Module 1

Syllabus

Systems of earth

Lithosphere- composition, rocks, soils; Atmosphere-layers, ozone layer, greenhouse effect, weather, cyclones, atmospheric circulations, Indian Monsoon; hydrosphere- Oceans, inland water bodies; biosphere

Definition and meaning of key terms in Disaster Risk Reduction and Management- disaster, hazard, exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster, risk reduction, disaster risk management, early warning systems, disaster preparedness, disaster prevention, disaster mitigation, disaster response, damage assessment, crisis counselling, needs, assessment.

Introduction to various systems of earth

The area near the surface of the earth can be divided up into four interconnected geo-spheres that make up the carbon cycle these include:

- Lithosphere
- Hydrosphere
- Biosphere
- Atmosphere

The understanding of '-sphere- in this situation means 'to surround or encompass' .

The following help us understand the mean of the four spheres:

- Lithosphere - *litho* referring to rocks and minerals
- Hydrosphere - *hydro* referring to water
- Biosphere - *bio* referring to life
- Atmosphere - *atmo* referring to steam and vapour

THE LITHOSPHERE -

The lithosphere is the rigid, rocky outer layer of the Earth on which all known life happens, and which and extends on average to about 70 km (40 miles) to 100 km (60 miles) deep in the mantle.
The lithosphere is a layer extremely thin compared to the rest of the planet that has a depth of 6,371 km., Representing 1.56% of the radius of the Earth.

The lithosphere can be classified as “continental crust” (with a thickness up to 70 km mainly composed of plutonic and metamorphic rocks with an estimated age maximum of 3.8 billion years) and “oceanic crust” (from 5 to 10 km composed of thick basalt, sediments and plutonic rock mineral denser than continental crust with an estimated age maximum of 180 million years because it contains less silicate)

It is believed the lithosphere evolved about 4.6 billion years ago. The lithosphere refers to the solid, rocky crust that covers the entire planet. This solid, rocky crust is composed of a number of different rocks that have been grouped into three categories based on how they are formed.

These three groups include:

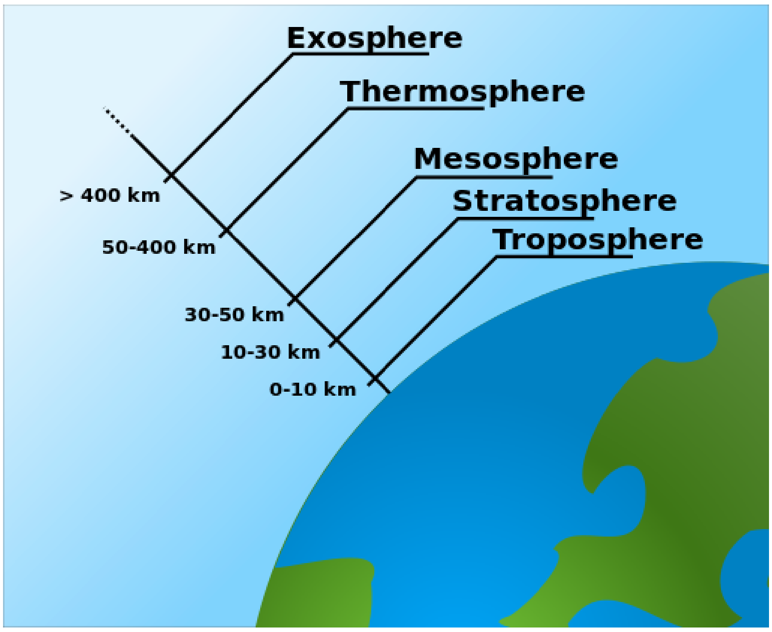
1. ***Metamorphic rocks*** – Metamorphic rocks are formed by heat and / or pressure from pre-existing rocks.
2. ***Igneous rocks*** – igneous rocks are formed by the cooling of hot molten rock also known as magma. When the hot magma cools it begins to harden meaning once it had fully cooled it create what is known to be an igneous rock.
3. ***Sedimentary rocks*** – sedimentary rocks are formed from pre-existing rocks. When rocks erode and mix with other dirt, clay and particles then settle together the mix together to form a sedimentary rock.

LAYERS OF EARTH'S ATMOSPHERE

The atmosphere is comprised of layers based on temperature. These layers are the troposphere, stratosphere, mesosphere and thermosphere. A further region at about 500 km above the Earth's surface is called the exosphere.

The different layers of the atmosphere

The atmosphere can be divided into layers based on its temperature, as shown in the figure below. These layers are the troposphere, the stratosphere, the mesosphere and the thermosphere. A further region, beginning about 500 km above the Earth's surface, is called the exosphere.



1. The Troposphere

This is the lowest part of the atmosphere - the part we live in. It contains most of our weather-clouds, rain, snow. In this part of the atmosphere the temperature gets colder as the distance above the earth increases, by about 6.5°C per kilometre. The actual change of temperature with height varies from day to day, depending on the weather.

The troposphere contains about 75% of all of the air in the atmosphere, and almost all of the water vapour (which forms clouds and rain). The decrease in temperature with height is a result of the decreasing pressure. If a parcel of air moves upwards it expands (because of the lower pressure). When air expands it cools. So air higher up is cooler than air lower down.

The lowest part of the troposphere is called the boundary layer. This is where the air motion is determined by the properties of the Earth's surface. Turbulence is generated as the wind blows over the Earth's surface, and by thermals rising from the land as it is heated by the sun. This turbulence redistributes heat and moisture within the boundary layer, as well as pollutants and other constituents of the atmosphere. The top of the troposphere is called the tropopause. This is lowest at the poles, where it is about 7 - 10 km above the Earth's surface. It is highest (about 17 - 18 km) near the equator.

2. The Stratosphere

This extends upwards from the tropopause to about 50 km. It contains much of the ozone in the atmosphere. The increase in temperature with height occurs because of absorption of ultraviolet (UV) radiation from the sun by this ozone. Temperatures in the stratosphere are highest over the summer pole, and lowest over the winter pole.

By absorbing dangerous UV radiation, the ozone in the stratosphere protects us from skin cancer and other health damage. However, chemicals (called CFCs or freons, and halons) which were once used in refrigerators, spray cans and fire extinguishers have reduced the amount of ozone in the stratosphere, particularly at polar latitudes, leading to the so-called "Antarctic ozone hole".

Now humans have stopped making most of the harmful CFCs we expect the ozone hole will eventually recover over the 21st century, but this is a slow process.

3. The Mesosphere

The region above the stratosphere is called the mesosphere. Here the temperature again decreases with height, reaching a minimum of about -90°C at the "mesopause".

4. The Thermosphere and Ionosphere

The thermosphere lies above the mesopause, and is a region in which temperatures again increase with height. This temperature increase is caused by the absorption of energetic ultraviolet and X-Ray radiation from the sun.

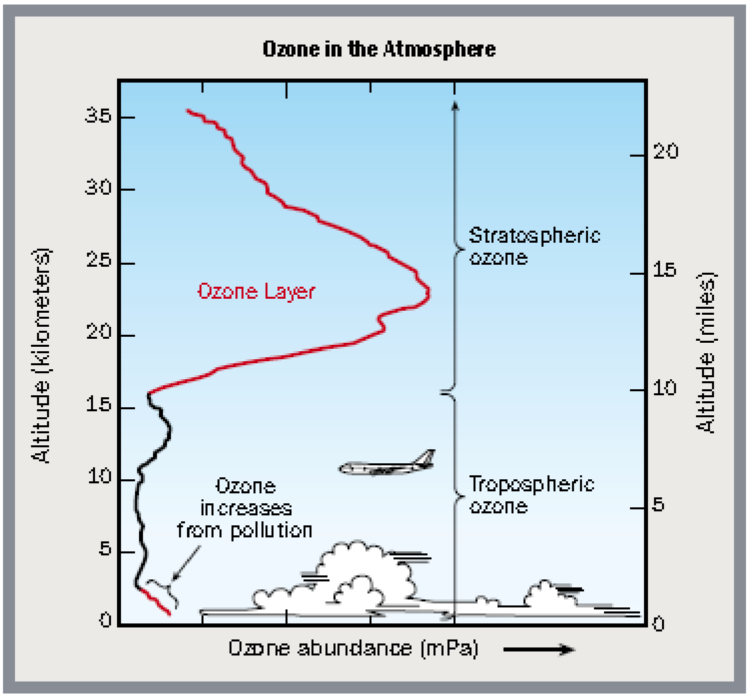
The region of the atmosphere above about 80 km is also caused the "ionosphere", since the energetic solar radiation knocks electrons off molecules and atoms, turning them into "ions" with a positive charge. The temperature of the thermosphere varies between night and day and between the seasons, as do the numbers of ions and electrons which are present. The ionosphere reflects and absorbs radio waves, allowing us to receive shortwave radio broadcasts in New Zealand from other parts of the world.

5. The Exosphere

The region above about 500 km is called the exosphere. The exosphere is the uppermost region of Earth's atmosphere as it gradually fades into the vacuum of space. The air in the exosphere is extremely thin - in many ways it is almost the same as the airless void of outer space. It contains mainly oxygen and hydrogen atoms, but there are so few of them that they rarely collide - they follow "ballistic" trajectories under the influence of gravity, and some of them escape right out into space.

OZONE LAYER

Most atmospheric ozone is concentrated in a layer in the stratosphere, about 9 to 18 miles (15 to 30 km) above the Earth's surface (see the figure below). Ozone is a molecule that contains three oxygen atoms. At any given time, ozone molecules are constantly formed and destroyed in the stratosphere. The total amount has remained relatively stable during the decades that it has been measured.



The ozone layer in the stratosphere absorbs a portion of the radiation from the sun, preventing it from reaching the planet's surface. Most importantly, it absorbs the portion of UV light called UVB. UVB has been linked to many harmful effects, including skin cancers, cataracts, and harm to some crops and marine life.

Scientists have established records spanning several decades that detail normal ozone levels during natural cycles. Ozone concentrations in the atmosphere vary naturally with sunspots, seasons, and latitude. These processes are well understood and predictable. Each natural reduction in ozone levels has been followed by a recovery. Beginning in the 1970s, however, scientific evidence showed that the ozone shield was being depleted well beyond natural processes.

Ozone Depletion

When chlorine and bromine atoms come into contact with ozone in the stratosphere, they destroy ozone molecules. One chlorine atom can destroy over 100,000 ozone molecules before it is removed from the stratosphere. Ozone can be destroyed more quickly than it is naturally created.

Some compounds release chlorine or bromine when they are exposed to intense UV light in the stratosphere. These compounds contribute to ozone depletion, and are called ozone-depleting substances (ODS). ODS that release chlorine include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), carbon tetrachloride, and methyl chloroform. ODS that release bromine include halons and methyl bromide. Although ODS are emitted at the Earth’s surface, they are eventually carried into the stratosphere in a process that can take as long as two to five years.

Some natural processes, such as large volcanic eruptions, can have an indirect effect on ozone levels. For example, Mt. Pinatubo's 1991 eruption did not increase stratospheric chlorine concentrations, but it did produce large amounts of tiny particles called aerosols (different from consumer products also known as aerosols). These aerosols increase chlorine's effectiveness at destroying ozone. The aerosols in the stratosphere create a surface on which CFC-based chlorine can destroy ozone. However, the effect from volcanoes is short-lived.

Not all chlorine and bromine sources contribute to ozone layer depletion. For example, researchers have found that chlorine from swimming pools, industrial plants, sea salt, and volcanoes does not reach the stratosphere. In contrast, ODS are very stable and do not dissolve in rain. Thus, there are no natural processes that remove the ODS from the lower atmosphere.

GREEN HOUSE EFFECT

The greenhouse effect is the rise in temperature that the Earth experiences because certain gases in the atmosphere (water vapor, carbon dioxide, nitrous oxide, ozone, methane, for example) trap energy that comes from the sun. These gases are usually called greenhouse gases since they behave much like the glass panes in a greenhouse. The glass panels of the greenhouse let in the light but keep heat from escaping and this is similar to the effect these gasses have on earth.

