Introduction

Lecturers: Ayodele O. P & Oladele S. O

DEPARTMENT OF AGRONOMY

House Rule

• Attendance is key
• Schedule Adherence
• All phones on Silence
• Decent Dressing
• Participatory
CLIMATOLOGY & BIOGEOGRAPHY

AGY 201

DEPARTMENT OF AGRONOMY
CLIMATOLOGY & BIOGEOGRAPHY

Course Outline

• The principles, aims and scope of climatology and biogeography.

• The elements and controls of climate and weather and the dynamics of the earth’s atmosphere.

• Radiation and heating of the atmosphere systems.

• Condensation and precipitation processes.

• Seasonal variations in temperature, day length, radiation, rainfall and evapotranspiration.

• Equipment and maintenance of standard meteorological stations.

• The tropical climate; relation between agriculture and climate with reference to crops, livestock, irrigation, pests and diseases.
• **Definitions:** Climatology, Climate, & weather

- Climatology is the scientific study of climate.

- Climate of a place can be defined as the ‘average’ weather conditions obtained through the synthesis of weather elements prevailing there for over a period of 30-35 years.

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

• **Comparison:** Climate & weather

<table>
<thead>
<tr>
<th>Climate</th>
<th>Climatology</th>
<th>Cumulative</th>
<th>Gradual Change</th>
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<tbody>
<tr>
<td>Weather</td>
<td>Meteorology</td>
<td>Instantaneous</td>
<td>Highly Variable</td>
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Comparison: Climate & weather

‘Climate is what you expect, weather is what you get’

Some atmospheric scientists consider ‘average’ weather to be an inadequate definition of climate; as it entails variations, patterns, and extremes. Thus, climate is the sum of all statistical weather information that helps to describe a place or region, i.e., Tropical climate.

Question

If a scientist reported that last month in your state was warmer than the same month a year ago, would you consider this to be evidence for climate change? Why or why not? What kind of data would be most convincing: changes in short-term (daily, weekly, or monthly) weather or changes in longer-term climate data?
Definition: Biogeography

Bio = Life

Geography

where it lives

how it lives there

how it came to live there

A science that deals with the description, distribution, and interaction of the diverse physical, biological, and cultural features of the earth’s surface - Merriam Webster Dictionary

Biogeography is defined as the study of distribution of plants and animals including microorganisms together with the geographical relationship with their environment

-Phytobiogeography (Plant)

-Zoobiogeography (Animal)
Biogeography

Idea

1. Centres of origin and Dispersal

2. Vicariance Biogeography

Case Study: Tapirs

[Map showing the distribution of Tapirus species and their evolutionary history]

- Tapirus indicus
- Tapirus pinchaque
- Tapirus terrestris
- Tapirus bairdi

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Biogeographical Regions

The Old World
Europe and northern Asia, Africa south of the Sahara, India and southern Asia, and Australia

The New World
North America and South America

Sclater—Wallace scheme

Neogaea (New World)

Neotropical

Ethiopian

Oriental

Australian

Palaeogaea (Old World)

Nearctic

Palaearctic

Division based on support for a distinct set of animals and a distinct set of plants

Philip L. Sclater, (1858)

Alfred Russel Wallace (1876)
Biogeographical Regions

Philip L. Sclater, (1858)

Division based on support for a distinct set of animals and a distinct set of plants

<table>
<thead>
<tr>
<th>Region</th>
<th>Subregion</th>
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<td>Palaeogaea (Old World)</td>
<td>North Europe</td>
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<td>Mediterranean</td>
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<td>Siberia</td>
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<td>Manchuria (or Japan)</td>
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<td>Hindustan (or central India)</td>
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<td>Neogaea (New World)</td>
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<td>Neotropical</td>
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<td>Canada</td>
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<td>Nearctic</td>
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Source: After Wallace (1876)
Rationale for Studying Climatology & Biogeography

- Climate change and variability
- Dependency of Organisms on climatic elements
- Influences of organisms on the climate - Deforestation and Afforestation, Burning...
The Atmosphere

The term atmosphere refers to the gaseous envelope surrounding the earth.

- Two gases make up the bulk of the earth’s atmosphere: Nitrogen ($\text{N}_2$) which comprises of 78% of the atmosphere, and oxygen ($\text{O}_2$), which accounts for 21%. Various trace gases make up the remainder.

- Based on temperature, the atmosphere is divided into four layers: the troposphere, stratosphere, mesosphere, and thermosphere.

