Written as per the new CBCS pattern syllabus (2019 -20) prescribed by Savitribai Phule Pune University for F.Y.Bsc . Useful for Students and faculty of Geography across Maharashtra and for students of Competitive Exams.

Introduction to Physical Geography : *Atmosphere and Hydrosphere*

Dr. Shrikant Karlekar

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info@diamondbookspune.com
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Preface

This book is written as per the new revised syllabus (Choice based Credit System) for First Year Bachelor of Science (F.Y.B.Sc.) Geography students of Savitribai Phule Pune University for their first semester course.

The book tries to give the necessary knowledge of all the concepts included in the syllabus with the help of illustrations and examples. We are sure that the book will definitely fulfil the requirement of the students for this course.

- Dr. Shrikant Karlekar

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CHAPTER

1

Introduction to Atmosphere

a. Definition and evolution

Definition :

The earth's atmosphere is a fundamental part of the environment of the Earth together with the lithosphere and the biosphere. It is defined as the the gaseous envelope surrounding the earth held in place by its gravity. It is also defined as the whole mass of air surrounding the earth.

Evolution :

Our present day atmosphere is quite different from the earth's original atmosphere during its formation 4.5 billion years ago. It was mostly hydrogen and helium with lesser amounts of ammonia and methane. The earth was hot and Hydrogen and helium were moving around with enough speed that they could overcome the pull of the earth's gravity. This early atmosphere either escaped into space or was swept into space by the solar wind.

Oxygen was nearly absent in the atmosphere of early Earth. With the important exception of oxygen, most of our present atmosphere is thought to have come from volcanic eruptions. In addition to ash, volcanoes send a lot of water vapour, carbon dioxide, and sulphur dioxide into the atmosphere. Carbon dioxide and water vapour are two of the 5 main gases in our present atmosphere. After numerous eruptions in Prehistoric times, the atmosphere's composition became more

diversified. As the earth began to cool and increasing amounts of water vapour being emitted from eruptions, the vapour condensed and formed clouds. These in turn precipitated and formed bodies of water. Carbon dioxide dissolved in the oceans and was slowly turned into rock.

With water vapour in the atmosphere and liquid water on the earth's surface, the formation of oxygen became possible. Oxygen probably formed in two ways : The photo dissociation of water and the photosynthesis reaction. The nitrogen level gradually increased over time and is now in balance with biological processes. Argon is an inert gas. It is released from the radioactive decay of crustal material. Much of the carbon dioxide was locked up in the lithosphere. The water was collected into oceans, ice, rivers, lakes, underground water, and the atmosphere.

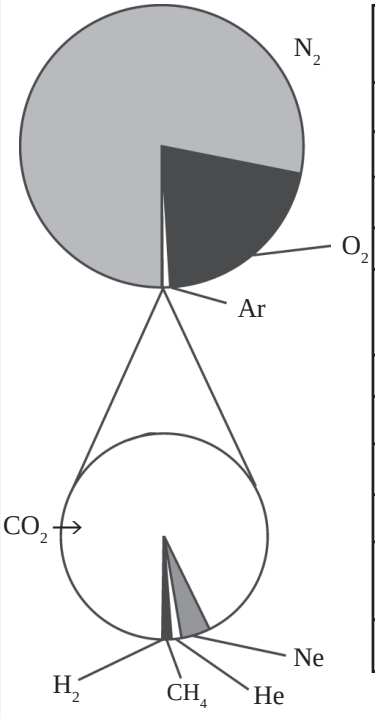
Because of the complexity of the atmosphere that surrounds the Earth, atmospheric scientists often divide its study into aerology, meteorology, and climatology. Aerology is essentially the study of the free atmosphere through its vertical extent. Aerology deals mostly with the chemistry and physical reactions that occur within the various atmospheric layers. Meteorology is the science that deals with motion and phenomena of the atmosphere, with the view to both forecast the weather and explain the processes involved. It deals largely with the status of the atmosphere over a short period.

