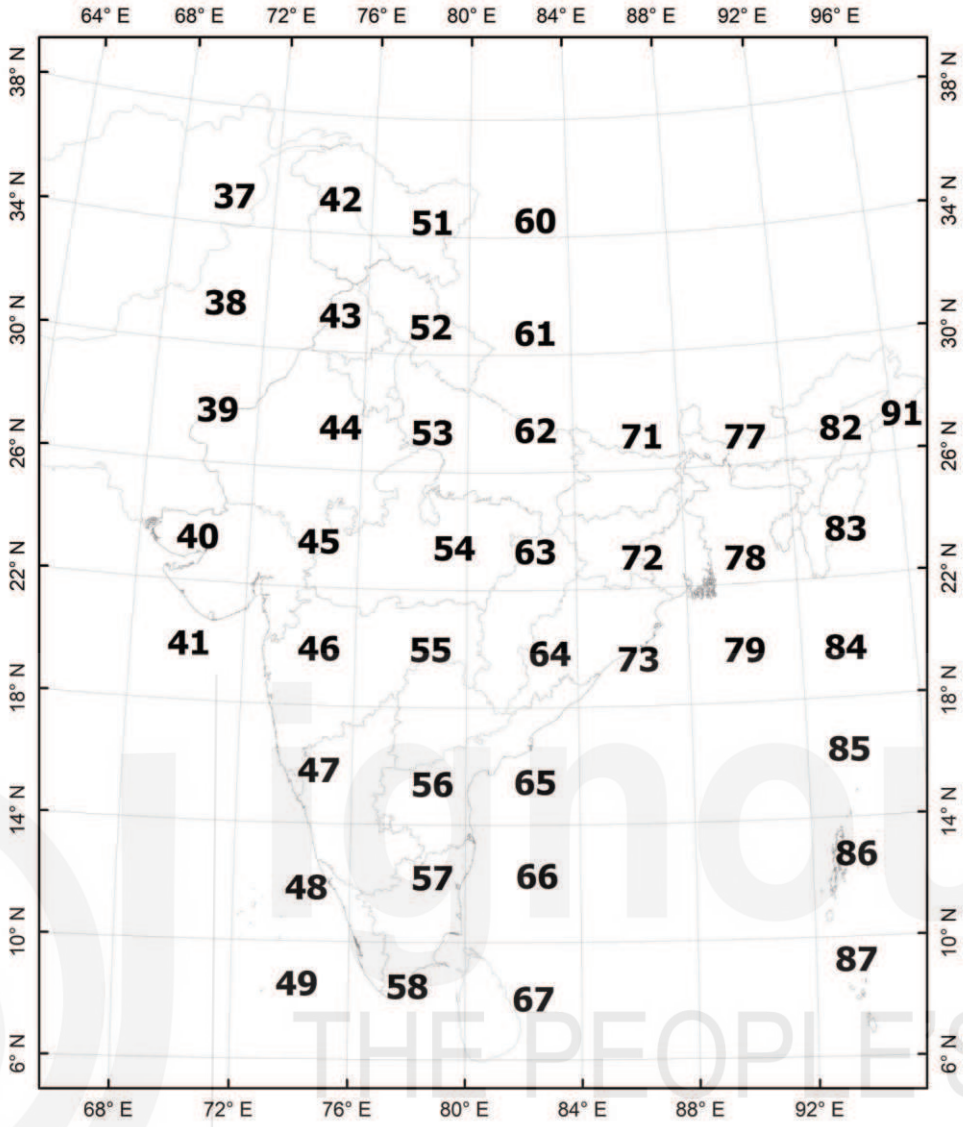


Fig. 11.2: Toposheet numbers of India and adjacent countries series.

You may refer to Fig.11.3, which explains about the Indian topographic numbering system adopted by SOI for making toposheets on different scales.

Again, each 1° x 1° map (degree sheet), is subdivided into two ways. In the first order, each sheet is divided into 4 equal parts of 30' x 30' and are named as NW, NE, SW and SE for example 53M/SE. These maps are drawn at the scale of 1:100,000 (1 inch to 2 miles) and are known as half-degree sheets or half-inch or quadrant maps. In the second order, each degree sheet is further sub-divided into 16 equal parts of 15' x 15'. These sheets are designated by numbers 1, 2, 3, ...16 and are named as 53B/1, 53 B/2, 53 B/3, and so on. The scale of these maps is 1: 50,000 (1 inch to 1 mile), and are known as one inch sheets.

The 1:50,000 scale sheet (one inch sheet) is again sub-divided into two ways. In the first order, each sheet is divided into 6 equal parts of 5' x 7' 30" and designated as numbers 1, 2, 3, 4, 5 and 6. The scale of these sheets is 1:25,000. In the second order, each one inch sheet is further sub-divided into 4 equal parts. Each part has the grid extent of 7' 30" latitude and 7' 30" longitude. These sheets are numbered as 53 O/14/NW, 53 O/14/NE, 53 O/14/SW, and 53 O/14/SE. The scale of these sheets is 1:25,000.

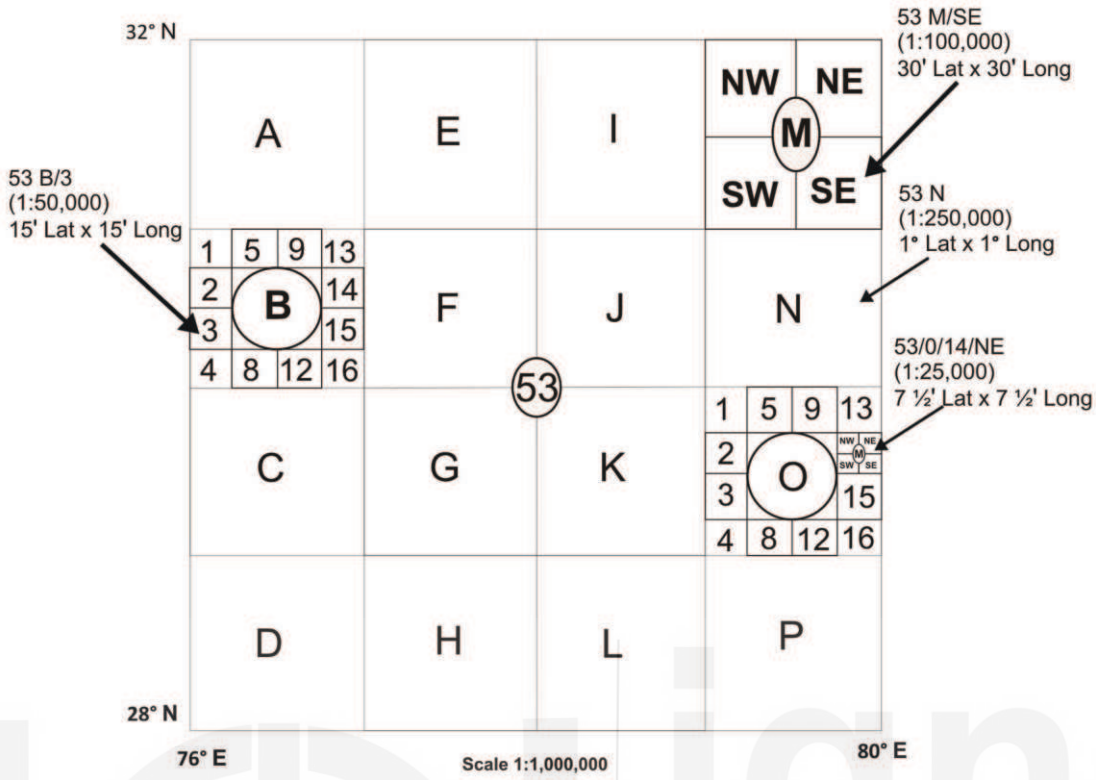


Fig. 11.3: Indian topographic numbering system.

You will further understand by studying the following table of Indian topographic map numbering system which has been adopted by SOI to identify a particular sheet of an area.

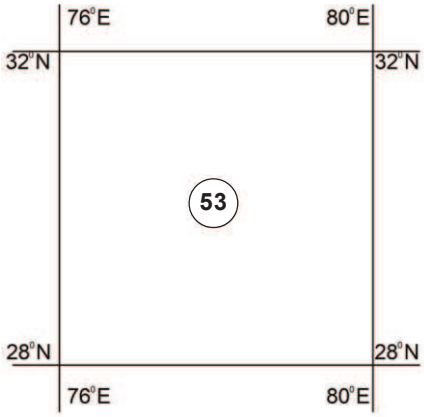
Toposheet	Scale	Extent	Contour Interval (Meters)	Example with numbering
1M	1:1,000,000	4°×4°	Varies depending on terrain	65
Degree	1:250,000	1° x 1°	100	65 O
Half Degree	1:100,000	30′ x 30″	50	65 O/NE
Quadrant	1:50,000	15′ x 15″	20	65 O/1
Quadrant Sheet Special	1:25,000	5′ x 7′ 30″	10	65 O/1″4
1:25,000 Sheet	1:25,000	7′30″ x 7′ 30″	10	65 O/1/NE

Now you will get an idea after going through the example given below.

Example 1: Find the adjacent sheets of 53 F/7 on 1:50,000 scale?

Solution: Let us learn how to solve the above problem.

Step 1: The given number is 53 F/7. The numeric number 53 shows the grid (longitude: vertical line and latitude: horizontal line), as under:



Step 2: Divide the grid - 53 into 16 equal parts and assign each box with an alphabet in the following manner. We need to have 53 F. This you can find from the box which is highlighted.

A	E	I	M
B	F	J	N
C	G	K	O
D	H	L	P

53F

Step 3: Further divide the grid - 53 F into 16 cells and assign numbers from 1 to 16. Now, shaded cell shows as 53 F/7.

1	5	9	13
2	6	10	14
3	7	11	15
4	8	12	16

53F/7

Step 4: You now know the adjacent numbers of 53 F/7.

2	6	10
3	53 F/7	11
4	8	12

Therefore, the adjacent sheets of 53 F/7 are 53 F/2, 53 F/3, 53 F/4, 53 F/6, 53 F/8, 53 F/10, 53 F/11, and 53 F/12.

11.3.3 Open Series Maps

Survey of India has now introduced the new map numbering system in place of the previous numbering system of India and Adjacent Countries (IAC) series according to the National Map Policy of 2005. There are two map series suggested namely **Defense Series Maps (DSMs)** and **Open Series Maps (OSMs)**. Maps of these two series are topographical maps. DSMs are prepared by using Everest/WGS-84 Datum and Polyconic/UTM Projection on various scales to cater mainly for defense and national security requirements.

On the other hand, OSMs are printed in UTM Projection on WGS-84 datum. These maps are available for general public without showing any civil and military Vulnerable Areas and Vulnerable Points (VA's/VP's). OSMs of scales larger than 1:1 million either in analogue or digital format can be purchased from SOI or through an agreement for specific end use. License agreement is necessary for purchasing of digital maps.

Numbering system adopted for OSM is based on International Map of the World. The layout of sheets covering the entire country is presented in Fig. 11.4. Details of various categories of OSM are presented in Table 11.1. Map numbering system is as follows:

- The area is covered by 32 UTM Zones with a dimension of 6°× 4°.
- These numbers are B46, C42, C43, C44, C46, D42, D43, D44, D46, E43, E44, E45, F42, F43, F44, F45, F46, G42, G43, G44, G45, G46, G47, H42, H43, H44, H45, H46, H47, I43, I44, and J43.
- These numbered toposheets are drawn on 1:1,000,000 scale called as million sheets.
- Each million sheet is divided into 24 degree sheets on 1:250,000 scale and are designated by letters A, B, C, D, E, ... X.
- Each 1 degree sheet is further divided into 16 sheets on 1:50,000 scale and are designated by numbers 1, 2, 3, 4, ...16. These are called 15' x 15' sheets.
- Here, each 15' x 15' sheet is divided into two series. The first series is quadrant sheets of 7' 30" x 7' 30" and second series is large scale maps or LS sheets.
- The quadrant sheets are drawn on 1: 25,000 scale and are referred to as NW, NE, SW, and SE sheets.
- Secondly, each 15' x 15' sheet contains 25 sheets with a dimension of 3' x 3' on 1:10,000 scale and are designated by alphabets A, B, C, ... Y.
- And, each 3' x 3' sheet is again subdivided into 25 sheets of 36' x 36' on 1:2,000 scale and are assigned by numbers 1,2,3, ...25.

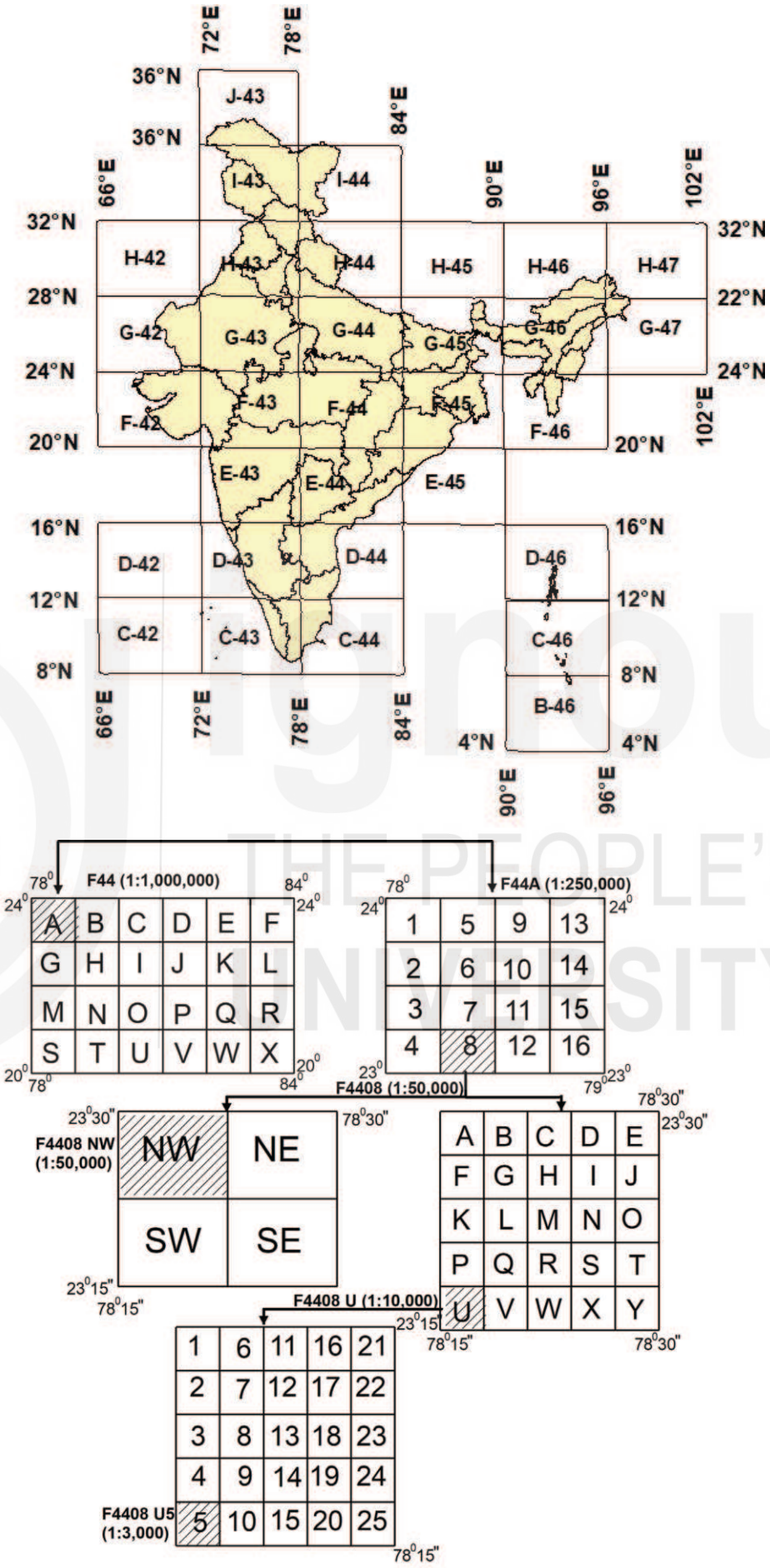


Fig. 11.4: Numbering system of Open Series Maps (OSM).

(Source: Adopted from Survey of India, Govt. of India, New Delhi)

Table 11.1: Details of various categories of the OSM toposheets.

Category	Details
General	Latitude/Longitude Name of State/District/ Administrative index Toposheet Number/Year of Survey/Edition No./Index to toposheets Magnetic variation from true North direction Map reference Bar scale/Representative Factor
Administrative boundaries	Names: Administrative/Locality or tribal Boundary: International to village, Forest, Boundary Pillars: All boundary pillars, village tri-junctions
Communication and Transmission lines	All Roads All Tracks, pass, footpath Railways: All gauges with stations, tunnels Light railways or tramway, All embankments, Road/ rail/tank Transmission lines
Hydrological details	All streams/canals All earthwork dams All rivers with details, banks, islands All wells/tube wells/springs All tanks (excluding overhead tanks), lightship, buoys, anchorages
Settlement/ Cultural details	Village inhabited, deserted and forts Huts, tower, antiquities Religious places, tombs/grave All post/telegraphic/police stations hut All bungalows
Relief	Contours with sub-features All sand features Ice forms (all features) Spot height, approximate height Bench marks (Geodetic tertiary, canal)
Vegetation	All trees, Vine on trellis, grass, scrub
Forest	Reserved/protected

(Source: Survey of India, Govt. of India, New Delhi)

SAQ 2

a) Match the following:

i)	Degree sheet	a)	1:250,000
ii)	Half-degree sheet	b)	1:1,000,000
iii)	Quadrant sheet	c)	1:50,000

b) Identify adjacent F44K10 sheets of OSM?

11.4 STUDY OF TOPOGRAPHICAL MAPS

Till now, you have understood about the numbering system of topographical maps that is published by SOI. Now, let us study a toposheet. To read and interpret any topographical map, you need to know some procedures including study of marginal information and identification of the physical and cultural features. There are several conventional signs and symbols and standard colours and letters developed for understanding the information of toposheet as each and every details of the area cannot be represented on the map. You can find the conventional signs and symbols on the toposheet itself for identifying various features of the area. Fig 11.5 represents the conventional signs and symbols of a topsheet. You must be aware of these signs and symbols and marginal information, etc., before you start reading a topographical map.

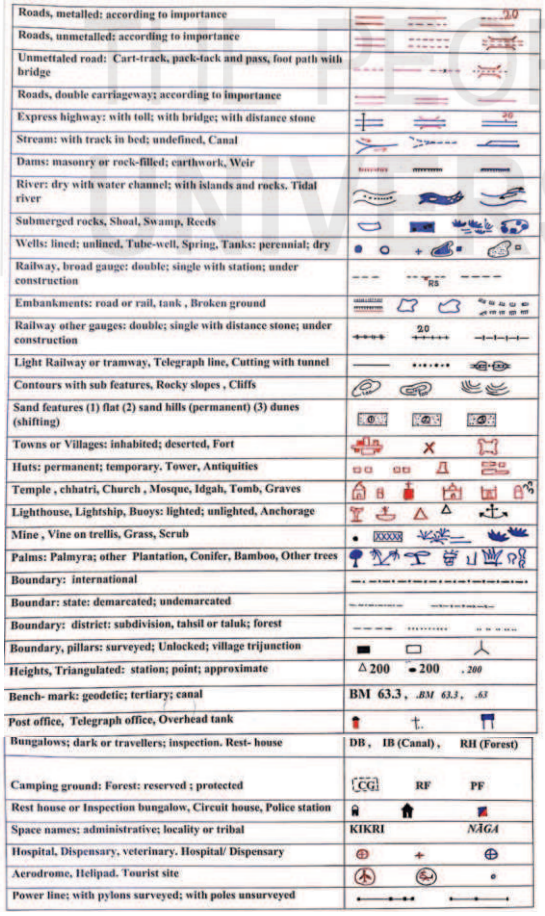


Fig. 11.5: Conventional signs and symbols of SOI toposheet.

(Source: Adopted from Survey of India, Govt. of India, New Delhi)

Let us now study the marginal information of SOI toposheet. Refer to Fig. 11.6, which shows the marginal information of a toposheet. The information related to the given area of toposheet is provided by map maker on the margin of topographical map. Fig. 11.6 shows the marginal information of a published toposheet of SOI and the details of information are given in Table 11.2. The numeric numbers on map are explained with their corresponding information of the toposheet. You must also remember that the toposheet always show direction of the north as indicated towards the top.

Fig.11.6: Marginal information of a toposheet.

(Source: Survey of India, Govt. of India, New Delhi)

Table 11.2: Description of marginal information of the toposheet.

S. No.	Information	General Description	On Toposheet
1	Sheet Name	Upper center margin and either the right or left side of the lower margin	BIHAR BHAGALPUR, MUNGER AND SAHARSA DISTRICTS
2	Sheet number	Upper right margin: Numerical numbers, and alphabet	NO. 72 K/15
3	Adjoining sheets	Bottom left:This box has been divided into nine parts. Each box having a number. The center box is outlined in black line and it contains a number which is the same as the map's sheet number. This is the index to adjoining sheets.	Index to sheets
4	Scale	Center of bottom: The scale representing that one unit of measurement on the map is equal to fifty thousand of the same units on the actual ground. The graphic scale is used to convert map distance to ground distance and vice-versa. On the map which explains you that 1 cm distance of the map covers an area of 500 m on the actual ground.	1: 50, 000 On bar scale: left margin 500 m to 1 cm and right margin 2 cm to 1 km.
5	Contour interval	Center of the bottom and beneath the bar scale: It gives you the vertical distance between contour lines and the unit of measurement in feet or metres.	Contour interval 20 metres
6	Colour tinting	Center of the bottom and beneath the contour interval: It explains different colors representing various features of the map.	Water features are shown in blue where they generally contain water. Cultivated areas are coloured in yellow. The boundaries of areas of Reserved or

			Protected Forests are shown by green bands. Wooded areas are coloured in green. Scattered trees and other vegetation are shown in green, but prominent surveyed trees are coloured in black.
7	Legend	Bottom left and right margin: It covers signs, colours and symbols to represent natural and man-made features.	Boxes contain the information
8	Credit Note	Upper center margin and lower center (above the scale): It provides the information regarding the map like who made it and when it was printed.	Surveyed 1977-78 Published under the direction of Major General, Surveyor General of India, 1982
9	Extent of the toposheet	Four corners of the boundaries of toposheet: North Latitudes and East Longitudes of the surveyed toposheet.	25°15' 86°45' 25°15' 87°0' 25°30' 86°45' 25°30' 87°0'
10	Orientation	Center of the toposheet	Magnetic Variation from True North about 1/2° West in 1975

Now you have understood about the marginal information of toposheet. Based on the above information and observation, you will now be able to study the marginal information of different toposheets. You can also try to download the topographical maps from Survey of India website (www.surveyofindia.org). Survey of India is a designated Government agency that publishes and sells topographical maps of India on different scales to cater the needs of users like academicians, researchers, etc.

