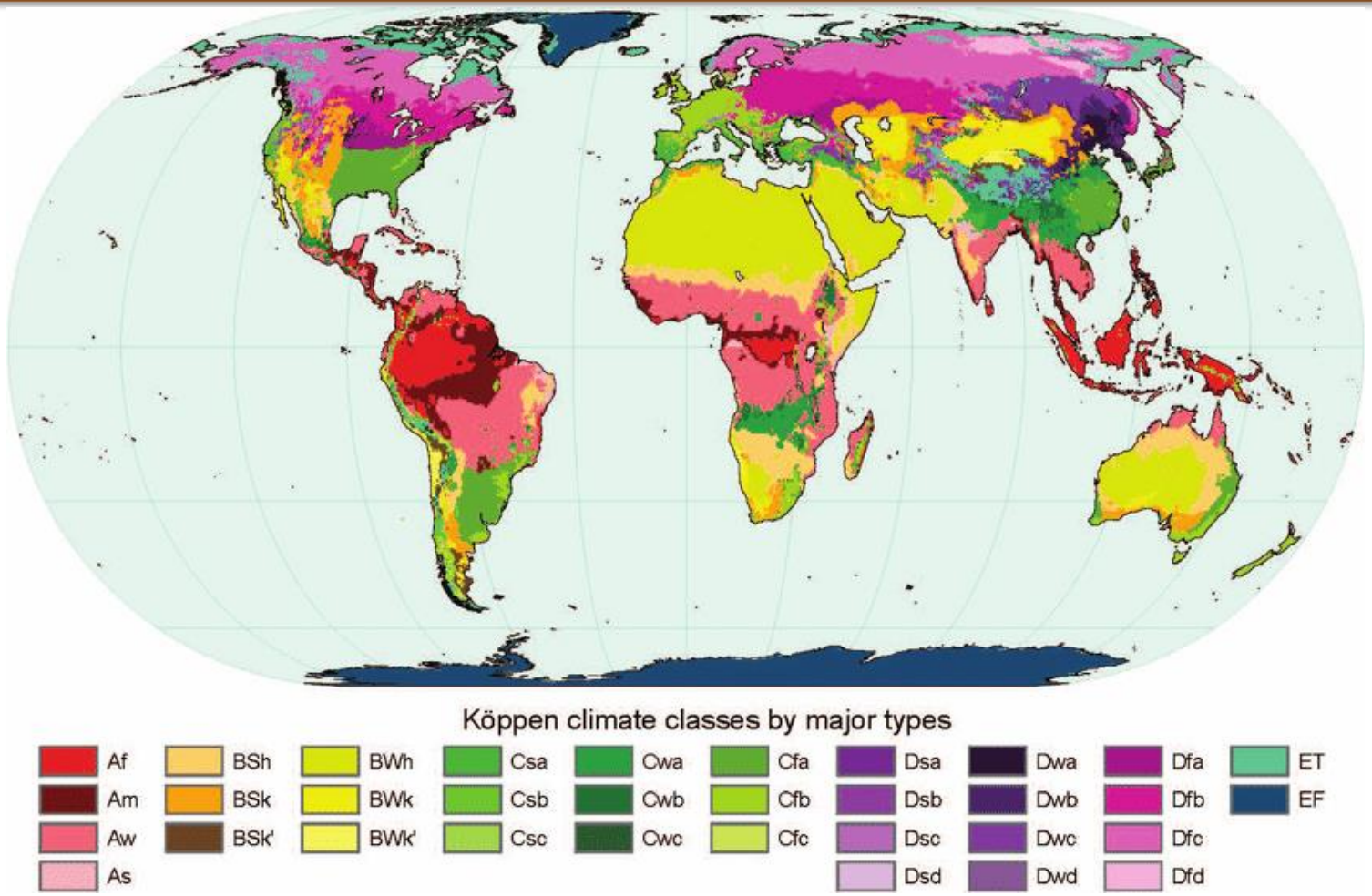
Chapter six

Climate Classification



By: Ayele Behaylu (Ass Prof)

6.1. Climatic classification: General Considerations

- The climatic controls interact to produce such a wide array of different climates that no two places experience exactly the same climate.
- However, the similarity of climates within a given area allows us to divide Earth into climatic regions.

