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

We wish to thank all the reviewers for their comments and constructive criticism which have led to an improved manuscript. The main changes from the previous version are:

1) A revised figure (Figure 1 below) of the domain which clarifies that all 125 reservoirs are simulated and the usage they are operated with.

2) Addition of a schematic (Figure 2 below):

i) The schematic lays out the overall chain of models in the initialization process and in the simulation mode of the water resources model. This clarifies multiple comments on what changes in the modeling framework from one experiment to another – i.e. nothing but the operating rules. The paper focuses on the improvement of operating rules for joint flood control and irrigation usages with respect to single priority operating rules, and on a sensitivity analysis with respect to predictors used to derive the operating rules.Table 1 lists the combinations of predictors and priorities used in previous work.

ii) The schematic is also complemented by the newly added tables as follows: Table 2 specifies equations used for the different reservoir usage categories. Table 3 specifies the exact equations used for the different combinations of predictors for the operating rules. They lay out the sensitivity analysis framework and clarify abbreviations used for the experiments.

4) A new table (Table 4 below) with performance metrics by evaluating simulated regulated flow against observations in order to further support the improvement from the new set of operating rules and their implementation.

5) In the figure showing the supply deficit (Figure 3), there is an additionnal panel mapping the fraction of the total withdrawals supplied by groundwater. A short paragraph commenting on the Snake River Basin has been added as well.

6) Text has been edited for clarity with shorter sentences and an organization in section 3 that follows the new schematics, acronyms, references.

Individual responses follow.

Table 1: Summary of the experiments used to assess the sensitivities to priorities, use of natural versus regulated flow, use of consumptive use versus withdrawals, and improvement of using combined priorities. The names of nine experiments with different combinations of predictors (flow, demand), and priorities are shown.

Flow, Demand \ Priorities	Irrigation	Flood Control	Combined
Natural flow, withdrawals	Irrig nat	FC nat [Hanasaki et al. 2006]	combined nat
Regulated flow, withdrawals	Irrig reg [Biemans et al. 2011]	FC reg	combined reg
Natural flow, consumptive use	Not run [Doell et al. 2009]	Not run [Pokhrel et al. 2012]	Not run
Regulated flow, consumptive use	Irrig reg consum	FC reg consum	Combined reg consum

Table 2: reservoir operating rules by usage category for the three priority cases.

Scenario with priorities	Irrigation and no flood control (48 dams)	Irrigation and flood control (29 dams)	No irrigation (48 dams)
Priority to Irrigation (Irrig)	Irrigation rule (Eqs 3 & 4)	Irrigation rule (Eqs 3 & 4)	Eq. 2
Priority to Flood control (Fld Ctrl)	Irrigation rule (Eqs 3 & 4)	Eq. 2	Eq. 2
Combined priority (combine)	Irrigation rule (Eqs 3 & 4)	Combined rules: Eqs 3, 4, & 6	Eq. 2

Table 3: detailed operating rules for multiple predictor combinations.

Predictors	Flood Control Rule (Eq. 2, & 5)	Irrigation Rule (Eqs. 3 & 4, & 5)	Combined (Eqs 3 & 4 , & 5 + Eq. 6)
Withdrawals and natural flow (nat)	$r'_m = \bar{\imath}_{NAT}$	$if\ \overline{Wdraw}_m \geq 0.5\,\bar{\imath}_{NAT}$ $r'_m = \frac{\bar{\imath}_{NAT,m}}{10} + \frac{9}{10} \cdot \bar{\imath}_{NAT} \cdot \frac{\overline{Wdraw}_m}{\overline{Wdraw}}$ else $r'_m = \bar{\imath}_{NAT} + \overline{Wdraw}_m - \overline{Wdraw}$	$Drop = \sum_{m=STFC}^{NDFC-1} (r_m - \bar{\imath}_{NAT})$
Withdrawals and regulated flow (reg)	$r'_m = \bar{\imath}_{REG}$	$if\ \overline{Wdraw}_m \geq 0.5\,\bar{\imath}_{REG}$ $r'_m = \frac{\bar{\imath}_{NAT,m}}{10} + \frac{9}{10} \cdot \bar{\imath}_{REG} \cdot \frac{\overline{Wdraw}_m}{\overline{Wdraw}}$ else $r'_m = \bar{\imath}_{REG} + \overline{Wdraw}_m - \overline{Wdraw}$	$Drop = \sum_{m=STFC}^{NDFC-1} (r_m - \bar{\imath}_{REG})$
Consumptive use and regulated flow (reg consum)	$r'_m = \bar{\imath}_{REG}$	$if\ \overline{Csum}_m \geq 0.5\,\bar{\imath}_{REG}$ $r'_m = \frac{\bar{\imath}_{NAT,m}}{10} + \frac{9}{10} \cdot \bar{\imath}_{REG} \cdot \frac{\overline{Csum}_m}{\overline{Csum}}$ else $r'_m = \bar{\imath}_{REG} + Csum_m - \overline{Csum}$	$Drop = \sum_{m=STFC}^{NDFC-1} (r_m - \bar{\imath}_{REG})$

