Lab 14

Climate Classification

Climate is a generalization of atmospheric conditions over a long period of time. It is more than an average, for extremes must always be considered in any climatic description along with the prevailing "normal" or mean conditions. This lab will assist students in understanding the worldwide distribution of climates and the resulting impact upon people.

The global patterns of air temperature and other weather elements that occur based upon the Earth's tilt, rotation and land/sea distribution are responsible for the Earth's many climates. Climates are the general weather conditions usually found in a particular place. While the weather varies from day-to-day at any particular location, over the years, the same type of weather will reoccur. This recurring weather pattern for each location is known as the climate for that location.

The first widely used climate classification was devised by Dr. Wladimir Köppen (1846-1940) in 1918, revised most recently by him in 1931, and modified many times by others since then. This system is based upon annual and monthly means of temperature and precipitation, but many of his boundaries were created with specific types of vegetation limits in mind. Köppen, a German climatologist and amateur botanist, divided the world's climates into several major categories based upon general temperature profiles related to latitude. Köppen's classification divides the world into four (4) major types of climate groups (A, C, D, E) based upon temperature values alone. A fifth group (B) for dry climates is determined by both temperature and precipitation values (so that evaporation, transpiration, and the availability of water for plant growth can be considered).

A - tropical humid
B - dry (arid) climates based on relationship between temperature and evapotranspiration
C - warm temperate humid/cool winter
D - cool temperate humid/cold winter
E - polar
H - highland (not used in Köppen's classification)

These groups are further subdivided on the basis of seasonality of precipitation, and once again on the basis of extremes of temperature.

The following diagram (Figure 13.1) illustrates some of the factors that are responsible for the creation of weather and climate.

Figure 13.1 Köppen's classification system basis

Climatic Controls	*act upon* →	Climatic Elements	*to produce* →	Types and Varieties of Weather and Climate
Latitude or Sun Angle				A – Tropical
Land–water Distribution		Insolation		
Winds and Air Masses				B – Dry
Semi-permanent Highs & Lows		Temperature		
Storms				C – Mesothermal
Altitude (elevation)		Pressure		
Mountain Barriers				D – Microthermal
Ocean Currents		Moisture		
				E – Polar

In addition to the five main classification letters described above, by adding additional letter symbols, based on additional climatic criteria, we derive 16 major *climate types*.

Af	-	Tropical Rainforest
Am	-	Tropical Monsoon
Aw	-	Tropical Savanna
BSh	-	Low Latitude Steppe
BWh	-	Low Latitude Desert
BSk	-	Middle Latitude Steppe
BWk	-	Middle Latitude Desert
Csa/Csb	-	Mediterranean (Dry Summer subtropical)
Cfb/Cfc	-	Marine West Coast
Cfa	-	Humid Subtropical
Cwa/Cwb	-	Subtropical Monsoon
Dfa/Dwa	-	Humid Continental – Long Summer
Dfb/Dwb	-	Humid Continental – Short Summer
Dfc/Dwc	-	Subarctic
Dfd/Dwd	-	Subarctic
ET	-	Tundra
EF	-	Ice Cap

In more detail, Figure 13.2 also provides some further classification characteristics.

Figure 13.2 Köppen's classification system detailed

Tropical Climates
(Classification **A**)
Tropical moist climates extend north and south from the equator to about 15° to 25° latitude. In these climates all months have average temperatures greater than 18° C (64°F) and annual precipitation greater than 150 cm (59").

Dry Climates
(Classification B)
The most obvious climatic feature of this climate is that potential evaporation and transpiration exceed precipitation. These climates extend from 20°-35° North and South of the equator and in large continental regions of the mid-latitudes often surrounded by mountains.

Moist Subtropical Mid-Latitude Climates
(Classification **C**)
This climate generally has warm and humid summers with mild winters. Its extends from 30° to 50° latitude mainly on the eastern and western borders of most continents. During the winter, the main weather feature is the mid-latitude cyclone. Convective thunderstorms dominate summer months.

