Supplementary Materials

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Table S1: Number of accepted OHS sites (*n*=825) in each aquifer type [57] and aggregated ecoregion [34].

	Northeast	**Southeast Coastal Plain**	**East Highlands**	**Southeast Plains**	**Central Plains**	**Mixed Wood Shield**	**West Mountains**	**West Xeric**	**West Plains**
Other	72	5	20	13	53	20	129	19	40
Carbonate-Rock	6	8	26	7	4	1	0	1	0
Semi consolidated sand	0	16	0	59	0	0	0	0	2
Sandstone and carbonate-rock	9	0	48	4	5	0	5	0	7
Igneous and Metamorphic	0	0	23	39	0	0	15	6	0
Sandstone	3	0	35	6	13	5	13	5	22
Unconsolidated sand and gravel	0	18	0	1	0	0	30	5	7
TOTAL	**90**	**47**	**152**	**129**	**75**	**26**	**192**	**36**	**78**

Table S2: Number of sites used in the OHS and NHM-PRMS comparison (*n*=662) in each aquifer type [57] and aggregated ecoregion [34].

	Northeast	**Southeast Coastal Plain**	**East Highlands**	**Southeast Plains**	**Central Plains**	**Mixed Wood Shield**	**West Mountains**	**West Xeric**	**West Plains**
Other	59	3	17	11	45	16	106	7	36
Carbonate-Rock	6	3	21	7	4	1	0	1	0
Semi consolidated sand	0	11	0	46	0	0	0	0	1
Sandstone and carbonate-rock	8	0	44	3	4	0	5	0	7
Igneous and Metamorphic	0	0	19	33	0	0	13	2	0
Sandstone	2	0	32	6	11	4	8	4	19
Unconsolidated sand and gravel	0	9	0	1	0	0	19	2	6
TOTAL	75	26	133	107	64	21	151	16	69

Table S3: Minimum, maximum, and mean long-term average volumetric and percent contribution to total flow from OHS and NHM-PRMS on an annual (water year) and monthly time step.

Group	**Statistic**	**Annual m^3yr^{-1} (%)**	**Month m^3month^{-1} (%)**
OHS BF*	Minimum	2.8E+04 (0.7%)	2.2E+01 (2.4%)
GWF*		1.0E+03 (0%)	7.8E+01 (0.1%)
GWFSF*		1.0E+03 (0%)	7.8E+01 (0.1%)
observed streamflow		1.9E+05	1.4E+04
seg_outflow		6.3E+05	6.2E+04
OHS BF*	Maximum	7.2E+09 (99.0%)	6.0E+08 (98.9%)
GWF*		5.3E+09 (96.3%)	4.4E+08 (96.8%)
GWFSF*		7.6E+09 (99.9%)	6.3E+08 (194%)[+]
observed streamflow		7.5E+09	6.2E+09
seg_outflow		8.1E+09	6.8E+09
OHS BF*	Mean	1.6E+08 (62.2%)	1.4E+07 (68.1%)
GWF*		1.5E+08 (48.7%)	1.2E+07 (55.7%)
GWFSF*		2.1E+08 (66.6%)	1.8E+07 (67.1%)
observed streamflow		2.7E+08	2.3E+07
seg_outflow		3.0E+08	2.5E+07

*a percent contribution to total flow is included in parentheses

[+] Percent can be higher than 100% due to examining components that are derived from HRU-based volumes to routed segment-based volume (streamflow in NHM-PRMS). This can be enhanced as well by averaging over larger timesteps.

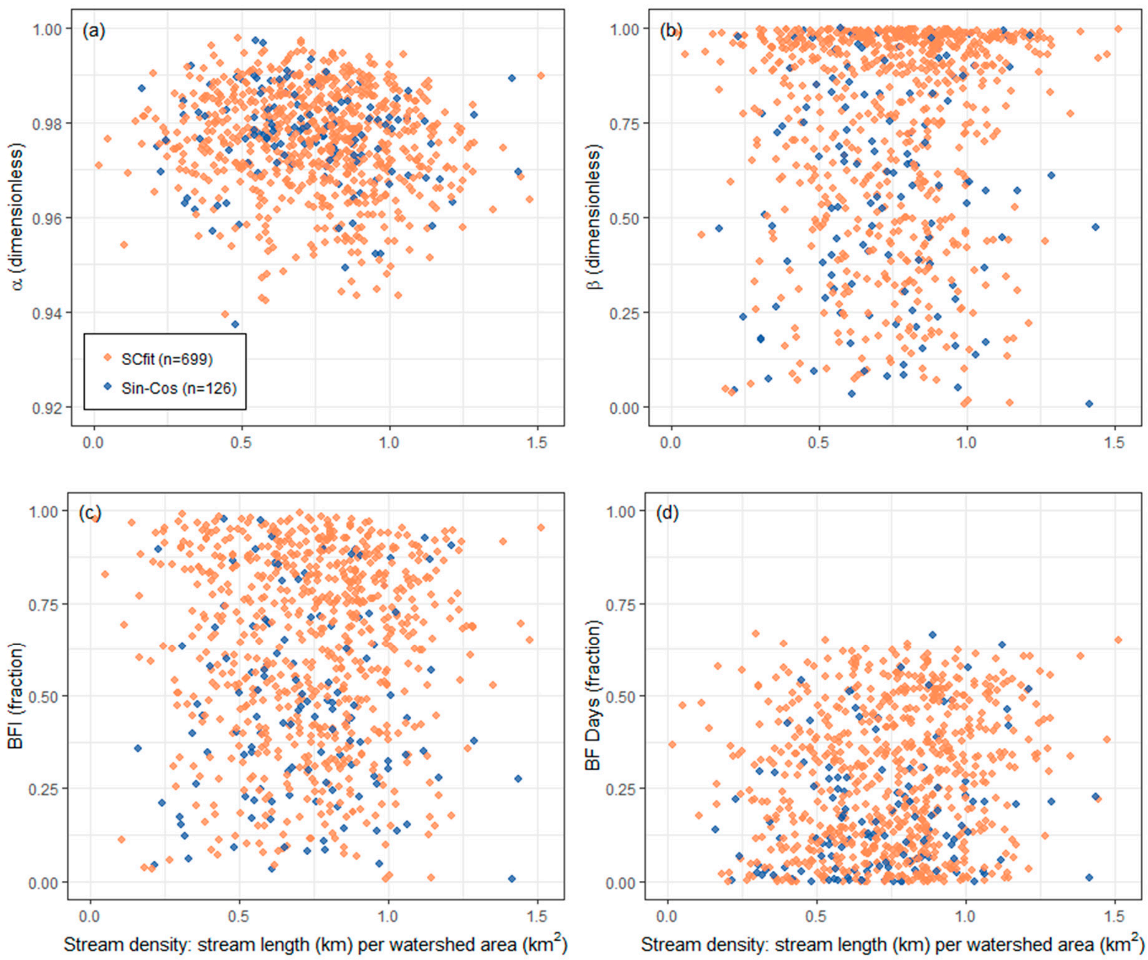

Figure S1: OHS model variables (**a**) α, (**b**) β, (**c**) BFI, and (**d**) BF Days are distributed without pattern among a range in watershed stream density of accepted GAGESII locations. Stream density is an attribute compiled in the GAGES-II dataset [34].

