

Response reviewer 2

Authors: We thank the reviewer for her/his time to read the paper and provide very detailed comments. We found the comments and suggestions helpful, and we have revised the paper accordingly. We think that the revised paper has been significantly improved.

Reviewer 2: Lack of adequate referencing

Key references of this work are the following: a. Bishop, C. M. (2006), Pattern Recognition and Machine Learning, Springer, ISBN 978-0-387-31073-2 b. The two works: Solomatine, D.P., Ostfield, A. Data-driven modelling: some past experiences and new approaches. Journal of hydroinformatics, 10 (1), 3-22; Dibike, Y.B., Solomatine, D.P., 2001. River flow forecasting using artificial neural networks. Physics and Chemistry of the Earth Part B: Hydrology, Oceans and Atmosphere. Volume 26, Issue 1, Pages 1-7. c. The ebook "GFDRR. 2018. Machine Learning for Disaster Risk Management. Washington, DC: GFDRR.

May be others are also included, but I do believe a much wider bibliography is needed to support this work. In fact, the first two are surely crucial supporting references, but are not adequately representing and supporting the submitted research/perspective, considering that after 2001 and 2006 tremendous advancements and scientific production was developed not only for ML in general, but within the topic of ML for floods specifically (see quick search on SCOPUS below in Figure 1 and Figure 2).

Authors: Thank you for this feedback. We have added 21 additional references to further support the paper. As such and while still not exhaustive, the list of 96 references included in our manuscript cover key contributions relevant to understand current state of the art in applications of machine learning methods for flood risk and impact analysis.

Reviewer 2: Summary and review of state of the art ML

I'd suggest authors to better introduce and categorize major concepts, procedures and tools of ML. In the introduction the reference to Bishop's book is then followed by few specific examples (see also specific comments). I'd see here a flow chart or summary table to improve the manuscript while addressing this general remark. I'm sure authors can benefit and extrapolate the work already done and cited within the GFDRR book on the topic. Additional scientific referencing can further strengthen this important part of the manuscript where the reader will be guided with key concise definitions and adequate referencing on state of the art ML for earth/geo/water science and flood risk management in particular. Please see this general comment as a further extension of general comment n.1, a surely expected contribution by authors to better support and introduce the final findings/perspectives of this work.

Authors: We described the state of the art of machine learning for flood risk assessments with numerous references within specific sections on exposure, hazard and impact. We choose this structure so we can, for each topic, transition easily from what is already being done to what could be done in the future, and directly discuss the difference between science and application. This gap between science and application causes a lot of grey area in the state-of-the-art description and makes it therefore necessary to do this in the main body of the paper. In a traditional research paper this information would indeed all be expected in the introduction, but this paper is a perspective on the latest scientific advances and how they can be extrapolated and be applied. The introduction therefore remains on a somewhat higher level of abstraction. We have further added a description of the paper structure up front in the in the introduction.

As for the state of the art on machine learning techniques themselves, we deliberately focused on applications of these methods (i.e. what can you do with it) rather than theory (i.e. how do they work). For each method presented, we included references to papers and books that describe the specifics of the algorithms and underlying theory. Our target audience are flood risk management experts interested to understand the potential applications of these methods. We believe that covering theory of the ML methods would be beyond the scope of the paper, and detract readers from the main messages communicated. We did expand the description of the advances in machine learning to better highlight what is possible with the latest innovations that wasn't possible before (see also response to reviewer 1).

Reviewer 2: Structure of the manuscript

Sections 2, 3 and 4 should be merged into a Section 2 with subsections. I see the three components "exposure, hazard and impact" as a unique core section with subsections related to descriptive versus predictive assessment models and related comments.

Authors: We merged sections 2, 3 and 4 into one section.

Reviewer 2: Scientific soundness of the "Perspectives" section

Section 5 seems to be a bit general. As requested to Invited perspectives my opinion is that authors miss to explicitly include in the paper sound arguments, facts, published research studies to support the conclusive remarks. Those remarks remain, in fact, general and simplistic relying on few selected, yet relevant, references (mostly the GFDRR that is not even a research work).

