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Discussions

Interactive comment on "Quantification of climate change impact on dam failure risk under hydrological scenarios: a case study from a Spanish dam" *by* Javier Fluixá-Sanmartín et al.

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In this paper, authors propose a comprehensive framework for assessing dam failure risk under climate change, and apply their framework to a Spanish case. They use the classic definition of risk as the expected value of annual damages, use a sophisticated hydrological and water resource management model, consider several sources of failures and several climatic futures. Overall, this piece is a thorough and widely applicable methodology for engineers to assess risks to water infrastructure. It is of fairly good quality but could become excellent research with a thoughtful revision.

My main concerns are about 1) the lack of specifics and metrics for the hydrological

(and water resource) model validation, 2) the lack of critical analysis associated with the production of risk indicators associated to very high magnitude, very low probability events when only having a comparatively short flow record in hand, and 3) how results can be made meaningful for risk and resilience planning in a changing world.

I would advise authors to prioritise these aspects when preparing a revised version of this manuscript. A general remark is that authors seem keen to follow governmental guidelines and engineering practice, but the purpose of research should be to inform and improve these instead. For instance, research can do so by pointing out the limitations of engineering regulations and practice as a first step towards improving them. There is scope for authors, by engaging in a critical reflection of the assumptions they had to make, to shed light on the limitations of the current guidelines, and on which assumptions are critical. This would be a well-thought-out research publication with real-world consequences for engineering practice. This would require little extra modelling work, even though a basic sensitivity analysis would be a low-investment, high-reward endeavour in that it would highlight the parameters that have an outsized influence on the final risk indicators (and this would ease their discussion of which assumptions are critical).

1) Calibration / validation is not very precise on how much data there is to calibrate / validate against (how many years?), how the different periods are divided, or what the calibration criteria are. In particular, the quality of the fit (measured with Nash-Sutcliffe or Kling-Gupta) should be disclosed.

Figure 6: I understand this is simulated vs. observed daily flow from January 1st 2011 to December 31 2015. This should be made clearer, e.g. by inserting specific dates on the x-axis instead of having year labels at the middle of each year. Also on the same figure: why are the calibration results presented only for 2011-2015, a short five-year period? I understand the choice for figure presentation, but I would assume that the model is calibrated / validated against a longer period, and that should be made clear in the text.

More importantly maybe, it is not clear how the peak magnitudes in the model and observations match, and this is the crucial part of the flow for dam safety. Would it be possible to plot the differences between the two for days with flows have a certain threshold? Or for annual maxima (since those are the days used to derive the Gumbel distribution)? Likewise, the most important component of the hydrological model validation is whether the behaviour at high storage is reproduced for events during the historical record. In 2001 in particular, simulated reservoir levels are higher than observed levels: authors should understand why that is and what may be the consequences for their model-based risk assessment.

In summary for 1), authors should be more precise in the calibration and validation procedures, especially concerning the consequences of the choice of validation metrics on the risk assessment.

2) The lack of depth of the analysis of the relationships between modelling assumptions, the uncertainties associated with them, and modelling outcomes is not limited to the calibration of the hydrological and water resource models.

A central observation regarding this analysis is that risks to the dam are fully dependent on the existence of rare events whose probability of occurrence is extrapolated by fitting a predetermined distribution to short (< 100 data points) annual maxima time series. This has several consequences:

(i) The magnitudes of very long return period events will almost certainly be very sensitive to the parameters of the fitted distribution (not to mention the fact that other distributions than Gumbel's exist), so it seems compulsory to quantify the uncertainty on the Gumbel distribution's parameters, and understand the consequences of that uncertainty on the results.

(ii) Similarly, the choice of data (annual maxima vs. peak over threshold) may influence the estimates and therefore, risk indicators.

(iii) The formula linking hourly and daily intensity (equation (3)) is climate- and location-dependent, and the study explores future climates for which the parameters of this formula may change.

Authors could improve the value of their manuscript by showing how accounting for uncertainty in the estimates could change failure probabilities. Similarly, while readers can only appreciate the inclusion of gate performance indicators, the consequence of the assumptions of deterioration in performance on the overall results should be clarified (in other words, how does deterioration in gate performance affect future probabilities of failure?).

3) Maybe it is because the visuals are not conclusive (they often tend to show a risk increase but individual models / scenarios are all over the place), but it is not clear what the results mean for reservoir managers and planners. I would suggest for authors to present the ensemble of climate projections they use as... an ensemble, by deriving mean / uncertainty (e.g. standard deviation?) for each emission scenario and each period. Uncertainty analysis on the parameters that influence risk indicators calculation (see remarks (2)) would make these estimates of ensemble mean and standard deviation more robust and enable them to present their results in a way that can inform decision-making.

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