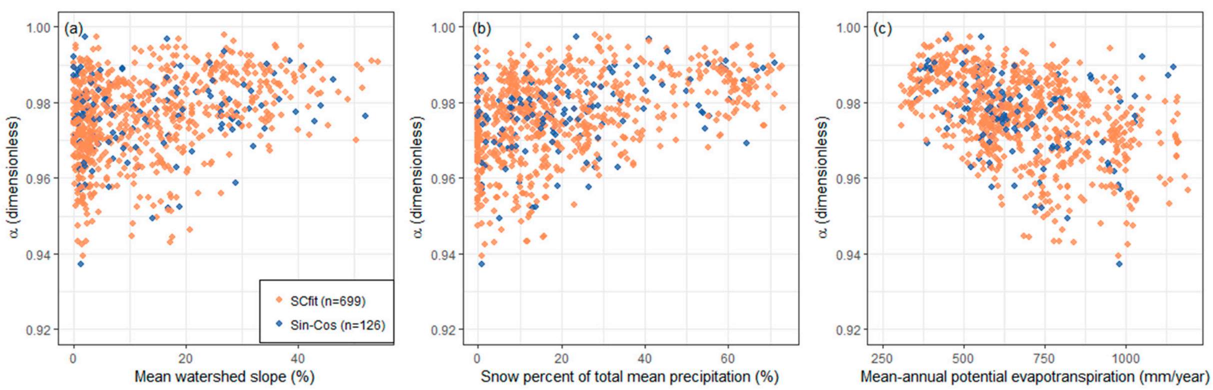

Figure S2: The range in α values decrease with increasing (a) mean watershed slope and (b) the snow percent of total of mean estimated precipitation within the watershed (period 1901-2000). However, the range in α values increase with increasing (c) mean-annual potential evapotranspiration in the watershed. These watershed characteristics were compiled in the GAGES-II dataset [34].

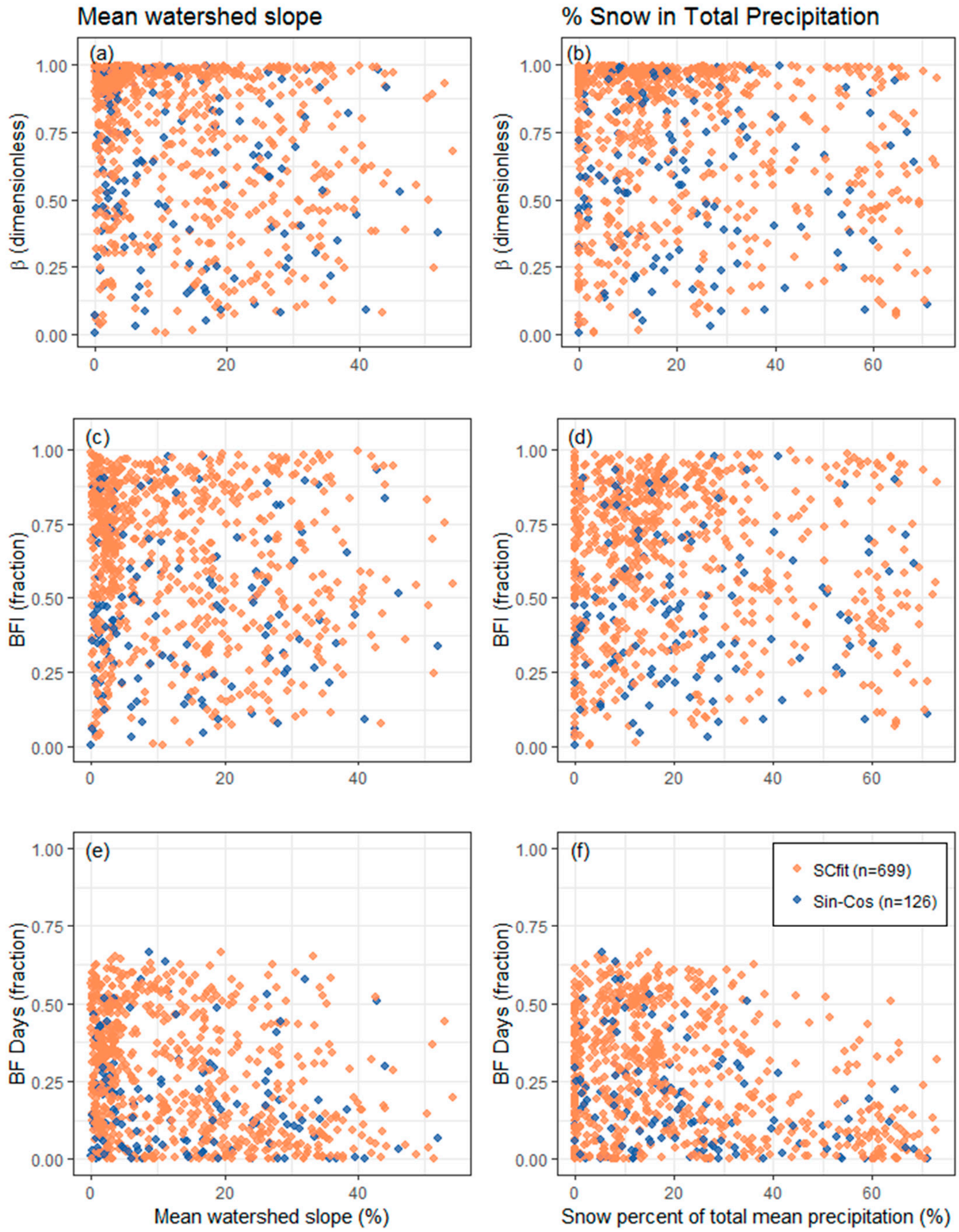

Figure S3: Ranges in mean watershed slope (column 1) and in the snow percent of total of mean estimated precipitation within the watershed - averaged period from 1901-2000 (column 2), had no influence on OHS accepted model variables of (**a,b**) β, (**c,d**) BFI, and (**e,f**) BF Days from either model type (*SCfit* or *sin-cos*). Although all sites have an average BF Days less than 0.7, there is a group of sites with an average BF Days less than 0.25 that also coincide with greater mean watershed slope and snow percent total of mean precipitation (**e, f**). These watershed characteristics were compiled in the GAGES-II dataset [34].

