Response to the comments about the submitted paper *Implementation and sensitivity analysis of a Dam-Reservoir OPeration model (DROP v1.0) over Spain*

Reviewer #1 comment

This manuscript introduces the implementation and validation of a reservoir model, mostly based on the existing Hanazaki scheme, over Spain, with a focus on parameter sensitivity analysis. After reading the manuscript and carefully considering the comments from Reviewers #1 and #2 and the authors' responses, I am inclined to agree with Reviewer #1's comments, which I don't think the authors have satisfactorily addressed. In a nutshell, the insensitivity analysis is not sufficiently novel and valuable to warrant publication. There have been many existing land-river models that have adapted the Hanazaki scheme, and most have done the sensitivity analysis, more or less. The authors could shift their focus and thus elevate their study in two directions: 1) As Reviewer #1 suggested, using the model as a tool to provide some new understanding of Spain's reservoirs (and/or river systems) since there are very good observational data and now a model that works reasonably well; 2) Systematically point to the possible deficiencies in Hanazaki's scheme and feasible directions to improve based on the recent, new understanding and observational data related to reservoirs. Hanazaki's scheme has been there for so many years, and it'd be interesting (although challenging) to propose a new reservoir scheme.

Reviewer #2 comment

The authors developed a reservoir model (DROP) based on a well-established reservoir scheme introduced by Hanasaki et. al. (2006) and then did a sensitivity analysis to identify the control parameters of the reservoir scheme in Spain rivers. Overall the manuscript is well written and the narrative is easy to follow. As a new reviewer for the 2nd round review of this manuscript, I noticed that my main concerns (i.e. lack of novelty) were brought up by the previous reviewers already. However, I am satisfied by the authors' responses to the previous reviewers and think the study can be published as is.

We would like to express our gratitude for the efforts of the reviewers and for their valuable time. We think the reviewers' comments have helped us improving the manuscript and we hope that the new revised version is now up to GMD standards.

The main concern from this review round is the lack of novelty of the study. In our opinion, the main novelty of this study is twofold.

1. First comprehensive uncertainty analysis of the Hanasaki scheme

We agree that some sensitivity tests may have been done when implementing the Hanasaki scheme into land-river models (as cited in the manuscript), but to our knowledge, no study can be found in the literature on such a comprehensive sensitivity analysis with a full exploration of statistical moments and Sobol's indices. Previous studies mainly focused on a few sensitivity criteria for one or two model parameters and what was still unclear was the sensitivity to all the parameters, as well as the interactions between them. So we think that the comprehensive sensitivity analysis using a thorough and well documented method is quite novel for this model, especially in the context of the Spanish water management practices. Also, given the importance of uncertainty quantification and sensitivity analysis in hydrological modelling (which has been more documented in the introduction of the new revised version of the manuscript), we are convinced that the results of our sensitivity analysis could help other researchers in implementing this scheme in their modelling framework or in setting up data assimilation technics within this scheme. In the latter case, it is worth noting that qualitative understanding of parameter sensitivity is not sufficient, quantitative estimates are required to compute the error covariance matrices. Moreover, such a comprehensive sensitivity analysis represents a large amount of work that most scientists generally do not take the time to undertake (which is understandable, because it can be very time consuming and interpretation of the results is not always straightforward: it is a significant undertaking), which, we think, also increases the usefulness of our results.