SAQ 3

What is marginal information of a toposheet?

11.5 REPRESENTATION OF RELIEF BY CONTOURS

In this section, you will learn different techniques that are used to represent relief on topographical maps. Relief depicts the elevation of the land above sea level on a flat surface. Various techniques such as hachures, form lines, layer colouring, hill shading, contours and spot heights/benchmarks/ triangulation stations are employed to show relief on maps.

Hachures are fine small broken lines drawn along the direction of maximum slope. It is a kind of flow line symbol which was first proposed by Lehman, an Austrian Army officer, in the year 1799, for the depiction of terrain. Steep slopes have thick hachures and are very close to each other and a little wider when the slope is gentle. The blank portion shows flat areas. These are present visual impression of relief but they do not provide actual height of the areas.

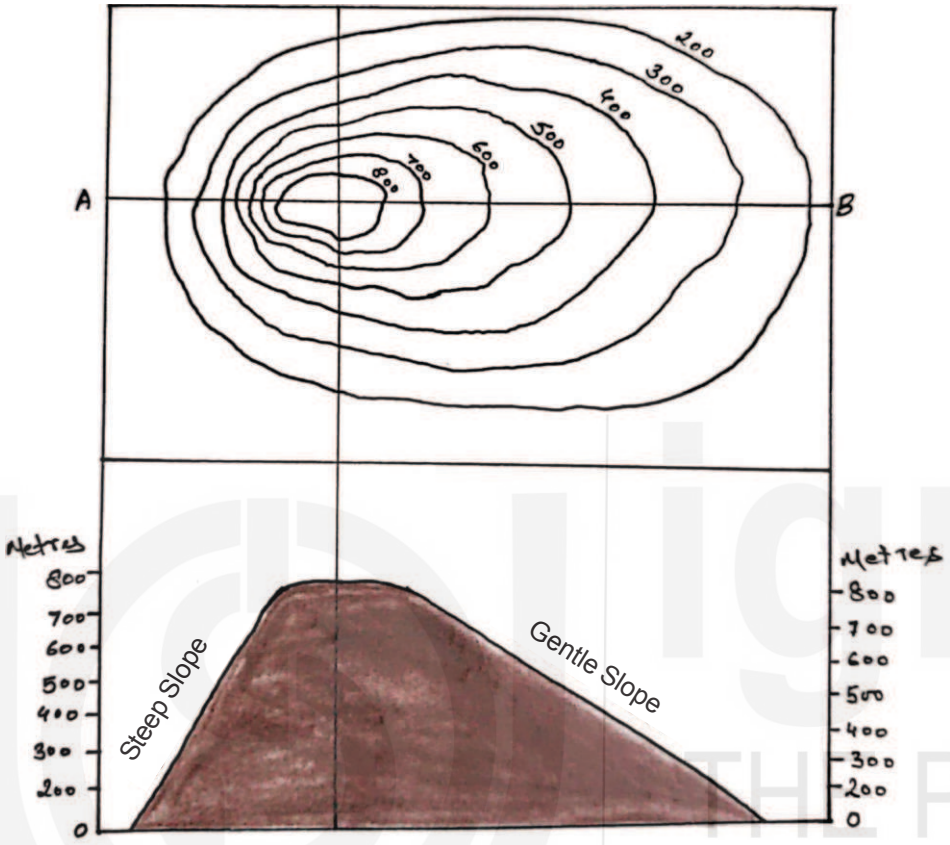
Form lines are broken lines drawn in between contour lines. These are approximations based on observations of surveyors without direct measurements of the region. For example, mountainous topography, where some areas are very difficult in order to conduct actual survey.

Spot height, bench mark and **triangulation stations** are marked on the toposheet which indicates the real height of any point on the ground. **Spot heights** are shown to indicate exact height of the ground surface above mean sea level. On the toposheet, it is shown as a dot symbol accompanied by numeric numbers indicating the height in meters or feet. The height of the prominent points/objects like buildings, pillars, bridges or rocks are determined with greater accuracy and are represented as **bench marks**. On the toposheet, the letters BM followed by numeric numbers show the actual elevation of the point and not that of the ground. **Triangulation stations** are different from spot heights that shows the height which actually exist on the ground in the form of a triangulation pillar. On the toposheet, it is depicted as triangle symbol followed by number. More precisely located and more accurate in elevation, the trigonometric points are marked by a plate fixed permanently on the ground.

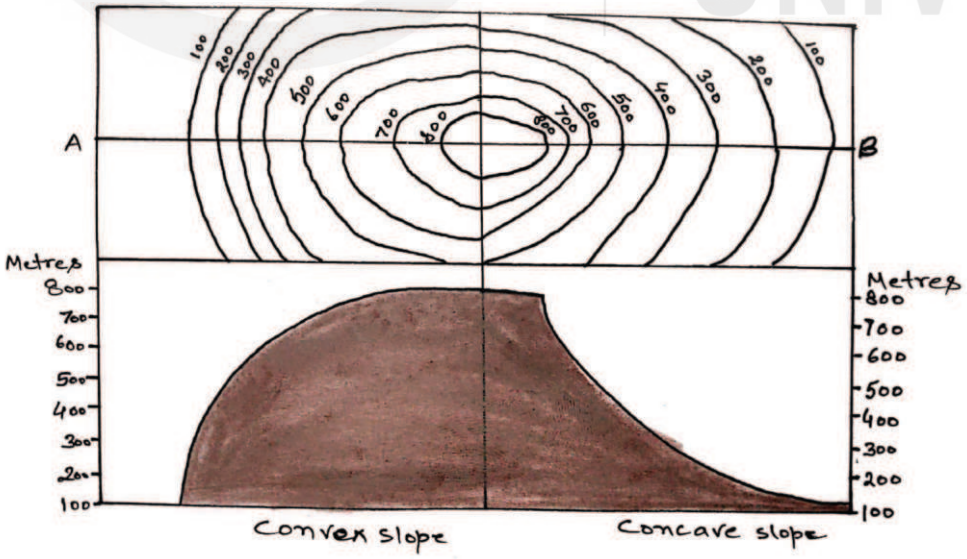
Contouring is the standard and best method of representing relief on topographical maps. Contours are isarithm which connect points of same elevation. It is a technique of line symbol first used by Cruquins, a Dutch man in 1730. Contours can be defined as imagery lines that connect points of equal elevations on the surface of ground above or below a reference surface, such as mean sea level. Contours cannot merge or cross each other on a map, except on vertical surfaces such as cliffs, caves or walls. On the toposheet, the height of the contour is generally printed on the contour line. The index contour i.e., every fifth or tenth contour line is drawn as thick line than the rest with the labelled information which enables us to know the heights more easily (e.g., 100, 200, etc.). The vertical distance between contour lines is known as **contour interval**. The specific values of contour interval depend on the map scale, the degree of relief and the purpose of map.

Based on the contour pattern, one can easily understand the shape of land

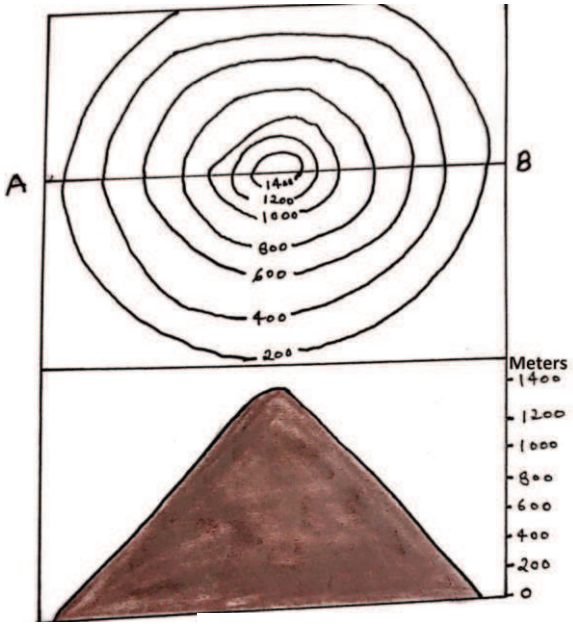
surface. The spacing of contours is significant which explains the steepness of the land surface. The contour lines are closed together; they represent a steep slope, whereas gentle slope indicates that contour lines are far away from each other. Let us know some of the surface features and how they are represented by contour patterns. You will understand these surface features by studying the following diagrams.



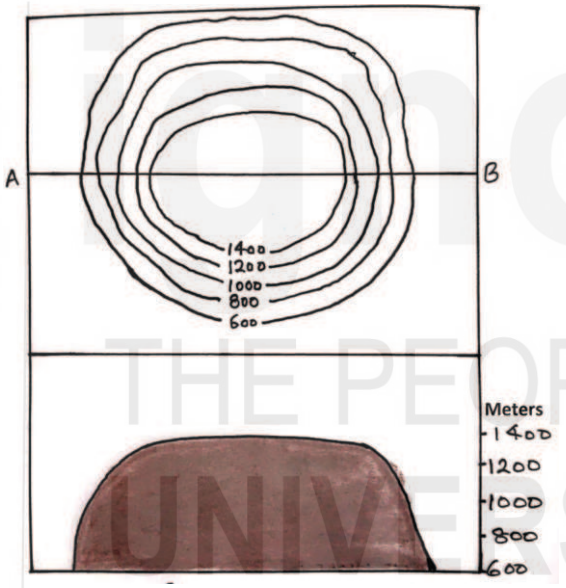
Gentle slope: contour lines wide apart; and Steep slope: contour lines close to each other.



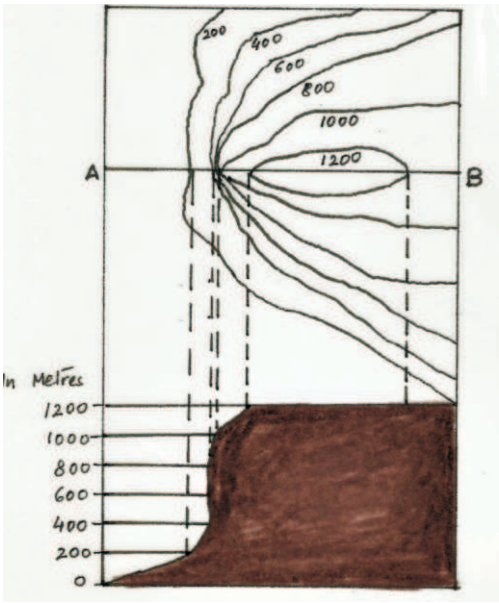
Convex slope: close contours (steep), at lower than top of the hill and Concave slope: close contours at top than the lower part of the hill.



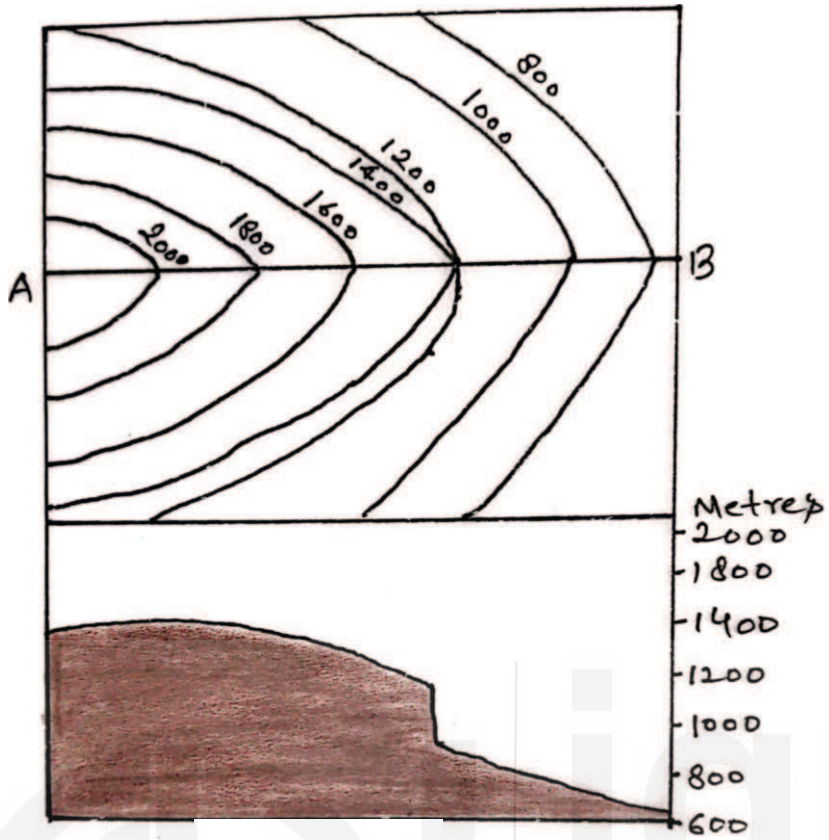
Conical hill: concentric circles of contour lines on top of the hill.



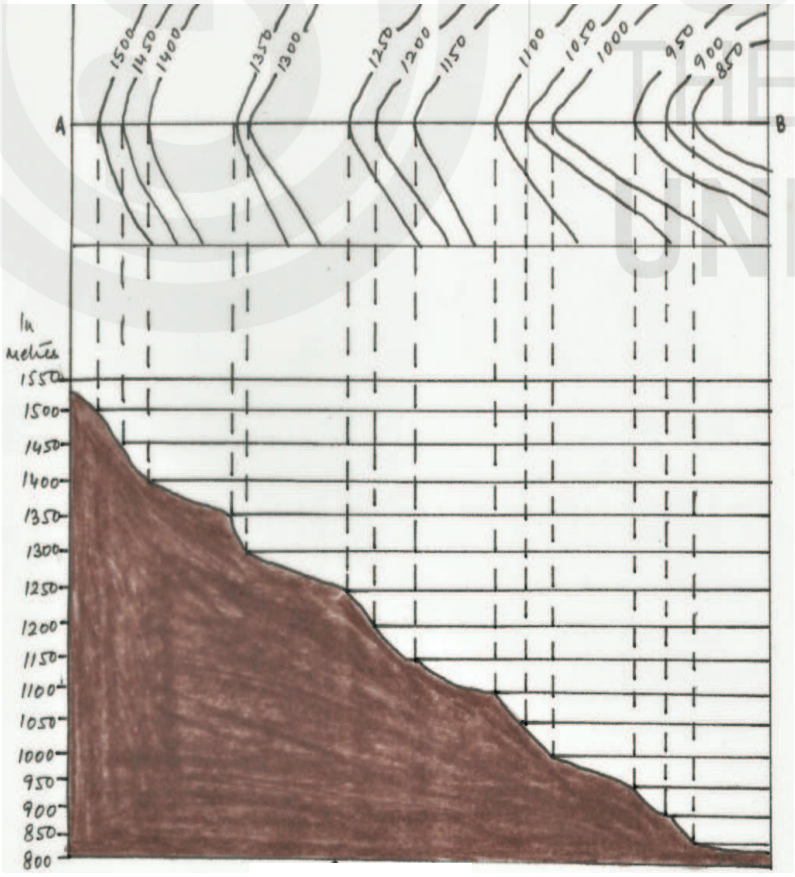
Plateau: elevated land covering with large area at the top shown with few contours surrounded by number of contours.



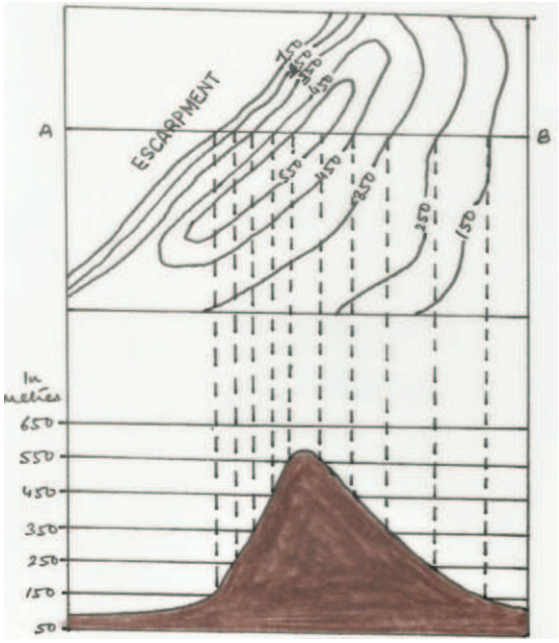
Cliff: contours merge into one and the other on the face of the cliff.



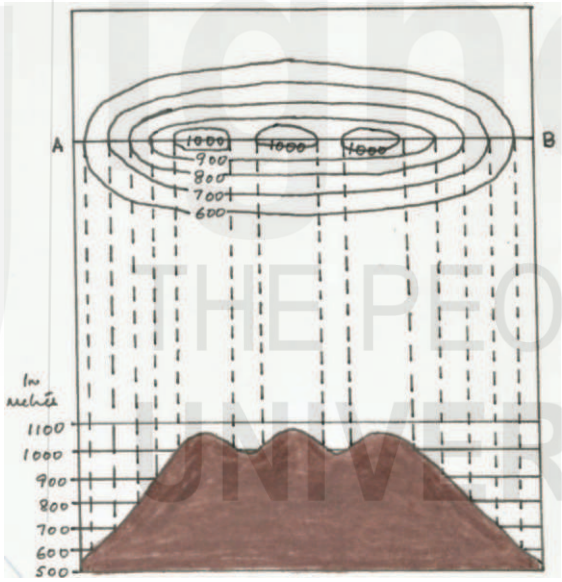
Waterfall: contours closely connect one and other or merge at a particular point when crossing a stream.



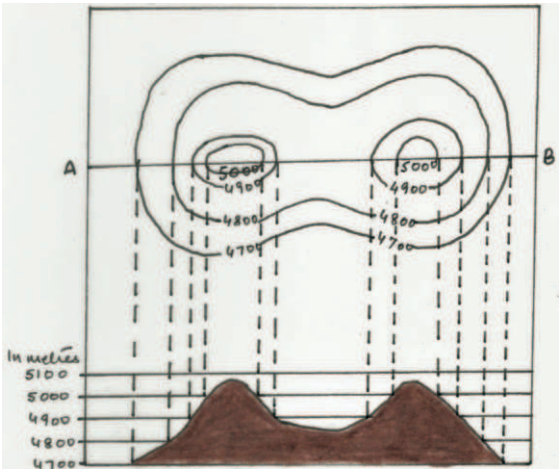
Rapids: contours are relatively distant at particular places of hill.



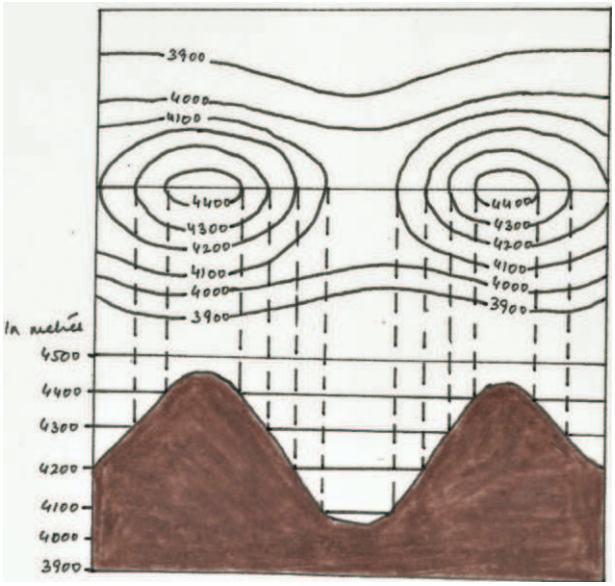
Escarpment: a sudden drop of slopes in ground level or steep hill sides. Very closely spaced contours or sometimes shown with a cliff symbol.



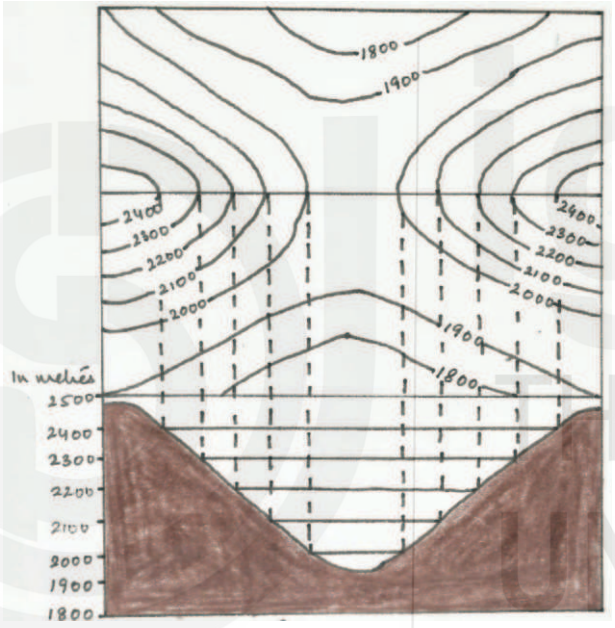
Ridge: a chain of hills.



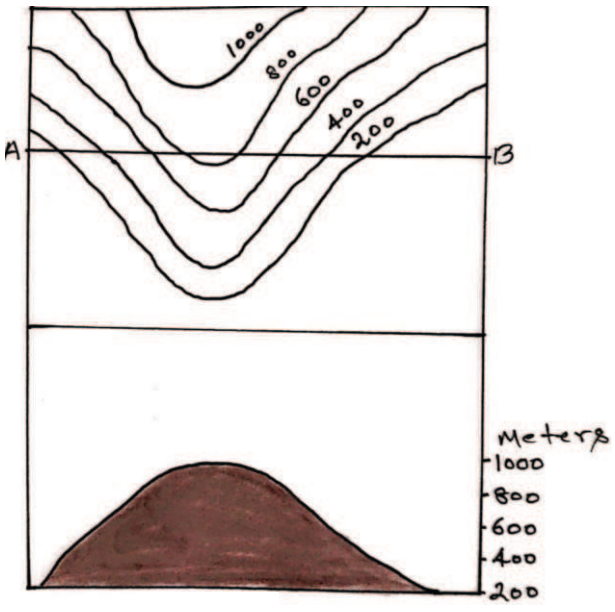
Saddle: low elevation points on ridges.



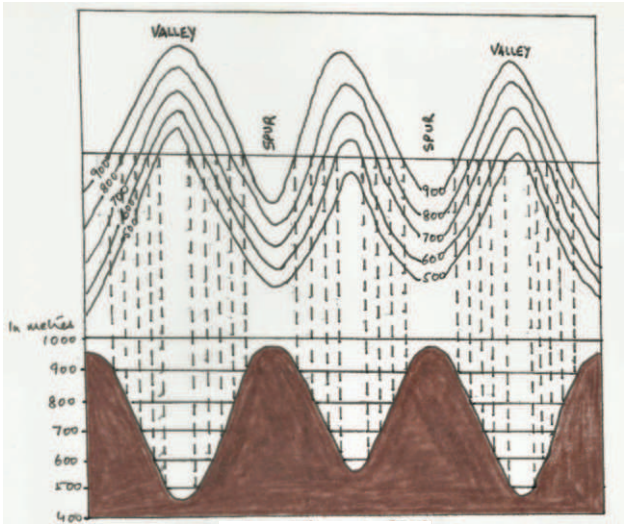
Pass: a passage through a mountain range showing low elevations.