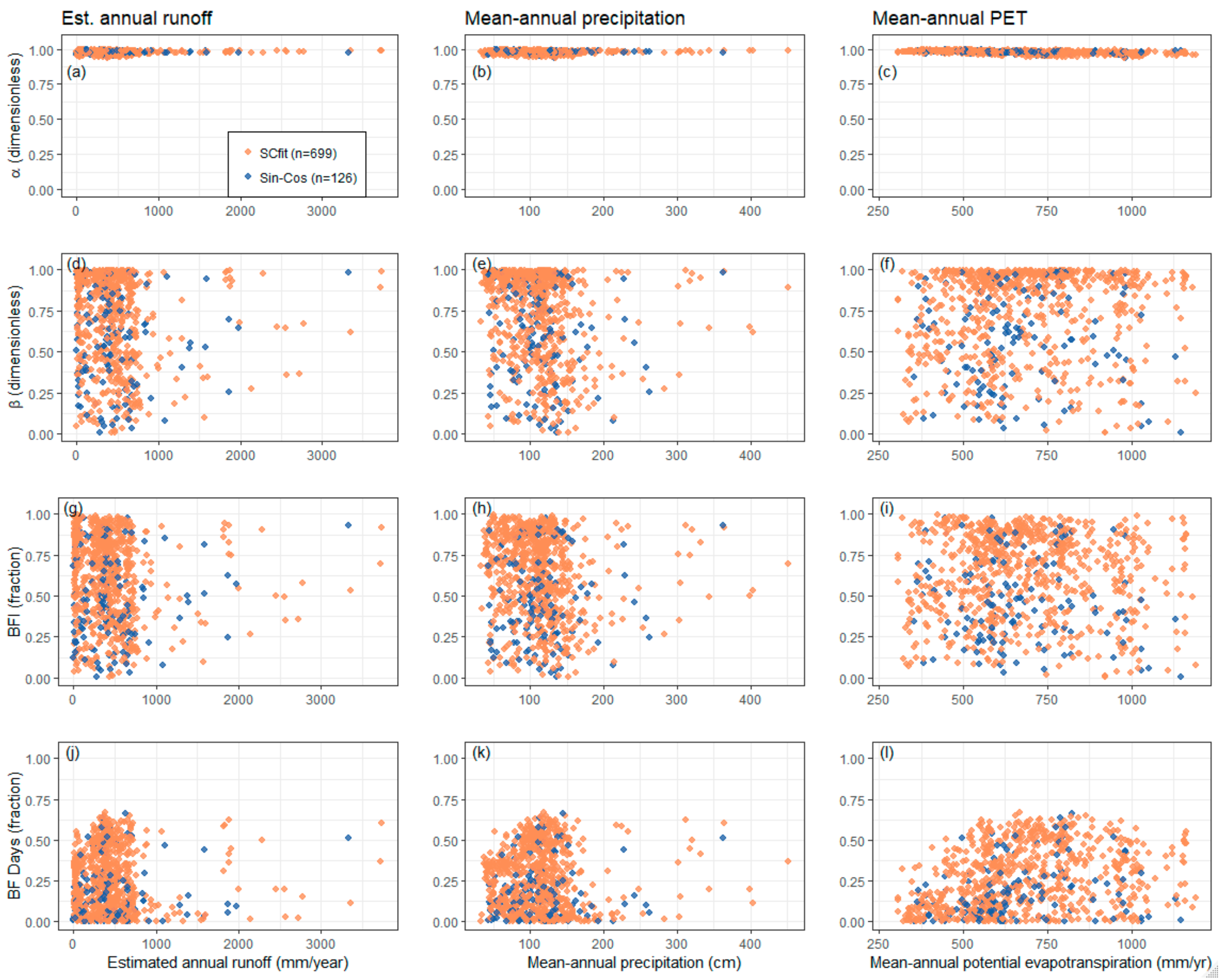

Figure S4: The estimated annual runoff (column 1), mean-annual precipitation (column 2), and the mean-annual potential evapotranspiration (column 3) had no influence on accepted OHS model parameters of (**a,b,c**) α, (**d,e,f**) β, (**g,h,i**) BFI, and (**j,k,l**) BF Days. These watershed climatological characteristics were compiled in the GAGES-II dataset [34]. α has a smaller range than β, BFI, and BF Days, but is shown on the same scale for comparison.

