

### **Chapter Outline**

- 12.1 Introduction
- 12.2 Instruments for Measuring Weather Elements



- **12.3** Advancement in Measuring Weather Elements
- 12.4 Weather Symbols
- 12.5 Station Model
- **12.6** Reading Weather Map
- 12.7 Weather Map Interpretation
- **12.8** Weather Forecasting
- 12.9 Tracking of Cyclones

#### **12.1 Introduction**

A weather map is a map of the world or part of it showing at a stated time, the weather conditions like temperature, pressure, direction and velocity of the wind, humidity, clouds, visibility, nature and amount of precipitation with the help of symbols. The trained observers in observatories or in meteorological station note the temperature, pressure, directions and strength of the wind, the

## **Of Learning Objectives:**

- Aware of weather instruments
- Identify weather symbols
- Ability to draw a station model
- Interpretation of weather map
- Enhance the knowledge about weather forecasting and cyclone tracking.

amount of cloud and precipitation. These observations are entered on a weather map with symbols. Thus, weather map portrays the weather elements marked with recorded symbols for a region at a particular time. It reveals the prevailing weather condition.

# 12.2 Instruments for Measuring Weather Elements

Weather varies with the changes in weather elements such as temperature, pressure, wind, humidity, cloudiness, precipitation, sunshine and visibility. The weather is measured employing particular instruments and recorded in weather stations. The weather elements are listed below.

#### Temperature

Temperature is the hotness or coldness of a substance. The temperature of a particular place changes based on the factors like latitude, altitude, season, time of day, cloud cover, wind, location of the sea etc. Temperature is measured utilizing thermometers. They are Centigrade, Fahrenheit, Wet Bulb, Dry Bulb and Tele thermometers.

In Centigrade thermometer, the temperature of melting ice is taken as 0<sup>°</sup> C and the temperature of boiling water as 100°C. In Fahrenheit thermometer, 32°F represents the freezing point and 212°F represents the boiling point of water. Wet Bulb and Dry Bulb thermometers are used to measure humidity in temperature. Tele thermometer is used to record temperature continuously within and outside the building. Thermograph produces a continuous trace of the changing temperature of a place.

#### Pressure

Pressure is defined as the weight of a unit column of air at any place. The barometer is an instrument to measure atmospheric pressure. While both Barometer and Aneroid Barometer measures atmospheric pressure above and below sea level. Altimeter measures air pressure at a height above sea level. Barograph provides a continuous record of air pressure. The unit of pressure is measured in millibars (mb). Globally, the pressure determines the wind and weather pattern. High pressure and low pressure are highly related with the increase or decrease in temperature.

#### Wind

The wind is moving air over the earth's surface. The air moves from high pressure to low pressure either vertically or horizontally. Wind vane records the direction of the wind and points out from which direction it blows. Cup Anemometer measures wind velocity, which is expressed in knots.(1.852 km speed) Wind Sock is a device that indicates the origin of wind direction and speed.

#### Humidity

The amount of water vapour present in the atmosphere is termed as Humidity. It concentrates in the lower layer of the atmosphere. It varies from place to place and time to time. It may be classified as absolute, specific and relative humidity. Hygrometer is the instrument that measures the relative humidity. Hygrograph is an automatic instrument showing the change in relative humidity. Hygrothermograph records both humidity and temperature.

#### Cloudiness

Cloudiness indicates the amount of sky covered by clouds. Clouds are present in the lower atmosphere at varying altitude. They are varying in size and shape. The clouds are classified as high, middle and low clouds. Ceilometer is an instrument that uses a laser to determine the height of the cloud base. Ceiling projectors measure the height of the base of clouds above the ground. Cloud mirror measures the percentage of cloud cover. An Okta is a unit of measurement to describe the amount of cloud cover. The measurement of 0 Okta indicates clear sky and 8 Okta denotes completely overcast sky.

