

## ***Interactive comment on “An educational model for ensemble streamflow simulation and uncertainty analysis” by A. AghaKouchak et al.***

### **Anonymous Referee #4**

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General comments The paper describes the HBV-Ensemble modelling toolbox and how it has been used in teaching. The use of hands-on tools like this toolbox is valuable for teaching students about rainfall-runoff modelling and how it can be used to simulate hydrological processes. A valuable contribution of the toolbox is that it addresses the uncertainties inherent in the modelling of natural hydrological systems. However, the quality of the paper can be improved from a number of aspects (see below) and I recommend a major revision of the text before it is published.

1) A more in-depth literature review on how similar modelling tools have been used in teaching and what has been found regarding their effectiveness in improving student learning is needed. This would also be important for reference in the discussion of the

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results.

2) The aim of the study could be more clearly stated, also against previous studies.

3) The abstract only describes the toolbox not the paper/study as a whole. The conclusions part is now written like an abstract, I would suggest using this part as the basis for the new abstract and deleting or substantially shortening the conclusions section.

4) Instead of having the Conclusions section it would be more interesting to include a Discussion section that discussed the results and gives an outlook to the future about how teaching using the toolbox can be developed, and how the toolbox itself can be further developed. The experiences from this study in light of what others have found in previous studies also needs to be discussed. More discussion on modelling uncertainty in the teaching is needed given that this is a main focus of the paper.

5) The term “model” is used instead of “modelling toolbox” in several places throughout the paper. Since the hydrological model used is HBV, it would be better to consistently refer to HBV-Ensembles as a “modelling toolbox” to avoid confusion.

Specific comments 1) Page 7298, line 18. Not only hydrological extremes, but also water balance is important, especially for this type of model application. 2) Page 7299, line 5. “Student centred methods” sounds vague, can you give an example? 3) Page 7299, line 25 change “batch simulations” to “Monte Carlo simulations for uncertainty analysis”. Since the HBV-light enables uncertainty estimation using Monte Carlo methods and is used for this in teaching hydrology (see e.g. Seibert and Vis, 2012 in this special issue), it would be relevant to describe this further – especially considering the discussion on page 7300, line 10-13. It could also be made clear how the uncertainty estimation using HBV-Ensembles differs from the one in HBV-light and other toolboxes used in education such as RRMT (also implemented in Matlab, Wagener et al., 2004) 4) The background section on uncertainty estimation in hydrological modelling and the references in this section could be revised, e.g. referring to books like Beven, 2009, and review studies on the topic. It would be good with a few sentences about the dif-

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ferent uncertainty estimation methods there are (statistical, non-statistical, etc) as an overview and background to the method chosen here. 5) Page 7302, paragraph 1. This section could be deleted as this is covered in the introduction and background and no references are given for the statements. 6) Page 7303, Line 8-16. This needs to be revised as much information is repeated within the paragraph and with previous paragraphs. "all simulations that satisfy the objective function will be accepted as one realization in the ensemble output" this is not clear, how are all the simulations one realisation? 7) Page 7303, line 5. How are the samples drawn – from a uniform distribution? 8) Page 7303, line 12. The correlation coefficient is mentioned as well in another part of the paper. 9) Page 7303. The difference to GLUE is not clear and point 5 is repeated 10) Page 7304, Line 10-12. Could be change to "The grey lines show the uncertainty limits for all the acceptable parameter value sets, the simulation from the best-estimate parameter-value set is also shown." 11) Pages 7305-7306. Discuss how uncertainty in the modelling was handled in the teaching and perceived by the students. Discuss how the modelling toolbox and the teaching using it can be further developed in the future. 12) Fig. 2. It would be good to plot the rainfall and temperature data in a subplot to show students how the runoff relates to the input. Simulated should be "best-estimate simulated".

Technical corrections A detailed review of the text with respect to language is needed and repeated text could be deleted in several places.

References Beven, K. J. 2009. Environmental Modelling: An Uncertainty Future? Routledge, London T. Wagener, H. S. Wheater, H. V. Gupta, 2004. Rainfall-runoff modeling in gauged and ungauged catchments. Imperial College Press, London.

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