Supplementary Information for

Multi-variable, multi-configuration testing of ORCHIDEE land surface model water flux and storage estimates across semi-arid sites in the southwestern US

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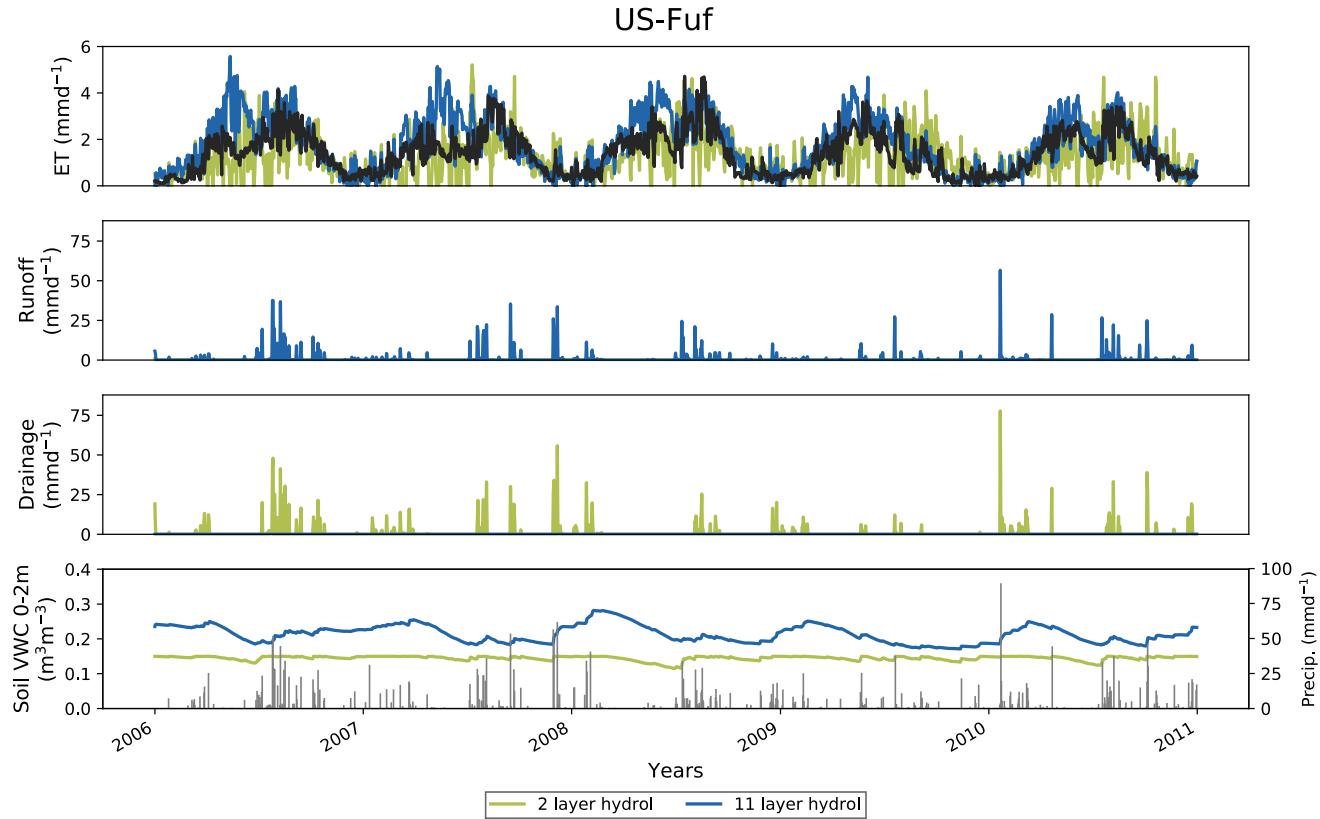
Table S1: Depths of the ORCHIDEE 11-layer discretized hydrology model

ORCHIDEE Layer	Layer thickness (m)	Cumulative Depth (m)
1	0.001	0.001
2	0.003	0.004
3	0.006	0.01
4	0.012	0.022
5	0.023	0.045
6	0.047	0.092
7	0.092	0.186
8	0.188	0.374
9	0.375	0.750
10	0.750	1.5
11	0.5	2.0

Figure S1: Complete daily time series comparing the 2LAY (green curve) and 11LAY (blue curve) simulations for the following hydrological variables: i) ET (top panel for each site) compared to observations (black curve); ii) surface runoff (2nd panel for each site); iii) drainage (3rd panel for each site); and iv) total 2m column volumetric water content (VWC) soil moisture (bottom panel for each site). Precipitation is shown in the grey bars in the bottom panel for each site. Sites in following order: a) US-Fuf; b) US-Vcp; c) US-SRM; d) US-Whs; e) US-SRG; f) US-Wkg. Precipitation is shown in the grey lines in the bottom panel for each site.

a) US-Fuf

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b) US-Vcp

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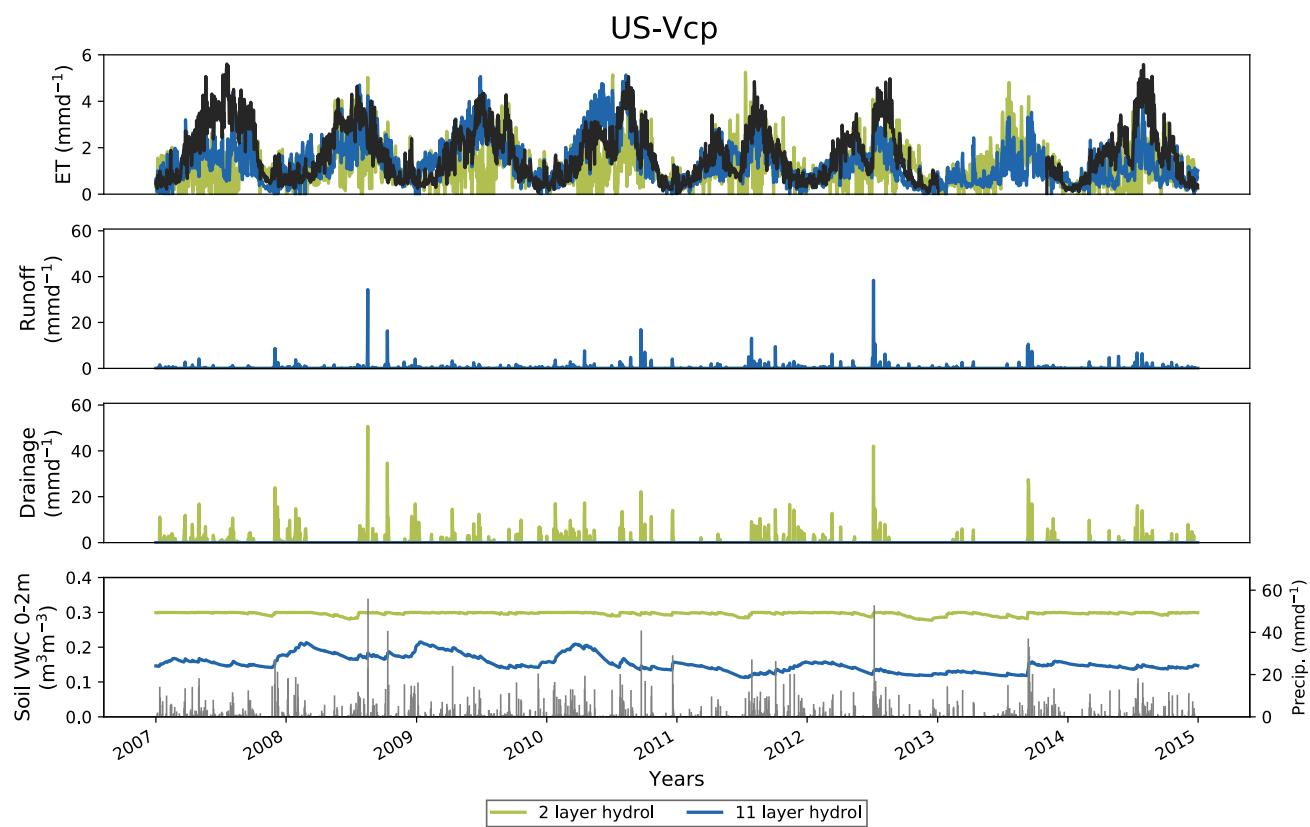
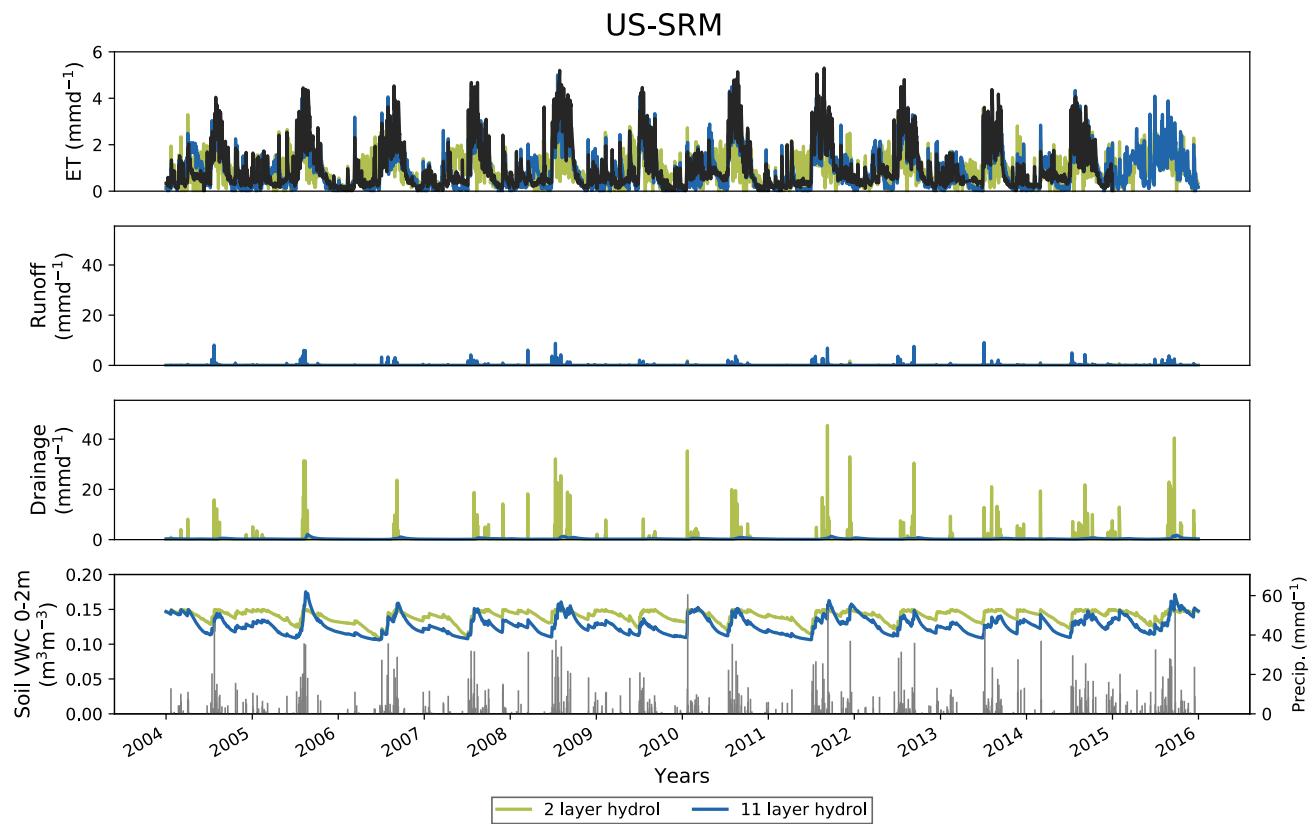
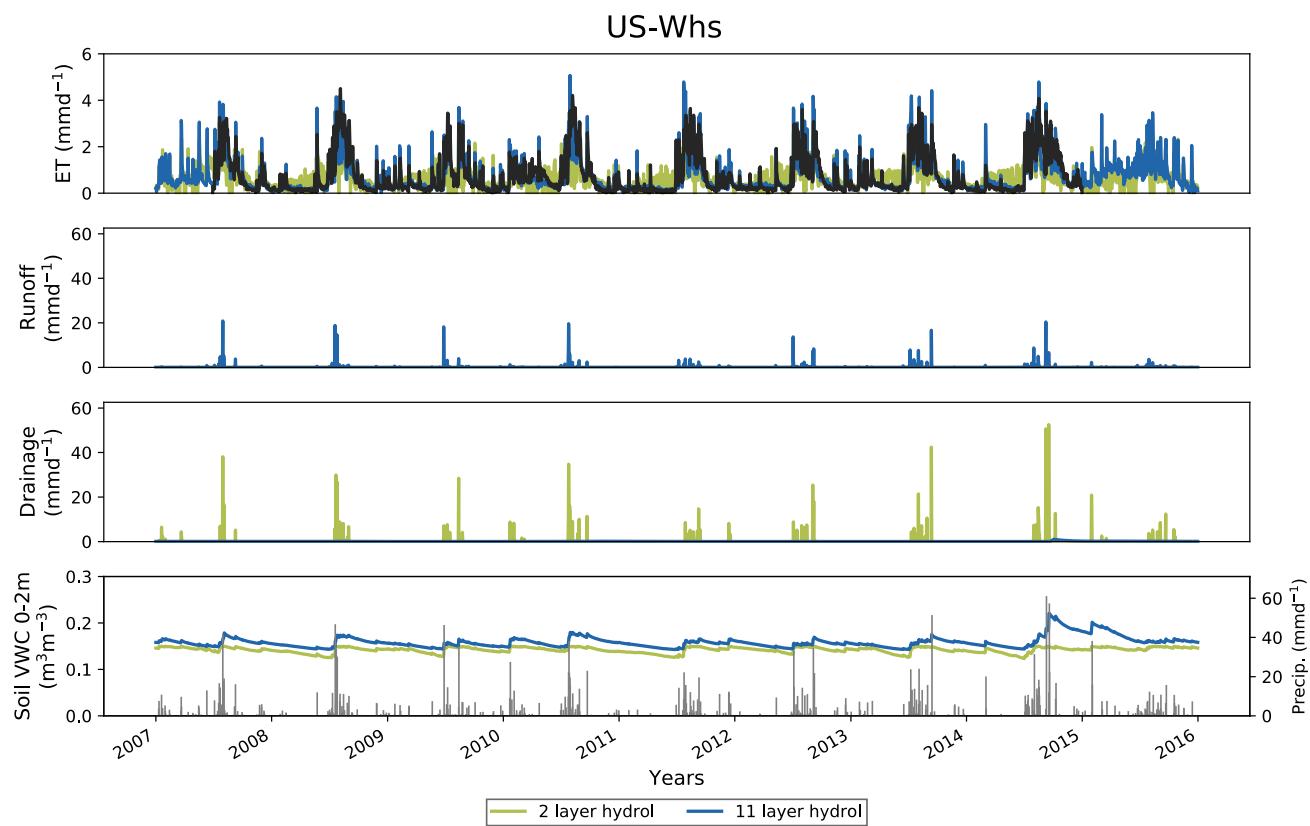
60   **c) US-SRM**

