Hydrology and
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Supplement of

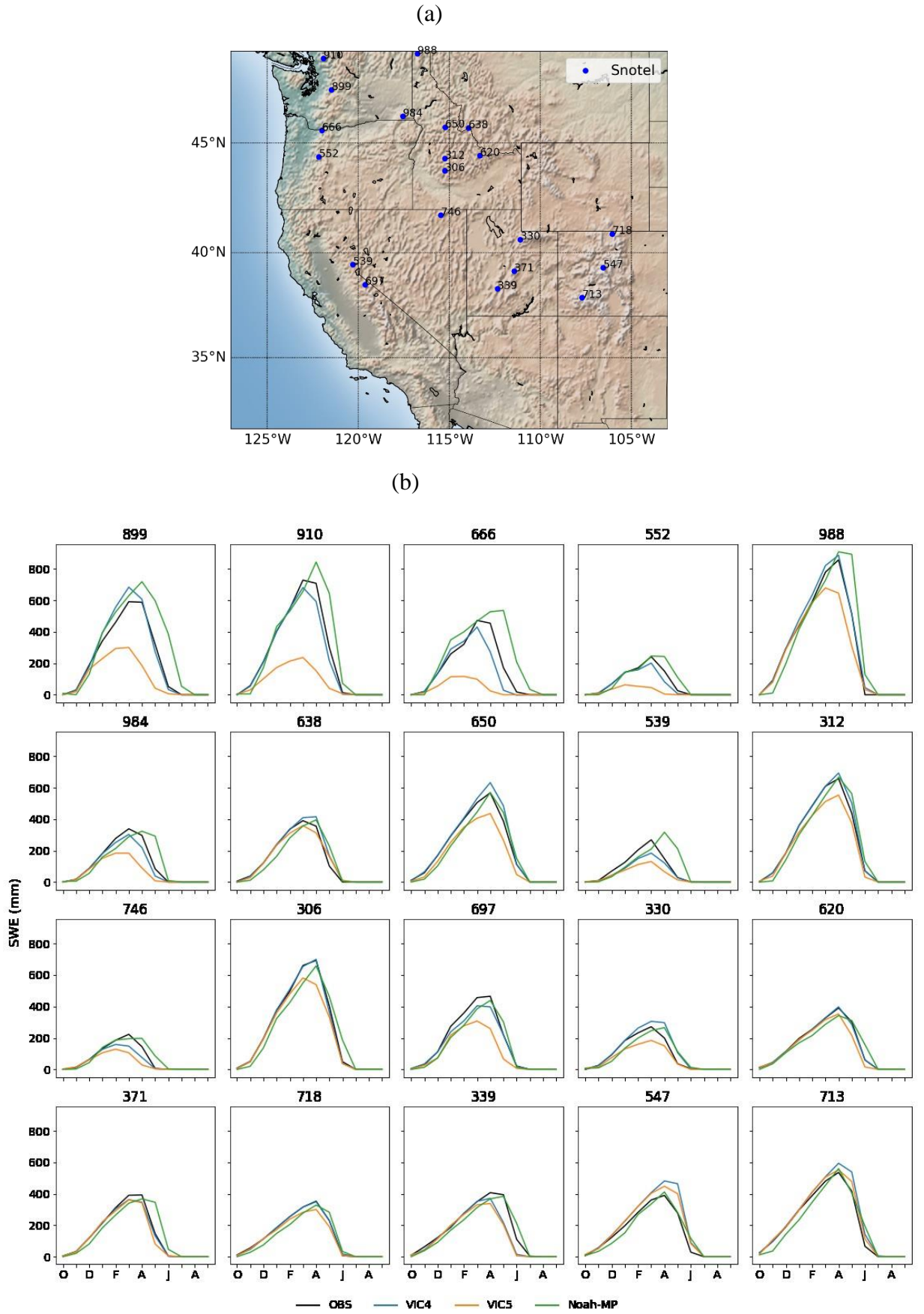# Improving runoff simulation in the Western United States with Noah-MP and VIC models

Lu Su et al.

