



Sep 22: Climate Zones and Characteristics

- 1) **Student feedback and changes**
- 2) **Results from Quiz 2**
- 3) **Climate Zone**

- Köppen Climate Classification
- Continental vs Marine Climate
- Mediterranean climate

Reading

Peel, M. C., Finlayson, B. L., & McMahon, T. A. (2007). Updated world map of the Köppen–Geiger climate classification. *Hydrology and Earth System Sciences*, 11(5), 1633–1644. <https://doi.org/10.5194/hess-11-1633-2007>

Reference

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006: [World Map of the Köppen-Geiger climate classification updated](#). *Meteorol. Z.*, **15**, 259-263. DOI: [10.1127/0941-2948/2006/0130](https://doi.org/10.1127/0941-2948/2006/0130).



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1) Student feedback and changes

Some changes will be made. More interactive actions during the class will be implemented.

More essential materials will be uploaded to D2L

Other actions?

2) Results from Quiz 2

Average = 8.6

Min = 7

Max = 10

3) Climate Zones



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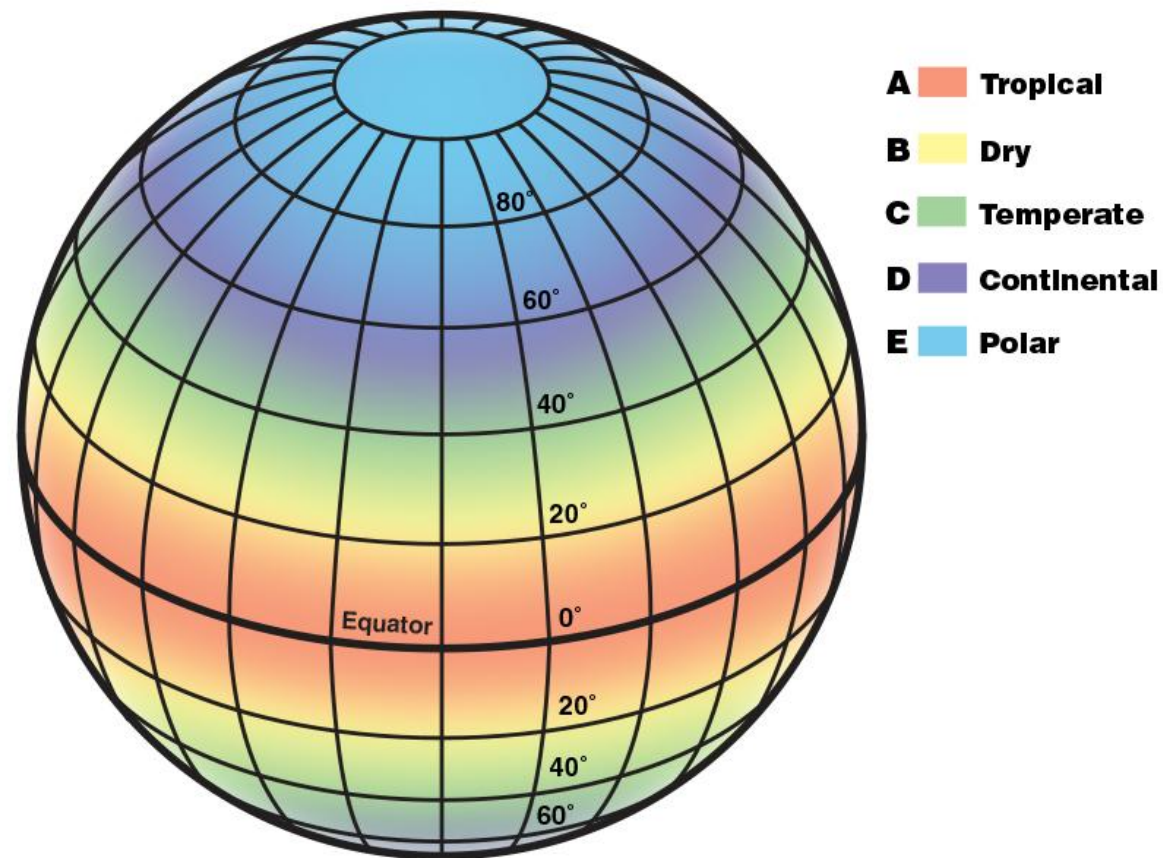
Reference

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006: [World Map of the Köppen-Geiger climate classification updated](#). *Meteorol. Z.*, **15**, 259-263. DOI: [10.1127/0941-2948/2006/0130](https://doi.org/10.1127/0941-2948/2006/0130).

