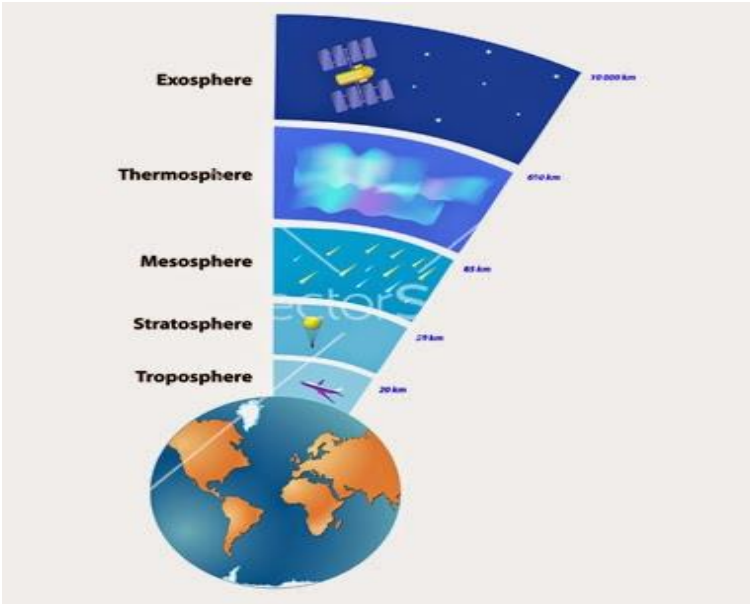
SNS COLLEGE OF TECHNOLOGY

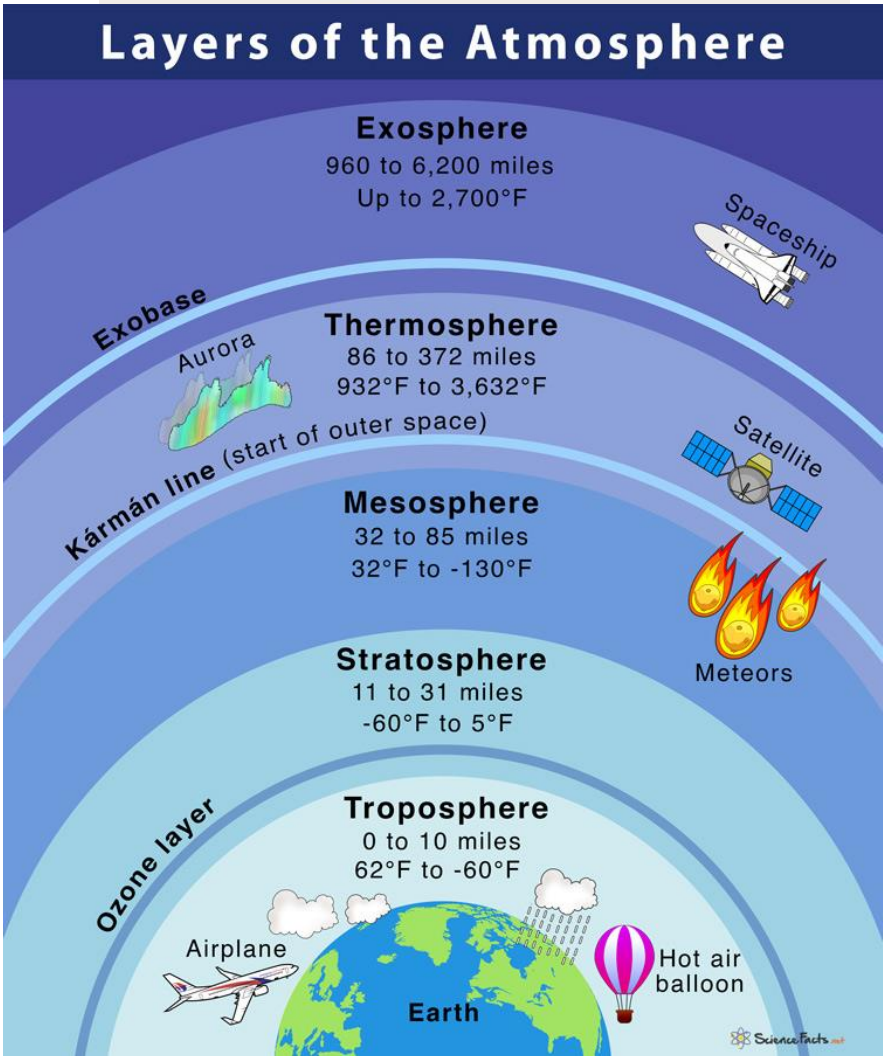
(An Autonomous Institution)

