COURSE CODE: SLM 307

COURSE TITLE:
INTRODUCTION TO SOIL MICROCLIMATOLOGY

SLM 301
INTRODUCTION TO SOIL MICROCLIMATOLOGY

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INTRODUCTION

Soil Microclimatology is the study concerned with the influence of weather and climate on boundary layer. Microclimatology of soil is the distance between the deepest tree-root to about one meter above crop canopy.

Soil microclimate can be defined as a complex of certain factors which determine the state of a soil considering the soil as an environment for plants, animals or other objects. Temperature, Humidity, aeration – but also composition of the soil air and of the soil solution and permeability to water and to air – are examples of such factors (van Wijk, 1965).

Weather is the physical state of the atmosphere at a given point in time at a given location. It is described in terms of the instantaneous or short period mean value of the various atmospheric variables such as precipitation, temperature, humidity, sunshine, pressure, cloudiness and evaporation. Weather determines the period of day-to-day human activities and comport of both plants and livestock. Climate on the other hand is the long term regime of the atmospheric variables or the aggregate of the day-to-day values of the weather elements over a long period of time for a given location. The standard used in expressing climatic condition of an area is about 30 – 35.

The field of interest of soil microclimatology extends from the soil surface layer to the depth up to which tree roots penetrate while in the atmosphere it is interested in the air layer near the ground in which crops and higher organisms live.

The importance of microclimate in influencing ecological processes such as plant regeneration and growth, soil respiration, nutrient cycling, and wildlife habitat selection has become an essential component of current ecological research (Chen et al. 1999). It therefore follows that ecosystem processes such as decomposition, nutrient cycling, succession, and productivity are partially dependent on microclimatic variables too. Many animals are also adapted to specific microclimatic conditions. Wind speed, air temperature, humidity, and solar radiation can influence migration and dispersal of flying insects. Soil microbe activity is affected by soil temperature and moisture. In addition, most fish have specific thermal ranges in which they are able to survive and reproduce, suggesting that changes in variables that affect stream temperature, such as solar radiation, cause changes in habitat suitability.

WHAT YOU WILL LEARN IN THIS COURSE

From the course material, the course guide will tell you what to expect as you read through. The study of soil microclimatology cuts across two broad disciplines, climatology and soil science. The biotic and abiotic components of the environment respond in different ways to the atmospheric situations. The interaction between the atmospheric environment and soil land scape is what constitute the major concern to soil microclimatology.

In terms of approach, the study can be subdivided into microclimatic zone which is the description of climate near the earth surface; soil climatic zone which is the description of climatic zones based on soil and climate regimes; agroclimatic zone which is the description of agroecological zones based on soil grouping.

COURSE AIM

This course aims at providing a good understanding of microclimatic environment of soil for better management of agricultural activities and expressly states the relationship between climate and agriculture

COURSE OBJECTIVES

After going through this course, you should be able to:

- Explain the nature and scope of soil microclimatology
- Explain weather and climatic variables
- Appreciate the seasonal variation of the soil environments
- Appreciate the influence of soil factors on microclimatology
- Differentiate between the influence of soil and air temperature on crops
- Identify the equipments used in measuring various elements of climate and how to maintain them

WORKING THROUGH THIS COURSE

This course has been designed as an introductory course. Much effort has been put in place to adequately explain the important concepts and issues to be treated in the work. Table and diagrams have been used where necessary to aid your understanding. You are advised to spend good time to study the work with your classmate and compare knowledge.

COURSE MATERIALS

You will be provided with the following materials:

A course guide

Study units

Also, the course comes with a list of recommended text books which though not compulsory for you to acquire, are essential to give you more insight into the topics discussed.

STUDY UNITS

The course is divided into 3 modules, with each module containing 5 units (15 units in all). The following are the study units contained in the course:

Module 1

Unit 1: The Principles, Aims and Scope of Soil Microclimatology
Unit 2: Elements of Weather and Climate
Unit 3: Atmospheric Dynamics
Unit 4: Solar Radiation and Heating effects of the Atmosphere
Unit 5: Heat transfer in soils

Module 2

Unit 1: Forcing Mechanisms in the Boundary layer
Unit 2: Atmospheric Moisture
Unit 3: Soil Moisture
Unit 4: Soil Properties
Unit 5: Soil Conservation

Module 3

Unit 1: Equipments and Maintenance of a Standard Meteorological Station
Unit 2: Measurement of Climatic Variables
Unit 3: Measurement of Evaporation and Evapotranspiration
Unit 4: Microclimate and Soil Management in the Tropics
Unit 5: Influence of Microclimate on Agriculture

Module 1

In the opening unit, you will be taken through the definitions of both soil and microclimatology and how the activities of man influence these two phenomena. Elements of weather and climate will be discussed in unit two as well as the factors controlling them. In unit three, the major focus will be on the dynamics of the atmosphere. Here, you will be taken through the peculiarities of the atmospheric circulation system which includes the general circulation system among others.

Unit four will discuss the general principles of atmospheric radiation system. You will be taken through the form and nature of solar radiation and how the atmosphere is heated up by short wave radiation and counter radiation or terrestrial radiation (long wave). You will also learn about heat transfer within the soil as influenced by soil physical and chemical properties

Module 2

Unit one will introduce the students to the forcing mechanisms within the boundary layer which is the microclimatic environment in the lowest layer of the atmosphere. Unit two will discuss the source of the moisture in the atmosphere. The students will also be introduced to the knowledge of the amount and distribution of atmospheric moisture. Unit three will introduce you to the sources and dynamics of soil moisture. You will also learn about the various factors affecting soil i.e physical and chemical properties of the soil in unit four. In unit five, you will learn about soil conservation and how it affects the growth and development of crops.

Module 3

In unit one of this module, you will learn about the categories of weather stations and how to maintain them. The measurement of elements like rainfall, air temperature and humidity will be dealt with in unit two. You will be exposed to the instruments and procedures of measuring air pressure, wind speed, wind direction, radiation and sunshine duration.

In unit three, you will learn about the influence of Evapotranspiration on relative humidity. Unit four introduces you to the microclimate of the tropical environment and the type of agricultural management practiced in that environment. You will further learn about agriculture and pests and diseases and the relationships between climate and livestock in unit five.

TEXT BOOKS AND REFERENCES

The following textbooks are recommended for further reading

Ayoade, J.O. (2004). *Introduction to Climatology for the Tropics*. Ibadan: Spectrum Books Limited.

Ayoade, J.O. (2008). *Introduction to Agroclimatology*. University of Ibadan Press PLC.

Reddy S.R. and D.S. Reddy (2007). Agrometeorology. Kalyani Publishers, New Delhi India

ASSESSMENT

There are three components of assessment for this course. They are the Tutor-Marked Assignment (TMA), Practical and the end of course examination.

TUTOR-MARKED ASSIGNMENT

The TMA is the continuous assessment component of your course. It accounts for 30% of the total score. A written test will be given to you at the end of mid-semester

PRACTICAL ASSESSMENT

It accounts for 10% of the total score. The practical assessment will be given to you by your facilitator and you will return it after you have done the assignment.

FINAL EXAMINATION AND GRADING

This examination concludes the assessment for the course. It constitutes 60% of the whole course. You will be informed of the time for the examination.

SUMMARY

This course intends to provide you with the knowledge of microclimatology of soil as it affects agricultural production. By the end of this course you will be able to answer the following questions.

- What is weather and climate and how do they affect human activities?
- Discuss the nature and scope of soil microclimatology.
- Discuss solar radiation and heating effects of the atmosphere.
- Describe and explain atmospheric dynamics.
- Discuss the global distribution of soil moisture, temperature and aeration.
- Discuss the important steps to be adopted in the maintenance of meteorological stations.
- Explain the influence of evapotranspiration on crop growth and development.
- Explain the influences of microclimatology on crop production in the tropics.

We wish you a better understanding of the microclimatic phenomena in your environment.

MAIN COURSE

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Module 1

Unit 1 The Principles, Aims and Scope of soil microclimatology
Unit 2 Elements of Climate and Weather
Unit 3 Atmospheric Dynamics
Unit 4 Solar Radiation and Heating effects of the Atmosphere
Unit 5 Heat transfer in the soils

Module 2

Unit 1 Forcing Mechanisms in the Boundary layer
Unit 2 Atmospheric Moisture
Unit 3 Soil Moisture
Unit 4 Soil Properties
Unit 5 Soil Conservation

Module 3

Unit 1 Equipment and Maintenance of a Standard Meteorological Station
Unit 2 Measurement of climatic variables
Unit 3 Measurement of Evaporation and Evapotranspiration
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Unit 5 Influence of Microclimate on Agriculture

MODULE 1

Unit 1 The Principles, Aims and Scope of soil microclimatology
Unit 2 Elements of Climate and Weather
Units3 Atmospheric Dynamics
Unit 4 Solar Radiation and Heating effects of the Atmosphere
Unit 5 Heat transfer in soils

UNIT 1 PRINCIPLES, AIMS AND SCOPE OF MICROCLIMATOLOGY

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3.1 Weather and Climate

3.2 Principles and Scope of microclimatology

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0 INTRODUCTION

The various activities of man revolve around his search for food, shelter and clothing which are in numerous ways influenced by the weather. The study of the weather and microclimatic environment of soil as a medium of plant growth and development is therefore as ancient as man's curiosity about his environment. The way man lives, the air he breathes, the food he eats and the water he drinks are all weather related. The works represented the sum of knowledge on weather and soil microclimatology atmosphere interface. Modern climatology emerged from the challenges posed by the needs of society and the improvement in data collection and analysis. This unit examines the principles, aims and scope of climatology.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define weather and climate
- define microclimatology
- understand the principles and aims of microclimatology
- understand the scope of climatology and microclimatology.

3.0 MAIN CONTENT

3.1 Weather and Climate

Weather refers to the state of the atmosphere at a given point in time at a given location. Weather is the day-to-day state of the atmosphere and pertains to short-term changes in conditions of heat, moisture and air movement. Weather is therefore the instantaneous state of the atmosphere which results from the processes that attempt to equalize the differences in the distribution of net radiant energy from the sun. Climate on the other hand, is the process of heat exchange between the earth and the atmosphere over a long period of time. Climate is therefore the accumulation of daily and seasonal weather events of a given location over a period of 30-35 years. The concept of climate is not limited to average weather condition, it also includes weather events, considerations of variability (departure from averages), extreme conditions, and the probabilities of frequencies of occurrences of given weather conditions. Weather and climate play a major role in our lives. Weather is what determine crop yield and if the planted crops will grow to maturity, while climate determines what types of crops can be planted and when to plant the crops. The most immediate effect of weather and climate is on our comfort. On a cold, windy day the effects of wind chill tell us that it feels much colder than it really is, and if not properly dressed, we run the risk of catching cold or developing catarrh. On a hot humid day we normally feel uncomfortably warm and blame it on the humidity of the weather. If we become too warm our bodies overheat and heat exhaustion may result.

1. How does weather differ from climate?
2. Describe the role of weather and climate in our lives.

3.2 Principles and Scope of Soil microclimatology

Microclimatology is the scientific study of microclimate that deals with pertinent factors like solar radiation, temperature, wind, vapour pressure and carbon dioxide of the environment in the zone lying between the highest level reached by the plant and the lowest depth to which air penetrates into the soil. This area is within what is known as “Boundary layer”, that part of the troposphere responds to the surface forcings with a time scale of about an hour or less.”

Soil microclimatology focuses on the micro scale portion of the meteorological spectrum of soil, those phenomena with spatial scales between the deepest plant root to about 1m above the highest level reached by plant and with temporal scales between a few seconds up to a couple of hours.

Soil microclimatology has a wide scope. It can be classified largely on the purpose for which it is needed. Three broad classifications can be made as follows:

1. **Empirical:** This is based on quantification of observable elements of weather by statistics and / or experiments and their impacts on soil of a microclimatic environment. On the basis of temperature, soil may be hot, warm or cold etc and on the basis of moisture (rainfall) – wet, humid or dry etc. Combination of temperature and moisture may give soil types hot-wet, hot-humid, hot-dry etc. These classifications are more reliable and stable as they are based on experimentation and mathematical coding.

2. **Genetic:** It is based on the genesis of the soil of the microclimatic environment. Explanations are often theoretical, incomplete and generalized. This is because soils developed from a variety of parent materials derived from weathering of sedimentary rocks and from recent fluvial and marine deposits. Factors like latitude, general circulation, effects of oceans and continents, mountain barriers, polar, temperate and tropical climates are the basis for this classification.

3. **Applied:** It is based on the effect of climatic factors on non-climatic features such as wild vegetation, cultivated crops etc. Examples of this type of classification are aquic, ustic, aridic, xeric soil moisture regimes etc.

1. Define microclimatology. How does it differ from climatology?

2. Explain the scope of soil microclimatology

4.0 CONCLUSION

The study of soil microclimatology`is essentially hinged on the knowledge of weather and climate, the processes of soil development at micro scale level.

5.0 SUMMARY

In this unit we have learnt that:

1. All human activities are influenced by the weather
2. Weather is the state of the atmosphere at a given time and place while climate is the aggregate of weather over a long period of time
3. Microclimate is that part of the troposphere responds to the surface forcings with a time scale of about an hour or less
4. Soil microclimatology focuses on the micro scale portion of the meteorological spectrum of soil

6.0 TUTOR-MARKED ASSIGNMENT

Genetic classification of soil is based on the genesis of the soil of the microclimatic environment. Explain the above.

7.0 REFERENCES/FURTHER READING

Reddy, S.R. and D.S. Reddy (2011). *Agrometeorology*. New Delhi: Kayani Publishers.

Ojanuga, A.G. (2006). *Agroecological Zones of Nigeria Manual.* National Special Programme for Food Security

UNIT 2 ELEMENTS OF CLIMATE AND WEATHER

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2.0 Objectives

3.0 Main Content

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3.2 Non-Climatic Elements

3.3 Solar Radiation

3.3.1 Factors of Solar Radiation

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0 INTRODUCTION

The elements of weather and climate are normally observed and measured using weather instruments at synoptic hours by observers. These elements include temperature, precipitation, pressure, winds and humidity. The spatial distribution of these elements are controlled by one or all these factors; latitude, altitude, continentality, ocean currents, insolation, prevailing winds, natural vegetation and soil. This unit will discuss the characteristics of temperature, precipitation and winds as well as their control.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Understand the characteristics of these climatic elements
- Understand the effects of non-climatic factors on these elements

3.0 MAIN CONTENT

3.1 Climatic Elements

Temperature

Temperature is defined as the degree of hotness or coldness of a body. This is as a result of the heat absorbed by the earth and atmosphere from the main source of energy to the earth (sun) as solar radiation and partly converted into sensible heat or other form of energy.

Factors Influencing Temperature

Temperature characteristics of a place are influenced by climatic and non-climatic factors. The climatic elements acting as factors include solar radiation, net radiation, pressure and winds, humidity, evaporation and cloud cover. Non-climatic elements include type of surface, latitude and continentality.

Solar and Net Radiation

The amount of solar or net radiation available on a particular surface is what greatly affects temperature. Temperatures are particularly higher during summer than during winter period because of higher insolation received during summer. During a daily cycle, on a sunny day, temperatures are highest in the afternoons when values of solar radiation and consequently net radiation are highest.

Pressure and Winds

In climatology, the foremost elements and important factors to temperature and precipitation are pressure and winds. Atmospheric pressure can be defined as the weight exerted upon the earth by the atmosphere. The average air pressure at sea level is around 1013mb with little variation according to latitude. The air pressure decreases with altitude; at 5000m it is only about 500mb. This is because at high altitude air is less dense.

Rise in temperature causes air to expand thereby reducing the pressure and vice versa. Over the earth surface, air flow is from high pressure to low pressure areas. But because of earth rotation, air flow is deflected to the right in the northern hemisphere and to the left in the southern hemisphere.

Humidity and Evaporation

Humidity is the amount of water vapour in the atmosphere. Because of its origin, humidity which is atmospheric water vapour is concentrated in the lower layers of the atmosphere. There are different indices used in measuring this moisture content of the atmosphere which includes absolute humidity, specific humidity, mass mixing ratio, relative humidity and dew-point temperature. Evaporation is the process by which moisture in its liquid or solid form is converted into gaseous form-water vapour. Moisture availability at the evaporating surface and the ability of the atmosphere to vaporize the water, remove and transport the vapour upward are the fundamental factors that determine the rate of evaporation. Many factors including solar radiation, temperature, wind speed and humidity also determine evaporation.

Cloud Cover

Another significant climatic element that influences temperature by reducing the amount of energy received or absorbed at a particular place is cloud cover. This factor accounts for the lower temperatures in the humid areas with a lot of clouds compared with the arid areas where there is little or no cloud. The effects of cloud cover lessen the diurnal temperature ranges by preventing high maxima by day and low minima by night. This is usually the situation in the humid areas of the tropical rain forest of West Africa, compared with the arid areas such as in the Sahara Deserts where the ranges of temperatures are always high.

3.2 Non-Climatic Elements

Types of Surfaces

Various types of surfaces react differently to solar radiation incidence in terms of reflection, absorption, and transmission and these accounts for the variation in heating potentials.

Vegetation surface: Both the reflectivity and transmission coefficient affect the amount of solar radiation over vegetated surfaces and consequently the amount of sensible heat generated. Also, part of the heat is lost through evaporation and transpiration. Surfaces with high evapotranspiration heat more slowly than surfaces with less evapotranspiration.

