

Multiple indicators of extreme changes in snow-dominated streamflow regimes, Yakima River basin region, USA

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Table S1. Characteristics for the 22 automated SNOTEL stations from Natural Resources Conservation Service, including SNOTEL site name and number, latitude, longitude, elevation, and basin location.

Site Name	Latitude	Longitude	Elevation (m)	Location (Basin)
Fish Lake (478)	47.54	-121.09	1,045	Yakima
Pope Ridge (699)	47.99	-120.57	1,094	Upper Columbia
Stampede Pass (788)	47.27	-121.34	1,173	Yakima
Stevens Pass (791)	47.75	-121.09	1,204	Upper Columbia
Olallie Meadows (672)	47.37	-121.44	1,228	Yakima
Blewett Pass (352)	47.35	-120.68	1,292	Upper Columbia
Thunder Basin (817)	48.53	-120.99	1,317	Puget Sound
Upper Wheeler (841)	47.29	-120.37	1,320	Upper Columbia
Sasse Ridge (734)	47.38	-121.06	1,323	Yakima
White Pass E.S. (863)	46.64	-121.38	1,353	Yakima
Park Creek Ridge (681)	48.44	-120.92	1,402	Upper Columbia
Bumping Ridge (375)	46.81	-121.33	1,405	Yakima
Rainy Pass (711)	48.52	-120.74	1,490	Puget Sound
Lost Horse (599)	46.36	-121.08	1,561	Yakima
Grouse Camp (507)	47.28	-120.49	1,643	Yakima
Morse Lake (642)	46.91	-121.48	1,649	Yakima
Trough (832)	47.23	-120.29	1,670	Upper Columbia
Corral Pass (418)	47.02	-121.46	1,768	Puget Sound
Pigtail Peak (692)	46.62	-121.39	1,768	Yakima
Green Lake (502)	46.55	-121.17	1,804	Yakima
Lyman Lake (606)	48.20	-120.92	1,823	Upper Columbia
Harts Pass (515)	48.72	-120.66	1,978	Upper Columbia

Table S2. Characteristics for the eight Washington state streamflow gages and sites analyzed in this study. Site name and abbreviated description, USGS ID, latitude, longitude, basin area, elevation of USGS gage, and basin location.

Site Name (Short Name)	USGS ID	Latitude	Longitude	Area (km ²)	Elevation (m)	Location
American River Near Nile (AMRW)	12488500	46.98	-121.17	79	823	Yakima River
Yakima River at Cle Elum (YUMW)	12479500	47.19	-120.95	502	580	Yakima River
Yakima River at Umtanum (UMTW)	12484500	46.86	-120.48	1,594	396	Yakima River
Tieton River at Canal Headworks near Naches (TIECH)	12492500	46.67	-121.00	239	695	Yakima River
Yakima River near Parker (PARW)	12505000	46.50	-120.44	188	270	Yakima River

Site Name (Short Name)	USGS ID	Latitude	Longitude	Area (km ²)	Elevation (m)	Location
Wenatchee River near Plain (WENPL)	12457000	47.76	-120.67	591	550	Wenatchee River
Stehekin River at Stehekin (STEHE)	12451000	48.33	-120.69	321	335	Stehekin River
Methow River at Twisp (METTW)	12449500	48.37	-120.12	1,301	482	Methow River

