Lecture Notes

on

Observational Systems

For

Integrated Meteorological Training Course

By

Dr. Prakash Khare, Scientist E

&

Dr. D. M. Rase, Meteorologist-B

India Meteorological Department
Meteorological Training Institute
Pashan,Pune-8

CHAPTER 1

Observational Systems, Meteorological elements

Objectives: After reading this article, reader will be able to:

- Describe General principles of observations:
- Distinguish between Classifications of Surface observations
- Describe the Meta data of a weather stations
- Explain the elements of meta data
- Discuss the need of such data
- Write Important features of meta data and where it is generated and archived

- Explain exposure of instruments
- Write Important details of observational systems
- Describe and define various Meteorological elements
- Measurement and procedure of different elements
- Write Important details of observational systems
- Errors, troubleshooting and upkeep of instruments met . measuring elements

Introduction:

Weather and climate of a place are described by the composite effect of atmospheric factors like pressure, temperature, wind, humidity, clouds and visibility etc. These interrelated factors are termed as elements of weather and climate. Weather of a place at a given time is the instantaneous effect of these elements. Climate of the place is the average weather conditions obtained by averaging the elements over a long period of time (usually 30 to 50 years). Meteorological elements are usually measured quantitatively, for example temperature in degree centigrade and rainfall as a depth in inches or millimeters but qualitative estimates are often given as in descriptions of rain as light moderate or heavy and clouds as types such as cirrus or cumulus. In a meteorological observatory, measurement of one or more of several meteorological elements is carried out by an observer. These observations are needed for weather forecasting and also for other branches of study and application like climatology, agricultural meteorology and hydrometeorology.

The usefulness of the observations will depend upon the care and accuracy with which the observations are recorded by the observer. The routine reporting of weather by the observer as a part of a worldwide collection of data and is therefore an important and valuable service. Meteorological observations are taken regularly and simultaneously at standard hours of observations all over the world.

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Classification of Surface Observatories:

Surface meteorological observatories of the India Meteorological Department are divided into six classes;

Class –I : These are observatories equipped with both eye-reading and self-recording instruments.

Class – II : Most of these observatories are equipped only with eye reading instruments. Regular observations are taken at least twice daily.

Class – III : These observatories are same as class-II only difference is here observations are recorded only once in a day.

Class – IV, V & VI: These observatories have a lesser number of instrumental equipment or take non-instrumental observation only.
A large majority of the observatories of this department belongs to Class –II.

The basic **surface instruments** at any meteorological observatories are exide for

- Mercury Barometer
- Four Thermometers i.e. Dry Bulb, Wet Bulb, Maximum and Minimum fixed inside the Thermometer screen (Stevenson screen).
- Raingauge and Measure glass.
- Wind instruments – Wind vane and Anemometer.

Metadata

Background

The general definition for metadata is "data about data." Metadata is what helps us understand the data. It represents who, what, when, where, why, and how of the data. Metadata records include library catalog elements such as title, abstract, and publication data; geographic elements such as geographic extent and projection information; and database elements such as attribute label definitions and attribute domain values. metadata information about data holdings and include elements such as siting, elevation, latitude, longitude, and equipment type for various weather and climate stations as well as dataset station listings and dataset inventories.

Metadata (data about data), as applied to measurement and observation, describe the location, instrument and method of observation, quality, and other characteristics of data. Metadata are important for data users, as they need to know the circumstances of the observations/ measurements and understand the origins of the meteorological values themselves. Metadata are especially important for the elements that are particularly sensitive to exposure, such as precipitation, wind and temperature.

Metadata can be considered as an extended version of the station administrative record, containing all possible information related to the station and instruments installed, type and time of changes that occurred during the history of an observing system. The expanded metadata information can include digital images, a wide range of instrument specifications, calibration and maintenance records, and many other pieces of information.

Metadata are dynamic. Station location, ground cover, instruments, observation/ measurement practices, processing algorithms, data formats etc. change over time. The system has to track all these changes. Therefore, metadata should be as complete as possible, as up to date as possible, and as readily available as possible. Basic metadata should be available together with the observational data.

A sound quality management system entails the availability of detailed information on the observing system itself and on all changes that occur during the time of its observation. Such information on data, known as metadata, enables the operator of an observing system to take the most appropriate preventive, corrective, and adaptive actions to maintain or to enhance data quality.

As computer data management systems gradually become an important component of the data delivery systems, it is desirable that metadata are available as a computer database enabling computerized composition, updating, and use. The metadata files have to be organized in such a way to be both easily maintained and accessible. The development of a metadata system requires considerable interdisciplinary organization, and its operation, particularly the scrupulous and accurately-dated record of changes in the metadata base, requires constant attention.

Metadata presented in a uniform format is an essential requirement for the interpretation of measured data and siting criteria and metadata standards should be developed for that purpose.

ELEMENTS OF A METADATA DATABASE RELATED TO AN AUTOMATIC WEATHER STATION

The proposed standard set of metadata elements

A metadata database should provide detailed information necessary for users to gain adequate background knowledge about the station and observational data, together with updates due to changes that occur.

Major database elements include the following:

- Network information (beyond a scope of this document);
- Station information;
- Individual instrument information;
- Data processing information;
- Data handling information;
- Data transmission information.

National Data Centre (NDC) of IMD is the sole custodian of all Meteorological Data being collected from various parts of India. The data are available for more then 125 years. The mandate is to preserve quality controlled data and supply for Weather Prediction, Aviation, Agriculture, Environmental studies, Oceanography and Shipping and Researchers of various Institutions and Universities.

Site and Exposure of the Instruments

Measurements of some meteorological elements depend on the exposure of the instruments. In order that observations at different stations may be comparable, the exposure should be similar.

A plot of level ground covered with short grass and about 9m by 6m in size is satisfactory for the outdoor temperature and humidity sensing instruments. It must, however, be suitably sited.

It should be located in such a position as to afford a fair representation of surrounding conditions. Hence, it should be away from the immediate influence of trees and buildings. As far as possible it should not be sited upon, or close to, steep slopes, ridges, cliffs or hollows.

An exception is made in the case of precipitation-measuring instruments. These require a suitable distribution of trees and shrubs or their equivalent, in order to serve as a wind break. On the other hand, these obstructions should not be such that they create objectionable turbulence.

A synoptic station should be located so as to give meteorological data which are representative of the area in which it is situated.

In general, a climatological station should be located at a place and under an arrangement which will provide for the continued operation of the station for at least ten years.

At an aeronautical meteorological station, care is necessary in siting the instruments to ensure that the values are as representative as possible of the conditions at or near the aerodrome. Similarly an agricultural meteorological station should be located at a place which is representative of agricultural and natural considerations in the area concerned.

A large majority of the observatories of this department belongs to Class –II.

<u>Meteorological Elements :</u> The basic instrumental equipment at observatories of the Clas-III and higher categories is :-

a) **<u>Barometric Pressure :</u>** The pressure of the air that is measured with the barometer.

b) **<u>Dry bulb temperature :</u>** The temperature of the air as measured by the dry bulb thermometer in the Thermometer Screen at the time of observation.

c) **<u>Wet bulb temperature :</u>** Which gives in conjunction with the dry bulb temperature, the humidity of the air inside the Thermometer screen and its dew point temperature.

d) **<u>Maximum Temperature :</u>** The highest temperature of the air indicated by the Maximum thermometer in the SS screen since its last setting.

e) **<u>Minimum Temperature :</u>** The lowest temperature of the air indicated by the minimum thermometer in the Stevenson Screen (SS) since its last setting.

f) **<u>Precipitation :</u>** The amount of rain fallen between the successive observations.

g) **<u>Wind direction & Speed :</u>** The direction and speed is given by Wind vane and Anemometer respectively.

h) **<u>Visibility :</u>** As judged by the observer according the visibility land marks.

i) **<u>Cloud :</u>** The amount, formation & direction of the movement of the cloud and height of the base of low cloud above station level.

j) **<u>Weather :</u>** The character of the weather since the last observation and at the time of observation.

k) **<u>Wave observation :</u>** For coastal stations only.

Atmospheric Pressure

Pressure: The pressure of the atmosphere at any point is the weight of the air column which stands vertically above the unit area with the point as it**s** center.

Units of the atmospheric pressure:

The C.G.S. unit of the atmosphere is dynes/cm² but this is inconveniently small. The unit employed for reporting pressure for **meteorological** purposes is, therefore, the **millbar** or **hecta Pascal**, which is defined as equal to the 1000dynes/cm².

In meteorology the atmospheric pressure is reported in **hecta Pascal (hPa).**

1 hPa = 100 Pa (Pascal being the SI unit of pressure)

Also 1 Pa = 1 N/m²

i.e. 1hPa = 100 N/m²

Also 1mb = 100 N/m²

Therefore 1hPa = 1mb

Under the standard conditions, a column of mercury of 760mm exerts a pressure of 1013.25 hPa.

The accepted standard conditions for pressure measurement are 0ºC temperature, density of mercury 13.5951 g/m³ and acceleration due to gravity = 9.80665 m/s².

Therefore the average pressure at sea level = 0.76x136.0x9.81 = 1013.25 hpa.

Correction of Barometer readings to standard conditions:

In order that mercury barometer reading made at different times and at different places should be comparable, the following corrections should be made:

(a) Correction for index error.
(b) Correction for temperature.
(c) Correction for gravity.

(a) Correction for index error :

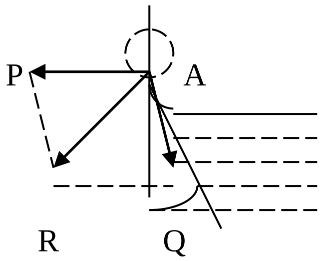
(1) It is assume that a given reading on the scale represents the actual difference between the levels of the mercury surfaces but it is impossible to subdivide the scale perfectly.

(2) Glass is not wetted by the mercury and meniscus is convex upward the cohesive force between the mercury molecules is greater than that of adhesion between the glass and mercury.

The rise of level (Water) or fall the level (Mercury) in a thin tube called capillary the effect is known as capillarity.

(3) Error due to the residual gas in vacuum above the mercury column.

These errors should not exceed few tenth of a millibar, combined together to form an index error.



(b) **Correction for temperature:** Various components parts such as Mercury, scales, cistern, glass tube etc are calibrated at a temperature of 0°C . Any departure from this temperature will cause in the dimension of these components.

For this one thermometer is attached to mercury barometer, by reading this thermometer, it is possible to make a correction to the barometer measurement, so that it will refer to the standard temp. of 0°C.

(c) **Correction for gravity**: The reading of a barometer at a given pressure and temperature depends on the value of the acceleration due to gravity. This in turn varies with latitude and altitude.

For any particular barometer used in a fixed position these correction may be conveniently combined in a single table.

The main sources of error, with regard to mercury barometers:

(A) **Effect of wind**: Dynamical fluctuation of pressure may be superimposed on static pressure in conditions of strong and gusty winds.

(B) **Effect of temperature stratification in barometric room**: The temperature at the barometric reservoir and at the upper part of the barometer may be different.

A small electric fan can prevent such conditions from arising.

(C) **Pressure of gas or vapours in barometer's Torricellian vacuum**: A perfect vacuum is assumed above the mercury column inside the barometric tube.

Mercury vapour does not affect the accuracy of the measurement because of its negligible pressure value.

(D) **Effect of capillary depression**: Due to the small bore barometer tubes, the surface tension of mercury, may cause an appreciable depression of the mercury column.

(E) **Deviation from the vertical position of the barometer**: A departure from the lowest point of the barometer from the vertical position of 12.3mm will cause a pressure reading about 0.133hpa too high.

(F) **Effect of dirt, oxidized mercury**: Impurities of all kind in the barometer's mercury are a source of error in pressure measurement. Oxidized mercury has an appreciably capillary depression and the barometer would read lower pressure values.

Sources of error of the aneroid barometer :

(A) Incomplete compensation for temperature changes:

With increasing temperature and worsening of the elastic properties of the capsule. A well designed bimetallic compensation can control the temperature error over the whole range of measured pressure values.

(B) Hysteresis:

If the aneroid capsule is subjected to a large and rapid change of pressure, Which is then brought back to its initial value., the capsule will indicate a different initial pressure which will change slowly until it reaches its true original value. This phenomena is called hysteresis.

(C) Secular changes of the elastic properties of aneroid capsule:

Because of gradual material structural changes the elastic properties of the capsule eventually deteriorate, leading to errors, which increase, with time

Barometric Pressure:-The pressure of air that is measured with the barometer.

