

***PRECIPITATION
AND ITS
MEASUREMENT***

AGSM 335

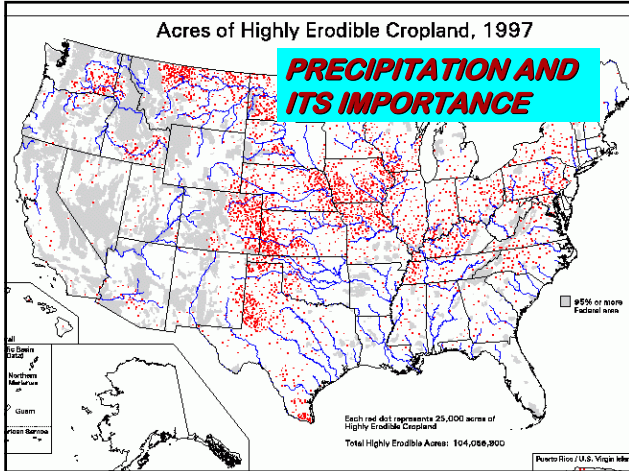
READING ASSIGNMENT

CHAPTER 5 OF TEXT

AND

Chapter 2 of handouts (web)





Moisture in the Atmosphere

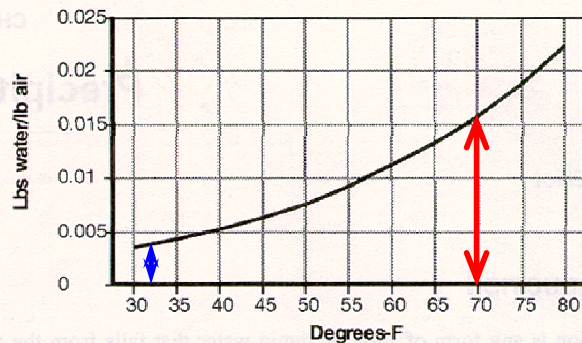
Precipitation is formed from water vapor
As air cools → capacity to hold water decreases

Saturated (100% relative humidity)

Saturated at 70 °F vs. 32 °F
4 times more water at 70 °F!

SEE NEXT FIGURE

The relationship between water content of air at saturation and air temperature



Moisture in the Atmosphere

Cooling effect → moist unsaturated air can become saturated (dew point)

Cooling beyond 100 % saturation → condensation

Water droplets on cold glass / dew on grass

Precipitation

Occurs when three conditions are met:

#1. Atmosphere is saturated

#2. Small particles are present

Dust

Ocean salt

#3. Drops are big enough to reach the surface

Have to overcome updrafts

Precipitation

The movement and collision of air masses lead to atmospheric instability

The result is often precipitation

Precipitation

Atmosphere becomes saturated when the air mass is cooled by lifting (almost always)

Air mass lifting caused by:

Frontal systems (warm fronts / cold fronts)

Orographic effects (induced by mountains)

Rain-shadow produces deserts

Convection - summer thunderstorms / hail

Frontal Systems

Cold fronts

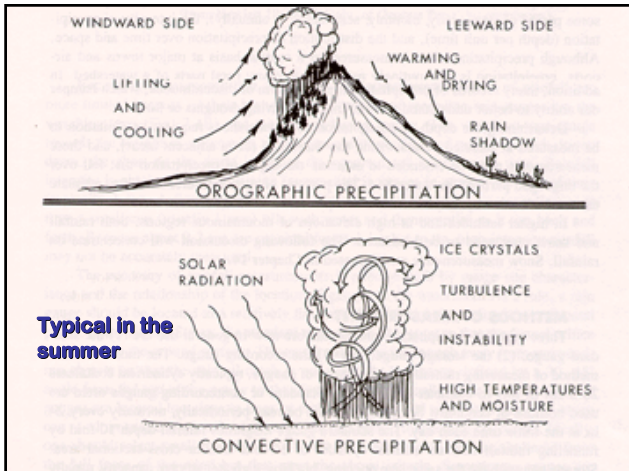
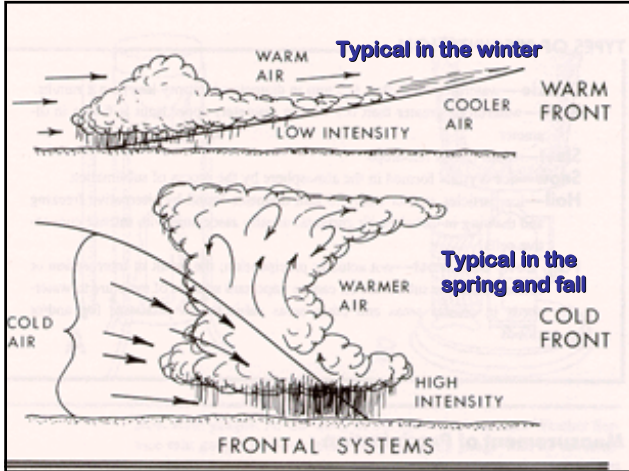
High intensity / short duration / narrow zone. Typical in the spring and fall

