Ⅱ−27 GENETIC ALGORITHMS FOR AUTOMATIC CALIBRATION OF TANK MODEL

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Genetic algorithms have shown to be a useful tool for finding the optimum of multi-modal functions like those handled while calibrating rainfall-runoff models. This study deals with the application of a genetic algorithm for the automatic calibration of the rainfall-runoff *Tank Model* for Ishite River basin, in Ehime Prefecture. The results indicate that the genetic algorithm can be more efficient than the classical optimization techniques

1. INTRODUCTION

One of the major tasks in using a mathematical model to simulate a natural phenomenon is the calibration of values for the model parameters so that the model efficiently simulates the behavior of the phenomenon. Rainfall-runoff models usually handle several parameters. They can be calibrated by formulating an optimization problem in which the objective function to be minimized is proportional to the difference between observed and computed discharges. Many studies have been carried out on the use of optimization techniques for calibrating rainfall-runoff models. In general, they have found that the standard techniques often fail in finding the optimum because of the high dimensionality and irregularities of the objective functions such as multi-modality (several peaks), discontinuity, etc. For solving these kinds of ill-conditioned problems genetic algorithms (*GAs*) have been found out to be more suitable. One reason is that *GAs* do not need strong assumptions regarding the objective function (continuity, differentiability, etc.) as well as auxiliary information (derivatives, etc.), which are required by the standard techniques.

GAs mimic Darwin's evolution process by implementing a "survival of the fittest" strategy. During each iteration, a *GA* maintains a population of potential solutions to the problem (chromosomes). Each solution is evaluated to give some measure of the "fitness". Then, a new population is formed by selecting the more fit individuals. Some members of this new population undergo transformations by means of "genetic" operators (crossover and mutation) to form new solutions. After some number of generations the algorithm converges [2]. Because of its robustness *GAs* have been applied to calibration of rainfall-runoff models by various researches, e.g., *Duan et. al.* [1] and *Wang* [4].

This study deals with the application of a genetic algorithm for the automatic calibration of *Tank Model* for Ishite River basin, located in Ehime Prefecture.

2. MATERIALS AND METHODS

Ishite River basin is a sub-basin of Shigenobu River basin in Matsuyama City. Its area is about 72.6 km^2 and the main river is 11 km long. Pine forest is the predominant vegetation. The mean annual precipitation lies between 1300 and 1500 mm, and the rainy season lasts from middle of June to middle of July.

The principle of Tank Model (Sugawara, 1995) is to substitute the river basin with several tanks where the outflow from each tank is assumed to be proportional to the water height from the position of the side outlet. Precipitation is an input added to the uppermost tank and evapotranspiration is subtracted from all the tanks. The total outflow from the side outlets becomes the river discharge to be calculated. This can be assumed to correspond to the structure of the aquifers of the watershed. A four-tank model with fourteen parameters was used (Figure 1).

The *GA* incorporates six genetic operators based on float number representation for the chromosomes as used in Michalewicz's GENOCOP system [2].

The calibration was based on the minimization of the sum of squares of differences between observed and simulated discharges $F^2 = (Q_{obs} - Q_{sim})^2$. The model efficiency was measured by the coefficient $R_{eff} = 1 - F^2 / F_0^2$, where F_0^2 is the sum of squares of differences between observed discharges and its mean value. The correlation coefficient was also analyzed. One year's data (1995) was used for this analysis.

