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Discussions

Interactive comment on "An evaluation of the importance of spatial resolution in global climate and hydrological models based on the Rhine and Mississippi basins" *by* Imme Benedict et al.

Anonymous Referee #3

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I thank the authors for this revised version and for addressing my comments. In this revised version, the authors recognise that an increase in resolution does not necessarily lead to better streamflow simulations, and clearly state it in the abstract and in the main text. This made me wonder why it was not the case, so I went through the different versions of the manuscript, reviewers' comments and authors' replies. In a nutshell, I am concerned that i) the GHM was not ideally set up and ii) the experimental setup chosen by the authors prevented them from fully exploiting the benefits of the higher resolution.

GHM setup: When forced using ERAI, the GHM severely underestimates streamflow

in the Rhine basin (Figure 5c), in particular in summer, when as much as half of the streamflow is missing. The authors recognise that the "GHM is too dry in the summer months", since ERAI precipitation estimates are "good". I raised this issue in a previous round of revisions, and the authors replied that they "have not performed an in-depth analysis on the performance of W3RA as this study focuses on the sensitivity to resolution." I regret to say that I do not agree with this argument. Before increasing the resolution, the authors should have made sure that the basic hydrological behaviour of the basin (its water balance) is adequately captured. In this specific case, the streamflow underestimation in summer indicates that the GHM is not adequately setup for the Rhine catchment. From a more general perspective, the authors mentioned in their reply that "The global hydrological model which we use is not calibrated for the specific catchments of this study. In general, calibration of global hydrological models is limited." I recognise that, when run at the global scale, GHMs are challenging to calibrate, but for this study, I consider that the authors should have taken the time to adjust model parameters in order to provide acceptable streamflow simulations for the two basins they selected, before increasing the GHM resolution.

Parameter estimation under higher resolution: In the revised manuscript, the authors mention that for the GHM, "to allow a fair comparison between the two model resolutions, we remapped these parameters from the 0.5° to the 0.05° resolution." The authors explained in a previous round of reviews that "we remap the parameters from the low to the high resolution using the resample statement in PCRaster (Karssenberg et al., 2010)". How the remapping exactly works is unfortunately not documented in the revised manuscript, but my impression is that a resampling routine alone is not sufficient to incorporate the new data and knowledge necessary to enable the model to resolve smaller-scale processes. In their revised abstract, the authors report that "Increasing the resolution of vegetation and orography in the high resolution GHM (from 0.5° to 0.05°) shows no significant differences in discharge for both basins, likely because the hydrological processes depend highly on model parameter values that are not readily available at high resolution." All this indicates that although the GHM was

run at higher resolution, it was probably run using parameters at an effective resolution close to the original (coarser) resolution, because model parameters are higher resolution were not “readily available”. This likely explains why the benefits of increasing the GHM resolution were limited. Arguably, increasing the resolution of a model goes beyond decreasing its grid spacing, it should also involve the incorporation of new data and knowledge on process representation across scales. It is my impression that this part is essentially missing and this is preventing us from truly assessing the benefits of the increased resolution.

In conclusion, this study addresses an interesting research question, and it is clear that a lot of effort has gone into it. However, I consider that the experimental setup presents fundamental flaws, which cannot be easily corrected (it would be necessary to re-run most of the analysis to fix them), and which significantly limit the insights the authors (and the community) can gain into the benefits of model resolution increase.

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