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# Improving runoff simulation in the Western United States with Noah-MP and variable infiltration capacity

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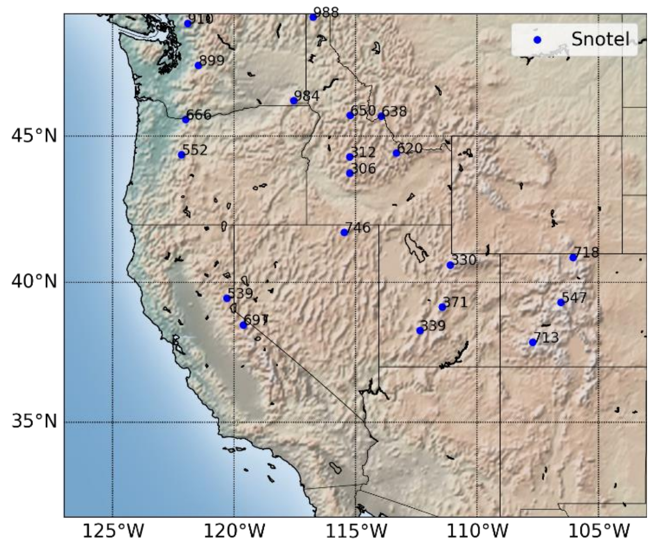
Table S1. Features considered for regionalization of calibrated parameters to ungauged basins in VIC and Noah-MP models (see also main text Section 4).

| 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)