Sunlight enters the Earth's atmosphere, passing through the greenhouse gases. As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy. Once absorbed, this energy is sent back into the atmosphere. Some of the energy passes back into space, but much of it remains trapped in the atmosphere by the greenhouse gases. This is the completely natural process and without these gases all the heat would escape back into space and Earth's average temperature would be about 30 degrees Celsius (54 degrees Fahrenheit) colder. The greenhouse effect is very important process, because without the greenhouse effect, the Earth would not be warm enough for humans to live. But if the greenhouse effect becomes stronger, it could make the Earth warmer than usual. Even a little extra warming may cause problems for humans, plants, and animals.

Some human activities also produce greenhouse gases and these gases keep increasing in the atmosphere. The change in the balance of the greenhouse gases has significant effects on the entire planet. Burning fossil fuels - coal, oil and natural gas - releases carbon dioxide into the atmosphere. Cutting down and burning trees also produces a lot of carbon dioxide. A group of greenhouse gases called the chlorofluorocarbons have been used in aerosols, such as hairspray cans, fridges and in making foam plastics.

Since there are more and more greenhouse gases in the atmosphere, more heat is trapped, which makes the Earth warmer. This is known as global warming. A lot of scientists agree that man's activities are making the natural greenhouse effect stronger. If we carry on polluting the atmosphere with greenhouse gases, it will have very dangerous effects on the Earth. Today, the increase in the Earth's temperature is increasing with unprecedented speed.

To understand just how quickly global warming is accelerating, consider that during the entire 20th century, the average global temperature increased by about 0.6 degrees Celsius (slightly more than 1 degree Fahrenheit). Using computer climate models, scientists estimate that by the year 2100 the average global temperature will increase by 1.4 degrees to 5.8 degrees Celsius (approximately 2.5 degrees to 10.5 degrees Fahrenheit).

Greenhouse Gases

Many greenhouse gases occur naturally in the environment, such as water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Others such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) are created and emitted solely through human activities. Human activities also add significantly to the level of naturally occurring greenhouse gases. The principal greenhouse gases that enter the atmosphere because of human activities are:

• Carbon Dioxide (CO2): Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide is also removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

• Nitrous Oxide (N2O): Nitrous oxide is emitted during various agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

• Methane (CH4): Methane is emitted during the production and transport of coal, natural gas, and oil. Methane is also emitted when organic waste decomposes, whether in landfills or in connection with livestock farming.

• Fluorinated Gases: Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (i.e., CFCs, HCFCs, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").

Greenhouse gases vary in their ability to absorb and hold heat in the atmosphere. HFCs and PFCs are the most heat-absorbent, but there are also wide differences between naturally occurring gases. For example, nitrous oxide absorbs 270 times more heat per molecule than carbon dioxide, and methane absorbs 21 times more heat per molecule than carbon dioxide. However, carbon dioxide contributes the most, since its level in the atmosphere is the highest.

Not all, human sources of greenhouse gas emissions are expected to rise in the future. This growth may be reduced by ongoing efforts to increase the use of newer, cleaner technologies and other measures. Additionally, our everyday choices about such things as commuting, housing, electricity use, and recycling can influence the amount of greenhouse gases being emitted.

Weather

Weather is the mix of events that happen each day in our atmosphere. Weather is different in different parts of the world and changes over minutes, hours, days and weeks. Most weather happens in the troposphere, the part of Earth's atmosphere that is closest to the ground.

The weather events happening in an area are controlled by changes in air pressure. Air pressure is caused by the weight of the huge numbers of air molecules that make up the atmosphere. Typically, when air pressure is high there skies are clear and blue. The high pressure causes air to flow down and fan out when it gets near the ground, preventing clouds from forming. When air pressure is low, air flows together and then upward where it converges, rising, cooling, and forming clouds. on low pressure days those clouds might cause rain or other types of precipitation.

The average weather pattern in a place over several decades is called climate. Different regions have different regional climates. For example, the climate of Antarctica is quite different than the climate of a tropical island. Global climate refers to the average of all regional climates.

As global climate changes, weather patterns are expected to change as well. While it is impossible to say whether a particular day's weather was affected by climate change, it is possible to predict how patterns might change. For example, scientists predict more severe weather events as climate warms. Also, they predict more hot summer days and fewer extreme cold winter days. That doesn't mean that there will be no more winter weather, in fact, large snowstorms might even be more likely in some areas as less cold air is able to carry more water with which to make snowflakes.

Cyclones

Cyclones can be the most intense storms on Earth. A cyclone is a system of winds rotating counter clockwise in the Northern Hemisphere around a low pressure center. The swirling air rises and cools, creating clouds and precipitation.

There are two types of cyclones: middle latitude (mid-latitude) cyclones and tropical cyclones. Mid-latitude cyclones are the main cause of winter storms in the middle latitudes. Tropical cyclones are also known as hurricanes.

An anticyclone is the opposite of a cyclone. An anticyclone's winds rotate clockwise in the Northern Hemisphere around a center of high pressure. Air comes in from above and sinks to the ground. High pressure centers generally have fair weather.

Global Atmospheric Circulations

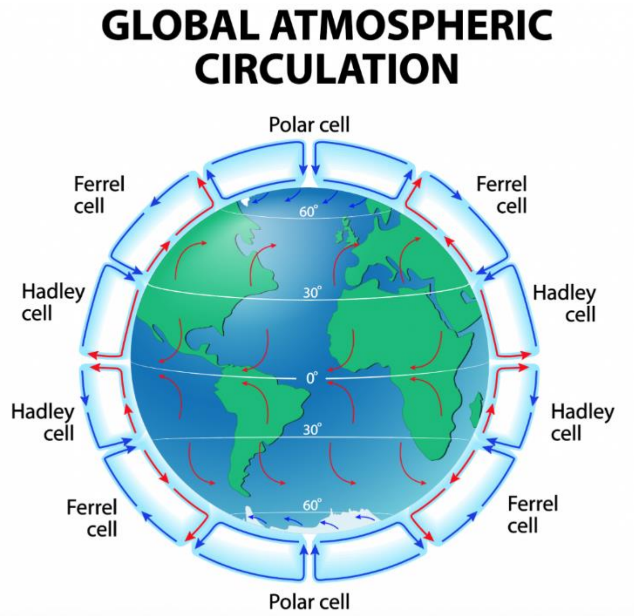
What is atmospheric circulation?

The Earth is surrounded by a thin layer of air called the atmosphere. The air in the atmosphere moves in response to differences in temperature at the equator (warm) and the poles (cold). This movement of air is called global atmospheric circulation.

Temperatures at the equator are high because incoming solar radiation is more intense as the sun's energy is more concentrated. Due to high temperatures at the equator, the air rises up into the atmosphere. This creates low pressure (as the air is rising it puts less pressure on the Earth's surface). As the air rises it becomes colder, causing condensation (forming clouds) that leads to rainfall. This is why tropical rainforests are found along the equator!

When the air reaches the top of the atmosphere it needs somewhere to go. Some of the air travels north and some south of the equator. The air cools and then sinks at around 30° north and south of the equator. As the air is sinking this creates high pressure. As moisture in the sinking air fell at the equator it is dry so few clouds form here. This is why deserts are found along 30° north and south of the equator.

he movement of air between the equator and 30° north and south is known as the Hadley Cell. Air rises again at around 60° north and south and descends again around 90° north and south forming the Ferrel and Polar Cell.



Global atmospheric circulation creates winds across the planet as air moves from areas of high pressure to areas of low pressure. It also leads to areas of high rainfall, like the tropical rainforests, and areas of dry air, like deserts.

In addition to heat from the equator moving towards the poles through atmospheric circulation, ocean currents also transfer heat. Oceans transfer approximately 20 per cent of the total heat from the tropics to the poles. Each ocean has a circular pattern of surface currents called a gyre.

They are produced as assess of water move from one climate zone to another. They are created by surface winds generated by global atmospheric circulation.

Indian monsoon

Indian monsoon, the most prominent of the world's monsoon systems, which primarily affects India and its surrounding water bodies. It blows from the northeast during cooler months and reverses direction to blow from the southwest during the warmest months of the year. This process brings large amounts of rainfall to the region during June and July.

At the Equator the area near India is unique in that dominant or frequent westerly winds occur at the surface almost constantly throughout the year; the surface easterlies reach only to latitudes near 20° N in February, and even then they have a very strong northerly component. They soon retreat northward, and drastic changes take place in the upper-air circulation (see climate: Jet streams). This is a time of transition between the end of one monsoon and the beginning of the next. Late in March the high-sun season reaches the Equator and moves farther north. With it go atmospheric instability, convectional (that is, rising and turbulent) clouds, and rain. The westerly subtropical jet stream still controls the flow of air across northern India, and the surface winds are northeasterlies.

As the high-sun season (that is, the Northern Hemisphere summer) moves northward during April, India becomes particularly prone to rapid heating because the highlands to the north protect it from any incursions of cold air. There are three distinct areas of relative upper tropospheric warmth—namely, (1) above the southern Bay of Bengal, (2) above the Plateau of Tibet, and (3) across the trunks of the various peninsulas that are relatively dry during this time. These three areas combine to form a vast heat-source region. The relatively warm area above the southern Bay of Bengal occurs mostly at the 500–100-millibar level. (This atmospheric pressure region typically occurs at elevations between 5,500 and 16,100 metres [18,000 and 53,000 feet] but may vary according to changes in heating and cooling.) It does not appear at a lower level and is probably caused by the release of condensation heat (associated with the change from water vapour to liquid water) at the top of towering cumulonimbus clouds along the advancing intertropical convergence. In contrast, a heat sink appears over the southern Indian Ocean as the relatively cloud-free air cools by emitting long-wavelength radiation. Monsoon winds at the surface blow from heat sink to heat source. As a result, by May the southwest monsoon is well-established over Sri Lanka, an island off the southeastern tip of the Indian peninsula.

EARTH SYSTEM

ORIGIN OF UNIVERSE

A large number of hypotheses were put forth by different philosophers and scientists regarding the origin of the earth. The most popular argument regarding the origin of the universe is the *Big Bang Theory*. It is also called expanding universe hypothesis. Edwin Hubble, in 1920, provided evidence that the universe is expanding. As time passes, galaxies move further and further apart.

The Big Bang Theory considers the following stages in the development of the universe.

(i) In the beginning, all matter forming the universe existed in one place in the form of a "tiny ball" (singular atom) with an unimaginably small volume, infinite temperature and infinite density.

(ii) At the Big Bang the "tiny ball" exploded violently. This led to a huge expansion. It is now generally accepted that the event of big bang took place 13.7 billion years before the present. The expansion continues even to the present day. As it grew, some energy was converted into matter. There was particularly rapid expansion within fractions of a second after the bang. Thereafter, the expansion has slowed down. Within first three minutes from the Big Bang event, the first atom began to form.

(iii) Within 300,000 years from the Big Bang, temperature dropped to 4,500 K and gave rise to atomic matter. The universe became transparent.

EARTH IN THE SOLAR SYSTEM

The solar system was created about 4.6 billion years ago (about 9 billion years after the big bang), supposedly after gravitational waves from a supernova produced density anomalies in an interstellar cloud, which acted as condensation centers for the sun and the planets. In addition to hydrogen and helium generated during the big bang higher elements from the ashes of burnt-out stars were present in the cloud. After the sun had formed, its radiation pressure (solar wind) forced the light gases to the edge of the cloud where the large gas planets (Jupiter, Saturn, Uranus, Neptune) formed, whereas the earth-type planets (Mercury, Venus, Earth, Mars) developed in the vicinity of the sun.

