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WMA 202 : INTRODUCTION TO CLIMATOLOGY AND BIOGEOGRAPHY

Definition of climatology

Climatology is the scientific study of climate. The Climate of a place can be defined as the average weather conditions obtained through the synthesis of weather elements prevailing there for over a period of 30-35 years. The weather, on the other hand, is defined by the atmospheric condition of a place or a given location at a particular time. The weather elements at a particular place and time are sunshine, temperature, pressure, precipitation, humidity, evaporation, wind conditions etc Thus climatologists seeks the understanding of how the world's climate system works, how it varies from time to time and space to space, and any use that can be made of resources provided by climate.

Weather and climate are explained by the same element in combination but weather and climate are not one the same. The climate pertains to an area and a long period of time while weather pertains to a place and at a particular time. In other words weather is an instantaneous condition of the atmosphere and it keeps changing all the time but the climate of an area is fairly constant over a period of time.

Weather and Climate

Weather and climate are the two major physical components of the atmosphere that are closely related. Therefore in order to place the atmosphere within the scale of our understanding and also to have a better picture of the effects of its dynamic characteristics on the components of the terrestrial ecosystems, we need to study weather and climate more closely.

Weather

Weather is the atmospheric condition of a place or a given location at a particular time or for a short time and can be described in terms of the various elements such as sunshine, temperature, pressure, precipitation, fog/visibility, and humidity, evaporation, and wind conditions. Weather keeps changing all the time and the time-scale of such changes could

vary from minute to minute hour to hour and day to day. Weather deals with specific and changing event at a given point in time and at a specific location. For instance a period of bright sunshine can within few minutes change to one of complete cloud cover. Also after a heavy downpour of rain a bright sunshine may emerge. It is these sorts of changes in the atmosphere we call weather

Climate

The word “climate” indicates a broad generalization of weather conditions. The Climate of a place is therefore the average weather conditions obtained through the synthesis of weather elements prevailing there for over a period of 30-35 years. Thus climate pertains to an area and a long period of time of repeated observation of climatic elements in that area. It is important to note that climate of an area is fairly constant over a period of time and it is the constancy of the occurrence of a dominant weather element over an area for a long period or time that characterizes the climate of that area. Thus the nature of climate is indicated by the same elements used to express weather condition. But from the earlier observation weather and climate are not identical.

