Paper CC5
Unit 2 Topic 8

Climatic Classification after Koppen

Dr. Mitrajit Chatterjee

- The **Köppen climate classification** is one of the most widely used climate classification systems.
- It was first published by the German-Russian climatologist Wladimir Köppen (1846–1940) in 1884, with several later modifications by Köppen, notably in 1918 and 1936.

Basis

- As Köppen designed the system based on his experience as a botanist, his main climate groups are based on what types of vegetation grow in a given climate classification region.
- In addition to identifying climates, the system can be used to analyze ecosystem conditions and identify the main types of vegetation within climates.
- Due to its link with the plant life of a given region, the system is useful in predicting future changes in plant life within that region

Climatic Groups

- The Köppen climate classification divides climates into five main climate groups, with each group being divided based on seasonal precipitation and temperature patterns.
- The five main groups are *A* (tropical), *B* (dry), *C* (temperate), *D* (continental), and *E* (polar).
- Each group and subgroup is represented by a letter. All climates are assigned a main group (the first letter).
- All climates except for those in the *E* group are assigned a seasonal precipitation subgroup (the second letter). For example, *Af* indicates a tropical rainforest climate.
- The system assigns a temperature subgroup for all groups other than those in the *A* group, indicated by the third letter for climates in *B*, *C*, and *D*, and the second letter for climates in *E*. For example, *Cfb* indicates an oceanic climate with warm summers as indicated by the ending *b*. Climates are classified based on specific criteria unique to each climate type.

1st	**2nd**	**3rd**
A (Tropical)	f (Rainforest)	
	m (Monsoon)	
	w (Savanna, Dry winter)	
	s (Savanna, Dry summer)	
B (Arid)	W (Desert)	
	S (Steppe)	
		h (Hot)
		k (Cold)
C (Temperate)	w (Dry winter)	
	f (No dry season)	
	s (Dry summer)	
		a (Hot summer)
		b (Warm summer)
		c (Cold summer)
D (Continental)	w (Dry winter)	
	f (No dry season)	
	s (Dry summer)	
		a (Hot summer)
		b (Warm summer)
		c (Cold summer)
		d (Very cold winter)
E (Polar)	T (Tundra)	
	F (Eternal frost (ice cap))	

Group A: Tropical climates

- This type of climate has every month of the year with an average temperature of 18 °C (64.4 °F) or higher, with significant precipitation.
- *Af* = Tropical rainforest climate; average precipitation of at least 60 mm (2.4 in) in every month
- *Am* = Tropical monsoon climate; driest month (which nearly always occurs at or soon after the "winter" solstice for that side of the equator) with precipitation less than 60 mm (2.4 in)
- *Aw* or *As* = Tropical wet and dry or savanna climate; with the driest month having precipitation less than 60 mm (2.4 in)

Group B: Dry climates

- This type of climate is defined by little precipitation.
- The threshold in millimeters is determined by multiplying the average annual temperature in Celsius by 20, then adding:

  (a) 280 if 70% or more of the total precipitation is in the spring and summer months (April–September in the Northern Hemisphere, or October–March in the Southern), or

  (b) 140 if 30%–70% of the total precipitation is received during the spring and summer, or

  (c) 0 if less than 30% of the total precipitation is received during the spring and summer.
- If the annual precipitation is less than 50% of this threshold, the classification is BW (arid: desert climate); if it is in the range of 50%–100% of the threshold, the classification is BS (semi-arid: steppe climate).
- A third letter can be included to indicate temperature. Originally, h signified low-latitude climate (average annual temperature above 18 °C (64.4 °F)) while k signified middle-latitude climate (average annual temperature below 18 °C).
- *BWh* = Hot desert climate
- *BWk* = Cold desert climate
- *BSh* = Hot semi-arid climate
- *BSk* = Cold semi-arid climate

Group C: Temperate climates

- This type of climate has the coldest month averaging between 0 °C (32 °F) (or −3 °C (27 °F)) and 18 °C (64.4 °F) and at least one month averaging above 10 °C (50 °F).
- For the distribution of precipitation in locations that both satisfy a dry summer (CS) and a dry winter (CW), a location is considered to have a wet summer (CW) when more precipitation falls within the summer months than the winter months while a location is considered to have a dry summer (CS) when more precipitation falls within the winter months.
- This additional criterion applies to locations that satisfies both DS and DW as well.

- *Cfa* = Humid subtropical climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)), at least one month's average temperature above 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled). No dry months in the summer.
- *Cfb* = Temperate oceanic climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)), all months with average temperatures below 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled).
- *Cfc* = Subpolar oceanic climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)) and 1–3 months averaging above 10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled).
- *Cwa* = Monsoon-influenced humid subtropical climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)), at least one month's average temperature above 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (alternative definition is 70% or more of average annual precipitation is received in the warmest six months).

