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Temporal Distribution of Heavy Rainfall for Upper Klang Catchment

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Abstract. Data from 4 pluviograph stations in the upper Klang basin were used to derive time distributions of heavy rainfall using the NOAA method. *Rainfall cases for the temporal distribution analysis were selected from the annual maximum series usually used in the rainfall* frequency analysis. Each case (*i.e.*, maxima) was the total accumulation over a selected duration (1,6 ,12, 24 hour for this study). For each rainfall case, cumulative rainfall amounts were converted into percentages of the total rainfall amount at specified time increments. All cases for a specific duration were then combined and these rainfall cases were analysed separately, determining the percentage accumulated to 10, 20,30,40,50,60,70,80,90 and 100% of its total duration. For each duration, the percentage was determined by a percentage series of total rainfall, and the probabilities calculated.

In order to obtain the values of rainfall based on above definition, linear interpolations were carried out between the probabilities and the immediately previous and subsequent probabilities. The temporal distribution curves for nine deciles (10% to 90%) were plotted in the same graph.

Results show that first-quartile and second-quartile storms occurred most frequently with durations less than or equal to 12 hours; and first-quartile and fourth quartile storms most often had durations of 24 hours. Following the principles of Huff (1990), the temporal distribution curves derived in this study are recommended to be used for normal design as follows:

• For 1 hour duration, it is recommended that second quartile relations be used to establish typical time distributions.

• Time distributions for storms lasting 6 hours ,12 hours and 24 hours are most likely to conform to a first-quartile distribution.

For most purposes, the median curves are probably most applicable to design. These curves are more firmly established than the more extreme curves, such as those for the 10% and 90% probability levels, which are determined from a relatively small portion of each quartile's sample. However, the extreme curves should be useful when runoff estimates are needed for the occurrence of unusual storm conditions, such as typified by the 10% curves.

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1 Need and Objective

In flood design. an average rainfall temporal distribution is generally used which is derived from a large number of rainfall stations in a region. Temporal patterns have been developed in Malaysia in Hydrological Procedure No 1 by simple averaging of storm rainfall (DID 1982) and these have been used in flood estimation for catchments in Peninsular Malaysia. Long time intervals were used in these patterns and these may result in calculated discharge missing the peak of the hydrograph. This study aims to use the NOAA method to derive the rainfall temporal pattern for Upper Klang catchment. The NOAA method used the similar method in defining rainfall cases as the Average Variability method (ARR 1987) and Huff method in temporal distribution analysis.

In this study, pluviograph data for the Upper Klang catchment with records of over 30 years are used to derive temporal patterns for 4 standard storm durations. These are:

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Storm duration Minutes (Hrs)	Time interval Minutes (Hrs)
(1)	5
(6)	30
(12)	30
(24)	(1)

Temporal patterns for other durations can be derived by the same method.

For each station the n highest rainfall totals were obtained for each of the 4 durations of storm burst, where n is the number of years of record for a particular rainfall station, each of the storms was then subdivided into a number of equal time intervals or periods, ranging from 5 minutes for short duration storms to 1 hours for the 24 hour storm. These form the partial series storm events for each rainfall station. Adequate durations and time intervals for the storms were chosen so that the response times of actual catchments can be properly modeled when a rainfall runoff method is used.

The rainfall total chosen should be sufficiently large for the event to be one of the n largest values for the particular duration from n years of record. The storm burst should be independent so that there is no overlapping in time of successive storms. The rain did not have to persist for the entire length of specified duration, in this case the storm burst duration begins when the rain begins. There can be little or no rain in the later periods of the storm bursts.

The patterns presented in this report demonstrate the use of NOAA method in deriving design rainfall temporal distributions for data of the Klang catchment and the patterns derived can be used for design flood estimations for catchments in the same general region.

Temporal patterns for annual exceedance rainfall series are provided for 1,6,12 and 24 hour durations. The temporal distributions are expressed in probability terms as cumulative percentages of rainfall totals at various time steps. To provide information on varying temporal distributions, separate temporal distributions were also derived for

4 rainfall cases defined by the duration quartile in which the greatest percentage of the total rainfall occurred.

2 Data

The locations of the chosen stations are shown in Figure 1. Details of the stations are:

Station name	Station number	Years of record
Kg. Sg. Tua	3216001	27
Ibu Bekalan km 16 Gombak	3217001	27
Genting Sempah	3317004	27
Pusat Penyedidekan JPS Ampang	3117070	30

Pluviograph data for these stations are obtained from DID(Drainage and Irrigation Department) databank and checked for consistency and completeness for this study.