Land and water surface: Although the heating properties of the many kinds of land and vegetated surfaces vary considerably, the greatest contrasts are those between land and water surfaces, which react so differently to solar radiation. The surfaces of relatively deep bodies of water heat and cool slowly compared with land surfaces. The most important reason for this slowness of temperature change is that in water, a highly mobile matter, redistribution of heat occurs mainly through turbulence. In contrast to this medium of heat distribution, heat in the solid earth is distributed by molecular heat conduction, and so proceeds by moving from particle to particle. In water, on the other hand ocean currents, waves, tides and conventional overturning systems help dispersed to absorbed solar energy throughout a large mass of water. Because there is no such mixing on land, and assuming that equal amount of energy fall on both surfaces, water surfaces would heat up more slowly and have lower temperatures than land surfaces.

Latitude: As a result of the earth's inclination, the midday sun is almost overhead within the tropics but the sun's rays reach the earth at an angle outside the tropics. Thus there is a decrease in temperature from the equatorial regions to the poles. This is illustrated in Figure 1. Band R1 falls vertically over the equatorial latitudes on surface E. Band R2 falls obliquely over the temperate latitudes on surface T. R1 travels through a shorter distance and its concentrated solar insolation heats up a smaller surface area; temperature is thus high. On the other hand, R2 travels through a longer distance and much of its heat is absorbed by clouds, water vapour and dust particles. Its oblique rays have to heat up a larger area; temperature is therefore low.

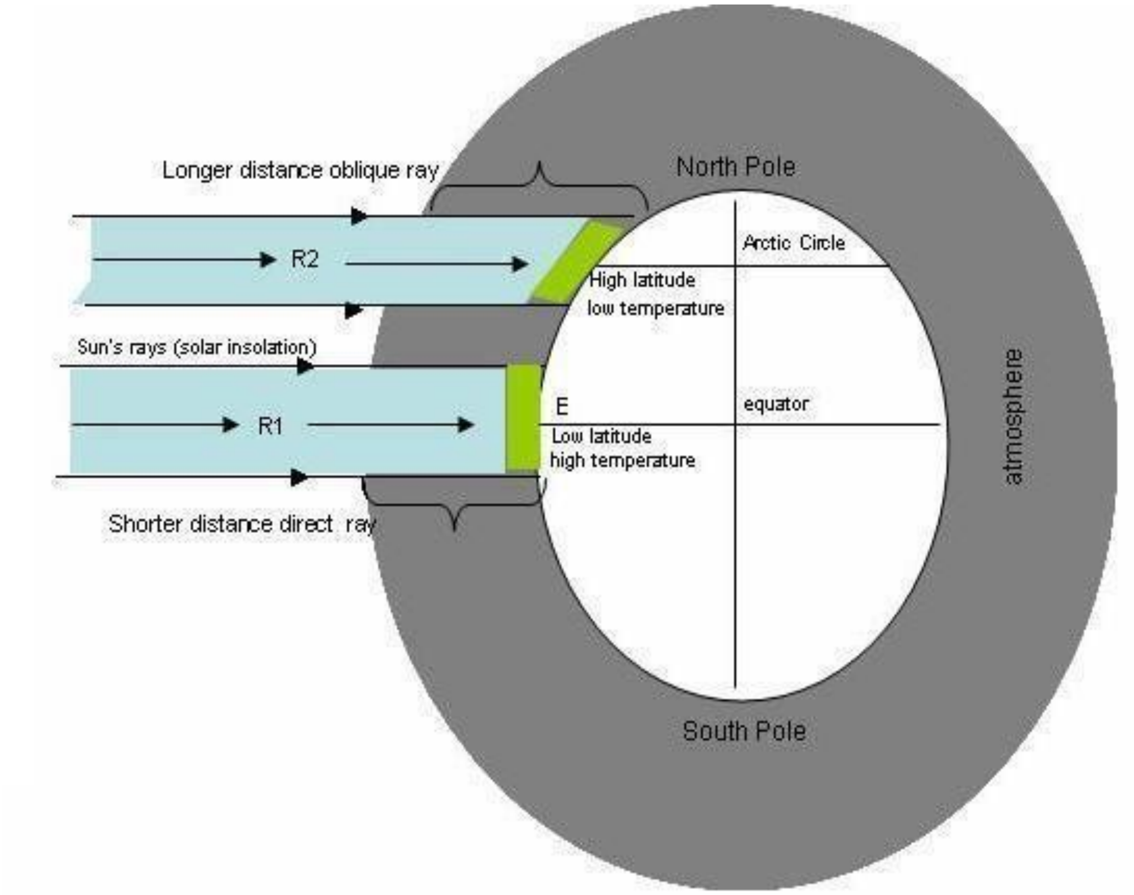

Figure 1: Varying distance in the distribution of Insolation and Continentality (Distance from the Sea)

Continentality (or distance from the sea) is another factor which affects the characteristics of temperature in time and space. For example, near the ocean or water surface, daily temperature extremes are smaller than within the continental areas. Moreover, the variability of temperature is greater in areas far away from the sea than along the coastal areas. Thus maximum temperatures are higher and minimum temperatures are lower over continental climates than in oceanic or marine climates.

3.3 Solar Radiation All of physical and biological processes of life taking place on the earth's surface are dependent on solar radiation involving some form of energy transfer. Solar radiation is also required for other processes related to water, land, soli, vegetation and animals. The sun provides over 99% of the heat energy required for the physical processes taking place in the atmospheric system.

3.3.1 Factors of Solar Radiation

Solar Input

The solar constant, which is the basic amount of solar input, is a major factor of solar radiation received by the earth's surface, outside the atmosphere. In general the amount of solar radiation received outside the atmosphere also depends on a number of other factors, which include solar altitude and the duration of solar energy (length of day).

Solar Altitude

The altitude of the sun (angle between the rays of the sun and at tangent to the earth's surface at a point of observation) is an important factor which affects the amount of insolation received at the earth's surface. It depends on the time of the day, the latitude of the location and the time of the year (session). When the sun's altitude is great, the solar radiation intensity per unit area is highly concentrated at the earth's surface (Fig. 2). For example at noon, the intensity of insolation is greatest, but in the morning and evening hours when the sun is at a low angle, the amount of insolation is small. The same principle has a broader application with respect to latitude and the seasons. In winter and at high latitudes even the noon sun's angle is low. In summer and at low latitudes, it is more nearly vertical and the oblique rays of the low angle sun are spread over a greater surface than are vertical rays, thus less heating per unit areas is produced by the low -angle sun.

The angle at which the solar radiation strikes the earth's surface however, also depends upon the surface configuration of the land. For example, in the middle and high latitudes of the northern hemisphere, southern slopes receive more direct rays while northern slopes may be entirely in the shade. Also the possible hours of sunshine in a deep valley may be greatly reduced by surrounding hills.

The Length of Day

The longer the time of day during which the sun shines, the greater the quantity of radiation which a given portion of the earth will be able to receive. Table 2 shows the latitudinal variations of sunshine hours during the solstices and the equinoxes. Note that there are shorter days during winter solstice of every latitude to the north or south of the equator. During equinoxes the length of days and nights are equal for each latitude. Also note that there are six months of daylight hours during the summer solstice at the pole and zero hours of daylight hours (six months of darkness) during the winter solstice.

The variation in the length of day is as a result of the revolution of the earth around the sun and its rotation on its axis. Whereas the earth's rotation on its own axis causes day and night, its orbit round the sun explains the seasons. A complete rotation takes 24 hours resulting in the alternation of day and night, while a complete revolution takes 365 ¼ days at a variable speed which averages about 26km per second.

The effect of the atmosphere slightly affects the radiation received on the earth's surface. The atmosphere absorbs, reflects, scatters and reradiates solar energy. Among the atmospheric constituents involved in the absorption are water vapour, liquid water carbon dioxide and ozone. Part of the incoming solar radiation is also scattered or reflected back to space. About 80% of the incoming solar radiations are reflected by clouds; clouds are powerful reflectors of shortwave radiation.

4.0 Conclusion

The spatial distributions of temperature are affected by climatic elements and non-climatic elements.

5.0 Summary

In this unit, we have learnt that:

1. Temperature is influenced by climatic and non-climatic elements
2. Solar input, solar altitude and the length of day are some of the of the factors that affects temperature
3. The main source of energy in the atmospheric system is solar radiation

6.0 Tutor-Marked Assignment

Enumerate the factors that influence temperature as an element of climate

7.0 References/Further Readings

Reddy, S.R. and D.S. Reddy (2011). *Agrometeorology.* New Delhi: Kayani Publishers.

Ojanuga, A.G. (2006). *Agroecological Zones of Nigeria Manual.* National Special Programme for Food Security

UNIT 3 ATMOSPHERIC DYNAMICS

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3.2.1 General Atmospheric Circulation

3.2.2 Other Circulation

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6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0 INTRODUCTION

Atmospheric circulations are caused by energy inequalities which produce temperature and pressure variations. These are variations in the net radiation over the earth's surface and between the earth surface and the atmosphere. This is what is responsible for the dynamism experienced in the atmosphere.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Describe the atmospheric dynamism at various scales
- Explain some of the factors responsible for atmospheric circulation

3.0 MAIN CONTENT

3.1 Atmospheric Circulations

3.1.1 Factors Generating Atmospheric Circulation

The major factors influencing the general atmospheric circulations include radiation balance, pressure gradient force, earth's rotation etc.

Radiation Balance

This is the difference between the incoming short wave radiation from the sun and the outgoing long wave or terrestrial radiation which adds up to zero for the earth's atmospheric system over a period of one year. This equilibrium occurs at global level. In the low latitudes, there is an excess of radiation balance while marked deficits is found in the high latitudes. These results in a pole ward temperatures gradient both at the surface and in the atmosphere. The tropics are thus belts serving as a heat source, while the poles serve as heat sinks. If there were no circulation to transport the excess from equatorial regions to the poles, the tropics would be getting hotter and the high latitude getting colder. With the general circulation however, heat is transferred from the heat source to the heat sinks, so maintaining the average temperatures of the world. The leveling up of temperature is done mostly through the transfer of sensible heat and by the transportation of water vapour and its latent heat from the zones where evaporation is predominant to zones where precipitation is predominant and between the oceans, which provide 90 per cent of atmospheric water vapour and the continents.

Pressure Gradient

Pressure gradient is the result of pressure differences as a result of differences in temperature which produce air movements or winds. The atmosphere exerts pressure because air has weight or mass. The mass of a column of air over a given point determines the atmospheric pressure at the point. At sea level the average pressure is 1013 mb.

There are thus differences in the distribution of pressure due to thermal causes, and winds generally move from the areas with cold heavy air to areas with the lighter warm air. In addition there are also mechanical causes. The differences in the distribution of pressure between two adjacent areas in turn sets the air in motion and causes winds to blow from areas of high to areas of low pressure. The difference in relation to the slope of the two adjacent areas is called pressure gradient. A pressure gradient is thus the immediate cause of all air movement, the direction of air flow being from high pressure to low pressure, and the velocity of the air flow being directly related to the pressure gradient, that is the rate of change of pressure with distance. The pressure gradient is steep when the rate of change is great, and the steeper the gradient, the more rapid will be the flow of the air.

The Earth's Rotation

The rotation of the earth prevents direct meridional circulation that would result from the imbalance of net radiation of the world. Coriolis force is the term given to the force resulting from the rotation of the earth. As mentioned earlier, the effect of the force is at maximum at the poles while at the equator the effect becomes zero. The deflective force causes the winds to be deflected to the right in a northern hemisphere and to the left in the southern hemisphere.

Frictional force

The frictional force affects both wind speed and wind direction. The movement of air is retarded by friction between the moving air and the surface of the earth. The frictional effect of the earth's surface varies with height. It is of importance only below the frictional layer 1500 to 1000 meters although it tends to be deeper over rough terrain or under unstable conditions

There is also internal friction within the air itself, although this is very small and varies with height. Because the force acts in the opposite direction to the wind direction, the flow of surface air is not essentially parallel to the isobars as is the air in the free atmosphere which increases with the frictional force.

3.2 Circulation Systems.

Let us now examine the categories of the atmospheric circulations systems.

3.2.1 The General Atmospheric Circulation

The underlying cause of the general circulation is the unequal distribution of net radiation. These inequalities exist between the atmosphere and earth's surface on one hand and between the tropics and extra tropical areas on the other. To balance these inequalities, the atmosphere transfers warm air pole-wards and cool air equator wards.

If we assume a homogenous non-rotating earth the global wind systems would look much simpler than they are shown in Figure 3. However, with a homogenous rotating earth, the winds will be subject to both the pressure gradient and coriolis forces. Winds moving from areas of high pressure to those of low pressure are deflected as explained in unit 3, to the right of their path in the northern hemisphere and to the left of their path in the southern hemisphere. For a heterogeneous rotating earth, the pressure distribution patterns are more cellular than zonal owing to the differential heating of land and water surface. The global wind systems will then be as shown in Figure 3. If we impose the varied topography of the earth's surface on this, the pattern of wind system will be more complex than that shown in Figure 3.

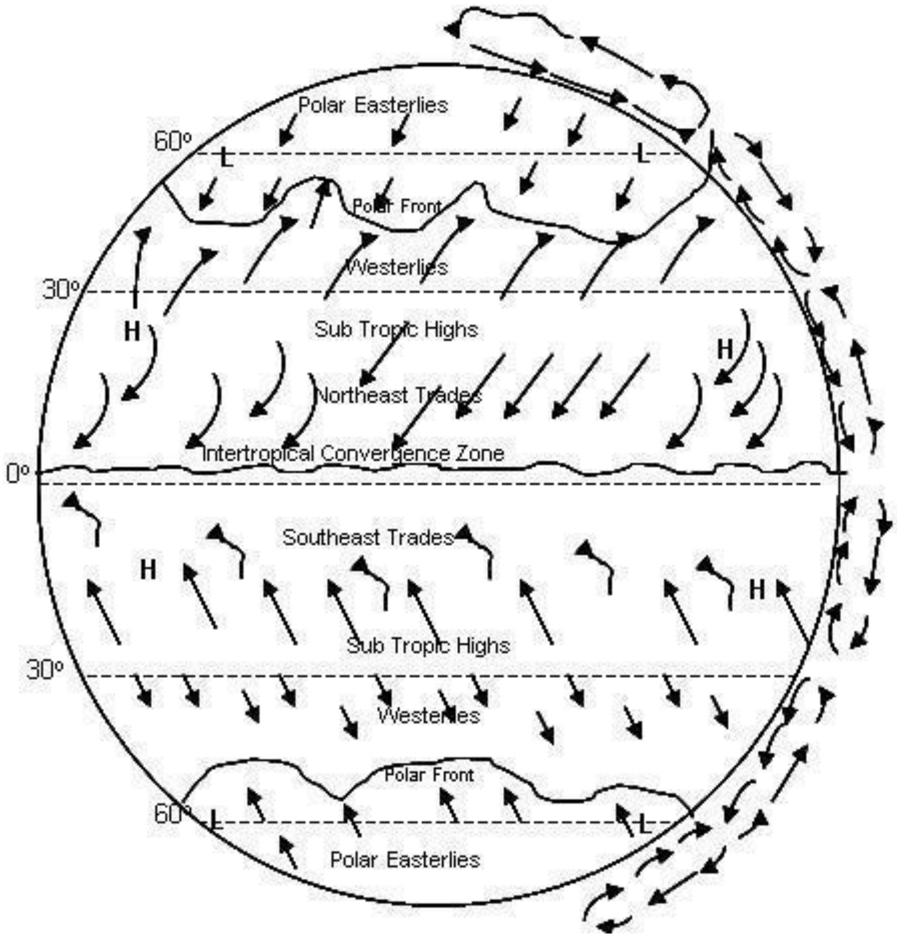

Fig 3: Global wind system

Relief can influence the wind systems in various ways. First they can pose a barrier to air flow; secondly, they can have a channeling effect on air flow. Relief also reduces wind speed at low levels through frictional drag on air flow.

The global pattern of general circulations is thus influenced by a change in any of the factors discussed above. The global wind systems discussed above are for the surface level only. Other wind systems like the Rossby waves, easterly waves and jet streams are also encountered at the middle and upper levels of the atmosphere.

3.2.2 Other Circulations

The day-to-day weather activities over a given area are determined more by secondary and tertiary circulation systems which are embedded in the general circulation of the atmosphere. These include the monsoon, cyclones, anticyclones, land and sea breeze.

The Monsoon

The seasonal variation in the temperature between the land and sea result in the seasonal wind systems called monsoons. During summer, the continental land masses become warmer than the surrounding water surfaces, resulting in temperature induced low pressure centre over the land surface. The wind therefore blows from the sea to the land, bringing abundant moisture. (Fig. 3). During the winter however, the continental land masses are much colder than the seas. This consequently causes a shallow high pressure cell over land with a lower pressure over the adjacent water surface which leads to the development of a land to sea pressure gradient and wind. (Fig. 3). The cold dry air from the land is poor in moisture content and brings no precipitation.

Monsoons are best developed in eastern and southern Asia, because of the size of the continent which intensifies the continental effect on weather. In areas such as West Africa and North America, the systems are not as well developed.