Correspondence to: Dennis P. Lettenmaier (dlettenm@ucla.edu)

Table S1. Features considered for regionalization of calibrated parameters to ungauged basins in VIC and Noah-MP models (see also main text Section 4).

Features in order of rank for VIC	Features in order of rank for Noah-MP
Longitude Centroid	Latitude Centroid
Latitude Centroid	Longitude Centroid
Max Elevation	Area
Precipitation Fall Mean	**KGE stops increasing for below features**
Temperature Fall Mean	Temperature Summer Mean
KGE stops increasing for below features	Min Elevation
Mean Elevation	Precipitation Annual Mean
Min Elevation	Precipitation Fall Mean
Temperature Summer Mean	Perimeter
Precipitation Spring Mean	Temperature Spring Mean
Precipitation Winter Mean	Max Elevation
Precipitation Summer Mean	Precipitation Winter Mean
Precipitation Annual Mean	Temperature Winter Mean
Mean Annual Max 1-D Precipitation	Temperature Annual Mean
Temperature Winter Mean	Precipitation Spring Mean
Temperature Spring Mean	Precipitation Summer Mean
Temperature Annual Mean	Mean Elevation
Perimeter	Temperature Fall Mean
Area	Mean Annual Max 1-D Precipitation

(a)

(b)

Figure S1. (a) selected 20 SNOTEL locations across the Western U.S. (b) snow

water equivalent (SWE) in mm observed and simulated by VIC5, Noah-MP, and VIC 4.1.2. The subtitle displays the ID number of each SNOTEL station. Our assessment indicates that both models' parameterizations for snow processes reproduced observed SWE at most sites across our study region, however VIC 4.1.2 outperformed VIC5 substantially in a few cases. This finding led to our adoption of VIC 4.1.2 rather than the newer VIC5 version.

Figure S2. Cumulative Distribution Function (CDF) of daily Nash-Sutcliffe Efficiency (NSE) for (a) VIC and (b) Noah-MP models in baseline and calibrated runs across WUS catchments. The results indicate significant improvements in NSE following calibration for both models. VIC's median NSE increased from 0.19 in the baseline to 0.56 after calibration, while Noah-MP's median NSE improved from -0.09 to 0.22.
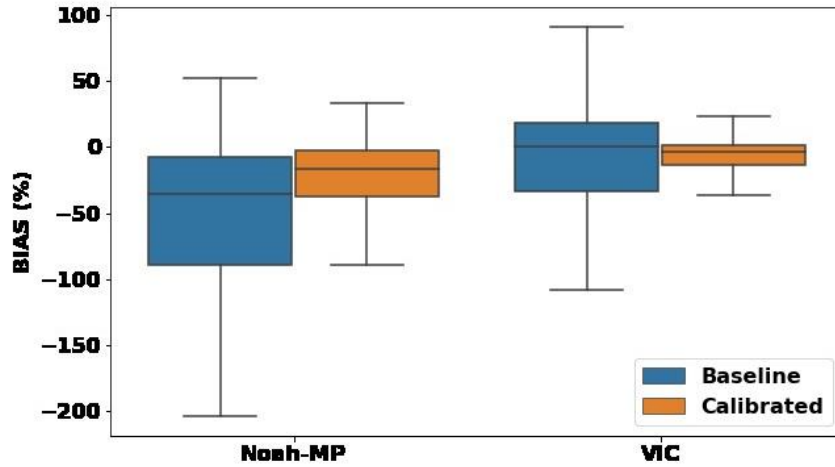
Figure S3. Comparison of daily streamflow simulation bias (%) for (a) VIC and (b) Noah-MP Models in baseline and calibrated runs across all WUS catchments. For VIC, the interquartile bias improved from (-33%, 18%) in the baseline to (-13%, 1%) after calibration. Similarly, Noah-MP's interquartile bias decreased from (-89%, -7%) to (-37%, -2%) post-calibration.
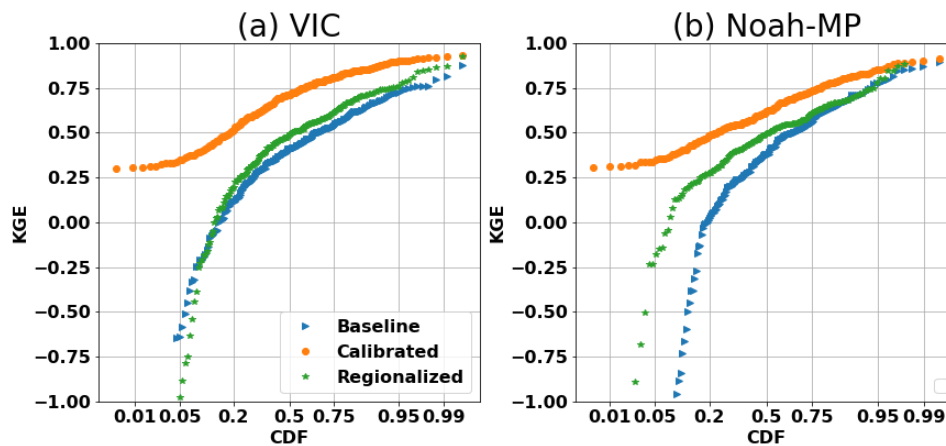

