# AN INTEGRATED APPROACH FOR ESTIMATING PROBABLE MAXIMUM PRECIPITATION INCORPORATING THE CONCEPT OF THRESHOLD

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## DECLARATION

This thesis is a report of research carried out in the Department of Civil Engineering, University of Moratuwa, between March 2006 and December 2010. Except where references are made to other work, the contents of this thesis are original and have been carried out by the undersigned. The work has not been submitted in part or whole to any other university.

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# ABSTRACT

Probable maximum precipitation (PMP) is widely used as an input in rainfall-runoff modelling to estimate probable maximum flood (PMF), which is required for the design of spillways of large dams. Two methods for estimating PMP, namely, the hydro-meteorological and statistical techniques which are characteristic of the deterministic and probabilistic approaches are used extensively. International research shows substantial differences in the results obtained by these methods. In this study an integrated approach, which incorporates the concept of threshold, which has not been practiced in the global context is developed to estimate PMP.

This integrated approach modifies Hershfield's statistical procedure to account for the total absence of outliers or presence of multiple outliers by incorporating the concept of threshold. Further, it is coupled with the hydro-meteorological approach to derive realistic values of the frequency factor, K. Thus K is perceived as a factor depending on the mean and coefficient of variation which are statistical characteristics, and on extreme precipitable water and precipitation efficiency, which are hydro-meteorological factors. It is also vital that Hershfield K values should not be directly applied without first ensuring their validity by using a meteorological and statistical analysis of data at the given location. The method is used to estimate 24-h, point PMP at 18 rainfall stations in Sri Lanka. The threshold is determined by detecting outliers using the Inter Quartile Range test (IQR). In the presence of multiple outliers, Hershfield's PMP results could be as much as 45% higher than those of the modified method.

While the integrated approach yields valuable results, it is of significant scientific interest to explore what the outcome would have been if the physically based hydro-meteorological procedure had been adopted. For this purpose, long series of annual maximum daily rainfall data from seven stations were analysed. The research shows that the maximum moisture and corresponding wind run or the use of maximum moisture alone are two scenarios, which yield results compatible with the modified

statistical PMP. Although globally there is a tendency to exclude wind maximization, this does not automatically apply to a country like Sri Lanka, which experiences cyclonic rainfall and special attention should be paid to precipitation efficiency. These results are further confirmed by a frequency analysis based on the generalized extreme value (GEV) distribution.

Data from 22 meteorological stations from 11 other countries have also been used to develop some useful relationships between PMP, observed maxima, mean, median and threshold, hitherto not published elsewhere. The current practice of using 2.0-3.0 times the observed maxima as an approximation to PMP, can yield very misleading results. In comparison, the relationship between PMP and threshold is a far superior approximation for obtaining a reliable estimate of PMP. It is also found that when the observed maxima approach 2.5 to 3.0 times the threshold, the observed maxima approach PMP values, for all values of K. These relationships are further confirmed by extensive use of simulation.



The integrated approach yields far more realistic estimates of PMP and offers much potential for design office practice and developing PMP maps for Sri Lanka. Aspects needing further investigation are also mentioned.

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