Land and Sea Breezes

These occur as a result of diurnal variation in the heating of land and water and they may be called daily monsoons. They differ from the large seasonal monsoons because they result from lesser changes in pressure. During the day, the air moves from the sea to the much heated land while at night, a reversed condition occurs, the wind blows from the much cooled land to the sea (Ayoade 2002).

4.0 CONCLUSION

The atmosphere is highly dynamic due to the variation in the amount of solar radiation received over the earth’s surface. Between the earth’s surface and the atmosphere the global atmospheric circulation system has the regional and local circulation embedded in it and it is these lower level circulation systems that are responsible for the day to day weather activities over any given area.

5.0 SUMMARY

In this unit we have learnt that:

1. Radiation balance, pressure gradient force, rotation of the earth and frictional force are some of the factors of the general circulation of the atmosphere.
2. General circulation of the atmosphere is caused by unequal distribution of net radiation.
3. The atmosphere transfers heat from the equator pole wards and cold from the poles towards the equator.
4. There are other wind systems in the middle and upper atmosphere i.e. Rossby wave, easterly waves and jet stream.
5. The day-to-day weather is determined by secondary and tertiary circulation systems like the monsoons, cyclones anticyclones, land and sea breezes among others.

6.0 TUTOR-MARKED ASSIGNMENT

Explain the main forces responsible for atmospheric circulation and enumerate the various systems of atmospheric motion.

7.0 REFERENCES/FURTHER READING

Ayoade, J. O. (1983). *Introduction to Climatology for the Tropics.* ChiChester: John Wiley and Sons.

Ojo, O. *et al* (2001). *Fundamentals of Physical and DynamicClimatology*. Lagos: SEDEC Publishers.

UNIT 4 SOLAR RADIATION AND HEATING EFFECTS OF THE ATMOSPHERE

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main Content
3.1 Solar Radiation and Heating of the Atmospheric System
3.1.1 The Sun
3.1.2 Disposition of Solar Radiation in the Earth's Atmospheric System
3.1.3 Terrestrial and Atmospheric Radiation
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5.0 Summary
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7.0 References/Further Readings

1.0 INTRODUCTION

Solar energy represents almost all the energy available to the earth (99.97%). As earlier mentioned, it is an important source of energy for life on the surface of the earth. It is the great engine which drives the earth's atmosphere and oceanic circulations. It generates weather and makes the earth a loveable place for plants and animals. Processes such as photosynthesis, on which man's existence partly depends are almost impossible without radiation

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the sun
- state how solar energy is transmitted to the earth
- state how the earth is heated
- state how the atmosphere is heated.

3.0 MAIN CONTENT

3.1 Solar Radiation and Heating of the Atmospheric System

3.1.1 The Sun

The sun, which is a star of about medium mass, has a surface temperature of about 6000^{o}K. It emits a form of energy known as electromagnetic radiation. This energy travels about 150 million kilometers to reach the earth's surface and takes about 9 ½ minutes to complete the journey.

The totality of wavelength is known as solar spectrum. The solar spectrum consists of both short and long wave radiation. A wavelength may be defined as the distance from crest to crest of succeeding waves. The conventional unit used in the measurement of wavelength is the micron (1 micron = 0.000km or 10^{-4}). The symbol used is µ. Another unit used which is smaller than the micron is angstrom =10^{8} cm. The total bulk of all solar radiation occurs in the narrow range of wavelength from 0.30 µ to 0.74 µ, usually referred to as short wave radiation. Short wave radiation is visible as light to human eye. The colours of visible radiation are violet, indigo, blue, green, yellow, orange and red.

The solar spectrum consists of:

1. X-rays, gamma rays, alpha rays and ultraviolet rays consisting about 9% of the total energy.
2. Visible light rays (0.4-0.74 µ) carrying 41%
3. Invisible infrared (heat) rays (0.7-3000 µ) consisting 50%.

The term short wave radiation is applied to the visible and ultraviolet portion of the spectrum (wavelengths less than 0.7 µ) as distinct from the infrared or long wave portion (longer than 0.7 µ). Radiation is energy in transit. When it comes in contact with an object or substance it may be transmitted, reflected or absorbed in proportions which depend on the nature of the medium and wavelength of the radiation. It is the amount of the radiation absorbed by a medium that is effective in heating it.

3.1.2 Disposition of Solar Radiation in the Earth's Atmospheric System

The solar radiation intercepted by the earth is either absorbed or returned back to space by scattering or reflection. Mathematically the disposition of solar radiation is expressed by

$$Qs = Cr+Ar+Ca+Aa+(Q+q)(1- \sigma)+(Q+q) \sigma$$

From the expression, the solar radiation incident on top of the atmosphere can be scattered and reflected back to space by cloud (Cr), cloud cover blocks the penetration of insolation. About 25% of incoming solar radiation is reflected back to space by clouds. Solar radiation can also be scattered or reflected by air molecules, dust particles and water vapour (Ar). Dust particles, air molecules and water vapour in the atmosphere are capable of scattering a lot of solar radiation. The scattering is either upward towards the space or downwards toward the earth's surface. About 6% of the insolation reaching the top of the atmosphere is scattered downward and reaches the surface as diffuse radiation. Radiation is also reflected by the earth's surface (CQ+q) σ), where Q and q are direct solar beam and diffuse solar radiation respectively and σ is the surface albedo.

On the other hand, solar radiation can be absorbed by cloud (Ca). Clouds act as temporary thermal reservoirs for they absorb a part of the energy they intercept. Solar radiation is also absorbed by air molecules, dust and water vapour (Aa). About 18% of the insolation is absorbed directly by ozone and water vapour. Ozone absorbs it mainly in the ultraviolet region consisting Hartley band (0.20-0.33µ). Water vapour absorbs in the near infrared band centering at 0.93, 1.13, 1.42 and 1.47µ.Water vapour is a selective absorber of radiation. Carbon dioxide absorbs radiation with wavelengths greater than 4 µ. The earth's surface represented by (CQ+q)(1- σ), also absorbs solar radiation. Land and water have different thermal properties and react differently to insolation. Land heats up rapidly and loses heat rapidly while water heats up slowly and releases heat slowly.

3.1.3 Terrestrial and Atmospheric Radiation

The surface of the earth when heated, becomes a source of long wave radiation. Because the surface temperature of the earth is 285^{o}K most of the radiation is emitted in infrared spectral range from 4 µ to 100 µ with a peak near 10 µ.

Like the earth, the atmosphere absorbs and emits radiant energy. Although the atmosphere is nearly transparent to short wave radiation, it easily absorbs terrestrial radiation. The principal absorbers being water vapour (5.3-7.7 µ and beyond 20 µ), Ozone absorbs (9.4-9.8 µ), carbon dioxide (16.9 µ) (13.1 -and clouds absorb radiation at all wavelengths. While the atmosphere absorbs only 24% of incoming solar radiation (short wave), 91% of infrared terrestrial radiation is absorbed.

The atmosphere in turn re-radiates the absorbed terrestrial radiation partly to space and partly back to the earth's surface. This is known as counter-radiation.

3.1.4 Radiation Balance

Radiation balance or net radiation is the difference between the absorbed solar radiation by a surface and the effective outgoing radiation from the surface.

On the average, the earth's surface absorbs about 124 kilolangleys of solar radiation each year and in turn effectively radiates 52 kilolangley yr^{-1}.

4.0 CONCLUSION

Solar radiation is very important to human existence on the earth's surface as it touches all spheres of man's life, particularly agricultural activities.

5.0 SUMMARY

1. The sun emits a form of energy known as electromagnetic radiation
2. The totality of wavelength is known as solar spectrum which consists of short and long-wave
3. The incoming solar radiation is scattered, reflected or absorbed by cloud, air molecules, dust particles, water vapour and the earth's surface.
4. The atmosphere is significantly heated by terrestrial radiation.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is the importance of solar radiation to man?
2. Account for the disposition of solar radiation in the earth's atmospheric system.
3. Explain the radiation balance of the earth's atmospheric system.

7.0 REFERENCES/FURTHER READING

Ayoade, J. O. (1983). *Introduction to Climatology for the Tropics*. ChiChester: John Wiley and Sons..

Ojo, O. *et al* (2001).*Fundamentals of Physical and DynamicClimatology.* Lagos: SEDEC Publishers.

UNIT 5 HEAT TRANSFER IN SOILS

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1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 Sensible Heat Flux

3.2 Soil Temperature

3.2.1 Temperature Profile on bare Soil

3.2.2 Temperature Profile in Plant Canopy

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0 INTRODUCTION

Heat transfer in soil is influenced by the thermal properties of soil. These are properties which influence how energy is partitioned in the soil profile. While related to soil temperature, it is more accurately associated with the transfer of energy (mostly in the form of heat) throughout the soil, by radiation, conduction and convection.

It is hard to say something general about the soil thermal properties at a certain location because these are in a constant state of flux from diurnal and seasonal variations. Apart from the basic soil composition, which is constant at one location, soil thermal properties are strongly influenced by the soil volumetric water content, volume fraction of solids and volume fraction of air. As such soil moisture properties and soil thermal properties are very closely linked and are often measured and reported together. Temperature variations are most extreme at the surface of the soil and these variations are transferred to sub surface layers but at reduced rates as depth increases.

2.0 OBJECTIVES

At the end of this unit, the students should be able to:

- Explain the thermal properties of soil based on composition of the soil
- Explain how heat is transferred from surface to sub-surface layers as depth increases

3.0 MAIN CONTENT

3.1 Sensible Heat Flux

The net energy flux available at the earth surface partly gets transferred in to the soil as soil heat flux (S). This is used for heating the air as sensible heat flux (H) and partly used for evaporation which is latent heat flux (λE). The net energy balance equation can be written as:

$$\mathbf{Rn = S + H + \lambda E}$$

Sensible heat flux is the heat exchange between ground surface and air, because this is the flow of heat which determines air temperature, the property of air which we sense. Flow of sensible heat per unit area per unit time is **sensible heat flux** and is, generally, measured in Wm^{-2} (Wm^{-2} $Jm^{-2}s^{-1}$, 1 Langley = 697.7). Large quantities of heat energy are transferred between the warm surface and air by the process of convection. During the day time, heat will be transferred from warm ground or crop surface to the cooler air above. At night, when the air is warm and the surface is cool, heat will be transferred to surface.

3.2 Soil Temperature

Soil temperature is one of the most important environmental factors of plant growth and development. Heat exchange between the soil and its surface is through soil gain and lose of heat. Soil gains heat by absorption of solar radiation and long wave counter radiation from the atmosphere. downward transfer of sensible heat and horizontal transfer of heat from the surrounding. On the other hand, soil lose heat by long wave radiation to the atmosphere, evaporation, horizontal transfer of heat from the column to surrounding and upward transfer of sensible heat to air when the soil surface is hotter than air.

3.2.1 Temperature Profile on bare Soil

Radiational heating and cooling, condensation, evaporation etc appear to be operative in modifying the temperature profiles in the soil or ground vicinity. During the daytime, soil gets heated thereby heating air layers above it. This heating by the absorbed ground heat will go on decreasing with increasing height. Thus during the daytime, lapse conditions are observed. During night, ground losses heat by Radiational cooling.

3.2.2 Temperature Profile in Plant Canopy

Temperature profiles into plant canopies differ from those in free air due to several reasons such as shading, air movement, ground heating, evaporation of soil moisture etc.

In general, surface in soil vicinity will be colder than the upper surface. After sunrise, soil surface and the crop surface nearby will get heated and the temperature will be comparatively higher in the lower crop surface. Temperature of the crop surface goes on increasing from morning till midday due to stomatal closure and radiation interception.

4.0 CONCLUSION

Exchange of heat between the soil and its surface is through soil gain and lose of heat is one of the most important environmental factors of plant growth and development. Soil gains heat by absorption of solar radiation and terrestrial radiation from the atmosphere.

5.0 SUMMARY

1. Sensible heat flux is the flow of sensible heat per unit area per unit time, generally, measured in Wm^{-2} (Wm^{-2} $Jm^{-2}s^{-1}$, 1 Langley = 697.7)
2. Soil temperature is the temperature within the soil profile that is important for seed germination and crop growth and development
3. During the daytime, soil gets heated thereby heating air layers above it. This heating by the absorbed ground heat will go on decreasing with increasing height.
4. Temperature of the crop surface goes on increasing from morning till midday due to stomatal closure and radiation interception.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the process of heat transfer in the soil profile or ground vicinity
2. Derive the net energy balance equation
3. Define sensible heat flux giving its unit of measurement

7.0 REFERENCES/FURTHER READINGS

Reddy, S.R. and D.S. Reddy (2011). *Agrometeorology*. New Delhi: Kayani Publishers.

Ayoade, J. O. (1983). *Introduction to Climatology for the Tropics*. ChiChester: John Wiley and Sons..

Ojo, O. *et al* (2001).*Fundamentals of Physical and DynamicClimatology.* Lagos: SEDEC Publishers.

Module 2

Unit 1Forcing Mechanisms in the Boundary layer
Unit 2 Atmospheric Moisture
Unit 3 Soil Moisture
Unit 4 Soil Properties
Unit 5 Soil Conservation

UNIT 1 FORCING MECHANISMS IN THE BOUNDARY LAYER

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main Content
3.1 Forcing Mechanisms
3.1.1 Wind in the boundary layer
3.2 Turbulance
3.2.1 Turbulance and Taylor Hypothesis
4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Readings

1.0 INTRODUCTION

The earth's surface is the lower boundary on the atmospheric domain and hence, interacts with the lower part of the earth's atmosphere. It can be defined as: "that part of the troposphere that is directly influenced by the presence of the earth's surface and responds to surface forcings with a time scale of about an hour or less”. Boundary layer depth is variable, typically between 100-3000 m deep (see Fig. 1.1). The tropospheric depth is on one order of magnitude greater than boundary layer depth ratio of tropospheric depth to radius of earth: 10 km/6400 km = 0.001 or .1% ratio of boundary layer depth to radius of earth: 1 km/6400 km = 0.0001 or 0.01%.

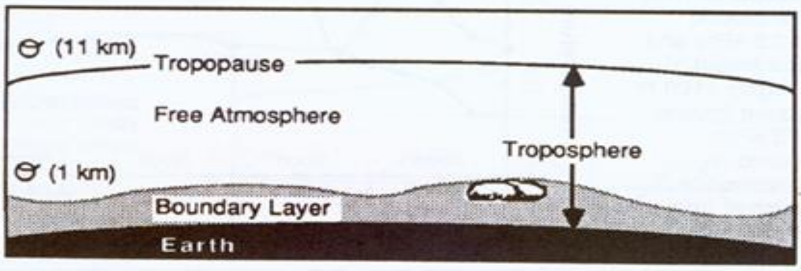


Fig. 1.1 The troposphere can be divided into two parts: a boundary layer (shaded) near the surface and the free atmosphere above it.

2.0 OBJECTIVES

At the end of this course, the student should be able to understand,

1. The limit of boundary layer and its climate
2. The forcing mechanism within the boundary layer
3. Decomposition of observed wind within the boundary layer

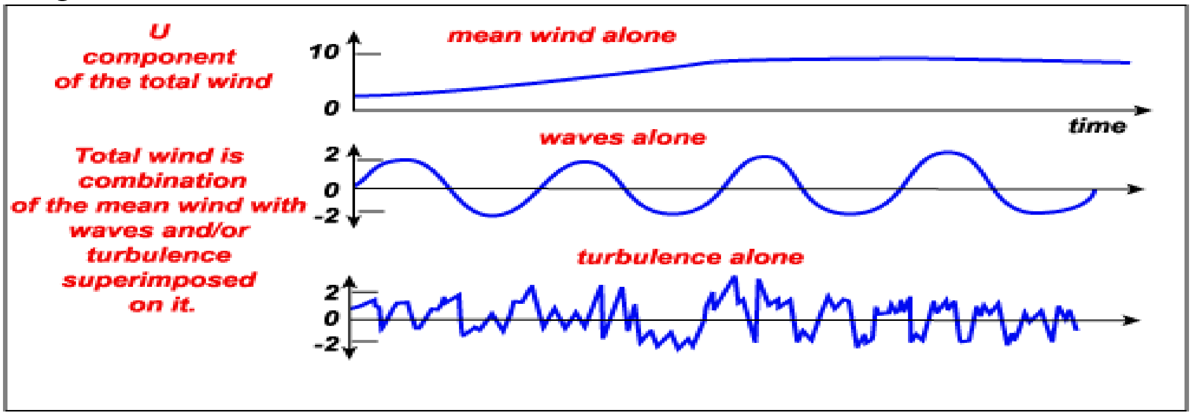
3.0 MAIN CONTENT

3.1 Forcing Mechanisms

Forcing mechanisms are physical processes that acts to modify a parcels temperature, moisture content or wind velocity that are important in the boundary layer e.g. Heat transfer to/from the ground, Frictional drag, Evaporation & Transpiration, Terrain - induced flow modification, Pollution emission.

3.1.1 Wind in the boundary layer

Within the boundary layer, the observed wind can usually be decomposed into three main categories: Mean wind, waves and turbulence.



Each of these three wind properties can exist individually

Mean Wind:

- The mean wind is important for *horizontal* transport of quantities such as moisture, heat, momentum, and pollutants - i.e., advection
- Typical speeds are 2-10 m/s
- Friction slows the winds near the surface, the wind velocity is 0 m/s right at ground level

Waves:

- Occur mostly at night in the nocturnal boundary layer.
- Transport little heat, moisture and other scalar variables like pollutants
- Are effective at transporting energy and momentum.