Figure S4. CDF of daily KGE for (a) VIC and (b) Noah-MP, comparing baseline and calibrated runs and regionalized basins across selected basins within the WUS.

Figure S5. Regionalized VIC land surface parameters over WUS.
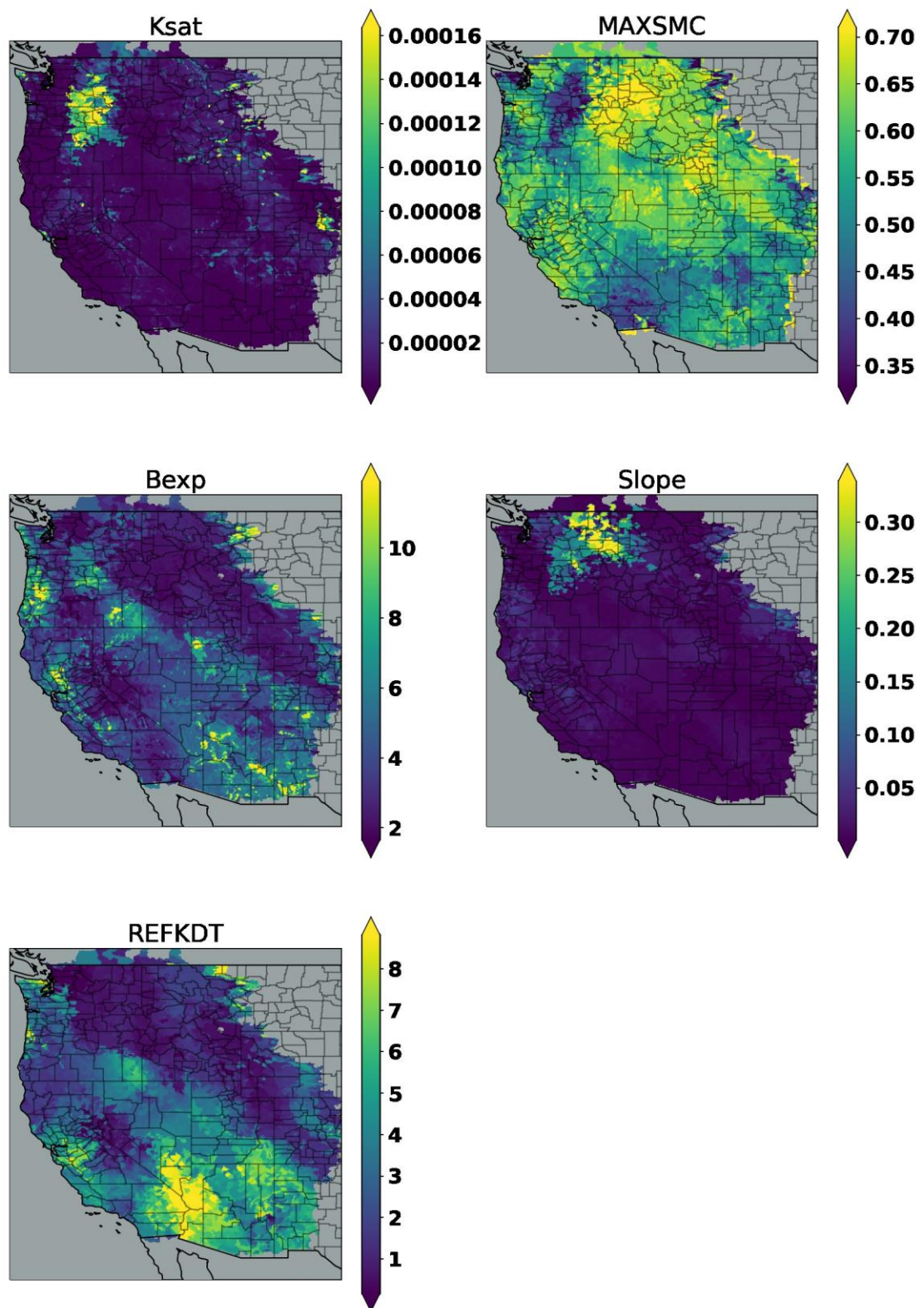
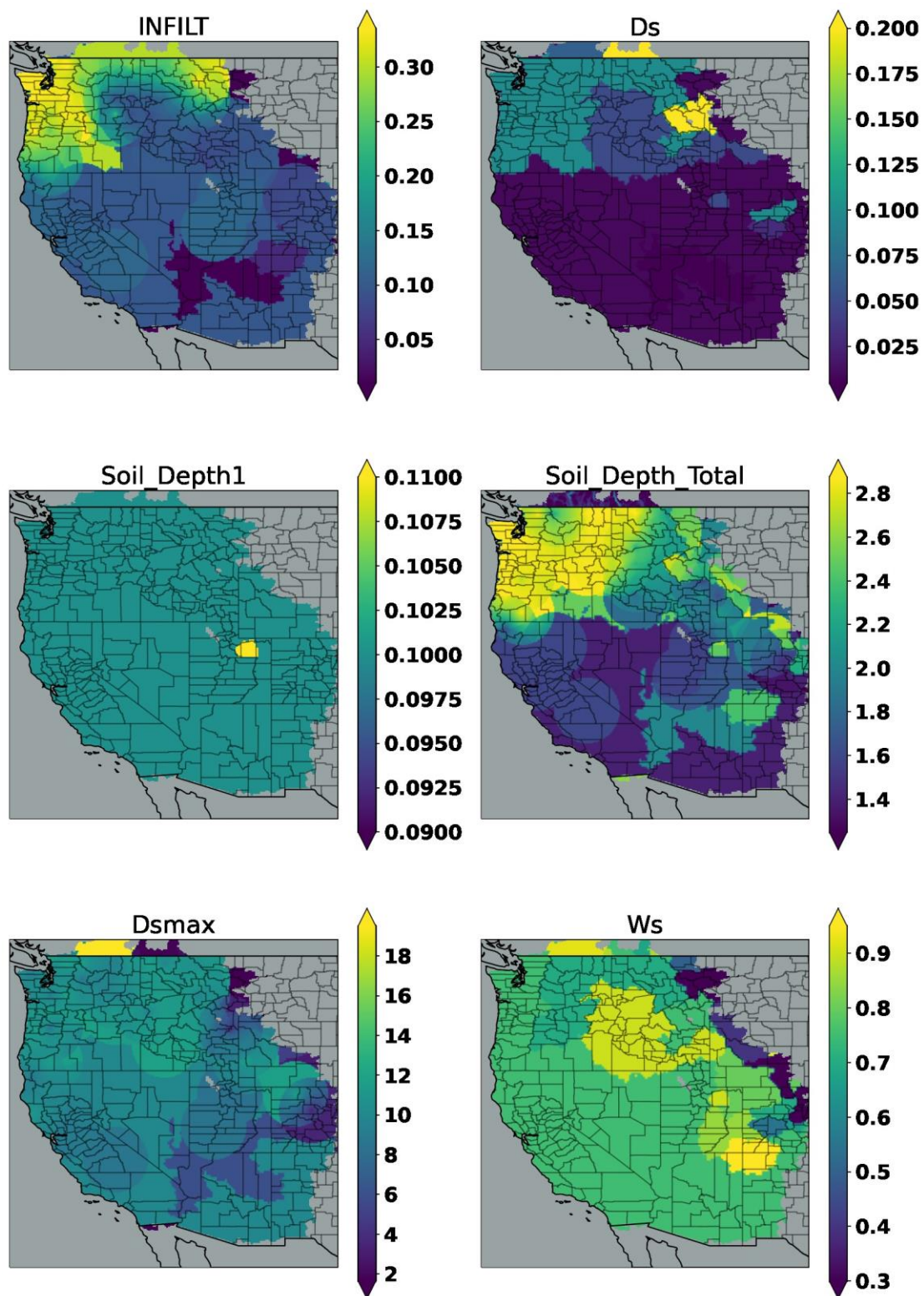Figure S6. Regionalized Noah-MP land surface parameters over WUS.

