

MAKKO BILLI SCHOOL

Grade 11 student note

UNIT TWO

CLIMATE CLASSIFICATION

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Introduction

What is climate?

What are the criteria of climate classification?

- **Climate** is the average of all weather conditions of an area over a long period of time. Climate is a multifaceted and abstract notion that contains data on all aspects of the global environment.
- climate classification to recognize, clarify, and simplify climatic similarities and variations between geographic regions. Climate classification is useful for determining expected weather patterns for a certain region, comparing exceptional and regular daily meteorological variables, and indicating climate variability and change through time. Different environmental elements and criteria are used in the classification schemes.
- Data on soil, vegetation, temperature, and precipitation is widely available and has been collected over long periods.

2.1. Criteria for climate classification

- ☛ There are criteria used for different types of climate classification, including **ancient Greeks**, **genetic**, and **empirical**.
- The **ancient Greeks** divided the earth into latitudinal zones based on their **perceptions** of habitability in particular zones, those are
 1. **Frigid Zone**,
 2. **Temperate Zone**,
 3. **Tropical (Torrid) hot Zone**.

they did so by considering **temperature** and the distribution of **sunlight** around the earth. The planet's Polar Regions, including the Arctic and Antarctic circles, are represented by the

- Frigid Zone, which has extremely frigid temperatures.
- The Temperate Zone, which lies between the Torrid and Frigid Zones, is thought to offer the best climate and habitat.

- The tropics, or warmer areas south of the Mediterranean Sea, are represented by the Torrid Zone.
- **According to the data utilized for classification**, climate classification methods can be divided into **two types**:

1. **genetic**
2. **empiric**

Climates are classified using a genetic classification method based **only** on the major **forcing processes** that shape climate, like **the activity** and **features of air masses, circulation systems, fronts, jet streams, solar radiation, topographic effects**, and other. Genetic systems, while more scientifically desirable, are more complex to implement and less successful overall.

The most widely utilized genetic systems are called air **mass ideas**.

The empirical classification system is a classification system that uses data input to calculate the climatic type based on specified class boundaries.

Those are called **Köppen and Trewartha's systems**,

Köppen's climatic classification system. For world climate classification, the Köppen method typically **includes yearly and monthly temperature and precipitation, as well as the seasonality of those variables**.

Note Winds, temperature extremes, precipitation intensity, sunshine quantity, cloud cover, and net radiation are **not considered in Köppen's climatic classification system**.

Trewartha's classification incorporates the fundamentals of both empirical and genetic classification schemes. The classification structure is based on the most important and basic weather parameters, such as **temperature** and **precipitation**. The impacts of water surfaces on a region's climate are also taken into account.

Note

Compare and contrast the Köppen and Trewartha's climatic classification systems' criteria

☛ **Both are empirical classification schemes that use temperature and precipitation as input data to classify the climate. But Trewartha's classification, unlike Köppen's, blends the empirical foundations (average temperature and precipitation) with genetic classification methods (effect of water surfaces on the climate of a given area).**

2.2. Köppen's climate classification

2.2.1 simplified Köppen's climate classification

Because of its simplicity and strong alignment with climatic areas, natural vegetation, and soil types. Köppen climate classification system is commonly used for classifying world climate.

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The Köppen method recognizes that most vegetation types respond immediately to climate inputs, particularly temperature and moisture fluctuations, and is based on dominant vegetation types.

❖ **Köppen published his initial climate classification scheme in 1900 and revised it in 1940**

➤ Based on the aforementioned criteria, the Köppen system distinguishes between **five** major terrestrial climatic types:

1. **Tropical climate (A):** All months have an average temperature above 18° C (64° F). There is no real winter season because every month of the year remains warm.
 2. **Dry Climate (B):** It has deficient precipitation most of the year.
 3. **Meso-thermal or Mid-Latitude Mild (C):** Average temperature of the coldest month is below 18° C (64° F) and above -3° C (27° F).
 4. **Micro-thermal or Mid-Latitude Cold (D):** The average temperature of the warmest month exceeds 10° C (50° F), and the coldest monthly average drops below -3° C (27° F).
 5. **Polar Climate (E):** It has extremely cold winters and summers. The average temperature of the warmest month is below 10° C (50° F). Given that all months are cold, there is no real summer season.
- ❖ The climates A, C, and D stimulate tree growth,
- ❖ the climates B and E are too dry and too cold, respectively, generally do not.
- ❖ The four primary climatic kinds, A, C, D, and E, are characterized by temperature, although type “B” denotes a climate in which dryness, rather than coldness, is the governing element of vegetation.

