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# Computing continuous record of discharge with quantified uncertainty using index velocity observations: A probabilistic machine learning approach

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Application of the index velocity method for computing continuous records of discharge has become increasingly common, especially since the introduction of low-cost acoustic Doppler velocity meters (ADVMs). In general, the index velocity method can be used at locations where stage-discharge methods are used, but it is especially appropriate and recommended when more than one specific discharge can be measured for a specific stage such as backwater and unsteady flow conditions caused by but not limited to the following; stream confluences, streams flowing into lakes or reservoirs, tide-affected streams, regulated streamflows (dams or control structures), or streams affected by meteorological forcing, such as strong prevailing winds.
In existing index velocity modeling techniques, two models (ratings) are required; index velocity model and stage-area model. The outputs from each of these models, mean channel velocity (Vm) and cross-sectional area (A), are then multiplied together to compute a discharge. Mean channel velocity (Vm) can generally be determined by a multivariate regression parametric model such as linear regression in the simplest case.
The main challenges in the existing index velocity modeling techniques are; 1) Preprocessing and QA/QC of continuous index velocity data and synchronizing them with discharge measurements. 2) Nonlinear relationship between mean velocity and index velocity which is not uncommon at monitoring locations.
3)Model exploration and analysis in order to find the optimal regression model predictor(s) and model type (linear vs nonlinear and if nonlinear number of the parameters). 3) Model changes caused by dynamical changes in the environment (geomorphic, biological) over time 5) Deployment of the final model into the Data Management Systems (DMS) for real-time discharge calculation 6) Objective estimation of uncertainty caused by: field measurement errors; structural uncertainty; parameter uncertainty; and continuous sensor data uncertainty used for real-time derivation. Model uncertainty is often ignored but it is in fact an important source of uncertainty caused by building imperfect regression models due to lack of measurement and/or overfitting/under-fitting on data produced by the level of complexity of the model (number of model parameters).
In this presentation we demonstrate a solution to these problems using a novel machine learning techniques to use index velocity and field measurement observations with measurement uncertainty to build a non-parametric/non-linear self-adaptive Bayesian.