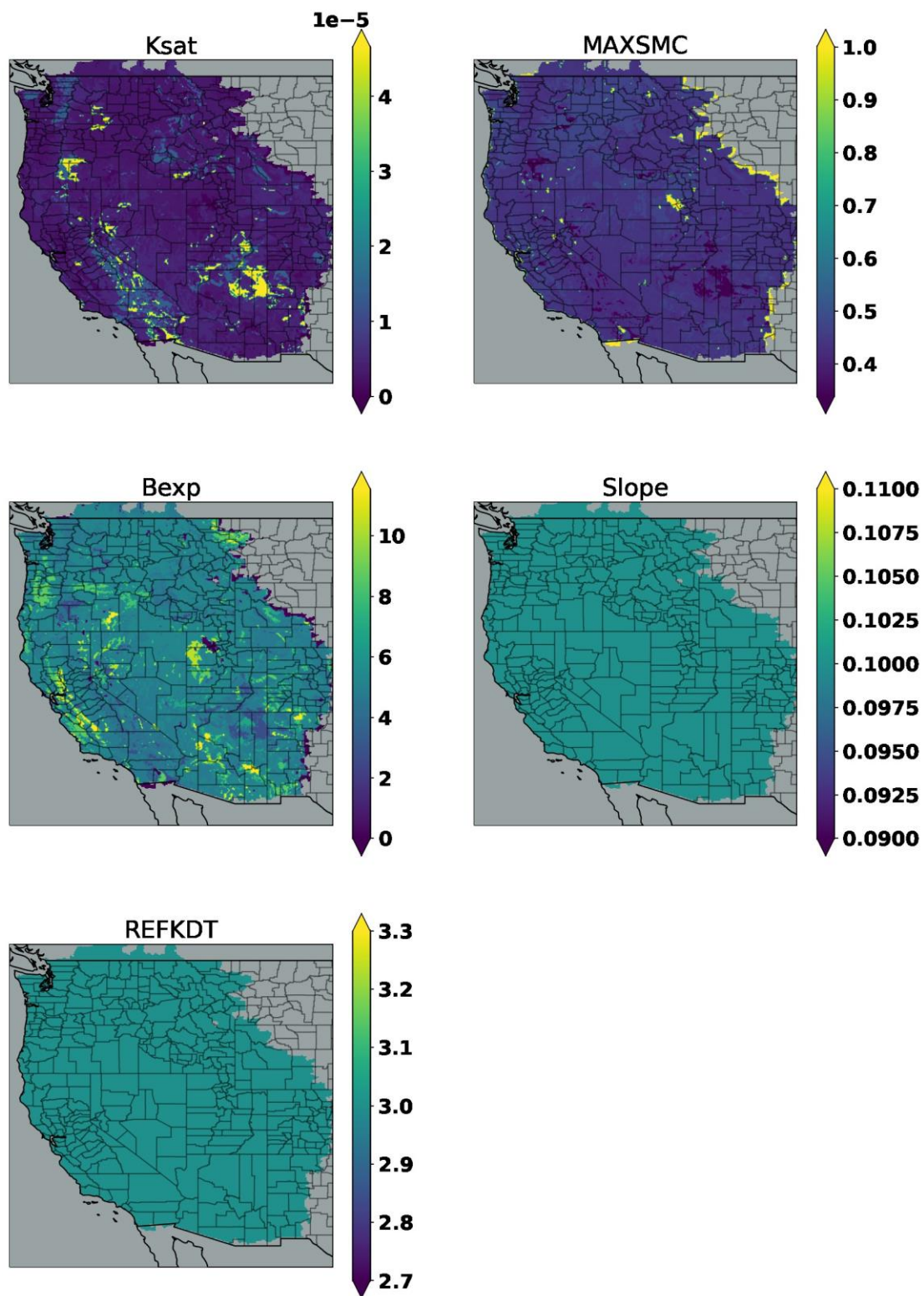Figure S7. Baseline VIC land surface parameters over WUS.