A new group, highlands (H), was later created to account for the significant climate changes in mountainous areas over short distances.

2.2.2 Modified Köppen’s climate classification

Rudolf Geiger, a climatologist, altered the Köppen classification system in 1961 to improve the alignment of climate zones and biomes. By merging appropriate first, second, and third-order subdivisions,

➤ **modified Köppen–Geiger climatic types are produced.**

To classify regional climates more precisely, those primary (first) climatic types were subsequently classified into second and third-order subdivisions.

The average monthly and total annual precipitation for A, C, and D climates is **denoted by the second-order** subdivision (with “f” denoting a climate that is wet all year, “m” denoting tropical monsoon conditions, “s” denoting dry summer climates, “w” denoting dry winter climates and “m” representing tropical monsoon conditions).

- The second-order subdivision in the case of B climate is “W” if the dry climate is a true desert, and “S” if the dry climate is only semi-arid.
- Second-order subdivisions for “E” climate include
 - ⇒ “T” for Tundra climate, a milder arctic sub-type, and
 - ⇒ “F” (frozen) for Ice Cap climate.
- The third order subdivisions in the Mesothermal and Microthermal climates specify the features of summer temperatures, with
 - ⇒ “a” indicating hot summers,
 - ⇒ “b” indicating warm summers,
 - ⇒ “c” indicating mild summers, and the rare
 - ⇒ “d” indicating cool summers.
- The third-order subdivision of arid climates is “h” for hot and “k” for cold. From the equator to 15° to 25° north and south latitudes, the tropical wet climate (A) exists.
- The average temperature in all monthly records exceeds 18° C (64.4° F). More than 60 inches (>1500mm) of rain falls each year.

The climate in this category is divided into three minor Köppen climatic types

1. Tropical wet or equatorial rainforest climate (Af):

Af refers to a tropical environment with year-round precipitation. In this environment, monthly temperature differences are fewer than 3° C. Cumulus and cumulonimbus clouds occur practically every day early in the afternoon due to severe surface heating and high humidity. The average daily high temperature is 32° C, while the average nighttime temperature is 22° C. This climate is found in areas such as Amazon rain forest and Congo basin.

2. Tropical monsoon climate (Am)

Am denotes a climate with yearly rainfall similar to or greater than Af, but with the majority of precipitation falling during the 7 to 9 hottest months to support the rainforest. There is extremely little rain throughout the dry

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season. This type of climate found in regions such as parts of India and South east Asia.

3. Tropical wet and dry or savanna (Aw)

The third group, tropical wet and dry or savanna (Aw), is characterized by a prolonged dry season in the winter. During the rainy or summer season, precipitation is frequently less than 40 inches. examples inculed the african savanna and the tropical regions of south america.

The difference between Aw and Am climates is determined by annual precipitation and the driest month's precipitation, using the formula

$$a = 3.94 - r/25$$

where

A = precipitation of driest month, and

R = annual precipitation.

If the precipitation of the driest month of a place is less than the value of "a", it will be Aw climate, whereas if it is more than the value of "a", it will be Am climate.

Dry climate (B)

Dry climates are generated by their location: In trade wind belts, On the leeward side of high mountains, and in the interior of continents along cool ocean currents.

During most months, mean evapotranspiration tends to exceed mean precipitation in a dry environment.

Type B climates are characterized by a lack of precipitation for the majority of the year, which limits vegetation growth and spread. **Aridity** is defined by Köppen in terms of the temperature-precipitation index, with evaporation thought to be controlled by temperature.

Evapotranspiration is the term for the combination of two distinct processes of water loss, one by evaporation from the soil surface and on other by transpiration form a plant.

dry climate is classified into two minor classes.