6.2. History and philosophical base of climate classification

- As an integral part of the organization of knowledge and discipline development, climatic classification has a **long history**.
- **Earliest classifications** were based upon a ***single variable***, often ***day-length***.
- Increased availability of data in the late 19th c permitted ***more quantitative approaches*** and the ***use of more than one variable***.
- Vegetation distribution strongly influenced classification system development, with that devised by Köppen proving the most durable.

- Formulation of climatic indices permitted the development of an ***applied empiric approach*** and the ***development of the moisture-balance concept.***
- Modern taxonomists have used ***air mass*** and ***synoptic climatological approaches*** in attempts to incorporate atmospheric processes.
- Synoptic approaches have been of importance since the introduction of methods of ***numerical taxonomy***.
- The availability of ***large data sets*** and ***computer-generated analytic techniques*** has helped numeric classification to be of ***major research importance today***.
- In the future, knowledge of classifications will remain an important component for an understanding of the climate system while newer techniques promise a highly utilitarian approach to the classification of climate.

6.3. Significance of climate classification

- Climatic classification has a number of advantages, both to the geographer as well as to the scientists actively associated with other aspects of our natural environment such as soils, plant life, animal life, and the configuration of the land surface.
- By identifying climatic types, we are able to predict various associated visible aspects of the environment.
- It may also enable a geographer to predict the climate of a region through his observation of vegetation, animal life, soils, or landforms.

For more than thirty years, climatic classification has been regarded as an essential tool in geography for the teaching of world climatic distribution and for regional description.

6.4. Approaches to Climatic Classification

According to ***John E. Oliver (1973),*** there are two approaches to classifying climates—**Empirical** and **Genetic**.

Climate classification system

Climate classification systems (CCSs) are important tools in the study of agriculture, enabling knowledge of the climatic characteristics of a region.

Approaches to classification

Empirical :- It is based on observation and the effects of the phenomenon (ex. Precipitation, temperature, soil etc.) for climatic differentiation.

Genetic :- It emphasizes causes or origin of the formation of climatic factors based on weather processes.

1. Empirical classification: -

- Empirical classifications are based on the observable features of climate.
- Heat and moisture are factors used to classify climate types.
- Temperature criteria, for example, might yield “hot, warm, cool and cold” climates, each of which can be defined in terms of strict mathematical limits.

2. Genetic classification: -

- This classification attempts to organize climates according to their cause.
- Latitude, features of the general atmospheric circulation, effect of continents and oceans, mountain barriers, and altitude are the common bases for genetic classification, which produces climate types such as polar and tropical, trade wind littoral, maritime and continental or highland climates.

THE ANCIENT GREEKS' CLASSIFICATION SYSTEM

- By considering **temperature** and **worldwide *sunshine* distribution**, the ancient Greeks categorized the world into **three climatic regions**:

1. A low-latitude *tropical* (or *torrid*) *zone;* bounded by the northern and southern limit of the sun's vertical rays (23½°N and 23½°S); here, the noon sun is always high, day and night are of nearly equal length, and it is warm year-round.
2. A high-latitude *polar* (or *frigid*) *zone;* bounded by the Arctic or Antarctic Circle; cold all year long due to long periods of winter darkness and a low summer sun.
3. A middle-latitude *temperate zone;* sandwiched between the other two zones; has distinct summer and winter, so exhibits characteristics of both extremes.

- Such a **sunlight-based**, or **temperature-based, the** climatic scheme is, of course, far **too simplistic**.
- It **excludes precipitation**, so there is no way to differentiate between wet and dry regions.

- The best classification of climates would take into account as many meteorological factors as can possibly be obtained.

THE KÖPPEN CLASSIFICATION SYSTEM

- A widely used classification of world climates based on the ***annual*** and ***monthly averages*** of ***temperature*** and ***precipitation*** was devised by the German scientist **Wladimir Köppen** (1846–1940).