#### Precipitation

The water or ice particles reaching the ground surface from the atmosphere is known as precipitation. The various forms of precipitation are dew, mist, fog, sleet, drizzle, rain and hail. Conventionally, the amount of rain has been recorded by the instrument called Rain gauge. The amount of rain will be recorded in mm or cm or inches at a given time. The Automated Weather Station (AWS) instrument records the rainfall with the help of sensors.

#### Sunshine

Sunshine means that the sun's rays lie within the visible spectrum that reaches the earth's surface. The amount or duration of sunshine in hours per day at a given region is measured using a sunshine recorder. The sunshine of a place depends on various seasons.

#### Visibility

Visibility means the transparency of the air in the particular place. It depends on the presence of water, ice, dust and smoke particles in the atmosphere. Visibility is measured by the distance at which prominent objects can be seen and the details discerned. The scale of visibility varies from zero, when objects cannot be easily seen beyond 25 metres, to visibility 9, when objects can be easily seen at a distance of 50 kilometres. Scale 0 to 3 indicate Fog, scale 4 represents Haze or Mist, scale 5 to 9 represents poor to Excellent visibility.

#### 12.3 Advancement in Measuring Weather Elements

In recent days, weather stations use weather balloons, aircraft and ships to carry the instruments for measuring the temperature, pressure, humidity in the lower atmosphere. Weather Radars are used to locate precipitation, type, intensity.

Radiosonde (an instrument carried by balloon or other means to various levels of the atmosphere and transmitting measurements by radio) is an instrument used to measure the vertical profiles of temperature, dew point and winds. It estimates the wind direction, velocity based on radar tracking.

Weather satellites help in providing all weather information accurately. Some of the important weather satellites are: METSAT-1/KALPANA-1,OCEANSAT-2, INSAT -3D, SCATSAT-1

#### 12.4 Weather Symbols

Symbols are the pictorial representation of the various elements. On a weather map, weather elements are represented using symbols. Weather codes are used in weather charts as meteorological symbols. Weather symbols are created and standardized by the World Meteorological organization and also by Natural Weather Bureaus. Knowledge of weather symbols is prime for weather map interpretation and weather forecasting. Weather symbols are listed below for precipitation, wind direction, cloud cover and sea conditions. Weather symbols depicted in weather charts help in weather forecasting.

WEATHER MAP SYMBOLS											
CLOUD COVER					WIND CONDITIONS						
ky Completely Clear		1/8 <sup>th</sup> Cloud Cover		1/4 <sup>th</sup> Cloud C	Cover C		<b>X</b> Calm	Light Air		Light Breeze	
3/8 <sup>th</sup> Cloud	l Cover	Sky	Half Cloudy	5/8 <sup>th</sup> Cloud Cover	1	G Bi	entle reeze	Moderate Breeze	þ	F. Br	resh reeze
/4th Cloud Cover		7/8 <sup>th</sup> Cloud Cover		Sky Comple Cloudy	tely	Strong Breeze		Moderate Gale		Fresh Gale	
Sky Obstructed from view				St	rong Gale	Whole Storm Gale		orm			
WEATHER CONDITIONS											
O Pure Air	с <sub>На</sub>	<b>D</b> nze	Light Fog	Shalow Fog	=	=	Heavy Fog			フ	<u> </u>
2	$\searrow$	/	$\checkmark$	<b>)</b> Drizzle	• Rair	ı	Rain Showers	<b>★</b> Snow	Sho	7 wer	Rain and snow Showers
€ Rain and Snow	Slee	rt et	Snow Grains	← → Ice Crystals	Drifti Snow H	ng Tigh	Drifting Snow Low	$\mathbb{X}$	×	₽	X
Hail	Ice Pel	llets	Lighting	Thunder storms	Hea	vy ider	Ę	<b>E</b> Dust Devil	Squa	1 all	$\xrightarrow{\text{Dust/Sand}}$

Figure 12.1 Weather Map Symbols

#### 12.5 Station Model

The weather station is the place where all the data about the weather are being recorded, evaluated and documented. Station model is the symbolic drawing of the current weather condition, based on the collected data of weather elements in the particular station. The weather elements observed are shown in symbols in station models.