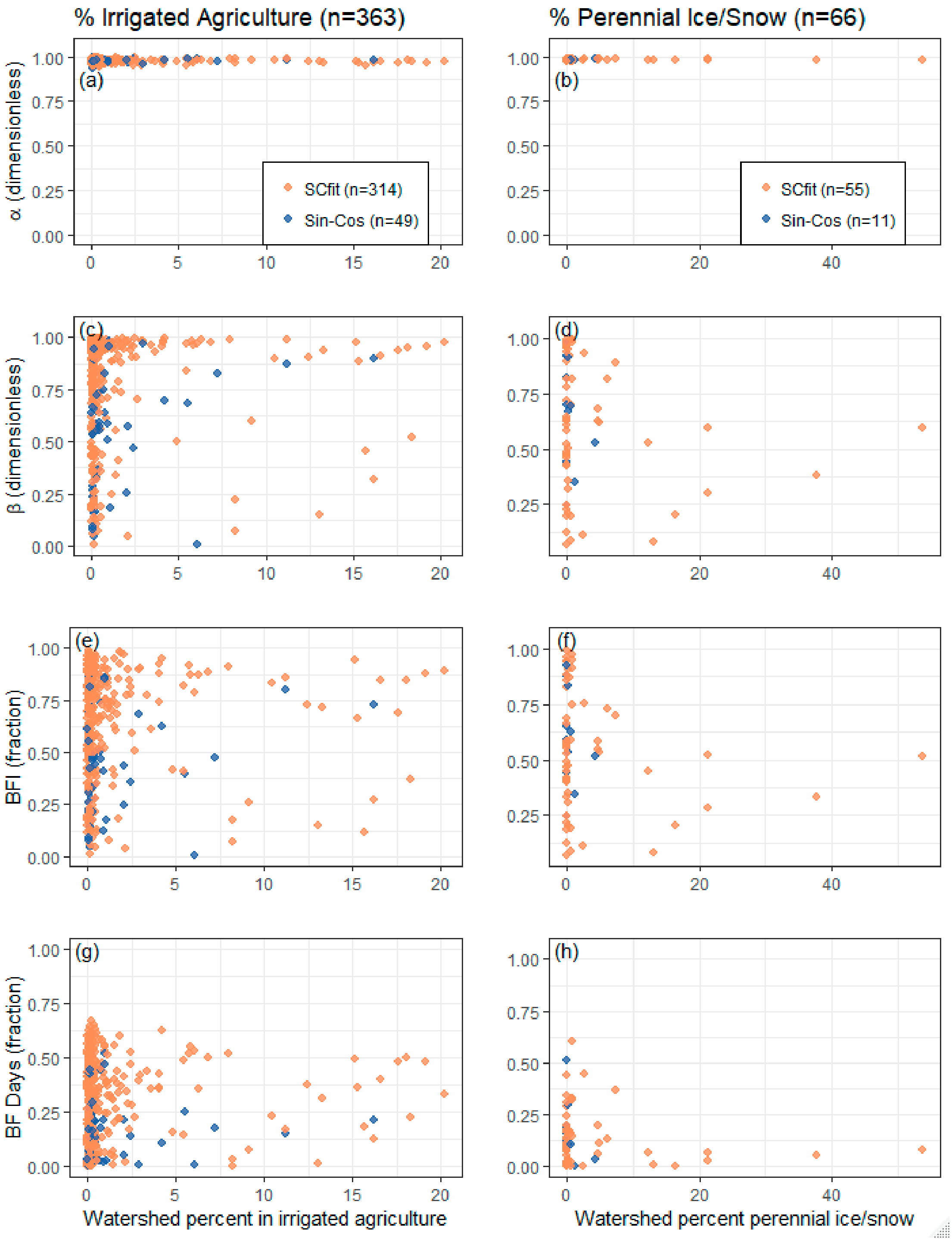

Figure S5: The percent of a watershed in irrigated agriculture (column 1) or comprised of perennial ice/snow (column 2) had little influence on accepted OHS model parameters (**a,b**) α, (**c,d**) β, (**e,f**) BFI, and (**g,h**) BF Days. Sites with no irrigated agriculture or perennial ice/snow coverage were removed from the plots for clarity. These land cover characteristics were compiled in the GAGES-II dataset [34]. α has a smaller range than β, BFI, and BF Days, but is shown on the same scale for comparison.

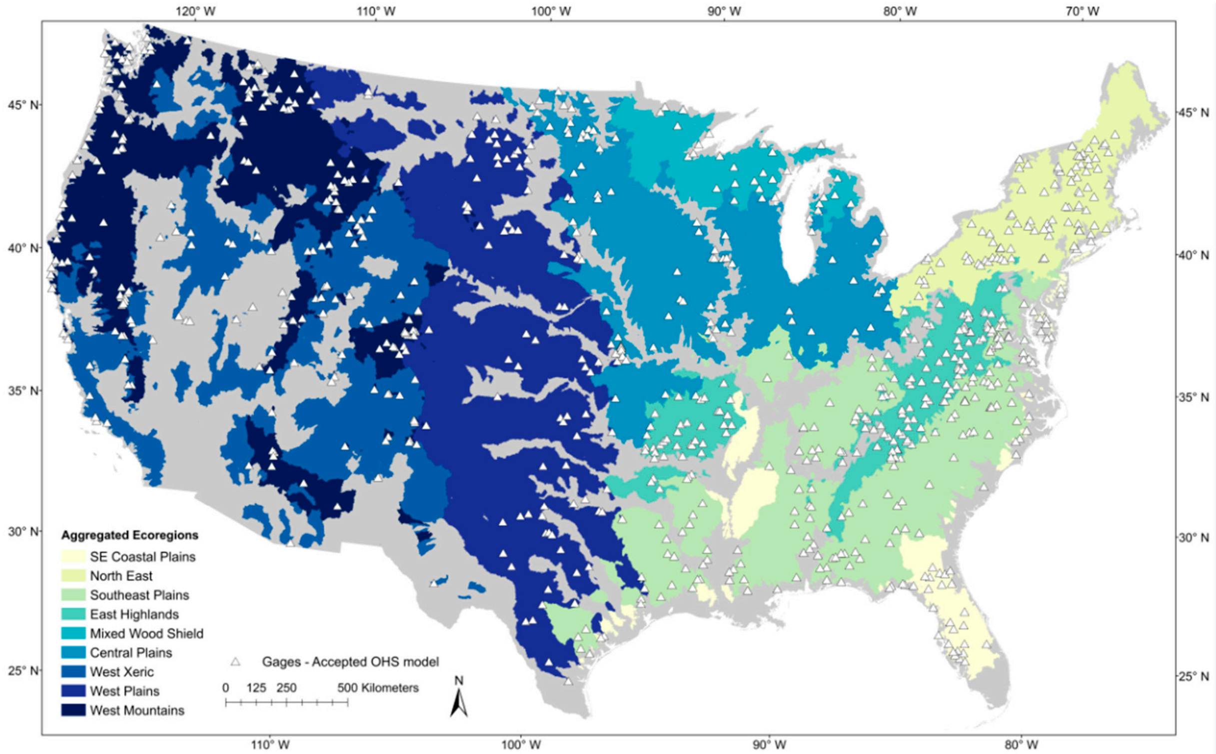

Figure S6: Reference and non-reference basins designated by aggregated ecoregion [34]. White triangles represent the GAGESII site locations where OHS worked. In some cases, the representation of the gage has hidden the outline of the drainage area (i.e. several sites in the Great Basin region). All accepted models were associated with an aggregated ecoregion.

