KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed to be University)
(Established Under Section 3 of UGC Act 1956)
Coimbatore – 641 021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

SUBJECT: WEATHER FORECASTING

SEMESTER : V

SUBJECT CODE: 17PHU501B

Objective: The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques

UNIT -I
Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.

UNIT -II
Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

UNIT- III
Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

UNIT -IV
Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.

UNIT -V
Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

TEXT BOOKS

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books

2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.

REFERENCE BOOKS:

1. Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
2. Meteorology, Steven A. Ackerman, John A Knox, 2015, Jones & Bartlett Learning, ISBN – 978-1-284-02737-2.
3. Challenges and Opportunities in Agrometeorology, edited by S.D. Attri, L.S. Rathore.
4. M.V.K. Sivakumar, S.K. Dash, 2011, Springer Verlag Berling Heidelberg, ISBN – 978-3-642-19359-0.
5. PRACTICAL Agricultural Meteorology by New India Publishing, 2011, ISBN - 9789380235776

UNIT-I

SYLLABUS

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics

ELEMENTARY IDEA OF ATMOSPHERE:

- Our planet earth is enveloped by a deep blanket of gases extending several thousands of kilometres above its surface. This gaseous cover of the earth is known as the atmosphere.
- Like land (lithosphere) and water (hydrosphere), the atmosphere is an integral part of the earth.
- Compared to the earth's radius, the atmosphere appears to be only a very thin layer of gases. However, because of the force of gravity, it is inseparable from the earth.
- **Atmospheric pressure:** The air exerts pressure on earth's surface by virtue of its weight. This pressure is called atmospheric pressure. Atmospheric pressure is the most important climatic element. The atmospheric pressure at sea level is **1034 gm per square centimetre.**

Role of Earth's Atmosphere:

- The atmosphere contains various gases like oxygen, carbon dioxide, nitrogen etc.
- Plants require carbon dioxide to survive while animals and many other organisms need oxygen for their survival. The atmosphere supplies these life giving gases.
- All life forms need a particular range of temperature and a specific range of frequencies of solar radiation to carry out their biophysical processes. The atmosphere absorbs certain frequencies and lets through some other frequencies of solar radiation. In other words, the atmosphere **regulates the entry of solar radiation**.
- The atmosphere also keeps the temperature over the earth's surface within certain limits. In the absence of the atmosphere extremes of temperature would exist between day and night over the earth's surface.
- Harmful ultraviolet radiation would find its way through, if the atmosphere (ozone in stratosphere to be specific) were absent.
- The atmosphere also takes care of extra-terrestrial objects like meteors which get burnt up while passing through the atmosphere (mesosphere to be precise) due to friction.

- Weather is another important phenomenon which dictates the direction of a number of natural and man-made processes like plant growth, agriculture, soil-formation, human settlements, etc. Various climatic factors join together to create weather.

COMPOSITION OF ATMOSPHERE:

- The atmosphere is a mixture of many gases. In addition, it contains huge numbers of solid and liquid particles, collectively called **'aerosols'.**
- Some of the gases may be regarded as **permanent atmospheric components** which remain in **fixed proportion** to the total gas volume.
- Other constituents vary in quantity from place to place and from time to time. If the suspended particles, water vapour and other variable gases were excluded from the atmosphere, then the dry air is very stable all over the earth up to an altitude of about 80 kilometres.
- The proportion of gases changes in the higher layers of the atmosphere in such a way that oxygen will be almost in negligible quantity at the height of 120 km. Similarly, carbon dioxide and water vapour are found only up to 90 km from the surface of the earth.
- **Nitrogen and oxygen** make up nearly **99%** of the clean, dry air. The remaining gases are mostly **inert** and constitute about 1% of the atmosphere.
- Besides these gases, large quantities of water vapour and dust particles are also present in the atmosphere. These solid and liquid particles are of great climatic significance.
- Different constituents of the atmosphere, with their individual characteristics, are discussed below.

Constituent	*Formula*	*Percentage by Volume*
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Carbon dioxide	CO_2	0.036
Neon	Ne	0.002
Helium	He	0.0005
Krypto	Kr	0.001
Xenon	Xe	0.00009
Hydrogen	H_2	0.00005

1. Oxygen:

Oxygen, although constituting only 21% of total volume of atmosphere, is the most important component among gases. All living organisms inhale oxygen. Besides, oxygen can combine with other elements to form important compounds, such as, oxides. Also, combustion is not possible without oxygen**.**

2. Nitrogen:

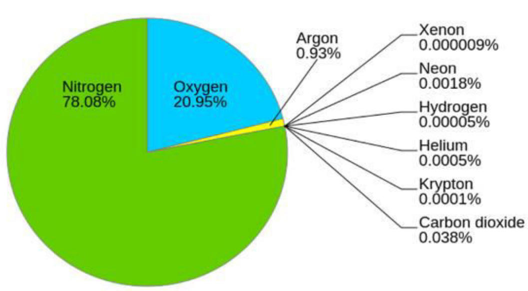
Nitrogen accounts for 78% of total atmospheric volume. It is a relatively inert gas, and is an important constituent of all organic compounds. The main function of nitrogen is to control combustion by diluting oxygen**.** It also indirectly helps in oxidation of different kinds.

3. Carbon Dioxide:

- The third important gas is Carbon Dioxide which constitutes only about 03% of the dry air and is a product of combustion. Green plants, through photosynthesis, absorb carbon dioxide from the atmosphere and use it to manufacture food and keep other bio-physical processes going.
- Being an efficient absorber of heat, carbon dioxide is considered to be of great climatic significance. Carbon dioxide is considered to be a very important factor in the heat energy budget.
- With increased burning of fossil fuels – oil, coal and natural gas – the carbon dioxide percentage in the atmosphere has been increasing at an alarming rate.
- More carbon dioxide in the atmosphere means more heat absorption. This could significantly raise the temperature at lower levels of the atmosphere thus inducing drastic climatic changes.

4. Ozone (03):

- Ozone (03) is another important gas in the atmosphere, which is actually a type of oxygen molecule consisting of three, instead of two, atoms. It forms less than **00005%** by volume of the atmosphere and is **unevenly distributed**. It is between **20 km and 25** km altitude that the greatest concentrations of ozone are found. It is formed at higher altitudes and transported downwards.
- Ozone plays a **crucial role in blocking the harmful ultraviolet radiation** from the sun.
- Other gases found in almost negligible quantities in the atmosphere are **argon, neon, helium, hydrogen, xenon, krypton, methane etc.**



5. Water Vapour:

- Water Vapour is one of the most variable gaseous substances present in atmosphere – constituting between 02% and 4% of the total volume (in cold dry and humid tropical climates respectively). 90% of moisture content in the atmosphere exists within 6 km of the surface of the earth. Like carbon dioxide, water vapour plays a significant role in the insulating action, of the atmosphere.
- It absorbs not only the long-wave terrestrial radiation (infrared or heat emitted by earth during nights), but also a part of the incoming solar radiation.
- Water vapour is the source of precipitation and clouds. On condensation, it releases latent heat of condensation, the ultimate driving force behind all storms.

6. Solid Particles:

- The Solid Particles present in the atmosphere consist of sand particles (from weathered rocks and also derived from volcanic ash), pollen grains, small organisms, soot, ocean salts; the upper layers of the atmosphere may even have fragments of meteors which got burnt up in the atmosphere. These solid particles perform the function of absorbing, reflecting and scattering the radiation.
- The solid particles are, consequently, responsible for the orange and red colours at sunset and sunrise and for the length of dawn (the first appearance of light in the sky before sunrise) and twilight (the soft glowing light from the sky when the sun is below the horizon, caused by the reflection of the sun's rays by the atmosphere. Dusk: the darker stage of twilight.). The blue colour of the sky is also due to ***selective scattering*** by dust particles.
- Some of the dust particles are hygroscopic (i.e. readily absorbing moisture from air) in character, and as such, act as nuclei of condensation. Thus, dust particles are an important contributory factor in the formation of clouds, fog and hailstones.

PHYSICAL STRUCTURE OR COMPOSITIONAL LAYERS OF ATMOSPHERE:

The atmosphere can be studied as a layered entity – each layer having its own peculiar characteristics. These layers are systematically discussed below.

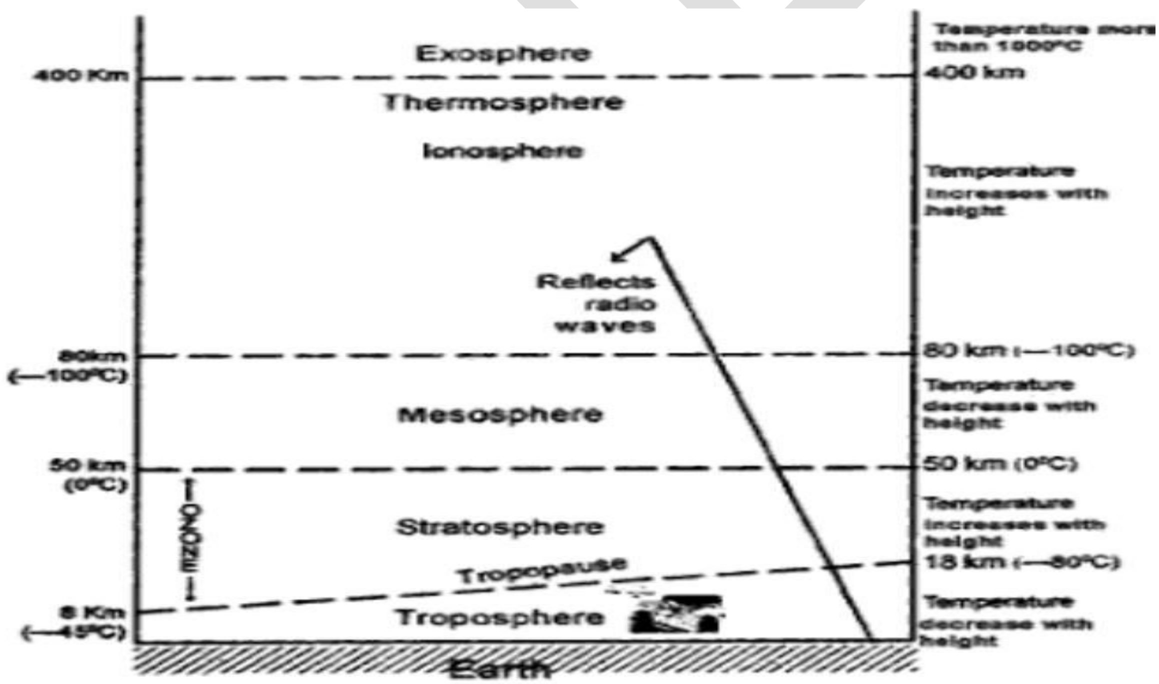
Troposphere:

- It is the atmospheric layer between the earth's surface and an altitude of **8 km at the poles and 18 km at the equator.**
- The thickness is greater at the equator, because the **heated air rises to greater heights**.
- The troposphere ends with the **Tropopause**.
- The temperature in this layer, as one goes upwards, falls at the rate of **5°C per kilometer**, and reaches -45°C at the poles and -80°C over the equator at Tropopause (greater fall in temperature above equator is because of the greater thickness of troposphere – 18 km).
- The fall in temperature is called **'lapse rate'.** (more about this in future posts)
- The troposphere is marked by **temperature inversion**, turbulence and eddies.

- It is also meteorologically the most significant zone in the entire atmosphere (Almost all the weather phenomena like rainfall, fog and hailstorm etc. are confined to this layer).
- It is also called the **convective region**, since **all convection stops at Tropopause**.
- The troposphere is the theatre for weather because all cyclones, anticyclones, storms and precipitation occur here, as all water vapours and solid particles lie within this.
- The troposphere is influenced by seasons and jet streams.

Tropopause:

- Top most layer of troposphere.
- It acts as a boundary between troposphere and stratosphere.
- This layer is marked by **constant temperatures**.



STRUCTURE OF THE ATMOSPHERE

Stratosphere:

- It lies beyond troposphere, up to an altitude of 50 km from the earth's surface.
- The temperature in this layer remains constant for some distance but then rises to reach a level of 0°C at 50 km altitude.
- This rise is due to the **presence of ozone**(harmful ultraviolet radiation is absorbed by ozone).

- This layer is **almost free from clouds** and associated weather phenomenon, making conditions **most ideal for flying aeroplanes**. So aeroplanes fly in lower stratosphere, sometimes in upper troposphere where weather is calm.
- Sometimes, **cirrus clouds** are present at lower levels in this layer.

Ozonosphere:

- It lies at an altitude between **30 km and 60 km** from the earth's surface and spans the stratosphere and lower mesosphere.
- Because of the presence of ozone molecules, this layer reflects the harmful ultraviolet radiation.
- The ozonosphere is also called **chemosphere** because, a lot of chemical activity goes on here.
- The temperature rises at a rate of **5°C per kilometer** through the ozonosphere.

Mesosphere:

- This is an intermediate layer beyond the ozone layer and continues upto an altitude of 80 km from the earth's surface.
- The temperature gradually **falls** to -100°C at 80 km altitude.
- **Meteorites burn up in this layer on entering from the space**.

Thermosphere:

- In thermosphere **temperature rises very rapidly** with increasing height.
- **Ionosphere** is a part of this layer. It extends between **80-400 km.**
- This layer helps in ***radio transmission***. In fact, radio waves transmitted from the earth are reflected back to the earth by this layer.
- ***Person would not feel warm because of the thermosphere's extremely low pressure***.
- The **International Space Station and satellites** orbit in this layer**.** (Though temperature is high, the atmosphere is extremely rarified – gas molecules are spaced hundreds of kilometers apart. Hence a person or an object in this layer doesn't feel the heat)
- **Aurora's** are observed in lower parts of this layer.

Ionosphere:

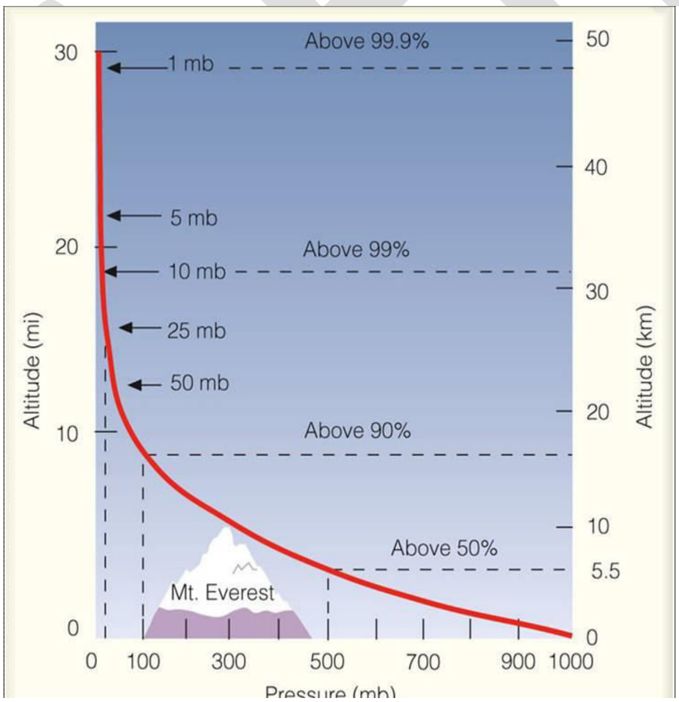
- This layer is located between 80 km and 400 km and is an **electrically charged layer**.
- This layer is characterized by **ionization of atoms**.
- Because of the electric charge, radio waves transmitted from the earth are reflected back to the earth by this layer.
- Temperature again starts increasing with height because of radiation from the sun.

Exosphere:

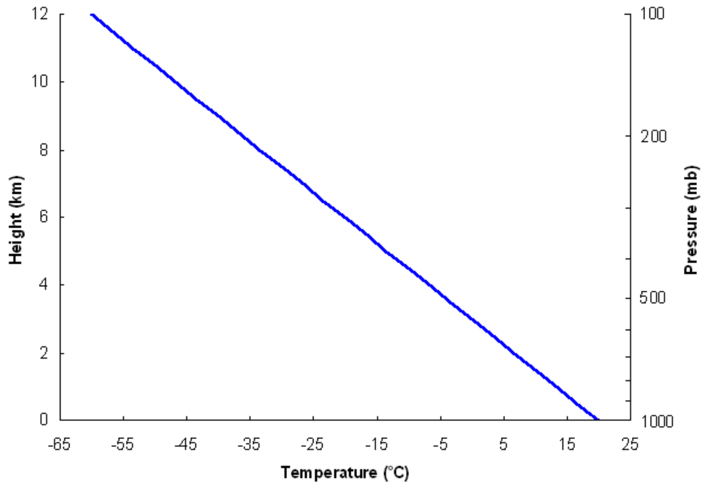
- This is the **uppermost layer** of the atmosphere extending beyond the ionosphere above a height of about 400 km.
- The air is extremely rarefied and the temperature gradually increases through the layer.
- Light gases like **helium and hydrogen**float into the space from here.
- Temperature gradually increases through the layer. (As it is exposed to direct sunlight)
- This layer coincides with space.

VARIATION OF PRESSURE AND TEMPERATURE WITH HEIGHT:

The molecules that make up the atmosphere are pulled close to the earth's surface by gravity. This causes the atmosphere to be concentrated at the Earth's surface and thin rapidly with height. Air pressure is a measure of the weight of the molecules above you. As you move up in the atmosphere there are fewer molecules above you, so the air pressure is lower. Figure B shows how pressure decreases with height. The black dotted lines show how much of the atmosphere is below you at a certain level. For example, at 10 miles up, 90% of the atmosphere is below you. At the peak of Mount Everest, as shown, the air pressure is 70% lower than it is at sea level. This means when mountain climbers breathe air on top of the mountain, they are only inhaling 30% of the oxygen they would get at sea level. It is no surprise that most climbers use oxygen tanks when they climb Mt. Everest.



Temperature vs. Height and Pressure of the Troposphere



Temperature decreases with height in the troposphere. This is true for a couple different reasons. First, even though the sun's energy comes down from the sky, it is mostly absorbed by the ground. The ground is constantly releasing this energy, as heat in infrared light, so the troposphere is actually heated from the ground up, causing it to be warmer near the surface and cooler higher up. Another reason is the decreasing air pressure with height. If the warm air at the surface gets blown upward into the cooler air above it, the surface air will continue to rise. As air rises into areas of lower pressure it expands because there are less molecules around it to compress it. The molecules in the air use some of their energy to move apart from each other, causing the air temperature to decrease. The constantly decreasing air pressure in conjunction with the ground-up heating keeps the temperature in the troposphere decreasing with height.
In the real atmosphere, the actual vertical temperature structure depends on air masses with specific properties of temperature and humidity being blown into the area as well as effects of daytime heating. If you have a layer of air with warm temperatures above the surface, we call that an "inversion". That layer can act as a cap which prevents clouds and sometimes severe weather from forming.