Climate type

There are ~five main climate types on Earth (<https://scijinks.gov/climate-zones/>):

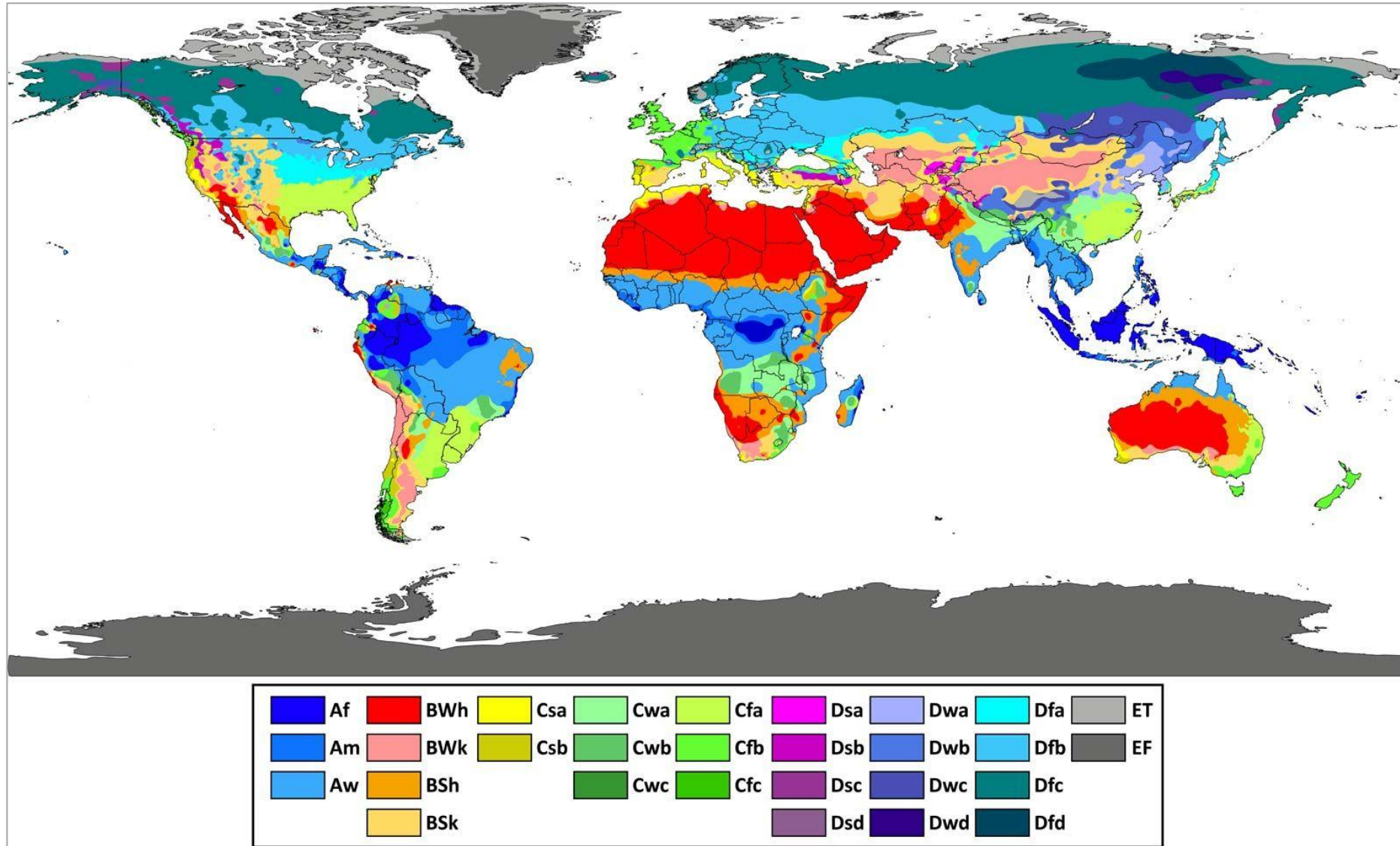
- Tropical (A)
- Dry (B)
- Temperate (C)
- Continental (D)
- Polar (E)



