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Simulation of extreme reservoir level distribution with the SCHADEX method (EXTRAFLO project)

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The standard practice for the design of dam spillways structures and gates is to consider the maximum reservoir level reached for a given hydrologic scenario. This scenario has several components: peak discharge, flood volumes on different durations, discharge gradients etc. Within a probabilistic analysis framework, several scenarios can be associated with different return times, although a reference return level (e.g. 1000 years) is often prescribed by the local regulation rules or usual practice.

Using continuous simulation method for extreme flood estimation is a convenient solution to provide a great variety of hydrological scenarios to feed a hydraulic model of dam operation: flood hydrographs are explicitly simulated by a rainfall-runoff model fed by a stochastic rainfall generator. The maximum reservoir level reached will be conditioned by the scale and the dynamics of the generated hydrograph, by the filling of the reservoir prior to the flood, and by the dam gates and spillway operation during the event. The simulation of a great number of floods will allow building a probabilistic distribution of maximum reservoir levels. A design value can be chosen at a definite return level.

An alternative approach is proposed here, based on the SCHADEX method for extreme flood estimation, proposed by Paquet et al. (2006, 2013). SCHADEX is a so-called "semi-continuous" stochastic simulation method in that flood events are simulated on an event basis and are superimposed on a continuous simulation of the catchment saturation hazard using rainfall-runoff modelling. The SCHADEX process works at the study time-step (e.g. daily), and the peak flow distribution is deduced from the simulated daily flow distribution by a peak-to-volume ratio. A reference hydrograph relevant for extreme floods is proposed. In the standard version of the method, both the peak-to-volume and the reference hydrograph are constant.

An enhancement of this method is presented, with variable peak-to-volume ratios and hydrographs applied to each simulated event. This allows accounting for different flood dynamics, depending on the season, the generating precipitation event, the soil saturation state, etc. In both cases, a hydraulic simulation of dam operation is performed, in order to compute the distribution of maximum reservoir levels. Results are detailed for an extreme return level, showing that a 1000 years return level reservoir level can be reached during flood events whose components (peaks, volumes) are not necessarily associated with such return level.

The presentation will be illustrated by the example of a fictive dam on the Tech River at Reynes (South of France, 477 km^2). This study has been carried out within the EXTRAFLO project, Task 8 (https://extraflo.cemagref.fr/).

References:
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