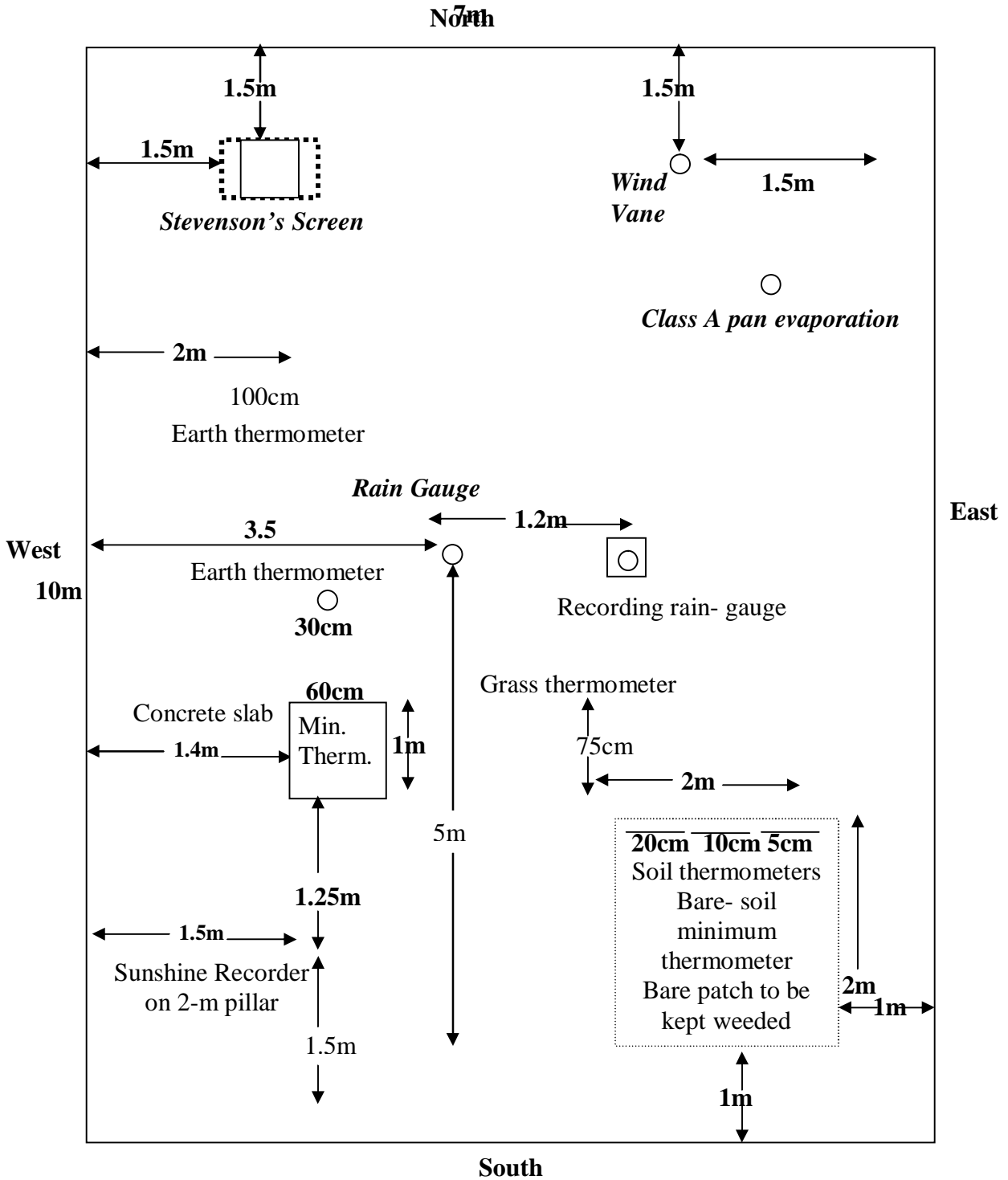
Weather and Climate Compared

Weather and climate are explained by the same element in combination but weather and climate are not one and the same. Climate of a place can be defined as the average weather conditions obtained through the synthesis of weather elements prevailing there for over a period of 30-35 years. The weather, on the other hand, is defined by the atmospheric condition of a place or a given location at a particular time. Thus climate pertains to an area and a long period of time while weather pertains to a particular place and at a specific time or for a short time. Weather keeps changing all the time and the time-scale of such changes could vary from minute to minute hour to hour and day to day. Generally the time scale of the variability in weather is considerably shorter than that of climate. The meteorologist studies weather conditions of the atmosphere by making use of the laws of classical physics and mathematical techniques.

Layout of a weather station

The layout of a conventional weather station is shown below. It is possible to

up grade a conventional weather station to an automatic weather observing station



The Atmosphere

The term atmosphere refers to the gaseous envelope surrounding the earth. The atmosphere is believed to have developed some millions of years ago and it is still maintaining its present form and composition as a result of chemical and photochemical processes combined with differential escape rates from the earth's gravitational field. Composed of a mixture of various gases, water vapour, and aerosols, the atmosphere is held to the earth by the gravitational attraction of the earth and it is densest at the sea level and thins rapidly upwards. Generally the atmosphere is highly oxidized and contains very little hydrogen. The most important constituents of the air in the earth's atmosphere are nitrogen and oxygen. The atmosphere helps to shield and protect all life forms from the harmful radiation from the sun and its gaseous content sustains plants and animals.

Composition of the Atmosphere

The average composition of the atmosphere is presented in Table 1 below.

Although some of the gases like water vapour and ozone are highly variable, the atmosphere is well mixed and is constant in composition in the lower layer referred to as the homosphere. At the higher levels, the Heterosphere, there is little mixing and so, diffusive separation tends to take place up to about 100km. Generally the composition of the atmosphere changes with the height above the sea level. Water vapour is limited to 10-12km while at higher levels oxygen and minor constituents such as carbon dioxide are dissociated by solar ultraviolet radiation.

The non-gaseous constituents are concentrated in the lower layer of the atmosphere.

The non-gaseous constituents are the aerosols such as the particles of dust, smoke, organic matter, sea salt and the by-products of fire and industry such as carbon, sulphur dioxide, carbon monoxide and lead. The aerosols are so light that even minor movements in air can sustain them. Dust, salt, carbon, sulphur, lead and aluminum compounds are the most abundant in the aerosols.

Table 1 The Composition of the Atmosphere.

Costituent	Chemical formula	Volume (%) dry air
Nitrogen	N ₂	78.08
Oxygen	O ₂	20.95
Argon	Ar	0.93
Carbon dioxide	CO ₂	0.03 (highly variable)
Water Vapour	H ₂ O	Highly variable
Ozone	O ₃	0.02-10ppmv
Neon	Ne	18ppmv
Helium	He	5ppmv
Hydrogen	H ₂	0.5ppmv
Krypton	Kr	1ppmv
Xenon	Xe	0.08ppmv
Methane	CH ₄	2ppmv
Nitrous oxide	N ₂ O	0.3ppmv
Ammonia	NH ₃	4ppb
Nitrogen dioxide	NO ₂	1ppbv
Sulphur dioxide	SO ₂	1ppbv
Hydrogen sulphide	H ₂ S	0.05ppbv

ppmv and ppbv are parts per million and parts per billion by volume respectively

The Layered structure of the Atmosphere

In general, the atmosphere can be divided into a total of four layers. They are the Troposphere, Stratosphere, Mesosphere, and the thermosphere which can be further subdivided into ionosphere and exosphere. Three of these layers are relatively warm layers (these are the layers near the surface; between 50 and 60 km: and above about 120 km) and the remaining two that separate the warmer layers are the relatively cold layers (between 10 and 30 km, and around 80 km). Figure 1.2 shows the arrangement of these layers in the atmosphere.