d) US-Whs

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e) US-SRG

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100

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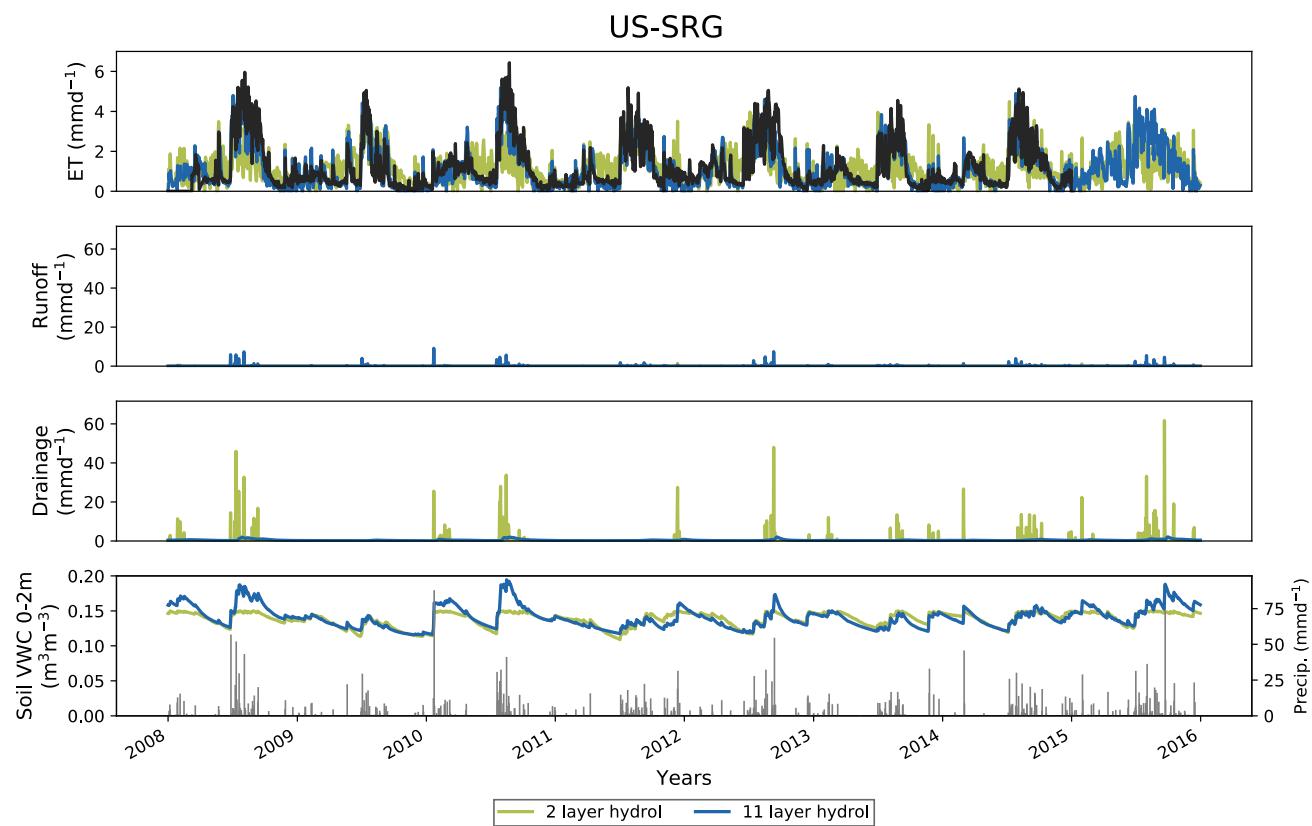

f) US-Wkg

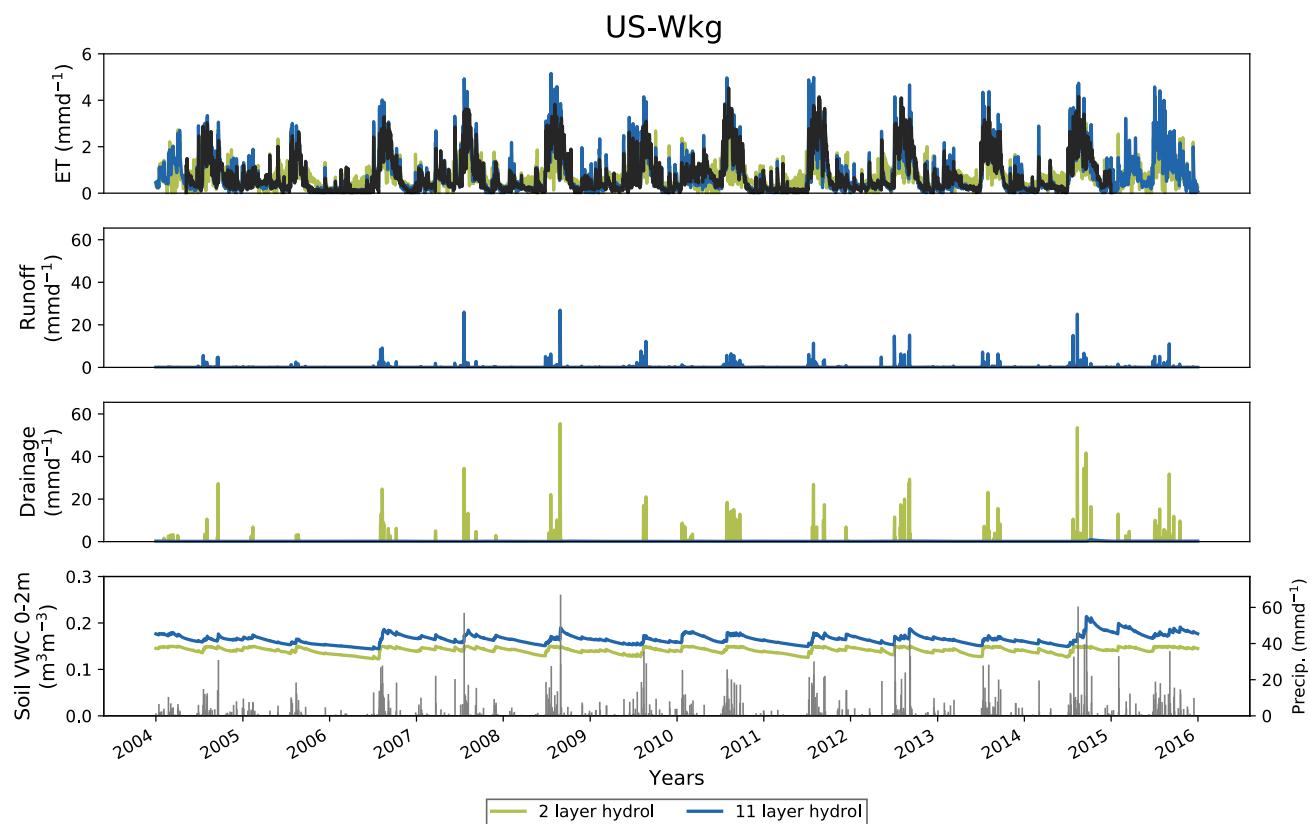
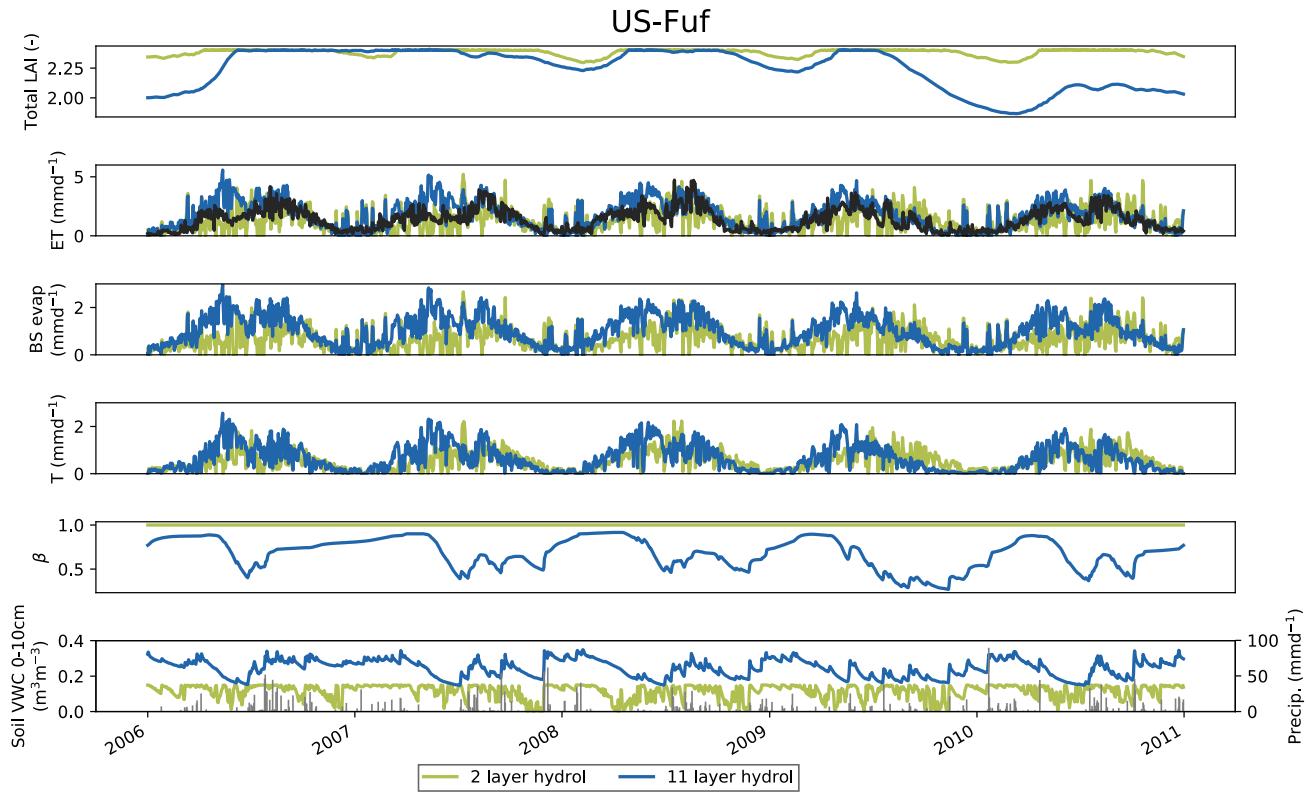
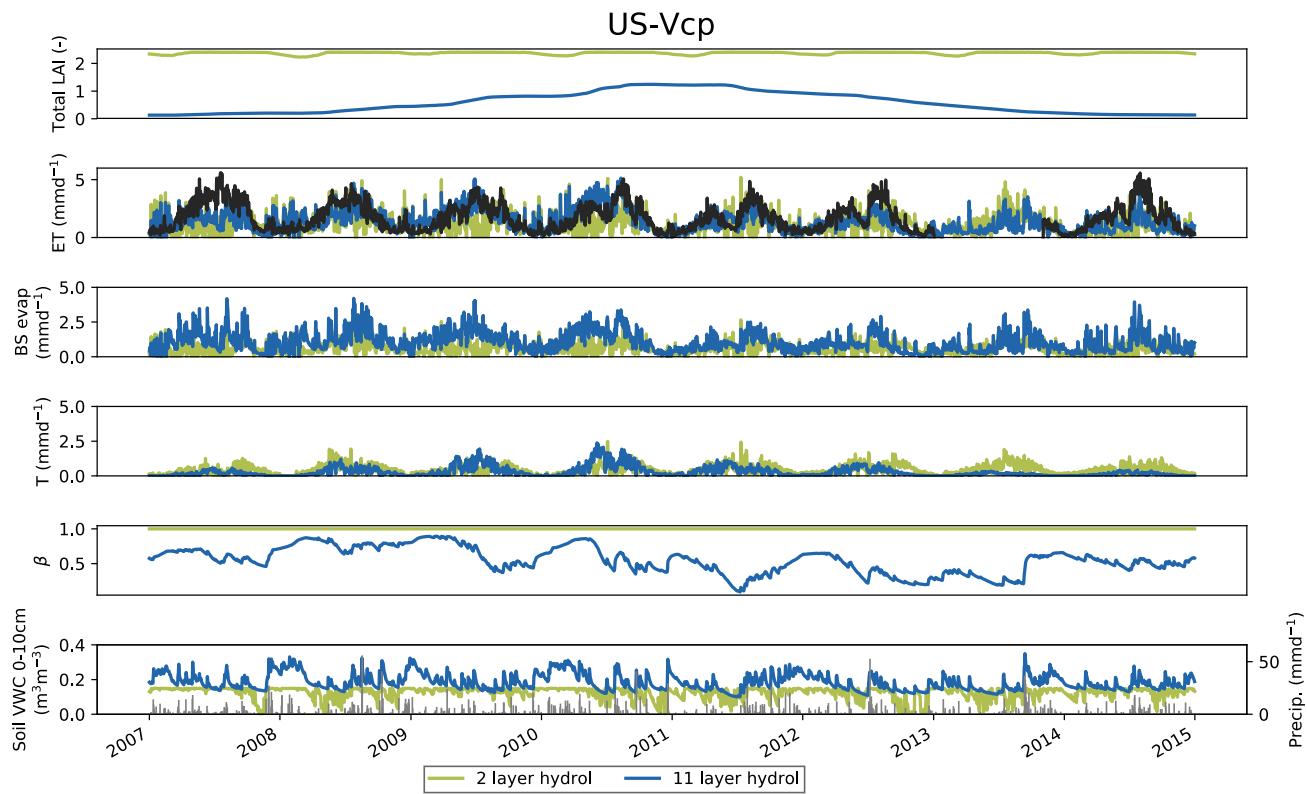
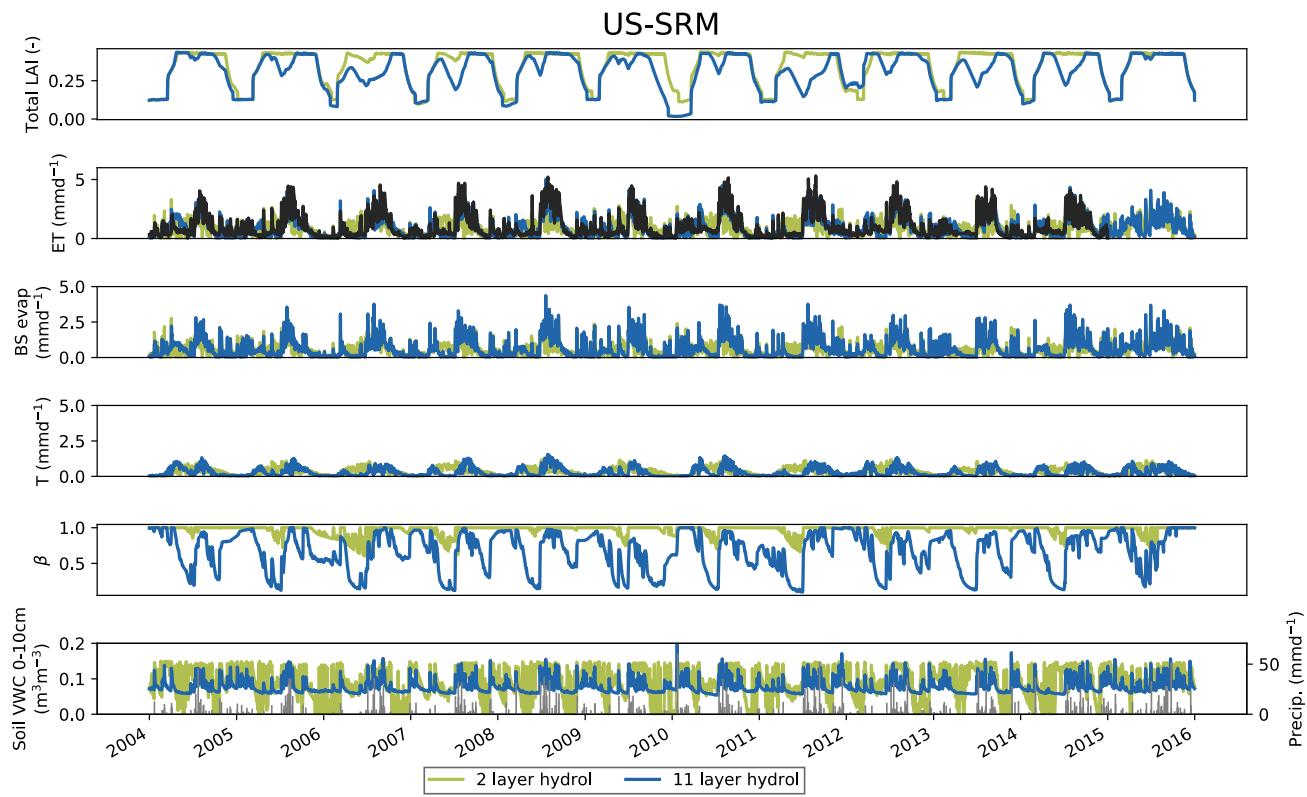