Energy is transferred between the earth’s surface and the atmosphere via conduction, convection, and radiation.
The Atmosphere

Key features of the Atmosphere’s layers.

**Troposphere**
- Bottom layer at the earth surface.
- Atmosphere has its highest density here – about 80% of total mass.
- All weather phenomena occur within, although some turbulence effect may reach lower portion of stratosphere.
- It actually height varies with latitude – around 18 km and 8 km from the equator and the poles respectively.
- Maximum temperature occurs near earth surface and decreases with altitude.

**Stratosphere**
- Within the first 9 km, temperature is constant with height – Isothermal layer.
- From 10 km – 50 km, temperature increases with altitude due to ozone gas molecules.
The Atmosphere

Key features of the Atmosphere’s layers.

Mesosphere

• The atmosphere reaches its coldest temperatures (about -90° Celsius) at a height of approximately 80 kilometers.

Thermosphere

• Temperatures in this layer can be greater than 1200°C. These high temperatures are generated from the absorption of intense solar radiation by oxygen molecules (O₂).

• The air in the thermosphere is extremely thin with individual gas molecules being separated from each other by large distances.

• Consequently, measuring the temperature of thermosphere with a thermometer is a very difficult process.
Temperature

- Temperature is defined as the degree of hotness or coldness.
- The main source of the energy for the earth-atmosphere system is the solar radiation.
- The degree of sensible heat generated represents what is known as temperature.
- It is commonly measured in Celsius (°C) or Fahrenheit (°F).

Factors Influencing Temperature

Climatic Elements
- Solar and Net Radiation
- Cloud Cover

Non Climatic Elements
- Types of Surfaces
- Latitude
- Continentality
**Temperature**

**Lapse Rate**
The atmosphere gets most of the heat energy from the ground in the form of terrestrial radiation therefore the lower parts of the atmosphere are heated more than the upper part. The average rate of fall of temperature with height in the troposphere is about 6.5 degree per km of ascent. This is called the *normal lapse rate*.

**Temperature Inversion**
The inversion of temperature refers to a condition of temperature increasing with increasing height in the atmosphere.

**Types of Inversion**
- Ground or surface inversions
- Upper-air inversions
- Frontal inversions
- Radiation inversion
- Subsidence inversion
- Advection inversion
- Turbulence and convective inversion
Temperature

Radiation Inversion
• The surface inversion produced by radiational cooling of lower air is called radiational inversion.
• The inversion layer develops at an altitude of about 90 meters.
• Nocturnal cooling produced by the terrestrial radiation is the principal factor for this type of temperature inversion.

Advection Inversion
• Horizontal movement of a thick layer of warm air over a cold surface produces an inversion of temperature in the lower layers of the atmosphere.

Subsidence Inversion
• This type of upper-air inversion occurs in an air mass when a thick mass of air subsides (sinks).
• The sinking air warms at the dry adiabatic rate of 10°C/km.
Temperature

Turbulence and Convective Inversion

- The phenomena of turbulence and convection cause a thorough mixing of the atmosphere in turbulent layers. However, the turbulent or convective mixing is limited to a certain height beyond which it does not and cannot penetrate.

- The transition from this cold upper part of the turbulence zone to the air above with its temperature unaffected by adiabatic cooling comprises a temperature inversion.

Frontal Inversion

- When differing air masses are brought together by converging movements; the warmer air being relatively higher tends to overlie the colder and denser air in a horizontal layer.

- The boundary zone between the air masses with contrasting physical properties are sloppy not horizontal due to Coriolis force.

- At the frontal zone, temperature increases with altitude.
Solar Radiation

- The sun provides over 99 per cent of the heat energy required for the physical processes taking place in the earth – the atmospheric system.

- The amount of solar radiation received at the outer boundary of the earth’s atmosphere, at normal incidence and at mean distance between the earth and the sun is known as the solar constant.

Interactions:

- Atmosphere
  - Reflection
  - Scattering
  - Absorption

- Earth Surface
  - Reflection
  - Absorption
Solar Radiation

Distribution of Solar Radiation

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

Radiation balance is the difference between absorbed solar radiation and effective outgoing radiation. It adds up to zero for the earth’s atmospheric system over a period of a year.

Radiation Balance

Heat Budget

The term radiation or heat budget refers to the accounting of the radiant/heat energy received by the earth and its atmosphere from the sun.
Precipitation

- Precipitation is the deposition of moisture on the earth surface.
- Precipitation may occur in the form of rainfall, Dew, snowfall, hail or sleet.
- It is always preceded by condensation or sublimation or a combination of the two.
- Rainfall is the most common form of precipitation in the tropical regions.
- Snow is the major form of precipitation in the temperate region.