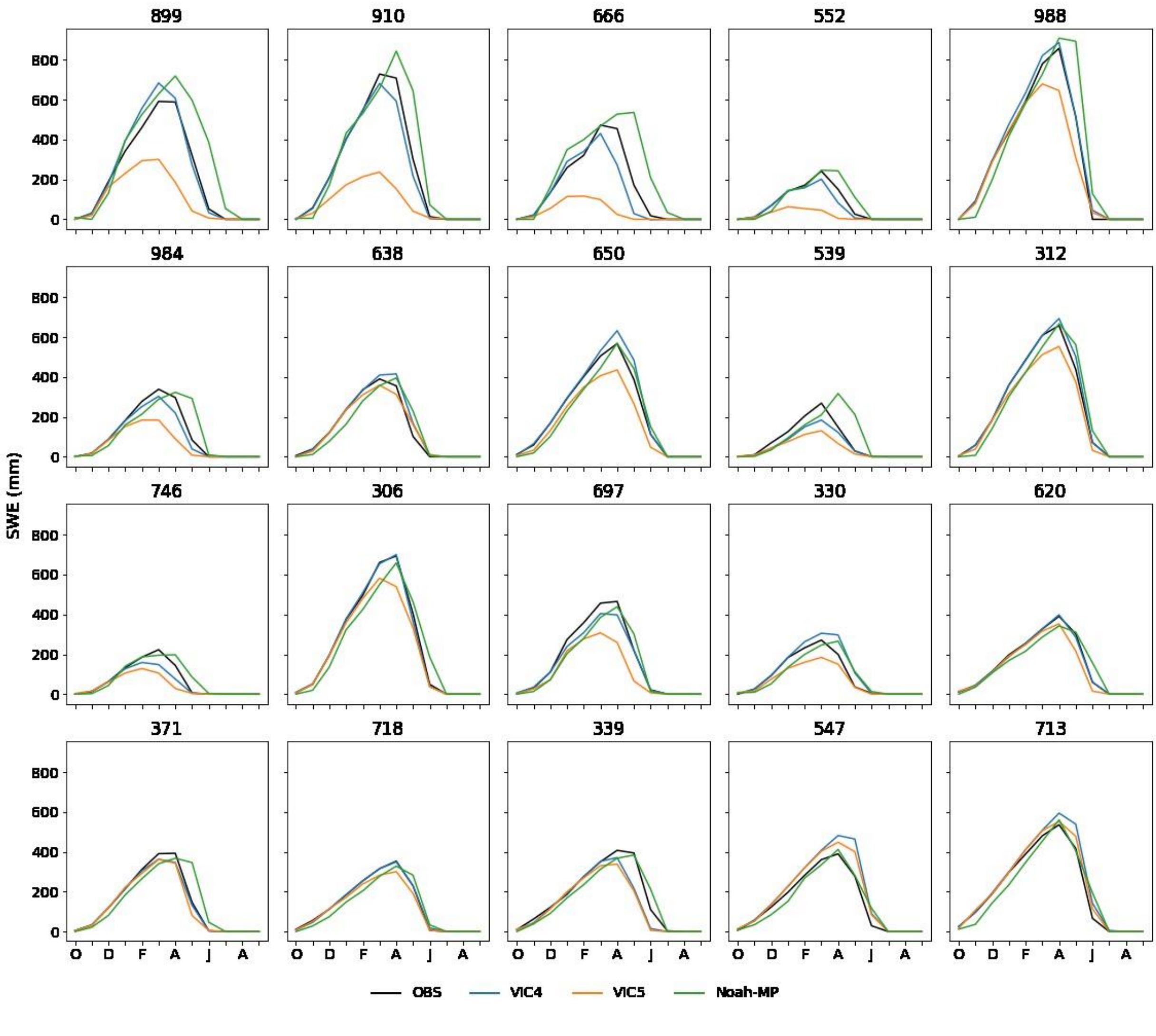



Figure S1. (a) selected 20 SNOTEL locations across the Western U.S. (b) snow water equivalent (SWE) in mm observed and simulated by VIC5, Noah-MP, and VIC 4.1.2. The subtitle displays the ID number of each SNOTEL station. Our assessment indicates that both models' parameterizations for snow processes 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.

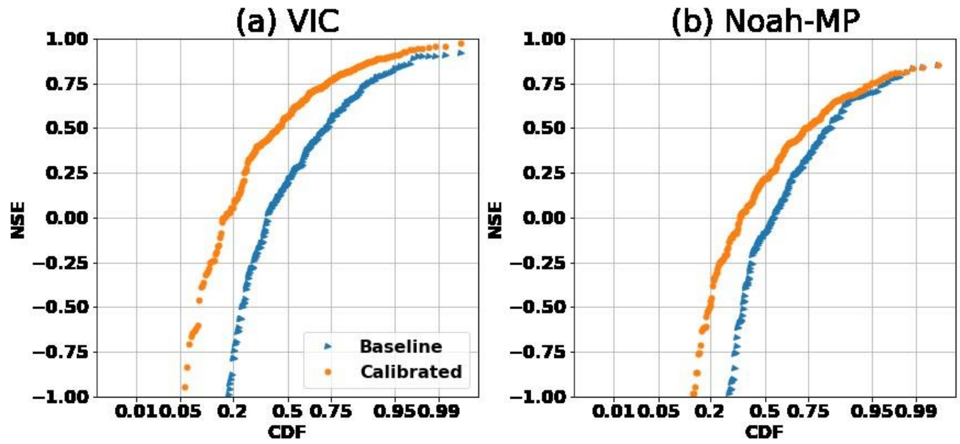



Figure S2. Cumulative Distribution Function (CDF) of daily Nash-Sutcliffe Efficiency (NSE) for (a) VIC and (b) Noah-MP models in baseline and calibrated runs across WUS catchments. The results indicate significant improvements in NSE following calibration for both models. VIC's median NSE increased from 0.19 in the baseline to 0.56 after calibration, while Noah-MP's median NSE improved from -0.09 to 0.22.

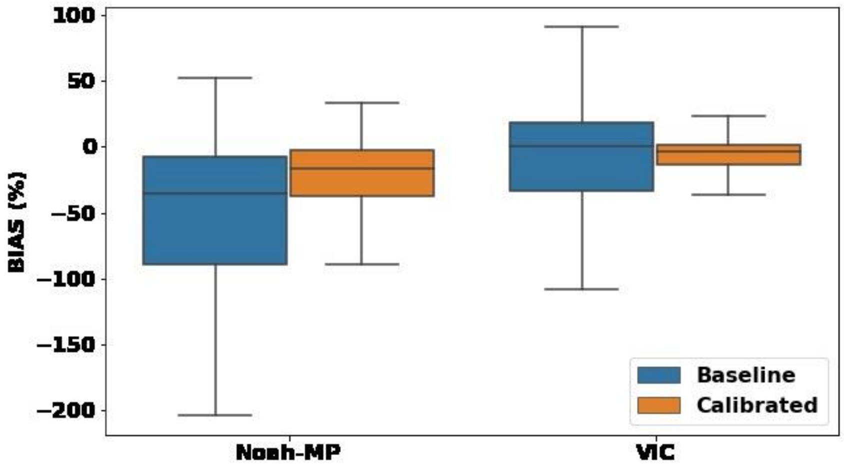



Figure S3. Comparison of daily streamflow simulation bias (%) for (a) VIC and (b) Noah-MP Models in baseline and calibrated runs across all WUS catchments. For VIC, the interquartile bias improved from (-33%, 18%) in the baseline to (-13%, 1%) after calibration. Similarly, Noah-MP's interquartile bias decreased from (-89%, -7%) to (-37%, -2%) post-calibration.

