551.506.2 : 551.577.33

Relationship of the clock-hour to 60-min and the observational day to 1440-min rainfall

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ABSTRACT. Return period values of rainfall for different durations are required in many design problems. For durations of 1 hour and 24 hours, clock-hour and observational-day rainfalls are readily available. To obtain 60-min and 1440-min rainfall from these data suitable conversion factors have to be determined. From a study of rainfall data of about seventy recording raingauge stations, it was found that a conversion factor 1·15 can be adopted to transform clock-hour to 60-min and observational-day to 1440-min rainfall.

1. Introduction

Maximum rainfall estimates of different durations and return periods are required in many hydrological design problems. For durations of one hour and 24 hours, the basic data generally available are clock-hour tabulations of hourly rainfall and observational-day records of daily rainfall. For getting from these data rainfall values for any hour (60 minutes) as distinct from a clock-hour and any 24 hours (1440 minutes) as distinct from an observational day, it is necessary to determine their relationship to the 60-min rainfall and 1440-min rainfall. Hershfield (1961), on the basis of U.S. data, obtained the conversion factor of 1·13 for obtaining 60-minute rainfall from clock-hour rainfall for any return period. He also found that the same factor could be used to transform observational-day amounts to corresponding 1440-minute amounts for different return periods. No such factor has so far been worked out on the basis of representative Indian data. Recently, Dhar and Ramachandran (1970) found this factor to be of the order of 1·11 on the basis of rainfall data of only one station, *viz.*, Calcutta. However, detailed studies have to be carried out for a large number of representative rainfall recording stations in the country for obtaining an average conversion factor. The present note is an attempt in this direction.

2. Data and method

15-min rainfall tabulations for 47 and 1-hr tabulations for 67 recording raingauge stations in India distributed over the country were uti-lized in the present study. 15-min tabulations give rainfall amounts for every 15-min duration beginning from clock hour, *i.e.*, for the period from 0000 to 0015 hr, from 0015 to 0030 hr, from 0030 to 0045 hr and so on. The maximum rainfall in each year from particular station during any four consecutive 15-min intervals (total 60-min period) were noted. 1-hr tabulations give rainfall values for each clock-hour duration, *i.e.*, from 0000 to 0100 hr, from 0100 to 0200 hr, and so on. The annual maximum values for each station for the clock-hour period were also noted. Similarly the annual maximum values for any 24-hr and also in one day were obtained. In this way, the annual series of maximum rainfall in 60-min (any four 15-min values from 15-min tabulations), in 1-hr, in any 24-hr and in one day (from 0000 IST of date to 0000 IST of next day) from hourly tabulations, were formed for each station and were subjected to frequency analysis using Gumbels (1954) extreme value technique. The ratios of 60-min rainfall to clock-hour rainfall and of any 24-hr rainfall to one-day rainfall for standard return periods were worked out and tabulated and the mean ratio was calculated. The results are given in Tables 1 and 2.

3. Results

It is seen from Table 1 that the mean ratio of 60-min rainfall (computed from 15-min tabulations) to clock-hour rainfall is 1·10. To get the ratio of any 60-min rainfall to clock-hour rainfall, ratio of any 60-min rainfall to 60-min rainfall (from 15-min tabulations) was found for 4 stations

