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Reply on RC2

Joseph L. Gutenson et al.

Author comment on "Comparison of estimated flood exposure and consequences generated by different event-based inland flood inundation maps" by Joseph L. Gutenson et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2022-27-AC2, 2022

Summary

In this study, the authors compare three modeling frameworks for mapping inundation extent and flood depth in Clear Creek watershed, a tributary of Galveston Bay in Texas, U.S. They evaluate the performance of AutoRoute, HEC-RAS, and Fathom-US frameworks against in-situ USGS high-water marks of Hurricane Harvey, a well-studied compound flood event in 2017. Also, the authors estimate flood exposure, consequences, and damages to buildings using available data from FEMA. It is shown that both HEC-RAS and Fathom-US outperform AutoRoute due to inherent limitations of the latter framework to simulate flooding in low-lying areas. Although Fathom-US and HEC-RAS achieve high location accuracies and low error and bias, they present some discrepancies regarding the evaluation metrics. The authors suggest an ensemble, multimodel probabilistic methodology to leverage these frameworks and provide more accurate flood maps as discussed in similar studies.

Major comments

This study presents an inter-model comparison with a practical application in terms of flood exposure and damage assessments, but it does not provide essential information for doing so. In contrast to Fathom-US (Wing et al., 2017, 2019), there is no evidence of model calibration and validation of both AutoRoute and HEC-RAS models for the study area. If the goal is to evaluate model’s performance, then input data, forcing, mesh extent, and grid resolution should be identical among the frameworks. This compromises not only the validity of the results, but the analyses presented throughout the manuscript. I suggest the authors to consult or follow other studies that provide guidelines for model comparison (Shustikova et al., 2019; Muñoz et al., 2021; Afshari et al., 2018; Liu et al., 2018).

The authors investigate the performance of the frameworks knowing beforehand that AutoRoute is not suitable in coastal areas (Line 63 in the Introduction). This rises concern about the usefulness of a low-skill model in this study. If the authors want to consider steady-state models like AutoRoute (or HAND) in the model comparison, I suggest to follow the approach of Jafarzadegan et al., (2022) to enhance model simulations via hydrogeomorphic classifiers.

Response: We are thankful for the reviewer's comments, critiques, and suggestions. Unfortunately, the reviewer has misinterpreted the goals of this study. We intend for the evaluation of each flood inundation mapping framework to be used as a tool for discerning if and how the flood inundation maps differ in their spatial composition and if those differences lead to different estimates of exposure and consequences for a case study event (Hurricane Harvey). We have deliberately chosen maps with differing DEM resolution, streamflow forcing, and numerical schemes to simulate what would occur in reality during a Harvey-like flood event. Any three of these flood inundation mapping frameworks we chose for the study could be deployed for flood inundation mapping during a flood event. Understanding that each flood inundation map is different and that an emergency manager or the public could make different conclusions based upon those differences is critical for real-time flood inundation map coordination. The authors think that our manuscript offers evidence that the different quantification and spatial patterns of exposure and consequences produced using each flood inundation map from our study could lead a user, such as an emergency manager or member of the public, to draw different conclusions about the flood events impacts. The differences we observe justify the need to centrally vet and adjudicate flood inundation maps and promote an official map that should be used for a given time and location, using groups such as the integrate Flood Inundation Map (iFIM) team (Mason et al., 2020). The study also offers further evidence that use of multiple flood inundation maps offers utility over an individual map.

Because of the reviewers misinterpretation of the focus of this study, we intend on revising the manuscript to better focus on the primary goals of the study. This will include a revision of the title and general wording of the manuscript.

Minor comments

L16: 'Event maps' is too generic for referring to flood inundation maps. 'Event maps' are also used to describe the modeling framework making the manuscript difficult to follow in some sections.

Response: We will revise the manuscript to refer to reduce confusion. The companion reviewer also had some trouble with our reference of Event Maps.