Forms of Condensation
- Dew
- Frost
- Fog
- Cloud

Forms of Precipitation
- Drizzle
- Rain
- Snow
- Sleet
- Hail
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 1013 millibars.

• It varies slightly according to latitude.

• The air pressure decreases with altitude - high altitude air is less dense.

• Temperature affects pressure inversely.

• Air flow from areas of high pressure towards areas of low pressure though deflected by earth rotation.
Factors of the General Circulation of the Atmosphere

- Radiation Balance,
- Pressure Gradient Force,
- Rotation of The Earth

**Radiation Balance**

- Excess of radiation balance in the low latitudes and deficits in the high latitudes.

- These results in a pole ward temperatures gradient both at the surface and in the atmosphere.

- The tropics thus serve as 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.
Pressure Gradient

- Horizontal pressure differences result primarily from temperature differences which produce air movements or winds.

- Winds generally move from the areas with cold heavy air to areas with the lighter warm air.

- 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.

- Pressure Gradient is the rate of change of pressure with distance.

- The steeper the gradient, the more rapid will be the flow of the air.
DYNAMICS OF EARTH’S ATMOSPHERE

Earth Rotation

- The rotation of the earth prevents direct meridional circulation that would result from the imbalance of net radiation of the world.
- Coriolis force resulting from the rotation of the earth causes deflection of winds.
- The deflective force causes the winds to be deflected to the right in a northern hemisphere and to the left in the southern hemisphere.

Friction

- 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.
- There is also internal friction within the air itself.
- It acts in opposite direction.
DYNAMICS OF EARTH’S ATMOSPHERE

The General Circulation of the Atmosphere

Unequal distribution of net radiation between tropics and the poles

Due to homogenous rotating of earth, the winds are subjected to both pressure gradient and coriolis forces

Other Circulations

Monsoon

Land and Sea Breezes
Evaporation is the process by which moisture in its liquid or solid form is converted into gaseous form – water vapour.

Transpiration 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.

Factors Affecting Evaporation and Evapotranspiration:

- Availability of moisture
- Ability of the atmosphere to vaporise, remove and transport vapour
- Solar radiation
- Temperature
- Wind speed
- Humidity
Atmospheric Moisture: Humidity

- Humidity is a measure of the amount of water (water vapour) in the atmosphere. It is exclusive of water droplet and ice.
- The amount of moisture in the atmosphere decreases steadily with increase in height. Water vapour is virtually absent after the tropopause.

Indices of Humidity

- Absolute humidity
  - The mass of water in a given volume of air (g/m³)
- Specific humidity
  - This is the mass of water vapour per kilogram of air including its moisture
- Humidity Mixing Ratio
  - This 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.
Atmospheric Moisture: Humidity

Indices of Humidity

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

Relative Humidity

- Measures degree of saturation of the air – (does not tell us about the quantity of moisture in the air)
- The values are dependent on air temperature
Atmospheric Moisture: Humidity

Distribution of Humidity

The variability in humidity is important for the following reasons:

Water vapour

- Water vapour is the source of all forms of condensation and precipitation.
- It is a principal absorber of solar and infrared radiation.
- It has an important influence on temperature.
- The amount of vertical distribution of water vapour in the atmosphere indirectly affects the buoyancy of air and hence its tendency to ascend.

- 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.

- 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.

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The dynamics of pressure and wind systems

- The movement of air in the atmospheric system may be vertical or horizontal; in the latter case it is commonly known as wind.

- Winds result from differences in air pressure.

- An increase in temperature causes air to heat, expand, become less dense and rise, creating an area of low pressure below.

- Drop in temperature produces an area of high pressure.

The Pressure belts of the world are:

- Equatorial low (Doldrums) - Equator, within 5° S and 5° N
- Sub tropical high (Horse Latitude) - 30° N and 30° S
- Temperate Low - 60° N and 60° S
- Polar High - 90° N and 90° S
Winds are always named after the direction they come from.
The condensation and precipitation process essentially act to remove water from the atmosphere.

- Condensation can be defined as the formation of water droplets when air has been cooled beyond its dew point.
- For condensation to take place, it is necessary for some kind of nuclei to be present on which the droplets can form.
- The condensed droplets when formed are so minute that they float in the air as fog or clouds.
- Larger drops form on leaves and grass as dew, or hoar-frost if temperature is below freezing point.
- When droplets coalesce in the air to a certain critical size, they may fall to earth as one or other of the forms of precipitation.
THE CONDENSATION AND PRECIPITATION PROCESS

- Drops may form and continue to exist in liquid form, even when the temperature is below freezing point, as long as air is undisturbed. This phenomenon is known as **super cooling**.

