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Hydrology and Earth System Sciences
Discussions

# *Interactive comment on* "Real-time reservoir flood control operation enhanced by data assimilation" *by* Jingwen Zhang et al.

**Anonymous Referee #3**

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In this paper, the authors propose a human-machine interactive method, namely Real-time Optimization Model Enhanced by Data Assimilation (ROMEDA) for reservoirs that have complex storage and stage relations (e.g. long and narrow reservoirs). The ROMEDA is essentially a decision support system for reservoir simulation and optimization. Authors conduct case studies to show that for both small and large flood events, ROMEDA shows better performance on flood risk mitigation and water use (hydropower) benefit than the case with historical operation records (HOR) or optimization with single/multi-objective. An on-channel reservoir for flood control from China is selected to test the proposed ROMEDA method. Results compare the proposed ROMEDA against three additional scenarios OPT-S, OPT-M, and historical release decisions. The OPT-S is the optimal decision obtained from the Dynamically Dimensioned



Search algorithm (DDS) (Tolson and Shoemaker, 2007) for single-objective optimization. The OPT-M is the optimal decision obtained from the Pareto archived dynamically dimensioned search algorithm (PADDS) (Jahanpour et al., 2018) for multiple objective optimizations.

First off, the reviewer does not agree with the authors' statement in the paper that "ROMEDA is one of the first attempts of a human-machine interactive method for online use of an optimization model for real-time reservoir operation based on integrated modeling, observation, and operators' choice." Two reasons:

1. Human-machine interactive method does not mean users simply play with the computer program and software. From computer science, it is a two-way interaction mechanism that machine also learns and improves the computation logic via human's inputs. The decision support system in water resources, specifically, reservoir operation falls into the one-way category, and it is not a unique feature of the proposed ROMEDA framework. Many existing software and decision support systems, for instance, OASIS, Delft-FEWS, Riverwares, HEC-RES, also include similar features that dynamic updating and re-calculation are parts of the software/program. The authors claimed "human-machine interative method" (Figure 1) as well as throughout the manuscript, is essentially only human define conditions/states for computers to generate outputs. Therefore, the novelty claimed by authors as "human-machine interactive method" for the ROMEDA is not convincing for me.

2. The merging of observation data, optimization algorithms, and operators' choice for quick and effective decision making is the goal of any decision support system, and it is not unique to the proposed ROMEDA framework. Refer to the UNESCO book "Water Resources Management and Planning" by Daniel P. Loucks and Eelco van Beek, any decision support system shall include the elements to inject data, the element to conduct simulation and optimization, the elements for presenting GIS information, and the elements to visualize the results for decision making. The integration of all those elements makes a decision support system. From this perspective, the ROMEDA system

does not provide any new features or different elements for a decision support system. In other words, what are the essential features, differences, and advancements of the proposed ROMEDA system as compared to the existing decision making support systems in the field of reservoir operation? This point is also raised by other referees.

Secondly, the reviewer thinks the experimental design does not illustrate the claimed advantage of the ROMEDA framework. Two reasons are listed below:

3. Authors claimed that "demonstrate that an unsteady flow routing simulation model is needed for reservoirs that are a long and narrow channel, for which it is not accurate enough to use a static storage-stage relationship to simulate the reservoir storage; while it is also impossible to measure the storage directly because the reservoir surface is not flat." Reviewer is wondering how significant are the uses of data assimilation technique in enhancing the accuracy of the unsteady flow routing model? In the presented case, the reviewer did not see any proof that the unsteady flow routing could be more accurate than the case using a static storage-stage relationship. The latter is a commonly accepted approach in many operational sectors as it is simple and accurate enough to do reservoir planning for hydropower, water supplies, flood control objectives, etc. If the authors could not demonstrate the significant amount of errors of this assumption, the technical foundation for the motivation of this study is questionable.

4. In line 206-210, authors confirmed that "ROMEDA is similar to Model Predictive Control (MPC) (Garcia et al., 1989; Camacho and Alba, 2013; Macian-Sorribes and Pulido-Velazquez, 2019) and other real time control approaches, such as on-line adaptive control (Soncini-Sessa et al., 2007), open-loop and closed- loop control (Soncini-Sessa et al., 2007; Gerdts, 2012) with respect to more effective use of computer-based models and observed data." In fact, the MPC is also a commonly accepted approach in many decision support system to account for forecast-informed operation. The reviewer is glad authors mentioned this, but was expecting the later experiments to compare the advances or improvements of the proposed ROMEDA framework v.s. a decision making support system with MPC. However, this did not happen in later experiments. The



only comparison were made with standard dynamic optimization schemes, Dynamically Dimensioned Search algorithm (DDS) and Pareto archived dynamically dimensioned search algorithm (PADDS) (Jahanpour et al., 2018). Then, the question still remains, why the proposed ROMEDA framework is any better than the MPC or similar techniques used for real time control of reservoir and hydraulic systems?

Last, about the experiment's results and the limitations of the ROMEDA system. The reviewer does not have problems understanding the presented results regarding the flood risks and hydropower generation improvements in the result section. However, the reviewer was not fully convinced that the presented experiments have considered the real challenges of real-time reservoir operation. Three reasons:

5. The presented results demonstrate the ROMEDA system is much better on flood risks and hydropower generation than historical release decisions. This is not surprising when using historical inflow as perfect forecasts (also see Line 562-564). In reality, reservoir operators do not know for sure how much inflows will be coming to the reservoir and channel systems until it happens. This essentially will cause the historical decision becomes more conservative than the optimized results. So, in theory, the optimized results could easily beat historical decisions when lifting or lowering the storage level correspondingly and creates some aggressive moves towards global optimal solutions when reanalyzing the historical inflow as inputs. The reviewer is especially interested in how ROMEDA treats the forecasts with uncertainties. However, the manuscript does not specifically test it out, say if perturb the inflow forecast by some random errors and see whether the conclusion could be changed.

6. The reservoir system being investigated in this manuscript may not represent other systems. The reviewer is wondering about the specific hydraulic constraints and the real operation rules guiding the release decisions. For example, whether there are soft constraints in the presented system, and besides flood control and hydropower, are there other objectives or constraints this system is designed for? I think this is also reflected in other referees' comments. How does the ROMEDA deal with environmental

constraints?

7. Last, the reviewer is interested in the runtime of the proposed ROMEDA framework. Could the authors demonstrate a few cases to show the runtime? Say, for one-day simulation at hourly steps? And a 30 day simulation at hourly steps? I think the presented results are less than a month, maybe authors could include some run time statistics of all the employed models as comparison.

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