TABLE 1

Station	Period of data (Yr)	Ratio of 60-min rainfall (computed from 15-min tabulations) to clock-hr rainfall for the return period of					Mean ratio	Station	Period of data (Yr)	Ratio of 60-min rainfall (computed from 15-min tabulations) to clock-hr rainfall for the return period of					Mean ratio
		2-yr	5-yr	10-yr	25-yr	50-yr				2-yr	5-yr	10-yr	25-yr	50-yr	
Agartala	17	1·12	1·13	1·13	1·13	1·13	1·13	Baroda	24	1·04	1·06	1·07	1·07	1·08	1·07
Mohanbari	14	1·08	1·07	1·06	1·05	1·05	1·06	Bhuj	7	1·05	1·04	1·03	1·03	1·03	1·04
Jamshedpur	17	1·07	1·04	1·03	1·02	1·01	1·03	Veraval	10	1·11	1·07	1·15	1·07	1·07	1·09
Bamrauli	17	1·08	1·10	1·11	1·12	1·12	1·11	Colaba	32	1·09	1·08	1·08	1·08	1·08	1·08
Lucknow	10	1·13	1·14	1·14	1·14	1·14	1·14	Chikalthana	11	1·14	1·13	1·13	1·13	1·13	1·13
Mukhim	6	1·15	1·19	1·21	1·24	1·25	1·21	Mahabalesh-war	31	1·08	1·08	1·08	1·09	1·09	1·08
Tehri	6	1·07	1·02	1·00	0·98	0·97	1·01	Nagpur	15	1·06	1·03	1·02	1·01	1·00	1·02
New Delhi	21	1·14	1·11	1·09	1·08	1·08	1·10	Nandurbar	5	1·20	1·26	1·29	1·32	1·34	1·28
Amritsar	11	1·12	1·14	1·15	1·15	1·16	1·14	Poona	33	1·15	1·14	1·13	1·13	1·13	1·14
Simla	5	1·09	1·03	1·01	0·99	0·98	1·02	Vengurla	11	1·17	1·12	1·09	1·07	1·06	1·10
Srinagar	22	1·22	1·21	1·20	1·19	1·19	1·20	Anantapur	6	1·26	1·27	1·27	1·28	1·28	1·27
Chambal Dam	7	1·06	1·15	1·19	1·22	1·24	1·17	Begumpet	33	1·15	1·14	1·14	1·14	1·14	1·14
Dholpur	7	1·02	1·02	1·02	1·02	1·02	1·02	Visakhapat-nam	12	1·05	1·04	1·03	1·03	1·02	1·03
Erinpura Rd.	7	1·14	1·09	1·21	1·05	1·04	1·11	Kodaikanal	31	1·09	1·10	1·10	1·10	1·10	1·10
Jaipur	13	1·04	1·02	1·01	1·00	0·99	1·01	Madras	14	1·10	1·12	1·13	1·14	1·14	1·13
Jodhpur	18	1·11	1·10	1·10	1·09	1·09	1·10	Tiruchi	9	1·09	1·12	1·14	1·15	1·16	1·13
Bagratawa	12	1·08	1·10	1·11	1·12	1·13	1·11	Bangalore	11	1·04	1·03	1·02	1·02	1·02	1·03
Bhopal	10	1·04	1·03	1·03	1·02	1·02	1·03	Mangalore	9	1·00	1·01	1·01	1·01	1·01	1·01
Jabalpur	12	1·08	1·06	1·05	1·04	1·03	1·05	Trivandrum	10	1·19	1·14	1·12	1·10	1·10	1·13
Jagdalpur	10	1·08	1·08	1·08	1·07	1·07	1·08	Dandeldhura	11	1·09	1·11	1·12	1·13	1·13	1·12
Punasa	12	1·15	1·14	1·14	1·14	1·14	1·14	Gangtok	5	1·11	1·10	1·09	1·08	1·07	1·09
Raipur	9	1·11	1·08	1·06	1·05	1·04	1·07	Kathmandu	22	1·13	1·09	1·08	1·07	1·06	1·09
Thikri	14	1·15	1·13	1·11	1·11	1·10	1·12	Taplejung	22	1·12	1·09	1·07	1·06	1·05	1·08
Ahmadabad	11	1·14	1·12	1·12	1·11	1·11	1·12								

Total : 51·66

Mean : 1·10

whose hyetograms were easily available. The results are given below :

Station	Period of data (Yr)	Ratio of any 60-min rainfall to 60-min rainfall (from 15-min tabulations) for return period of					Mean ratio
		2-yr	5-yr	10-yr	25-yr	50-yr	
Rampurhat	8	1·02	1·04	1·05	1·06	1·06	1·05
Jangipur	8	1·03	1·04	1·05	1·05	1·06	1·05
Bamrauli	26	1·03	1·03	1·04	1·04	1·04	1·04
New Delhi	29	1·02	1·04	1·04	1·05	1·05	1·04
Mean							1·05

Hence the ratio of any 60-min rainfall to clock-hour rainfall can be taken to be $1·10 \times 1·05 = 1·15$.