Mercury Barometer :-

There are two types of mercury barometers are use at meteorological stations. They are the Fortin and the fixed cistern (or Kew pattern) barometers. The **kew pattern barometers** are being used in the India Meteorological Department.

Its essential parts are (1) Glass tube of about 90cm long closed at the top and open below (2) a cup or cistern (3) a brass scale. The glass tube is filled with mercury and its open end is dip in the mercury in the cistern, which prevent air from entering the tube. There is vacuum above the mercury column in the tube. Presence of air in minute quantity will affect the readings of the instrument. The mercury column in the tube is supported by the pressure of the air on the surface of the mercury in the cistern. This is the basic principle on which the barometer is constructed.

As the mercury in the barometer tube rises or falls due to changes in the atmospheric pressure, the mercury level in the cistern changes in the opposite direction. This change of level in the cistern is taken into account in the graduation of the scale itself.

In the **Fortin Barometer** the level of mercury in the cistern can be adjusted to bring it into contact with a fixed ivory pointer. The top of this pointer is at the zero of the barometer scale.

Aneroid Barometer : -

An aneroid barometer consists of a flexible sealed metal chamber. It is completely or partly evacuated and the distance between the centres of its opposite walls changes with atmospheric pressure. A strong spring system prevents the chamber from collapsing due to the external atmospheric pressure. At any given pressure there will be an equilibrium position in which the force due to spring balances that of the external pressure. One end of the cell is fixed, while the other is coupled to a pointer which move over a dial mark with pressure values. The coupling magnifies the movement of the pointer. An aneroid barometer must be calibrated against the mercury barometer.

Advantages:

(i) It is compact and portable

(ii) Convenient to use at sea or in field.

Disadvantage:

(i) Source of error due to incomplete compensation for temperature.

(ii) Weakening of spring with increasing temperature, which causes high pressure indicated by the instrument.

(iii) Elasticity error also occurs due to the variation of temperature, which will affect true pressure.

Temperature and its measurement

Thermometer:-

Temperature of a body is the condition, which determines its ability to communicate heat to other bodies or to receive heat from them. Meteorologist is interested in the temperature of the air, of the soil and of water bodies. Temperature is measured by means of a thermometer. Thermometer consists of a glass bulb containing mercury or spirit connected with the glass tube of very small bore closed at the top. The rise or fall of mercury or spirit in tube due to expansion or contraction of mercury or spirit is measured by calibrating the tube with standard temperatures. The temperature measured by thermometer is in degree Celsius.

Why mercury is used in Thermometer?

(i) It is shining, silvery white, which can be seen easily from outside the glass.
(ii) It does not stick to the glass.
(iii) Its expansion is fairly uniform over a wide range of temperature.
(iv) Its freezing point is -39ºc and boiling point is 357ºc whereas alcohol thermometers are used to measure between -125ºc to about 50ºc.

Maximum temperature: - The highest temperature of the air indicated by the maximum thermometer in the thermometer screen since its last setting.

Minimum temperature: - The lowest temperature of the air indicated by the minimum thermometer in thermometer screen since its last setting.

Dry Bulb temperature: - Temperature of the air as measured by the dry bulb thermometer, kept inside the Thermometer Screen, at the time of observation.

Wet Bulb temperature: - Which gives in conjunction with the dry bulb temperature, the humidity of the air inside the thermometer screen and its dew point temperature.

Maximum Thermometer :-

The maximum thermometer is mercury in glass thermometer with a constriction in the bore below the lowest graduation. When the temperature falls after reaching the maximum value the mercury does not return to the region below the constriction, provided that the stem of the thermometer is approximately horizontal.

The maximum thermometer bulb rests downwards at an angle of about 2º to the horizontal. The reason for the slight slope is to prevent the mercury column from drawing away from the constriction.

Minimum Thermometer :-

The liquid inside the minimum thermometer is spirit in which is immersed a dumb bell shaped index. When the temperature falls, the spirit drags the index along with it towards the bulb end; but when the temperature rises the spirit expands and runs past the index without disturbing it. Thus, the end of the index farthest from the bulb gives the lowest temperature attained by the instrument.

To set the minimum thermometer, it is removed from its supports and tilted slowly, bulb upwards, until the index touches the end of the spirit column.

Dry bulb Thermometer :-

Dry bulb thermometers have usually small bulbs, which may be round or cylindrical. The surface air temperature refers to the free air at a height of between 1.25 and 2m above ground level. It is necessary to read thermometer as rapidly as is consistent with accuracy, in order to avoid the changes in the temperature due to presence of the observer. The end of mercury column is curved and this surface is known as the meniscus. The air temperature is read to the nearest tenth of a degree.

Wet bulb Thermometer :-

This helps to find out the relative humidity of the surrounding air. The Wet bulb thermometer is as similar as dry bulb thermometer. The bulb is always kept wet by means of a muslin sheath, fed by water from a bottle through a wick. The diameter of muslin is 3cm (circular). For the wick, take four strands of darning cotton and loop them round the neck of the bulb over the muslin in the form of the noose, so that 8 tips of the thread will be dipped in the bottle filled with distil water. Cloth and thread should be changed every fortnight.

The bottle must have a small neck so that air inside the S.S. may not be moistened by evaporation of water in it. The bottle must not be placed below the wet bulb but a little on one side of it away from the dry bulb; otherwise the thermometer may read too high. The part of the wick exposed to the air should be about 10 to 15 cm in length and must not form any loop so that water will not drip out.

Stevenson's Screen :-

It is used for keeping Hygrograph/Thermograph/thermometer to prevent them from direct solar heat and wind speed. It is made up of wooden rectangular box with its sides and door double louvered and with a double-layered roof with air space in between. The upper roof projects 5cms beyond the sides of the screen and slopes from front to back. Due to white paint, effect of heating of wood by solar radiation is avoided. The height of the top of the support from ground is 1.25mtrs.The thermometer screen is to be erected on four stout wooden posts with its door opening to the north and at such a height that the bulbs of the wet and dry bulb thermometer shall be between 1.30 and 1.40 meters above the ground.

Atmospheric Humidity and its Measurement

Definition :-

The relative humidity is the ratio of mass of water vapour actually present in the unit volume of air to that required to saturate it at the same temperature. It is usually expressed as a percentage.

$$R.\ H.\ (\%) = \frac{\text{Actual water vapour pressure at dry bulb temperature}}{\text{Saturation vapour pressure at dry bulb temp.}} \times 100$$

Dew point temperature:-

Dew point temperature may be defined as the temperature to which a sample of moist air has to be cooled at constant pressure for it to becomes saturated.

If the temperature of the air is cooled below the dew point, condensation will occur.

Instruments for measuring surface atmospheric humidity :-

Instruments used for measuring humidity or water vapour content of the atmosphere are called hygrometer. The two main types of instruments used for measuring the humidity of the air are:

(1) Wet and dry bulb hygrometer
(2) Hair hygrometers

A wet and dry bulb hygrometer is also known as a psychrometer. Psychrometer is subdivided as follows:

(1) Stationary screen type
(2) Aspirated Type

Hair Hygrograph : -

The hair hygrograph is an instrument which gives a continuous record of the relative humidity.

Principle : -

The hair hygrograph operates on the principle that human hair which has been free from fats varies considerably with the relative humidity. The change in the length is magnified and recorded on a rotating chart by a pen. The length of the hair increases as the relative humidity increases and vice-versa, the increase in length as the R.H. increases from 00 to 100 percent being about 2½% of the original length. The change in the length is however not directly proportional to the change of humidity. A change of 10% in humidity from 80% to 90% causes much smaller change in the length of the hair than the equal change from 30% to 40%. But between 20 and 100 percent R.H., the change in the length of hair is proportional to the logarithm of the change in the relative humidity.

A suitable designed Cam has therefore been introduced in the hygrograph to modify the magnification so that the movement of the pen is proportional to the relative humidity. The divisions in the chart may then be evenly spaced. (A cam is devise to convert one type of motion into a different type of motion).

Instrument : -

The main feature of this instrument are shown in the enclosed diagram. The figure 1 shows a side view , while the figure 2 indicates its appearance from above.

The bundle of hair is held by the two jaws AA, and is caught up at approximately its center by the hook B. The horizontal axis of the lever C, to which the hook is fixed, is fastened to the cam piece D.

The cam piece D is kept in contact with a second cam piece E by means of the light spring F. The second cam piece E is clamped to the pen arm axis by the screw G.

In this way, alterations in the length of the hair with humidity are magnified and communicated to the pen. The greater part of the magnification of the changes in the hair length results from the action of the pen arm and of the lever C. However, The cam pieces and the angle in the hair also produce some magnification.

Exposure : -

The hygrograph should be exposed in a large double Stevenson screen. Its performance depends largely on the care given to the hairs. The screen should be located in a place where the air is not polluted with smoke, dust, brine or oil vapour. Industrial plants using ammonia in the immediate vicinity should be avoided.

A length of hair is about 190+/- 10 mm and consists of 25 to 30 stands of French blonde. It survives for 15 to 20 years. The hair can be cleaned by carbon tetra chloride with the help of brush. Other than CCL_4 acetone can be used (CH_3COCH_3).

Source of Error :

(1) **Change in zero position**:- The hygrograph is liable to change in its zero position. The most common cause is perhaps excess of force applied to the hairs in one direction or if the hygrograph is kept for a long time in a very dry air. Such an error is rectified by keeping the instrument in saturated air for sometime or by doing 100% humidity.

(2) **Dust on hairs** can appreciably affect the record of relative humidity (15%). The hair should therefore be cleaned and washed regularly.

Observation procedure : -

The hair hygrometer should always be tapped lightly with a finger before reading. However, between changes of the chart, it should as far as possible not be touched except for making time mark.

Hair Hygrograph :

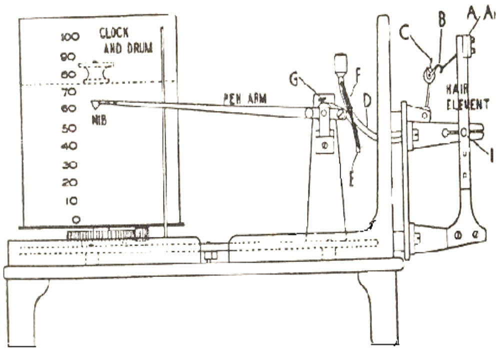


Fig. 1

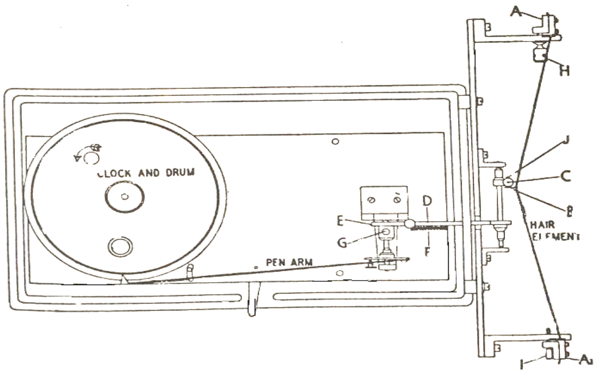


Fig. 2

A, A_1,- Jaws in which element is held,

B- Hook catching centre of hair element

C- Lever, D- First CAM piece, E- Second CAM piece

F- Light spring holding CAM pieces in close contact

G- Screw clamping second CAM piece to pen arm axis

H- Capstan headed screw for moving JAW 'A' (Large zero adjustment).

I- Zero set screw (Small Adjustment)

J- Ranging screw (For lowering or raising Hook 'B')

Wind Instruments and its measurement

Wind :

Wind is defined as air in motion and is expressed in terms of direction and speed. Wind direction is regarded as the direction from which it blows and speed as the rate of movement of air in its instantaneous direction.

Beaufort scale :

Beaufort wind scale was developed by Admiral sir Francis Beaufort in 1905 for use at sea. Later it was adapted for use over land

Wind speed equivalent for the various effects.

