Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2019-82-AC2, 2019

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "A Comprehensive Evaluation of the National Water Model (NWM) – Height Above Nearest Drainage (HAND) Flood Mapping Methodology" *by* J. Michael Johnson et al.

J. Michael Johnson et al.

mike.johnson@geog.ucsb.edu

Received and published: 3 August 2019

Dear Editor and Reviewers,

Thank you all for the opportunity to revise this manuscript.

We want to first note that the suggestions to change error statistics and include an analysis of the bias introduced by the NWM to the NWM-HAND methods (Tarboton) were very useful but caused some changes to the format of the paper. Because of this, not all new additions / changes can be highlighted in these responses. However, we

have made every effort to specifically address each reviewers' specific concerns.

The largest structural change is that, as the methods section grew, it became more useful to move all methods into their own section and allow the results section to simply communicate what we found. A new (4.2-4.3) section describing the analysis of gaged catchments has been added and the discussion/conclusion have been updated to reflect these results.

Attached to this submission is the revised manuscript, with continuous page numbers and in-text figures.

In the remainder of this response Dr. Blodgett's requests are indicated as **; Our responses are surrounded by » TEXT «; And specific sentences from the text are surrounded by parenthesis (TEXT).

Dear Dr. Blodgett,

First, thank you for the clear and thought-provoking review. It substantially aided the revisions of this paper and we have added you to the acknowledgements section.

**Firstly, both reviewers raised concerns with the title of the paper.

»We recognize the challenge with executing a truly comprehensive evaluation as conceptualized by the reviewers. As such the title has been changed (per D. Blodgett's suggestion) to:

An Integrated Evaluation of the National Water Model (NWM) Height Above Nearest Drainage (HAND) Flood Mapping Methodology. «

**Dr. Blodgett asked us to be more upfront with our choice of using a 2D fit statistic and the implications of not treating floods as a 4D event.

»Thank you for this comment, it prompted some thoughts about what our analysis truly

entails, the choice of methods, and why it was important.

The choice for a 2D statistic (XY) is driven by the limitations of remote sensing imagery that only offers a snapshot at a single time point (T). Analysis of time-space outside of this snapshot is doable for streamflow and simulated events but not for our observed 'truth' reference dataset. As for the depth dimension, while there are some new methods for looking at flood water depths from RS imagery (see Cohen et al, 2018), doing so would have added a new source of uncertainty into an analysis where we were already trying to isolate and attribute errors from multiple sources.

In the revised manuscript we now explicitly state that we are implementing a 2D analysis of the flooded area coinciding with the timing of aerial imagery and that it should not be read that we are analyzing peak flooded areas (lines 170-174).

(The choice of a 2D fitness statistic (examining only the extent of flood, as opposed to depth and timing of flood propagation) is governed by the aerial imagery products available (which only captures the extent of the flood, at a singular point in time). By electing this form of evaluation, we only analyze the strengths of NWM-HAND simulations at the given time-step coinciding with the time of image capture (not necessarily peak flooding).) «

**Dr. Blodgett suggested bringing our discussion of limitations and realistic potential up from the discussion to the introduction/abstract.

»Thank you for this important suggestion. We have moved the ideas as suggested. Please see lines 44-49.

(The current objective of the NWM-HAND approach is high-ïňĆow prediction for the purposes of ïňĆood warning and guidance. Model accuracy should therefore be viewed in this context and expectations should be tempered while recognizing the importance of having an operational, continental scale flood forecasting system.) «

**Dr. Blodgett asked us to include more information regarding the NWM forcing data,

parameterization, and routing.

» Thank you for this suggestion. To be upfront, deciding on the level of detail to include with respect to NWM, HAND, SRC, and USFIMR background has proven to be a difficult task to making this paper both complete and concise. As such we have listed the attributes of the model you suggest but have avoided discussing any implications. Further, we point readers to a presentation talking about the model in detail (please see lines 106-113).

(The core of the NWM is the WRF-Hydro modelling architecture supported by the National Center for Atmospheric Research (NCAR) (Gochis et al., 2018). The NWM routes water over the NHD, producing streamflow values at the end point of each reach (indexed by COMID (Figure1A – pink dot)). The NWM runs in four configurations: analysis and assimilation, short range, medium range, and long range (NOAA, 2016a; 2016b; Salas et al., 2017). The analysis and assimilation configuration assimilates observed streamflow data from the USGS NWIS network and provides an hourly snapshots of current hydrologic conditions out to three hours. The short-range configuration produces hourly deterministic streamflow and hydrologic state forecasts 18 hours out; the medium range configuration produces 3-hourly forecasts out to 10 days; and the long-range configuration generates a 30-day, four-member forecast ensemble (NOAA, 2016a).) «

**Dr. Blodgett noted that the introduction is lacking a general overview of the NWM's objectives which could/should be used to temper the expectations and focus the aims of an evaluation.