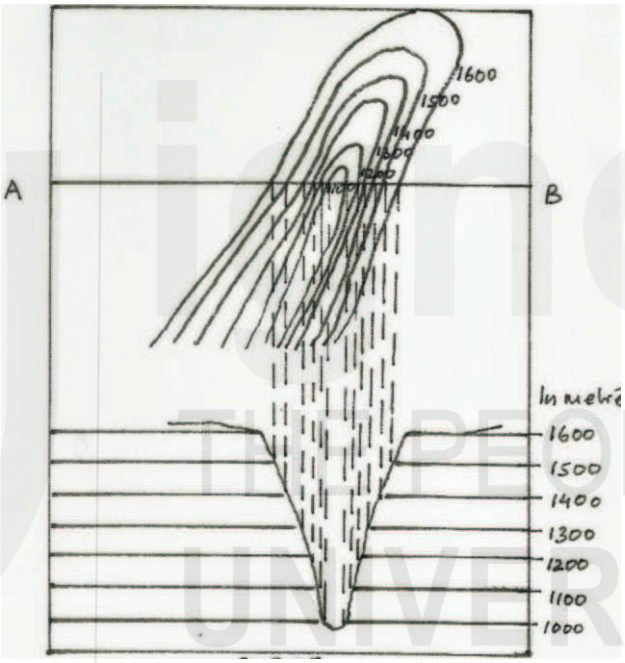
Col: the lowest point of a ridge between two mountain peaks.



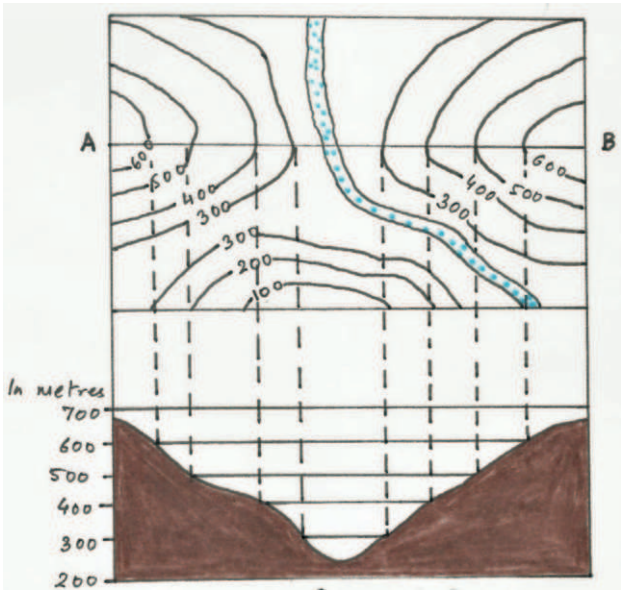
Spur: a chain of small ridges connected to a ridge or hill.



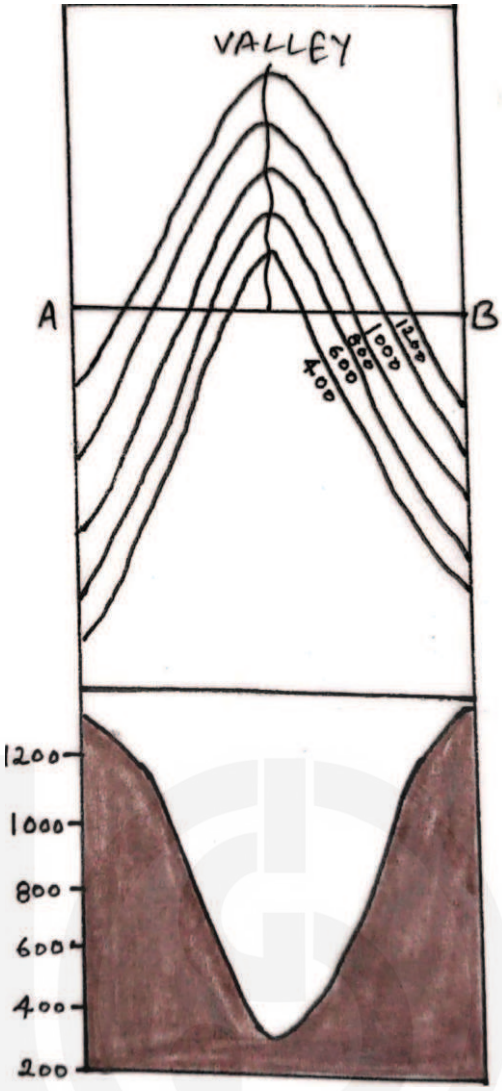
Vally and Spur: 'V' points uphill (valley) and points downhill (Spur).



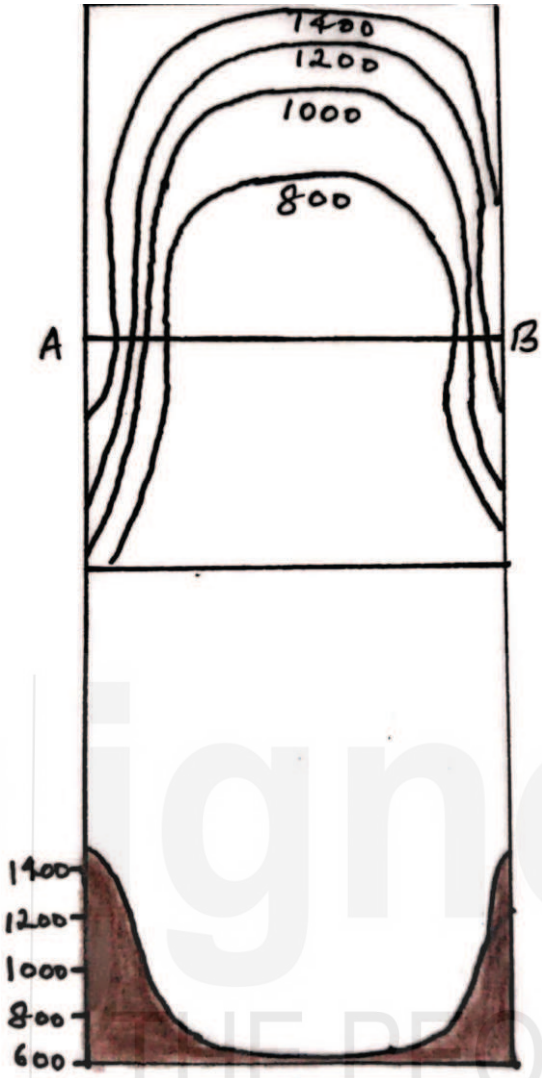
Gorge: contours parallel and very close to each other.



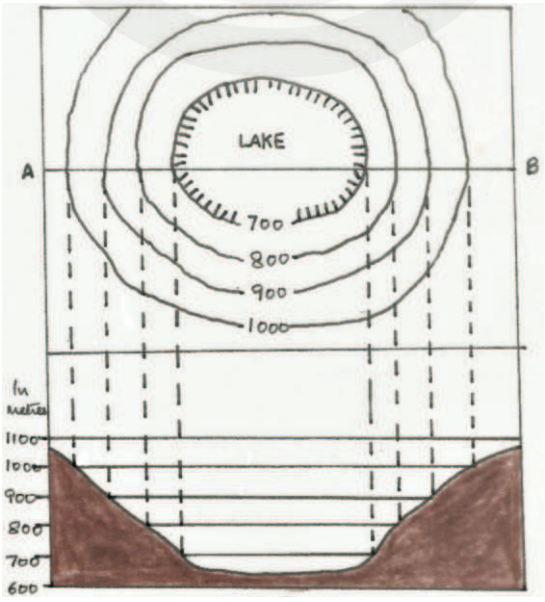
River Gap: 'U' shaped gap.



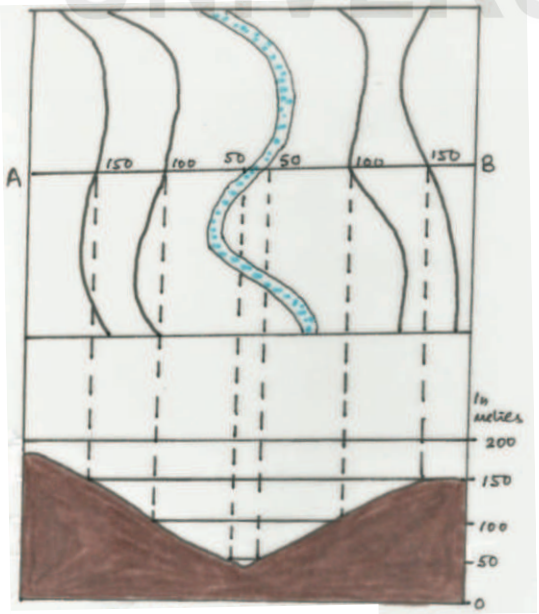
Valley: Represents 'V' shape



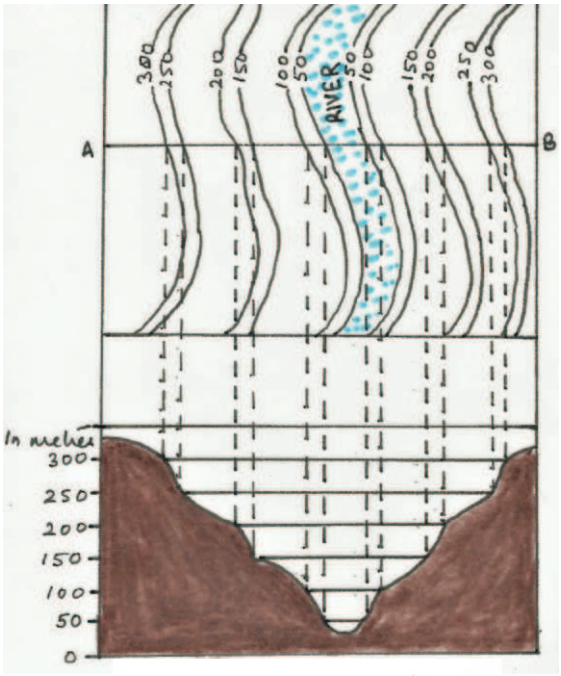
Valley: Represents 'U' shape



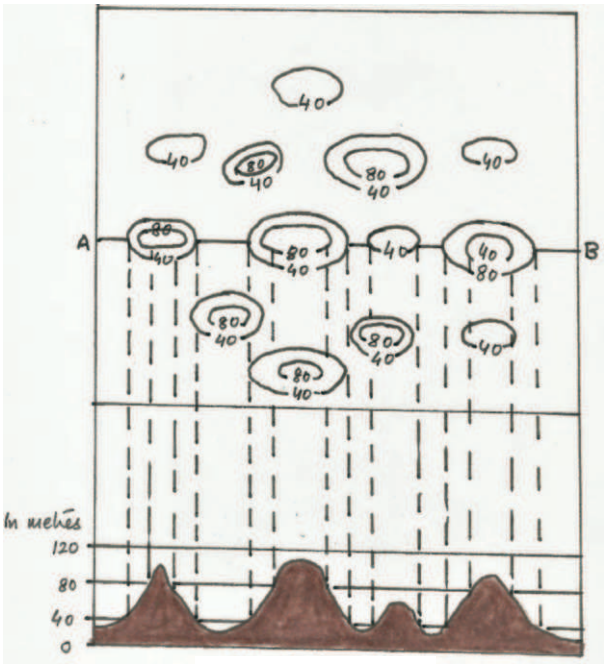
Lake: the closer points on its center represents deeper water



River Meandering



River Terraces: step-like contours.



Sand Dunes

SAQ 4

What are contour lines?

11.6 IDENTIFICATION OF PHYSICAL AND CULTURAL FEATURES

You have studied about the marginal information of toposheet and relief features which are represented by contour lines on topographical maps. As we know that the topographical map represents physical and cultural features of small areas on a large scale. As a cartographer and map interpreter, you must be familiar with conventional signs and symbols, marginal information, relief features, etc., to identify, locate and describe the immense amount of information given on the topographical map. Let us now study how to identify various physical and cultural features from the toposheet. You must refer to Fig.11.5 for understanding various signs and symbols which are conventionally assigned for identification of physical and cultural features given on a toposheet.

11.6.1 Physical Features

You could find several natural features like mountains, hills, plains, streams, vegetative cover, etc., in your surrounding landscape. These features are generally referred to as physical features. The first step for identification of physical features is to prepare the layout for broad features such as mountains, plateaus, plains and valleys, etc. Then, note the major rivers, streams and nallahas, etc. and study carefully into the details of broad features such as ridges, peaks, spurs, escarpment, cirques, knolls, cols, flood plains, valleys, rivulets, glaciers and moraine deposits, etc. Finally record the natural

vegetation of the toposheet. Broad categories of physical features are explained below.

Relief Features

You have already studied some of the relief features represented by contours on topomap from the previous Sec. 11.5. Other features including dunes, rock outcrops, stony waste and sheet rock, etc., can be identified by the conventional signs and letter symbols. Based on the pattern and spacing of contour lines, you will be able to identify the relief features. On the toposheet, the contour lines are either completely missing or only a few are present, thus, it indicates flat or plain area. Whereas, a large number of contours or elevation points are marked on the topomap, then it could be mountainous or hilly terrain.

Drainage

Even if you do not have a proper geological and elevation records, but a good knowledge of drainage system of a region, will help in understanding the rock structure and lithology of that area. It is necessary to study different drainage patterns while map reading. Drainage of an area can be studied based on its pattern and density. Drainage pattern is simply the way of arrangement of streams or drainage channels on the landscape. There are several types of drainage patterns which can be identified. Some of the most frequently observed patterns are explained here.

- ***Dendritic pattern***: It is a branching tree-like drainage pattern. This pattern is developed in the areas of homogeneous rocks, for example, Igneous rocks. These areas are generally characterised by lack of structural control like folding or faulting.
- ***Trellis pattern***: Streams flow parallel to each other and the tributaries join almost at right angles. The longer streams will always have the preference to flow in one particular orientation. The drainage pattern so developed will be rectangular in shape. This pattern is predominantly developed in the folded regions with alternating bands of hard and soft rocks.
- ***Rectangular pattern***: It reflects the areas where joints or fault system is the main controlling factor. In this pattern, streams meet at right angles with each other.
- ***Radial pattern***: Drainage channels tend to flow away from the central point of a conical hill or dome or volcano.
- ***Centripetal pattern***: Streams are converging into a central depression that indicates the development of a structural basin.

We can also estimate the **drainage density** by careful reading of drainage channels present on topomap. The drainage density can be defined as the ratio of the total length of channels to the area of that basin. It is simply a measure of the closeness of the spacing of channels. Higher drainage densities can be expected where the slopes are steep, commonly found in the

hilly or mountainous terrain. Further interested in knowing more details of the drainage system, you may refer any good book of Physical Geography.

The drainage network is shown on the topographical map with the line symbols. Other drainage features including perennial channels, non-perennial channels, canals, meanders, cutoff and chute, etc., can be identified with the help of line symbols and associated patterns. Islands, gully erosion, rapids and waterfalls, etc., are represented by conventional symbols. The given explanations of drainage may help the cartographer to interpret a topographical map.

Vegetation

Forest including reserve and protected categories, scrub lands, orchards and groves, horticulture, silviculture, and plantations comprise of mango, cashew, teak, causirina, pine and bamboo, etc., come under vegetation category. These features can be identified with the help of letter and conventional symbols given on the topographical map.

11.6.2 Cultural Features

The identification of human-made features can be done with the help of the marginal information, conventional symbols and abbreviations which are published by Survey of India on the topographical map. You must remember that each toposheet may contain some special features of that particular surveyed area and vice-versa. The map reader should focus on the information provided by the map maker while studying it. The important cultural features commonly found in the plains and plateau regions of India are explained below:

Settlements

Settlements for example rural or urban and other buildings, and structures including monument, factory, chimney, post-office, temple, church, mosque, tomb, pagoda, idgah, fort, burial grounds, etc. can be identified with the help of conventional symbols. Settlement patterns like compact, scattered, linear, or circular, must be interpreted while studying a topographical map.

Transport and Communication

Record the means of transport and communications like railways i.e., narrow, meter gauge, broad gauge; roads: metalled, unmetalled, cart track, packtrack; ports, harbours, power lines and telephone lines, etc. Transport and communication lines are shown by line symbols with varying widths.

Landuse

You can identify landuse pattern such as forest, wood, cultivated lands, waste lands and irrigation system, etc.

Other cultural features such as waterway, ferry, airport, bridges, embankment and bunds, etc., are marked with letter symbols. You may also note the administrative boundaries, forest boundaries, institutions, post offices, hospitals and temples, etc., and other features, if any, not mentioned in the list.

You will further learn how to identify and interpret various physical and cultural

features from the toposheet by doing the exercises given in the Laboratory course of BGGCL-134 of B.Sc. Geography programme.

SAQ 5

List out any three physical and cultural features of a topographical map?

11.7 SUMMARY

In this unit, you have studied so far:

- The topographical map represents various relief features, hydrological features, vegetation and other cultural features.
- Survey of India (SOI) is the only organisation publishing topographical maps of India on various scales.
- Survey of India numbering system must be understood for identification of any topographic map of India. There are three map series namely IMW series, IAC series and OSMs published by SOI. Open series maps are introduced for the purpose of general public according to National Map Policy of 2005.
- Noting the marginal information is of utmost importance for those who are reading and interpreting the toposheet.
- Representation of relief is possible through hachures, form lines, layer colouring, hill shading, contours, spot heights/benchmarks/triangulation stations.
- You have also studied the identification of various physical and cultural features from the SOI toposheet.

11.8 TERMINAL QUESTIONS

1. Explain the importance of topomap and its characteristics.
2. Explain about India and Adjacent Countries Series and Open Series Maps with examples.
3. Describe any three prominent methods used for representing relief.
4. Draw any three relief features using contour method.
5. How do you identify the physical and cultural features from SOI toposheet? Explain.

11.9 ANSWERS

Self Assessment Questions

1. a) Topographical map represents physical and cultural features.

   b) Survey of India and United States Geological Survey.

2. a) i-B, ii-A, iii-C

   b) F44K09, F44K05, F44K06, F44K07, F44K11, F44K15, F44K14, F44K13.

3. Map maker provides the information with regard to the surveyed toposheets on its margins.

4. Contours are lines which connect the points of same elevation on a map.

5. Physical features: mountains, river and reserved forest; Cultural features: monuments, roads and wooded lands.

Terminal Questions

1. Topographical map shows various features of relief, hydrological, vegetation and human-made etc. These maps are produced by different national organizations for their country needs from time to time. Topomap contains latitude and longitude values and map scale. It mainly represents earth's physical and cultural features that existed during the period of survey. Refer to the Sec. 11.2.

2. India and Adjacent Countries series maps are covered in the entire region of India and each map is divided by 4^0 latitude and 4^0 longitude. Open series maps are printed in UTM Projection on WGS-84 datum. For further information, you may refer to Sub-Secs. 11.3.2 and 11.3.3.

3. Relief can be represented by using different techniques such as hachures, form lines, spot heights and contouring etc. You may refer to the Sec. 11.5.

4. Refer to the Sec. 11.5.

5. Refer to the Sec. 11.6.

11.10 REFERENCES/SUGGESTED FURTHER READING

- Khan, M.Z. (1998). *Text Book of Practical Geography*. New Delhi: Concept Publishing Company.
- Misra, R.P. and Ramesh, A. (1986). *Fundamentals of Cartography.* New Delhi: McMillan.
- Robinson, A., Morrison, J.L., Muehrcke, P.C., Kimerling, A.J. and Guptill, S.C. (2011). *Elements of Cartography.* 6th edition. New York: Wiley.
- Sarkar, A. (2008): *Practical Geography: A Systematic Approach.* Kolkata: Orient BlackSwan.
- Singh, G. (2004). *Map Work and Practical Geography.* Delhi: Vikas Publication House.
- Singh, R.L. and Singh, R.P.B. (2003). *Elements of Practical Geography*. New Delhi: Kalyani Publishers.
- http://www.surveyofindia.gov.in/files/50%20K_2.pdf (accessed on 12.12.2019.
- http://www.surveyofindia.gov.in/pages/view/10-about-us-**

UNIT 12

REPRESENTATION OF CLIMATIC DATA

Structure

12.1 INTRODUCTION

You have read climatology in the course on 'Physical Geography' in your First Semester. You might have seen various diagrams and maps namely isotherm, isobar, line and bar diagram and wind rose etc. Just imagine a situation where you will be provided with monthly data for temperature and rainfall of ten places for thirty years, it would be difficult for you to compare and interpret the data. However, the same data is represented through multiple line diagrams. We are sure that it would be easier for you to comprehend, compare and interpret. Therefore, we say visualization is one of the effective methods of representation of data in general and climatic data in particular.

In this unit, we will discuss about representation of climatic data through diagrams namely climograph, hythergraph, ergograph and wind rose. Like

previous units, we will explain concept and its uses along with one example and steps involved in the construction of such diagrams. Once you complete this unit, you would understand the steps of construction, utility and application of these climatic diagrams.

In the next unit i.e., Unit-13, we will discuss about representation of climatic data through maps. We will also explain in detail about representation methods of geographical data in Unit-14.

Expected Learning Outcomes

After studying this unit, you should be able to:

- identify appropriate diagrams for representing varied climatic data;
- describe concepts, methods of construction and their uses; and
- represent climatic data through appropriate diagrams.

12.2 ELEMENTS OF CLIMATIC DATA

Before discussing about the representation of climatic data, we should know the elements of climate on which data is gathered. If you remember, we watch it on the television, listen it on the radio, read it in the newspapers where it is presented in the form of weather report. Today, you can also see it in your mobile phone. Generally, it presents weather condition of past 24 hours and predicts what would happen in the next 24 hours or more. In that weather bulletin particularly in newspapers and television, many a time, it is supplemented by satellite image and diagrams. We are sure that till now, you might have recollected all the weather or climatic elements we are talking about. If not, then please read it from newspaper, listen to news bulletin or watch it from television and revisit the Unit on “Elements of Weather and Climate” which you have already read in the First Semester Course on “Physical Geography”.

Most of the weather reports present five major elements of weather namely temperature, pressure, wind flow, humidity and precipitation. Some aspects of these five elements are shown in diagrams like line diagram, bar diagram, wind flow diagram etc., and some of them are presented in the maps like isotherm and isobar etc. We will discuss about the representation of climatic data through diagrams in this unit. Representation in the form of isotherm, isobar, and pressure gradient will be taken up in the next Unit 13 titled “Weather Maps”.

Let us now discuss in brief about the five climatic elements as mentioned above.

(i) **Temperature**: The most significant factor that determines weather is temperature. Temperature is measured using a thermometer in degrees Fahrenheit or Celsius. We generally represent all sorts of variations starting from diurnal i.e., in a day, monthly, annual and over a longer period of time. This provides you the maximum, minimum, range and average temperature of different places on the globe.