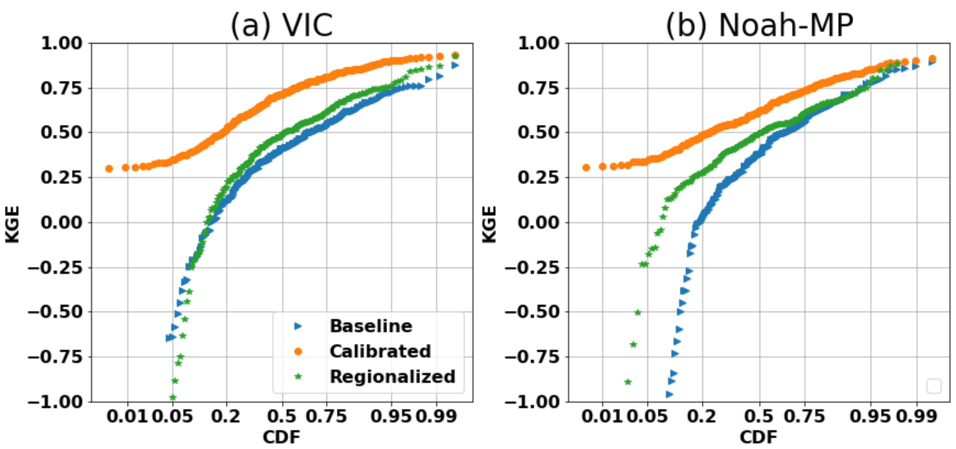



Figure S4. CDF of daily KGE for (a) VIC and (b) Noah-MP, comparing baseline and calibrated runs and regionalized basins across selected basins within the WUS.