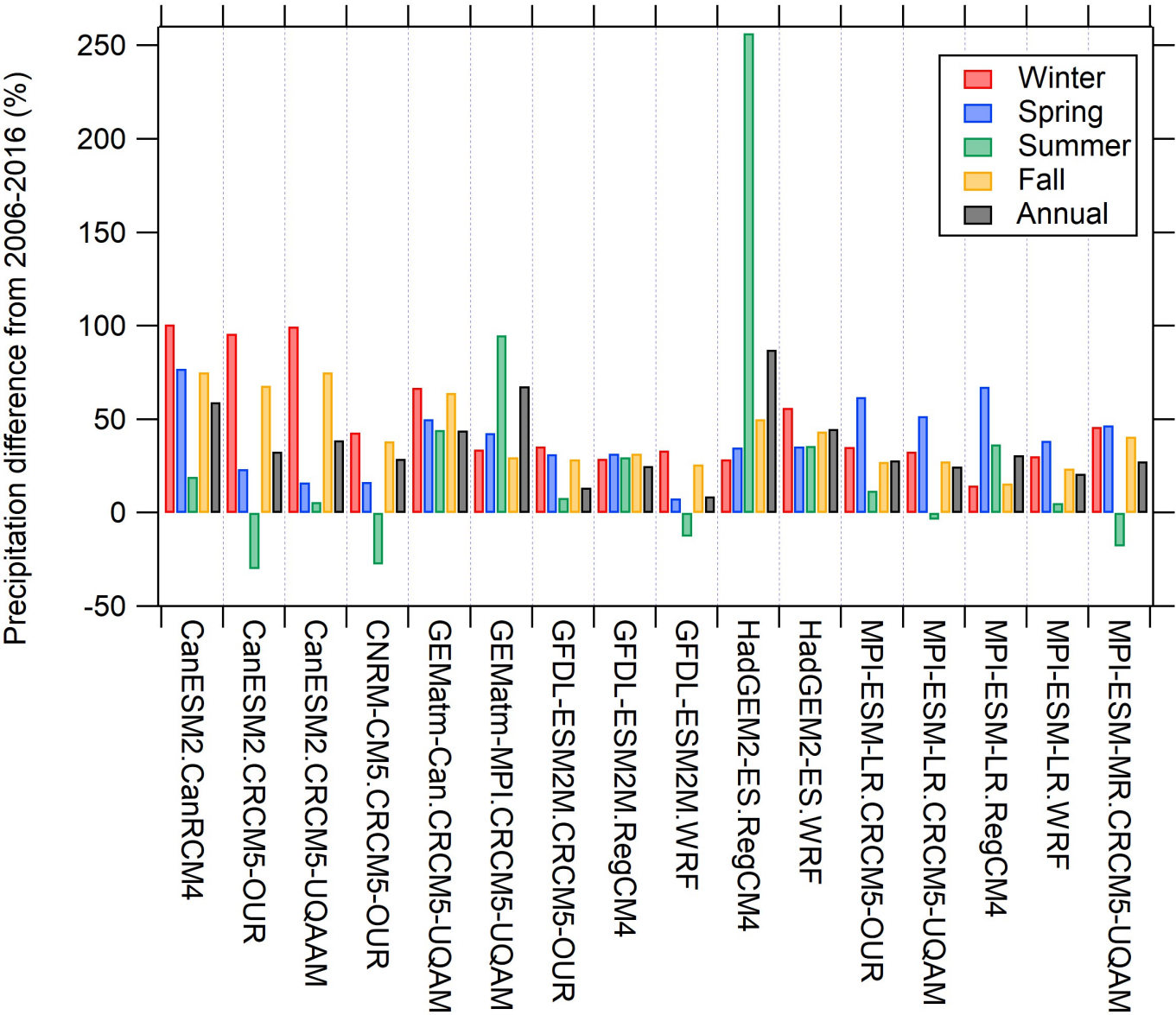


Figure S1. Precipitation comparison between 2006-2016 (current/historical) and 2070-2099 (future) for the CORDEX RCP 8.5 models that support the selection of our two future models. The CanESM2.CanRCM4 model shows the wettest winter and spring for the current climate compared to future projections and the GFDL-ESM2M.WRF model is the driest (winter and spring) in comparison to the future climate.

