1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 01 (Class XI, Semester - 1)
Module Name/Title	Composition and structure of atmosphere – Part 1
Module Id	kegy_10801
Pre-requisites	Basic knowledge about the Atmospher
Objectives	After reading this lesson, learners will be able to know about: • Explain the composition of the atmosphere and the role and importance of the various constituents. • Describe layered structure of the atmosphere and the importance of each layer.
Keywords	Greenhouse Gases, Troposphere, Stratosphere, Mesosphere, Thermosphere, Ionosphere, Exosphere.

2. Development Team

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Can a person live without air? We need to eat food two - three times a day and drink water more frequently but we breathe every few seconds. Air is essential for the survival of all organisms. An organism may survive for some time without food and water but can’t survive even a few minutes without air. This shows us the importance of air and tells us why we should understand the atmosphere in greater detail. The atmosphere is a mixture of different gases and some solid and liquid particles surrounding the earth and retained by its grairty. It has an important role in maintain global temperature and shields the earth from harmful radiation. The atmosphere becomes thinner with increasing altitude and finally merges into outer space. There is no definite boundary between the atmosphere and outer space although the Karman line, at 100km from the surface may be said to mark. The outer limit of the earth’s effective atmosphere. Atmospheric effects become noticeable during atmospheric re-entry of spacecraft at an altitude of around 120km. The atmosphere is easily compressible and most of their masses in concentrated within 32km of the atmosphere are colourless and odourless, the presence of air is felt only when wind blows.

Fig No.01 Blue light is scattered more than other wavelengths by the gases in the atmosphere, giving Earth a blue halo when seen from space on-board

Sources:

https://en.wikipedia.org/wiki/Atmosphere_of_Earth#/media/File:Top_of_Atmosphere.jpg

COMPOSITION OF THE ATMOSPHERE

The early Greeks considered "air" to be one of four elementary substances along with earth, fire, and water. By the early 1800s however, scientists such as John Dalton recognized that the atmosphere was in fact composed of several chemically distinct gases in the lower atmosphere. They were able to separate and determine the relative amounts of these gases in the lower atmosphere. They were easily able to identifies nitrogen, oxygen, and a small amount of something incombustible, later shown to be argon.The development of the spectrometer in the 1920s allowed scientists to find gases that existed in much smaller concentrations in the atmosphere, such as ozone and carbon dioxide. The concentrations of these gases, while small, varied widely from place to place. Table shows the concentration of various gases in the atmosphere, particularly in the lower atmosphere. The permanent gases whose percentages do not change from day to day are nitrogen, oxygen and argon. Nitrogen accounts for 78% of the atmosphere, oxygen 21% and argon 0.9%. Gases like carbon dioxide, nitrous oxides, methane, and ozone are trace gases that account for about a tenth of one per cent of the atmosphere. The proportion of gases changes with height in such a way that oxygen is almost negligible beyond 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. The atmosphere is concentrated at the earth's surface and rapidly thins as you move upward, blending with space at roughly 100 miles above sea level.

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

Permanent gases of the atmosphere

When we compare our atmosphere with that of Venus, mars and an older earth, we find a major difference in the presence of carbon dioxide. Carbon dioxide is the dominant gas in mars, Venus and the older earth while the atmosphere of present day earth is dominated by nitrogen and oxygen while CO2 makes up less than 0.04% of its volume**.**

