CLIMATOLOGY   SUBJECT CODE: 18BGE12C

UNIT – I: Climatology – Definition, aims and scope of Climatology- Atmosphere: Definition, Origin, Structure and Composition-Weather and climate.

DEFINITION

Climatology (from Greek, *klima*, "place, zone"; and --*logia*) or **climate science** is the scientific study of climate, scientifically defined as weather conditions averaged over a period of time. This modern field of study is regarded as a branch of the atmospheric sciences and a subfield of physical geography, which is one of the Earth sciences.

Climatology is the study of climate and how it changes over time. This science helps people better understand the atmospheric conditions that cause weather patterns and temperature changes over time.

AIMS AND SCOPE OD CLIMATOLOGY

Climatology is the science of studying the average atmospheric conditions of a region in long-term perspective. **Climatology** plays a leading role in the survival and longevity of all life living on the planet earth. It helps to unravel the mysteries of the past and the myth of the future.

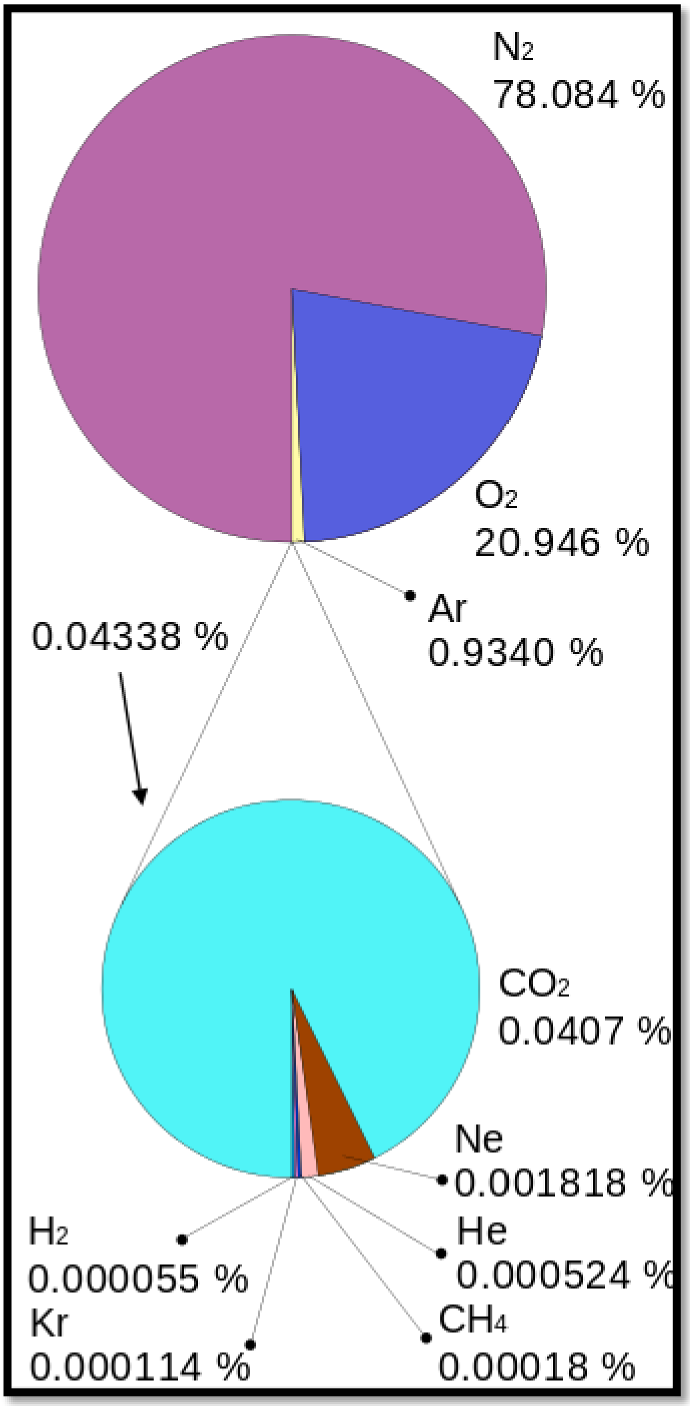
Climatology is important since it helps determine future **climate** expectations. Through the use of latitude, one can determine the likelihood of snow and hail reaching the surface. You can also be able to identify the thermal energy from the sun that is accessible to a region.

