

## Parameter estimation of distributed rainfall-runoff model using global optimization approach

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### 1. Introduction

Recently, distributed rainfall-runoff models with the spatial heterogeneity of rainfall and catchment characteristics begins to be applied to numerous rainfall-runoff analysis for planning, design, operation and management of water resources systems.

Despite various utilizations of distributed models in hydrological fields, a few works have been performed with regard to parameter estimation. It is one of principal reasons that a number of parameters and variables in a distributed model are much larger and more complicated than those of a lumped model for the same study site. Another essential reason is the structure complexity of distributed models in terms of computational procedures for calculating outputs. Calibration procedures can be classified into two groups, manual and automatic calibration. The former requires comprehensive understanding of the catchment runoff behavior and the model structure and could be extremely time consuming. In addition, the termination of calibration process is based on the subjective decision of the hydrologists. On the other hand, the latter can improve shortcomings of manual methods in terms of calibration running time, extensive search of the existing parameter possibilities.

This study develops an automatic approach for calibrating appropriate parameters that control reproducibility and accuracy of simulation of KSEDFEFC2D, distributed model based on kinematic wave scheme. Sensitivity analysis is conducted before the calibration process to identify the most important / sensitive parameters, and model components. Insensitive parameters can be fixed to suitable values to decrease the dimensionality of the calibration problem through this step. Parameter estimation is performed as combined with the Shuffled Complex Evolution(SCE) algorithm, global optimization strategy developed by Duan *et al.*(1992). This calibration methodology has been found to be consistent, effective, and efficient in locating the globally optimal model parameters with respect to a given objective function(Wagener *et al.* 2004). To assess the applicability of global optimization strategy, mountainous Asuwagawa cathment is selected.

### 2. Distributed hydrologic model

KSEDFEFC2D is a physically based distributed hydrologic model developed by Ichikawa *et al.* (2001) and discharge stage relationship including unsaturated flow is imbedded by Tachikawa *et al.* (2004). The model solves the one-dimensional kinematic wave equation with the discharge-stage equation using Lax-Wendroff finite difference scheme according to ordering nodes and edges, edge connection along flow direction map. All constituent information are extracted from DEM. Channel routing is also carried out by kinematic routing scheme as well as calculation of slope elements reflecting contributing areas.

### 3. Study site and storm events

The study site is the Asuwagawa catchment which lies within Fukui prefecture and covers an area of 353 km<sup>2</sup>. Topographic data processing is basically performed with 250m DEM(Geographical Survey Institute). Figure 1(a) shows the study area described by ExtractNodeEge, one of the geo-processing procedures in Geohyos(<http://flood.dpri.kyoto-u.jp/product/geohyos/geohyos.html>) and figure 1(b) describes drainage outlet and location of ground gage stations used for estimating a spatially distributed rainfall. For sensitivity analysis, parameters calibration, and model validation, nine past storm events gauged on 17 ground gauge stations are collected.

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**Keywords :** Automatic calibration, Shuffled Complex Evolution algorithm, Distributed hydrologic model, KSEDFEFC2D

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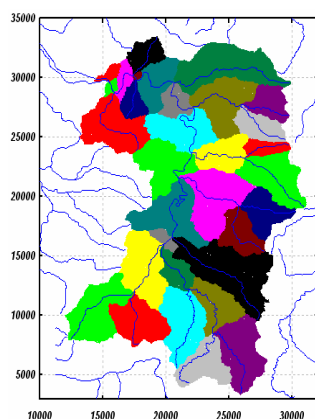


Fig 1(a). Channel networks and subcatchments of Asuwagawa watershed

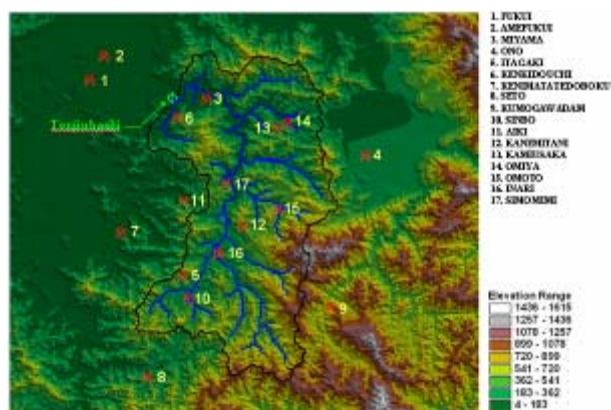


Fig 1(b). Location of ground rainfall gage stations in Asuwagawa catchment

#### 4. Optimization algorithm ; Shuffled Complex Evolution(SCE) method (Duan *et al.*, 1992)

Main concepts of global optimization using the SCE algorithm are represented by 1) combination of probabilistic and deterministic approaches, 2) systematic evolution of a complex of points spanning the parameter space, and 3) competitive evolution and complex shuffling. The SCE scheme is also expanded through the following procedures : 1) a population is sampled and partitioned into a number of complexes ; 2) each of the complexes is allowed to evolve in the direction of global improvement, using competitive evolution techniques that are based on the downhill simplex method ; and 3) at periodic stages in the evolution, the entire set of points is shuffled and reassigned to new complexes to enable information sharing.

This study divides the model parameters of KSEDGEFC2D model into two kinds. One is model input parameter, which can be read directly from topographic data processing and the other is model calibration parameter, which is estimated from historical rainfall and flow data. These calibration parameters in the model must be calibrated by applying SCE algorithm, optimization technique.

#### 5. Further study

Model calibration does not guarantee reliability of model predictions. The parameters obtained during calibration and the subsequent predictions made using the calibrated model are only as realistic as the validity of the model assumptions for the study site and the quality and quantity of actual watershed data used for calibration and simulation. Therefore, quantitative estimation of uncertainty is necessary to investigate potential uncertainties related with model structure, parameter and observational data. However, Uncertainty, caused by input data, model structure and so on, prediction is excluded in this study.

#### 6. References

- Wagener, T., Wheater, H.S. and Gupta, H.V.(2004). Rainfall-Runoff Modelling in Gauged and Ungauged Catchments. *Imperial college press*
- Duan, Q., Sorooshian, S. and Gupta, V.K.(1992). Effective and efficient global optimization for conceptual rainfall-runoff models. *Water Resources and Research* 28(4), 1015-1031
- Ichikawa, Y., Murakami, M., Tachikawa, Y., Shiiba, M.(2001). Development of a basin runoff simulation system based on a new digital topographic model. *Journal of Hydraulic, Coastal and Environmental Engineering*, JSCE, no. 691/II-57, 43-52
- Tachikawa, Y., Nagatani, G., and Takara, K.(2004). Development of stage-discharge relationship equation incorporating saturated – unsaturated flow mechanism. *Annual Journal of Hydraulic Engineering*, JSCE, 48, 7-12