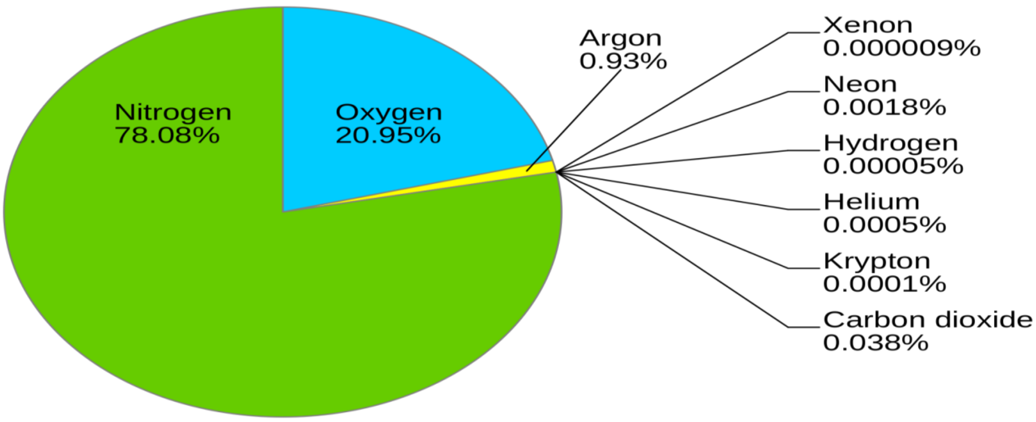

Fig: 02 Composition of Atmosphere

Source

https://upload.wikimedia.org/wikipedia/commons/thumb/c/c9/Atmosphere3.svg/2000px-

Atmosphere3.svg.png

Although both nitrogen and oxygen are essential for all life on the planet, they have little effect on weather and other atmospheric processes. The variable components, which make up far less than 1 per cent of the atmosphere, have a much greater influence on both short-term weather and long-term climate. These include greenhouse gases ozone water vapour and particulate matter. Their Presence varies from place to place and from time to time.

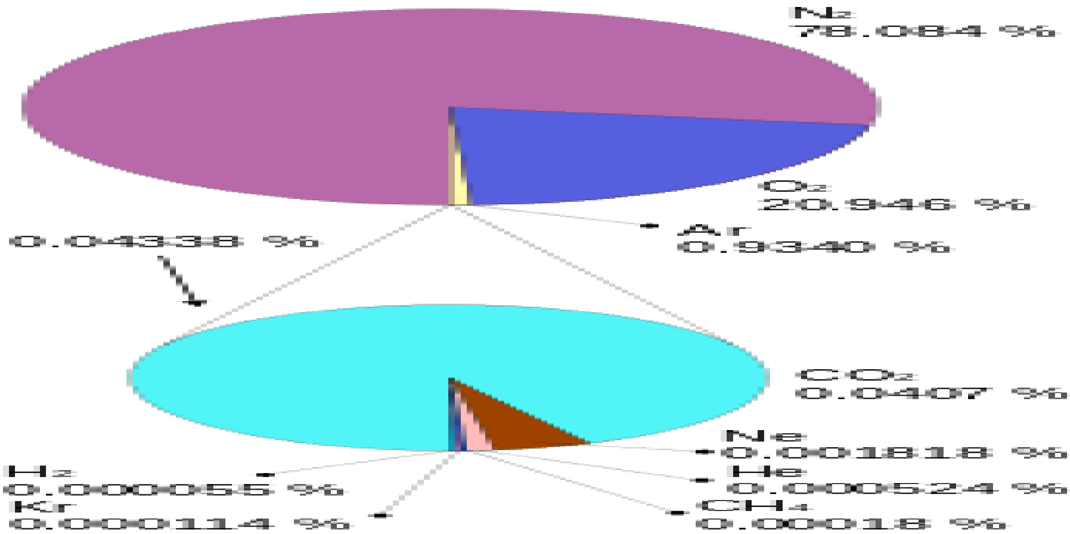

Fig. No. 03 Composition of Earth's atmosphere by volume.

Source https://en.wikipedia.org/wiki/Atmosphere_of_Earth#/media/File:Atmosphere_gas_proportions.svg

Greenhouse Gases

A group of diverse gases, commonly referred to as greenhouse gases, have physical and chemical properties which make them interact with incoming and outgoing energy. They allow almost all the short wave radiation from the sun to reach the earth's surface. However, terrestrial radiation (the energy radiated from the earth), which has a longer wavelength, is easily absorbed by them and therefore retained in the earth's atmosphere. This causes global temperature to rise, and triggers off a number of other changes that pose a serious threat to humanity today. This is why scientists are carefully monitoring the change in the presence of these gases. Carbon dioxide, carbon monoxide, methane, nitrous oxides and water vapour are some prominent greenhouse gases. We must remember, however, that the greenhouse effect is not entirely a bad thing. The presence of greenhouse gases is small amounts makes the earth warmer and therefore more liveable, than it would have been without them. The rapid increase in their amount that has been witnessed in the last few decades is what is causing alarm bells to ring.