1. Desert (BW):

A true arid climate dominated by xerophytes vegetation that covers 12% of the earth's land surface. It is found between 15 and 30° North and South, where warm, dry air sinks because of subtropical high zones. Vast deserts such as the Sahara or Gobi are included.

2. Dry Semiarid or Steppe (BS):

A grassland climate that encompasses 14% of the planet's land area. The climate gets more precipitation than the BW from the inter-tropical convergence zone or mid-latitude cyclones.

The boundary between BW and BS is established using the formula:

$$r = 0.44t - 8.5/2,$$

where

r = represents annual precipitation (inches) and

t = represents temperature (°F).

If the annual precipitation of a certain location exceeds the value of "r," the climate is BS, but if it is less than "r," the climate is BW.

Dry (B) climates are further classified based on annual temperature.

- ☛ when the mean annual temperature is greater than 18°C represented by the letter "h"
- ☛ when the mean annual temperature is less than 18°C represented by the letter "k"

❖ **Desert climates are further divided into**

1. hot/tropical/desert (BWh) climates,
 - ✓ which have an average annual temperature greater than 18°C
2. middle latitude cold desert climates (BWk),
 - ✓ which have an average annual temperature less than 18°C.
3. Hot dry semiarid or tropical steppe (BSh)
 - ✓ climate, with a mean annual temperature above 18°C, and
4. cold dry semiarid or middle-latitude cold steppe climate (BSk),
 - ✓ with mean annual temperature below 18°C, are two third-order divisions of steppe climates.
 - ✓ The BWh climate is found in areas such as the sahara desert
 - ✓ BWk climate is found in colder desert regions, such as the Gobi Desert.

Mid-latitude Mild or Mesothermal (C)

- Warm and humid summers alternate with mild winters in this region, which is located between 25 and 40° latitudes
- primarily on the eastern and western borders of most continents.
- It is frequently dominated by convective thunderstorms during the summer months.
- During the winter season, the dominant cyclone.
- ☛ Based on precipitation divides into four distinct climatic subgroups.
 1. **Cf climate:** This climate is characterized by

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- ✓ precipitation throughout the year, with more than 1.2 inches
- ✓ This is the most common climate in Western Europe. There are two third-order sub-divisions within this climatic type:
 - A. Humid subtropical (Cfa), are characterized
 - ✚ warm humid summers with frequent thunderstorms;
 - ✚ precipitation coming from mid-latitude cyclones during the mild winter season;
 - ✚ Is found along east costs of continents
 - B. Marine west coast (Cfb),
 - ✓ is found in the western sides of continents are characterized by humidity, short dry summer, cyclones (causing heavy precipitation during mild winters).
- 2. **Cw Climate:** Characterized by
 - dry winters, and has 10 times more precipitation in the wettest month of summer season than the driest month of winter season.
 - It is the dominant climatic type in China.
- 3. **Cs (Mediterranean):** Characterized by
 - The primary rainfalls from mid-latitude cyclones during the winter season.
 - Extreme summer aridity is caused by the sinking airs of the subtropical highs.
 - The wettest winter month receives at least three times the amount of rain as the driest summer month.

Mid-latitude Cold or Microthermal (D) Climate

This climate type also called continental climate is found on the poleward side of the moderate (C) mid-latitude climate.

- Snowstorms, high winds, and brutal cold from polar or arctic air masses characterize the harsh winters.
- **Df climate** humid cold climate with no dry season
- **,Dw climate** humid cold climate with dry winters, and
- **DS climate** (humid cold climate with wet winters)

Polar Climate (E) This climate is characterized by

- cold temperatures year-round,
- the warmest month having a temperature of about than 10⁰C.

- it is found on the landmasses of Greenland and Antarctica, as well as the northern coastal portions of North America, Europe, and Asia.

❖ The two minor types of polar climate are **polar tundra (ET)** **polar ice caps (EF).**

- Polar tundra (ET) is defined by permafrost, which is soil that is permanently frozen to depths of hundreds of meters.
- The warmest month's average temperature is greater than 0⁰C but less than 10⁰C.
- Mosses, lichens, dwarf trees, and scattered woody shrubs are common

polar ice cap (EF) is characterized by

- a land surface permanently covered with snow and ice.
- The average temperature of the warmest month is 0⁰ C (320F) or below.

