Reply to EC

EC: The authors have partially addressed the concerns of both reviewers. While the scope of the paper that focuses primarily in describing the model updates and providing evaluation results is appropriate for GMD, as it currently stands, the paper could strongly benefit from a stronger introduction and a discussion section. I provide below some context for why these two additions would help the paper:

Reply: Thank you for your assessment and the chance to revise the manuscript. We reply to the editor comments **EC** by our **Reply.**

EC: 1. The current introduction is very sparse and doesn't really set the stage for the paper. This is an opportunity to explain why the changes that are made to the model are made; if this is done and the modeling results still don't improve modeling results, at least a rationale for why the changes are made is clear. If not, it gives the appearance that random additions were made without a concrete plan for addressing model improvement or process representation. As it currently reads, there are only a few sentences here and there that address this need. If this were expanded, this would greatly benefit providing context for all the work that was done. The introduction in the 2021 paper was much stronger and gives context for the work.

Reply: Thank you very much for this clarification. We fully agree that such a rationale would help to set the scope of the paper but also to avoid the impression that the modifications are somehow random. We have strongly extended the introduction (from 2 to 4 pages) to provide the scientific rationale of all the modifications and additions in the new model version, also including more references to the literature.

EC: 2. The paper could benefit from a discussion section. The authors recognize issues of the calibration (among other issues) but fail to address them directly in the paper. Reviewer #1 provided feedback but that feedback was mostly deflected. Even if the weaknesses of the calibration (among others) are not addressed directly in an update to the methodology and results; it should be discussed more explicitly. More broadly, adding a discussion section that also provides a perspective on future efforts and model development focus in the future would be a valuable addition to the paper and would provide the additional information that provides stronger context for the results and future directions.

Reply: Thank you for the good idea to provide a discussion and future outlook section. As model calibration is one key element of the model, we have enhanced the results section by an assessment of the added value of the newly added 119 gauging stations (New section 7.5, new Fig. 13 and Table 10). Furthermore, we have included this topic in a new (discussion) section 8 on benefits and limitations of the calibration approach. Furthermore, we have improved the Conclusions section by an outlook that covers three topics: 1. Modification of the reservoir algorithm, 2. Inclusion of an updated glacier model, 3. Converting WaterGAP into a community-based model.

Reply to RC1

RC1: The authors have clarified that the goal of the paper is to provide a complete description of the current version of the model rather than a scientific contribution based on the model outputs. It may be a goal of GMD to provide space for such contributions. The authors have mostly deflected, suggesting that the model updates do not necessarily lead to a quantifiable improvement in terms of accuracy or process representation.

On the other points, the updated reservoir algorithm has been removed from the manuscript. The bias adjustment has been clarified, though remains simple and difficult to justify.

Reply: Thank you for your continued efforts in reviewing and commenting on the manuscript, we appreciate your time and thoughts. We reply to the referee comments **RC1** by indicated by **Reply**, and corresponding actions, indicated by **Action.**

RC1: It is true that the paper describes significant effort on the model development, and modeling at this scale is no small task. But the scientific justification appears to rest on previous studies, and the reader must take at face value the authors' claims of an improved model without much notable difference in the output. This reflects a broader problem with global models that are challenged by overparameterization and scale mismatches when accounting for human impacts on the water cycle.

Reply: Thank you for pointing out that the scientific justification is lacking. We would like to reply to this comment in three ways. 1. In order to frame the scientific scope, we have revised the introduction to provide a scientific background of the modifications in the model version. This also leads to scientific objectives that are written at the end of the introduction. 2. We have included a discussion of the calibration, in particular the benefit of the newly introduced stations for calibration. 3. Within the conclusions, we have integrated paragraphs about future perspectives on model development. We trust these modifications lead to a better scientific justification but also touches general issues with global-scale modelling.

Action: 1. Within the introduction, we describe the scientific reasons for each of the modifications. 2. At the end of the introduction we formulate objectives. 3. We introduce a new section „Discussion of calibration" that focuses on the calibration topic and the added value of the 119 newly introduced gauging stations for calibration. Furthermore, we further discuss the limitations of the calibration procedure and consequences when modifying maximum soil moisture, but also elaborate on alternative (multivariate) calibration procedures. 4. We extend the section „Conclusion" with an outlook of future model developments and provide three examples to improve global scale hydrological modeling.

RC1: The updates to the paper itself are fairly minor, so my concerns from the previous round remain. It would be difficult for the paper to move forward as a standard scientific contribution. However, I will leave it to the editors whether the technical description of the model improvements is sufficient to move forward in GMD.

Reply: We believe this comment is rather dedicated to the Editor and cannot add to our reply to the original comment 1 of Referee #1 (that it is within the scope of GMD, in particular of this manuscript type, to provide technical descriptions).