Ozone triatomic oxygen is another important component of the atmosphere found between 10 and 50 km above the earth's surface. It acts as a filter that absorbs the *ultra-violet rays* radiating from the sun and prevents them from reaching the surface of the earth. Chlorofluorocarbons (CFCs) and other substances released by us into the atmosphere have damaged this layer of ozone, especially in polar areas.

Water Vapour

Water vapour is another variable gas, which decreases with altitude. In the warm and wet tropics, it may account for four per cent of the air by volume, while in dry and cold areas in deserts and near the poles, it may be almost absent. Water vapour also decreases from the equator towards the poles. It absorbs scatters and reflects part of the insolation from the sun and also preserves the earth's radiated heat. It thus, acts like a blanket allowing the earth neither to become too cold nor too hot.

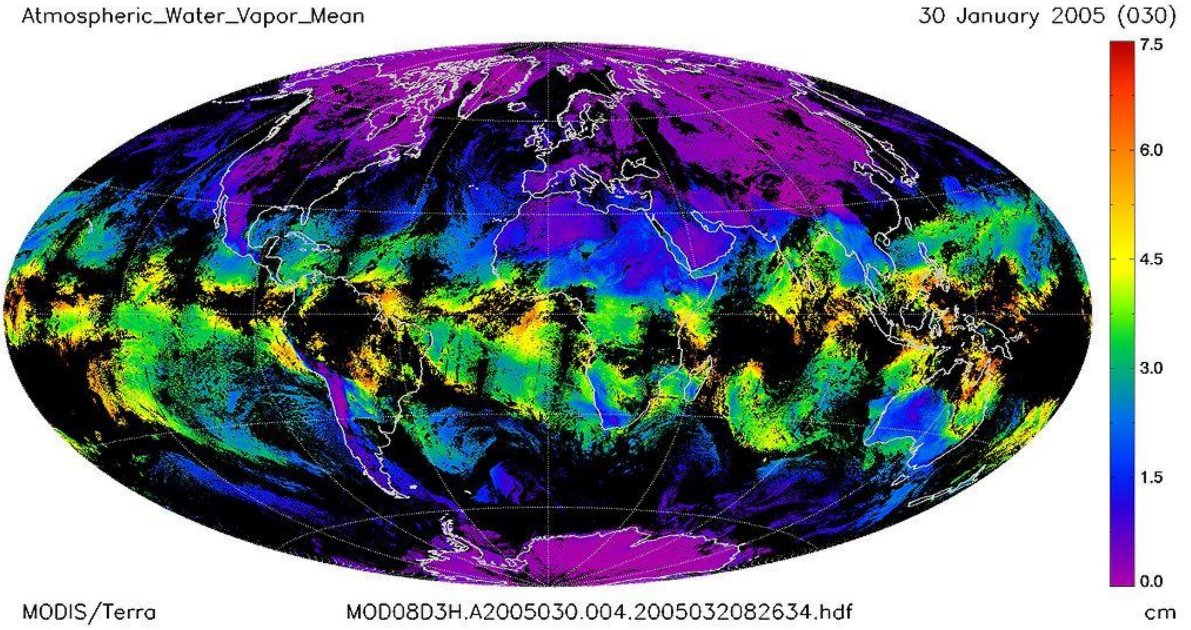

Fig. No 04 Mean atmospheric water vapor

https://en.wikipedia.org/wiki/Atmosphere_of_Earth#/media/File:Atmospheric_Water_Vapor_Mean.2005.030.jpg

Water vapours also affect the stability and instability of air and play an important role in the redistribution of energy and moisture across the globe.