Highland Climate

- ✓ Due to the effects of height, tundra and polar conditions could be seen in low latitude places.
 - ✓ Over a relatively little vertical shift in elevation, highland climates often show a tremendous lot of diversity in temperature, precipitation, and flora.
 - ✓ The presence of glaciers in tropical mountains demonstrates that altitude has a cooling impact.
- The afro-alpine zones on the highest parts of the Ethiopian plateaus, and highland climate.

Example

- ⇒ The Senate Plateau (Bale Zone),
- ⇒ Simien Mountains (north Gonder),
- ⇒ Mount Guna (south Gonder),
- ⇒ Amara Saint (South Wollo), a
- ⇒ Choke Mountains (Gojam)

Group Assignment

1. *Explain the Merits and Demerits of Köppen's System Despite many critics,*
2. **WORLD CLIMATIC REGIONS**

2.5. FACTORS INFLUENCING THE WORLD CLIMATIC REGIONS

2.5.1. Latitude (Seasonality)

- ✚ On any given day, solar energy insolation strikes the earth at a decreasing angle from 90^0 (direct overhead) to 0^0 (where the sun is on the horizon).
- ✚ Above the horizon, when the sun's angle is lower, there is less intense insolation (i.e. closer to 0^0). This is because when solar rays reach a high latitude region, low angle earth
- ✚ Solar rays flow through the atmosphere most efficiently when the sun is directly overhead (i.e., at a 90^0 sun angle) at equatorial locations because they reach the surface perpendicular to it
- ✚ Every day, 12 hours of bright sunlight will be experienced in the low latitude zone (equatorial locales), providing more time for the surface to heat up and resulting in little seasonal change.
- ✚ On the other side, high latitude regions (arctic/polar locations) have highly distinct seasons, with cool summers and relatively long days. Winters are bitterly cold, and the nights are long.

2.5.2. Combined Effects of Revolution, Rotation and Tilt of the Earth What is the difference between Revolution and Rotation?

Rotation is the movement of the earth on its axis.

Revolution is the movement of earth around the sun.

- ✚ The difference in day length December and June is smaller the closer an area is to the equator,
- ✚ The difference in day length of December and June is bigger the closer it is to the pole or high latitude.

Example

- ✚ In June,
 - the daylight covers more than half of any parallel latitude in the northern hemisphere, whereas darkness covers more than half of any parallel latitude in the southern hemisphere.
- ✚ In December,
 - more than half of any latitude in the northern hemisphere is in darkness, while more than half in the southern hemisphere is in the sunshine

2.5.3. Continentalities (distance to large water bodies)

- Large bodies of water are capable of storing massive amounts of energy during high-energy times
- These energy flows can have a major impact on the climate of places with negligible continentality along an ocean shoreline and places in the interior of a landmass regarded to be very continental.

Example

- Inland areas (extremely continental) heat up and cool down more quickly than areas near huge bodies of water.
- Inland locations have a wider temperature range than coastal locations
- Lakes, swamps, and marshes, for example, can generate significant temperature variations.
- Some insolation is required on the lake surface to evaporate water rather than to heat surfaces.
- Evaporation converts radiant energy into latent energy, which cannot be used to heat air at the same time (sensible energy).

2.5.4. Atmospheric Circulation

- ➔ Two locations may not have the same climate despite they have the same latitude, the same distance to the ocean, and being located in the same hemisphere. This is because the climate of a place is also affected by the location relative to atmospheric circulation. This means one location may be affected by atmospheric circulation from a certain direction more often than another.
- ➔ According to the second law of thermodynamics, the job of atmospheric circulation is to balance energy inequities across latitudes. Horizontal inequalities in atmospheric pressure produce the circulations that result in climate differences throughout space. "High pressure" refers to pressure above mean sea level, whereas "low pressure" refers to a pressure below mean sea level. In either the vertical or horizontal directions, atmospheric mass or air travels from additional air, i.e. high-pressure regions, to lower pressure locations.