AIR TEMPERATURE AND ITS REQUIREMENTS OF MEASUREMENT:

Air temperature:

Air temperature affects the growth and reproduction of plants and animals, with warmer temperatures promoting biological growth. Air temperature also affects nearly all other weather parameters. For instance, air temperature affects:

- the rate of evaporation
- relative humidity
- wind speed and direction
- precipitation patterns and types, such as whether it will rain, snow, or sleet.

How is Air Temperature measured?

Temperature is usually expressed in degrees Fahrenheit or Celsius. 0 degrees Celcius is equal to 32 degrees Fahrenheit. Room temperature is typically considered 25 degrees Celcius, which is equal to 77 degrees Fahrenheit.

A more scientific way to describe temperature is in the standard international unit Kelvin. 0 degrees Kelvin is called absolute zero. It is the coldest temperature possible, and is the point at which all molecular motion stops. It is approximately equal to -273 degrees Celcius and -460 degrees Fahrenheit.

Measurement of air temperature:

Air consists of gas molecules, which are combinations of two or more atoms. Although you cannot see them with your eyes, the molecules are constantly moving this way and that at very high speeds. As they move, they collide with one another and with solid surfaces. The temperature of the air is a measure of how quickly the molecules are moving. The more energy of motion the molecules have, the higher the temperature you feel in the air.

Air temperature is measured with thermometers. Common thermometers consist of a glass rod with a very thin tube in it. The tube contains a liquid that is supplied from a reservoir, or "bulb," at the base of the thermometer. Sometimes the liquid is mercury, and sometimes it is red-colored alcohol. As the temperature of the liquid in the bulb rises, the liquid expands. As the liquid expands, it rises up in the tube. The tube is marked with a scale, in degrees Fahrenheit or in degrees Celsius.

When you are measuring the air temperature, be sure to have the thermometer in the shade. If the sun shines on the thermometer, it heats the liquid. Then the reading is higher than the true air temperature. Also, when you take the thermometer outside, give it enough time to adjust to the outdoor air temperature. That might take several minutes.

TEMPERATURE SENSORS AND ITS TYPES:

A temperature sensor plays an important role in many applications. For example, maintaining a specific temperature is essential for equipment used to fabricate medical drugs, heat liquids, or clean other equipment. For applications like these, the responsiveness and accuracy of the **detection circuit** can be critical for quality control.

More frequently, however, **temperature detection is part of preventative reliability**. For example, while an appliance may not actually perform any high temperature activities, the system itself may be at risk to overheating. This risk arises from specific external factors such as a harsh operating environment or internal factors like self-heating of electronics. By detecting when overheating occurs, the system can take preventative action. In these cases, the temperature detection circuit must be reliable over the expected operating temperature range for the application.

Temperature Sensor Types :
Temperature detection is the foundation for all advanced forms of temperature control and compensation. The temperature detection circuit itself monitors ambient temperature. It can then notify the system either of the actual temperature or, if the detection circuit is more intelligent, when a temperature control event occurs. When a specific high temperature threshold is exceeded preventative action can be taken by the system to lower the temperature. An example of this is turning on a fan.
Similarly, a temperature detection circuit can serve as the core of a temperature compensation function. Consider a system such as liquid measuring equipment. Temperature, in this case, directly affects the volume measured. By taking temperature into account, the system can compensate for changing environment factors, enabling it to operate reliably and consistently. There are four commonly used temperature sensor types:

1. Negative Temperature Coefficient (NTC) thermistor
A thermistor is a **thermally sensitive resistor** that exhibits a large, predictable, and precise change in resistance correlated to variations in temperature. An NTC thermistor provides a very high resistance at low temperatures. As temperature increases, the resistance drops quickly. Because an NTC thermistor experiences such a large change in resistance per °C, small changes in temperature are reflected very fast and with high accuracy (0.05 to 1.5 °C). Because of its exponential nature, the output of an NTC thermistor requires linearization. The effective operating range is -50 to 250 °C for gas encapsulated thermistors or 150°C for standard.
2. Resistance Temperature Detector (RTD):
An RTD, also known as a resistance thermometer, measures temperature by correlating the resistance of the RTD element with temperature. An RTD consists of a film or, for greater accuracy, a wire wrapped around a ceramic or glass core. The most accurate RTDs are made using platinum but lower cost RTDs can be made from nickel or copper. However, nickle and copper are not as stable or repeatable. Platinum RTDs offer a fairly linear output that is highly accurate (0.1 to 1 °C) across -200 to 600 °C. While providing the greatest accuracy, RTDs also tend to be the most expensive of temperature sensors.
3. Thermocouple:
This temperature sensor type consists of two wires of different metals connected at two points. The varying voltage between these two points reflects proportional changes in temperature. Thermocouples are non-linear, requiring conversion when used for temperature control and compensation, typically accomplished using a lookup table. **Accuracy is low**, from 0.5 to 5 °C. However, they operate across the **widest temperature range**, from -200 to 1750 °C.
4. Semiconductor-based sensors:
A semiconductor-based temperature sensor is placed on **integrated circuits** (ICs). These sensors are effectively two identical diodes with **temperature-sensitive voltage** vs current characteristics that can be used to monitor changes in temperature. They offer a linear response but have the lowest accuracy of the basic sensor types at 1 to 5 °C. They also have the slowest responsiveness (5 to 60 s) across the narrowest temperature range (-70 to 150 °C).

Typical Temperature Sensor Characteristics				
Typical Charac-teristics	Thermistors General Purpose	Resistance Temperature Devices (RTDs)	Thermocouples (TCs)	Semiconductor Temperature Sensors
Temperature Range	- 55°C to + 125°C	- 200°C to + 850°C	-600°C to +2000°C	-50°C to +150°C
Linearity	Exponential	Fairly linear	Fairly Linear	Best
Sensitivity	High	Low	Medium	Highest
Response Time	Fast	Slow	Fast to Slow (depends on construction)	Slow
Excitation or power	Needed	Needed	Not Needed	Needed
Long-Term Stability	Low	High	High	Medium
Self-heating	Yes	Yes	No	Yes
Cost	Low	Low (film) High (wire wound)	Moderate to High (depends on construction)	Low to Moderate

ATMOSPHERIC PRESSURE AND ITS MEASUREMENT:

Atmospheric pressure:

The atmospheric pressure is the force exerted by the weight of the Earth's atmosphere, expressed per unit area in a given horizontal cross-section. Thus, the atmospheric pressure is equal to the weight of a vertical column of air above the Earth's surface, extending to the outer limits of the atmosphere.

Unit of Atmospheric pressure:

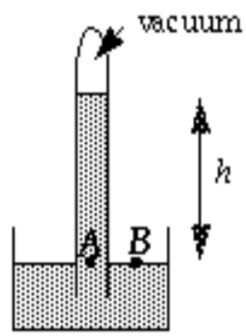
In meteorology, atmospheric pressure is reported in hectopascals (hPa). 1 hPa is equal to 100 Pa, the pascal being the basic SI (System of International Unit) . 1 Pa is equal to 1 Newton per square meter (N/m2). And 1 hPa is equal to 1mb that was used formerly.

The scales of all barometers used for meteorological purposes should be graduated in hPa. Some barometers are graduated in the unit inHg or mmHg. Under standard conditions, the pressure exerted by a pure mercury column which is 760 mm high is 1013.250 hPa, so the conversion factors are represented as follows:

1 hPa = 0.750062 mmHg;

1 mmHg = 1.333224 hPa.
And because of the relation between inch and mm (1 inch = 25.4 mm), the following conversion coefficients are provided:
1 hPa = 0.029530 inHg;
1 inHg = 33.8639 hPa;
1 mmHg = 0.03937008 inHg.
Pressure data measured with the barometer should preferably be expressed in hectopascals (hPa).

Measurement of Atmospheric pressure:
The atmospheric pressure is the weight exerted by the overhead atmosphere on a unit area of surface. It can be measured with a mercury barometer, consisting of a long glass tube full of mercury inverted over a pool of mercury:



When the tube is inverted over the pool, mercury flows out of the tube, creating a vacuum in the head space, and stabilizes at an equilibrium height h over the surface of the pool. This equilibrium requires that the pressure exerted on the mercury at two points on the horizontal surface of the pool, A (inside the tube) and B (outside the tube), be equal. The pressure PA at point A is that of the mercury column overhead, while the pressure PB at point B is that of the atmosphere overhead. We obtain P_A from measurement of h:

$$P_A = \rho_{Hg} g h$$

where ρHg = 13.6 g cm-3 is the density of mercury and g = 9.8 m s-2is the acceleration of gravity. The mean value of h measured at sea level is 76.0 cm, and the corresponding atmospheric pressure is 1.013x105 kg m-1 s-2 in SI units. The SI pressure unit is called the Pascal (Pa); 1 Pa = 1 kg m-1 s-2. Customary pressure units are the atmosphere (atm) (1 atm = 1.013x105 Pa), the bar (b) (1 b = 1x105 Pa), the millibar (mb) (1 mb = 100 Pa), and the torr (1 torr = 1 mm Hg = 134 Pa). The use of millibars is slowly giving way to the equivalent SI unit of hectoPascals (hPa). The mean atmospheric pressure at sea level is given equivalently as P = 1.013x105 Pa = 1013 hPa = 1013 mb = 1 atm = 760 torr.

CYCLONES AND ANTICYCLONES:

Description:
Cyclones and anticyclones are the major forces that shape everyday weather. Understanding how these systems behave is critically important to accurate meteorological forecasting.

Working of Cyclones:
Cyclones are areas of low pressure. Since air moves from areas of high pressure to low pressure, cyclones produce a convergence at the surface. This converging air is forced upwards into the atmosphere, creating a divergence aloft. As warm, moist air is sucked into the low and forced aloft, it produces an unstable atmosphere. This warm, moist air cools, condenses and forms storm clouds. That is why the word cyclone is almost synonymous with the word storm which denotes a period of heavy rainfall over a specific area. Cyclones can be tropical in nature, such as a hurricane, or a low-pressure system over a land mass, such as the United States. In tropical belt cyclones originate at low latitudes in the oceans from thermal convection. It develops into a violent whirling air mass having horizontal dimensions of 150 to 500 km and wind speed exceeding 120 km/hour. The tropical revolving storms of this type are called Hurricane in general but are known by name Cyclone in India and Typhoons in Far East region. The cyclones which are formed in mid-latitude belt (30° to 60°) are called extra-tropical cyclones. They form along the boundaries between warm and cold air masses (The boundary is known by a technical name 'Front').

Effects of Cyclones:
In general, cyclones are associated with clouds, rain and thunderstorms. They produce steep pressure gradients, creating strong surface winds. Over the United States, cyclones will draw in warm, moist air from the Gulf of Mexico, creating a warm front. This generally produces light, steady rain to the northeast of a low, ahead of the warm front. Cyclones also draw in cold air from the north. This colder air forms a cold front, which collides with the warm, moist air to produce showers and thunderstorms to the southeast of a low, ahead of the cold front.
Working of **Anticyclones:**
Anticyclones are areas of high pressure. The sinking air spreads out when it reaches the ground, producing a divergence at the surface. Aloft, air rushes in to fill the void, creating a convergence aloft. Anticyclones produce a stable atmosphere. Anticyclones, or highs, are also referred to as blocking highs because they tend to force areas of low pressure to travel around them. For example, a hurricane (tropical cyclone) that encounters an area of high pressure will be deflected around the cyclone. Blocking highs have spared the East Coast of the United States from many hurricane strikes, pushing them out over the Atlantic Ocean.

Effects of Anticyclones:
In general, anticyclones are associated with fair weather. As the air sinks, it warms and dries. This produces clear skies and increases the air's ability to transmit radiant energy. In the summer, this means high temperatures due to solar heating of the surface. During the winter, this means

low temperatures due to the radiation of heat from the surface into space. Cyclones typically have low-pressure gradients, producing light, variable winds at the surface. Cyclones tend to be slow movers, providing extended periods of fair weather. During the summer and fall, a Bermuda High can establish itself off the eastern coast of the U.S. for long periods of time, producing high temperatures in the Southeast and blocking hurricanes.

Differences between Cyclones and Anticyclones:

1. Pressure:

The primary difference between the two types of weather systems is their atmospheric pressure. Cyclones represent areas of low pressure, while anticyclones represent areas of high pressure.

2. Direction:

Cyclones spin in a counter clockwise direction in the Northern Hemisphere and clockwise in the Southern Hemisphere. Anticyclones spin in a clockwise direction in the Northern Hemisphere and counter clockwise in the Southern Hemisphere.

3. Weather

In general, cyclones are associated with clouds, rain and thunderstorms. In general, anticyclones are associated with fair weather.

POSSIBLE QUESTIONS

PART B

1. Define atmosphere.
2. Differentiate cyclones and anticyclones.
3. Write the four types of temperature sensors?
4. What is the structure of our atmosphere?
5. Describe the composition of the atmosphere?
6. Define atmospheric pressure.
7. How is Air Temperature measured?

PART C

1. Draw and explain the physical structure of the atmosphere.
2. Define cyclone and anticyclone. Explain its characteristics.
3. Explain the variation of pressure and temperature with height in atmosphere.
4. Briefly explain the composition of atmosphere.
5. Write a short notes about requirement of measuring an air temperature.
6. Describe the types of temperature sensors.
7. What is meant by atmospheric pressure? Explain the measurement of atmospheric pressure.
8. Discuss about the various compositional layers in atmosphere.

UNIT-II

SYLLABUS

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

FORCES ACTING TO PRODUCE WIND:
Wind is motion of air in response to unbalanced forces acting in horizontal direction. The different forces involved in the flow of the wind are described below:-

1. Horizontal pressure gradient (PG) force:
The rate of change in atmospheric pressure between two points at the Same elevation is called the pressure gradient or isobaric slope. It is proportional to the difference in pressure and is the immediate Cause of horizontal air movement. The direction of air flow is from high to Low pressure and the speed of flow is directly related to the pressure Gradient. The pressure gradient is said tube steep when the rate of change Is great and the gradient the more rapid will be the flow of air. The direction of the pressure gradient is perpendicular to the isobars and pointing towards low pressure.

$$PG = 1/P^{*}\ dp/dn$$

Where P= air density
Dp/dn = rate of change in pressure with distance.

2. The earth's rotational deflective force [Coriolis force]:
This force comes into play due to rotation of the earth on it axis. It has most potent influences upon wind direction. The Coriolis force effect Causes all winds in the nor them hemisphere to move or deflect toward the Right and those of the sot herm hemisphere to move to the left with respect to the rotating earth. At the equator the effect has a value of zero (Sin 90=1).and it increases regularly towards the poles (and becomes Sin 90=1). The Coriolis effect changes wind direction but does not change wind speed.

3. Centrifugal force:
This force tends to throw the air particles outward from the centre of small circle path on which the particle is moving. The centrifugal force works against the gravitational attraction directed forwards the earth centre.

4. Frictional force:

The roughness of the surface provides frictional resistance to the air motion. It is the retarding effect of trees, buildings and other irregularities in the topography; It is always opposed to the direction of the air motion and therefore fends to decrease the wind speed. Friction causes a movement of air across the isobars towards low pressure.

5. Geotropic winds:
When a wind flows in a straight line with no acceleration or frictional force on it, the only forces acting are the carioles and pressure gradient foresee. The wind that blows under these conditions is called as geotropic wind.

WIND SPEED AND DIRECTION:
Wind speed describes how fast the air is moving past a certain point. This may be an averaged over a given unit of time, such as miles per hour, or an instantaneous speed, which is reported as a peak wind speed, wind gust or squall.
Wind direction describes the direction on a compass from which the wind emanates, for instance, from the North or from the West.
Importance of wind speed and direction:
Wind speed and direction are important for monitoring and predicting weather patterns and global climate. Wind speed and direction have numerous impacts on surface water. These parameters affect rates of evaporation, mixing of surface waters, and the development of seiches and storm surges. Each of these processes has dramatic effects on water quality and water level.

Measurement of wind speed and direction:
Wind speed is typically reported in miles per hour, knots, or meters per second. One mile per hour is equal to 0.45 meters per second, and 0.87 knots.
Wind direction is typically reported in degrees, and describes the direction from which the wind emanates. A direction of 0 degrees is due North on a compass, and 180 degrees is due South. A direction of 270 degrees would indicate a wind blowing in from the west.
Wind Speed and Direction Technology:
The measurement of wind speed is usually done using a cup or propeller anemometer, which is an instrument with three cups or propellers on a vertical axis. The force of the wind causes the cups or propellers to spin. The spinning rate is proportional to the wind speed
Wind direction is measured by a wind vane that aligns itself with the direction of the wind.

MEASURING WIND SPEED AND DIRECTION:
Wind has both speed and direction. Anemometers measure wind speed and wind vanes measure wind direction.
A typical wind vane has a pointer in front and fins in back. When the wind is blowing, the wind vane points into the wind. For example, in a north wind, the wind vane points northward.

A cup anemometer is a common tool to measure wind speed. The cups catch the wind and produce pressure difference inside and outside the cup. The pressure difference, along with the force of the wind, causes the cups to rotate. Electric switches measure the speed of the rotation, which is proportional to the wind speed.

At wind speeds below about 3 mph, the cup anemometer is prone to error because friction keeps the cups from turning. At wind speeds above 100 mph, cup anemometers often blow away or give unreliable measurements. In freezing rain, the anemometer can literally freeze up and stop turning.

Propellers also can measure wind speed. The propeller blades rotate at a rate proportional to the wind speed.

A windsock often is used at airports. A windsock is a cone-shaped bag with an opening at both ends. When it is limp, winds are light; when it is stretched out, winds are strong. Pilots can quickly determine the wind direction and speed along a runway just by observing the shape and direction of a windsock.

Sonic anemometers use sound waves humans cannot hear to measure wind speed and direction. The instrument determines the wind velocity by measuring the time between when the instrument sends a sonic pulse and when it is received.

HUMIDITY:
"Humidity" refers to the presence of water vapour in the atmosphere. It is measured in either relative terms (relative humidity) or absolute terms (dew point temperature).

Water vapour is, as the name implies, the vapour form of water. It is totally transparent, just like the rest of the gases in the atmosphere. So, we really can't see humidity with our eyes...only the effects of water vapour condensing back into water droplets.