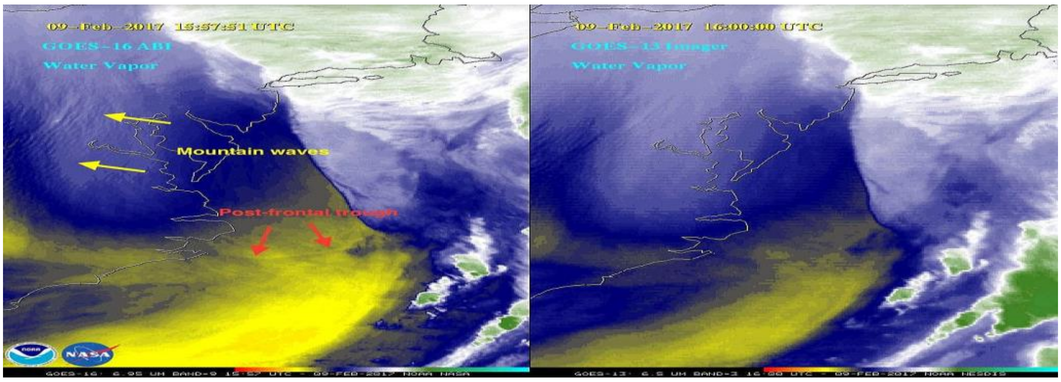

Fig: 05 Water vapour in winter storm

Source: https://c1.staticflickr.com/3/2648/32842301846_bcc7c1673a_b.jpg

Dust Particles

Atmosphere has the capacity to keep small solid particles in suspension. These particles include sea salts, fine soil, smoke; soot, ash, pollen, and meteoric dust. Particulate matter is generally concentrated in the lower layers of the atmosphere, though; convectional air currents may transport it to great heights. The higher concentration of dust particles is found in subtropical and temperate regions in comparison to the more humid equatorial and Polar Regions. Dust and salt particles act as hygroscopic nuclei around which water vapour condenses to produce clouds. They can significantly affect risibility and constitute an important category of atmosphere pollutants.

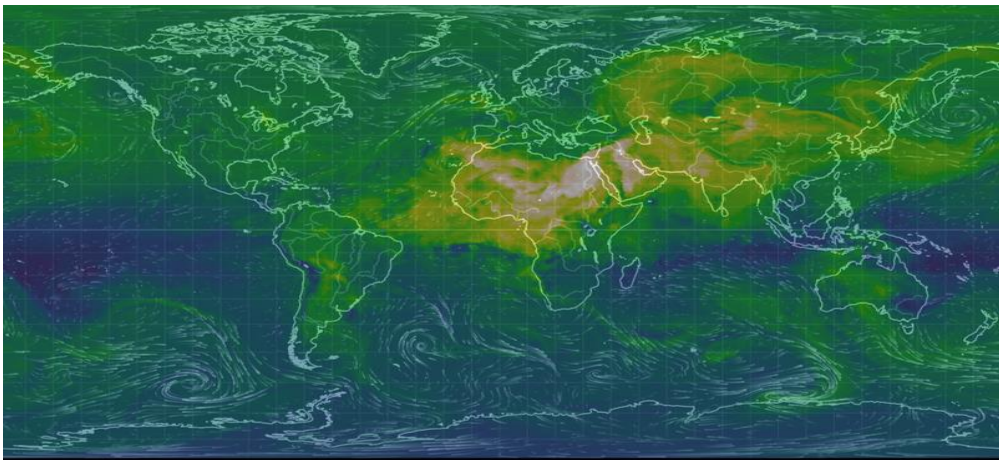

Fig**:** 05 Dust particles in the world

Source: ttps://commons.wikimedia.org/wiki/File:Dust2017.png

Structure of the Atmosphere

The atmosphere has a layered structure and these layers are identified on the basis of characteristics such as temperature and composition. The study of Earth's atmosphere and its processes is called atmospheric science (aerology).Generally speaking, air pressure and density decrease with altitude in the atmosphere. However, temperature has a more complicated profile, and may remain relatively constant or even increase with altitude in some parts. As the general pattern of the temperature/altitude profile is constant and measurable by means of instrumented balloons, temperature behaviour provides a useful metric to distinguish atmospheric layers. In this way, the earth's atmosphere can be divided (called atmospheric stratification) into five main layers. Excluding the Exosphere, there are four primary layers, which are the troposphere, stratosphere, mesosphere, and thermosphere. From lowest to highest, the five main layers are:

1. Troposphere: 0 to 12 km (0 to 7 miles)
2. Stratosphere: 12 to 50 km (7 to 31 miles)
3. Mesosphere: 50 to 80 km (31 to 50 miles)
4. Thermosphere: 80 to 500 km (50 to300 miles)
5. Exosphere: 400 to 10,000 km (300 to 6,200 miles)

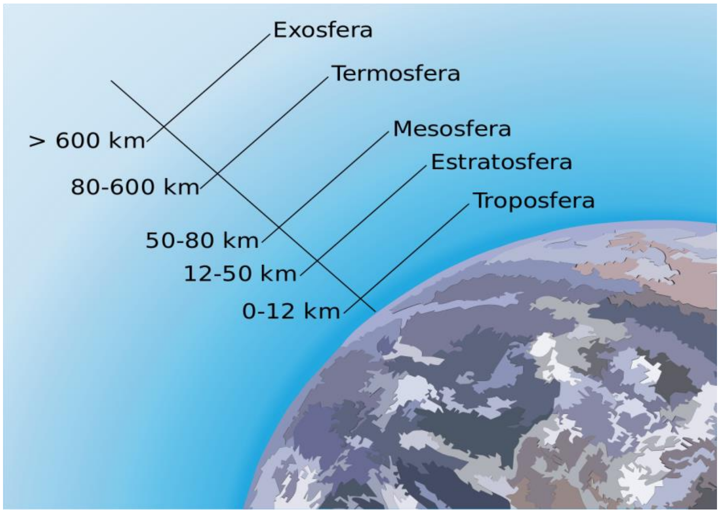

Fig : 06 Different Layers of Atmosphere.

Source https://upload.wikimedia.org/wikipedia/commons/thumb/9/93/Atmosphere_structure-es.svg/1263px-Atmosphere_structure-es.svg.png

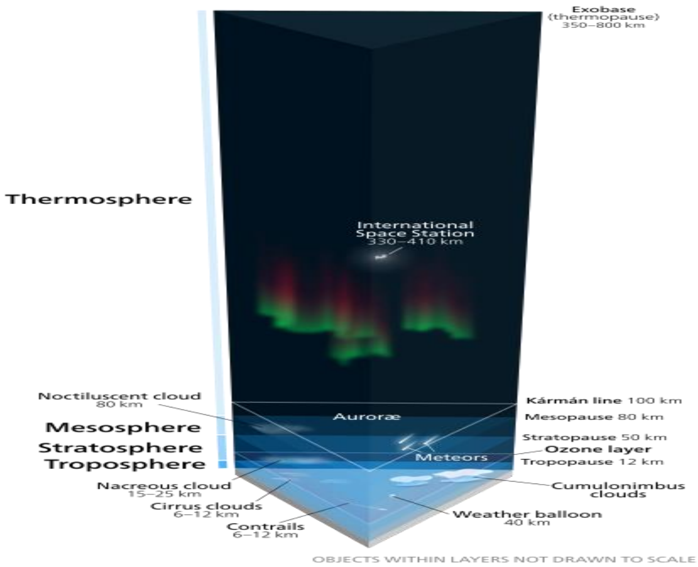

Fig : 07 Earth's atmosphere Lower 4 layers of the atmosphere in 3 dimensions as seen diagonally from above the exobase.

https://en.wikipedia.org/wiki/Atmosphere_of_Earth#/media/File:Earth%27s_atmosphere.svg

Troposphere

The troposphere is the lowest layer of earth's atmosphere. It extends from the surface to an average height of about 12 km, although this altitude actually varies from about 9 km at the poles to 17 km at the equator with some variation due to weather. Thickness of the troposphere is greatest at the equator because heat is transported to great heights by strong convectional currents.The temperature in this layer decreases at the rate of 1°C for every 165m of height.