Beaufort wind scale is useful method for estimating wind speeds when other aids are not available. Following table shows the wind speed equivalents of the various Beaufort numbers:

Wind speed equivalents

Beaufort numbers	Description	wind speed equivalent at standard height of 10 meters above open flat ground			
		knots	mps	kmph	Specifications for estimating speed over land
0	Calm	< 1	0 – 0.2	< 1	Calm, smoke rises vertically
1	Light air	1 - 3	0.3 – 1.5	1 – 5	Direction of wind shown by smoke – drift but not by wind vanes.
2	Light breeze	4 - 6	1.6 – 3.3	6 - 11	Wind felt on face; leaves rustle, ordinary vanes moved by wind
3	Gentle breeze	7 - 10	3.4 – 5.4	12 - 19	Leaves and small twigs in constant motion; wind extend light flag

4	Moderate Breeze	11 - 16	5.5 – 7.9	20 - 28	Raises dust and loose paper; small branches are moved
5	Fresh breeze	17 - 21	8.0–10.7	29 - 38	Small trees in leaf begin to sway, crested wavelets form on inland waters
6	Strong breeze	22 -27	10.8-13.8	39 - 49	Large branches in motion; whistling heard in telegraph wires, umbrellas used with difficulty
7	Near gale	28 - 33	13.9-17.1	50-60	Whole trees in motion, inconvenience felt when walking against the wind
8	Gale	34-40	17.2-20.7	62-74	Break twigs off trees, generally impedes progress
9	Strong gale	41 - 47	20.8-24.4	75 - 88	Slight structural damage occurs (Chimney pots and slates removed)
10	Storm	48 - 55	24.5-28.4	89 - 102	Seldom experienced inland, trees uprooted; considerable structural damage occurs.
11	Violent storm	56 -63	28.5-32.6	103-117	Very rarely experienced, accomplished by widespread damage
12	Hurricane	64 and over	32.7 and over	118 and over	Severe and extensive damage

Wind vane :- The wind direction is given by an instrument called the windvane. It is a balanced lever, which turns freely about a vertical axis. The one end of the lever exposes a broad surface to the wind, while the other end is narrow and points to the direction from which the wind blows. Wind direction is determined with reference to 16 points of compass. Wind speed is measured in knots or kilometers per hour.

In an open site it can be installed on a steel or wooden lattice tower or mast 6 meters high and well guyed within observatory enclosure. When obstructed by trees or building or a high mast so that it is higher by at least 3meter than the highest obstacle in the immediate vicinity. When both the anemometer and wind vane are fixed on the same platform they should be at least 2meters apart.

Maintenance of wind vane :-

(1) Lubrication :- Lubrication is done every fortnight. Lubricate the ball bearings with few drops of spindle oil. For this remove the horizontal arm after taking out the top nut. Take out the screw and put a few drops of oil into the hole and replace it.

(2) Overhauling :- Keep the instrument clean. Examine the four set screws once in a month and tighten them if necessary. Once every six months examine carefully all the parts of the instrument and wash them thoroughly in kerosene oil, clean , dry then lubricate.

Anemometer : - The wind speed is measured by an instrument called the Anemometer.

Principle:- The instrument consists of three large semi-conical cups with beaded edges fixed at the ends of three rods. The cups are mounted symmetrically about a vertical axis so that the diametral plane of each cup is vertical. As the force on the concave side of any cup, due to the wind is greater than that on a convex side in a similar position, the cup wheel rotates.

The cups are attached to a central spider, which is mounted on a spindle carrying a worm. The worm engages with a gear wheel and drives a revolution counter mounted in a water proof aluminum housing.. To obtain the run of the wind in kilometers and tenths over a given period, the counter is read at the beginning and end of a period, and the difference noted. The mean wind speed during this given period is obtained by dividing the difference in counter reading by the time interval in minutes.

Exposure:- The standard exposure of wind instruments over level, open terrain is 10 meters above the ground. Open terrain is defined as an area where the distance between the anemometer and any obstruction is at least 10 times the height of the obstructions. The standard exposure is especially important at airports. The ideal exposure will rarely be obtainable in practice, but great care should be taken to ensure that the site actually chosen be best possible. When there is any obstruction by trees etc the instrument may be erected on a building or high mast, so that it is higher by at least three meters than the highest obstacle in the immediate vicinity.

Maintenance of anemometer :-

The instrument suitable lubricated and no lubrication is required soon after installation. However, the instruments should be inspected, cleaned and lubricated at intervals of three months according to the following routine:-

(a) Place the instrument on a clean bench, remove the cap nut and lift the cup wheel with spider off spindle. If the cup wheel is stuck to the spindle, loosen the cap nut but do not remove it; support the cup wheel in one hand and strike the cap nut smartly with a mallet or the wooden handle of a screwdriver.

(b) Clean the cup wheel thoroughly checking that cup retaining nuts are light and that the cups are not loose in their arms.

(c) Clean thoroughly the exterior of the housing and spindle tube.

(d) Undo the five screw screws, which held the lid of housing and lift the lid and spindle assembly off the housing. Clean the inside of the housing and dry it thoroughly, if damp. Clean the glass cover of the window. Grease the threaded socket at bottom, which goes over 13mm pipe.

(e) Put a drop one or two of clock oil in the worm and over the teeth of the gear wheel.

(f) Similarly, put a drop of spindle oil down the inside of the spindle, projecting out at top. The oil will go down the spindly through the top bushing and will lubricate the ball bearing below it.

(g) Apply a drop of clock oil below the worm and gear where the lower thrust bearing is just visible in the slot of the tube. This will lubricate the lower thrust bearing.

(h) Now re-assemble the anemometer.

Dust and other foreign matter may get into the instrument case and settle on the revolving parts. The bearings and gear also require thorough cleaning and lubrication once in while. The instrument should therefore be carefully inspected and all the bearings thoroughly washed, cleaned and lubricated at interval of six months (and especially after every dust storm).

Rainfall and its measurement

Precipitation :- Precipitation is expressed as the depth to which it would cover a horizontal projection of the earth's surface, if there were no loss by evaporation, run-off or infiltration and if any part of the precipitation fall as snow or ice were melted.

Rainfall :- The simplest method of measuring precipitation is by setting up gauges with a horizontal circular aperture of known area, collecting and measuring at regular intervals the precipitation collected in them. It is assumed that the amount of precipitation collected in the gauge is representative of a certain area around the point where the measurement is made.

Measurement of Rainfall:-

The amount of rainfall at a station is measured by a rain gauge The recommendations of the World Meteorological organization for the use of Fibre Glass Reinforced Polyster (FRP) Raingauges as the standard instruments at all raingauge station in the country.The essential parts of a raingauge are (1) a collector with a gunmetal rim truly circular shape 100 or 200 sq. cm. area. (2) base (3) a polythene bottle and (4) a measure glass.

Both the collector and the base are made of fibre glass reinforced polyster. The collector has a deep-set funnel and the complete raingauge has a slight taper with the narrowest portion at the top. The collectors have their apertures so designed that the 100 and 200 sq cm area ones are interchangeable. The small collector has a diameter of 112.9mm corresponding to 100 sq.cm and the bigger one is of 159.6 mm diameter corresponding to 200 sq cm. There are also two types of interchangeable base, the small base being used for all types of receivers except the largest. The rain fall into the funnel collect in the bottle kept inside the base and is measured by means of special measure glass which is appropriate to the area of the aperture and which is graduated in the tenths of millimeter. This has usually a capacity of 20mm of rain.

Exposure of Raingauge :-

The amount of precipitation collected in a raingauge depends to a considerable extent on its exposure and great care must be exercised in selecting a suitable site. The raingauge should be set on a level ground away from trees, buildings and other obstructions and not upon a slope or terrace. The distance between raingauge and obstacles should be as far as possible 4 times the height of the obstacle. In any case, the distance between the rain gauge and the nearest object should not be less than twice the height of the object above the rim of gauge. (Subject to the above conditions, a position sheltered from wind is preferable to an exposed one.)

In order that the observations at different stations are comparable, the exposure must be as uniform as possible at all stations. The rim of the rain gauge should be exactly horizontal and remain at a height of 30cm, above the ground level. This rule must be strictly adhered to in the erection of the instrument. The site of the thermometer screen should be so chosen that the raingauge could be placed at the plot of ground at a distance of 3.6mtr from the screen to its south.

Erection of raingauge:-

The rain gauge should be fixed on a masonary of concrete foundation 60X60X60 cm sunk into the ground. The base of the gauge should be embedded in the foundation, so that the rim of the gauge is exactly 30cm, above the surrounding ground level. The height is necessary to prevent more than a negligible amount of rain splashing into the gauge from the surrounding ground. If the height exceeds the 30cm limit, a positive correction to catch of the rain gauge will be necessary, since the catch decreases owing to wind eddies set up by the gauge itself. The rim of the gauge should be kept perfectly level. The horizontally should be checked with a spirit level laid across the rim.

Care of the rain gauge and rain measures:

- It should be ensured that the collector of the rain gauge doesn't get chocked with dirt and the receiving bottle and additional cylinder, if any, are always clean. They should be emptied regularly of sediment or other material that may have fallen in to them and cleaned periodically.
- The outer surface of the visible portion of the raingauge should also be kept clean by wiping it occasionally with a wet cloth. The rain gauge doesn't need any painting and this should not be attempted any time.
- The collector, receiving bottle (and additional cylinder, if provided) and the base should be examined for leak regularly. If found to be leaking, they should be repaired either locally if possible with the aid of repair kit or replaced by refresh components.
- While replacing the collector on the base it should be ensured that the two locking rings have engaged properly. The locking ring fixed to the collector and base are delicate and should not be handled roughly.
- Care should be taken not be dent or deform the gun metal rim of the collector by rough handling.
- The rain gauge should always be kept locked for safety.
- The grass round the gauge should be kept short. No shrubs or plants should be allowed to grow round the gauge.
- Both the rain measures glasses should be kept spotlessly clean. They should be handled gently to avoid breakages and stored dry in a safe place when not in use. Always, wipe it dry before leaving it in the Thermometer screen after use. This is very important in freezing weather when there is risk that it may become frozen to the wood by any residual water left adhering to the base.

Snow Gauge :

Description and working, measurement of snow:

Snowfall is measured either as the depth of snow which has fallen in a stated period, or melted and measured as water. The depth of snow is usually measured in millimetres and its water equivalent in millimetres and tenths obtained by dividing the snow depth by 10, assuming the density of snow as 0.1. This value is however, only a rough approximation and varies very much with the depth and texture of the snow. For accurate measurement of precipitation at stations where snowfall is likely, special snowgauges are used.

A snowgauge consists of a cylindrical receiver 203 mm or 127mm in diameter, mounted on an iron stand at such a height as to be well above the average snow level at the station and provided with wind shields. Unshielded gauges are quite unreliable in strong winds because their catch may either be increased by drifting snow or blown off by the wind eddies around the mouth of the gauges.

At the stations where the snow gauges are not available, the snow is measured with the ordinary raingauges if the snowfall is light. In heavy snowfalls, the depth of snow is measured with snow poles and the water equivalent of snow determined; or cut samples of snow taken, melted and measured as water in ordinary 127 mm measure glass.

CHAPTER 2

Clouds and their descriptions, Visibility, weather

Objectives: After reading this article, reader will be able to:

- Define and identify the clouds by their appearance
- Classify the types of clouds
- Measure the heights of clouds
- Distinguish between the genera of clouds
- Explain the movement of clouds
- Describe Visibility, land marks, and night visibility
- Describe present/past weather phenomenon
- Understand wave observations, recording of surface observations and entries in meteorological registers

Clouds

Definition :- A cloud is visible aggregate of minute particles of water or ice or of both in the free air.

Appearance of clouds :- It is determined by the nature, sizes, number & distribution in space of its constituent particles. It also depends on the intensity & colour of light received by the cloud and relative position of the observer and source of light (luminary) with respect to the cloud. It is best described in terms of the dimensions, shape, structure, texture, luminance & colour of the cloud.

Luminance (brightness) :- It is determined by the light reflected, scattering and transmitted by its constituent particles. Light comes directly from the luminary or from the sky, it may also come from the surface of the earth.

Colour : - When the sun is sufficiently high above the horizon, clouds or portions of clouds in direct sunlight are white or grey, parts which receives light mainly from blue sky are bluish grey. Cloud colours also vary with height of cloud and its relative position with regard to observer and sun. When the sun is closed to or below the horizon high clouds may look almost white while clouds at the middle level exhibit a strong orange or red colour and very low clouds in the shadow of the earth are grey.

A cloud observation consists of : -

(i) Identifying the form of cloud
(ii) Estimating its amount
(iii) Estimating the height of its base above the station level
(iv) Determining the direction of its movement.