r'_m is the monthly pre-release
r_m is the monthly release (Eq. 5)
$\bar{\imath}_{NAT}$ is the mean annual natural flow
$\bar{\imath}_{NAT,m}$ is the mean monthly natural flow
$\bar{\imath}_{REG}$ is the mean annual regulated flow
$\overline{Wdraw}_m$ is the mean monthly withdrawal
$\overline{Wdraw}$ is the mean annual withdrawal
$\overline{Csum}_m$ is the mean monthly consumptive use
$\overline{Csum}$ is the mean annual consumptive use
STCF is month when Flood Control starts
NDFC is month when Flood Control stops

Table 4: performance metrics for simulated 1983/10 to 1999/09 monthly regulated flow for the nine experiments at three locations: The Dalles, Grand Coulee and American Falls.

Location	Predictors	Priority	Correlation	NSE	relative bias	relative RMSE
The Dalles						
	Natural Flow, withdrawals	Irrigation	0.95	0.27	1.04	0.34
		Flood Control	0.93	0.58	1.04	0.26
		Combined	**0.95**	**0.62**	**1.03**	**0.24**
	Regulated Flow, withdrawals	Irrigation	0.94	-0.03	1.04	0.40
		Flood Control	0.94	0.35	1.04	0.32
		Combined	**0.95**	0.38	1.04	0.31
	Regulated Flow, consumptive	Irrigation	0.94	-0.01	1.04	0.40
		Flood Control	0.94	0.35	1.04	0.32
		Combined	**0.95**	0.39	1.04	0.31
Grand Coulee						
	Natural Flow, withdrawals	Irrigation	0.80	-1.81	1.06	0.51
		Flood Control	0.77	-0.63	1.06	0.39
		Combined	**0.85**	**-0.11**	1.06	**0.32**
	Regulated Flow, withdrawals	Irrigation	0.79	-2.54	1.05	0.57
		Flood Control	0.78	-1.33	1.05	0.46
		Combined	0.84	-0.78	1.05	0.40
	Regulated Flow, consumptive	Irrigation	0.79	-2.48	1.05	0.57
		Flood Control	0.78	-1.34	1.05	0.46
		Combined	0.84	-0.72	1.05	0.40
American Falls						
	Natural Flow, withdrawals	Irrigation	0.81	-0.35	1.17	0.82
		Flood Control	0.79	-0.43	1.18	0.84
		Combined	0.80	**-0.30**	1.15	**0.80**
	Regulated Flow, withdrawals	Irrigation	**0.83**	-0.47	**1.10**	0.85
		Flood Control	0.79	-0.80	1.16	0.94
		Combined	0.81	-0.64	1.12	0.90
	Regulated Flow, consumptive	Irrigation	0.80	-0.61	1.11	0.89
		Flood Control	0.79	-0.77	1.17	0.93
		Combined	0.79	-0.72	1.13	0.92