Moist Continental Mid-latitude Climates
(Classification **D**)
Moist continental mid-latitude climates have warm to cool summers and cold winters. The location of these climates is poleward of the **C** climates. The average temperature of the warmest month is greater than 10°C (50°F), while the coldest month is less than 0°C. Winters are severe with snowstorms, strong winds, and bitter cold from Continental Polar or Arctic air masses.

Polar Climates
(Classification **E**)
Polar climates have year-round cold temperatures with the warmest month less than 10°C (50°F). Polar climates are found on the northern coastal areas of North America, Europe, Asia, and on the landmasses of Greenland and Antarctica.

Highlands
(Classification **H**)
These are unique climates based on their elevation. Highland climates occur in mountainous terrain where rapid elevation changes cause climatic changes over short distances.

Identification of Climate Types Using Köppen's Classification

It is not necessary to check climate types in a specific order as the categories are mutually exclusive. However, since dry climates tend to be more difficult to deal with, you might want to check for dry climates first and then proceed through the other major climatic types.

Whenever a climate station receives less than 750 mm (30") of precipitation, it is possible that it may be a "B" type (dry) climate. As more moisture is lost to evaporation and transpiration in warmer climates, you must consider temperature data as well. To check as to whether a climate is Dry, use the "Sector Graphs for Climates" (Figure 13.5). Each graph helps you to determine whether the climate you are examining is "BW" (desert), "BS" (steppe) or is some type of humid climate (A, C, or D). The distribution of precipitation during the year determines which of the three graphs you should use.
Even regime (precipitation well distributed throughout the year) = moderate evaporation loss,
Summer regime (April - September in the Northern Hemisphere / October to March in the Southern Hemisphere) = high loss of moisture, and
Winter regime (October to March in Northern Hemisphere / April - September in the Southern Hemisphere) = low loss of moisture through evaporation and transpiration.

Climate data for Boston, MA

Month	**Temperature**		**Precipitation**	
	°F	°C	Inches	Millimeters
January	28.8	-1.8	3.6	91.9
February	30.4	-0.9	3.6	91.9
March	38.5	3.6	3.7	93.7
April	48.0	8.9	3.6	91.4
May	58.1	14.5	3.2	82.5
June	67.6	19.8	3.1	78.4
July	73.4	23.0	2.8	72.1
August	71.8	22.1	3.2	82.2
September	64.8	18.2	3.1	77.7
October	54.7	12.6	3.3	83.8
November	45.1	12.6	4.2	107.1
December	33.4	0.8	4.0	101.8
Annual	51.3	10.7	41.5	1054.3

(Annual temperature is average while precipitation is total or sum)