ATMOSPHERE

An **atmosphere** (from the greek words ἀτμός *(atmos)*, meaning 'vapour', and σφαῖρα *(sphaira)*, meaning 'ball' or 'sphere'[1][2]) is a layer or a set of layers of gases surrounding a planet or other material body, that is held in place by the gravity of that body. An atmosphere is more likely to be retained if the gravity it is subject to is high and the temperature of the atmosphere is low.

COMPOSITION OF ATMOSPHERE

The composition of Earth's atmosphere is largely governed by the by-products of the life that it sustains. Dry air from Earth's atmosphere contains 78.08% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide, and traces of hydrogen, helium, and other "noble" gases (by volume), but generally a variable amount of water vapor is also present, on average about 1% at sea level. The atmospheres of the planets Venus and Mars are primarily composed of carbon dioxide, with small quantities of nitrogen, argon, oxygen, and traces of other gases.



The low temperatures and higher gravity of the Solar System's giant planets Jupiter, Saturn, Uranus and Neptune—allow them more readily to retain gases with low molecular masses. These planets have hydrogen–helium atmospheres, with trace amounts of more complex compounds.

Two satellites of the outer planets possess significant atmospheres. Titan, a moon of Saturn, and Triton, a moon of Neptune, have atmospheres mainly of nitrogen. When in the part of its orbit closest to the Sun, Pluto has an atmosphere of nitrogen and methane similar to Triton's, but these gases are frozen when it is farther from the Sun.

Other bodies within the Solar System have extremely thin atmospheres not in equilibrium. These include the Moon (sodium gas), Mercury (sodium gas), Europa (oxygen), Io (sulfur), and Enceladus (water vapor).

The first exoplanet whose atmospheric composition was determined is HD 209458b, a gas giant with a close orbit around a star in the constellation Pegasus. Its atmosphere is heated to temperatures over 1,000 K, and is steadily escaping into space. Hydrogen, oxygen, carbon and sulfur have been detected in the planet's inflated atmosphere.

SRUCTURE OF ATMOSPHERE

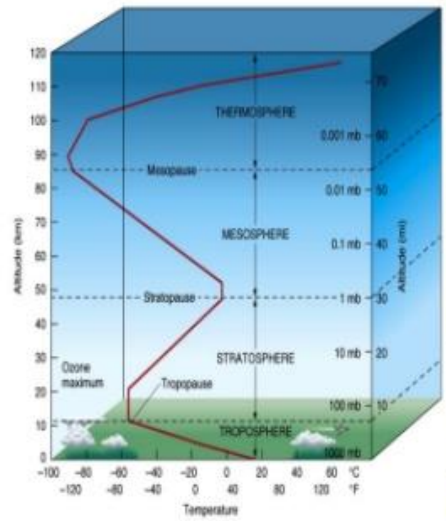
Earth's atmosphere consists of a number of layers that differ in properties such as composition, temperature and pressure. The lowest layer is the troposphere, which extends from the surface to the bottom of the stratosphere. Three quarters of the atmosphere's mass resides within the troposphere, and is the layer within which the Earth's terrestrial weather develops. The depth of this layer varies between 17 km at the equator to 7 km at the poles. The stratosphere, extending from the top of the troposphere to the bottom of the mesosphere, contains the ozone layer. The ozone layer ranges in altitude between 15 and 35 km, and is where most of the ultraviolet radiation from the Sun is absorbed.