Relative humidity is a measure of how close to saturation the air is with water vapour. At any given temperature and pressure, air can "hold" only so much water vapour before the vapour begins to form liquid water drops, such as fog or clouds. At 100% relative humidity, the air is saturated. A relative humidity of 0% would indicate that no water vapour is present.

Dew point temperature is an absolute measure of how much water vapour is in the air. The warmer the air, the greater the amount of water vapour it can contain. So, for example, if air at a temperature of 100 deg. F had a dew point of 80 deg. F, this would be a very large amount of water vapour in absolute terms, but the relative humidity would only be about 53%, indicating the air could hold almost 2 times more vapour before becoming saturated.

At a very cold temperature of, say, 0 deg. F, if the dew point is also 0 deg. F, then the relative humidity is 100% (the air cannot hold any more vapour without liquid droplets or ice crystals forming), but the absolute humidity is very low, that is, there is very little water vapour in the air in absolute terms. Scientists have developed a system to classify the different types of clouds.

Each cloud you see can be put into one of the many categories based on both their general shape and how high up they are in the atmosphere.

CLOUDS:

Clouds are large groups of tiny water droplets (vapour) or ice crystals that cling to pieces of dust in the atmosphere.
Clouds are so important to the earth's weather that meteorologists (people who study the weather) also study the clouds and their movement. In fact, without clouds, it wouldn't rain or snow! They come in all different shapes and sizes. Some are really low to the ground and

1. Cirrus Clouds:
These are the highest clouds in the atmosphere. Cirrus clouds are thin, wispy clouds that often appear on days with fair weather conditions and low winds. In fact, the word cirrus means "curl of hair" in Latin!
Because of the freezing temperatures high up in the atmosphere, these clouds are usually made up of ice crystals which give them a bright white appearance.
These clouds form in flat sheets, so they aren't as thick as the other types of clouds. Cirrus clouds are also spread out in patches, with large breaks of the sky in between them.
Since these clouds are so far from the ground, they aren't often affected by the changing weather on the earth's surface. Instead, they peacefully float along from west to east.

2. Cumulus Clouds:
Cumulus clouds are bright white and look like big puffs of cotton. The word cumulus is Latin for "heap" or "pile." This is because these clouds are sometimes extremely thick and tall and they often grow upward in size. An easy way to remember this is to think of the word accumulate, which means "to gather an increasing amount."
The bases of these clouds are often flat and the tops are usually composed of rounded sections. Cumulus clouds are vertically developing clouds which mean they can become extremely tall clouds.

3. Stratus Clouds:
Stratus clouds are thick, gray clouds that look like fog that hasn't touched the ground. In fact, these clouds sometimes are made up of fog that has lifted from the ground. As you may have guessed, these are low-altitude clouds, which means they are really close to the ground.
When someone says, "today is a gray and cloudy day", they are usually referring to these thick, uniform clouds. Stratus clouds often produce a light, drizzly rain or snow, especially when it's a nimbostratus cloud.

4. Nimbus Clouds:
The word "nimbus" means rain in Latin, so these are the clouds that produce rain. Any cloud with the prefix "nimbo" or the suffix "nimbus" is a type of rain cloud. For example, a

nimbostratus cloud is a stratus cloud that will cause rain or snow. Since stratus clouds are dull, gray, and featureless, nimbostratus clouds can be seen on gray, rainy days.
Another type of rain cloud is the cumulonimbus. Since cumulus clouds are the heaping, giants, cumulonimbus clouds are giant, heaping rain clouds. These clouds can be so huge that their bases start at only 1,000 feet above the ground with a top of 39,000 feet! These clouds, sometimes called thunderheads, form into the shape of an anvil which is a sure sign of a storm!
Heavy thunderstorms and even tornadoes are associated with this type of cloud (a tornado is a rotating column of air connected to a cumulonimbus cloud.)

Cloud Name	Type	Latin Meaning
Altocumulus	Mid-level	"high heap"
Altostratus	Mid-level	"high sheet"
Cirrus	High-level	"curl of hair"
Cirrocumulus	High-level	"wispy heap"
Cirrostratus	High-level	"wispy sheet"
Cumulonimbus	Vertical developing (all levels), rain	"rain cloud"
Cumulus	Vertical developing (all levels)	"heap"
Nimbostratus	Low-level, rain	"rain sheet"
Stratocumulus	Low-level	"heap & sheet"
Stratus	Low-level	"sheet"

RAINFALL:
Precipitation is any form of moisture which falls to the earth. This includes rain, snow, hail and sleet. Precipitation occurs when water vapour cools. When the air reaches saturation point (also known as condensation point and dew point) the water vapour condenses and forms tiny droplets of water.

Types of rainfall:
Rainfall has been classified into three main types –

- Convectional rainfall
- Orographic or relief rainfall
- Cyclonic or frontal rainfall

1. Convectional rainfall:

- The air on being heated becomes light and rises up in convection currents.
- As the air rises, it expands and drops the temperature and subsequently, condensation takes place and cumulous clouds are formed.
- Heavy rainfall with thunder and lightning takes place which does not last long.
- Such rain is usual in the summer or in the hotter part of the day.

- This type of rainfall is common in the equatorial regions and internal parts of the continents, predominantly in the northern hemisphere.

2. Orographic or relief rainfall:

- When the saturated air mass comes across a mountain, it is forced to rise.
- The rising air expands, the temperature falls, and the moisture is condensed.
- The principal characteristic of this type of rain is that the windward slopes get more rainfall.
- After giving rain on the windward side, when these winds reach the other slope, they drop away, and their temperature increases. Then their ability to take in moisture increases and hence, these leeward slopes remain rainless and dry.
- The region situated on the leeward side is known as the rain-shadow area.

3. Cyclonic or frontal rainfall:

- Cyclonic Rain is occurred by cyclonic activity and it occurs along the fronts of the cyclone.
- It is formed when two masses of air of unlike density, temperature, and humidity meet.
- A layer separating them is called the front.
- This front has two parts called the warm front and the cold front.
- At the warm front, the warm lighter wind increases slightly over the heavier cold air.
- As the warm air rises, it cools, and the moisture present in it condenses to form clouds
- rain falls gradually for a few hours to a few days.

APSORBTION IN ATMOSPHERE:

Absorption is the process by which "incident radiant energy is retained by a substance." In this case, the substance is the atmosphere. When the atmosphere absorbs energy, the result is an irreversible transformation of radiation into another form of energy. This energy is transformed according to the nature of the medium doing the absorbing.

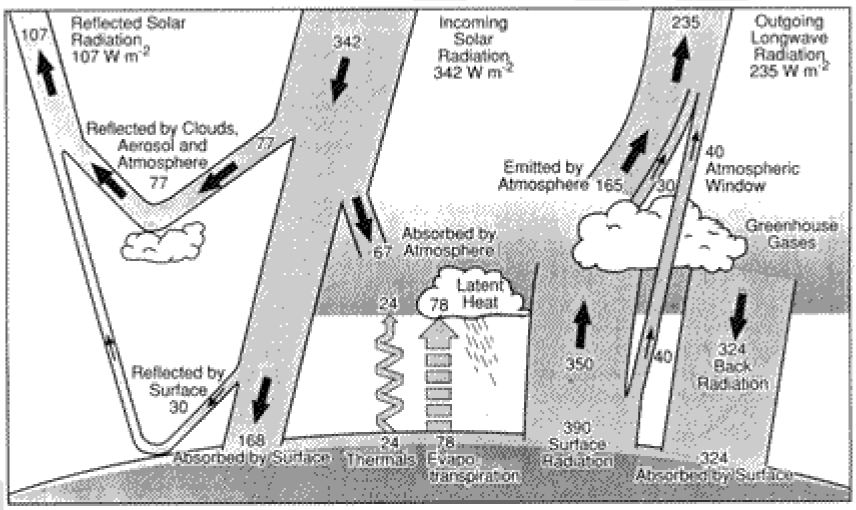
The absorbing medium can also do much more. The medium will only absorb a portion of the total energy. The other energy will either be reflected, refracted, or scattered. The energy absorbed can also be transmitted back into other parts of the atmosphere.

The atmosphere, due to the many different gases and particles contained therein, absorbs and transmits many different wavelengths of electromagnetic radiation. The wavelengths that pass through the atmosphere unabsorbed constitute the "atmospheric windows." The atmospheric windows can be seen in the graphic below, taken from The Columbus Optical SETI Observatory, which shows the lines of transmission through the atmosphere. The valleys, like at the left end of the scale for visible light, are the "windows" where there is very little attenuating of the radiation by the medium it pass through.

Absorption is mainly caused by three different atmospheric gases. Contrary to popular belief, water vapour causes the most absorption, followed by carbon dioxide and then ozone. In the picture below, one can see how much of the total incoming radiation the atmosphere typically absorbs.

Atmospheric absorption of electromagnetic radiation helps the earth in two main ways. First, absorption helps people by preventing high-energy radiation from reaching the surface which limits our exposure to harmful radiation. The atmosphere absorbs most of the radiation from the ultraviolet region through the X-ray region.

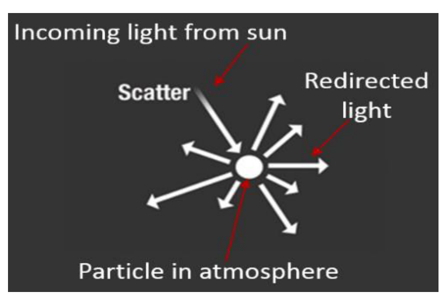
The second way in which absorption helps the earth is as a heat source for it. If one were to take a vertical cross section of the entire atmosphere, one would note that the temperature generally increases with height. This increase in temperature is caused by an increase in absorption of electromagnetic radiation with height due to higher concentrations of high-energy wavelength absorbing gases present at higher atmospheric levels.



SCATTERING IN ATMOSPHERE:

In addition to being absorbed or transmitted, electromagnetic radiation can also be scattered by particles in the atmosphere. **Scattering** is the redirection of electromagnetic energy by suspended particles in the atmosphere. The type and amount of scattering that occurs depends on the size of the particles and the wavelength of the energy. There are three main types of scattering that impact incoming solar radiation.

- Rayleigh Scatter
- Mie Scatter
- Non-Selective Scatter



1. Rayleigh Scatter:

Rayleigh scatter occurs when radiation (light)

interacts with molecules and particles in the atmosphere that are ***smaller*** in diameter that the wavelength of the incoming radiation. Shorter wavelengths are more readily scattered that longer wavelengths. Light at shorter wavelengths (blue and violet) are scattered by small particles that include NO_2 and O_2. Since blue light is at the short wavelength end of the visible spectrum, it is more strongly scattered in the atmosphere than long wavelength red light. This results in the blue colour of the sky. Rayleigh scatter is also responsible for haze in images. In aerial photography special filters are used to filer out the scatter blue light to reduce haze. In digital images there are different techniques used to minimize the impacts of Rayleigh scatter.
At sunrise and sunset the incoming sunlight travels a longer distance through the atmosphere. The longer path produces leads to scatter of the short (blue) wavelengths that is so complete we only see the longer wavelengths of light, the red and orange. In the absence of particles and scattering the sky would appear black.

2. Mie Scatter:

Mie scatter occurs when the wavelength of the electromagnetic radiation is a ***similar*** size to the atmospheric particles. Mie scatter generally influences radiation from the near UV through the mid- infrared parts of the spectrum. Mie scatter mostly occurs in the lower portions of the atmosphere where larger particles are more abundant, and dominates when cloud conditions are overcast. Pollen, dust and smog are major cause of Mie scatter.

3. Non-Selective Scatter:

Non-selective scattering occurs when the diameter of the particles in the atmosphere are much ***larger***than the wavelength of radiation. Non-selective scatter is primarily caused by water droplets in the atmosphere. Non-selective scatters scatter all visible light evenly - hence the term non-selective. In the visible wavelength light is scattered evenly, hence fog and clouds appear white. Since clouds scatter all wavelengths of light this means that clouds block all energy from reach the Earth's surface. This can make interpreting and analysing remote sensed imagery difficult in areas prone to cloud cover. Clouds also cast shadows that change the illumination and relative reflectance of surface features. This can be a major limitation in remote sensing imagery.

RADIATION LAWS:

The radiation reaching to the earth surface from the sun, atmosphere and from earth to atmosphere, space follows certain physical laws known as radiation laws. They are

1. Plank’s Law:

The Electromagnetic radiation consists of a stream or a flow of particles or quanta. Each quantum having energy content

E=hv.

Where, h=Plank's constant (6.625x1027 ergs sec-1)
V=frequency of Electro-magnetic length.
Greater the frequency (i.e. shorter the wave length) greater is the energy content of the quantum.

2. Stefan Boltzman's Law:

The intensity of radiation emitted by a radiating body is proportional to the fourth power of its absolve temperature.

E=ST

Where E=Emissive of the body
S=Stephen's constant (5. 67x10-8W m-2.K-4)
T=surface temp of the body in absolute 0K

3. **Weins displacement Law:**

The wavelength of maximum intensity of emission is inversely proportional to the absolute temperature, of that body.

µ Max (um) =2897

For example, the temp. of earth surface is 2870K then its peak emission will be close to 10 µ similarly for the sun having temp, of 6000 0K it will peak at 0.5π

4. **Kirchhoff's Law:**
Kirchhoff's Law state that the absorptivity of a material for a radiation of a specific wave length is equal to its emissivity for the same wave length at same temperature.

POSSIBLE QUESTIONS

PART B

1. What is atmospheric emission?

2. Write a short notes about rainfall.

3. How do you measure the wind speed and direction?

4. Define the term "humidity".

5. Define the unit of wind speed.

6. State four radiation laws.

7. Mention the forces produce a wind.

PART C

1. Comment upon the following terms.
   (i) Humidity (ii) Clouds (iii) Rainfall

2. Explain in detail about forces acting to produce wind.

3. Briefly explain about the measuring of wind speed and direction.

4. Write a short notes about absorption and scattering in atmosphere.

5. Describe the production of wind.

6. State and explain the four radiation laws.

7. Write a short notes on the following:-
   (i) Measuring of wind speed (ii) scattering in atmosphere

8. Define rainfall. Explain the various types of rainfall.

UNIT-III

SYLLABUS

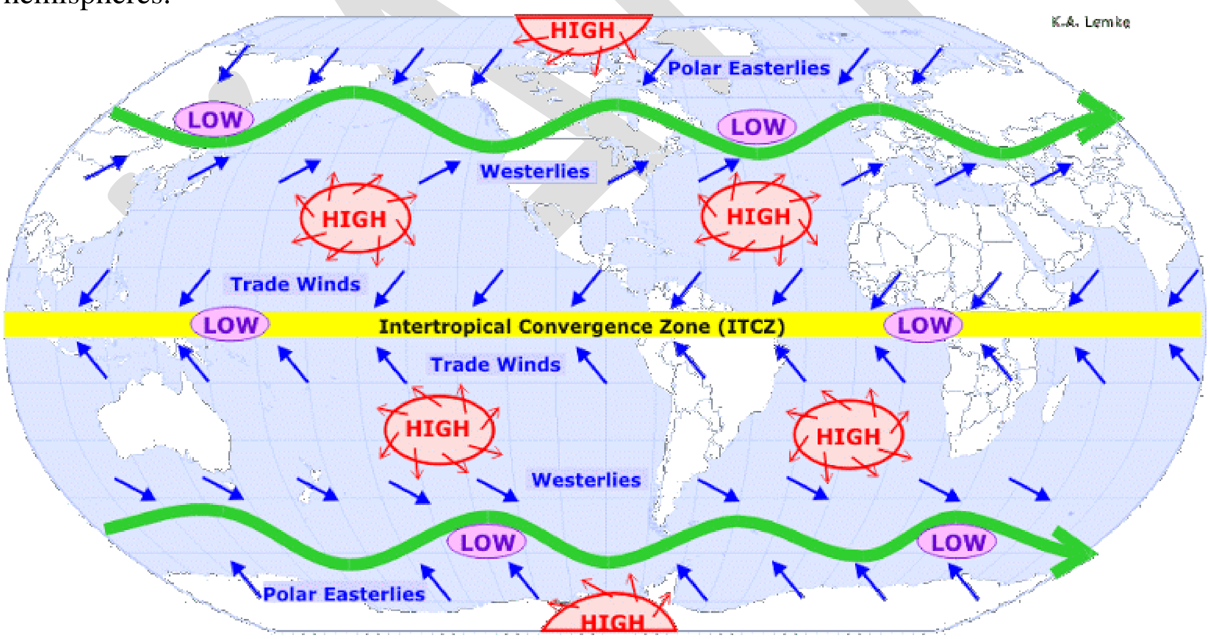
Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

GLOBAL WIND SYSTEMS:

The four major wind systems are the Polar and Tropical Easterlies, the Prevailing Westerlies and the Intertropical Convergence Zone. These are also wind belts. There are three other types of wind belts, also. They are called Trade Winds, Doldrums, and Horse Latitudes.

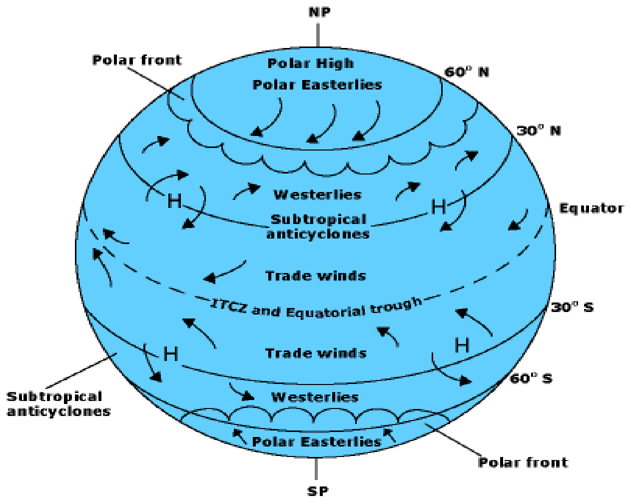
Polar Easterlies- Polar Easterlies can be found at the north and south poles and they are cold and dry because of where it is located, which is at high latitudes. This type of wind system forms when cool air, at the poles, and then transfers to the equator. Polar Easterlies are located 60-90 degrees latitude in both the southern and northern hemispheres.

Tropical Easterlies- Tropical Easterlies take direction in an east to west flow because of the rotation of the Earth. As air from the equator rises, it gets warmer and when it cools down, it comes back down to the equator. Tropical easterlies are located 0-30 degrees latitude in both hemispheres.