The lowest part of the troposphere is typically the warmest section of the troposphere. This promotes vertical mixing. The troposphere contains roughly 80% of the mass of earth's atmosphere. The troposphere is denser than all its overlying atmospheric layers because a larger atmospheric weight sits on top of the troposphere and causes it to be most severely compressed. Fifty per cent of the total mass of the atmosphere is located in the lower 5.6 km of This layer contains dust particles and water vapour. All changes in climate and weather take place in this layer. Nearly all atmospheric water vapour or moisture is found in the troposphere, so it is the layer where most of Earth's weather takes place. This is the most important layer for all biological activity.

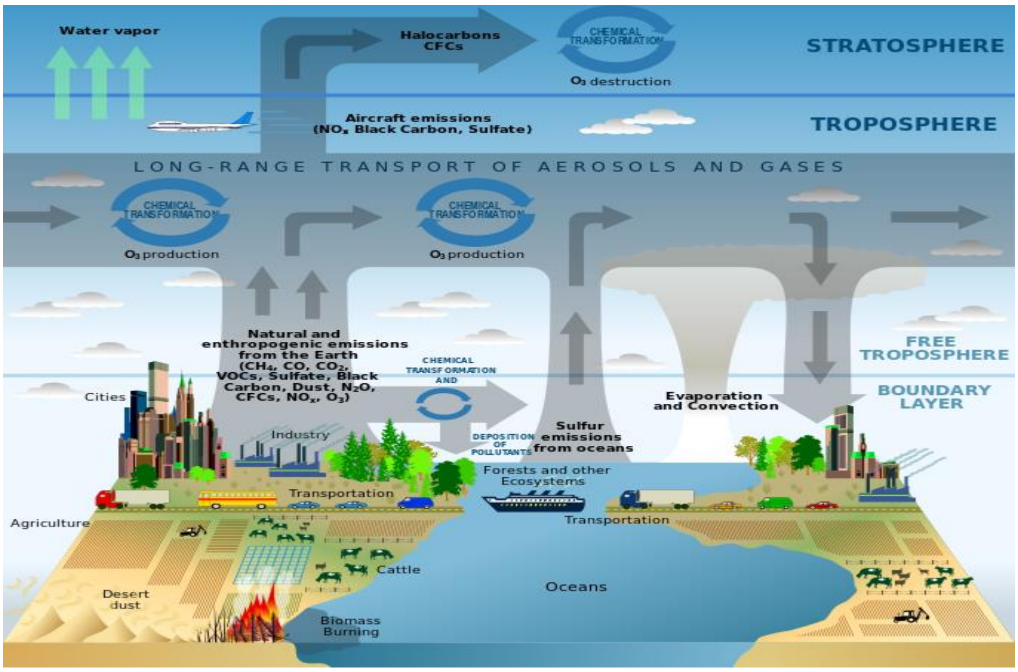

Fig. No 08 Evolution/cycles of various elements in earth's atmosphere

https://commons.wikimedia.org/wiki/File:Atmosphere_composition_diagram-en

Temperature decreases with height in the troposphere. Temperature at the tropopause is about-80 degree Celsius over the equator and – 45 degree Celsius at the poles.

Stratosphere

The stratosphere is the second-lowest layer
of earth’s atmosphere. It lies above the troposphere and is separated from it by the tropopause. This layer extends from the top of the troposphere at roughly 12 km above Earth's surface to the stratopause at an altitude of about 50 to 55 km .The atmospheric pressure at the top of the stratosphere is roughly 1/1000 the pressure at sea level. It contains the ozone layer, which is the part of earth's atmosphere that contains relatively high concentrations of that gas. The stratosphere defines a layer in which temperatures rises with increasing altitude. This rise in temperature is caused by the absorption of ultraviolet radiation (UV) radiation from the sun by the ozone layer. Although the temperature may be −60 °C (−76 °F; 210 K) at the tropopause, the top of the stratosphere is much warmer, and may be near 0°C. The stratosphere is almost completely free of clouds and other forms of weather. However, polar stratospheric or nacreous clouds are occasionally seen in the lower part of this layer.