(ii) **Pressure**: Air pressure or simply we can say pressure has a direct relationship with temperature. It includes the amount of pressure exerted by the air in a particular air mass. Air pressure is also called barometric pressure because it is measured using a barometer and commonly measured in inches of mercury. You might have seen in weather reports, it has been depicted in terms of areas of high pressure and low pressure.

(iii) **Humidity**: Humidity is also another important factor that determines the weather of a place. Humidity is a measure of the water content present in the air mass. It plays a vital role in weather formation and agricultural activities etc.

(iv) **Precipitation**: You have read various forms of precipitation namely snow, rain, hailstorm and drizzle etc. As you know, it is one of the essential elements for survival of the planet earth in general and survival of plants, animals and human beings in specific. We generally measure amount of rainfall in a place by using rain gauge.

(v) **Wind**: As you know temperature and pressure are the major determinants of wind flow. Wind speed and direction, gives you an idea about wind patterns of a particular place. If you remember while presenting a report about cyclonic storm, the reporter describes the wind speed as well as direction. This type of data we present through wind rose diagrams.

After knowing the elements of climate related data, let us discuss briefly about the instruments used for collecting above mentioned weather related data. Different types of instruments are used to measure different parameters. As you already know that thermometer is used for measuring temperature, barometer for pressure, anemometer for measuring wind velocity etc. Today, we have automated weather station (AWS's), in which these instruments are found at one place and as name suggests weather phenomena are recorded automatically. You will read more about this in the next unit. Once data is recorded, these data have to be gathered and communicated to different stakeholders like farmers, policy makers and general public etc. for different purposes. While communicating this huge data, we take the help of certain diagrams to make communication more effective and easily understandable. What exactly we want to see out of this huge data? We look for trends, patterns and relationships. Once we understand these three processes, it would be easy for us and respective stakeholders to draw inferences from such graphs and diagrams.

There are certain diagrams which are general in nature and represent various types of data including climatic data. Examples are line diagram, bar diagram, combined line and bar diagram etc. We will discuss about these diagrams in Unit 14. But there are certain diagrams which were developed for depicting climatic data exclusively. Examples of such diagrams are climograph, hythergraph, ergograph, wind rose and star diagrams etc. We will discuss about these exclusive diagrams in the next Sections.

Before that, let us know what we have learnt so far, by answering the questions as given below.

SAQ 1

Fill in the blanks with suitable words.

(i) Weather bulletin in newspaper and television, many a time is supplemented by _____ and _____.

(ii) Weather phenomena of a place are recorded automatically by _____.

(iii) Communicating huge data with the help of diagrams make communication more _____ and _____.

12.3 REPRESENTATION OF CLIMATIC DATA THROUGH DIAGRAMS

As mentioned above, we will discuss only those diagrams which are exclusively used for representing climatic data. While doing so, we can define the month or season and place of interest used for representation of the weather phenomena. The weather data including past weather conditions and long-term averages can be used for representation through various diagrams. Some of the diagrams with the help of which you can represent these data are given below:

1. Climograph
2. Hythergraph
3. Ergograph
4. Wind rose and Star diagram

Let us discuss these diagrams, their uses and steps involved in the construction with one example each.

12.3.1 Climograph

Climograph or climogram is nothing but the short form of climatological diagram. ***This is a twelve sided polygon that represents selected two climatic elements of a particular station against one another.*** This twelve sided polygon or climograph was constructed by taking wet bulb temperature and relative humidity as indicators for representing climatic condition of a place.

This was first conceived by J. Ball in 1910 and later expanded and improved by Leighly (1926), USDA (1941), and Taylor (1949). This diagram was also extensively used by Koeppen to summarize variations in world climatic conditions while developing his classification of climatic regions (you have already read it in a Unit of third block titled ‘climatology’ in first semester

course). If we look at the history behind the construction of climograph, it was also used to identify the places on the basis of scale of habitability or hospitability for white settlers in the tropic regions.

As mentioned above, the sole purpose for which Griffith Taylor constructed climograph was to identify the places in tropical area that were suitable or hospitable for white settlers. That is why he coined four special terminologies for four distinct climatic conditions. These four terms are always mentioned in the four corners of the climograph. These terms are raw, muggy, scorching and keen and are marked in South East, North East, North West and South West corners of a climograph respectively. Let us discuss each term along with its specified parameters like wet bulb temperature, measures in degree Fahrenheit (^{O}F), or degree Celsius (^{O}C), and relative humidity as well as the climatic conditions which it represents. These are as follows:

(i) **Raw**: Wet bulb temperature below 40^{O}F (4.4^{O}C), and relative humidity over 70 percent. Therefore, raw represents **cold and moist condition**.

(ii) **Muggy**: Wet bulb temperature over 60^{O}F (15.5^{O}C), and relative humidity over 70 percent. Therefore, muggy represents **hot and humid condition**.

(iii) **Scorching**: Wet bulb temperature over 60^{O}F (15.5^{O}C), and relative humidity below 40 percent. Therefore, scorching represents **hot and dry condition**.

(iv) **Keen**: Wet bulb temperature below 40^{O}F (4.4^{O}C), and relative humidity below 40 percent. Therefore, keen represents **cold and dry condition**.

Griffith Taylor has also constructed the scale of discomfort based on his experience gained from the plotting of climograph for different places across the globe.

Scale of Discomfort by Griffith Taylor

Griffith Taylor's Scale of Discomfort was divided into six categories. These are as follows:

1. 40^{O}F – 45^{O}F represents **very rarely uncomfortable.**
2. 45^{O}F – 55^{O}F represents **ideal condition.**
3. 55^{O}F – 60^{O}F represents **very rarely uncomfortable.**
4. 60^{O}F – 65^{O}F represents **sometimes uncomfortable.**
5. 65^{O}F – 70^{O}F represents **often uncomfortable.**
6. 70^{O}F – 75^{O}F represents **usually uncomfortable.**

The location of this twelve sided figure in the graph also gives us the idea about the climatic condition of that particular place. How is it possible? This is possible because each corner depicts a particular type of climatic condition. For example, if the climograph is located in the north western corner of a graph, it indicates hot and dry conditions. This also indicates that particular place is situated in arid or semi-arid areas.

Apart from the position of climograph, the shape of climograph is also helpful in identifying the nature of climate. Some of the prominent shape and its associated climate are given below.

(i) A spindle shaped climograph shows dry continental type of climate.

(ii) North East to South West diagonally oriented climograph represents monsoon type of climate.

(iii) North West to South East diagonally oriented climograph represents Mediterranean type of climate.

(iv) Climograph which is fully spread represents the British type of Climate.

Let us discuss methods of construction of climograph with the help of an example given below. You will also be provided with more exercises in the Practical Manual in integrated laboratory course, BGGCL 134.

Example 1: Draw a Climograph of Kolkata representing the below given data in table.

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Wet - Bulb Temp (in degree Fahren-heit	64.8	68.5	70.5	78.1	82.9	82.3	80.8	80.7	80.0	78.0	68.9	68.4
Relative Humidity (in percent)	40	44	38	38	57	69	81	79	75	72	48	48

Steps involved in the construction of Climograph are as follows:

(i) Draw X-axis and Y-axis on a graph sheet as OX and OY respectively. Mark Relative Humidity (RH), in the X-axis and Wet-Bulb Temperature in Y-axis. As you have already studied in the Course on Physical Geography, Wet-Bulb Temperature is either in Degree Celsius or Degree Fahrenheit (^oC or ^oF), and Relative Humidity is in percentage (%).

(ii) The Wet-Bulb Temperature is plotted in Y-axis, graduated from -10 ^oF to 90 ^oF while the relative humidity is plotted along the X-axis graduated from 20% to 100%. Do you know why this fixed value is taken into consideration? As mentioned earlier, in this graph, mean monthly values of Wet-Bulb Temperature are plotted against those of Relative Humidity on a fixed frame as devised by Taylor to show the physiological effects of climate on human beings.

(iii) To represent above said two climatic indicators in X-axis and Y-axis, we have to select a suitable scale. You have already learnt about different types of scales in Unit 3, Block 1 of this course. In this case, we have selected a scale of 1 CM = 10^0 F for Wet Bulb Temperature and 1CM = 10 % for Relative Humidity.

(iv) Once we selected the scale and mark the X-axis and Y-axis accordingly, try to plot 12 points which represents Relative Humidity and Wet-Bulb Temperature of 12 months of the year. How to do it? For example, to get the points for the month of January, you have to draw perpendiculars from 6.5 cm (64.8/10) and 4.0 (40/10), that represents Relative Humidity and Wet-Bulb Temperature for the month of January. The point of intersection of these perpendiculars will show the position of point representing the values of January month. Mark the letter 'J' at this point.

(v) In a similar manner, plot other points representing the remaining eleven months and mark their names in similar way as suggested in the previous paragraph. Each month is represented by a letter symbol. In this case, the symbols are generally represented by first letter of their names written in capital letters. For example, September would be represented by the letter 'S' whereas October would be represented by the letter 'O' and so on.

(vi) Join all the 12 points sequentially with the help of a scale and complete the 12 sided polygonal figure. When you will complete the exercise, your climograph would look like the diagram as given below (see Fig. 12.1). Write down the words 'Raw', 'Muggy', 'Scorching' and 'Keen' in four corners of the diagram as explained earlier.

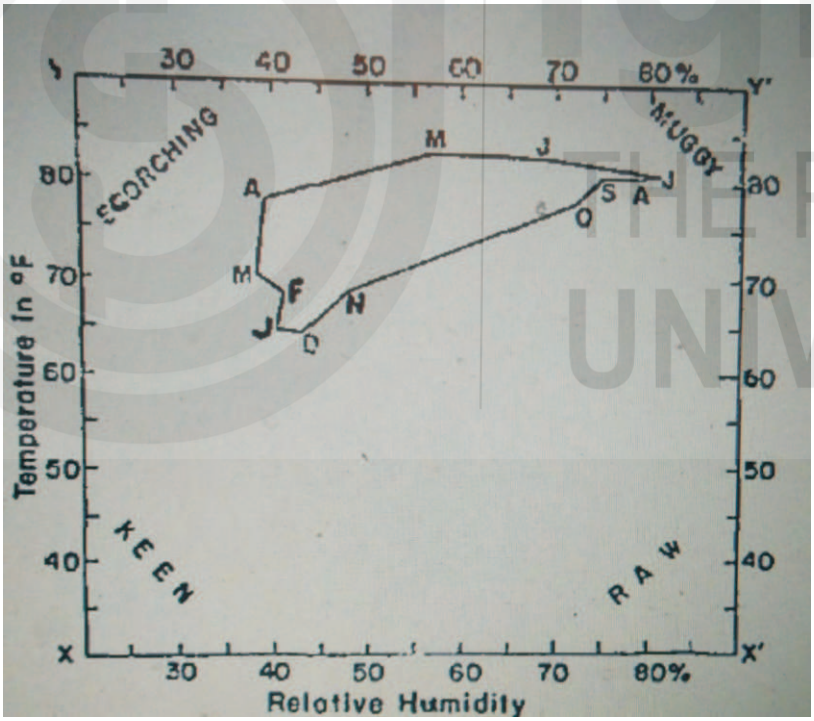


Fig. 12.1: Climograph of Kolkata.

12.3.2 Hythergraph

Hythergraph is another form of climatological diagram. This diagram was first devised by Griffith Taylor. Like climograph, hythergraph also represents climatic condition of a particular place. Then the question that automatically might be arising in your mind is that then why another diagram for the same purpose? As you know, climate of a particular place is determined by various weather elements like temperature, pressure and precipitation etc. In a two

dimensional diagram, we cannot plot more than two variables. Therefore, various climatic diagrams were developed by using combination of any two suitable variables.

The only difference between climograph and hythergraph is of the indicators. If you remember correctly, in climograph relative humidity is plotted in X axis whereas wet bulb temperature is plotted in Y axis. In the case of hythergraph, rainfall is plotted in X axis whereas temperature is plotted in Y axis. Therefore, **hythergraph** is also another twelve sided polygon that represents mean monthly temperature and rainfall of a particular selected station against one another. Secondly, unlike climograph, the propounder of this diagram did not coin any term for representing climatic conditions.

Construction of a hythergraph is similar to climograph. Let us understand the construction of a hythergraph by solving the below given exercise.

Example 2: Draw a Hythergraph of Delhi representing the below given data in table.

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Temperature (in Degree Celsius)	14	17	23	29	34	34	31	30	29	26	20	16
Rainfall (in mm)	25	22	17	7	8	65	211	173	150	31	1	5

Steps involved in the construction of Hythergraph are as follows:

(i) Draw X-axis and Y-axis on a graph paper as OX and OY respectively. Mark mean monthly rainfall on the X-axis and mean monthly temperature on the Y-axis.

(ii) To represent above said two climatic indicators in X-axis and Y-axis, we have to select a suitable scale. In this case, we have selected a scale of 1 CM = 3^0 C Temperature and 1CM =10 mm for rainfall.

(iii) Once we selected the scale and mark the X-axis and Y-axis accordingly, try to plot 12 points which represents mean monthly rainfall and mean monthly temperature of 12 months of the year. How to do it? For example, to get the points for the month of January, you have to draw perpendiculars from 4.7 (14/3), and 2.5 (25/10), that represents the values of temperature and rainfall for the month of January. The point of intersection of these perpendiculars will show the position of point representing the month of January. Mark the letter 'J' at this point.

(iv) In a similar manner, plot other points representing the remaining eleven months and mark their names in similar way as suggested in the previous paragraph. Each month is represented by a letter symbol. In this case, the symbols are generally represented by first letter of their names written in capital letters as you have done in climograph. Join all the 12 points sequentially with the help of a scale and complete the 12 sided polygonal figure. When you will complete the exercise, your

hythergraph would look like the diagram as given below (Fig. 12.2).

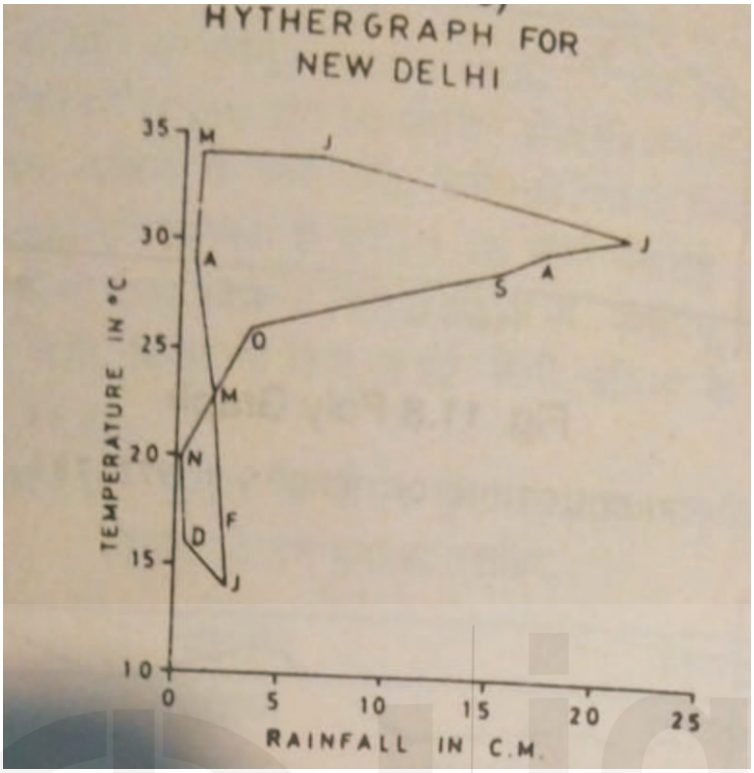


Fig. 12.2: Hythergraph of Delhi.

SAQ 2

Match the two columns.

Shape	**Climatic Condition**
A) Spindle	i) Monsoon
B) Diagonal (North East-South West)	ii) Continental
C) Fully Spread	iii) Mediterranean
D) Diagonal (North West-South East)	iv) British Type

12.3.3 Ergograph

The word ergo was derived from Greek word *erogon* which means work. There are certain economic activities that are performed during different periods of the year or in a particular season. Therefore, ergograph depicts economic activities performed during different seasons of the year along with area or production. This was developed by Arthur Geddes. This graph also contains associated weather phenomena that favour a particular type of economic activities. Till now, you might have realized that this diagram depicts multiple variables.

Let us explain this with an example. In India, crops are grown in different seasons and are known as *Rabi, Kharif and Zaid*. Rabi crops like wheat are grown in winter months, rice is mainly a kharif crop grown during the hot and wet seasons and crops like sugarcane requires ten months from sowing to

harvesting. When we prepare ergograph of a particular place, we represent weather along with the area utilized for growing crops. Mostly two to three elements of weather we depict are temperature, humidity and rainfall. This is because these two elements of weather have direct relationship with growing of crops.

In this diagram, we use combination of three types of statistical diagrams. Temperature and humidity are represented by line and rainfall is depicted through bar. The third dimension representing cultivated area is presented in the form of rectangular diagram.

However, Arthur Geddes and A. G. Oglive prepared circular ergograph to depict the continuous rhythm of activities performed in different seasons throughout the year. Here, we will construct an ergograph as suggested in the first case.

Let us understand the processes involved in the construction of ergograph through an example.

Example 3: Draw an Ergograph of Ambala representing the below given data in table.

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Temperature (in degree Celsius)	13	16	22	27	29	31	30	29	28	27	19	14
Rainfall (in mm)	29	57	7	10	12	58	297	296	195	11	6	8

Net Acreage of various Crops along with their growing season

Crops	Growing Season	Net Sown Area (in hectares)
Rice	May to October	1422
Wheat	November to April	2530.5
Cotton	June to December	668.5
Sugarcane	March to December	114.9

Steps involved in the construction of Hythergraph are as follows:

(i) Draw X-axis and Y-axis on a graph paper as OX and OY. In X-axis, we represent twelve months and in Y-axis we represent temperature and rainfall. Area covered under different crops will be shown through rectangular diagram and placed below the graph. We will discuss it in detail while discussing about its construction steps.

(ii) To represent above said two climatic indicators in X-axis and Y-axis, we have to select a suitable scale. In this case, we have selected a scale of 1 cm = 3^0 C temperature and 1cm = 20 mm for rainfall.

(iii) As temperature is a continuous data, it is represented through line diagram and rainfall is a discrete data, it is normally represented through bar diagram. Plot the points for temperature of each month after converting it according to scale. Once you mark the twelve points for the twelve months, join them with free hand and complete the line diagram.

Similarly, convert the data related to rainfall according to the scale and construct twelve bars representing twelve months of a year.

(iv) As mentioned above, area would be represented through rectangular diagram. The formula for calculating area is as follows:

Area = Length x Breadth

Like temperature and rainfall, we have to fix a scale for area of production. Let us assume 1 cm = 10,000 hectare.

By doing so, we will get the value for area to be represented in the graph. In our map, length is already derived. Can you identify how it is derived? It is very simple. If one month is shown by 1 cm, then six months would be shown by 6 cm, 10 months by 10 cm and so on. Once we obtain the value for area and length, we can easily calculate the breadth or width of a rectangle (Breadth=Area/Length).

(i) After obtaining all the values, we will construct rectangular diagram to represent the area. When you will complete the exercise, your ergograph would look like the diagram as given below (see Fig. 12.3).

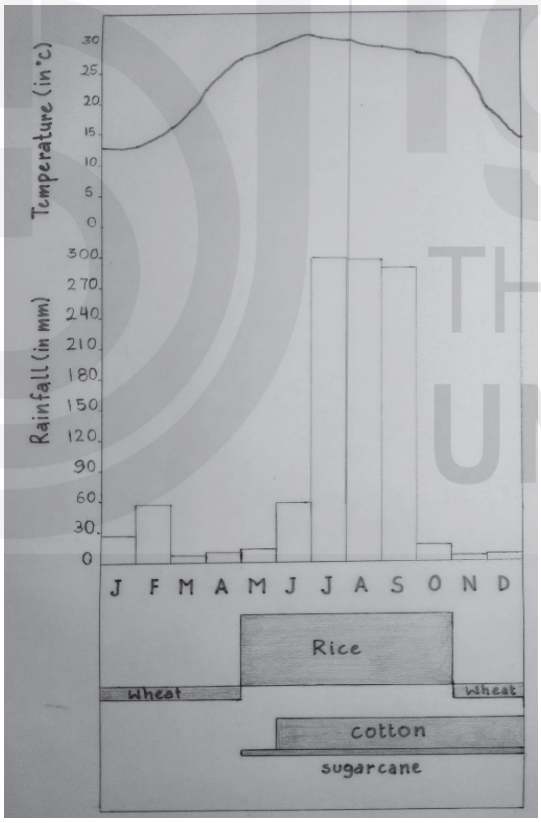


Fig. 12.3: Ergograph of Ambala.

12.3.4 Wind Rose or Star Diagram

This diagram is also known as star diagram or direction diagram. It's because this diagram looks like a star in which the light emanates from the centre to all the directions. As you know, there are sixteen directions – four cardinal or primary directions and twelve secondary directions. Therefore, in a wind rose, maximum sixteen lines can be drawn from the centre representing corresponding sixteen directions (see Fig. 12.4).

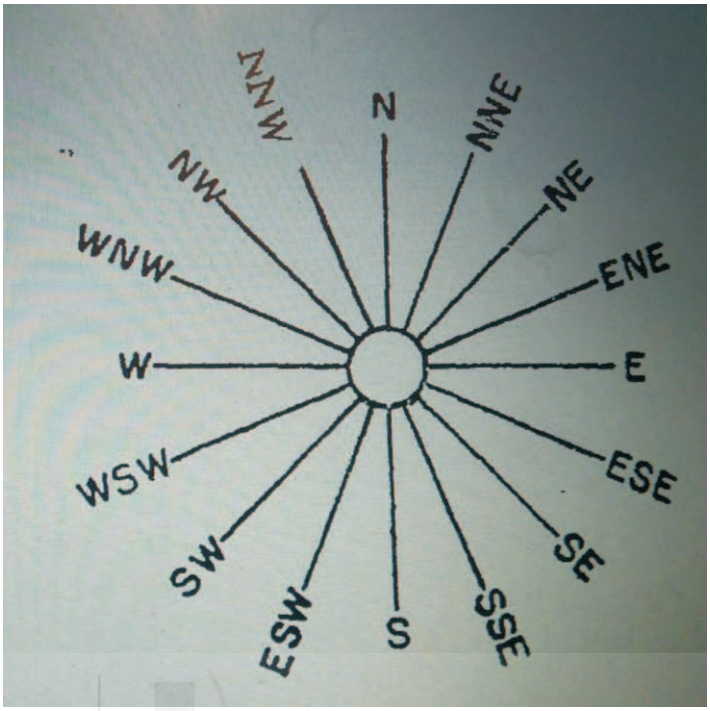


Fig. 12.4: Four cardinal and twelve secondary directions.