- ***In the absence of adequate observing stations*** throughout the world, Köppen related the ***distribution*** and ***type*** of ***native vegetation*** to the ***various climates***.
- In this way, climatic boundaries could be approximated where no climatological data were available.
- Initially published in 1918, the **Köppen classification system** has since been modified and refined by a number of researchers.
- Köppen's scheme identifies ***five major climatic types***, with each type designated by a ***capital letter***:

Each type is designated by a capital letter. A, B, C, D, E

A. *Tropical moist climates:* All months have an average temperature above 18°C (64°F). Because all months are warm, there is no real winter season. Equatorial

B. *Dry climates:* Deficient precipitation most of the year. Potential evaporation and transpiration exceed precipitation. Arid

C. *Moist midlatitude climates with mild winters:* Warm-to-hot summers with mild winters. The average temperature of the coldest month is below 18°C (64°F) and above −3°C (27°F). Warm temperate

D. *Moist midlatitude climates with severe winters:* Warm summers and cold winters. The average temperature of the warmest month exceeds 10°C (50°F), and the coldest monthly average drops below −3°C (27°F). Continental

E. *Polar climates:* 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. Polar

https://youtu.be/jZhlnzf4TV4

- In mountainous countries, where rapid changes in elevation bring about sharp changes in the climatic type, delineating the climatic regions is impossible.
- These regions are designated by the letter ***H***, for ***highland climates.***

NB

- Keep in mind that within the Köppen system, each major climatic group contains subgroups that describe special regional characteristics, such as seasonal changes in temperature and precipitation.

- The last two letters of the 2 or 3-letter code describe the precipitation and temperature of the region:

2nd Letter (Precipitation)	Type
W	Desert
S	Steppe
f	Fully Humid
s	Summer Dry
w	Winter Dry
m	Monsoonal

3rd Letter (Temperature)	Type
h	Hot Arid
k	Cold Arid
a	Hot Summer
b	Warm Summer
c	Cool Summer
d	Extremely Continental
F	Polar Frost
T	Polar Tundra

A: Tropical climates. Vegetation is tropical rain forests.	**Af** = Tropical Rainforest	
	Am = Tropical Monson	
	Aw = Tropical Savanna	

