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Transformation of Point Rainfall to Areal Rainfall by Estimating Areal Reduction Factor: Scaling Approach

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1. Introduction

Many hydrological and meteorological applications require knowledge about the spatial and temporal variability 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. To estimate ARFs at sparely gauged basins, to derive the Intensity-Duration-Area-Frequency (IDAF), incorporating the scaling properties of rainfall in time and space is essential.

With this approach, the study is to deal with the question how the rainfall properties at a point scale is linked with areal rainfall in term of time and space. Scaling properties of extreme rainfall in time and space are explored for disaggregation / aggregation of rainfall intensity from low to high resolution time scale / from point to area in spatial scale.

2. Time scaling

For time scaling, the simple scaling theory can be applied to derive IDF curves consistent with hourly rainfall series in rain gauges where only daily data are available. These curves are developed for gauged sites based on scaling of the generalized extreme value (GEV) and Gumbel probability distributions. Statistical analysis was performed on annual maximum rainfall series for the Yodo River catchment for durations ranging from 1 hour to 24 hours. The results showed that rainfall does follow a simple scaling process in time.

3. Space scaling

To obtain spatial scaling, spatially distributed rainfall data with 2.5 km^2 spatial resolution and hourly time resolution was arranged for 21 years. By using the data set, the simple scaling properties in space were examined. It was found that two ranges less than 1,000 km^2 and more than 1,000 km^2 show different scaling properties. The rainfall intensity-area- frequency (IAF) with fixed duration (D) can be derived from small area to lager area based on space scaling.

4. Space-Time scaling

The IDAF curves reflect the variability of rainfall in time and space, thus it is necessary to make joint analysis of scaling properties of the rainfall field in duration and area (see below figure).

We adopt a statistical analysis to obtain the Areal Reduction Factor (ARFs) based on its scaling properties in space and time. The concepts of the statistical scaling are used to study the variability of a random process in time and space. The approach is expected to be more useful and practical to evaluate design rainfall for a specified area. The rain gauges network in the Yodo River basin is the target for this study.

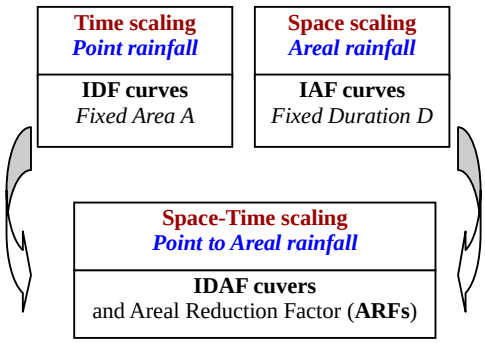

Figure. *Linking the time and space scaling to derive ARFs*