Method to Estimate Optimal Parameters

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Contents

Abstract

Model, data, and parameter estimation are three fundamental elements in hydrologic process modeling and forecasting. Recent progresses in hydrologic modeling have been made toward more efficient and effective estimation of model

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parameters. In this chapter, classical and recently developed parameter optimization methods and their applications in hydrological model calibration are reviewed. Those methods include gradient-based optimization methods, direct search methods, and recently developed stochastic global optimization methods. A recently developed surrogate model approach, with the purpose to reduce computational burden of model which runs through replacing the hydrologic process model with a cheaper-to-run surrogate model, is also discussed. Extending from a single objective function parameter optimization, multi-objective optimization methods and their core concept in deriving trade-offs are also summarized. Examples are provided to demonstrate the strengths and limitations of optimization algorithms summarized in this chapter.

Keywords
Optimization · Hydrologic Model · Evolutionary Algorithm · Automatic Parameter Estimation · Surrogate Model

1 Introduction

Hydrologic models are extensively used in academia, industry, and operating agencies for flood forecasting, streamflow simulation, and water resources management. The successful use of hydrologic models to simulate natural processes depends on many factors, including (1) the mathematical formulation of hydrologic model, i.e., the mathematical representation of natural rainfall-runoff processes in a certain level of sophistication and its corresponding assumptions; (2) sufficiency and accuracy of observation data at proper temporal and spatial resolutions, such as in situ streamflow observations and precipitation measurements from rain gauge, radar network, or remotely sensed information; (3) the properly calibrated model parameters (i.e., the global optimal parameters in the feasible domain), which significantly affect the accuracy and uncertainty of hydrological prediction.

This chapter presents model parameter calibration methods in three parts. The first part reviews recent development of the methods to estimate optimal parameters of hydrologic models, especially those heuristic methods used in automatic parameter estimation. The second part focuses on the search mechanism and procedures employed in different methods. And the third part provides examples to illustrate the strengths and limitations of different methods. An overall review of this chapter is summarized below.

This chapter starts with an introduction of hydrologic models and a general mathematical formulation of parameter estimation from the maximum likelihood perspective. Two classical parameter estimation methods are introduced, namely the *Steepest decent method* and *Newton method*, known as the gradient-based local