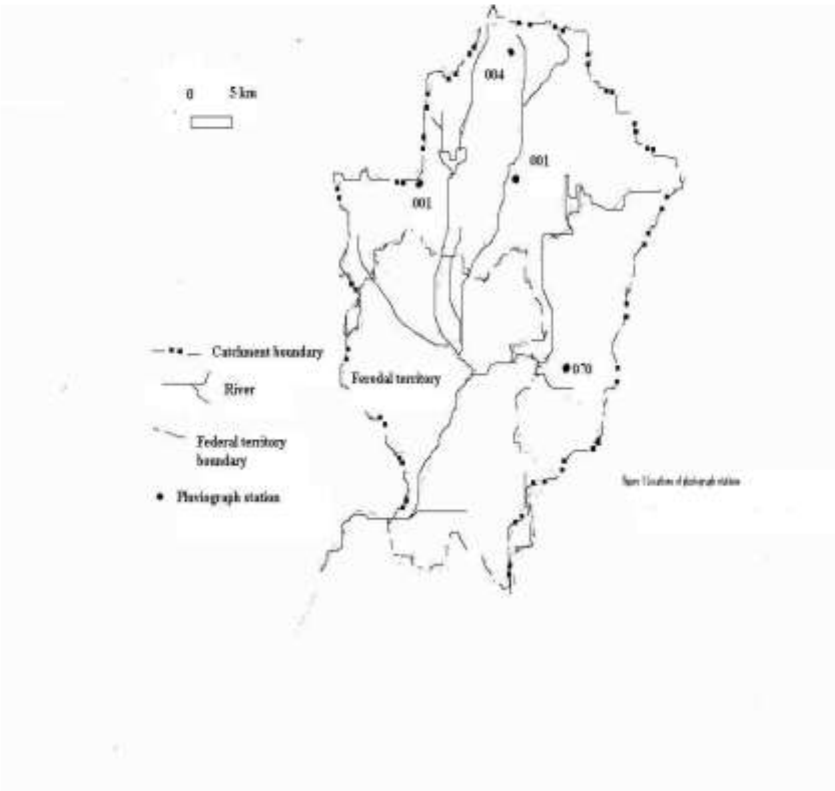

Fig. 1. Location of rainfall stations

3 Methodology

This study used the method similar to that of NOAA (2014) in deriving the time distribution of annual maximum rainfall. The NOAA method is similar to the one developed by Huff(1967) except in the definition of rainfall cases. *Rainfall cases for the temporal distribution analysis were selected from the annual maximum series used in the rainfall* frequency analysis. Each case (*i.e.*, maxima) was the total accumulation over a selected duration (1,6 ,12, 24 hour). Therefore, the rainfall cases for this analysis may contain parts of one or more storms. Because of this, temporal distribution curves presented will be different from corresponding temporal distribution curves obtained from the analysis of single storms. As rainfall cases always start with rainfall but not necessary end with rainfall resulting in potentially more front-loaded cases when compared with distributions derived from the single storm analysis. For this study, the annual exceedance rainfall series from each station were included for analysis in order to have enough samples to maintain the stability of the estimates. Table 1 shows the number of rainfall cases used to derive the temporal distributions for each duration.

Table 1. Number of rainfall cases (and percent) in each quartile for selected duration

Duration (hours)	All cases	First quartile	Second quartile	Third quartile	Fourth quartile
1	135	33(24.4)	97(34.8)	25(18.5)	30(22.2)
6	110	53(48.2)	31(28.2)	22(20)	4(3.5)
12	110	73(66.4)	25(22.7)	6(5.5)	6(5.5)
24	115	58(50.4)	14(12.2)	16(13.9)	27(23.5)

For each rainfall case, cumulative rainfall amounts were converted into percentages of the total rainfall amount at specified time increments. All cases for a specific duration were then combined and these rainfall cases were analysed separately, determining the percentage accumulated to 10, 20,30,40,50,60,70,80,90 and 100% of its total duration. For each duration, the percentage was determined by a percentage series of total rainfall, and the probabilities were calculated by the Weibull's formula:

$$P = \frac{m}{N+1} \quad (1)$$

Where P=the accumulated empirical probability
m is the order number of each element of the series
And N is the total number of elements in the series

In order to obtain the values of rainfall based on above definition, linear interpolations were carried out between the probabilities and the immediately previous and subsequent probabilities.

The temporal distribution curves for nine deciles (10% to 90%) were plotted in the same graph.

Computation of time distributions is carried out using MS Excel.

4 Results

The temporal distributions for the 24 hour duration for all cases are presented in Table 2 as an example.

Table 2. Temporal distribution (%) for 24 hour duration rainfall, all cases

Percentile \ Cumulative% of duration	0	10	20	30	40	50	60	70	80	90	100
90	0	3.49	6.95	10.35	13.99	16.97	20.50	26.65	35.77	45.75	100
80	0	10.20	19.97	24.97	25.63	29.07	38.75	42.52	55.25	71.70	100
70	0	19.75	27.69	37.75	41.01	43.69	50.22	58.43	71.07	88.74	100
60	0	25.29	39.22	44.89	50.18	52.49	63.10	71.66	81.17	95.64	100
50	0	34.29	46.48	52.06	59.20	64.67	75.02	86.14	92.56	99.09	100
40	0	43.28	57.29	59.80	68.28	75.08	88.52	95.10	98.69	100.00	100
30	0	47.86	69.71	75.79	82.18	89.54	95.85	99.24	100.00	100.00	100
20	0	55.76	81.26	93.10	95.45	98.43	99.86	100.00	100.00	100.00	100
10	0	74.97	97.05	99.22	100.00	100.00	100.00	100.00	100.00	100.00	100

Temporal distributions were derived for all rainfall cases, i.e. all cases and the first second, third and fourth quartile where the greatest percentage of the total rainfall occurred. In general, the distribution of rainfall in each quartile is more uniform for the 1 hour duration as rainfall is evenly distributed in each of the four quartiles for this duration. The 6 and 12 hour duration look more similar to each other as heavy rainfall always occur in the first and second quarteile. The 24 hour rainfall has heavy rainfall in the first and fourth quartiles. For most purposes, the median curves are probably most applicable to design. These curves are more firmly established than the more extreme curves, such as those for the 10% and 90% probability levels, which are determined from a relatively small portion of each quartile's sample

5 Conclusions

Data from 4 pluviograph stations in the upper Klang basin were used to derive time distributions of heavy rainfall using the NOAA method.

Results show that first-quartile and second-quartile storms occurred most frequently with durations less than or equal to 12 hours; and first-quartile and fourth quartile storms most often had durations of 24 hours. Following the principles of Huff (1990), the temporal distribution curves derived in this study are recommended to be used for normal design as follows:

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