Precipitation and its Measurement

Precipitation

When the water/moisture in the clouds/atmosphere gets too heavy, the water / moisture falls back to the earth. This is called ***precipitation.***

Forms of Precipitation	
Rain	Water drop size (0.5 - 6) mm
Snow	Ice crystals combine to form flakes having average density of 0.01 g/cm^3
Drizzle	Water droplets size less than 0.5mm and intensity less than 1mm/h
Glaze/Freezing Rain	Water drops freeze to form ice coating called glaze or freezing rain
Sleet	Precipitation of snow and rain simultaneously
Hail	Lumps of ice of size more than 8mm

Precipitation: Rainfall

- Rainfall is classified into:
  - *Light rain* – if intensity is trace to 2.5 mm/h
  - *Moderate rain* – if intensity is 2.5 mm/hr to 7.5 mm/hr
  - *Heavy rain* – above 7.5 mm/hr

- **Measurement Units:**

***Amount of precipitation/rain* (mm or inch)**

- It is measure as total depth of rainfall over an area in one day.

***Intensity of precipitation/rain* (mm/hr or inch/hr)**

- It is the amount of precipitation at a place per unit time (rain rate). It is expressed as mm/hr or inch/hr

Measurement of Precipitation

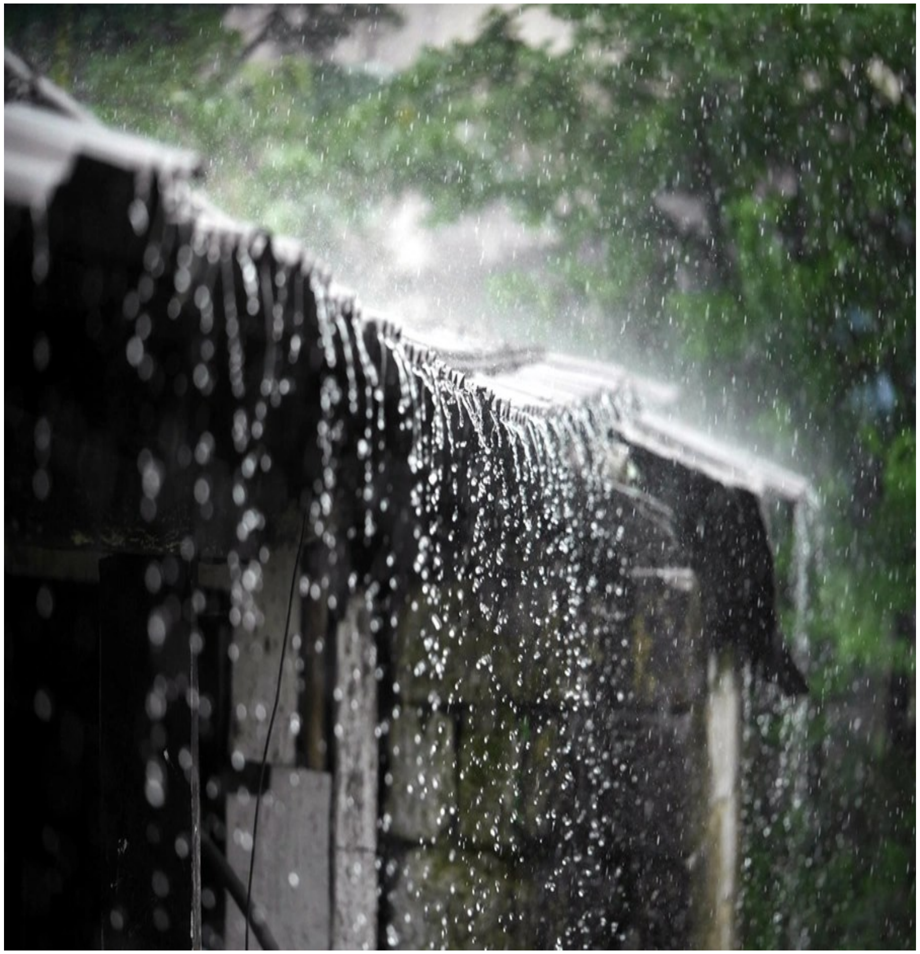
Why do we need to measure rainfall?

- ***Agriculture*** – what to plant in certain areas, where and when to plant, when to harvest

- ***Horticulture/viticulture*** - how and when to irrigate

- ***Engineers*** - to design structures for runoff control i.e. storm-water drains, bridges etc.