Climatology is the study of atmospheric conditions prevailing over long periods of time. It includes the study of the weather that occurs at a place. It is concerned not only with the most frequently occurring weather types, but the infrequent and unusual types as well. Climatology is the study of all the weather at a given place over a given period.

b.Composition of atmosphere

The atmosphere consists of a mixture of gases and in its normal state is colourless, odourless and tasteless. Some of the particles in the atmosphere are single atoms, such as argon and helium. Others are molecules like water vapour and carbon dioxide. The gases making up the atmosphere can be divided into two groups. They are the constant

gases and the variable gases are nitrogen (78% by volume), oxygen (21%) and argon (0.93%).Nitrogen is the most abundant of the gases, but it is relatively inactive in the atmosphere. (Fig.1.1).



Gas Name	Chemical Formula	Percent Volume
Nitrogen	N_2	78.08%
Oxygen	O_2	20.95%
*Water	H_2O	0 to 4%
Argon	Ar	0.93%
*Carbon Dioxide	CO_2	0.0360%
Neon	Ne	0.0018%
Helium	He	0.0005%
*Methane	CH_4	0.00017%
Hydrogen	H_2	0.00005%
*Nitrous Oxide	N_2O	0.00003%
*Ozone	O_3	0.000004%

* **Gases variables**

Fig. 1.1 : Composition of Atmosphere

Argon is also inactive, but it is present in small amounts. Oxygen is present in large quantities and is very active in the chemical processes. There are many other constant gases in lesser amounts. Variable Gases as the term implies, vary in proportion of total atmospheric gases from tune to time and place to place.

The most important variable gases are water vapour and carbon dioxide. Water vapour content varies from near zero to a maximum of about 4% by volume, but this small relative volume is extremely important. Carbon dioxide exists in amounts that average near 0.03%.

Water vapour is the source of all precipitation that falls on the earth. Water vapour, carbon dioxide, and dust ail absorb solar radiation. Ozone, another variable gas, is in the lower atmosphere in small amounts, the average being about one part per million. Another variable element of the atmosphere, which in many ways acts like a gas, is the particulate matter suspended in the air (aerosol). This includes soil particles, smoke residue, ocean salt, bacteria, seeds, spores, volcanic ash, and meteoric particles (see Table). The primary source of the solid particles is the earth's surface. Particulate matter decreases rapidly with altitude. High-altitude particles occur from meteoric dust, volcanic eruptions, and nuclear explosions in the atmosphere.

Table : Major Ingredients in Troposphere Aerosol

Source	Total (tons) .	% of Total
Vegetation	1.7×10^7	25.8
Dust by wind	1.6×10^7	24.1
Sea Spray	7.6×10^6	11.9
Forest tires	6.2×10^6	9.9
Sulphur cycle	5.5×10^6	8.6
NO_3	5.5×10^6	7.7
Nitrogen cycle	$3{,}9 \times 10^6$	6.0
Combustion and industrial	1.7×10^6	2.6
Anthropogenic sulfates	1.7×10^6	2.6

The overall amount of particulate matter in the atmosphere varies from as little as 100 parts per cubic centimetre to several million parts per cubic centimetre. Both particulate matter and water vapour are quite important in the atmosphere. They are largely responsible for the day-to-day variation in solar energy reaching the surface of the earth. Solid particles serve as nuclei for condensation of water vapour and thus are necessary for precipitation.

c : Vertical structure of the atmosphere

The atmosphere can be divided vertically into several different zones based on a various properties. (Fig.1.2).

1.Troposphere :

The lowest zone in the atmospheric column is called the troposphere. It is a turbulent zone that shows a uniform decrease in