Prevailing Westerlies- Prevailing Westerlies are located in the 30-60 degrees latitude in the northern and southern hemispheres. They blow from west to east and occur in the clement part of the Earth.

Intertropical Convergence Zone (ITCZ)- The Intertropical Convergence Zone is also known as Equatorial Convergence Zone or the Intertropical Front. It forms when southest and northeast trade winds converge in a low pressure zone, near the equator. It usually appears as a band of clouds and comes with thunderstorms, which are short but produce extreme amounts of rain.



Horse Latitudes- Horse latitudes, also known as the subtropical high, are about 30-35 degrees north and south of the equator. Horse latitudes is a region where there is weak winds because of high pressure and decreasing dry air.The orgin of the name Horse latitudes is uncertain but it is said that ships that needed wind power couldn't move on the water and the sailors threw the horses and cattle over the ship to save on provisions.

Trade Winds- Trade winds blow from the horse latitudes to the low pressure of the ITCZ. Trade winds get its name from its capability of blowing trade ships across the ocen, very quickly. In the northern hemisphere, the winds blow from the northeast, which is called the Northeast Trade winds. In the Southern hemisphere, the trade winds blow from hemisphere, the trade winds blow from the southeast, and surprisingly, they're called the Southeast Trade Winds.

Doldrums- Doldrums is the same thing as the Intertropical Convergence Zone, it's just a different name for it. This name originated from some sailor who noticed the stillness in the rising air and called it the "doldrums", which means depression or despondency. Like I've stated earlier, it takes place 5 degrees north and south of the equator the equator and between the two belts of trade winds. When the trade winds converge, it produces convectional storms

AIR MASSES AND ITS CLASSIFICATION:

Air Masses:

1) When the air remains over a homogenous area for a sufficiently longer time, it acquires the characteristics of the area. The homogenous regions can be the vast ocean surface or vast plains and plateaus.

2) The air with distinctive characteristics in terms of **temperature** and **humidity** is called an air mass. It is a large body of air having **little horizontal variation** in temperature and moisture.
3) Air masses form an integral part of the **global planetary wind system**. Therefore, they are associated with one or other wind belt.
4) They extend from **surface to lower stratosphere** and are across thousands of kilometres.

Classification of air masses:

1) Broadly, the air masses are classified into polar and tropical air masses.
2) Both the polar and the continental air masses can be either of maritime or continental types.

1. Continental Polar Air Masses (CP):

3) Source regions of these air masses are the Arctic basin, northern North America, Eurasia and Antarctica.
4) These air masses are characterized by **dry, cold and stable conditions.**
5) The weather during winter is frigid, clear and stable.
6) During summer, the weather is less stable with lesser prevalence of anticyclonic winds, warmer landmasses and lesser snow.

2. Maritime Polar Air Masses (MP):

7) The source region of these air masses are the oceans between **40° and 60° latitudes**.
8) These are actually those continental polar air masses which have moved over the warmer oceans, got heated up and have collected moisture.
9) The conditions over the source regions are **cool, moist and unstable**. These are the regions which cannot lie stagnant for long.
10) The weather during winters is characterized by high humidity, overcast skies and occasional fog and precipitation.
11) During summer, the weather is clear, fair and stable.

3. Continental Tropical Air Masses (CT):

12) The source-regions of the air masses include tropical and sub-tropical deserts of Sahara in Africa, and of West Asia and Australia.
13) These air masses are dry, hot and stable and do not extend beyond the source.
14) They are dry throughout the year.

4. Maritime Tropical Air Masses (MT):

15) The source regions of these air masses include the oceans in tropics and sub-tropics such as Mexican Gulf, the Pacific and the Atlantic oceans.
16) These air masses are **warm, humid and unstable.**
17) The weather during winter has mild temperatures, overcast skies with fog.

18) During summer, the weather is characterized by high temperatures, high humidity, cumulous clouds and convectional rainfall.
19) Tropical cyclones are violent storms that originate over oceans in **tropical areas** and move over to the coastal areas bringing about large scale destruction due to violent winds (squalls), very heavy rainfall (torrential rainfall) and **storm surge.**
20) They are irregular wind movements involving **closed circulation** of air around a low pressure centre. This closed air circulation (whirling motion) is a result of **rapid upward movement of hot air** which is subjected to Coriolis force. The low pressure at the centre is responsible for the wind speeds.
21) Squall : a sudden violent gust of wind or localized storm, especially one bringing rain, snow or sleet.
22) Torrent : strong and fast-moving stream of water or other liquid.
23) The cyclonic wind movements are **anti-clockwise in the northern hemisphere** and **clockwise in the southern hemisphere** (This is due to Coriolis force).
24) The cyclones are often characterized by existence of an anticyclone between two cyclones.

FRONTS AND ITS CLASSIFICATION:

25) Front is that sloping boundary which separates two opposing air masses having contrasting characteristics in terms of air temperature, humidity, density, pressure, and wind direction. An extensive transitional zone between two converging air masses is called frontal zone or frontal surface which represents zone of discontinuity in the properties of opposing contrasting air masses.
26) Frontal zone is neither parallel nor vertical to ground surface; rather it is inclined at low angle. Though fronts differ from each other in terms of their location, types, and areal extent but they are characterized by the following common characteristics e.g., large differences in air temperature across a front, bending isobars, abrupt shift in wind direction, cloudiness and precipitation.

Classification of Fronts:

Fronts are classified into four principal types on the basis of their different characteristic features.

(1) Warm front,
(2) Cold front,
(3) Occluded front
(4) Stationary front.

(1) Warm Front:

1) Warm front is that gently sloping frontal surface along which warm and light air becomes active and aggressive and rises slowly over cold and dense air. The average slope of

warm fronts in middle latitudes ranges between 1:100 to 1:400. The gradually rising warm air along the gently sloping warm front is cooled adiabatically, gets saturated and after condensation precipitation occurs over a relatively large area for several hours in the form of moderate to gentle precipitation.

(2) Cold Front:

1) Cold front is that sloping frontal surface along which cold air becomes active and aggressive and invades the warm air territory and being denser remains at the ground but forcibly uplifts the warm and light air.
2) Since the air motion is retarded at the ground surface due to friction while the free air above has higher velocity and hence the cold front becomes much steeper than warm front. This is why the slope of cold front varies from 1:50 to 1:100 (which means the rise of the wedge of cold air at the rate of one kilometre for every 50 to 100 kilometres).
3) A cold front is associated with bad weather characterized by thick clouds, heavy downpour with thunderstorms, lightning etc. Sometimes, cold frontal precipitation is also associated with snowfall and hailstorms.

(3) Occluded Front:

1) Occluded front is formed when cold front overtakes warm front and warm air is completely displaced from the ground surface.

(4) Stationary Front:

1) Stationary front is formed when two contrasting air masses converge in such a way that they become parallel to each other and there is no ascent of air. In fact, the surface position of stationary front does not move either forward or backward.

Changing Weather Associated With Fronts:

1) Since fronts are formed due to convergence of two air masses of contrasting temperatures and hence contrasting weather conditions are found from north to south or south to north. Differences in terms of temperature, humidity, precipitation, cloudiness, and wind direction are experienced along different fronts e.g., warm and cold fronts.

(1) Weather Associated With Warm Fronts:

1) Warm air becomes active and aggressive along warm front as it invades cold air zone and thus being lighter it gradually rises over cold air and is cooled adiabatically from below. Cooling of warm air causes condensation and cloud formation followed by precipitation. If the aggressive warm air is stable and less humid, condensation occurs at great height and hence much lifting of air is required.
2) On the other hand, if the warm air is moist and unstable, only a slight lifting causes condensation and precipitation. The warm front precipitation is of long duration, moderate but widespread because of gentle slope of warm front. There are frequent

changes in cloud types. The sequence of clouds from above downward comprises cirrus, cirro- stratus, alto-stratus and nimbo-stratus.

3) When warm front advances forward, the warm sector comes over the observation place. There is sudden change in weather conditions with the arrival of warm sector e.g., sudden increase in temperature and specific humidity, decrease in air pressure, disappearance of clouds, clear sky, and break in precipitation.

(2) Weather Associated With Cold Front:

1) Cold and dense air becomes active and aggressive along cold front wherein cold air invades warm air region and pushes it upward while it, being denser, settles downward. If cold front passes away soon, weather also becomes clear soon, otherwise if the front becomes stationary, the sky becomes overcast with cumulo-nimbus clouds provided that cold air is moist and unstable, and frontal thunderstorms are formed. Heavy precipitation occurs but is of short duration.
2) The consequent weather is characterized by decrease in air temperature, increase in air pressure, decrease in specific and relative humidity and change in wind direction from 45° to 180°. Precipitation is accompanied by lightning and cloud thunder. Sometimes, rainfall is associated with hailstorms. After the passage of cold front, clouds disappear, precipitation terminates and weather becomes clear and north-west cold winds set in.

JET STREAMS AND ITS CLASSIFICATION:

1) In fact, jet stream was discovered during second world war when American jet bomber fighter planes while flying towards Japan (from east to west) found obstructions of an air circulation which was moving in opposite direction (west to east) resulting into marked reduction in the velocity of jet fighter planes, these planes registered marked increase in their velocity while they used to return to their bases (west to east).
2) After careful study of this phenomena, it was found that there was a strong upper air circulation from west to east in the upper portion of troposphere which presented obstruction in the free movement of jet fighter planes. Based on this fact, westerly strong meandering upper air circulation was called as jet stream.

Classification:

(1) Polar Front Jet Streams:

Polar front jet streams are formed above the convergence zone (40-60 lats.) of the surface polar cold air mass and tropical warm air mass. The thermal gradient is steepened because of convergence of two contrasting air masses. These move in easterly direction but are irregular.

(2) Subtropical Westerly Jet Streams:

Subtropical westerly jet streams move in the upper troposphere to the north of subtropical surface high pressure belt (at the poleward limit of the Hadley cell in both the hemispheres) i.e., above 30°-35° latitudes. Their circulation is from west to east in more regular manner than the polar front jet streams.

(3) Tropical Easterly Jet Streams:

Tropical easterly jet streams develop in the upper troposphere above surface easterly trade winds over India and Africa during summer season due to intense heating of Tibetan plateau and play important role in the mechanism of Indian monsoon.

(4) Polar Night Jet Streams:

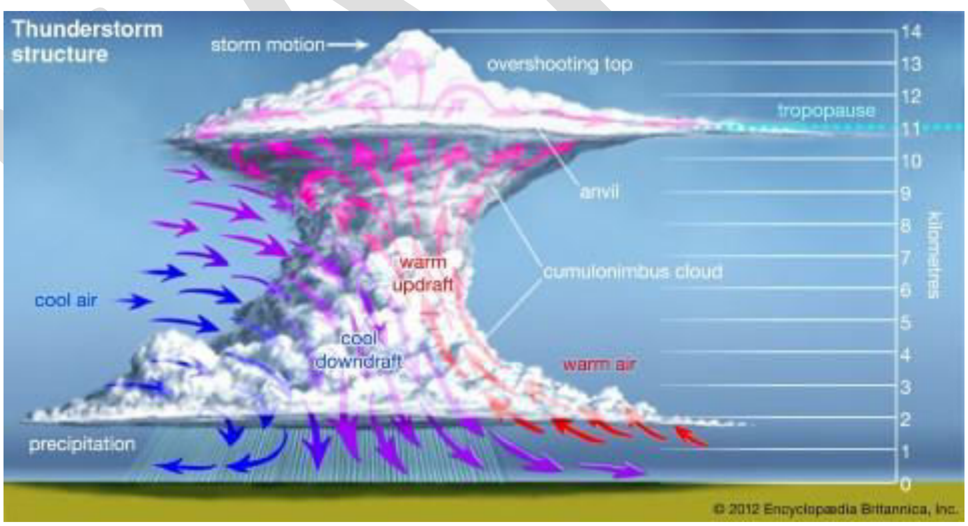
Polar night jet streams, also known as stratospheric sub-polar jet streams, develop in winter season due to steep temperature gradient in the stratosphere around the poles at the height of 30 km. These jet streams become very strong westerly circulation with high wind velocity during winters but their velocity decreases during summers and the direction becomes easterly.

(5) Local Jet Streams:

Local jet streams are formed locally due to local thermal and dynamic conditions and have limited local importance.

LOCAL THUNDERSTORM:

1) Thunderstorms and tornadoes are **severe local storms**. They are of **short duration**, occurring over a **small area** but are **violent.**
2) Thunderstorm is a storm with **thunder and lightning** and typically also **heavy rain or hail.**
3) Thunderstorms **mostly occur on ground** where the temperature is high. Thunderstorms are less frequent on water bodies due to low temperature.
4) Worldwide, there are an estimated 16 million thunderstorms each year, and at any given moment, there are roughly 2,000 thunderstorms in progress.



Formation of thunderstorm:

1. Cumulus stage:

1) Ground is significantly heated due to solar insolation.
2) A low pressure starts to establish due to intense upliftment of an air parcel (convention).
3) Air from the surroundings start to rush in to fill the low pressure.

4) Intense convection of moist hot air builds up a towering cumulonimbus cloud.

5) 2. Mature stage:

1) Characterized by intense updraft of rising warm air, which causes the clouds to grow bigger and rise to greater height.
2) Later, downdraft brings down to earth the cool air and rain.
3) The incoming of thunderstorm is indicated by violent gust of wind. This wind is due to the intense downdraft.
4) The updraft and downdraft determine the path of the thunderstorm. Most of the time, the path is erratic.

5) 3. Dissipating stage:

1) When the clouds extend to heights where sub-zero temperature prevails, hails are formed and they come down as hailstorm. Intense precipitation occurs.
2) In a matter of few minutes, the storm dissipates and clear weather starts to prevail.

3) Types of thunderstorm:

1. Orographic thunderstorm:

1) Forceful upliftment of warm moist air parcel when it passes over a mountain barrier creates cumulonimbus cloud causing heavy precipitation on the windward side.
2) Orographic 'Cloud bursts' are common in Jammu and Kashmir, Cherrapunji and Mawsynram.

2. Frontal thunderstorm:

1) Thunderstorms occurring along cold fronts.

3. Single-cell thunderstorm:

1) Single-cell thunderstorms are small, brief, weak storms that grow and die within an hour or so. They are typically driven by heating on a summer afternoon.
2) Single-cell storms may produce brief heavy rain and lightning (Very common in India during summers, mostly April, May. In **Kerala** they are called **'Mango Showers'** and in Karnataka **'Blossom showers'**).

4. A multi-cell thunderstorm:

1) A multi-cell storm is a thunderstorm in which new updrafts form along the leading edge of rain-cooled air (the gust front).
2) Individual cells usually last 30 to 60 minutes, while the system as a whole may last for many hours.
3) Multi-cell storms may produce hail, strong winds, brief tornadoes, and/or flooding.

5. A super-cell thunderstorm:

1) A super-cell is a long-lived (greater than 1 hour) and highly organized storm feeding off an updraft (a rising current of air) that is tilted and rotating.
2) Most large and violent tornadoes come from super-cells.

TROPICAL CYCLONES AND ITS CLASSIFICATION

Tropical cyclone, also called **typhoon** or hurricane, an intense circular storm that originates over warm tropical oceans and is characterized by low atmospheric pressure, high winds, and heavy rain. Drawing energy from the sea surface and maintaining its strength as long as it remains over warm water, a tropical cyclone generates winds that exceed 119 km (74 miles) per hour. In extreme cases winds may exceed 240 km (150 miles) per hour, and gusts may surpass 320 km (200 miles) per hour. Accompanying these strong winds are torrential rains and a devastating phenomenon known as the storm surge, an elevation of the sea surface that can reach 6 metres (20 feet) above normal levels. Such a combination of high winds and water makes cyclones a serious hazard for coastal areas in tropical and subtropical areas of the world. Every year during the late summer months (July–September in the Northern Hemisphere and January–March in the Southern Hemisphere), cyclones strike regions as far apart as the Gulf Coast of North America, north western Australia, and eastern India and Bangladesh.

- Tropical cyclones are known by various names in different parts of the world. In the North Atlantic Ocean and the eastern North Pacific they are called hurricanes, and in the western North Pacific around the Philippines, Japan, and China the storms are referred to as typhoons. In the western South Pacific and Indian Ocean they are variously referred to as severe tropical cyclones, tropical cyclones, or simply cyclones. All these different names refer to the same type of storm.

Classification:

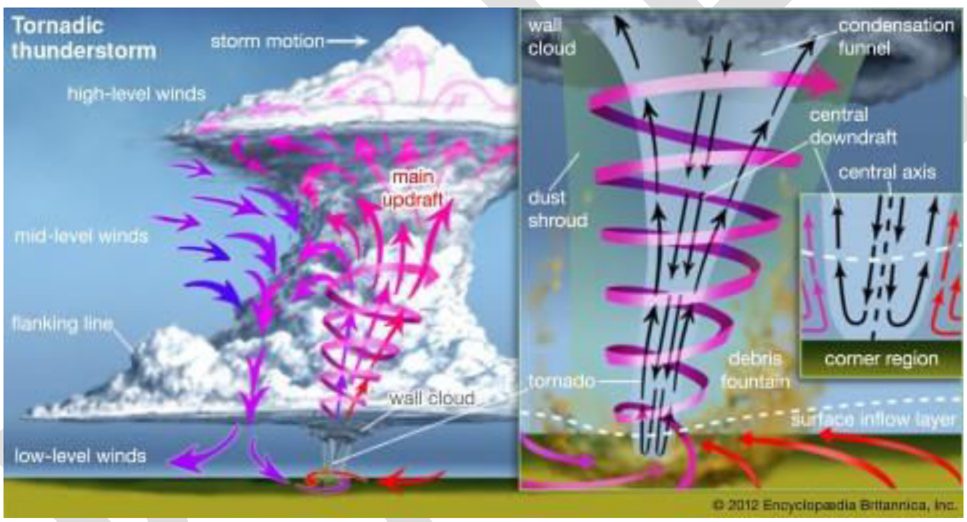
Tropical cyclones are classified in accordance with the World Meteorological Organization's recommendation by the maximum sustained wind speeds near the centre. In Hong Kong, the classification is defined in terms of wind speeds averaged over a period of 10 minutes as follows

Tropical Cyclone Classification	Maximum 10-minute mean wind near the centre
Tropical Depression	41 to 62 km/h
Tropical Storm	63 to 87 km/h
Severe Tropical Storm	88 to 117 km/h
Typhoon	118 to 149 km/h
Severe Typhoon	150 to 184 km/h
Super Typhoon	185 km/h or above

TORNADOES:

1) From severe thunderstorms sometimes spiralling wind descends like a trunk of an elephant with great force, with very low pressure at the center, causing massive destruction on its way. Such a phenomenon is called a tornado.