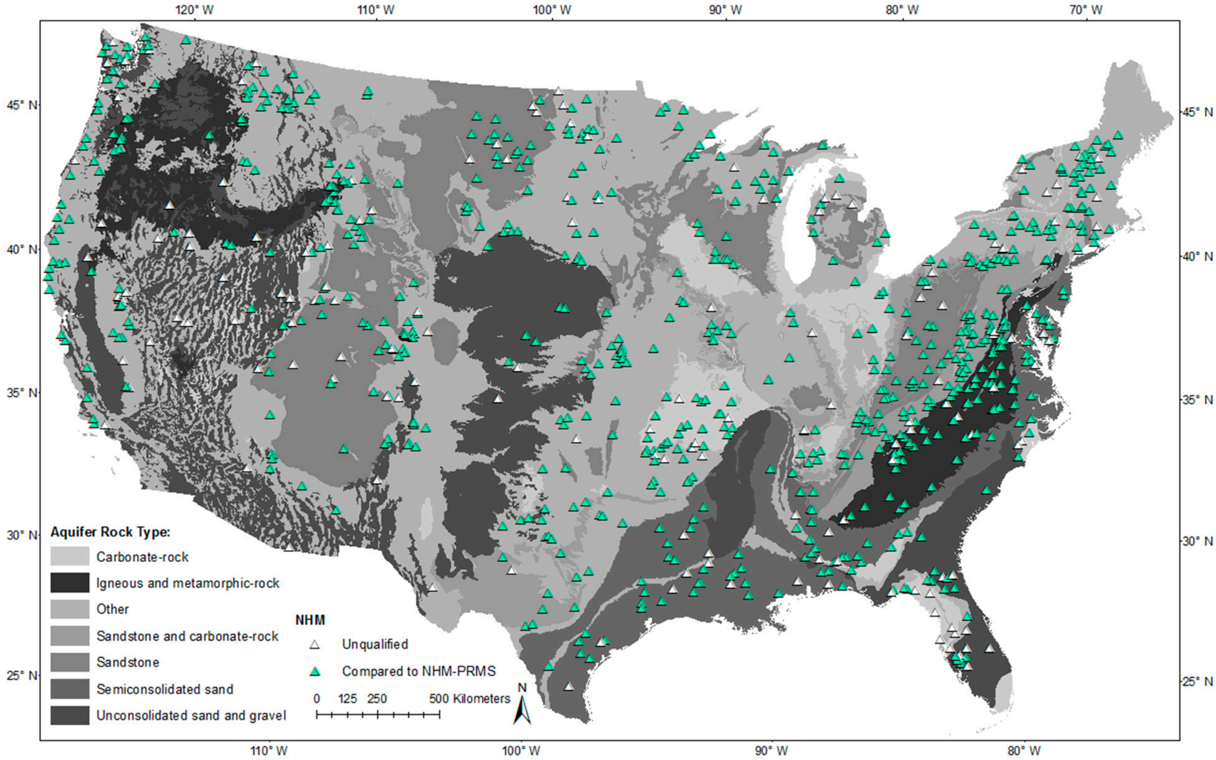

Figure S7: Of the sites with acceptable OHS models, most met the criteria to be compared to the NHM-PRMS output (green triangles; n = 662). However, several sites did not meet the criteria (white triangles). Given this removal of sites, there is still spatial coverage over the US.

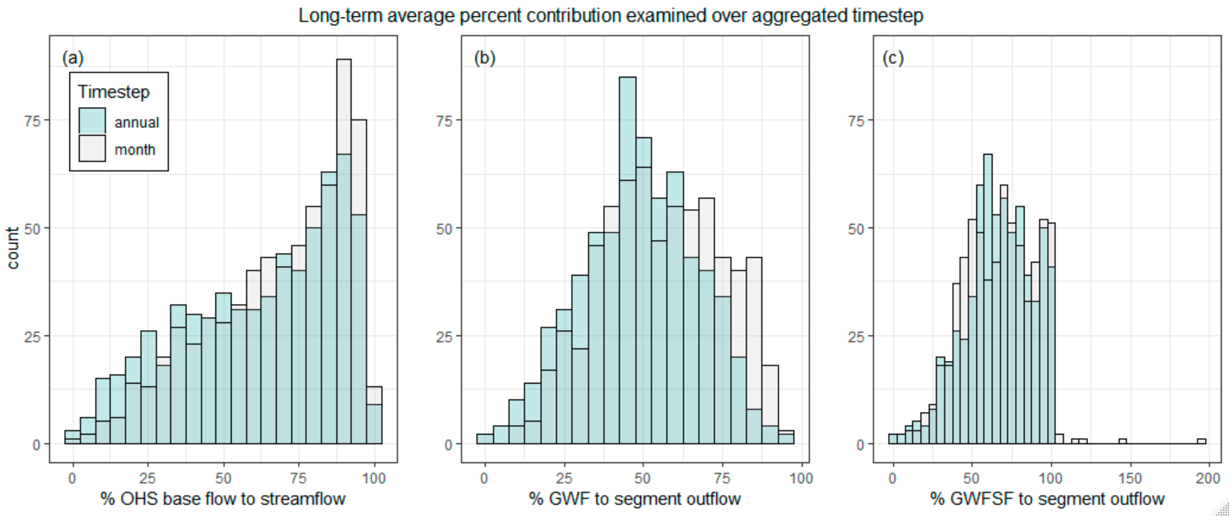

Figure S8: Long-term average percent contributions of (**a**) OHS-derived baseflow to streamflow, (**b**) percent contribution of GWF to *seg_outflow*, and (**c**) percent contribution of GWFSF to *seg_outflow*, identified by aggregated timestep. The 662 sites that had accepted OHS models and were compared to the NHM-PRMS (Figure S7) are displayed for each timestep, within each panel. There is little difference between the distributions produced by different timesteps. Units are in percent.