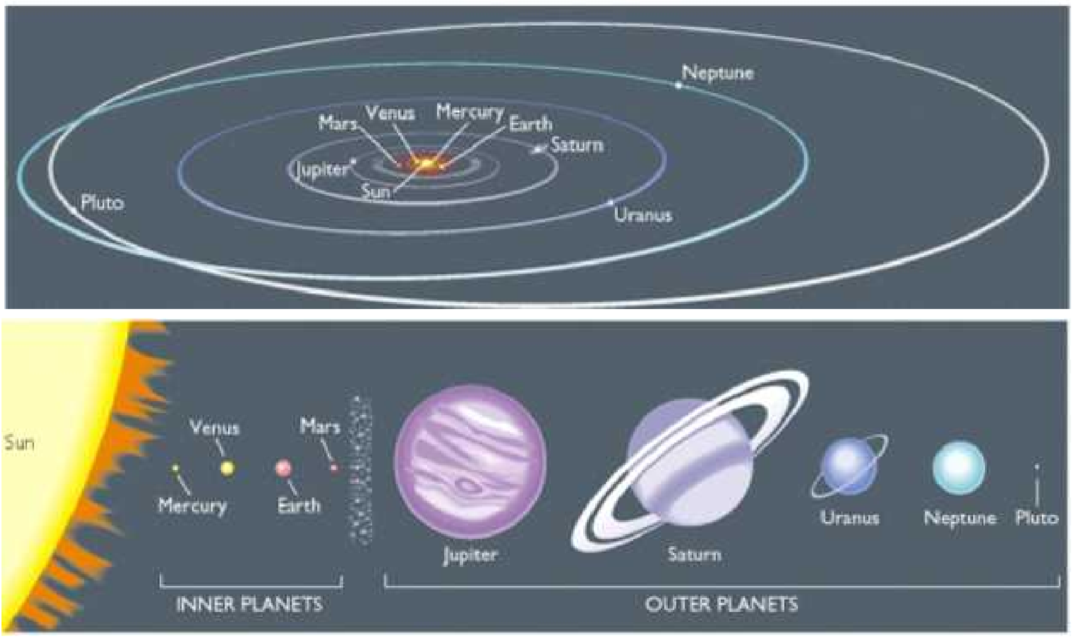


Figure: The planets of the Solar System. The upper panel displays the elliptical orbits of the planets around the sun, the lower panel shows the sizes of the planets.

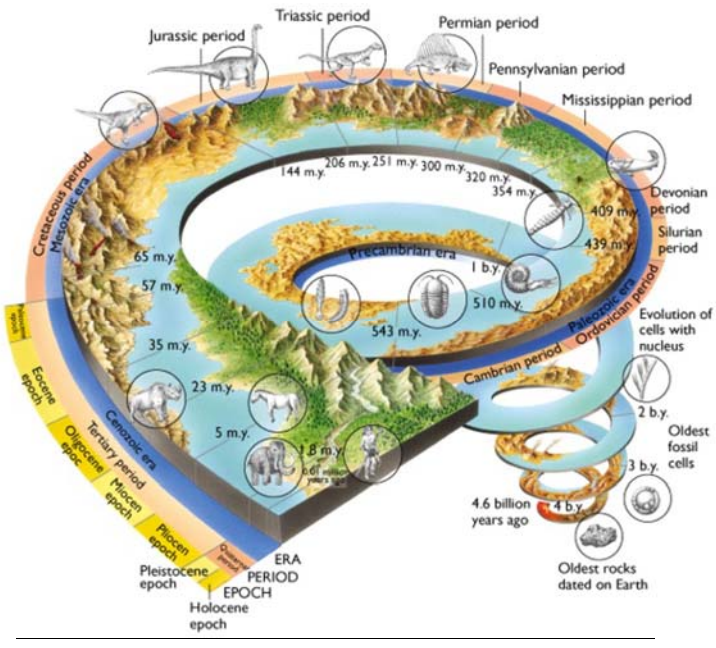
Earth is the largest of the four planets closest to the sun: it differs in many ways from all other planets. Only Earth possesses an atmosphere which supports oxygen-breathing life forms. No other planet has a hydrosphere and living systems which are comparable to our biosphere. The size of the Earth is important because it supports enough gravitational attraction to keep atmospheric gases on the planet. For example, Mercury is too small to prevent the light gases as oxygen and carbon dioxide from escaping while Venus is large enough to keep an atmosphere.

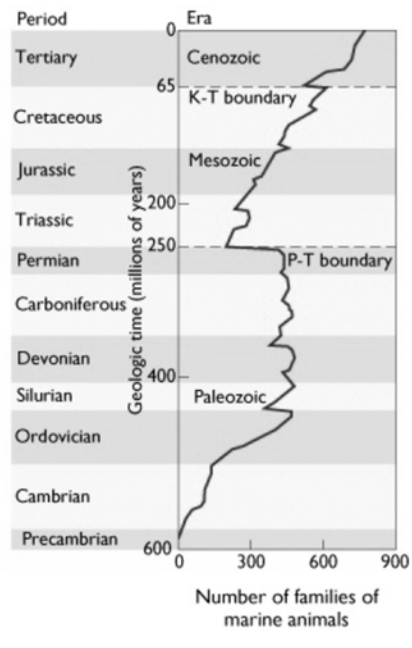
EVOLUTION OF THE EARTH

The planet earth initially was a barren, rocky and hot object with a thin atmosphere of hydrogen and helium. This is far from the present day picture of the earth. Hence, there must have been some events– processes, which may have caused this change from rocky, barren and hot earth to a beautiful planet with ample amount of water and conducive atmosphere favoring the existence of life. In the following section, you will find out how the period, between the 4,600 million years and the present, led to the evolution of life on the surface of the planet. The earth has a layered structure. From the outermost end of the atmosphere to the centre of the earth, the material that exists is not uniform. The atmospheric matter has the least density. From the surface to deeper depths, the earth's interior has different zones and each of these contains materials with different characteristics.

ORIGIN OF LIFE

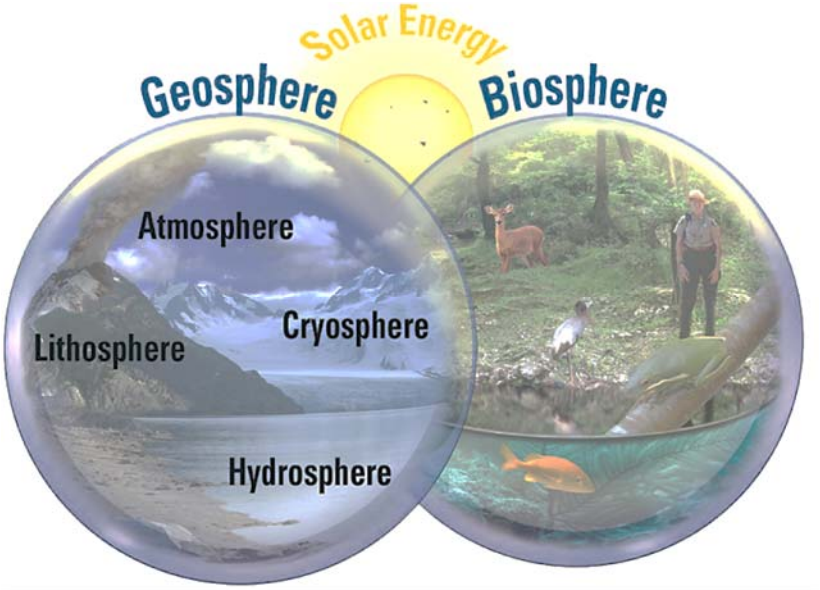
The last phase in the evolution of the earth relates to the origin and evolution of life. It is undoubtedly clear that the initial or even the atmosphere of the earth was not conducive for the development of life. Modern scientists refer to the origin of life as a kind of chemical reaction, which first generated complex organic molecules and assembled them. This assemblage was such that they could duplicate themselves converting inanimate matter into living substance. The record of life that existed on this planet in different periods is found in rocks in the form of fossils. The microscopic structures closely related to the present form of blue algae have been found in geological formations that are much older than these were some 3,000 million years ago. It can be assumed that life began to evolve sometime 3,800 million years ago.





The Earth is subject to constant change. Even the solid body of the Earth or the great polar ice caps are not steady but change over periods of tens to millions of years. These changes are essentially fueled by the sun's energy, the heat stored in the Earth's interior and energy given off through radioactive decay of minerals in the crust and upper-mantle. The living world is also affected by these large-scale processes and is involved in the exchange between various components of the Earth system.

The Earth is made up of the following subsystems: **geosphere, atmosphere, hydrosphere**, the great ice caps, the sea ice in the Polar Regions and the many mountain glaciers (**cryosphere**) and the living world (**biosphere**). On short time scales (years or tens of years) each of these subsystems is in a state of dynamic equilibrium. Consequently, the many different processes of interaction between the various subsystems tend to vary little. If longer periods of time are considered, fluctuations and transitions from one state of equilibrium to another become visible. These delicate states of equilibrium may be permanently disturbed by changes in external conditions. Most of the subsystems obey certain natural laws which will be introduced in the course of the following chapters.



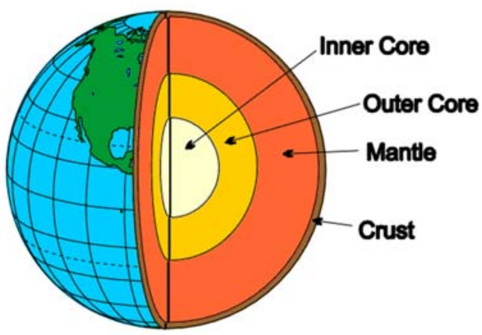
The Geosphere

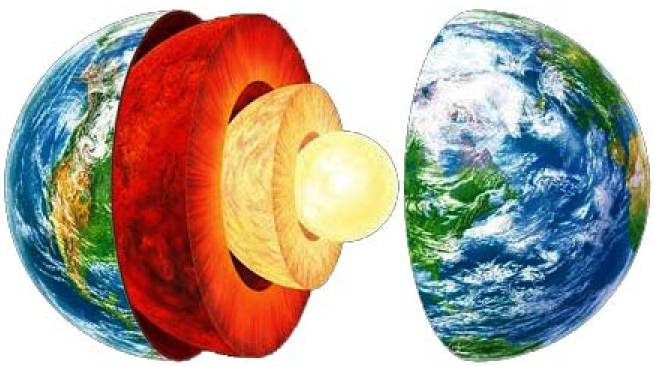
The Earth's internal structure is subdivided into crust, mantle and core and was formed very early during its development. Compared to the Earth radius, the crust is extremely thin, only 4to7 km under the oceans and about 100 km under the continents. At the mid-ocean ridges, which can be described as a series of active magma chambers

Internal Structure of Earth

Final picture based on the study of seismic waves divides earth into **3 well defined shells or zones**

1. **The Crust**
2. **The Mantle**
3. **The Core**





The Crust

- **Uppermost shell of earth**
- Study of seismic waves reveals following details about thickness of the crust

(a) Mountain areas

- Under the Himalayas, the crust is believed to be 70 – 75 km thick
- Under Hindukush Mountains it is 60 km thick
- Under the Andes it is 75 km thick

(b) Continental Areas

- The thickness varies from 30 – 40km
- Along the continental slopes thickness if the crust shows considerable variation