Mesosphere

The mesosphere is the third layer of earth's atmosphere, occupying the region above the stratosphere and below the thermosphere. It extends from the stratopause at an altitude of about 50 km to the mesopause at 80–85 km above sea level. Temperatures drop with increasing altitude up to the mesopause that marks the top of this middle layer of the atmosphere. It is the coldest place on earth and has an average temperature around −85 degrees centigrade. Just below the mesopause, the air is so cold that even the very scarce water vapour at this altitude can be sublimated into polar-mesospheric noctilucent clouds. The mesosphere is also the layer where most meteors burn up upon atmospheric entrance.

Thermosphere

Thermosphere is the second-highest layer of earth's atmosphere. It means “ heat sphere”. It extends from the mesopause (which separates it from the mesosphere) at an altitude of about 80 km up to the thermo pause at an altitude range of 500–1000 km. The height of the thermo pause varies considerably due to changes in solar activity. Because the thermopause lies at the lower boundary of the exosphere, it is also referred to as the exobase. The lower part of the thermosphere, from 80 to 550 kilometres (50 to 342 mi) above earth's surface, contains the ionosphere, a layer containing many ions that helps in radio communication.The temperature of the thermosphere gradually increases with height. The temperature of this layer can be as high as 1500 °C or more, though the gas molecules are so far apart that its temperature in the usual sense is not very meaningful. It would not feel hot to a human in direct contact, because its density is too low to conduct a significant amount of energy to or from the skin. This layer is completely cloudless and free of water vapours. However aurora borealis and aurora australisare occasionally seen in the thermosphere. The aurorae are displays of light visible close to the magnetic poles. The International space station orbits in this layer, between 350 and 420 km.

Fig No 09 Polarlicht

Source: https://upload.wikimedia.org/wikipedia/commons/a/aa/Polarlicht_2.jpg

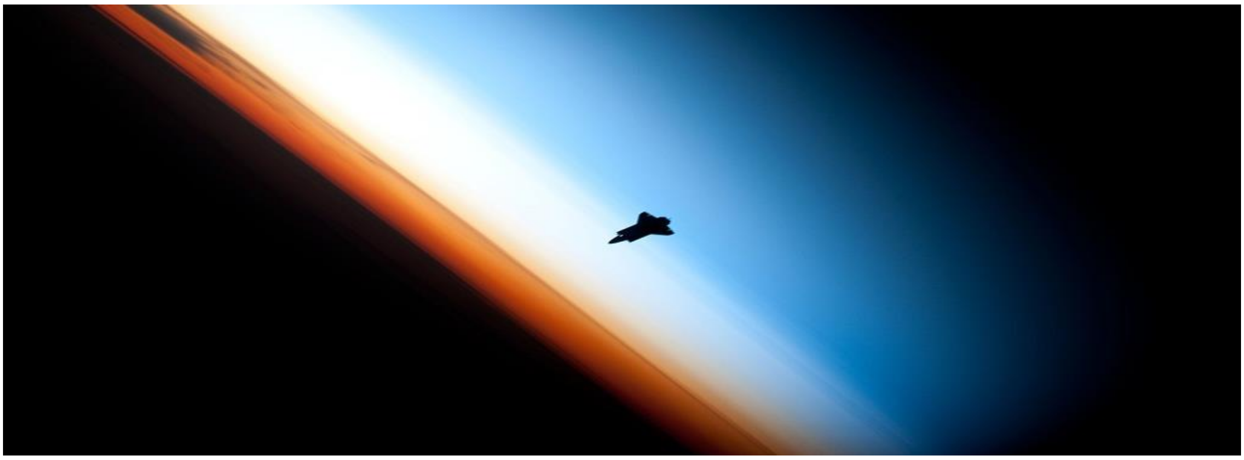

Fig No 10 Space Shuttle *Endeavour* orbiting in the thermosphere.