2) Tornadoes generally occur in **middle latitudes**. The tornado over the sea is called **water sprouts.**
3) These violent storms are the manifestation of the atmosphere's adjustments to varying energy distribution. The potential and heat energies are converted into kinetic energy in these storms and the restless atmosphere again returns to its stable state.
4) Tornado is a small-diameter column of violently rotating air developed within a convective cloud and in contact with the ground.
5) Tornadoes occur most often in association with thunderstorms during the spring and summer in the mid-latitudes of both the Northern and Southern Hemispheres.
6) These whirling atmospheric vortices can generate the strongest winds known on Earth: wind speeds in the range of 500 km (300 miles) per hour.
7) They are often referred to as **twisters or cyclones.**



Damage caused by thunderstorms and tornadoes:

1) Many hazardous weather events are associated with thunderstorms.
2) Under the right conditions, rainfall from thunderstorms causes flash flooding, killing more people each year than hurricanes, tornadoes or lightning.
3) Lightning is responsible for many fires around the world each year, and causes fatalities.
4) Hail up to the size of softballs damages cars and windows, and kills livestock caught out in the open.
5) Strong (up to more than 120 mph) straight-line winds associated with thunderstorms knock down trees, power lines and mobile homes.
6) Tornadoes (with winds up to about 300 mph) can destroy all but the best-built man-made structures.

HURRICANES:

1) Hurricanes are large, swirling storms. They produce winds of 119 kilometers per hour (74 mph) or higher. That's faster than a cheetah, the fastest animal on land. Winds from a hurricane can damage buildings and trees.
2) Hurricanes form over warm ocean waters. Sometimes they strike land. When a hurricane reaches land, it pushes a wall of ocean water ashore. This wall of water is called a storm surge. Heavy rain and storm surge from a hurricane can cause flooding.
3) Once a hurricane forms, weather forecasters predict its path. They also predict how strong it will get. This information helps people get ready for the storm.
4) There are five types, or categories, of hurricanes. The scale of categories is called the Saffir-Simpson Hurricane Scale. The categories are based on wind speed.

Category 1: Winds 119-153 km/hr (74-95 mph) - faster than a cheetah
Category 2: Winds 154-177 km/hr (96-110 mph) - as fast or faster than a baseball pitcher's fastball
Category 3: Winds 178-208 km/hr (111-129 mph) - similar, or close, to the serving speed of many professional tennis players
Category 4: Winds 209-251 km/hr (130-156 mph) - faster than the world's fastest rollercoaster
Category 5: Winds more than 252 km/hr (157 mph) - similar, or close, to the speed of some high-speed trains

Parts of a Hurricane:
Eye: The eye is the "hole" at the center of the storm. Winds are light in this area. Skies are partly cloudy, and sometimes even clear.
Eye wall: The eye wall is a ring of thunderstorms. These storms swirl around the eye. The wall is where winds are strongest and rain is heaviest.
Rain bands: Bands of clouds and rain go far out from a hurricane's eye wall. These bands stretch for hundreds of miles. They contain thunderstorms and sometimes tornadoes.

POSSIBLE QUESTIONS

PART B

1. Differentiate cyclone and hurricanes.

2. Define tornadoes.

3. What is meant by “thunderstorm” and mention its four types.

4. Write a short notes about cyclone.

5. What is a jet stream?

6. Define air masses.

7. Write a short notes global wind system.

PART C

1. Describe about Global wind systems.

2. What is meant by air masses and explain its classifications.

3. Write a short notes about jet streams and local thunderstorms.

4. "Global winds are the main belts of wind that move in particular directions across the earth". State and explain the various types of wind belts.

5. Discuss in detail about classification tropical cyclones.

6. Briefly explain about tornadoes and hurricanes.

7. "Front is an extensive transitional zone between two converging air masses". Classify a fronts into different types and explain about each types.

UNIT-IV

SYLLABUS

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.

CLASSIFICATION OF CLIMATE:

A widely-used vegetation-based climate classification system, the **Koppen climate classification system**, was created by Wladimir Koppen, a German botanist, and climatologist. The classification system attempts to derive a formula to categorize vegetation zones or biomes across the globe, in accordance with their climatic boundaries.
In 1900, the climatic classification was a novel concept. In 1918, Koppen revised his classification system and republished, and continued revising the system until his death in 1940. Introduced as a map in 1928, the Koppen climate classification system was co-authored by Koppen's student Rudolph Geiger. Various geographers have modified and utilized this classification since its first publication by Koppen and Geiger.

Koppen Climate Classification System:

A land-based classification of climatic zones, the Koppen classification system divides the earth into five major types, represented with the letters A, B, C, D, and E. Presently, the system utilizes both **precipitation** and **temperature**, as well as corresponding vegetation, to categorize biomes across the world. All zones **except Zone B** can be defined by temperature because the determining criteria for the vegetation in this zone are dryness, **which falls under precipitation**.

The Five Zones:

A – Tropical Moist Climates:

About 15-25º latitude northwards and southwards of the equator are the tropical, moist climates. The temperature in these areas remains above 18ºC throughout the year, and the annual rainfall in this region is about 1500mm. Three types of climatic variation may be found within the Tropical Moist Climate region:
Af, or tropical wet climate, where precipitation occurs year-round. Variations in temperature are less than 3ºC. Humidity is extremely high and the surface temperature results in the formation of cumulus and cumulonimbus clouds in the early afternoon time, daily. This results in high rainfall.
Am, or tropical monsoon climate, where annual rainfall is similar to that of Af, but precipitation usually occurs within the 7-9 of the warmest months of the year. During the rest of the year, there is less precipitation.

Aw, or the tropical wet and dry climate, also known as the **savanna** climate, where there is an extended dry season during the winter. During the wet season, rainfall is less than 1000mm, occurring mainly in the summertime

B – Dry Climates:
Evaporation and **transpiration** play a greater role in shaping the vegetative state than temperature, here. The regions extend 20-35º latitude northwards and southwards from the equator. There are four subdivisions within this region:
BW or dry, arid climate, or **true desert climate**, spans about 12 percent of the Earth's total land. Xerophytic vegetation usually grows in this climatic zone. The letters **h** and **k** are used as suffixes after BW to represent whether the zone is subtropical (h) or mid-latitudinal (k).
BS or dry, semi-arid climate, which is also referred to as steppe climate, spans about 14 percent of the Earth's land and makes up grassland type climate. These regions receive more rainfall than their BW counterparts because of mid-latitude cyclones and areas of inter-tropical convergence. Here, the letters **h** and **k** are again suffixed to note the region.

C – Moist Mid-Latitude Climates with Mild Winters:
These zones typically face hot and humid summers and mild winters. Extending between 30-50º latitude northwards and southwards from the equator, these regions are typically the eastern and western extremes of each continent. Sometimes, summer months may feature convective thunderstorms, and winter months may feature mid-latitudinal cyclones. The climatic classification is further broken into three types:
Cfa, or humid sub-tropical climate, in which summers are sweltering and humid, with frequent thunderstorms. Winters are milder in comparison, and precipitation occurs due to mid-latitude cyclones.
Cfb or **marine** climates are usually on the western coasts of each continent. These areas are generally humid, with a hot and dry summer. While winters are milder, they come with heavy rainfall due to mid-latitude cyclones.
Cs or the **Mediterranean climatic zones**are where precipitation is heaviest during the winters due to mid-latitude cyclones. There is hardly any rainfall during the summer. Examples include Portland, Oregon or California.

D – Moist Mid-Latitude Climates with Cold Winters:
Summers are typically warm but can also be cool, while winters are cold. These regions are typically situated towards the poles from C regions. During the summer months, average temperatures climb above 10º Celsius, while in the colder months it can be less than 3º Celsius. The wintertime in this region is usually biting cold, with strong winds and the possibility of snowstorms coming in from the Continental Polar and the Arctic air masses. This Koppen climate classification is further divided into three subsections:
Dw, which denotes dry winters
Ds, which denotes dry summers
Df, for year-round rainfall
E – Polar Climates:

Temperatures are usually low all year round in the Polar climatic regions. The warmest months see temperatures less than 10º Celsius. Usually occurring in the northern coastal regions of North America, Asia, Europe, and in Greenland and Antarctica, these climates are divided into two categories:

ET, or **Polar Tundra**, where soil remains permanently frozen as **permafrost** and can be hundreds of meters deep. The only vegetation in this region consists of lichen, mosses, dwarf trees, and woody shrubs.

EF, or Polar Ice Caps are the second category, in which the surface is permanently covered in ice or snow.

CAUSES OF CLIMATE CHANGE:

There is nothing new about climate change. For hundreds of millions of years the Earth's temperature has been influenced by continental shifts, which have triggered volcanic eruptions among other things. Sometimes these shifts released large volumes of CO_2 which heated up the Earth. They also caused young rocks to rise to the surface, which chemically bound CO_2. As a result, CO_2 was dispelled from the atmosphere in the longer term.

Today, natural phenomena still make a deep impression on the climate. Take, for example, El Niño, which occurs at intervals of three to seven years. When the trade winds ease, the warm water from the Western Pacific (Indonesia, Philippines) moves east and causes a rise in sea temperature in an area west of Peru. This occurrence creates worldwide deviations in cloud patterns, precipitation and temperature.

So, the causes of climate change are many and varied. And the effects on our climate system are complex.

Influence of humans:

Humans have been influencing the climate since the start of the Industrial Revolution. Since then, the average world temperature has risen by approximately 0.8 degrees Celsius. In North-West Europe (including the Netherlands) the average temperature has risen by 1.5 degrees. The sea level has risen by around twenty centimetres and most of the glaciers have shrunk dramatically.

Up to 1950 the influence of nature was more important than human influence. After that, the pattern in the average world temperature can only be explained by factoring in the human influence.

Even so, a slight decline in temperature did appear from the mid-1940s to the mid-1970s. It was linked to a dramatic increase in cooling aerosols from the post-war industrialisation in the western world. It was also caused by a mild decline in solar activity and some major volcanic eruptions in the second half of this period.

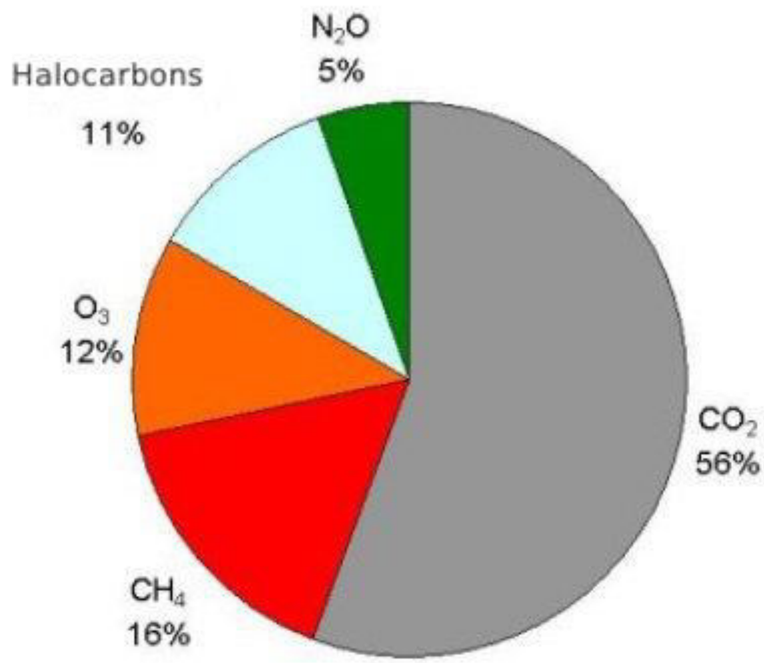
According to the latest IPCC report, it is more than likely (more than 90 per cent probability) that most of the global warming in recent decades is attributable to the observed increase in greenhouse gases.

CO2 and climate change:

The most well-known and the most important greenhouse gas is CO2. The concentration of CO2 in the atmosphere is subject to variation even without human intervention. The carbon cycle causes an exchange of CO2 between the biosphere and the oceans on the one hand and the atmosphere on the other.

Vast amounts of CO2 are also released by the burning of fossil fuels. There is incontrovertible evidence that the CO2 concentration in the air has never been so high in 800,000 years (probably even 60 million years) as it is now. The trend suggests that CO2 emissions will continue to rise globally, although the economic crisis did prevent a rise in 2009. The Netherlands (per head of population) is high on the list of CO2 emitters in the world.

Besides CO2, methane (CH4), nitrous oxide (N2O), fluorinated gases, ozone (O3) and water vapour are important greenhouse gases. Water vapour plays a unique role as it strengthens the heat-trapping effect caused by other greenhouse gas emissions. This is because a warmer atmosphere retains more water. The amount of water vapour cannot be artificially increased or decreased.



Aerosols:

Aerosols are less well-known than greenhouse gases. Aerosols are dust particles which, in addition to CO2, are released into the atmosphere in large quantities when wood and fossil fuels are burned. Some aerosols have a cooling effect on the climate, others have a warming effect. On balance they have a cooling rather than a warming effect, but no-one can give a clear idea of the

magnitude, because we still do not understand how aerosols influence the occurrence and characteristics of clouds.
Natural phenomena, greenhouse gases and aerosols create an imbalance in the incoming and outgoing radiation in the atmosphere. This process is known as radiative forcing. When the Earth heats up, the short-wave radiation from the sun that enters the atmosphere is greater than the long-wave radiation that exits the atmosphere. The temperature changes on Earth will not stop until the radiation balance is restored. Given the immense capacity of oceans to absorb heat, it will take a long time to strike a new balance.

Uncertainty:

The extent of global warming in the future is swathed in uncertainty; first, because we have no idea of how much of an increase to expect in greenhouse gases (depending on economic growth), and secondly, because we do not know exactly how our climate system will respond (climate sensitivity).

GLOBAL WARMING AND ITS OUTCOMES:

Global Warming:

Global warming means continuous rise in ***Earth's*** average surface or environmental ***temperature*** due to greenhouse effect. Now what's greenhouse effect? The Earth's atmosphere is composed of nitrogen, oxygen, etc which is responsible for maintaining average temperature for life on Earth at 16 degree Celsius. When the sun rays collide with the Earth's surface, most of the energy is absorbed by greenhouse gases such as carbon dioxide, methane, nitrous oxide, sulphur dioxide, carbon monoxide, while a part of the solar radiation called infrared radiation returns into space by means of clouds, snowflakes, and other reflective things.

Causes:

The most important reason for the increase in the temperature of our Earth is the continuous increase in the pollution, due to which the level of greenhouse gases is increasing, which is damaging the ozone layer. With the Industrial Revolution over the last hundred years, the proportion of carbon dioxide and greenhouse gases has increased in the atmosphere. Increasing number of factories, vehicles, fossil fuels, and the population of humans all have contributed to the increase in the amount of these gases. The use of chemical fertilizers and pesticides is also increasing pollution in soil, water and air. Due to the cutting of trees and use of fossil fuel (coal) to operate power plants, the level of carbon dioxide is increasing. As a result, the quantity of sun's heat absorbed by them has also increased, leading to global warming.

Effects:

1: – The melting of glaciers.
2: – Depletion of ozone layer.
3: – Toxic gases in the environment.
4: – Unseasonal rains.
5: – Fierce storm, cyclone, hurricanes and droughts.
6: – Different types of skin ailments, cancer-related diseases, malaria & dengue.

7: – Disappearance of many species of birds and animals who are unable to cope with the changing environment.
8: – Increasing incidence of forest fires.
9: – Increasing risk of flood as snow melts on the mountains.
10: – Expansion in the desert due fierce heat.
11: – Decreasing forest cover.

Prevention:

- To prevent the effects of global warming, it is necessary that we take immediate hard steps for this. We have to reduce the proportion of carbon dioxide and greenhouse gases in the atmosphere.
- It is necessary that we minimize the use of fossil fuels, and reduce pollution in factories.
- Control of emissions by vehicles is necessary too.
- We have to use sources of energy in which carbon is used in a limited amount or not at all, such as solar energy, atomic energy and wind power etc.
- Trees, our biggest helper in our fight against global warming, should be protected from cutting and more trees should be planted.
- If mankind has to move towards sustainability, it has to take into account those things which nature can give to us again and again.
- We should take the resolve to save the Earth and the environment. Public awareness campaigns, meetings, seminars and conferences, and programs like planting trees, cleaning streams of rivers need to be organized.
- Climate change needs to be understood closely. And this understanding should not be confined to scientists only, it is necessary to bring this knowledge to the common man.
- The government can employ such devices in domestic aircraft which can give us an opportunity to know about the climate of the upper surface; the data obtained from it can be used for betterment.
- How water has been polluted in recent times, is a matter of deep concern. Reducing pollution will also entail the responsibility for monitoring the quantity and quality of water.
- We should deliberate seriously upon preserving the Earth in the future. The focus should be on how the Earth can be sustainable and worth the use.
- We know that we do not have control over natural disasters, but if we understand the global warming, by protecting the environment from being contaminated, major disasters can be avoided.

AIR POLLUTION:

The World Health Organization defines air pollution as "the presence of materials in the air in such concentration which are harmful to man and his environment."
In fact air pollution is the occurrence or addition of foreign particles, gases and other pollutants into the air which have an adverse effect on human beings, animals, vegetation, buildings, etc.

Cause of Air Pollution:
The various causes of air pollution are:
(i) Combustion of natural gas, petroleum, coal and wood in industries, automobiles, aircrafts, railways, thermal plants, agricultural burning, kitchens, etc. (soot, flyash, CO_2, CO, nitrogen oxides, sulphur oxides).
(ii) Metallurgical processing (mineral dust, fumes containing fluorides, sulphides and metallic pollutants like lead, chromium, nickel, beryllium, arsenic, vanadium, cadmium, zinc, mercury).
(iii) Chemical industries including pesticides, fertilizers, weedicides, fungicides.
(iv) Cosmetics.
(v) Processing industries like cotton textiles, wheat flour mills, asbestos.
(vi) Welding, stone crushing, gem grinding.
Natural air pollutants include (a) pollen, spores, (b) marsh gas, (c) volcanic gases and (a) synthesis of harmful chemicals by electric storms and solar flares. The major cause of pollution in the urban areas is automobiles which inefficiently burn petroleum, releases 75% of noise and 80% of air pollutants. Concentration of industries in one area is another major cause of air pollution.