Turbulence:

the *vertical* transport of moisture, heat, momentum, and pollutants is dominated by turbulence.. this is a very important process .

3.2 Turbulence

This is the apparent chaotic nature of many wind flows which is manifested in the form of irregular, almost random fluctuations in velocity, temperature and scalar concentrations around their mean values in time and space. It is simply stated as **GUSTINESS** of wind

3.2.1 Turbulence and Taylor Hypothesis

- When studying turbulence (the spectrum of eddy sizes, for example), it is difficult to obtain an instantaneous snapshot of the boundary layer and all eddies formed within it.

- It is often easier and cheaper to make measurements of eddies in the boundary layer at one point over a long period of time (i.e., a weather station versus a Doppler radar)
- To study turbulence from a continuous record of measurements from a single point, we need to assume that the turbulence is frozen.
  What does this mean?
- As the mean flow advect the eddies past your sensor, the fundamental properties of the eddies remain unchanged, or frozen.

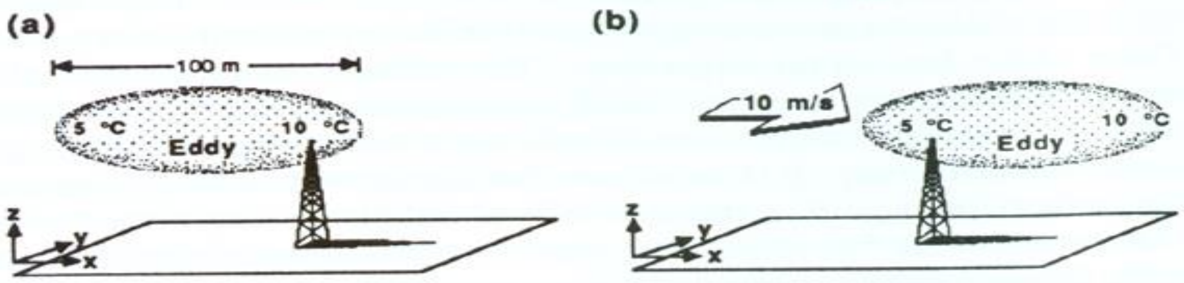


Fig. 1.4 Illustration of Taylor's hypothesis. (a) An eddy that is 100 m in diameter has a 5 ° C temperature difference across it. (b) The same eddy 10 seconds later is blown downwind at a wind speed of 10 m/s.

from Stull 1988

4.0 CONCLUSION

Forcing mechanisms in the boundary layer are the actual determinants of weather within the microclimatology of soil and ground vicinity

5.0 SUMMARY

1. The observed wind properties in the boundary layer can exist individually and in combination
2. The mean wind is important for horizontal transport of quantities, the wave is important in the nocturnal boundary layer while the turbulence is important for vertical transport of quantities

6.0 **TUTORED-MARKED ASSIGNMENT**

1. Distinguish between the three wind properties within the boundary layer
2. Explain how to study turbulence as hypothised by Taylor
3. Discuss forcing mechanisms in the boundary layer

7.0 REFERENCES/FURTHER READINGS

Reddy, S.R. and D.S. Reddy (2011). *Agrometeorology*. New Delhi: Kayani Publishers.

Stull R.B. (1950). An Introduction to Boundary layer Meteorology

Ayoade, J. O. (1983). *Introduction to Climatology for the Tropics*. ChiChester: John Wiley and Sons..

Ojo, O. *et al* (2001).*Fundamentals of Physical and Dynamic Climatology.* Lagos: SEDEC Publishers.

UNIT 2 ATMOSPHERIC MOISTURE

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main Content
3.1 Atmospheric Moisture
3.1.1 Evaporation and Evapotranspiration
3.2 Humidity
3.2.1 Distribution of Humidity
Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Readings

1.0 INTRODUCTION

Water can exist in solid, liquid or gaseous states. It is a highly important element for all living things and the environment. Water in its gaseous state or "water vapour" forms the bulk of what we refer to as atmospheric moisture. Water vapour is of great significance in deciding weather and climate and so climatologists and meteorologists are interested in its amount and distribution over time and space. This unit examines the nature, amount and distribution of atmospheric moisture.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- understand the term atmospheric moisture
- define humidity and the various indices of humidity
- explain the distribution of humidity.

3.0 MAIN CONTENT

3.1 Atmospheric Moisture

3.1.1 Evaporation and Evapotranspiration

Atmospheric water vapour is derived from evaporation and transpiration. Evaporation is the process by which moisture in its liquid or solid form is converted into gaseous form – water vapour.

Transpiration on the other hand refers to the loss of water from plants to the atmosphere. Evapotranspiration differs from evaporation because it describes water losses from surfaces where transpiration is a major contributor. Essentially, it combines evaporation and transpiration.

Availability of moisture at evaporating surface and the ability of the atmosphere to vaporise the water, remove and transport the vapour upward are fundamental factors that determine the rate of evaporation and evapotranspiration over any given area. Evaporation and evapotranspiration will occur at the maximum level if moisture is always available at the evaporating surface. This has given rise to the concept of potential evapotranspiration. However, moisture is not always available at the evaporating surface, and evaporation and evapotranspiration have often occurred below maximum level. This has also given rise to the concept of actual evapotranspiration.

Many factors including solar radiation, temperature, wind speed and humidity also determine evaporation and evapotranspiration. Energy is needed to vaporise water and in the absence of radiation data, energy is indicated by air temperature. Wind speed removes the moistened air lying over the evaporating surface and replaces it with dry air to maintain the evaporation process. The humidity of air determines the capacity of the air to hold moisture. It also affects the evaporation rate. The lower the humidity, the greater the capacity of air to hold moisture while the higher the humidity the lower the capacity of air to hold water.

Condensation and precipitation which have been explained in an earlier unit help to remove water vapour from the atmosphere. The most conspicuous aspects of the weather (e.g. rain, snow, hail, fog etc) result from the presence of water in the atmosphere.

3.2 Humidity

Humidity is a measure of the amount of water in the atmosphere. It does not cover the other forms of moisture in the atmosphere, i.e. liquid form (water droplets) and solid form (ice). Because of its origin (earth's surface) atmospheric water vapour is concentrated in the lower layers of the atmosphere. In fact, about half of the total water vapour in the atmosphere is found below 2000 metres. The amount of moisture in the atmosphere decreases steadily with increase in height. Water vapour is virtually absent after the tropopause.

There are different ways of measuring the moisture content of the atmosphere. The indices of humidity usually applied include the following:

Absolute humidity: It is expressed in grains per cubic metres of air. It is the total mass of water in a given volume of air.

Specific humidity: This is the mass of water vapour per kilogram of air including its moisture.

Mass mixing ratio or humidity mixing ratio: It is the mass of water vapour per kilogram of dry air.

Relative humidity: It is the ratio of the actual moisture content of a sample of air to that which the same volume of air can hold at the same temperature and pressure when saturated. It is usually expressed in percentage.

Dew-point temperature: This is the temperature at which saturation will occur if the air is cooled at constant pressure without addition or removal of vapour.

Vapour pressure is the pressure exerted by the vapour content of the atmosphere in millibars.

The relative humidity is the most popularly used index for measuring air humidity. It is easily measured and indicates the degree of saturation of the air. However, it is highly influenced by the air temperature. A change in air temperature can change the value of relative humidity even though the moisture content remains constant. For instance, the relative humidity of the air varies inversely with temperature, being lower in the early afternoon and higher at night. It is important to note that relative humidity does not tell us about the quantity of moisture in the air but tells us how close to saturation the air is.

Unless they have been obtained at about the same hour of the day when air temperatures are not too different, relative humidity for different stations cannot be compared since the values are dependent on air temperature. For the purpose of comparison other indicators of atmospheric moisture such as the vapour pressure or the absolute humidity should be used. Unlike relative humidity these measures are not unduly influenced by air temperatures.

3.2.1 Distribution of Humidity

Water vapour as earlier mentioned is the most important air component that has influence on weather and climate. It is highly inconstant varying from nearly zero up to a maximum of about 3% in the middle latitude, and 4% in the humid tropics. This variability in both place and time is of outstanding importance for the following reasons.

Water vapour is the source of all forms of condensation and precipitation.

Water vapour is a principal absorber of solar and infrared radiation. It therefore has an important influence on temperature. Because of its latent heat, the amount of vertical distribution of water vapour in the atmosphere indirectly affects the buoyancy of air and hence its tendency to ascend. This in turn is closely related to the formation of clouds and precipitation.

The latent heat of water vapour is an important energy source for atmospheric circulations. Humidity is an important factor of evaporation, a process that is important for animal and plant life.

Generally, relative humidity is greater over the ocean than over the continental areas. This reflects the high rate of evaporation due to the fact that the supply of water is unlimited at the ocean surface while over many land areas; water is an important limiting factor of evaporation because it is scarce. Also relative humidity is high throughout in very humid climates and low in arid and semi-arid climates. In seasonally humid areas, relative humidity is higher during the rainy season than during the dry season

The vapour pressure distributions have similar characteristics with relative humidity over the oceans and the very humid areas of the work; for instance, vapour pressures are almost at saturation level. In the arid and semi -arid areas, vapour pressures are low, causing the saturation deficit of evaporability of air to be high.

When vapour is continuously added to the atmosphere and the limit is reached, the air is said to be saturated. The resulting vapour pressure of the upper limit of water holding capacity is termed saturation vapour pressure. The saturation vapour pressure increases with higher temperatures and reaches a maximum at 1013 mb at which point the introduction of more water vapour into the air results in condensation of an equivalent amount of water vapour.

The saturation point can be reached at a particular temperature without the moisture content changing. The critical temperature at which the saturation vapour pressure is reached is known as the dew point temperature, which may be defined as the temperature at which the quantity of water vapour in the air represents the maximum holding capacity of the air at that temperature. This critical temperature may be attained by increasing the water vapour content of the air at a particular temperature, or decreasing the air temperature and consequently, reducing the relative moisture content of the air at a constant temperature. Once the dew point is reached, any further cooling beyond it will result in condensation either in the form of minute particles of water if temperature is above 0^0C or ice if it is below 0^0C. The dew point and relative humidity are closely related. At high relative humidity, the air is close to saturation and only slight cooling will be required to attain the dew point. On the other hand, when relative humidity is low, a large amount of cooling is required for the dew point to be attained.

4.0 CONCLUSION

Atmospheric moisture is made up of water vapour, water droplets and ice. They are derived from evaporation and removed by condensation and precipitation.

5.0 SUMMARY

In this unit we have learnt that:

1. Water vapour highly influences weather and climate
2. Atmospheric moisture is derived through evaporation from the water bodies on the earth's surface
3. Humidity is a measure of the amount of water vapour in the atmosphere.
4. The amount of water vapour decreases with height.
5. There are different indices for measuring humidity
6. Relative humidity is the most popularly used index for measuring air humidity.
7. Relative humidity is higher over the ocean than over the continent.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the process of acquisition and removal of atmospheric moisture.
2. a. What do you understand by relative humidity?
   b. Explain the dew point temperature and how it is related to relative humidity.

7.0 REFERENCES/FURTHER READING

Ayoade, J.O. (2004). *Introduction to Climatology for the Tropics.* Ibadan: Spectrum Books Limited.

Ayoade, J.O. (2002). *Introduction to Agro Climatology*. Ibadan:Vintage Publishers.

Ojo, O. *et al* (2001).*Fundamentals of Physical and DynamicClimatology* SEDEC Publishers.

UNIT 3 SOIL MOISTURE

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1.0 Introduction
2.0 Objectives
3.0 Main Content
3.1 Soil Moisture
3.1.1 Effective Precipitation
3.2 Soil Aeration

4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Readings

1.0 INTRODUCTION

The term 'soil moisture' refers to the moisture state of soil as influenced over time by either groundwater or rain water held by the soil at different tensions. This is largely determined by climate and soil physical and chemical properties. Soil and its moisture are very important in acting as a buffer system for plants, between times of water supply and demand in the microclimatic environment of plants.

Soil moisture is the water stored in the soil and is affected by precipitation, temperature, soil characteristics, and more. These same factors help determine the type of biome present, and the suitability of land for growing crops. The health of our crops relies upon an adequate supply of moisture and soil nutrients, among other things. As moisture availability declines, the normal function and growth of plants are disrupted, and crop yields are reduced. And, as our climate changes, moisture availability is becoming more variable.

Where is the water in soil? Solids, liquids, and gasses, the three phases of matter, are always present in soil. Small mineral and organic particles comprise the solid fraction, and there are spaces (pores) between the solid particles. Some pores are large, and others are very small. Air and water, the gas and liquid phases, exist in the pores.

2.0 Objectives

At the end of this unit, you should be able to:

- understand what soil moisture stands for
- define soil available water and the various indices
- explain the distribution of water within the soil.

2.0 Main Content

This unit will discuss the aspect of soil moisture and available water of soil in a microclimatic environment.

3.1 Soil Moisture

The macrospores are filled up with water immediately after heavy rain when the oxygen content falls to near zero. When the soil is artificially drained again, the macrospores are filled up with air and the oxygen content of the soil increases.

3.1.1 Effective precipitation

Effective precipitation is that fraction of the total precipitation available for the consumptive use of crop. This is because all the intense precipitation received in a single occasion may not be useful for crop as part of it may be lost as surface runoff, deep percolation beyond root zone or by evaporation. The extent of its utility in any given region determines effectiveness of rainfall or rainfall efficiency.

Effective precipitation is influenced by so many factors like, land characteristics such as topography, soil texture and structure, bulk density, permeability and infiltration. There is ground water contribution then management factors such as ridging, tillage, terracing and mulching which are aimed at minimizing surface runoff. Crop characters like root zone depth, degree of ground cover and growth stage also affect precipitation effectiveness. Annual effective rainfall is estimated to be about one-third of total rainfall.

3.2 Soil Aeration

Soil consists of pore spaces of varying sizes, which are filled with either water or air. The air present in soil is known as soil air.

Soil aeration is phenomenon of rapid exchange of oxygen and carbon dioxide between the soil pore space and the atmosphere, in order to prevent the deficiency of oxygen and/or toxicity of carbon dioxide in the soil air. The well aerated soil contains enough oxygen for respiration of roots and aerobic microbes and for oxidation reaction to proceed at optimum rate.

4.0 CONCLUSIONS

The main source of soil moisture is from the various forms of precipitation that falls from the atmosphere. This is as a result of hydrological cycle in which part of the falling precipitation will percolate into the soil while some will run-off to stream and rivers which may later be used to irrigate lands. Within the soil profile, there is exchange of oxygen and carbon dioxide between the soil pores and the atmosphere which useful for roots respiration and aerobic microbes.

5.0 SUMMARY

1. Effective precipitation is that fraction of the total precipitation available for the consumptive use of crop.
2. Effective precipitation is influenced by so many factors like, land characteristics such as topography, soil texture and structure, bulk density, permeability and infiltration.

3. Soil consists of pore spaces of varying sizes, which are filled with either water or air. The air present in soil is known as soil air.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between actual precipitation and effective precipitation
2. Discuss briefly the importance of soil aeration to crop performance
3. What is the main source of soil moisture?

7.0 REFERENCES/FURTHER READINGS

Ayoade, J.O. (2004). *Introduction to Climatology for the Tropics.* Ibadan: Spectrum Books Limited.

Ayoade, J.O. (2002). *Introduction to Agro Climatology*. Ibadan:Vintage Publishers.

Ojo, O. *et al* (2001).*Fundamentals of Physical and DynamicClimatology* SEDEC Publishers.

UNIT 4 SOIL PROPERTIES

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main Content
3.1 Soil Physical Properties
3.2 Soil Chemical Properties
4.0 Conclusion

5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Readings

1.0 INTRODUCTION

Properties of the soil consist of the physical and chemical state of soil at a given period of time. These properties are important to a soil manager because the chemical state of soil in terms of cation and anion exchanges determines availability of nutrients while the soil reaction is what determines the healthy state of the soil in a microclimatic environment.

2.0 OBJECTIVES

At the end of this course, the student will learn about

1. Soil properties as affected by the microclimate of an area
2. How to manage soils of a microclimate for optimum utilization
3. To describe the size of the soil particles, this is critical for understanding soil behaviour and its management.

3.0 MAIN CONTENT

3.1 Soil Physical Properties

Soil Texture

Texture is what describes the size of the soil particles, which is critical for understanding soil behaviour and its management. The main soil separates are Gravel (>2mm), sand (0.05-2mm), silt (0.002-0.05mm) and clay (<0.002mm). Coarse soil reduces the volume of soil available for water and nutrient retention and root growth. In dense soils however, the space between them may create paths for water drainage and root penetration. Sandy soils are have low water holding capacities and are prone to drought. A Clay particle exhibit electromagnetic charges that attracts positive and negative ions as well as water.

Soil Structure

This relates to the arrangement of primary soil particles into groupings known as aggregates. Soil structure is important because it gives a more permeable soil through which roots can explore more water. Water holding capacity is effectively increased and it enhances water movement and good drainage.

3.2 Soil Chemical Properties

Cation Exchange Capacity

Cation exchange capacity is the quantity of cations that can be held or exchanged by a given amount of soil. This is because soil particles have charges which attract simple and complex ions of opposite charges. Clay soils for example have negatively charged sites in their lattices and attract and hold positively charged cations.

