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Discussions

Interactive comment on "A framework for likelihood functions of deterministic hydrological models" *by* Lorenz Ammann et al.

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The authors would like to thank Mr. Montanari very much for his interest in this work, for reading the discussed paper, and for the very valuable and highly relevant comments that he provided. We will address all of those comments together with other future comments of the reviewers in this revision cycle. Nonetheless, we additionally reply to all of the comments by Mr. Montanari in the following paragraphs. We hope that those replies are satisfactory and we are happy to further discuss any potential misunderstandings of the comments.

Sincerely,

Lorenz Ammann, Peter Reichert and Fabrizio Fenicia

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Discussion paper

Page1, Line6: Yes, we mean the autocorrelation of the errors. We will include this in the next version.

Page2, Line3: If we understand correctly, there is general agreement on this point, the question is just whether residuals “cannot” be well represented by a normal distribution with constant mean and variance, or whether they “are rarely” well represented by such a distribution. We would prefer to stay with the latter formulation.

Page2, Line6: We agree that model structural errors can also lead to autocorrelation of errors. We will include this in the next version.

Page2, Line16: Yes, this is right, non-negativity is a characteristic of the streamflow, not of the errors. We will correct the wording. We will also adapt the wording in Page3, Line9 based on this.

Page3, Line22: Very valid comment, we did not formulate this clearly enough. In the next version, we will explain more clearly the difference between a parameterization of the innovation of the process describing the errors, and a parameterization of the distribution of streamflow given a model output. Generally speaking, the former approach is less intuitive and it is more difficult to formulate prior knowledge about what shape the distribution of the innovations of a stochastic process have. In particular, as the consequences of the distribution of the innovations on the marginal distributions of streamflow can often not be derived analytically. It is easier for hydrologists to formulate the marginal distribution of streamflow given model outputs, as this is a quantity hydrologists are much more familiar with.

Page4, Line5: Thanks. Yes, we believe that more complex error models in general have the potential to open new avenues for inference in hydrology, but they are still associated with some problems, the origin of which we do not fully understand yet. Therefore, it is important to investigate the potential causes of those problems to suggest improvements.

Page4, Line7: It was not our intention to say that those approaches are “loose” or “empirical”. We wanted to say that some weaknesses of the simpler error models are not revealed in common approaches of uncertainty analysis, e.g. simple error models can often provide reasonable error bands. But when other characteristics are of interest, e.g. the flashiness index of the modelled streamflow, more complex error models might be needed. We will adapt the wording accordingly, and include a reference to the suggested paper.

Page5, Line9: We were not aware of that paper and agree that it would be appropriate to include a reference to it.

Page5, Line24: We agree that this paragraph is not formulated clearly enough. “i” is the index of the time points at which the streamflow was observed. We will rephrase the paragraph and try to make it more easily understandable.

Page6, Line11 and subsequent comment: This might be a misunderstanding. The presented method does account for heteroscedasticity and includes a “variance stabilization”: the transformation of the observed streamflow is dependent on the modelled streamflow. This means that the streamflow at each time point is transformed by the same family of distributions, but with a different standard deviation accounting for larger errors in high-flows. Figure 6 shows the transformed observed streamflow (eta) as a function of the modelled streamflow. We did not include a formal test for homoscedasticity, but visual assessments indicate successful variance stabilization. The performance measure “reliability” can be seen as a test of normality, since it quantifies the deviance between a normal distribution and the set of transformed observed streamflow. If this was a misunderstanding we recognize that we were not clear enough and will include more explanations in the next version.

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