(c) Oceanic Areas

- The thickness varies from a maximum of 19 – 5 km in deep oceans

The Continental Crust

It is further distinguished into 3 layers: **A, B and C**

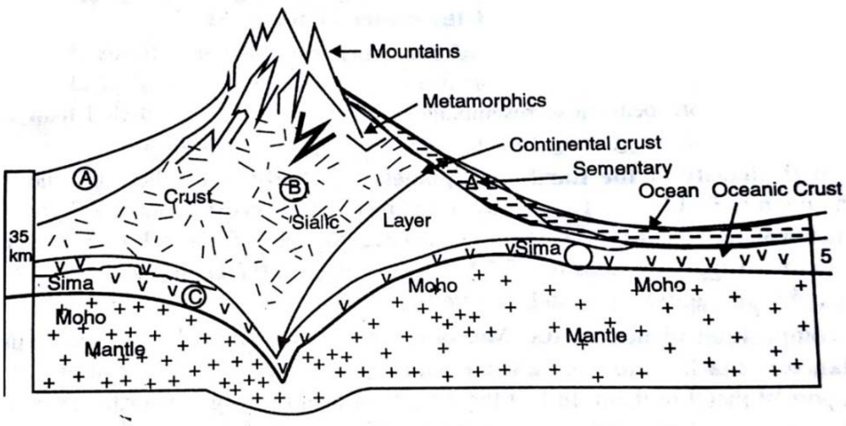
i. *The A or the upper Layer*
   - Thickness : 2 – 10 km
   - Low density : 2.2 g/cc
   - Mostly made up of sedimentary rocks

ii. *The B or Middle layer*
   - Thickness : 20km or more
   - Relatively dense : 2.4 to 2.6 g/cc
   - Sometimes also called granite layer
   - Made up mostly of granites and other igneous and metamorphic rocks

iii. *The C or lowermost layer*
   - Thickness : 25 – 40 km
   - Density : 2.8 to 3.3 g/cc
   - Made predominantly of basic minerals (rich in magnesium silicates)
   - Sometimes named as SIMA (Si – Silica, Ma – Magnesium)

The Oceanic Crust

- It is generally extension of C layer
- A & B layers of continental crust are absent from here
- Estimated to have a volume of 2.54 x 10^9 cc
- Average density of 3.00 g/cc



Structure of the Earth (not to scale)

A = Sedimentary layer; B= Granitic layer (SIAL); C= Basaltic layer (SIMA)

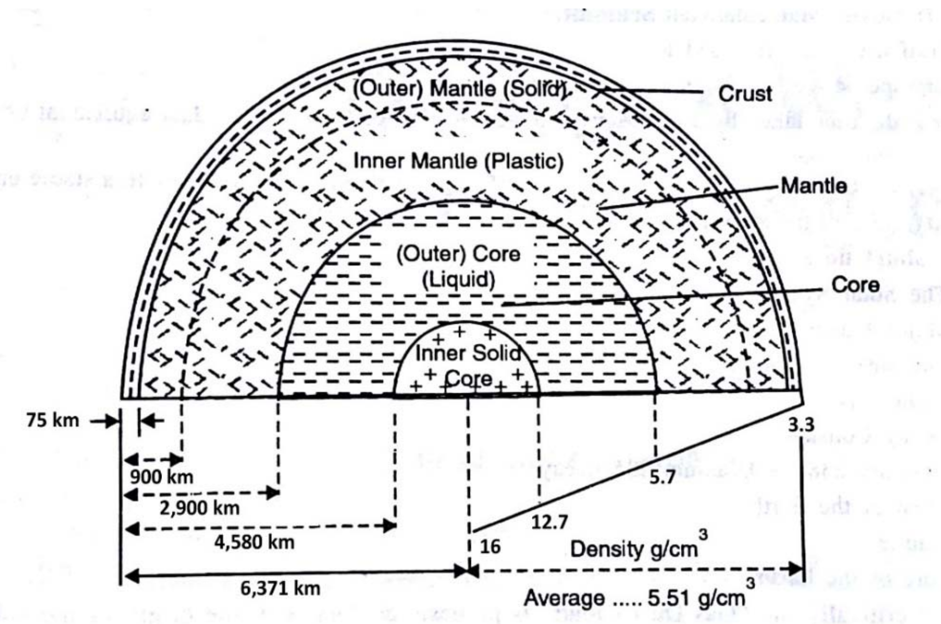
– Second concentric shell of the Earth
– Lies beneath the crust, makes upto 84% of earth's volume
– Extends **up to a depth 2900 km**
– Nature of mantle is incompletely understood
– Sub-divided into : **Upper** (Depth 100 – 900 km) **& Lower mantle** (Depth 900 – 2900 km)
– The upper mantle us further divided into 2 layers of 400 & 600 km thickness respectively
– Density ranges from : **3.3 g/cc – just below the crust**
5.7 g/cc – at the base of mantle
– A part of upper mantle (100 – 500 km depth) is in plastic state rather than solid state – **Asthenosphere** (Source of volcanic activity). The asthenosphere is believed to be **located entirely in upper mantle** and support the slowly moving tectonic plates
– **Lithosphere –** the rigid outer part of the earth, consisting of the crust and upper mantle.

<u>The Core</u>

– Innermost concentric shell of the Earth
– The core boundary **begins at depth of 2,900 km from the surface and extends to center of earth at 6,371 km**
– Sub-divided into : **Outer Core & Inner Core**

<u>Outer Core</u>	**<u>Inner Core</u>**
• Depth : 2,900 km – 4,580 km • Behaves more like a liquid	• Thickness : 1,790 km • Solid metallic body

– **Density :** 5.7 g/cc – at the base of mantle
9.9 g/cc – at top of the mantle
12.7 g/cc – at boundary of inner core
13.0 g/cc – at the center of earth



The Hydrosphere

The Earth is a 'water planet'. A good two-thirds of its surface, more specifically 362,000 km^2 of area, is covered with water. The large oceans are an essential prerequisite for the existence of the biosphere. They were the cradle of the first life on Earth and provide an indispensable habitat for numerous organisms. The mean depth of the World Oceans is 3,700 m and thus much larger than the mean elevation of the continents, given by 875 m. The total volume of water in the ocean is about 1.35 x 10^{9}km^3 while the water in frozen state on Earth amounts to only 24.4 x 10^{6}km^3 (water in lakes is about 190,000km^3). Ocean water, however, is saline whereas water on land and specifically in the frozen state in glaciers and ice caps is fresh water. The hydrosphere has a direct influence on weather and climate conditions on Earth, with the worldwide oceanic circulation playing a particularly important role.

The Atmosphere

The composition of the atmosphere has changed fundamentally in the course of the Earth's history due to a number of different biological, chemical and physical processes. The early atmosphere of the Earth consisted mainly of nitrogen and carbon dioxide. Thus, it was similar to the present atmospheres of the planets Venus and Mars. Only with the emergence of life and biochemical processes lasting several billion years did the current atmosphere of about 78% nitrogen, 21% oxygen and 1% other gases evolve. This development of the Earth has been possible due to a number of fortunate circumstances, the most important one being the distance of the Earth from the sun, which enabled the formation of a proto-ocean at an early state in its evolution. Any change in orbit parameters might have led to completely different conditions.

The Earth's atmosphere provides only a thin protective cover from outer space. The thickness of the entire atmosphere is about one twentieth of the Earth's radius. The atmosphere is subdivided into four layers of varying heights, based on the mean vertical temperature distribution: the troposphere between the surface of the Earth and an altitude of 11 km, the stratosphere between 11 km and 50 km, the mesosphere between 50 km and 85 km, and the thermosphere from 85 km to about 300 km.

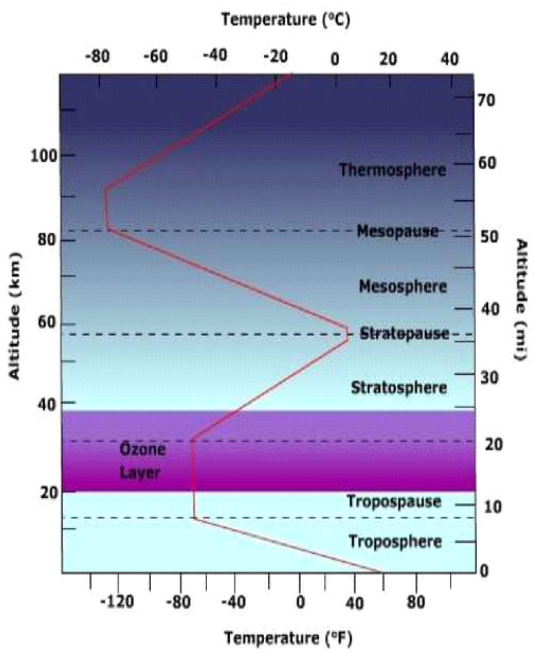


Figure: Vertical temperature profile of the Standard Atmosphere.

Each layer is characterized by a uniform change in temperature with increasing altitude. In some layers there is an increase in temperature with altitude, whilst in others it decreases with increasing altitude. The top or boundary of each layer is denoted by a 'pause', where the temperature profile abruptly changes.

The stratosphere could be called the Earth's 'sun-glasses'. This is where most of the ultraviolet solar radiation, which is harmful for man and all living organisms, is filtered out. This is mainly achieved by ozone, a molecule consisting of three oxygen atoms. About 90% of the total quantity of ozone is to be found in the stratosphere.

The Biosphere

With the exception of the ice sheets of Antarctica and Greenland, the land on Earth is populated by a large variety of living organisms. According to conservative estimates at least eight million different species of animals and plants exist on Earth.

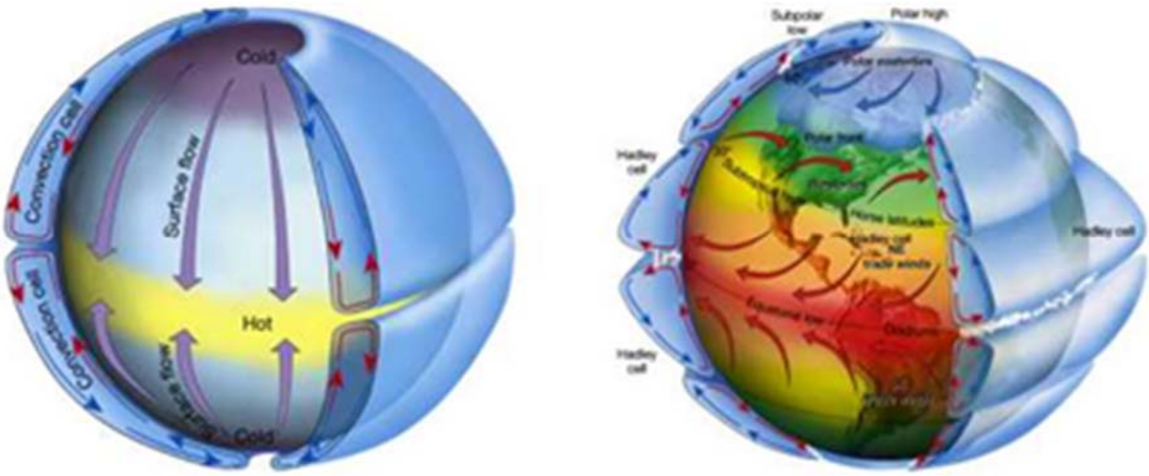


Figure: The circulation of the atmosphere. The left panel is for idealized, non-rotating planet where only the Hadley cell exists. The right panel is for the real Earth with Hadley and Ferrel cells. The corresponding surface winds are shown schematically.

Life on Earth originated from the ocean. This is where the first microorganisms emerged, whose remains have been discovered in rocks up to four billion years old. The oldest known organisms are primitive cells without a nucleus (prokaryotes). A first biosphere developed after unicellular algae began to release oxygen into the atmosphere due to photosynthetic conversion of carbon dioxide. Cells with nucleus (eukaryotes) developed much later in Earth history, about two billion years ago. During the next 400 million years evolution created an enormous multiplicity of species.

The biosphere is a consumer and producer of greenhouse gases. Carbon dioxide in the atmosphere is reduced by plants in photosynthesis. Methane is stored in permafrost soils and gas hydrates on the ocean bottom. Both gases are currently released to the atmosphere by human activities and reinforce the greenhouse effect.

The term ***ecosystem*** describes a holistic concept comprising the total of organisms in a specified spatial unit, their physical conditions and the numerous interactions between the living and non-living components of the system. An ecosystem can either be an isolated pool within an arid region or a whole ocean. It is assumed that each element in the ecosystem is linked directly or indirectly with the other elements and influences them.

The link between living and non-living components of the ecosystem is maintained by two coupled processes: ***the flow of energy and the exchange of nutrients.*** As the major source of energy, the sun is the pre-requisite for plant photosynthesis. In this process carbon dioxide, water and other biogenous elements such as nitrogen, phosphorus and sulphur are converted into protein, fats and starches via a number of intermediate stages. These substances can be called the building blocks of life. The organisms participating in photosynthesis are producers in the ecosystem.