The value highlighted in the upper left corner is the temperature in degree Celsius. The image portrays the temperature as 12 degrees Celsius. The value highlighted in the lower left corner is the dew point temperature in degrees Celsius. According to the example, the dew point of temperature which is 5 degrees Celsius. The image at the centre refers to cloud cover which is 7/8 cloudy. The value highlighted in the upper right corner represents the last three digits of the sea level pressure or in other words,

#### Sea Condition

	Weather	
	Elements Sea	Representation
Sl.No.	Condition	of Symbol
1.	Calm	Cm
2.	Smooth	Sm
3.	Slight	Sl
4.	Moderate	Mod
5.	Rough	Ro
6.	Very Rough	V.Ro
7.	High	Hi
8.	Very High	V.Hi
9.	Phenomenal	Ph

Barometric pressure reduced to sea level. The image indicates the sea level pressure as 105 millibars. The symbol extending from cloud cover is the wind barb, that shows wind direction and wind speed (velocity). According to the image, the wind blows from the North East direction to the South West direction at a speed of 15 knots.

#### 12.6 Reading Weather Map

Based on the above flow chart basic weather elements are represented. The following points are to be described while reading the weather map.

#### Pressure

- Location of high pressure shown as 'H' in the weather map. The number and location must be specified
- Location of low pressure, represents as 'L' the number of occurrence, location and nearby isobar value to be noted.
- 3. Trend of Isobars-The general path of isobars are to be observed.



Figure 12.2 Station model

4. Pressure gradient denotes gentle or steepness based on the spacing of isobars. When the isobars are closely spaced the pressure gradient is steep and gentle if the isobars are widely spaced.

#### Wind Direction and Speed

- In weather Map interpretation, wind barbs indicate wind direction and wind speed. The staff part shows wind direction. The staff is a line above the circle that indicates wind direction. The number and size of the feather and pennants included to the wind barb show the wind velocity.
- 2. Sky condition is represented using circle, shaded according to the cloud cover
- 3. Sea condition is shown as codes, for example, Ro- Rough.
- 4. Precipitation and temperature and the other weather data are generally tabulated and attached to the Indian daily weather map.

#### **12.7 Weather Map Interpretation**

The weather map is а symbolic representation of the atmospheric conditions of an area at a given time. On a weather map, you will find isobars and symbols related to pressure, direction and velocity of winds, clouds, precipitation and sea condition on a base map with political boundaries. These details are recorded at different weather stations at specified time.

Meteorological Departments forecast weather conditions by evaluating these weather elements shown on a weather map. This weather map is used in predicting weather conditions for a day, a week or a month in advance, which helps in taking precautions and safety measures. Weather forecasts help farmers, fishermen and crew of ships. It also helps air flights in predicting atmospheric condition a few hours ahead.

Weather maps are the collection of weather information from various meteorological stations pertaining to the

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Figure 12.3 Wether Map

particular map area. The weather charts are prepared daily based on weather observations collected by the Indian Meteorological Department (IMD). The basic knowledge of weather elements is needed to interpret the weather maps. The essential weather elements to interpret the given weather maps are:

Schematic representation of weather map elements

#### Weather Map Interpretation

The Indian daily weather map is a political map of India, which also includes Pakistan, Afghanistan, part of China, Nepal, Bhutan, Myanmar and Sri Lanka with weather symbols indicating recorded weather data, isobars and keys for symbols.

#### Weather Map Interpretation – Monsoon Season (Example 1)

Weather map interpretation includes study and interpretation of all the weather parameters. The given weather map depicts the observed weather conditions on Monday 1<sup>st</sup> June 1992 at 08.30 Hrs I.S.T (0300 HRS GMT). Generally in India this observation is predicted as the southwest monsoon season that gives rain.

