Reply to reviewer #1

The manuscript tests the hypothesis that coupling a global glacier model (i.e., GloGEM) with a global hydrological model (i.e., PCR-GLOBWB 2) leads to a more realistic glacier representation and improved runoff prediction in the global hydrological model. both the uncoupled benchmark and the coupled model were run for 25 large-scale glacierized basin during the hydrological years 2001-2012. Overall, the manuscript is clearly written, and the results are well discussed.

We highly appreciate this positive overall assessment of our manuscript.

I have only two main concerns and one specific point for this study:

- *The authors test a widely accepted hypothesis that the physical representation and simulation of hydrological model will be improved if its corresponding parameterization is optimized on a global scale. I am not quite sure that a test of a widely accepted hypothesis is a true innovation (I leave this question to the editor). If the test is done by coupling the global hydrological model and global glacier model physically instead of simply replacing the PCR-GLOBWB 2 runoff by the GloGEM runoff for glacierized areas, the novelty of this study make sense at least from a practical point of view.*

We acknowledge the reviewer for expressing this valid concern. We argue that replacing the PCR-GLOBWB 2 runoff by the GloGEM runoff for glacierized areas is a physical coupling that goes beyond parameterization of the hydrological model. We structure our reply into two parts:

- Glaciers lie at the origin of streams were the exchange of water between glaciers and the rest of the catchment predominantly takes place on the surface level and in only one direction. Replacing the glacier runoff of one model with the glacier runoff of another model as a coupling method does therefore not produce large physical inconsistencies. One simplification we applied is that all glacier runoff ends up in the stream and that therefore none of it drains to the subsurface before reaching the stream. Although there is exchange in the subsurface we consider this simplification acceptable at the global scale as we describe in section 3.1 (lines 136 – 140). This simplification makes the coupling of a glacier model with a hydrological model feasible and straightforward to implement without losing too much physical basis. Such a straightforward implementation of one-way coupling of models demonstrates that this method can be adopted by other global hydrological models. The slight loss in physical basis induced by the coupling method can then be compensated by the gain in glacier representation accuracy of the GGM relative to the GHM.
- Global hydrological models without a sufficiently detailed glacier representation will likely produce less reliable results in glacierized basins. All new methodologies that have the potential to alleviate this problem, among which the one presented in this study, are an improvement of the current state of research in hydrology. Additionally, this study could also incentivize GHM model developers to carefully evaluate and improve the physical process descriptions applied in their respective GHMs in the future. The relevance of this new methodology is exemplified by the rise in GHM-related publications, the large amount of people depending on glacial runoff worldwide and the significant projected climate change induced changes in glacier runoff.

We will adjust the first paragraph of section 3.1 to the following: "Within the context of this study, the term ‘coupling’ refers to the replacement of the PCR-GLOBWB 2 runoff by the GloGEM runoff for glacierized areas. **We deem this simplification of coupling physically plausible since much of the**

exchange of water between glaciers and the rest of the catchment occurs at the surface in the form of runoff. To the best of our knowledge, this **coupling approach** has not been applied before for glacio-hydrological modeling purposes. Several situations can be thought of for which further coupling between a glacier model and a hydrological model could be applied, such as surging glaciers damming upstream rivers (Sevestre and Benn, 2015) or the flow of subglacial groundwater (Vincent et al., 2019), but these are considered irrelevant at the considered scale."

- *In both Abstract and Introduction sections, the authors mentioned that global runoff prediction can be improved through the coupling of GHMs and GGMs. However, only runoff "simulation" was tested in this study rather than "prediction". The authors are suggested showing the results of runoff prediction (not for the calibration/validation periods but for the prediction period) as well.*

We thank the reviewer for this comment. The reviewer is correct in pointing out that the use of the term "prediction" is not accurate and therefore we will adjust it in the revised manuscript. As the reviewer states correctly, we only performed historical simulations and no predictions. However, the simulations can be seen as a test of the prediction quality, since PCR-GLOBWB 2 is not calibrated over the simulation years. The results show that the current hydrological model carries large uncertainties in the simulation of glacierized basins, also after the coupling. Therefore, we deem it unsuitable to perform future simulations with in glacierized catchments and this is left for future studies.

To clarify this part, we will add a sentence at the end of section 3.2: "All model setups are run between the hydrological years 2000-2012. As PCR-GLOBWB 2 is not calibrated, the simulation over these 12 years can be seen as a test for the prediction quality of the coupled model versus the uncoupled model."

A specific point: Paragraph 165 in P7, extra periods.

Noted and will be adjusted.