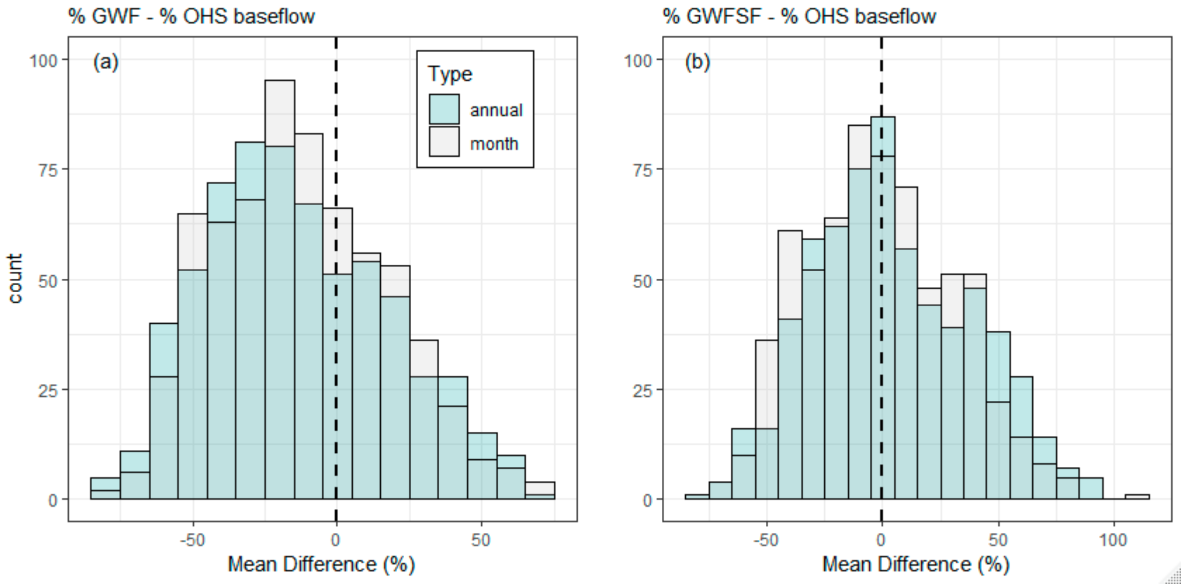

Figure S9: Distributions of the mean difference between the percent contribution of OHS-derived baseflow to streamflow versus the percent contribution of GWF to *seg_outflow* **(a)** and the percent contribution of OHS-derived baseflow to streamflow versus the percent contribution of GWFSF to *seg_outflow* (**b**) over different timesteps. The 662 sites that had accepted OHS models and were compared to the NHM-PRMS (Figure S7) are displayed for each timestep, within each panel. There is little difference between the distributions produced by different timesteps.

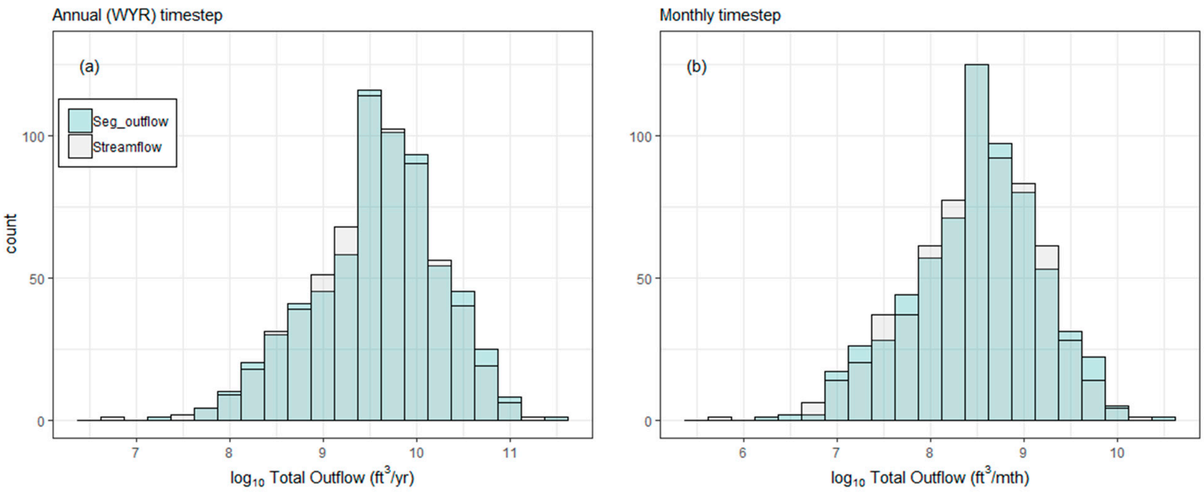

Figure S10: Distributions of long-term average volumetric flows from streamflow and *seg_outflow* on an annual (**a**) and monthly (**b**) timestep. The 662 sites that had accepted OHS models and were compared to the NHM-PRMS (Figure S7) are displayed for each timestep, within each panel. There is little to no difference between the streamflow and *seg_outflow* volumetric distributions.