- ***Scientists*** - hydrological modelling of catchments



Measurement of Precipitation

Method of measuring rainfall:

- Instruments for measuring precipitation include rain gauges and snow gauges, and various types are manufactured according to the purpose at hand.

- Rain gauges are classified into
  - *Non-recording* (Manual) and
  - *Recording types* (Automatic)

Instrument used to collect and measure the precipitation is called rain gauge and the location at which raingage is located is called gauging station.

Measurement of Precipitation

Non-recording (Manual) types:

- *Often have a funnel opening into a cylinder gauge.*
- *Come in a variety of shapes and sizes*
- *Calculate the rainfall (in mm) by dividing the volume of water collected by the area of the opening of the cup. (The gauge marking often accounts for this).*

Figure: Non-recording gauge (Source: Google)

Measurement of Precipitation

Non-recording (Manual) types:

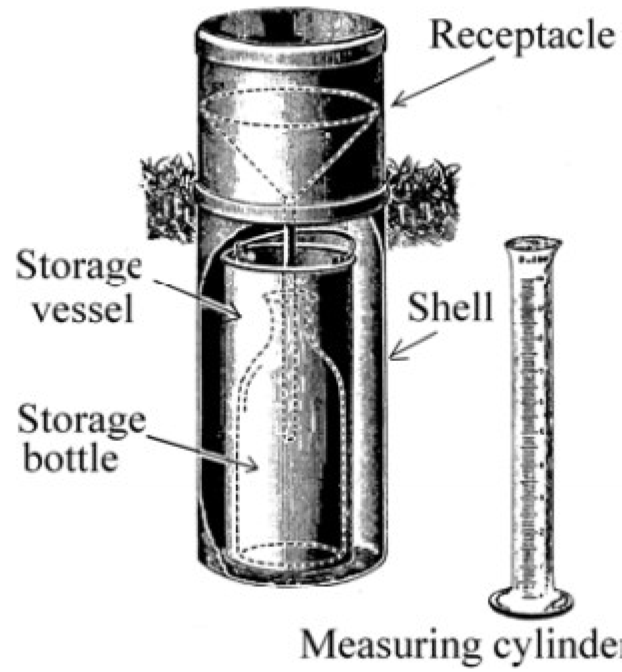


Figure: Symons' gauge (Source: Google)

Measurement of Precipitation

Recording (Automatic) types:

- *Tipping bucket gauges*
- *Weighing type gauges*
- *Float recording gauges*

For <u>tipping bucket gauge</u>, when 0.25 mm of rainfall collects in one bucket it tips and brings the other one in position.

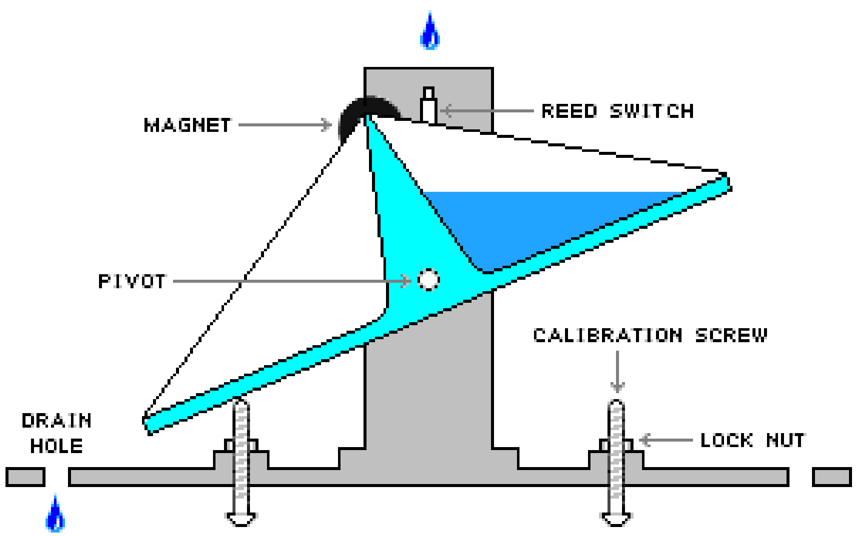


Figure: Tipping bucket gauge (Source: Google)

Measurement of Precipitation

Recording (Automatic) types:

- **Radar** - *Ground-based radar equipment can be used to determine how much rain is falling and where it is the heaviest.*