The length of each line would be proportionate to the quantity it represents. So, each ray will represent the number of hours or days, the wind blows from the corresponding direction in a particular period. But there are some hours or days (as the case may be), when the wind is calm. These calm periods are generally shown by drawing a small circle at the centre and writing the number within the circle. After all the lines are drawn, the end points of all the lines are joined. This closed diagram is known as star diagram.

Like other cases, let us understand the process of constructing wind rose through the below given exercise.

Example 4: Draw a Wind Rose of Bengaluru representing the below given data in table.

Wind Direction	North	North East	East	South East	South	West	South West	North West
No. of Days	14	25	64	14	13	109	37	24

Steps involved in the construction of Wind Rose are as follows:

1. Draw a small circle having radius of 1 cm. There is no strict rule for it. It can be little bigger also. The basic purpose of drawing the circle is to write the number of calm days inside the circle.

2. Draw a horizontal straight line that passes through the centre representing east-west direction. Similarly, draw a vertical straight line bisecting horizontal line which would represent north and south direction. Needless to say, that this vertical line will also pass through the centre. These two lines will represent four cardinal directions.

3. To find out the rest of four secondary directions i.e., north east, south

east, north west and south west, bisect all the cardinal directions associated with it. For example, to derive north east, bisect the area between north and east at 45 degree angle and draw the straight line. Derive rest of three secondary directions in a similar manner.

4. To decide the length of all the eight lines drawn, we have to choose a scale. In this exercise, let us assume 1 cm = 10 days. Accordingly, let us calculate length to represent wind flow in all directions. For example, the length for the north direction would be 1.4 cm whereas for east, it would be 6.4 cm. Calculate for the rest of the six directions accordingly.

5. Once we draw the eight lines according to the scale, join the tip of each line by drawing straight lines with the help of a scale and complete the diagram. When you will complete the exercise, your diagram would look like the diagram as given below (see Fig. 12.5).

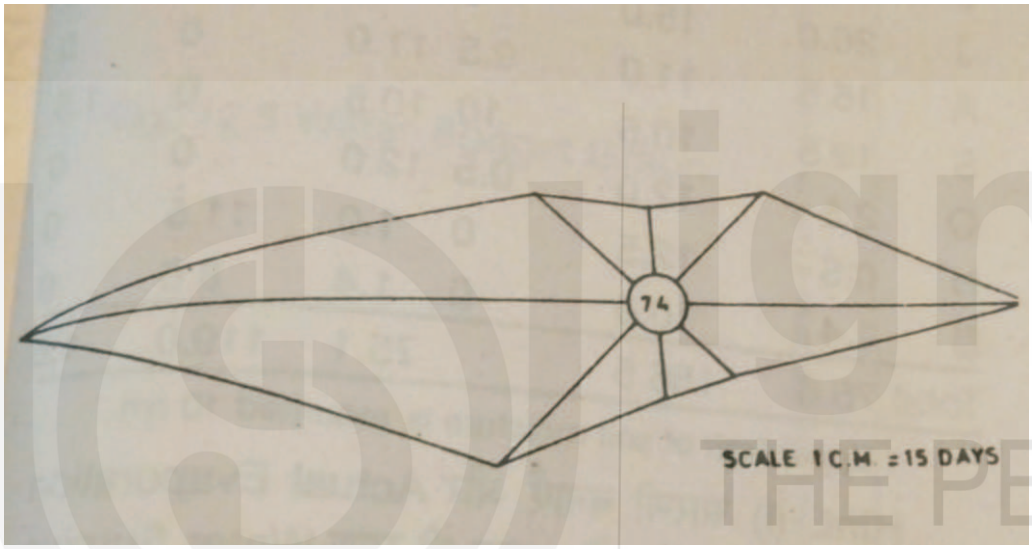


Fig. 12.5: Wind rose diagram of Bengaluru.

SAQ 3

Which of the following statements are true and which are false.

(i) Ergograph was developed for the first time by Griffith Taylor.

(ii) The word ergo was derived from Greek word *erogon* which means work.

(iii) In a wind rose, maximum twelve lines can be drawn from the centre representing corresponding four cardinal and eight secondary directions.

(iv) In wind rose diagram, calm period is generally shown by drawing a small circle at the centre and writing the number within the circle.

12.4 SUMMARY

In this unit, you have studied so far:

- Climatic elements namely temperature, pressure, humidity, precipitation etc. are represented through maps and diagrams. Some of the methods used for representation of climatic data are wind rose, star diagram, climograph, hythergraph and ergograph.

- Climograph or climogram is a twelve sided polygon that represents selected two climatic elements of a particular place against one another. This twelve sided polygon or climograph was constructed by taking wet bulb temperature and relative humidity as indicators for representing climatic condition of a place.
- This was first conceived by Ball in 1910 and later improved by Leighly (1926), USDA (1941), and Taylor (1949). This diagram was also extensively used by Koeppen to summarize variations in world climatic conditions.
- Hythergraph is another form of climatological diagram. This diagram was first devised by Griffith Taylor. Like climograph, hythergraph also represent climatic condition of a particular place. Hythergraph is also another twelve sided polygon that represents mean monthly temperature and rainfall of a particular station against one another.
- The word ergo was derived from Greek word *erogon* which means work. Therefore, ergograph depicts economic activities performed during different parts of the year along with area or production. This was developed by Arthur Geddes. Arthur Geddes and Oglive prepared circular ergograph to depict the continuous rhythm of activities performed in different seasons throughout the year.
- Wind rose is also known as star diagram or direction diagram. It's because this diagram looks like a star in which the light emanates from the centre to all the directions. Each ray will represent the number of hours or days, the wind blows from the corresponding direction in a particular period.

12.5 TERMINAL QUESTIONS

1. What is a Climograph? Who used climographs scientifically to divide the world into climatic regions? Describe the 'Scale of Discomfort' developed by Griffith Taylor.
2. Who was the founder of hythergraph? What are the similarities and dissimilarities between hythergraph and climograph?
3. What is an ergograph? Describe the purpose of an ergograph.
4. What is a wind rose? What is the significance of each "spoke" in the wind rose? How do we represent calm days in wind rose?

12.6 ANSWERS

Self Assessment Questions (SAQ)

1. (i) Satellite image, diagrams

   (ii) Automated weather station

   (i) Effective, easily understandable

2. A - ii; B - i, C - iv; D - iii

3. (i) False

   (ii) True

   (iii) False

   (iv) True

Terminal Questions

1. Your answer should include all the key points like meaning and terminologies with reference to Climograph systematically as explained in the Section 12.3.1.

2. In order to answer this question, you should highlight the key differences between the two by referring to the Section 12.3.2.

3. Your answer should briefly describe the ergograph and highlight its main purpose. Refer to the Section 12.3.3.

4. Your answer should briefly incorporate the meaning, significance and highlight the importance of calm days in a wind rose diagram. Refer to the Section 12.3.4.

12.7 REFERENCES/SUGGESTED FURTHER READING

- Khullar, D.R. (2003), *Essentials of Practical Geography.* Jalandhar: New Academic Publishing Co.
- Mishra, R. P. and Ramesh, A. (1989). *Fundamentals of Cartography.* New Delhi. Concept Publishing Company.
- Robinson, Arthur, H.J., Morrison, P., Muehrke, A., Kimmerling & Guptill, S. (eds.) (1995). *Elements of Cartography.* New York: Wiley.
- Sarkar, A. (2009). *Practical Geography: A Systematic Approach.* Kolkata. Orient Blackswan Private Limited.
- Singh, L.R. and Singh, R. (1973). *Map Work and Practical Geography.* Allahabad: Central Book Depot.
- Singh R. L. and Singh, R. P. B. (1991). *Elements of Practical Geography.* Ludhiana. Kalyani Publishers.

UNIT 13

WEATHER MAPS

Structure

13.1 INTRODUCTION

You have studied and learnt in the previous Units 11 and 12 of this Block about the topographical maps and representation of climatic data with the help of diagrams respectively. In this unit, you will learn about the multifarious elements of weather portrayed in a map, interpretation procedures of weather maps and iso-lines, seasonal characteristics of Indian weather and a brief on

weather forecasting etc. As a whole, you will learn the nitty-gritty of how and why the weather maps and its interpretation is relevant to the human society in general and for specific purposes spanning navigational (both sea and air), academic, agricultural and scientific pursuits to indicate few prominent fields in particular etc. Besides determining and shaping our habits, concepts and perceptions, weather also affects our work culture, health and well-being. There are two fatal health risks, which may put the life of a human being into danger during extreme cold and hot weather conditions (if not well aware about such health risks). These two are hypothermia (when temperature drops below a body's core threshold value for normal functioning), and hyperthermia (when temperature rises above a body's core threshold value for normal functioning), with which most of you may be already familiar. Broadly on a large scale, weather affects the entire gamut of health, prosperity and economy of a nation. We hope that all of you must be familiar with the popular adage which says that the success and failure of Indian agriculture depend upon the vagaries of nature i.e., on monsoonal rain.

You might get curious and many questions may sneak into your mind to understand as what weather map is like, what does it tells us, how it is read and its importance etc. Besides, some more questions like what are the weather elements and the set of mechanisms which makes the process of weather happen etc. may confront you. To deal with such important questions, we have dealt with this unit on weather maps divided into several sections. To begin with, Section 13.2 deals with the elements of weather with an aim to provide you the nuanced understanding of the same. You will be learning the way weather experts and meteorologists do deal with to interpret such simple to complex natural atmospheric events classified broadly into six major weather and climatic elements with the help of internationally devised weather code systems in last Section 13.3. You all are well familiar with the different weather seasons and their characteristic features in general. The prominent scientific Government agency named 'Indian Meteorological Department' (IMD), which deals with the science of weather and meteorology has characteristically divided the Indian weather system into four distinct seasons. To read this information, you have to study the Section 13.4. Last Section 13.5 will briefly focus onto the broad aspects of weather forecasting. All of you are familiar that weather also acts as easily ready subject to begin a conversation with our known as well as unknown accomplices. But, it is far from an easy subject. Weather is driven by the energy of giant Sun and oceans which is linked with the diverse ecosystems, characterised by simple to complex processes on the planet Earth.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- define the various elements of weather and climate on a given map;
- examine and comprehend the meaning of various coded symbols to describe the elements of weather and climate on a given map;
- demonstrate the step-wise interpretation procedures of weather maps and iso-lines on a given weather map;

- classify the seasonal character of Indian weather and illustrate the main characteristic weather features along with spatial variations therein; and
- broadly describe the few leading features of weather forecasting.

13.2 REPRESENTATION OF WEATHER ELEMENTS

Knowledge and study of weather has always been a matter of interest to one and all since time immemorial. Besides influencing the day-to-day life, it also affects the agriculture and its allied activities, perception and work culture, intellect and efficiency etc., of the human beings across the geographical regions. These factors together shape the attitude, behaviour and capabilities of human beings to do the same tasks in a different manner across the human societies on the planet Earth with which you are already familiar. Weather is the average condition of atmosphere at any given place and point of time over the part of or entire earth's surface. The climate is the sum total of weather conditions over a long period of time, normally more than three decades. Weather and climate are together characterized and determined mainly by six parameters such as namely temperature, pressure, wind, sunshine, cloudiness and precipitation. These climatic parameters can be further sub-divided into several sub-types. For example, precipitation may be classified as drizzle, rain, hailstorm and snow etc. We trust that many of you are quite familiar with these parameters along with their role and importance.

Weather components are dealt with lot of scientific and technological inputs. ***Meteorology*** is the science which studies all the weather parameters in detail. In earlier times (before 1980s), the weather predictions were based on either personal observations or irregular data inputs. The term 'Meteorology' was coined by the renowned philosopher Aristotle approximately 350 B.C taken from the Greek word 'meteoros' which mean 'high in the sky'. You may know that many ancient civilizations knew about the importance of Sun to nurture good yield of food crops. That's why they might have worshiped the Sun as God for good rainfall. In our Indian civilization, we worship the God of rain 'Indra' for seeking the blessings of good rainfall is well known. But, since last couple of decades, rapid progress has been made in the field of meteorology with the help of advanced instruments and accurate satellite data inputs. It has been made possible through satellite imageries such as dedicated Indian satellite systems like Meteorosat. Such type of satellites is meant for continuous weather monitoring and for relaying the timely cyclone warning predictions. Predictions based on the satellite information could be useful to the vulnerable sections of populace living in and around coastal regions. These modern advancements have enabled the precise weather predictions on hourly, daily, weekly, monthly and seasonal basis. Such accurate and timely weather predictions may immensely help in the decision-making process of varied stakeholders including scientists, administrators and policy makers, farmers, businessmen and others alike.

In India, initially, the Department of Meteorology was established at Shimla in 1864. Later on, after First World War (1914-18), it was shifted to Pune and thereafter at Calcutta corresponding with the subsequent expansions. Now, the headquarter of this department is located at National Capital Region, New

Delhi. There are 36 meteorological observatory sub-divisions covering around 350 weather stations spread across the length and breadth of the country as shown in Fig. 13.1. These stations belong to five different categories of observation as shown in Table 13.1. There are several components of weather that are either individually or collectively displayed on a map through internationally standardised coded symbols. We have tried to briefly cover the essential characteristics of these components within the scope of this unit.

Table 13.1: Type and frequency of observation and transmission of weather data.

Category of Observatory	Type of Instruments used for Observation	Frequency of Message Transmission
First	Eye-reading and self-recording	Two times in a day
Second	Eye reading only	Two time in a day
Third	Eye reading only	Once in a day
Fourth	Collection of Rainfall and Temperature Data	Not daily
Fifth	Collection of Rainfall Data only	At 8 hours local time during past 24 hours

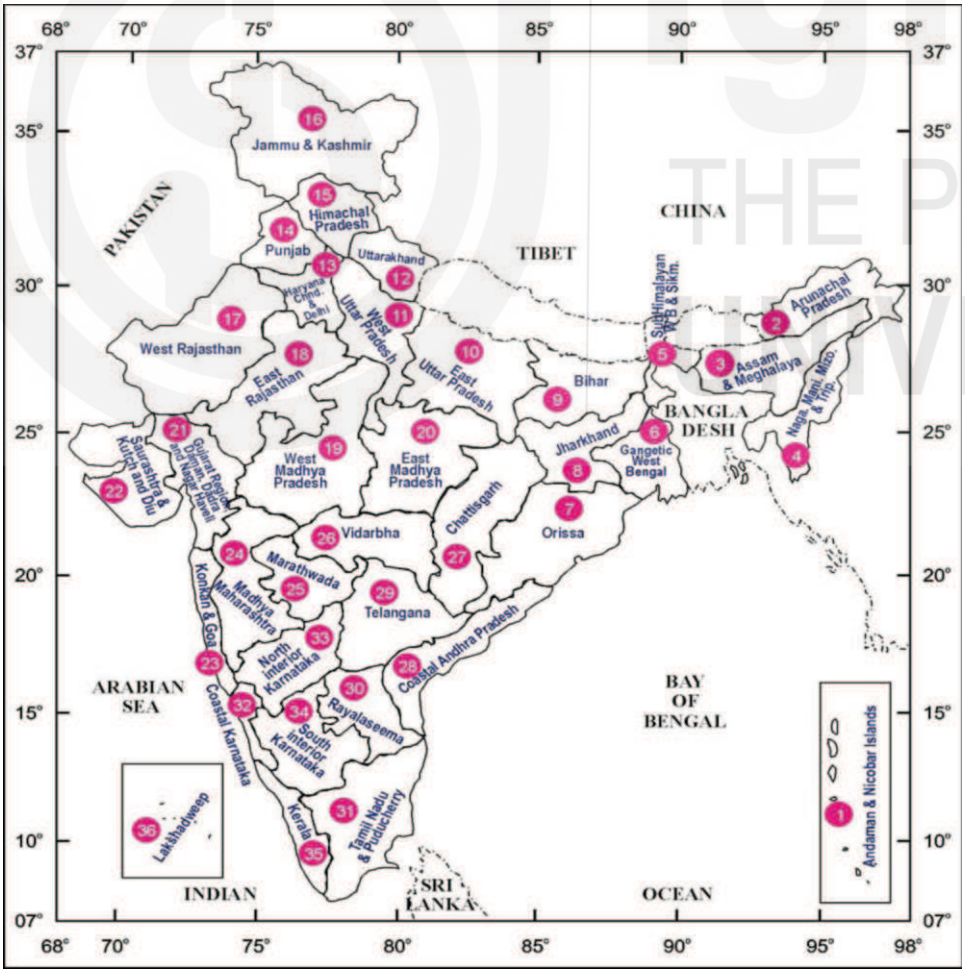


Fig. 13.1: Map showing the location of subdivision-wise meteorological observatory stations in India.

(Source: Forecasters' Guide, Indian Meteorological Department (IMD), Pune, 2008)

13.2.1 Atmospheric Pressure

You are already familiar with this element as like many other elements which you might have studied in your senior secondary classes. You know that it refers to the total weight of a unit column of air at any given place. An instrument called **'barometer'** or **'barograph'** is employed to measure this column of air. It could be a mercury type, fortin's or aneroid barometer as depicted in Fig. 13.2 (a, b and c). The unit of expression could be in milibars, millimetres, centimetres or in inches etc., of mercury column. One milibar equals 1000 dynes per square centimetre. 1000 milibar of pressure is called 1 bar. Atmospheric pressure is depicted by an imaginary line known as **'isobar'** that joins the places having equal magnitude of surface air pressure. Pressure condition of a given geographical region is represented by the pattern, spacing and given values of an isopleths or isobars as shown in Fig. 13.3.

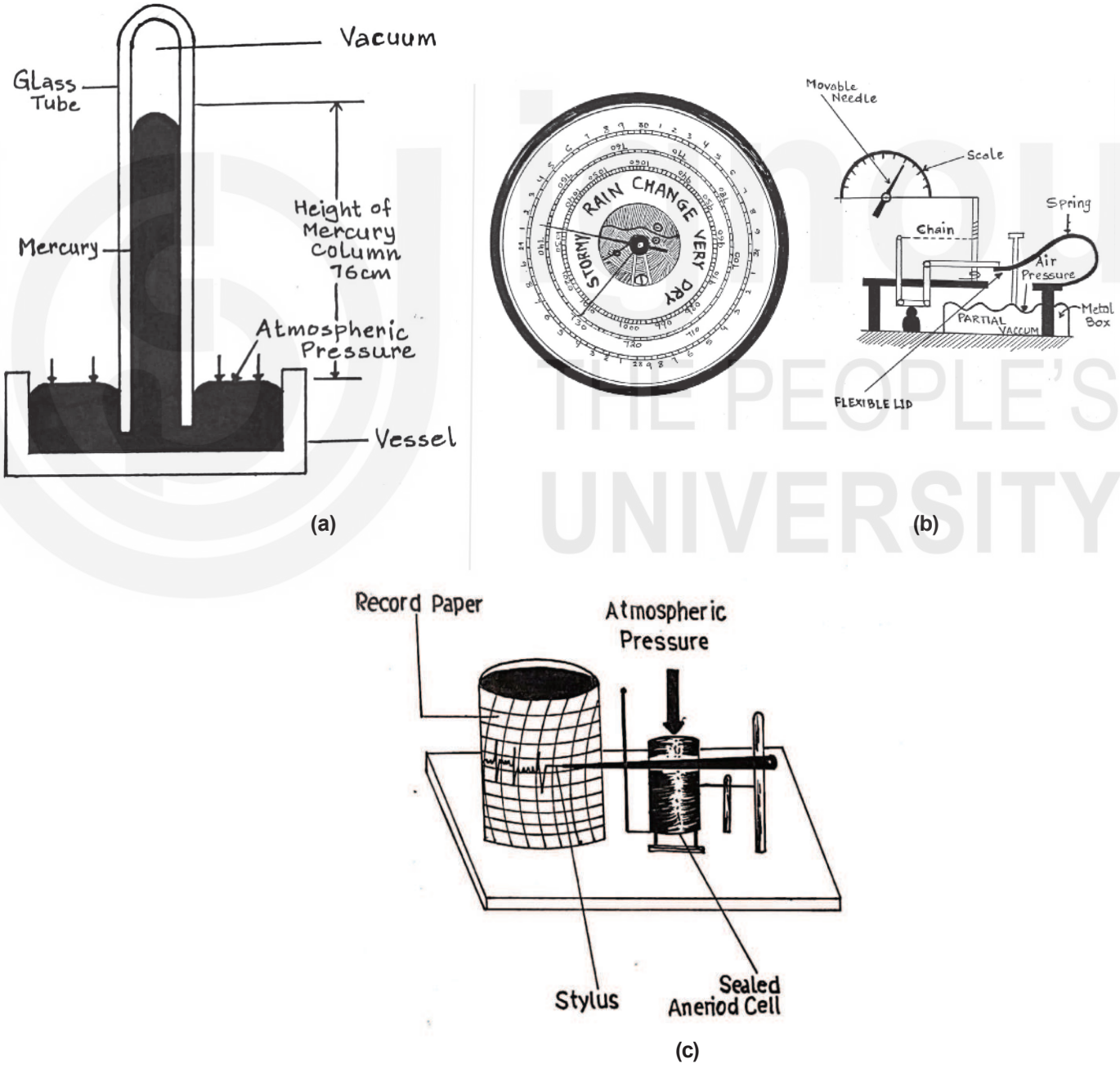


Fig. 13.2: An atmospheric pressure can be measured by a) Mercury barometer b) Aneroid barometer and c) Barograph.