The key elements for weather map interpretation are:

- 1. **Range of Isobars:** From the given weather map it is observed that the isobars range from 1002 mb to 1010mb. The lowest value of 1002 mb is found over Bihar, Uttar pradesh and West Bengal as an enclosed isobar. The 1010 mb is the highest value and is observed in the extreme south western part of the Arabian Sea.
- 2. Location of Low Pressure: In this weather map, four low pressure zones are identified. Low pressure prevails in Bihar and West Bengal, North Western Pakistan, Assam, Eastern part of India and Lakshadweep Island.
- 3. Location of High Pressure: The high pressure prevails over Afghanistan with 1008mb and the other high pressure prevails over the south western part of the Arabian Sea with 1010 mb.

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Figure 12.4 Example 1 (Monsoon Season)

- 4. **Gradient of Pressure:** On this map, the pressure gradient is steep along the western coast of India.
- 5. Wind Direction: The wind moves from west to east in the extreme southern part of India, The wind flows from North West to the south east in the rest of the Plateau region. The wind velocity ranges from 5 – 15 knots in most of the places on the given day.

The wind is not strong in North but comparatively strong in south.

- 6. Cloud Cover: Clear sky is noticed in the North and north western part of India. Eastern coastal states are partly clouded and the southern states show extreme cloudiness and or overcast.
- 7. **Sea Condition:** Northern Limit of Monsoon prevails over the Andaman Sea.

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- 8. **Precipitation:** The rainfall occurred in Assam and Meghalaya because low pressure prevails in near Assam, southern parts of Karnataka, Kerala and Lakshadweep.
- 9. Departure of Maximum and Minimum temprature from Normal

Day temperature is above normal in the west, Karnataka and eastern parts of India.

Below normal in the places like northwest India and extend over the adjoining areas.

**Conclusion:** The general prevalence of the South Westerly winds the location of low pressure over the land and high pressure over the ocean, the occurrence of rainfall over South and eastern part of India. This season is observed as the monsoon season.

## INDIAN DAILY WEATHER REPORT WEATHER MAP AT 08.30 HRS .I.S.T. (0300 HRS. G.M.T)

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Tuesday 5th November 1991 (14 Jyaistha 1913 Saka)



Figure 12.5 Example 2 (Monsoon Season)

#### Weather Map Interpretation – Monsoon Season (Example 2)

The given weather map shows the weather condition on Tuesday 5<sup>th</sup> November 1991 at 08.30 Hrs IST 0300 Hrs GMT.

#### **Distribution of Pressure Condition**

- 1. Low Pressure: Low pressure areas exist over Northern and Southern Bay of Bengal and Lakshadweep (1012mb).
- 2. **High Pressure**: Central part of India, the plateau region is marked with High pressure. High pressure also prevails over Gujarat and Rajasthan. The other two high pressure areas are located in Afghanistan (1014mb), to the East of India. The pressure gradient is gentle throughout India.
- 3. Wind Condition: Calm weather prevails in north western coast of Orissa. Winds are northern in Tamilnadu, Southernly in Gujarat. In Central India, it is from the northeast.
- 4. **Sky Cover**: Sky cover is almost clear in North. In the South, it is partially cloudy. Sea condition is moderate. Haze is found near north eastern part of India.
- 5. **Precipitation**: Rain or thundershowers have occurred at a few places in coastal Andhra Pradesh, Tamil Nadu and South Interior Karnataka at one or two places in Telangana, Rayalasaema and Kerala.

6. Departure of Maximum and Minimum temperature from Normal: South west states record above normal temperature, eastern states have below normal temperature, except of the northwestern part of Rajasthan.

**Conclusion:** Low pressure prevails in sea and High pressure inland, so it indicates north east monsoon.

#### **12.8 Weather Forecasting**

Weather forecasting plays a major role in predicting the weather in the near future. It is difficult to predict the weather that could prevail in the future. A thorough understanding of meteorology is necessary for the forecast familiarity with the local weather helps to correlate the existing weather conditions and in forecast the future weather. The prediction of weather for a given place, is normaly for a period of time, for instance is for 24 to 48 hours.