Anion Exchange

The principles of anion exchange are similar to those of cation exchange. Anions are held by soil colloids by anion adsorption mechanism and by reacting with surface oxides or hydroxides of metallic ions. Anion exchange is very important in making anions available for plant growth and at the same time in retarding the leaching of such anions.

Soil Reaction (pH)

Soil reaction is determined by soil pH which affects a wide variety of chemical and biological phenomena in soils. Soil pH influences the availability of plant nutrients as well as microorganisms activities in the soil. In strongly acid soils (pH 4 - 5) the availability of macronutrients is curtailed. In contrast, availability of micronutrients is increased.

4.0 CONCLUSIONS

Availability of soil macro and micronutrients to the plant root is governed by the chemical properties of the soil. The physical properties of the soil on the other hand describes the soil structure and texture which are very important in knowing soil behaviour and management

5.0 SUMMARY

1. Soil structure is important because it gives a more permeable soil through which roots root can explore more water.
2. Soil texture is what creates paths for water drainage and root penetration
3. Soil reaction is determined by soil pH which affects a wide variety of chemical and biological phenomena in soils.
4. Anion exchange is very important in making anions available for plant growth and at the same time in retarding the leaching of such anions.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the importance of soil properties
2. How does soil reaction affects the availability of nutrients supply to plants?

7.0 REFERENCES/FURTHER READINGS

Manual on soil fertility assessment

Reddy, S.R. and D.S. Reddy (2011). *Agrometeorology*. New Delhi: Kayani Publishers.

Ayoade, J. O. (1983). *Introduction to Climatology for the Tropics*. ChiChester: John Wiley and Sons..

UNIT 5 SOIL CONSERVATION

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main Content
  3.1 Soil Conservation
  3.1.1 Wind breaks
  3.1.2 Cover crops/Crop rotation
  3.1.3 Soil conservation farming
  4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Readings

1.0 INTRODUCTION

Soil Conservation is the name given to a handful of techniques aimed at preserving the soil. Soil loss and loss of soil fertility can be traced back to a number of causes including over-use, erosion, salinization and chemical contamination. Unsustainable subsistence farming and the slash and burn clearing methods used in some less developed regions, can often cause deforestation, loss of soil nutrients, erosion on a massive scale and sometimes even complete desertification.

2.0 OBJECTIVES

At the end of this course the student will learn about

1. Soil conservation techniques in a microclimate for sustainable land use
2. The various methods of soil conservation
3. How this techniques can affect both erosion and fertility

3.0 MAIN CONTENT

3.1 Soil Conservation

Soil conservation includes all those measures which help in protecting the soil from erosion and exhaustion. Soil erosion has been continuing over, such a large part of India for such a long time that it has assumed alarming proportions. Some of the methods that must be adopted for conserving soil are as follows: Afforestation, Checking Overgrazing, Constructing Dams and Changing Agricultural Practices

Slash-and-burn and other unsustainable methods of subsistence farming are practiced in some lesser developed areas. A sequel to the deforestation is typically large scale erosion, loss of soil nutrients and sometimes total desertification. Techniques for improved soil conservation include crop rotation, cover crops, conservation tillage and planted windbreaks, affect both erosion and fertility. When plants die, they decay and become part of the soil.

3.1.1 Windbreaks – Rows of tall trees are used in dense patterns around the farmland and prevents wind erosion. Evergreen trees can provide year round protection but deciduous trees can be adequate as long as foliage is apparent during the seasons when the soil is bare.

3.1.2 Cover Crops/ Crop Rotation – Cover crops such as turnips and radishes are rotated with cash crops in order to blanket the soil all year- round and produces green manure the replenishes nitrogen and other critical nutrients. Using cover crops can also suppress weeds.

3.1.3 Soil Conservation Farming – A mixture of farming methods intending the mimic the biology of virgin land. These practices can be used to prevent erosion and even restore damaged soil and encourage plant growth. Eliminating the use of nitrogen fertilizer and fungicides can increase yields and protect crops from drought and flooding.

4.0 CONCLUSION

Soil conservation is one a very vital technique in sustainable agriculture and there several methods to conserve soil for maximum land use.

5.0 SUMMARY

1. Soil Conservation is aimed at preserving the soil against soil loss and loss of soil fertility due to a number of causes including over-use, erosion, salinization and chemical contamination.
2. Soil erosion and exhaustion has been continuing at an alarming proportion.
3. Techniques for improved soil conservation include crop rotation, cover crops, conservation tillage and planted windbreaks, affect both erosion and fertility.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is soil conservation and the techniques used in conserving soils?
2. What method of soil conservation will you adopt to increase yields and protect crops from drought and flooding?

7.0 REFERENCES/FURTHER READINGS

Wikipedia.org

Brady N.C and Weil R.R. (2002). The nature and properties of Soils. Library Cataloguing-in-publication Data. Macmillan Publishing Company

MODULE 3

Unit 1 Equipments and Maintenance of Standard Meteorological Station

Unit 2 Measurements of Climatic Variables

Unit 3 Measurement of Evaporation and Evapotranspiration

Unit 4 Microclimate and Soil Management in the Tropics

Unit 5 Influence of Agriculture on Microclimate

UNIT 1 EQUIPMENT AND MAINTENANCE OF STANDARD METEOROLOGICAL STATIONS

CONTENTS

1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 Categories of Weather Stations

3.2 Weather Measurement

3.2.1 Rainfall

3.2.2 Air Temperature

3.2.3 Humidity

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0 INTRODUCTION

A weather station otherwise known as a meteorological station or meteorological enclosure is a place where all elements of weather are measured and recorded. In dimension, it measures 10 metres by 6 metres. It should be located on a level ground covered with short grasses. Furthermore, the station should not be sited on or close to a hill, in a depression or on steep slope, near buildings or tall trees. The station is also usually fenced around with wire gauze for the security of the instruments and to ensure free air circulation. Based on the number of elements measured or observed and the frequency of observation of these elements, four categories of weather stations are recognized.

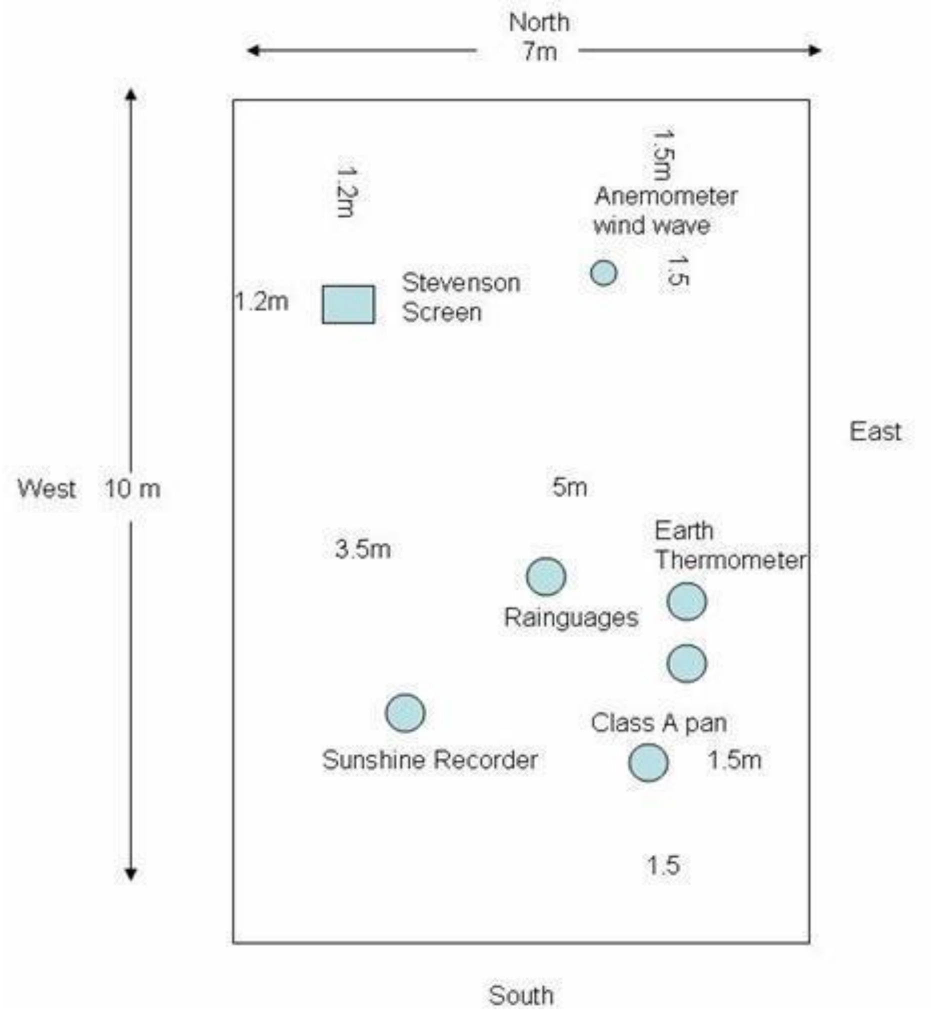


Fig. 13: Layout of a Weather Station (Source: Ayoade, 2002)

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the layout of a weather station
- recognise the equipment for measuring rainfall, air temperature and humidity
- measure rainfall, air temperature and humidity.

3.0 MAIN CONTENT

3.1 Categories of Weather Stations

We have the following categories of weather stations:

1. Rainfall stations: These are stations manned by part-time observers who take daily readings of rainfall only. In the strictest sense of the term these are not weather stations, as the only weather element measured is rainfall.

2. Climatological stations: These stations are also manned by parttime observers but in addition to measuring daily rainfall, they make once or twice daily instrumental observations of air temperature and humidity.

3. Agroclimatological stations: These are stations where daily instrumental observations of temperature and humidity, as well as soil temperatures of various depths are made once or twice. Other elements which are measured only once daily include rainfall, wind speed and direction, evaporation, sunshine duration and radiation. They are manned by part- time observers.

4. Synoptic station: These are stations manned by full-time professional observers. Continuous weather monitoring and hourly instrumental observation are maintained here. The main climatic elements observed include temperature, humidity, pressure, rainfall, duration of sunshine, cloud amount and wind speed and direction.

3.3 Weather Measurement

Elements of weather are observed and measured by weather instruments which are kept within the confines of weather stations. Weather instruments may be manual or self-recording (autographic). The autographic instruments provide continuous measurements of weather elements over a period of time, usually 24 hours. Autographic instruments are more expensive than manual instruments. The general procedures for the measurements of the major weather elements are discussed here.

3.2.1 Rainfall

Rainfall is measured by a rain gauge. A rain gauge consists of a copper cylinder with a metal funnel which leads into a smaller copper container or a glass bottle. The hole in the funnel that leads down to the container is very small so that evaporation of the collected rain is minimised. The gauge should be at least 30cm above the ground and firmly fastened to avoid splashing. Rainfall falling in the funnel trickles into the jar below and at the end of a 24-hour period this is poured into a graduated measuring cylinder which is tapered at the bottom to enable very small amounts (such as 0.25mm) to be measured accurately. The reading should be done at eye-level and to an accuracy of up to 0.1cm.

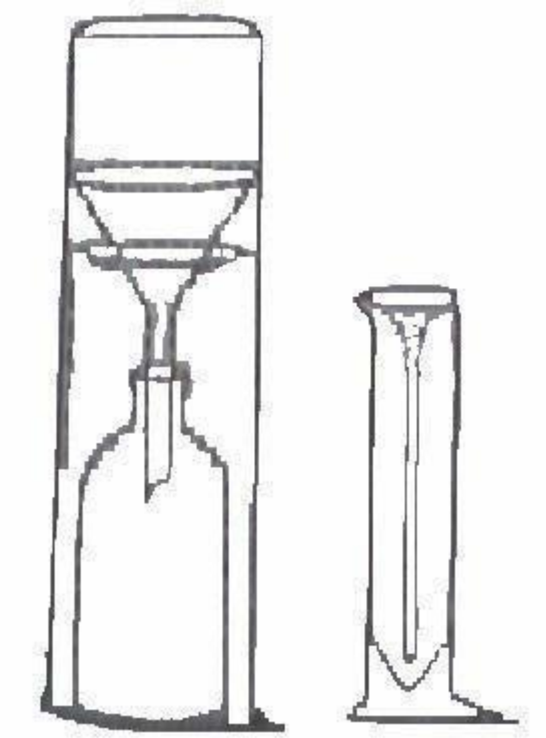


Fig. 14: Rainguages

Rainfall is generally stated in units of inches, millimeters and centimeters that fall per unit of time. For instance, 20mm of rainfall would cover the ground to a depth of 20mm, provided that none is lost by runoff evaporation or sinking into the ground. For meteorological recordings, a rain-day is reckoned by a period of 24 hours with at least 0.25mm of rain recorded.

There are different types of autographic rain gauges, depending on the type of operating mechanism; they include the tilting siphon, the tipping bucket and the weighing collector system (W.M.O 1970). The most popular of these rain gauges is the tilting siphon autographic rain gauge. It contains a collecting chamber fitted with a float. When the chamber fills up as rain falls, the float rises and a pen attached to the top traces a graph on a chart fixed to a cylindrical drum driven by clock wave. After the chamber is filled, it tilts over on its pivot and the contents siphon out of the gauge. The float then returns to its original level and the pen rests on the base of the chart. The chamber fills up again as the rain continues to fall and the process is repeated until the rain stops. One complete cycle measures 5mm of rainfall.

3.2.2 Air Temperature

Air temperature is measured manually with the aid of maximum and minimum thermometers and autographically by a thermograph.

Each weather station has a Stevenson screen in which the thermometers are kept. They are maximum and minimum thermometers, wet bulb thermometer and dry bulb thermometer.

The screen is built to provide shade under which the shade temperature of the air can be measured. It is a wooden box whose four sides are louvered to allow adequate ventilation. The roof is made of double boarding to prevent the sun's heat from reaching the inside of the screen while the white paint further improves the insulation against solar radiation. It is placed on a stand, about 121cm (4ft) above the ground level.

The maximum thermometer is a mercury-in-glass thermometer which contains a small glass index. When the temperature rises the mercury expands and pushes the index along the tube. When the temperature falls, the mercury contracts leaving behind the index. The maximum temperature is read on the scale at the end of the index nearer the mercury.

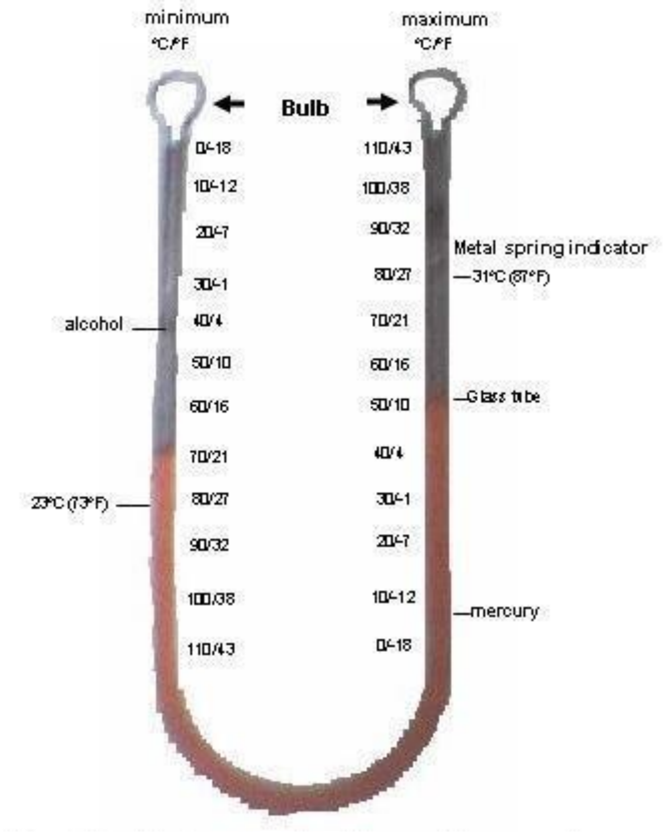


Fig. 15: Maximum and minimum thermometers

The minimum thermometer is an alcohol in-glass thermometer in which when the temperature rises, the alcohol expands and flows past the index and when the temperature falls, the alcohol contracts and pulls the index

along the tube. The end of the index nearer the meniscus shows the minimum temperature. The instrument is reset by tilting or by using a magnet to draw back the index to the mercury. The maximum and minimum thermometers are used at weather stations to measure the highest and lowest temperatures within the day respectively. The air temperature at any given time can be read off an ordinary mercury in-glass thermometer with or without an index.