Figure S2: Complete daily time series of variables influencing changes in ET between the 2LAY (green curve) and 11LAY (blue curve) simulations at three sites: left column = high elevation tree-dominated site (US-Fuf); middle column = low elevation mesquite shrub-dominated site (US-SRM); right column = low elevation C4 grass site (US-SRG). At each site, top panel: LAI; 2nd panel: ET compared to observations (black curve); 3rd panel: transpiration; 4th panel: bare soil evaporation; 5th panel: empirical water limitation function (β) that scales photosynthesis and stomatal conductance; bottom panel: soil moisture expressed as volumetric water content (VWC) in the uppermost 10cm of the soil. Precipitation is shown in the grey bars in the bottom panel for each site. Sites in following order: a) US-Fuf; b) US-Vcp; c) US-SRM; d) US-Whs; e) US-SRG; f) US-Wkg. Precipitation is shown in the grey lines in the bottom panel for each site.

a) US-Fuf

b) US-Vcp

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d) US-Whs

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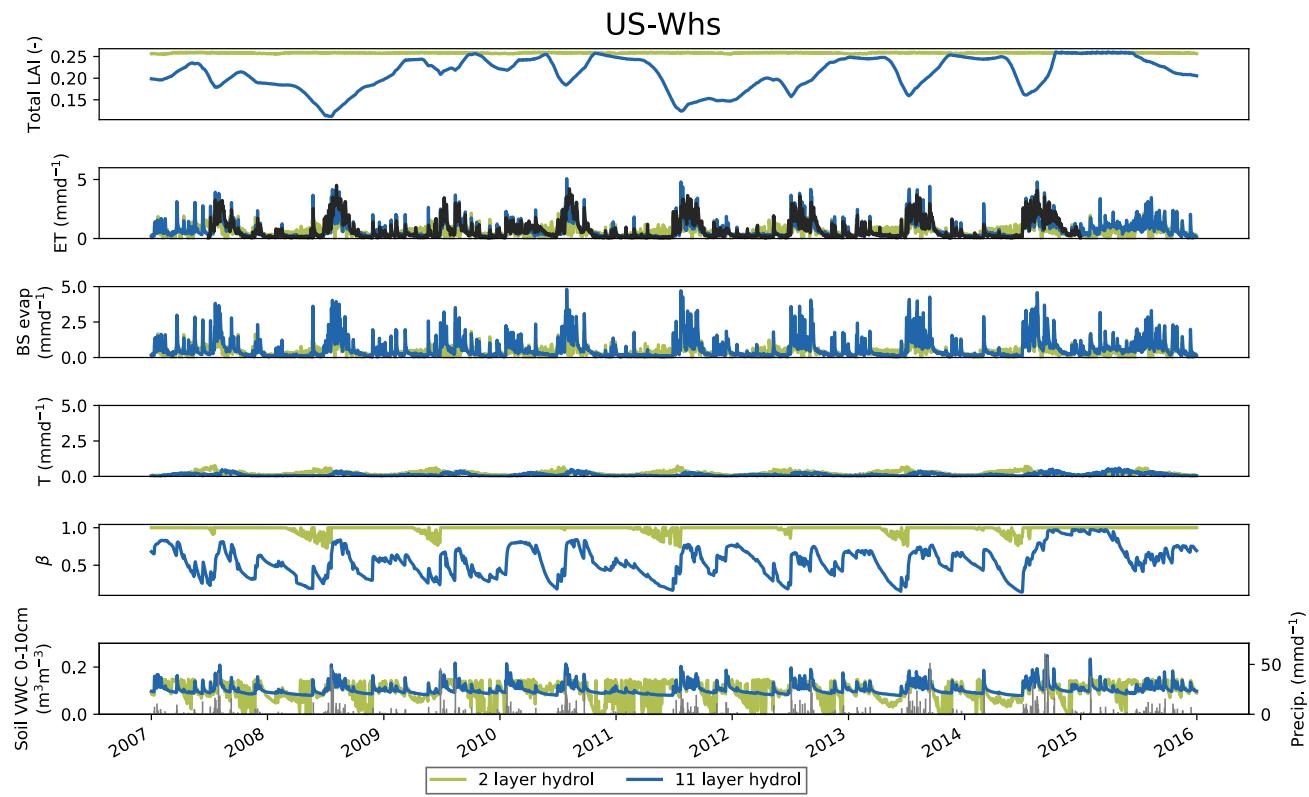
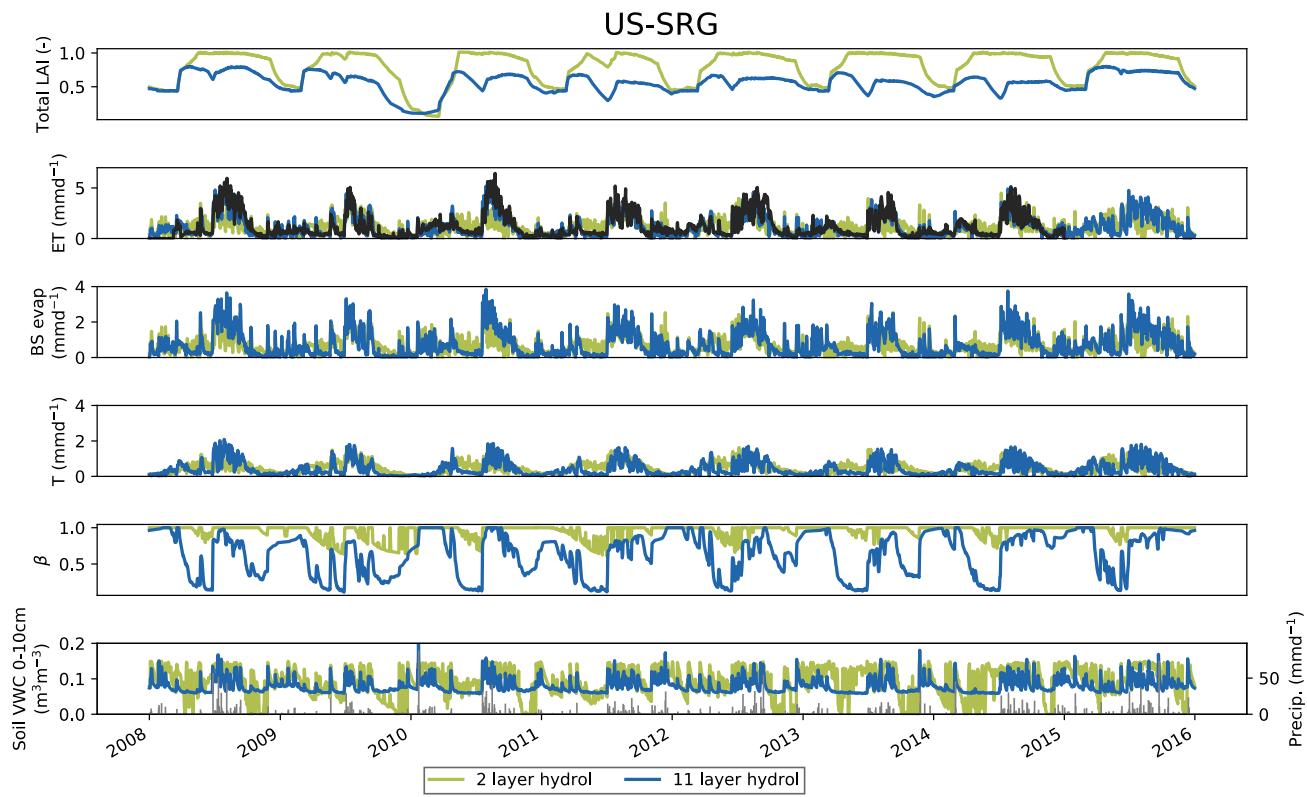
195