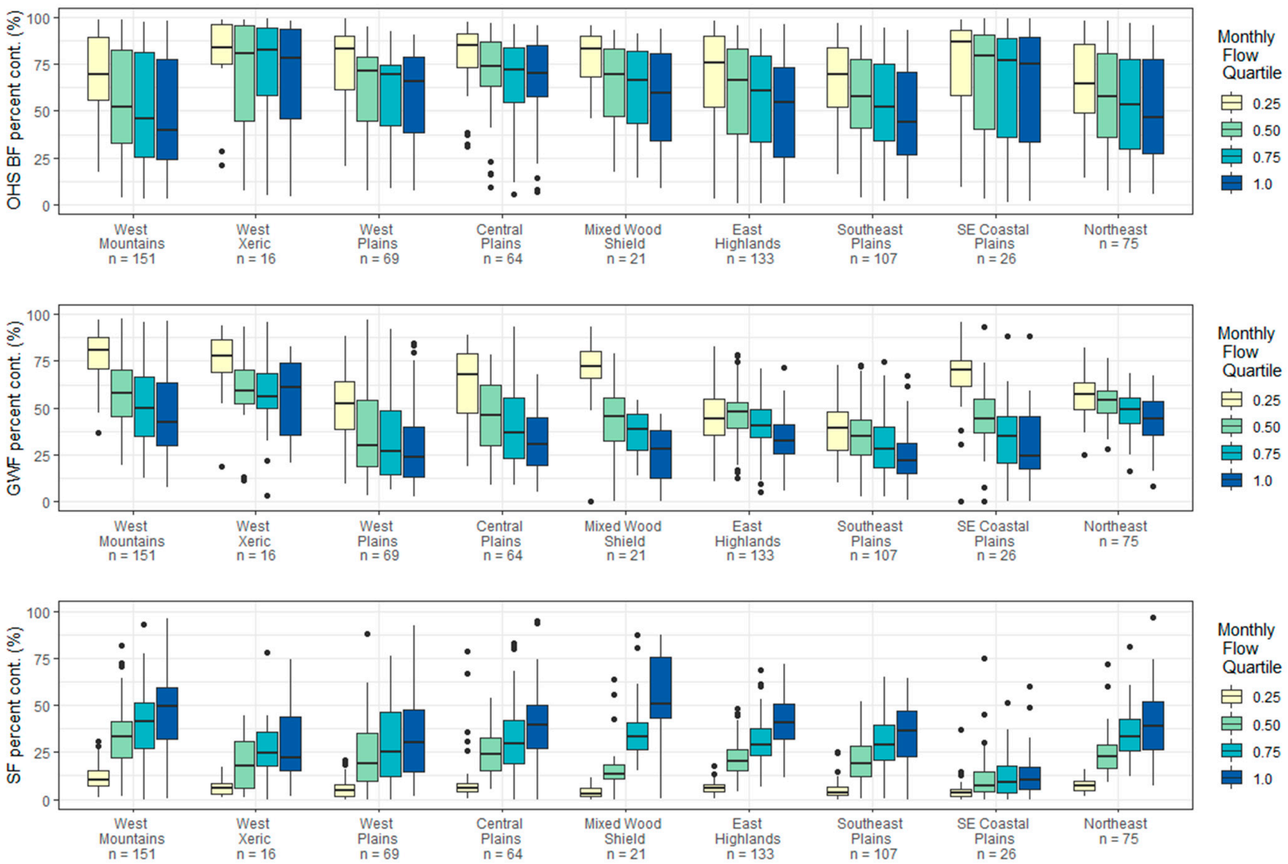

Figure S11: OHS base flow, GWF, and SF average monthly percent contribution to total flow over normalized monthly flow quartiles for sites compared with NHM-PRMS (n = 662) corresponding to aggregated ecoregions [34].

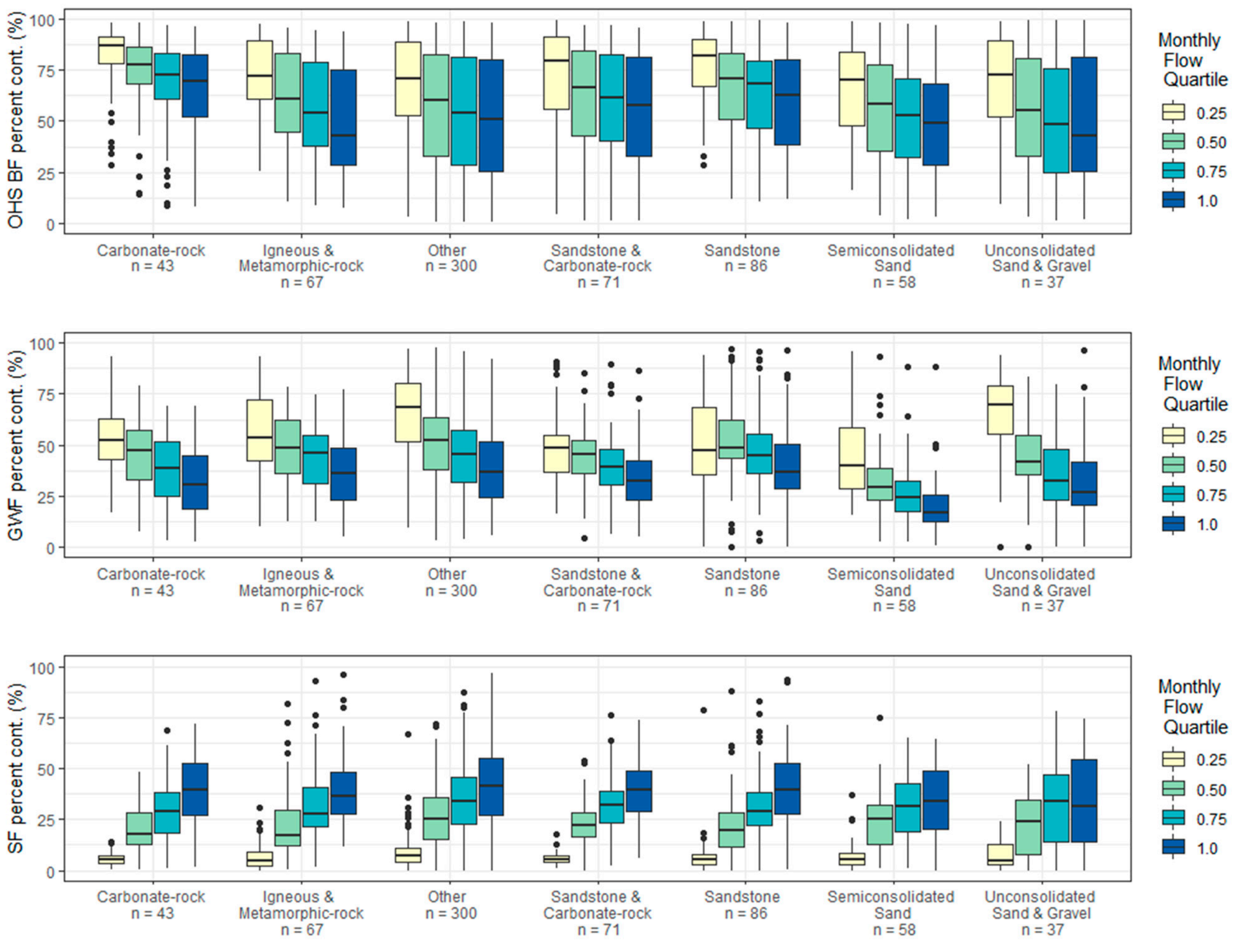

Figure S12: OHS base flow, GWF, and SF average monthly percent contribution to total flow over normalized monthly flow quartiles for sites compared with NHM-PRMS (n = 662) corresponding to aquifer rock types [57].