Classification of clouds :- Clouds are classified as low, middle or high level according to their base heights. These are not rigid classifications as there will be some overlap in the heights and variation with latitudes. Each cloud observation should be treated on its merit

Cloud Height :- Cloud Height is meant the vertical distance of the base of cloud from the ground level. If the cloud base is diffuse and irregular, the height of the lowest patch of such clouds should be reported. Cloud height can be measured with the help of balloons or by cloud search light at night. At stations where these facilities are not provided cloud height can only be estimated.

The height of base of low cloud is measured by means of balloons called "Ceiling balloons" which are filled with hydrogen and released with known rate of ascent. The time of travel between release of the balloon and its disappearance into the cloud is measured by means of a stop watch. If the rate at which the balloon is ascending is 'n' metres and it takes 't' minutes to enter the cloud the height of the base is n't' meteres above ground

The method has its own limitation but as guide line , the following may be kept in view:

(i) As far as possible the balloon should be released at such a time when it is most likely to enter the lowest cloud layer.

(ii) The observer should be able to determine by some practice when the balloon enters cloud especially when thin shreds of stratus are present.

(iii) Ceiling balloon should not be released during rain or drizzle as the constant rate of ascent may not hold good under such circumstances.

Cloud Heights (WMO)

Stages	Tropical Region (30ºN-0º-30ºS)	Mid-Latitude (Temperate Zone) 30ºN-S-60ºN-S	Polar regions (60ºN-S -90ºN-S)
High	20,000-60,000 ft	16500-45000ft	10000-25,000 ft
	6-18 km	5-13 km	3-8 km
Middle	6500-25000 ft	6500-23000 ft	6500-13000 ft
	2-8 km	2-7 km	2-4 km
Low	0-6500 ft	0-6500 ft	0-6500 ft
	0-2 km	0-2 km	0-2 km

Cloud Forms : - Clouds are continuously in a process of formation or dissipation and appear therefore in an infinite variety of forms. However, some characteristics forms frequently observed all over the world; and these form the basis of the classification of clouds in 10 main groups.

Cloud Amount : - The international unit for reporting cloud amount is "Okta" or 1/8th of the sky. When the sky is completely cloudless the amount is 0 and when it is completely overcast, without any opening or gaps, the amount is recorded as 8. In estimating the partial amounts of the different cloud forms present at the time of observations. The observer should estimate how many oktas of the sky would be covered by each form if it alone were present, disregarding the other forms below or above it.

Cloud Names : - The names of clouds are descriptive of their type and form. Two Main groupings of clouds, Cumiliform Clouds refer to cumulus – type formations in which the clouds are usually separated from each other by clear spaces. By contrast stratiform clouds form sheets or layers covering large areas of the sky.

Cloud Genera : - Ten main groups of clouds can be distinguished. Each is called a genus, the plural being denoted by the word genera. Each genus may be further sub-divided into species and varieties, However , we shall not consider these subdivision at this stage.

Clouds are grouped into the ten following genera :

High Clouds

(1) Cirrus (Ci) (2) Cirrocumulus (Cc) (3) Cirrostratus (Cs)

Medium Clouds

(1) Altocumulus (Ac) (2) Altostratus (As) (3) Nimbostratus (Ns)

Low Clouds

(1) Stratocumulus (Sc) (2) Stratus (St) (3) Cumulus (Cu)

(4) Cumulonimbus (cb)

Direction of Movement of Cloud : -

A few departmental observatories have been provided with an instrument called '**Nephoscope**' for measuring the direction of movement of cloud. At other observatories, the direction of movement of cloud is visually estimated nearest to the eight points of the compass (i.e. N, NE, E, SE, S, SW, W and NW) , from which the predominant low cloud and predominant medium or high cloud are coming. This id done by observing the movement of the cloud against a fixed point like a pole erected in an open space, corner of a building or star at night. ***(Explain why cumulus clouds are conspicuously absent over a cool water surface?).***

Cumulus clouds are formed by convection i.e. due to thermal. On the cool water surface evaporation will be less & environmental lapse rate will be smaller, therefore less possibility of formation of cumulus clouds. ***(Why are cumulus clouds more frequently observed during the afternoon?).***

During the afternoon air temperature is more & more instable i.e more environmental lapse rate, so warm parcel will be taken at considerable height to achive condensation level and due to instability of atmosphere it will grow further to form cumulus cloud in the atmosphere.

Why cumulonimbus clouds have flat tops?

Cumulonimbus clouds develop up to upper most limits up to tropopause. After tropopause there is stratosphere where the temperature rises. At tropopause it stops vertically & spread horizontally. The low temperature at this altitude produces ice crystals in upper section of cloud. High wind near the tropopause blows the ice crystals horizontally producing the flat anvil shaped top.

Describe the conditions necessary to produce stratocumulus clouds by mixing?

Stirring of moist layer of stable air will produce a deck of stratocumulus clouds. If the air is stable and close to saturation and suppose a strong wind mixes the layer from the surface up to an elevation of 600m. Lapse rate will steeper as the upper part of layer cools and the lower part warms. At the same time mixing will make the moisture distribution in the layer more uniform. The warmer temperature and decreased moisture content causes the lower part of the layer to dry out .On the other hand, the decrease in the temperature and increase in moisture content saturates the top of the mixed layer, producing a layer of stratocumulus clouds.

Care should be taken to avoid the following:

- **(i) Wrong identification of clouds.**
- **(ii) Incorrect reporting of cloud amounts.**
- **(iii) Reporting of high cloud when the sky is overcast with low clouds.**
- **(iv) Wrong reporting of height of base of clouds.**

Visibility

Definition :- Visibility defined as the farthest horizontal distance at which a person with normal vision can see an object under normal day light condition (such as a tree or a building) distinctly enough to recognize it.

Visibility during night may be defined as the longest distance upto which light of moderate intensity can be identified as such. Therefore the criteria used for day light visibility cannot, therefore, be used for night measurement.

The first step in estimating is to choose some prominent object called visibility landmarks situated at standard distance as laid down in the visibility code or a near to them as possible, preferably within 10% margin An ideal visibility land mark should be an object intrinsically dark in colour and so placed that it can be viewed against horizon sky or other light background. Minarets, towers, factory chimneys and like objects can serve as good land mark for shorter distances while for longer distance larger objects like hills and large building would be better, as they can be easily seen without straining the eyes.

Visibility in different directions :- When visibility is different in different direction, the lowest figure should be reported in the weather telegram but in the register visibility in the different direction should be entered as under 95E, 96 NW, 98.This means that visibility is represented by code figure 95 towards east, 96 towards NW and 98 in other directions. As 95 is the lowest code figure this will be reported in telegram.

Weather

Observation of weather are recorded under the heading present weather and past weather and phenomena observed are those specified in the codes ww and W1W2 in the weather code. In addition to reporting them in weather telegram, the observer is required to keep a detail record of weather in the register maintained by him giving the times of commencement and cession of each phenomenon.

Present Weather (ww) :-

The observation of present weather is actually nothing the state of the sky and the phenomena occurring at the station or within site of the station at the time of observation or during hour immediately presiding it. At the time of observations means during the period occupied in taking and recording the observation for a given hour namely ten minutes ending schedule hour of observation

Past Weather :-

The period covered by past weather different for different hours of observation and is governed by special rule.

Some Important Weather phenomena :-

Squall, Gustiness, Gale, Dust or Sand storm, Drizzle, Rain, Thunderstorm, Showers, Snow, Hail, Fog, Mist

Wave Observation

Waves are produced by action of wind over sea surface. Observations of waves are of practical importance in detecting the approach of a storm and locating the approximate position of its centre when other observations are lacking. Hence observers at coastal stations are required to record and report observations of wave in addition to other element like pressure temperature etc.

Simple Wave :- A simple wave is defined by the following characters

1) **Speed (cw) : -** Speed at which individual wave travel. It is usually express in knots.

2) **Length (lw) : -** Horizontal distance between successive crests or successive troughs (Express in meters)

3) **Direction (ddw) : -** Direction from which the waves are coming, measured in 16 points of compass.

4) **Period (pw) : -** Time travel required for passage of successive trough or crests. (Seconds)

5) **Height (H) : -** Vertical distance between the top of crest and the bottom of a trough. (Expressed in meters)

* For symbols please refer symbol card

Meteorological Register

All observations are to be entered in the Meteorological Register (Met –T-186(R)), in accordance with the instructions contained in the pamphlet “instructions for making entries in the Meteorological Register” supplied to the observatories.

Observations recorded at class V observatories are to be entered in the ‘Monthly weather diary’ for use at class V observatories (OBS-198) in accordance with the instructions printed thereon.

Evaporation and soil temperature readings are to be entered in separate registers specially supplied to the stations where these observations are regularly taken.

Punctuality is of the greatest importance in Meteorological observations and must be striven for at any cost. If, however an observation is taken earlier or later than the fixed hour, the actual time when the observation was taken is to be indicated against the time.

CHAPTER 3

Objectives: After reading this article, reader will be able to:

- Understand various self recording instruments
- Explain their descriptions, working principles
- Describe their operations and maintenance

SELF RECORDING INSTRUMENTS

General description : - Instruments, which have been designed to give a continuous record of the values of the meteorological elements on a chart, are known as self-recording or autographic instruments.

The main parts of these instruments are : -

1. A sensitive element, which responds to changes of the meteorological parameter, which the instrument registers.
2. A system of magnification such as levers or cams by which the minute movements of the sensitive element are magnified in a known ratio and transmitted to the arm of the writing pen.
3. A chart drum rotating by means of clockwork for ink recording.

General instructions applicable to the self recording instruments given below :-

A. Cleanliness : -

All the self-recording instruments should be kept clean by wiping with damp cloth (External parts). Cleanliness improves performance, lengthens their useful life and improves their appearance. A camel hairbrush can be used every morning for internal cleaning of levers etc. See that no ink or oil is spilt on the instrument. If any is spilt by accident take care to wipe if off at once. Oil should not be used in autographic instruments for lubrication as dust collected in oil may hamper proper functioning.

B. Care and Punctuality : -

A well maintained self-recording instrument offer a means of determining either directly or indirectly the absolute value of meteorological parameter recorded at any instrument. The observer should, therefore watch the performance of the instruments frequently and see to it that no part of the record is lost.

This may generally happen due to:

1) Stopping of the clock

REMEDY:-

(i) The clock should be wound regularly once in every week.

(ii) Over –winding of the clock should be avoided.

(iii) Clock is to be oiled once in six months (One or two drops)

2) Drying of the pen

REMEDY:-

(i) Each morning the pen is to be recharged with a few drops of ink.

3) Pen going beyond the range of the chart

REMEDY:-

(i) Adjust the range of the chart so that the mean valus are almost at the centre of the chart.

4) The instrument are kept free from damage to the sensitive element

REMEDY:-

(i) Do not close the hinged cover with a bang.

(ii) Pen setting should be done slowly without causing undue strain on the sensing element.

Magnifying mechanism (Lever or Cams) is not to be tampered.

Control observation are taken regularly

Time marks are made regularly on the charts by depressing the pen between 3 to 4mm. The three main causes of error that can affect the timing of the record are:-

(i) Backlash between the drum and spindle.

(ii) Error in the clock rate.

(iii) Errors due to change in length of the chart with humidity variations

Following particulars must be entered in each chart :

(i) Name of the station.

(ii) Name of the maker of the instrument

(iii) Serial number of the instrument.

(iv) The actual time (IST) correct to a minute, at which the chart was set (While chart is being loaded)

(v) The actual time (IST) correct to a minute, at which the chart was removed (Immediately after removing from the drum).

(vi) The actual time (IST) correct to a minute of each time mark, the corresponding reading of the control instruments and chart readings, as given below.

- For thermograph, reading of the Dry bulb Thermometer corrected for index error.
- For barograph reading of the barometer corrected for index error, reduced to standard temperature and gravity.
- For Hair Hygrograph relative humidity as calculated from dry bulb thermometer and wet bulb thermometer after applying index correction.
- In case of rainfall, total rainfall for previous 24 hours measured out from the ordinary rain gauge should be entered.
- For daily recording instruments, there will be 3 or 4 marks per day. For weekly recording instrument one mark for each day.
- The difference between eye readings and chart readings should be worked out.

Correction obtained should not exceed following limits:

Thermograph	± 1.0ºC
Hygrograph	±6%
Barograph	±1 hpa

FRICTION : - Occasionally lubricate the bearings of the instruments. First remove dust with clean brush and then put a drop of good clock oil in case of DPTA. Do not lubricate the pivots of thermograph, Hair Hygrograph and the barograph.

