Introduction to the Earth and Planetary Science

Atmosphere: Role, Composition & Structure

Atmosphere: Our planet earth is surrounded by a deep blanket of gases extending several hundreds 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 atmosphere (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 (benefit) of Earth's Atmosphere:

1. 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.
2. 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.
3. 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.
4. Atmosphere protects us from the harmful ultraviolet radiation (ozone layer in the stratosphere).
5. The atmosphere also takes care of extraterrestrial objects like meteors which get burnt up while passing through the atmosphere (in the mesosphere) due to friction.
6. Weather is another important phenomenon which decides 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 are discussed below.

Permanent Gases

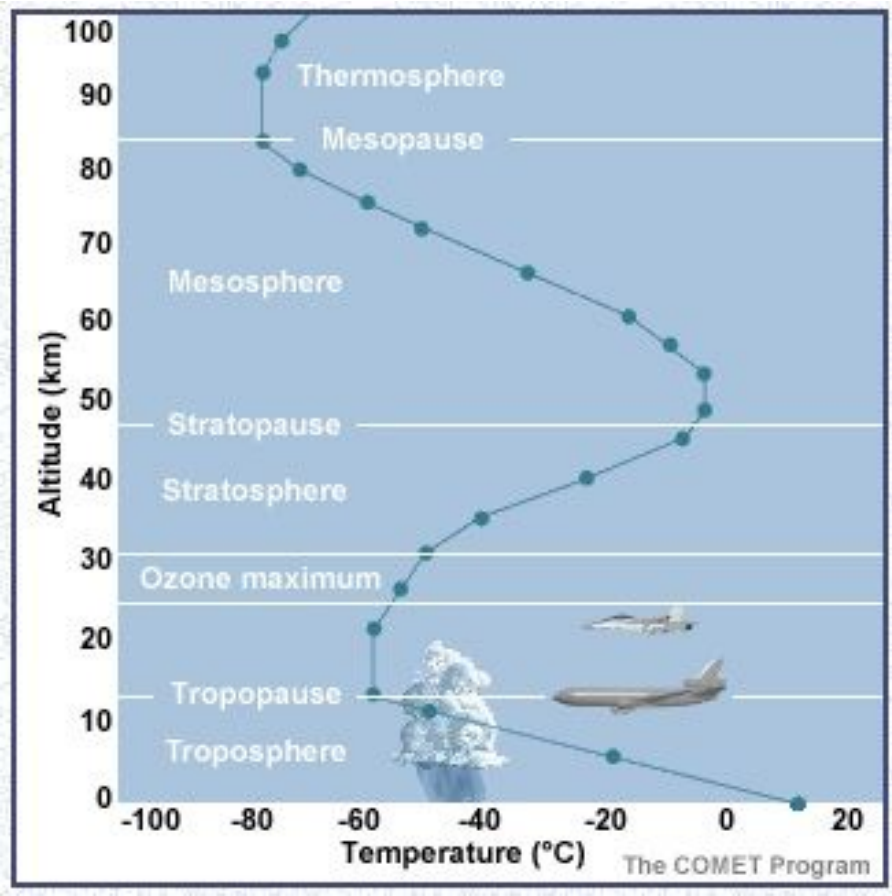
Constituent	*Formula*	*Percentage by Volume*
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Carbon dioxide	CO_2	0.036
Neon	Ne	0.002
Helium	He	0.0005
Krypto	Kr	0.001
Xenon	Xe	0.00009
Hydrogen	H_2	0.00005

Major Greenhouse Gases:

1. **Carbon dioxide** is meteorologically a very important gas as it is transparent to the incoming solar radiation but opaque to the outgoing terrestrial radiation. It absorbs a part of terrestrial radiation and reflects back some part of it towards the earth's surface. It is largely responsible for the greenhouse effect.
2. **Ozone** is another important greenhouse gas. But it is very small proportions at the surface.
3. **Water vapour** is also a variable gas in the atmosphere, which decreases with altitude. Water vapour also decreases from the equator towards the poles. In the warm and wet tropics, it may account for four per cent of the air by volume, while in the dry and cold areas of desert and Polar regions it may be less than one per cent of the air. It also absorbs parts of the insolation from the sun and preserves the earth's radiated heat. It thus, acts like a blanket allowing the earth neither to become too cold nor too hot. Water vapour also contributes to the stability and instability in the air.
4. **Methane** is one of the most important greenhouse gases. It is produced from decomposition of animal wastes and biological matter.

Structure of Atmosphere

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



1. 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 6.5°C per kilometre, 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'. 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.

2. 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.

2.1Ozonosphere

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 kilometre through the ozonosphere.

3. 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 -90°C at 80 km altitude. Meteorites burn up in this layer on entering from the space.

4. 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 rarefied – gas molecules are spaced hundreds of kilometres 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.

4.1 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.

5. 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.

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