Hess-2023-19

Response to referee comment: Anonymous Referee #1

We greatly appreciate Anonymous Referee #1 for the time and effort put to review our manuscript and for the constructive comments. We believe it will help improving and better clarifying our work. Please see below our point-to-point response.

Comment: The paper contributes a reconstruction of the filling strategy of the Grand Ethiopian Renaissance Dam (GERD) in Ethiopia based on a combination of hydrological modeling and satellite data processing. The approach also explores the role of precipitation data uncertainty by considering five alternative rainfall products as input to the conceptual hydrological model (HBV). The study is very timely and interesting for HESS readership. However, despite the modeling framework looks solid and well designed, its implications and value for the ongoing water management dispute in the Nile River Basin should be better elaborated (see comments below) before accepting the paper for publication.

1) Since the abstract and in most of the introduction, the authors emphasize the value of inferring the GERD filling strategy to support a better management of the Nile River despite the long-lasting international tensions between Ethiopia and downstream countries (see lines 19-22; 57-58 74-75). I do second this point but would argue that the paper falls shy of these contributions to water management. The proposed approach uses a conceptual hydrological model calibrated at the Eldiem station (close to the Ethiopia-Sudan border) before the GERD construction to estimate the volume of water stored during the filling period as the difference between the simulated discharge in natural conditions minus the observed one. The resulting storage trajectory is validated against a trajectory reconstructed from Landsat images according to the method proposed by Vu et al. (2022). As said before, this modeling approach sounds solid and well-designed, except for a couple of minor points reported below.

Response: We believe that our manuscript delivers on its promise by offering valuable insights to improve the management of the two downstream dams in Sudan, particularly in light of the current dispute and the lack of shared GERD filling plans. No other study has presented quantitative information about the impact of GERD on downstream discharge, which is crucial for water managers in Sudan to optimize the operation of the dams for food security and hydropower generation. With the information provided in our manuscript, it is possible, for example, to reschedule the filling of the Roseires dam to align with agricultural requirements in the coming years (discussed in line 388-389). However, while our aim is to provide this necessary information, we do not intend to apply it to optimize current management practices since this would require significant additional work.

Page 3 line 75: “Blue Nile River” is replaced by “Lower Blue Nile River”.

Page 3 line 75: after “…. in Sudan.” we have added “Nonetheless, the work does not attempt to use the findings to optimize current management practices since this would go beyond the goal of this study.”

Comment: However, the discussion in Section 4.4 about the value of these findings for the ongoing water management dispute in the Nile River Basin is relatively simplistic. Here, the authors only comment about the reconstructed filling strategy (Fig. 10) and streamflow entering in Sudan (Fig. 11), raising the following doubt: is the proposed approach really necessary for informing water management? On the one hand, the reconstructed trajectory in Fig. 10 could be obtained with the approach by Vu et al (2022) only using satellite images; on the other hand, the flow entering in Sudan is directly measured at Eldiem station, regardless of the models developed for the upstream part.

Response: While the approach presented by Vu et al. (2022) is useful, we acknowledge that it has certain limitations that we have addressed in our manuscript. In the case of GERD, we believe that having a fine time scale (daily or less) is crucial, especially given the proximity of the Roseires dam to GERD.

Page 22 line 399: we have added "Beside the approach discussed here, the downstream analysis can also be based on satellite images using, for example, the approach propose by Vu et al. (2022). However, relying on the latter approach for real-time operation presents certain challenges. Firstly, given the current availability of free satellite data (such as Sentinel and Landsat), it is not feasible to achieve daily time steps, unlike in the case of relying on hydrological modelling. Secondly, waiting for a few days to acquire satellite data can be problematic, particularly during flood events, such as those experienced in Sudan in 2020. It is important to note that our proposed approach relies on outflow observations, which may not always be available. As such, both approaches have their respective applications and limitations."

Comment: To satisfy the (high) expectations generated in the abstract-introduction, I believe the authors should try to expand this part of the manuscript in order to better show the potential value of their model. For example, can you use your results to infer a rule that could be used to simulate the rest of the filling period? can you quantify the value of the information produced by your model for supporting the pro-active operations of Roseires and Sennar dams (as mentioned at line 67)? how should these two dams be operated to adapt/coordinate with the upstream filling policy?

Replying to this type of questions is in my opinion necessary to make the paper's findings valuable on the policy side. If authors believe this is going beyond the scope of their work, I would suggest revising the narrative of the abstract and intro in order to downplay these aspects and better characterize their contribution.

Response: Regarding the statement in line 67 of our manuscript, our intent was to provide justification for the proposed methodology. However, we acknowledge that the first two questions raised by the referee are integral to the objectives of our study. While we believe that our methodology could provide valuable insights on these questions, we also recognize that their answers are uncertain given the unfinished construction of GERD, as we have discussed in line 382. In practice, if the construction of GERD dam was completed, these questions could be addressed using our methodology, which involves utilizing stochastic hydrological simulations based on historical discharge data. Additionally, we declare that a more effective management of dams could be achieved by understanding past filling strategies, particularly given the uncertainty surrounding future filling strategies based on the information currently available. As for the third question, it is addressed in our response to the first comment.

Comment: 2) The reconstruction of the filling strategy is built on the hydrologic simulation of the HBV-light model. This conceptual model was calibrated during the 2006-2019 period and validated over the period 1991-1996. How reliable is this strategy given the evident global warming/climate change trends? Did the authors check the presence of trends in precipitation and temperature data?