PEN PRESSURE : -

The friction between the pen and the paper is usually much larger than the total amount of friction in the bearings of the instrument. The pressure of the pen point on the chart therefore requires careful adjustment. Too much pressure might result in a thick steppe trace, while too little pressure might not ensure sufficient flow of ink and result in loss of records.

The correct pen pressure is that for which the pen falls away from the chart when the instrument (With base) is tilted forward at an angle of 30º.

ROUTINE DUTIES : -

(1) **Setting of charts**:

Lift the pen from the old chart by means of pen lifter. Note the time correct to minute

(i) Remove the drum.

(ii) Wrap the chart closely on the drum such that :

There is no air pocket between drum and chart. Lower edge of the chart rest on the flange of the drum.

See that bottom and top lines of the chart are continuous.

Replace drum on the clockwork.

Rotate the drum clockwise to set the chart to a proper time.

(2) **Ideal trace**:

I. The record on the chart, which is as thin and fine as possible without becoming illegible or without the pen scratching the paper.

II Inking of the pen: Normally one drop of ink is sufficient for a day.

III Renewal of the pen:

Note down the type of the pen and correct pen arm length before renewing the pen.

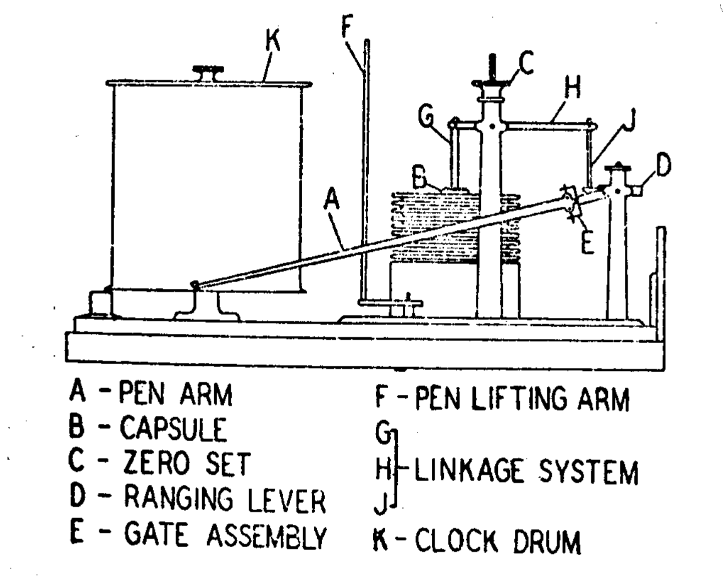
Aneroid Barograph

Barograph:- The barograph is an instrument which gives a continuous and automatic recording of atmospheric pressure.

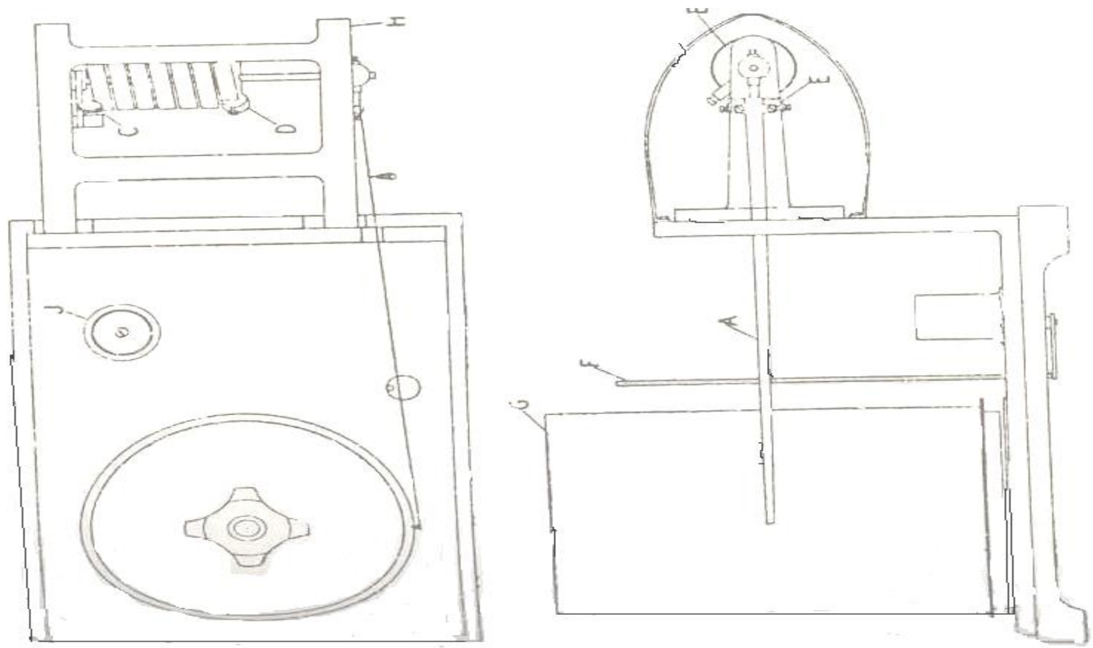
Instrument:- The barograph is a portable instrument for the continuous and automatic recording of atmospheric pressure exerted at a given location over a period of time. The essential parts of the barograph are an aneroid element, which is sensitive to changes in the atmospheric pressure, a system of livers and a clock mechanism, which drives a drum on which a chart is wrapped or wound. The movement of aneroid element, which either expands or contracts due to changes in the atmospheric pressure is magnified by a system of livers and recorded by a pen on the chart graduated in units of pressure.

The aneroid element consists of a closed circular box of a thin metal shit; partly or fully evacuated and a strong steel spring, contained within it. The spring operates to keep the box from collapsing under the external pressure of the atmosphere and at a given pressure there will be equilibrium between the force due to air and that due to the spring

ANEROID BAROGRAPH



BIMETALLIC THERMOGRAPH



(A) Pen Arm (B) Helix Spring (C) Zero Set (D) Ranging Lever (E) Gate Assembly (F) Pen Lifting Arm (G) Clock Drum (H) Guard For Helix Spring (J) Ink Bottle Container.

THERMOGRAPH

Thermograph is an instrument used for obtaining a continuous and automatic record of temperature of the surrounding air**.**

Principle : - Thermograph consists of a temperature sensitive element connected by a system to a pen recording on a chart fixed on a drum driven by a clock work mechanism. The sensitive element of thermograph used for normal recording of temperature is a bimetallic strip. Two alloys having widely different coefficient of expansion like invar (Nickel/Zinc) and bronze (Cu 88%, Sn 10%, Zn 2%) or steel and brass (Cu 60-90%, Zn 40-10%) welded together or rolled together in the form of a thin single strip to form a the bimetallic element. It is either bent to form an arc of a circle or wound into a close helix of several turns with the metal having the higher temp. coefficient of expansion on the outer side.

One end of the arc or helix is rigidly attached to the frame of the instrument while the other end is fixed to the horizontal spindle to which pen arm is screwed. The coefficient of expansion of invar is less compared to that of bronze. So when temperature changes the curvature of helix or arc increases or decreases or spiral coils or uncoils as a result of the different expansion of the two metals. The movement is transmitted to the pen point and is recorded on chart called thermogram fixed on a resolving clock drum. (Brass 19×10^{-6} / º C, Steel 12×10^{-6} / º C linear coeff. of expansion).

Description : - The bimetallic thermograph, in general contains a bimetallic helix. The bimetallic helix is formed from aqua flex or coflex strips 560 mm long, 6 mm wide, 0.6mm thick. The strip is wound in the form of a close left handed helix of about 6 turns with the metal with larger coefficient of expansion on the outer side.

The thermograph is mounted within a frame consisting of two brackets and a protecting guard. The whole unit is mounted on a vertical sidewall of the base. One end of the helix is rightly anchored to a setting arm, which in turn is attached to one bracket of the frame. A fine adjustment screw enables the setting arm to be rotated about the horizontal axis passing through the centre of helix against the pressure of a steel spring (Beryllium copper). Coinciding with the horizontal axis of the helix is a stainless steel (brass) spindle, which can revolve freely in a bush in the bracket and which passes through the outer bracket of the frame.

The spindle also passes through a hole drilled at right angles to the axis of a small brass column, which is rigidly by a screw to the free end of the helix.

Another screw ensures that the column cannot rotate relative to the spindle. The pen arm is carried by a normal gate suspension, which is attached to the end of the spindle that extends beyond the frame. A small screw fixes the suspension rigidly to the spindle. The length of the pen arm from the tip of the pen to the spindle axis exactly 185mm. As the temperature changes the end of the bimetallic helix rotes round its axis and at the same time causes the spindle and pen arm to rotate. The chart used in IMD to record the temperature in a day is No. 15 with a range, each small division being 0.5^0 Celsius. No fixed ranges of temp are printed on the chart, though hours lines are drawn on the chart. This enables alteration of temperature to suit local and seasonal requirement.

Installation : - In order to record free air temperature the thermograph should be exposed in a large Stevenson screen in observatory enclosure. It must be so placed in the screen that the sensitive element (Bimetallic Strip) is at least 15cms from the louvered sides. In the same screen for comparison a dry bulb thermometer may also be placed with its bulb near the sensitive element and at a horizontal distance of about 15cm from it.

Operation : - Ensure that the chart is properly placed on the rotating clock drum. See that corresponding lines on the chart are coincident at the bottom flange with the base of the chart touching, the bottom of the drum surface. Wind the clock, after fitting the drum on the clock-work. Now gently move the pen arm with the finger over the drum and check whether it traces an arc parallel to the hour line on the chart. Ink the pen properly and ensure its recording correctly by proper cleaning the pen. Time marks must be put on the thermograph during main synoptic hours for scrutinizing.

Accuracy : - Friction is the main source of error in the bimetallic mechanism. One cause of this is due to bed alignment of the helix with respect to the spindle. Unless accurately placed, it acts as a powerful spring and if improperly anchored it pushes the spindle hard against one side of the bearing. Friction in the bearing can be minimised by proper alignment and effective lubrication. Friction between the pen and the chart can be kept to a minimum by proper adjustment of the gate suspension for optimum pen pressure and also by squaring of the tip of the pen to have a smooth finish.

Precipitation

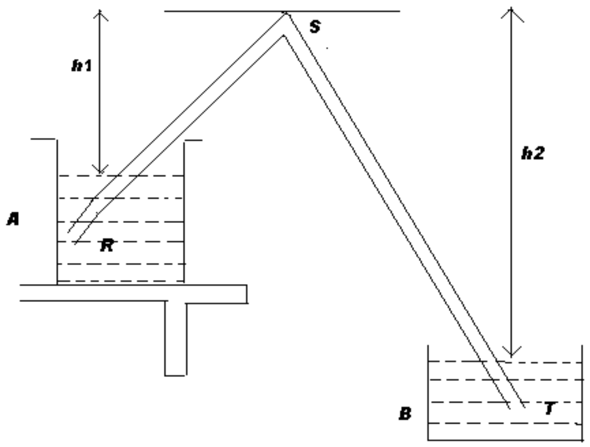
Definition:- Precipitation, whether it is rain or snow is expressed as the depth to which it would cover a horizontal projection of the earth's surface, If there were no loss by evaporation, run off or infiltration of if any part of precipitation falling as snow or ice were melted.

Measurement of Precipitation,:- The simplest method of measuring precipitation is by setting up a gauge with a horizontal circular aperture of known area, collecting and measuring at regular intervals the precipitation collected in there.

Siphon:- Siphon is a tube which is bent at a point that it has two unequal arms SR and ST. It is used for transferring liquids from higher to lower levels. The siphon is completely filled with the liquid and is so inverted that the end of its arm RS is immersed in the liquid at the higher level and that of the arm ST lies in the vessel at a lower level. The liquid filled in the longer arm falls in the lower level due to its weight and causes a momentary vacuum at the upper most point of the tube. It is filled in by the liquid rushing in as a result of excess atmospheric pressure on the liquid surface in the vessel at higher level over the highest point of bent tube. Thus, successive fall and rise of the liquid in the longer and shorter arms respectively maintain a constant flow of the liquid till either the vessel at higher level is exhausted or the heights of the bent portion of the siphon over the surfaces of the liquid in the two vessel become equal.

Siphon

Diagram:-



Self Recording Rain Gauge (S.R.R.G.) OR (Natural Siphon Recording Rain Gauge)

SRRG is an instrument designed to establish a continuous and automatic record of rainfall apart from recording the total amount of rainfall. It also records: -

1) The time of beginning and ending of rainfall and hence the duration of the rainfall.
2) The rate of rainfall i.e. Intensity

It is usually used along with an ordinary rain gauge which is installed close to it at a distance of 3 meters and is used as a standard by means of which the recording of the S.R.R.G can be checked.

