GENERAL STUDIES

PHYSICAL GEOGRAPHY

For

UPSC/KPSC-CIVIL SERVICES

SAHARA

#1710, 2nd Floor, Service Road, Behind Maruthi Mandira, Vijayanagara, Bangalore-560040.

Mob: 8123482818

e-mail:info.saharaias@gmail.com

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Mob:8123482818,

e-mail:info.saharaias@gmail.com

ATMOSPHERE

What is Atmosphere?

- The **atmosphere is a thick layer of gases** that surrounds the Earth and is attached to the earth's surface by **gravitational forces.** Atmosphere is important component of biospheric ecosystem which makes life on the earth possible.

Importance of Atmosphere

- Life on the earth is possible only due to the atmosphere.
- It contains life-giving gases like **oxygen** for humans and animals and **carbon dioxide** for plants.
- It protects us from **electromagnetic radiations** emitted by the Sun**.**
- Gases which are currently in atmosphere are not because of the earliest activities of the planet, rather they are **evolutionary in nature** i.e. their compositions is still changing.
- Like land (lithosphere) and water (hydrosphere), the atmosphere is an integral part of the earth.

Composition of permanent Gases of the Atmosphere

Constituent	Formula	Percentage by Volume
Nitrogen	N2	78.08
Oxygen	O2	20.95
Argon	Ar	0.93
Carbon dioxide	CO2	0.036
Neon	Ne	0.002
Helium	He	0.0005

Characteristics of Atmosphere:

- The atmosphere is composed of **various gases, water vapour and dust particles**.
- 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.
- The composition of gases changes in the higher layer of atmosphere in such a way that at the height of 120 km oxygen is almost negligible.
- Water vapor can be found only up to 90 km.

- Oxygen will be almost negligible 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.

Different constituents of the atmosphere, with their individual characteristics, are discussed below:-

Gases	Source	Role
Nitrogen	Degassing, Weathering of Igneous rocks, Nitrogen Cycle.	Presence of Nitrogen **controls reactive nature of Oxygen**. Due to abundance of Nitrogen, the combustible effect of Oxygen is subdued.
Oxygen	Photosynthesis by green plants.	Combustion/Oxidation
Carbon Dioxide	Respiration, Degassing, Burning of fuels.	Photosynthesis Absorbs heat radiations (greenhouse effect).
Water Vapours	Degassing. Hydrological Cycle.	Weather phenomenas. Greenhouse Gases.
Ozone	Ozone Cycle.	Absorbs UV rays. Increase in the Ozone layer temperature.
Dust Particles	Volcanic eruption, Industries. Cosmic Dust.	Nuclei for the process of **Condensation.** Reflecting and Scattering of Sunlight.

Structure of Atmosphere

The atmosphere is divided into different layer because of **Difference in density and temperature.** Density is highest near the earth surface and decreases with increase in height.

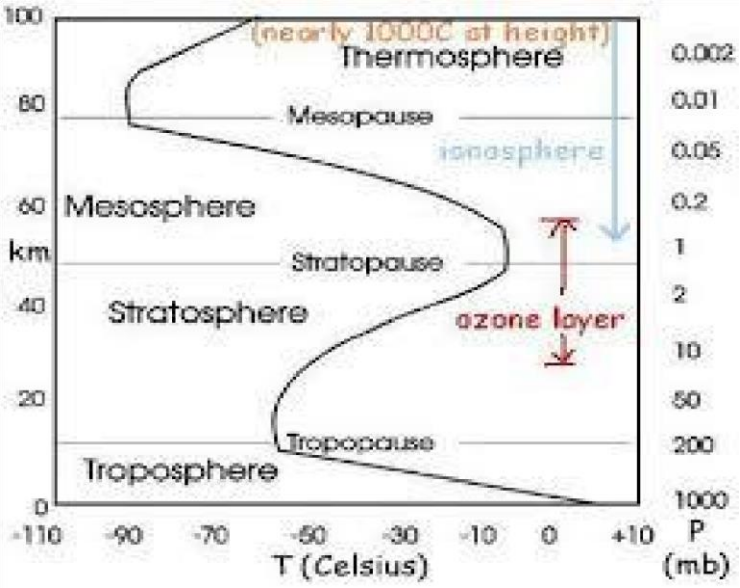

Fig: Structure of Atmosphere

Troposphere

- Troposphere is the **lowermost layer** of the atmosphere.
- The **average height** of troposphere is **13 km**, it extends roughly to a height of **8 km near pole and 18 km at the equator**.
- It is the most important layer because **all the weather phenomena occur in this layer**.
- This layer contains dust particles and water vapour.
- **Temperature decreases with increasing height** at the rate of 6.5°c per 1000 m. The rate of decrease of temperature is called **normal lapse rate**.
- The exchange and movement of water between the earth and atmosphere is called the water cycle. The cycle occurs in the troposphere
- The zone separating the troposphere from stratosphere is known as the tropopause because temperature here is nearly constant.

Composition:

- The troposphere contains 99% of the water vapor in the atmosphere.
- Most prevalent gases are nitrogen (78 percent) and oxygen (21 percent). The remaining 1 percent consists of argon, carbon dioxide, and other gases.