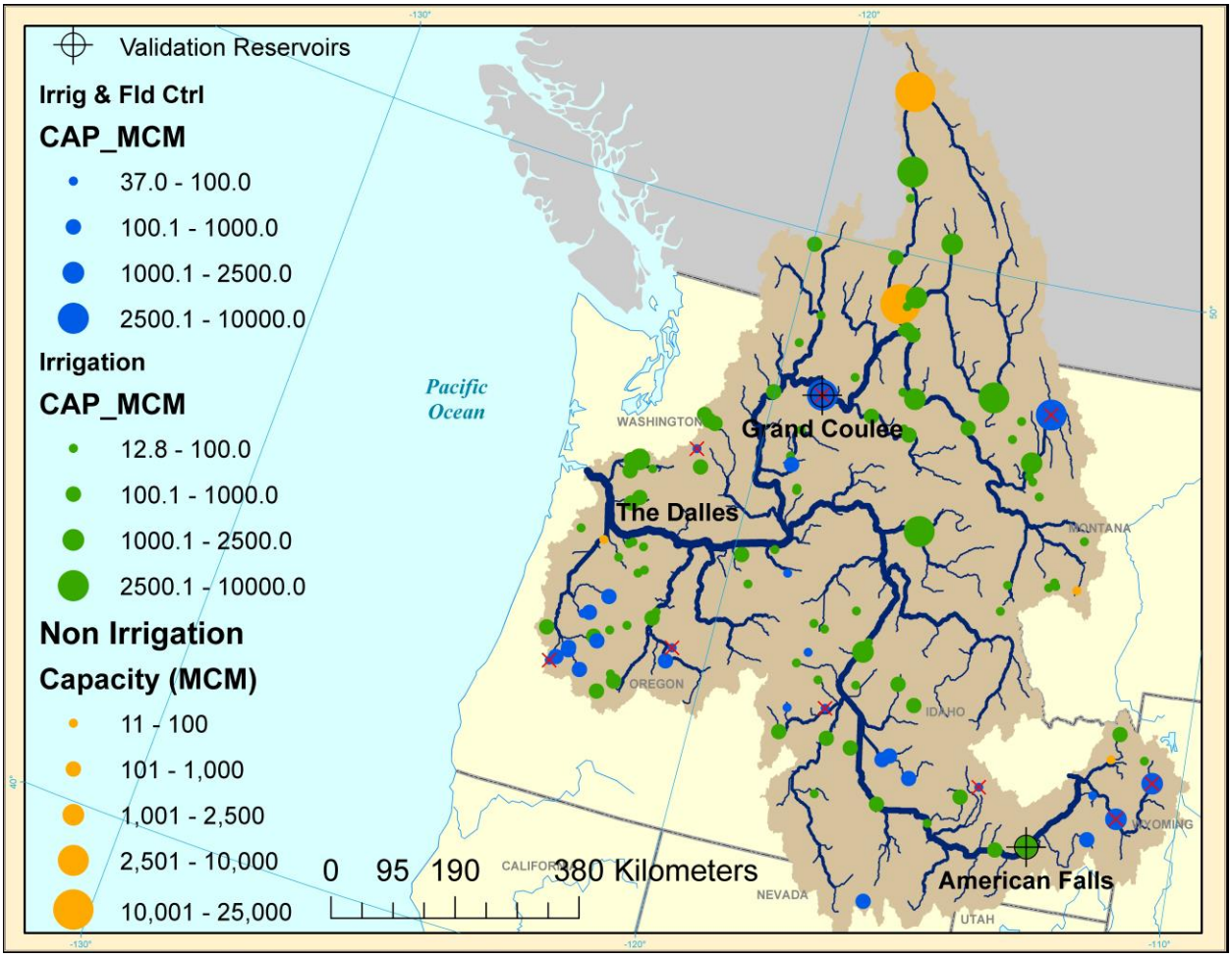

Figure 1: 125 reservoirs of the Grand database over the Columbia River Basin. Reservoirs used for irrigation among other uses but not flood control are displayed in red. Reservoirs used for irrigation and flood control are displayed in blue. Irrigation and flood control reservoirs to which combined rules could be applied are in orange. The reservoir module is validated at The Dalles, Grand Coulee, and American Falls