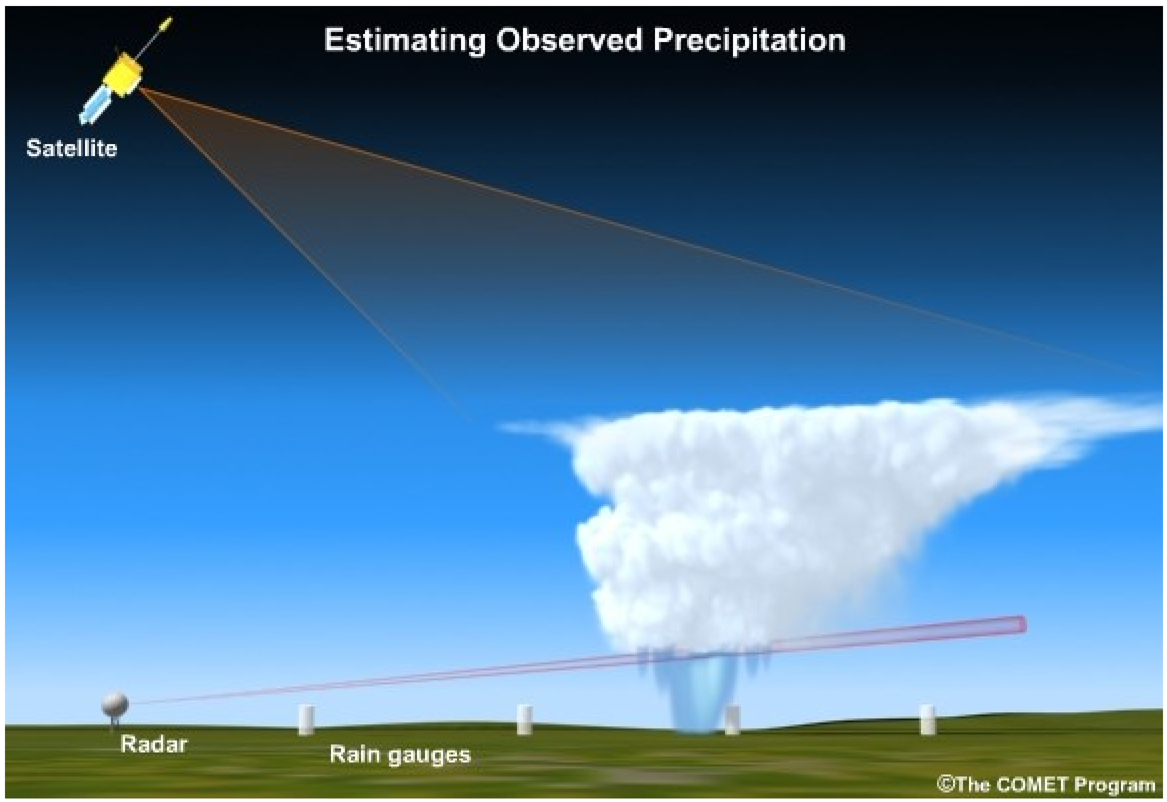


Figure: Radar measurement of rainfall (Source: Google)

Preparation of Data

- Before using rainfall data for any analysis, it is necessary to check the record for
  - *Missing data and*
  - *Consistency of data*

- Inconsistency in rainfall data may be due to
  - *Change of gauge location*
  - *Change of gauge type*
  - *Change of gauge environment*
  - *Change of gauge observer*
  - *Change of gauge climate*

Preparation of Data: Missing Data

Methods:

Let annual precipitation at stations 1, 2, …, M are $P_{1,}$ $P_{2,}$ ….. P_m repectively and normal annual precipitation in $(M+1)$ stations are $N_{1,}$ $N_{2,}$ ….., $N_{(m+1)}$ repectively.

To find the missing annual precipitation P_X at station X following methods are used:

- **Station-average method**: It is used when the normal annual precipitations at various stations are within about 10% of the normal annual precipitation at station X

$$P_X = [P_1 + P_2 + \ldots.. + P_m]/M$$

- **Normal-ratio method:** It is used when the normal precipitation vary considerably

$$P_x = \frac{N_x}{M}\left[\frac{P_1}{N_1} + \frac{P_2}{N_2} + \ldots.. + \frac{P_m}{N_m}\right]$$