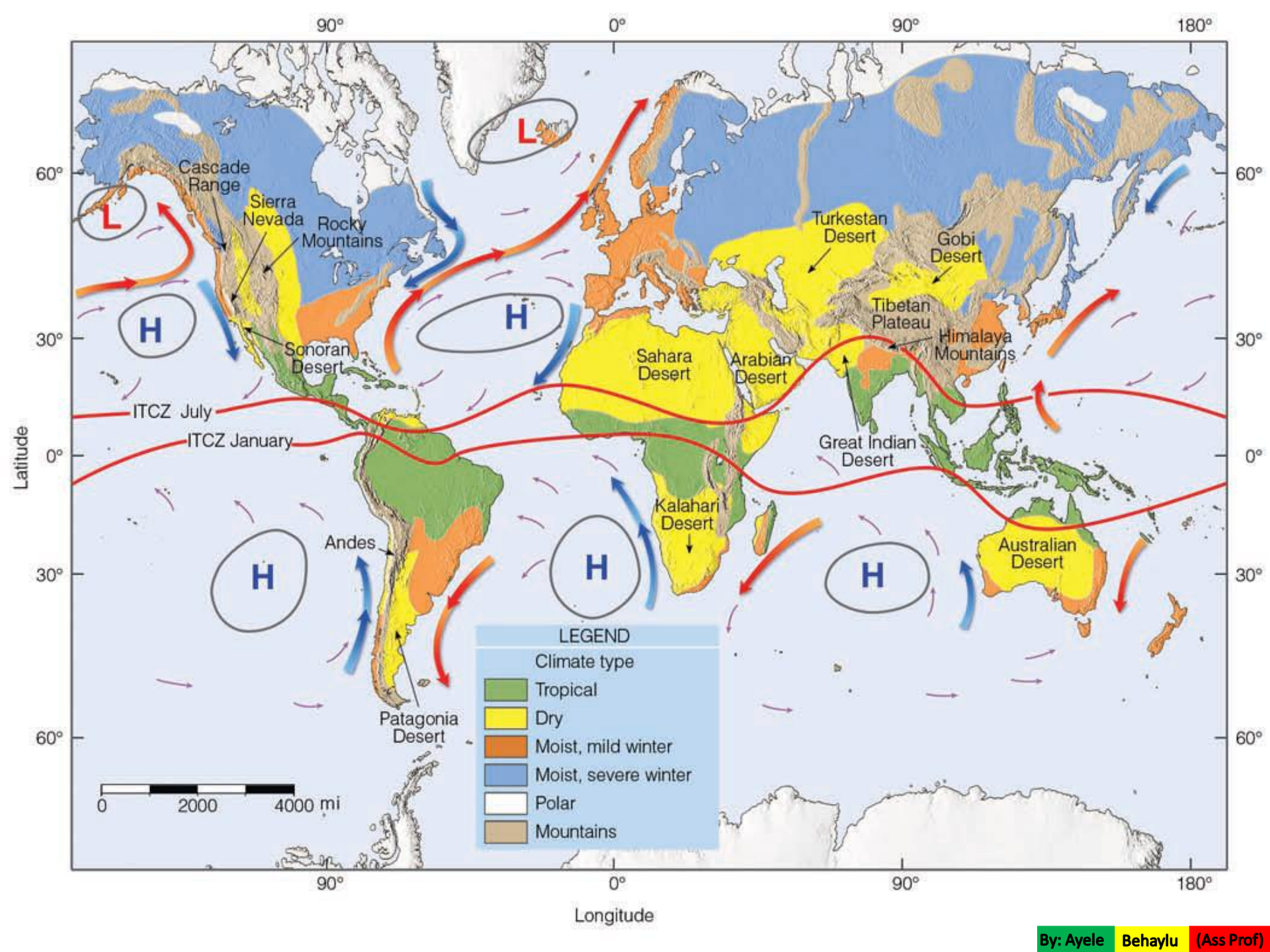
B: Dry (arid and semi-arid) climates. Xerophytes type of vegetation	**BS** = Arid Semiarid/Steppe	**BSh** = semiarid hot low latitude steppe
		BSk = semiarid cold mid-latitude steppe
	BW = Arid Waste/Desert	**BWh** = arid low latitude desert
		BWk = arid mid-latitude desert

C: Temperate climate. Plants adapted to moderate heat and moisture	**Cf** = Year around precipitation	**Cfa** = humid sub-tropical, warmest month temperature >22ºC
		Cfb = marine west coast, warmest month temperature <22ºC
	Cs = Summer dry	**Csa** = mild with dry, hot summer
		Csb = Summer dry, warm summer
	Cw = Winter dry	

D: Humid microthermal climates. Evergreen deciduous forests and steppes are the natural vegetation.	**Df** = Humid continental precipitation throughout the year.	**Dfa** = summer long and warm continental
		Dfb = summer long and cool
		Dfc = summer short and cool
	Dw = Humid continental-winter dry.	**Dwa** = humid with severe dry winter hot summer
		Dwb = humid with severe dry winter warm summer
		Dwc = dry winter, cool short summer (sub-Arctic)
		Dwd = very cold and dry winter, cool summer
	Ds = Humid continental-summer dry.	

E: Polar Climates/ Hekistothermal type of vegetation. Mosses, lichens etc. are the natural vegetation.	**ET** = Mild tundra climate with average temperatures between 0ºC and 10ºC.
	EF = Permanent snow fields, average temperature in all the months <0ºC.

H: Highlands climate	High insolation, low temperature, low pressure, high precipitation and larger diurnal ranges.



By: Ayele Behaylu (Ass Prof)

Merits of the Köppen climate classification system:

- ✓ The scheme only three alphabets, therefore easy to represent.
- ✓ Along with main divisions there are subdivisions which represent smaller climatic variations.
- ✓ The major group boundaries correspond roughly to the general features of atmospheric circulation.
- ✓ The parameters are easy to measure.