From Table 2, it is seen that the mean ratio

of any 24-hr rainfall to one-day rainfall is 1·15. From the study of hyetograms of 7 stations, it was found that any 1440-min rainfall is the same as any 24-hr rainfall as is shown below :

Station	Period of data (Yr)	Ratio of any 1440-min rainfall to any 24-hr rainfall for return period of					Mean ratio
		2-yr	5-yr	10-yr	25-yr	50-yr	
Rampurhat	8	1·00	1·00	1·00	1·00	1·00	1·00
Jangipur	8	1·00	1·00	1·00	1·00	1·00	1·00
Agartala	17	1·01	1·00	1·00	1·00	1·00	1·00
Mohanbari	18	1·01	1·00	1·00	1·00	1·01	1·00
Bamrauli	26	1·00	1·01	1·01	1·01	1·01	1·01
New Delhi	29	1·00	1·00	1·00	1·00	1·00	1·00
Srinagar	31	1·00	1·00	1·00	1·00	1·00	1·00
Mean							1·00

TABLE 2

Station	Period of data (Yr)	Ratio of any 24-hr rainfall to one-day rainfall for the return period of					Mean ratio	Station	Period of data (Yr)	Ratio of any 24-hr rainfall to one-day rainfall for the return period of					Mean ratio
		2-yr	5-yr	10-yr	25-yr	50-yr				2-yr	5-yr	10-yr	25-yr	50-yr	
Agartala	17	1·14	1·18	1·20	1·21	1·22	1·19	Dholpur	7	1·12	1·04	1·01	0·98	0·97	1·02
Imphal	14	1·14	1·13	1·12	1·11	1·11	1·12	Erinpura Road	7	1·32	1·31	1·31	1·31	1·31	1·31
Mohanbari	16	1·10	1·06	1·05	1·03	1·02	1·05	Jaipur	13	1·13	1·16	1·17	1·19	1·19	1·17
Asansol	15	1·07	1·08	1·08	1·08	1·08	1·08	Jodhpur	18	1·10	1·21	1·22	1·23	1·23	1·22
Durgapur	14	1·21	1·24	1·25	1·26	1·27	1·25	Bagratawa	12	1·18	1·12	1·10	1·09	1·08	1·11
Jangipur	8	1·15	1·19	1·20	1·22	1·22	1·20	Bhopal	10	1·12	1·16	1·17	1·19	1·19	1·17
Konar	13	1·17	1·13	1·12	1·11	1·11	1·13	Gwalior	9	1·17	1·10	1·08	1·05	1·04	1·09
Luchipur	12	1·12	1·08	1·07	1·06	1·05	1·08	Indore	7	1·11	1·14	1·15	1·16	1·17	1·15
Madhupur	8	1·03	1·01	1·00	0·99	0·99	1·00	Jabalpur	12	1·13	1·07	1·04	1·02	1·01	1·05
Panchet Hill	13	1·12	1·09	1·07	1·06	1·06	1·08	Jagdalpur	10	1·19	1·11	1·07	1·04	1·02	1·09
Rampurhat	8	1·21	1·27	1·28	1·30	1·31	1·27	Punasa	12	1·19	1·16	1·14	1·13	1·13	1·15
Barhi	18	1·16	1·19	1·20	1·21	1·22	1·20	Thikri	14	1·18	1·25	1·28	1·31	1·32	1·27
Bishungarh	18	1·22	1·15	1·13	1·11	1·10	1·14	Ahmadabad	11	1·34	1·21	1·16	1·12	1·10	1·19
Bokaro	16	1·12	1·06	1·04	1·03	1·02	1·05	Baroda	24	1·22	1·23	1·23	1·24	1·24	1·23
Chandwa	19	1·09	1·05	1·03	1·01	1·01	1·04	Bhuj	7	1·08	1·06	1·06	1·05	1·05	1·06
Dumri	20	1·18	1·12	1·10	1·08	1·07	1·11	Okha	6	1·13	1·00	0·96	0·92	0·90	0·98
Hazaribagh	20	1·18	1·28	1·32	1·36	1·39	1·31	Veraval	10	1·09	1·13	1·14	1·16	1·16	1·14
Jamshedpur	17	1·20	1·16	1·15	1·14	1·13	1·16	Colaba	32	1·12	1·09	1·09	1·08	1·07	1·09
Khalari	12	1·21	1·32	1·37	1·41	1·44	1·35	Chikalthana	11	1·13	1·12	1·12	1·11	1·11	1·12
Maithon	13	1·13	1·10	1·08	1·07	1·07	1·09	Mahabaleshwar	31	1·15	1·13	1·11	1·10	1·09	1·12
Naya Dumka	8	1·15	1·34	1·43	1·52	1·57	1·40	Nagpur	15	1·09	1·08	1·08	1·07	1·07	1·08
Putki	10	1·18	1·17	1·17	1·16	1·16	1·17	Nandurbar	5	1·31	1·19	1·16	1·13	1·12	1·18
Ramgarh	19	1·11	1·08	1·07	1·07	1·06	1·08	Poona	33	1·18	1·10	1·07	1·05	1·03	1·09
Sindri	8	1·07	1·08	1·01	1·00	0·99	1·02	Vengurla	11	1·22	1·30	1·34	1·37	1·39	1·32
Tilaiya Dam	15	1·16	1·11	1·09	1·07	1·06	1·10	Begumpet	33	1·14	1·09	1·07	1·06	1·05	1·08
Bamrauli	17	1·22	1·13	1·17	1·16	1·15	1·18	Visakhapatnam	11	1·18	1·19	1·20	1·21	1·21	1·20
Lucknow	10	1·09	1·14	1·16	1·18	1·19	1·15	Coimbatore	9	1·08	1·08	1·08	1·08	1·08	1·08
Mukhim	6	1·20	1·23	1·24	1·25	1·26	1·24	Kodaikanal	31	1·15	1·13	1·13	1·13	1·13	1·13
Tehri	6	1·13	1·28	1·34	1·39	1·41	1·31	Madras	13	1·12	1·18	1·21	1·23	1·24	1·20
New Delhi	21	1·04	1·09	1·10	1·11	1·12	1·09	Tiruchi	9	1·07	1·06	1·05	1·05	1·04	1·05
Amritsar	11	1·12	1·07	1·06	1·05	1·04	1·07	Bangalore	11	1·08	1·05	1·04	1·03	1·03	1·05
Simla	5	1·19	1·22	1·24	1·25	1·26	1·23	Mangalore	9	1·27	1·37	1·42	1·47	1·50	1·41
Srinagar	22	1·13	1·11	1·10	1·09	1·09	1·10	Trivandrum	9	1·09	1·02	0·99	0·97	0·95	1·00
Chambal Dam	6	1·60	1·48	1·44	1·41	1·40	1·47								

