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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Temporal parameter sensitivity guided verification of process dynamics" *by* M. Pfannerstill et al.

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We are very thankful to the anonymous referee for providing us his concerns about the manuscript. Based on the remarks and recommendations, we firstly would like to summarise the two most relevant shortcomings of the current version of the manuscript. Based on the provided remarks, we firstly conclude that imprecise definitions of specific terms make the current manuscript hard to understand. This could be also the reason why the referee missed the point of how we use different TEDPAS-methods for model verification, which is the second main shortcoming of the current manuscript. The manuscript needs to be reworked to clarify the differences between the two TEDPAS methods (TEDPASsingle, TEDPASall) since these two methods are the central

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points of our verification framework. We would like to take the chance to explain our suggestions to improve the manuscript. For this, we will get through the different comments step by step and reply them carefully with respect to the mentioned two main remarks.

Referee2 1: To be honest, I find the manuscript hard to read for a combination of reasons. The language is unnecessarily complicated in places (see below for a couple of particularly striking sentences), and the used terminology really makes it hard to understand what is exactly meant (e.g., I was halfway through the paper before I understood more or less what was meant with "expected sequence of parameter sensitivity".

Answer 1: We agree with the referee that the language needs some improvements. Especially the used terminology seems to be a problem for the reader as several specific terms are not clearly defined.
We will certainly check the entire manuscript and simplify complicated sentences. Furthermore, we suggest to elaborate on this aspect of missing or imprecise definitions and would like to provide two solutions.
Solution 1: One solution would be to carefully screen the manuscript for specific terms to integrate a precise definition at the point when specific terms are introduced or mentioned for the first time.
Solution 2: The second solution would be to integrate the precise definitions of specific terms according to solution 1 together with an additional table.

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Referee2 2: But more importantly, the way that I understand the procedure I can only conclude that it is fundamentally flawed. I really wonder how the use of TEDPAS as a diagnostic tool does more than just reflecting the properties of the procedural model as it is implemented. The authors present an application in which they modify the groundwater representation of the SWAT model. They include two pathways, one being faster shallow aquifer response and one slower responding aquifer. From the TEDPAS analysis, they conclude that the parameters related to the faster pathway are more sensitive earlier after a rainfall response, and the parameters related to the slower pathway are more sensitive a longer time after the precipitation event.

Answer 2: Based on this critical comment we would like to explain again the idea of TEDPAS as a verification tool. Obviously the core ideas of the manuscript were not described as precisely as needed. We have developed a verification tool using two steps of TEDPAS (TEDPASsingle and TEDPASall). Apparently, the current version of our manuscript emphasises TEDPASsingle while the role of TEDPASall is not as clear as intended. Thus, we would like to describe the purpose of both TEDPAS applications as follows.

The idea of TEDPASsingle is to verify the appropriate temporal parameter sensitivity. The temporal parameter sensitivities of the modified model are compared with the expectations that are derived from the model structure. For this point, the referee is totally right by stating that TEDPASsingle is used to test for expected parameter behaviours. However, this kind of analysis is only one part of the model verification.

The idea of TEDPASall is fundamentally different to TEDPASsingle. The difference seems to be not clearly explained and there is the need to rework this aspect of the manuscript. The core idea of TEDPASall is to use observations and knowledge of the catchment to verify the processes that are simulated by the model. We derive hypotheses from processes that were observed within the catchment and from the general knowledge of processes within the catchment. These hypotheses about process occurrence are compared with the simulated process occurrence. We make use of catchment information (observed processes) to verify proper process representation

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by the model (simulated processes).
In our opinion, three modifications of the manuscript could help to clarify the difference between TEDPASsingle and TEDPASall. The first point would be an integration of a flowchart that clearly depicts the underlying assumptions and objectives of each method (please find attached Fig. 1). Additionally, we suggest to modify the terms of each method to emphasise that one method is focused on model structure related hypotheses (TEDPASmodel) and that the other method is focused on observed hydrological processes within the catchment (TEDPAScatchment). Finally, the manuscript can be partly restructured by separating the approaches of verification with model-structure based hypotheses from the verification with catchment/observational based hypotheses.

Referee2 3: So how does this say something about the model performance? Does it not just reflect that the mathematical model does what is intended, i.e. represent a faster and a slower pathway? I do not think that this can be seen as an independent evaluation, on the contrary, I think the authors get trapped in a circular reasoning pattern, where the model parameter behaviour is a direct result of the assumptions made when building the model.

Answer 3: With respect to model performance evaluation we refer to our previous publication (Pfannerstill et al., 2014), which focuses explicitly on model performance. In contrast, the current manuscript aims to investigate the hydrological consistency of the modified model. Of course, model performance evaluation of the modified model is an additional crucial point. Up to now, Pfannerstill et al (2014) is not depicted in Fig. 1 of the current paper. If the integration of this reference would help to clarify the remark about model performance evaluation, we could offer to integrate the study of Pfannerstill et al. (2014) into Fig.1 of the paper.
Considering the remark about model parameter and model behaviour evaluation, we hope that the explanation of TEDPASsingle and TEDPASall in the previous comment gives detailed information: The aim of the manuscript is to verify that a modified model

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is able to reproduce the hydrological processes in a realistic way. As described before, there are two methods that need to be applied to verify the model. According to the description of the referee, the method of TEDPASsingle verifies that the included parameters of the modified model component meet the expectations that were derived from the modified model structure. We agree with the referee for the point that the parameter sensitivity should be a result of the assumptions of the modified model structure. By doing so, we make sure that the assumptions are properly integrated into the model.
However, as mentioned in the previous answer there is another crucial aspect for the verification. TEDPASall is used to verify that the modified model is able to reproduce the hydrological processes. For this, hypotheses about the processes are derived from observations within the catchment and from knowledge of the catchment's processes. These hypotheses are compared with the results of TEDPASall. As a conclusion, we also make sure that real-world processes are used to evaluate the model modification.