- Developed by Wladimir Köppen
- Based on temperature and precipitation
- 5 main climate groups: A, B, C, D, E
- Many subtypes based on seasonal patterns

Köppen climate classification map (<https://www.britannica.com/science/Koppen-climate-classification>)

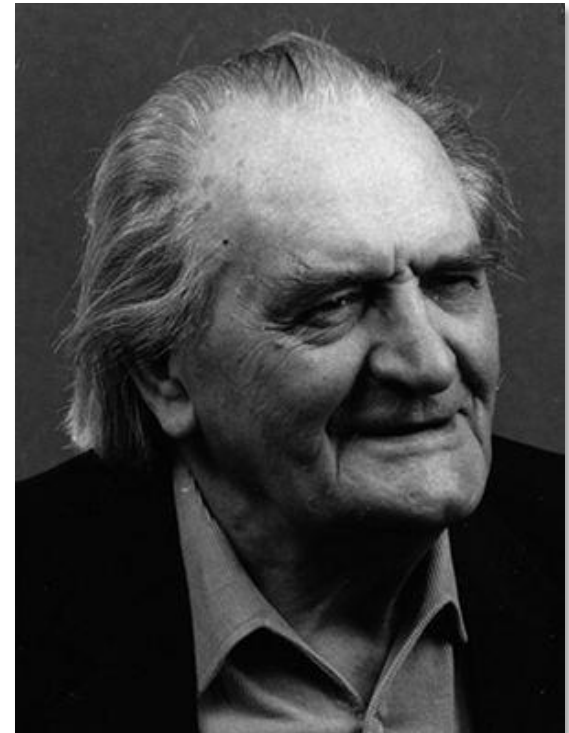
The major climatic types are based on patterns of average precipitation, average temperature, and natural vegetation.





Overview

- German climatologist and amateur botanist **Wladimir Köppen** (1846-1940) divided the world's climates into categories based upon general temperature profile related to latitude.
- He worked with **Rudolf Geiger** to modify these categories into what is known today as the Köppen-Geiger climate classification system.





Group	Description	Temperature	Precipitation	Extent
A	Tropical Moist Climates	Mean Temperature: above 64°F	Annual Rainfall: over 59"	From Equator to between 15° and 25°
B		Dry Climates	Deficient most years, evaporation exceeds precipitation	Extend from 20° to 30° latitude in large continental regions, often surrounded by mountains
C	Moist Subtropical Mid-Latitude Climates	Humid, mild winters with mean temperatures below 64°F but above 27°F		On the eastern and western regions of most continents from about 25° to 40°
D	Moist Continental Climates	Mean winter temperatures are below 27°F, mean summer temperatures above 50°F		North of moist subtropical mid-latitude climates
E	Polar Climates	Year round temperatures are below 50°F		Northern coastal areas of North America and Eurasia, Greenland and Antarctica

Source: [Fluxnet](#) | [NASA](#)