Total : 77·11

Mean: 1·15

Also a study of rainfall data of 5 stations showed that the observational day (from 0830 IST of date to 0830 IST of next day) rainfall is the same as one-day (from 0000 IST of date to 0000 IST of next day) rainfall as can be seen from the following table :

Station	Period of data (Yr)	Ratio of calendar-day rainfall to observational-day rainfall for return period of					Mean ratio
		2-yr	5-yr	10-yr	25-yr	50-yr	
Colaba	32	0·95	0·99	1·01	1·03	1·04	1·00
Mohanbari	18	1·15	1·04	1·00	0·95	0·93	1·01
New Delhi	29	1·00	1·03	1·04	1·05	1·05	1·03
Bamrauli	26	0·97	0·97	0·97	0·97	0·97	0·97
Srinagar	31	1·01	1·01	1·01	1·01	1·01	1·01
Mean							1·00

Hence the ratio of the observational-day (or calendar-day) rainfall to 1440-min rainfall can also be taken to be 1·15. This is the same as the ratio of any 60-min rainfall to clock hour rainfall which was found to be 1·15.

4. Conclusion

From the study of rainfall data of about 73 self-recording raingauge stations in India, it was found that the conversion factor 1·15 can be adopted to transform clock-hour rainfall to any 60-min rainfall and observational-day (or calendar-day) amounts to corresponding 1440-min rainfall amounts for different return periods.

Acknowledgement

REFERENCES

Hershfied, D. M.	1961	U.S. Weath. Bur. Tech. Pap. No. 40.
Dhar, O. N. and Ramachandran, G.	1970	Indian J. Met. Geophys., 21, 1, p. 93.
Gumbel, E. J.	1954	Applied Mathematics, Series No. 33, National Bureau Standards, U.S. Dep. Comm.