Warm fronts

**Gentle rainfall / long term / widespread
Typical in the winter**

Orographic precipitation

Increasing rainfall with increasing elevation



Frontal Systems

Convective precipitation
High intensity / short duration / limited area

Earth surface and air close to surface heated → lifted
Typical summer thunderstorm

Moisture Sources and Movement

- Eastern, Central U.S. - Gulf of Mexico
- Western U.S. - Pacific Ocean
- Contribution from continental evaporation is small

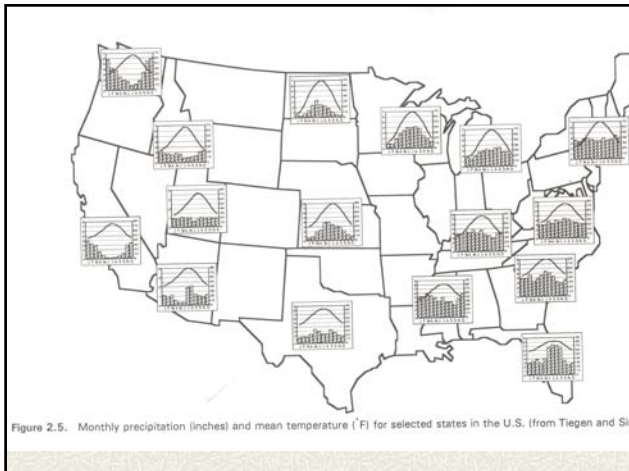
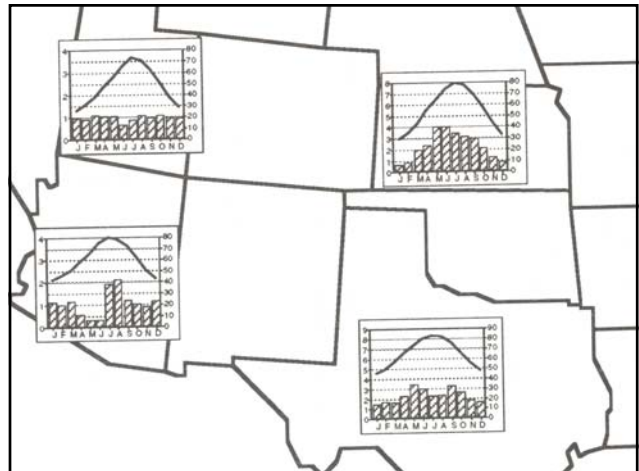
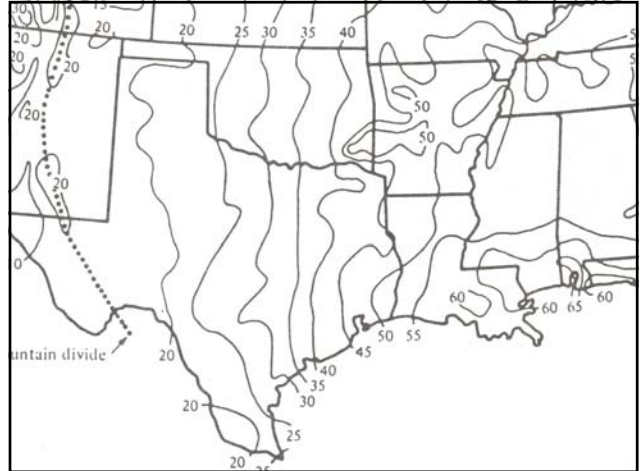
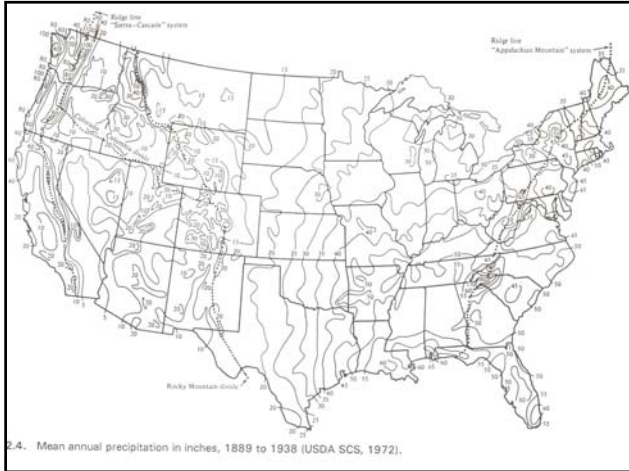