L20: Are you talking about modeling frameworks or flood inundation maps? How can event maps be physically different?

Response: We are talking about flood inundation mapping frameworks. We will make this correction.

Apologies for any confusion, physical differences was a reference to the different spatial compositions of each flood inundation map. We will update the manuscript to remove references to the maps physical differences.

L26: Do you mean flood emergency response instead of flood fights?

Response: Yes, the authors will make this change in the manuscript.

L28: We find that the modeling frameworks are much different physically…

Response: Apologies for any confusion, physical differences was a reference to their different spatial compositions. We will update the manuscript to remove references to the maps physical differences and replace the reference with a

more appropriate terminology.

L43: Typo. Event Maps help emergency managers…

Response: We will address this error in the revised manuscript.

L63: HAND can be adapted to simulate coastal flooding in low-lying areas. See Jafarzadegan et al., (2022).

Response: We will add the Jafarzadegan et al., (2022) reference to the manuscript and distinguish between the traditional HAND methodology and the newer, revised versions that intend to improve flood inundation maps in low-lying, coastal regions.

L88: I can anticipate that you will find substantial differences based on the DEM resolution and forcing data you have chosen for each framework.

Response: We agree and this is the intended investigation of this manuscript. During Hurricane Harvey, any of these three flood inundation mapping frameworks could have been deployed to assist emergency management and response. The fact that each map is composed using different DEM resolution and forcing is something that will inevitably occur in real world scenarios. We intend for this manuscript to demonstrate that the different compositions of each flood inundation mapping framework (e.g., DEM resolution and forcing) can lead to resulting differences in the spatial composition of each flood inundation map estimate. These differences in each flood inundation map lead to different exposure and consequence estimates providing evidence that the differences in each flood inundation map are substantive and that a central vetting and adjudication process for the flood inundation maps (e.g., the integrated Flood Inundation Mapping (iFIM) effort (Mason et al., 2020) is necessary for flood events.

L98: Details of the hydrologic and hydraulic modeling are missing. For example, what is the grid size for the 2D component?

Response: We will revise the manuscript to include any missing and necessary details of the hydrologic modeling.

L120: Diffusive wave is a simplified version of the shallow water equations. Given the nonlinearities and complexities arising in compound coastal flooding, the complete set of equations (SWL) available in HEC-RAS should be used. This might lead to a better accuracy of the HEC-RAS in terms of inundation extent and flood depth.

Response: An on-going Regional Flood Study effort, led by the Texas General Land Office, is evaluating how HEC-RAS model accuracy changes due to the usage of the Diffusion Wave equations and the original Shallow Water equations (SWE-ELM, which stands for Shallow Water Equations, Eulerian-Lagrangian Method). The preliminary findings of this analysis shows the differences between these two equation usages in HEC-RAS model prediction accuracy on inundation extent and depth are negligible in the upstream of the watershed, whereas minor differences exist, especially near the model downstream locations. We can make a note of this in Section 3.3 of the manuscript.

L123: What are those mysterious downstream boundary conditions? Figure 1 should include the location of those boundaries for the three modeling frameworks.

Response: The authors disagree with adding this detail to Figure 1. Inclusion of multiple boundary condition locations within Figure 1 will only cause Figure 1 to become illegible and adds little to the discussion of the main topic of the manuscript.

L129: Are roughness values calibrated afterwards? These initial 1D and 2D roughness values are event-specific and have to be tuned for future flood events.

Response: The hydrologic and hydraulic components of the HEC-RAS framework were calibrated for Hurricane Harvey and the 2016 Tax Day floods (Nielsen and Schumacher, 2020). Roughness values in the 1D portion of the modeled come from standard values described in the MAAPNext process that were based on the Harris County Policy, Criteria, and Procedures Manual (PCPM). Those values are consistent with recognized and accepted engineering standards. The basis of the 2D roughness coefficients is a combination of values developed by the Houston-Galveston Area Council (HGAC) and early calibration/testing efforts by the contracted model developer (Freese and Nichols, Inc., 2021). We can add this description to the manuscript.

