Analysis of Hydrologic Behaviors under Equifinality

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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, uncertainty in the calibrated parameter estimates still remains very large since response surface contains undefined manifold similar solutions in terms of objective function values at widely different locations in the parameter space.

This phenomenon occurs, when for a given set of calibration scenarios, various set of parameter provide equally good responses. Especially, distributed models with a large number of parameters are quite good at mimicking hydrological behavior. Beven and Binely (1992) used the special term, *equifinality* to describe the possibility of plausible parameter sets in calibration procedure and it has been one of the interesting major issues in complicated hydrological and environmental modeling. However, while various uncertainty analysis methods, there are not the right tools to reduce parameter uncertainty, hence the reduction of parameter uncertainty in such cases is a major challenge. Parameter uncertainty in rainfall-runoff modeling can be reduced by a design of framework to filter out non-physical sets of parameters, allowing the decrease of the number of potentially (unreliable) relevant parameter sets. The most efficient technique to search for more reliable parameter set among several plausible ones is to use ancillary information such as soft data (Seibert and McDonnell, 2002) to impose physical constraints on the model outputs.

In this study, we illustrates a particular example of *equifinality* satisfying two conditions in terms of qualitative and quantitative model performances in distributed hydrological modeling and then proposes a new reduction approach of parameter uncertainty, which is a physically-based validation procedure (post-calibration process) using additional useful information to narrow down a range of reliable model parameter sets. The adopted auxiliary physical data is spatiotemporal-recorded matrix (Sayama *et al.*, 2007) which enables to trace the spatiotemporal aspect of runoff variation for distributed grid cells. The development of this tracer method makes it possible to analyze internal responses of catchment. Moreover, this method may help to understand the model structure and reject erroneous parameter sets. Modelers, if armed with sufficient comparable observed information obtained from a well-organized monitoring system to the computed internal catchment dynamics, would employ this complementary information for decreasing parameter uncertainty in distributed rainfall-runoff modeling.

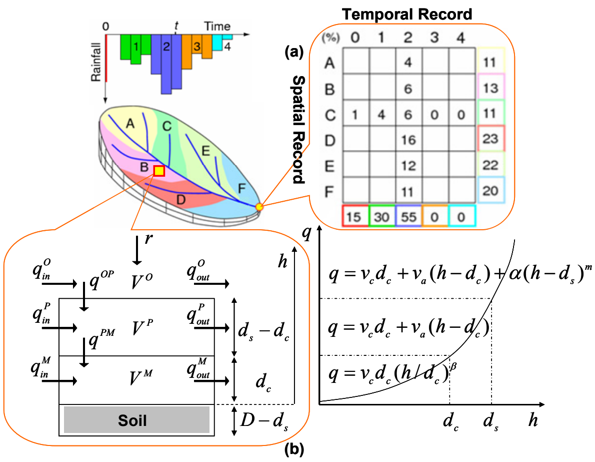

Fig 1. Illustration of Spatiotemporal Matrix

References

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