On the other hand there are consumers — e.g. bacteria, fungi and animals — which mainly feed on the producers' organic material. This transfer of organic substance from the producer to numerous consumers, taking place in several steps, is called a food chain. As a final link of this chain, organisms break down animal and plant substances into their inorganic constituents. These serve as food for the producers. Due to the transformation of organically bound energy from one component of a food chain to another, more and more energy is gradually lost. In contrast to this loss, the nutrient budget of the ecosystem largely remains unchanged. The nutrients are only transferred between living and non-living components.

GLOBAL CYCLES

Most of the exchange processes in the Earth system occur in the form of closed loops. While they constantly influence each other they obey certain natural laws. The major energy source for these processes is the sun, which enables the flow of matter through the system.

In the environment, energy can be in the form of radiation (solar or short-wave radiation and infrared or long-wave radiation), sensible heat (thermal energy), latent heat (heat released when water goes from the gas to the liquid or solid state), kinetic energy (energy of motion including winds, tides, and ocean currents), potential energy (stored energy), and chemical energy (energy absorbed or released during chemical reactions).

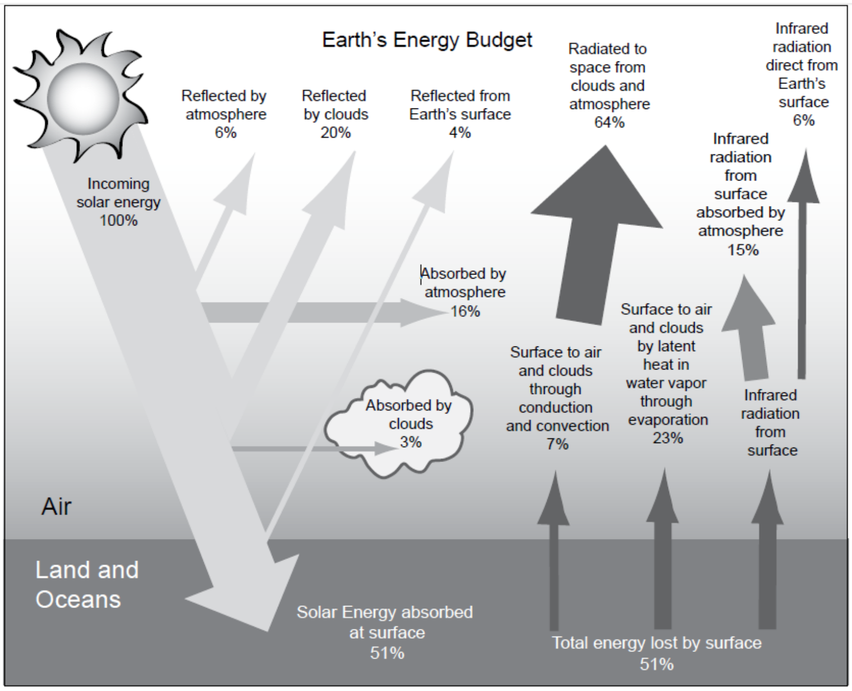


Figure: Schematic Diagram of the Earth's Energy Budget

The energy cycle is intertwined with the hydrologic cycle. Some of the energy in the sunlight reaching Earth's surface causes evaporation from surface water and soils. The atmosphere transports the resulting water vapor until it condenses in clouds, releasing the latent energy that evaporated the water. Water droplets and ice particles in clouds grow in size until they form precipitation, falling to the surface as rain, snow, sleet, or hail. Once the precipitation falls, the water can remain frozen on the surface to melt at a later time, evaporate again into the atmosphere, fill spaces in the soil, be taken up by plants, be consumed by animals, leach through the soil into groundwater, run off the land surface into rivers, streams, lakes and ultimately into the oceans or become part of a surface water body. Snow and ice reflect more sunlight back to space than ocean water or most other types of land cover, so the amount of snow or ice covering Earth's surface affects the energy cycle.

The major cycles that connect the different parts of the Earth are the energy cycle, the water cycle (hydrologic cycle, and the cycles of important individual elements (e.g., carbon, nitrogen). Each cycle is made up of reservoirs, places where energy, water, and elements are stored for a period of time (e.g., chemical energy, sea ice, oceans, carbon dioxide), fluxes, the movement of energy and matter from one reservoir to another (e.g., radiation, precipitation, transpiration, ocean currents, wind, river flow) and processes that change the form of energy, water, and elements (e.g., photosynthesis, condensation, fire).

Energy from the sun flows through the environment, heating the atmosphere, the oceans, and the land surface, and fueling most of the biosphere. Differences in the amount of energy absorbed in different places set the atmosphere and oceans in motion and help determine their overall temperature and chemical structure. These motions, such as wind patterns and ocean currents redistribute energy throughout the environment. Eventually the energy that began as sunshine (short-wave radiation) leaves the planet as Earth shine (light reflected by the atmosphere and surface back into space) and infrared radiation (heat, also called long wave radiation) emitted by all parts of the planet which reaches the top of the atmosphere. This flow of energy from the sun, through the environment, and back into space is a major connection in the Earth system; it defines Earth's climate.

The Water Cycle

In contrast to all other planets of the solar system Earth has water in great abundance and in all three states: gaseous, liquid and solid. By far the greatest share (97%) of the Earth's water is found in the oceans, 2% is bound as ice and the rest (1%) is accounted for by ground water, soil water, surface water, the atmosphere and the biosphere. This 3% of the total quantity consists mainly of fresh water. The fraction of water bound in ice caps depends strongly on the temperature of Earth; during the coldest stage of last ice age, the average sea level was about 120 m deeper than today, the water being bound in large ice shields. Rivers and lakes contain less than a thousandth of the total water on Earth, and the atmosphere only a very small fraction of that.

Although the atmosphere contains only a trace amount of the total water on Earth, it acts as an important pathway for transferring water from one reservoir to another. This is because the residence time of water in the atmosphere is quite small; on average a water molecule that is evaporated stays only about 10 days in the atmosphere before it precipitates again. Most of the water that evaporates precipitates over the ocean; only less than a third precipitates over land.

Water plays a crucial role in many global exchange processes. Carbon, nitrogen, phosphorus and oxygen are transported in the Earth system through the medium of water in liquid state. Knowledge of the magnitude and variability of the hydrological cycle is particularly important for understanding the Earth system. Even slight changes in the proportions of components in the water cycle can have considerable ecological consequences (e.g. flooding, drought and the processes of desertification). The hydrologic cycle is intimately coupled to the energy balance and the redistribution of heat, because evaporation and precipitation result in large amounts of heat being transferred.

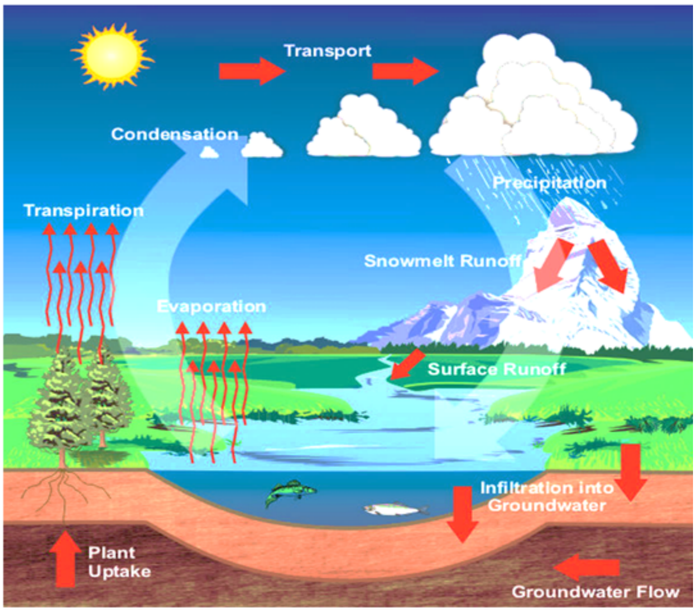


Figure: The water cycle of the Earth.

Water participates in a global cycle as vapor, liquid or ice. It evaporates into the atmosphere, where it is transported in the gaseous state following atmospheric circulation patterns. Later it condenses and falls as rain or snow on the Earth.

The Bio-geochemical Cycle

Each of the chemical elements undergoes chemical reactions, but the total amount of each on Earth remains essentially fixed. In this way, the environment consists of a set of cycles for water, carbon, nitrogen, phosphorous, etc. Since the cycles of the elements involve life, chemicals, and the solid Earth, they are collectively known as biogeochemical cycles.

An important issue of long-term climate variability and global changes are biological nutrient inventories and cycles: carbon, nitrogen, sulphur and phosphorus. These bio-geochemical cycles link the most important reservoirs of these elements: the hydrosphere, components of the solid Earth, the biosphere and the atmosphere. The processes which mainly drive these cycles include the constant oxidation of living and dead biomass by atmospheric oxygen. An important issue of long-term climate variability and global changes are biological nutrient inventories and cycles: carbon, nitrogen, sulphur and phosphorus. These bio-geochemical cycles link the most important reservoirs of these elements: the hydrosphere, components of the solid Earth, the biosphere and the atmosphere. The processes which mainly drive these cycles include the constant oxidation of living and dead biomass by atmospheric oxygen.

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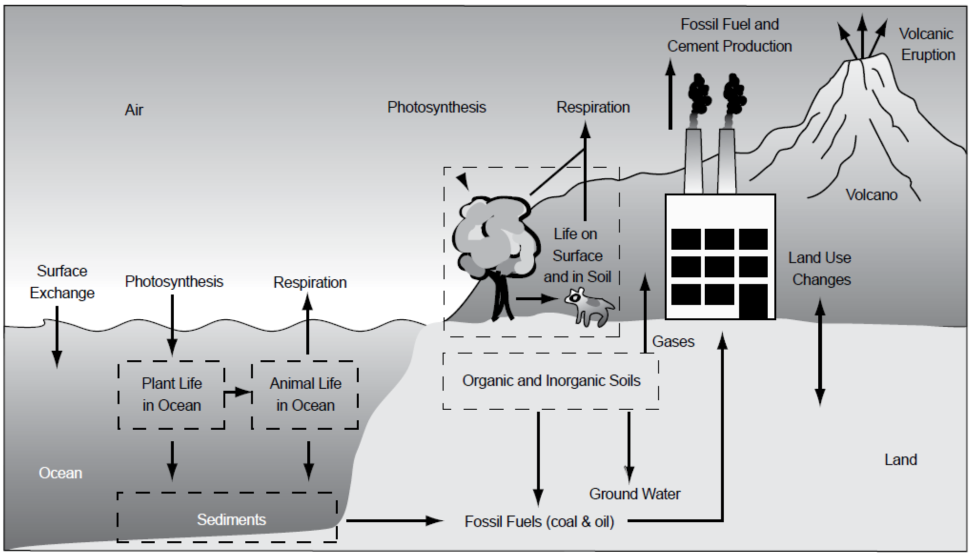


CLIMATE SYSTEM

The term ‘climate’ is used for long-term average weather conditions, conventionally taken over 30 years. At the same time, ‘climate’ denotes a specific state of equilibrium in the energy balance and global energy transports. The climate system is usually defined as consisting of the atmosphere, the ocean, and sea ice and ice sheets. Conditions of the land surface are prescribed, as well as all external forcing factors, as e.g. the greenhouse gas concentrations. It is a dynamic system which at most times is in a transient equilibrium. Changes in the climate system are forced through external impacts, e.g. changing carbon dioxide, volcano output, or the orbital parameters of the Earth, and through internal interactions. The solar power has increased by about 30% since its birth; the continents have changed over millions of years; Earth alters its orbit with prominent periods of 100,000, 41,000, 23,000 and 19,000 years; the contents of greenhouse gases has varied from years to billions of years.