Figure 2.5. Monthly precipitation (inches) and mean temperature (°F) for selected states in the U.S. (from Tieggen and Sit)





Precipitation Data

Necessary for most land use plans
Municipal / industrial / agricultural / forestry / flood prevention / recreation

Data collection by State and Federal agencies

Much of the data is now on-line via the internet

Precipitation records report amounts
Yearly / monthly / daily / hourly

<http://lwf.ncdc.noaa.gov/oa/ncdc.html>

World's Largest Archive of Climate Data
National Climatic Data Center
 Protecting the Past, Revealing the Future

Land Based

Upper Air

Satellite

Marine

Weather/Climate Events, Information, & Assessments

Rainfall

Units of measurement → depth (in. / mm / etc.)

Can get volume easily by multiplying by area

Accuracy of measurement → 0.01 in.

Mis-leading since no two rain gages will ever record the same amount of rain even if they are side by side!

Rainfall Measurement

Standard rain gages are point samples only

Generally a high degree of variation in any rainfall

Rain gages are usually cylindrical with circular top

Therefore least subjected to edge effect errors

Rainfall Measurement

Standard rain gages are point samples only

Mounted vertically

Height of 2 m (about 6 ft)

2:1 obstruction rule

If top of object is 30 ft above gage

Place gage 60 ft away

Eliminates obstructions that may affect rainfall capture

Rainfall Measurement

Two types of rain gages

Non-recording

Low cost / maintenance free

Accuracy = 0.1 in.

Rainfall Measurement

Two types of rain gages

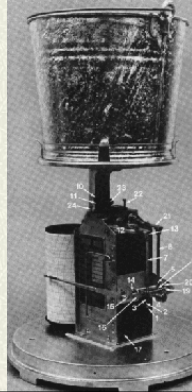
Recording

Paper only

Paper and electronic
data collection

Some type of
datalogger required

Electronic only



Recording rain gages

Weighing bucket type

Good for large rainfall events

Can't accurately measure (weigh)
small rainfall events

Tipping bucket type

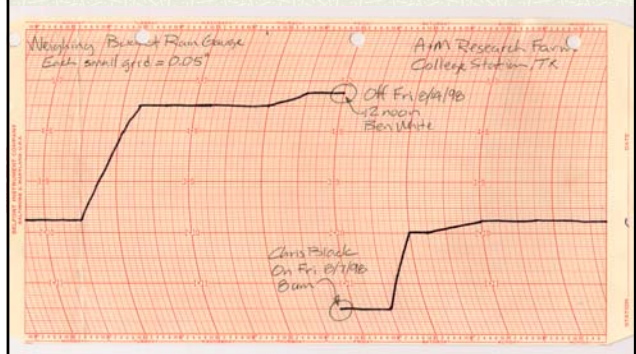
Good for small rainfall events

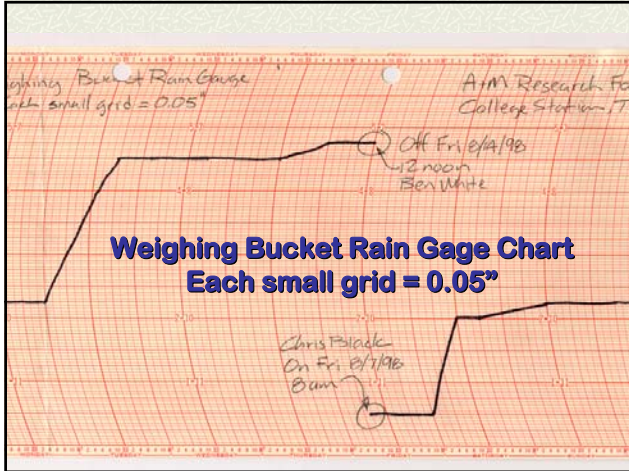
Can't keep up during heavy rainfall
events

