Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2020-46-AC2, 2020

Geoscientific Model Development Discussions
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Interactive comment on "The Ensemble Framework For Flash Flood Forecasting (EF5) v1.2: Description and Case Study" *by* Zachary L. Flamig et al.

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Received and published: 10 August 2020

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Discussion paper

Response to Interactive comment on "The Ensemble Framework For Flash Flood Forecasting (EF5) v1.2: Description and Case Study" by Zachary L. Flamig et al. from Anonymous Referee #2

August 10, 2020

General comments

Reviewer. This manuscript describes the EF5 that allows to produce hydrological runoff outputs (e.g., discharge) by i) adapting different inputs for precipitation (e.g. from multi-radar multi-sensor MRMS for the presented case over the CONUS) and ii) combing (as an "ensemble" of) existing algorithms of snow melt (not presented details here), water balance, routing, and calibration (not used in the presented case). The method (Section 2) focuses on details mostly three water balance models and routing parts of EF5 and case analyses for the evaluation (Section 3), which were parts of the author's Ph.D. dissertation published in 2016 with Open Access: https://shareok.org/handle/11244/44865, e.g., Chapter 3 and some parts in Chapter 2 with major duplications of figures, texts and the presented cases.

Response. We appreciate the comments supplied by this reviewer. Indeed, a number

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of figures and results are adapted from the first author's dissertation work completed at the University of Oklahoma. Below, we respond to each comment and cite instances in which there are revisions made to the manuscript.

Reviewer. The submission of theses (unpublished yet to another peer-review journal) is in general encouraged. However, I found the method and evaluation of EF5 presented here is not sufficient to fulfill the key scope of GMD (e.g. reproductivity of the work). Here, this reproductivity is very briefly mentioned in summary and future section; e.g., implementations for flash flood forecasting within the FLAHS project (cited briefly in P22, L3-4; Gourley et al. 2017) and at Namibia (P21, L9-10; Clark et al. 2017). However, it should be better addressed by adding discussions and implemented case summaries in this manuscript as well. So, I do not recommend its publication without a major revision considering following points that may help the manuscript to be more interesting and updated. (Note: P- page, L- line number in each page)

Response. We have added the input configurations and variables to GitHub at https://github.com/HyDROSLab/EF5-US-Parameters to improve the reproducibility of the test case studies conducted here. The GMD guidelines stipulate that, "The scientific goal is reproducibility: ideally, the description should be sufficiently detailed to in principle allow for the re-implementation of the model by others, so all technical details which could substantially affect the numerical output should be described." The standard as we understand it is that someone should be able to take this paper and create their own version of the model which can be run to produce scientifically similar results (i.e. explicitly not bitwise reproducibility). As noted in the GMD guidelines, we are supporting the model description with "summary outputs from test case simulations" that are not meant to be exhaustive of all configurations, modes of operation, and modules included in EF5. Nevertheless, the availability of model forcings, parameters, code, documentation, and training materials satisfy the reproducibility requirement for the journal.

On Pg. 22, Line 21, we have added the following statement in response to this comment: "The spatially distributed DEM, routing, and surface water balance parameters as well as potential evapotranspiration forcings are available at https://github.com/HyDROSLab/EF5-US-Parameters."

Reviewer. 1. The code uploaded in the provided link (https://github.com/HyDROSLab/EF5, Flamig, Z. L., Vergara, H., Clark, III, R., Hong, Y., and Gourley, J. J.: EF5: Version 1.0, doi:10.5281/zenodo.59123, http://dx.doi.org/10.5281/zenodo.59123, 2016) is indeed v1.0 not v1.2 that is indicated in the title. If there is any update in the code and manual, please comment them in the text. Also, I found the following version by the same author but under the name of "training", would this example can be presented in this paper as well? Zac Flamig. (2018, March 13). HyDROSLab/EF5: More bug fixes. (Version v1.2.3). Zenodo. http://doi.org/10.5281/zenodo.1197006 The manual exists in Latex file but pdf can be also appreciated.

Response. We have updated the DOI (http://doi.org/10.5281/zenodo.569078) to correctly point to version 1.2 in the text. EF5 is under active development so there are newer versions than presented here in this paper.

Reviewer. 2. Although the name of the model contains "for flash flood forecasting" and the abstract says "the results of the study show that the three uncalibrated water balance models linked to kinematic wave routing are skillful in streamflow prediction", the presented method and analyses hardly contain any predicted outputs ahead in time. The evaluation is also done only in terms of the discharge assessment (every 5 minutes at USGS gauge points in near real time precipitation forcing). Abstract should reflect better what has been presented in this work. Adding more examples from the implementational works including detail limitations will also make the manuscript more solid;

e.g., P6 L2-3 and P13 L17-19 given that EF5 is now operational over CONUS.

