Geophysical Research Abstracts
Vol. 20, EGU2018-3495, 2018
EGU General Assembly 2018

Neural networks mapping non-unique stage-discharge relationships in run-of-river impoundments

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Rating curves or stage-discharge relationships are convenient, widely used tools to determine flow rates from water-level data, which can often be recorded easily, reliably and at low cost. Rating curves typically work well in case a unique relationship exists between water-level elevation and discharge. In practice, conditions may, however, deviate from this uniqueness property (one-to-one relationship), due to, for instance, the impact of tides or a hysteresis loop with different relationships for rising and falling flow rates, resp.
Hydraulically similar to the problem type of tidal effects, the operation of hydropower plants along rivers may also affect water-depths within their respective reaches of impoundment. The obvious solution of the problem, i.e. to move the measuring station out of the impounded reach, will not always be feasible, especially in strongly regulated rivers with impoundments quasi 'overlapping' each other. In such cases, which are frequent in highly industrialized European countries, no unique rating curve can be established, as at least one (additional) downstream boundary condition must be taken into account as well. Thus, a nonlinear relationship between one output (the flow rate at the stream gauge) and at least two input variables (concurrent water-levels at the gauging station and at a site further downstream, reflecting the backwater effect due to hydropower plant operation) is to be determined. One or more further input variables may stem from the presence of tributaries, which, in turn, may affect the situation within the impoundment reservoir.
The work presented here addresses the application of Artificial Neural Network models to this kind of task, reporting the results of an Austrian pilot study conducted with data from the River Danube. Flow rates at the Danube stream gauge Mauthausen are not only a function of concurrent water-level elevations there, but are also affected by the operation of the run-of-river plant Wallsee-Mitterkirchen (not far downstream from Mauthausen) and by the inflow contributed by a major tributary, the Enns River. A feedforward error backpropagation neural network with an input layer comprising three input nodes, one hidden layer and one output node representing the concurrent Danube River flow rate at Mauthausen was developed and found to perform well.