Journal: NHESS
Title: **How do changes along the risk chain affect flood risk?**
Author(s): Metin et al.
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The objective of the paper is to contribute in filling the gap in current understanding of the roles of the different components of the risk chain on changes in flood risk. To this aim a simulation-based approach is implemented where, starting from the investigation of a baseline scenario, six components of the risk chain are changed (namely: climate change, implementation of reservoirs in the catchment, flood protection along the rivers, land use change, change in asset values and changes in the vulnerability of flood-affected objects) by both increasing and decreasing their reference value. Thanks to the implementation of the DFRA, this allows to simulate 729 damage series (of 4000 years) from which the EAD and the risk curve are derived and investigated: (i) at the catchment scale, (ii) at two typical upstream and downstream sub-basins, and (iii) for summer and winter seasons.

The topic of the paper is in the scope of NHESS and results can contribute to a better understanding of flood risk and risk mitigation strategies, also in the light of future climate change. The paper is overall clear, well-structured and well-written; conclusions are mostly supported by simulation results. Still, there are some points that need further clarification or that must be better explained in order to make the paper totally understandable; these are reported as "specific criticisms". On the other hand, in the following, some suggestions are reported that could increase the robustness and the completeness of the research.

Suggestions

- The choice of considering a double storage capacity as the change in the catchment hydrology is not totally clear to me. In the light of choosing "plausible deviations from the baseline", it makes more sense considering a change in the operational rules like, for example, in the value of the cut-off discharge. I suggest authors to explore also this scenario;
- Again, in the light of choosing "plausible deviations from the baseline", also the change in building quality should be investigated. This is a quite cheap strategy for risk mitigation that can be easily encouraged/achieved by public and private incentives. I suggest authors to explore also this scenario;
- The whole analysis is based on the estimation of damage to the only residential sector. Still, risk can be heavily affected by damage to other sectors like agriculture, commerce, tourism, population, etc. For some of these sectors flood damage is strongly related to the season of occurrence of the event (e.g. agriculture, tourism), and it may be the case that the effect of climate change on such sectors modifies present conclusions on EAD and on the role of the different components of the risk chain. I think that more than one sector should be included in the analysis or, at least, some considerations must be added on the possible role of damage to other exposed sectors.

Specific minor comments (which can increase the readability and clarity of the paper)

<u>Section 1</u>

Pg. 2 line 65 "A major problem is the superposition of several drivers of risk changes" → what authors mean here with "superposition"? Please, specify

<u>Section 3</u>

Pg. 6 line 164 "the approach provides the complete flood hydrograph" → on a daily base, is it correct?

Pg. 6 line 166 “the spatial dependence between flood damages at different locations in the catchment is taken into account” → what authors mean with “spatial dependence between flood damages at different locations”? Please, specify

Pg. 7 line 183 “The weather generator is parameterized on a monthly basis.” → this is already stated in the following page. The sentence can be deleted

Pg. 8 lines 215 -221 → Some assumptions made for the modelling of reservoirs are not totally clear to me: (1) are reservoirs empty at the begging of the simulation? If yes, is it realistic? If no, which is the initial volume? Why? (2) What happens if the storage capacity is reached before the discharge falls below HQ100? (3) Why the return period of 100 years was chosen? Is it the design return period of dikes? (4) Which is the necessary information collected from Sächsisches Landesamt für Umwelt und Geologie?

Pg. 9 line 226 “The calibration and validation results illustrate obvious improvement in this new model setup compared to the version used in Falter et al. (2015)” → I cannot appreciate this improvement in Figure 3. On the left, only results from the new model and observations are reported so I cannot see the difference between the two models. Graphs on the right suggest that the two models are mostly equivalent. Please, comment on this

Pg. 9 line 231 “with the new setup, the SWIM model seems to be able to represent the cut-off process more accurately” → Of course, the old model did not consider cut-off

Pg. 10 line 254 “the minimum height was assumed at 1.8 m” → on which bases?

Pg. 10 line 255 “the 2D raster based model uses a 100 m resampled computational grid from DEM10, which was found an acceptable compromise for representation of inundation characteristics and computation time” → I think some considerations must be included on topography. 100 m can be enough in flat areas (i.e. downstream) but can introduce big errors in damage estimation in steep areas (i.e. upstream). Did authors consider different resampling of the DEM in different areas of the catchment?