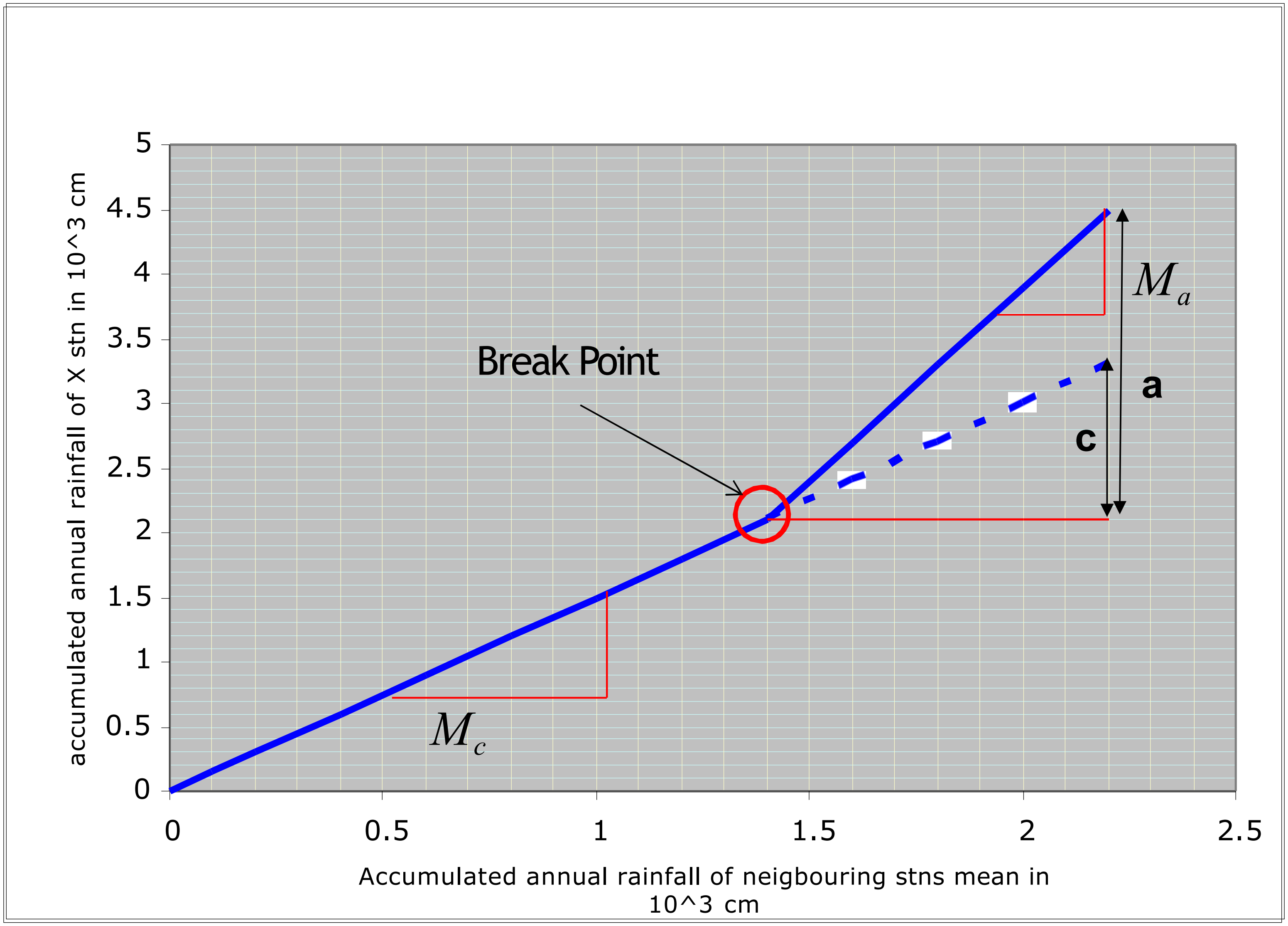
Preparation of Data: Consistency of Data

Double Mass Curve Technique

- Let's take a group of 5 to 10 base stations in the neighbourhood of the problem station X is selected
- Arrange the data of stn X rainfall and the average of the neighbouring stations in reverse chronological order (from recent to old record)
- Accumulate the precipitation of station X $(\sum P_x)$ and the average values of the group base stations $\left(\sum P_{avg}\right)$ starting from the latest record.
- Plot $\sum P_x$ against $\sum P_{avg}$.
- A decided break in the slope of the resulting plot is observed that indicates a change in precipitation regime of station X, i.e., inconsistency.
- Therefore, data at stn X should be corrected/adjusted as

$$\boldsymbol{P_{cx} = (M_c/M_a) \times P_x}$$

$\boldsymbol{M_c}$ is slope of data before breakpoint
$\boldsymbol{Ma}$ is slope of line after breakpoint
$\boldsymbol{P_{cx}}$ is corrected precipitation at Station X
$\boldsymbol{P_x}$ is original precipitation at Station X



$$\frac{M_c}{M_a} = \frac{c}{a}$$

Figure: Double mass curve analysis

Methods of Spatial Averaging Rainfall Data

Arithmetic Mean Method

- When the area is physically and climatically homogenous and the required accuracy is small, the average rainfall ($\bar{P}$) for a basin can be obtained as the arithmetic mean of the P_i values recorded at various stations.
- Applicable rarely for practical purpose.