Each tip = 0.01"



Weighing Bucket Rain Gage Chart
Each small grid = 0.05"





Precipitation Terms

Hyetograph

A plot of rainfall intensity vs. time

Isohyete

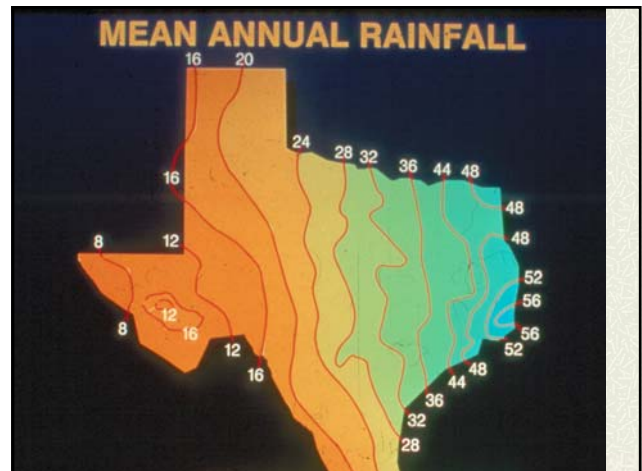
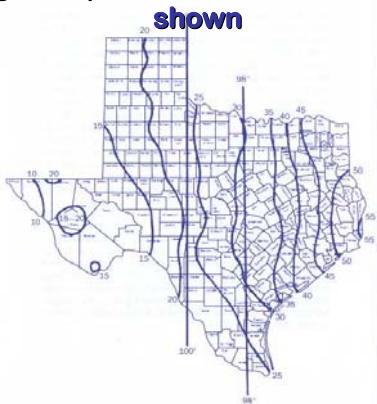
Contours of constant rainfall

Similar to contours of constant elevation

Isohyetal Map

Map with contours of constant rainfall

Mean Annual Rainfall in inches with the longitude parallels 98° and 100° also shown



Description of Precipitation

Intensity (RATE)

How hard it rains. Measured in units of depth per time, usually in/hr or cm/hr

Duration (TIME)

How long it rains. Measured in units of time. From intensity and duration you can determine total rainfall depth.

Description of Precipitation

Return Period (Frequency)

How often, on average, a storm of a certain intensity and duration occurs at a particular location. Measured in units of time, generally years.

Description of Precipitation

1. For any given return period, **intensity (RATE)** decreases as duration increases. Short storms generally have higher intensities.
2. For any given duration, **intensity** increases as the return period increases. Severe events are less frequent.

Description of Precipitation

3. Higher **intensity** storms generally have larger raindrops. Impacts the energy released when the drop hits the ground. This is one of the forces which causes erosion.

Measurement of Precipitation

What we want:

Total rainfall amount → volume = depth
x area

Rainfall intensity → in/hr or mm/hr

Rainfall distribution

Over Time & Over Space

What we have:

Point measurements at a few locations

Must extrapolate over the entire
watershed

Calculating Average Precipitation Over an Area

Arithmetic mean method

Thiessen polygon method

Isohyetal method

All use the same algorithm

$$P_{avg} = [\sum W_i \times P_i] / \sum W_i$$

P = precipitation

W = weighing factor

i = number of gages

Calculating Average Precipitation Over an Area

Arithmetic mean method

Assumes uniform rainfall distribution

Very seldom occurs

Easiest to use but least accurate

Calculating Average Precipitation Over an Area

Thiessen polygon method

Assumes linear variation between
gages

Use when gages are not uniformly
distributed

Can use gages outside of watershed

Calculating Average Precipitation Over an Area

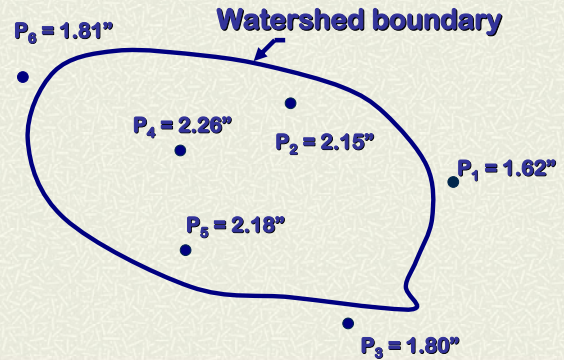
Isohyetal method (Lines of constant depth)

