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Part- I

Group- A: Climatology

Topic: Structure and Composition of the Atmosphere

Structure of Atmosphere

Structure means the arrangement of different part into one. In another words, it is the skeleton or organization or anatomy of a whole by looking at the relationships with its parts. According to this background, the study of different parts of the atmosphere and the relationship with its parts is said to be the structure of the atmosphere. Vertically, the atmosphere is divided into different layers/ parts. Therefore, the study of different layers is known as structure of atmosphere. Based on chemical composition, the atmosphere is classified into two. They are homosphere and heterosphere.

A) **Homosphere:** Homosphere is that part of atmosphere where the chemical composition of the air is uniform or similar. It is the lowest layer in terms of chemical composition. It extends from the earth's/ ocean surface to about 85 km. The density of the air changes very rapidly with increasing altitude but the proportion of the major gases found there remain alike throughout this layer with the exception of water vapour, pollutants, ozone and some trace/ very minor gases. On the basis of the changes in temperature, the atmosphere is divided into five layers out of them, three lower layers falls under homosphere (i.e. within 85 km of altitude). They are troposphere, stratosphere and mesosphere.

1) **Troposphere:** It is the lowest and densest layer of the atmosphere. It extends till a height of about 8 km over pole but over equator, it is 18 km. About 80 percent of the total mass of the atmosphere lays in this layer. With increase in height, the temperature keeps on declining till the limit of this layer. On an average, the decrease in temperature with height is 60Celsius par km. The upper boundary is known as troposphere laying between 8 and 18 km. At this level, the average temperature reaches to minus 500 to minus 600 Celsius (Figure 8). Water

vapour is found in this layer in abundance and about 99 percent of the total atmospheric water vapour is concentrated here but wide variation is seen in terms of height and longitudes. Vapour plays very vital role in regulating the temperature of the earth by creating greenhouse effect. All weather phenomena are occurring in this layer only. Troposphere is the home of all types of clouds, atmospheric turbulence and mixing of the air. Both horizontal and vertical mixing is quite prominent here. In fact, the term troposphere is derived from the Greek word 'tropos' means 'turn'. Sphere is signifying 'ball' or a structure which is round in shape attaining a three-dimensional space. Therefore, the troposphere is a three-dimensional object with turning or mixing characteristics. Every sort of living life is confined to the biosphere which include land water and air. The upper limit of troposphere is tropopause which is a transition zone another upper layer known as stratosphere.