We added the following text in the introduction to enhance the importance of uncertainty quantification and sensitivity analysis, and the need for a comprehensive sensitivity analysis on the reservoir scheme:
A large number of studies can be found in the literature focusing on the sensitivity analysis of various models, in various science fields, such as machine learning (e.g., Zouhri et al., 2022) or civil engineering (e.g., Zamanian et al., 2021), etc. Pianosi et al. (2016) provided a classification of the sensitivity analysis methods used in environmental sciences and their benefits. A comprehensive sensitivity analysis, as provided by global methods such as Sobol indices, is essential for a precise understanding of a model (Saltelli et al., 2008; Saltelli, 2013). It can help to improve parameter calibration efficiency and avoid overparameterization (e.g., Shin and Jung, 2022; Tang et al., 2007a, 2007b). It is also an efficient tool to better understand the model structure (Saltelli et al., 2008), its uncertainties (e.g., Pheulpin et al., 2022) and the dominant processes under various conditions (e.g., Huang et al., 2021; Zhang et al., 2013). If understanding and quantifying uncertainties is necessary for hydrological modelling, it is also particularly critical to efficiently weight observations and model states in data assimilation technics (Liu and Gupta, 2007; Abdolghafoorian and Farhadi, 2016). Finally, for a potential extension to the global scale, in which the model parameters cannot be calibrated and validated using observations (that does not exist or are not accessible in most reservoirs of the world), a full understanding of the model sensitivity to the parameters is crucial, especially when models are used as support tools for decision-making (Herrera et al., 2022). A few sensitivity tests on the Hanasaki scheme can be found in the literature (e.g., Hanasaki et al., 2006; Shin et al., 2019), but all of them only focused on one or two parameters supposed to be the most sensitive, which may not be sufficient for a thorough understanding of the impact of parameters uncertainties (Saltelli and Annoni, 2010). To our knowledge, no comprehensive sensitivity analysis has been conducted on this scheme yet.

2. Application of the model in standalone mode with real observations (volumes and outflows) and reconstructed inflows to exclude inflow uncertainties from the analysis

The reservoir scheme requires reservoir net inflows and water demands as inputs to estimate volume variations and outflows. In existing studies, water demands are estimated and net inflows are either modelled by a river routing scheme or estimated from gauge observations in rivers and tributaries upstream the reservoir. Reservoir abstraction is also sometimes accounted for in the reservoir water balance. But some processes are usually neglected, such as precipitation interception, direct runoff, evaporation or groundwater exchanges. This introduces a bias in the water budget and consequently increases the model uncertainties, especially when inflows are derived from land surface and river routing models (see, e.g., Vanderkelen et al., 2022). In our study, the water balance is used in a first step to derive the resultant of all these components (net inflow) from observations of reservoir volume and outflow, as described in section 3.3.2. The advantage compared to previous studies is that it removes the uncertainties related to each of these components, enabling the study of the model uncertainties themselves and the capacity of the model to reproduce the reservoir behaviour alone, without additional uncertainties or potential compensations between the components of the water budget and the model parameters.

These details have been added at the beginning of section 3.3.2 “Reconstructing inflows”.

Finally, reviewer #1 suggested two directions to shift the focus of the study. The first one – providing some new understanding of Spain's reservoirs – is, in our opinion, out of the scope of the present study and could be the focus of a new article, starting for example from the calibration results presented in the supplementary material. As explained above, the objective of this study relies on the comprehensive sensitivity analysis of the DROP mode based on the Hanasaki scheme, and the region of Spain has been chosen mainly because of the reservoir dataset that is available in this country and that makes the sensitivity analysis possible. The efficiency of the DROP model over Spanish reservoirs has been explored only to assess the suitability of the model to reproduce the main behaviour of reservoirs (section 4.1).
The second direction proposed by the reviewer consists in exploring the possible deficiencies in Hanazaki scheme and feasible directions for improvement. Note that in section 5.1 of the manuscript, we present some limitations of the model that have been identified in the current study. For example, the model considers a non-realistic constant dam release for reservoirs not designed primarily for irrigation purposes. Also it is not able to account for multi-objective reservoirs or for multi-reservoir systems. Release rules are also too simple to represent complex socio-economic and political factors, which are furthermore different in each country.

Thus, in summary of our response: we have added considerable discussion in the Introduction in order to document the importance of doing a parameter sensitivity analysis using a sophisticated and statistically-based method, which has never been done with the Hanasaki scheme. We have also added text to highlight the additional novelty of this study in section 3.2.2. Finally, we feel that the goal of this study is not to focus on improved understanding of Spanish reservoirs per say: we have chosen this region owing to the availability of data (since such data needed for a robust evaluation of such a model is not always public domain in some countries such as, for example, France). We address the second proposition of this reviewer in Section 5.1 as explained above. We sincerely hope that the additional text (including new references) have added the suggested focus and address the questions proposed by reviewer #1.

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