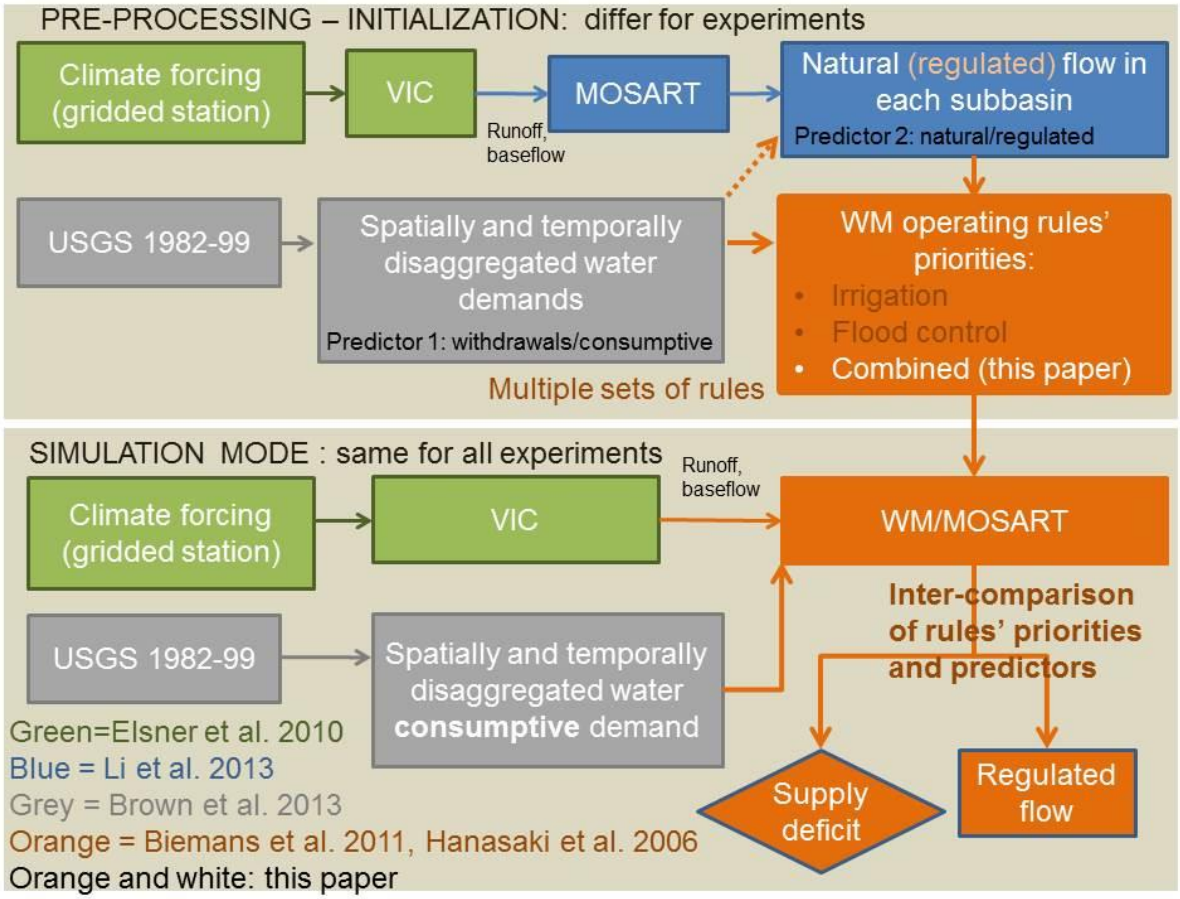

Figure 2: schematic of the initialization and simulation modes of the WM/MOSART system.