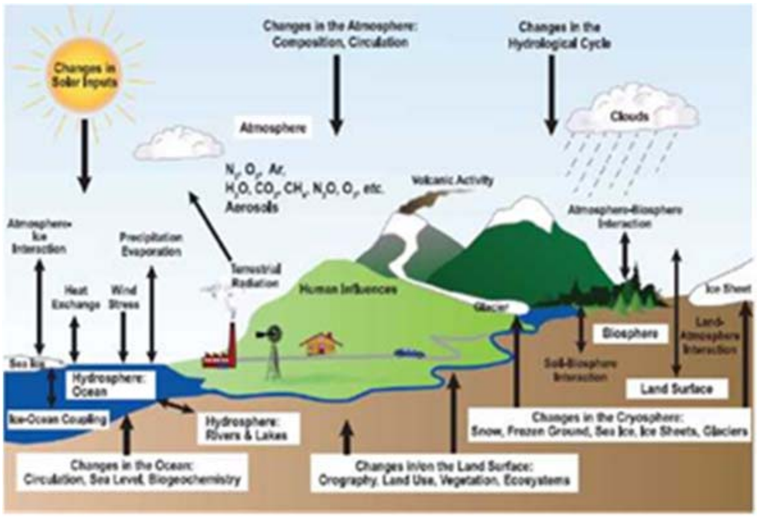


Figure: Schematic view of the components of the climate system, their processes and interactions.

Over the long term, the amount of incoming solar radiation absorbed by the Earth and atmosphere is balanced by the Earth and atmosphere releasing the same amount of outgoing long wave radiation. About half of the incoming solar radiation is absorbed by the Earth’s surface. This energy is transferred to the atmosphere by warming the air in contact with the surface (thermals), by evapotranspiration and by longwave radiation that is absorbed by clouds and greenhouse gases. The atmosphere in turn radiates longwave energy back to Earth as well as out to space.

CLIMATE CHANGE

Climate change is a phrase that is essentially self-explanatory, it is the change in the climate of a country, region, or the world over, and is believed to be caused either directly or indirectly by the activity of the human race.

The type of climate we experience now might be prevailing over the last 10,000 years with minor and occasionally wide fluctuations. The planet earth has witnessed many variations in climate since the beginning. Geological records show alteration of glacial and inter-glacial periods. The geomorphological features, especially in high altitudes and high latitudes, exhibit traces of advances and retreats of glaciers. The sediment deposits in glacial lakes also reveal the occurrence of warm and cold periods. The rings in the trees provide clues about wet and dry periods. Historical records describe the vagaries in climate. All these evidences indicate that *change in climate is a natural and continuous process.*

India also witnessed alternate wet and dry periods. Archaeological findings show that the Rajasthan desert experienced wet and cool climate around 8,000 B.C. The period 3,000- 1,700 B.C. had higher rainfall. From about 2,000-1,700 B.C., this region was the centre of the Harappan civilisation. Dry conditions accentuated since then.

Climate in the recent past

Variability in climate occurs all the time. The nineties decade of the last century witnessed extreme weather events. The 1990s recorded the warmest temperature of the century and some of the worst floods around the world. The worst devastating drought in the Sahel region, south of the Sahara desert, from 1967-1977 is one such variability. During the 1930s, severe drought occurred in southwestern Great Plains of the United States, described as the dust bowl. Historical records of crop yield or crop failures, of floods and migration of people tell about the effects of changing climate.

Causes of Climate Change

Climate refers to the long-term average of the aggregation of all components of weather—precipitation, temperature and cloudiness, for example. The climate system includes processes involving ocean, land and sea ice in addition to the atmosphere.

The Earth system encompasses the climate system. Many changes in Earth system functioning directly involve changes in climate. However, the Earth system includes other components and processes, biophysical and human those are important for its functioning. Some Earth system changes, natural or driven by humans, can have significant consequences without involving changes in climate. Global change should not be confused with climate change; it is significantly more, indeed, climate change is part of this much larger challenge.

The causes for climate change are many. They can be grouped into **astronomical and terrestrial causes**. The ***astronomical causes*** are the changes in solar output associated with sunspot activities. Sunspots are dark and cooler patches on the sun which increase and decrease in a cyclical manner. According to some meteorologists, when the number of sunspots increase, cooler and wetter weather and greater storminess occur. A decrease in sunspot numbers is associated with warm and drier conditions. Yet, these findings are not statistically significant.

An another astronomical theory is Millankovitch oscillations, which infer cycles in the variations in the earth's orbital characteristics around the sun, the wobbling of the earth and the changes in the earth's axial tilt. All these alter the amount of insolation received from the sun, which in turn, might have a bearing on the climate.

Climate Change – Inter relationships with earth subsystems

Geosphere

The global distribution of water and land at the Earth's surface significantly affects the circulations in the ocean and the atmosphere. Thus, plate tectonics contribute to the development of climate and to changes in global environment. Volcanic eruptions, even though local in origin, can affect the Earth system as a whole. They devastate wide areas of land and drastically change the habitat of flora, fauna and man, and — for climate purposes — the volcanic output reflects in the substance composition of the atmosphere. Submarine volcanoes create and destroy groups of islands. Some large volcanic events cause eruptions of volcanic ash reaching the stratosphere, where it remains for many years, substantially influencing the radiation balance of the Earth. Identification of volcanic ash of particular volcanic events in ice cores obtained in the Arctic and the Antarctic provide evidence for the worldwide distribution of volcanic ash in the atmosphere.

Volcanism is considered as another cause for climate change. Volcanic eruption throws up lots of aerosols into the atmosphere. These aerosols remain in the atmosphere for a considerable period of time reducing the sun's radiation reaching the Earth's surface. After the recent Pinatoba and El Cion volcanic eruptions, the average temperature of the earth fell to some extent for some years. The most important anthropogenic effect on the climate is the increasing trend in the concentration of greenhouse gases in the atmosphere which is likely to cause global warming.

Hydrosphere

It is generally accepted that the oceanic circulation has a profound influence on the mean state of the Earth's climate and on climate changes on decadal and longer time scales. Large-scale transports of heat and fresh water by ocean currents are key climate parameters. The stratification and circulation in the upper ocean is crucial for the penetration of heat and substances into the ocean.

The circulation is determined by the structure and strength of the wind systems, the regional distribution of precipitation patterns, and the heat exchange with the atmosphere. The shape of the sea floor, particularly the great deep-sea basins, also has a decisive influence on ocean current systems.

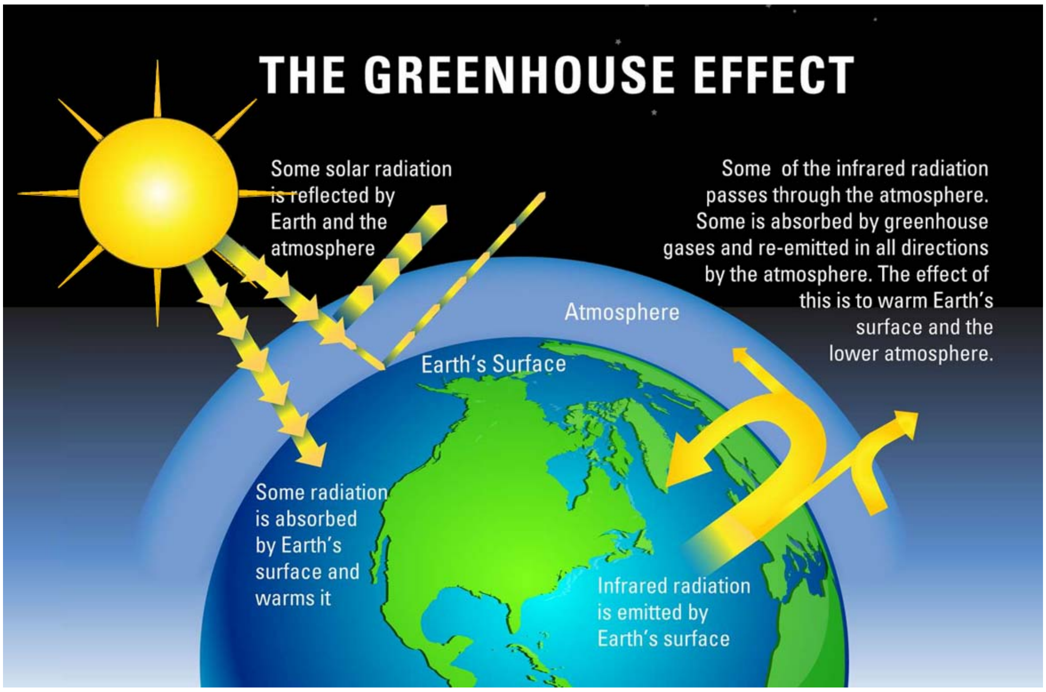
The World Ocean plays a twofold role in the Earth's climate system. On the one hand climate fluctuations are caused by long-term changes in the heat distribution of the ocean. On the other hand the thermal 'inertia' of the great water masses slows down climatic changes. The close link between ocean and atmosphere is also effective on shorter time scales. This is seen by the close correspondence between the surface temperature of the ocean and the air temperature close to the ground. The surface winds also strongly contribute to changes in the oceanic circulation and thus regional weather conditions.

Biosphere

The most important anthropogenic effect on the climate is the increasing trend in the concentration of greenhouse gases in the atmosphere which is likely to cause global warming.

GLOBAL WARMING

The continuous rise in temperature of the planet is really upsetting. The root cause for this is *global warming*. Global warming begins when sunlight reaches the Earth. The clouds, atmospheric particles, reflective ground surfaces and surface of oceans then sends back about 30 % of sunlight back into the space, whilst the remaining is absorbed by oceans, air and land. This consequently heats up the surface of the planet and atmosphere, making life feasible. As the Earth warms up, this solar energy is radiated by thermal radiation and infrared rays, propagating directly out to space thereby cooling the Earth.



However, some of the outgoing radiation is re-absorbed by carbon dioxide, water vapours, ozone, methane and other gases in the atmosphere and is radiated back to the surface of Earth. These gases are commonly known as *greenhouse gases* due to their heat-trapping capacity. It must be noted that this re-absorption process is actually good as the Earth's average surface temperature would be very cold if there was no existence of greenhouse gases.

The dilemma began when the concentration of greenhouse gases in the atmosphere was artificially increased by humankind at an alarming rate since the past two centuries. As of 2004, over 8 billion tons of carbon dioxide was pumped thermal radiation is further hindered by increased levels of greenhouse gases resulting in a phenomenon known as human enhanced global warming effect.

GREENHOUSE EFFECT

While other planets in the solar system of the Earth are either roasting hot or bitterly cold, Earth's surface has relatively mild, steady temperatures. Earth enjoys these temperatures because of its atmosphere, which is the thin layer of gases that cover and protect the planet.

However, 97 % of climate scientists and researchers agree that humans have changed the Earth's atmosphere in dramatic ways over the past two centuries, resulting in global warming. To understand global warming, it is first necessary to become familiar with the greenhouse effect. As Figure below depicts, the natural greenhouse effect normally traps some portion of heat in such a way that our planet is safe from reaching freezing temperatures while human enhanced greenhouse effect leads to global warming. This is due to burning of fossil fuels which increase the amount of greenhouse gases (carbon dioxide, methane and oxides of nitrogen) present in the atmosphere.

