ESTIMATES OF MISSING DATA AND ADJUSTMENT OF RECORDS

For frequency analysis of rainfall data, a sufficiently long record is required. It may so happen that a particular rain-gauge is not operative for part of a month or so (since it is broken or for some other reason), when it becomes necessary to supplement the missing record by one of the following methods:

A. Simple arithmetic: -

In this method the amounts at the index station are equal weighted with all other stations. This method used when the normal annual precipitation at any

index station differs from that at the station in question by less than 10 percent.

$$P_x = \frac{1}{n} * (P_A + P_B + P_C)$$

Where:-

P_x= precipitation of station x,

n = number of stations, and

P_A, P_B, P_C= precipitations of stations A, B, and C

B. Normal-ratio method: -

In this method the amounts at the index station are weighted by the ratio of the normal-annual-precipitation values. This method used when the normal annual precipitation at any index station differs from that at the station in question by more than 10 percent.

$$P_x = \frac{1}{n} \left[\frac{N_x}{N_A} P_A + \frac{N_x}{N_B} P_B + \frac{N_x}{N_C} P_C \right]$$

P_x = Precipitation at station (x).

N = is the normal annual precipitation

n= number of stations

TEST OF CONSISTENCY OF RECORDS

Double-mass analysis—the trend of the rainfall records at a station may slightly change after some years due to a change in the environment (or exposure) of a station either due to coming of a new building, fence, planting of trees or cutting of forest nearby, which affect the catch of the gauge due to change in the wind pattern or exposure. The consistency of records at the station in question (say, *X*) is tested by a double mass curve by plotting the cumulative annual (or seasonal) rainfall at station *X* against the concurrent cumulative values of mean annual (or seasonal) rainfall for a group of surrounding stations, for the number of years of record . From the plot, the year in which a change in regime (or environment) has occurred is indicated by the change in slope of the straight line plot. The rainfall records of the station *x* are adjusted by multiplying the recorded values of rainfall by the ratio of slopes of the straight lines before and after change in environment.

Example : One of four monthly reading gages on catchment area develops a fault in a month when the other three gages record respectively (122 , 89 , 107 mm) in the average annual precipitation for the three gages are (935 , 1120 , 979) mm respectively and (1200) mm of the broken gage . Estimate the missing monthly precipitation at later station.

$$\frac{935-1200}{1200} \times 100\% = -22\ \% \Rightarrow ABS = 22\ \% > 10\ \%$$

$$\frac{1120-1200}{1200} \times 100\% = 7\ \% < 10\ \%$$

$$\frac{979-1200}{1200} \times 100\% = 18\ \% > 10\ \%$$

a) by normal ratio method :

$$\therefore P_X = \frac{N_X}{3}\left(\frac{P_A}{N_A} + \frac{P_B}{N_B} + \frac{P_C}{N_C}\right)$$

$$P_X = \frac{1200}{3}\left(\frac{122}{935} + \frac{89}{1120} + \frac{107}{979}\right)$$

$P_x = 127.7\ mm\ \ \therefore OK$ (since one of ratio > 10 % (one enough) (22 % and 18 % > 10 %))

6) by arithmetic method :

$$P_X = \frac{122+89+107}{3} = 106mm$$ (approx. since 22 % & 18 % > 10 %)

Example: *The annual rainfall at station X and the average annual rainfall at 18 surrounding stations are given below. Check the consistency of the record at station X and determine the year in which a change in regime has occurred. State how you are going to adjust the records for the change in regime. Determine the a.a.r.(annual average rainfall) for the period 1952-1970 for the changed regime*

	Annual rainfall (cm)	
Year	Stn. X	18-stn. average
1952	30.5	22.8
1953	38.9	35.0
1954	43.7	30.2
1955	32.2	27.4
1956	27.4	25.2
1957	32.0	28.2
1958	49.3	36.1
1959	28.4	18.4
1960	24.6	25.1
1961	21.8	23.6
1962	28.2	33.3
1963	17.3	23.4
1964	22.3	36.0
1965	28.4	31.2
1966	24.1	23.1
1967	26.9	23.4
1968	20.6	23.1
1969	29.5	33.2
1970	28.4	26.4

Solution

Year	Cumulative Annual rainfall (cm)	
	Stn. X	18-stn. average
1952	30.5	22.8
1953	69.4	57.8
1954	113.1	88.0
1955	145.3	115.4
1956	172.7	140.6
1957	204.7	168.8
1958	254.0	204.9
1959	282.4	233.3
1960	307.0	258.4
1961	328.8	282.0
1962	357.0	315.3
1963	374.3	338.7
1964	396.6	374.7
1965	425.0	405.9
1966	449.1	429.0
1967	476.0	452.4
1968	496.6	475.5
1969	526.1	508.7
1970	554.5	535.1