     f) US-Wkg

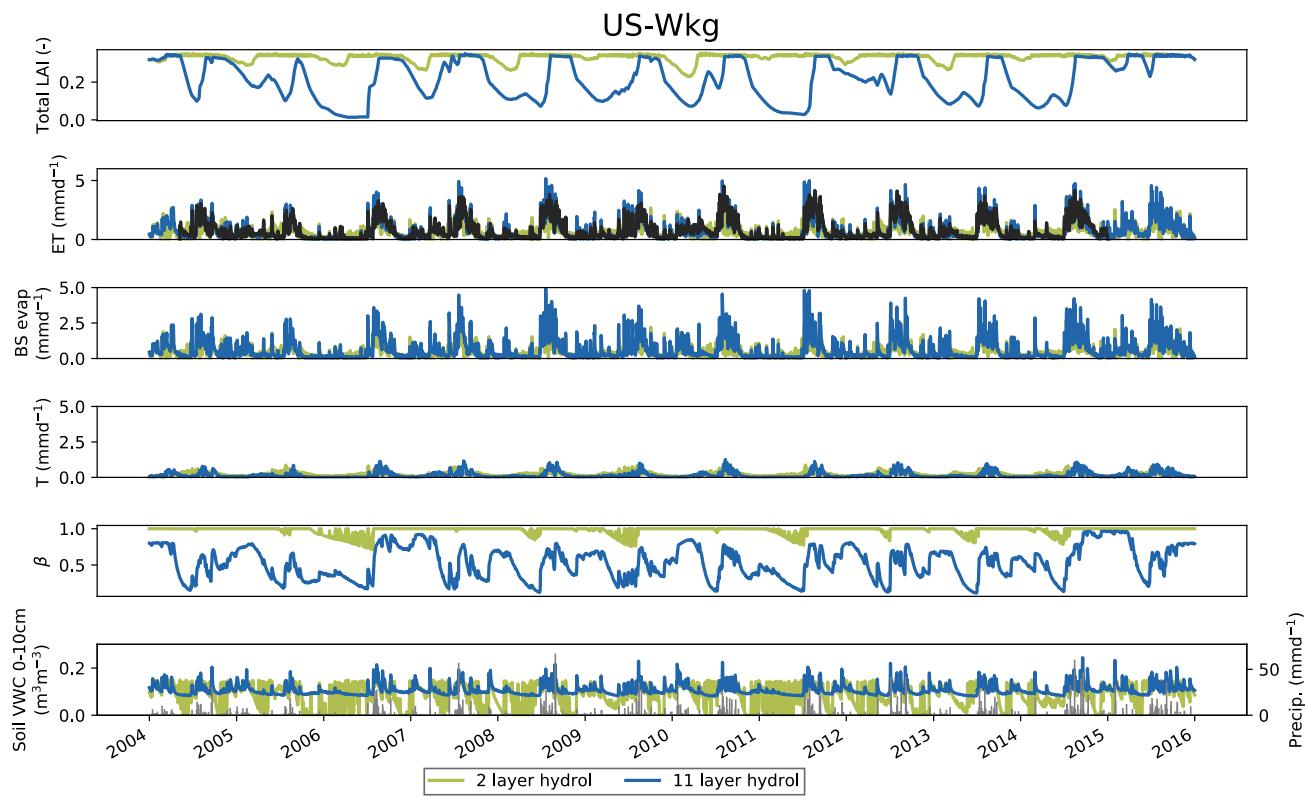
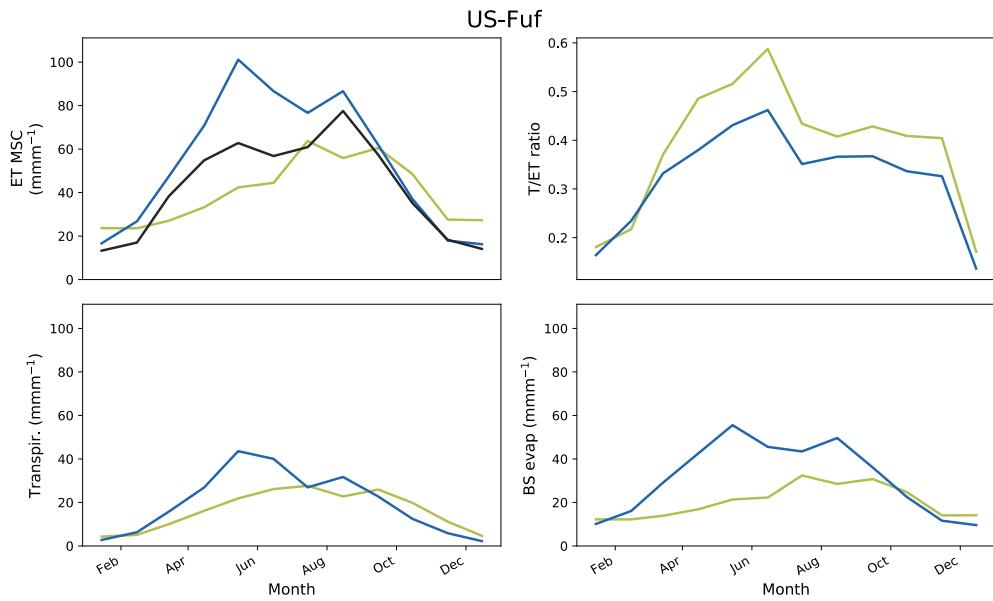



Figure S3: Monthly mean seasonal cycle for each site comparing the 2LAY (green curve) and 11LAY simulations (blue curve) with observations (black curve). Top left: ET; top right: T/ET ratios; bottom left: transpiration; bottom right: bare soil evaporation. Units in mmd-1. Sites in following order: a) US-Fuf; b) US-Vcp; c) US-SRM; d) US-Whs; e) US-SRG; f) US-Wkg.

a) **US-Fuf**

220 b) **US-Vcp**

c)   US-SRM

225

d)   US-Whs

230 **e)   US-SRG**

f)   US-Wkg

235

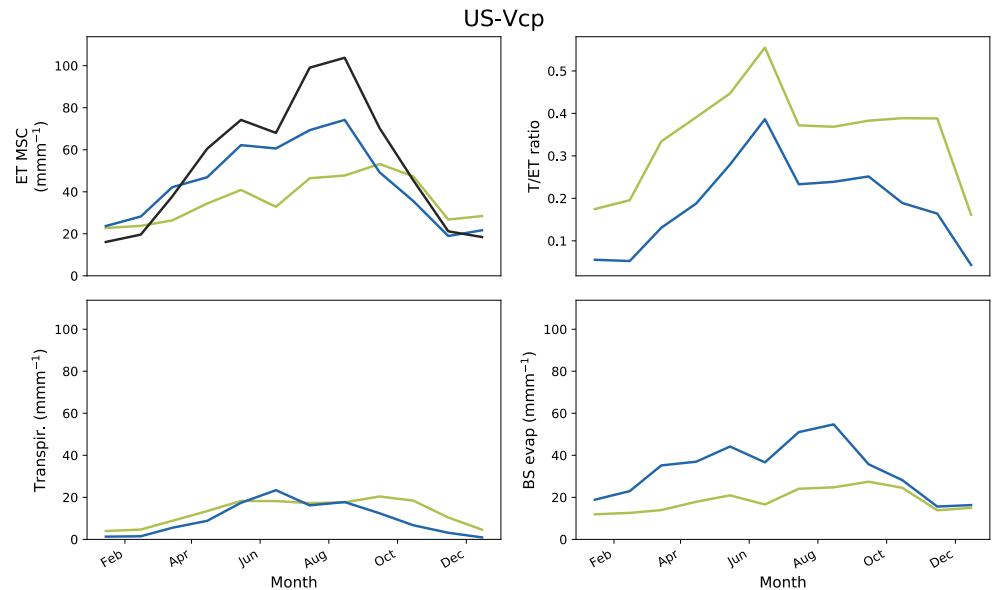
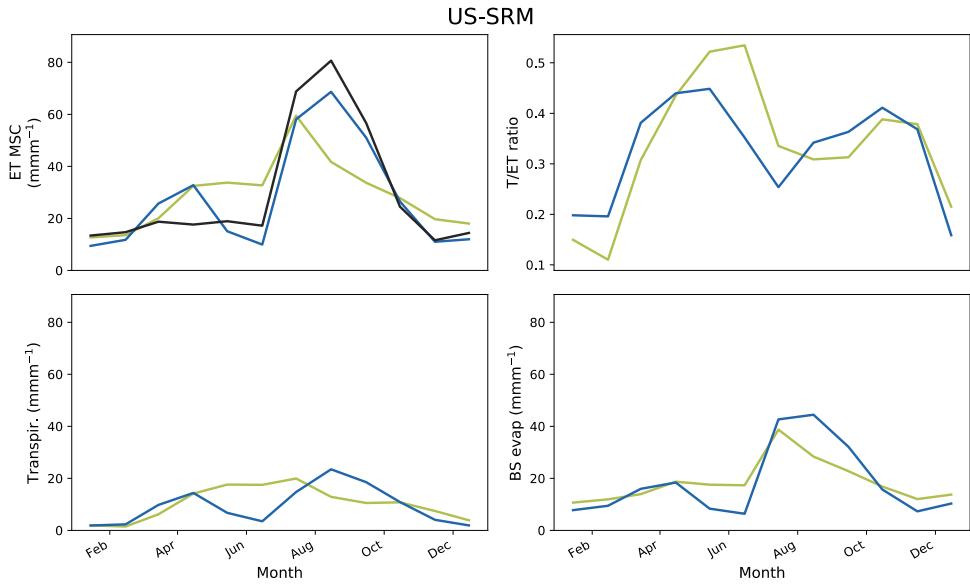
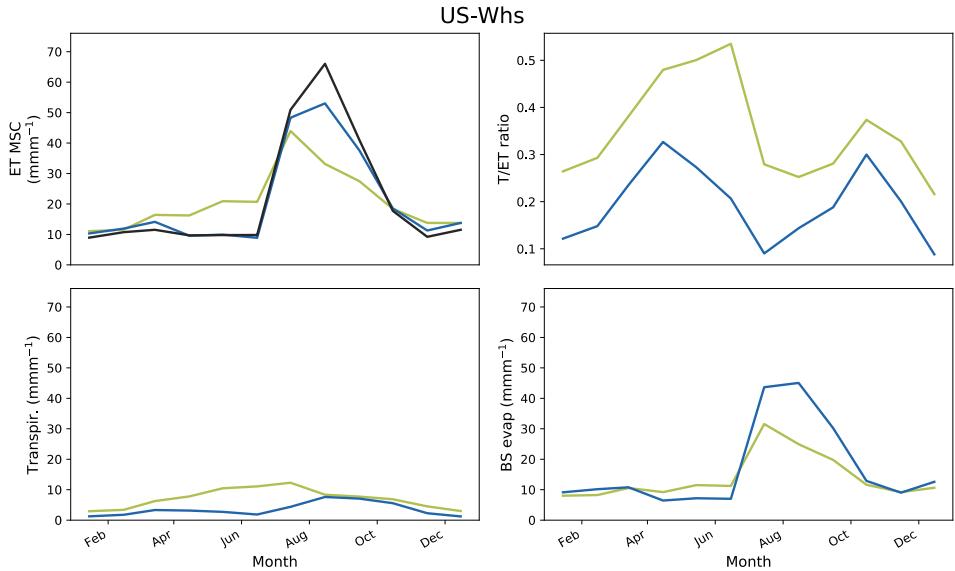
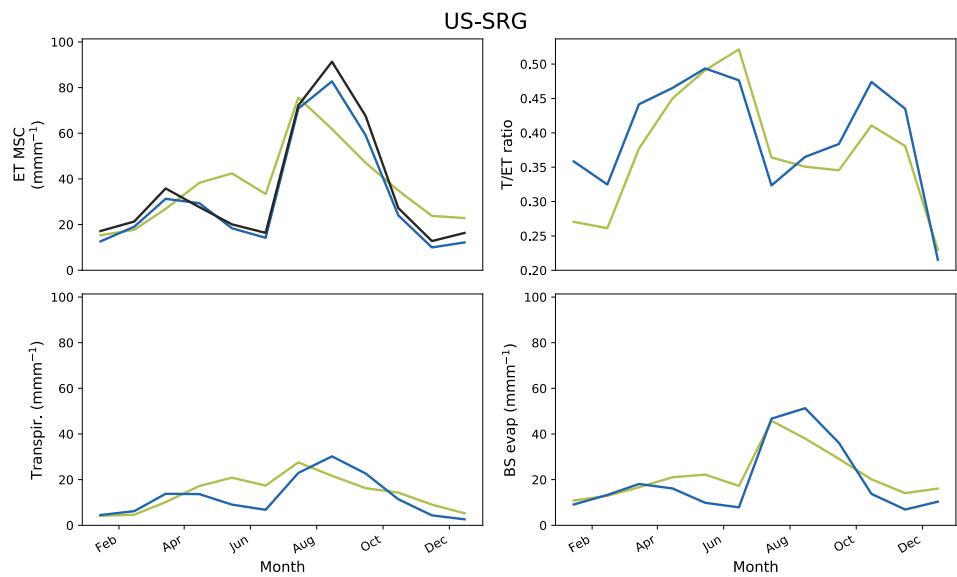
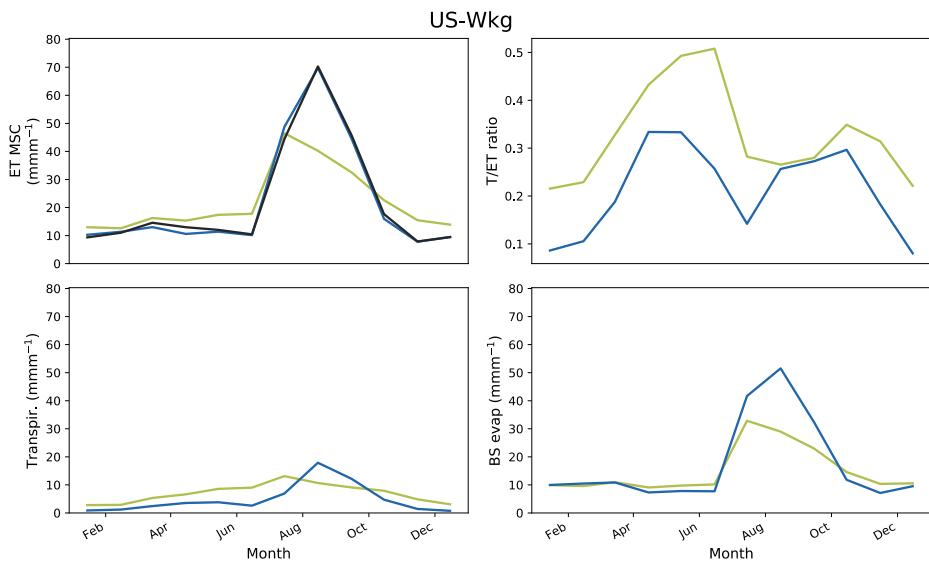
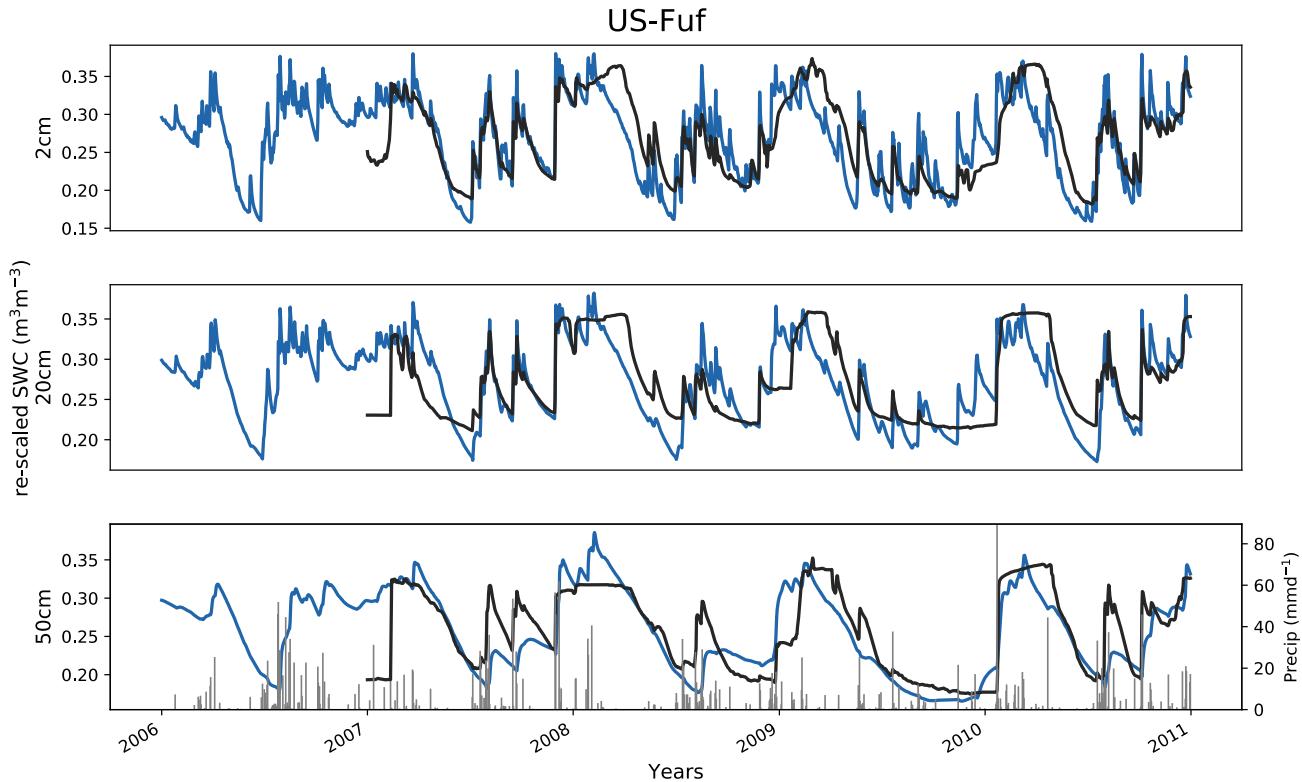



