第Ⅱ部門

Parameter Sensitivity Analysis and Automatic Calibration for a Distributed Hydrological Model

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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 utilization of distributed models in hydrological fields, a few works have been performed with regard to parameter specification and calibration because 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. Calibration procedures are divided into two classes, 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 KSEDGEFC2D, distributed model with kinematic wave routing. Sensitivity analysis is conducted before the calibration process to identify the most important / sensitive parameters, and model components. Insensitive parameters can be fixed to a suitable value to decrease the dimensionality of the calibration problem through this step. Parameter estimation is performed as combined with the Shuffled Complex Evolution(SCE) algorithm, stochastic global optimization algorithm developed by Duan *et al.* (1992). This calibration methodology is proved to be an efficient, popular method for the automatic optimization(Wagener *et al.* 2004). Whole procedures are applied to the Asuwagawa watershed to demonstrate the effectiveness.

2. Distributed hydrologic model

KSEDGEFC2D 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 with 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 watershed which lies within Fukui prefecture and covers an area of 351 ㎢. Topographic data processing is basically performed with 50m DEM(Geographical Survey Institute). Figure 1 shows the study area described by ExtractNodeEge, one of the geoprocessing procedures in Geohymos(http://flood.dpri.kyoto-u.jp/product/geohymos/geohymos.html). For sensitivity analysis, parameters calibration, and model validation, nine past

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Giha LEE, Yasuto TACHIKAWA, Kaoru TAKARA storm events gauged on several ground gauge stations are collected as listed in Table 1.

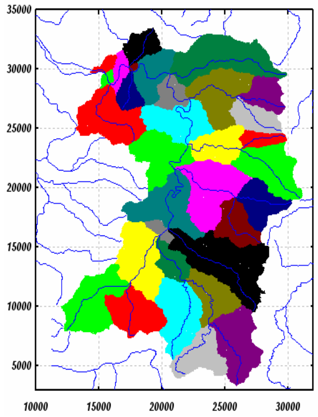

Fig 1. Channel networks and subcatchments of Asuwagawa watershed

Table 1. Flood events used in this study

Event period	Number of rainfall gage station
1979 / 9 / 28 / 0:00 ~ 10 / 3 / 24:00	6
1981 / 6 / 30 / 0:00 ~ 7 / 5 / 24:00	4
1982 / 7 / 30 / 0:00 ~ 8 / 4 / 24:00	7
1983 / 9 / 26 / 0:00 ~ 10 / 1 / 24:00	4
1985 / 7 / 5 / 0:00 ~ 7 / 10 / 24:00	10
1989 / 9 / 5 / 0:00 ~ 9 / 10 / 24:00	10
1990 / 9 / 17 / 0:00 ~ 9 / 22 / 24:00	10
1993 / 7 / 10 / 0:00 ~ 7 / 15 / 24:00	10
2004 / 7 / 18 / 0:00 ~ 7 / 19 / 24:00	12

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

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