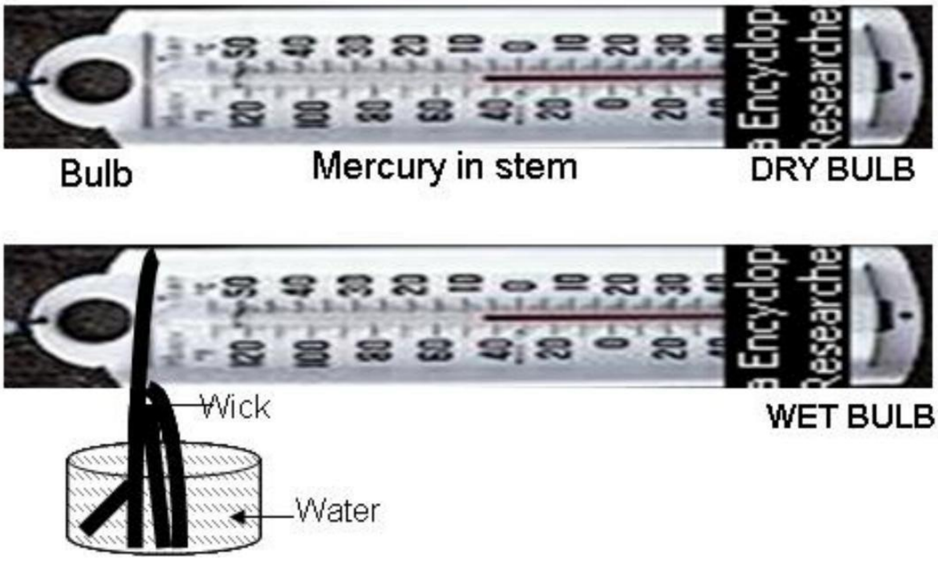
Continuous measurement of air temperature can be done with the aid of a self recording thermometer known as a thermograph.

3.2.3 Measurement of Humidity

There are various measures of humidity (i.e. the water vapour content of the atmosphere). These include, as earlier discussed, relative humidity, absolute humidity, specific humidity, humidity mixing ratio, vapour pressure and dew point temperature. Relative humidity is however, the most commonly used measure of humidity, perhaps because it is easy to compute using the wet and dry bulb thermometer. The instrument for measuring relative humidity is the hygrometer, which comprises wetand dry bulb thermometers placed side by side in the Stevenson screen. The dry bulb is in fact the ordinary thermometer that measures shade temperature (Td). The wet bulb thermometer has its bulb covered with muslin which is perpetually dipped in a reservoir of distilled water. When air is saturated, evaporation, which produces a cooling effect, takes place from the wet muslin. The wet bulb therefore always shows lower reading (T w) than the dry bulb. The difference between the two readings (T d-Tw) is known as the wet bulb depression. The drier the atmosphere is the greater this difference. Psychometric tables are used to obtain values, vapour pressure, dew point and relative humidity from readings of dry and wet bulb thermometers. A simplified version of the psychometric tables is given below.

Table 11.1: Psychrometric tables – Relative humidity

Air Temp. F	Depression of wet-bulb thermometer, F																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
0	67	33	1																																
5	73	46	20																																
10	78	56	34	12																															
15	82	64	46	29	11																														
20	85	70	55	40	26	12																													
25	87	74	62	49	37	25	13	1																											
30	89	78	67	56	46	36	26	16	6																										
35	91	81	72	63	54	45	36	27	19	10	2																								
40	92	83	75	68	60	52	45	37	29	22	15	7																							
45	93	86	78	71	64	57	51	44	38	31	25	18	12	6																					
50	93	87	80	74	67	61	55	49	43	38	32	27	21	16	10	5																			
55	94	88	82	76	70	65	59	54	49	43	38	33	28	23	19	11	9	5																	
60	94	89	83	78	73	68	63	58	53	48	43	39	34	30	26	21	17	13	9	5	1														
65	95	90	85	80	75	70	66	61	56	52	48	44	39	35	31	27	24	20	16	12	9	5	2												
70	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33	29	25	22	19	15	12	9	6	3										
75	96	91	86	82	78	74	70	64	62	58	54	51	47	44	40	37	34	30	27	24	21	18	15	12	9	7	4	1							
80	96	91	87	83	79	75	72	68	64	61	57	54	50	47	44	41	30	35	32	29	26	23	20	18	15	12	10	7	5	3					
85	96	92	88	84	81	77	73	70	66	63	59	57	53	50	47	44	41	38	36	33	30	27	25	22	20	17	15	13	10	8	6	4	2		
90	96	92	89	85	81	78	74	71	68	65	61	58	55	52	49	47	44	41	39	36	34	31	29	26	24	22	19	17	15	13	11	9	7	5	3
95	96	93	89	86	82	79	76	73	69	66	63	61	58	55	52	50	47	46	42	39	37	34	32	30	28	25	23	21	19	17	15	13	11	10	8
100	96	93	89	86	83	80	77	73	70	68	65	62	59	56	54	51	49	46	44	41	39	37	35	33	30	28	26	24	22	21	19	17	15	13	12
105	97	93	90	87	84	81	78	75	72	69	66	64	61	58	56	53	51	49	46	44	42	40	38	36	34	32	30	28	26	24	22	21	19	17	15
110	97	93	90	87	84	81	78	75	73	70	67	65	62	60	57	55	52	50	48	46	44	42	40	38	36	34	32	30	28	26	25	23	21	20	18
115	97	94	91	88	85	82	79	76	74	71	69	66	64	61	59	57	54	52	50	48	46	44	42	40	38	36	34	33	31	29	28	26	25	23	21
120	97	94	91	88	85	82	80	77	74	72	69	67	65	62	60	58	55	53	51	49	47	45	43	41	40	38	36	34	33	31	29	28	26	25	23
125	97	97	91	88	86	83	80	78	75	73	70	68	66	64	61	59	57	55	52	51	49	47	45	44	42	40	38	37	35	33	32	30	29	27	26
130	97	94	91	89	86	83	81	78	76	73	71	69	67	64	62	60	58	56	54	52	50	48	47	45	43	41	40	38	37	35	33	32	30	29	28



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. 16: Hygrometer (Dry and Wet bulb thermometer)

4.0 CONCLUSION

There are four categories of weather stations. Weather equipment is kept in weather stations. Thermometers and dry and wet bulb thermometers are kept in the Stevenson screen which in turn is placed in a weather station.

5.0 SUMMARY

In this unit we have learnt that:

1. A weather station is a place where all weather elements are measured and recorded.
2. Four categories of weather stations are recognised – rainfall stations, climatological stations, agroclimatological stations and synoptic stations.
3. The dimension of a weather station is 6x10m.
4. Rain gauges (both manual and self-recording) are used in measuring rainfall.
5. Thermometers (both manual and self recording) are used in measuring temperature.
6. Dry and wet bulb thermometers are used to measure humidity.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the main features of rain gauges and how the amount of rain is measured with the equipment.
2. Explain how you will set up a standard meteorological station.

7.0 REFERENCES/FURTHER READING

Areola, O. (1999). *Certificate Physical and Human Geography forSenior Secondary Schools*. Ibadan: University Press Plc.

Ayoade, J.O. (1983). *Introduction to Climatology for the Tropics*. ChiChester: John Wiley and Sons.

Ayoade, J.O. (2002). *Introduction to Agroclimatology*. Ibadan: Vantage Publishers.

Bunnet, R.B. (1973). *General Geography in Diagram*. London: Longman.

Nieuwolt, S (1977). *Tropical Climatology*. *An Introduction to theClimates of the Low latitudes*. ChiChester: John Wiley and Sons.

Ojo, O. (1977). *The Climates of West Africa.* Ibadan: Heinemann Educational Books.

Ojo,O.*etal.* (2001) .*Fundamentals of Physical and Dynamic Climatology.* Lagos: SEDEC Publishers.

UNIT 2 MEASUREMENT OF CLIMATIC VARIABLES

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main Content
3.1 Measurement of Air Pressure
3.2 Measurement of Wind Speed
3.3 Measurement of Wind Direction
3.4 Measurement of Radiation
3.5 Measurement of Sunshine Duration
4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0 INTRODUCTION

Weather observation and measurements started in Unit 11 and continues in this unit.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- recognise the equipment for measuring air pressure, wind speed, wind direction, radiation and sunshine duration
- measure air pressure, wind speed, wind direction, radiation and sunshine duration.

3.1 Measurement of Air Pressure

Air has weight and the weight of the vertical column of air is measured by barometers. The instrument which measures air pressure is called a barometer. There are various types of barometers. They are the mercury barometer, the aneroid barometer, the barograph and altimeter.

1. The mercury barometer: The principle which operates the mercury barometer is the balancing of the column of air against a column of mercury in a scaled glass tube. Fluctuations in air pressure produce corresponding differences in the height of the mercury and a graduated vanier is mounted along the tube to facilitate accurate reading to a thousandth of an inch. At sea level,
   the atmosphere balances a column of mercury 29.29 inches. In general the mercury barometer is large and cumbersome to carry about but it is very accurate and is used in many weather stations.

2. T
   he aneroid barometer measures pressure using the principle of sylphon cells, which is partially evacuated metal wefer. When pressure in the outside air increases, the cell tends to "collapse"; when pressure decreases, the cell expands. These fluctuations with pressure changes are mechanically linked to an indicator or a calibrated dial. The dial is commonly calibrated in inches of mercury. Although the aneroid barometer is less reliable, it is more compact, portable and convenient to use on the field.

3. The altimeter is an altitude barometer. The principle is the same as that of the aneroid barometer. The chief difference lies in the fact that barometric scales are calibrated in terms of atmospheric pressure, whereas, altimeters are calibrated in feet or metric height units.

4. The barograph: Atmospheric pressure can also be measured with the aid of a self-recording barometer known as a barograph. The most commonly used barograph employs the sylphon cells.

Sylphon cells activate pen arm which moves the ink record.

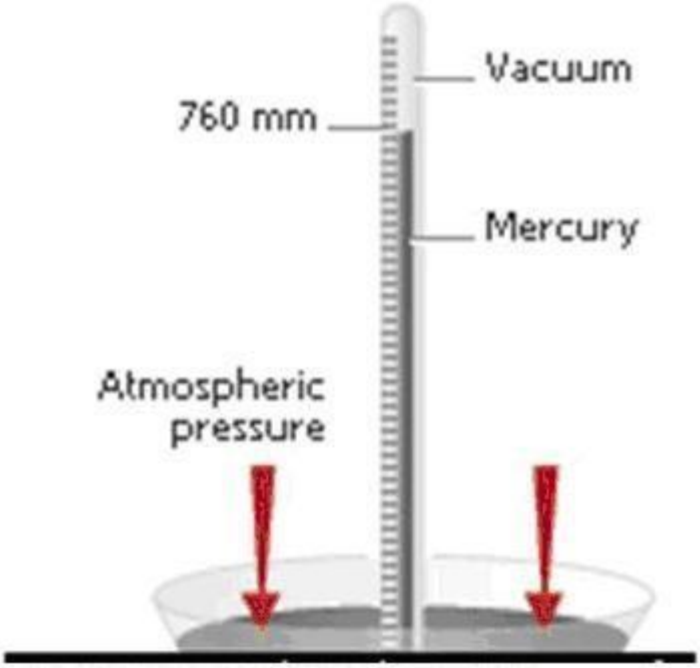

Fig. 17: Mercurial barometer

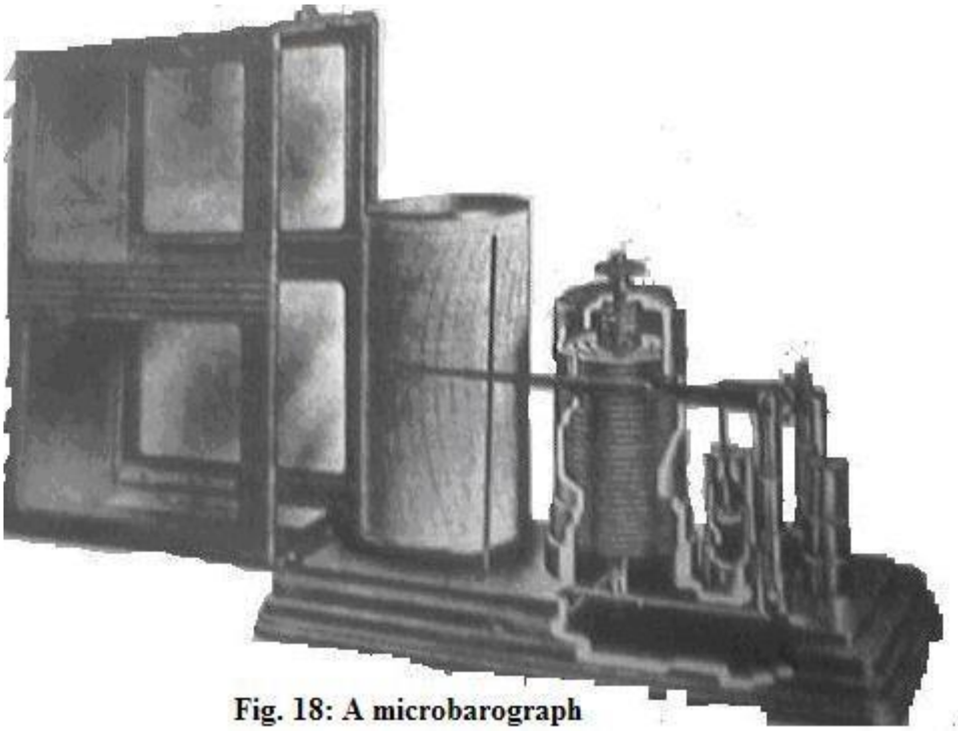

Fig. 18: A microbarograph

Measurement of Wind Speed

3.2 Wind speed is measured by a cup anemometer which consists of three or four cups, conical or hemispherical in shape mounted symmetrically about vertical axis.

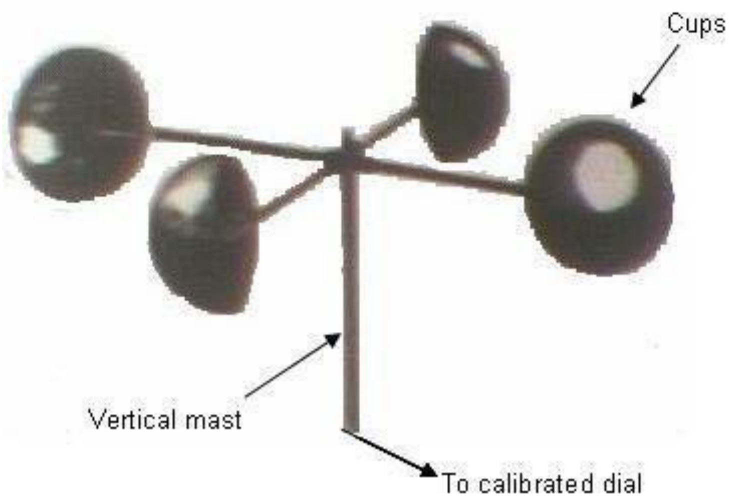

Fig. 19: Wind aneometer

The metal cups which are fixed to the ends of the arms rotate according to the prevailing wind speed. In the cup generator anemometer the rotating cups are made to generate voltage, which registers on a dial calibrated in knots, miles or kilometres per hour. In the cup-counter anemometer the integrated flow of the air in miles or kilometres is registered on a counter. In the latter case, wind speed is obtained by dividing in wind run between two observation times by the intervening period of time, usually 24 hours. A self-recording anemometer which produces a continuous record of wind velocity overtime is called an anemograph.

3.3 Measurement of Wind Direction

Wind direction is observed with the aid of a wind vane which consists of a rotating arm pivoted on a vertical shaft. The arrow of the wind vane always points in the direction from which the wind blows and the wind is named after the direction.

Fig. 20: Wind vanes

3.4 Measurement of Insolation

A number of instruments are available for measuring the different components of the earth's radiation balance, the equation of which is in the form

$$Rn = (Q+q)(1-\sigma) + I - I$$

Where R nis the net radiation, (Q+q) is the sum of the shortwave direct

(Q) and diffuse (q), solar radiation incident on the earth's surface, I is the counter radiation from the atmosphere which is the long-wave (infrared) and I is the terrestrial radiation which is also a long -wave ▼ or infrared.

Instruments used for measuring radiation are generally expensive and therefore are not commonly used in many developing countries. The instruments fall into five basic types as follows:

1. Net Radiometers – for measuring only the net radiation.
2. Pyranometers- for measuring the total short wave radiation from the sky incident on a horizontal surface at the ground.
3. Pyrheliometers – for measuring the solar intensity or the direct beam solar radiation (Q) at normal incidence. These are the most accurate of all radiation instruments.
4. Pyrradiometers – for measuring only the albedo of the surface 5.Pyrgeometers – for measuring infrared long wave radiation from the earth's surface or the atmosphere depending upon whether it is downward facing or upward facing.

6.Albedometers – for measuring only the albedo of the surface.

Measurements of some radiation components are described below.

Pyrheliometers are instruments designed for measuring the direct beam solar radiation at normal incidence, usually called solar intensity. It has a blackened receiving surface oriented perpendicular to the solar beam and is either inserted in a blackened tube or surrounded by a series of spaced diaphragms arranged in such a way that only radiation from the sun and a narrow annulus of sky is intercepted.