Effect of Air Pollutants:
Air pollutants are broadly classified into particulate and gaseous. The particulate substances include solid and liquid particles. The gaseous include substances that are in the gaseous state at normal temperature and pressure. The air pollutants have adverse effect on human beings, animals, vegetation, buildings. Air pollutants also change earth's climate. Aesthetic sense is also influenced by air pollutants. The different air pollutants and their effects are as follows:
1. Particulate Matter:
It is of two types—settleable and suspended. The settleable dusts have a particle longer than 10 (am. The smaller particles are able to remain suspended for long periods in the air. The important effects of particulate matter are.
(i) Dust and smoke particles cause irritation of the respiratory tract and produces bronchitis, asthma and lung diseases.
(ii) Smog is a dark or opaque fog which is formed by the dust and smoke particles causing condensation of water vapours around them as well as attracting chemicals like SO_2, H_2S, NO_2, etc. Smog harms plant life through glazing and necrosis besides reduced availability of light. In human beings and animals it produces respiratory troubles.
(iii) Particulate matter suspended in air, scatters and partly absorbs light. In industrial and urban areas, sunlight is reduced to 1/3 in summer and 2/3 in winter.
(iv) At a concentration above 150 g/100m^3, cotton dust in ginning process produces pneumoconiosis or lung fibrosis called byssinosis. Lung fibrosis produced in other industries includes asbestosis (in asbestos industry), silicosis (stone grinders), siderosis (iron mill), coal miners' pneumoconiosis, flour mill pneumoconiosis, etc.
2. Carbon monoxide:
It accounts for 50% of the total atmospheric pollutants. It is formed by incomplete combustion of carbon fuels in various industries, motor vehicles, hearths, kitchens, etc. Carbon monoxide

combines with haemoglobin of blood and impairs its oxygen carrying capacity. At higher concentration, carbon monoxide proves lethal.

3. Sulphur Oxides:

They occur mainly in the form of sulphur dioxide. It is produced in large quantity during smelting of metallic ores and burning of petroleum and coal in industries, thermal plants, home and motor vehicles. In the air, SO_2combines with water to form sulphurous acid (H_2SO_3) which is the cause of acid rain. It causes chlorosis and necrosis of vegetation. Sulphur dioxide, above 1 ppm, affects human beings. It causes irritation to eyes and injury to respiratory tract. It results in discolouration and deterioration of buildings, sculptures, painted surfaces, fabrics, paper, leather, etc.

4. Nitrogen Oxides:

They are produced naturally through biological and non-biological activities from nitrates, nitrites, electric storms, high energy radiations and solar flares. Human activity forms nitrogen oxides in combustion process of industries, automobiles, incinerators and nitrogen fertilizers. Nitrogen oxides act on unsaturated hydrocarbons to form peroxy-acyl nitrates or PAN. It gives rise to photochemical smog. They cause eye irritation, respiratory troubles, blood congestion and dilation of arteries.

5. Carbon dioxide:

Due to excessive combustion activity, the content of $C0_2$ has been steadily rising. As carbon dioxide accumulates in the atmosphere it absorbs more and more of the reflected infrared radiation. This could cause an increase in temperature referred to as the green house effect. Melting polar ice caps and glaciers could cause sea levels to rise, flooding most of the major population centres and fertile lands.

6. Phosgene and Methyl Isocyanate:

Phosgene ($COCl_2$) is a poisonous and suffocating volatile liquid which is employed in dye industry and synthesis of organic compounds. Release of phosgene and MIC in industrial accident of Bhopal (Dec. 2, 1984) killed over 2500 and maimed several thousand persons.

7. Aerosols:

They are widely used as disinfectants. Other sources are jet plane emissions which contain chlorofluorocarbons. Chlorofluorocarbons are also used in refrigeration and formation of certain types of solid plastic foams. Burning of plastics produces polychlorinated biphenyls (PCBs). The latter are persistent and pass into the food chain. Chlorofluorocarbons and carbon tetrachloride react with ozone layers of stratosphere and hence deplete the same.

8. Photochemical oxidants:

Hydrocarbons have carcinogen properties. Some of these are also harmful to plants because they cause senescence and abscission. In the presence of sunlight, hydrocarbons react with nitrogen oxides to produce ozone, peroxy-acyl nitrates, aldehydes and other compounds. Peroxy-acyl nitrates are a major constituent of air pollution. They cause eye irritation and respiratory diseases.

9. Automobile Exhausts:

They are one of the major sources of air pollution. The important pollutants are Carbon monoxide, Benzpyrene, Lead, Nitrogen oxides, Sulphur compounds and Ammonia.

10. Pollen and Microbes:

Excess of microbes in the atmosphere directly damage the vegetation, food articles and causes diseases in plants, animals and human beings. Excess of pollen causes allergic reactions in several human beings. The common reactions are also collectively called hay-fever. The important allergic pollen belong to Amaranthus spinosus, Chenopodium album, Cynodon dactylon, Ricinus communis, Sorghum vulgare, Prosopis chilensis etc.

Control of Air Pollution:

1. Industrial estates should be established at a distance from residential areas.
2. Use of tall chimneys shall reduce the air pollution in the surroundings and compulsory use of filters and electrostatic precipitators in the chimneys.
3. Removal of poisonous gases by passing the fumes through water tower scrubber or spray collector.
4. Use of high temperature incinerators for reduction in particulate ash production.
5. Development and employment of non-combustive sources of energy, e.g., nuclear power, geothermal power, solar power, tidal power, wind power, etc.
6. Use of non-lead antiknock agents in gasoline.
7. Attempt should be made to develop pollution free fuels for automobiles, e.g., alcohol, hydrogen, battery power. Automobiles should be fitted with exhaust emission controls.
8. Industrial plants and refineries should be fitted with equipment for removal and recycling of wastes.
9. Growing plants capable of fixing carbon monoxide, e.g. Phaseolus vulgaris, Coleus blumei, Daucus carota, Ficus variegata (Bidwell and Bebee, 1974).
10. Growing plants capable of metabolising nitrogen oxides and other gaseous pollutants, e.g., Vitis, Pimis, Jttniperus, Quercus, Pyrus, Robinia pseudo-acacia, Viburnum, Crataegus, Ribes, Rhamnus.
11. Afforestation of the mining area on priority basis.

AERSOLS:

A collection of microscopic particles, solid or liquid, suspended in a gas. They drift in Earth's atmosphere from the stratosphere to the surface and range in size from a few nanometers-less than the width of the smallest viruses to several several tens of micrometres—about the diameter of human hair. Despite their small size, they have major impacts on climate and health. Different specialists describe the particles based on shape, size, and chemical composition. Toxicologists refer to aerosols as ultrafine, fine, or coarse matter. Regulatory agencies, as well as meteorologists, typically call them particulate matter—PM2.5 or PM10, depending on their size. In some fields of engineering, they're called nanoparticles. Everyday terms that hint at aerosol sources, such as smoke, ash, haze, dust, pollution, and soot are widely used as well. Climatologists typically use another set of labels that speak to the chemical composition. Key aerosol groups include sulphates, organic carbon, black carbon, nitrates, mineral dust, and sea salt. In practice, many of these terms are imperfect, as aerosols often clump together to form complex mixtures. It's common, for example, for particles of black carbon from soot or smoke to mix with nitrates and sulphates, or to coat the surfaces of dust, creating hybrid particles.

OZONE DEPLETION:

To understand ozone layer, it would be helpful to know the different layers of the atmosphere. The earth's atmosphere is composed of many layers, each playing a significant role. The first layer stretching approximately 10 kilometers upwards from the earth's surface is known as the troposphere. A lot of human activities such as gas balloons, mountain climbing, and small aircraft flights take place within this region.

The stratosphere is the next layer above the troposphere stretching approximately 15 to 60 kilometers. The ozone layer sits in the lower region of the stratosphere from about 20-30 kilometers above the surface of the earth. The thickness of the ozone layer is about 3 to 5 mm, but it pretty much fluctuates depending on the season and geography.

Ozone layer is a deep layer in earth's atmosphere that contain ozone which is a naturally occurring molecule containing three oxygen atoms. These ozone molecules form a gaseous layer in the Earth's upper atmosphere called stratosphere. This lower region of stratosphere containing relatively higher concentration of ozone is called Ozonosphere. The Ozonosphere is found 15-35 km (9 to 22 miles) above the surface of the earth.

The concentration of ozone in the ozone layer is usually under 10 parts per million while the average concentration of ozone in the atmosphere is about 0.3 parts per million. The thickness of the ozone layer differs as per season and geography. The highest concentrations of ozone occur at altitudes from 26 to 28 km (16 to 17 miles) in the tropics and from 12 to 20 km (7 to 12 miles) towards the poles.

The ozone layer forms a thick layer in stratosphere, encircling the earth, that has large amount of ozone in it. The ozone layer protects life on earth from strong ultraviolet radiation that comes from the sun. Ultraviolet rays are harmful rays that can drive up the risk of deadly disorders like skin cancer, cataracts and damage the immune system. Ultraviolet rays are also capable of destroying single cell organism, terrestrial plant life, and aquatic ecosystems.

The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson. The ozone layer has the capability to absorb almost 97-99% of the harmful ultraviolet radiations that sun emit and which can produce long term devastating effects on humans beings as well as plants and animals.

Composition of the Ozone Layer:

It comes as a surprise that the same UV rays form the bulk of ozone layer. Ozone is an extraordinary kind of oxygen composed of 3 oxygen atoms instead of the normal 2 oxygen atoms. Ozone layer normally develops when a few kinds of electrical discharge or radiation splits the 2 atoms in an oxygen(O_2) molecule, which then independently reunite with other types of molecules to form ozone. The ozone layer has been shielding life on planet earth for billions of years, but it's now being worn out by human activities.

People began to value the importance of the ozone layer when scientists released a research finding suggesting that certain human-made chemicals known as chlorofluorocarbons managed to reach the stratosphere and depleted the ozone via a profound series of chemical reactions. The results of this research study prompted the signing of a global treaty known as the Montreal

Protocol in 1973. This treaty helped in the reduction of the production of these harmful human-made chemicals.
These targeted efforts have seen the ozone layer recovering over the past years. The thickness of the ozone layer varies immensely on any day and location. Due to relentless vertical atmospheric air circulation in both the stratosphere and troposphere, the amount of ozone layer shielding humans from strong UV rays can be lesser or greater. In addition, those residing in higher elevations are at risk of UV radiation than those at lower elevations.
The Stratospheric ozone plays a big role in protecting humans from the harshness of the sun. However, there is also a kind of ozone developed just above the ground as a result of sun rays coming into contact with pollution in the atmosphere, which is hazardous to human health. In some individuals, it can lead to complications in breathing and often takes place during summer when pollution is rampant in cities where the air is static.

Why Ozone Layer is Necessary?
An essential property of ozone molecule is its ability to block solar radiations of wavelengths less than 290 nanometers from reaching Earth’s surface. In this process, it also absorbs ultraviolet radiations that are dangerous for most living beings. UV radiation could injure or kill life on Earth. Though the absorption of UV radiations warms the stratosphere but it is important for life to flourish on planet Earth. Research scientists have anticipated disruption of susceptible terrestrial and aquatic ecosystems due to depletion of ozone layer.
Ultraviolet radiation could destroy the organic matter. Plants and plankton cannot thrive, both acts as food for land and sea animals, respectively. For humans, excessive exposure to ultraviolet radiation leads to higher risks of cancer (especially skin cancer) and cataracts. It is calculated that every 1 percent decrease in ozone layer results in a 2-5 percent increase in the occurrence of skin cancer. Other ill-effects of the reduction of protective ozone layer include – increase in the incidence of cataracts, sunburns and suppression of the immune system.

Causes of Ozone Layer Depletion:
Credible scientific studies have substantiated that the cause of ozone layer depletion is human activity, specifically, human-made chemicals that contain chlorine or bromine. These chemicals are widely known as ODS, an acronym for Ozone-Depleting Substances. The scientists have observed reduction in stratospheric ozone since early 1970’s. It is found to be more prominent in Polar Regions.
Ozone-Depleting Substances have been proven to be eco-friendly, very stable and non-toxic in the atmosphere below. This is why they have gained popularity over the years. However, their stability comes at a price; they are able to float and remain static high up in the stratosphere. When up there, ODS are comfortably broken down by the strong UV light and the resultant chemical is chlorine and bromine. Chlorine and bromine are known to deplete the ozone layer at supersonic speeds. They do this by simply stripping off an atom from the ozone molecule. One chlorine molecule has the capability to break down thousands of ozone molecules.
Ozone-depleting substances have stayed and will continue to stay in the atmosphere for many years. This, essentially, implies that a lot of the ozone-depleting substances human have allowed

to go into the atmosphere for the previous 90 years are still on their journey to the atmosphere, which is why they will contribute to ozone depletion.

The chief ozone-depleting substances include chlorofluorocarbons (CFCs), carbon tetrachloride, hydrochlorofluorocarbons (HCFCs) and methyl chloroform. Halons, sometimes known as brominated fluorocarbons, also contribute mightily to ozone depletion. However, their application is greatly restricted since they are utilized in specific fire extinguishers. The downside to halons is they are so potent that they are able to deplete the ozone layer 10 times more than ozone-depleting substances.

Scientists in this age are working around the clock to develop Hydrofluorocarbons (HFCs) to take the place of hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs) for use in vehicle air conditioning. Hydrochlorofluorocarbons are powerful greenhouse gases, but they are not able to deplete ozone. Chlorofluorocarbons, on the other hand, significantly contribute to climate change, which means Hydrofluorocarbons continue to be the better alternative until safer alternatives are available.

There are two regions in which the ozone layer has depleted.

In the mid-latitude, for example, over Australia, ozone layer is thinned. This has led to an increase in the UV radiation reaching the earth. It is estimated that about 5-9% thickness of the ozone layer has decreased, increasing the risk of humans to over-exposure to UV radiation owing to outdoor lifestyle.

In atmospheric regions over Antarctica, ozone layer is significantly thinned, especially in spring season. This has led to the formation of what is called 'ozone hole'. Ozone holes refer to the regions of severely reduced ozone layers. Usually ozone holes form over the Poles during the onset of spring seasons. One of the largest such hole appears annually over Antarctica between September and November.

Natural causes of depletion of ozone layer: Ozone layer has been found to be affected by certain natural phenomena such as Sun-spots and stratospheric winds. But this has been found to cause not more than 1-2% depletion of the ozone layer and the effects are also thought to be only temporary. It is also believed that the major volcanic eruptions (mainly El Chichon in 1983 and and Mt. Pinatubo in 1991) has also contributed towards ozone depletion.

Man-made causes of depletion of ozone layer: The main cause for the depletion of ozone is determined as excessive release of chlorine and bromine from man-made compounds such as chlorofluorocarbons (CFCs). CFCs (chlorofluorocarbons), halons, CH_3CCl_3 (Methyl chloroform), CCl_4(Carbon tetrachloride), HCFCs (hydro-chlorofluorocarbons), hydrobromofluorocarbons and methyl bromide are found to have direct impact on the depletion of the ozone layer. These are categorized as ozone-depleting substances (ODS).

The problem with the Ozone-Depleting Substances (ODS) is that they are not washed back in the form of rain on the earth and in-fact remain in the atmosphere for quite a long time. With so much stability, they are transported into the stratosphere. The emission of ODS account for roughly 90% of total depletion of ozone layer in stratosphere. These gases are carried to the stratosphere layer of atmosphere where ultraviolet radiations from the sun break them to release chlorine (from CFCs) and bromine (from methyl bromide and halons).

The chlorine and bromine free radicals react with ozone molecule and destroy their molecular structure, thus depleting the ozone layer. One chlorine atom can break more than 1, 00,000 molecules of ozone. Bromine atom is believed to be 40 times more destructive than chlorine molecules.

Main Ozone Depleting Substances (ODS):
Chlorofluorocarbons (CFCs)
It's billed as the most extensively utilized ozone-depleting substance because it attributes to more than 80% of overall ozone depletion. It was utilized as a coolant in home appliances like freezers, refrigerators and air conditioners in both buildings and cars that were manufactured prior to 1995. This substance is usually contained in dry cleaning agents, hospital sterilants, and industrial solvents. The substance is also utilized in foam products like mattresses and cushions and home insulation.
Hydrofluorocarbons (HCFCs)
Hydrofluorocarbons have over the years served in place of Chlorofluorocarbons. They are not as harmful as CFCs to ozone layer.
Halons
It's especially used in selected fire extinguishers in scenarios where the equipment or material could be devastated by water or extinguisher chemicals.
Carbon Tetrachloride
Also used in selected fire extinguishers and solvents.
Methyl Chloroform
Commonly utilized in industries for cold cleaning, vapor degreasing, chemical processing, adhesives and some aerosols.
Serious Effects of Ozone Depletion:
Damage to human health
If the ozone layer is depleted, it means humans will be overly exposed to strong UV light. Overexposure to strong UV light causes skin cancer, cataracts, sunburns, weakening of immune system and quick aging.
Devastation to environment
Many crops species are vulnerable to strong UV light and overexposure may well lead to minimal growth, photosynthesis and flowering. Some of the crop species vulnerable to UV light include barley, wheat, corn, oats, rice, broccoli, tomatoes, cauliflower just to name a few. Forests equally bear the brunt of ozone depletion.
Threat to marine life
Certain marine life, especially planktons, is greatly impacted by exposure to strong ultraviolet rays. In the aquatic food chain, planktons appear high up. If planktons decrease in number due to ozone layer destruction, the marine food chain would be disrupted in many ways. Also, overexposure of sun rays could reduce the fortunes of fishers. On top of that, certain species of marine life have been greatly affected by overexposure to ultraviolet radiation at their early stage.
Effect on animals
In domesticated animals, too much Ultraviolet radiation could also lead to skin and eye cancer.
Impacts certain materials

Materials like plastics, wood, fabrics, rubber are massively degraded by too much ultraviolet radiation

Solutions to Ozone Depletion:

Desist from using pesticides

Pesticides are great chemicals to rid your farm of pests and weeds, but they contribute enormously to ozone layer depletion. The surefire solution to get rid of pests and weeds is to apply natural methods. Just weed your farm manually and use alternative eco-friendly chemicals to alleviate pests.

Discourage driving of private vehicles

The easiest technique to minimize ozone depletion is to limit the number of vehicles on the road. These vehicles emit a lot of greenhouse gases that eventually form smog, a catalyst in the depletion of ozone layer.

Utilize environmentally friendly cleaning products

Most household cleaning products are loaded with harsh chemicals that find way to the atmosphere, eventually contributing to degradation of the ozone layer. Use natural and environmentally friendly cleaning products to arrest this situation.