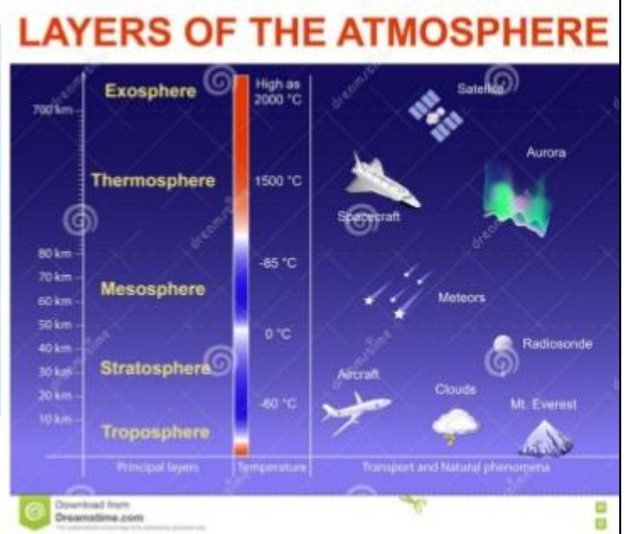
The top of the mesosphere, ranges from 50 to 85 km, and is the layer wherein most meteors burn up. The thermosphere extends from 85 km to the base of the exosphere at 400 km and contains the ionosphere, a region where the atmosphere is ionized by incoming solar radiation. The ionosphere increases in thickness and moves closer to the Earth during daylight and rises at night allowing certain frequencies of radio communication over a greater range. The Kármán line, located within the thermosphere at an altitude of 100 km, is commonly used to define the boundary between Earth's atmosphere and outer space. The exosphere begins variously from about 690 to 1,000 km above the surface, where it interacts with the planet's magnetosphere. Each of the layers has a different lapse rate, defining the rate of change in temperature with height.