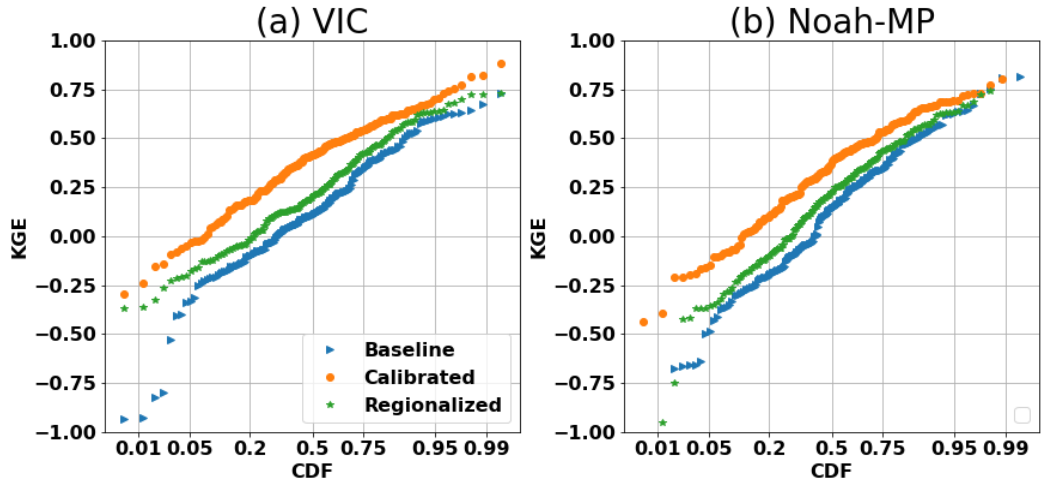Figure S8. Baseline Noah-MP land surface parameters over WUS.