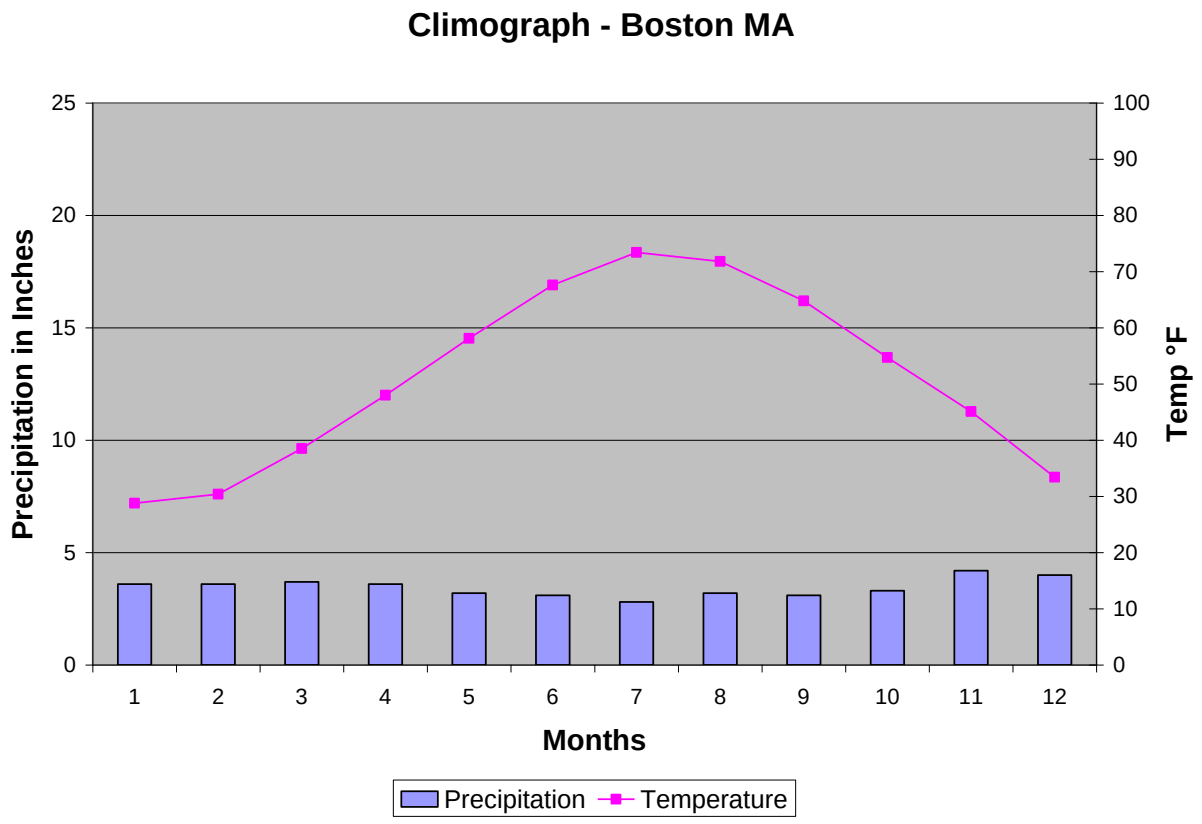
Köppen Classification _____

Winter:	cold, humid	Temp. max.:	73.4°F	23.0 °C
Summer:	warm, humid	Temp. min.:	28.8°F	-1.8 °C
Precip. total:	41.5" 1054.3 mm	Temp. range:	44.6°F	24.8 °C

Climographs

Basic climatic characteristics may be visualized by plotting the temperature and precipitation data for a station. This is referred to as a Climograph, or Temperature-Precipitation Graph.