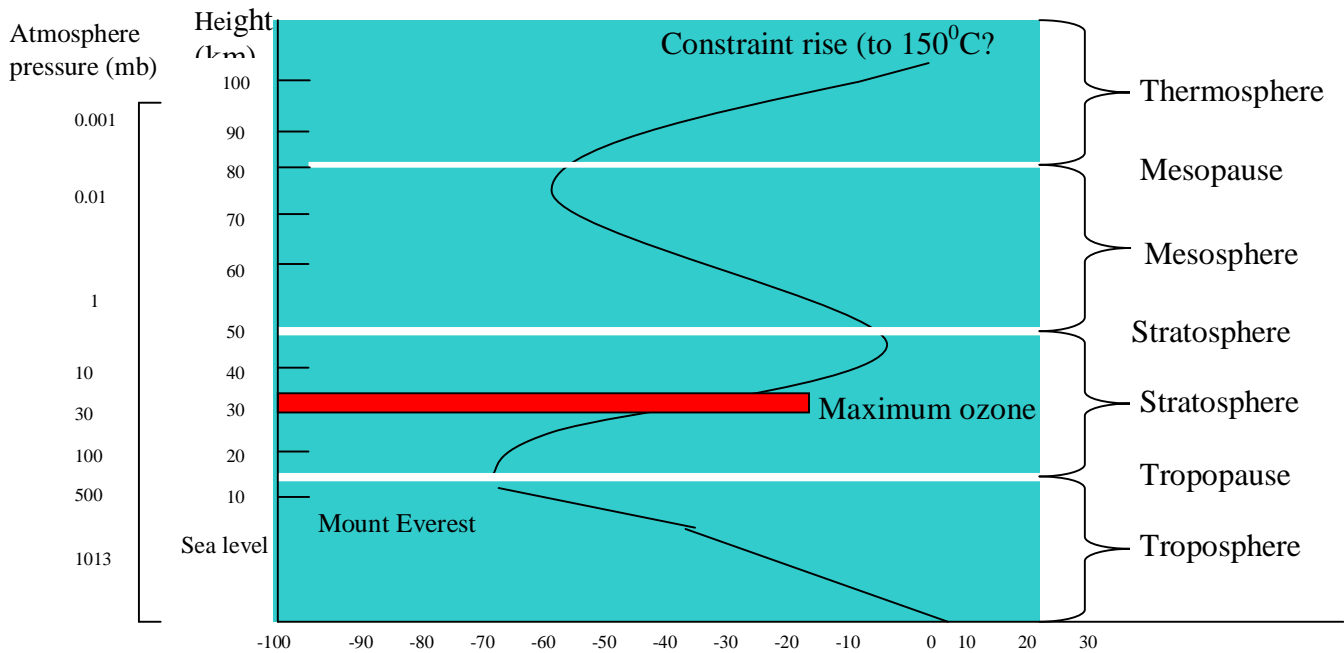


Fig.1 Layered structure of the atmosphere

Principles and Concept of Biogeography

Biogeography deals with the geographical aspects of the distribution of plants (phytogeography) and animal (zoogeography) life. The geographical distribution of plants is referred to as phytogeography, while the distribution of animals is referred to as zoogeography. Biogeography also provides explanation of the factors responsible for the distribution of plants and animals using the scientific principles of environmental studies. From this preamble, From this preamble, biogeography is defined as the study of distribution of plants and animals including microorganisms together with the geographical relationship with their environment

Biogeography includes the study of all components of the physical environments that constitutes habitat or various species and organisms. Biogeography focuses on the Biological and Geographical components of the environment. Therefore biogeography as a subject is both biological and geographical. This is because it studies the spatial distribution of plants and animals and the biological process taking place in nature. Furthermore it tries to explain the biological factors of distribution and the implication of

the pattern of distribution. Biogeography also studies the biotic complex of the environment. Biotic complex is the interacting complex of soil, plants, animals and the interaction of plants and animals with climate

Rationale for studying both Climatology and Biogeography

In recent years climate change and variability have become more obvious than ever before. There is therefore no doubt that the global climate change and the vulnerability of the bio-physical environment to the various climate-related hazards have significant implications to the components of terrestrial and aquatic ecosystems. It is therefore becomes necessary to treat the environmental problems holistically. In other words problem solving in environmental issues has to adopt both interdisciplinary and multidisciplinary approach. Therefore this course titled climatology and biogeography will consider the characteristics of the environment and examined the influence of atmospheric processes particularly the climate on the biotic and abiotic components of the terrestrial and aquatic ecosystems. Generally climatic elements have significant influence on the ecological parameters studied in biogeography.

The Climatic Elements

The climatic elements that have been considered in this course are solar radiation, precipitation, temperature, and other hydrothermal variables that have direct and indirect influence on the components of the aquatic and terrestrial ecosystem

Solar Radiation.