Theoretically the most accurate

Most time consuming method

Can use gages outside of the watershed

Measured Rainfall at Six Rainfall Gages



Arithmetic Mean Method

$$P_{\text{avg}} = [\sum W_i \times P_i] / \sum W_i$$

All gages given equal weight

Weight = 1

$$P_{\text{avg}} = (1.62 + 2.15 + 1.80 + 2.18 + 2.26 + 1.81) / 6$$

$$P_{\text{avg}} = 1.97 \text{ in.}$$

Thiessen Polygon Method

These enclosed areas are known as Thiessen Polygons

The area within each polygon is closer to the rain gage enclosed than any other rain gage.

The rainfall measured in the polygon is assumed to be representative of the rainfall in the entire polygon

Thiessen Polygon Method

First: Draw straight dashed lines between each rainfall gage

Second: Draw solid perpendicular bisectors to these lines so that watershed area associated with each gage is enclosed by bisector lines

Thiessen Polygon Method

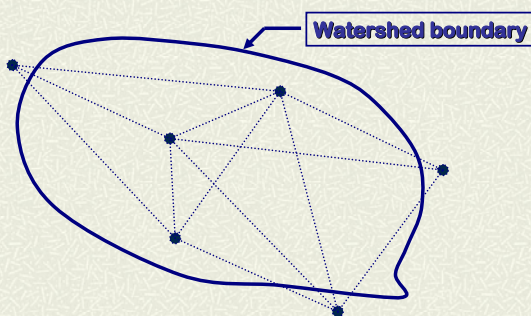
Third: Determine the area of each polygon

The rain gage weight is the area of the polygon it is located in

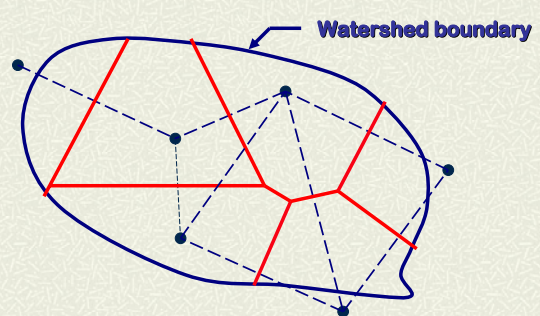
Fourth: Calculate the average rainfall using:

$$P_{avg} = [\sum W_i \times P_i] / \sum W_i$$

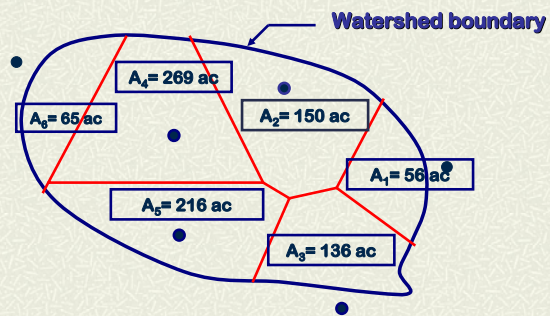
Step #1: Dashed Lines Between Each Rain Gage



Step #2: Draw the Perpendicular Bisector Lines



Step #3: Determine the Area of Each Polygon



Step #4: Calculate the Average Rainfall

$$P_{\text{avg}} = [\sum W_i \times P_i] / \sum W_i$$

$$P_{\text{avg}} = \frac{[(56 \times 1.62) + (150 \times 2.15) + (136 \times 1.80) + (269 \times 2.26) + (216 \times 2.18) + (65 \times 1.81)]}{[56 + 150 + 136 + 269 + 216 + 65]}$$

$$P_{\text{avg}} = 2.08 \text{ in.}$$