Figure S9. CDF of high flow KGE for (a) VIC and (b) Noah-MP, comparing baseline and calibrated runs across selected calibration catchments across the WUS.
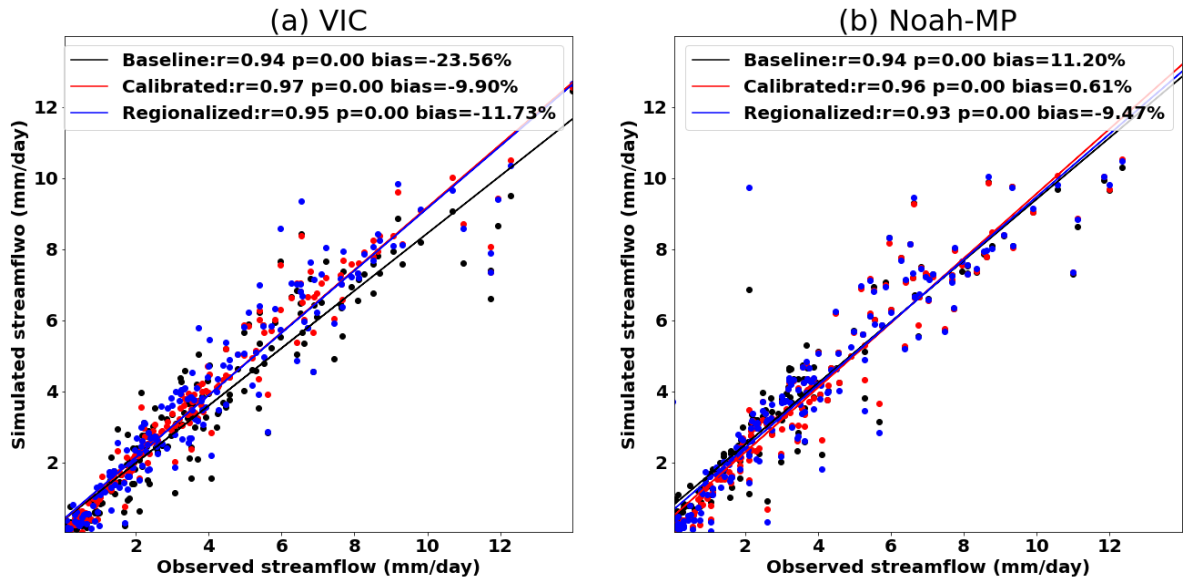

Figure S10. Scatterplot of 7q10 low flows (the lowest 7-day average flow that occurs (on average) once every 10 years) for the baseline and calibrated and regionalized runs for (a) VIC and (b) Noah-MP. The correlation coefficients, P-values and percentage bias are denoted in the upper section of the figures. The x axis is observed low flow and the y axis is simulated low flow.
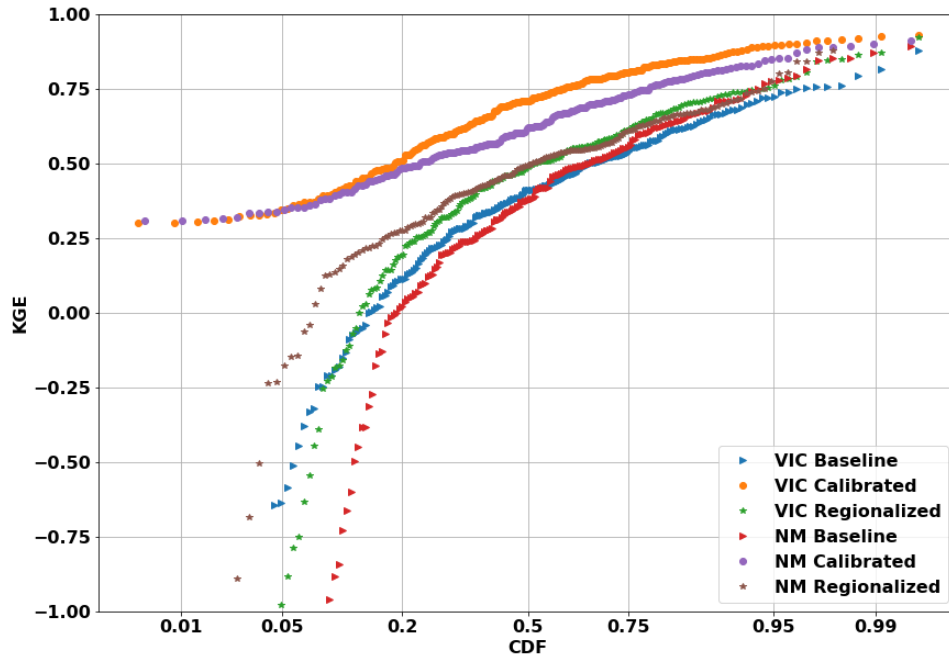
Figure S11. Same as S4 but with both VIC and Noah-MP shown in the same plot (note that KGE values less than -1.0 are truncated).
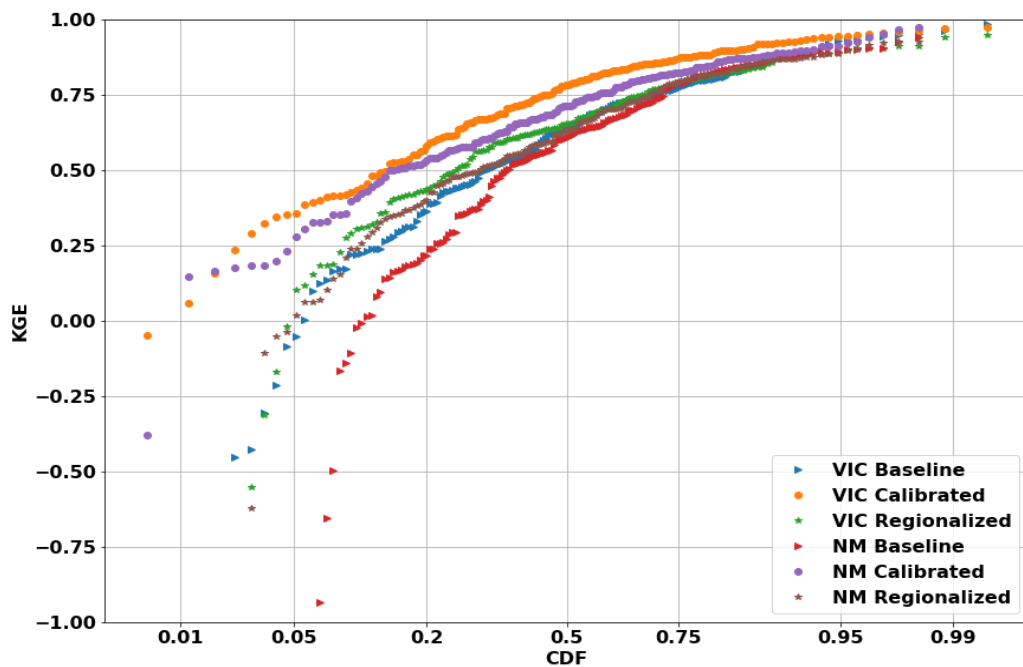