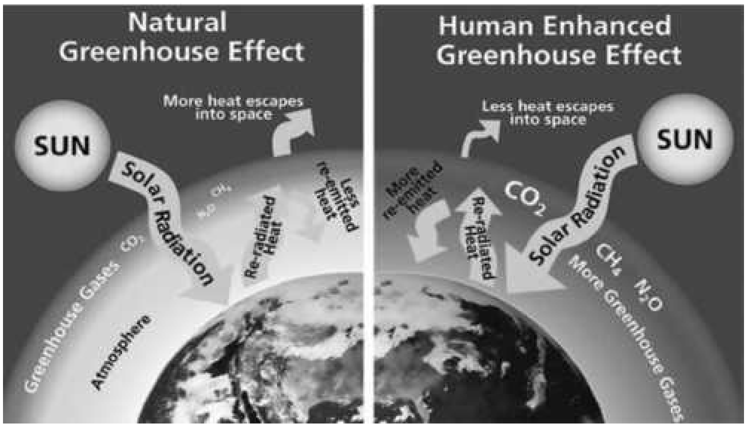


Figure: Types of greenhouse effects

Due to the presence of greenhouse gases, the atmosphere is behaving like a greenhouse. The atmosphere also transmits the incoming solar radiation but absorbs the vast majority of long wave radiation emitted upwards by the earth's surface. The gases that absorb long wave radiation are called greenhouse gases. The processes that warm the atmosphere are often collectively referred to as *the greenhouse effect.*

Greenhouse Gases (GHGs)

The primary GHGs of concern today are carbon dioxide (CO_2), Chlorofluorocarbons (CFCs), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). Some other gases such as nitric oxide (NO) and carbon monoxide (CO) easily react with GHGs and affect their concentration in the atmosphere.

The effectiveness of any given GHG molecule will depend on the magnitude of the increase in its concentration, its life time in the atmosphere and the wavelength of radiation that it absorbs. The chlorofluorocarbons (CFCs) are highly effective. Ozone which absorbs ultra violet radiation in the stratosphere is very effective in absorbing terrestrial radiation when it is present in the lower troposphere. Another important point to be noted is that the more time the GHG molecule remains in the atmosphere, the longer it will take for earth's atmospheric system to recover from any change brought about by the latter.

The largest concentration of GHGs in the atmosphere is carbon dioxide. The emission of CO_2 comes mainly from fossil fuel combustion (oil, gas and coal). Forests and oceans are the sinks for the carbon dioxide. Forests use CO_2 in their growth. So, deforestation due to changes in land use, also increases the concentration of CO_2. The time taken for atmospheric CO_2 to adjust to changes in sources to sinks is 20-50 years. It is rising at about 0.5 per cent annually. Doubling of concentration of CO_2 over pre-industrial level is used as an index for estimating the changes in climate in climatic models.

Chlorofluorocarbons (CFCs) are products of human activity. Ozone occurs in the stratosphere where ultra-violet rays convert oxygen into ozone. Thus, ultra violet rays do not reach the earth's surface. The CFCs which drift into the stratosphere destroy the ozone. Large depletion of ozone occurs over Antarctica. The depletion of ozone concentration in the stratosphere is called the ozone hole. This allows the ultra violet rays to pass through the troposphere.

Figure below shows pictorially the distribution of greenhouse gases. These gases are playing their negative part in increasing the havoc of global warming. They are continuously causing an increase in the earth's temperature.

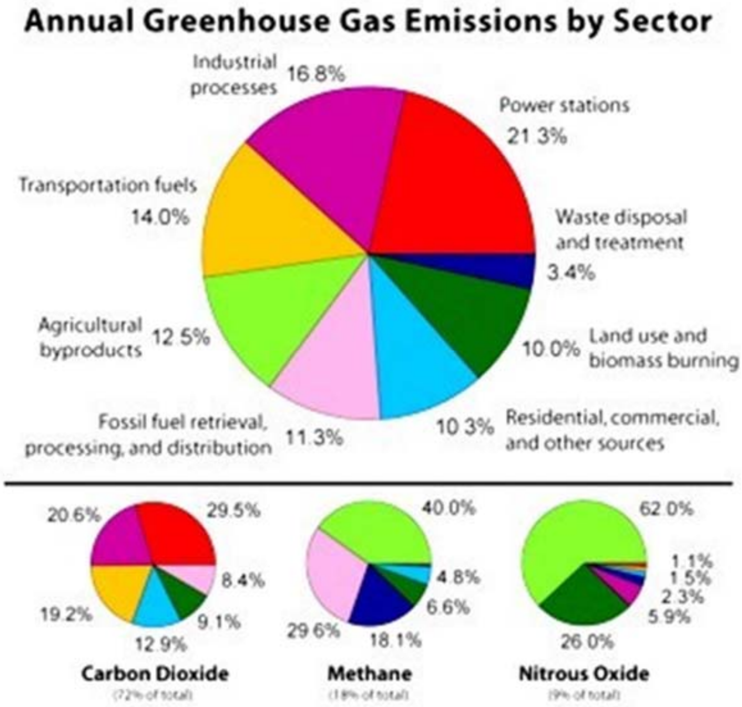


Figure: Distribution of greenhouse gases

CAUSES OF GLOBAL WARMING

The major cause of global warming is the greenhouse gases. They include carbon dioxide, methane, nitrous oxides and in some cases chlorine and bromine containing compounds. The build-up of these gases in the atmosphere changes the radiative equilibrium in the atmosphere. Their overall effect is to warm the Earth's surface and the lower atmosphere because greenhouse gases absorb some of the outgoing radiation of Earth and re-radiate it back towards the surface.

The second major cause of global warming is the depletion of ozone layer. This happens mainly due to the presence of chlorine- containing source gases. When ultraviolet light is present, these gases dissociate releasing chlorine atoms which then catalyses ozone destruction. Aerosols present in the atmosphere are also causing global warming by changing the climate in two different ways. Firstly, they scatter and absorb solar and infrared radiation and secondly, they may alter the microphysical and chemical properties of clouds and perhaps affect their lifetime and extent. The scattering of solar radiation acts to cool the planet, while absorption of solar radiation by aerosols warms the air directly instead of permitting sunlight to be absorbed by the surface of the Earth. The human contribution to the amount of aerosols in the atmosphere is of various forms. For instance, dust is a by-product of agriculture. Biomass burning generates a mixture of organic droplets and soot particles. Many industrial processes produce a wide diversity of aerosols depending on what is being burned or generated in the manufacturing process. Moreover, exhaust emissions from various sorts of transport produce a rich mixture of pollutants that are either aerosols from the outset or are transformed by chemical reactions in the atmosphere to form aerosols.

GLOBAL WARMING: THE EFFECTS

Predicting the consequences of global warming is one of the most difficult tasks faced by the climate researchers. This is due to the fact that natural processes that cause rain, snowfall, hailstorms, rise in sea levels is reliant on many diverse factors. Moreover, it is very hard to predict the size of emissions of greenhouse gases in the future years as this is determined majorly through technological advancements and political decisions. Global warming produces many negative effects some of which are described here. Firstly, extra water vapour which is present in the atmosphere falls again as rain which leads to floods in various regions of the world. When the weather turns warmer, evaporation process from both land and sea rises. This leads to drought in the regions where increased evaporation process is not compensated by increased precipitation. In some areas of the world, this will result in crop failure and famine particularly in areas where the temperatures are already high. The extra water vapour content in the atmosphere will fall again as extra rain hence causing flood. Towns and villages which are dependent on the melting water from snowy mountains may suffer drought and scarcity of water supply. It is because the glaciers all over the world are shrinking at a very rapid rate and melting of ice appears to be faster than previously projected. According to Intergovernmental Panel on Climate Change (IPCC), about one-sixth of the total population of the world lives in the regions which shall be - affected by a decrease in melting water. The warmer climate will likely cause more heat waves, more violent rainfall and also amplification in the severity of hailstorms and thunderstorms. Rising of sea levels is the most deadly effect of global warming, the rise in temperature is causing the ice and glaciers to melt rapidly. This will lead to rise of water levels in oceans, rivers and lakes that can pilot devastation in the form of floods.

Global warming can severely affect the health of living beings. Excess heat can cause stress which may lead to blood pressure and heart diseases. Crop failures and famines, which are a direct consequence of heating up of earth, can cause a decline in human body resistance to viruses and infections. Global warming may also transfer various diseases to other regions as people will shift from regions of higher temperatures to regions of comparatively lower temperatures. Warmer oceans and other surface waters may lead to severe cholera outbreaks and harmful infections in some types of sea food.

DISASTER

A disaster can be defined as "A serious disruption in the functioning of the community or a society causing wide spread material, economic, social or environmental losses which exceed the ability of the affected society to cope using its own resources".

The Disaster Management Act, 2005 defines disaster as "a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area".

The United Nations defines disaster as "the occurrence of sudden or major misfortune which disrupts the basic fabric and normal functioning of the society or community".

For a disaster to be entered into the database at least one of the following criteria must be fulfilled:

- Ten (10) or more people reported killed
- Hundred (100) or more people reported affected
- Declaration of a state of emergency
- Call for international assistance

A disaster is a result from the combination of hazard, vulnerability and insufficient capacity or measures to reduce the potential chances of risk. A disaster happens when a hazard impacts on the vulnerable population and causes damage, casualties and disruption.

HAZARD

Hazard may be defined as "a dangerous condition or event that threat or have the potential for causing injury to life or damage to property or the environment."

Hazards can be grouped into two broad categories namely natural and manmade.

1. Natural hazards are hazards which are caused because of natural phenomena (hazards with meteorological, geological or even biological origin). Examples of natural hazards are cyclones, tsunamis, earthquake and volcanic eruption which are exclusively of natural origin. Landslides, floods, drought, fires are socio-natural hazards since their causes are both natural and manmade. For example flooding may be caused because of heavy rains, landslide or blocking of drains

2. Manmade hazards are hazards which are due to human negligence. Manmade hazards are associated with industries or energy generation facilities and include explosions, leakage of toxic waste, pollution, dam failure, wars or civil strife etc. The list of hazards is very long. Many occur frequently while others take place occasionally. However, on the basis of their genesis, they can be categorized as follows

Geological Hazards

1. Earthquake 2. Tsunami 3. Volcanic eruption 4. Landslide 5. Dam burst 6. Mine Fire

Water & Climatic Hazards

1. Tropical Cyclone 2. Tornado and Hurricane 3. Floods 4. Drought 5. Hailstorm 6. Cloudburst 7. Landslide 8. Heat & Cold wave 9. Snow Avalanche 10. Sea erosion

Environmental Hazards:

1.Environmental pollutions 2. Deforestation 3. Desertification 4. Pest Infection

Biological Hazards:

1. Human / Animal Epidemics 2. Pest attacks 3. Food poisoning 4. Weapons of Mass Destruction

Chemical, Industrial and Nuclear Accidents

1. Chemical disasters 2. Industrial disasters 3. Oil spills/Fires 4. Nuclear

Accident related:

1. Boat / Road / Train accidents / air crash Rural / Urban fires Bomb /serial bomb blasts 2. Forest fires 3. Building collapse 4. Electric Accidents 5. Festival related disasters 6. Mine flooding

VULNERABILITY

Vulnerability may be defined as "The extent to which a community, structure, services or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrains or a disaster prone area."

Vulnerabilities can be categorized into physical and socio-economic vulnerability.

Physical Vulnerability: It is based on the physical condition of people and elements at risk, such as buildings, infrastructure etc; and their proximity, location and nature of the hazard. It also relates to the technical capability of building and structures to resist the forces acting upon them during a hazard event.

Socio-economic Vulnerability: The degree to which a population is affected by a hazard will not merely lie in the physical components of vulnerability but also on the socio- economic conditions. The socioeconomic condition of the people also determines the intensity of the impact. For example, people who are poor and living in the sea coast don't have the money to construct strong concrete houses. They are generally at risk and lose their shelters whenever there is strong wind or cyclone. Because of their poverty they too are not able to rebuild their houses

CAPACITY

Capacity can be defined as “resources, means and strengths which exist in households and communities and which enable them to cope with, withstand, prepare for, prevent, mitigate or quickly recover from a disaster”. People’s capacity can also be taken into account. Capacities could be:

Physical Capacity: Some people have skills, which enable them to find employment if they migrate, either temporarily or permanently.

Socio-economic Capacity: In most of the disasters, people suffer their greatest losses in the physical and materialistic manner. Rich people have the capacity to recover soon because of their wealth. Even when everything is destroyed they have the capacity to cope up with it.

