Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2020-46-AC1, 2020

Geoscientific Model Development Discussions

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

Zachary L. Flamig et al.

jj.gourley@noaa.gov

Received and published: 10 August 2020

article [utf8]inputenc [dvipsnames]xcolor

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 Seann Reed (Referee)

August 10, 2020

General comments

Reviewer. This paper provides a pragmatic look at three models which can provide nation-wide flash flood model guidance in the EF5 framework. While there are certainly theoretical limitations with the modeling approaches, it is commendable that the authors and developers have forged ahead with this approach to make it available to operational forecasters. The description of the modeling framework, parameter estimation, and analysis is an important contribution to the literature. The bulk, high-level results show that additional work is needed to develop recommendations to forecasters on whether to rely more on the CREST or SAC models. Additional work to determine where to invest in model enhancements would also be beneficial.

Response. We appreciate the constructive comments supplied by this expert re-

viewer. Below, we address each comment and provide revisions that were made to the manuscript. We believe an improved manuscript has resulted and we are thankful.

Reviewer. Specific comments

Reviewer. Somewhere there should be mention of the National Water Model and how the EF5 differs (e.g. temporal scale) and thus provides forecast information not available from the NWM.

Response. Agreed. The National Water Model is operational within NOAA and provides new hydrologic forecasting capabilities at ungauged grid points, similar to EF5. There are differences in the model structures, forcings, etc., but the largest differentiation between them is the frequency and latency at which forecast products are available. The NWM runs at the top of the hour and it takes approximately 30-45 min. for a simulation across the conterminous US to complete. In the case of EF5, forecasts are launched every 10 min., and are completed in less than 10 min. This means the maximum latency with NWM products is 1 hr 44 min and approximately 19 min with EF5. For these reasons, EF5 is more applicable to monitoring and forecasting of conditions at the flash flood scale (including pluvial, overland flooding), while NWM forecasts can apply to larger streams and rivers. Nevertheless, EF5 and NWM both serve to advance the tools available to NWS forecasters by supplying hydrologic model forecasts at ungauged grid cells across the U.S. and territories. We have now added the following text on Pg. 3. Line 28 in regard to this comment:

More recently, the U.S. NWS implemented the National Water Model (NWM), which is a variant of the Weather Research and Forecasting Model Hydrological modeling system (WRF-Hydro) (Gochis et al., 2014). This modeling framework is more holistic in that it is being developed to address multiple hydrologic applications ranging from water resources management, stream temperature forecasting, coupling to storm surge models for coastal flooding applications, surface and groundwater interactions, and channel

losses in semi-arid environments. The wide range of applications requires more model complexity and thus the framework utilizes the Noah-Multiparameterization Land Surface Model (NOAH-MP) as its core. The utility of the NWM for flash flood forecasting will require sub-hourly data latency, yet there has been some recent progress on applications (Viterbo et al., 2020).

Reviewer. I have some concern about applying the SAC-SMA model at increasingly smaller grid scales, particularly if the same a-priori parameters are used. I've seen 'good' results from 4 km2 and 16 km2 gridded SMA applications but there was also considerable improvement from calibration at these scales. There is definitely a scale dependency in the SAC-SMA model (. (Finnerty, B.D., Smith, M.B., Seo, D.-J., Koren, V., Moglen, G.E., 1997. Space-time sensitivity of the Sacramento model to radar-gauge precipitation inputs. Journal of Hydrology, Vol. 203, 21-38.). Also, the gridded SAC-SMA implementation assumes baseflow is an independent process by grid cell (no cell-tocell soil water exchange). This assumption becomes less plausible at smaller grid cells. However, I still think that your application at about a 1 km2 scale is still worthy of evaluation in this context.

Response. These are valid points. We should note that SAC-SMA model structure was adopted within EF5 largely given its legacy within the National Weather Service. There are many users of the model in the NWS who are experienced with it. EF5 was implemented at a grid cell resolution of 1 km^2 in line with the resolution of the MRMS radar-based rainfall forcing. Thus, a choice was made to implement the model as closely as possible to its original structure without the requirement of re-deriving all the parameters.