L134: Would it not be better to consider the 1-m DEM and so avoid inaccuracies due to DEM resolution? Previously, you suggest using observed meteorological data to avoid limitations in forecast skill...

Response: This would be true if the primary motivation for this study was to evaluate the accuracy of each flood inundation mapping framework. However, we intend for this manuscript to demonstrate that the different compositions of each flood inundation mapping framework (e.g., DEM resolution) can lead to resulting differences in the spatial composition of each flood inundation map estimate. These differences in each flood inundation map lead to different exposure and consequence estimates providing evidence that the differences in each flood inundation map are substantive and that a central vetting and adjudication process for the flood inundation maps (e.g., the integrated Flood Inundation Mapping (iFIM) effort (Mason et al., 2020) is necessary for flood events.

L150: Evaluation of simulated time series is very informative but missing in this study (e.g., timing and magnitude of peak water level). I strongly suggest assessing model's performance based on time series of available USGS (#08077637) and NOAA stations.

Response: We do not agree that further emphasis on evaluation of times series is necessary. The evaluation of each flood inundation modeling framework in our study intends on evaluating each flood inundation mapping framework to the extent that we prove that each resulting flood inundation map is of a different spatial compositions and that none of the maps prefect represent reality. We believe that we have successfully proven that each flood inundation mapping framework will produce a different flood map with the current evaluation process. A time series evaluation would be impactful if this study was considering the effects of hazard communication in our consequences assessment. However, we have chosen to evaluate the impact of differences in the peak flood inundation mapping on consequences and exposure, not the impact of hazard communication. Thus, evaluation of timing is beyond the scope of this manuscript.

L183: What are the upper and lower bounds?

Response: The upper and lower bounds are 26-30% as referenced in the preceding sentence.

L185. Typo in the diagram. "Create Kernel density maps".

Response: We will make the appropriate correction to Figure 3.

L197: Diffusion wave does not solve the full mass balance and momentum equations and therefore might have influenced flood inundation extent and depth. In addition, the 1D portion of the model cannot provide 2D flood maps and consequently miss nearby high water marks.

Response: An on-going Regional Flood Study effort, led by the Texas General Land Office, is evaluating how HEC-RAS model accuracy changes due to the usage of the Diffusion Wave equations and the original Shallow Water equations (SWE-ELM, which stands for Shallow Water Equations, Eulerian-Lagrangian Method). The preliminary findings of this analysis shows the differences between these two equation usages in HEC-RAS model prediction accuracy on inundation extent and depth are negligible in the upstream of the watershed, whereas minor differences exist, especially near the model downstream locations. We can make a note of this in Section 3.3 of the manuscript.

L200. I cannot find the calibration and validation process in this manuscript. The same holds for AutoRoute model.

Response: We will add these details to the manuscript.

L218: USGS high-water marks are referenced with respect to NAVD88. There may be uncertainties added in the NAVD88 to MSL conversion process. How did the authors conduct the datum conversion? What is the vertical datum of the DEMs?

Response: All vertical elevations are based upon NAVD88. This is a mislabeling on our part. We will correct this error in the manuscript.

L226: … and the steady state assumption. Also, AutoRoute is only forced by streamflow ignoring the contribution of coastal water level (e.g., storm-tide) to compound flooding (Figure 2).

Response: Yes, we will insert the description of the state assumption in this portion of the manuscript.

L228: Figure 4. Text size is too small.

Response: We will revise the text size in Figure 4.

L412: I agree that ensemble modeling is the way to go for better compound flood assessments. Nevertheless, I consider Figure 8 unnecessary in this study as you are not actually following this approach for simulating compound flooding due to Hurricane Harvey. A descriptive text is enough for future work in this regard.

Response: We will remove Figure 8 from the manuscript.

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