Pg. 10 line 265 “Although there is an underestimation of inundation, the model gives a reasonable estimate of inundation extent and depth for large-scale assessments” → which are the bases for this statement? 50% underestimation in flood extent is a significant error in my point of view

Pg. 11 lines 275-282 → I think that assumptions made for the estimation of damage must be better explained: (1) which is the scale of analysis? The 100*100 m2 cell? The municipal scale? Other? (2) how building type and level of precaution are assessed? (3) do asset values depend on building quality and type?

Pg. 11 line 283 “The sum of damages for all communities was officially reported as €240 million” → does it refer to the total damage or damage to residential buildings?

Pg. 11 line 285 “This underestimation may be explained by uncertainty in asset values and their spatial distribution and uncertainty in the damage model” → and underestimation of flood extend I guess

Pg. 11 line 302 “For example, the baseline scenario of the catchment component is represented by a model version calibrated for a recent time period and including the current implementation of reservoirs in the catchment. The specific time periods and assumptions for the baseline scenarios are given in sections 3.1.1 to 3.1.4 where the implementation, calibration and validation of the different modules for the current situation are described” → the meaning of the baseline scenario is clear to the reader at this point of the paper. This sentence can be omitted.

Pg. 13 line 356 – 360 → Are studies made in the Netherland transferable to the Mulde catchment? What authors mean with "potential" dike heightening? Potential with respect to what?

Pg. 13 line 364 "The change scenario EL2 is based on the increase in area of these two classes from 672 to 784 km2 between 1990 and 2012 where the change area was added to baseline scenario" → How the urban area was changed? I can understand this only at pg. 21

Pg. 13 line 367 "Pixels (100 x 100 m2) of the classes 111 and 112 were assigned to non-residential land cover classes (i.e. agricultural areas and semi-natural areas)" → how pixels were re-assigned? Why authors did not consider CORINE land use map of 1990? I think it is more realistic.

Section 4

Pg. 14 line 405 "This non-symmetry in the effects of the catchment component is explained by the specific implementation of the reservoir capacity: Implementing a capacity of 106 million m3 reduces the EAD significantly, but doubling this reservoir capacity at the same locations does not further reduce the risk substantially, because the damage is primarily generated at other locations within the catchment" → not clear, the role of reservoirs is not reducing damage downstream? Please, clarify

Pg. 16 line 455 "Regarding the change in catchment hydrology (C), change in flood storage capacity has a more dominant impact upstream which is explained by the reservoir locations. Due to the assumped reservoir operation the reservoir impact is only visible for very low probability events at the downstream sub-basin" → I still do not understand the influence of reservoirs in the catchment. Readers should be supported by a better description/discussion of the location of reservoirs with respect to the sub-basins.

Pg.17 line 464 "From the risk curves of different land use scenarios, it should be noted that the increased urban area scenario (EL2) increases risk upstream for high probability events" → I cannot see the difference between EL2 and the baseline scenario in Figure 7. Is one curve missing?

Pg. 17 line 468 "the baseline land use scenario (EL1) and the EL2 scenario behave almost identical upstream which can be explained by the steep topography" → I guess it depends on the rules adopted for increasing the urban area and on how the flood extent changes for different return periods

Pg. 17 line 472 "This can be explained by the specific setup of the residential buildings added in EL1 which are not exposed to floods." → not clear, please specify

Pg. 19 line 523 "Under the fixed A2 scenario, five scenario combinations are highlighted, each time altering a different component from its baseline value towards EAD decrease" → I can see four combinations leading to lower EAD. Could authors check?

Figures

Figure 1 – subcatchments are not visible in mountain areas

Figure 2 – (1) please specify what authors mean with XS profile (2) output of the flood loss model is missing (3) level of precaution and contamination are missing in the box related to FLEMOps

Figure 4 – I think that the figure is not explicative of the logic tree. Please, consider changes.

Figures 6, 7 and 8 are too small

Bibliography

I did not check the bibliography at this stage of the review. I reserve to do this in a second time.