$$\bar{P} = \frac{P_1 + P_2 + \ldots + P_i + \ldots + P_n}{N} = \frac{1}{N}\sum_{i=1}^{N} P_i$$

Methods of Spatial Averaging Rainfall Data

Thiessen Polygon Method

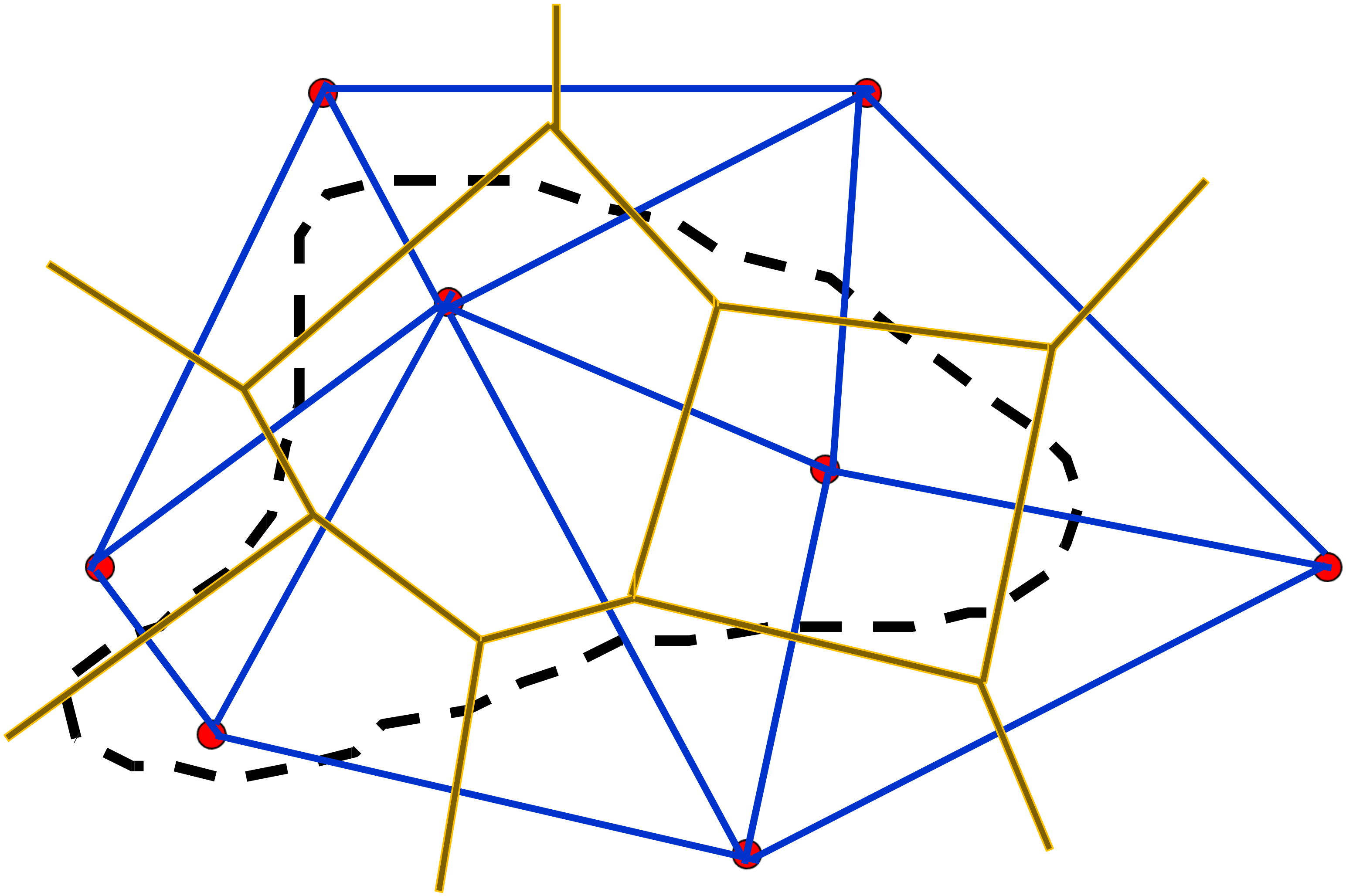


Figure: Polygon created over an area

Methods of Spatial Averaging Rainfall Data

Thiessen Polygon Method

$$\bar{P} = \frac{P_1 A_1 + P_2 A_2 + \ldots + P_m A_m}{(A_1 + A_2 + .. A_m)}$$

Generally, for M stations,

$$\bar{P} = \frac{\sum_{i=1}^{M} P_i A_i}{A_{total}} = \sum_{i=1}^{M} \frac{A_i}{A} P_i$$