### Rain Drop Formation Theories

**Bergeron-Findeisen and Coalescence theories**

The **Bergeron-Findeisen theory** of rain drop formation submits that ice crystals within clouds tend to grow larger at the expense of the water droplets until they become too heavy to be supported within the cloud and consequently fall. These ice crystals will melt to form **rain drops** if they encounter warmer air as they descend. If not, they will fall as **snow**. When the temperature near the earth’s surface is about freezing level, the ice crystals will partially melt and fall as **sleet**, a mixture of rain and snow.
In tropical clouds, drops do not extend into the freezing level in the atmosphere. These clouds are therefore made up solely of water droplets. Raindrops grow by the coalescence process. The larger water droplets within clouds fall at a faster rate than the smaller ones, overtaking and absorbing the smaller droplets along their paths. The larger droplets also drag or sweep the smaller ones and absorb them.

For condensation and precipitation to occur naturally, the appreciable ascent of an air-mass is essential. This ascent is brought about in three main ways:

- Convectional rainfall due to surface heating
- Orographic or relief rainfall due to ascent over land, particularly over a high range of hills
- Frontal or cyclonic rainfall
Relief or orographic precipitation
SEASONAL VARIATIONS IN RADIATION, DAYLIGHT AND TEMPERATURE

SEASONAL VARIATIONS IN RADIATION

- Length of day
- Angle of midday Sun
- Distance from Sun
- Atmospheric Absorption
- Reflection, Scattering

Solstice

Variation in the length of the day and night

Radiations

Summer Solstice

Winter Solstice
SEASONAL VARIATIONS IN RADIATION, DAYLIGHT AND TEMPERATURE

**Summer Solstice (June 21)**

- Noon ray is vertically on the Tropic of Cancer
- Length of the day increase from Antarctic circle in winter hemisphere to the pole in summer hemisphere.
- Zonal solar energy curve beginning at zero from Antarctic circle increases up to 40° N and decline up to 62° N due to increase in obliqueness of the sun ray which offset the increase length of the day.
- Afterwards the solar energy curve rises north of 62° N and reaches maximum at the north pole.

**Winter Solstice (Dec 22)**

- Noon ray is vertically on the Tropic of Capricorn
- Exact reverse of summer solstice operates
SEASONAL VARIATIONS IN RADIATION, DAYLIGHT AND TEMPERATURE

SEASONAL VARIATIONS IN RADIATION

Equinoxes
(Mar 21 & Sept 23)

- Maximum radiation is at the equator with minimum at the pole
- Both the north and the south hemisphere receives approximately equal amount of radiation
- At the polar, solar radiation received in a year is 40% of that of the equator
SEASONAL VARIATIONS IN RADIATION, DAYLIGHT AND TEMPERATURE

SEASONAL VARIATIONS IN DAY LIGHT

**Summer Solstice**  
(June 21)

- On June 21 the north pole of the earth tilts at $23\frac{1}{2}^\circ$ toward the sun and the south tilts away.
- Day length increases from zero on $66\frac{1}{2}^\circ$ S (Antarctic circle) of winter hemisphere to 24 hours in the arctic circle.

**Winter Solstice**  
(Dec 22)

- The north pole tilts $23\frac{1}{2}^\circ$ away from the sun and the south pole tilts towards the sun.
- Day length increases from zero on $66\frac{1}{2}^\circ$ N (arctic circle) of winter hemisphere to 24 hours in Antarctic circle of summer hemisphere.
SEASONAL VARIATIONS IN RADIATION, DAYLIGHT AND TEMPERATURE

SEASONAL VARIATIONS IN DAY LIGHT

Equinoxes
(Mar 21 & Sept 23)

- At equinox, equal day and night length is experienced (no tilt of the earth)

Summary

- In Summary, summer hemisphere witnesses longer days than the winter but the total annual exposure to the sun is the same for all places on earth.
- Difference between summer and winter day lights increases from the equator reaching its extreme at the pole
SEASONAL VARIATIONS IN RADIATION, DAYLIGHT AND TEMPERATURE
SEASONAL VARIATIONS IN RADIATION, DAYLIGHT AND TEMPERATURE

Solstice
Thank you

Lecture slide
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