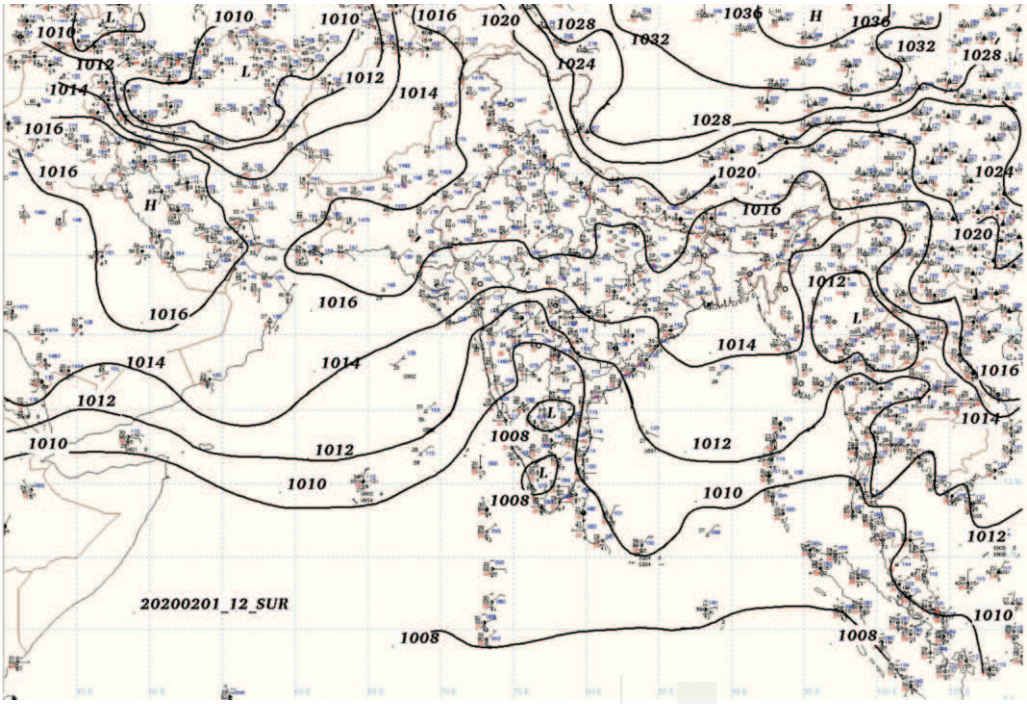


Fig. 13.3: Surface weather chart showing atmospheric pressure conditions of Indian subcontinent (February 2020, season of cold weather).
(Source: IMD, Pune, India)

13.2.2 Wind Systems

Planet earth experiences a horizontal motion of air known as 'wind'. Wind is characterised by two main properties of direction and velocity. The instrument which measures the direction is called **'wind vane'** whereas **'anemometer'** measures the velocity of wind as shown in Fig. 13.4 (a and b). It is indicated by a symbol i.e., arrow on a map showing the direction and a symbol representing the feathers that signifies the wind velocity. The observations or data inputs are obtained from 30 feet or 10 metres (equal to 1000 centimetres or 10 metres) above the earth's surface in order to construct and display it on weather maps.

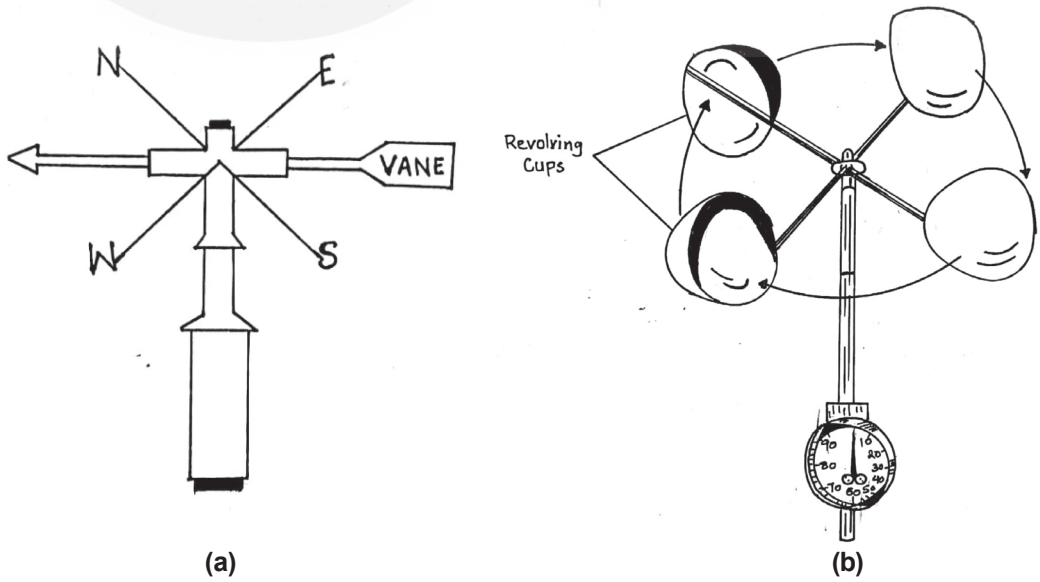


Fig. 13.4: (a) Wind vane shows wind direction and b) Anemometer measures the wind velocity.

13.2.3 Temperature

In the scientific subject of meteorology, the real air temperature is measured with the help of an instrument. You all are well familiar with this known as **'thermometer'** which is generally kept under shelter. It is called Stevenson's screen used to protect thermometer from direct sunlight or the sunlight which escapes back to the extra-terrestrial surface after reaching the earth's surface. You can easily surmise that the purpose behind such practice is to protect the instrument from the influence of both direct and indirect heat of sunlight which may otherwise lead to a substantial increase in the temperature values. You are also well familiar about two most common types of scale of measurement i.e., 'Celsius or Centigrade Thermometer' (ºC); and 'Fahrenheit Thermometer' (º F), as shown in Fig. 13.5 (a). Besides these, two more types are 'Absolute Thermometer' (employed for scientific purposes) and 'Reumer Thermometer' (employed for general purposes). The continuous (24 hours) readings of temperature values are also recorded in a mounted paper on a thermograph. All the above four types of thermometers are based on the conversion values as under:

$$\frac{º\,F - 32}{180} = \frac{ºC}{100} = \frac{ºR}{180} \qquad \text{and } ºC = A - 273$$

Then, there are 'Wet-bulb Thermometer' and 'Dry-bulb Thermometer' used to measure the level of humidity of a parcel of air in the atmosphere (Fig. 13.5 b). In the former type, the bulb is provided with a moist condition with the help of a part of muslin and taper generally kept dipped into a pure water container. The temperature values start decreasing the moment, when a parcel of dry air comes into contact with the wet bulb whereby its energy makes possible the water to evaporate. In the later type, i.e., dry bulb which remain open and hence unprotected to the parcel of air in the atmosphere. As such, the amount of water vapour present in a parcel of air doesn't affect the values of temperature readings. It generally remains greater than the readings as

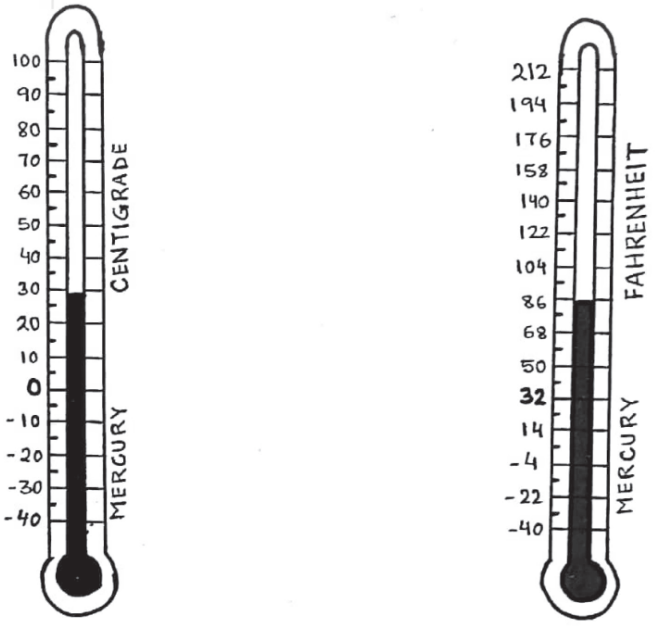


Fig. 13.5 (a): Centigrade (left side) and Fahrenheit (right side) thermometers to measure the values of temperature.

recorded in the former type. Besides the above-mentioned types, to record maximum and minimum values of temperature during the last 24 hours, such values are recorded with the help of maximum and minimum thermometers. These instruments record the daily range of temperature values for a specified place on the earth's surface.

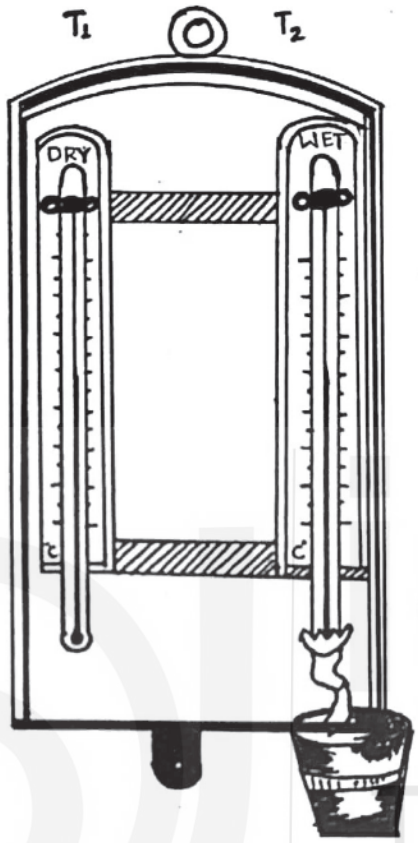


Fig. 13.5 (b): Wet bulb (right side) and dry bulb (left side) thermometers to measure the values of temperature.

13.2.4 Isobaric Systems

As you know that isobar is a line that connects the various points or places on a given map having same values of any geographical element with point data. In this unit, we are dealing with the weather and climatic elements, hence isobaric systems refer to the equal values of atmospheric pressure which is generally reduced to its sea level equal values. In weather maps, these are used with the help of various weather symbols and codes to depict the particular state of weather, climate and atmospheric conditions. We are discussing few important ones here for you to enable the reading of these on a given weather map or a synoptic chart as under:

i) Cyclonic Low or Depression

You are aware of the cyclones which invariably hits the coastal areas of our country and rest of the world every year during particular part of a year or a weather season. These are the areas characterised by low pressure located at the centre as depicted in idealised condition of the same in Fig. 13.6. You may recall this as learnt in a Block on climatology in your first semester course. We will once again discuss here as winds blow in an anti-clock

direction in the northern hemisphere whereas clock-wise in that of the southern hemisphere. This leads to the development of a depression covering an area as big as few hundreds of kilometres in diameter even in a shallow or small level depressions. The size and shape of an isobar depends on its latitudinal location. A cyclone that develops in mid-latitudes is known as temperate cyclone whereas when they develop in tropical latitudes or regions are known as **tropical cyclones**.

First one is characterised by elliptical shape isobars whereas the second type by circle shaped isobars. Tropical cyclones are relatively small in size but very intense and temperate cyclones are exactly opposite. Another feature of both the types are their wind speed. Tropical cyclone has faster wind speed but less marked temperature variations and temperate cyclones have slower wind speed but characterised by frequent and marked changes in the temperature values.

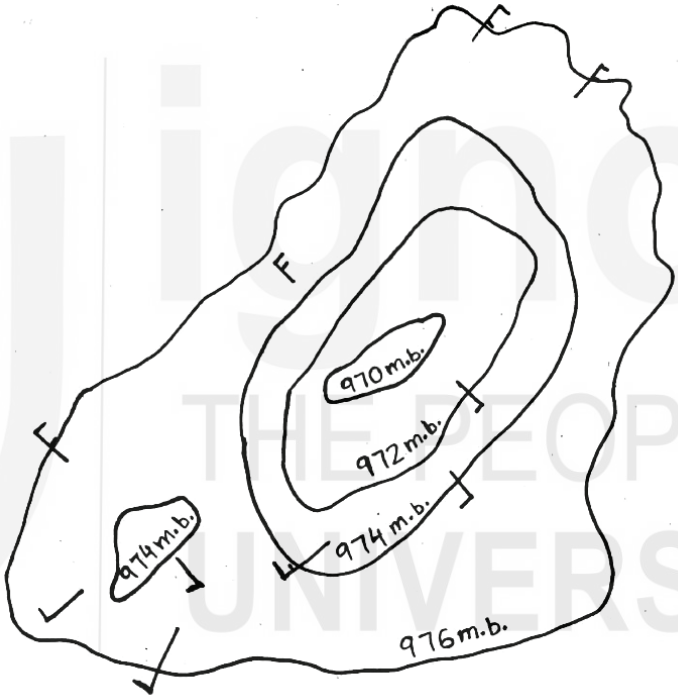


Fig. 13.6: Schematic diagram representing the cyclonic depression.

Cyclones convey a stormy weather conditions characterized with cloudy sky, immense amount of rainfall and changes in temperature values. Usually, the cloud cover is in sequence of high altitude clouds of cirrus and cirrostratus followed by medium altitude cloud of alto-stratus etc. However, the moment when a warm front knocks a cyclone, it starts raising the temperature, winds start deviating in a clock-wise direction and pressure also starts dropping considerably. This condition brings a state of normalcy whereby intense rain turns into a form of drizzle. In case of an air parcel or atmospheric pressure associated with cold front, temperature drops, winds deviate and still prevailing stormy conditions may result into downpouring accompanied by hail or a thunderstorm. The moment cold front starts waning; it may bring down the temperature followed by sporadic amount of rainfall.

ii) V-Shape Depression or Trough

This is a classic case associated with cyclonic depression whereby an isobar attains the V shape as like that of 23rd Capital letter of English alphabet. Mostly, trough or a V shape depression is usually characterised by more sudden changes in weather conditions which in turn depends on the type of an associated front (warm or cold).

iii) Secondary Depressions

These are attached with a main or a primary cyclone in the form of a simple bend or a semi-closed system of loops (schematically shown in Fig. 13.7). Its path follows the anti-clockwise direction in continuity with the primary cyclone. However, secondary depressions are characterised by their own wind system. Weather conditions are also in continuity to primary cyclone except frequent variations within these.

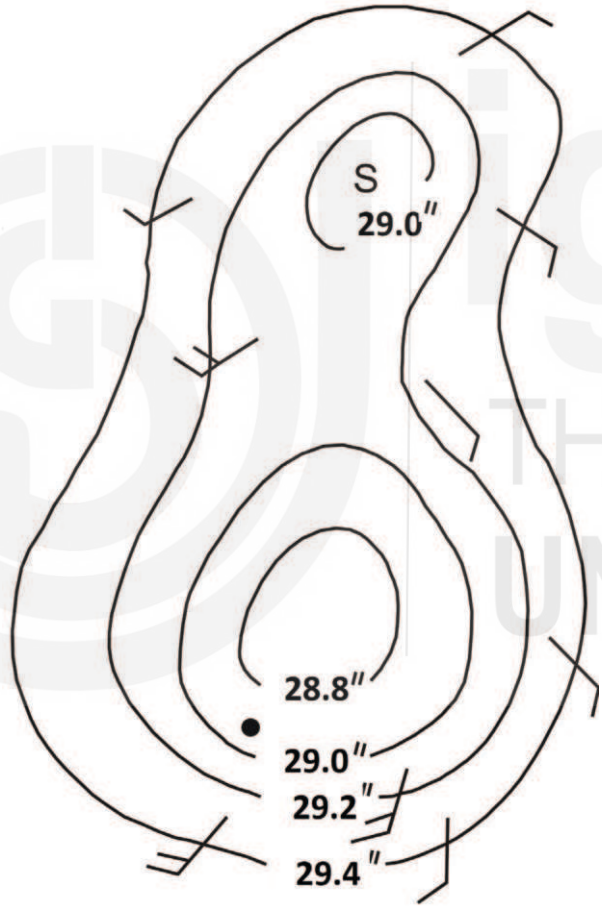


Fig. 13.7: Schematic diagram representing the secondary depressions.

iv) High or Anti-Cyclone

This case is opposite to that of cyclonic low or depression in which the high pressure is located at the centre. High or anti-cyclone is characterised by the divergent winds which moves in a clock-wise direction in the northern hemisphere. The shape of isobar is either circular or elliptical which may cover a larger area. As opposed to lows, the wind movement may remain sluggish to herald a calm weather condition. It can be noticed in a form of widely spaced

isobars which indicates the onset of a fair weather conditions except the intermittent incidence of drizzle dropping onto the earth's surface. You may be wondering how and why such weather incidence takes place or comes into motion. It happens owing to the inversion of temperature values above the surface which hampers the blending of water droplets on the air which would have otherwise brought a spell of rainfall.

v) Ridge

It is also known as wedge. You may notice from the below depicted schematic Fig. 13.8 that a ridge or a wedge projects out in the form of a tongue like that of a domesticated animals. It takes place from that of a region of high pressure into a region of low pressure zone. It is characterised with a V shaped isobar and are normally accompanied with fine weather conditions.

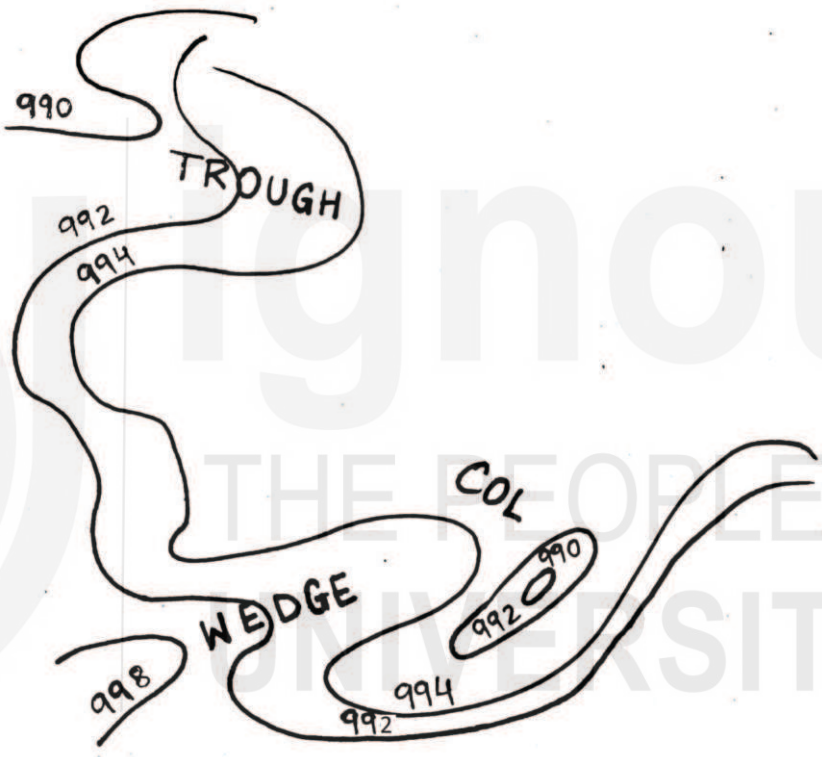


Fig 13.8: Schematic diagram representing a) ridge and b) col.

vi) Col

Col is nothing but marks a transitional zone located between two high and two low successive pressure regions in an isobar (refer above Fig. 13.8). They have the prevalence of characteristic weather features evident with calm weather conditions during winter season whereas stormy and thunderous weather conditions during summer season.

13.2.5 Humidity

You may have noticed that all of us quite frequently make use of the term humidity. Usually, when we say, today it is very humid. It signifies the level of discomfort particularly during the mid-months of hot and humid rainy or southwest monsoon season (particularly in land-locked plains and desert

regions), of our country, India. Humidity signifies the prevailing atmospheric conditions with respect to the amount of water vapour present in a parcel of air. Characteristically, the capacity of a parcel of air to hold the amount of water vapour invariably depends on the values of temperature. In simple words, that means the warmer air has the property to hold more amount of water as compared to the cool air. The term vapour capacity is used to refer when a parcel of air can hold maximum amount of water vapour at a given temperature. Normally, a parcel of warm air is considered as saturated at a temperature beyond which it can no longer hold any more moisture content. Humidity is expressed in grams per cubic feet or in grams per cubic metre.

For example, a parcel of air is considered as saturated, if it contains 8.0 grams of water vapour per cubic feet at a temperature value of 70 degree Fahrenheit. There are two terms frequently used to signify the different amount of humidity as a given parcel of air does not always gets fully saturated. These two are known as absolute and relative humidity and are always expressed in percentage. Absolute humidity refers to a condition when a parcel of air is not always saturated in terms of amount of water vapour and the actual amount of water vapour which it holds at a given temperature. Relative humidity refers to the ratio between the actual amount of moisture present in the air and that which would have been present if the air gets saturated at the same temperature. There is a formula to calculate the relative humidity as given under:

$$= \frac{\text{Actual amount of water vapour present per cubic foot} \times 100}{\text{Maximum amount of water vapour which a parcel of air can hold per cubic foot at given temperature}}$$

Suppose, a parcel of air is capable of holding 6 grams of water vapour at 70 degree Fahrenheit, then the relative humidity would be:

$$= \frac{6 \times 100}{8} = 75 \text{ percent}$$

13.2.6 Visibility

You may guess the meaning of this term immediately after reading it. It refers to the condition of atmosphere as how transparent it is especially during the overcast sky and ground conditions. It is measured in terms of distance from where certain physical as well as man-made objects can be easily seen and identified. Visibility is measured on a scale of 0 to 9 as shown in Table 13.2. The lowest scale of zero refers to an atmospheric condition when we cannot see the things and objects immediately beyond a distance of 25 metres. The highest scale signifies a condition when we can easily see the objects from a distance of 50,000 mts. (or 50 kms). The meteorological departments of different countries make use of such scale of visibility with minor changes especially based on the values set by the World Meteorological Organisation (WMO), located at Geneva, Switzerland.

Table 13.2: Scale depicting the element of visibility.

Scale	Associated Weather Phenomena	Visibility Distance (in mts.)
0	Dense fog	25
1	Thick fog	100
2	Fog	200
3	Moderate fog	500
4	Mist/Haze	1,000
5	Poor Visibility	2,000
6	Moderate Visibility	7,000
7	Good Visibility	10,000
8	Very Good Visibility	30,000
9	Excellent Visibility	50,000

13.2.7 Cloud Cover

Basically, cloud cover denotes the amount of sky partially or completely enclosed by various kinds of clouds at a particular time and place. It has arbitrarily been divided into four equal pieces and each piece is further sub-divided into two equal pieces for observational purposes. In order to infer the cloud cover, one-tenth part of the sky is generally taken from 0 to 10. If, it is zero, it denotes completely cloud free sky, if it is 5, then it indicates $5/10^{th}$ of the sky covered with clouds. It is then observed and documented as minute circles portraying varying proportions of the cloud cover with the help of conventional cartographic symbols as you can see in Fig. 13.9. We will briefly discuss ten main forms of clouds as categorised under three major types by the World Meteorological Organisation (WMO). These are discussed as below:

1. **High Clouds (extend between 25,000 to 35,000 feet):** Under this category, there are three main types of clouds. These are Cirrus denoted by letters Ci, Cirrostratus by Cist. and Cirrocumulus by Cicu.

   - **Cirrus** (Ci.) It appears like a feather in detached form having silky appearance and is white in colour during the partially overcast sky conditions.
   - **Cirrostratus (Cist.):** It covers the sky like a thin whitish blanket and is a special category of clouds as it is responsible for producing the characteristic feature which is known to us as 'halo of the Sun as well as Moon'.
   - **Cirrocumulus (Cicu.):** It appears in the form of minute circular masses organized either in small-small groups or lines. You can compare it with that of sand ripples which appears in the seashore areas.

2. **Medium Clouds (extend between 10,000 to 25,000 feet):**

   In this category, two types of clouds namely 'Altocumulus' denoted by letters Acu. and 'Altostratus' by Ast. comes under this second class.

Altocumulus: It appears either in flat circular layers or in patches during the overcast sky organized into groups, lines or waves etc.

Altostratus: It is quite similar to Cirrostratus cloud of high clouds category. However, it appears either striated or fibrous devoid of halo effects of Sun or Moon as like Cirrostratus.

