Geophysical Research Abstracts
Vol. 18, EGU2016-5817-3, 2016
EGU General Assembly 2016
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Estimation of the discharges of the multiple water level stations by multi-objective optimization

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This presentation shows two aspects of the parameter identification to estimate the discharges of the multiple water level stations by multi-objective optimization. One is how to adjust the parameters to estimate the discharges accurately. The other is which optimization algorithms are suitable for the parameter identification.

Regarding the previous studies, there is a study that minimizes the weighted error of the discharges of the multiple water level stations by single-objective optimization. On the other hand, there are some studies that minimize the multiple error assessment functions of the discharge of a single water level station by multi-objective optimization. This presentation features to simultaneously minimize the errors of the discharges of the multiple water level stations by multi-objective optimization.

Abe River basin in Japan is targeted. The basin area is 567.0km^2. There are thirteen rainfall stations and three water level stations. Nine flood events are investigated. They occurred from 2005 to 2012 and the maximum discharges exceed 1,000m^3/s. The discharges are calculated with PWRI distributed hydrological model. The basin is partitioned into the meshes of 500m x 500m. Two-layer tanks are placed on each mesh. Fourteen parameters are adjusted to estimate the discharges accurately. Twelve of them are the hydrological parameters and two of them are the parameters of the initial water levels of the tanks. Three objective functions are the mean squared errors between the observed and calculated discharges at the water level stations.

Latin Hypercube sampling is one of the uniformly sampling algorithms. The discharges are calculated with respect to the parameter values sampled by a simplified version of Latin Hypercube sampling. The observed discharge is surrounded by the calculated discharges. It suggests that it might be possible to estimate the discharge accurately by adjusting the parameters. In a sense, it is true that the discharge of a water level station can be accurately estimated by setting the parameter values optimized to the responding water level station. However, there are some cases that the calculated discharge by setting the parameter values optimized to one water level station does not meet the observed discharge at another water level station. It is important to estimate the discharges of all the water level stations in some degree of accuracy. It turns out to be possible to select the parameter values from the pareto optimal solutions by the condition that all the normalized errors by the minimum error of the responding water level station are under 3.

The optimization performance of five implementations of the algorithms and a simplified version of Latin Hypercube sampling are compared. Five implementations are NSGA2 and PAES of an optimization software inspyred and MCO_NSGA2R, MOPSOCD and NSGA2R_NSGA2R of a statistical software R. NSGA2, PAES and MOPSOCD are the optimization algorithms of a genetic algorithm, an evolution strategy and a particle swarm optimization respectively. The number of the evaluations of the objective functions is 10,000. Two implementations of NSGA2 of R outperform the others. They are promising to be suitable for the parameter identification of PWRI distributed hydrological model.