Referee2 4: I sincerely hope that I have missed the point of the manuscript. But as I currently understand the procedure, I think that the procedure simply reflects the way that the model is conceived. As such, it only confirms that the hypotheses are correctly implemented in a procedural model, but does not say anything about the real-world validity of those hypotheses.

Answer 4: We interpret this comment as a summary of the previous comments, emphasising the main concern of our study. As described in the previous answers, we hope that the provided answers give more precise information about the core ideas of our study and that the suggested modifications can help to fix the concerns of the referee.
The real-world character of our hypotheses is given by the fact that we derived the hypotheses H4-H9 (in TEDASall) directly from former studies in the catchment and knowledge we have about this catchment.

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Specific comments: *Referee2 1731/12-13: "how well they represent the corresponding real-world processes": See specific comments - I am not convinced that this is really tested. All that is tested is whether the model represents the perceptual model of the modeller.*

Answer: We refer to our previous explanations and hope, that the comments are sufficiently discussed by our responses.

Referee2 1732/3: "High temporal resolution": vague. What is the time step, and why do you consider it high resolution? Further on it seems that the model is implemented at daily resolution, which might even be considered relatively low for a catchment of only 50km2. The point of emphasizing this escapes me.

Answer: We are thankful for this comment. Our aim was to point out the contrast to classical parameter sensitivity analyses, which provide the parameter sensitivity in an aggregated way for the whole simulation period. The temporal parameter sensitivity analysis provides the sensitivity for each time-step. Consequently, we get an idea of how the relevance of a specific parameter changes over time. We suggest to change all occurrences of “high temporal resolution” into “daily resolution”.

Referee2 1732: "For this...": this is an example of a monster of a sentence. I really struggle to understand what is meant here.
Referee2 1733/1: wihthin -> within
Referee2 1736: I am not sure I really understand the difference between TEDPASsingle and TEDPASSall from the way that it is formulated here.
Referee2 1737/9: "the concept of the model structure": what do you mean with this?

Answer: As mentioned before, we will carefully check the language of our manuscript and we will take care of proper term definitions.

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Referee2 1737/15: "Therefore, the...": again, you try to test a hypothesis (the sequence of processes) with another hypothesis (the model structure) both based on the same knowledge (catchment processes). This would not seem to make sense.

Answer: We hope that this issue was clarified with our previous explanations. However, we see this example as reason to check again our definitions and language.

Referee2 1737/19: "Framework demonstration example": Is this not simply an application?

Answer: It is indeed an application of the framework.

Referee2 1746/19: build -> built?

Answer: We will fix this.

Referee2 1749/6: "The expected sequence of processes is derived from the model concept": again this is the fundamental issue. If you do so, of course you cannot use this sequence to evaluate the model structure, because this double counts the available information.

Answer: Again this seems to be an issue of imprecise wording as explained before. We will fix this according to our responses that were provided in the previous comments.

References

Pfannerstill, M., Guse, B., and Fohrer, N.: Smart low flow signature metrics for an improved overall performance evaluation of hydrological models, J. Hydrol., 510, 447–458, doi:10.1016/j.jhydrol.2013.12.044, 2014.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 1729, 2015.

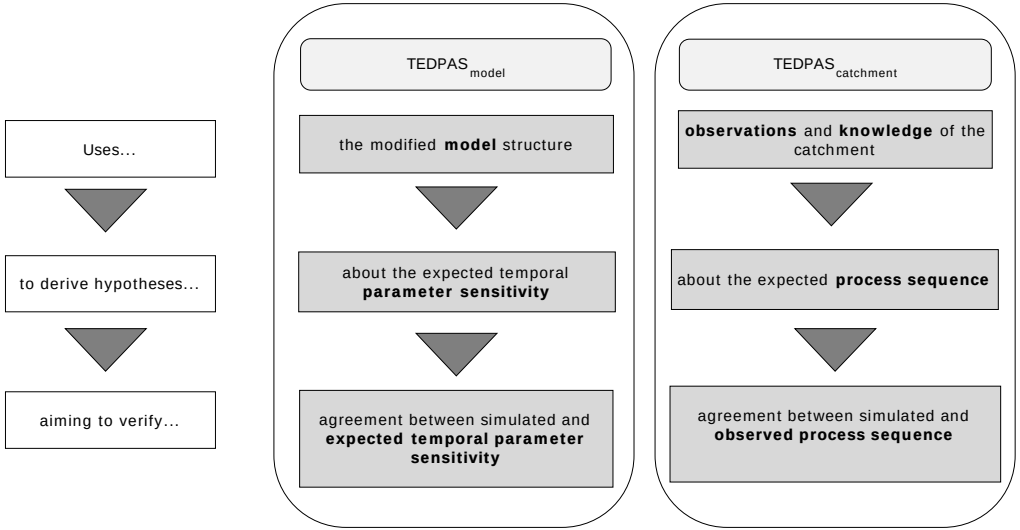

Fig. 1. Differences between model diagnostic analyses with TEPDASmodel (TEDPASsingle) and TEDPAScatchment (TEDPASall).

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