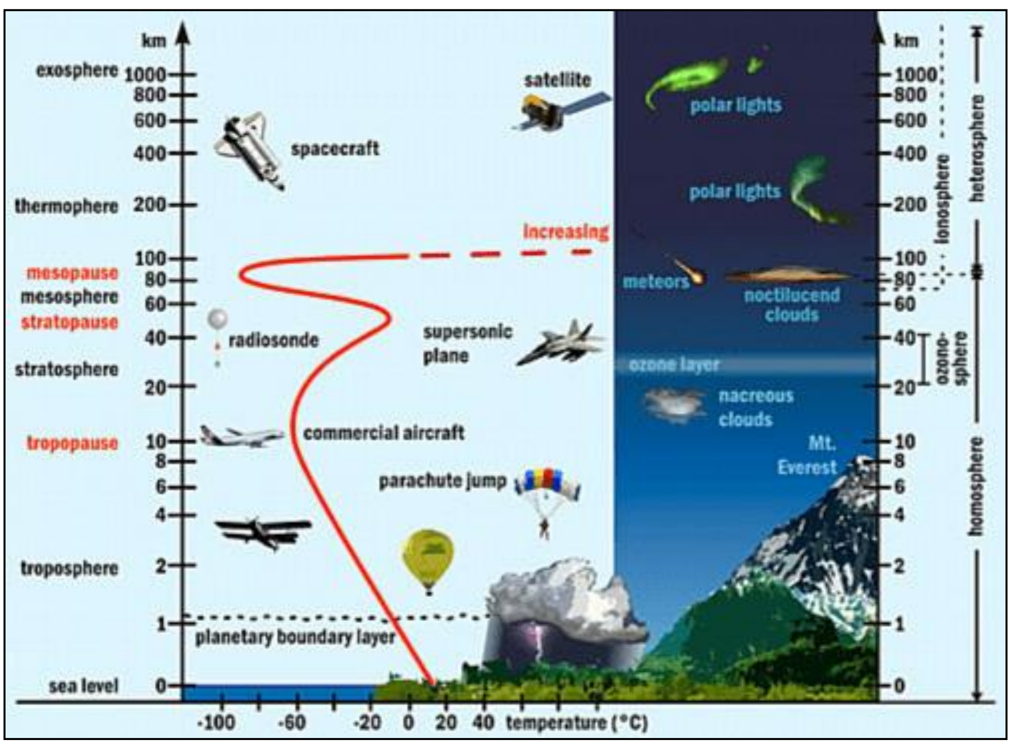
Atmosphere structure

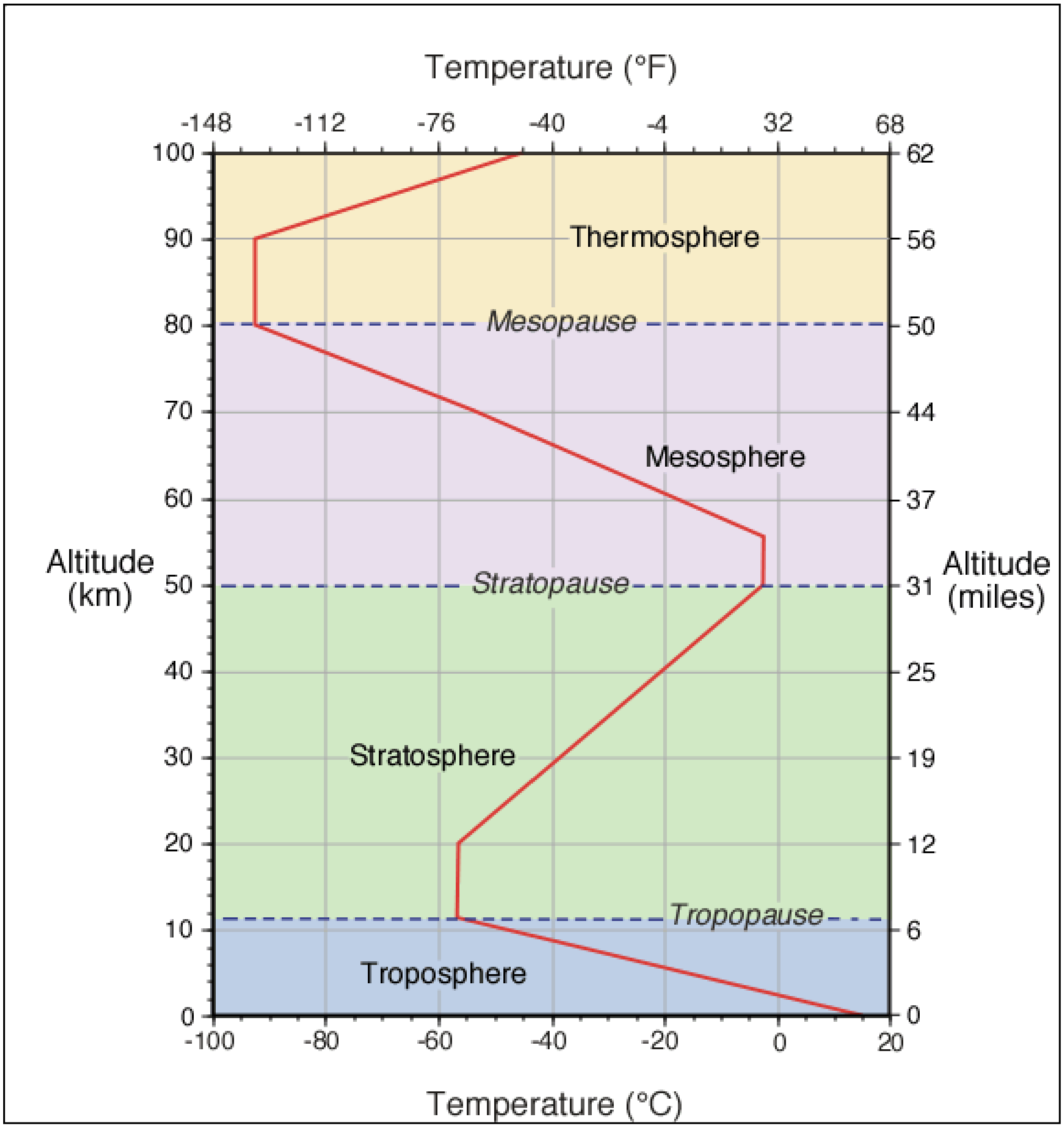
The Atmosphere is divided into layers according to major changes in temperature. Gravity pushes the layers of air down on the earth's surface. This push is called air pressure. 99% of the total mass of the atmosphere is below 32 kilometers.