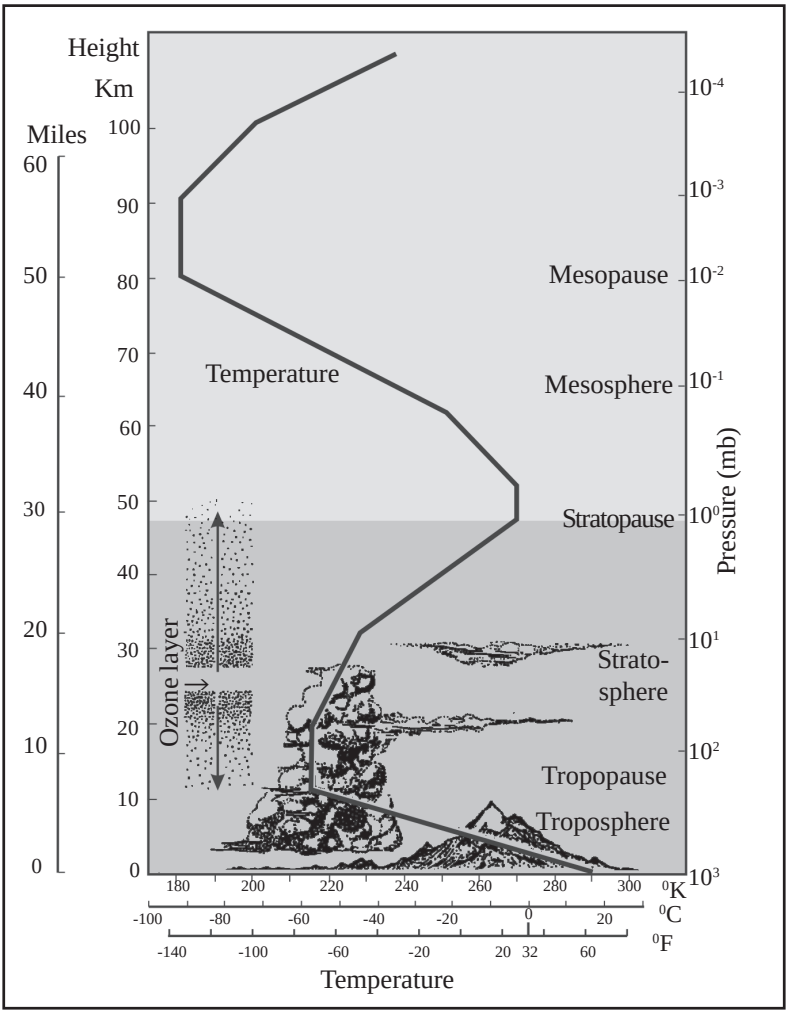


Fig. 1.2 : Structure of atmosphere

temperature with height. Tthe average rate of change in temperature with altitude which is called the lapse rate is 6.5 degrees Celsius per 1,000 meters (3.5°F/1,000 ft).

The troposphere has two subzones-the lower and upper troposphere. The lower troposphere extends upward to about 3 km above the surface .It is the zone in which there is maximum friction between the earth and the atmosphere. It is the zone most affected by the daily changes in surface conditions. Another characteristic of this zone is the frequent occurrence of temperature inversions in this zone. (A temperature inversion takes place when the temperature increases rather than decreases with height.). The upper troposphere extends to an average height of 11 km. It is less affected by the daily changes that take place near the surface and from the effects of friction at the surface. The primary changes that take place in this zone result from the seasonal change in solar energy and.atmospheric storms.

Air temperature is highest near the surface. Due to this water vapour content is also highest close to the surface. Due to the combination of atmospheric temperatures and altitude above the moisture source, the mean water vapour content decreases rapidly with altitude in troposphere.

Tropopause is a distinct boundary layer along the upper reaches of the troposphere. This boundary layer is significant in several ways. Basically it marks the upper limit of most turbulent mixing area, troposphere. It represents a low temperature point in the vertical structure of the atmosphere. It also marks the upper limit of most of the water in the atmosphere. Very little moisture penetrates the tropopause except through severe thunderstorms, which can be recorded as high as 20 km. The amount of water vapour in the atmosphere above the tropopause is very small.

At the equator, the tropopause is at a height of about 16 to 17 km. The temperature averages -70 to ~85°C, and the pressure averages only 100 millibars which is only a tenth of sea-level pressure. Above the north and south poles, the tropopause is at a height of 9 to 12 km with a temperature averaging -50 to -60°C and a pressure of about 250 millibars.