Figure S4: Daily simulated volumetric soil water content (VWC – m₃m₋₃) across all site years compared to re-scaled (via linear CDF matching) observations at each site for three depths (upper, middle, lower) in the soil profile. The soil depths and their corresponding model layers are given in Table 2. Precipitation is shown in the grey lines in the bottom panel for each site.

a) **US-Fuf**

b) US-Vcp

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265

270

c) US-SRM

d) US-Whs

e)   US-SRG

320   **f)   US-Wkg**

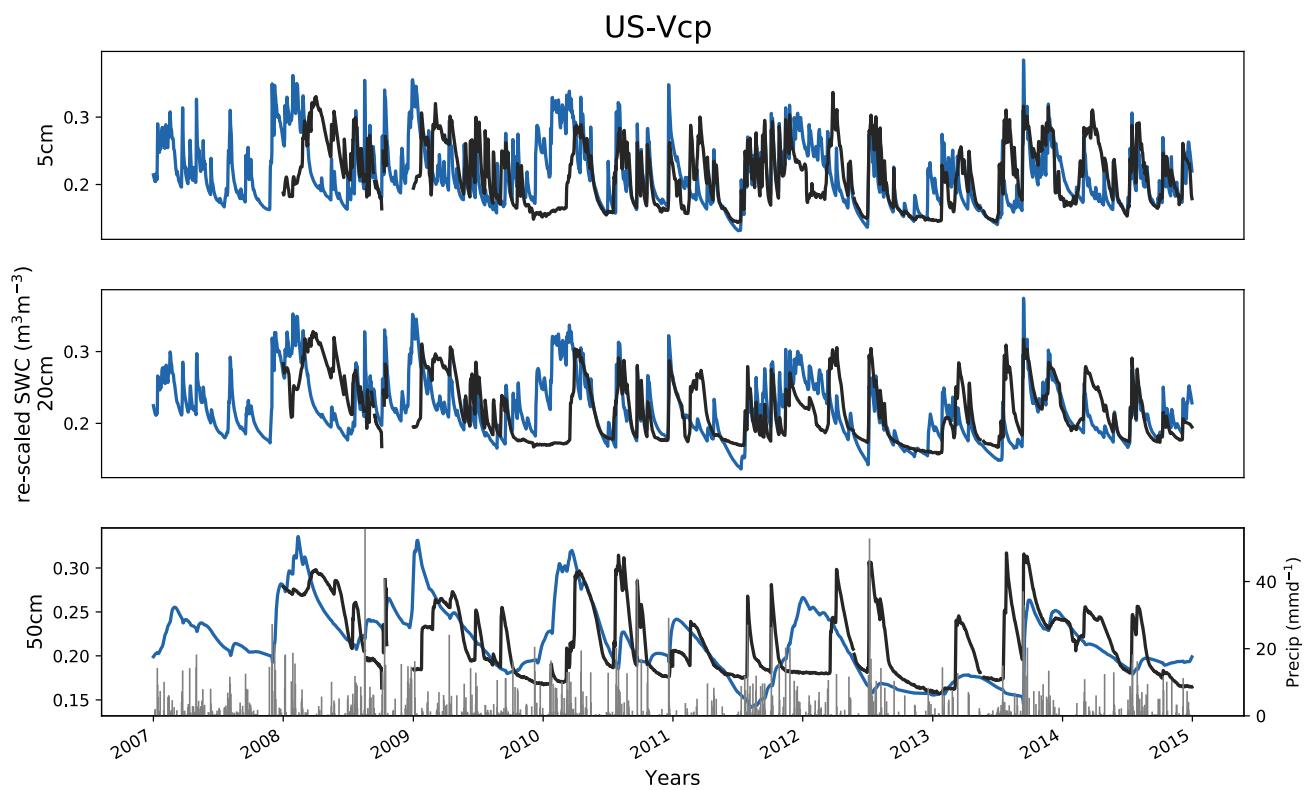
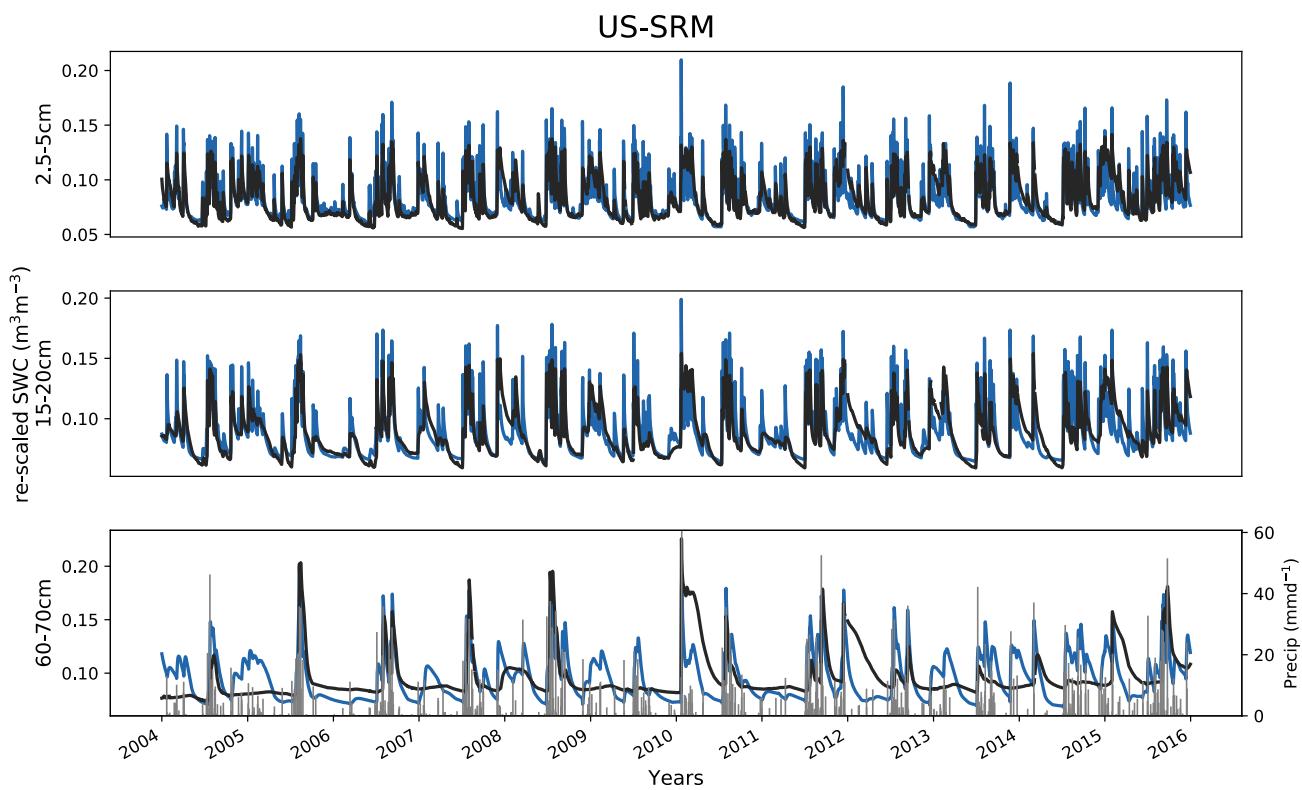
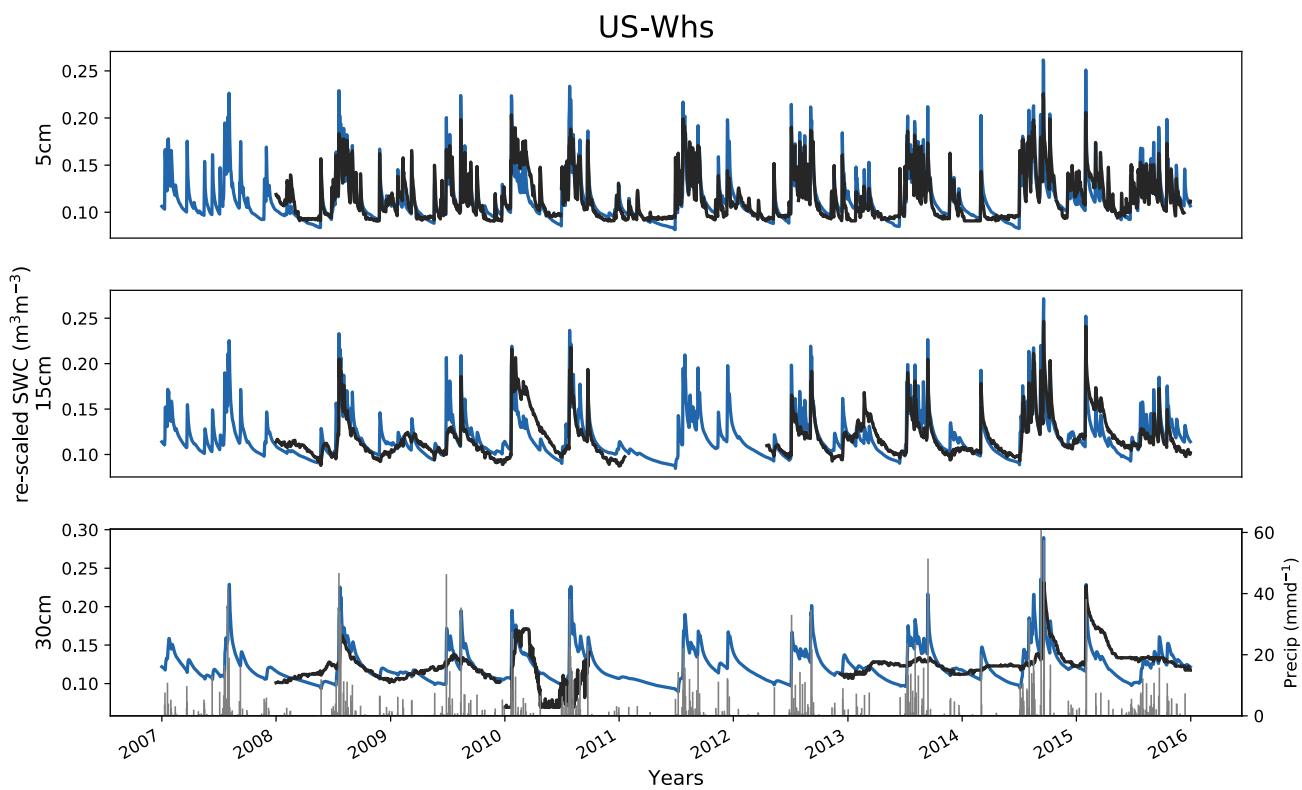
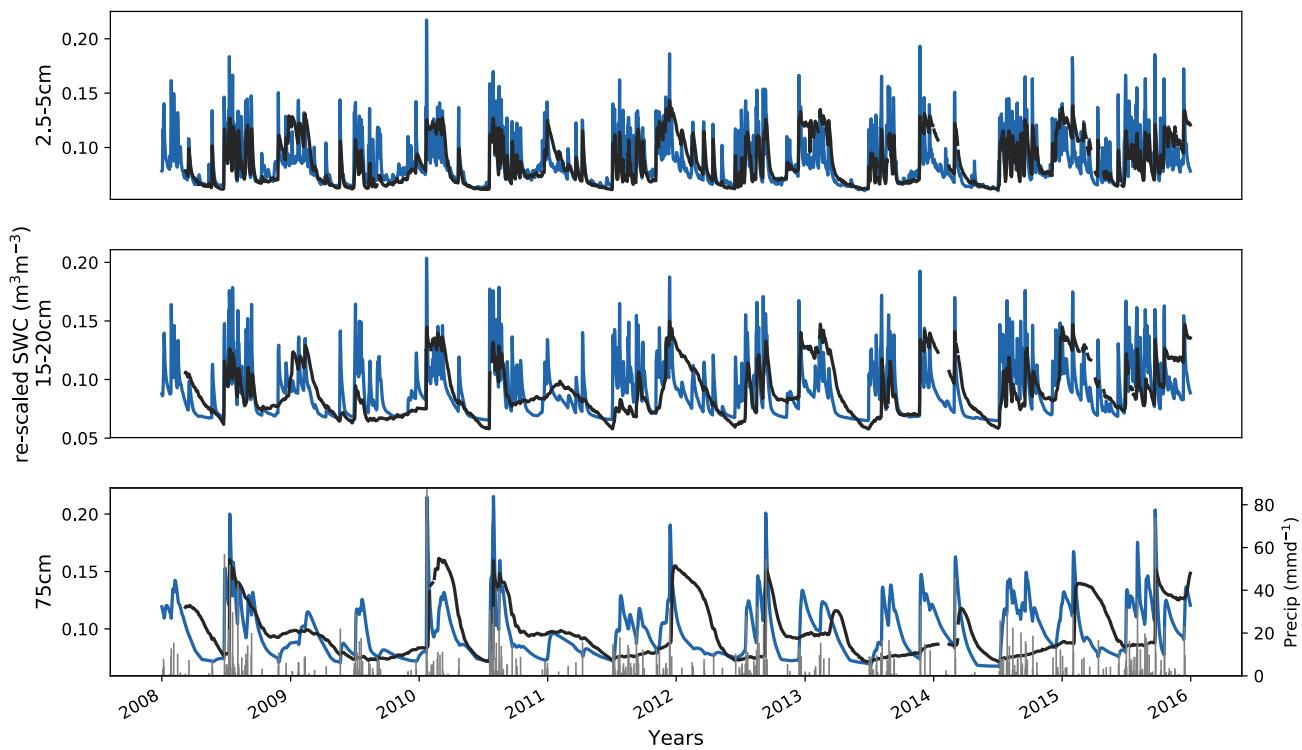
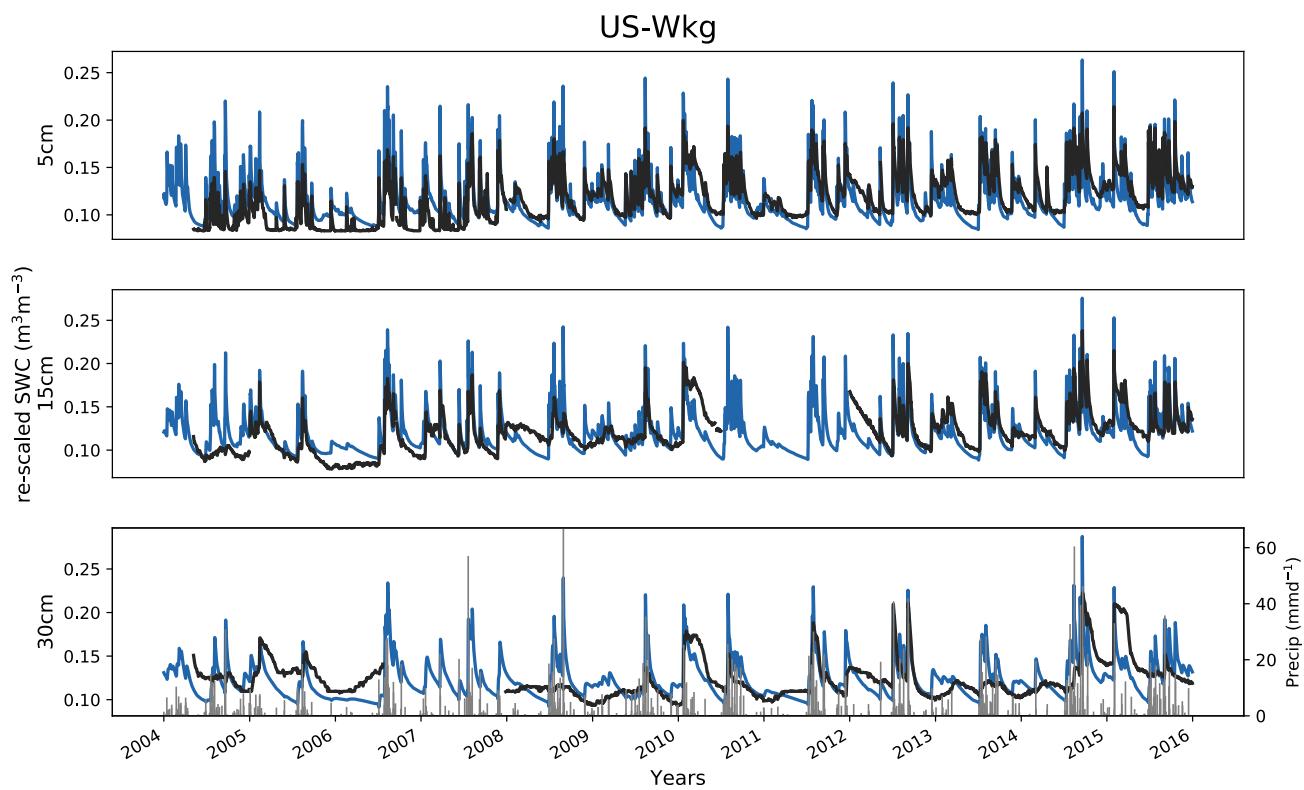