Solar radiation is the radiation from the sun. Solar radiation is the primary source of energy in to the terrestrial ecosystems Solar radiation from the sun is referred to as the incoming shortwave electromagnetic radiation

Interaction of the solar radiation with the atmosphere

The top of the earth's atmosphere receives about 4.5×10^{10} of the energy output from the centre of the sun (Photosphere). The amount is usually expressed in terms of the solar constant. Although numerous observations of the solar constant have been made, its value is not precisely known. The current best estimate is 1370 W m^{-2} .

Not all the solar energy that penetrates into the atmosphere that really gets to the earth surface. As solar energy impinges upon the top of the Earth's atmosphere a sort of energy cascade begins. For instance as solar radiation starts to pass down from the atmosphere, scattering and absorption of the radiation commences. Ozone absorbs all ultraviolet radiation below $0.29\mu\text{m}$ and water vapour a less amount ranging from $0.9\mu\text{m}$ to $2.1\mu\text{m}$. On the average about 20% of the incident solar energy is absorbed by ozone, water vapour and aerosols. Absorption by ozone is about 3%, and by water vapour and aerosols is 17%. From satellite data 30% of the incident solar energy are reflected back to space as reflection by cloud tops (20%) earth surface (4%) and scattering by air (6%). by cloud. Eventually only about 45% reach the earth's surface.

Solar radiation at the Earth's surface

The final interaction as the solar radiation passes through the atmosphere is with the surface of the earth. Radiation incident on the earth's surface is either absorbed or reflected. Usually a small amount is absorbed by the earth surface while the remaining is given off as the terrestrial long wave radiation. Carbon dioxide and water vapour in the atmosphere are able to absorb long wave radiation and thereby producing the radiation blanket over the earth's surface.

However the amount of incident energy that is reflected by the earth's surface back into the atmosphere depends on the reflective capacity of the receiving surface. Reflectivity of the short wave radiation at the earth's surface is referred to as the albedo (∞). Typical values of albedo and emissivities of common surface types (Table 4.1), show that most natural land surfaces have albedos between 0.10 and 0.25

Distribution of solar radiation

Solar radiation is unequally distributed over the earth. The unequal distribution of radiation is the primary cause of weather and climate. Not only does the distribution of solar energy control climate but it is itself a vital element of climate. It is directly responsible for photosynthesis and the varying lengths of day and night, have a major effect on the growth of plants. It also plays an important role in influencing evapotranspiration (i.e water loss) and therefore the water requirements of plants.

Furthermore, human comfort, and to some degree his health, is dependent on the duration and intensity of sunlight.

Generally the amount of energy received by the earth and its atmosphere in the form of insolation varies over space and time. Amount of insolation received by the earth, assuming no interference by the atmosphere, is influenced by the following four factors:

- Solar constant
- Altitude of the sun
- Distance from the sun
- Length of the day

Precipitation

Precipitation is the deposition of moisture on the earth surface. Precipitation may occur in the form of rainfall, Dew, snowfall, hail or sleet. Rainfall is the most common form of precipitation in the tropical regions. *Rainfall* occurs when the dew point of the air in which condensation is taking place is above the freezing point and the water vapour is converted into drops of water. However, if the dew point of the condensing air is below the freezing point, it leads to conversion of water vapour into small crystals of ice and the resulting precipitation is in the form of *snowfall*. Snow is the major form of precipitation in the temperate region.

Types of Precipitation – Convective, Orographic, Cyclonic and Frontal

The four types of precipitation are
convective,
orographic,
cyclonic and
the frontal..

Formation of Rain

Before rain can fall there must be water vapour, the condensation of the water vapour and there must be cloud. But in some cases cloudiness may not guarantee that rain will fall. But generally, cloudiness is a major factor indicating the probability of the

occurrence of rain.. Clouds are formed through the process of condensation and condensation, on the other hand, is the process by which water vapour in the atmosphere is changed into water droplets. This occurs when the temperature of the rising parcel of air falls below 0°C or when it cools until it is saturated. There must be cooling of a rising parcel of air for condensation to take place.

The cooling of a rising parcel of air may be achieved through the following mechanisms

- i. *Radiation (or contact) cooling*
- ii. *Advection cooling*
- iii. *Convective or Adiabatic cooling*
- iv. *Orographic and frontal uplift.*

Forms of Condensation – Clouds, Fog, Mist, Haze and Frost

The major form of condensation is the clouds while the minor ones are the fogs, mist, haze, dew and frost.

Table 2 Classification of Clouds

Group	Height (upper and lower level)	Types of Clouds
High Clouds	6000-12000 meters	Cirrus(Ci) Cirrocumulus (Cc) Cirrostratus (Cs)
Medium Clouds	2000-6000meters	Alto cumulus (Ac) Altostratus (As)
Low Clouds	Ground level-2000meters	Stratocumulus (Sc) Stratus (St) Nimbostratus (Ns) Cumulus (Cu) Cumulonimbus(Cb)

Simple Process of Cloud Formation

Once the surface layer of the atmosphere is heated, the air becomes warm and rises. The rising or ascending air is referred to as convection current. The convection current carries heat and as it rises, cooler air is drawn in from below and this leads to cloud formation. Four conditions have been identified as necessary for the production of rainfall.

