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Hydrology and Earth System Sciences
Discussions

Interactive comment on "On the potential of variational calibration for a fully distributed hydrological model: application on a Mediterranean catchment" *by* Maxime Jay-Allemand et al.

Anonymous Referee #2

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The purpose of this article is to present a calibration methodology based on variational data assimilation using the adjoint state of a conceptual rainfall-runoff model. The proposed model is then tested in the Gardon catchment. The added value of the distributed version of the model is also studied.

The topic is of great interest in the field of hydrology and the proposition is valuable to make advances in operational calibration for rainfall-runoff modeling. However, the present article lacks: (i) a clear presentation of the novelty of the study in the general context of data assimilation using variational methods in hydrology or more broadly for

environmental model calibration and (ii) a more thorough and substantiated analysis of their results as detailed in the comments below.

1. The abstract should be more precise and synthetic, both on the context and on the results of the study.

2. P1 L5 Replace "accounting for spatial variability of the rainfall and the catchment properties, based on the radar rainfall observation inputs" by "accounting for spatial variability of the catchment properties and the rainfall, based on the radar rainfall observation inputs".

3. P1 L15 "scalable" has not been defined yet.

4. P3 L12 and P17 L9-10 The calibration of a distributed hydrological model using variational methods including the adjoint model has already been tested, at least several years ago in two PhD Thesis using the MARINE model (References below). I think a thorough and well-documented review of the state of the art research in this topic is needed to emphasize the novelty of the present study.

Bessière, H., Roux, H. and Dartus, D., 2007. Data assimilation and distributed flash flood modelling. Second Space for Hydrology Workshop - "Surface Water Storage and Runoff: Modeling, In-Situ data and Remote Sensing", Geneva, Switzerland. Available online http://earth.esa.int/hydrospace07/participants/08_01/08_01_Bessiere.pdf

Bessière, H., 2008. Assimilation de données variationnelle pour la modélisation hydrologique distribuée des crues à cinétique rapide. PhD thesis, Institut National Polytechnique de Toulouse, France. http://ethesis.inp-toulouse.fr/archive/00000710/

Castaings, W., 2009. Analyse de sensibilité et estimation de paramètres pour la modélisation hydrologique : potentiel et limitations des méthodes variationnelles. PhD thesis, Institut National Polytechnique de Grenoble, France. https://tel.archives-ouvertes.fr/tel-00264807

Castaings, W., Dartus, D., Le Dimet, F.-X., and Saulnier, G.-M.: Sensitivity analysis and parameter estimation for distributed hydrological modeling: potential of variational methods, Hydrol. Earth Syst. Sci., 13, 503–517, https://doi.org/10.5194/hess-13-503-2009, 2009.

Larnier, K., Roux, H., Garambois, P.-A. and Dartus, D., 2012. Data assimilation method for real-time flash flood forecasting using a physically based distributed model, European Geosciences Union General Assembly 2012, Vienna, Austria. 14. Available online https://meetingorganizer.copernicus.org/EGU2012/EGU2012-12846.pdf

5. P4 L26 Replace "based on the temperature" with "based on the air temperature"

6. P6 L20 "This model is build on top of a digital elevation model, which defines the runoff directions between the routing nodes." Replace "build" with "built". How the runoff directions are defined? How many runoff directions are allowed for each cell: 4 or 8? Is there a fillsink algorithm?

7. P8 figure 1 The model doesn't include any representation of the surface flow? It is quite surprising for flash flood simulation. Even if the authors mentioned that for the Gardon catchment "the water circulation appends mainly underground" (P11 L20), this is likely not to be the case for all the catchments prone to flash flood. Moreover, even if the dominant process in the generation of runoff is not the Hortonian one, surface runoff can also be generated by soil saturation. Can the authors comment on this?

8. P9 L4 It is quite confusing to use the same letter P both for precipitation and for the parameter vector even if one is in capital letters and the other not.

9. P10 equation (20) the "T" is not in the right place, I assume it should be the limit of the integral.

10. P12 L6 "A model warm-up of one year long is performed before starting the simulations." Did you test the impact of the duration of the warm-up period on the simulation results? Is the initial state of both reservoirs completely "forgotten" after one year of simulation?

11. P13 L10-13 From a chronological point of view, it would be more relevant to calibrate on P2 and validate on P1 for forecasting purpose. Indeed, if there is a trend in the data, you will miss it when calibrating on P1 and validating on P2. Did you see any impact on your results?

12. P14 L15 "One can see that the model spatial predictive performance is also better if the distributed calibration (red) is used, with one exception" on fig. 4 right. There is also one exception on fig. 3 left (rank 8). Can the authors comment on these exceptions: any reasons? Maybe related to the catchment or the period? For the same reasons, it would be interesting to mention in the fig. 3 and 4 not the rank which is obvious but the catchment and the calibration period in order to see if there are any correlations between the performances and the calibration sets (also see previous comment on that aspect).

13. P14 L16 "This depends, however, on the spatial variability of the test signal (rainfall)." It would have been interesting to correlate the performances with the spatial variability of the rainfall, for instance using Zoccatelli et al. (2011) indices. This could also have helped justifying the analysis P14 L25 "This effect can be attributed to quite a different rainfall pattern over the reference periods."

Zoccatelli, D., Borga, M., Viglione, A., Chirico, G. B., and Blöschl, G.: Spatial moments of catchment rainfall: rainfall spatial organisation, basin morphology, and flood response, Hydrol. Earth Syst. Sci., 15, 3767–3783, https://doi.org/10.5194/hess-15-3767-2011, 2011.

14. P14 L28 "calibrating the model independently for different hydrological regimes" or maybe calibrating the model using a data set including the different hydrological regimes?

15. P16 Table 2 The parameter ct is presented as the capacity of the transfer reservoir (P4 L32) why isn't it in mm as cp?

16. P16 Table 2 and P17 Table 3 are never mentioned in the text.

17. P16 L3-5 "This poor hydraulic behaviour can be partially compensated by the others model parameters during the calibration process, which may explain the extreme (equal to the upper bound) parameter values." I assume this refers to the value of 5 m/s for v in Table 2 and 3? What about 1000 mm for cp, is it the upper bound too? What does it mean for a physical point of view if you need a biggest production reservoir?

18. P16 L11 "hit" instead of "heat"?

19. It would have been interesting to study the correlation of the value of the calibrated parameters ct and cp with the actual soil properties: storage capacities but also soil texture and soil depths. Of course GRD is a conceptual model but the calibration of the local routing velocity v clearly shows a distinct behaviour of the drainage network. Is it the same for the 2 others parameters? Can the analysis of the correlation between ct, cp and the actual soil properties be instructive to improve the model structure or the calibration methodology? I think that could be one of the interesting contributions of the study.

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