COIMBATORE-35

DEPARTMENT OF AEROSPACE ENGINEERING

Unit – 5 Study of Earth Atmosphere





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We live at the bottom of an invisible ocean called the atmosphere, a layer of gases surrounding our planet. Nitrogen and oxygen account for 99 percent of the gases in dry air, with argon, carbon dioxide, helium, neon, and other gases making up minute portions. Water vapor and dust are also part of Earth's atmosphere. Other planets and moons have very different atmospheres, and some have no atmospheres at all.

The atmosphere is so spread out that we barely notice it, yet its weight is equal to a layer of water more than 10 meters (34 feet) deep covering the entire planet. The bottom 30 kilometers (19 miles) of the atmosphere contains about 98 percent of its mass. The atmosphere—air—is much thinner at high altitudes. There is no atmosphere in space.

Scientists say many of the gases in our atmosphere were ejected into the air by early volcanoes. At that time, there would have been little or no free oxygen surrounding Earth. Free oxygen consists of oxygen molecules not attached to another element, like carbon (to form carbon dioxide) or hydrogen (to form water).

Free oxygen may have been added to the atmosphere by primitive organisms, probably bacteria, during photosynthesis. Photosynthesis is the process a plant or other autotroph uses to make food and oxygen from carbon dioxide and water. Later, more complex forms of plant life added more oxygen to the atmosphere. The oxygen in today's atmosphere probably took millions of years to accumulate.

The atmosphere acts as a gigantic filter, keeping out most ultraviolet radiation while letting in the sun's warming rays. Ultraviolet radiation is harmful to living things, and is what causes sunburns. Solar heat, on the other hand, is necessary for all life on Earth.

Earth's atmosphere has a layered structure. From the ground toward the sky, the layers are the troposphere, stratosphere, mesosphere, thermosphere, and exosphere. Another layer, called the ionosphere, extends from the mesosphere to the exosphere. Beyond the exosphere is outer space. The boundaries between atmospheric layers are not clearly defined, and change depending on latitude and season.

Troposphere

The troposphere is the lowest atmospheric layer. On average, the troposphere extends from the ground to about 10 kilometers (six miles) high, ranging from about 6 kilometers (four miles) at the poles to more than 16 kilometers (10 miles) at the Equator. The top of the troposphere is higher in summer than in winter.

Almost all weather develops in the troposphere because it contains almost all of the atmosphere’s water vapor. Clouds, from low-lying fog to thunderheads to high-altitude cirrus, form in the troposphere. Air masses, areas of high-pressure and low-pressure systems, are moved by winds in the troposphere. These weather systems lead to daily weather changes as well as seasonal weather patterns and climate systems, such as El Niño.

Air in the troposphere thins as altitude increases. There are fewer molecules of oxygen at the top of Mount Everest, Nepal, for example, than there are on a beach in Hawai'i. This is why mountaineers often use canisters of oxygen when climbing tall peaks. Thin air is also why helicopters have difficulty maneuvering at high altitudes. In fact, a helicopter was not able to land on Mount Everest until 2005.

As air in the troposphere thins, temperature decreases. This is why mountaintops are usually much colder than the valleys beneath. Scientists used to think temperature continued to drop as altitude increased beyond the troposphere. But data collected with weather balloons and rockets have showed this is not the case. In the lower stratosphere, temperature stays almost constant. As altitude increases in the stratosphere, temperature actually increases.

Solar heat penetrates the troposphere easily. This layer also absorbs heat that is reflected back from the ground in a process called the greenhouse effect. The greenhouse effect is necessary for life on Earth. The atmosphere’s most abundant greenhouse gases are carbon dioxide, water vapor, and methane.

Fast-moving, high-altitude winds called jet streams swirl around the planet near the upper boundary of the troposphere. Jet streams are extremely important to the airline industry. Aircraft save time and money by flying in jet streams instead of the lower troposphere, where air is thicker.

