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Implications of water management representations for watershed hydrologic modeling in the Yakima River basin

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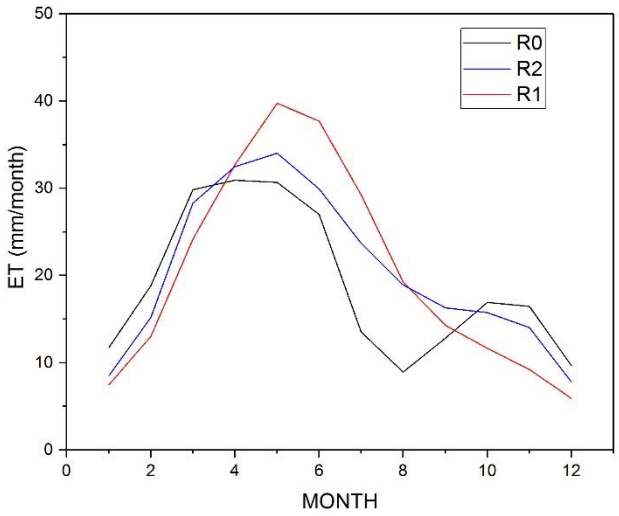

Figure S1. Seasonal changes in ET under the R0, R1, and R2 scenarios

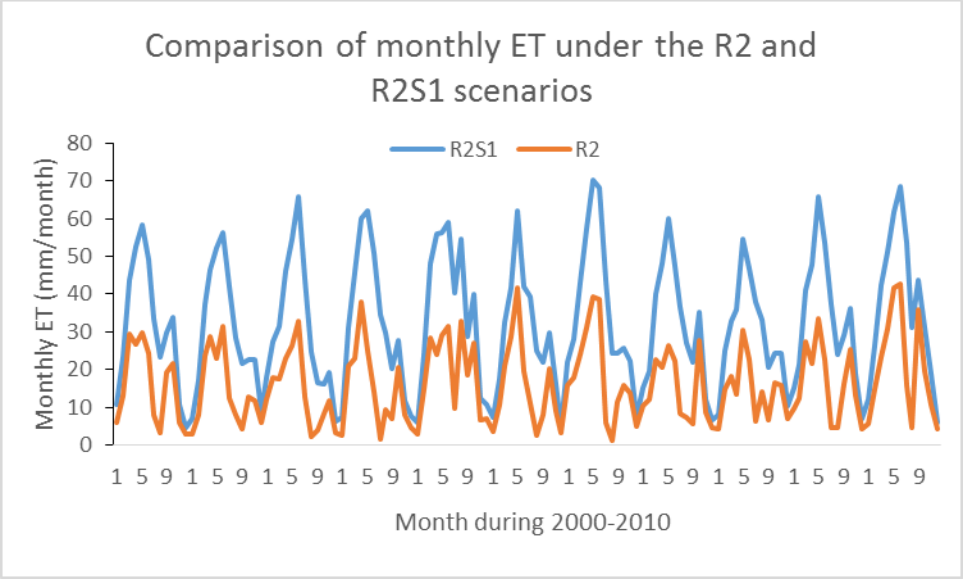

Figure S2. Comparison of monthly ET under the R2 and R2S1 scenarios

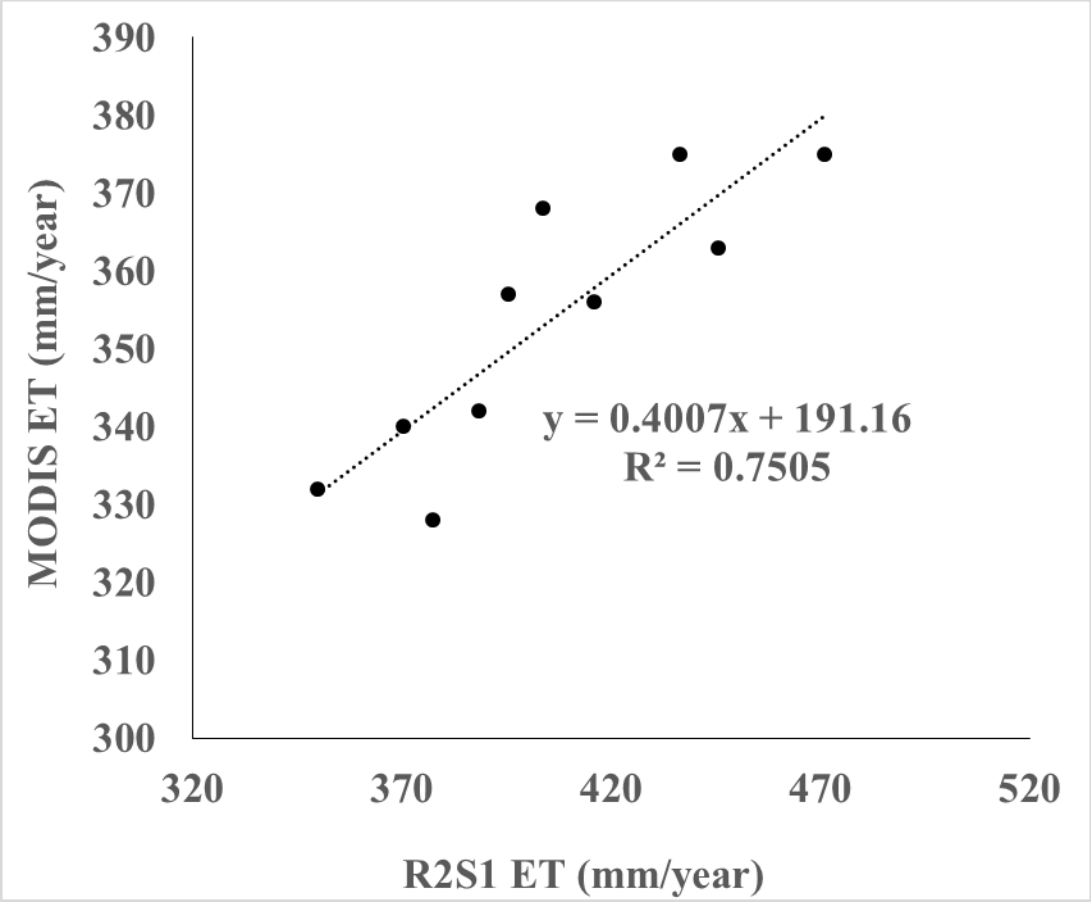

Figure S3. Scatter Plot between MODIS and R2S1 ET estimates

Table S1 Parameter sensitivity under various scenarios.

Parameters	**Description**	***T and P* values for parameter sensitivity[1,2,3]**				
		R0	R1	R2	R2S1	R2S2
SFTMP	Snowfall temperature (°C)	-8.06 (0.00)	-15.08 (0.00)	-12.18 (0.00)	-1.03 (0.31)	-9.32 (0.00)
CN2	Initial SCS runoff curve number for moisture condition	-10.75 (0.00)	-17.76 (0.00)	-15.25 (0.00)	-22.50 (0.00)	-11.22 (0.00)
SMFMX	Maximum melt rate for snow during year (occurs on summer solstice) (mm H_2O/°C/day)	-4.89 (0.00)	-6.72 (0.00)	-2.54 (0.01)	-0.32 (0.75)	-3.47 (0.00)
SMTMP	Snow melt base temperature (°C)	4.28 (0.00)	11.45 (0.00)	7.91 (0.00)	0.76 (0.45)	4.43 (0.00)
CH_N2	Manning's "n" value for the main channel	3.22 (0.00)	1.69 (0.09)	2.70 (0.01)	-0.73 (0.47)	1.16 (0.25)
