Response to referee comment: Anonymous Referee #2

Dear Referee 2,

Thank you for taking the time to review our paper. We are grateful for your thoughtful comments. We trust that the revisions presented below address the issues you raise.

The authors presented a model to simulate hydropower within the routing module of land surface models with a more detailed representation of hydropower plants and their operations. Specifically, the model is validated to produce hydropower at a 30-minute time-step for individual hydropower plants of three types: run-of-river, reservoir, and pumped-hydro-storage. Such a level of detailed representation in hydropower simulation is quite impressive.

Thank you for your review and for recognizing the potentially valuable contribution that our paper provides.

However, the authors did not demonstrate the value of using such a model. For example, how could such a model be useful to dispatch hydropower in the presence of intermittent renewable resources like wind and solar, and what could be its implications for other types of storage (e.g., batteries)? Answering such questions could be a valuable scientific contribution of the paper. Instead, much of the paper demonstrated the validation of the model to replicate observed river discharge and hydropower at the power plants.

We completely agree that exploring the questions you raise would be insightful for the scientific community. However, it would require the use of a power system model able to predict the dispatch of power demand to the different power sources, both non-dispatchable (photovoltaic, wind, run-of-river) and dispatchable (nuclear, gas, hydropower reservoir, …). The operation of hydropower reservoirs depends thus both on the predicted dispatch and the water resources available, thus requiring in the end the coupling between a power system model and a hydrological model. From our perspective, our paper lays the ground for such development and analysis.

On the one hand, we have shown that our approach can realistically simulate the hydroelectric potential within a land surface or hydrological model (Figure 13), which is crucial for informing power dispatch models about the potential output of hydroelectric plants. Given the uncertainties in atmospheric forcings, land surface processes, river discharge, and the hydropower network, achieving this level of detail is not straightforward.

On the other hand, we have shown that our approach can simulate a realistic operation of individual reservoirs based on the aggregate demand for dispatchable hydropower over a power grid. Indeed, when forced to replicate the national historical production (assumed to be the demand in our case), the model operates the reservoirs similarly to what is observed in terms of stock evolution (Figure 16). This is a significant step forward toward coupling with electrical system models, as these models often represent a single aggregated power plant per electrical zone. Indeed, it allows us to explore at the individual plant level the effects of a dispatch simulated at the aggregate level.

Building on this foundational work, the natural progression is to couple our model with a power system model to explore the dispatch of hydropower in the presence of intermittent renewable resources like wind and solar. To this end, we have recently submitted a manuscript to Applied Energy, presenting a coupled modeling framework that expands on the initial methodology detailed in this paper and is applied to energy scenarios with high shares of renewable.

We hope that the reformulation of the introduction will make this clearer in the revised manuscript.

Also, the authors' claim of "operations at the scale of a power grid" seems a bit misleading. The hydropower is simulated based on exogenous (observed) demand for hydropower but not based on the operation of a power grid, i.e., the model did not dispatch hydropower to meet grid-level demand considering other generation, storage, and transmission facilities.

We understand that the expression "*power grid*" can be misleading. We wanted to specify the geographic scale of our study and felt "*national*" would have been too limited as power grids are not necessarily national. Moreover, it highlights the fact that our method allows for the joint operations of all reservoirs within a given power grid in contrast to previous methods that operate each reservoir independently. We propose to clarify this in the introduction of the revised manuscript by defining it as the "*geographical scale relevant to electricity production and use*".

Moreover, the paper is not well-written. It is long and written in the form of a technical report (e.g., there are 18 figures and quite a few sections/paragraphs of a single sentence).

We acknowledge your concerns regarding the structure and length of the manuscript. We have revised the structure of the manuscript according to the suggestions of reviewer 1. In particular, we have moved the validation of river flows to the Appendix to focus more on hydropower operations, which removes 3 figures. Furthermore, we have removed small subsections (2.4.1, 2.4.2, and 2.4.3 for example) and reformulated them into a larger paragraph. Finally, we also propose to shorten the literature review presented in the introduction.

In summary, I suppose the study requires extended experiments and analysis to demonstrate the value of the proposed model, while the manuscript itself needs to be substantially improved.

We hope that the above replies to your comments clarify the value of this study and its originality relative to the current state-of-the-art.