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Development of Regional Rainfall Intensity-Duration-Frequency Curves Based on Scaling Properties

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The knowledge of rainfall Intensity Duration Frequency (IDF) relationships is of fundamental importance in hydrology. The IDF curves are used in developing design storms and also required/ needed in many hydrologic models and procedures in computation of water quantity and quality characteristics. For the site for which sufficient rainfall data is available, frequency analyses are commonly used for design of various hydraulic structures. In particular, precipitation frequency analysis studies are necessary for development of a design storm. However, these techniques have limitations to estimate the IDF characteristics for ungauged sites. For the site where rainfall record is unavailable or the data sample at the site is limited, “Regionalization” and “Scaling” methods should be studied more to transfer the rainfall information from one location to others.

Over the last two decades, the concepts of the scale invariance have come to the fore in both modeling and data analysis in hydrological precipitation research. The properties of the time scale invariances of rainfall quantiles are examined in the Yodo River basin: for time scaling, rainfall properties follow the simple scaling. The hypothesis of piecewise simple scaling combined with the Gumbel distribution was used to develop the IDF scaling formulas depending on the three parameters: the scaling exponent, and the two statistical parameters, location and scale parameters of 24 hour rainfall. The spatial distribution maps of these parameters are used to derive the rainfall intensity duration frequency at ungauged points which were interested for designing analysis. This study established the regional rainfall intensity duration frequency relationship for ungauged catchments based on three spatial distribution maps from scale invariance of rainfall in time. The paper presents a regional frequency analysis of annual maximum rainfall intensity for storm duration ranging from 1 hour to 24 hours, observed for a dense network of rain gauges located in the Yodo River catchment of Japan. The study investigates the scaling properties of rainfall extremes using the EV1 distribution (Gumbel) based on L-moments. We developed a regional scaling model that enables one to estimate the design storm at any ungauged sites of the study area. The uncertainty of the estimates for ungauged sites is quantified by using the RMSE. We obtained for the study area resampled estimates of the design storm characterised by relative errors, generally lower than 10% and never higher than 20%. The methodology should be examined in different areas and climatology in order to generalize the results.

Hydrological applications require knowledge about temporal and spatial variabilities of rainfall over an area. The intensity of point precipitation is only applicable for relatively small areas. For larger areas, design rainfall needs to be converted to average areal depths. Areal Reduction Factors (ARFs) have been commonly used to obtain this transformation. The ARFs must reflect the scaling properties of rainfall in time and space. Further research is needed on linking time and space scaling of rainfall properties to derive the ARFs for evaluation of the design rainfall using a scaling approach.