Stratosphere
The troposphere tends to change suddenly and violently, but the stratosphere is calm. The stratosphere extends from the tropopause, the upper boundary of the troposphere, to about 50 kilometers (32 miles) above Earth’s surface.

Strong horizontal winds blow in the stratosphere, but there is little turbulence. This is ideal for planes that can fly in this part of the atmosphere.

The stratosphere is very dry and clouds are rare. Those that do form are thin and wispy. They are called nacreous clouds. Sometimes they are called mother-of-pearl clouds because their colors look like those inside a mollusk shell.

The stratosphere is crucial to life on Earth because it contains small amounts of ozone, a form of oxygen that prevents harmful UV rays from reaching Earth. The region within the stratosphere where this thin shell of ozone is found is called the ozone layer. The stratosphere's ozone layer is uneven, and thinner near the poles. The amount of ozone in the Earth's atmosphere is declining steadily. Scientists have linked use of chemicals such as chlorofluorocarbons (CFCs) to ozone depletion.

Mesosphere

The mesosphere extends from the stratopause (the upper boundary of the stratosphere) to about 85 kilometers (53 miles) above the surface of the Earth. Here, temperatures again begin to fall.

The mesosphere has the coldest temperatures in the atmosphere, dipping as low as -120 degrees Celsius (-184 degrees Fahrenheit or 153 kelvin). The mesosphere also has the atmosphere's highest clouds. In clear weather, you can sometimes see them as silvery wisps immediately after sunset. They are called noctilucent clouds, or night-shining clouds. The mesosphere is so cold that noctilucent clouds are actually frozen water vapor—ice clouds.

Shooting stars—the fiery burnout of meteors, dust, and rocks from outer space—are visible in the mesosphere. Most shooting stars are the size of a grain of sand and burn up before entering the stratosphere or troposphere. However, some meteors are the size of pebbles or even boulders. Their outer layers burn as they race through the mesosphere, but they are massive enough to fall through the lower atmosphere and crash to Earth as meteorites.

The mesosphere is the least-understood part of Earth's atmosphere. It is too high for aircraft or weather balloons to operate, but too low for spacecraft. Sounding rockets have provided meteorologists and astronomers their only significant data on this important part of the atmosphere. Sounding rockets are unmanned research instruments that collect data during suborbital flights.

Perhaps because the mesosphere is so little understood, it is home to two meteorological mysteries: sprites and elves. Sprites are reddish, vertical electrical discharges that appear high above thunderheads, in the upper stratosphere and mesosphere. Elves are dim, halo-shaped discharges that appear even higher in the mesosphere.

Ionosphere

The ionosphere extends from the top half of the mesosphere all the way to the exosphere. This atmospheric layer conducts electricity.

The ionosphere is named for ions created by energetic particles from sunlight and outer space. Ions are atoms in which the number of electrons does not equal the number of protons, giving the atom a positive (fewer electrons than protons) or negative (more electrons than protons) charge. Ions are created as powerful x-rays and UV rays knock electrons off atoms.

The ionosphere—a layer of free electrons and ions—reflects radio waves. Guglielmo Marconi, the "Father of Wireless," helped prove this in 1901 when he sent a radio signal from Cornwall, England, to St. John's, Newfoundland, Canada. Marconi's experiment demonstrated that radio signals did not travel in a straight line, but bounced off an atmospheric layer—the ionosphere.

The ionosphere is broken into distinct layers, called the D, E, F1, and F2 layers. Like all other parts of the atmosphere, these layers vary with season and latitude. Changes in the ionosphere actually happen on a daily basis. The low D layer, which absorbs high-frequency radio waves, and the E layer actually disappear at night, which means radio waves can reach higher into the ionosphere. That's why AM radio stations can extend their range by hundreds of kilometers every night.

The ionosphere also reflects particles from solar wind, the stream of highly charged particles ejected by the sun. These electrical displays create auroras (light displays) called the Northern and Southern Lights.

Thermosphere

The thermosphere is the thickest layer in the atmosphere. Only the lightest gases—mostly oxygen, helium, and hydrogen—are found here.

