Response to Review #2

Dear Shervan Gharari,

We would like to thank you for reviewing our publication and for the comments. We agree with many of the suggestions and will adjust the publication accordingly. In your review you also touch upon the larger discussion in the hydrological community on different model structures and on the software used for our study. We will separate the review of our work from the broader discussion as we believe that the focus on this platform should be on the assessment and improvement of the quality of the publication. We would like to point out that through accepting this work into the review process of HESS the editor has decided that it, in principle, fits within the scope of the journal and that the primary purpose of the review process is to test if the research is sound and if the manuscript can be improved. .

The response to the review is structured as follows: Part 1, response to comments that will improve the quality of the publication. Part 2, response to the ongoing discussion on the topic vector- and grid-based simulations. Part 3, response to the software used for the methodology of this study.

Part 1: Response to comments regarding the publication

- *References*

We agree that the reflection on the use of references should be (greatly) improved and that the references need to be extended to include the broader land-surface community past and present. This will include works on parameter identifiability such as Gupta & Sorooshian (1983), Grayson et al., (1992), and Oreskes et al., (1994). Works on parameter transferability over space such as Finnerty et al., (1997), Haddeland et al., (2002), Wagener and Wheater (2006), and Melsen (2016). A better description of the scaling/closure problem by including Wood et al., (1988), Bloschl and Sivapalan (1995), Beven (2006). This list will be extended in the revised publication.

- *Objective function relevance (KGE 0.22)*

This is a valid point that we will further address in the discussion section. In addition, we will extend the analysis by including methods presented in Clark et al. (2021) as per the Referee's suggestion. We believe that this will provide the reader with much needed reflection on the meaning of the differences in KGE score. The results will be incorporated in the discussion section of the publication.

- *Lakes and reservoirs*

We will report the presence of lakes and reservoirs in the model setup per subbasins. When relevant this will be included in the discussion section.

- *Basin selection*

The reason for selecting 454 CAMELS basins will be clarified as also per request of Referee #1. Reasons for excluding basins are errors that stem from parameter estimation from

external sources (mainly river network delineation related) and lacking streamflow observation records during the evaluation period of the model simulations.

- *Calibration methodology*

We will clarify the calibration routine by firstly stating the parameter range clearly. Secondly, by referencing previous sensitivity analyses (e.g., Imhoff et al., 2020; Wannasin et al., 2021). This information will be mentioned in section 2.2.3.

The model is calibrated "manually" by predefining a parameter range. The parameter corresponding to the highest KGE score at the basin outlet is then selected. The parameter range is selected based on the sensitivity of the parameter to the KGE score. We decided on manually calibrating the hydrological model as this greatly reduces the amount of compute time while still finding a close to optimal parameter value. This information will be included and clearly described in the publication.

- *Model selection*

In the publication we argue that the use of the wflow_sbm is of interest due to the premise of deriving a model that is semi-scale independent at various spatial resolutions from globally available data sources through the use of transfer functions. This is now more than relevant due to the trend in increasing the spatial resolution of grid-based models (e.g., Sutanudjaja et al., 2018). As these types of hydrological models are used for various applications we find it important to understand what this trend entails for users. In addition, we would like to note that the original Topog_SBM concept (Vertessy and Elsenbeer, 1999) was applied at a small scale.

- *Scaling in hydrology*

The focus in this study is on testing the effect that spatial model resolution has on the simulation of streamflow at the basin outlet on a large sample of basins and what this entails for users. This provides insights on the behavior of a hydrological model that holds the promise to derive comparable model instances at various spatial resolutions and therefore comparable streamflow simulations. Although we are not investigating the collective behavior of internal states and fluxes at various scales, we do investigate changes that occur in streamflow simulations due to variations in basin delineation, river network estimation, and topography (section 3.1). We consider these parts scaling from a hydrological model perspective.

- *Future research*

The Referee has made several valid points concerning the evaluation of the hydrological model. We hope these points will be addressed in future research (either by us or others in the community. For this publication the scope is on a single objective. Having said that, we do have some initial thoughts we want to share in this discussion:

- *Forcing and model resolutions*
  It is of great interest to investigate the effects that the native resolution of precipitation fields have on the simulations of the hydrological model. An initial assessment looked at applying stochastic downscaling using a climatology to (artificially) improve heterogeneity in the precipitation fields. Results on a small subset of the basins showed that this had small effects on the streamflow estimates at the outlet. However, in future

research we intend to further investigate the effect of native forcing resolution by including multiple forcing products (8km – 1km). In addition, we hope to investigate the effects of spatial resolution in relation to the numerics by applying uniform precipitation fields as a baseline, similar to Melsen et al. (2016).

- *States and fluxes, model fidelity.*
  We agree with the Referee that scaling in hydrology goes beyond adjustments of the model grid resolution. It is important to evaluate the collective behavior of the states and fluxes of the hydrological model at various scales to test whether parameterizations of processes are sufficient or not. This has been deemed out-of-scope and we invite the reviewers and the rest of the community to join us in working on this. This research should include a complete flux and state comparison and when possible states and fluxes are evaluated against (remote sensing) observations.

Part 2: Response to comments regarding vector- vs grid-based simulations

The discussion concerning grid-based simulation and vector-based simulation is an ongoing important discussion that can be held further during conferences and or commentaries. As the assessment of grid-based models is still relevant due to their application in operational and scientific settings, we consider analyzing such models as valuable to the hydrological community. Nonetheless, we would like to encourage a discussion on another platform on this topic with the Referee.

Part 3: Response to the software used for the methodology of this study

The work presented in this paper is one of the first to use the eWaterCycle platform for hydrological computational research. eWaterCycle is designed to let hydrologists be experts in hydrology without having to become a computer scientist in the process. As the reviewer rightly points out: There is a difference between users (hydrologists) and developers indeed. For any comments on the software of the eWaterCycle platform which is used in the workflow of this study we would like to refer you to the publication in GMD, https://doi.org/10.5194/gmd-2021-344. You are most welcome to write a reply to this study to start a discussion on the use of (Python) software packages and the philosophy behind eWaterCycle.

Best Regards,

Jerom Aerts