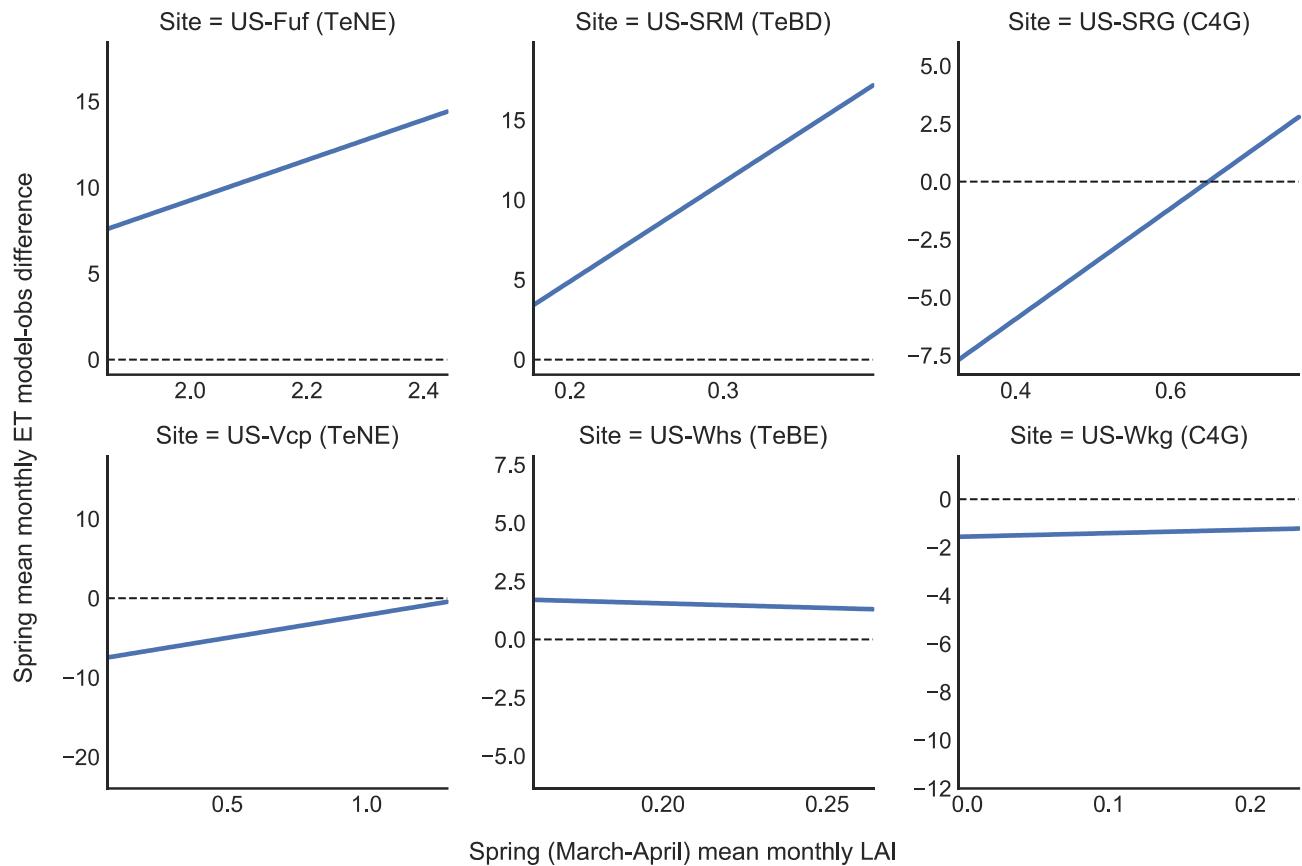
Figure S5: Linear regressions between spring (March-April) mean monthly LAI and spring mean ET model-data misfits for each site. The dominant PFT is given in brackets for each site. See Table 1 for PFT acronyms.

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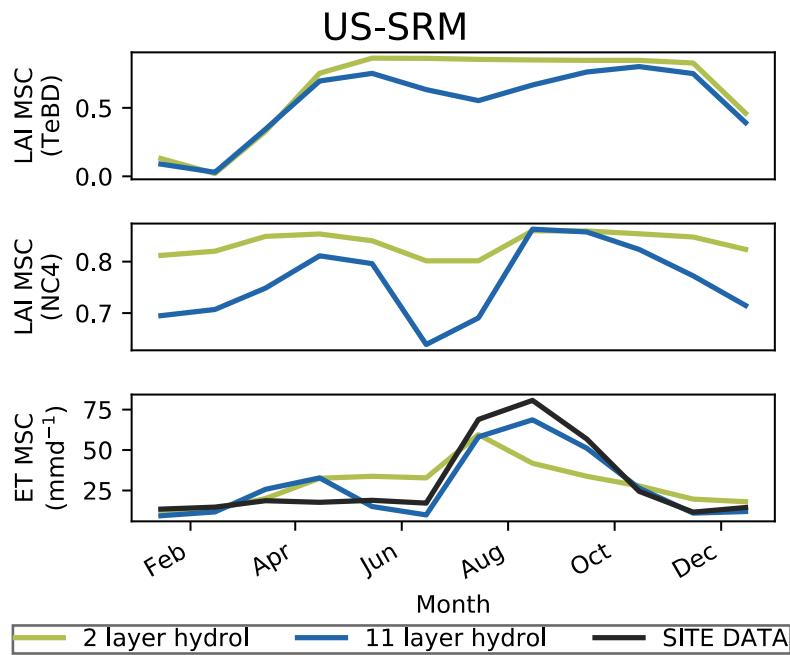
Figure S6: Plots comparing ET and LAI for C4 grasses (C4G) and mesquite shrubs (Temperate Broadleaved Deciduous – TeBD – PFT in ORCHIDEE) monthly mean seasonal cycles at US-SRM for the 2LAY (green curve) and 11LAY (blue curve) model versions in comparison to observations (black curve).