» Thank you for pointing this out. We have added a caution of sorts to the introduction as well as a statement reflecting the current goals and objectives of the model (please see lines 44-49; see above).

(The current objective of the NWM-HAND approach is rapid flood inundation prediction for the purposes of disaster warning and guidance. Model accuracy should therefore

be viewed in this context and expectations should be tempered while recognizing the importance of having an operational, continental scale flood forecasting system.) «

**Dr. Blodgett requested more information on the nature of the retrospective model run noting that it is only calibrated in some locations and should not be expected to produce realistic ïňĆow volumes. Additionally, he observed that the retrospective does not assimilate observed streamïňĆow and suggested including such a remark.

»Thank you for the comment, both of these have been noted (please see lines 115-121).

(In addition to the operational products, 23-year reanalysis studies have been run for NWM versions 1.0, 1.2, and now 2.0. These products use downscaled NLDAS-2 climate forcing's with Noah-MP, a groundwater bucket model, overland and subsurface routing, and NHDplus channel routing. Unlike the operational Analysis and Assimilation (A&A) products, the reanalysis simulations do not assimilate USGS streamflow data and have been calibrated in limited number of basins (Gochis et al., 2016). In this study, the v1.2 reanalysis product was accessed through Amazon Web Services (https://registry.opendata.aws/nwm-archive/).)

**Dr. Blodgett asked why we had not included NHD Areas in our masked-out regions.

»Thank you for this suggestion. We were unaware of the NHD area product and have now included it in our mask. Moreover, the NHD Fcodes (for both water bodies and areas) have been listed in text to increase transparency (see lines 144-145).

(A waterbody mask was created by combining the perennial NHD water bodies (NHD Fcode 39004, 39009) and NHDAreas (NHD FCode 40300, 40307, 40308, 40309) in each extent.) «

**Dr. Blodgett aske to re consider our binning by stream order?

»Despite variable density of streams across the country there was clear evidence in our evaluations that lower order reaches underpredict flood extents while higher order

(>4) reaches performed better. We attribute this to the use of a single default Manning n coefficient in the SRC generation and discuss the implications of this in a few spots throughout the manuscript. Most relevantly, we show how stream order is a driving factor resulting in disparate tendencies at the floodplain and catchment levels. «

**Dr. Blodgett suggested generating a driving hypothesis and provided the example that "Given that HAND is not a physically based model in that it does not route ïňĆow over the landscape or preserve mass, we would expect small errors in stage to produce large errors in inundated areas in low-relief landscapes."

»Thank you for this succinct explanation of the phenomenon we were trying to describe as "volume control" in regions of low-relief. This wording has been added to lines 310-312 and help clarify our point.

(Since HAND is not a physical model, it is unable to conserve volume through space or time. In areas of low relief, where many cells have similar if not equal HAND values, small errors in stage can have disproportionate errors in inundation extent at the 10m grid cell resolution.)

**Dr. Blodgett asked us to re think the distinction of 'Errors in the NHD' as a section heading

»This point is greatly appreciated. Paragraph 2 in section 4.6 now starts:

(With respect to the streamlines it is important to recognize that the NHD was developed as a cartographic representation of the nation's waterways and using a cartographic toolset for hydrologic modelling and routing applications has inherent limitations.)

This section discusses the previously listed issues in this context. A new paragraph about the challenges with using a cartographic data as a modelling geofabric has been made in lines 364-377 with specific references to issues of refactoring catchment delineations to more compact and consistent modelling units. These have been highlighted

in modifications to figure 8.

Lastly, the section heading has been changed to better represent this and add a brief discussion of DEM resolution.

(Data Models: Use, Limitations, and Adaptions) «

Again, thank you for helping make this paper substantially better than its original submission,

Sincerely,

Mike Johnson, Dinuke Munasinghe, Dami Eyelade, Sagy Cohen

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-82/nhess-2019-82-AC2-supplement.pdf

---

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2019-82, 2019.