Criticisms of the Köppen climate classification system:

- ❖ The scheme ignores causative factors.
- ❖ Vegetation is not only depends on climate, but factors like soil cover, biological activity etc. also have a significant role.
- ❖ Sharp boundary between climatic zones due to the use of vegetation to represent monthly temperature and precipitation. But, temperature and rainfall at any place differ from year to year. Therefore the position of climatic boundaries will also change accordingly.

THORNTHWAITE'S CLASSIFICATION SYSTEM

- To correct some of the Köppen deficiencies, the American climatologist ***C. Warren Thornthwaite*** (1899–1963) devised a ***new classification system*** in the early 1930s.
- Both systems utilized ***temperature and precipitation*** measurements and both related ***natural Vegetation to climate***.
- However, to emphasize the importance of precipitation (P) and evaporation (E) on plant growth, Thornthwaite developed a ***P/E ratio***, which is essentially monthly precipitation divided by monthly evaporation.
- The annual sum of the P/E ratios gives the **P/E index**.
- Using this index, the Thornthwaite system defines ***five major humidity provinces and their characteristic vegetation***: ***rainforest, forest, grassland, steppe, and desert.***

Thornthwaite used two factors, e.g. **precipitation effectiveness** and **temperature effectiveness**, for the delimitation of boundaries of different climatic regions.

- **Precipitation effectiveness** - Precipitation effectiveness or precipitation efficiency refers to the amount of precipitation which is available for the growth of vegetation.

P/E Index	Vegetation	Humidity Province
127	Rain Forest	A (Wet)
64 – 127	Forest	B (Humid)
32 – 63	Grassland	C (Sub-humid)
16 – 31	Steppe	D (Semiarid)
16	Desert	E (Arid)

Climate types and moisture index in Thornthwaite's classification					
Symbol	Humidity Province	Broad Group	Moisture index	(cm)	Thermal Province
A	Perhumid	Moist climate	100 and above	>114	Megathermal
B4	Humid		80 to 100	57 - 114	Mesothermal
B3	Humid		60 to 80		
B2	Humid		40 to 60		
B1	Humid		20 to 40		
C2	Moist sub-humid		0 to 20	28.5 - 57	Microthermal
C1	Dry sub-humid	Dry climate	-20 to 0	14.2 – 28.5	Tundra
D	Semi-arid		-40 to -20	<14.2	Frost
E	Arid		-60 to -40		

- Since it is difficult to obtain data on evaporation for every center and hence Thornthwaite suggested the following formulae for the calculation of precipitation efficiency ratio and index.

$$\text{P/E ratio} = 11.5\,(r/t-10)^{10/9}$$

$$\text{P/E Index} = \sum_{i=1}^{12} 11.5\,(r/t-10)^{10/9}$$

Where

r= mean monthly rainfall in inches

t= mean monthly temperature in Fahrenheit

Merits of the Thornthwaite climate classification system:

- ✓ More divisions of climatic types based on the variations of climatic conditions.
- ✓ Thornthwaite's scheme also became popular among zoologists, botanists and geographers.

Criticisms of the Thornthwaite climate classification system:

- ❖ Thornthwaite's scheme yielded the number of major climatic types (32) three times greater than Köppen's climatic types, so hard to remember.
- ❖ This scheme did not include the causative factors of climates into the classification of world climates.
- ❖ The complex empirical formulae devised by Thornthwaite require regular data but these are not always forthcoming. They also involve a lot of calculations for determining the climatic type of a particular place. This is why his scheme could not get more popularity and recognition.