Troposphere Stratosphere Mesophere Thermosphere Magnetosphere









Structure of the Atmosphere:

It surrounds the earth from all sides. Generally, it extends up to about 1600 kilometres from the earth's surface. 97 % of the total amount of weight of the atmosphere is limited up to the height of about 30 kilometres.

The atmosphere can be divided into five layers according to the variation of temperature and density:

(a) Troposphere,
(b) Stratosphere,
(c) Mesosphere,
(d) Ionosphere and
(e) Exosphere

a) Troposphere:

- This is the lowest layer of the atmosphere.
- The height of this layer is about 18 km on the equator and 8 km on the poles. The main reason for higher height at the equator is due to the presence of hot convection currents that push the gases upward.
- This is the most important layer of the atmosphere because all kinds of weather changes take place only in this layer. The air never remains static in this layer. Therefore, this layer is called the changing sphere or troposphere.
- The environmental temperature decreases with increasing height of the atmosphere. It decreases at the rate of 10C at a height of 165 meters. This is called Normal lapse rate.
- The upper limit of the troposphere is called the tropopause. After this, the temperature increases. This is a transitional zone. In this zone, characteristics of both the troposphere and ionosphere are found.

(b) Stratosphere

- This layer is above the troposphere.
- This layer is spread up to the height of 50 km from the Earth's surface. Its average extent is 40 km.
- The temperature remains almost the same in the lower part of this layer up to the height of 20 km. After this, the temperature increases slowly with the increase in height. The temperature increases due to the presence of ozone gas in the upper part of this layer.
- Weather-related incidents do not take place in this layer. The air blows horizontally here. Therefore, this layer is considered ideal for flying aircraft. The lower portion of the stratosphere is also influenced by the polar jet stream and the subtropical jet stream. In the first 9 kilometres of the stratosphere, the temperature remains constant with height.
- A zone with constant temperature in the atmosphere is called an isothermal layer. From an altitude of 20 to 50 kilometres, temperature increases with an increase in altitude. The higher temperatures found in this region of the stratosphere occurs because of a localized concentration of ozone gas molecules.

(c) Mesosphere

- It is the third layer of the atmosphere spreading over stratosphere.
- It spreads up to the height of 80 km from the surface of the earth. Its extent is 30 km.
- Temperature goes on decreasing and drops up to – 1000C.
- 'Meteors' or falling stars occur in this layer.

(d) Ionosphere

- This is the fourth layer of the atmosphere. It is located above the mesosphere.
- This layer spreads up to a height of 400 km from the surface of the earth. The width of this layer is about 300 km.
- The temperature starts increasing again with increasing height in this layer.
- Electrically charged currents flow in the air in this sphere. Radio waves are reflected back on the earth from this sphere and due to this radio broadcasting has become possible. The ionosphere is a region of the atmosphere that is ionized by solar radiation. It is responsible for auroras. During daytime hours, it stretches from 50 to 1,000 km and includes the mesosphere, thermosphere, and parts of the exosphere.
- However, ionization in the mesosphere largely ceases during the night, so auroras are normally seen only in the thermosphere and lower exosphere. The ionosphere forms the

inner edge of the magnetosphere. It has practical importance because it influences, for example, radio propagation on Earth.

(e) Exosphere:

- This is the last layer of the atmosphere located above ionosphere and extends to beyond 400 km above the earth.
- Gases are very sparse in this sphere due to the lack of gravitational force. Therefore, the density of air is very less here.

The last atmospheric layer has an altitude greater than 80 kilometres and is called the thermosphere. Temperatures in this layer can be greater than 1200° C.