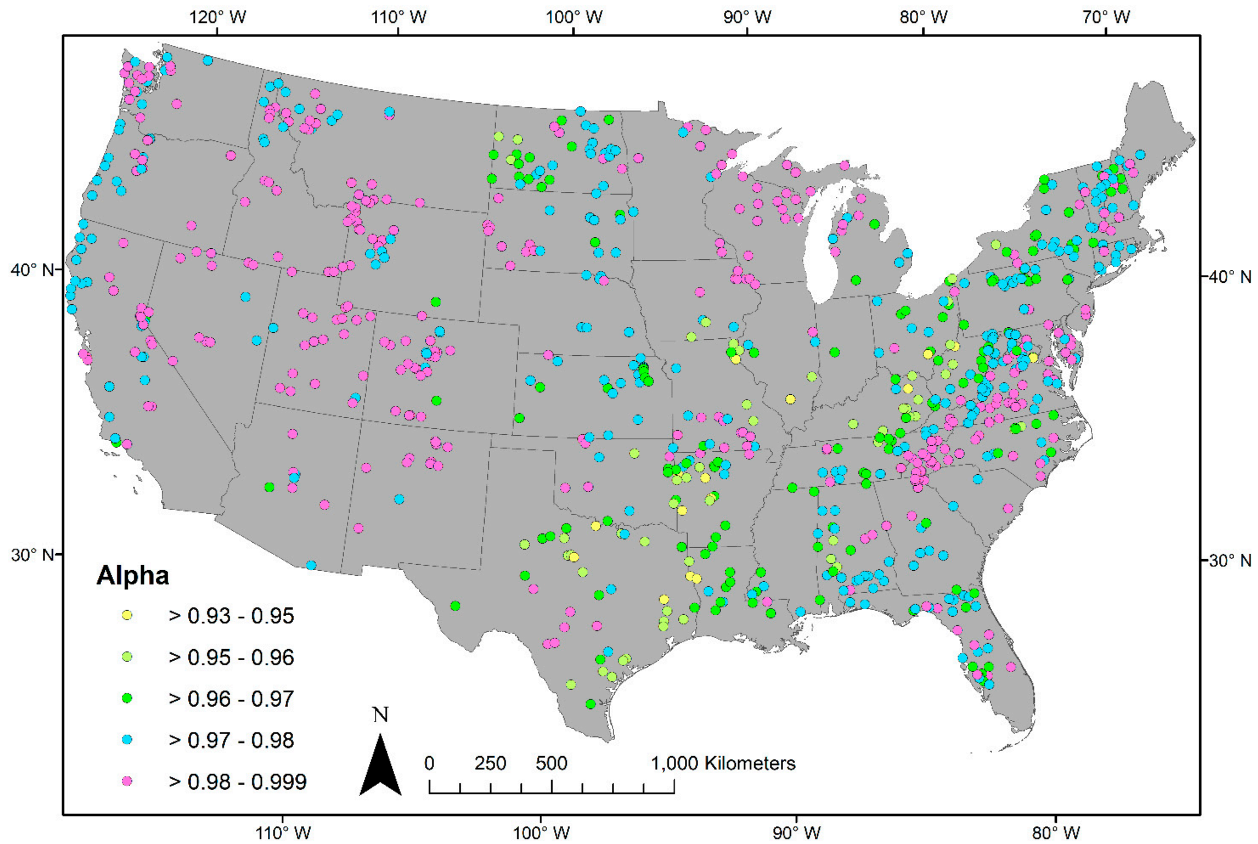

Figure S13: Spatial distribution of α from accepted OHS models (n = 825). The western US has generally greater α than the Midwestern US and east coast. The α parameter was derived from the NHM-PRMS coefficient, *gwflow_coef*, which was developed based on a regression [13,14].

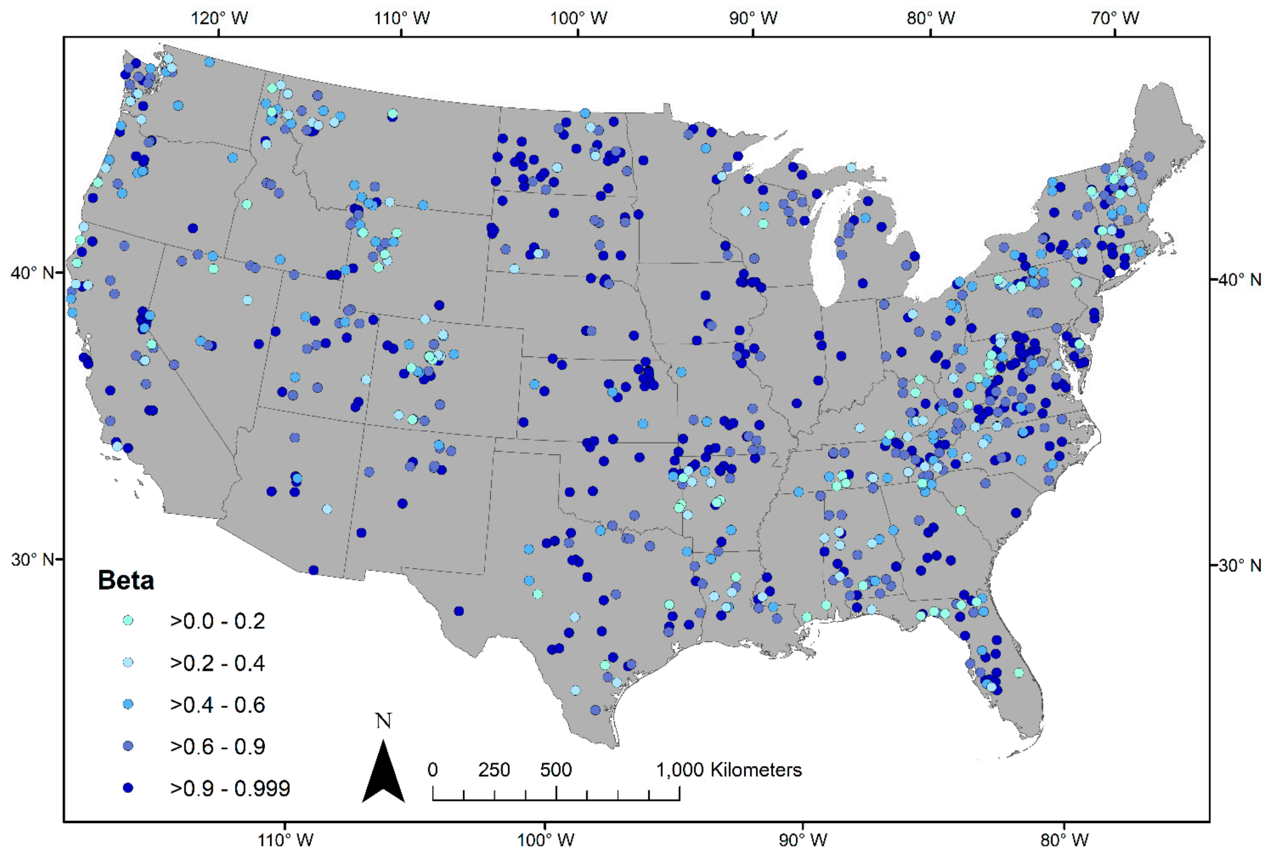

Figure S14: Spatial distribution of β from accepted OHS models (n = 825). Values of β are distributed well across the conterminous US. There are generally greater values in the upper Midwestern US, however the east coast and west coast contained mixed values.