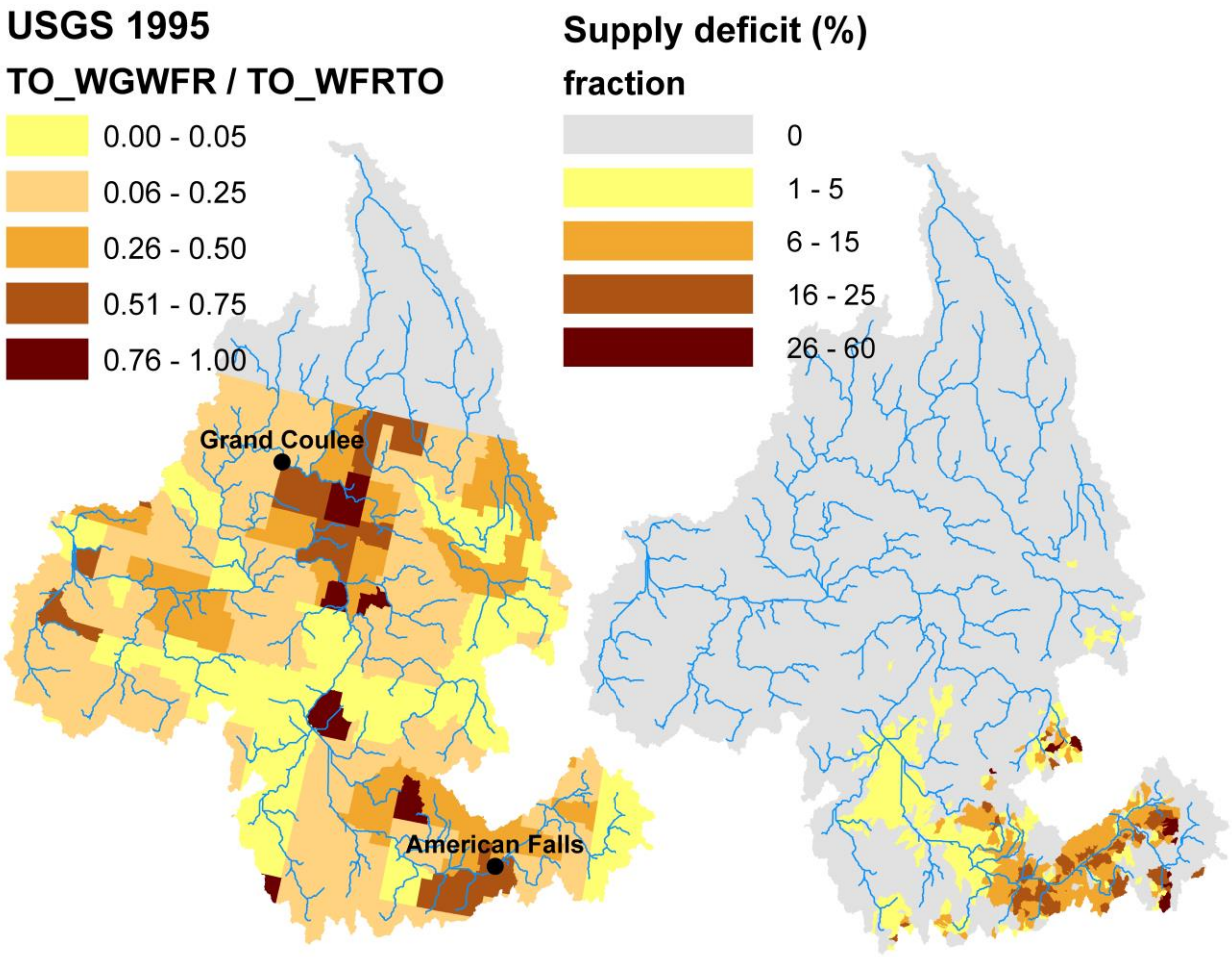

Figure 3: Left: observed contribution of groundwater (ration of the groundwater withdrawals over the total withdrawals – USGS 1995). Right: Simulated fraction of the annual demand that is not met

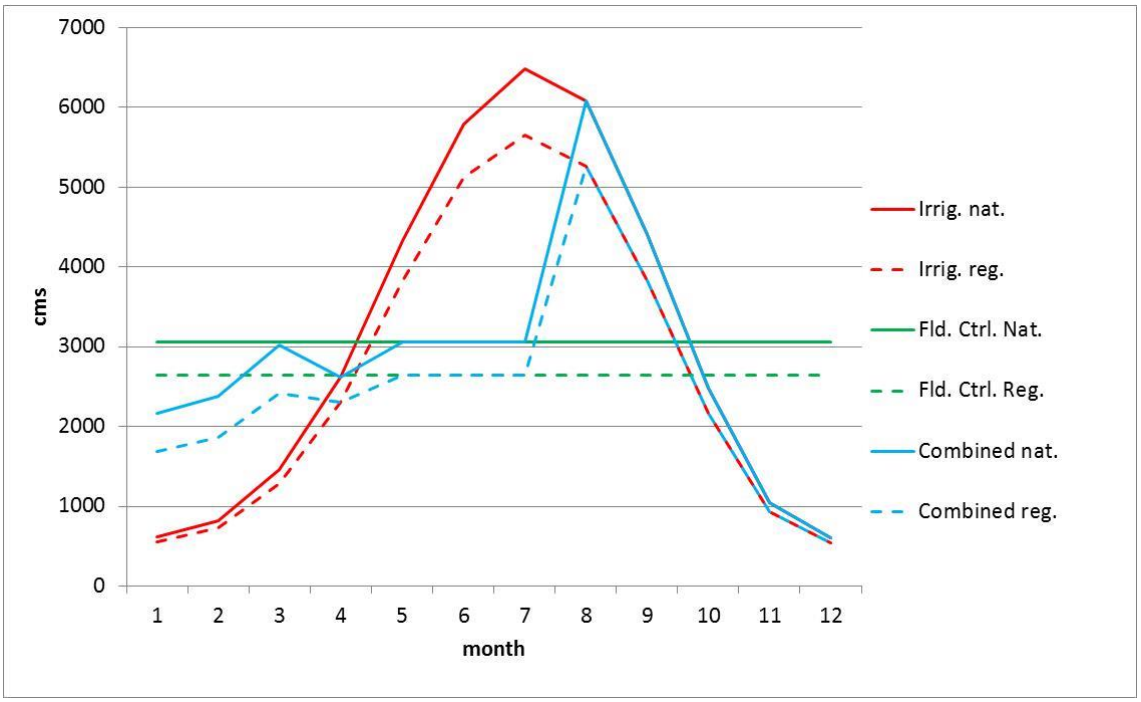

Figure 4: sensitivity of the pre-releases of Grand Coulee to different priorities and predictors.