Response to Reviewer #6.

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 #6

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Dear Editor and Authors, With interest, I have read the manuscript by Voisin et al. The authors investigated generic reservoir operating rules for global and macro-scale hydrological models. They set up a hydrological model with such rules developed by Hanasaki et al. (2006), Doell et al. (2009), and Biemans et al. (2011), and applied it to the Columbia River Basin. First they compared the simulated results with observation for river flows, reservoir storage, and water use. Then, they proposed a new generic reservoir operating rule for multi-purpose reservoirs in snowmelt controlled regions and found it performed well in the basin. Finally, they compared the methodologies to calibrate the rules that were proposed in earlier literature. More than 45,000 large dams have been constructed in the world, the modeling technique of reservoir operation for global and macro-scale hydrological models is still in its infancy. The draft paper reports some interesting findings of this field. The advance of reservoir modeling has been largely hampered by the complexity of problem and the availability of data for calibration and validation. The draft paper is unique and valuable because it reports the results of modeling exercise in the Columbia River Basin, one of the most data-rich major river basins in the world.

The paper is well written and structured. Particularly, the Introduction and Method Sections summarize the earlier works excellently.

Thank you.

However, I got an impression that the Results and Discussion Sections could be further organized and deepen (see below for details).

We wish to thank the reviewer 6 for his/her comments and constructive criticism which has led to an improved manuscript. Below are answers in line with the comments.

Specific comments

Page 3504, line 14: “Doell and Lehner (2009)” reads “Doell et al. (2009)”.

Corrected.

Page 3506, line 25: I think one more question should be added at the beginning of questions: How well does the existing generic reservoir operation rule perform in a specific basin? Actually, the Results Section starts with answering this question. Indeed this is a quite important scientific question since both Hanasaki et al. (2006) and Biemans et al. (2009) used global hydrological models. Calibration of their models and validation of their simulation were more or less insufficient.

We added the scientific question. Calibration of the reservoir model brings more difference in the simulated regulated flow than the sensitivity to operating rules predictors. This is another source of uncertainty (hydrologic errors) that needs to be taken into consideration when evaluating the regulated flow.

Page 3509, lines 1,6: “Grand” reads “GRanD”.

Revised.

Page 3509, line 15 “(historical simulations obtained from Elsner et al., 2010) with parameter calibration...”: The Columbia River Basin includes irrigated area and its river flow is regulated by reservoirs. Does VIC include irrigation process? Did VIC use river flows when it was calibrated? If it was the case, were the effects of reservoirs and water withdrawal excluded from the observation? I’m interested in these points because the parameter of VIC might include some of these effects.

We clarifies that VIC was run without irrigation and was calibrated with respect to naturalized flow.

Page 3511, line 21 “Hanasaki et al. (2006) defined. . .”: Just a very minor correction. Hanasaki et al. (2006) describes “We set the maximum distance as grid intervals below the reservoir, approximately 1100 km downstream, or the distance traveled by released flow in a month (river flow velocity was set at 0.5 m s-1 or 1300 km mo-1).”

We corrected it – thank you.

Page 3512, line 4 “In Hanasaki et al. (2006), grid cells can request water from only one reservoir”: Again a minor correction. Hanasaki et al. (2006) allowed grid cells to request more than one reservoir by introducing a coefficient kalc. They described as “where kalc is an allocation coefficient for grid-squares that had more than one reservoir upstream; kalc is proportional to the mean annual inflow from upstream reservoirs, and kalc is 1 if the grid point has only one irrigation reservoir upstream”.

Thank you for the clarification, we revised it.

Page 3513, line 4: Remove “yr”.

Removed.

Page 3516-3521, Results Section: It would be further readable if the sub-sections of Results Section correspond to the scientific questions raised in the Introduction Section. I got an impression from the current form of manuscript that the questions are answered in different order and sometimes the answers are mixed up for more than two questions.

We revised the results section and the conclusion in order to answer directly individual scientific questions.

Page 3516, line 21, “Highest priority rule: irrigation or flood control or combined priorities”: It could be more readable if the authors specify the combination of equations for each here. For example, “Highest priority rule: irrigation (combination of Eq 3 and Eq 5) or flood control (Eq 4 and Eq5) or combined priorities (Eq 3 and Eq 6)”

We added it in the text.

Page 3519, line 14, “Demand and supply”: It would be more consistent if it is “Demand and supply validation”.

This has been modified with the section organization.

Page 3522, lines 12-16, “A more sophisticated. . .” This sentence is too long. Anyway, here is just a related comment. In case of grid-based simulation (and most likely sub-basin-based simulation as well), trans-grid-cell water transfer becomes critically important as the spatial extend of grid-cell getting finer. the grid-cells next to main stems become unrealistically prone to water scarcity.

Revised. We agree that the reservoir-subbasin dependencies will differ between different spatial scales and representation (grid or subbasin). The spatial distribution of the supply to grid cells has been set to be proportional to the demand asked – this ensures to some extent that drier grid cells get more support from the reservoirs than wetter grid cells. Grid cells at the egde of the buffers are also vulnerable to spatial representation and scales as they might be in or out of the reservoir-supported irrigation zone. We added this point in the text.

Page 3523, lines 14-: The reservoir operation model used and discussed here is heavily influenced by the formulations of Hanasaki et al. (2006). Since their formulations were designed for the combination of natural-flow and water-withdrawal, it could be no surprise it performed best among combinations.

We added the insight in the discussion section for the recommendation on the best implementation of the operating rules.