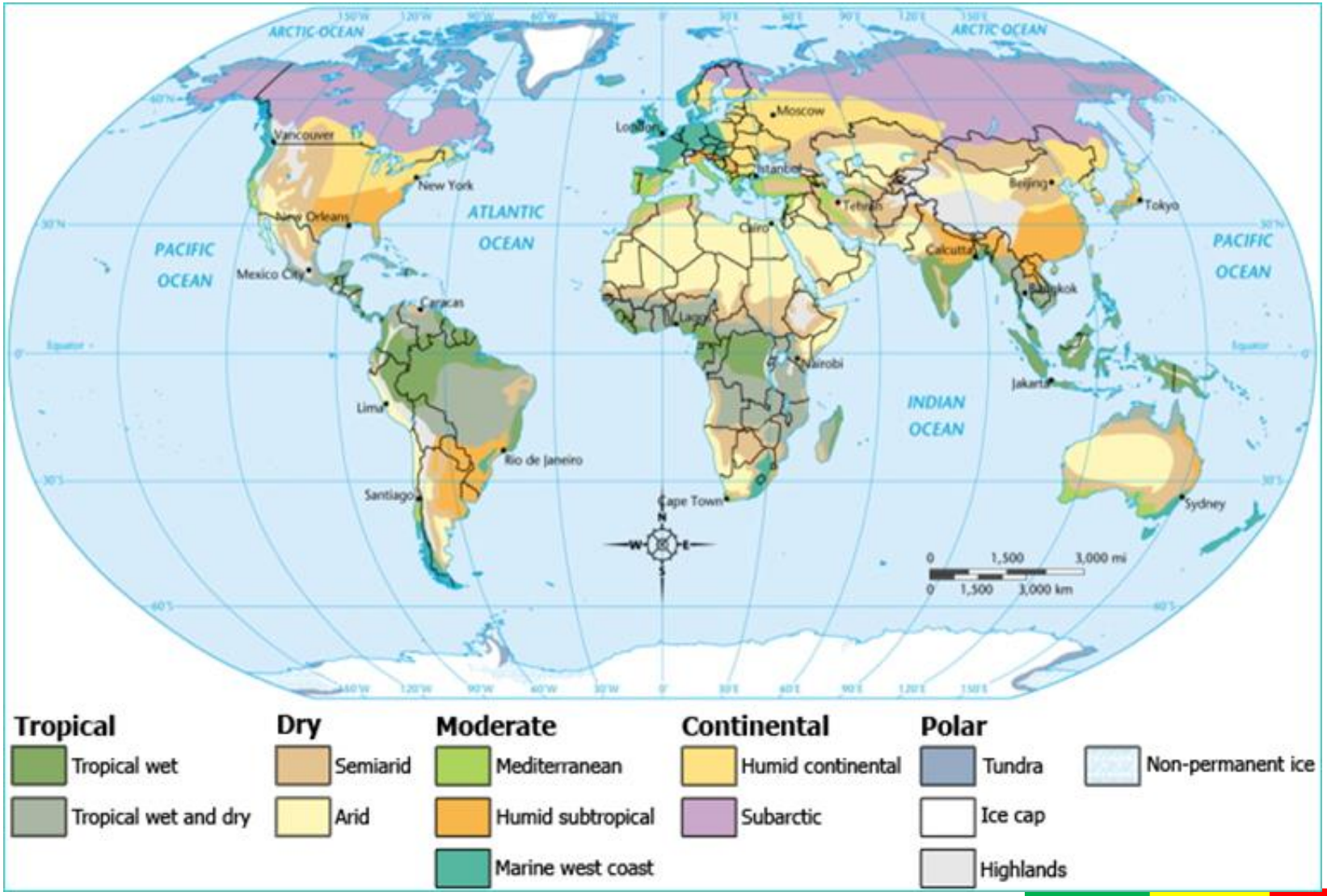
TREWARTHA'S CLASSIFICATION SYSTEM

Trewartha's scheme is a compromise between purely empirical and genetic methods of climatic classification. He was also opposed to produce large number of climatic types on the basis of statistical and quantitative parameters. That is why he recognized only a limited number of major climatic types.