- i. The mechanism to produce cooling of the air
- ii. The mechanism to produce condensation
- iii. The mechanism to produce growth of cloud droplets
- iv. The mechanism to produce accumulation of moisture of sufficient intensity to account for the observed rate of rainfall. The simultaneous occurrence of all these mechanisms is sufficient condition for heavy rainfall

Temperature

Temperature is a measure of heat in the body, be it the atmosphere or the earth or some living being. However, here the term temperature refers to the heat in the lower part of the atmosphere and on the surface of the earth. It is one of the vital controls of life on earth. Temperature is the direct result of the energy received by the earth from the sun.

Factors influencing the distribution of temperature

Effect of Clouds

Greenhouse Effect

Effect of Land and Sea

Aspects

Elevation

Lapse rate and Temperature Inversion

Lapse Rate

The atmosphere gets most of the heat energy from the ground in the form of terrestrial radiation therefore the lower parts of the atmosphere are heated more than the upper part.

The average rate of fall of temperature with height in the troposphere is about 6.5 degree per km of ascent. This is called the *normal lapse rate*.

Inversion of Temperature

Phenomenon of temperature inversion is one of the anomalies sometimes observed in the vertical distribution of temperature. The *inversion of temperature* refers to a condition of temperature increasing with increasing height in the atmosphere. Certain processes in the lower atmosphere may cause an actual increase in the temperature with increasing height and five major causes of inversion may include:

- Radiation Inversion
- Drainage Inversion
- Frontal Inversion
- Advection Inversion
- Subsidence Inversion

Radiation Balance

The average receipt of solar radiation over the earth is about 340 WM^{-2} and is balanced by a similar long wave radiation LW flux to space.

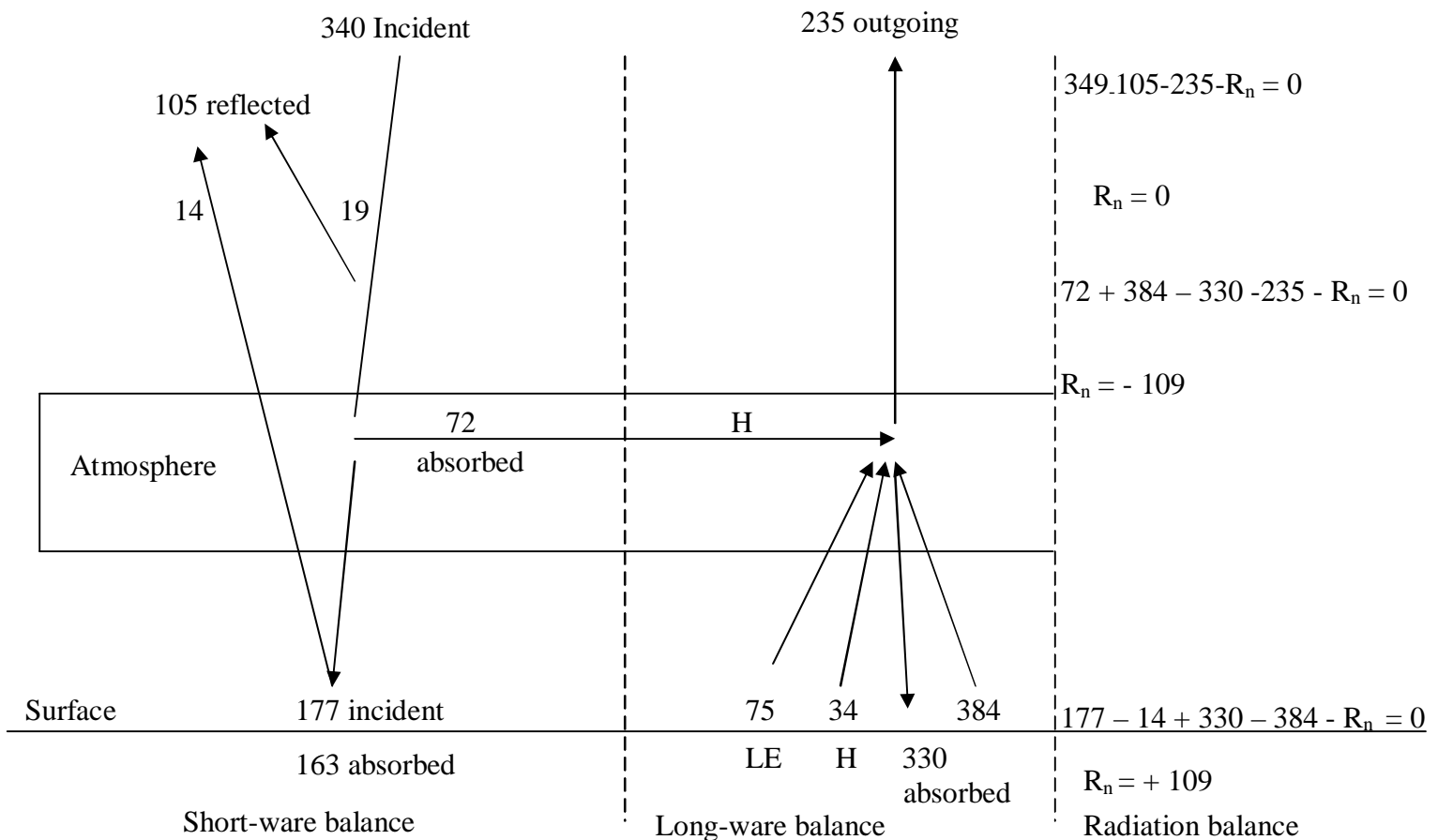
The atmosphere is relatively transparent to SW radiation but it is almost opaque to LW radiation from earth due to strong absorption by water evaporation other gasses. The max for terrestrial radiation is near $9.6 \mu\text{m}$, however, and an atmosphere with to LW radiation exists at $8-14 \mu\text{m}$. This radiation is an input route for LW Loss to space.

