Parameter Estimation for River Flows

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Abstract: Flows in open channels can be modeled by using the Saint-Venant equation under the assumptions: The pressure in the water obeys the hydrostatic pressure law, the bed slope is small, the effects of friction and turbulence can be characterized by a friction slope, and the course of a river should be straight enough to be transformed into a straight line. For a large river, some of those requirements cannot be satisfied, especially if the system has confluent (bifurcation) nodes. Hence, we have to divide the considered river system into a large number of sections so that the above assumptions can be considered as fulfilled, consequently, the Saint-Venant equation can be applied to each of them. We have to solve the two following problems:

- Estimating unknown parameters for river systems. Every above mentioned section has local geometrical and hydraulic parameters. Hence, the number of parameters for the whole system is very large, thus manual parameter estimation, as often done by hydrologists, does not work effectively anymore. To avoid this problem and to come up with accurate parameter values, we estimate these parameters by solving a corresponding least squares problem. This high dimensional nonlinear constrained optimization problem is solved by applying the special reduced Gauss-Newton method implemented in the software packages PARFIT and FIXFIT.

- Solving a system of Saint-Venant equations for the fixed parameters. We discretize this system of PDEs in space by using the method of lines to obtain a large time dependent system of ODEs connected by algebraic constraints, which is solved by the BDF method implemented in the solver DAESOL.

Some computational results of parameter estimation for the Red river are presented as concrete examples. These show that the software packages PARFIT, FIXFIT, and the solver DAESOL developed at the IWR (University of Heidelberg) are stable, efficient and robust tools for modeling and parameter estimation.

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