New trends in numerical simulation of shallow flows with application to basin management for Hydroelectric generation

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Abstract

Basin regulation of rivers and affluents is always a hot topic when planning and managing water resources for the production of hydroelectric energy. Nowadays the amount and quality of data offers to practitioners new opportunities in the modelization of the domains of analysis that till recently where not affordable. Flow in rivers is commonly shallow and therefore vertical scales can be ignored by depth averaging its properties. These hypothesis allows to define flow circulation by means of one and two dimensional version of the SWE (Shallow Water Equations). Even being much less computational expensive that tree dimensional models, in the past, evolution of flooding waves was predicted by conceptual models, without a physical base. The development of computer technology has allowed to use very simplified versions of the one and two dimensional shallow water equations, but always in reduced domains, in coexistence with conceptual models. Most popular simplified version is the kinematic wave equation, that due to its simplicity is unable to predict reasonable results in a variety of flow conditions. Despite of having well known problems regarding numerical stability and considering that computational efficiency has exponentially increased in the last years, simplified model are still widespread used when modeling basin evolution. The main reason is that the whole set of equations shaping the shallow water equations has been traditionally considered computationally very expensive. In fact, solving the complete shallow equations has a higher cost if compared with simplified models that only require the resolution of one equation, but the computational cost can also be attributable to the numerical tool used to solve the equations. It is worth mentioning that earlier solvers were based in numerical technology generated for gas dynamics. These type of equations present similarities with the properties of the SWE, with the exception of the presence of source terms, that involve the bed slope and the bed friction. Recently, the construction of numerical schemes properly defined to solve the SWE with its own characteristics, has allowed an increase in the computational efficiency, while the simplified models, that still present problems regarding their stability as they can not afford
all type of waves present in the flow. The definition of proper numerical techniques also allows the combination of one and two dimensional SWE, reducing strongly the computational cost. Then, new opportunities appear, not only in the type of possible flows that can be predicted, but also from the combination with high performance computing techniques, such as distributed computing or GPU programming, that allow simulations of extensive hydraulic domains during long time events. In this context, the use of SWE can also be expanded to analyze the effect of the regulation in water quality, sediment transport and other type of environmental parameters.

References