The roles of CO_2 , water vapour, other gasses and clouds in maintains a warm earth are referred to as the GREENHOUSE

Radiation Balance and Heat Budget

The equilibrium condition which exists in average terms between radiation received from the sun (insolation) by the earth and the atmosphere and that re-radiated or reflected is

referred to as the heat balance. The term radiation or heat budget refers to the accounting of the radiant/heat energy received by the earth and its atmosphere from the sun. In the long run, the amount of heat energy lost by the earth to space equals the amount of energy received by it from the sun. Thus the earth retains no energy. If the earth does not lose to space energy equal to that received from the sun, the temperature of the earth and its atmosphere will rise to an unbearable level. The figure below shows the global average short-wave and long-wave radiation fluxes and balances



At the top of the atmosphere $340 - 105 - 235 = 0 \text{ W}_m^{-2}$ the incoming and outgoing radiation fluxes balance at the surface of the atmosphere. If they fail to balance, Earth's temperature would simply increase or decrease until they did (i.e. until they balance). On the surface of the earth, additional term must be included in the balance. One is the down

ward flux of LW from the warm slay. SW incident - SW reflect + LW incident-LW reflect-LW emit = +/- 0

The Ecosystem

Ecosystem is an area of nature comprising of both the biotic and abiotic organisms living together in harmony and exchanging energy and matter. The ecosystem depends on two basic process. These are energy flow and material cycling. The flow of energy in the ecosystem leads to a clearly defined trophic structure, biotic diversity and material cycles (i.e. the exchange of materials between the biotic and abiotic components).

Ecology and Ecosystems

The term ecology, meaning 'home', refers to the study of the interrelationships between organisms and their habitats. An organism's home or habitat lies in the biosphere – i.e. the surface zone of the earth and its adjacent atmosphere in which all organic life; plants, animals and man exist.

The hierarchical structure of an ecological unit (See Table below) shows that the concept of environment is basic to the four ecological units The environment is a collective term to include all the conditions in which an organism lives. It can be divided into:

- a. the physical, non-living or abiotic environment, which includes temperature, water, light, humidity, wind, carbondiozide, oxygen, pH, rocks and nutrients in the soil; and
- b. the living or biotic environment, which comprises all organisms; plants, animals, humans, bacteria and fungi.

The Components of Ecosystem

The two basic components of the ecosystem are the biotic and the abiotic parts. The three major groups of living forms that constitute the biotic part are the producers, consumers and decomposers

The Components of an Ecosystem

Organic /Abiotic Part	Physical /Abiotic Part
1. Procedures	1. Climatic Factors
1.1 Green plants 1.2 Photosynthetic bacteria 1.3 Chemosynthetic bacteria	1.1 Light 1.2 Temperature 1.3 Precipitation 1.4 Atmosphere and wind
2. Consumers	2. Edaphic Factors: Soils
2.1 Herbivores : Animal that eat plants 2.2 Carnivores: Animal that eat animal e.g lion 2.3 Omnivores: 2.4 Detritivores	2.1 Nutrient content 2.2 Acidity 2.3 Moisture content
3. Decomposers	3. Topographic factors
3.1 Bacteria 3.2 Fungi	3.1 Aspect 3.2 Angle of slope 3.3 Altitude

Consumers essentially convert ingested food into new protoplasm. The ultimate source of the food energy obtained and used by consumers is the organic matter produced autotrophs in any ecosystems.