Changes in Composition

- Concentration of Carbon dioxide has nearly doubled since 1900's. Greenhouse Gas effect has led increase in temperature of troposphere in recent decades.

- Climate change is mainly associated with changes in composition of troposphere.

Modifying factors:

- **Anthropogenic Factors:** Composition of troposphere has been changing in recent years with percentage of CO2 increasing. CO2 is transparent to the incoming shortwave radiation and opaque for outgoing longwave radiation, capturing more heat. Recent changes have been mainly accorded to industrial development.
- Concentration of methane has also increased due to agriculture, melting of permafrost cover, etc.
- **Natural Factors:** Volcanism leads to addition of oxygen, carbon dioxides and other gases. The gases and dust particles thrown into the atmosphere during volcanic eruptions have influences on troposphere.

Stratosphere

- It lies beyond troposphere, Its height extends upto 50 km. Temperature in this sphere increases with the height.
- This layer is **almost free from clouds(Cirrus clouds form in lower stratosphere)** and associated weather phenomenon, making conditions most ideal for flying airplanes. So airplanes fly in the lower stratosphere, sometimes in the upper troposphere where weather is calm has strong, steady, horizontal winds.

Ozonosphere:

- The lower portion of the stratosphere having maximum concentration of ozone is called **ozonosphere** which lies between 15 km to 35 km.
- Ozone Molecules present in this layer are transparent to most of UV-A but it prevents most harmful UV-B and UV-C wavelengths of ultraviolet light to reach earth's surface, which causes cancer, cataract and skin diseases.

- Ozone is measured in what are called **Dobson units**.
- **Ozone layer depletion** is one of the most serious problems faced by our planet earth. It is also one of the prime reasons which are leading to global warming.
- Chlorofluorocarbon and volatile organic compounds (VOCs) cause depletion of ozone layer.

Modifying factors

- Chlorofluorocarbon(CFC), Hydrochlorofluorocarbon(HCFC).
- Ozone reaction takes place in the presence of sunlight.

Ozone Depletion

The molecules of CFCs when exposed to UV radiation breaks up and Chlorine atoms get freed. Free chlorine atom further easily reacts with ozone atom to form Chlorine monoxide. Molecule of chlorine monoxide further reacts with oxygen which results into oxygen molecule and chlorine atom.

The reaction cycle starts again which converts ozone into oxygen and chlorine which leads to ozone depletion.

Why does a ozone hole form over Antarctica and Arctic ?

The ozone hole is caused by the effect of pollutants in the atmosphere destroying stratospheric ozone. During the Antarctic winter some special phenomenons happen in the Antarctic weather.

- The Antarctic stratosphere is very cold. Low temperature enables formation of **Polar Stratospheric clouds**.
- Ozone absorbs sunlight causing increase in temperature with increase in altitude in the stratosphere.
- Chlorine released by breakdown of CFCs exists initially as pure chlorine or as chlorine monoxide but they further react to form Chlorine nitrate and HCL that are stable.
- Usually reaction between Chlorine nitrate and HCL is very slow but stratospheric clouds provide suitable substrate and reaction occurs at a faster rate.
- HCL + Chlorine Nitrate → Molecular Chlorine.
- Molecular Chlorine now available can be broken down to atomic chlorine and the ozone depletion reaction continues as discussed in above box.

During spring season, the sun comes back after the long polar night, the ozone levels are severely depleted around the Antarctic continent causing the "**ozone hole**"

"**ozone hole**". Unfortunately, there then follows a particularly long period of high sunshine and long days, it makes the effect of the ozone hole worse with all that uv light around.

Mesosphere

- It lies above stratosphere.
- Mesosphere extends up to 80km.
- Temperature decreases with an increase in height.
- The **temperature gradually falls** to -100°C at an altitude of 80 km.
- The upper limit is called mesopause, above which with increase in height temperature increases.

Thermosphere

- It is the outermost layer above mesosphere. In thermosphere **temperature rises** very rapidly with increasing height.
- Ionosphere and exosphere are part of this layer. Ionosphere extends from 80 to 400 km whereas exosphere extends beyond 640 km height from sea level. Very little is known about exosphere.
- Because of high energy from Sun and cosmic rays, atoms in ionosphere lose their electrons.

  They become positively charged and electrons behave as free particles. Sun's upper atmosphere known as Corona produces constant stream of plasma, UV rays, X rays which ionize earth's ionosphere. These ions help in radio transmission.
- **Ionosphere** reflects the medium and high frequency **radio waves** back to the earth. This layer is used for radio transmission.
- The thermosphere is home to the **International Space Station** as it orbits Earth. This is also where we will find low Earth orbit satellites.
- Despite such high temperature, this layer doesn't create a burning sensation(Except when ultra high speed space vehicles create friction) because of

low density of molecules present in here cannot transmit kinetic energy. Insolation increases temperature of molecules but it does not produce actual heat.

- While on the other hand, in the lower atmosphere, due to high density of molecules kinetic energy is transmitted and actual heat is produced, leading to heat sensation.

Exosphere

- This is the uppermost layer of the atmosphere extending beyond the ionosphere above a height of about 640 km.
- The density is extremely low in this layer, due to absence of gravitational pull.
- Temperature gradually increases through the layer. (As it is exposed to direct sunlight).
- This layer ultimately merges with space.