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A Simple Method for Estimating Five-Minute Point Rain-Rate Distributions Based on Available Climatological Data

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This brief presents a method for estimating 5-minute rain-rate distributions based on climatological data for over 250 locations as published annually by the National Oceanic and Atmospheric Administration (NOAA). A *maximized* 5-minute rain-rate distribution, which is believed to be more appropriate for use in predicting rain attenuation, is also introduced.

The sample form in Table I, showing the NOAA method of computation of maximum short-time rates of rainfall for the years 1896–1935, is taken from Ref. 1. On this form are shown the storms of July 14, 1912, and September 2, 1922, at Washington, D. C. The times of beginning and ending of the storms and other data are entered on the "Obs. Precip." line, which shows the precipitation at consecutive 5-minute intervals up to 50 minutes from the beginning of the period of excessive precipitation, as copied from Weather Bureau records. The "Increment" entries are computed directly from the figures on the line above. The maximum precipitation shown for any storm is the maximum for the time period indicated by the figure in the column heading, and is determined by selection from the 5-minute increments. For example, in the 1912 storm, the maximum precipitation indicated for 5 minutes occurs in the sixth increment, that for 10 minutes is found by combining the fifth and sixth increments, and that for 20 minutes is found by combining the fourth, fifth, sixth, and seventh increments. In the 1922 storm, the stated maximum for 5 minutes is half of the eleventh increment, which is for 10 minutes. The 10-minute maximum is the eleventh increment, but the 15-minute maximum is the second, third, and fourth together.

Table I — Sample form of computation of maximum short-time rates of rainfall (from Ref. 1)

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Compiler....................

Intense Precipitation Records

Station		Duration of Storm		Total Precip.	Time Excess Prec. Began	Prec. Prior Excess Rate	Time in Minutes													
		From	To				5	10	15	20	25	30	35	40	45	50	60	80	100	120
1912	Date 1912 July 14																			
	Obs. Precip.	p 5.40	p 10.20	2.93	p 6.01	0.02	0.05	0.25	0.59	0.93	1.38	1.78	2.14	2.38	2.50	2.54				
	Increment						0.05	0.20	0.34	0.34	0.45	0.40	0.36	0.24	0.12	0.04				
	Max. Precip.						0.45	0.85	1.21	1.55	1.89	2.13	2.33	2.45	2.50	2.54				
1922	Date 1922 Sept. 2																			
	Obs. Precip.	a 1.55	a 10.25	5.16	a 5.32	0.66	0.21	0.41	0.67	0.93	1.10	1.25	1.37	1.51	1.65	1.81	2.35	2.96	3.45	
	Increment						0.21	0.20	0.26	0.26	0.17	0.15	0.12	0.14	0.14	0.16	0.54	0.61	0.49	
	Max. Precip.						0.27	0.54	0.72	0.93	1.10	1.25	1.37	1.51	1.71	1.94	2.35	2.96	3.45	

The present NOAA method, adopted with data for the calendar year 1936, gives the maximum fall of precipitation for periods of 5 to 180 minutes, the amounts being taken for the periods in which the fall is greatest for the given length of time without regard to a prescribed starting or sampling time and is tabulated for 5, 10, 15, 20, 30, 45, 60, 80, 100, 150, and 180 minutes. A sample[2] of the NOAA climatological data for maximum precipitations in 1972 at Miami, Florida is shown in Table II. Yarnell reported that the maximum 5-minute precipitation, as determined by the newer method (post-1935), exceeds the maximum of the earlier method (pre-1935) by 8 to 10 percent. Similarly, comparisons for the 1-hour maxima showed a 4- to 5-percent increase.[1]

The procedure for obtaining 5-minute rain-rate distributions, based on available climatological data since 1896, is as follows.

(*i*) Multiply the maximum precipitations for the time periods 5 to 180 minutes by the following factors:

Time Periods in Minutes	F
5	0.917
10	0.922
15	0.926
20	0.931
30	0.938
45	0.948
60	0.957
80	0.966
100	0.973
120	0.979
150	0.986
180	0.990

This table is made up from the formula

$$F = 1/(1 + 0.096e^{-0.0126t}),^{*}$$

where t is the time in minutes. (Omit this step for 1935 and earlier data.)

(*ii*) Convert the maximum precipitations into increment rates by taking differences between all pairs of adjacent elements in succession.

* This formula was obtained by fitting an exponential function to the two observed values reported by Yarnell: $1/F = 1.09$ at $t = 5$ minutes and $1/F = 1.045$ at $t = 60$ minutes.

