第Ⅱ部門

Analysis of Model Predictability through Parameter Uncertainty Estimation

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1. Introduction

All rainfall-runoff models are simplifications of the real natural system, that is, conceptual-numerical representation of dominant processes controlling the transformation of precipitation over a watershed into streamflow in the river channel. Whole these models, regardless of how spatially precise (*i.e.* even distributed model), are to some lumped so that their structures and parameters reflect effectively the processes as aggregated in space and time. As a consequence, some model parameters are not directly observable and measurable because the available measurement technologies are incapable of providing accurate measurements at the correct watershed scale, and hence have to be specified through an indirect process of parameter estimation often called model calibration (manually or automatically).

Despite a remarkable improvement of automatic optimization tools such as global optimization algorithm, SCE-UA (Duan *et al*., 1992), such methods have received criticism for lack of rigor in properly dealing with parameter uncertainty. Several approaches have been developed and conducted to assess parameter uncertainty and its propagation into subsequent predictions (Uhlenbrook *et al*., 1999; Vrugt *et al*., 2003). Traditional statistical theory based on first-order approximations and multinormal distributions is typically unable to treat the non-linearity of complex hydrological models. On the other hand Markov Chain Monte Carlo (MCMC) based methods generate samples from a Markov chain adapts to the stationary posterior parameter distribution and can be applied to complex inference, search and optimization problems (Vrugt *et al*., 2003). The posterior parameter distribution quantifies the uncertainty of model parameters with considering the observations in study catchment.

Especially, we focus on estimating predictability (confidence limits) owing to the indeterminacy of rainfall-runoff model parameters. In other words, it means to quantify the effect of parameter uncertainty on streamflow simulation. In this study, we use the Shuffled Complex Evolution Metropolis (SCEM-UA) algorithm (Vrugt *et al*., 2003) to infer the posterior distributions for the parameters of the distributed hydrological model, KsEdgeFC2D (Ichikawa et al., 2001). More detail descriptions of the used model and optimization algorithm are introduced in subsections. The objective of this work is 1) to explore the capacity of SCEM-UA to identify the posterior parameter distributions for the KsEdgeFC2D model applied to Kamishiiba catchment (211km^2), 2) to compare between SCEM-UA derived parameter values and those obtained from deterministic SCE-UA calibrations and 3) to evaluate the effect of parameter uncertainty on the predictive capability of the applied model.

2. Applied hydrological 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 ordered nodes and edges, edge connection based on flow

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Giha LEE, Yasuto TACHIKAWA, Kaoru TAKARA direction map. All constituent information is extracted from 250m DEM data. Channel routing is excluded in this study for simplifying the calibration procedure.

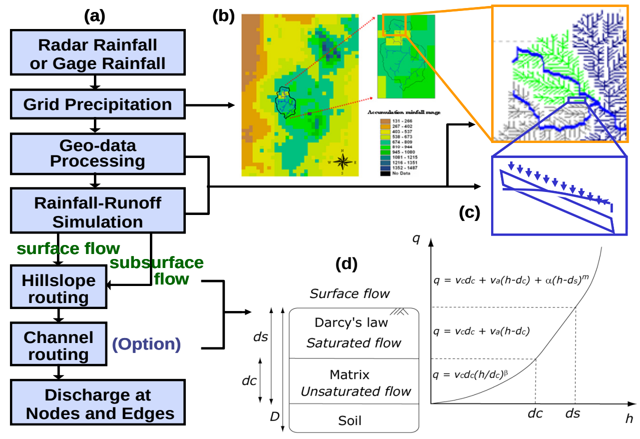

Fig 1. Schematic representation of KsEdgeFC2D (a) Modular structure of KsEdgeFC2D (b) Distributed grid rainfall data (c) Slope and channel components extracted from DEM (d) Model structure for the hillslope soil layer and discharge-stage relationship.

3. General outline of the SCEM-UA algorithm

The goal of the SCE-UA algorithm (Duan *et al.*, 1992) is to find a single optimal parameter set in the feasible space. The SCE-UA begins with a random sample of points distributed throughout the feasible parameter space, and uses the Downhill Simplex search algorithm to continuously evolve the population toward better solutions in the search space, progressively relinquishing occupation of regions with lower posterior probability. This genetic drift, where the members of the population drift towards a single location in the parameter space, is typical of many evolutionary search algorithms. By replacing the Downhill Simplex strategy with a Metropolis-Hasting strategy, the tendency of the algorithm to collapse into the relatively small region containing the optimal parameter set is avoided. The SCEM-UA algorithm is a general-purpose global optimization algorithm that provides an efficient estimate of the most likely parameter set and its underlying posterior probability distribution within a single optimization run.

4. Results and Discussions

Case study showed that the SCEM-UA algorithm was able to efficiently and effectively explore the feasible parameter space and to successfully converge to the target posterior parameter distributions. Hydrograph predictions based on the posterior parameter distributions demonstrated that KsEdge-FC2D is able to reproduce the observed discharges with reasonable accuracy for the Kamishiiba catchment. Moreover, it shows good agreement between the value of most likely parameter set estimated by SCEM-UA and the optimal solution of SCE-UA. This indicates that previous deterministic calibrations used the SCE-UA algorithm are likely to yield robust parameters for this distributed rainfall-runoff modeling.

5. References

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