Authors: Section 5 only contains general perspectives that apply to multiple topics and are seen throughout the paper or summaries of key points. Specific perspectives are covered in the exposure, hazard and impact sections and sometimes repeated here and classified by future likelihood. There is argumentation for the future likelihood. We have now added references to these earlier chapters in the perspectives chapter. In this way we now emphasize where the general comments are coming from and that they often arise from the specific chapters. We also changed the name of the chapter from "perspectives" to "general perspectives" so that we take away the expectation that only this chapter has perspectives.

Reviewer 2: I understand this paper, as written in the Acknowledgement section, is the result of a “2 week long intensive collaboration during the Understanding Risk Field lab on urban flooding in Chiang Mai, but “Out of the context” and the intent is to share these ourcomes with the scientific audience, but the submitted manuscript seems not to capture the surely significant value of authors’ knowledge and experience as well as the value of the Understanding Risk Field lab workshop discussion and reasoning.

Authors: We have re-written the acknowledgement section to better reflect the role of the event as a convening and facilitating platforms for multi-disciplinary experts, from which emerged much of this manuscript.

Reviewer 2: Line 16-20: I think the second sentence is redundant, merge into one sentence.

Authors: We have modified this sentence to clarify that one refers to the past and the other to the future.

Reviewer 2: Line 27: “avoid repetitions just here rephrase” and line 29: “same comment as before”

Authors: We removed some of the repetition.

Reviewer 2: Line 33: I'd expect a clear definition of machine learning as well a solid reference to this statement

Authors: We repeated the reference from line 35 here now because that also covers this statement. A more solid definition of machine learning is provided in line 69-70 .

Reviewer 2: Line 39: Again, as remarked before, I see redundancies. You are repeating that advantages vs limitations shall be considered. No references added here also makes the introuction weak. See general comment n.1

Authors: The second sentence was removed and the first has been integrated with the one prior.

Reviewer 2: Line 42: hazard, exposure and impact are key concepts of flood risk. Why mentioning here floods and society. And, again, why no references supporting key statements of the introduction?

Authors: Exposure and impact are only relevant for floods when the relationship between floods and society is studied. The “interaction between floods and society” is a less technical term then just “flood risk” . We added a reference to this key concept now.

Reviewer 2: Line 51: I don't find a close link between this introductory sentence of ...application of floof risk and impact assessment, and the disaster managementy cycle

Authors: The disaster management cycle is a paradigm that includes everything that is done to fight the negative consequences of floods. Every flood risk and impact assessment should therefore have a benefit somewhere in this paradigm. The second line also refers directly to the first sentence already making the link clear, we strengthened that reference even more by repeating the word “different” before applications.

Reviewer 2: Line 57-58: you are here referring to reconstruction of real events. I'd make this clear and cite relevant papers

Authors: We are not referring to reconstructing hazard events. For a reconstruction you need to know what happened. We are talking about having a descriptive hazard (e.g. remote sensing based observation) and then developing a model to predict the impact. We rewrote this sentence to clarify it.

Reviewer 2: Line 63: there are two references by Wagenaar et al 2019 (make sure the manuscript not accepted is removed from the list)

Authors: The first is already published. The second is under final review and will be published shortly. Since it is very relevant to the accompanying statement, we feel that it should be included as a reference, and should be made available to readers as relevant literature. Our understanding is that we should reference relevant literature, even if “unpublished” or “grey” literature.

Reviewer 2: Line 69: improve the introduction to machine learning, from definition to key concepts, procedures, tools etc

Authors: The paragraph starts with a definition, then clarifies this definition with an example. Procedures and tools go a bit unnecessarily deep for this paper see the response to the general comment “Summary and review of state-of-the-art ML”.

Reviewer 2: Line 73 a reference is needed here, otherwise it becomes quite unclear the reading

Authors: We have added a reference.