Table II — Excessive short-duration rainfall (from Ref. 2)
Year 1972

Station and Date	Maximum Precipitation in Inches (5 to 180 Minutes)											
	5	10	15	20	30	45	60	80	100	120	150	180
Miami												
Feb 2	0.25	0.45	0.49	0.60	0.75	0.79	0.81	0.85	0.86	0.87	0.87	0.88
Mar 5	0.26	0.44	0.49	0.55	0.55	0.55	0.55	0.55	0.58	0.78	0.78	0.78
Mar 17	0.28	0.31	0.36	0.38	0.39	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Apr 1	0.25	0.36	0.40	0.53	0.55	0.62	0.63	0.63	0.67	0.75	0.77	0.82
May 6	0.14	0.27	0.37	0.40	0.58	0.70	0.82	1.05	1.25	1.37	1.40	1.50
May 10	0.19	0.32	0.39	0.48	0.55	0.70	0.76	0.80	0.81	0.81	0.81	0.81
May 18	0.45	0.65	0.85	1.05	1.55	1.72	1.75	1.76	1.76	1.76	1.76	1.76
May 18	0.35	0.48	0.63	0.78	0.87	1.07	1.15	1.15	1.15	1.15	1.15	1.15
May 19	0.25	0.44	0.55	0.71	0.93	0.94	1.02	1.05	1.07	1.07	1.07	1.07
May 20	0.29	0.53	0.60	0.66	0.77	0.82	0.87	0.92	0.92	0.92	0.92	0.92
May 22	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
May 26	0.60	1.16	1.40	1.42	1.62	1.90	2.07	2.07	2.07	2.09	2.11	2.11
May 31	0.28	0.31	0.32	0.32	0.34	0.34	0.34	0.34	0.34	0.44	0.65	0.65
Jun 1	0.40	0.70	0.80	0.90	0.91	0.95	1.07	1.09	1.11	1.11	1.11	1.11
Jun 11	0.60	0.90	1.00	1.20	1.80	1.95	2.00	2.01	2.05	2.07	2.17	2.24
Jun 11	0.30	0.52	0.60	0.65	0.83	1.20	1.38	1.45	1.50	1.53	1.56	1.65
Jun 12	0.40	0.62	0.70	0.73	0.90	1.15	1.32	1.52	1.74	1.74	1.79	1.82
Jun 26	0.25	0.33	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Jul 11	0.55	0.85	1.00	1.05	1.07	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Jul 19	0.22	0.30	0.50	0.60	0.80	0.89	0.91	0.91	0.92	1.16	1.16	1.18
Jul 31	0.25	0.50	0.52	0.54	0.57	0.59	0.62	0.70	0.74	0.77	0.82	0.84
Aug 6	0.35	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Aug 15	0.41	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Aug 23	0.22	0.43	0.47	0.50	0.55	0.57	0.58	0.85	0.90	0.93	0.95	0.95
Aug 28	0.45	0.65	0.86	1.20	1.70	1.85	1.97	1.99	2.00	2.01	2.05	2.05
Sep 4	0.27	0.32	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Sep 4	0.20	0.33	0.40	0.45	0.62	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Sep 24	0.30	0.55	0.60	0.65	0.92	0.93	0.95	1.05	1.20	1.22	1.25	1.27
Oct 3	0.22	0.34	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Oct 28	0.33	0.60	0.68	0.75	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Nov 15	0.27	0.36	0.43	0.47	0.50	0.53	0.58	0.62	0.68	0.72	0.75	0.75
Dec 4	0.20	0.35	0.40	0.45	0.55	0.75	0.90	1.00	1.07	1.15	1.18	1.20
Dec 15	0.30	0.36	0.39	0.43	0.55	0.65	0.68	0.68	0.68	0.68	0.82	1.08

(*iii*) Obtain the uniform 5-minute rain rates for those elements with time intervals greater than 5 minutes. For example, between 20 and 30 minutes, assume two 5-minute intervals with equal rain rates that are equal to half of the 10-minute increment rate; similarly, between 30 and 45 minutes, 5-minute increment rates are one-third of the 15-minute increment rate, etc.

(*iv*) Find the distribution based on the 5-minute rain rates as obtained above.