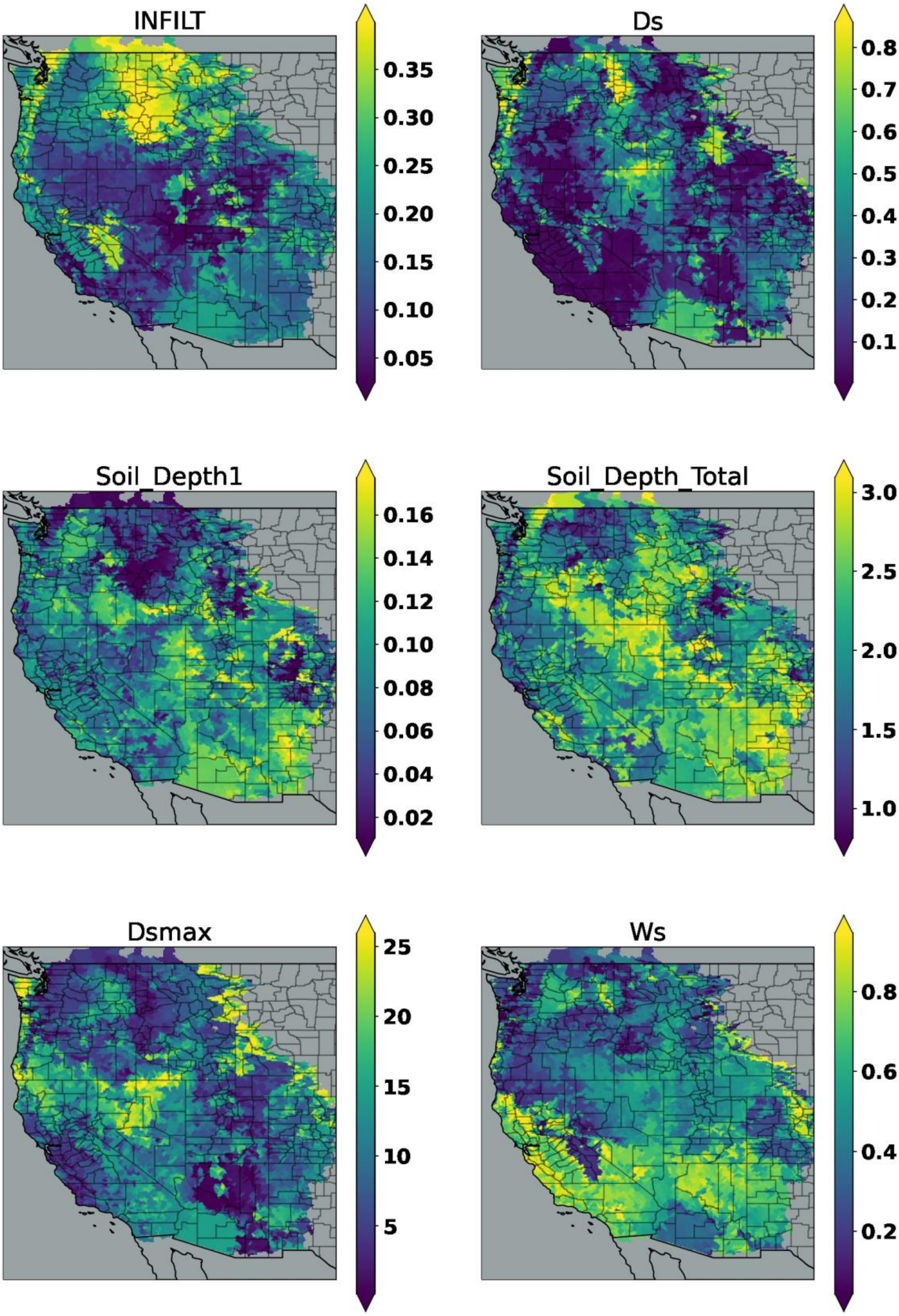



Figure S5. Regionalized VIC land surface parameters over WUS.

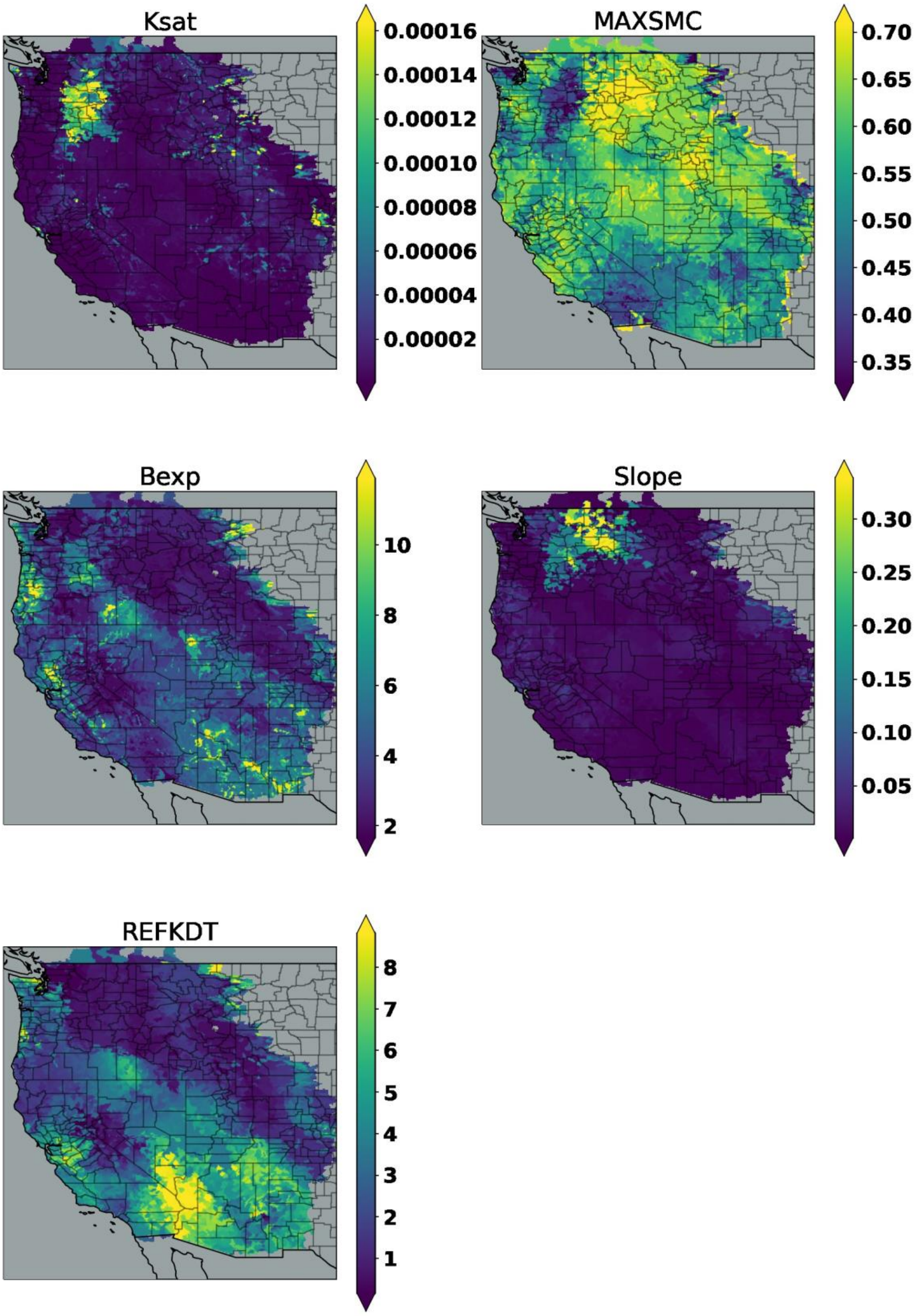



Figure S6. Regionalized Noah-MP land surface parameters over WUS.