Trends in weekly, seasonal, and annual streamflow

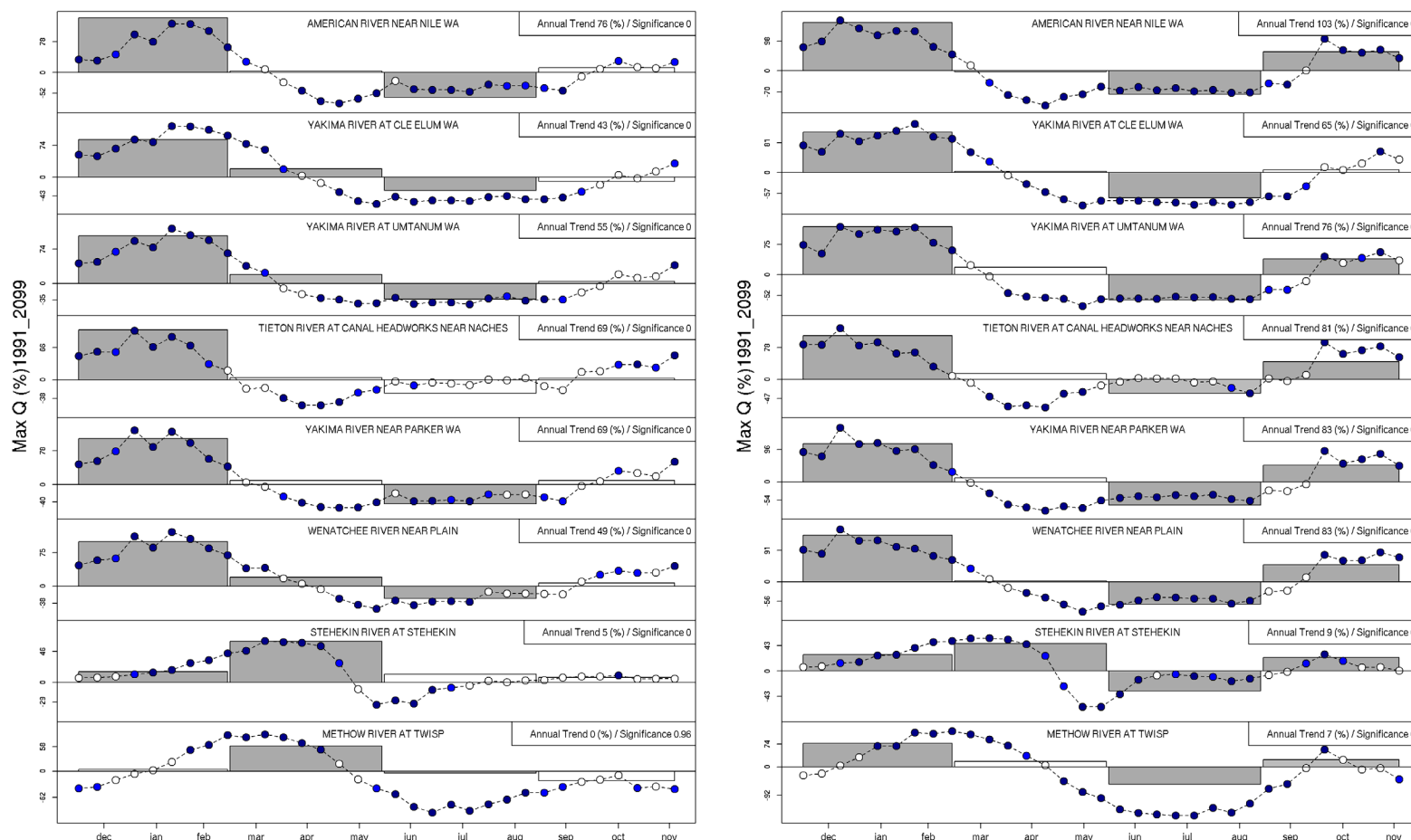


Figure S2. Left, GFDL-ESM2M for 1991-2099 maximum streamflow. Right, CanESM2 for 1991-2099 maximum streamflow. Darker shades of blue represent p-values ≤ 0.01 , while lighter shades of blue represent p-values ≤ 0.05 for statistical significance.