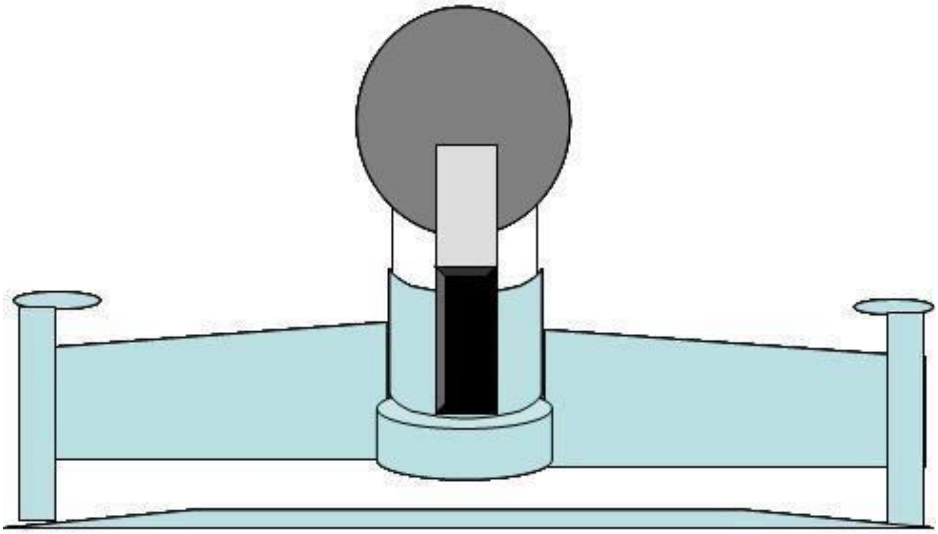

Fig. 21: Pyranometer

Pyronometers are more commonly used than pyrheliometers. They measure the total short wave radiation from the sun and sky incident on a horizontal surface of the ground (i.e. both direct and diffuse radiation). The receiver of the pyranometer is enclosed in a glass or quartz casing that must be kept clean and dry. To provide the best possible result, the pyranometer should be treated so that a shadow will not be cast on it at any time.

Fig. 22: Star Pyranometer

3.5 Measurement of Duration of Sunshine

The duration of sunshine is measured with the aid of Campbell-stokes sunshine recorder. It consists of a glass sphere which

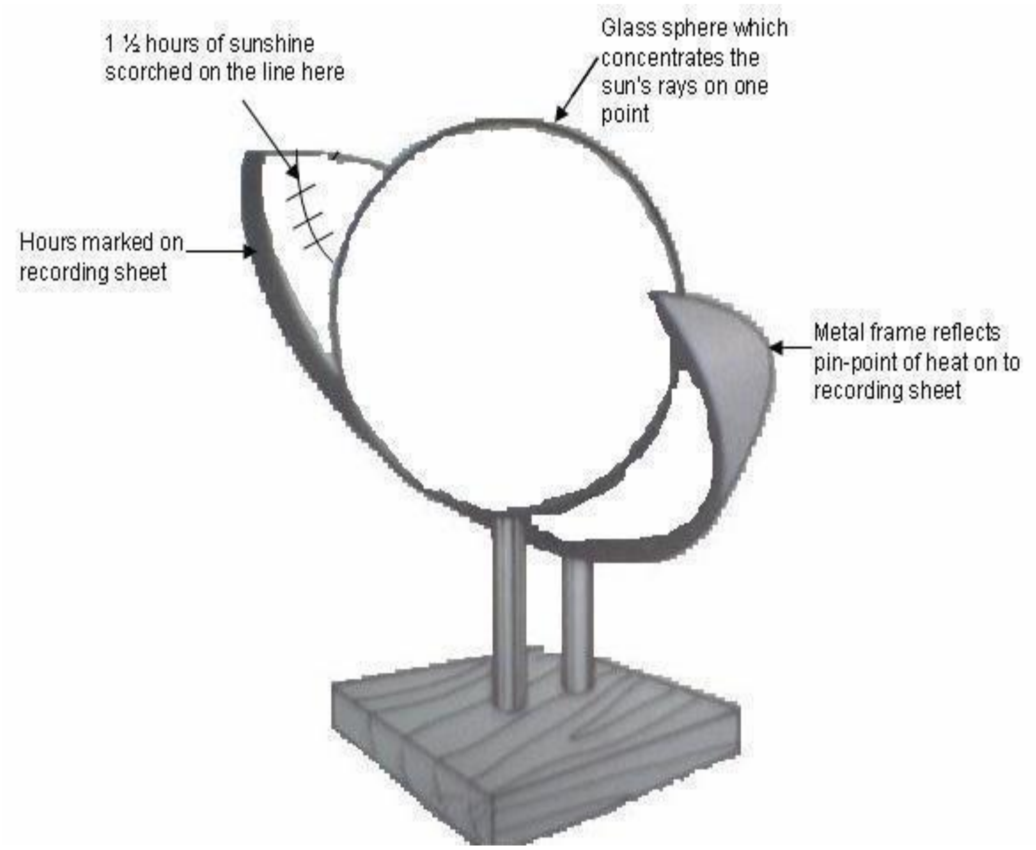

Fig. 23: Campbell-Stokes Sunshine Recorder

concentrates the sun's rays on a sensitised card graduated in hours and minutes and held in a metal half-bowl with which the sphere is concentric. The instrument is installed on a concrete pillar in the open about 1-5m above the ground. Bright sunshine leaves a trace of burnt line along the sensitised card while cloudy periods are blank. To measure the total duration of sunshine for the day, the total length of the burnt traces on the card which is graduated in hours and minutes is calculated.

3.6 Measurement of Soil Temperature

Soil temperatures are measured at various depths – 5cm, 10cm, 20cm, 50cm and 100cm. The instrument used for measuring soil temperature is known as soil thermometer. It is a mercurial thermometer with bulbs embedded in paraffin wax. The thermometer is suspended in steel tubes and inserted into the soil at various depths.

4.0 CONCLUSION

Equipment for measuring air pressure, wind speed and direction, radiation and sunshine duration have been identified in this unit. Methods of measuring the climatic elements have also been discussed.

5.0 SUMMARY

In this unit we have learnt that:

1. Various types of barometers are used for measuring air pressure.
2. Cup anemometer is the equipment used for measuring wind speed.
3. The wind vane is used for measuring wind direction.
4. Various types of radiometers are used for measuring various aspects of radiation.
5. Campbell-stokes sunshine recorder is used for measuring the duration of sunshine.

6.0 TUTOR-MARKED ASSIGNMENT

1. List all the equipment used for measuring all aspects of solar radiation and describe pyrgeometers.
2. Explain how to measure wind speed.
3. Draw an annotated diagram of the mercury barometer.

7.0 REFERENCES/FURTHER READING

Areola, O. (1999). *Certificate Physical and Human Geography forSenior Secondary Schools*. Ibadan: University Press Plc.

Ayoade, J.O. (1983). *Introduction to Climatology for the Tropics* ChiChester: John Wiley and Sons.

Ayoade, J.O. (2002). *Introduction to Agroclimatology*. Ibadan: Vantage Publishers, Tropical Climatology: A

Bunnet, R.B. (1973).*GeneralGeography in Diagrams*.London: Longman,

Nieuwolt, S (1977). *An Introduction to the Climates of the LowLatitudes*. ChiChester: John Wiley and Sons.

Ojo, O. (1977). *The Climates of West Africa*. Ibadan: Heinemann Educational Books.

Ojo,O.*et al*. (2001).*Fundamentals of Physical and Dynamic Climatology*. Lagos: SEDEC Publishers.

UNIT 3 MEASUREMENT OF EVAPORATION AND EVAPOTRANSPIRATION

CONTENTS

Introduction

Objectives

Main Content
3.1 Measurement of Evaporation
3.2 Measurement of Evapotranspiration
3.3 Maintenance of a Standard Meteorological Station

4.0 Conclusion

5.0 Summary
6.0 Tutor-Marked Assignment

7.0 References/Further Readings

1.0 INTRODUCTION

Weather observation and measurements started in Unit 11 continue in this unit.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- recognise the equipment for measuring evaporation and evapotranspiration
- take care of a meteorological station.

3.0 MAIN CONTENT

3.1 Measurement of Evaporation

The equipment for measuring evaporation are generally called evaporimeters. There are two basic types of evaporimeters: those in which evaporation takes place from a continuously wetted porous surface of blotting-paper, fabric or ceramic material, an example of which is the piche evaporimeter; and those in which evaporation takes place from a free water surface in tanks or pans.

The Piche Evaporimeter

The most common instrument for measuring evaporation in West Africa is the piche evaporimeter, a graduated measuring cylindrical tube

22.5cm long with an internal diameter of 11mm and an external diameter of 14mm. It has a closed and an open end. At the open end of the tube is a wetted surface (a filter paper disc) held by a spring fitted with a disc and collar. The total evaporating surface is given in centimeters. Water is supplied to the paper at the open end by a wick inking it to a small water container normally graduated in millimeters. The evaporation from the instrument is the difference between the readings of the container at the beginning and end of the period. The Piche evaporimeter is not reliable and it has been criticised as measuring the drying power of air rather than the amount of water lost by evaporation to the atmosphere. The piche evaporimeter is also kept in the Stevenson screen.

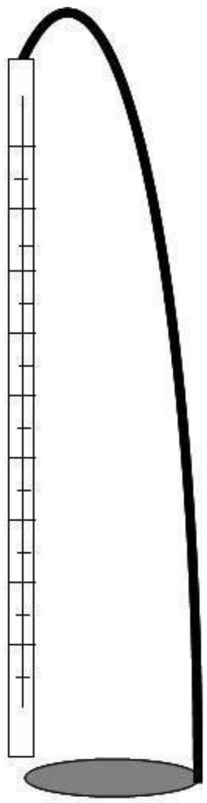

Fig. 24: Piche Evaporimeter

There are different types of evaporation pans depending on their size, shape and manner of exposure. Only the three most common ones are described here. These are the United States Weather Bureau (USWB) Class A pan, the raised tank and the sunken tank. The USWB Class A pan has been recommended for worldwide use by the WMO. It is circular with a diameter of 1206mm and 254mm deep. It is made of galvanised iron and mounted on a wooden open frame platform about 150mm above the ground. The pan is filled with water to within 51mm of the rim.

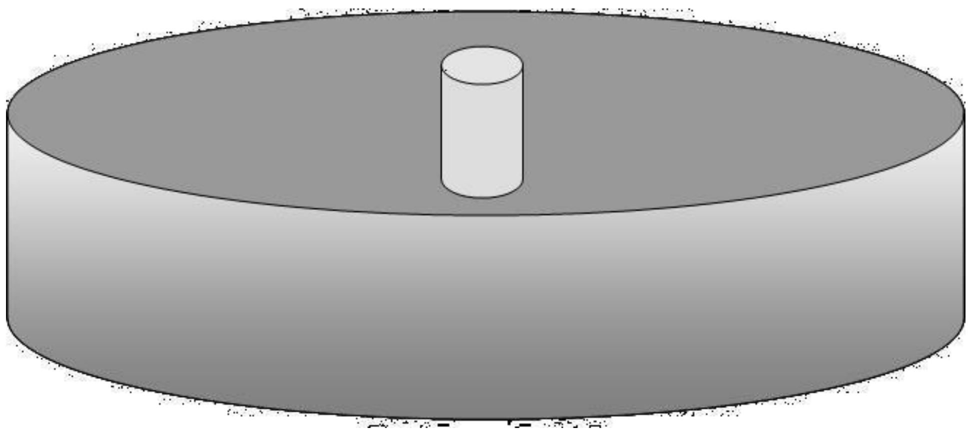

Fig. 25: Class A pan

The sunken tank is about 1829mm^2 with the water level at the ground level and a rim of 76mm protruding above the ground to prevent inflow of surface water when it rains.

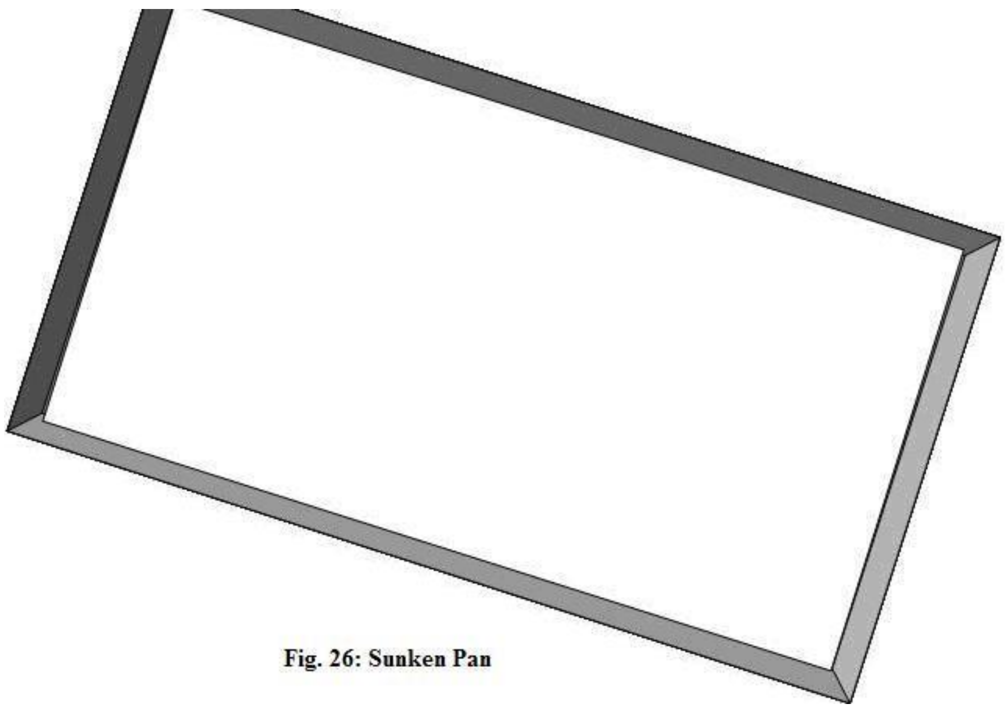

Fig. 26: Sunken Pan

A third type, the raised tank, is a rectangular tank which is 915mm by 1270mm and 432mm deep. The depth of the water in the tank is about 350mm. A wooden platform is used to raise the tank so that the water surface is about 457mm above the ground.

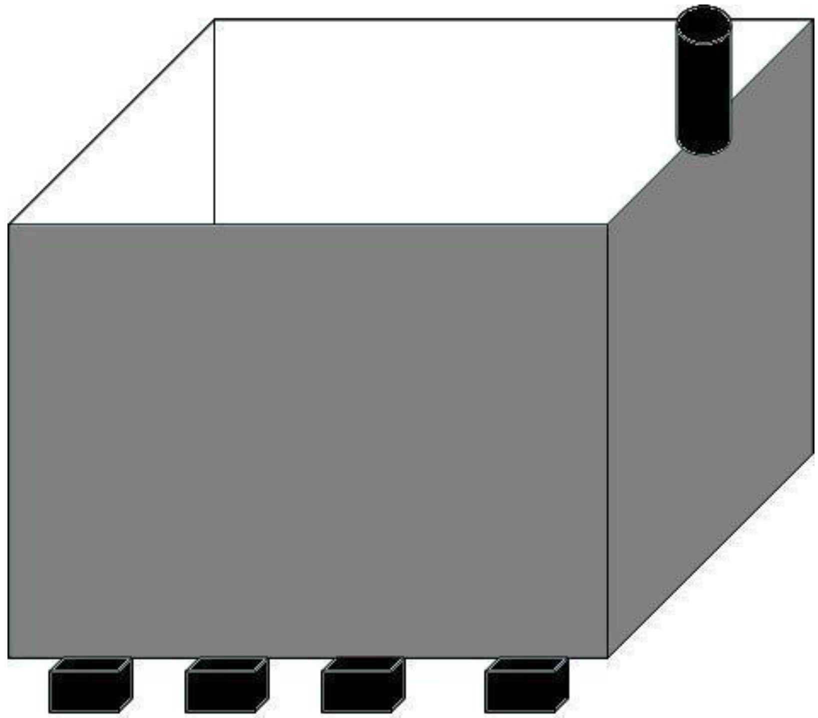

Fig. 27: Raised Tank

The principle employed in all evaporation pans to measure evaporation rates is the same: Evaporation measurements are taken by refilling the water in the tanks to a fixed level. After a period of time, which is usually 24 hours, the level of water in the pan is checked. Unless some rain has fallen during the intervening period, the level of water in the pan would have fallen owing to evaporation. The pan is reset by filling it back with water to the original level. The amount of water added to reset the pan represents the evaporation that has occurred in the intervening period. Each pan has a cup specific to it and this is used to refill the pan. When rain falls, the rain water is allowed for by adding the amount of rainfall measured in a nearby rain gauge to the amount of the apparent evaporation.

There are a number of disadvantages to pans and sunken tanks. It is difficult to detect leakage. Because of their closeness to the ground, the tanks tend to get dirty, which influences the rate of evaporation. Another problem is that rain water can splash into the tanks or overflow from them. The tanks and pans are difficult to clean. The tanks and pans about ground level may be subject to radiation from the sides and bottom, so that readings may be higher.

One other common problem with evaporation pans and tanks is the difficulty of preventing herds or stray animals from drinking water from the pan.

However, tanks or pans have the advantage of being inexpensive to install and easy to handle. They can be used throughout the life span of a crop.

3.2 Measuring of Evapotranspiration

Rates of evapotranspiration over a surface are measured by the cost of lysimeter. There are two types of lysimeter; the weighing lysimeter and the drainage lysimeter. Lysimeter are tanks buried in the ground to measure the percolation of water through the soils. They provide the most reliable and accurate method for the direct measurement of evapotranspiration provided the necessary precautions in designing, operating and sitting are taken. The installation of lysimeter in West Africa has been impossible; however, one of the reasons is that it is very expensive.

The weighing lysimeter is a rather sophisticated device consisting of a soil-filled tank, the evapotranspirometer tank, in which grass is planted.