Response. The name of the tool reflects the goal and overall utility of the framework in association with its current operational implementation in the U.S. National Weather Service. EF5 is a framework designed and implemented for real-time flash flood forecasting, thus we choose to keep the name as accurate and descriptive as possible. Regarding the use of the terms "prediction" or "forecasting" versus "simulation", the reviewer is correct in that it would be a different exercise altogether to perfectly replicate a real-time environment by providing EF5 inputs up to a specific time and then launching forecasts into the future. Instead, we provide EF5 continuous rainfall estimates and evaluate the simulation capabilities of the system. As such, we have changed the aforementioned sentence to the following on Pg. 1, Line 6: "The results of the study show that the three uncalibrated water balance models linked to kinematic wave routing are skillful in simulating streamflow." Throghout the remainder of the manuscript, the model outputs that are evaluated are correctly referred to as "simulations".

Reviewer. 3. It is not clear that how important adding “Snow (melt) component” in EF5; this seems a newly added feature to EF5 (introduction e.g., P4, L5-7), yet the detail background/examples were not presented in the method. Also, the interpretation of the presented cases (P19, L22-24 linked to the not-used “snow module”) needs more solid evidences. What kind of caution (or a priori parameter development as mentioned in P22, L10) should be considered by the users? Please explain more explicitly.

Response. This paper is not intended to be an all inclusive review and evaluation of all components available in EF5. Instead, our intention is to describe the framework that was transitioned to the National Weather Service as part of the EF5 initial operational capability. There are additional features of EF5, such as handling snowmelt, assimilation of soil moisture to improve model states, etc., that are under active development and will be fully explained and evaluated in future papers, in synchronicity with their transition to operations. We are not making any claims about handling snow, merely

cautioning users that they should be weary of results when they know frozen precipitation is present. To improve the communication of the intention of the current study, we added the following statement on Pg. 13, Line 15: "The intention of this study is to evaluate the accuracy of the model version that was transitioned to the NWS as part of the EF5 initial operational capability."

Minor comments

Reviewer. 1. The reference link was broken - Flamig, Z. L., Vergara, H., Clark, III, R., Hong, Y., and Gourley, J. J.: EF5: Version 1.0, doi:10.5281/zenodo.59123, http://dx.doi.org/10.5281/zenodo.59123, 2016.

Response. We have updated the DOI referenced to match version 1.2 for this paper.

Reviewer. 2. Some acronyms need to be better informed: e.g.,P13, KW, NED, P14 GAMLSS

Response. There were numerous acronyms that were not defined upon first use. These have all been fixed. Thanks for catching that.

Reviewer. 3. Table1, fix parameters the same as written in P9, IWU has no unit? Check units in other tables as well.

Response. Thanks for pointing this out. The IWU parameter is the initial value of soil saturation in percent, used when a soil water content grid (e.g. from a warm-up simulation run) is not available. We have revised the table including now the units, changing the name from "Initial soil water content" to "Initial soil saturation", and including Minimum and Maximum values of 0.0 and 100.0 respectively. We have also changed the nomenclature of the parameters to match that used in the text.

Reviewer. 4. P6, 20-22: add reference or provide evidence.

Response. The use of the HP solution for diagnosing flash floods and debris flows on burn areas was an outcome through operational use by NWS forecasters in the West. In fact, the developers of EF5 had no intention to transition the HP solution to operations in the NWS. We were only using it to diagnose errors in CREST or in the MRMS rainfall forcings. But, when we took the product off the transition list, forecasters said they wanted to include it. We have thus changed the aforementioned sentence to the following: "Given that the hydrophobic model provides the "worst case scenario" in terms of runoff responses to rainfall, operational forecasters have used it to approximate hydrophobic land surfaces for situations in which the soils are completely saturated, urbanized basins allowing very little infiltration, and for soils that have been affected by wildfire."

Reviewer. 5. P20, L1-3, L4-5, L8, P21 L1-2: Need better explanations.

Response. The first sentence (now on Pg. 21, Line 1) has been revised to the following: "The results from this study using EF5/CREST, EF5/SAC-SMA, and EF5/HP, all with a-priori, uncalibrated parameters andcoupled to the kinematic wave routing scheme, show no significant systematic errors as a function of watershed scale."

The second sentence (now on Pg. 21, Line 2) has been changed to the following: "It took one week of computer time to simulate streamflow across the CONUS with rainfall estimates being input to the models at a five-min frequency."

We also made the following changes to the sentences being referred to in this comment: "The overall skill of the system is reasonable given the lack of optimized parameters, and on some watersheds the skill is equivalent to that expected with a calibrated hydrologic model. The results in Figure 7 show no significant trend in accuracy as a function of basin area for the range of flash flood basins from 1 km^2 to 1,000 km^2. The EF5/HP model yields a “worst case scenario” and exhibits large positive bias for most watersheds which is expected behavior for a completely impervious land surface.

We kept the last sentence as-is given this is how forecasters use it in operational practice, as per our response to Comment 4.

Reviewer. 6. P22, L2-4: Provide more clear explanation and supporting materials in the results.

Response. Sentence has been removed.

Reviewer. 7. P22, L15-16, It is not clearly written. Revise the sentence.

Response. This sentence has been changed to the following: "As the spatiotemporal resolution of hydrologic models is increasing, the need for validating observations also increases."

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