Figure 13.3 Climograph – Boston, Massachusetts



Internet Resources for Climate

World Cimates (data source for this chapter)
http://www.worldclimate.com/

Figure13.4 – Simplified Koppen Classification of Climates

FIRST LETTER		SECOND LETTER		THIRD LETTER		
E	Warmest month less than 10°C (50°F) ICE CLIMATES	T	Warmest month between 10°C (50°F) and 0°C (32°F)	NO THIRD LETTER (with ice climates) SUMMERLESS		ET EF
		F	Warmest month below 0°C (32°F)			
B	Arid or Semiarid Climates If annual precipitation less than 750 mm (~30 in) use sector graphs (Figure 13.5) ARID CLIMATES: BS – Steppe BW – Desert	S	Semiarid Climate (see sector graphs, Fig. 13.5)	h	Mean annual temperature is greater than 18°C (64.4°F)	BSh BSk
		W	Arid Climate (see sector graphs, Fig. 13.5)	k	Mean annual temperature is less than 18°C (64.4°F)	BWh BWk
A	Coolest month is greater than 18°C (64.4°F) TROPICAL CLIMATES: Am – Tropical Monsoon Aw – Tropical Savanna Af – Tropical Rain Forest	f	Driest month has at least 60 mm (2.4 in)	NO THIRD LETTER (with Tropical Climates) WINTERLESS		Af Am Aw
		m	Seasonally, excessively moist (see Fig 13.4.1)			
		w	Dry winter, wet summer (see Fig 13.4.1)			
C	Coolest month is between 18°C (64.4°F) and 0°C (32°F) and at least one month over 10°C (50°F) WARM TEMPERATE CLIMATES	s	DRY SUMMER: Driest month in the summer half of the year with less than 30 mm (1.2 in) of precip. and less than $^1/_3$ of the wettest winter month.	a	Warmest month above 22°C (71.6°F)	Csa Csb Cwa Cwb Cfa Cfb Dwa Dwb Dwc Dfa Dfb Dfc
				b	Warmest month below 22°C (71.6°F), with at least 4 months above 10°C (50°F)	
		w	DRY WINTER: Driest month in the winter half of the year, with less than $^1/_{10}$ of the precip of the wettest summer month	c	Warmest month below 22°C (71.6°F), with 1 to 3 months above 10°C (50°F)	
D	Coldest month less than 0°C (32°F) and at least one month over 10°C (50°F) SNOW CLIMATES			d	Same as c, but coldest month is below -38°C (-36.4°F)	Dfd Dwd
		f	ALWAYS MOIST: Does not meet conditions for s or w above.			
H	HIGHLAND CLIMATES	NO SECOND LETTER CHARACTERIZED BY VERTICAL ZONATION		NO THIRD LETTER OF CLIMATES GIVEN ABOVE		H