Water enters through this tank and drains through an outlet pipe into an overflow chamber and supported by a weighing mechanism.

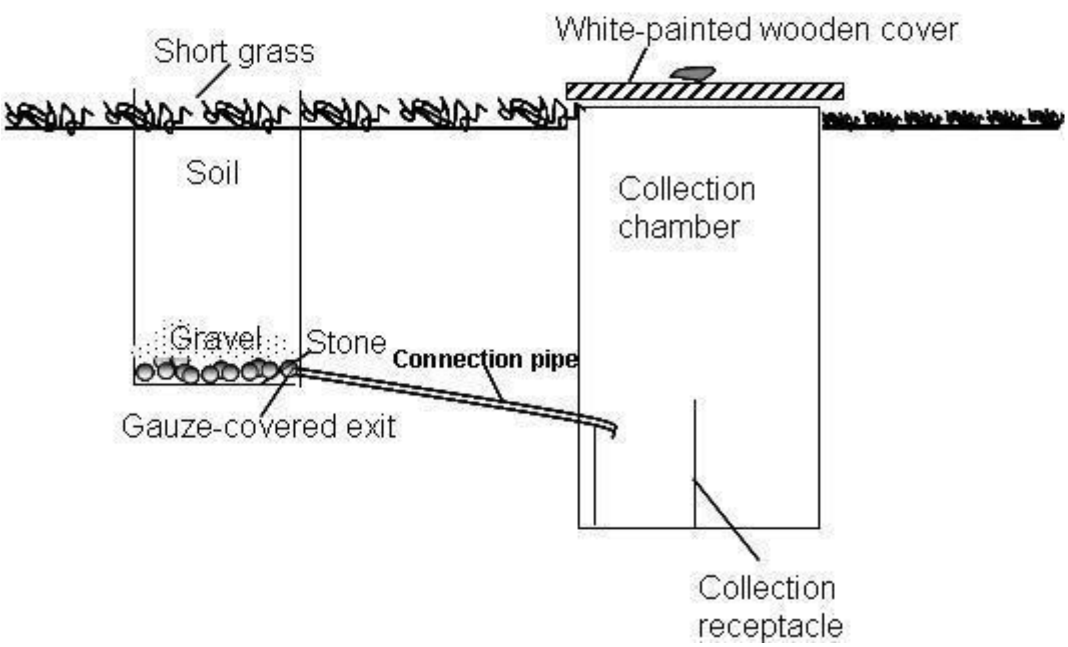

Fig. 28: Evapotranspirometer

Evapotranspiration values are obtained directly by calculating changes in the weight of the soil-vegetation system within the tank over a specified period of time, usually 24 hours, to obtain daily values of evapotranspiration. If the experimental surface is surrounded by a buffer zone with the same type of vegetation and kept moist by watering. The values of evapotranspiration obtained would be those of potential evapotranspiration. The buffer zone is necessary to ensure that

energy and drier air are not advected over the experimental plot from the surrounding. Weighing lysimeter are often used to measure actual evapotranspiration when the experimental surface and the surroundings are not kept at field capacity.

The drainage lysimeter which operates on a sample water balance basis is more widely used than the weighing lysimeter as it can be constructed. The principle on which it operates is that evapotranspiration is the difference between water input in form of rainfall and irrigation if necessary and water output in form of percolation and runoff in a soil plant system. (Chang, 1964). The drainage lysimeter is normally used to measure rates of potential evapotranspiration. There is therefore, the need to keep the tank and the surrounding area continuously moist by irrigation.

3.3 Maintenance of a Standard Meteorological Station

To ensure that observations at the meteorological stations are accurate and comparable over time, the following should be observed:

1. Buildings should not be located close to the meteorological station.
2. Big trees should not be allowed to grow around the station.
3. The grass of the meteorological station should be kept low at all times.
4. Observation of the elements should be regular and prompt.
5. Animals should not be allowed access to the station, particularly the pans and tanks; in drier areas birds and small animals use the tanks for bathing.
6. Malfunctioning equipment should be replaced promptly.

4.0 CONCLUSION

Equipment for measuring evaporation and evapotranspiration has been fully discussed in this unit. The methods of maintenance of a weather station have also been discussed.

5.0 SUMMARY

In this unit we have learnt that:

1. Evaporimeters which are of two types (piche evaporimeter, pans) are used for measuring evaporation.
2. Lysimeter which are also of two types (drainage lysimeter, weighing lysimeter) are used for measuring evapotranspiration.
3. Keeping the grass inside the weather station low, clearing the surrounding, fencing the weather station, reporting and replacing the malfunctioning equipment are some of the ways of maintaining a weather station.

6.0 TUTOR-MARKED ASSIGNMENT

1. With the aid of a diagram, describe how to measure evapotranspiration.
2
   a. Describe piche evaporimeter
   b. What is its shortcoming as an instrument for measuring evaporation?
3. List ways of maintaining a weather station.
4. Explain the main features of rain gauges and how the amount of rain is measured with the equipment.
5. Explain how you will set up a standard meteorological station.
6. List all the equipment used in measuring all aspects of solar radiation and describe pyrogeometers.
7. Explain how to measure wind speed.
8. Draw an annotated diagram of a mercury barometer.
9. With the aid of a diagram, describe how to measure evapotransipiration.
10. List ways of maintaining a weather station.

7.0 REFERENCES/FURTHER READING

Areola, O. (1999). *Certificate Physical and Human Geography forSenior Secondary Schools*. Ibadan: University Press Plc.

Ayoade, J.O. (1983). *Introduction to Climatology for the Tropics*. ChiChester: John Wiley and Sons.

Ayoade, J.O. (2002).*Introduction to Agroclimatology*. Ibadan: Vantage Publishers.

Bunnet, R.B. (1973).*General Geography in Diagram*.London: Longman.

Nieuwolt,S.(1977).*TropicalClimatology*: *An Introduction tothe Climates of the Low latitudes* ChiChester: John Wiley and Sons.

Ojo, O. (1977). *The Climates of West Africa*. Ibadan: Heinemann Educational Books.

Ojo,O.*et al*. (2001).*Fundamentals of Physical and Dynamic Climatology*. Lagos: SEDEC Publishers.

UNIT 4 MICROCLIMATE AND SOIL MANAGEMENT IN THE TROPICS

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main Content
3.1 Microclimate of Soils
3.2 Soil Management in the Tropics
4.0 Conclusions
5.0 Summary
6.0 Tutor- Marked Assignment
7.0 Reference/Further Readings

1.0INTRODUCTION

Microclimate is the suite of climatic conditions measured in localized areas near the earth's surface. These environmental variables—which include temperature, light, wind speed, and moisture—provide meaningful indicators for habitat selection and other ecological activities. In seminal studies, Shirley (1929, 1945) emphasized microclimate as a determinant of ecological patterns in both plant and animal communities and a driver of such processes as growth and mortality of organisms. The importance of microclimate in influencing ecological processes such as plant regeneration and growth, soil respiration, nutrient cycling, and wildlife habitat selection has become an essential component of current ecological research (Chen et al. 1999).

2.0 OBJECTIVES

The objectives of this course is to learn about

1. The importance of microclimate in influencing ecological process
2. Determining effect of microclimate in both plant and animal
3. The environmental variables that provides meaningful indicators for habitat selection

3.0 MAIN CONTENT

3.1 Microclimate and Soil Management in the Tropics

Soil microclimate may be defined as a complex of certain factors which determine the state of the soil, considering the state of the soil as an environment for plants, animals or other objects. Temperature and humidity are very important variables in determining soil microclimate, the knowledge of which enables quantitative discussion and comparison of the microclimate in different soils under various meteorological conditions.

Human activities, such as agriculture and forestry, and natural disturbances, such as outbreaks of insects and diseases, can modify the physical environment of an ecosystem (i.e., the patterns of temperature, moisture, wind, and light) by altering structural features. Typically, forest structure is described at the stand and landscape levels. Stand structure is well defined in forestry (e.g., stocking densities, over story coverage, and species composition). Landscape structure can be defined by the spatial arrangement (pattern) of elements of topography, vegetation, soil, or the physical environment itself. However, vegetative features are also commonly used at the landscape scale.

3.2 Overall influence of Temperature on Crop Growth

The uniform temperature and its small seasonal variation characteristic of the tropics provide a wide range of choice of suitable crops in relation to temperature conditions; therefore temperatures are rarely a critical factor in tropical agriculture (Nieuwolt, 1977). As temperature conditions are frequently below optimum for most crops, there exists close a correlation between yields and temperature. It is also expressed in the varit Hoff law which states that dry matter production doubles for every rise in temperature of about 10^0C. Such correlations are however, not valid for many tropical crops.

Soil temperature is another significant control of crop growth and development. At times, it is of greater ecological importance to crop life than air temperature. Soil temperature affects the germination of seed and later influences root development and the growth of the entire crop. Soil also affects the physical, chemical and biological processes in the soil that determine overall crop growth. For instance, potatoes require air temperature of between 8^0C and 28^0C, the optimum being 18^0C.

3.3 Pests, Diseases and Agriculture in the Tropics

The combination of high temperatures and high humidities characteristic of tropical lowlands, carries serious drawbacks for tropical agriculture. For many tropical crops the yields are reduced both in quantity and quality by high temperatures, mainly because some diseases and pests thrive well under warm conditions. High temperatures and humidities in the tropics also create highly favourable conditions for the proliferation and growth of numerous micro-organisms and insects, which spread diseases and pests. They also encourage rapid and profuse growth of weeds and parasites which can drastically reduce yield. Losses are not limited to crops on the field; they are equally serious after harvesting and during storage and transportation.

In Nigeria, crop losses due to pests have been estimated to be of the order of 50 to 60% of total crop production (Ayoade, 2002). The periodic or seasonal nature of outbreaks of crop pests and diseases suggests that weather conditions play an important role. Favourable temperature and humidity conditions encourage the growth and development of crop pests and disease causing germs. Wind conditions control the transport and distribution of disease causing germs and spores.

4.0 CONCLUSIONS

Environmental variables in localize areas of the earth's surface are very important in influencing ecological processes such as plant regeneration and growth, soil respiration, nutrient cycling, and wildlife habitat selection

3.0 SUMMARY

1. Microclimatic variables include temperature, light, wind speed, and moisture which are useful as indicators for ecological activities.
2. Current ecological research has recognized the importance of microclimate in influencing ecological process of plant growth and soil
3. Soil temperature is at times, of greater ecological importance to crop life than air temperature.
4. Physical environment of an ecosystem is modified by human activities and natural disturbances
5. As temperature conditions are frequently below optimum for most crops, there exists close a correlation between yields and temperature.
6. The combination of high temperatures and high humidities characteristic of tropical lowlands, carries serious drawbacks for tropical agriculture.

6.0 **TUTOR- MARKED ASSIGNMENT**

1. Discuss how physical environment of an ecosystem is being influenced by human activities

2. Define soil microclimate and explain the influence of temperature and humidity on crop diseases and pest

7.0 REFERENCE/FURTHER READINGS

Robert J. Naiman, ... Gene E. Likens, in Riparia, 2005

M.S. Fonseca, in Encyclopedia of Ecology, 2008 van Wijk W.R. (1965). Meteorological Monographs

Nieuwolt, S. (1977).*Tropical Climatology:An Introduction to theClimates of the Low Latitudes*. ChiChester: John Wiley & Sons.

Ojo, O. (1977). *The Climates of West Africa.* Ibadan:.Heinemann Educational Books.

UNIT 5 INFLUENCE OF MICROCLIMATE ON AGRICULTURE

CONTENTS

1.0 Introduction
2.0 Objectives
3.0 Main Content
    3.1 Effects of moisture on Crop Growth
    3.2 Effects of Photoperiodism on Crop Growth
    3.3 Microclimate – Livestock Relationship
4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment
7.0 References/Further Readings

1.0 INTRODUCTION

World over, agriculture is one of the most important economic activities pursued by man and it is also highly dependent on the weather. There is obvious need to study the relations between microclimate and agriculture in all climates, but it is particularly important in the tropics. Climatic conditions in the tropics are generally not as favourable for agriculture as is often assumed (Nieuwolt, 1977). The luxuriant vegetation in many parts of the tropics and the rapid growth of plants has erroneously led to the belief that food can be produced with very little effort. The general relationship between climate and agriculture will be discussed below.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

1. Explain the effects of solar radiation and moisture on crops
2. Explain the relationship between microclimate and pest and diseases on crops

3.0 MAIN CONTENT

3.1 Effects of moisture on Crop Growth

Water is the major constituent of the physiologically active plant tissue; a reagent in photosynthesis and hydrolytic such as starch digestion; the solvent in which salt, sugar and other solutes move from cell to cell and organ to organ; and an essential element of the maintenance of plant turgidity necessary for cell enlargement and growth.

It is not, however, easy to establish a relationship between water stress and the various aspects of crop function. The relationship varies with crop characteristics, stages of soil development, and climatic conditions. Water deficiency not only reduces the yield but also changes the pattern of growth. In general, effective rooting depth decreases as the soil moisture level increases. Roots developed under limited moisture conditions are finer and have more and longer branches than roots developed under favourable moisture conditions. The ratio of root to shoot usually is increased by water stress. Leaf area is often reduced but leaf thickness is increased.

Water deficit in crop has a profound effect in the rate of photosynthesis because dehydrated protoplasm has lowered photosynthesis capacity. Indirectly, once the leaf looses its turgidity, the stomata guard cell close, thus preventing any further intake of carbon dioxide for photosynthesis.

In general the respiration rate of crops tends to increase as moisture decreases. This change is however, much smaller than the accompanying changes in photosynthesis.

Soil moisture which is an important source of moisture to crops is determined by rainfall, evaporation rate and soil characteristics.

The supply of soil moisture may vary from wilting point when no water is available for crop use to field capacity when the soil is fully saturated with moisture but is well drained. In a water logged condition (i.e. when all the soil pores are completely filled with water), free movement of air within the soil is impeded and compounds toxic to the roots of crops may be formed. At the opposite end is the condition of drought in which the amount of water required for evapotranspiration exceeds the amount available in the soil. Drought condition makes crops wilt and eventually die. Hence, too little or too much water is not good for agriculture.

3.2 Effects of Photoperiodism on Crop Growth

The length of daily exposure to light is known as a photoperiod while the response of crop development to a photoperiod is called photoperiodism.

Plants are divided into three groups on the basis of their response to the photoperiod namely; long-day plants, short-day plants and day neutral plants. Long -day crops flower only under day-light less than 14 hours. Examples are wheat, mustard, oats, burkey, rye and clover. In short day-crops flowering are induced by short photoperiods of less than 10 hours. Examples are cotton, millet, corn, beans, cucumber and sweet potatoes. The day neutral crops can form the flower buds under any period of illumination. Examples are tomato and carrot. Later Allard (1938) added the fourth group which is designated as intermediate. The intermediate crops flower at a day length of 12 -14 hours but are inhibited in reproduction by day lengths either above or below this duration.

Photoperiodism is an important factor in the natural distribution of plants. In general plants that have originated in low latitude require short- day for flowering while those from high latitudes are long- day plants. When the latter are moved to low latitudes they will not produce blossom. When the low latitudes plants are grown in high latitudes they will continue to grow vegetatively until they are killed by frost.

3.3 Microclimate – Livestock Relationship

Weather and climate influence livestock directly or indirectly in three important ways. First, climate conditions affect the availability of water for animal consumption and determine the type, quantity and quality of pastures available for animal feed. Second, weather and climate have direct effects on animals and their body physiologic functions. Third, weather and climate affect livestock production indirectly by determining the type of animal pests and diseases that would be prevalent in a given area.

The distribution of animals is affected by the availability and reliability of water supplies. The distribution of precipitation over a given area provides a rough guide to the availability of water in an area. Areas with little or no rainfall are deficient in water while areas of abundant rainfall have plenty of water, all things being equal. Humid climates are however not very favourable for most types of livestock because of the numerous pests and diseases such climatic breeds. Again, climates promote forest ecosystems, whereas livestock prefer grass ecosystems, such grass ecosystems of the world as the African savanna the veldt of South of Africa, the steppes of Russia, the downs of Australia, the pampas of Argentina and the prairies of North America.

4.0 CONCLUSION

Microclimates have direct influences on crop and animal production through moisture, humidity and the indirect influence on pest and diseases

5.0 SUMMARY

1. Microclimate of an environment determines the choice of crops that can be produced in an area
2. Microclimate creates favourable conditions for the proliferation of numerous microorganisms and insects which spreads pests and diseases
3. Moisture serves to regulate heat on both crops and livestock
4. Photoperiodism is an important factor in the natural distribution of plants.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the direct and indirect influences of climate on crop growth
2. Discuss the effects of photoperiodism on crop growth and development

3. Highlight the importance of moisture on tropical agriculture

7.0 REFERENCES/FURTHER READINGS

Ayoade, J.O. (1983). *Introduction to Climatology for the Tropics*. ChiChester: John Wiley and Sons.

Ayoade, J.O. (2002).*Introduction to Agro climatology.* Ibadan: Vantage Publishers.

Nieuwolt, S. (1977).*Tropical Climatology:An Introduction to theClimates of the Low Latitudes*. ChiChester: John Wiley & Sons.

Ojo, O. (1977). *The Climates of West Africa.* Ibadan:.Heinemann Educational Books.