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2.5.5. Seasonal Movement of Subtropical High Pressure

- Because the Subtropical High Pressure (STH) is the source of surface westerlies, the seasonal migration of the STH has climatic implications.
- The STH about 30° latitudes, according to the general circulation model, pulls surface air toward the pole and equator.
- Rising motions of trigger clouds and precipitation-forming processes connected with thunderstorm weather are triggered by the convergence of winds into a low-pressure center or cyclone

2.5.6. Coriolis Effect, Centrifugal Acceleration, and Friction

- ✎ The Coriolis Effect (CE) is when other factors cause air to shift its trajectory and speed.
- ✎ The apparent outward-directed force on an item traveling along a curved trajectory is known as centrifugal acceleration (CA). It is an example of inertia in action.
- ✎ The other force that influences wind direction and velocity is friction. It is greatest at the surface and diminishes with increasing height until it is negligible in the free atmosphere (friction-free zone).
- ✎ The degree of friction provided to the flowing air is determined by the type of the surface; for example, mountains have a lot of friction, while ocean bodies have less or no friction.

2.5.7. Ocean Circulation

- ✎ Ocean circulation, like air circulation, is a process for balancing energy on the surface. The most significant oceanic circulation influences on climate are surface currents, which often follow the winds produced by semi-permanent pressure zones in the atmosphere

2.5.8. Topography or elevation

- Because of fast fluctuations in height and hence temperature, as well as the quantity of solar exposure throughout the year, the climate in mountainous areas fluctuates greatly over short distances.
- High diurnal temperature ranges are prevalent at high elevations due to a decrease in mass and density compared to other areas that are lower in elevation but along the same latitude parallel.

2.6. LOCAL CLIMATE CLASSIFICATION OF ETHIOPIA

Ethiopia's local climate classification is based on height, temperature, and growing season length.

☞ according to the traditional climatic classification system, the country can be divided into five primary climatic zones:

1. Bereha,

- The hot lowlands are referred to as Bereha.
- It's the climate of the desert-like lowlands, which are found below 500 meters above sea level
- The average annual rainfall of fewer than 16 inches
- temperature of more than 30°C. Because of the harsh environment
- mainly inhabited by pastoralists.
- Strong winds, high temperatures, low relative humidity, and limited cloud cover characterize the climatic zone.
- Examples of such climate are found in Afar lowlands, Somali lowlands, etc.

2. Kolla:

- ✎ describes a semi-arid environment that is warm to hot.
- ✎ It is the climate that defines the hot lowlands,
- ✎ which are located between 500 and 1500 meters above sea level.
- ✎ The average annual temperature is between 20 and 30°C,
- ✎ The average annual rainfall is between 16.4 and 32.8 inches.
- ✎ This area has a climate that is both hot and humid. Common crops include sorghum, finger millet, groundnuts, cowpeas, and sesame.

3. Woina-Dega:

- ⇒ It encompasses the temperate highlands
- ⇒ which are located between 1500 and 2300 meters above sea level.
- ⇒ The average annual temperature is 15°C to 20°C,
- ⇒ average annual rainfall of 48 inches.
- ⇒ Wheat, teff, barley, maize, sorghum, chickpeas, and haricot beans are often grown in this climatic zone.

4. Dega

- ➔ describe the climate of cold temperate highland
- ➔ located between 2300 and 3300 meters above sea level.
- ➔ The coldest month sees temperatures below 10°C and rainfall ranging from 40 to 80 inches.

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➔ Wheat, highland pulses, and highland oil seeds are the most common crops.

5. Wurch

- ✎ refers to an Alpine climate found
- ✎ elevations greater than 3,300 meters above sea level.
- ✎ This climatic zone includes Afro-alpine plateaus (Senate plateaus), Simien Mountain (Ras Dejen mountains), Guna Mountains, Choke Mountains in Gojjam, and Amare Saint in south Wollo.
- ✎ The yearly average temperature is below 10°C, and annual rainfall is between 35.2 and 80 inches. In the climatic area, barley is commonly produced.