$\frac{A_i}{A}$ is called weightage factor of station ***i*.**

Methods of Spatial Averaging Rainfall Data

Isohyetal Method

- An isohyet is a line joining points of equal rainfall magnitude.

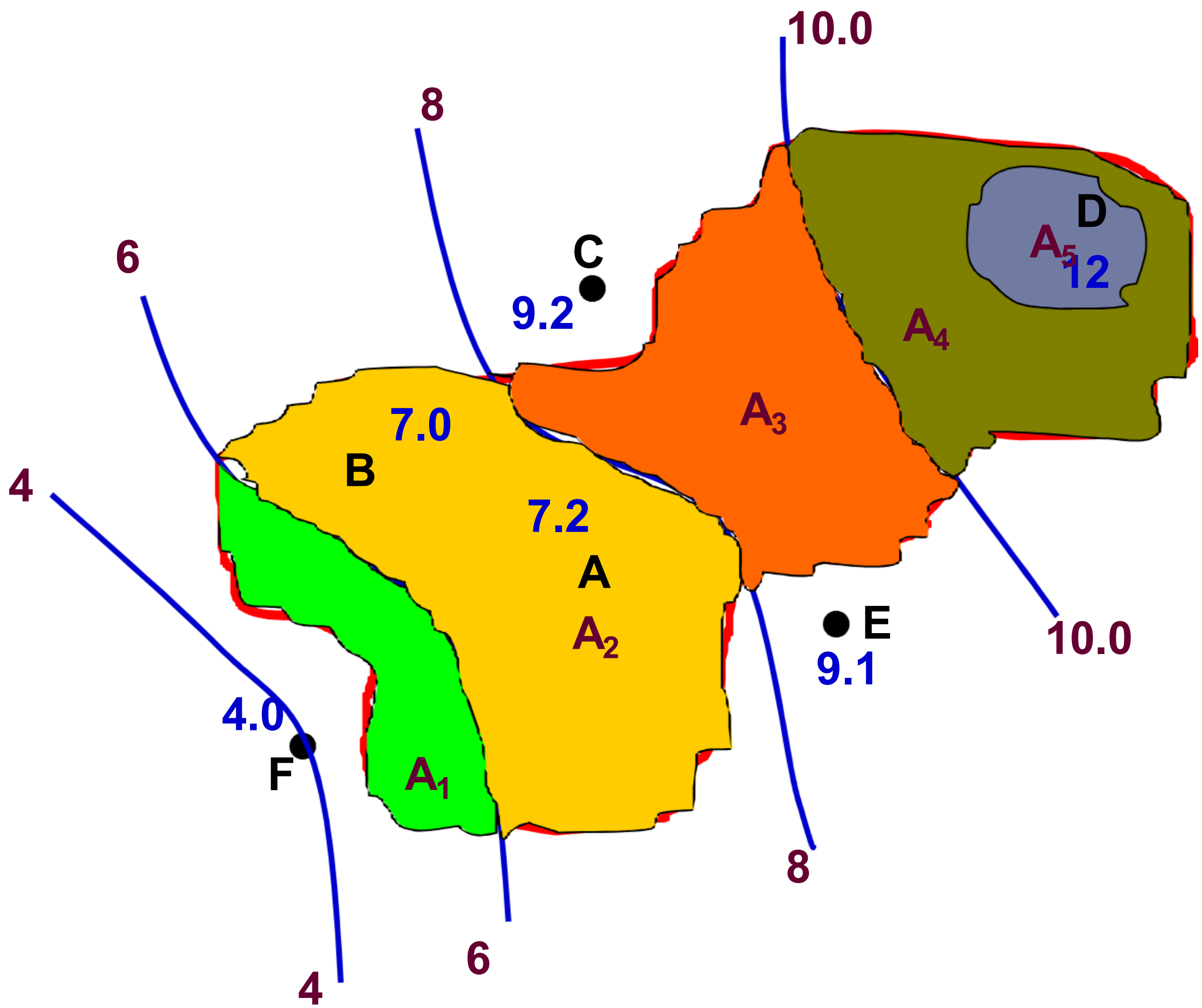


Figure: Isohyets are shown here.