The methods used for weather forecasting are conventional, synoptic, numerical weather prediction. Conventional interprets the trend of weather system. Numerical solutions, global circulation models, variation analysis for synoptic hours.

The weather forecast categories are now casting, short range, medium range long range and forecasting. Now casting gives the details of the current weather



and forecasts up to a few hours ahead using radar products.

Short range forecasts is for one to three days. Weather mainly rainfall for each successive 24 hour intervals may be predicted up to three days. It concerned about the observed latest weather charts and new systems.

Medium range forecasts are for 4 to 10 days – average weather conditions and the weather on each day may be prescribed with progressively lesser details and accuracy than that for short range forecasts dependent on NWP (Numerical Weather Prediction) products.

Long range forecast is an extended range forecast for more than 10 days in a season. It may range from a monthly to a seasonal forecast. Local forecast is a location specific forecast valid for a radius of 50 km around the weather stations.

A persistence forecast predicts that future weather will be the same as present weather. Analogue forecast will be like the weather that historically occurred when similar conditions were present. Statistical forecast is made routinely of weather elements based on the past performance of computer models. Trend forecast: surface weather systems tend to move in the same direction and at approximately the same speed as they have moved.

#### Current Scenario of Weather Forecasting

The weather satellites monitor the weather conditions and provide accurate information of weather. Satellite imageries are pictorial representations of radiation reaching the sensors from the earth from the different spectral bands that imprints the accurate weather elements such as winds, rainfall, and sea surface temperature.

Weather forecasting is based on the weather observation of surface data based on radars. Numerical Weather Prediction (NWP) using current and past observations to predict weather in near future AWIPS- Advanced Weather Interactive Processing Systems used by forecasters and process satellite, radar, surface observations, and weather forecasting models.

Occultation method is one of the most recent and capable atmospheric remote sensing technique applied to GPS measurements.

The meteogram is a chart that shows how one or more weather variables has changed at a station over a given period of time. Auxiliary charts- satellite imageries, satellite bulletins, satellite observations and current weather observations. These predictions are significant for warning of natural hazards.

#### 12.9 Tracking of Cyclones

Tropical cyclone forecasting involves the prediction of several interrelated features, including the track of the cyclone, its intensity, resulting rainfall and storm surge and the areas threatened. Cyclone tracking is a constantly evolving science.

Different methods are used, including using satellites, radars, etc. A skilled meteorologist has often developed an ability to detect overall patterns in climatological conditions and can assess how these may affect cyclone development. Manual forecasts made by skilled



**Figure 12.6** Very Severe Cyclonic Storm meteorologist may be a good complement to other forecasting techniques.

At present, the cyclones are tracked with the help of satellite images. The satellite images are collected and put into motion for several hours, and with the gathered information, the development of a tropical cyclone is tracked. Doppler radars detect rain associated with cyclones, which locate and estimate the amount of rainfall and depicts a hurricane's rainfall.

In the satellite based techniques, track and intensity of cyclone are forecast based on the cloud pattern associated with the cyclone. Generally the outer cloud bands of cumulonimbus clouds indicate the future direction, and the cloud pattern surrounding eye of the cyclone indicates the future intensity of the cyclone. Below is an example of tracking Vardah Cyclone by using satellite images.