The above cumulative rainfalls are plotted as shown in figure below. It can be seen from the figure that there is a distinct change in slope in the year 1958, which indicates that a change in regime (exposure) has occurred in the year 1958. To make the records prior to 1958 comparable with those after change in regime has occurred, the earlier records have to be adjusted by multiplying by the ratio of slopes $m2/m1$ i.e., 0.9/1.25.
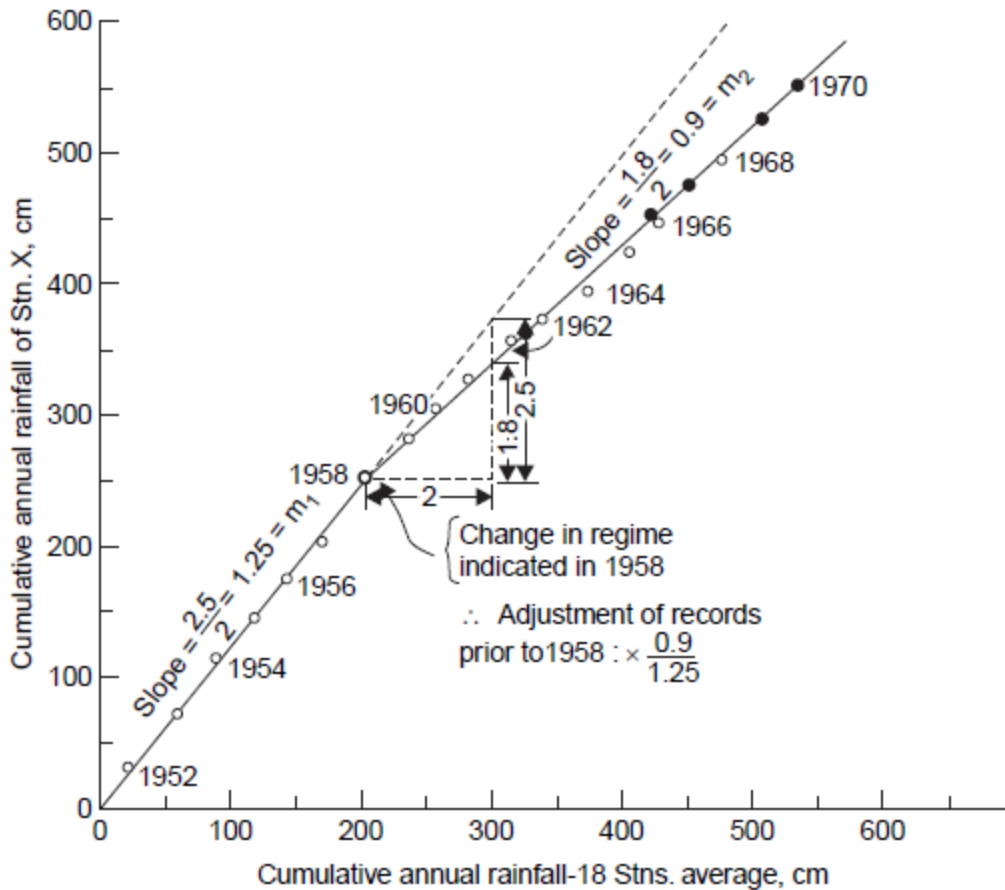
Fig. (   ) Double mass analysis example

Cumulative rainfall 1958-1970

$$= 554.5 - 204.7 \qquad = 349.8 \text{ cm}$$

Cumulative rainfall 1952-1957
adjusted for changed environment

$$= 204.7 \times \frac{0.9}{1.25} \qquad = 147.6 \text{ cm}$$

Cumulative rainfall 1952-1970
(for the current environment) $\qquad = 497.4 \text{ cm}$
a.a.r. adjusted for the current regime

$$= \frac{497.4 \text{ cm}}{19 \text{ years}} \qquad = 26.2 \text{ cm.}$$

Old average annual rainfall $= \dfrac{554.5}{19} = $ **29.2 cm**

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Example: The annual precipitation at station X and the average annual precipitation at 15 surrounding stations are as shown in the flowing table

a) Determine the uniformity of the record at the station X

b) In what year is a change in regime indicated?

c) Compute the mean annual precipitation for station X for the entire 30 years period without adjustment.

d) Repeat part C for station X at its 1979 site with the data adjusted for the change in regime.

Years	Annual precipitation (cm)	
	Station X	Average of 15 stations
1950.	47	29
1951.	24	21
1952.	42	36
1953.	27	26
1954.	25	23
1955.	35	30
1956.	29	26
1957.	36	26
1958.	37	26
1959.	35	28
1960.	58	40
1961.	41	26
1962.	34	24
1963.	20	22
1964.	26	25
1965.	36	34
1966.	35	28
1967.	28	23
1968.	29	33
1969.	32	33
1970.	39	35
1971.	25	26
1972.	30	29
1973.	23	28

1974.	37	34
1975.	34	33
1976.	30	35
1977.	28	26
1978.	27	25
1979.	34	35