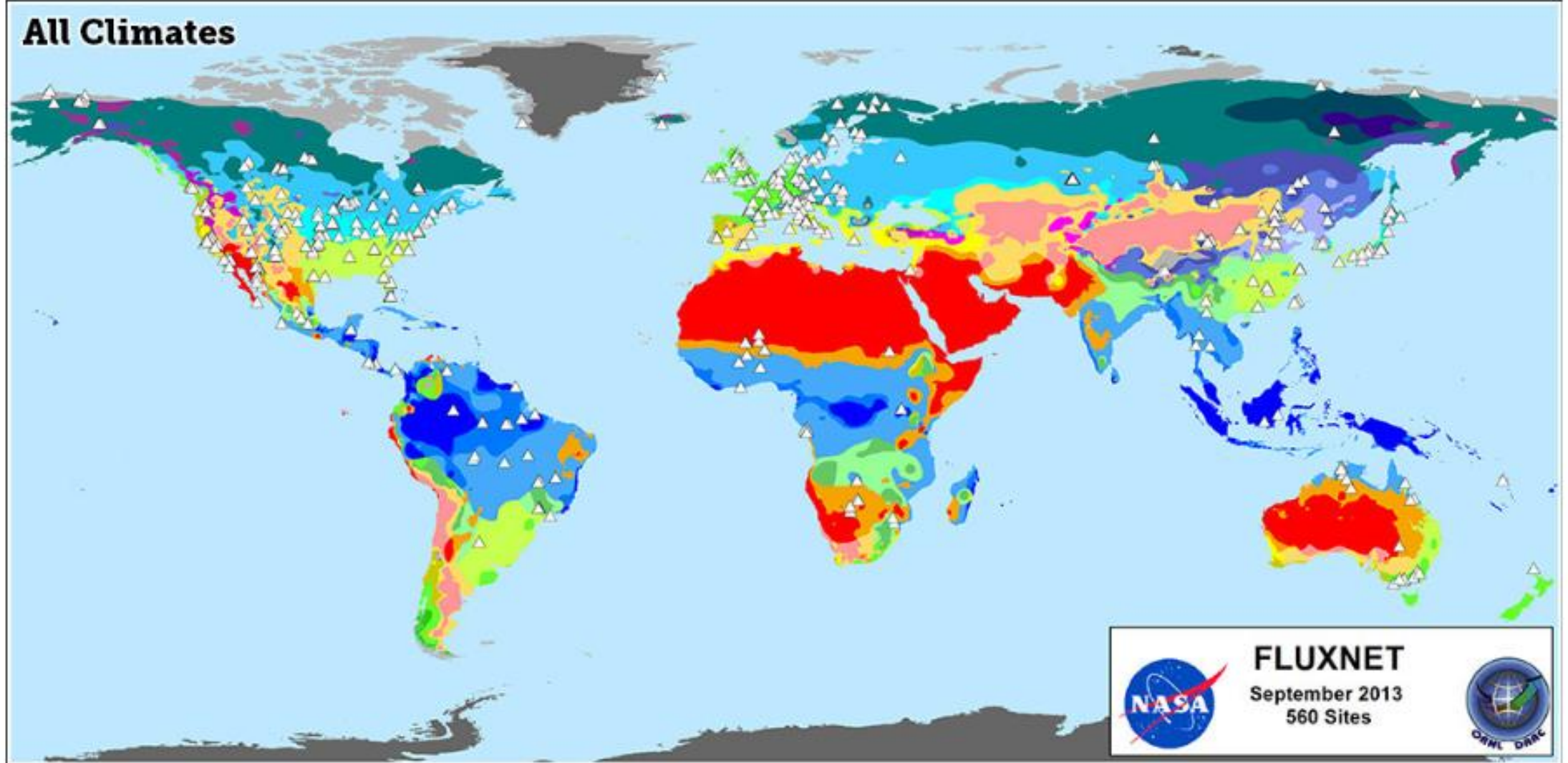
Table 1. Description of Köppen climate symbols and defining criteria.

- A total of 30 types, static
- Observed data, rather than experience (biases in station distribution)
- Data from one period is comparable with data from any other period
- Each variable was interpolated using
- a two-dimensional (lat. & long.) thin-plate spline with tension onto a 0.1×0.1 degree for each continent