Response: In our manuscript, we explicitly acknowledged in line 165 that the approach we took was necessitated by a notable deficiency in the available data. Given this constraint, we made a deliberate decision to partition the periods in this way. We appreciate your suggestion to consider the impact of global warming on our findings, and we would like to address your concerns regarding this matter.

We are confident that the findings based on the current strategy are reliable for two reasons. First, the change in climate between calibration and validation is likely much larger than between calibration and the present, since these periods are much closer in time. Second, as noted by Melsen et al. (HESS, 2018), parameter sets are not typically the dominating source of uncertainty when considering long-term changes simulated with hydrological models such as HBV, which was also employed in this study.

Comment: Since the calibration relies on 10,000 random parameter sets that returned 1756 simulations with NSE>0.75 (lines 242-244), I suspect the "best" parameterization adopted might not necessarily be so valid when applied to the 2020-2022 time period.

Response: As stated in lines 250-255, the value of NSE is greatly influenced by the discharge seasonality of the basin. As such, we only obtained 407 simulations with an NSE greater than 0.5 in retrieving the storage, as indicated in lines 332-333. We believe that these 407 simulations are more valid than the 1756 simulations. Our results indicate that the "best" parameterization is reasonably valid since it achieved the highest performance during the calibration period and obtained a high NSE value in retrieving the storage. However, we acknowledge that other parameterization options may also be valid, but we have attempted to make our methodology as objective as possible.

Comment: 3) The authors are validating the reconstruction based on the HBV-light model using the approach by Vu et al. (2022). However, they notice only 53% of the Landsat images are cloudless, with several missing data during the wet season, which is also the most critical in terms of filling. Why did they not consider also using radar altimetry data to complement Landsat images?

Response: The Global Reservoirs and Lakes Monitor (G-REALM; Birkett et al., 2011) has actually been part of our methodology initially, but as it turned out to be too uncertain it was excluded. As depicted in Fig. 1(a) below, the measurement location provided in G-realm (Jason and Sentinel) was about 80km upstream of the dam body. The storage volume derived from G-realm had an unreasonable rapid decline after peak and was high compared to Landsat data (see Fig. 1(b) below). As a result, we validated only using Landsat data. Additionally, radar altimetry data will only add a few points to the time series, which is not enough to be useful. We hope the reviewer agrees with our motivation not to consider altimetry. However we will make sure to discuss the potential of altimetry in the discussion section.

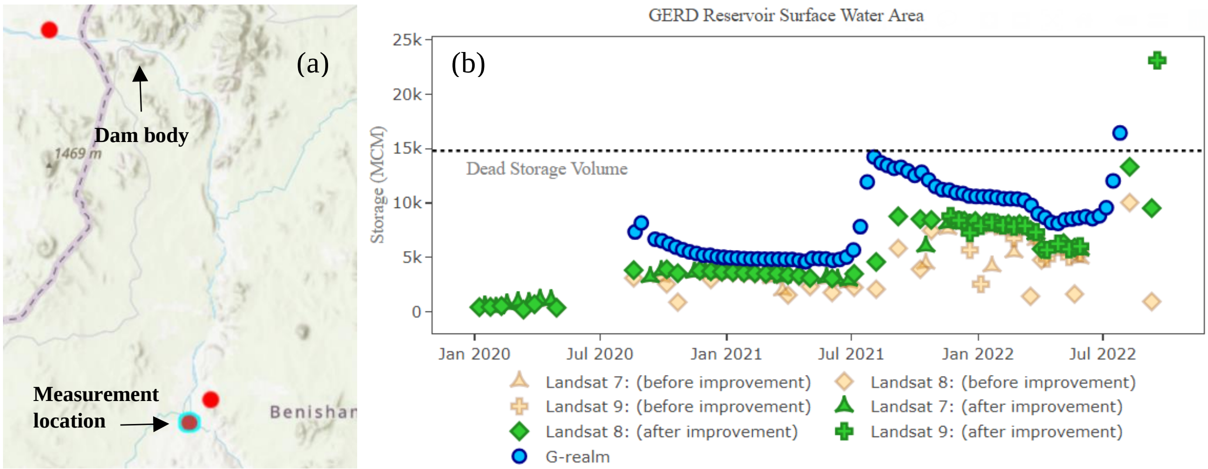

Fig. 1: Panel (a): dam body and G-realm measurement location (Birkett et al., 2011), Panel (b): GERD storage volume obtained using G-realm (blue) and Landsat (before improvement: orange, after improvement: green).

References:

Birkett, C., Reynolds, C., Beckley, B., & Doorn, B. (2011). From research to operations: The USDA global reservoir and lake monitor. Coastal altimetry, 19-50.

Melsen, L. A., Addor, N., Mizukami, N., Newman, A. J., Torfs, P. J., Clark, M. P., ... & Teuling, A. J. (2018). Mapping (dis) agreement in hydrologic projections. Hydrology and Earth System Sciences, 22(3), 1775-1791.

Vu, D. T., Dang, T. D., Galelli, S., & Hossain, F. (2022). Satellite observations reveal 13 years of reservoir filling strategies, operating rules, and hydrological alterations in the Upper Mekong River basin. Hydrology and Earth System Sciences, 26(9), 2345-2364.