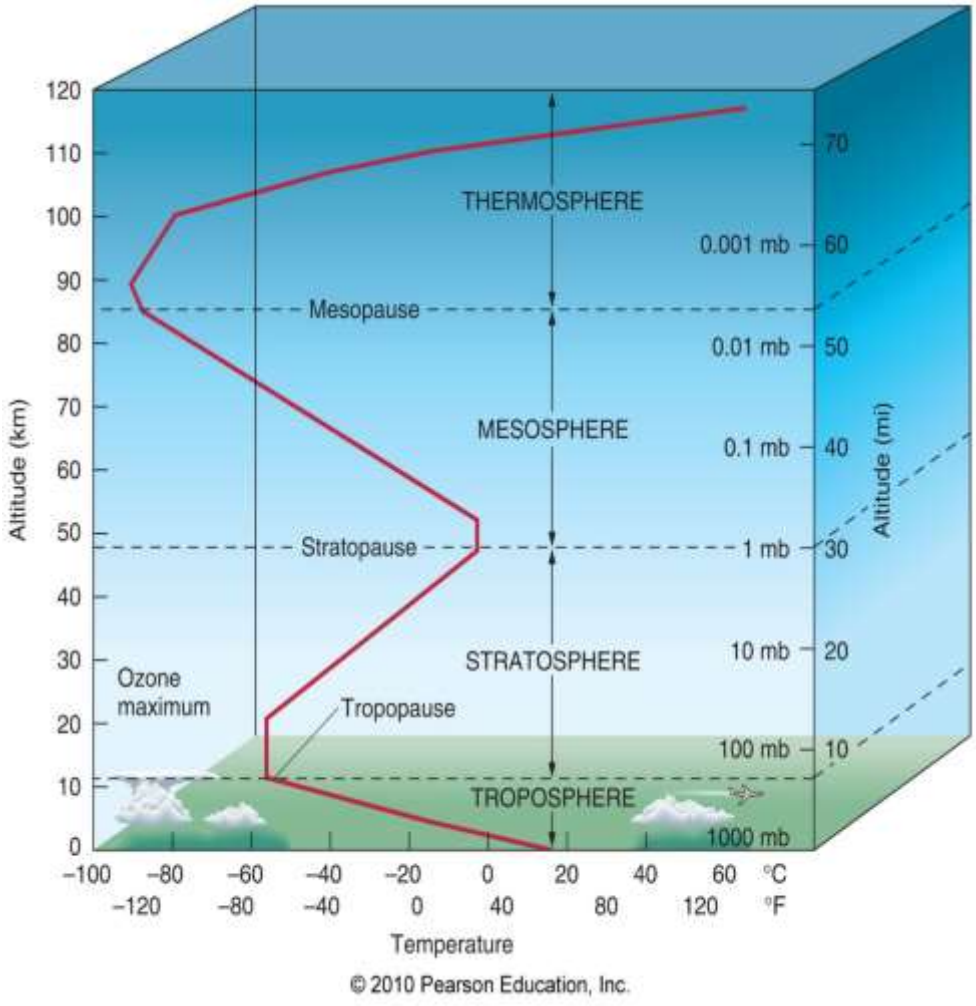

Fig: Different Layers of Atmosphere

2) **Stratosphere:** Stratosphere is the upward second layer as well as middle layer of the homosphere. It starts from tropopause to approximate height of 50 km. The temperature at the tropopause remains almost constant till the height of 20 km. After that, it starts increasing and continue the trend till the height of 50 km (Figure 8). At this level, the estimated temperature is about minus 100 to minus 150 Celsius. Though the temperature is on rise, but there is no atmospheric turbulence. This layer is completely free from clouds and other weather conditions. That is why, it has an advantage for flying long-distance supersonic jets/aeroplanes through this layer. The increase in temperature in this layer is caused by absorption of solar radiation by ozone (O3). Ozone is abundant in this layer and its 90 percent is concentrated (found between 15 km to 50 km) in this layer only. The upper limit is stratopause which is a very narrow strip of transition zone beyond which mesosphere is found.

Stratosphere is also termed as ozonosphere, a layer made up of ozone. This layer protects the living world of the planet from the harmful effects ultra-violet rays. The ozone depletion and hole over Antarctic was discovered in 1985. Since then, we have observed that this layer has reached to a dangerous level of depletion of ozone. The main ozone depleting substances are received from the release of chlorofluorocarbon (CFCs), hydro-chlorofluorocarbon (HCFCs) and carbon tetrachloride. When the molecules of chlorine atom come into contact with ozone (O_3), it turns O_3 into O_2 which is normal oxygen. One chlorine atom can destroy more than a lakh atoms of ozone. Therefore, the chain of depletion is very serious. O_3 turned into O_2, an ordinary oxygen molecule is not capable to absorbing ultra-violet rays.

3) **Mesosphere:** Mesosphere is the third but the upper-most layer of the homosphere. After this layer, heterosphere starts. The literal meaning of mesosphere is the middle sphere. It is separated by tropopause~~ below from troposphere and me~~sopause on the top from thermosphere. It is extended from 50 km to 85 km from the earth's surface. The air pressure is very low. This layer is characterised by decreasing temperature and the coldest/ lowest atmospheric temperature is recorded in this layer. The lowest temperature estimated near the mesosphere is around minus 1300Celsius. It is colder that the lowest temperature recorded

over Antarctic. Between 75 to 85 km from the earth, noctilucent clouds are normal affairs in the summer nights between 500 to 700 north and south latitudes. Its literal meaning is night shining. It is a deep twilight seen only when the sun is on horizon but the sunlight is still falling at that height. The seen clouds are made up of ice crystals. Meteoric dust particles work like nuclei for ice crystallization which are falling as well as produced due to burning of meteor caused by friction.

B) Heterosphere: The atmosphere laying beyond the homosphere is termed as heterosphere. The term itself is self-explanatory and it is used for that part of atmosphere where the air is not uniform. In this part of atmosphere, the air is rare and the molecules are wide apart. Relatively heavier gas molecules are concentrated in the lower part whereas the lighter are forced to be above. Beyond 85 km height, the composition of the atmosphere with increasing altitude vary significantly. The mixing of the gases are not possible as the turbulence is not happening there. Different layers of prominently different gases are nitrogen layer, oxygen layer, helium layer and hydrogen layer are differentiated. However, the heterosphere, is divided into two main spheres – thermosphere and exosphere.

4) Thermosphere: This sphere extends from mesopouse i.e., 85 km to about 650 km from earth. The temperature is on rise in this layer due to absorption of solar radiation by small amount of oxygen molecules present. It is highly dependent upon the solar activities. The temperature reaches beyond 12000C at an altitude of about 350 km but by 650 km it may even rise to 20000C. This much high temperature is primarily defined by average speed with which molecules are moving. Because of this, the temperature may be high. The effectiveness of this temperature is not that great. Its exposure to astronaut, if they are coming out from the capsule, is not affecting at all.

5) Exosphere: Exo means external. Therefore, exosphere the external or the outer most layer of the atmosphere. Its lower boundary starts from the thermopause (650 km) to the limit from where the void space begins. This limit is estimated to be about 10000 km. This much distance is little less than the diameter of the earth. It is really a very big size of the limit of the atmosphere. In exosphere, very light gases are traced and they are hydrogen and helium.

Their molecules are spaced very widely. Beyond the upper limit of exosphere, the space is considered to be void.

Composition of the Atmosphere

The envelope of atmosphere around the earth, a mechanical mixtures of numerous gases and other substances are very important to all living organisms of the planet. The four major gases – nitrogen, oxygen, argon and carbon dioxide together constitute 99.99% of the total volume of dry air. The maximum concentration is of nitrogen with more than 78 percent while the oxygen is little less than 21 percent.

Table 1: Composition of atmospheric Gases

Groups	Gases	Volume % of dry air
Major Gases	1. Nitrogen	78.084
	2. Oxygen	20.9476
	3. Argon	0.934
	4. *CO_2	0.04
Minor Gases (***** are also variable gases)	5. *Methane	0.002
	6. Neon	0.001818
	7. Helium	0.000524
	8. Krypton	0.000114
	9. Hydrogen	0.00005
	10. Xenon	0.0000087
	11. *Ozone	0.00006
Variable Gasses (CO2, methane and ozone gases are also variable)	12. Water vapour	Variable amount
	13. Dust particles	Variable amount
	14. Aerosols	Variable amount

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