1st	2nd	3rd	Description	Criteria*
A			Tropical	$T_{\text{cold}} \geq 18$
	f		- Rainforest	$P_{\text{dry}} \geq 60$
	m		- Monsoon	Not (Af) & $P_{\text{dry}} \geq 100 - \text{MAP}/25$
	w		- Savannah	Not (Af) & $P_{\text{dry}} < 100 - \text{MAP}/25$
B			Arid	$\text{MAP} < 10 \times P_{\text{threshold}}$
	W		- Desert	$\text{MAP} < 5 \times P_{\text{threshold}}$
	S		- Steppe	$\text{MAP} \geq 5 \times P_{\text{threshold}}$
		h	- Hot	$\text{MAT} \geq 18$
C		k	- Cold	$\text{MAT} < 18$
			Temperate	$T_{\text{hot}} > 10$ & $0 < T_{\text{cold}} < 18$
	s		- Dry Summer	$P_{\text{sdry}} < 40$ & $P_{\text{sdry}} < P_{\text{wwet}}/3$
	w		- Dry Winter	$P_{\text{wdry}} < P_{\text{swet}}/10$
	f		- Without dry season	Not (Cs) or (Cw)
		a	- Hot Summer	$T_{\text{hot}} \geq 22$
		b	- Warm Summer	Not (a) & $T_{\text{mon10}} \geq 4$
		c	- Cold Summer	Not (a or b) & $1 \leq T_{\text{mon10}} < 4$
D			Cold	$T_{\text{hot}} > 10$ & $T_{\text{cold}} \leq 0$
	s		- Dry Summer	$P_{\text{sdry}} < 40$ & $P_{\text{sdry}} < P_{\text{wwet}}/3$
	w		- Dry Winter	$P_{\text{wdry}} < P_{\text{swet}}/10$
	f		- Without dry season	Not (Ds) or (Dw)
		a	- Hot Summer	$T_{\text{hot}} \geq 22$
		b	- Warm Summer	Not (a) & $T_{\text{mon10}} \geq 4$
		c	- Cold Summer	Not (a, b or d)
		d	- Very Cold Winter	Not (a or b) & $T_{\text{cold}} < -38$
E			Polar	$T_{\text{hot}} < 10$
	T		- Tundra	$T_{\text{hot}} > 0$
	F		- Frost	$T_{\text{hot}} \leq 0$



All Climates





FLUXNET

September 2013

560 Sites



Koppen-Geiger Climate Classification (2006)

Af - Tropical/Rainforest	BSk - Arid/Steppe/Cold	Cfa - Temperate/Without dry season/Hot Summer	Dsd - Cold/Dry Summer/Very Cold_Winter	Dfb - Cold/Without dry season/Warm Summer
Am - Tropical/Monsoon	Temperate/Dry Summer/Hot Summer	Cfb - Temperate/Without dry season/Warm Summer	Dwa - Cold/Dry Winter/Hot Summer	Dfc - Cold/Without dry season/Cold Summer
Aw - Tropical/Savannah	Temperate/Dry Summer/Warm Summer	Cfc - Temperate/Without dry season/Cold Summer	Dwb - Cold/Dry Winter/Warm Summer	Dfd - Cold/Without dry season/Very Cold Winter
BWh - Arid/Desert/Hot	Temperate/Dry Summer/Cold Summer	Dsa - Cold/Dry Summer/Hot Summer	Dwc - Cold/Dry Winter/Cold Summer	ET - Polar/Tundra
BWk - Arid/Desert/Cold	Cwb - Temperate/Dry Winter/Warm Summer	Dsb - Cold/Dry Summer/Warm Summer	Dwd - Cold/Dry Winter/Very Cold Winter	EF - Polar/Frost
BSh - Arid/Steppe/Hot	Cwc - Temperate/Dry Winter/Cold Summer	Dsc - Cold/Dry Summer/Cold Summer	Dfa - Cold/Without dry season/Hot Summer	ET - Polar/Tundra
				EF - Polar/Frost



Köppen Climate Zones — Land Area Coverage

Köppen Zone	Description	% of Land Area	Approx. Million km ²
A – Tropical	Rainforest, monsoon, savanna (hot & wet)	~20%	~29 million km ²
B – Dry (Arid & Semi-arid)	Deserts, steppes (hot or cold, dry)	~26%	~38 million km ²
C – Temperate (Mesothermal)	Mild winters, warm summers (Mediterranean, subtropical)	~20%	~29 million km ²
D – Continental (Microthermal)	Cold winters, warm summers (humid continental, subarctic)	~21%	~31 million km ²
E – Polar	Tundra, ice cap (very cold, dry)	~13%	~19 million km ²
Highlands (H)	Mountains (varies with altitude, small patches globally)	~2–3%	~4 million km ²



Group Exercise

Students will be divided into 4–5 groups. Select 1–3 global locations (outside of Michigan) that you have visited, and assign each to one of the five Köppen climate zones. Briefly describe the vegetation in each location and explain the reasons for your classification.



Take-home-messages

- 1) Five major climate zones in Köppen Climate Classification
- 2) Criteria for the classification
- 3) Uncertainty (e.g., station distribution, resolution, landscape complexity, etc.)
- 4) User dependent



Sept 24: **Vegetation Characteristics of Climate Changes**

- Vegetation in different climate zones
- Students input