Twenty randomly selected rainstorms taken from Ref. 1, Table I, were used to test the accuracy of the method. The result in Fig. 1

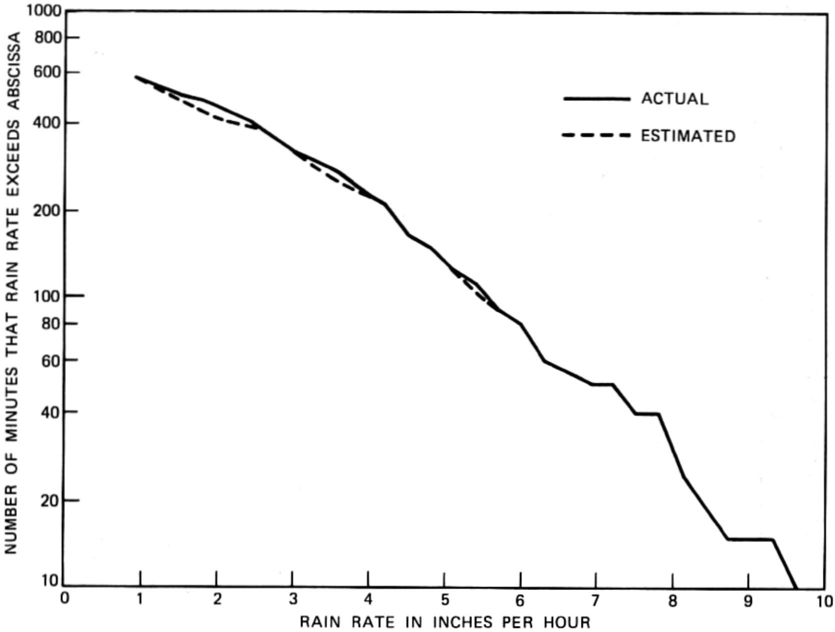

Fig. 1—Five-minute rain-rate distributions for 20 randomly selected, heavy rainstorms.

shows that the distribution computed by this method is in good agreement with the actual 5-minute rain-rate distribution. The actual distribution was obtained from the "Increment" entries in Table I and the estimated distribution (Fig. 1) was obtained from the "Maximum for Period" entries with those for periods 25, 35, 40, and 50 minutes deleted. The deletion was made to enable the original data to conform to the published data. It is seen from Fig. 1 that the error of the estimated distribution is small compared with that of the actual distribution. The trend of the error indicates that the higher the rain rate, the smaller the error. The maximum error in the range of interest is in the order of 5 percent.

The 1972 Miami data given in Table II were also processed using this method. Thirty-three heavy rainstorms occurred at Miami, Florida, in 30 days during 1972. The resulting 5-minute rain-rate distribution is shown by the dashed curve in Fig. 2.

A similar distribution can be obtained from the post-1935 NOAA data using the method by skipping the first step. The distribution curve thus obtained will lie above the 5-minute randomly sampled distribution and will be called the maximized 5-minute distribution.

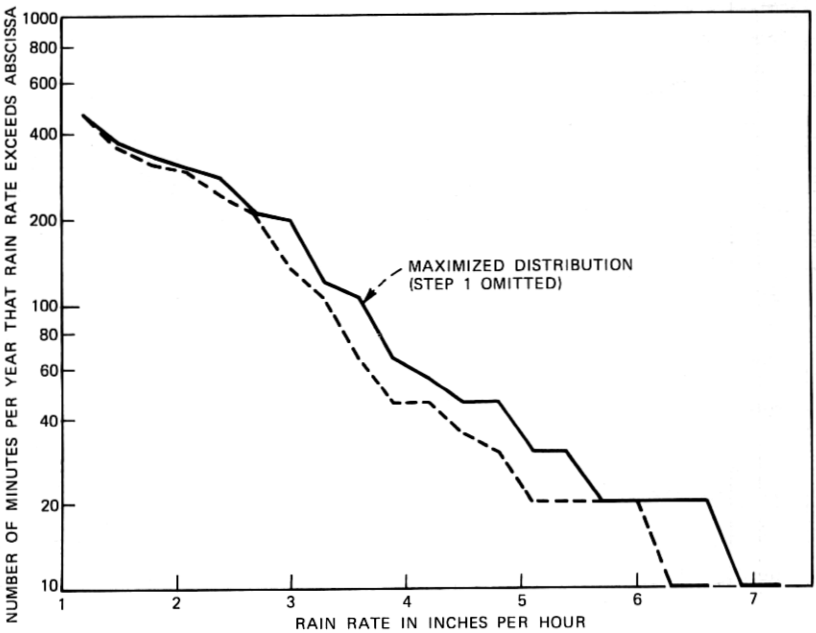

Fig. 2—Five-minute rain-rate distributions for Miami, Florida (1972).

Since this new distribution is expected to be closer to the 1-minute rain-rate distribution, it is believed to be more useful than its corresponding 5-minute rain-rate distribution for the purposes of attenuation estimation.[3] The maximized 5-minute rain-rate distribution for Miami, Florida, in 1972 was obtained and the results compared with the 5-minute rain-rate distribution obtained above, as shown by the solid curve in Fig. 2. It should be noted that, in a low rain-rate region of the distribution (<3 in./hr.), there exists a problem of "thresholds." This is the subject of the companion paper.[4]

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