Source;https://en.wikipedia.org/wiki/Atmosphere_of_Earth#/media/File:Endeavour_silhouette_STS-130.jpg

Exosphere

The exosphere is the outermost layer of earth's atmosphere (i.e. the upper limit of the atmosphere). It extends from the exobase, which is located at the top of the thermosphere at an altitude of about 700 km above sea level, to about 10,000 km (6,200 mi; 33,000,000 ft) where it merges into the solar wind. This layer is mainly composed of extremely low densities of hydrogen, helium and several heavier molecules including nitrogen, oxygen and carbon dioxide closer to the exobase.

Other layers

Within the five principal layers that are largely determined by temperature, several secondary layers may be distinguished by other properties. The homosphere and heterosphere are defined on the basis of composition. The surface-based homosphere 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 about 100 km. Above this altitude lies the heterosphere, which includes the exosphere and most of the thermosphere. Here, the chemical composition varies with altitude as there is no turbulent mixing. Here the gases are stratified stratify by molecular weight, with the heavier ones, such as oxygen and nitrogen, present only near the bottom of the heterosphere. The upper part of the heterosphere is composed almost completely of hydrogen, the lightest element. The different constituents that make up the atmosphere as well as the different layers found within it have properties that make life possible on earth. Various other elements and atmospheric processes are equally vital in supporting life.

Elements of Weather and Climate

The main elements of atmosphere which are subject to change and which influence human life on earth are temperature, pressure, winds, humidity, clouds and precipitation. Temperature is a very important factor in determining the weather because it influences or controls other elements of the weather. Humidity is the amount of water vapor in the atmosphere.Precipitation is the product of a rapid condensation process (if this process is slow, it only causes cloudy skies). It may include snow, hail, sleet, drizzle and rain.Atmospheric pressure (or air pressure) is the weight of air resting on the earth's surface. Wind is the movements of air masses, especially on the Earth’s surface.

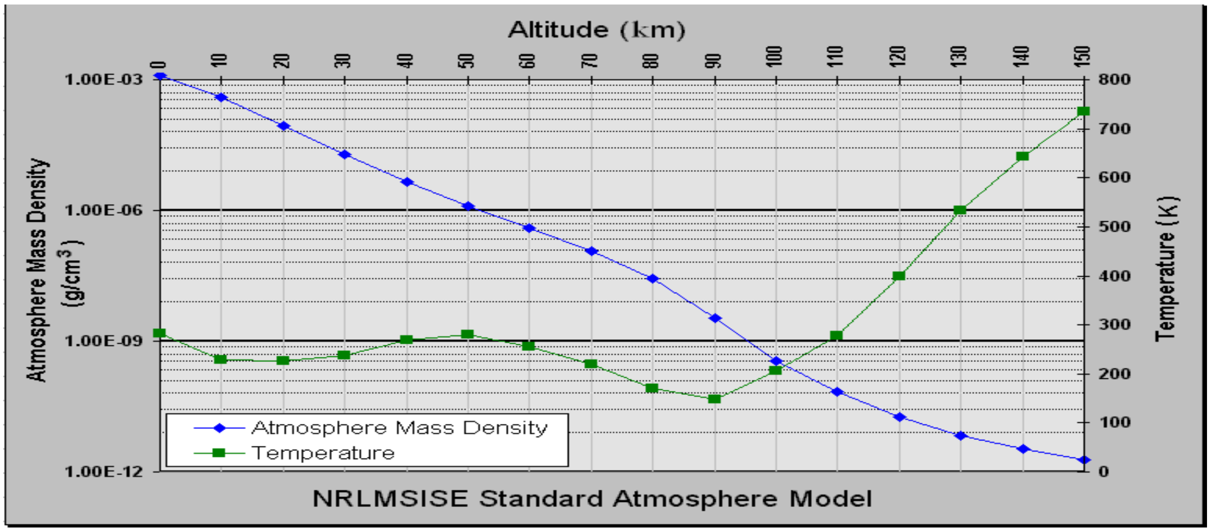

Fig No 11. Temperature and mass density against altitude from the NRLMSISE-00 standard atmosphere model (the eight dotted lines in each "decade" are at the eight cubes 8, 27, 64, ..., 729)

Source:

https://en.wikipedia.org/wiki/Atmosphere_of_Earth#/media/File:Atmosphere_model.png