Prohibit the use of harmful nitrous oxide

The Montreal Protocol formed in 1989 helped a lot in the limitation of Chlorofluorocarbons (CFCs). However, the protocol never covered nitrous oxide, which is a known harmful chemical that can destroy the ozone layer. Nitrous oxide is still in use today. Governments must take action now and outlaw nitrous oxide use to reduce the rate of ozone depletion.

ACID RAIN:

Acid rain refers to a mixture of deposited material, both wet and dry, coming from the atmosphere containing more than normal amounts of nitric and sulfuric acids. Simply put, it means rain that is acidic in nature due to the presence of certain pollutants in the air due to cars and industrial processes. It is easily defined as rain, fog, sleet or snow that has been made acidic by pollutants in the air as a result of fossil fuel and industrial combustions that mostly emits Nitrogen Oxides (NO_x) and Sulfur Dioxide (SO_2). Acidity is determined on the basis of the pH level of the water droplets. Normal rain water is slightly acidic with a pH range of 5.3-6.0, because carbon dioxide and water present in the air react together to form carbonic acid, which is a weak acid. When the pH level of rain waterfalls below this range, it becomes acid rain.
When these gases react with water molecules and oxygen among other chemicals found in the atmosphere, mild acidic chemical compounds such as sulfuric and nitric acid are formed resulting to acid rain. Acid rain generally leads to weathering of buildings, corrosion of metals, and peeling of paints on surfaces. Erupting volcanoescontains some chemicals that can cause acid rain. Apart from this, burning of fossil fuels, running of factories and automobiles due to human activities are few other reasons behind this activity.
Presently, large amounts of acid deposition is witnessed in the southeastern Canada, northeastern United States and most of Europe, including portions of Sweden, Norway, and Germany. In

addition, some amount of acid deposition is found in parts of South Asia, South Africa, Sri Lanka, and Southern India.

Forms of Acid Rain:
There are two forms in which acid deposition occurs – wet and dry. Both are discussed below:
Wet Deposition: When the wind blows the acidic chemicals in the air to the areas where the weather is wet, the acids fall to the ground in the form of rain, sleet, fog, snow or mist. It removes acid from the atmosphere and deposit them on the earth's surface. When this acid flows through the ground, it affects large number of plants, animals and aquatic life. The water from drain flows into rivers and canals which is them mixed up with sea water, thereby affecting marine habitats.
Dry Deposition: If the wind blows the acidic chemicals in the air to the areas where the weather is dry, the acidic pollutants slip into dust or smoke and fall to the ground as dry particles. These stick to the ground and other surfaces such as cars, houses, trees and buildings. Almost 50% of the acidic pollutants in the atmosphere fall back through dry deposition. These acidic pollutants can be washed away from earth surface by rainstorms.
It was discovered way back in 1800s during the Industrial Revolution. A Scottish chemist, Robert Angus Smith, was first to discover this phenomenon in 1852 as a relationship between acid rain and atmospheric pollution in Manchester, England. But it gained public attention mainly in 1960s. The term was coined in 1972 when the NY Times published reports about the climate change effects which started arising due to the occurrence of acid rain in the Hubbard Brook Experimental Forest in New Hampshire.

Causes of Acid Rain:
Both natural and man-made sources are known to play a role in the formation of acid rain. But, it is mainly caused by combustion of fossil fuels which results in emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x).
1. Natural Sources
The major natural causal agent for acid rain is volcanic emissions. Volcanoes emit acid producing gases to create higher than normal amounts of acid rain or any other form of precipitation such as fog and snow to an extent of affecting vegetation cover and health of residents within the surrounding. Decaying vegetation, wildfires and biological processes within the environment also generate the acid rain forming gases. Dimethly sulfide is a typical example of a major biological contributor to sulfur containing elements into the atmosphere. Lighting strikes also naturally produces nitric oxides that react with water molecules via electrical activity to produce nitric acid, thereby forming acid rain.
2. Man-made sources
Human activities leading to chemical gas emissions such as sulfur and nitrogen are the primary contributors to acid rain. The activities include air pollution sources emitting sulfur and nitrogen gases like factories, power generations facilities, and automobiles. In particular, use of coal for electrical power generation is the biggest contributor to gaseous emissions leading to acid rain. Automobiles and factories also release high scores of gaseous emissions on daily basis into the

air, especially in highly industrialized areas and urban regions with large numbers of car traffic. These gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds such as sulfuric acid, ammonium nitrate, and nitric acid. As a result, these areas experience exceedingly high amounts of acid rain.

The existing winds blow these acidic compounds over large areas across borders and they fall back to the ground in the form of acid rain or other forms of precipitation. Upon reaching the earth, it flows across the surface, absorbs into the soil and enters into lakes and rivers and finally gets mixed up with sea water.

The gases i.e. i.e. sulfur dioxide (SO2) and nitrogen oxides (NOx) are primarily gases occurring from electric power generation by burning coal and responsible for acid rain.

Effects of Acid Rain:

Acid rain has significant effects on the world environment and public health.

Effect on Aquatic Environment: Acid rain either falls directly on aquatic bodies or gets run off the forests, roads and fields to flow into streams, rivers and lakes. Over a period of time, acids get accumulated in the water and lower the overall pH of the water body. The aquatic plants and animals need a particular pH level of about 4.8 to survive. If the pH level falls below that the conditions become hostile for the survival of aquatic life. Acid rain tendency of altering pH and aluminum concentrations greatly affects pH concentration levels in surface water, thereby affecting fish as well as other aquatic life-forms. At pH levels below 5, most fish eggs cannot hatch. Lower pHs can also kill adult fish. Acid rain runoff from catchment areas into rivers and lakes has also reduced biodiversity as rivers and lakes become more acidic. Species including fish, plant and insect types in some lakes, rivers and brooks have been reduced and some even completely eliminated owing to excess acid rain flowing into the waters.

Effect on Forests: It makes trees vulnerable to disease, extreme weather, and insects by destroying their leaves, damaging the bark and arresting their growth. Forest damage due to acid rain is most evident in Eastern Europe – especially Germany, Poland and Switzerland.

Effect on Soil: Acid rain highly impacts on soil chemistry and biology. It means, soil microbes and biological activity as well as soil chemical compositions such as soil pH are damaged or reversed due to the effects of acid rain. The soil needs to maintain an optimum pH level for the continuity of biological activity. When acid rains seep into the soil, it means higher soil pH, which damages or reverses soil biological and chemical activities. Hence, sensitive soil microorganisms that cannot adapt to changes in pH are killed. High soil acidity also denatures enzymes for the soil microbes. On the same breadth, hydrogen ions of acid rain leach away vital minerals and nutrients such as calcium and magnesium.

Vegetation Cover and Plantations: The damaging effects of acid rain on soil and high levels of dry depositions have endlessly damaged high altitude forests and vegetation cover since they are mostly encircled by acidic fogs and clouds. Besides, the widespread effects of acid rain on ecological harmony have lead to stunted growth and even death of some forests and vegetation cover.

Effect on Architecture and Buildings: Acid rain on buildings, especially those constructed with limestone, react with the minerals and corrode them away. This leaves the building weak and susceptible to decay. Modern buildings, cars, airplanes, steel bridges and pipes are all affected by acid rain. Irreplaceable damage can be caused to the old heritage buildings.

Effect on Public Health: When in atmosphere, sulfur dioxide and nitrogen oxide gases and their particulate matter derivatives like sulfates and nitrates, degrades visibility and can cause accidents, leading to injuries and deaths. Human health is not directly affected by acid rain because acid rain water is too dilute to cause serious health problems. However, the dry depositions also known as gaseous particulates in the air which in this case are nitrogen oxides and sulfur dioxide can cause serious health problems when inhaled. Intensified levels of acid depositions in dry form in the air can cause lung and heart problems such as bronchitis and asthma.

Other Effects: Acid rain leads to weathering of buildings, corrosion of metals, and peeling of paints on surfaces. Buildings and structures made of marble and limestone are the ones especially damaged by acid rain due to the reactivity of the acids in the rain and the calcium compounds in the structures. The effects are commonly seen on statues, old grave stones, historic monuments, and damaged buildings. Acid rain also corrodes metals like steel, bronze, copper, and iron.

Solutions to Acid Rain:

Cleaning up Exhaust Pipes and Smokestacks

Most of the electric power supporting the modern-day energy requirements comes from combusting fossil fuels such as oil, natural gas, and coal that generate nitrogen oxides (NOx) and sulfur dioxide (SO2) as the chief contributors to acid rain. Burning coal largely accounts for SO2 emissions while NOx emissions are mostly from fossil fuel combustions.

Washing coal, use of coal comprised of low sulfur, and use of devices known as “scrubbers” can provide technical solution to SO2 emissions. “Scrubbing” also called flue-gas desulfurization (FGD) typically work to chemically eliminate SO2 from the gases leaving smokestacks. It can eliminate up to 95% of SO2 gases. Power generation facilities can also shift to using fuels that emit much less SO2 such as natural gas instead of burning coal. These methods are simply called emission reduction strategies.

Similarly, NOx emissions from automobile fossil fuel combustions are mitigated upon by use of catalytic converters. Catalytic converters are fixed on the exhaust pipe system to reduce NOx emission. Improvement of gasoline that combusts cleaner is also a strategy for reducing emission of NOx gases.

Restoring Damaged Environments

Use of limestone or lime, a process called liming, is a practice that people can do to repair the damage caused by acid rain to lakes, rivers and brooks. Adding lime into acidic surface waters balances the acidity. It’s a process that has extensively been used, for instance in Sweden, to keep the water pH at optimum. Even though, liming is an expensive method and has to be done repeatedly. Furthermore, it only offers a short-term solution at the expense of solving the broader challenges of SO2 and NOx emissions and risks to human health. Nevertheless, it helps to restore and allow the survival of aquatic life forms by improving chronically acidified surface waters.

Alternative Energy Sources

Besides fossil fuels, there is a wide range of alternative energy sources that can generate electrical power. These include wind energy, geothermal energy, solar energy, hydropower, and nuclear power. Harnessing these energy sources can offer effective electrical power alternatives instead of using fossil fuels. Fuel cells, natural gas, and batteries can also substitute use of fossil fuel as cleaner energy sources. As of today, all energy sources have environmental and economic costs as well as benefits. The only solution is using sustainable energy that can protect the future.

Individual, National/State, and International Actions

Millions of people directly and indirectly contribute to SO2 and NOx emissions. Mitigation of this challenge requires individuals to be more informed about energy conservation and ways of reducing emissions such as: turning off lights or electrical appliances when not using them; use public transport; use energy efficient electrical appliances; and use of hybrid vehicles or those with low NOx emissions.

ISSUES RELETED TO CLIMATE:

1. Pollution: Pollution of air, water and soil require millions of years to recoup. Industry and motor vehicle exhaust are the number one pollutants. Heavy metals, nitrates and plastic are toxins responsible for pollution. While water pollution is caused by oil spill, acid rain, urban runoff; air pollution is caused by various gases and toxins released by industries and factories and combustion of fossil fuels; soil pollution is majorly caused by industrial waste that deprives soil from essential nutrients.

2. Global Warming: Climate changes like global warming is the result of human practices like emission of Greenhouse gases. Global warming leads to rising temperatures of the oceans and the earth' surface causing melting of polar ice caps, rise in sea levels and also unnatural patterns of precipitation such as flash floods, excessive snow or desertification.

3. Natural Resource Depletion: Natural resource depletion is another crucial current environmental problems. Fossil fuel consumption results in emission of Greenhouse gases, which is responsible for global warming and climate change. Globally, people are taking efforts to shift to renewable sources of energy like solar, wind, biogas and geothermal energy. The cost of installing the infrastructure and maintaining these sources has plummeted in the recent years.

4. Waste Disposal: The over consumption of resources and creation of plastics are creating a global crisis of waste disposal. Developed countries are notorious for producing an excessive amount of waste or garbage and dumping their waste in the oceans and, less developed countries. Nuclear waste disposal has tremendous health hazards associated with it. Plastic, fast food, packaging and cheap electronic wastes threaten the well being of humans. Waste disposal is one of urgent current environmental problem**.**

5. Climate Change: Climate change is yet another environmental problem that has surfaced in last couple of decades. It occurs due to rise in global warming which occurs due to increase in temperature of atmosphere by burning of fossil fuels and release of harmful gases by industries. Climate change has various harmful effects but not limited to melting of polar ice, change in seasons, occurrence of new diseases, frequent occurrence of floods and change in overall weather scenario.

6. Deforestation: Our forests are natural sinks of carbon dioxide and produce fresh oxygen as well as helps in regulating temperature and rainfall. At present forests cover 30% of the land but every year tree cover is lost amounting to the country of Panama due to growing population demand for more food, shelter and cloth. Deforestation simply means clearing of green cover and make that land available for residential, industrial or commercial purpose.

7. Ocean Acidification: It is a direct impact of excessive production of CO_2. 25% of CO_2 produced by humans. The ocean acidity has increased by the last 250 years but by 2100, it may shoot up by 150%. The main impact is on shellfish and plankton in the same way as human osteoporosis.

8. Ozone Layer Depletion: The ozone layer is an invisible layer of protection around the planet that protects us from the sun's harmful rays. Depletion of the crucial Ozone layer of the atmosphere is attributed to pollution caused by Chlorine and Bromide found in Chloro-floro carbons (CFC's). Once these toxic gases reach the upper atmosphere, they cause a hole in the ozone layer, the biggest of which is above the Antarctic. The CFC's are banned in many industries and consumer products. Ozone layer is valuable because it prevents harmful UV radiation from reaching the earth. This is one of the most important current environmental problem.

9. Acid Rain: Acid rain occurs due to the presence of certain pollutants in the atmosphere. Acid rain can be caused due to combustion of fossil fuels or erupting volcanoes or rotting vegetation which release sulfur dioxide and nitrogen oxides into the atmosphere. Acid rain is a known environmental problem that can have serious effect on human health, wildlife and aquatic species.

POSSIBLE QUESTIONS

PART B

1. How are climate zones classified?

2. What is global warming?

3. Mention any two reasons for acid rain.

4. Why the ozone layer is depleting?

5. State some air pollutants.

6. Define acid rain.

7. Mention some causes of air pollution.

PART C

1. Briefly explain about the impacts will global warming have in the future?

2. What is meant by acid rain? Discuss about the reasons of acid rain.

3. List the adverse effects of depletion of ozone layer. Suggest to prevent it.

4. Describe about the classification of climate.

5. Write the potential and contribution of greenhouse gases to global warming phenomenon.

6. Comment upon the following:
   (i) Causes of climate change (ii) Aerosols

7. Discuss the phenomenon of global warming and the factors contributing it.

8. Explain any two issues related to climate.

9. (i) What are reasons for air pollution?
   (ii) Explain the effects of air pollution.

UNIT-V

SYLLABUS

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

WEATHER FORECASTING ANALYSIS AND ITS HISTORICAL BACKGROUND:
The task of predicting the weather that will be observed at a future time is called weather forecasting. As one of the primary objectives of the science of meteorology, weather forecasting has depended critically on the scientific and technological advances in meteorology that have taken place since the latter half of the 19th century.

Historical Background

Throughout most of history, forecasting efforts at any given site depended solely on observations that could be made at that site. Observations of sky, wind, and temperature conditions and a knowledge of local climate history permitted a limited predictive ability. Weather lore was also accumulated in an effort to codify apparent patterns in the behavior of the atmosphere.

With the development of the telegraph in the mid-1800s, weather forecasters were able to obtain observations from many distant locations within a few hours of the collection of such data. These data could then be organized into so-called synoptic weather charts, synoptic meaning the display of weather data occurring at the same time over an area. These were the predecessors of the synoptic weather maps produced today. The physical bases of atmospheric motions were not yet understood, however, so prediction depended on various empirical rules. The most fundamental rules developed in that period were that weather systems move and that precipitation typically is associated with regions of low atmospheric pressure.

Weather forecasting was revolutionized in the 1920s by the work of a group of Norwegian scientists led by Vilhelm Bjerknes. Bjerknes, who introduced the polar-front theory to account for the large-scale movement of air masses. His group provided a consistent and empirically based description of atmospheric circulation systems such as cyclones and anticyclones and of the formation of precipitation.

By the 1930s, radio technology had provided forecasters with an important new tool, the radiosonde. Radiosondes are balloon-borne automated packages of meteorological instruments that relay back observations while ascending through the atmosphere. Such devices extended and refined the forecasting concepts of polar-front theory by revealing major upper-atmosphere features such as the jet stream.

Current weather-forecasting techniques were initiated by the theoretical work of American meteorologist Jule Charney in developing numerical weather prediction. That is, weather phenomena are predicted by solving the equations that govern the behavior of the atmosphere.

Experimental numerical forecasts in 1950 proved so fruitful that they were soon adopted on a practical basis. Since then, computerized systems based on numerical models have become a central part of weather forecasting.

The Forecasting Process

Making a weather forecast involves three steps: observation and analysis, extrapolation to find the future state of the atmosphere, and prediction of particular variables. One qualitative extrapolation technique is to assume that weather features will continue to move as they have been moving. In some cases the third step (prediction) simply consists of noting the results of extrapolation, but actual prediction usually involves efforts beyond this.

The tools that meteorologists can use for forecasting depend on the intended range of the forecast, or how far into the future the forecast is supposed to extend. Short-range forecasts, sometimes called "nowcasts," extend up to 12 hours ahead. Daily-range forecasts are valid for 1 to 2 days ahead; this is the range in which numerical forecasting techniques have made their greatest contribution. In the 1980s, however, the techniques also became useful in the development of medium-range forecasts, which extend from three to seven days ahead. Extended-range forecasts, which extend more than a week ahead, depend on a combination of numerical and statistical forecast guidance. Finally, short-term climate forecasts, such as the one-month and three-month average forecasts issued by the Climate Prediction Center of the National Weather Service (NWS), depend mostly on statistical guidance.

The decreasing usefulness of numerical forecasts with increasing range reflects imperfections in current numerical models, but it also reflects the extreme complexity of the atmosphere. Theoretical results show that "perfect" forecasting schemes should become useless for describing daily weather at a range of two to three weeks, although skill remains for forecasting monthly averages in certain cases.

Observation and Analysis

Meteorological observations taken around the world include reports from surface stations, radiosondes, ships at sea, aircraft, radar, and meteorological satellites. Although data-access policies vary among countries, many of these reports are transmitted on the Global Telecommunications System (GTS) of the World Meteorological Organization (WMO) to regional and global centers. There the data are collated, redistributed back across the GTS, and used in various numerical forecast models. Typically, these numerical models start out with data observed at 0000 and 1200 Universal Coordinated Time (7 A.M. and 7 P.M. Eastern Standard Time, respectively). Accordingly, special efforts are made to collect as much meteorological data as possible at those times of day.