- *Cwb* = Subtropical highland climate or Monsoon-influenced temperate oceanic climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)), all months with average temperatures below 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (an alternative definition is 70% or more of average annual precipitation received in the warmest six months).
- *Cwc* = Cold subtropical highland climate or Monsoon-influenced subpolar oceanic climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)) and 1–3 months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (alternative definition is 70% or more of average annual precipitation is received in the warmest six months).
- *Csa* = Hot-summer Mediterranean climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)), at least one month's average temperature above 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). At least three times as much precipitation in the wettest month of winter as in the driest month of summer, and driest month of summer receives less than 30 mm (1.2 in).
- *Csb* = Warm-summer Mediterranean climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)), all months with average temperatures below 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). At least three times as much precipitation in the wettest month of winter as in the driest month of summer, and driest month of summer receives less than 30 mm (1.2 in).
- *Csc* = Cold-summer Mediterranean climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)) and 1–3 months averaging above 10 °C (50 °F). At least three times as much precipitation in the wettest month of winter as in the driest month of summer, and driest month of summer receives less than 30 mm (1.2 in).

Group D: Continental climates

- This type of climate has at least one month averaging below 0 °C (32 °F) (or −3 °C (27 °F)) and at least one month averaging above 10 °C (50 °F).

- *Dfa* = Hot-summer humid continental climate; coldest month averaging below −0 °C (32 °F) (or −3 °C (27 °F)), at least one month's average temperature above 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled).
- *Dfb* = Warm-summer humid continental climate; coldest month averaging below −0 °C (32 °F) (or −3 °C (27 °F)), all months with average temperatures below 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled).
- *Dfc* = Subarctic climate; coldest month averaging below 0 °C (32 °F) (or −3 °C (27 °F)) and 1–3 months averaging above 10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled).
- *Dfd* = Extremely cold subarctic climate; coldest month averaging below −38 °C (−36.4 °F) and 1–3 months averaging above 10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled).
- *Dwa* = Monsoon-influenced hot-summer humid continental climate; coldest month averaging below 0 °C (32 °F) (or −3 °C (27 °F)), at least one month's average temperature above 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (alternative definition is 70% or more of average annual precipitation is received in the warmest six months).
- *Dwb* = Monsoon-influenced warm-summer humid continental climate; coldest month averaging below 0 °C (32 °F) (or −3 °C (27 °F)), all months with average temperatures below 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (alternative definition is 70% or more of average annual precipitation is received in the warmest six months).

- *Dwc* = Monsoon-influenced subarctic climate; coldest month averaging below 0 °C (32 °F) (or −3 °C (27 °F)) and 1–3 months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (alternative definition is 70% or more of average annual precipitation is received in the warmest six months).
- *Dwd* = Monsoon-influenced extremely cold subarctic climate; coldest month averaging below −38 °C (−36.4 °F) and 1–3 months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (alternative definition is 70% or more of average annual precipitation is received in the warmest six months).
- *Dsa* = Mediterranean-influenced hot-summer humid continental climate; coldest month averaging below 0 °C (32 °F) (or −3 °C (27 °F)), average temperature of the warmest month above 22 °C (71.6 °F) and at least four months averaging above 10 °C (50 °F). At least three times as much precipitation in the wettest month of winter as in the driest month of summer, and driest month of summer receives less than 30 mm (1.2 in).
- *Dsb* = Mediterranean-influenced warm-summer humid continental climate; coldest month averaging below 0 °C (32 °F) (or −3 °C (27 °F)), average temperature of the warmest month below 22 °C (71.6 °F) and at least four months averaging above 10 °C (50 °F). At least three times as much precipitation in the wettest month of winter as in the driest month of summer, and driest month of summer receives less than 30 mm (1.2 in).
- *Dsc* = Mediterranean-influenced subarctic climate; coldest month averaging below 0 °C (32 °F) (or −3 °C (27 °F)) and 1–3 months averaging above 10 °C (50 °F). At least three times as much precipitation in the wettest month of winter as in the driest month of summer, and driest month of summer receives less than 30 mm (1.2 in).
- *Dsd* = Mediterranean-influenced extremely cold subarctic climate; coldest month averaging below −38 °C (−36.4 °F) and 1–3 months averaging above 10 °C (50 °F). At least three times as much precipitation in the wettest month of winter as in the driest month of summer, and driest month of summer receives less than 30 mm (1.2 in).

Group E: Polar and Alpine climates

- This type of climate has every month of the year with an average temperature below 10 °C (50 °F).
- *ET* = Tundra climate; average temperature of warmest month between 0 °C (32 °F) and 10 °C (50 °F).
- *EF* = Ice cap climate; eternal winter, with all 12 months of the year with average temperatures below 0 °C (32 °F).

Significance

- The Köppen climate classification is based on the empirical relationship between climate and vegetation. This classification provides an efficient way to describe climatic conditions defined by temperature and precipitation and their seasonality with a single metric. Because climatic conditions identified by the Köppen classification are ecologically relevant, it has been widely used to map geographic distribution of long term climate and associated ecosystem conditions.
- Over the recent years, there has been an increasing interest in using the classification to identify changes in climate and potential changes in vegetation over time. The most important ecological significance of the Köppen climate classification is that it helps to predict the dominant vegetation type based on the climatic data and vice versa.
- In 2015, a Nanjing University paper published in *Nature* analyzing climate classifications found that between 1950 and 2010, approximately 5.7% of all land area worldwide had moved from wetter and colder classifications to drier and hotter classifications. The authors also found that the change "cannot be explained as natural variations but are driven by anthropogenic factors."