Methods of Spatial Averaging Rainfall Data

Isohyetal Method

- $P_1, P_2, P_3, \ldots, P_n$ – the values of the isohytes
- $A_1, A_2, A_3, \ldots, A_{n-1}$ – are the inter isohytes area respectively
- A_{total} – the total catchment area
- $\bar{P}$ = the mean precipitation over the catchment

$$\bar{P} = \frac{A_1\left(\frac{P_1 + P_2}{2}\right) + A_2\left(\frac{P_2 + P_3}{2}\right) + \cdots + A_{n-1}\left(\frac{P_{n-1} + P_n}{2}\right)}{A_{total}}$$

Note: The isohyet method is superior to the other two methods especially when the stations are large in number.

Presentation of rainfall data

Mass Curve of Rainfall - is a plot of the accumulated precipitation against time plotted in chronological order.

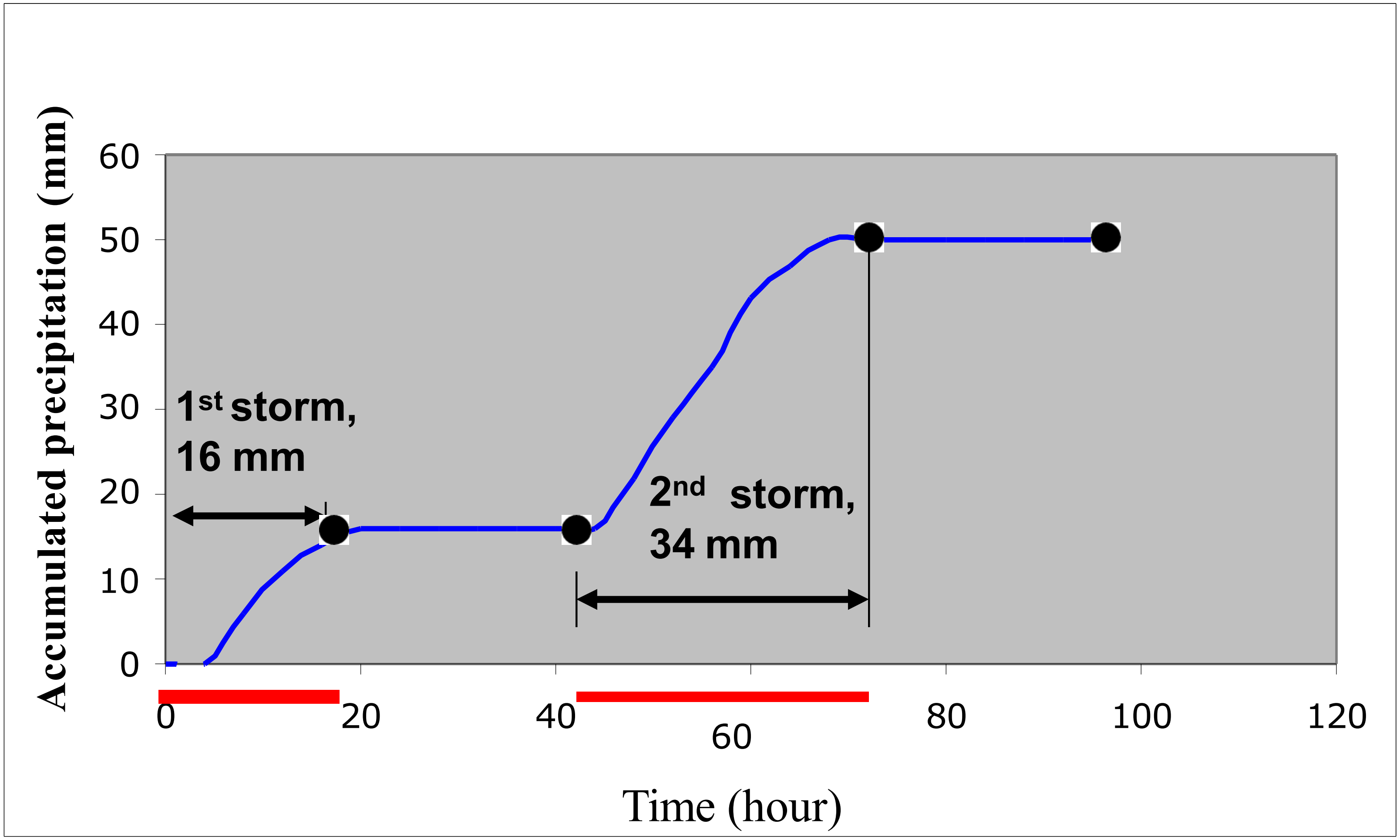


Figure: Mass curve of rainfall

Presentation of rainfall data

Hyetograph - is a plot of rainfall intensity against the time interval.