SMFMN	Minimum melt rate for snow during the year (occurs on winter solstice) (mm H_2O/°C/day)	-1.19 (0.23)	-1.97 (0.05)	-0.10 (0.92)	-0.87 (0.38)	-0.77 (0.44)
SLSUBBSN	Average slope length (m)	5.04 (0.00)	5.54 (0.00)	3.32 (0.00)	8.65 (0.00)	4.85 (0.00)
CH_N1	Manning's "n" value for the tributary channels	-0.18 (0.86)	0.44 (0.66)	0.72 (0.47)	-0.45 (0.65)	-0.06 (0.95)
SOL_K	Saturated hydraulic conductivity (mm/hr)	-2.63 (0.01)	-1.98 (0.05)	-2.49 (0.01)	-8.57 (0.00)	-2.57 (0.01)
GW_REVAP	Groundwater "revap" coefficient	-1.21 (0.23)	-1.19 (0.23)	1.34 (0.18)	1.34 (0.18)	-0.80 (0.43)
CANMX	Maximum canopy storage (mm H_2O)	0.05 (0.96)	-0.31 (0.75)	0.69 (0.49)	-0.06 (0.95)	-0.01 (0.99)
HRU_SLP	Average slope steepness (m/m)	-0.87 (0.38)	-2.17 (0.03)	-0.25 (0.80)	-4.60 (0.00)	-0.46 (0.65)
RES_K	Hydraulic conductivity of the reservoir bottom (mm/hr)	-1.46 (0.14)	2.14 (0.03)	0.11 (0.91)	5.33 (0.00)	0.15 (0.88)
GW_DELAY	Groundwater delay (days)	-1.45 (0.15)	-0.51 (0.61)	0.71 (0.47)	-0.25 (0.81)	-1.60 (0.11)
EVRSV	Lake evaporation coefficient	-0.60 (0.55)	3.36 (0.00)	0.66 (0.51)	1.37 (0.17)	-0.49 (0.63)
TIMP	Snow pack temperature lag factor	-0.02 (0.98)	-0.04 (0.97)	-0.73 (0.46)	-0.06 (0.95)	-0.10 (0.92)