3. Low Clouds (extend from ground surface up to 10,000 feet)

This category has the maximum number of five clouds. These are known as Stratocumulus denoted by letters Stcu., Nimbostratus by Nbst., Cumulus by Cu., Cumulonimbus by Cunb. and Stratus by St.

Stratocumulus: You can observe such cloud appearing as a roll of huge circular dark clouds during overcast sky. Such cloud seems to be organized into clusters, streaks and waves etc. Many a times, these clusters may join together from edges and may extend or cover the entire sky.

Nimbostratus: It is characterised as a low height shapeless cloud and is dark grey in colour which may uniformly cover the sky. It is rain yielding cloud.

Cumulus: It is a thick cloud characterised by dome like shape in upper surface with a horizontal base.

Cumulonimbus: This is popularly known as the 'storm of thunder clouds' characterised with flat base which generally brings rain or snow depending upon the type of climate where it falls. The upper surface of this cloud type exhibits greater vertical development with cumuliform like pinnacles which ascend in the form of mountain ridges or high rising building towers etc.

Stratus: It forms as a result of condensation of fog that gets lifted with rising temperature of the air. Stratus acquires the lowest height among all cloud types and appears in the forms of horizontal sheets or layers of uniform clouds.

Table 13.3: Conventional symbols for cloud cover and rainfall.

Amount of Sky Coverage	Type of Clouds	
	Low and Medium Altitude	High Altitude
1/8		
1/4		
3/8		
1/2		
5/8		
3/4		
7/8		
Overcast Sky		
Obscured Sky		
Symbol for Rainfall in Cms. — = 0.25 to 0.74 | = 0.75 to 1.49		

All of these are visible during the different phase of overcast weather conditions. Next time, whenever you happen to see such types of clouds, you can observe these carefully and may like to identify the various types of clouds on the basis of their characteristic features and decipher the probability and potential of impending weather conditions fairly.

13.2.8 Precipitation

Precipitation or rainfall constitutes a part of entire water or hydrological cycle. An instrument named **'rain gauge'** is used to record the rainfall in metric units i.e., either in millimetres, centimetres or inches. It is recorded for the entire length of day and night i.e., 24 hours. Rainfall occurs from the overcast sky into the atmosphere whenever substantial rain giving cloud cover develops e.g., nimbus clouds. You can see the rain gauge as shown in Fig. 13.9.

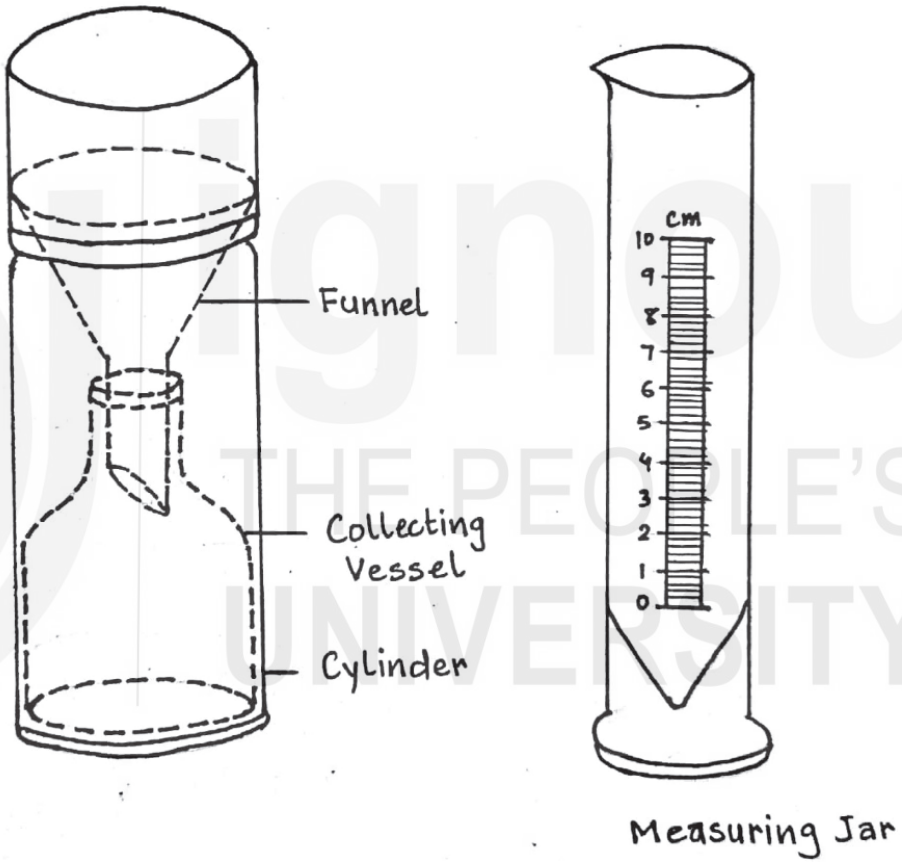


Fig. 13.9: A schematic diagram representing a rain gauge used to record rainfall.

13.2.9 Atmospheric Attributes

There are several types of atmospheric attributes. Most important ones are haze, mist, fog, dew, frost, drizzle, hailstones, snow, dust storm and cyclonic depressions etc. These are represented by the standardized and internationally accepted cartographic symbols adopted by the *'International Meteorological Organisation '*(IMO), Warsaw, Poland. All of these phenomenon's are associated with the different weather conditions that occur during different seasons of the year across geographical regions. These are shown in Table 13.5 in the next section.

Fog: It is a phenomenon in which small water droplets remain suspended in the air. It reduces the visibility distance to a range of one kilometre or even lesser.

Hail: It is composed of hard pellets of ice in various size and shapes having more or less transparent structure. Hail is associated with *'cumulonimilibarus'* clouds. The grain with opaque white varying in size between 2 to 5 mm in diameter is known as a *'soft hail'*. If the nucleus of a soft hail is underlain with a thin layer of clear ice, then it is known as a *'small hail'*.

Snow: It is a kind of fine needle like or feathery precipitation of ice crystals. The ice crystals may fall separately as well as in groups in the form of large flakes.

Sleet: Sleet is a type of precipitation either in combination of rain and snow or rain and melting snow.

Frost: The deposit of ice crystals is known as '*frost'* or '*hoarfrost'*. These deposits develop when the temperature of the air falls below freezing point. This leads to the direct conversion of water vapour into ice crystals. *'Glazed frost'* develops when the rain falls into the bare surfaces and freezes to a layer of smooth ice.

Soft Rime: When frost and wet fog occurs together, rough ice crystals grow-out to windward or exposed objects.

Hard Rime: The ice crystals deposited from wet air or drizzle chiefly on vertical surfaces.

Mist and Haze: In both the cases, the visibility is less than two kilometres. In case of mist, the obscurity occurs due to condensed water particle and in case of haze; it is because of either wet dust or salt particles etc.

Squall: A very strong wind which may attain a speed of 16-22 knots or even higher for approximately a minute or so.

Line Squall: It denotes thin group of dynamic thunderstorms. It is generally employed to explain the firm or broken lines of strong thunderstorms.

Corona and Halo: Corona is a kind of disk of light. It gets created due to the diffraction of illumination by tiny water particles adjoining the Sun or Moon. Halo originates from the ice crystals in cirrus clouds due to the refraction of light.

13.2.10 Conditions of the Sea

Sea surface conditions are determined by the constantly prevailing wind systems. It is expressed or measured in several units including length, altitude, frequency and gradient of the waves reflecting the entire cycle of the sea waves. All of these denote different conditions of the sea ranging from calm to phenomenal as shown by different standard letter symbols shown in Table 13.4.

Table13.4: Letter symbols depicting sea conditions.

Letter Symbols	Sea Conditions
Cm	Calm
Sm	Smooth
Sl	Slight
Mod	Moderate
Ro	Rough
V. Ro	Very Rough
Hi	High
V.Hi	Very High
Ph	Phenomenal

SAQ 1

a) Mention various elements of climate and weather.

b) Describe any one element in detail.

13.3 INTERPRETATION OF WEATHER MAPS

Now, you will learn about the weather elements which a meteorologist, scientists and academic community reads with the help of certain well defined internationally devised interpretation system of procedures. You will study the solved exercises and also perform practical exercises in your 'Laboratory 'Course' (BGGCL-134). We shall discuss one example pertaining to different month of a different weather season based on weather maps as developed by Indian Meteorological Department (IMD), New Delhi. Before doing so, as explained earlier, the thorough knowledge of weather symbols and codes are very important to study the weather maps which are discussed as under:

13.3.1 Weather Symbols

Before interpreting the weather maps of India, it is of utmost importance to first learn about the most commonly used specific weather symbols corresponding with different weather phenomenon. Because, it is these two which will enable you to read and comprehend the various climatological parameters pertaining to the different weather seasons in details.

Basically, it is a combination of symbols and abbreviation of letters. These are used to denote various weather elements. It is devised by Admiral Beaufort initially in 1806 and was subsequently modified in 1830. You will be surprised to know that the same plan is still in use at present, albeit, with some additions into it as shown in Table 13.5.

Table 13.5: Types of Meteorological Symbols to denote Weather Elements (as approved by International Meteorological Organisation, Warsaw, Poland in 1935).

	Pure Air		Shower of Snow		Glazed Frost
	Haze		Shower of Rain & Snow (Sleet)		Soft Rime
	Mist		Soft Hail		Hard Rime
	Fog V < 1 km		Small Hail		Gale
	Shallow Fog		Hail		Sunshine
	Ground Fog		Distant Lightning		Solar Halo
	Frost Fog		Thunderstorm		Lunar Halo
	Drizzle		Drifting Snow (High up)		Solar Corona
	Rain		Snowstorm		Lunar Corona
	Snow		Drifting Snow (Near the Ground)		Rainbow
	Sleet		Dust or Sandstorm		Aurora Borealis
	Granular Snow		Dust Devil		Mirage
	Grains of Ice		Snow Lying		Zodiacal Light
	Ice Needles		Dew		
	Shower of Rain		Hoar Frost		

This plan of symbols was approved by the International Meteorological Organisation located in Warsaw, Poland in 1935 (Singh and Singh 2003). It shows the versatility of weather symbols along with its praxis for various applications ranging from mundane tasks of daily commuting to that of highly specialised fields of scientific endeavours like precision farming and sophisticated navigation systems etc., to indicate few important and prominent ones. If you are curious to know more about such fields, try to list out the same in the margins to further invoke your divergent thinking and thought process. Table 13.6 (a, b and c), shows the description of Beaufort notation and scale of winds along with standard symbolisation.

Table 13.6 (a): Beaufort Notation and its description.

Letter used in Beaufort Notation	Description
B	Denotes blue sky
Bc	Means partly overcast sky with one half coverage
C	Usually overcast with separate opening clouds
D	Precipitation in the form of drizzle

E	Wet air without rainfall usually deposited in the form of water on trees and buildings etc.
F	Represents fog with visibility ranging between 220-1100 yards
Fe	Denotes wet fog
Fs	Means fog over sea mainly in coastal stations
fg	Fog on lower ground near inland station
F	Shows thick fog with visibility less than 220 yards
G	Denotes darkness
H	Hail
I	Intermittent
Jp	Precipitation within sight of station
Ks	Storm of drifting snow
KQ	Line squall
I	Lightning
M	Mist, visibility 1,100-2,200 yards
O	Overcast sky, i.e., the entire sky covered with one solid cloud
P	Passing showers
Q	Squalls
R	Rain
S	Snow
Rs	Sleet
T	Thunder
Tl	Thunderstorm
U	Ugly threatening sky
V	Unusual visibility of distant objects
W	Dew
X	Hoar-frost
Y	Dry air – less than 60 per cent humidity
Z	Haze, range of visibility is 1,100 yards or more but less than 2,200 yards

The capital letters are used to designate the intensity of the phenomenon. The lesser intensity is designated by a small suffix ‘o’. The recurrence of letters

denotes the continuity and intermittence by prefixing the letter 'I'. These are as under:

R: heavy rain; r: (moderate), rain; or: slight rain; RR: continuous heavy rain.

rr: continuous (moderate), rain; and iro: intermittent slight rain.

However, the distinction between real present weather condition and former weather condition is designated by a letter called 'solidus'. Therefore, b/r means open sky after rain. The (-), sign indicates decrease in the intensity whereas (+), sign signifies increase in intensity of the particular phenomenon under observation. A symbol shown in brackets as (1), tells the occurrence of that phenomenon in the vicinity of the given observing station. There are various indices which can be used like 0, 1, 2, 3 and 4 to portray the happening of the intensity of various phenomenon's under question or investigation.

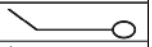
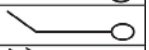
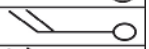
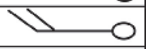
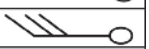
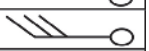
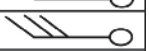
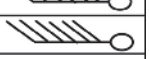
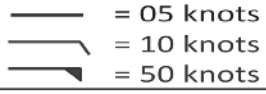
Table 13.6 (b): Beaufort scale of wind (for a standard height of 10 metres above flat open ground).

Beaufort Number (force)	Descriptive Term	Estimated Mean Speed (range)				Specifications for use		
		Knots	m/s	km/h	mph	On Land	At Sea	On the Coast
0	Calm	<1	0-0.2	<1	<1	Calm; smoke rises vertically	Sea like a mirror	Calm
1	Light air	1–3	0.3–1.5	1–5	1–3	Direction of wind shown by smoke drift but not by wind vanes	Ripples with the appearance of scales are formed, but without foam crests	Fishing smack just has steerage way
2	Light breeze	4–6	1.6–3.3	6–11	4–7	Wind felt on face; leaves rustle; ordinary vanes moved by wind	Small wavelets; still short but more pronounced; crests have a glassy appearance and do not break	Wind fills the sails of smacks which then travel at about 1–2 knots
3	Gentle breeze	7–10	3.4–5.4	12–19	8–12	Leaves and small twigs in constant motion; wind extends light flag	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses	Smacks begin to careen and travel about 3–4 knots
4	Moderate breeze	11–16	5.5–7.9	20–28	13–18	Raises dust and loose paper; small branches are moved	Small waves, becoming longer; fairly frequent white horses	Good working breeze, smacks carry all canvas with good list
5	Fresh breeze	17–21	8.0–10.7	29–38	19–24	Small trees in leaf begin to sway; created wavelets form on inland waters	Moderate waves, taking a more pronounced long form; many white horses are formed (chance of some spray)	Smacks shorten sails
6	Strong breeze	22–27	10.8–13.8	39–49	25–31	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray)	Smacks have double reef in mainsail; care required

								when fishing
7	Near gale	28–33	13.9–17.1	50–61	32–38	Whole trees in motion; inconvenience felt when walking against wind	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind	Smacks remain in harbour and those at sea lie to
8	Gale	34–40	17.2–20.7	62–74	39–46	Breaks twigs off trees; generally impedes progress	Moderately high waves of greater length; edges of crests begin to break into the spindrift; the foam is blown in well-marked streaks along the direction of the wind	All smacks make for harbour, if near
9	Strong gale	41–47	20.8–24.4	75–88	47–54	Slight structural damage occurs (chimney pots and slates removed)	High waves; dense streaks of foam along the direction of the wind; crests of waves begin to topple, tumble and roll over; spray may affect visibility	–
10	Storm	48–55	24.5–28.4	89–102	55–63	Seldom experienced inland; trees uprooted; considerable structural damage occurs	Very high waves with long overhanging crests; the resulting foam, in great patches is blown in dense white streaks along the direction of the wind; on the whole the surface of the sea takes a white appearance; the "tumbling" of the sea becomes heavy and shock-like; visibility affected	–
11	Violent storm	56–63	28.5–32.6	103–117	64–72	Very rarely experienced; accompanied by widespread damage	Exceptionally high waves (small and medium-sized ships might be for a time lost to view behind the waves); the sea is completely covered with white long patches of foam lying along the direction of the wind; everywhere the edges of the wave crests are blown into froth; visibility affected	–
12	Hurricane	64 and over	32.7 and over	118 and over	73 and over	–	The air is filled with foam and spray; sea completely white with driving spray; visibility very seriously affected	–

(Source: Guide to the Global Observing System, WMO-No.-488, Geneva, Switzerland, 2010 edition, updated in 2017)

Table 13.6 (c): Standard symbolization of Beaufort's scale of winds.

Descriptive Term	Beaufort Number	Symbol
Calm	0	
Light Air	1	
Light Breeze	2	
Gentle Breeze	3	
Moderate Breeze	4	
Fresh Breeze	5	
Strong Breeze	6	
Near Gale	7	
Gale	8	
Strong Gale	9	
Storm	10	
Violent Storm	11	
Hurricane	12	
Wind Speed:  = 05 knots = 10 knots = 50 knots		

Additionally, barometric trend is also shown in most of the weather maps. The meteorological stations having barographs record the amount and nature of change in pressure every three hours. Barometric trend means the consecutive increase and decrease in the amount of pressure. The 'characteristics' denotes the nature of changes whether it is increase first or decrease or any other kind of changes. The lines joining the places with same barometric trend are called 'isallobars'. Most of the current weather maps show the cloud types with the help of standard cartographic symbols.

13.3.2 Interpretation Procedure of Weather Map

Significant weather and climatic parameters along with their sub-parameters that need to be studied in order to interpret the weather maps are briefly discussed as under:

i) Introductory Reading/Observation

Any study pertaining to the interpretation of weather map begins with the brief introduction to different aspects of a given weather map. These are briefly discussed as under:

- Date (may have been given in both Indian and English Calendar);
- Day;
- Time (as per the division into 06 parts of a day by IMD); and
- Locational aspects etc.

ii) Conditions of Atmospheric Pressure

Atmospheric pressure governs the entire gamut of prevailing weather conditions at a particular time and place on the globe. You have read how we take the reading and measure the pressure in milibars with the help of an instrument in previous Section. It is generally placed at an interval of 2 millibars. While describing this prominent element of weather and climate, you are required to study the following five associated characteristic features:

- Location of high bars
- Location of low bars
- Isobar trends
- Pressure gradients
- Overall arrangement of pressure systems

iii) Wind Conditions

In this element, you have to carefully observe and describe the wind direction and wind velocity which will help you to indicate the corresponding changes in the state of atmospheric pressure.

Wind Direction: You are required to indicate the four cardinal and four sub-cardinal directions along with eight secondary directions from where the wind blows on a given weather chart or a map.

Wind Velocity: You have to indicate the speed of the wind with the help of given weather symbols and codes as depicted on a given weather chart or a map.

iv) Sky Conditions

You have to describe the following two elements with the help of given symbols under this category. These two are cloud cover and cloud character that will help you to ascertain the prevailing state of the weather for the given day, date and time on a given weather chart or a map.

v) Precipitation

In this category, you have to indicate the following two conditions with the help of rainfall values given in millimetres on a weather map or a synoptic chart. The rainfall values may have been given in the main map or in an attached sub-set map. These are as under:

(1) Nature of broad distribution of rainfall across the geographical regions; and

(2) Geographic regions which experienced intense amount of different forms of precipitation.

vi) Conditions of the Sea

You have to locate and interpret different state of the weather with the help of given letter symbols on a given weather map that characterises the prevalent sea conditions (see Table 13.4).

vii) Departure of Atmospheric Pressure and Temperature

The values may be shown with the help of isobar lines on a given sub-set or an inset weather map. You have to describe the nature, trend and patterns of broad geographical distribution across the region to signify the prevailing weather conditions.

viii) Other Atmospheric Attributes

As like all the major elements, interpretation of atmospheric attributes as per the given symbols on a weather map will be covered under this category. It may include fog, mist, haze, frost, hail, squall, dust storm, snow storm, corona and halo, etc.

SAQ 2

Describe in brief the list of various weather elements used to interpret a weather map.

13.4 SEASONAL CHARACTERISTICS OF INDIAN WEATHER

Indian weather system is primarily characterised by four major seasons. Each season is characterised by variety and diversity of weather conditions every season year after year. The agricultural calendar across the geographical regions of India coincides and revolves around these major seasons. For example, the sowing and harvesting of major cereal crop of wheat in Northwest India takes place during the commencement of cold and hot weather seasons respectively. You will study the nature, rhythm and relevance of these seasons in brief here and can visualize some parameters from the corresponding figures.

13.4.1 Season of Cold Weather

Main characteristic feature of this season is the development of high and low pressure areas. High pressure areas develop in the north and north-western parts whereas low pressure develops along the Bay of Bengal and Indian Ocean respectively. Differing pressure conditions thus, facilitates the direction of pressure from north to south along with land to sea reflected through different pressure gradients. High pressure conditions are characterised by ***'wedge and col'*** developing towards the north-western and Indo-Gangetic plains. Lines showing the areas having same pressure known as 'Isobars' are almost uniformly spaced across the Indian subcontinent barring the zones of high pressure areas.

Normally, this season is known for visible sky and good weather except minor variations therein. Variation may be seen in the form of prevalence of calm and light wind systems. However, rainfall may occur covering the mountainous Kashmir, Gangetic and Punjab plains etc., caused due to western disturbances. It may also cause snowfall in most of mountainous states straddling from north-western to the easternmost frontiers including states like Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and few other north-eastern states. Western disturbances coming from Mediterranean Sea also brings cold wave conditions in the form of downhill katabatic winds over much of the plain's areas. Katabatic winds refer to the cold winds which blow down a slope or mountain valley particularly at night under the influence of gravity as like that of a water rivulet. It may happen as a result, when a cold dense air cools by the factor of radiation at high altitudes. This gives birth to the foggy weather conditions covering most of the plains and coastal areas where there is a concentration of very large cities and million plus cities as well.

Fig. 13.10 shows the characteristic features of two weather elements namely mean pressure and surface wind of this season for you to envision these visually.

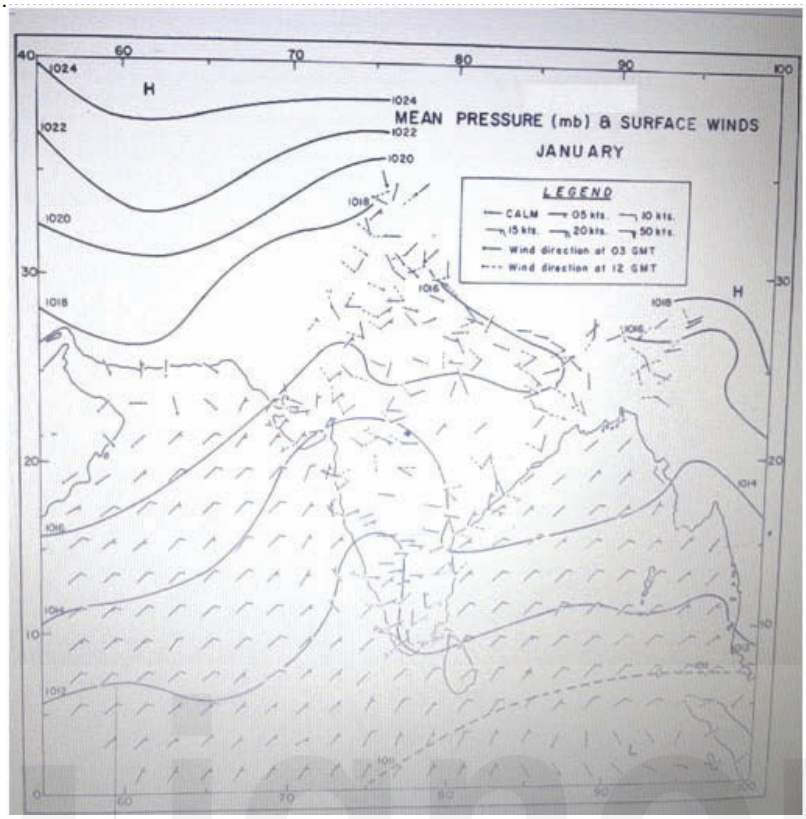


Fig. 13.10: Synoptic chart showing the mean pressure (in millibars) and surface winds (in knots) of January month, India.

