Mechanistic modeling of glaciated alpine basins: model development

P. Perona and P. Burlando

Institute of Environmental Engineering, ETH Zurich, Switzerland

The seasonal behaviour of water inputs, storage and melting in alpine basins may hide some clues of low dimensional determinism arising from the intrinsic role that the annual temperature evolution plays in such environments. Extracting such determinism would therefore help understanding the long-term dynamics of such hydrologic systems and, in turn, to point out their relation to climatic forcing. This work presents a mechanistic hydro-climatic model for glaciated alpine basins, inferred from measured precipitation p, temperature T and river runoff Q. This model is a 2-D input/output nonlinear differential (flow) model, which describes the seasonal dynamics of the volume V of water that is stored on the basin and the runoff Q at the basin outlet. The model structure is built by assuming that a low-dimension determinism governs the dynamics of glaciated alpine basins, and by deducing the link among the quantities p, T, Q, V from the observed data. The resulting differential model has a polynomial form with 7 unknown coefficients, the numerical value of which is reconstructed using the "Trajectory Method" for the reconstruction of differential equations from time series. The reconstruction takes place by working on the observed data trajectory in the state plane (V, Q), thus allowing for a potentially stable nonlinear fitting of the flow. After the fitting, the model accurately mimics the original data and seems to have captured some essential properties of the underlying dynamics. Hence, the model offers a unique dynamical system interpretation of the hydro-climatic behaviour of glacial alpine basins in terms of its damping and elastic properties and their link to the hydro-climatic variables (p, T). Applications to experimental glacial basins are presented in a companion paper ("Mechanistic modeling of glaciated alpine basins: case studies", by Perona, Pasquale and Molnar, this Session).