ESCO	Soil evaporation compensation coefficient	-0.11 (0.91)	-1.82 (0.07)	-0.13 (0.90)	-0.95 (0.34)	0.11 (0.91)
GWQMN	Threshold water level in the shallow aquifer for the base flow (mm)	0.26 (0.79)	0.47 (0.64)	-0.82 (0.41)	-0.89 (0.38)	0.02 (0.99)
PLAPS	Precipitation lapse rate (mm H_2O/km)	-0.33 (0.74)	-5.01 (0.00)	-2.70 (0.01)	-2.54 (0.01)	-0.89 (0.38)
OV_N	Manning's "n" value for overland flow	-2.51 (0.01)	0.42 (0.67)	0.44 (0.66)	1.53 (0.13)	-2.11 (0.04)
REVAPMN	Threshold depth of water in the shallow aquifer for "revap" to occur (mm)	0.08 (0.94)	-0.23 (0.81)	0.57 (0.57)	0.56 (0.58)	-0.03 (0.98)
SOL_AWC	Available water capacity of the soil layer (mm H_2O/mm soil)	0.00 (1.00)	-1.89 (0.06)	-0.10 (0.92)	-0.35 (0.72)	0.63 (0.53)
NDTARGR	Number of days to reach target storage from current reservoir storage	-1.27 (0.21)	0.44 (0.66)	1.48 (0.14)	2.48 (0.01)	-0.46 (0.65)
ALPHA_BF	Baseflow alpha factor (1/day)	0.37 (0.71)	-0.47 (0.64)	1.10 (0.27)	1.70 (0.09)	0.59 (0.55)
SOL_Z	Depth from soil surface to the bottom of the layer (mm)	3.89 (0.00)	2.43 (0.01)	2.40 (0.02)	4.75 (0.00)	3.87 (0.00)
TLAPS	Temperature lapse rate (°C/km)	-0.44 (0.66)	8.91 (0.00)	1.25 (0.21)	3.02 (0.00)	0.21 (0.83)
SURLAG	Surface runoff lag coefficient	-0.53 (0.60)	-0.03 (0.98)	0.11 (0.91)	0.18 (0.85)	-1.35 (0.18)
EPCO	Plant uptake compensation factor	1.56 (0.12)	1.34 (0.18)	-2.29 (0.02)	0.66 (0.51)	1.14 (0.25)

[1,] format the T and P values is: T (P)

[2,] For *P* values less than 0.01, we use "0.00" in the above table.

[3,] According to Abbaspour et al., (2017), SWAT sensitivity analysis is to find the influential parameters in the model. In the above sensitivity analysis, we held all other parameters unchanged while modifying one specific parameter to identify how this parameter affect streamflow simulation. In the sensitivity analysis, model simulations were run hundreds of times to quantify how model output is affected by changes in each parameter. Specifically, the sensitivity analysis uses a multiple regression approach to quantify sensitivity of each parameter:

$$Ob = \alpha + \sum \beta_i b_i$$

In the above equation, Ob is the objective function value (r-squared, E*ns* etc.), α is the regression constant, and β is the coefficient of parameters, and b refers to a specific parameter (Abbaspour et al., 2017). In the analysis, the t-test is employed to identify the relative significance of each parameter.

Abbaspour, K., Vaghefi, S. and Srinivasan, R.: A Guideline for Successful Calibration and Uncertainty Analysis for Soil and Water Assessment: A Review of Papers from the 2016 International SWAT Conference, Water, 10(1), 6, doi:10.3390/w10010006, 2017.

Table S2. SWAT performances in the five scenarios during the calibration and validation period

Metrics / Scenarios		Calibration		validation	
		Ens	*R*	*Ens*	*R*
R0	Site 67	0.204	0.532	-0.480	0.297
	Site 99	0.377	0.620	-0.093	0.452
	Site 160	0.229	0.479	0.013	0.498
	Site 171	0.216	0.469	0.519	0.590
R1	Site 67	0.249	0.501	0.288	0.538
	Site 99	0.281	0.557	0.276	0.543
	Site 160	0.440	0.671	0.245	0.503
	Site 171	0.427	0.666	0.326	0.578
R2	Site 67	0.311	0.560	0.312	0.589
	Site 99	0.298	0.585	0.322	0.575
	Site 160	0.404	0.648	0.246	0.511
	Site 171	0.360	0.653	0.318	0.575
R2S1	Site 67	0.372	0.631	0.221	0.531
	Site 99	0.423	0.664	0.228	0.506
	Site 160	0.282	0.534	0.213	0.512
	Site 171	0.280	0.536	0.291	0.576
R2S2	Site 67	0.094	0.362	-0.451	0.595
	Site 99	0.074	0.388	-0.874	0.429
	Site 160	0.343	0.613	-0.883	0.252
	Site 171	0.364	0.618	-0.148	0.368

Ens and *R* are Nash–Sutcliffe efficiency coefficient and correlation coefficient, respectively