These high temperatures are generated from the absorption of intense solar radiation by oxygen molecules (O2). While these temperatures seem extreme, the amount of heat energy involved is very small.

Homo-sphere and Hetero-sphere:

- The homo-sphere and hetero-sphere are defined by whether the atmospheric gases are well mixed. The surface-based homo-sphere includes the troposphere, stratosphere, mesosphere, and the lowest part of the thermosphere, where the chemical composition of the atmosphere does not depend on molecular weight because the gases are mixed by turbulence.
- This relatively homogeneous layer ends at the turbo-pause found at about 100 km, which places it about 20 km above the meso-pause.
- Above this altitude lies the hetero-sphere, which includes the exosphere and most of the thermosphere. Here, the chemical composition varies with altitude.
- This is because the distance that particles can move without colliding with one another is large compared with the size of motions that cause mixing.
- This allows the gases to stratify by molecular weight, with the heavier ones, such as oxygen and nitrogen, present only near the bottom of the hetero-sphere. The upper part of the hetero-sphere is composed almost completely of hydrogen, the lightest element

WEATHER

Weather is the state of the atmosphere, describing for example the degree to which it is hot or cold, wet or dry, calm or stormy, clear or cloudy. On Earth, most weather phenomena occur in the lowest level of the planet's atmosphere, the troposphere, just below the stratosphere. Weather refers to day-to-day temperature and precipitation activity, whereas climate is the term for the averaging of atmospheric conditions over longer periods of time. When used without qualification, "weather" is generally understood to mean the weather of Earth.

Weather is driven by air pressure, temperature, and moisture differences between one place and another. These differences can occur due to the Sun's angle at any particular spot, which varies with latitude. The strong temperature contrast between polar and tropical air gives rise to the largest scale atmospheric circulations: the Hadley cell, the Ferrel cell, the polar cell, and the jet stream. Weather systems in the middle latitudes, such as extratropical cyclones, are caused by instabilities of the jet streamflow. Because Earth's axis is tilted relative to its orbital plane (called the ecliptic), sunlight is incident at different angles at different times of the year. On Earth's surface, temperatures usually range ±40 °C (−40 °F to 100 °F) annually. Over thousands of years, changes in Earth's orbit can affect the amount and distribution of solar energy received by Earth, thus influencing long-term climate and global climate change.

Surface temperature differences in turn cause pressure differences. Higher altitudes are cooler than lower altitudes, as most atmospheric heating is due to contact with the Earth's surface while radiative losses to space are mostly constant. Weather forecasting is the application of science and technology to predict the state of the atmosphere for a future time and a given location. Earth's weather system is a chaotic system; as a result, small changes to one part of the system can grow to have large effects on the system as a whole. Human attempts to control the weather have occurred throughout history, and there is evidence that human activities such as agriculture and industry have modified weather patterns

Studying how the weather works on other planets has been helpful in understanding how weather works on Earth. A famous landmark in the Solar System, Jupiter's Great Red Spot, is an anticyclonic storm known to have existed for at least 300 years. However, the weather is not limited to planetary bodies. A star's corona is constantly being lost to space, creating what is essentially a very thin atmosphere throughout the Solar System. The movement of mass ejected from the Sun is known as the solar wind.

CLIMATE

In the early 20th century, climatology was mostly focused on the description of regional climates. This descriptive climatology was mainly an applied science, giving farmers and other interested people statistics about what the normal weather was and how big chances were of extreme events. To do this, climatologists had to define a *climate normal*, or an average of weather and weather extremes over a period of typically 30 years.

Around the middle of the 20th century, many assumptions in meteorology and climatology considered climate to be roughly constant. While scientists knew of past climate change such as the ice ages, the concept of climate as unchanging was useful in the development of a general theory of what determines climate. This started to change in the decades that followed, and while the history of climate change science started earlier, climate change only became one of the mean topics of study for climatologists in the seventies and onward.

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