Assessment of the impact of climate change on the hydrological safety of the Eugui Dam (Spain) with gated spillways

Enrique Soriano[1], Andrea Petroselli[2], Davide Luciano De Luca[3], Ciro Apollonio[4], Salvatore Grimaldi[5] and Luis Mediero[1]

(1) *Department of Civil Engineering: Hydraulics, Energy and Environment, Universidad Politécnica de Madrid, 28040, Madrid, Spain*
(2) *Department of Economics, Engineering, Society and Business (DEIM), Tuscia University, 01100, Viterbo, (VT), Italy*
(3) *Department of Informatics, Modelling, Electronics and System Engineering, University of Calabria, 87036, Arcavacata di Rende (CS), Italy*
(4) *Department of Agriculture and Forest Sciences (DAFNE), Tuscia University, 01100, Viterbo, (VT), Italy*
(5) *Department for innovation in biological, agro-food and forest systems (DIBAF), Tuscia University, 01100, Viterbo, (VT), Italy*

Dam breaks can cause important economic and human losses. Dam spillways are designed from either hydro-meteorological or statistical analyses with observed data. However, time series of observations are usually short, incomplete and recorded at a daily time step. Moreover, design floods have to be estimated for high return periods usually greater than 500 years, arising high uncertainties. In addition, climate change is expected to increase the frequency and magnitude of floods in the future. Therefore, new methodologies are required to assess hydrological dam safety considering both short time series of observations and climate change.

In this study, a stochastic methodology is presented to assess hydrological dam safety considering the impact of climate change on floods, by integrating a stochastic rainfall generator and a continuous rainfall-runoff model. The methodology is applied to the Eugui Dam on the Arga River in the north of Spain, characterized by a catchment area of 69 km^2, a reservoir volume of 22 hm^3, and a gated spillway.

First, the stochastic rainfall generator STORAGE (De Luca and Petroselli, 2021), based on the Neymann-Scott Rectangular Pulse Model, is used to simulate time series of 500 years of precipitation with a time step of 15 minutes. The generator is calibrated with rainfall observations. In addition, the STORAGE model parameters are adapted to generate time series considering the effect of climate change. Delta changes extracted from precipitation projections of 12 climate models, three periods (2011-2040, 2041-2070, 2071-2100) and two emission scenarios (RCP 4.5 and RCP 8.5) are considered (Garijo and Mediero, 2019).

Second, the stochastic precipitation time series are transformed into runoff time series by using the COSMO4SUB model (Grimaldi et al., 2021). COSMO4SUB is a continuous rainfall-runoff model that uses a high-resolution digital terrain model, land cover and soil type data, and precipitation supplied by the STORAGE model as input data, providing continuous runoff time series as output. The COSMO4SUB parameters have been calibrated with runoff observations by minimizing a set of objective functions.

Third, annual maximum hydrographs, characterised by peak flows and hydrograph volumes, are extracted from the runoff time series generated by COSMO4SUB. The Volume Evaluation Method (MEV) (Girón, 1988) is used to simulate the operation of spillway gates in flood events, obtaining maximum reservoir water levels and outflow hydrographs. The MEV method specifies when the spillway gates have to be opened and closed to reach the target reservoir water level at the end of the flood event. Hydrological dam safety at the

Eugui Dam is assessed by analysing the frequency curve of maximum reservoir water levels for the climate change scenarios mentioned above.

The methodology proposed allows practitioners and dam owners to check the hydrological dam safety requirements detailed in the regulations, including the expected impact of climate change on floods.

References

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