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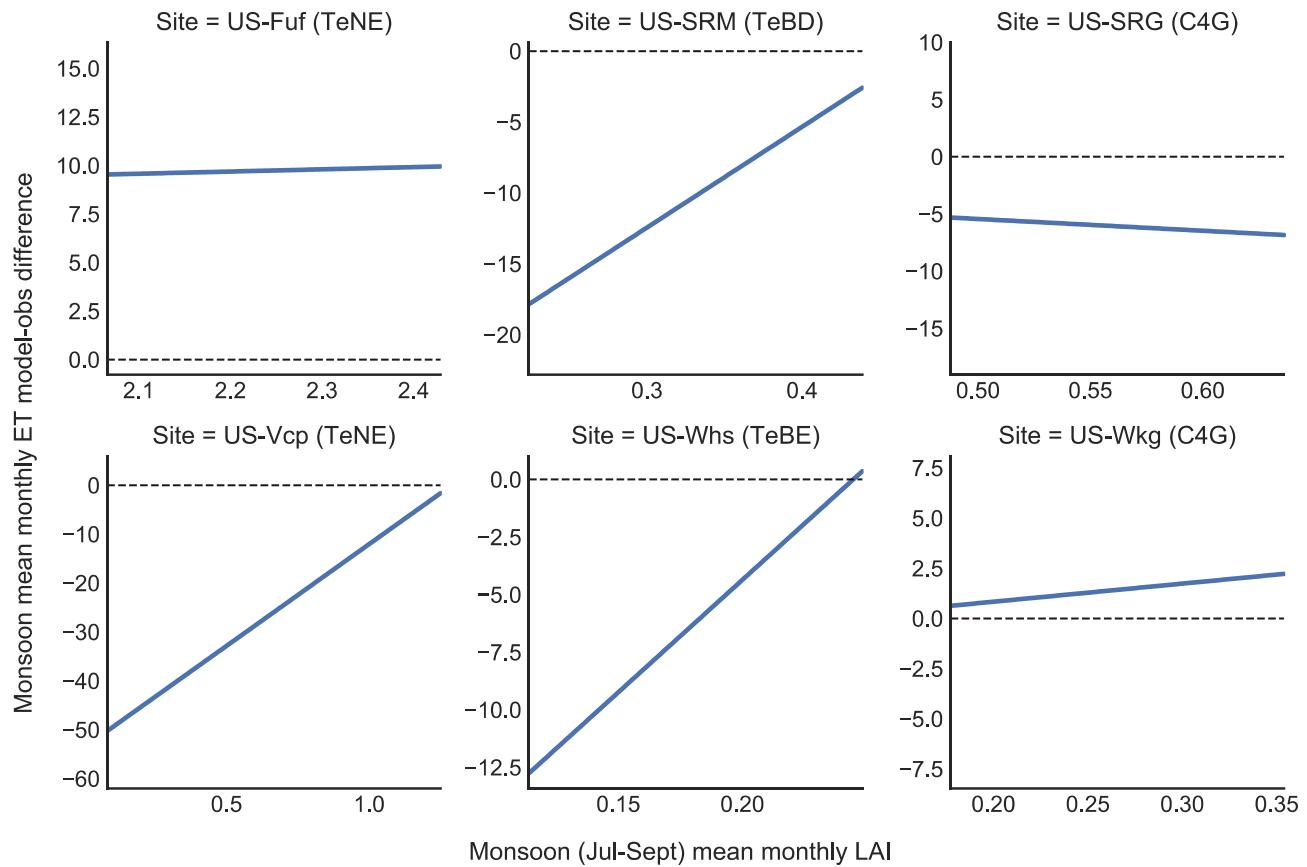
Figure S7: Linear regressions between monsoon (July-September) mean monthly LAI and monsoon mean ET model-data misfits for each site. The dominant PFT is given in brackets for each site. See Table 1 for PFT acronyms.

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Figure S8: ET monthly mean seasonal cycle for all low elevation sites comparing the default 11LAY simulations (blue curve) with a simulation that increased the C4 grass fraction at the expense of the bare soil fraction (yellow curve). ET is compared to observations (black curve). Units in mmmonth-1.
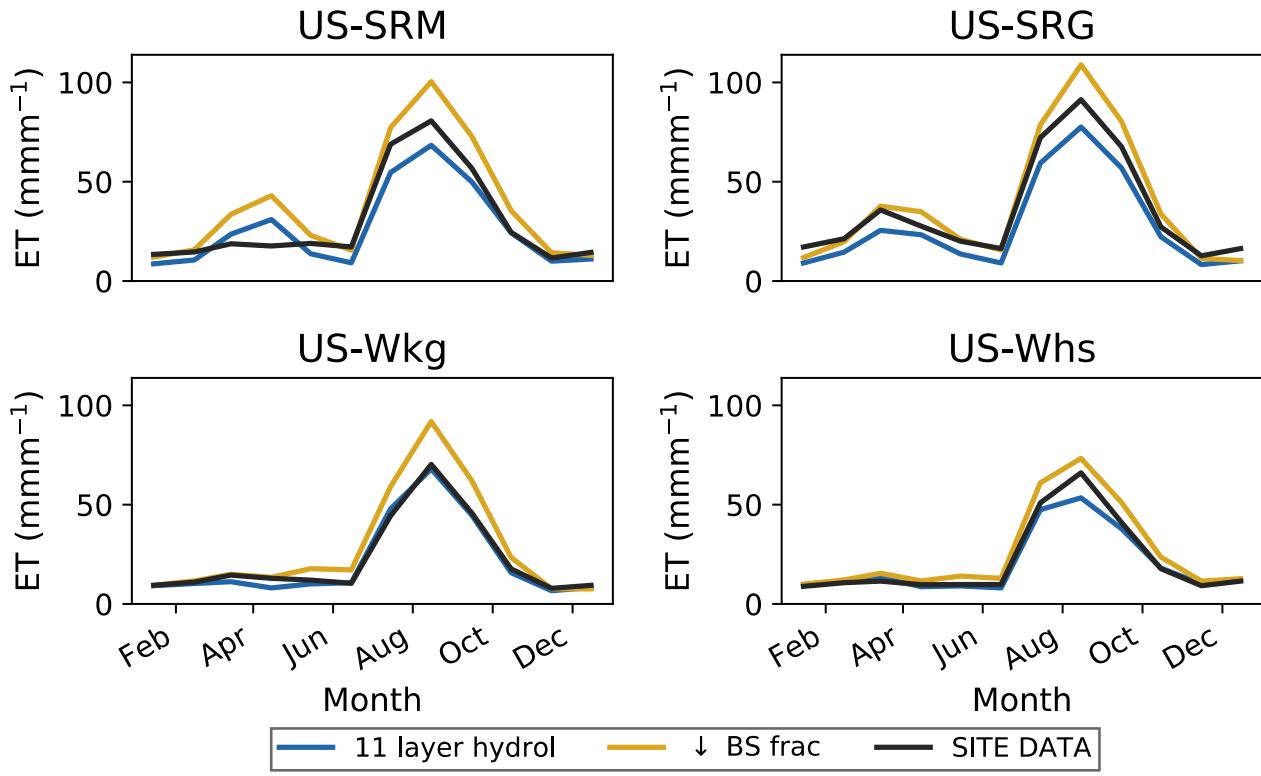
Figure S9: Monthly mean seasonal cycle for all sites comparing the default 11LAY simulations (blue curve) with a simulation that included an additional bare soil evaporation resistance term (red curve). ET is compared to observations (black curve). In all subfigures – top right: T/ET ratios; bottom left: transpiration; bottom right: bare soil evaporation. Units in mmmonth-1.

405   **a)**   **US-Fuf**

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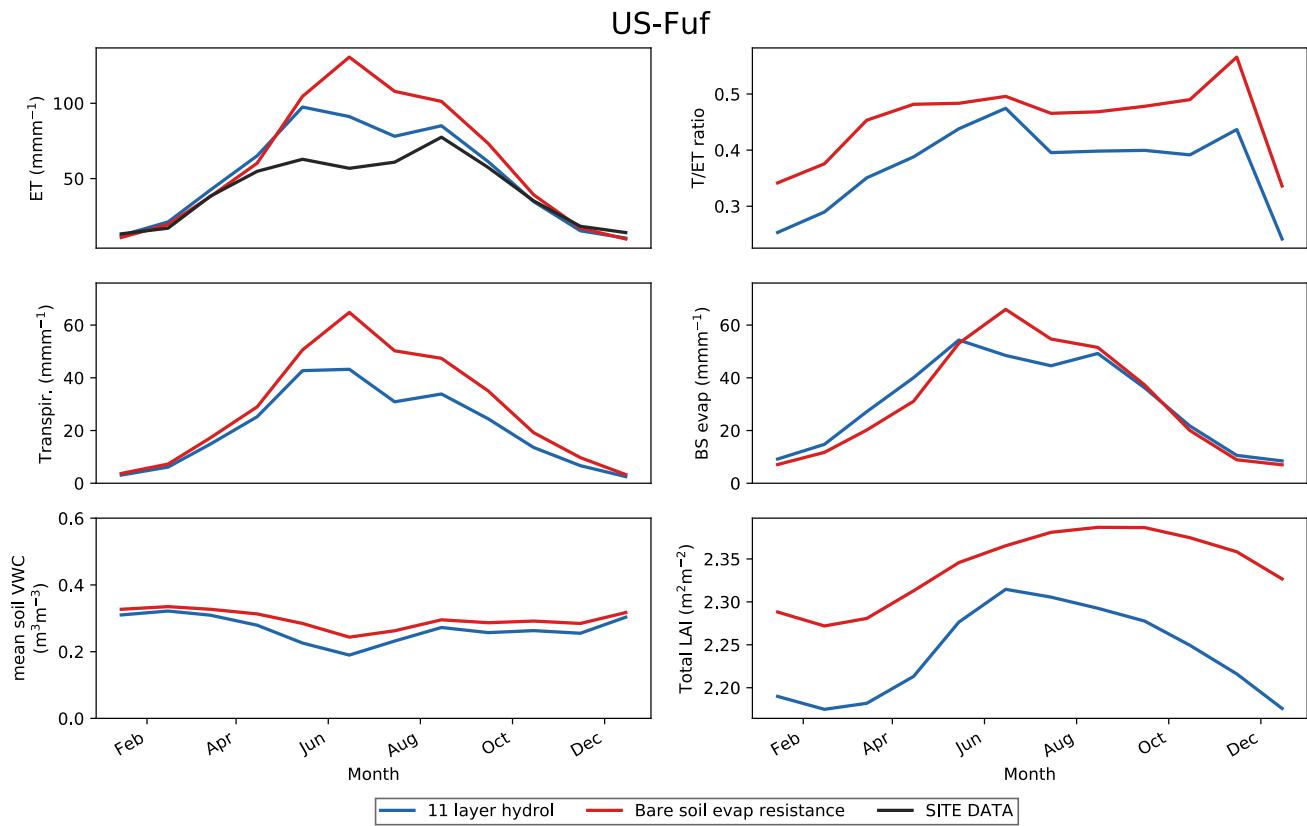
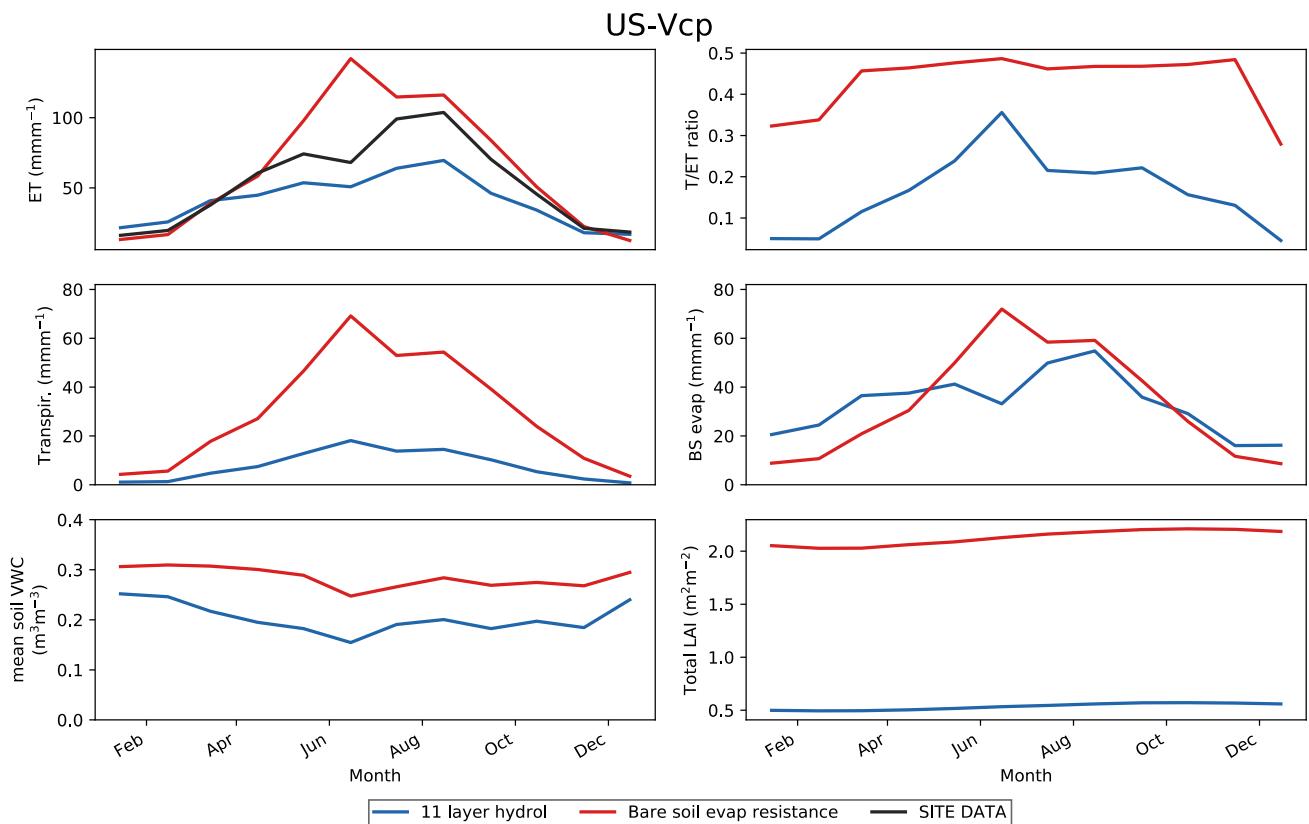

