AUTHOR'S RESPONSES TO REFEREE #2

These are the Authors' replies to comments from Referee #2, received and published on 5 August 2019. We use blue colour for our replies and black colour for Referee's comments.

RESPONSES:

Firstly, we want to sincerely thank Referee #2 for the remarks and recommendations which will undoubtedly improve the quality and scope of the paper.

The manuscript contributes to the knowledge of how climate change might affect dam risk management and the definition of long-term strategies to reduce risk. The paper presents a method for addressing different climate change scenarios to evaluate their influence on future risk. The results obtained for the case study show how dam failure risk may vary depending on different scenarios and identify the most influencing factors regarding affected risk components (e.g. estimated income floods or reservoir levels). The proposed method can be applied to evaluate the potential impact of climate change in other cases and provides a tool for applying a dynamic approach in terms of risk analysis and management. This topic fits well into the scope of the Journal. In my opinion, the methodological approach and the discussion of results are of interest for the general audience of the journal and the paper deserves publication.

However, I include several specific questions which clarification could improve the quality and understandability of the paper, and should be addressed:

- Page 3. Line 15. Regarding the definition of study periods, for the Base Case, please further explain the reasons why the period 1970-2005 is selected and whether it is proposed as a general approach.
  The 1970-2005 period has been selected as the Base Case because it was the longest period for which we had both observed and historical data (for the climate projections).
- Section 3 would require further description on why this case study has been chosen for the conducted research and why the analysis of the impact of climate change is of interest for this dam.
  A risk analysis was already applied to the Santa Teresa dam in a previous study (Ardiles et al., 2011; Morales-Torres et al., 2016). Results from this study showed that, although the dam didn't required urgent correction measures, its risk was important enough to be carefully monitored. Thus, we considered interesting to evaluate if the risk situation of the dam was expecting to increase and thus immediate actions were necessary, or if its risk was expected to decrease until no urgent actions were necessary.
- Section 4. Page 9. Please further describe why different maximum water pool levels per month are considered for the case study.
  In this particular case, different maximum water pool levels are considered for each month because of the expected seasonality of high flows which tend to increase in winter (December to February). In prevision of important water volumes entering the reservoir, the dam exploiters increase the freeboard volume to absorb them. These exploitation rules are contained in the Hydrological Plan of the Duero River Basin (Confederación Hidrográfica del Duero, 2015).
- Section 5.2.1. A more detailed description of the calibration process for the hydrologic-hydraulic model is required (parameters calibrated, efficiency indicators used, etc.).
  Please refer to the author's response to Referee #1 concerning this matter. More details about the calibration process will be included in the reviewed version of the paper.

- Section 5.3.1. Page 17. Line 20. The authors introduce the concept of event tree not yet described up to this point. Please contextualize the link between the proposed risk model and the event tree mentioned in this section.
  Event trees help representing all the possible chains of events resulting from an initiating event and are used as a basis for the dam risk model used in the manuscript. A detailed description will be included in the reviewed version of the paper.
- Section 5.3.4. Further details on how variations on the population and water supply demands are considered in future scenarios in terms of potential economic consequences (i.e. in terms of future demands) would be convenient. Do the authors consider that provided services remain unchanged in future scenarios?
  Although population and water demands are supposed variable with time in the paper, for simplicity no new services are considered in the future. This will be included in the reviewed version of the paper.
- Section 7. Conclusions:
  - The added value of using risk models to integrate information on projected effects of climate change is highlighted, however, how the proposed approach can be adapted to low-data available cases?
    The paradigm of low-data study cases has not been considered in this work. Under such circumstances, another approach might be of use. We encourage Referee #2 to consult a previous paper of the authors (Fluixá-Sanmartín et al., 2018) where this situation is tackled.
  - In terms of supporting dam safety management, how results for this case study will influence long-term actions for this dam? Please describe how obtained results can be considered for the definition of future actions (for instance, in terms of new operating rules or water pool levels).
    Although this work represents a useful tool for dam safety management, it is clear that further analyses are required before decision can be made. In particular, the uncertainty associated to future risks imposes a deeper evaluation of the recommendations to make. However, this problem as well as some suggestions will be mentioned in the new version of the paper.
  - A sensitivity analysis has been included to evaluate the impact on risk of each factor independently. A short discussion regarding uncertainty analysis would improve this section (e.g. their influence on risk outcomes).
    As suggested by Referee #2, a discussion on uncertainty will be included in the conclusions section.

In addition, please note the following suggestions regarding technical corrections:

- The size, quality and readability of figures is very good in general, although some figures might be improved (e.g. Figure 10).
  The composition of the figures will be re-evaluated to increase their readability.
- A list of minor corrections is here included:

Page	Line	Comment
1	29	these impacts
5	Figure 1	assess climate change impacts on
5	6	dam built in 1960
5	9	concrete gravity dam
6	12	AEMET. Please describe acronym.
6	17	CEDEX. Please describe acronym.

6	18	in this same platform.
8	15	of potential incoming floods
8	16	from the flood routing
8	17	gate availability
9	6	consequences for the non-failure case
9	26	reservoir's releases
9	29	is the limited water storage in the Santa Teresa reservoir
9	31	Consider replacing "in the computation of the risk model since they define the maximum possible water level issued from the study of previous pool levels" by "for estimating water pool levels"
12	11	divided into subbasins
12	17	The calibration process presents
13	13	Check sentence construction
13	15	Concerning basin discharges
14	5	by the Hydrological Plan
14	8	Consider replacing "The validation of this water resources model" by "model validation"
14	10	As shown
14	10	results performance
14	14	is not capable
14	16	Once the model is validated
15	21	Consider replacing "The time distribution of the rainfall" by "Temporal rainfall distribution"
17	1	Consider replacing "The characterisation of the peak discharges with their return Period" by "Peak discharge by return period"
17	11	and the social consequences used to compute the social risk
17	12	other risk model components
17	11	spillway gate and bottom outlet performance
17	15	increasingly
19	7	Consider replacing "will go from" by "will vary"
20	19	Reference is required
25	Tables	RCP2.6

We will take into account the Referee's remarks and corrections and will include them in the new version of the paper.

REFERENCES

Ardiles, L., Sanz, D., Moreno, P., Jenaro, E., Fleitz, J. and Escuder-Bueno, I.: Risk Assessment and Management for 26 Dams Operated By the Duero River Authority (Spain), in 6th International Conference on Dam Engineering, C.Pina, E.Portela, J.Gomes, Lisbon, Portugal., 2011.

Confederación Hidrográfica del Duero: Plan Hidrológico de la parte española de la demarcación hidrográfica del Duero. 2015-2021. [online] Available from: www.chduero.es, 2015.

Fluixá-Sanmartín, J., Altarejos-García, L., Morales-Torres, A. and Escuder-Bueno, I.: Review article: Climate change impacts on dam safety, Natural Hazards and Earth System Sciences, 18(9), 2471–2488, doi:10.5194/nhess-18-2471-2018, 2018.

Morales-Torres, A., Serrano-Lombillo, A., Escuder-Bueno, I. and Altarejos-García, L.: The suitability of risk reduction indicators to inform dam safety management, Structure and Infrastructure Engineering, 1–12, doi:10.1080/15732479.2015.1136830, 2016.