Hazards are always prevalent, but the hazard becomes a disaster only when there is greater vulnerability and less of capacity to cope with it. In other words the frequency or likelihood of a hazard and the vulnerability of the community increases the risk of being severely affected

RISK

Risk is a “measure of the expected losses due to a hazard event occurring in a given area over a specific time period. Risk is a function of the probability of particular hazardous event and the losses each would cause.” The level of risk depends upon:

- Nature of the hazard
- Vulnerability of the elements which are affected
- Economic value of those elements

A community/locality is said to be at ‘risk’ when it is exposed to hazards and is likely to be adversely affected by its impact. Disaster risk management includes all measures which reduce disaster related losses of life, property or assets by either reducing the hazard or vulnerability of the elements at risk.

1. Preparedness

   Preparedness includes the formulation of viable emergency plans, the development of warning systems, the maintenance of inventories and the training of personnel. It may also embrace search and rescue measures as well as evacuation plans for areas that may be at risk from a recurring disaster. Preparedness therefore encompasses those measures taken before a disaster event which are aimed at minimizing loss of life, disruption of critical services, and damage when the disaster occurs.

2. Mitigation

   Mitigation embraces measures taken to reduce both the effect of the hazard and the vulnerable conditions to it in order to reduce the scale of a future disaster. Therefore, mitigation activities can be focused on the hazard itself or the elements exposed to the threat. Examples of mitigation measures which are hazard specific include water management in drought prone areas, relocating people away from the hazard prone areas and by strengthening structures to reduce damage when a hazard occurs. In addition to these physical measures, mitigation should also aim at reducing the economic and social vulnerabilities of potential disasters.

EXPOSURE

The presence and number of people, property, livelihoods, systems or other elements in hazard areas (and so thereby subject to potential losses) is known as exposure. Exposure is one of the defining components of disaster risk

If a hazard occurs in an area of no exposure, then there is no risk. The extent to which exposed people or economic assets are actually at risk is generally determined by how vulnerable they are,it is possible to be exposed but not vulnerable.

EMERGENCY

Emergency is a disruption of the functioning of society, causing human, material or environmental damages and losses which do not exceed the ability of the affected society to cope using only its own resources.

Emergency is a situation in which normal operations cannot continue and immediate action is required so as to prevent a disaster Example – forest fire, oil spills, road accidents, outbreak of epidemics etc.

When an emergency or a disaster affect a city or a region, efforts are conducted initially to care for the wounded, to restore lifelines and basic services, and subsequently to restore livelihoods and to reconstruct communities. Such efforts can be structured in three phases:

Response phase, where activities such as search & rescue, rapid damage and needs assessments, and the provision of first aid are conducted; followed by the opening and management of temporary shelters for those left homeless as well as the provision of humanitarian assistance to those affected;

Rehabilitation phase where basic services and lifelines are restored, even on a temporary basis, including the road network and other essential facilities including bridges, airports, ports and helicopter landing sites;

Recovery phase where reconstruction efforts are carried out on the basis of a more precise assessment of damage and destruction of infrastructure. In addition, efforts are conducted to reconstruct infrastructure when needed and to restore the livelihoods of those affected

CRISIS

It is any event that is going (or is expected) to lead to an unstable and dangerous situation affecting an individual, group, community, or whole society. Crisis is a smaller version which may degenerate in to a disaster if not properly managed. Crisis develops over time and disaster is sudden

RESILIENCE

Disaster Resilience is the ability of individuals, communities, organizations and states to adapt to and recover from hazards, shocks or stresses without compromising long-term prospects for development. According to the Hyogo Framework for Action (UNISDR, 2005), disaster resilience is determined by the degree to which individuals, communities and public and private organizations are capable of organizing themselves to learn from past disasters and reduce their risks to future ones, at international, regional, national and local levels.

Disaster resilience is part of the broader concept of resilience – 'the ability of individuals, communities and states and their institutions to absorb and recover from shocks, whilst positively adapting and transforming their structures and means for living in the face of long-term changes and uncertainty

Disaster risk assessment

A qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend.

Disaster risk assessments include: the identification of hazards; a review of the technical characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability, including the physical, social, health, environmental and economic dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities with respect to likely risk scenarios.

Risk Mapping

Risk mapping is a process of analyzing the hazard, vulnerability and capacity through a scientific methodology. The process of risk map preparation includes analysis of several variables and parameters which are sub-sets of base categories; hazard, vulnerability and capacity. Hence, preparation of multi hazard risk map is a combination of all risk elements on several hazards. This process is important in risk map preparation and obviously in disaster management field for appropriate implementation of disaster risk reduction activities.

One of the key actions that can be associated with Disaster Risk Reduction (DRR) map will be re organising of urban spaces to strengthen urban morphology with appropriate spaces and several disaster management elements. The risk mapping technology will bridge the gap currently existing in urban settlement for hazard mapping. This mapping technology will allow the decision makers to carry out their work more rationally, by adopting a more scientific process than what is currently used; a mapping technology that is used for DRR in urban settlements.

Disaster Risk Reduction

Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts to analyse and reduce the causal factors of disasters. Reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness for adverse events are all examples of disaster risk reduction.

Disaster risk reduction includes disciplines like disaster management, disaster mitigation and disaster preparedness, but DRR is also part of sustainable development. In order for development activities to be sustainable they must also reduce disaster risk. On the other hand, unsound development policies will increase disaster risk - and disaster losses. Thus, DRR involves every part of society, every part of government, and every part of the professional and private sector

Disaster risk management

Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses

Disaster risk management plans set out the goals and specific objectives for reducing disaster risks together with related actions to accomplish these objectives. National-level plans need to be specific to each level of administrative responsibility and adapted to the different social and geographical circumstances that are present. The time frame and responsibilities for implementation and the sources of funding should be specified in the plan. Linkages to sustainable development and climate change adaptation plans should be made where possible.

Early Warning Systems

Early warning system is an adaptive measure for climate change, using integrated communication systems to help communities prepare for hazardous climate-related events. A successful EWS saves lives and jobs, land and infrastructures and supports long-term sustainability. Early warning systems will assist public officials and administrators in their planning, saving money in the long run and protecting economies.

Disaster Preparedness

Preparedness constitutes the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions. Preparedness action is carried out within the context of disaster risk management and aims to build the capacities needed to efficiently manage all types of emergencies and achieve orderly transitions from response through to sustained recovery. Preparedness is based on a sound analysis of disaster risks and good linkages with early warning systems, and includes such activities as contingency planning, stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. These must be supported by formal institutional, legal and budgetary capacities.

Disaster Prevention

Disaster prevention is the outright avoidance of adverse impacts of hazards and related disasters prevention (i.e. disaster prevention) expresses the concept and intention to completely avoid potential adverse impacts through action taken in advance. Examples include dams or embankments that eliminate flood risks, land-use regulations that do not permit any settlement in high risk zones, and seismic engineering designs that ensure the survival and function of a critical building in any likely earthquake. Very often the complete avoidance of losses is not feasible and the task transforms to that of mitigation. Partly for this reason, the terms prevention and mitigation are sometimes used interchangeably in casual use.

Disaster Mitigation

Disaster mitigation measures are those that eliminate or reduce the impacts and risks of hazards through proactive measures taken before an emergency or disaster occurs. Mitigation means the lessening or limitation of the adverse impacts of hazards and related disasters. The adverse impacts of hazards often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures encompass engineering techniques and hazard-resistant construction as well as improved environmental policies and public awareness. It should be noted that in climate change policy, "mitigation" is defined differently, being the term used for the reduction of greenhouse gas emissions that are the source of climate change.

Disaster response

Disaster response is the second phase of the disaster management cycle. It consists of a number of elements, for example; warning/evacuation, search and rescue, providing immediate assistance, assessing damage, continuing assistance and the immediate restoration or construction of infrastructure (i.e. provisional storm drains or diversion dams). The aim of emergency response is to provide immediate assistance to maintain life, improve health and support the morale of the affected population. Such assistance may range from providing specific but limited aid, such as assisting refugees with transport, temporary shelter, and food, to establishing semi-permanent settlement in camps and other locations. It also may involve initial repairs to damaged or diversion to infrastructure.

The focus in the response phase is on putting people safe, prevent next disasters and meeting the basic needs of the people until more permanent and sustainable solutions can be found. The main responsibility to address these needs and respond to a disaster lies with the government or governments in whose territory the disaster has occurred. In addition, humanitarian organisations are often strongly present in this phase of the disaster management cycle, particularly in countries where the government lacks the resources to respond adequately to the needs.

Damage assessment

Damage assessment is an important tool for retrospective and prospective analysis of disasters to assimilate the extent of impact of a disaster. This forms the basis for future disaster preparedness and preventive planning. It is essential in determining: what happened, what the effects were, which areas were hardest hit, what situations must be given priority and what types of assistance are needed, for example, Local, State, or Union? Emergency response can be more effective, equipment and personnel can be better used, and help can be provided quicker if a thorough damage assessment is performed beforehand. The basic objectives of damage assessment could be summarised as follows:

- To make a rapid assessment of areas affected to know the extent of impact for purpose of immediate rescue and relief operations;
- To prepare estimates for the amount of relief to be provided and the mode of relief, be it food, clothing, medicines, shelter or other essential commodities;
- To make a detailed assessment regarding requirements for long-term relief and rehabilitation planning; and
- To identify focus areas for the purpose of ‘retrofitting’ actions in similar future situations.

Damage Assessment is therefore a prerequisite for effective disaster response effort. For effective decisions, officials responsible for organising post-disaster relief operations should be properly informed of the damage/possible damage should the event repeat itself some time in the future, so that they can know the needs, current, as well as prospective, in precise terms. They must have appropriate and timely information about: what happened, what needs to be done, and what resources are available? Their decisions can save lives; minimise injury, damage and loss; prevent any further escalation; prevent secondary hazards and inform people who need to know. Well-organised response will also help in building confidence and enhancing the credibility of the administration

Crisis counseling

At different points in life most people experience some kind of crisis. A crisis is defined as a situation or event in which a person feels overwhelmed or has difficulty coping. A crisis might be caused by an event such as the death of a family member, the loss of a job, or the ending of a relationship. During such times people experience a wide range of feelings, and each person's response to a crisis is different. It is normal to feel frightened, anxious, or depressed at such a time.

Crisis counseling involves providing support and guidance to an individual or a group of people such as a family or community during a crisis. The purpose of crisis counseling is to decrease emotional pain, provide emotional support, make sure that the person in crisis is safe, and help develop a plan for coping with the situation. Sometimes it also involves connecting a person to other community or health services that can provide long-term support.

Crisis counseling can be linked to health education if it is used to increase knowledge of how to avoid or cope with a crisis in the future. It can also be used to change people's attitudes and beliefs about people in crisis, and to provide people with information about help available in their community. Public health professionals, for example, might educate a community on how to cope with a natural disaster such as a hurricane or an earthquake.

Crisis counseling is also related to health promotion. People can be taught useful skills that will help them to anticipate and cope with a crisis. Skills, information, and support services gained through crisis counseling can also help a person or a group of people to improve their health and quality of life. Crisis counseling can also be tied to health promotion through the development of health-related public policy and supportive environments. For example, public health professionals might create a policy to build crisis counseling centers or to develop a peer counseling program in high schools or colleges.

Needs Assessment

A rapid needs assessment involves carrying out primary and secondary research quickly to gain an understanding of key information that can steer program design and implementation. Primary research is firsthand data, gathered through the direct investigation of a topic or situation of interest. Secondary research is information that is already available about an issue such as studies, reports, peer-reviewed journal articles, gray literature and other documents. Both are recommended in emergency situations. Although rapid, the needs assessment conducted during the emergency phase requires nonetheless a systematic approach to the collection and study of data, findings and contextual information to understand the issue being addressed.

A rapid needs assessment can give insights and understanding about a range of factors that affect behaviors related to the emergency and about how to best support the population to reduce their risk. Dedicating even just a few days to a needs assessment is important to obtain information about how households and communities perceive a potential or existing emergency, what they know and do about it, what barriers and facilitators exist to the adoption of protective behaviors, and how cultural and social dynamics influence them. Equipped with this knowledge, program managers and implementers can develop targeted interventions to support the success of all response efforts.