Response to Reviewer #1.

Interactive comment on "On an improved sub-regional water resources management representation for integration into earth system models" by N. Voisin et al.

Anonymous Referee #1

This paper presents a comprehensive analysis on the sub-regional water resources system modeling, in which reservoir operation models using generic operating rules are studied in terms of the use of reservoir usage priorities, withdrawals vs. consumptive demand, as well as natural vs. regulated mean flow for calibrating operating rules. Generally, the case study of the Columbia River Basin is well demonstrated, and the simulations of flow, storage and supply are also well discussed with respect to implementations of generic reservoir operating rules. Although the obtained findings would make a good contribution to improving earth system models when incorporated with reservoir models, this manuscript should subject to major revision before acceptable, and the following issues need further clarification.

We wish to thank reviewer 1 for his/her comments and constructive criticism which have led to an improved manuscript. Below are specific answers in line with the comments.

1. Although the authors introduce the basin of interest in details, it is ambiguous to understand how the 125 reservoirs are indeed represented in the modeling system. I think only 29 reservoirs are used to analyze the priority in the operating rules, while there are less than 29 orange circles in the Fig.1. Therefore, the number of reservoirs using the combined priority is not same with that using irrigation or flood control. Thus, the conclusion "overall the best performing implementation is the use of the combined priorities operating rules calibrated with mean annual natural flow and mean monthly withdrawals (P 3502, L16)" should be clarified. In my opinion, the authors may want to refer to the improvement of the simulations.

Figure 1 showing the domain has been revised in order to clarify that all 125 reservoirs are simulated and with which priority usage they are operated with. The yellow reservoirs are operated for flood control and other purposes but not irrigation. In all experiments, those reservoirs follow the mean annual flow release target. Reservoirs in green are for irrigation and not flood control. In all three experiments those reservoirs follow the irrigation rule. The Blue reservoirs (29 of them) are those that vary from one experiment to another: when irrigation is priority they follow the irrigation rule. When flood control is the priority, they follow the flood control rule (mean annual flow). In the combined rule experiment, they follow the set of newly developed rules.

2. Calibration schemes of the operating rules have led to very important conclusions, while the authors do not clearly present the setups of the reservoir model configurations. For example, what is difference between the use of withdrawals and consumptive demand to calibrate the operating rules in simulation

processes? How do they may affect the integrated modeling system and its associated outputs? More details should be provided.

A schematic of the system modeling framework has being added, complemented by tables presenting how the operating rules are set up differently. They present the system in its set up mode and in its simulation mode, along with the explicit description of the input and output. In particular, it clarifies that only the operating rules change but the modeling framework is the same in each experiment.

3. The authors claim that “this approach allows us to isolate the sources of errors and uncertainties coming from the reservoir model and the hydrologic simulations without the vegetation growth and irrigation module components” (P 3507, L19). Would the authors please explain how to isolate the sources of errors and uncertainties from the hydrologic simulations of the CRB? This paper focuses on the water resources management and the reservoir model, and the effects of uncertainties from the VIC model and the routing modules on the sensitivity seem to be not well addressed. If the simulated natural flows based on VIC are the same, the uncertainties of the routing modeling as a result of different reservoir operation implementations should be discussed, and in addition, the calibration operation in the modeling system should be further clarified.

The sentence has been clarified. The schematics of the system also clarify this point along with a clarified section presenting the experiment based on the schematic. The system is forced with observed demand, and observed meteorology. The hydrology model forced with the observed meteorology has been the subject of multiple publications and is used in this referred set up and performance.

The errors in the hydrology model are quantified by the differences between the simulated and observed natural flow.

The errors between the observed regulated flow and the simulated regulated flow are due to a combination of errors in both the hydrology model and in the coupled water resources management – routing model. We assess the sensitivity of the simulated regulated flow to different operating rules in order to reduce errors in the water resources management model.

The schematic also clarifies that the hydrology and routing models are not recalibrated between different experiment but were calibrated independently in efforts reported in previous publications. Calibration of the operating rules is clarified and is part of the sensitivity analysis.

4. Although the authors have presented lots of details on the multiple reservoir operation representations, it is still hard to identify how the water resource management system was analyzed and how sub-regional water resources management representation was “improved”. A diagram to describe the modeling processes is highly recommended as well as the realizations for performing the sensitivity analysis. In addition, the authors used so many long and complex sentences, which significantly reduced the readability of this paper.

A diagram has been added and we revised the section presenting the system and the experimental approach for clarification.

Minor comments:

1. Page 3505, L4: Sentence ". . . adding a virtual-storage that stores water available for extraction from the simulated releases and keeps it available 5 for extraction for 5 days else is released into the river," should be revised.

The sentence has been revised.

2. Page 3513, L4: Replace "yr" with "(yr)", "krls" with "(krls)".

Corrected.

3. Pages 3513 and 3514: Please distinguish the same symbols in an equation. For example, symbols "dmean,m" and "c" in equations (4) and (5) are confusing. Please revise them and distinguish their different meanings in the equation. The same problem also exist in equation (6) for "rm,yr".

The equations have been revised along with more explicit explanation of the terms.

4. Page 3517, L 9: Replace "affect" with "affects".

Corrected.

5. Page 3517, L14: Sentence "We validate the improvement of the operating rules by evaluating the simulated natural and regulated flows at the outlet of the basin, The Dalles, and the simulated regulated flow and the simulated reservoir storage at Grand Coulee and American Falls reservoirs." should be rewritten.

The sentence has been revised.

6. Page 3519, L4: Should "at and upstream" be replaced with "at the upstream"?

The original wording was correct – the sentence has been revised for clarity.

7. Please specify the accurate meaning of MCM in Figs. 1, 2, 5, and 9.

MCM has been specified in the legend.

8. There are so many abbreviations in the legends of Figs. 4, 5, 6, 8 and 9, which significantly reduced the readability of the paper.

Table 1 summarizes the name of the different cases. The added schematic and tables clarify the sensitivity experiment and thus the figures.