Basis of classification	Climatic group	Subdivisions
Temperature	A. Tropical	Ar Aw
Precipitation	B. Dry	BS BW
Temperature	C. Subtropical	Cs Cf
Temperature	D. Temperate	Do Dc
Temperature	E. Boreal	
Temperature	F. Polar	Ft Fi
Temperature	H. Highland	

6.5. An over view of World Climatic regions:

~~Tropical, Temperate, cold, Deserts~~ ~~???MoE???~~

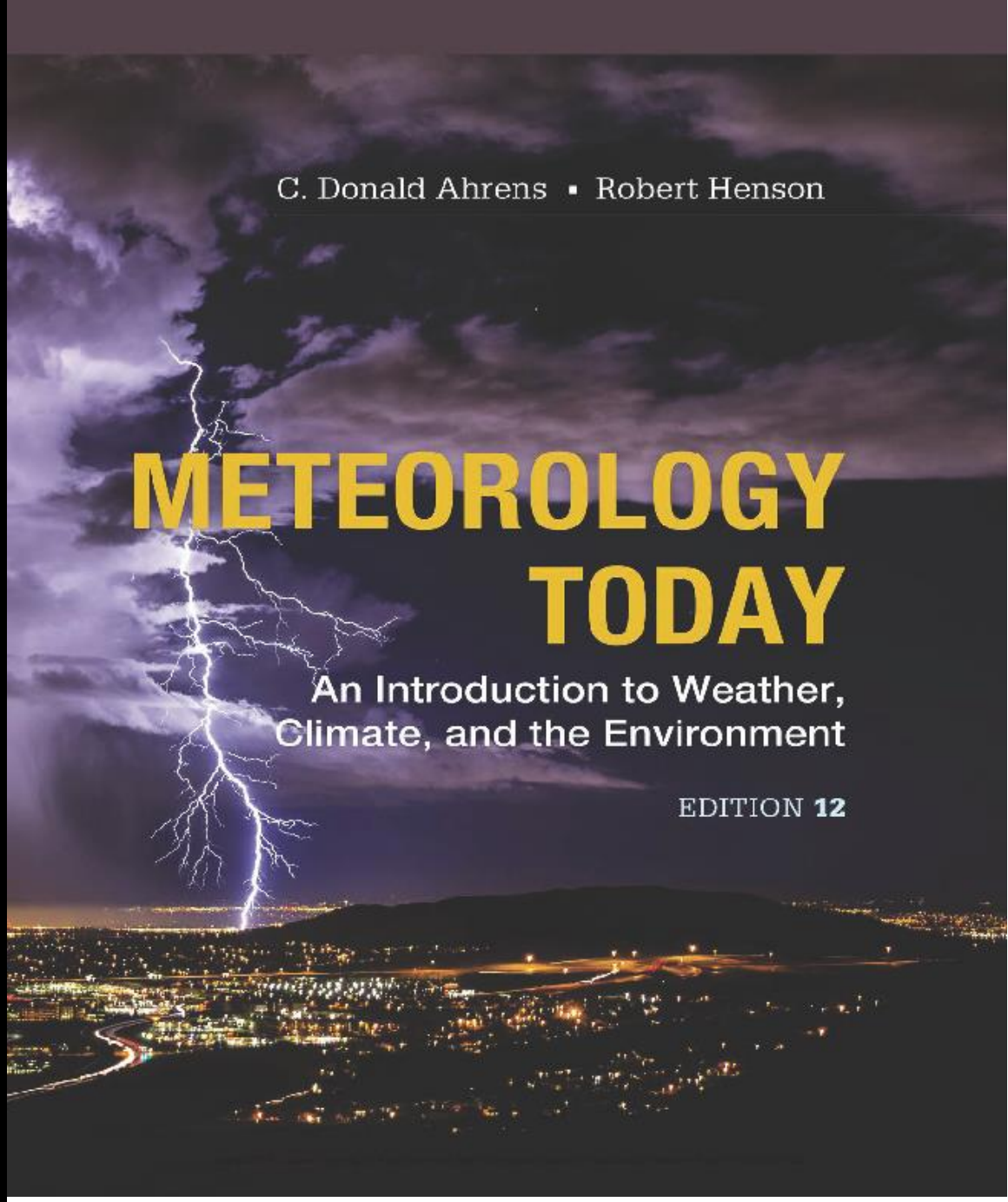


By: Ayele Behaylu (Ass Prof)

- It is my humble request for you to read the wonderful book entitled:

"**METEOROLOGY TODAY**

An Introduction To Weather, Climate, and the Environment"



- **Moreover, please click the YouTube links available on the slides to have a better understanding on the course.**