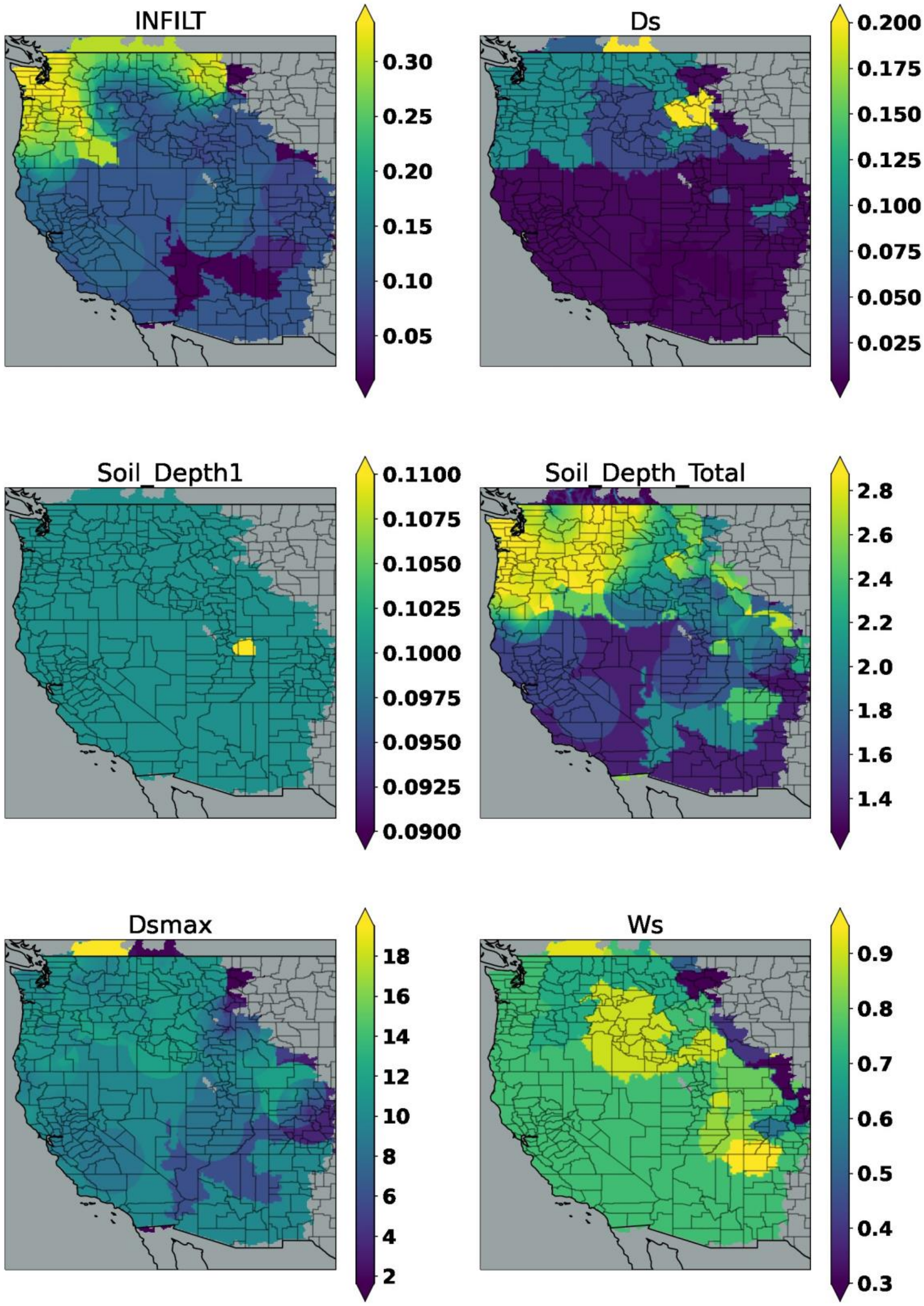



Figure S7. Baseline VIC land surface parameters over WUS.