#### Cyclone Tracking based on Satellite Images – Vardah (Example)

Vardah at peak strength on 11 December

Formed	December 6, 2016		
Dissipated	December 11, 2016		
	3- minute sustained :		
Highest	130 km/h 1-minute		
Winds	sustained : 155km/h		
Lowest			
pressure	975 mb		
Fatalities	38		
Damage	\$5.1 billion		
	Thailand, Sumatra,		
	Malaysia, Andaman and		
Areas	Nicobar Islands, Sri Lanka,		
affected	South India, Somalia		

Very Severe Cyclonic Storm, Vardah, was the fourth cyclonic storm, as well as the most intense tropical cyclone of the 2016 North Indian Ocean. The system struck the Andaman and Nicobar Islands, as well as South India. Originating as a low pressure area near the Malay Peninsula on December 3, the storm was designated as a depression on December 6. It gradually intensified into a Deep Depression on the following day, skirting off the Andaman and Nicobar Islands, and intensified into a Cyclonic Storm on December 8. Maintaining a generally westward track thereafter, Vardah consolidated into a Severe Cyclonic Storm on December 9, before peaking as a Very Severe Cyclonic Storm, with winds of 130 km/hr, and a minimum central pressure of 982 mb on December 11. Weakening into a Severe Cyclonic Storm, Vardah, made landfall close to Chennai on the following day, and degenerated into a remnant low on December 13. The name Vardah, suggested by Pakistan, refers to the red rose.

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## Satellite Images



8<sup>th</sup> December 2016



10<sup>th</sup> December 2016



9<sup>th</sup> December 2016



11<sup>th</sup> December 2017



12<sup>th</sup> December 2017

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#### Exercises

#### I. Answer the following

- 1. Give the weather symbols for the following.
  - a. Hail
  - b. Gentle breeze
  - c. Rain
  - d. Calm

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- e. Obscured
- 2. Find the wind direction and velocity from the following wind barbs.



3. Name the weather elements in the given Station Model.



4. Write an interpretation for the following station model.



- 5. Prepare a station model with the following weather parameters.
  - a. Dry Bulb temperature  $22^{\circ}$  C
  - b. Dew point -18°C
  - c. Barometric Pressure reduced to mean sea level standard gravity is 998mb
  - d. Total cloud amount -5 oktas
- 6. Prepare a small project of the Okchi cyclone with the help of the Satellite Images.

#### **II. Practice**

**A.** Make an Anemometer

#### Materials

- 4 small paper cups
- 4 plastic drinking straws
- Tape
- Scissors
- Straight pin
- Pencil with a new eraser
- Stapler

#### Procedure

1. This anemometer has four cups which catch the wind and cause the anemometer to spin. The inward curve of the cups receives most of the force of the wind. That's what makes the cups move. The more spins per minute, the greater the wind velocity.

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- 2. Arrange four (4) plastic drinking straws to form a cross and tape them together at the centre.
- 3. Staple the top side of one drinking cup, such as the small paper cups designed for bathroom dispensers, at the end of each straw, so the open ends of the cups all face the same direction.
- 4. Push a straight pin through the centre of the straws into an eraser on the end of a pencil. This provides the axle.
- 5. Mark one of the cups; this will be the one they use for counting when the anemometer spins.
- 6. Blow on the anemometer or turn an electric fan on low to make sure that it spins easily. How many times the anemometer will spin in one minute? Can you make a statement connecting the number of spins of your anemometer and the speed of the wind? (You can use the table below to record your practice trials).
- B. Use an Anemometer to measure Wind Speed

#### Materials

- Anemometer
- 1. Divide the students into small groups with the following roles (optional)
  - One time keeper who will be responsible for timing one minute for each trial.
  - One official "counter" for the day. The others may count on their own, but the counter's readings will be the ones recorded.
  - One person who will hold the anemometer while the spins are counted; the person holding

should make sure that he holds the anemometer so that the wind is unobstructed.

- 2. Mount or hold the anemometer in a place that has full access to the wind from all directions.
- 3. When the timekeeper says "Go", the counter in each group will count how many times the marked cup passes them in one minute and write it down.
- 4. If possible, repeat the above step four (4) times and record the average number of spins

Optional: you can multiply the average number of spins by 60 to find out how many times the anemometer would spin in an hour and come up with a statement such as: the speed of the wind today is about 1,000 spins per hour.

	Time	Number of
S. No	Interval	Spins
1.		
2.		
3.		
4.		

# References

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## Internet Resources

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WEATHER MAP