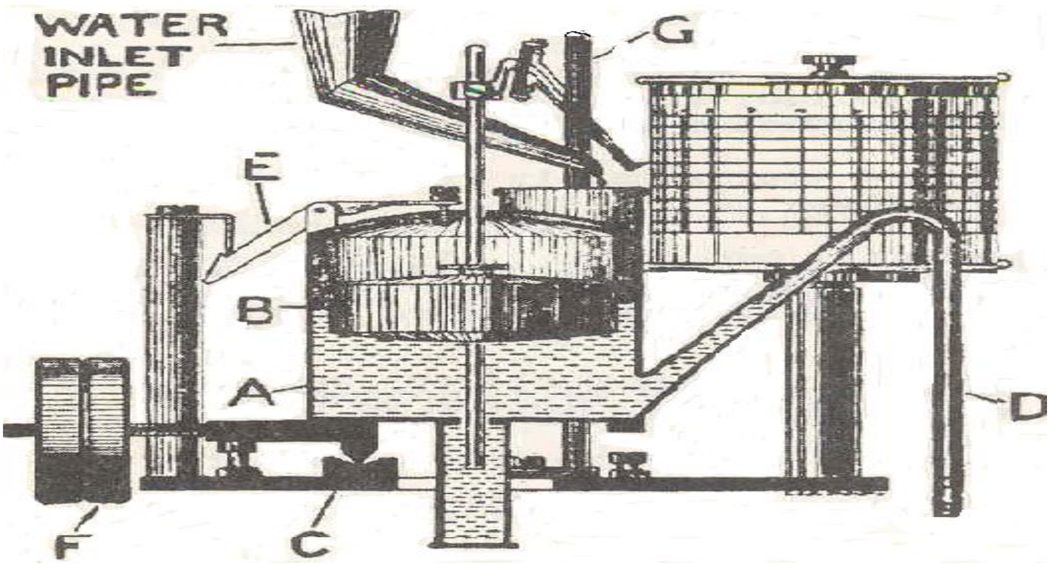
The rain water entering the gauge from the top of the cover which is led through the funnel to the receiver, consisting of a float chamber and a siphon chamber. The pen is mounted on the stem of float and as the water level rises in the receiver, the float rises and the pen records on a chart (placed on a clock drum) the amount of water in the receiver. The clock revolves ones in 24 hrs, so that a continuous record of the movement of the pen is made on the chart. Siphoning occurs automatically when the pen reaches the top of the chart and the pen comes down the zero level as the water is siphoned out. As the rain continue the pen rises again from the zero line of the chart and when there is no rain, the pen draws a horizontal line. The siphon chamber is directly connected to the float chamber through a “V” shaped disc.

A glass piece is placed over the joint of these tubes – the pen edge connecting. The two tubes at this joint is of almost capillary dimensions but the sectional area is large enough to discharge the water with a sufficient speed. The upper end of the inside tube is correctly adjusted so as to start the siphoned when the level of water has risen to definite height and the flow continue till the water level fall to a certain depth. The water column is restricted in a definite depth by an air bubble, which gets into a capillary and thus freedom from dribbling is ensured. After siphoning some water remains in the chamber just enough to float the float.

The passage connecting to a chamber is closed by a brass disc with “V” shaped opening in it. This ensures that a siphoning ends sharply and always at the same level of water in the float (By loosening four side screws and sliding up or down siphon tubes the siphoning level can be adjusted. After adjusting the four screws are tightened)

By allowing an air bubble to escape and break the water column so as to ensure capillary action the distance between glass cap and discharge tube must be small (In order of 2 mm). By changing the chart daily the observer must test the siphoning by pouring water into the chamber and a trace should be taken while the pen goes up and down. The time taken for one siphoned is about 5 sec.

SIPHON RAIN RECORDER



DINES PRESSURE TUBE ANEMOGRAPH:

A – Float Chamber. **B- Float.** **C- Knife Edge Pivot**

D- Siphon Tube **E- Trip.** **F- Counter –weight**

G- Automatic Pen Lifter.

The DPT Anemograph is an instrument used to get an automatic& continuous record of wind speed and direction.

The instrument mainly consists of two parts, the head-which is exposed to the wind & the recording apparatus, which is kept inside a room. Metal tubing & tubular shutting connect the two parts to each other.

The head is given free exposure to the wind by direction. At the top of the mast, the head consist of a horizontal tube that is open only at one end. The open-end faces the wind. The pressure of the air is raised by an amount that increases with the wind speed.

Now consider similar tube perforated with small holes. The tube is set into the winds by means of the weighing & suction tube around which rows of holes are made, which are exposed to the wind. The tube is held vertically so that the wind blows past the holes, the pressure inside the tube is reduced. Thus there is a suction effect.

The effect of wind is to produce the pressure in the former & the suction in the later, both dependent on the wind velocity.

Velocity Recorder :- The velocity recorder consists of specially designed copper float, which is crossed at one end. This float is placed with its open end downwards inside a vessel, which is partially filled with water**.**

A rod fixed to the top of float, passes through screw on an airtight collar in the cover of vessel. This rod carries a pen that records the movement of the float on a chart, fixed around a clock drum. The shape of the float is calculated mathematically according to the low governing relation of the pressure to wind velocity, for that an even velocity scale is obtained. The open-ended tube in the weighing is connected to a tube that opens just above the water level under the float by means of tubing through a stopcock. Pressure exerted on the bottom of float rises up according to the pressure, which in turn is proportional to the wind velocity. The suction tube is connected to a tube fixed just above the float by means of tubing through a stopcock. When air is sucked through the succession halve the effect is transmitted to the top of the float.

The resultant motion of the float due to the pressure created under it & the succession above it is transmitted to the chart. Every day the observer after setting the chart should see that the velocity-recording pen comes to zero line when both the pressure and succession cock are crossed. Also the water level in float chamber should be maintained to touch the water level indicated by adding water or removing water.

Direction recorder: - The direction rod is connected to a vertical cylinder on which is cut a double helix. The weighing is connected to the helix by means of the direction transmitting tube. Its rotating moments are transmitted to the recording pens as linear displacement in the vertical plane. The upper pen arm is so balanced with counter weights such that the upper pen always tends to rise and the lower pen is balanced so that the pen tends to firm. The upper & lower arms formed in the helix, controls the motion of both the pens when the wind oscillates above the north the record will be obtained at the bottom & the top of the scale. The circular scale (Disc) fixed above the direction tube provides an extra indication of the wind direction.

At any time one of the pen's rest on the top or the bottom north lines. If the wind direction as shown by the acting pen reaches the north line on which the other pen is resting, the acting pen immediately returns to the other north line & further variations in the wind direction are shown by either pen according to whether the wind veers (Lower pen becomes the acting pen) or backs (Upper pen comes to operation).

SUNSHINE RECORDER

It is an instrument used for measurement of the duration of bright sunshine during a day.

Principle : - The sun's rays are focused by means of a glass sphere upon a prepared card board strips graduated in terms of time , whenever there is sun shine only that portion of the card is burnt and whenever the sun is covered by the cloud that portion of the card is not burned. As the sun moves across the sky, its focused image burns a trace on the card so that by measuring the trace at sunset, the duration of sunshine may be accurately recorded.

Instrument : - The sunshine recorder consists of a glass sphere mounted centrically in a section of a spherical bowl. The diameter of which is such that the sun's rays are focused sharply on the card held in grooves, which are cut in bowl. There are three overlapping pairs of groves each to take cards suitable in shape for different seasons of the year. The sphere and the bowl are made with great accuracy and the base on which they are mounted is so designed that the sphere is easily and accurately centered on the bowl. On the arm carrying the glass sphere is sealed denoting latitude (0-45º) or engraved the values corresponding to the latitude of the station where the instrument is involved is brought against the arrow mark given in the support in which the arm can be slit up & down by loosening the screws . After exact adjustment two screws are tightened.

Setting : - Setting of sunshine recorder properly is very important for the accurate records. Following point should be taken into account while installation of Sunshine recorder.

1) Sunshine recorder must be installed at a place where it has good exposure. The proper exposure for sunshine recorder is from the east-west direction line there should not be any obstruction 30º North & South of this east west line. If there is any obstruction the distance between the sunshine recorder & the obstruction must be at least 10 times the height of obstruction.
2) The base of the instrument must be perfectly horizontal.
3) The frame carrying the chart must be tilted and clamped to the correct latitude of the place of observation.

4) The instrument must be corrected oriented parallel to the meridian geographical North-South of the place.

If the instrument is properly installed the lourned will be sharp & parallel to the line through the centre of the card.

The card should be changed only after sunset each day. The three types of card used are short curved, long curved and straight card which are inserted in the proper grooves as shown in the figure according to the dates given below.

(a) **Summer Card (Long Curved card) :-** Inserted with their convex edge uppermost beneath the flanges marked summer card.

(b) **Winter Card (Short curved card) :-** Inserted with their concave edge uppermost beneath the flanges marked " Winter Card ".

(c) **Equinoctial Cards (Straight Cards) :-** Inserted beneath the central pair of flanges marked Equinoctial Cards.

Long Curved Card: - April 12 to September 2

Short Curved Card: - October 15 to February 28/29

Straight Card: - September 3 to October 14 & March 1st to April 11th

The burned should be at 12 hrs mark on the card 12 LMT (After applying correction for the equation of time)

Exposure :- It should be set up on a firm and rigid support , ideally in a place where there is no obstacle to obstruct the sun's rays at any time of the day at any time of the year.

A free horizon is required in north east through east to southeast, and north west through west to south west.

<u>Local Mean and Local Apparent Time</u>:-

Time indicated by the image of the sun on the sunshine card does not in general, coincide with an hour line printed on the card. This apparent discrepancy arises for the following reasons.

When the center of the sun is due south of an observer the time is called 12 hours or noon, local Apparent Time (LAT) . The sun is said to "transit " at this time and the interval between two consecutive transits is conventionally divided into 24 equal parts. However, the orbit of the earth is elliptical and so the time interval between successive transits is not in fact constant throughout the year. Since it is convenient to have "a day" of variable length for most practical purpose. A constant day has been defined for a mean sun whose apparent motion rounds the earth is uniform throughout the year. Time in this day of constant length is designated Local Mean Time (LMT) ; LMT at the Greenwich Mean Time is called (GMT). The difference in time between the earth's true behavior is expressed in terms of "equation of time".

Local mean time is obtained from Local Apparent Time by adding or subtracting the equation of time.

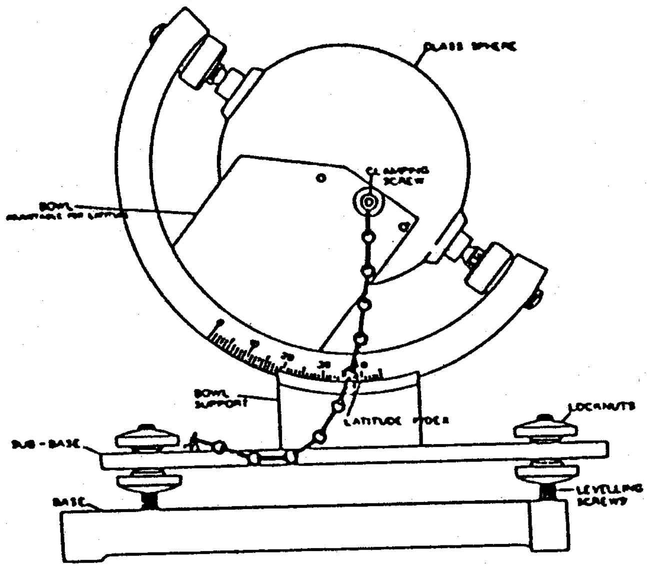
Time (GMT) of local noon = 1200-equation of time +/- longitude correction of four minutes per degree.

Date	**Sun's declination**	**Hemisphere** **Northern**	**Southern**
22^{nd} June	23 ½° N	A	E
21 April, 23 August	11¾° N	B	D
21 March, 23 September	0^o N	C	C
18 Feb, 25 October	11¾° S	D	B
22 December	23 ½°S	E	A

A= Summer solstice, C = Equinoxes, E = Winter solstices

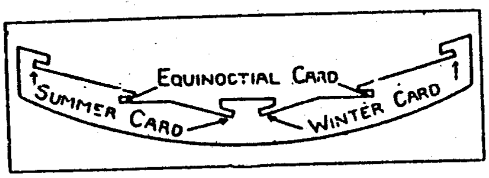
The Sun does not attain sufficient power to scorch the card until it is about 3^o above the horizon. Therefore, obstacles, which subtend an angle of not more than 3^o, do not cause loss of record. As a rough guide, an angle of 3^o is that subtended by an object 10m high and 200m away.