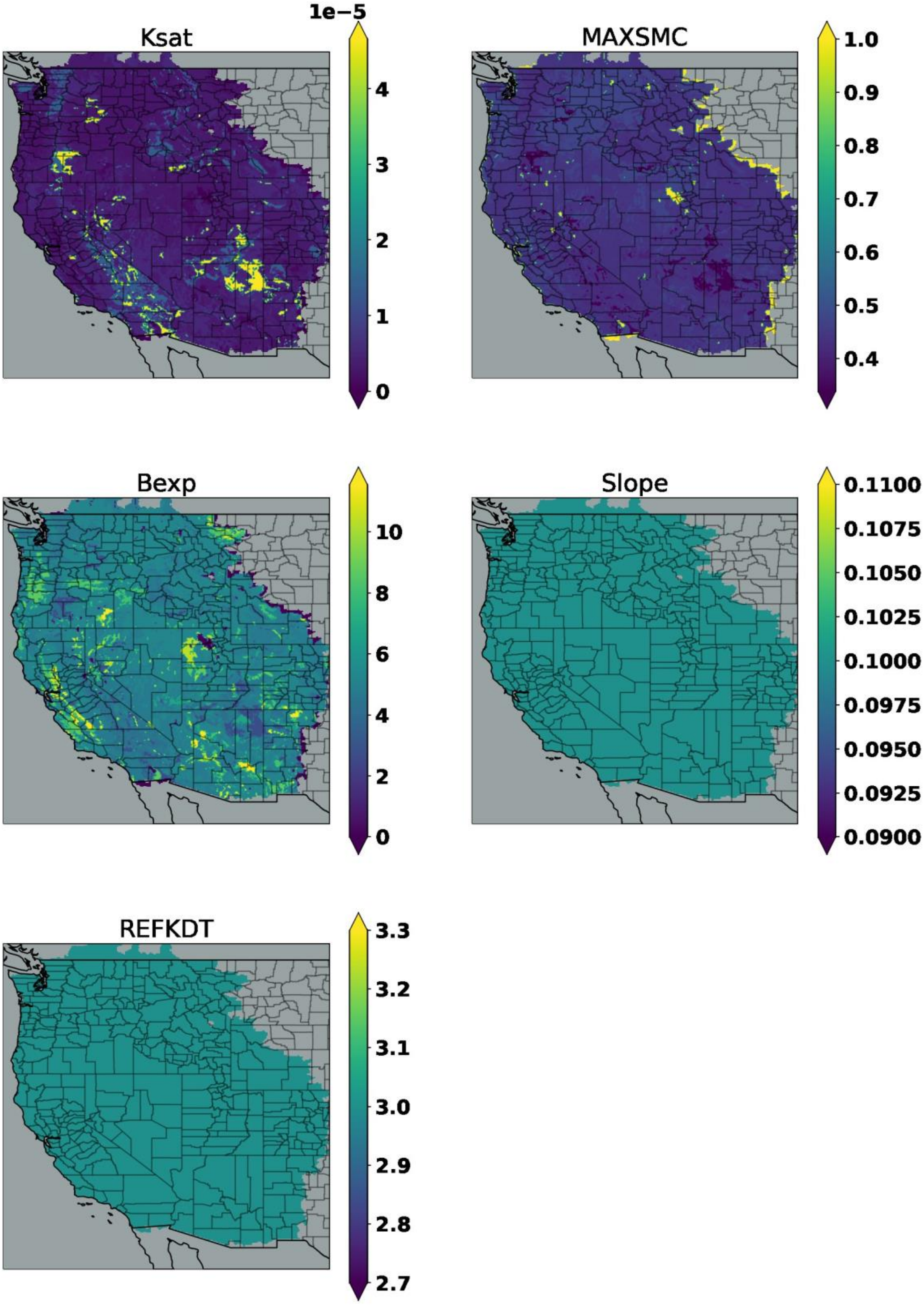



Figure S8. Baseline Noah-MP land surface parameters over WUS.

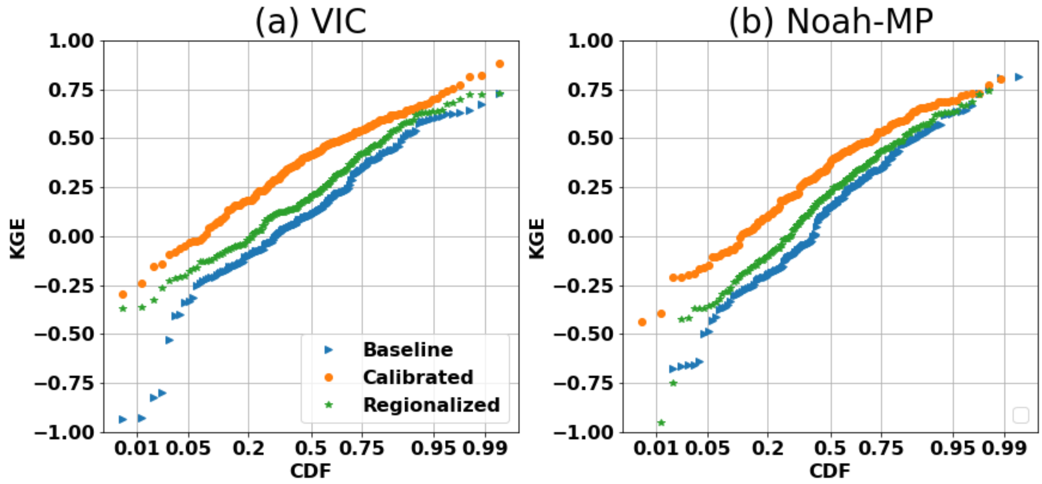



Figure S9. CDF of high flow KGE for (a) VIC and (b) Noah-MP, comparing baseline and calibrated runs across selected calibration catchments across the WUS.