Figure 13.4.1 – Use to determine moisture classification (m or w) for A climate

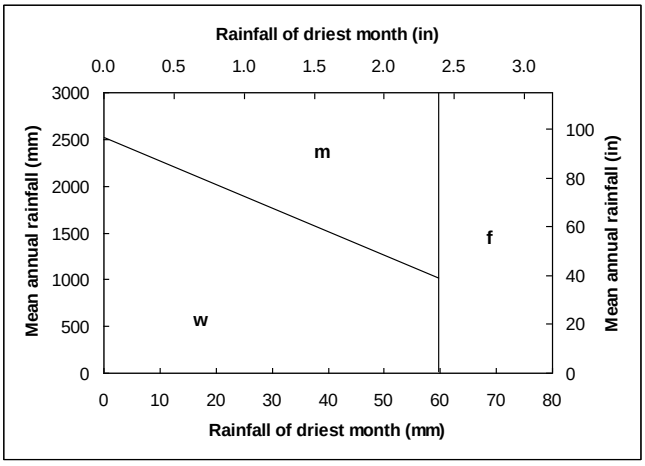
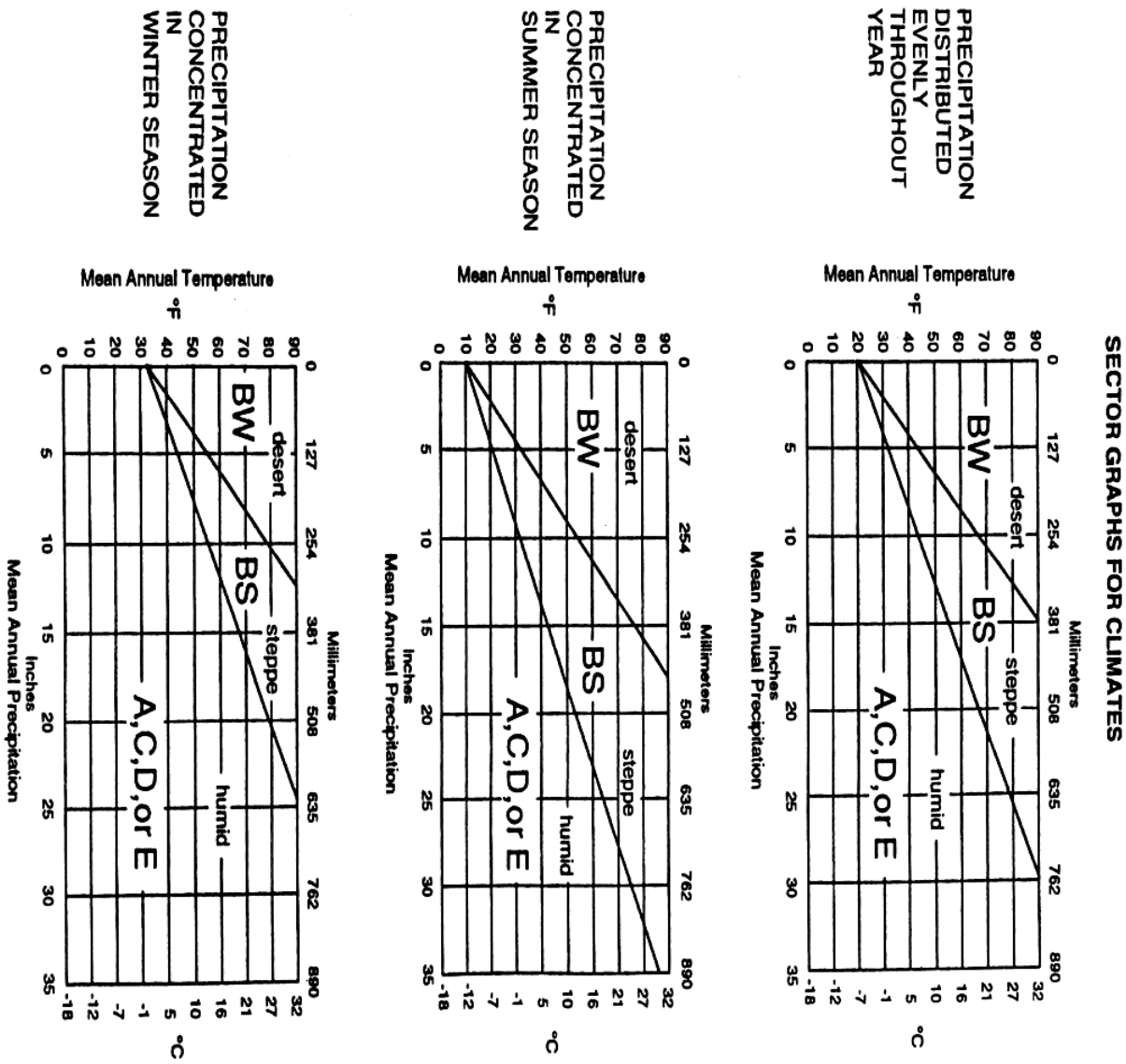


Figure 13.5 – If the total annual precipitation of a location is < 750 mm (~30 in), use the graphs to determine if the location is a 'B' (arid/semi-arid) climate.



Exercise #13 Lab Activity

Name: _____

Climate

Lab Section: _____

Please show your work. If necessary please use additional paper to show work.

Classify the following climatic stations using the Köppen system. Listing the temperature maximums and minimums, temperature range, and precipitation amounts will aid the classification process. You will need to determine whether the stations are in the northern or southern hemispheres. **Note:** the station data for precipitation is in millimeters (mm) and some charts are in millimeters and some are in centimeters (cm). To convert: 1 cm = 10 mm / 1 mm = 0.1 cm.

After classifying all ten stations, match the stations with the following cities:

Barrow, Alaska	Salem, MA
Ulaan Baatar, Mongolia	Singapore
Riyadh, Saudi Arabia	Santiago, Chile
Rome, Italy	Dar es Salaam, Tanzania
Cape Town, South Africa	Vostok, Antarctica