SUNSHINE RECORDER



Campbell- stockes Sunshine Recorder
(Universal Pattern)

Cross-Section of Sunshine Recorder Bowl



CHAPTER 4

Upper air Station Network, Ozone observations and data, Environmental Meteorology

Objectives: After reading this article, you will be able to:

- Explain Upper air observations in India and their networks
- Describe the Types of upper air observations
- List the importance of ozone observations and their networks etc.
- Discuss the importance of Environmental meteorology, their observations and networks etc
- **References**

Upper air Station Network

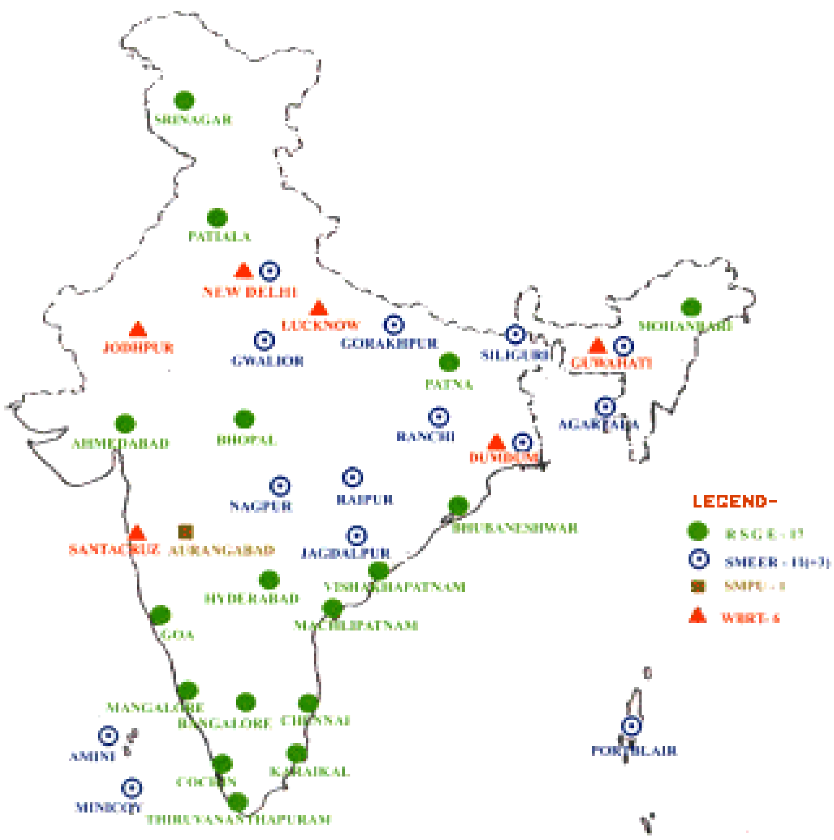
India belongs to that select group of countries who manufacture their own upper air and surface instruments. This is done by the meteorological department through in-house production facilities. The office of the Dy. Diretor General of Meteorology (Upper Air Instrument), New Delhi, consisting of Hydrogen Factory at Agra and Laboratories and Workshop at New Delhi, is responsible for co-ordination of all technical aspects related in the field of upper air instrumentation.

IMD's present Upper air observational network comprises 39 radiosonde and 62 pilot balloon observatories spread all over the country. Systematic upper air observations began in the Department in 1905 at Shimla. An upper air observatory was started in 1912 at Agra.

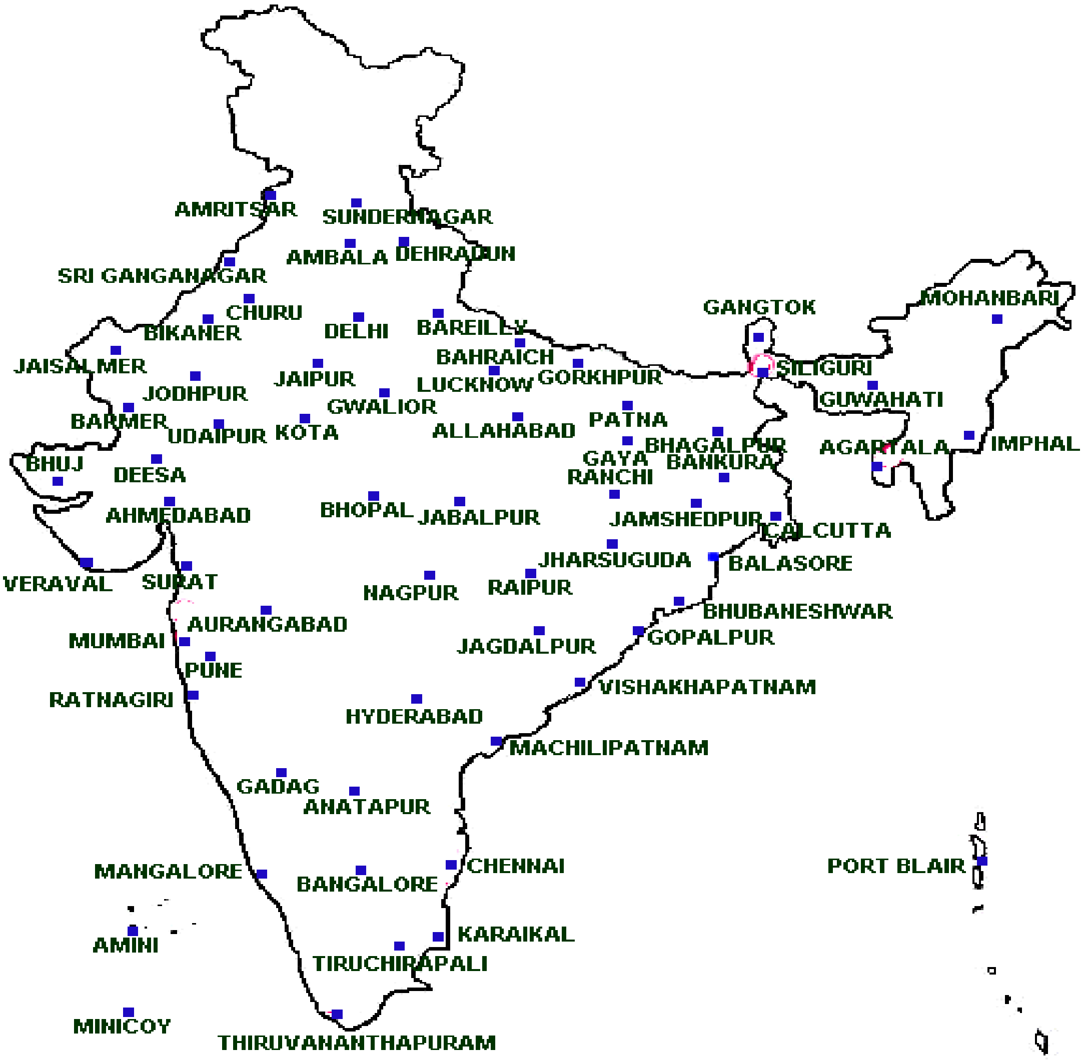
IMD manufactures its own radiosondes at its workshop in Delhi. IMD also supplies radiosondes to other agencies. Hydrogen gas is produced at Agra for Radiosonde observations.

Research and development for improving the quality of upper air data is an on-going process at IMD.

RS/RW stations ns in IMD



PB stations in IMD

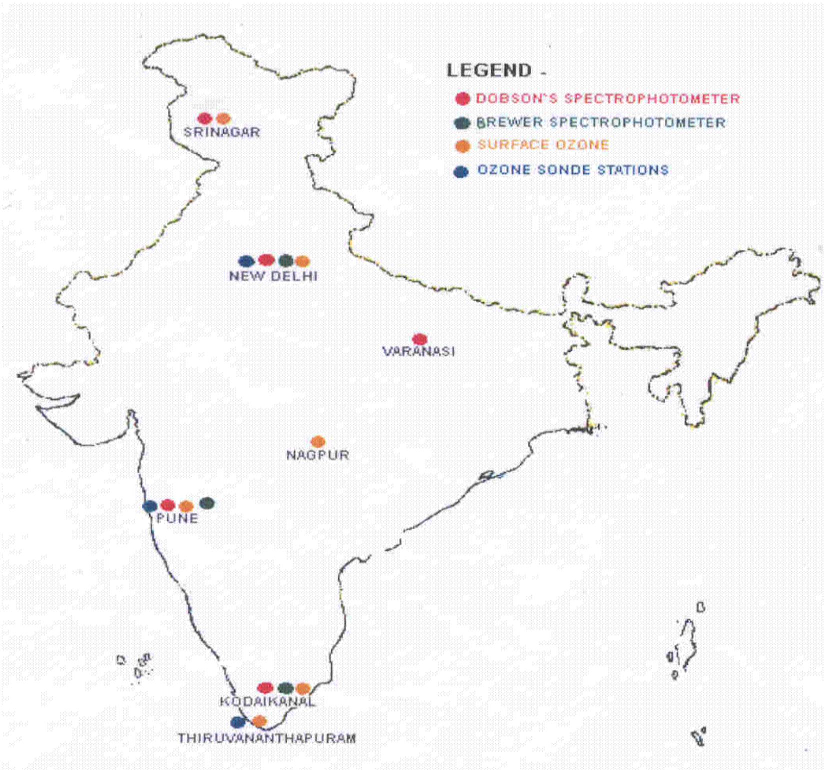


Ozone observations and data

IMD's National Ozone Centre at New Delhi is designated as Secondary Regional Ozone Centre for Regional Association II (Asia) of the World Meteorological Organisation. The centre maintains and controls a network of ozone monitoring stations including Maitri (Antarctica). Total ozone is measured with Dobson/Brewer Ozone Spectrophotometer from five locations including Maitri (Antarctica).

Vertical ozone profiles using indigenous balloon-borne ozone-sondes are observed fortnightly at 4 stations including Maitri. Surface ozone measurements using electrochemical method are recorded continuously at 6 stations including Maitri. Ozone data is being regularly sent to World Ozone Data Centre, Canada for archival. The data is available in the Internet on: http://www.woudc.org .

IMD is collaborating at both the national and international levels through international inter-comparison of instruments, conducting experiments to study tropospheric ozone over the Indian ocean, comparing satellite data with ground truth and studying diurnal and seasonal variations in the ozone layer over Indian and Russian stations.



INTRODUCTION

The *radiosonde* is a balloon-borne *instrument platform* with radio transmitting capabilities. Originally named a radio-meteorograph, the instrument is now referred to as a radiosonde, a name apparently derived by H. Hergesell from a combination of the words "radio" for the onboard radio transmitter and "sonde", which is messenger from old English.

The radiosonde contains instruments capable of making direct *in-situ* measurements of air temperature, humidity and pressure with height, typically to altitudes of approximately 30 km or more. These observed data are transmitted immediately to the ground station by a radio transmitter located within the instrument package. The ascent of a radiosonde provides an indirect measure of the wind speed and direction at various levels throughout the troposphere. Ground based radio direction finding antenna equipment track the motion of the radiosonde during its ascent through the air. The recorded elevation and azimuth information are converted to wind speed and direction at various levels by triangulation techniques.

A *rawinsonde* (or radio wind sonde) is a radiosonde package with an attached radar reflector that permits radio-direction finding equipment to determine the wind direction and wind speed at various altitudes during the ascent of the package.

History

While various efforts were attempted at remotely sensing the atmosphere with instruments on board unmanned free balloons, the current type of radiosonde dates back to January 1930, when Pavel A. Molchanov, a Russian meteorologist, made a successful radio sounding into the stratosphere. He launched his radiosonde at Pavlovsk. His goal was a cheap and expendable means of sounding the atmosphere for temperature, moisture and wind data.

Radiosondes were first used by the U.S. Weather Bureau in 1936. During that year a radiosonde network of several stations was inaugurated to obtain upper air soundings on a routine basis. Radiosondes can be launched in almost any type of weather. While the radiosonde is reasonably durable, severe thunderstorms and heavy precipitation may cause instrument failure or radio interference.

