



EGUsphere, author comment AC3
<https://doi.org/10.5194/egusphere-2022-52-AC3>, 2022
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Reply on CC1

Matthew Preisser et al.

Author comment on "Intersecting near-real time fluvial and pluvial inundation estimates with sociodemographic vulnerability to quantify a household flood impact index" by Matthew Preisser et al., EGU Sphere, <https://doi.org/10.5194/egusphere-2022-52-AC3>, 2022

We thank you for taking the time to review our paper and provide some insightful discussion points to improve the transparency and clarity of our work. We address your comments as follows:

C1: *One important assumption of this study is that the rainfall depth equals the runoff depth, which implies a 100% runoff coefficient. It should be noted that such an assumption is probably always invalid. Even a highly urbanized area can hardly reach a 80%+ runoff coefficient during a 5-hour storm event, since the actual impervious coverage could only be as high as 70%. A higher (90%+) runoff coefficient could possibly result from a prolonged storm duration, but such scenario doesn't seem permitted in this study due to the reset mechanism (see the next comment for more). Granted that this approach targets a 'worst-case' scenario, an 'impossible' estimate would not be very meaningful, would it?*

You are correct, in that our equating rainfall depth to runoff depth is an overestimate. However, we believe that our choice here is justified by the following three points:

First, as stated in section 4.1 (and expanded upon in the new manuscript at line 296), the nature of the local weather before the storm event favors the assumption of near saturated conditions. The previous five days leading up to the storm event under investigation all recorded some level of precipitation. Furthermore, the storm itself exhibited flash flood characteristics, with 80% of the precipitation (over 10-cm) falling within two hours. This intensity coupled with already wet soils signals that a significant portion of rainfall will be converted to runoff. We agree that while a 100% runoff coefficient is likely impossible, we believe that it is not unrealistic to assume many areas approached a relatively high runoff coefficient. When our methodology is applied to other areas, it is fully possible and feasible to take a fraction of the rainfall to assume some level of abstraction based on the local characteristics (impervious cover, potential soil conditions, rainfall patterns, etc.), but we believe for our scenario it would be better to slightly overestimate the amount of runoff rather than risk an underestimation.

Second, in a near-real time scenario, when the only available precipitation data is likely a set of point depths measurements, these estimates will continually change and grow as the storm develops. Rather than trying to estimate a proper abstraction value as it continues to rain and the amount of runoff only continues to increase, it would be timelier

to assume it is all converted to runoff, especially for emergency response purposes.

Our third and final reason relates to the overarching goal of the paper to create a near-real time impact index from an inundation estimate, and then the question becomes does a 30% reduction in the total precipitation change the impact estimate. We found that the extent of pluvial inundation is virtually the same when comparing a full conversion of rainfall to runoff to 70% conversion. The change in depths also had a negligible impact on the final impact index. This is because changes in pluvial flood depths occur predominantly in areas that ponded water collects at larger depths including underpasses, intersections, and open spaces (parks, culverts, parking lots, etc.) and not on residential parcels.

As previously mentioned, you are correct in that the assumption that 100% percent of the rainfall being converted to runoff is unlikely. However, we believe that for this storm event under the given circumstances that this assumption would fall within a real-world application of the proposed methodology, and it can be adjusted accordingly when applied to other study areas or other storm events. For example, previous studies examining water ponding over a landscape have made simple adjustments to inputs depths to consider runoff abstraction and this could easily be incorporated in future applications (Shaw et al., 2012).

C2: *There is a reset mechanism in the inundation mapping approach with a 5-hour frequency in the case study. This setting seems to consider the time of concentration at some spatial scale as well as the storm duration, but the rationale behind this setting is ambiguous in the manuscript. I recommend give some clear guidance on this setting to help expand the application over other areas. The essential problem with this setting is that pluvial inundation is set to be strongly driven by the rainfall accumulation within the 5 hours regardless of the initial condition i.e., how much water is ponded initially. I have concerns over the implication of the inundation maps produced in the middle of a long storm event (say, 12 hours) in reality.*

One of the known limitations of topographic based inundation models is that they lack a timing mechanism and can therefore only be used to show a single state of inundation (Bulti and Abebe, 2020; Fritsch et al. 2016; Lhomme et al., 2009). For our study, the storm event lasted 5 hours, therefore using the cumulative rainfall/runoff depth of those 5 hours is representative of the final inundation state given the assumption that there is no initial ponded water. As mentioned in response to **C1**, while there was recorded rainfall for the five days leading up to the storm event, the precipitation amounts were unlikely to cause a significant amount of ponding as they were relatively low daily amounts (less than an inch per day). Using the cumulative value for whatever time step the user is interested in, whether it is at the completion of a 5-hour storm or halfway through a 12-hour storm, that is the best assumption that can be made when using a topographic based model. Initial conditions could easily be applied using this methodology as well, by routing a volume/depth through the topography before any additional runoff is routed. limitation and its justification was added to section 6.4.

C3: *The current method also nullifies heterogeneous effects of land cover on runoff generation, leaving the pluvial inundation dictated by topology. Besides the obvious uncertainty introduced, it undermines the hyper-resolution enabled by the DEM data. I understand 'computational efficiency' is the key word here, but I can also see more realistic alternatives than assuming a uniformly impervious coverage. For instance, land use land cover data combined with curve number method seem to be efficient and well-suited for estimating runoff within the current framework.*

There are certainly simplified topographic based inundation methods that incorporate land use information including such factors as infiltration or friction (Chu et al., 2013; Appels et al., 2011; Antoine et al., 2009; Lhomme et al., 2009). However, a major difference

between the application of those methods and ours is the study area size and resolution of the underlying DEM. A goal of this research was to utilize 1-meter elevation data because of its increased prevalence within the US when it comes to inundation mapping and its ability to identify realistic urban pluvial flooding locations. Our DEM contains approximately 502 million cells, representing an area over 250 km² at a 1-meter horizontal resolution; a DEM size that far exceeds the previously listed studies. To meet the goal of near-real time at this resolution requires an oversimplification of processes, which is common for simplified inundation models. For example, the Rapid Flood Spreading Model (RFSM) only requires an input flood volume, elevation, and surface roughness (Lhomme et al., 2009; Bernini & Franchini, 2013). Even with this simplification, this method is approximately 3.8 times slower than the Fill-Spill-Merge method utilized on our study (calculated by comparing the ratio of DEM cells to computational time in our study to theirs, being 502 million cells in 28 minutes with our method and 387 thousand cells in 5 seconds with theirs). In a near-real time scenario when the entire storm event occurs in less than 5 hours, the difference between a computational time of 28 minutes (our computational time) and 106 minutes (our computational time multiplied by 3.8, the estimated speed ratio of RFSM to Fill-Spill-Merge) is substantial. This information was incorporated into section 6.4 in the new draft.

Land use and land cover data combined with the curve number method are certainly alternatives to the topographic method we utilized, and the robustness of our impact index is that alternative inundation methods can be applied based on the end users' preferences and data/computational power available to them.

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