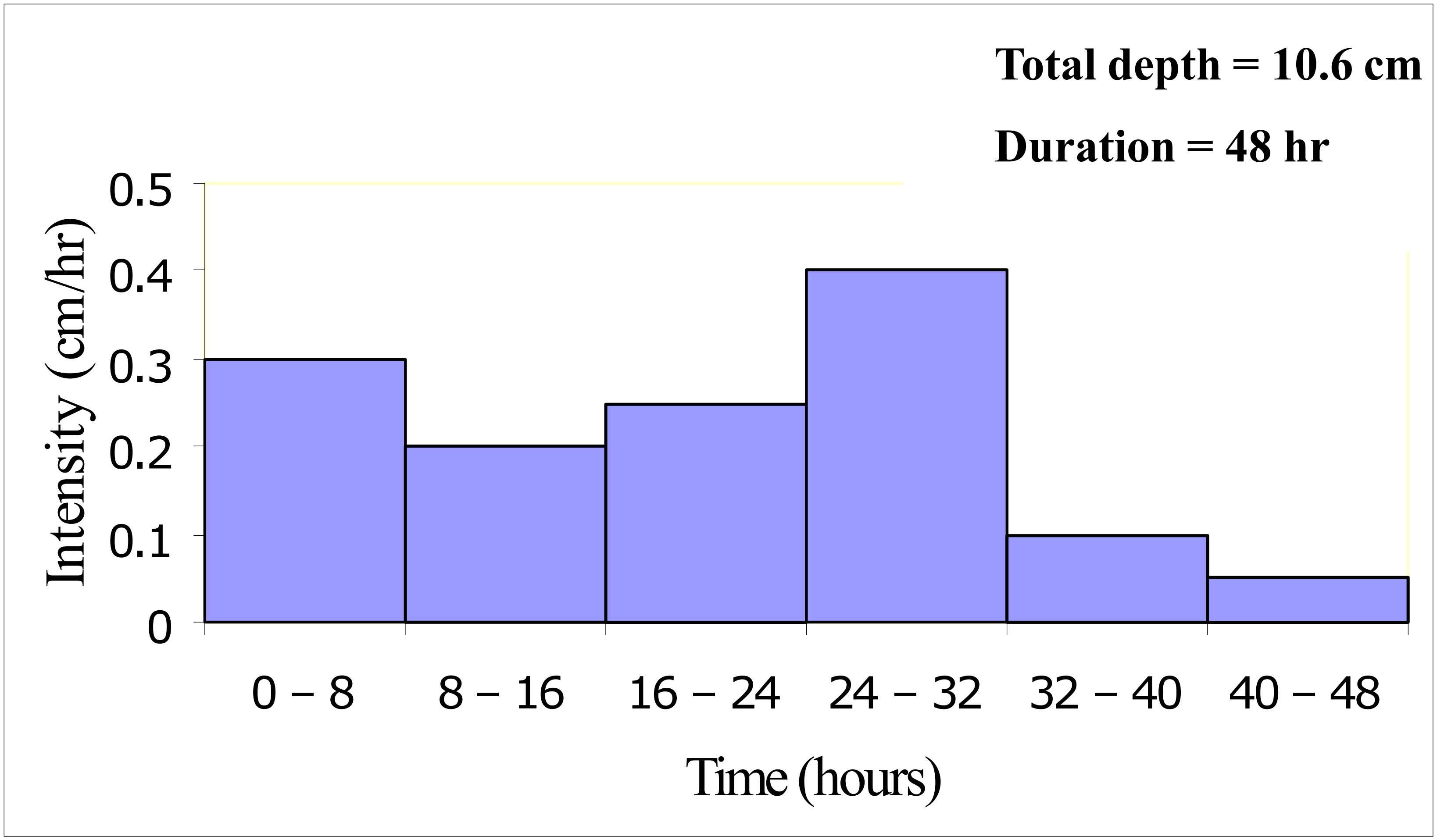


Figure: Hyetograph of a storm