	#1		#2		#3		#4	
	Temp (°C)	Precip (mm)	Temp	Precip	Temp	Precip	Temp	Precip
JAN	-26.2	4.5	14.3	13.8	-2.2	94.0	-20.5	1.5
FEB	-27.5	3.8	16.2	10.4	-2.2	88.9	-18.0	1.7
MAR	-26.1	3.6	20.8	29.8	1.7	104.1	-9.6	3.7
APR	-18.3	4.4	25.0	29.7	7.2	96.5	-0.4	9.3
MAY	-7.1	3.7	30.8	13.1	13.9	94.0	8.0	14.0
JUN	1.1	8.2	33.6	0.0	20	78.7	13.7	51.9
JUL	4.1	21.5	34.6	0.0	22.8	88.9	15.6	75.9
AUG	3.3	24.5	34.4	0.0	20.7	106.7	13.7	66.6
SEP	-0.8	15.6	31.4	0.0	17.2	86.4	7.3	30.0
OCT	-9.1	12.3	26.3	0.7	11.1	94.0	-1.2	5.9
NOV	-18.2	6.2	20.6	4.5	5.0	104.1	-11.0	4.0
DEC	-24.2	4.1	15.4	11.3	0.0	96.5	-18.4	2.4
ANNUAL	-12.3	113.4	25.2	112.7	9.5	1132.8	-1.7	268.0

Temp. Max.	_____	_____	_____	_____
Temp. Min.	_____	_____	_____	_____
Temp. Range	_____	_____	_____	_____
Precip Max.	_____	_____	_____	_____
Precip Min.	_____	_____	_____	_____
Classification	_____	_____	_____	_____
City	_____	_____	_____	_____

	#5		#6		#7		#8	
	Temp (°C)	Precip (mm)	Temp	Precip	Temp	Precip	Temp	Precip
JAN	7.2	80.0	21.7	15.9	-32.1	0.1	26.2	238.5
FEB	8.3	70.9	21.8	15.2	-44.3	0.0	26.9	165.1
MAR	10.5	68.6	20.8	21.6	-57.9	0.7	27.3	173.6
APR	13.7	66.8	18.6	49.5	-64.7	0.5	27.7	166.4
MAY	17.8	51.5	15.8	91.7	-65.6	0.4	27.7	170.7
JUN	21.7	34.1	13.9	105.4	-65.2	0.5	27.5	163.1
JUL	24.4	16.3	13.3	91.2	-66.9	0.6	27.2	149.8
AUG	24.1	24.4	13.7	82.6	-67.6	0.7	27.1	171.3
SEP	20.9	69.2	15.2	54.3	-66.0	0.3	27.1	163.5
OCT	16.6	113.3	17.1	39.6	-57.1	0.2	27.2	191.0
NOV	11.7	110.7	19.2	24.2	-43.3	0.1	26.8	250.1
DEC	8.4	97.1	20.5	19.3	-32.1	0.0	26.3	268.7
ANNUAL	15.4	802.9	17.6	612.5	-55.1	4.5	27.1	2272.2

Temp. Max.	_____	_____	_____	_____
Temp. Min.	_____	_____	_____	_____
Temp. Range	_____	_____	_____	_____
Precip Max.	_____	_____	_____	_____
Precip Min.	_____	_____	_____	_____
Classification	_____	_____	_____	_____
City	_____	_____	_____	_____

	#9		#10	
	Temp (°C)	Precip (mm)	Temp	Precip
JAN	27.5	71.1	20	0.0
FEB	27.6	63.2	19.4	2.5
MAR	27.2	128.1	17.2	5.1
APR	26.2	270.3	13.9	15.3
MAY	25.1	182.7	11.1	58.4
JUN	23.9	33.5	8.9	81.3
JUL	23.3	27.4	8.3	86.4
AUG	23.5	25.9	8.9	61.0
SEP	24.0	28.3	12.8	30.5
OCT	25.1	49.1	13.3	15.3
NOV	26.2	84.2	16.1	5.1
DEC	27.3	90.4	18.3	5.1
ANNUAL	25.6	1056.4	13.3	365.8

Temp. Max.	_____	_____
Temp. Min.	_____	_____
Temp. Range	_____	_____
Precip Max.	_____	_____
Precip Min.	_____	_____
Classification	_____	_____
City	_____	_____