b) US-Vcp

435 **c) US-SRM**

d) US-Whs

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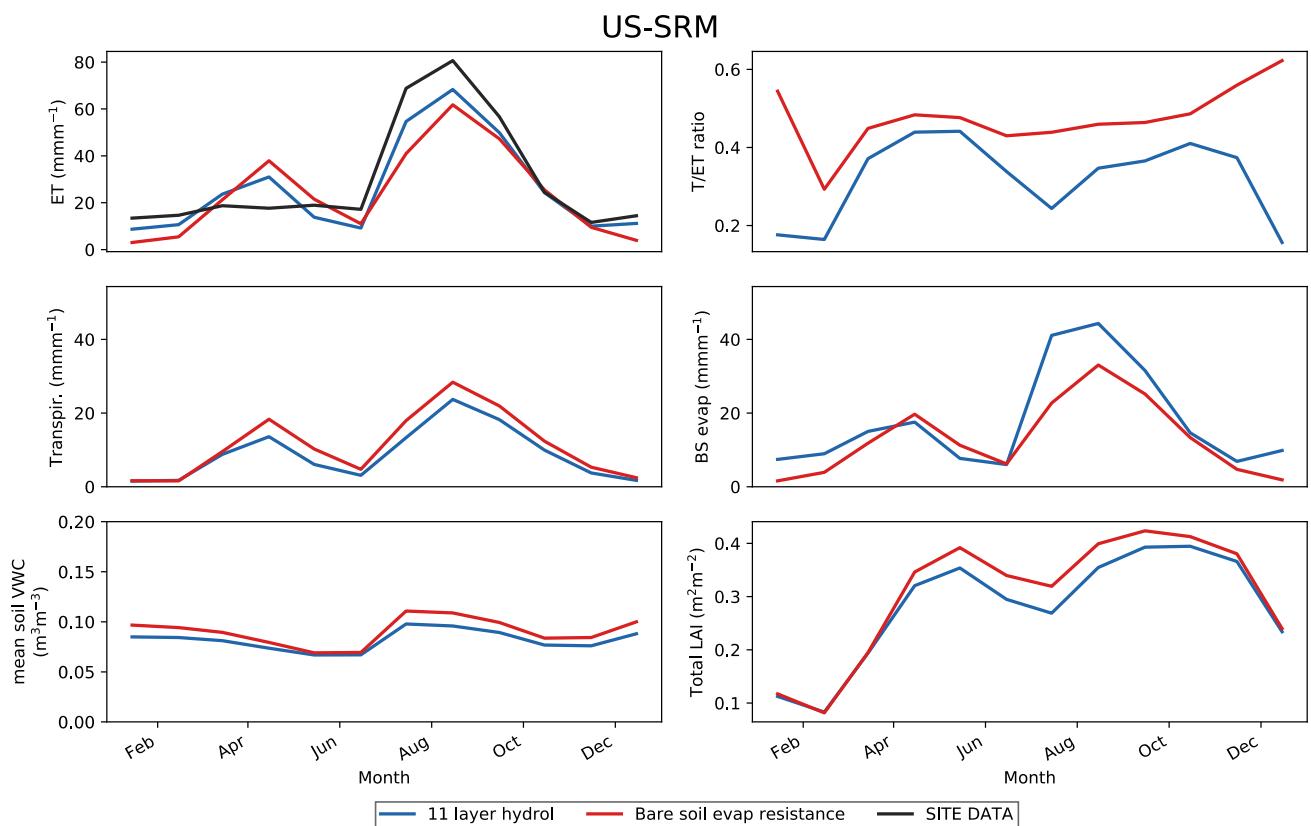
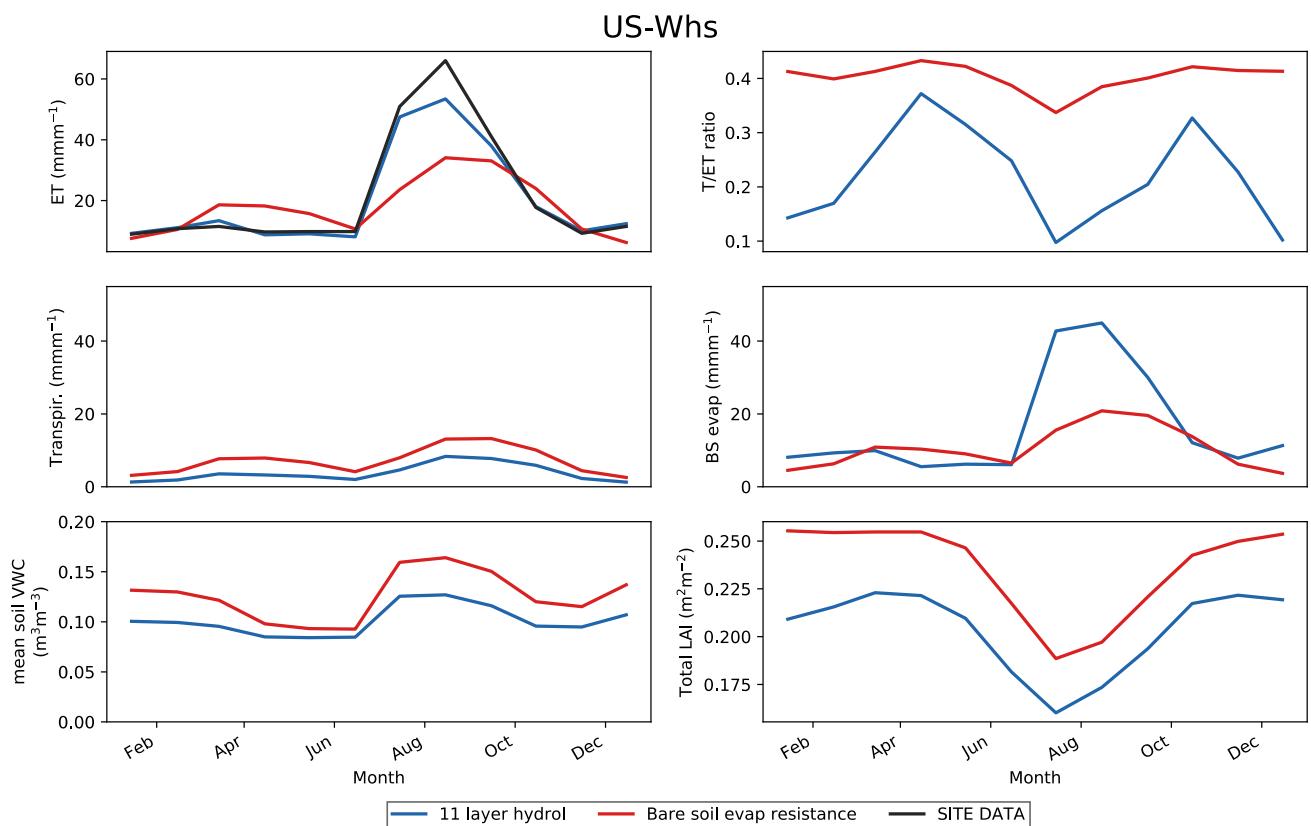
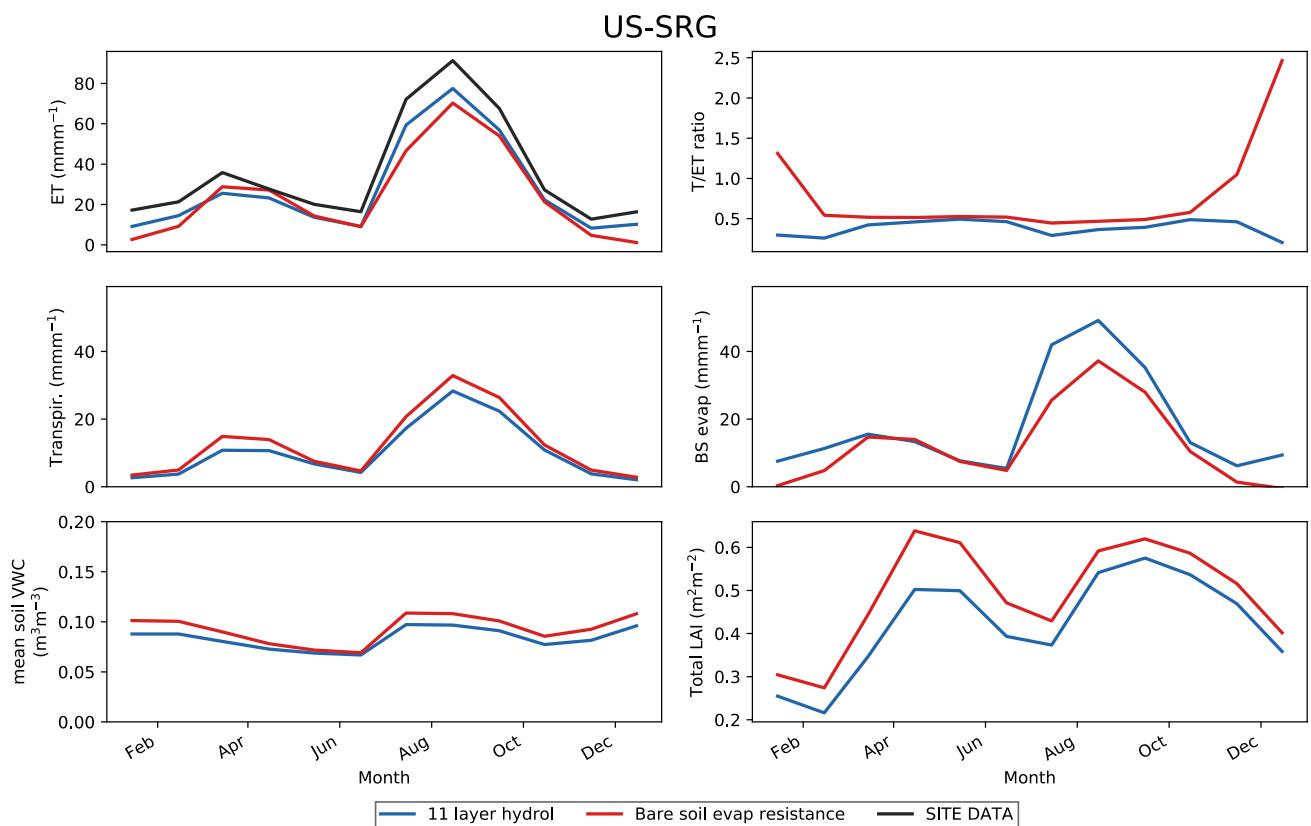
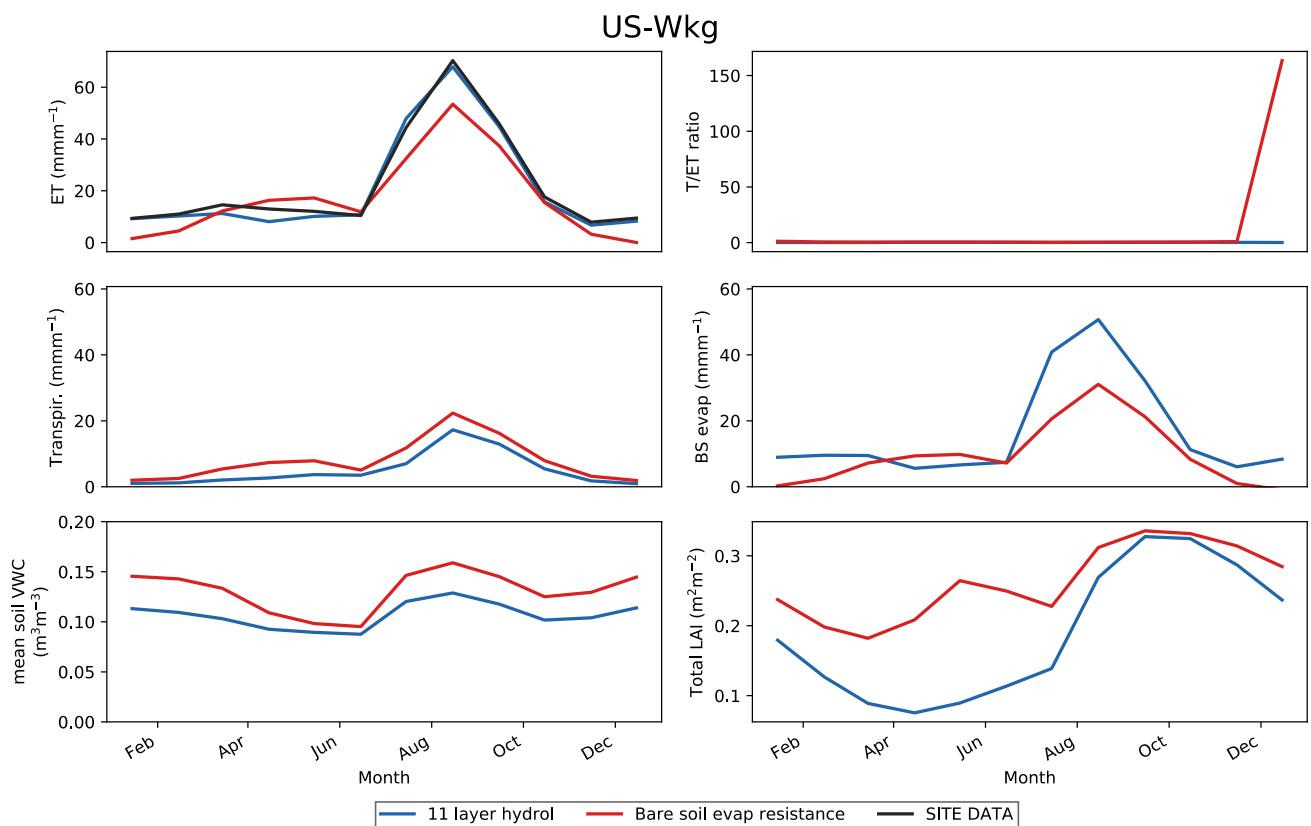

f) US-Wkg

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Figure S10: Monthly mean seasonal cycle for all sites comparing the default 11LAY simulations (blue curve) with a) with a simulation that increased the C4 grass fraction at the expense of the bare soil fraction (yellow curve); and b) a simulation that included an additional bare soil evaporation resistance term (red curve). In all subfigures – top left: mean soil moisture; top right: ET compared to observation (black curve); bottom left: transpiration; bottom right: bare soil evaporation. Units in mmmonth-1.

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