The data are printed, plotted, and graphed in a wide variety of forms to assist the forecaster. In addition, as the data enter a given forecast model, certain "initialization" routines slightly modify the data just for use in that model. This is done in order to provide the most consistent picture of the atmosphere within the model's limitations. In short-range forecasting a major effort is made toward providing flexible access to the most current observations. Interactive computer systems are very important for helping the forecaster to use the huge mass of data available.

NEED OF MEASURING A WEATHER:

There are many reasons why it is important to measure the weather. This information helps people make important decisions about their day and their future activities. Weather conditions can determine minor things like, "What clothes should I wear today?" to major things like, "Is it safe to fly an aeroplane today?".

Measuring the weather has become a lot more sophisticated and meteorologists are now able to warn people about bad weather that is approaching and that could have dangerous consequences.

Measuring and predicting the weather has the capacity to help people, businesses, farmers, transport systems and provide warning systems. It is also important in determining an area's climate, which involves measuring the weather over a long period of time.

People

People use weather predictions to determine many aspects of their day. What clothes they will wear, what activity they will participate in, where they might visit, what mode of transport they will take. What they need to take with them (a jacket, an umbrella, a hat) are questions that are all answered by weather measurements.

People are able to plan their daily activities and clothing with a lot more accuracy today thanks largely to new measuring techniques used by meteorologists. Weather measurements are constantly broadcast throughout the day on television and radio so that people are kept updated on changes.

Thermometers and rain gauges can often be found in people's homes today so that they are able to make their own measurements and predictions about the daily weather, especially the temperature.

Businesses

Many businesses operate in the open environment which makes them vulnerable to changing weather conditions. The fishing industry is one business that relies on weather measurements and predictions. The ocean reacts to different weather conditions (storms, high winds) and can be very dangerous for people on boats. It is for this reason that fishermen and anglers make sure they are up to date on all weather conditions.

Tourism companies that rely on the outdoors also need to use weather measurements to plan their daily activities. Business that rely on snow conditions or the need for sunshine are very concerned about weather as it will determine how many tourists they will receive and therefore the success of their business.

Farmers

Farmers and other people who rely on the land for their livelihood require ongoing weather information. This information is crucial in determining the best time to plant crops and when to harvest. Irregular weather conditions can have devastating effects on farms, which can lead to food shortages.

Farmers rely on different weather conditions (rain, sunshine) in the production of quality products. Droughts, floods, rain on the wrong day and bushfires are all weather conditions that can put crops at risk.
Farmers will also use weather measurements and predictions to help protect their livestock. If farmers know there are going to be unusual weather conditions (storms, cyclones, floods, droughts) then they can take action. This may involve stocking up on animal feed, conserving water or moving their animals to calmer areas.

Transport
The transport industry is another area that requires weather information to produce a safe product for the public. The weather can have negative effects on the efficiency and safety of many modes of transport. Wind, rain, hail, fog and snow are some weather conditions that can jeopardise and interfere with transport systems.

Air travel
Pilots must know what is happening in the atmosphere so that they can keep their passengers safe. Aeroplanes will often be caught in bad weather, especially winds, which passengers experience as turbulence. Weather is changeable, so aeroplanes often fly above the weather to try to avoid bumpy or dangerous situations. If weather conditions are very bad aeroplanes, do not fly.

Shipping
Boats and ships are also controlled by different weather conditions. Bad storms and winds that cause dangerous water conditions are weather events that people on boats and ships need to know about. Many boats will have their own weather monitors or have communication systems that allow them to receive weather updates.

Public transport
Public transport (trains, buses, ferries) can also be affected by extreme weather conditions. Train tracks can warp in extreme heat, roads can become flooded when there is high rainfall and buses cannot take their normal routes or thick fogs can disrupt ferries. It is important that people have weather information so that alternative public transport systems can be organised and people's days are not disrupted too much.

Warning systems
The measurement of the weather is not only important day to day but is important in the forecasting of approaching dangerous weather (storms, cyclones, floods). By developing measuring tools, meteorologists are able to develop better warning systems that will help save people's lives, properties and businesses. By having warning systems, people are able to receive information about the approach of dangerous weather.

TYPES OF WEATHER FORECASTING:
A daily weather forecast involves the work of thousands of observers and meteorologists all over the world. Modern computers make forecasts more accurate than ever, and weather satellites orbiting the earth take photographs of clouds from space Forecasters use the observations from ground and space, along with formulas and rules based on experience of what has happened in the past, and then make their forecast.

Meteorologists actually use a combination of several different methods to come up with their daily weather forecasts. They are

1. Persistence Forecasting
2. Synoptic Forecasting
3. Statistical Forecasting
4. Computer forecasting

1. Persistence Forecasting

The simplest method of forecasting the weather is persistence forecasting. It relies upon today's conditions to forecast the conditions tomorrow. This can be a valid way of forecasting the weather when it is in a steady state, such as during the summer season in the tropics. This method of forecasting strongly depends upon the presence of a stagnant weather pattern. It can be useful in both short range forecasts and long range forecasts. This assumes that what the weather is doing now is what it will continue to do. To find out what the weather is doing, meteorologists make weather observations.

2. Synoptic Forecasting

This method uses the basic rules for forecasting. Meteorologists take their observations, and apply those rules to make a short-term forecast.

3. Statistical Forecasting
Meteorologists ask themselves, what does it usually do this time of the year? Records of average temperatures, average rainfall and average snowfall over the years give forecasters an idea of what the weather is "supposed to be like" at a certain time of the year.

4. Computer forecasting

Forecasters take their observations and plug the numbers into complicated equations. Several ultra-high-speed computers run these various equations to make computer "models" which give a forecast for the next several days. Often, different equations produce different results, so meteorologists must always use the other forecasting methods along with this one.

Using all the above methods, forecasters come up with their "best guess" as to what weather conditions will be over the next few days.
Weather forecasting now has a wide range of operational products that traditionally are classified under the following groups:

- Very short-range forecast
- Short-range forecast
- Medium-range forecast
- Long-range forecast
- Each weather forecast can be defined on the basis of the following criteria:
- Dominant technology
- Temporal range of validity after emission
- Characteristics of input and output time and space resolution
- Broadcasting needs
- Accuracy

WEATHER FORECASTING METHODS:

Use of a barometer

Measurements of barometric pressure and the pressure tendency have been used in forecasting since the late 19th century. The larger the change in pressure, the larger the change in weather can be expected. If the pressure drop is rapid, a low pressure system is approaching, and there is a greater chance of rain.

Looking at the sky

Along with pressure tendency, the condition of the sky is one of the most important parameters used to forecast weather in mountainous areas. Thickening of cloud cover or the invasion of a higher cloud deck is an indication of rain in the near future. At night, high thin clouds can lead to halos around the moon, which indicates the approach of a warm front and its associated rain. Morning fog portends fair conditions, as rainy conditions are preceded by wind or clouds which prevent fog formation.

Now casting

The forecasting of the weather within the next six hours is often referred to as nowcasting. In this time range, it is possible to forecast smaller features such as individual showers and thunderstorms with reasonable accuracy, as well as other features too small to be resolved by a computer model. A human, given the latest radar, satellite and observational data will be able to make a better analysis of the small scale features present and so will be able to make a more accurate forecast for the following few hours.

Analog technique

The analog technique is a complex way of making a forecast, requiring the forecaster to remember a previous weather event which is expected to be mimicked by an upcoming event. It remains a useful method of observing rainfall in places such as oceans, as well as the forecasting of precipitation amounts and distribution in the future. A similar technique is used in medium range forecasting, which is known as teleconnections, when systems in other locations are used to help pin down the location of another system within the surrounding regime.

Numerical Weather Prediction model

Numerical Weather Prediction (NWP) is the science of predicting the weather using models of the atmosphere and computational techniques. Current weather conditions are used at the input of the mathematical models of the atmosphere to predict the weather. This model usually provides surrounding point around the wind farm with a spatial resolution of a few kilometers.NWP uses the power of computers to make a forecast. A forecaster examines how the features predicted by the computer will interact to produce the day's weather. The NWP method is flawed in that the equations used by the models to simulate the atmosphere are not precise.

A number of weather forecasting agencies operate modeling centers where supercomputers are used to run NWP models that span the entire globe. These include the National Center for Environmental Prediction (NCEP) in the United States, the United Kingdom Meteorological Office (UKMO), and the European Centre for Medium-range Weather Forecasts (ECMWF). Although costly, a global approach to NWP is essential, especially for long-range forecasting. For this reason, achieving accurate forecasts requires an accurate analysis from which to get the model started. This involves a computer-based process called data assimilation, in which the most recent weather observations from around the world are combined with model forecasts to create a global analysis of current conditions. This becomes the starting point for the next run of the NWP model, and is the computer equivalent of the manual analysis cycle that forecasters carry out on an on-going basis. Global models play a key role in modern weather forecasting, and meteorologists at Met Service routinely use the NCEP, UKMO and ECMWF models to assist with day-to-day production of forecasts and weather warnings. These models give insight into the behavior of weather systems on a large scale, without much emphasis on local detail.

Ensemble Forecasting.

To predict the weather forecast meteorologists have developed atmospheric models that approximate the atmosphere by using ensemble forecasting to describe how atmospheric temperature, pressure and moisture will change over time. The equations are programmed into a computer and the data on the present atmospheric conditions are fed into the computer. The computer solves the equations to determine how the different atmospheric variables will change over the next few minutes. The computer repeats this procedure again and again using the output from one cycle as the input for the next cycle. For some desired time in the future, the computer prints its calculated information. It then analyzes the data, drawing the lines for the projected position of the various pressure systems. A forecaster uses the prognostic chart as a guide to predicting the weather. There are many atmospheric models that represent the atmosphere, with each one interpreting the atmosphere in a slightly different way. Weather forecasts made for 12 and 24 hours are typically accurate. Forecasts made for two or three days are usually good. Beyond above five days, forecast accuracy falls off rapidly.

Weather information can also come from remote sensing, particularly radar and satellites.

Radar

Radar stands for Radio Detection and Ranging. In radar, a transmitter sends out radio waves. The radio waves bounce off the nearest object and then return to a receiver. Weather radar can sense many characteristics of precipitation, its location, motion, intensity, and the likelihood of future precipitation. Most weather radar is Doppler radar, which can also track how fast the precipitation falls. Radar can outline the structure of a storm and in doing so estimates the possibility that it will produce severe weather condition

CRITERIA OF CHOOSING WEATHER STATION

Step 1:

All AWSs maintain a digital record of one or more weather elements (air temperature, rainfall, sunshine, wind speed, and so on). Being clear from the outset what the essential system requirements are, and whether they can be expected to change over time, will quickly help narrow the search for suitable products. Many first-time purchasers rush into buying the first system that appears to satisfy their immediate requirements (and the available budget) without adequately considering future needs, only to regret the decision some weeks or months later when limited functionality, expandability or build quality results in frustration. It is better, of course, to be sure of what is needed – and what is not – at the outset to avoid subsequent disappointment. Writing off the initial system after only a short time to buy a more capable system will clearly be more expensive (in both financial terms and installation time) than if the desired system characteristics had been clearly identified beforehand. It is also important to regard money spent on the chosen system as a medium to long-term investment. With careful consideration given to the robustness and longevity of system components and supplier reputation, with appropriate maintenance (and occasional sensor replacements) a lifetime of 10 or even 20 years is not unreasonable. Take this into account when making your decisions.

Step 2:

The extent to which any specific requirement is met will depend on a number of factors, the most common of which are listed below. Each of these factors is briefly outlined within the following sections. As each system will have its own requirements, they are not arranged in any particular priority order.

Step 3:

The last item to consider is possibly the most important – namely, what is theavailable budget? There are a few excellent basic systems for less than $100 which will measure, display and log just one or two elements to tolerable accuracy. One of these may be perfectly adequate for a first-time purchasers, or for a present for a friend or relation to 'dip a toe in the water' of measuring the weather. Other users require more sophisticated, capable, expandable and robust systems, which depending on requirements may cost ten or a hundred times that of an entry-level system.

Not surprisingly, the more accurate, expandable, robust and flexible systems (with good post-sales support, should it be needed) tend to be more expensive.

For private individuals, the money spent on a system is best viewed as a multiyear investment. Provided care is taken in exposure and siting, and with occasional maintenance, a mid-range system should last 10 or 20 years or more with little further outlay required beyond the initial purchase price. For professional users, budgeting for a capable and robust system which should give many years trouble-free service will reduce future service costs and minimize downtime.

One-minute summary – Choosing a weather station

* There are many different varieties of automatic weather stations (AWSs) available, and a huge range of different applications for them. To ensure any specific system satisfies any particular requirement, consider carefully, in advance of purchase, what are the main purposes for which it will be used, then consider and prioritize the features and benefits of suitable systems to choose the best solution from those available.
* The choices can be complex and a number of important factors may not be immediately obvious to the first-time purchaser. Deciding a few months down the line that the unit purchased is unsuitable and difficult to use (or simply does not do what you want it to) is likely to prove an expensive mistake, as very few entry-level and budget systems can be upgraded or expanded.
* Decide firstly what the AWS will mainly be used for: some potential uses may not be immediately obvious. Once that is clear, review the relevant decision-making factors as outlined in this chapter, then prioritize them against your requirements.
* An AWS does not have to be the first rung on the weather measurement ladder. Short of funds? Not sure whether you'll keep the records going and don't want to spend a lot until you have given it a few months? Not sure where to start? Different options are covered in this and subsequent chapters.
* Consider firstly whether the site where the instruments will be used is suitable. There is little value in spending hundreds or even thousands of dollars on a sophisticated and flexible AWS if the location where it will be used is poorly exposed to the weather it seeks to measure. In general a budget AWS exposed in a good location will give more representative results than a poorly exposed topof- the-range system. Worthwhile observations can be made with budget instruments in limited exposures, but a very sheltered site may not justify a significant investment in precision instruments, as the site characteristics may limit the accuracy and representativeness of the readings obtained.
* Carefully consider the key decision areas. Should the system be cabled, or wireless? Is it easy to set up and use? How many sensors are offered, and how accurate and reliable will they be? Are all the sensors mounted in one 'integrated' system, or can they be positioned separately for the optimum exposure in each case? Do the records obtained need to conform to 'official standards'? Examples and suggestions are given in this chapter.
* Finally – and this should be the last step – match the available budget against the requirements and specifications outlined in previous steps. Consider that a reasonable mid-range or advanced system, when used with care and maintained, should last for 10 or even 20 years, and budget

accordingly. There are many 'cheap and cheerful' systems available, but will they last longer than their warranty period?

BASICS OF CHOOSING SITE AND EXPOSURE:

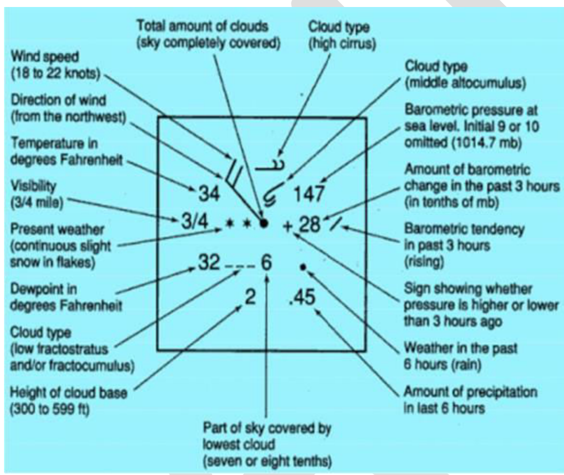
Site refers to 'the area or enclosure where the instruments are exposed', while exposure refers to 'the manner in which the sensor or sensor housing is exposed to the weather element it is measuring'.
* Satisfactory site and sensor exposure are fundamental to obtaining representative weather observations. An open well-exposed site is the ideal, of course, but with planning and careful positioning of the instruments, good results can often be obtained from all but the most sheltered locations.
* A good exposure for one sensor can be the exact opposite for another. For representative wind speed and direction readings, for example, an anemometer mounted on top of a tall mast is ideal, but this would be a poor exposure for a raingauge owing to wind effect.
* Based upon World Meteorological Organization (WMO) published guidance, outlines preferred site and exposure characteristics for the most common sensor types. No single exposure will provide a perfect fit for the requirements of all sensors. A simple and objective grading scheme to assess and report site, exposure and instrumentation is outlined.
* Rooftops or masts may provide much better exposure for some sensors, but carefully consider the accessibility of the site before attempting to install the sensors. If the proposed site cannot be reached safely, fit appropriate safety measures or find another site. Do not take personal risks, or encourage others to do so, when attempting to install weather station sensors, particularly at height.

SATELLITES POBSERVATIONS IN WEATHER FORECASTING:
Weather satellites have been increasingly important sources of weather data since the first one was launched in 1952. Weather satellites are the best way to monitor large scale systems, like storms. Satellites can also monitor the spread of ash from a volcanic eruption, smoke from fires, and pollution. They are able to record long-term changes. Figure 1.1 shows one of the geostationary satellites that monitors conditions over the world. Weather satellites may observe all energy from all wavelengths in the electromagnetic spectrum. Most important are the visible light and infrared (heat) frequencies.

WEATHER MAPS

Weather maps simply and graphically depict meteorological conditions in the atmosphere. Weather maps may display only one feature of the atmosphere or multiple features. They can depict information from computer models or from human observations. Weather maps are found in newspapers, on television, and on the Internet.

On a weather map, each weather station will have important meteorological conditions plotted. These conditions may include temperature, current weather, dew point, cloud cover, sea level air pressure, wind speed and direction. On a weather map, meteorologists use many different symbols. These symbols give them a quick and easy way to put information onto the map . Figure shows some of these symbols used for Weather Map.



POSSIBLE QUESTIONS

PART B

1. Mention some types of weather forecasting methods.

2. Name the elements of weather and climate.

3. Define weather maps.

4. Differentiate climate and weather.

5. Write a short notes about weather forecasting.

6. Why we need to measure weather?

7. Define weather station.

PART C

1. What is meant by weather forecasting? Explain the different types of it.

2. Why weather forecasting is important? Discuss about weather maps.

3. Explain the brief analysis and historical background of weather forecasting.

4. Describe in detail about satellites observations in weather forecasting.

5. Write a short notes of the following:

   (i) Historical background of weather forecasting (ii) Weather Forecasting methods

6. Write in detail note on criteria of choosing weather station.

7. Discuss about basics of choosing site and exposure.