Figure S12. CDF of annual average streamflow KGE for VIC and Noah-MP, comparing baseline and calibrated runs across selected calibration catchments across the WUS (note that KGE values less than -1.0 are truncated).
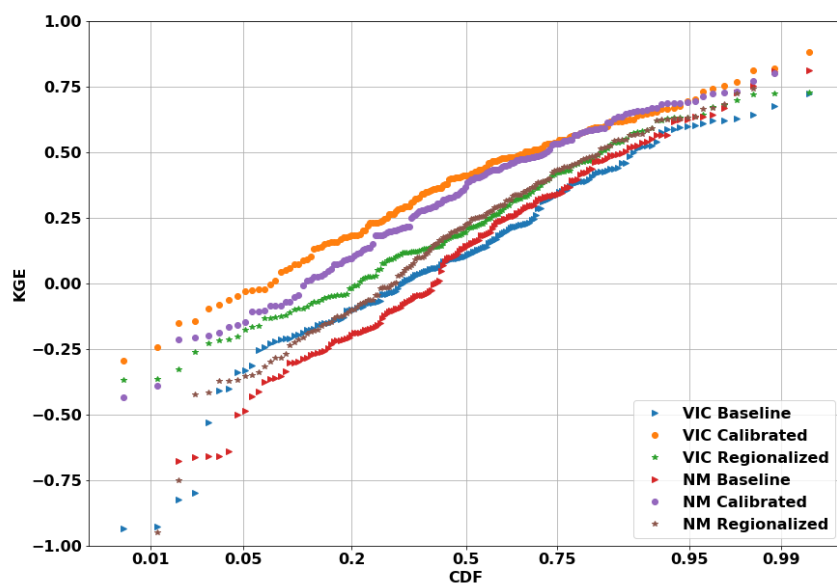
Figure S13. CDF of (POT3) flood KGE for VIC and Noah-MP, comparing baseline and calibrated runs across selected calibration catchments across the WUS.