Climate change impacts on outflow discharge resealed by dam to laminate more extreme events in the future

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Floods are expected to be more frequent and harmful in the future under some climate projections in Europe (Alfieri et al., 2015). In this context, hydrological dam safety may also change in the future, as floods are the hydrological load in dams. In a previous study, the impact of climate change on expected maxima reservoir water levels was quantified at the Eugui Dam (Spain). This study focuses on the impact of climate change on the outflow discharges at the Eugui Dam (Spain), quantifying also the expected changes in flood damages in the Metropolitan Area of Pamplona located downstream of the dam.

The methodology is divided into six parts: i) evaluation of future inflow hydrographs in the reservoir; ii) estimation of the impact of climate change on initial reservoir water levels at the beginning of flood events; iii) definition of a stochastic procedure to combine the probabilities of inflow hydrographs and initial reservoir water levels, simulating flood routing in the reservoir; iv) assessment of all the uncertainty sources in the procedure; v) hydraulic modelling of fluvial floods generated by the River Arga in Pamplona; and vi) assessment of flood damages in Pamplona with the SaferPlaces platform (Mediero et al., 2022).

Expected changes in flood quantiles were assessed in Lompi et al. (2021), using climate projections supplied by 12 climate models in two emission scenarios (RCP 4.5, RCP 8.5) and three time windows (2011-2040, 2041-2070, 2071-2100) (Garijo and Mediero, 2019) as input data in the RIBS (Garrote and Bras 1995a) fully-distributed hydrological model. Reservoir water level frequency expected in the future is obtained combining the HBV continuous hydrological model (Bergstrom 1992), to simulate future daily inflow discharges in the Eugui Dam, with a reservoir operation model, to obtain daily outflow discharges. The stochastic procedure generates 10.000 random initial reservoir water levels and inflow hydrographs with a 15-minute time step for each scenario. Flood routing in the reservoir is simulated using the Volumetric Evaluation Method (VEM), obtaining 10.000 maxima reservoir water levels and outflow discharges. Uncertainty in estimates of rainfall delta changes, inflow hydrographs given by the RIBS model, and reservoir water levels associated to HBV biases are considered. The uncertainty chain assessment provides the median values of the future outflow discharges with a confidence level represented by six percentiles (5^{th}-95^{th}, 10^{th}-90^{th}, and 32^{th}-68^{th}).

The River Arga in the city of Pamplona has a catchment area of 510 km^2. The Eugui Dam has a catchment area of 69 km^2. The median values of maxima outflow discharges released by the dam are summed to the natural contribution of the catchment downstream to the dam, obtained with the RIBS model, for all the scenarios. Water depths in the Pamplona Metropolitan Area are simulated with IBER (Bladé et al., 2014) that is a 2D hydrodynamic model. Finally, flood damages in Pamplona are obtained by the SaferPlaces Platform, highlighting an increase of the hydraulic risk in the future, especially in the RCP 8.5 at the end of the century.

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