Analysis of Peak Stream flow Distributions Based on Neyman-Scott Synthetic Rainfall

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This paper proposes a methodology for estimating peak stream flow involving rainfall data generated from a stochastic rainfall generator and rainfall-runoff modeling. The rainfall model was formulated following the temporal Neyman-Scott clustered Poisson rectangular pulse framework, NSM here for brevity. Essentially, we propose the effectiveness of the method via comparison to an existing method long established by the Japan Ministry of Land, Infrastructure and Transport.

The simulations involved hourly rainfall data (1950 – 2002) from AMeDAS Kyoto station and the Kamo River in Kyoto, Japan. For stationarity, we assumed that the heaviest rainfall and stream flow occurred within the month of June. Since discharge data from the Kamo River was limited, hourly rainfall-runoff modeling of the historical record was used to supply the historical stream flow. The corresponding peak stream flow from this period served as the historical peak flow information from which the comparison of the a) MILT method (M-I) and b) our proposed method (M-II) was carried out.

Estimating the 50-year return period peak flow based on M-I involve the following algorithm. 1) For the Kamo River Basin, an area of around 200 Km^2, determine the 53 maximum 24-hour rainfall values Y_i for each year i on record. 2) Estimate quantile value $Y_{q,50}$ for return period 50 years, based on a probability distribution such as the lognormal distribution. 3) From each record i, modify the 24-hourly hyetograph that accumulates into maximum Y_i by multiplier $Y_{q,50}/Y_i$. 4) Simulate stream flow on a suitable rainfall-runoff model using each of the 53 modified 24-hour rainfall patterns. 5) Each peak flow from the resulting 53 hydrographs is rendered an estimate of the 50-year peak flow flood Q_{50}. Such estimates inherently yield an uncertain value of the target event. It is evident as well that there is no clear way to address the uncertainty associated with each of the 53 values obtained. In contrast, we propose in M-II a method that is more straightforward than M-I.

The M-II algorithm proceeds as follows. 1) Determine NSM parameters using the method of moments from the historical rainfall. 2) Generate 53 synthetic rainfall records to correspond to the 53 historical rainfall records. 3) Simulate stream flow for each of the synthetic records. 4) Determine the peak flow for each of the resulting hydrographs. 5) Estimate the quantile Q_{50} from a fitted probability distribution (lognormal here as well) to the maxima as well as 95% confidence bands.

To ensure high quality of data input for each simulation, the synthetic rainfall maxima was first compared to the historical counterparts via Kolmogorov-Smirnov (KS) tests, showing that NSM parameters are best estimated using the so-called Fano factor based search. KS tests were also performed to the peak discharges from historical and synthetic stream flow, showing good agreement.

The following are the estimates based on M-I and M-II, in which we note the proximity of the M-II estimates in range to the historical counterparts.

Table 1. M-I and M-II estimates for peak discharge in Kamo River.

Historical (cms)		M-I (cms)		M-II(cms)	
lower 95%	upper 95%	lower	upper	lower 95%	upper 95%
473.58	536.82	277.63	856.88	413.27	480.24

We are currently testing the method for the typhoon month of September as well as other return period maxima.