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Stage-discharge rating curve model including the effect of seasonal aquatic vegetation

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The stage-discharge relations at hydrometric stations with aquatic vegetation are non-unique as they vary continuously in time due to the vegetation evolution. Maintaining rating curves for establishing discharge time series at such stations is therefore difficult. To our knowledge, no rating curve model but only manual adjustment methods (e.g. shift corrections of the base rating curve or of the stage time series, use of temporary rating curves that are built based on recent gaugings) exist to deal with such stations. To fill this gap, we have developed a dynamic rating curve model accounting for transient changes due to vegetation.

In most situations, the presence of plants induces temporal changes in bed roughness and impacts the flow resistance. The wetted area may also be reduced according to the density of plants present in the river bed and on banks. In this work, we focus only on the first cited impact. A simplified version of Järvelä (2004) equation is used to account for flow resistance variations, which are relative to the vegetation growth and its ability to bend. The bending function depends on the flow velocity and on the bio-mechanical characteristics of the plants (their flexibility). The vegetation growth is modeled using a modified version of Yin (2003) temporal equation initially used to predict the evolution of plant biomass. The plant growth cycle is described using four characteristic times corresponding to the start of growth, the maximum growth rate, the end of growth and the plant extinction.

The model was implemented in a numerical code, called BaM!, with the final aim to use it for operational purpose. BaM! enables estimating the parameters of the model (with their uncertainties) through Bayesian inference using prior knowledge on the hydraulic controls of the station and gauging data. The uncertainties of both sources of information are included. Two types of observations are required to be able to predict discharge, namely stage-discharge measurements (gaugings) and vegetation observations. Vegetation observations can be translated into a state of growth of the plant and then positioned within the vegetation cycle. The specific amount of biomass is thus not required. The model was tested on a French hydrometric station for which a lot of hydraulic gaugings and comments about vegetation are available over more than 20 years. For this particular case, the relative errors between the simulated discharges and the observed discharges were mostly ranging between $\pm$ 10%. New cases need to be tested for validation, and some improvements are already planned for the foreseeable future, as for example taking into account potential perturbations of the growth cycle (flood, brutal temperature drop).