Reviewer. At the top of p.13 the authors state that the subsurface discharge is routed through linear reservoirs rather than using kinematic wave. That sounds like a reasonable assumption, but I did not see an explanation in the paper as to how the linear reservoir parameters are estimated.

Response. Thanks for pointing this out. We have added the following text on 15, Line 6:

"Estimates for linear reservoir model parameters Under and LeakI for subsurface flow are based on *Fc* (hydraulic conductivity) and SAC-SMA's UZK parameter (Table 3) respectively, using conversion factors for units consistency."

Reviewer. P.14 – Why not derive a grid of PCTIM from the NLCD like you did with the comparable CREST parameter?

Response. We chose to concentrate new model developments in the CREST model given our experience with it, and decided to implement SAC-SMA as closely as possible to its original construction. Otherwise, the model would have deviated too much from its original implementation, from which NWS forecasters have familiarity and experience.

Reviewer. p. 19 – I would recommend using Snow17 if this analysis will be redone at any point in the future. The authors note 'As such, results in these regions should be used with caution when frozen precipitation processes are active.' I would not be surprised if excluding the Snow model also has some impacts on the relative performanc of SAC and CREST in the Northwest, North Central and North Eastern US. Without snow retention, simulated spring runoff could be sharper than what really occurs or there could be winter-time simulated events that don't really occur. Also, not modeling the effects of frozen ground in the North Central US could result in springtime under-simulations of events. Due to structural differences, the CREST and SAC-SMA would likely react relatively differently to changed rain-plus-melt series compared to how they react in your current study. I believe the last version of the HL-RDHM I saw was delivered with apriori estimates of the major Snow17 parameters and provides guidance on estimating the additional parameters needed for a basic simulation.

Response. We agree. The initial operational capability of EF5 did not include the

Snow17 module even though it is a component supported within the framework. At the time we implemented EF5 into NWS operations, we had little experience with Snow17 and didn't feel it had the level of validation in flash flood forecasting as the other core modeling components. As such, it didn't reach the technical readiness levels sufficient for transitioning to operations at that time. That being said, we have noted shortcomings in spring runoff responses in the northern tier of the U.S, just as you suggested. This was particularly true following the exceptionally high and late snowpack during the spring of 2019. Some forecasters noted more muted responses from EF5 given their observations of flooding. In short, soil saturation was underestimated in the models and this resulted in underforecasts of surface runoff. We are presently addressing this issue by including Snow17 in simulations and also assimilating observations and model states from NLDAS and NWM into EF5 to improve soil moisture simulations. Early results indicate improvements in doing this. We intend to transition these modules to operations with version 20 (currently we're transitioning MRMS v12). But, we felt this information was not sufficiently validated to include in the manuscript. To improve clarity of the study's intentions, 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."

Technical corrections

Reviewer. p2, line 10: 'high resolution forward hydrologic simulation'– take out the word 'forward'

Response. Done.

Reviewer. p3, line 26: Add comma 'Given the evidence above,'

Response. Done.

Reviewer. p3, line 32: Add comma 'resolution, necessitating'

Response. Done

Reviewer. p4, line 27: 'TRMM, and TMPA. . .'

Response. Changed to just TMPA as we accidentally expanded TRMM from the TMPA acronym.

Reviewer. p4, line 27: "While . . ." This is not a sentence. Could delete "While" or just delete the sentence altogether.

Response. Deleted.

Reviewer. p.5, Delete the sentence "For completeness the base classes for the routing and snow components are included below."

Response. Done.

Reviewer. p.5, third from last line, should say '. . .takes fast and slow components. . .'

Response. Changed.

Reviewer. p6, line 22: I suggest 'followed' rather than 'proceeded'

Response. Changed.

Reviewer. p6, line 24: is a 'derivative of'

Response. Changed.

Reviewer. p6, line 26: Wang et al. (2011) documented the first version of CREST. . .

Response. Done.

Reviewer. p8, line 12: should be "coarser" instead of "courser"

Response. Done.

Reviewer. p10, line 2: is 'classified' as

Response. Done.

Reviewer. p 12, line 3: No need for () around Ponce, 1991

Response. Corrected.

Reviewer. p.22, line 15: Should say "...as model resolutions are increasing the need for validating observations also increases."

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