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RADIOSONDE COMPONENTS

The complete radiosonde system, or rawinsonde, consists of a balloon-borne radiosonde instrument package, a radio receiver , a tracking unit and a recorder . Additional Radiosonde background information is provided.

THE INSTRUMENT PACKAGE

The main component of the radiosonde is a sturdy, lightweight, white cardboard (or plastic) instrument package, approximately the size of a large shoe box. The package is attached to the train containing the balloon and parachute.

The following weather sensing instruments are located within or attached to this package:

THERMISTOR (Temperature sensor)

ROD THERMISTOR

A type of thermistor that has high resistance, long time constant, and moderate power dissipation; it is extruded as a long vertical rod 0.250-2.0 inches (0.63-5.1 centimeters) long and 0.050-0.110 inch (0.13-0.28 centimeter) in diameter, of oxide-binder mix and sintered; ends are coated with conducting paste and leads are wrapped on the coated area.

The *hygristor* is a humidity sensor consisting of a glass slide or plastic strip covered with a moisture sensitive film of lithium chloride (LiCl) and a binder; metal strips are located along the edges. The electrical resistance of the chemical changes with a change in the atmospheric humidity. The hygristor is located within the instrument package at a place where the outside air passes the hygristor. The hygristor on most radiosondes is designed to record the ambient relative humidity in the range from 15% to 100%.

Recently Licl type hygrister replaced by Carbon hygrister.

Carbon Hygrometer (Hygrister) (resistance type)

- Flat glass plate or other resistor material (plastic) is coated with matrix of carbon particles and binding material.
- Carbon absorbs water.
- Carbon particles separate and resistance increases.
- One of most common humidity sensors in radiosondes.
- Cheap
- Not accurate below -40oC
- Time Response: 10 - 20 seconds
- Accuracy: ± 5% RH

ANEROID BAROMETER

The radiosonde measures pressure by means of an *aneroid barometer*, consisting of a small, partially evacuated metal canister. This temperature compensated instrument is central to the instrument package. The volume of the canister expands as the radiosonde ascends, in response to a reduction in the atmospheric pressure aloft. The aneroid is designed to register pressures from 1040 mb to 10 mb or less. The aneroid also serves another function as described below. A pen arm is attached to the aneroid.

BAROSWITCH

A switching mechanism, called a baroswitch, was used on older radiosondes to switch between the two sensor and the reference elements. This baroswitch involves a contact arm connected to the barometer passes over the commutator bar. The commutator bar is a selector switch with 180 contact points; the switch occurs at approximately 10 mb intervals. The contact arm, responding to the pressure changes, moves across the contact points on the commutator bar.

Newer model radiosondes use a capacitive transducer with an aneroid capsule.

COMMUTATOR BAR

Alternating conducting and insulating strips are used to change the frequency. The conducting strip transmits humidity and reference information while the insulator strip transmits temperature information. Each fifth contact is a reference contact.

OSCILLATOR RADIO TRANSMITTER

A miniature radio transmitter generates the FM radio frequency carrier, operating on a modulated carrier frequency of 1680 MHz. Variable modulation is used to transmit the collected information. That is, the radio frequency is changed by the position of the contact arm on the baroswitch. The radio transmitter is located in the pointed plastic cylinder attached to the base of the instrument package. In flight this conical antenna housing is pointed downward. The new IMD-MK-IV radiosonde uses time division multiplexing for getting PTU data in place of sensor switching by the pressure sensor (As in IMD-MK-III radiosonde). The IMD-MK-IV sonde provides one full data (PTU) set at 2-second intervals. The Met data frequency range is from

35 to 1200 Hz. Existing aneroid in the baroswitch (Mechanical pressure sensor) is being used as a pressure sensor. For temperature rod thermistor continues to be used. Lithium Chloride hygristor has been replaced by carbon hygristor. The sondes are developed and manufactured at IMD. IMD is currently using 401 MHz(Sameer auto computation system) as well as 1680 MHz (IMS-1500) bands and . currently GPS enabled radiosonde is introduced for the new Radiosonde.

BALLOON & PARACHUTE

The radiosonde package is carried aloft by a spherically shaped balloon. The balloon is made of a film of natural or synthetic rubber (neoprene). Before launch, a neoprene balloon is inflated with lighter-than-air gas, typically hydrogen or helium, to approximately 6 foot (2 meter) diameter. This size provides sufficient lift to carry a radiosonde payload of several pounds. The thickness of the balloon skin ranges from 0.002 to 0.004 inch at the time of inflation, but becomes 0.0001 inch just before the balloon bursts. As the balloon ascends, it expands in size from approximately 6 feet to a diameter between 24 and 32 ft before it bursts. The balloon carries the instrument package to an altitude of approximately 25 mi (27-37 km) where the balloon bursts (at a pressure of approximately 10 mb).

An attached parachute returns the instrument package safely to the ground. Return mailing instructions are included in the instrument package. Those radiosondes that are found and returned can be refurbished for subsequent flights, saving a considerable amount of the cost of a new radiosonde.

GROUND UNIT

The processing software has capability of on line plots of PTU data, generation of T-Phi gram, TEMP message, Climate TEMP, Monthly registers etc. The processed data is available for about every 10 meters height at 0.15 deg temperature intervals. The software has provision for thorough check up of radiosonde at site, which include finding out characteristics for conversion of sensor resistance to tones (frequency) over the complete range and generation of new constants specific for the sonde. It can use calibration constants of the individual temperature and humidity sensor. Software has rigorous quality checks, for checking the correct contact numbers, identification of bad / noisy data, deletion / correction of the data, filling of missing data through its horizontal and vertical consistency checks.

The following equipment is located at the upper air observing station to track the radiosonde, receive the telemetry data and process these data into a useable form :

RADIO RECEIVER

ANTENNA

The antenna receives the telemetry signal transmitted from the radiosonde. Highly directional radio direction finding antenna is used also to obtain the wind speed and direction at various levels in the atmosphere by tracking the radiosonde and determining the azimuth and elevation angles. The ascent rate of the radiosonde is known and timed between intervals.

FREQUENCY METER

(Output to other devices)

PULSE CONTROLLER

RECORDER

THE LAUNCH

Before launch, calibration of the baroswitch is made, with appropriate adjustment. The battery is activated. The balloon is carefully inflated to such a size that it will provide the proper lift. The balloon, parachute and instrument package are attached. The radio equipment is tuned.

Just before launch the surface weather conditions are measured.

The balloon and instrument train is launched. Care is taken so that the radiosonde does not become entangled with local obstacles.

Tracking of the radiosonde is begun immediately upon launch. Visual observations are continued until the radar tracking has locked on to the ascending instrument package. The data are recorded automatically during the flight and then processed for transmission.

ADDITIONAL INFORMATION

We are getting the following parameters in addition to Pressure, Temperature and Humidity. From RS/RW ascent.

Tropopause

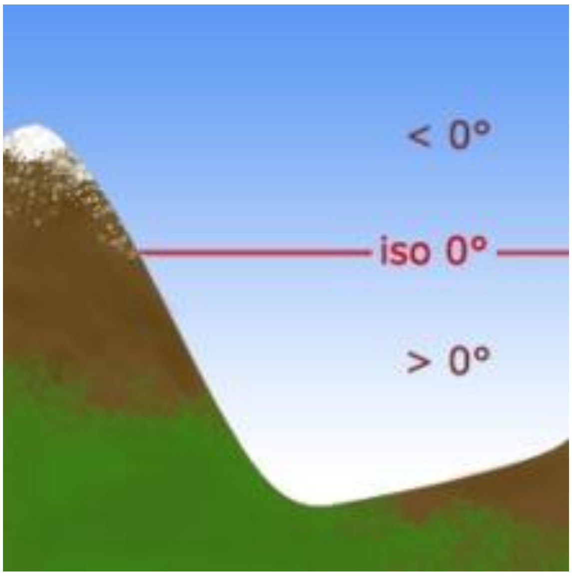
Following is the exact definition used by the World Meteorological Organization:

The boundary between the troposphere and the stratosphere, where an abrupt change in lapse rate usually occurs. It is defined as the lowest level at which the lapse rate decreases to 2 °C/km or less, provided that the average lapse rate between this level and all higher levels within 2 km does not exceed 2 °C/km.

Freezing level

The freezing level, or 0°C (zero-degree) isotherm, represents the altitude in which the temperature is at 0°C (the freezing point of water) in a free atmosphere (i.e. allowing reflection of the sun by snow, etc.). Any given measure is valid for only a short period of time, often less than a day.

Above the freezing level, the temperature of the air is below freezing. Below it, the temperature is above freezing. The profile of this frontier, and its variations, are studied in meteorology, and are used for a variety of forecasts and predictions. Whilst not given on general weather forecasts, it is used on bulletins giving forecasts for mountainous areas.



Measuring

- There are several different methods to examine the structure of the temperature of the atmosphere:
- A radiosonde attached to a weather balloon is the oldest and most common method used. Each area releases two balloons a day in locations hundreds of kilometres apart.
- Measuring devices attached to commercial airliners permit reporting the isotherm, and its height, to aerial traffic.
- Weather satellites are equipped with sensors which scan the atmosphere and measure the infrared radiation it emits.
- Weather radar detects bright bands, which are radar echoes produced just underneath the isotherm caused by the melting of snow in the layer above 0°C.
- A wind profiler, an upward pointing radar, can detect the speed of precipitation, which is different for rain, snow, and melting snow.
- Depending on the frequency and resolution at which these readings are taken, these methods can report the isotherm with greater or lesser precision. Radiosondes, for example, only report a reading twice daily and provide very rough information. Weather radar can detect a variation every five to ten minutes if there is precipitation, and can scan a radius of up to two kilometres.

Characteristics

- ❖ The isotherm is determined by releasing weather balloons into the atmosphere. This allows a chart to be produced from the data from the balloon.
- ❖ The isotherm varies globally as weather conditions vary globally. The measure is important for many reasons. It helps to predict the average temperature, the likelihood of snow and avalanches, and it therefore protects skiers and ski resorts.
- ❖ Variations in the isotherm.
- ❖ The isotherm can be very stable over a large area. It varies under two conditions.
- ❖ A change in the density of air due to weather fronts. This changes the isotherm gradually, over tens of kilometres for a cold front, and hundreds for a warm front.
- ❖ Local levels can be changed by wind, reflection of the sun, snow, and humidity level. These factors can cause the isotherm to change rapidly over several kilometres, in both winter and summer. Also, atmospheric subsidence and ascendence can contribute to variations in the isotherm.

Inversion (meteorology)

In meteorology, an inversion is a deviation from the normal change of an atmospheric property with altitude. It almost always refers to a temperature inversion, i.e. an increase in temperature with height, or to the layer (inversion layer) within which such an increase occurs.

Environmental Meteorology

This Unit of IMD was set up at New Delhi under an agency scheme of the Ministry of Environment & Forests. It provides specific services to this Ministry and other Government agencies for the assessment of pollution impacts from various industries and thermal power plants. Atmospheric dispersion models are employed for prediction of air quality, under different terrain and meteorological conditions. These studies facilitate decisions regarding siting of industries and adoption of control strategies.

This Unit also operates a meteorological observatory in the vicinity of the Taj Mahal at Agra. The data is provided to MoEF along with appropriate interpretations so that abatement measures can be planned. The scope of this activity is likely to expand in future by inclusion of a larger region in the studies.

Background Air Pollution Monitoring Network (BAPMoN)

With a view to documenting the long term changes in composition of trace species of the atmosphere as a result of changing land use pattern, WMO had commissioned a global programme called Background Air Pollution Monitoring Network (BAPMoN) which is now a part of the Global Atmospheric Watch (GAW) Programme. India had set up 10 such BAPMon stations.

At these stations, rain water samples are collected every month and these are sent to the Central Chemical Laboratory at Pune for complete chemical analysis. Acidity of rain and mineral deposition is determined from these.

Atmospheric turbidity which indicates the columnar aerosol load of the atmosphere is also measured at these stations using sun-photometers. These data are important for identifying the current levels of pollution as well as for study of the long term trends in the concentration of trace constituents of the atmosphere which may affect the environment and induce a climate change.

To study the impact of industrialization, urbanization and terrain modification on micro-climatological features of urban areas, urban climatological studies are carried out in metropolitan cities.

References :

1. Instructions to Observers at surface Observatories - Part I, 1987.

2. WMO compendium of Meteorology for Class IV Personnel, Vol. II- Meteorology

3. IMD Code Books

4. Symbol Card