The decomposers are micro-organisms, notably the so- called bacteria and fungi of decay that break down the complex organic molecules of the litter, wastes and remains of both producers and consumers. Decompose lead to the release of simple inorganic substances that can be reused by green plants. Decomposers are as essential a part of the ecosystem as producers and consumers; in their absence, the basic elements of life would become locked in the complex molecules of the wastes thereby rendering them unavailable to the producers in the ecosystem. A condition of equilibrium of ecosystems with their immediate surrounding is referred to as HOMOSTASIS

The major effects of climatic factors on the biotic community of the ecosystems

The major climatic factors that have significant influence on the biotic community of the ecosystems are: (i) Light (ii) Temperature (iii) Water availability and (iv) Wind

Light and temperature are influenced by the duration and intensity of solar radiation.. The three major aspect of light that influence the biotic community in the ecosystem are:

(i) Light intensity or energy content (ii) Quality or wavelength composition and (iii) Duration of light or day- length otherwise referred to as photoperiod

The role of temperature in an ecosystem

Temperature as an environmental factors acts directly and indirectly on the biotic community. Temperature directly affects the functioning of organisms by controlling their body chemistry. It also acts indirectly by influencing the status of other environmental factors such as evaporation which largely determines water availability in terrestrial habitats. Most living organisms function within a temperature range of between 0 and 50⁰C. generally absolute temperature otherwise referred to as the point at which thermal molecular motion ceases i.e. 00 controls the speed of biological and physical reactions as well as the heat lost by radiation from a body and the relative temperatures of organism or other components in the ecosystem indicates the direction and rate of heat flows in the environment.

The role of water in an ecosystem

Water constitutes the bulk of the living tissues of plants and animals. Most physiological and biochemical processes occur in an aqueous matrix.

Furthermore water is the medium of life in aquatic ecosystem. In terrestrial ecosystem its distribution, scarcity or abundance is largely responsible for then dramatic difference in vegetation. It of should be noted that differences in precipitation and solar radiation accounts for the variations in supply which basically determine the functioning of terrestrial ecosystem.

The role wind

The atmosphere in motion is the wind. Strong winds may directly induce physical damage on plants structure or cause malformation in terrestrial communities. Wind action may accelerate the process of transpiration by removing water vapour from the ambient

air of the vegetation, allowing further evaporation loss of water from leaf surfaces through the stomatal apertures.

The role of edaphic (i.e. soil) factors

The edaphic factor harbours biotic communities which include bacteria, fungi and other organisms that fix atmospheric nitrogen decompose organic matter and incorporate it with minerals matter. In terrestrial habitat, the soil serves as the medium of plant growth and provides anchorage for roots, water supply, essential inorganic nutrients, and aeration for the respiration of roots and decomposer organisms.

The role of topography or surface relief in an ecosystem

Topography or surface relief tends to modify the climatic factors in the environment and this can lead to a change in vegetation types. The aspects or slope orientation of a particular habitat determines the amount of solar radiation received at the surface. Slopes directly facing the sun are warmer and more productive than those under shade conditions. This explains the contrast between the vegetation along the slopes of a contrasting aspect.

Living systems and energy exchange in an ecosystem

Living systems in an ecosystem are organized in terms of (i) Species (ii) Populations (iii) Biological community

A **species** is defined as all organisms that are genetically similar enough to breed and produce live and fertile offspring in nature.

A **population** consists of all members of a species that lives in the same area at the same time.

A **biological community** consists of all the population living and interacting in an area. A biological community together with its physical environment that is, water, mineral resources, air and sunlight makes up an ecological system or ecosystem.

Energy flow and exchange in an ecosystem

The sun is the primary source of energy for all living organisms on earth. The sun provides heat energy which can not be captured by plants or animals but warms up the

plant and animal communities and their non living surrounding. The sun is also source of light energy which can be captured by green plants and transformed into chemical energy through photosynthesis.

Food Chains and Energy Flows

The *food chain* can be defined as the chain of organisms consuming other organisms and being consumed by other organisms. It is essentially a linear sequence of organisms representing the nutritional levels of various species through which energy and materials move within an ecosystem. A simple example of a food chain can be obtained from a grassland ecosystem in which the grasses synthesize the food using energy from the sun and nutrients from the soil. The animals (herbivorous) consume grass. The grazing herbivorous animals become food for the carnivores and upon their death the latter may become food for other carnivores or decomposers. In such a situation the food synthesized by the plants is passed onto the herbivorous animals, from them to the carnivorous animals and from them to the decomposers. The transfer of food or biomass implies the transfer of energy in the ecosystem.

The process of eating and being eaten, as described above, is called a food chain and each link to the food chain is called a *trophic level*. Such simple food chains have a limited number of trophic levels. In most cases, however, the food chains are very complex and a number of them may be interconnected. Such food chains with a number of inter-linkages are generally called *food webs*.

Bio-geo-chemical cycle

The circulation of nutrients in a cyclic manner through the ecosystem is known as *bio-geo-chemical cycle*. This is very necessary for sustained production of organic matter in an ecosystem. The various elements required for production of the nutrients or the chemical elements are classified as macronutrients and the micronutrients. Macronutrients include elements like oxygen, hydrogen, nitrogen and carbon. They constitute the bulk of the biomass in a given ecosystem.

The micronutrients are sulphur, phosphorus, potassium, sodium etc but they are needed in very small amounts.

SOILS FORMATION

The soil is one of the major components of the ecosystem. The soil is a natural body derived from rocks and organic matters by physical chemical and biological processes. Physical and chemical processes are climatic and hydrological. The results of the rock disintegration process depend on the local atmospheric condition. The loose materials may be transported by such agents of erosion as wind, water and ice and deposited elsewhere on the surface of the earth.