Reviewer 2: Line 80 -85: I think this should be absolutely expanded, supported by more references. I advise the use of a summary table or flow chart. This paper can't comply with the title without a deep description of state of the art ML. See General comment n.2

Authors: See the response to general comment 2. The paragraph is expanded to make a clarify what the new methods can do compared to the old methods. However, we want to stick to the choice to not get into the topic of how the techniques work as it isn't necessary to answer the question in the title.

Reviewer 2: Line 129: reference?

Authors: The first part of the sentence is a conclusion of our literature research that is shown just before this sentence where we found no more advanced applications. The second part of the sentence is a perspective. This perspective is now supported with some additional reasoning.

Reviewer 2: Line 136: references?

Authors: This is about a categorization we defined for this paper. See introduction so it won't be possible/necessary to reference to that.

Reviewer 2: Line 168: there are tons of papers on the use of crowdsourced data for flood hazard modelling and mapping.

Authors: We referenced here to 4 recent papers about this and added a sentence about something that isn't done yet but could potentially be done in the future.

Reviewer 2: Line 207: this is not included in the reference list. The reference should be this <https://arxiv.org/abs/1901.09583> but I don't find it proper for supporting this statement

Authors: That is indeed the correct reference, and thank you for pointing out that it is missing from the reference list. In the referenced paper, the authors suggest that hybrid ML-physical models will contribute to flood forecasting. Specifically, ML models 'responsible for calibration, error corrections, and perhaps additional processes that were not well modelled'. In this respect, we feel that using the paper to support our own argument (see below) is justified. "Hybrid component models assign machine learning a specific task in the modelling process that is either highly complex or not well understood. Examples of this include using machine learning for error correctors (see, for example, studies by Abraham et al. 2007 and Google Research - Nevo et al. 2019)"

Reviewer 2: Line 208-215: See General comments n.1 and n.2 I suggest inserting more references and also more clear descriptions of the ML modelling approaches.

Authors: We already reference to 5 papers in this paragraph and all key ideas are already supported by at least 1 reference. We added a newer reference on the real-time control of flood defences and systems. We don't intend to get into more detail about it, this is just one of many applications in this paper and this level of detail is appropriate for a high level understanding of the possibilities.

Reviewer 2: Line 220: all capital letters to define acronym

Authors: We changed this

Reviewer 2: Line 244: This may be generally true, but social networks are providing high amount of geotagged images and videos. This is in contrast to what authors stated in the hazard assessment when citing crowdsource data.

Authors: This sentence refers to labelled data that could be applied for training descriptive impact models (not for hazard assessment). Data from social networks is I expect only very rarely labelled with an object damage label that can be applied for training impact models. For descriptive hazard modelling the potential of social media data is already mentioned.

Reviewer 2: Line 248-253: This is quite superficial and not fully developed. What about drones, webcams and other sensors? Just to cite an example to trigger the discussion

Authors: We added a sentence that change detection might be applied to estimate damage from other angles than top view.

Reviewer 2: Line 281: check English

Authors: We will rewrite this sentence

Reviewer 2: Line 304: This entire section doesn't provide insightful comments and remarks on what's coming next. It is not, thus, respecting what was expected from the paper goal and title.

The lack of proper introduction, definition and review of ML methods is probably affecting the robustness of this section that doesn't go deeper in the discussion of perspectives of ML for flood risk management. See General comment n.3

Authors: See the response to general comment 3. In short the perspectives are included all over the paper and this section only summarizes general trends and classifies the likelihood of specific predictions earlier in the paper using argumentation. We added references to earlier section to better to make this link between this chapter and the rest of the paper clearer.

Reviewer 2: Line 323: These 4 references are all missing from the reference list

Authors: Thanks for pointing this out. We added them now.

Reviewer 2: Line 359: too general. Social media will help what? exposure, hazard, impact or what?? You can't here just mention flood risk management

Authors: We agree this is not well formulated. We rephrased this and referred to earlier chapters.