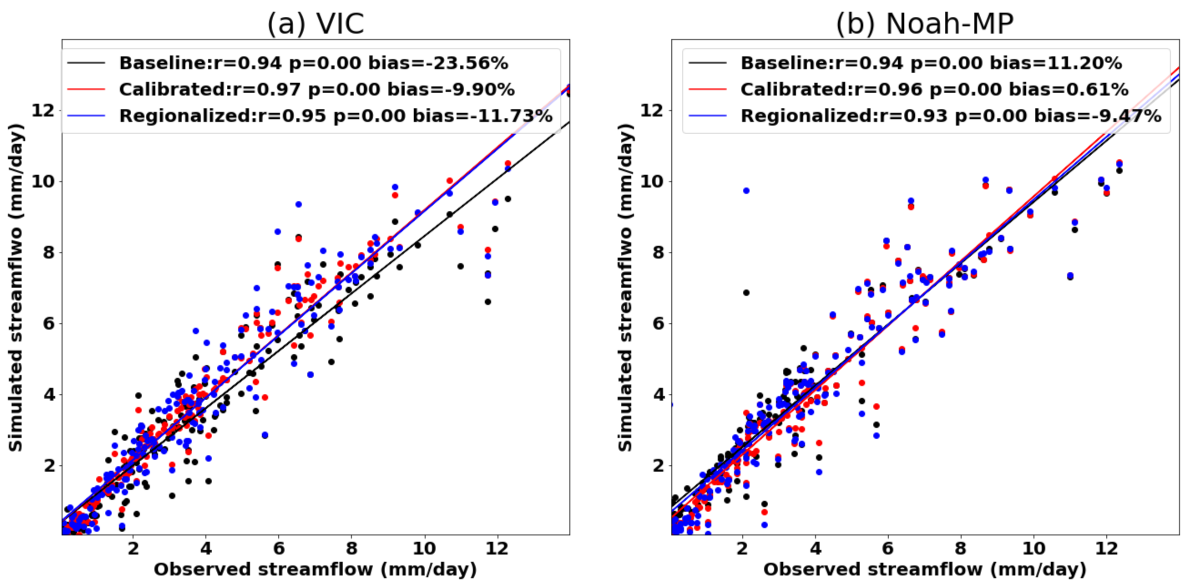



Figure S10. Scatterplot of 7q10 low flows (the lowest 7-day average flow that occurs (on average) once every 10 years) for the baseline and calibrated and regionalized runs for (a) VIC and (b) Noah-MP. The correlation coefficients, P-values and percentage bias are denoted in the upper section of the figures. The x axis is observed low flow and the y axis is simulated low flow.

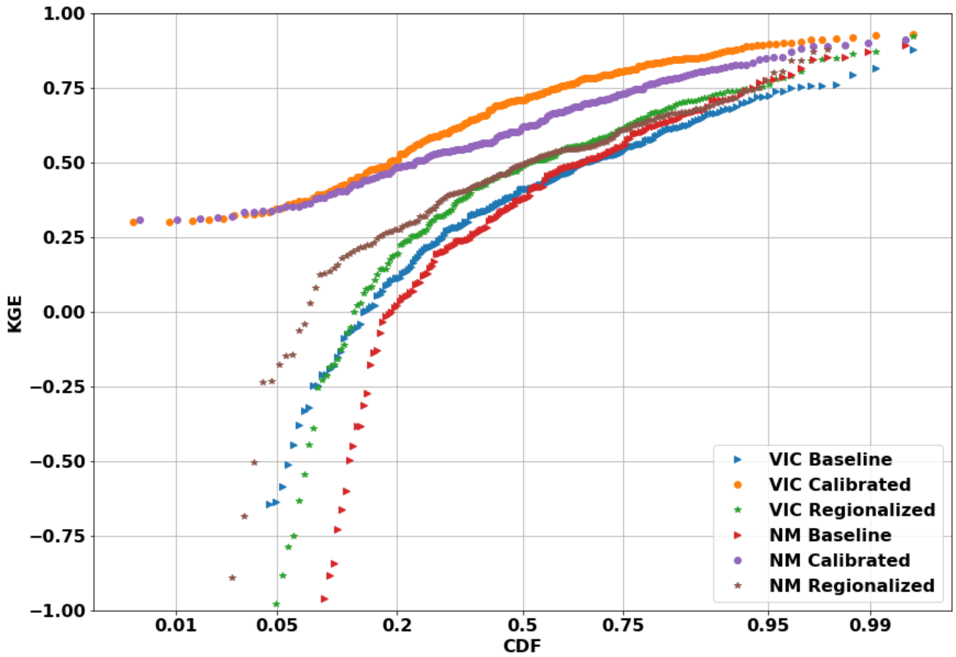



Figure S11. Same as S4 but with both VIC and Noah-MP shown in the same plot (note that KGE values less than -1.0 are truncated).