The deposited materials vary in depth and interval contents.

Few comparison between sandy and clayed soils are as below

Sandy Soils	Clayed Soils
1. Light	Heavy
2. Relatively large particles	Relatively small particles
3. Relative large air spaces	Relatively small air spaces.
4. Low capillarity	High capillarity
5. Rapid drainage i.e water not held by attraction to rock particles,	Very low drainage, water is held by attraction to rock particles and so they are wet soils
6. Mineral salts are quickly leached away by rain	Mineral salts are attracted by clay to particles and are so retained
7. low water retentively	High water retentively
Activities of micro organisms such as earth worms are low	Micro organisms are active except where soil is water logged.
9. very loose consistency and is easily evolved by wind	Particles are held tougher by surface tension of water surrounding them --- tend to cake when dry and it hinders root penetration
10.Low specific heat-- it shows extreme fluctuation in temperature	Has high specific heat ie. they show more constant temperature, though wet clays are rather cold.

Soil and subsoil

The 20 or 25 cm depth of surface soil is of extreme importance to the farmer. This is because humus which is rich in organic matter is concentrated here. Humus is concentrated between 30-25cm below.

When plants and animals die and they decompose, and humus is formed.

3 types of humus are formed depending on temperature and water supply.

i. Peat- forms when temperature is low and the soil is poorly drained.

That is under poor soil drainage and low temperature, organic materials on the surface do not decompose completely they are deposited on the soil surface as a layer of decayed but not decomposed organic materials.

ii. Mor-humus: - Formed under a better condition of temp and water supply. Thus decomposition is partly done but not thoroughly mixed with mineral matters of the soil.

iii. Mull-Humus: Form when there is adequate water supply and high temperature. in this case there is thorough decomposition and mixing with mineral matters of the soil. Mull humus is most beneficial to plants.

Soils and subsoil: - It is important to distinguish between soils and sub soils. Such a distinction is of value to agriculture. Below the soil comes the subsoil. However there is no sharp demarcation between soil and sub soil. But there are certain criteria used to distinguish between the two.

The main difference between the soil and the sub soil is in the quantities of humus. The surface soil is comparatively rich in humus and as such is deeper in colour than the sub soil.

Another difference is in the texture of the material in the soil and subsoil. In areas with heavy rainfall, the surface soil is usually made up of coarser particles than the subsoil. This is because the finer particles have been washed deeper into the soil. This happens to soils that are frequently cultivated. Thus subsoil will normally have finer particles than the soil surface.

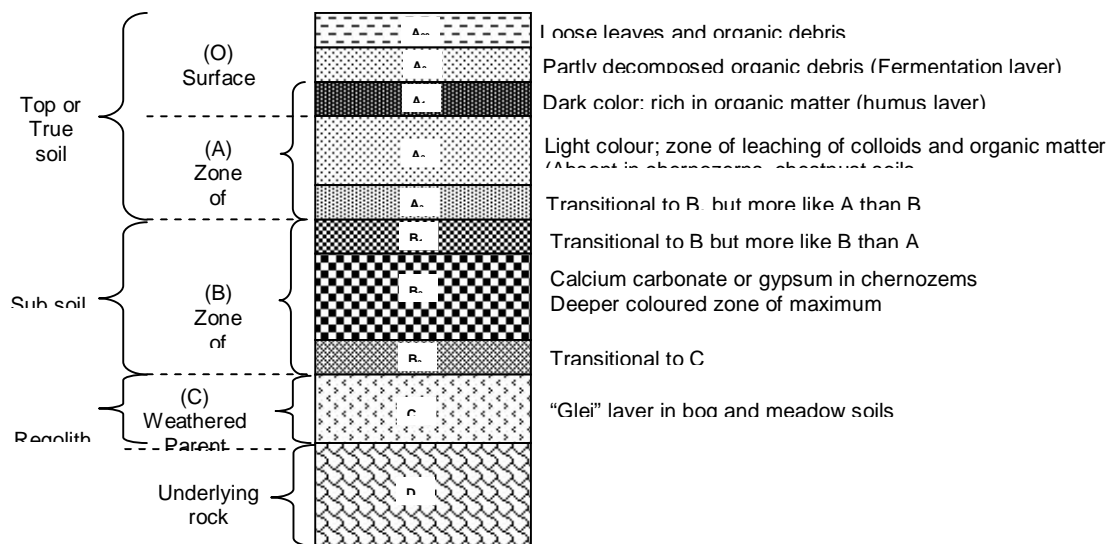
Under moderate rainfall, the surface soil is usually richer in plant nutrients than the subsoil, with the exception of potash.

For the above reason, care should be taken not to bring the subsoil into the surface by extra deep ridging or plugging.

Properties of the soil

- i. Soil has layers or profiles, it has colour, structure, texture, drainage organic matter and chemistry.

Layers of the soil is as shown below



An idealized soil profile