The thermosphere extends from the mesopause (the upper boundary of the mesosphere) to 690 kilometers (429 miles) above the surface of the Earth. Here, thinly scattered molecules of gas absorb x-rays and ultraviolet radiation. This absorption process propels the molecules in the thermosphere to great speeds and high temperatures. Temperatures in the thermosphere can rise to 1,500 degrees Celsius (2,732 degrees Fahrenheit or 1,773 kelvin).

Though the temperature is very high, there is not much heat. How is that possible? Heat is created when molecules get excited and transfer energy from one molecule to another. Heat happens in an area of high pressure (think of water boiling in a pot). Since there is very little pressure in the thermosphere, there is little heat transfer.

The Hubble Space Telescope and the International Space Station (ISS) orbit Earth in the thermosphere. Even though the thermosphere is the second-highest layer of

Earth's atmosphere, satellites that operate here are in "low-Earth orbit."

Exosphere

The fluctuating area between the thermosphere and the exosphere is called the turbopause. The lowest level of the exosphere is called the exobase. At the upper boundary of the exosphere, the ionosphere merges with interplanetary space, or the space between planets.

The exosphere expands and contracts as it comes into contact with solar storms. In solar storms particles are flung through space from explosive events on the sun, such as solar flares and coronal mass ejections (CMEs).

Solar storms can squeeze the exosphere to just 1,000 kilometers (620 miles) above the Earth. When the sun is calm, the exosphere can extend 10,000 kilometers (6,214 miles).

Hydrogen, the lightest element in the universe, dominates the thin atmosphere of the exosphere. Only trace amounts of helium, carbon dioxide, oxygen, and other gases are present.

Many weather satellites orbit Earth in the exosphere. The lower part of the exosphere includes low-Earth orbit, while medium-Earth orbit is higher in the atmosphere.

The upper boundary of the exosphere is visible in satellite images of Earth. Called the geocorona, it is the fuzzy blue illumination that circles the Earth.

Extraterrestrial Atmospheres

All the planets in our solar system have atmospheres. Most of these atmospheres are radically different from Earth's, although they contain many of the same elements.

The solar system has two major types of planets: terrestrial planets (Mercury, Venus, Earth, and Mars) and gas giants (Jupiter, Saturn, Uranus, and Neptune).

The atmospheres of the terrestrial planets are somewhat similar to Earth's. Mercury's atmosphere contains only a thin exosphere dominated by hydrogen, helium, and oxygen. Venus' atmosphere is much thicker than Earth's, preventing a clear view of the planet. Its atmosphere is dominated by carbon dioxide, and features swirling clouds of sulfuric acid. The atmosphere on Mars is also dominated by carbon dioxide, although unlike Venus, it is quite thin.

Gas giants are composed of gases. Their atmospheres are almost entirely hydrogen and helium. The presence of methane in the atmospheres of Uranus and Neptune give the planets their bright blue color.

In the lower atmospheres of Jupiter and Saturn, clouds of water, ammonia, and hydrogen sulfide form clear bands. Fast winds separate light-colored bands, called zones, from dark-colored bands, called belts. Other weather phenomena, such as cyclones and lightning, create patterns in the zones and belts. Jupiter’s Great Red Spot is a centuries-old cyclone that is the largest storm in the solar system.

The moons of some planets have their own atmospheres. Saturn’s largest moon, Titan, has a thick atmosphere made mostly of nitrogen and methane. The way sunlight breaks up methane in Titan’s ionosphere helps give the moon an orange color.

Most celestial bodies, including all the asteroids in the asteroid belt and our own moon, do not have atmospheres. The lack of an atmosphere on the Moon means it does not experience weather. With no wind or water to erode them, many craters on the Moon have been there for hundreds and even thousands of years.

The way a celestial body’s atmosphere is structured and what it’s made of allow astrobiologists to speculate what kind of life the planet or moon may be able to support. Atmospheres, then, are important markers in space exploration.

A planet or moon’s atmosphere must contain specific chemicals to support life as we know it. These chemicals include hydrogen, oxygen, nitrogen, and carbon. Although Venus, Mars, and Titan have similar atmospheric gases, there is nowhere in the solar system besides Earth with an atmosphere able to support life. Venus’ atmosphere is far too thick, Mars’ far too thin, and Titan’s far too cold.