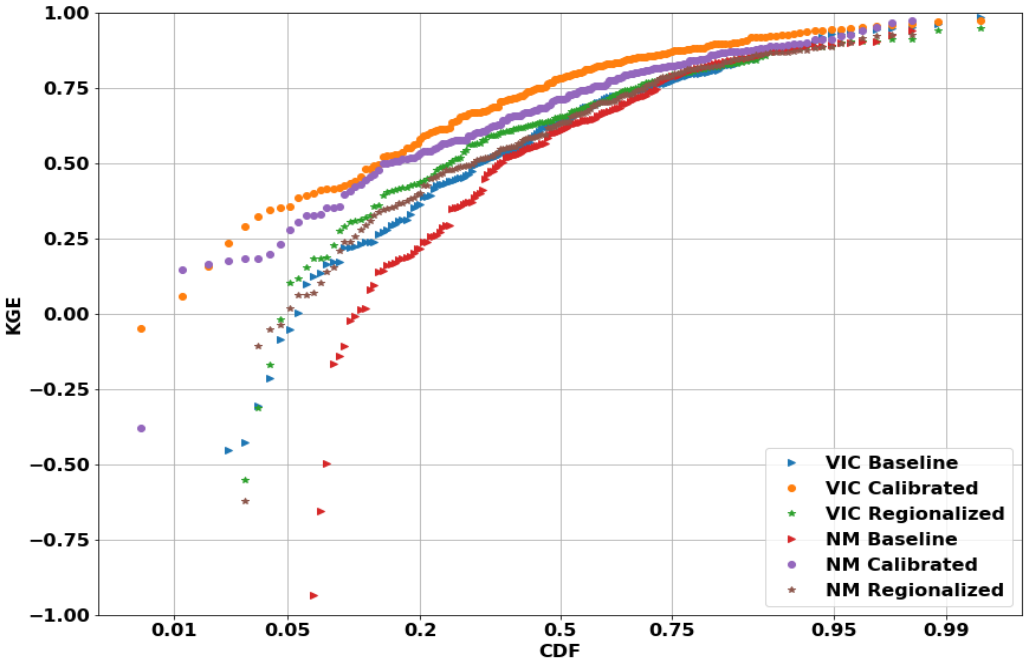



Figure S12. CDF of annual average streamflow KGE for VIC and Noah-MP, comparing baseline and calibrated runs across selected calibration catchments across the WUS (note that KGE values less than -1.0 are truncated).

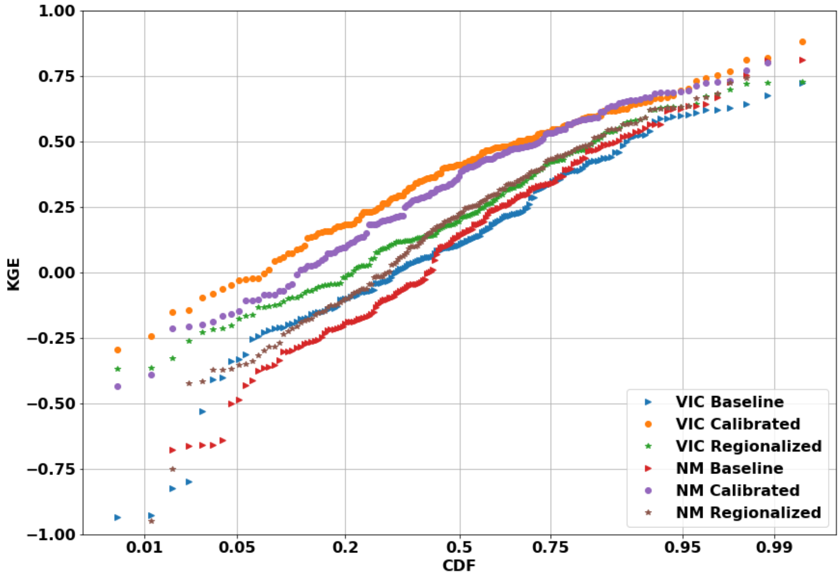



Figure S13. CDF of (POT3) flood KGE for VIC and Noah-MP, comparing baseline and calibrated runs across selected calibration catchments across the WUS.