

Nat. Hazards Earth Syst. Sci. Discuss., author comment AC2  
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## Reply on RC2

David P. Callaghan and Michael G. Hughes

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Author comment on "Assessing flood hazard changes using climate model forcing" by  
David P. Callaghan and Michael G. Hughes, Nat. Hazards Earth Syst. Sci. Discuss.,  
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### General Comments

- It could be useful to better explain in the introduction the novelty of the paper since in literature there already are some articles that assess future flood hazard under climate changes scenario by using hydrologic and hydraulic models. In the present form the original contribution could be not so evident because it is not fully clear how the proposed methodology differ or increase its effectiveness from other studies on this topic.
- I suggest in the introduction to add more recent bibliography on this topic and information about what was already proposed in other countries, i.e.: 1) Ryu, J.-H.; Kim, J.-E.; Lee, J.-Y.; Kwon, H.-H.; Kim, T.-W. Estimating Optimal Design Frequency and Future Hydrological Risk in Local River Basins According to RCP Scenarios. *Water*, 2022, 14, 945, <https://doi.org/10.3390/w14060945>. 2) Shrestha, S.; W. Lohpaisankrit W. Flood hazard assessment under climate change scenarios in the Yang River Basin, Thailand. *International Journal of Sustainable Built Environment*, 2017, 6, 285–298, <https://doi.org/10.1016/j.ijbsbe.2016.09.006>. 3) Janizadeh, S.; Pal, S.C.; Saha, A.; Chowdhuri, I.; Ahmadi, K.; Mirzaei, S.; Mosavi, A.H.; Tiefenbacher, J.P. Mapping the spatial and temporal variability of flood hazard affected by climate and land-use changes in the future. *Journal of Environmental Management*, 2021, 298, 113551, <https://doi.org/10.1016/j.jenvman.2021.113551>.

The reviewer is correct in these two comments that we are not the first to use both hydrologic and hydraulics models when assessing flood risk changes from a changing climate. However, we do appear to be the first to use the runoff from climate projections, simulating them over the entire projection period to produce flood projections. Other work in this area uses climate projections to determine key events or design events and simulation of those are undertaken. That is, we first determine flood projections and then use these to assess risk changes. We propose adding a new paragraph at line 36 of "Recent work investigating projected changes in flood risk under plausible climate futures includes Shrestha and Lohpaisankrit (2017) who forced a rainfall runoff model to estimate changes in discharges in the streamwise direction, allowing evaluation of changes in future risk. Moreover, Janizadeh et al (2021) trained a machine learning model to convert basin geometry and rainfall into risk, which was used with climate projections to evaluate future risk changes. Finally, Ryu et al (2022) analysed adjusted rainfall projections using flood frequency methods to assess risk changes at the basin level. The method here seeks to extend these by using a physics-based model to convert runoff into spatially explicit water surface levels and speeds across the entire floodplain and throughout the entire climate projection period. This objective overcomes issues around data poor regions (i.e., where machine learning methods are not possible), provides flood projections at consistent

spatial and temporal resolutions across the full extents of the model (both streamwise and cross-stream), and permits application to river systems with complex hydraulics and discharge patterns (e.g. multiple and parallel channels) which rainfall-runoff models are unable to reasonably simulate."

And editing paragraph starting at line 68 as follows with italics showing changes

"The purpose of this paper is to describe the successful application of a modelling framework developed to convert climate model projections to hydrodynamic outputs, which were then used to assess future changes to present-day regional flood hazard. We demonstrate the utility of the approach by applying it to the Gwydir River, a large valley-floodplain system located in the northern Murray-Darling Basin, Australia. After reviewing candidate numerical models, new methods for driving *hydrological flow-routing model* and the LISFLOOD-FP hydraulic model with climate projections for rainfall-runoff (or excess rainfall). NARCLIM1.5 climate projections are used as an example. *Rather than using the climate projections to determine key or design events for simulation, we simulated river floodplain hydraulics for the full climate projection time series.* Projected future regional flood inundation extents and the spatial distribution of flood hazard are presented for two global emission pathways (RCP4.5 and RCP8.5). Challenges associated with spatial and temporal sparsity in floodplain inundation and applying conventional extreme value distributions to evaluate future flood exceedance probabilities are discussed. These confound efforts to answer the question – will present-day flood hazard change under future climate projections – and we provide a new approach to answering that question."

#### Specific Comments

- Lines 214-215: LISFLOOD was preferred to WCAD2D because it was found that the first model was faster than WCAD2D. Did you compare these model only for speed or also in terms of flood modelling results? In the latter case, did the test performed show significant differences?

The tests between LISFLOOD and WCAD2D involved similar water level estimates for both steady and unsteady tests, consistent with previous evaluations within the literature. As the article points out the LISFLOOD is considerably quicker, we edited lines 212 to 215 as follows with italics showing changes

"The trade-off between accuracy and computational effort and seeking flood hazard information thereby requiring reasonable flow speed estimates, leads to the selection of partial inertial wave equation (LISFLOOD) and the cellular automata (WCAD2D). These two hydraulic models were compared in both steady and unsteady tests *and evaluated for speed. While estimates of flood levels from the two models were similar,* LISFLOOD was found to be 2 to 2.5 times faster when tested on large floodplains such as the Gwydir River. This led to the selection of LISFLOOD."

- Lines 241-242: please explain how you derive a total physical time of 1470 years starting by the 18 projections included by NARCLIM 1.5.

The climate model ensemble includes six global-regional climate models that delivered 6 historical projections from the start of 1951 to the end of 2005, which is 55 years each and a total of 330 years. The climate model ensemble also delivered six future projections for each of two emission pathways. These 12 future projections from the start of 2006 to the end of 2100, which is 95 years each, total 1140 years. Consequently, the total from historical and future projections is 330 plus 1140 or 1470 years.

- Paragraph 2.6 (Lines 267-275): I don't understand the criterium for selecting the epochs for flood hazard classification. How did you select as historical epoch the period 1980/1999, and as projected epochs the periods 2020/2039, 2050/2069 and 2080/2099 in the entire range 1950-2100?

Will correct. The periods selected follow those typically used for near, mid and far future time horizons in Australian government planning. At line 271, a new sentence will be added "These future epochs correspond to those typically used for near, mid and far future horizons in government planning."

#### Technical corrections

- Line 13 pag. 1: historical period (1950-2006) should be the same of that one reported in

line 99 (1950-2005).

The abstract and body of the manuscript have been corrected to match the projections to "(1951-2005) and a future period (2006-2100)".

- Line 489 pag. 15: in the reference you miss probably the comma before 2009.

Will Correct.