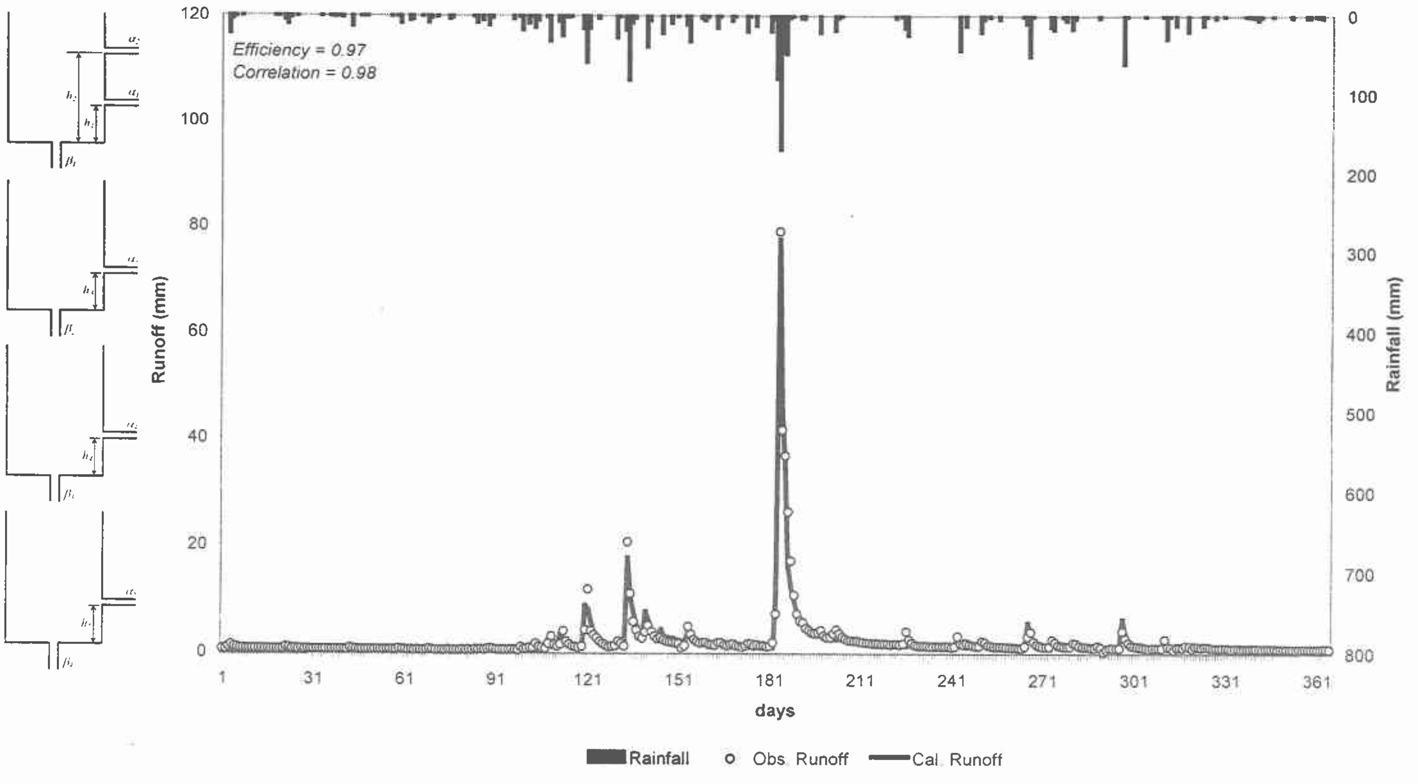

Figure 1. Layout of the Tank Model and results obtained by the *GA* for the calibration period.

3. RESULTS AND DISCUSSION

Figure 1 shows the results for the calibration period. The correlation between observed and computed runoff for this period was 98% and the coefficient of efficiency reached 97%. Data from 1993 and 1996 were used for validation. For 1993, correlation and efficiency were 96% and 89%, respectively. In 1996, the correlation was 95% whereas the efficiency was 89%. As a comparison, the model was also calibrated by using a calculus-based procedure included in the *Optimization Toolbox* of the commercial software *Matlab*. The results obtained for the calibration year using this procedure gave values of 68% for correlation and 37% for efficiency, which shows that it was not as efficient as the genetic algorithm.

4. CONCLUSIONS

This study showed that the genetic algorithm could be a more useful and robust tool for calibrating the Tank Model when compared to standard optimization techniques. *GAs* can also be applied to different rainfall-runoff models as well as other kinds of hydrologic models.

References

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