(Source: IMD, Pune, India)

13.4.2 Season of Hot Weather

Unlike earlier season, high pressure areas develop near the southern territory surrounding the Indian Ocean. Low pressure areas develop near the plateau areas encircling Chhotanagpur, parts of Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh of the Indian sub-continent. Some of the salient features are described as under:

- Hot weather season is characterised by the normal pressure magnitude except towards the end of a season, when it becomes high.
- However, the gradient of the pressure varies between gentle to moderate but its direction changes in response to the position of thermal lows.
- This leads to the growth of moderate to fresh gale situations including valley of Assam, lower parts of Gangetic plains, semi-arid and arid parts of north and northwest India along with Deccan plateau regions.
- Western parts of the country more prominently Rajasthan experiences stormy weather conditions in the form of frequent bouts of dust storms.
- Moisture laden winds having NE and NW direction sweeps the entire lower parts of Gangetic plains along with the valley of Assam. It is popularly known as *'Kalbaisakhi'* in local parlance. It may cause occasional rainfall followed by thunder and lightning events including parts of Deccan plateau.
- It is known as 'pre-monsoon showers' during the end of this season.
- Hot weather season is characterised by the peaceful sea conditions.

Fig. 13.11 shows the two weather elements namely mean pressure and surface wind of this season.

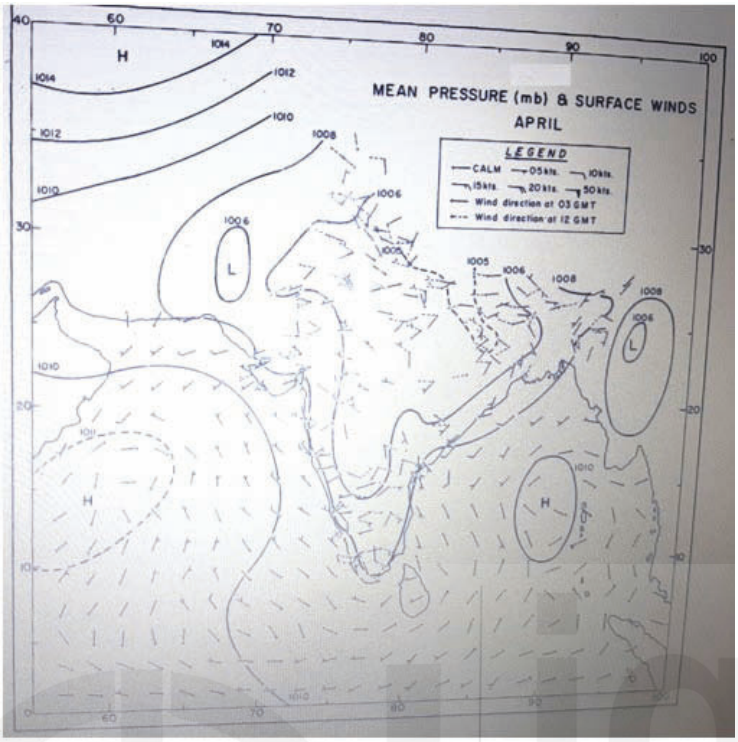


Fig. 13.11: Synoptic chart showing the mean pressure (in millibars) and surface winds (in knots) of April month, India.

(Source: IMD, Pune, India)

13.4.3 Season of Southwest Monsoon

This season is characterised by the unstable weather conditions unlike rest of the three seasons. It is evident from the growth of intense high pressure area adjoining the Indian Ocean and that of low pressure area in the north-western parts of the country. Few characteristic features are described as under:

- Trends of pressure shows fall from south towards north and SE towards NW parts of the country.
- The monsoon '***trough axis'*** follows a line that stretches from Punjab plains up to the Coastal Orissa regions.
- The gradient of the pressure turns steeper at a zone of shift between water and land territory as well as sloping side of the monsoonal trough surrounding the low pressure regions.
- The trends of isobars display North-West to South-East course surrounding the peninsular regions, West-South-West to East-North-East in the Arabian Sea whereas South-East to North-East orientation in the Bay of Bengal. They mostly run parallel to each other and are more extensive in extra-peninsular regions and Gangetic plains.
- Prevailing winds are generally calm to strong. Speed of the wind gets multiplied whenever the conditions like ***Geostrophic*** and ***Cyclostrophic*** sets into motion. The former is a type of wind that blows parallel to the isobars whereas latter one is associated with the cyclonic disturbances in the atmosphere.

- This season witnesses the extensive rainfall. It covers the lower Gangetic plains, Himalayan foothills regions, western coastal regions, hilly and mountainous north-eastern states alongside island of Andaman and Nicobar etc.
- Rainfall at times is followed by localised events of dust and thunderstorms. Thundering followed by lightening events results into downpour particularly in interior and plateau along with hilly and mountainous regions of the country.
- Monsoon season also experiences and records many cyclonic depressions. It affects and covers the tracts of eastern coastal regions. Coastal areas and seas are characterised by irregular weather conditions.

Fig. 13.12 visually shows the key features of two weather elements namely mean pressure and surface winds of monsoon season.

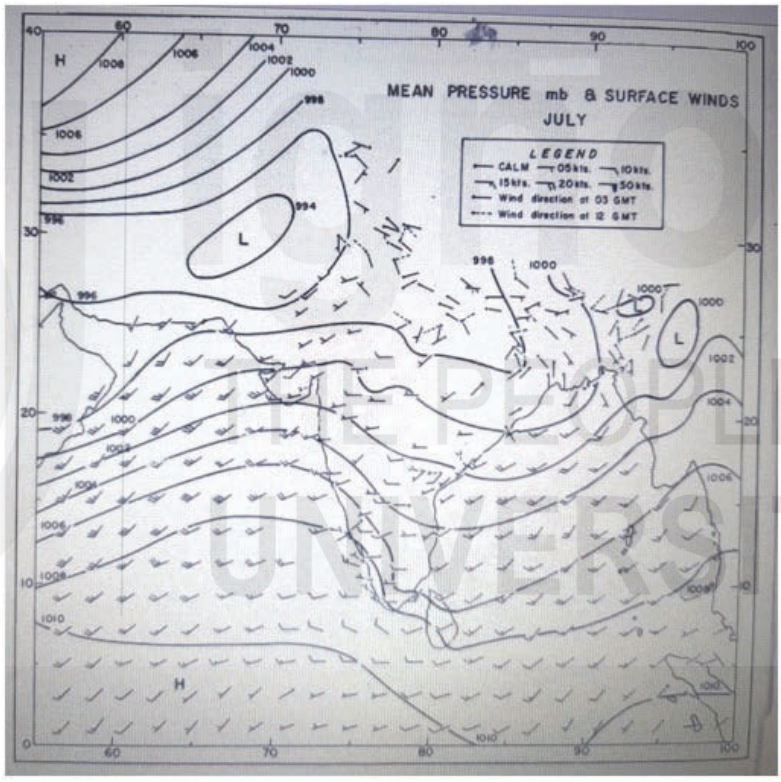


Fig. 13.12: Synoptic chart showing the mean pressure (in millibars) and surface winds (in knots) of July month, India.
(Source: IMD, Pune, India)

13.4.4 Season of Retreating Monsoon

The north-western region of Indian sub-continent experiences the growth of relative high pressure whereas relative low pressure develops in diverse regions. It covers Bay of Bengal, Arabian Sea, Indian Ocean, Peninsular India and Gangetic plains. Few of the characteristic features of this season are discussed below:

- Firstly, it shows the development of moderately to widely spaced 'isobars'.

- This season normally heralds the onset of good weather conditions barring Indo-Gangetic plains along with the states which lie in the eastern coastal regions. These areas show the development of different cloud types.
- It also causes rainfall covering the areas of coastal stretches of Andhra Pradesh, Tamil Nadu, Orissa and also Bihar and West Bengal, portions of northeast alongside Uttar Pradesh.
- Orientation of winds is generally offshore during morning time and onshore during afternoon time.

Over the coastal seas and adjoining regions, normally a peaceful weather condition prevails.

Key features related to two weather elements of this season viz., mean pressure condition and surface winds are depicted in Fig. 13.13.

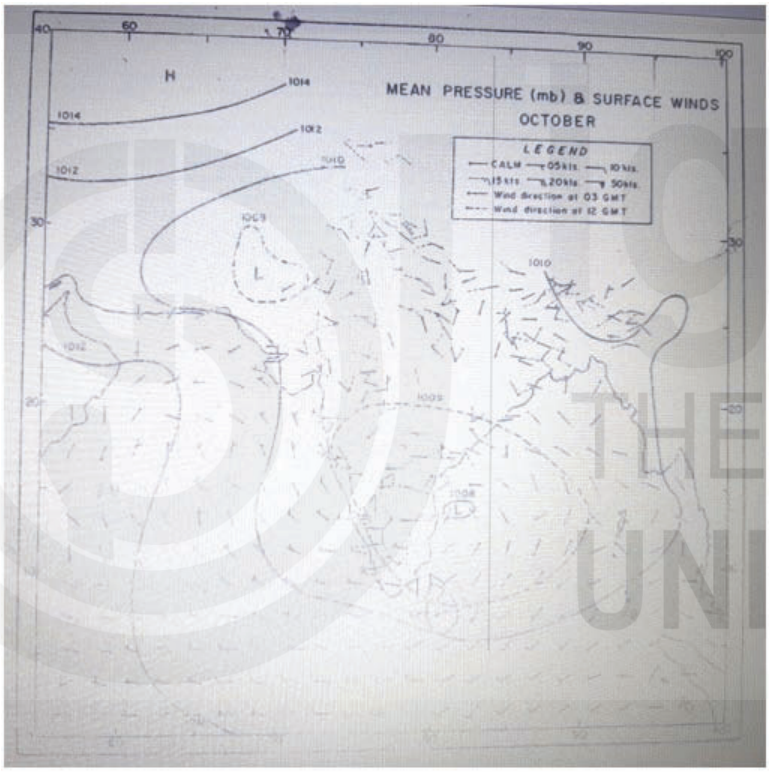


Fig. 13.13: Synoptic chart showing the mean pressure (in millibars) and surface winds (in knots) of October month, India.

(Source: IMD, Pune, India)

13.5 Weather Forecasting

All over the world in recent times, the importance of weather forecasting has grown and advanced tremendously, when it witnessed the transformation from conventional form into modern sophisticated form. India also followed the suit, more prominently since last couple of decades. Almost every nation routinely conducts weather forecasting through designated national level scientific agencies and many sub-agencies. Worldwide, the process involved in the science of weather forecasts is based on the numerical weather predictions (NWP), with the help of numerical models dealing with the atmosphere and its elements. In India, weather forecasts are of three main types with different lead

time/validity periods, such as **short range forecasts** (1 to 3 days or 24 to 72 hours), **medium range forecasts** (4 to 10 days or 96 to 240 hours), and **long/ extended range forecasts** (beyond 10 days or 240 hours). The IMD usually issues the last one category for a season. These are Southwest Monsoon rainfall and onset dates for Kerala, Northeast Monsoon rainfall and winter precipitation over Northwest India. Besides these, three main forecast types, IMD also issues a shorter range forecast known as 'nowcasting' with a lead time/validity period of less than one day or 24 hours. There are many forecasting methods being followed by different nations.

Such specialised weather observations are not only meant for weather forecasting but also involve the dissemination of observed data. This operation is taken care of by one of the specific UN agencies, which deals with the subject matter of weather and climate in an integrated manner as a part of International agreement. It is known as World Meteorological Organisation (WMO), located at Geneva in Switzerland as described earlier. The entire range comprising hundreds and thousands of such observed weather data is made available free of cost on day and night basis to all of the participatory or signatory nations for the educational, research and variety of spatial purposes. This integrated system is known as World Weather Watch, which is made up of three primary components. These are 1. global observing systems; 2. global data processing system; and 3. global telecommunication system. Observations of weather elements are carried out on many platforms with the help of sophisticated high end precision cameras. These include land based stations, ships stationed at high seas and oceans, aircrafts, meteorological satellites (like Metereosat of India). In addition, with the passage of time, more sophisticated and mobile platforms have also been added such as Automated Weather Stations (AWS's) which makes it possible to observe the weather conditions at geographically very difficult regions. Such regions could be high altitude youngest mountainous terrains of Himalayas (which made the monitoring of the health of a glacier feasible to propagate the accurate and authentic information on climate change analysis), pristine and uninhabited regions like Arctic and Antarctic etc.

The benefits may range from a mundane task of deciding a picnic spot to driving to a work place to that of a highly specialised navigational service etc. The weather events and processes together invariably determine and impact the course of our daily lives in myriad of ways. Usually, we tend to listen to the excerpts of weather forecasting in news channels, read in newspapers and check it in our mobiles before deciding a suitable course of action related to range of our spatial and economic activities. Besides, it has also enabled the Government agencies to gear up to take head on the preventive and mitigative measures to cope up with the devastating effects of cyclones, earthquake, floods and landslides, snow avalanches and other natural disasters etc.

With the passage of time, the field of weather forecasting within the science of meteorology has become ever more important and powerful medium. The 'Indian Meteorological Department' has achieved a remarkable feat in this field over the period of time. It is helping to save the huge numbers of precious human lives along with property and resources especially during the incidence of natural disasters like super-cyclones (you may recall the landmark super-

cyclone episode of Fani that hit Orissa and parts of West Bengal in 2018). Besides, it is also providing specialised weather forecasting services to cater the needs of various stakeholders. Some of the prominent ones are our farmers, fisherman, pilots both dealing with air and sea navigation, highway forecasting, local weather forecasting, mountain forecasting and pilgrimage forecasting etc. This has been made possible with the advancement of ever-increasing prowess in the twin fields of satellite navigation technologies and computational facilities coupled with the scientific knowledge and academic skills. It is not possible to discuss in detail all the aspects related to this amazing field here within the ambit of this unit.

You may visit and explore the website of IMD, India to know more nuanced understanding of the same and also some more weblinks as mentioned in the reference Section of this unit.

13.6 SUMMARY

In this unit, you have studied so far:

- Have learnt the various ways to scientifically study the weather and climatic elements.
- Besides learning the weather components, you have also learnt their nitty-gritty and significance in the science of meteorology.
- You have also learnt in detail the salient features of four distinct weather seasons of India.
- Learnt the interpretation procedures of a weather map to read the given weather symbols and codes related to the elements of weather and climate on a weather map or synoptic charts.
- You have got a broad idea about the weather forecasting and its significance in the lives and livelihood of people of India and the rest of the world.

13.7 TERMINAL QUESTIONS

1. Define in brief the various components of weather and mention in detail any of the two components?
2. List various climatic elements in detail in order to read a weather map of India?
3. Briefly highlight the importance and major features of weather forecasting.

13.8 ANSWERS

Self Assessment Questions (SAQ)

1. These parameters are temperature, pressure, wind, sunshine, cloudiness and precipitation etc. Main climatic parameters can further be sub-divided into several sub-types. For example, sub-division for precipitation is hailstorm, rain and snow.

2. There are three major genera of clouds. These are again sub-divided into three main and ten sub-types on the basis of their character and altitude. These are high altitude (3 types), medium altitude (2 types) and low altitude (5 types), clouds.

3. These are pressure and sky conditions, cloud cover, wind, temperature and sea conditions etc.

Terminal Questions

1. While answering this question, you should be able to succinctly mention the various elements of climate and weather along with their importance. You can refer to the Sec. 13.2.

2. Your answer should cover the different elements of climate and weather which helps to read weather maps. You can refer to the Sub-Sec. 13.3.

3. To answer it property, you should be able to throw a light on the major features along with key importance of weather forecasting in the lives and livelihood of people. You can refer to the Sec. 13.5.

13.9 REFERENCES/SUGGETSED FURTHER READING

- Singh, G. (2004). *Map Work and Practical Geography*. Delhi: Vikas Publication House.
- Singh, R.L. and Dutt, P.K. (1968). *Elements of Practical Geography*. Allahabad: Learners Friends.
- Singh, L.R. and Singh, R. (1973). *Map Work and Practical Geography*. Allahabad: Central Book Depot.
- Singh, R.L. and Singh Rana, P.B. (1992). *Elements of Practical Geography*. New Delhi: Kalyani Publisher.
- Sharma, J. P. (2001). *Prayogik Bhugol.* Meerut: Rastogi Publication.
- Sarkar, A. K. (1997). *Practical Geography: A Systematic Approach.* Kolkata: Orient Longman.
- Misra, R.P. and Ramesh, A. (1986). *Fundamentals of Cartography*. New Delhi: McMillan.
- Monkhouse, F.J. and Wilkinson, H.R. (1972). *Maps and Diagrams*. London: Mothuen and Co. Ltd.
- Robinson, Arthur, H.J., Morrison, P., Muehrke, A., Kimmerling & Guptill, S. (eds.) (1995). *Elements of Cartography.* New York: Wiley.
- www.imd.gov.in, India Meteorological Department, Pune, India
- www.worldclimate.com
- www.nws.noaa.gov

- www.weather.org.uk
- www.met.reading.ac.uk
- www.wmo.int
- www.weather.com
- www.intellicast.com
- www.rmets.org

GLOSSARY

Atmosphere: It is composed of various major and minor gases surrounding the planet earth's surface.

Climograph: This is a twelve sided polygon that represents selected two climatic elements namely wet bulb temperature and relative humidity of a particular station against one another.

Climate: Generally, it means the average weather conditions for more than 30 years or a span of more than three decades.

Cloud: It refers to the visible mass of tiny particles of water in its different forms that can be seen floating in the atmosphere and its layered structure often during cloudy or overcast sky conditions.

Contour: It is a line that connects points of equal elevation on the ground surface above mean sea level.

Cultural Features: Features that are constructed or formed by humans for example roads, railways, airports, buildings, settlements, administrative boundaries, state and international borders etc.

Depressions or Cyclones: It means a particular geographic area characterized by low atmospheric pressure conditions. The atmospheric winds drive counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere correspondingly. This term is also applied to denote the occurrence of catastrophic 'hurricane' in the Indian and Western Pacific Oceans.

Diffraction: It refers to the process of scattering of light energy triggered by the tiny water particles.

Ergograph: This is a graph that shows a relationship between human activities, or agricultural/climatic factors and a seasonal year.

Form Lines: These are broken lines drawn in between contour lines to represent elevation.

Geoscience Australia: This national organization publishes maps to cater the diverse needs of the country of Australia.

Hachures: One of the methods of elevation representation used to draw as a fine small broken line along the direction of maximum slope.

Humidity: It indicates the state of the atmosphere related to the amount of water vapour which it can hold in its separate states.

Hythergraph: This is also another twelve sided polygon that represents mean monthly temperature and rainfall of a particular station against one another.

India and Adjacent Countries Series: Under this IAC Series, Survey of India had published topographical maps on 1: 1M scale for its Indian regions and also adjacent country lands of Afghanistan, Tibet and China.

International Map of the World: This is also known as IMW. Under IMW series project, several countries published maps on 1:1 M scale.

Isobaric Systems: Weather maps showing the isobars are commonly shown in a normal way. However, the shapes of isobars have numerous varieties corresponding with various categories of weather conditions.

Keen: It represents cold and dry condition in which wet bulb temperature is below 40 degree Fahrenheit (4.4 degree Celsius) and relative humidity is below 40 percent.

Muggy: It represents hot and humid condition in which wet bulb temperature is over 60 degrees Fahrenheit (15.5 degree Celsius) and relative humidity is over 70 percent.

NRCAN: This national mapping agency provides topographical maps for the country of Canada. NRCAN stands for Centre for Topographic Information of Natural Resources Canada. The web link is *http://maps.nrcan.gc.ca.*

Open Series Maps: This is popularly known as OSM. SOI publishes toposheets by adopting new map numbering system according to the National Map Policy of 2005.

Physical Features: Features that are naturally formed for example mountains, hills, valleys, slopes and rivers etc.

Raw: It represents cold and moist condition in which wet bulb temperature is below 40 degree Fahrenheit (4.4 degree Celsius) and relative humidity is over 70 percent.

Refraction: It indicates the change in the direction of a source of energy like light or wave, when it obliquely crosses through a less dense to a denser medium.

Relief: It indicates the elevation difference of the particular natural landscape such as plateau, hills and mountains etc., above mean sea level.

Royal Survey: This acronym refers to a national survey organization, which prepares and provides diverse kinds of maps for the country of United Kingdom. The web link is *https://www.ordnancesurvey.co.uk/*.

Scorching: It represents hot and dry condition in which wet bulb temperature is over 60 degree Fahrenheit (15.5 degree Celsius) and relative humidity is below 40 percent.

SOI: It stands for the Survey of India. This national mapping agency conducts surveys and publishes topographical maps of Indian territories on various scales. Such maps are used for catering the diverse needs of the country like planning and management of natural and cultural resources. The web link is *http://www.surveyofindia.gov.in/*

Topographical Map or Toposheet: It is a map which represents accurate and authenticated information of the earth's surface features, including both physical and cultural features.

Trough Axis: It signifies a low pressure area having long and narrow axis that lies between two consecutive areas of high pressure.

USGS: This acronym stands for the United States Geological Survey of United States of America, which provides topographical maps on various scales. The web link is *http://store.usgs.gov*.

Visibility: It refers to a condition when we can see the things/objects or phenomenon in the natural landscape in a transparent manner from a distance. It depends on the time of a day, quality of light, presence or absence of atmospheric particles (dust, fog and mist etc.), along with height above mean sea-level where an observer situates him/her.

Weather: It denotes the atmospheric condition at any given time or place over the earth's surface.

Weather Forecasting: It is a highly scientific and technical sub-field within the science of meteorology to enable the prediction of the impending weather conditions based on numerical weather predictions in advance. Besides catering to the needs of various stakeholders, such forecasts are also useful to save the lives and livelihood of people and economy of a nation.

Wedge and Col: These two distinctive weather features represent a successive areas of high and low pressure situated between two anti-cyclones or depressions.

Wind Rose: A wind rose is a diagram which graphically displays wind speed and wind direction at a particular location over a period of time. Meteorologist use wind rose diagrams to summarize the distribution of wind speed and direction over a defined observation period.