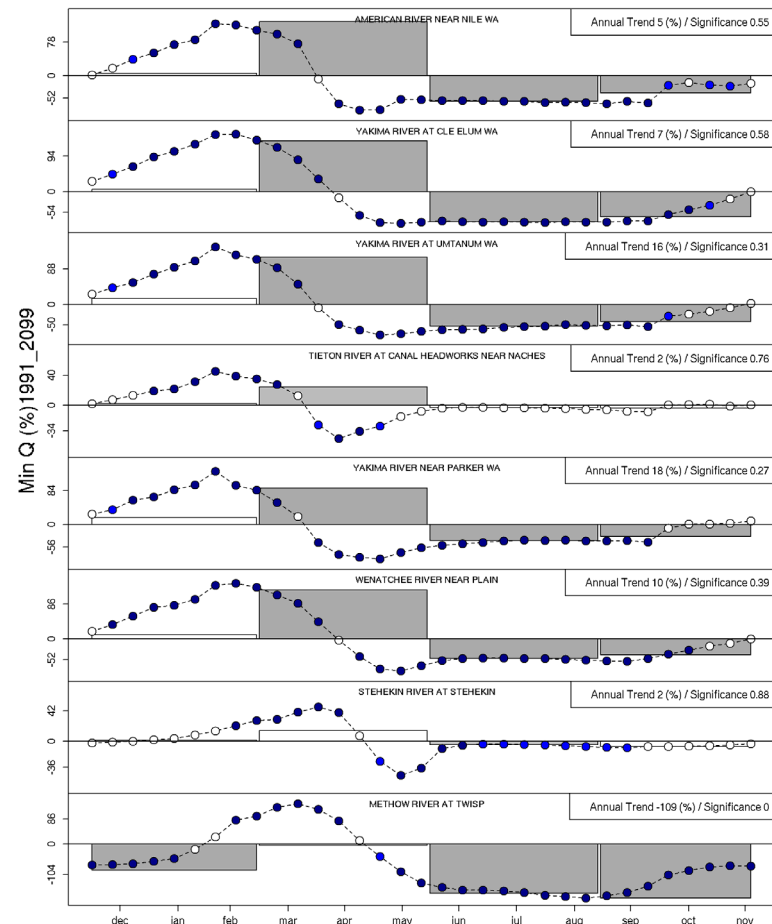
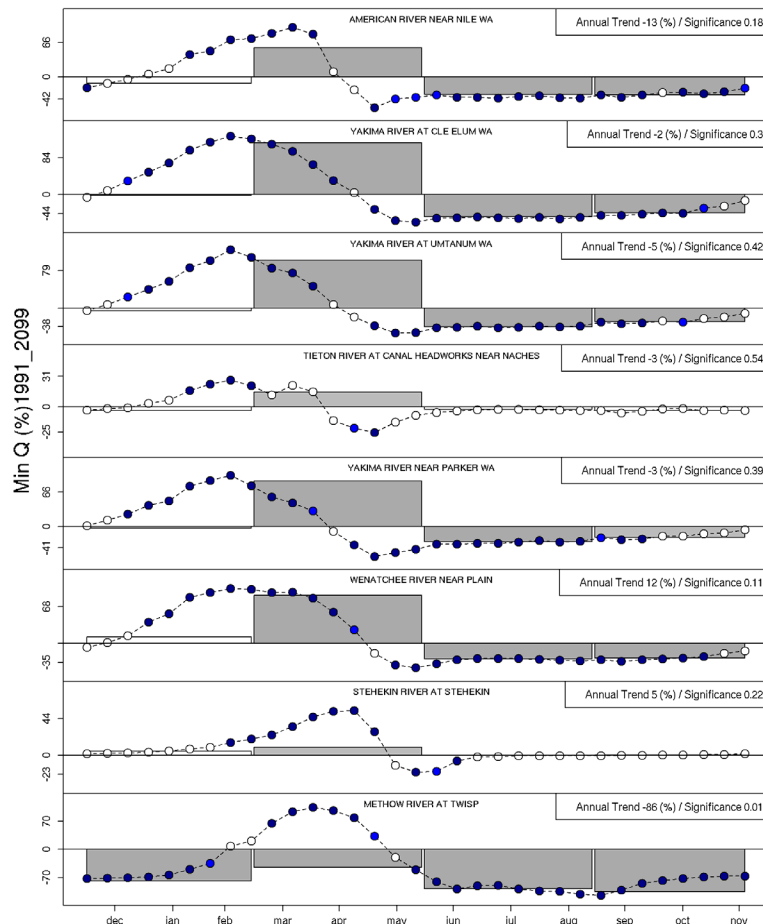


Figure S3. Left, GFDL-ESM2M for 1991-2099 minimum streamflow trends. Right, CanESM2 for 1991-2099 minimum streamflow trends. Darker shades of blue represent p-values ≤ 0.01 , while lighter shades of blue represent p-values ≤ 0.05 for statistical significance.

Table S3. Seasonal and annual trends for minimum and maximum streamflow (m3/s) for 1991-2099 for GFDL-ES2M. Trends are values occurring over the 109 year time period. Bold values indicate significant trends (p-value <= 0.05).

GFDL-ESM2M Streamflow Maximum	DJF	MAM	JJA	SON	YR
American River Near Nile (AMRW)	138.8	3.8	-63.8	12.5	75.8
Yakima River at Cle Elum (YUMW)	86.7	19.3	-31.0	-10.1	43.3
Yakima River at Umtanum (UMTW)	102.8	19.0	-33.5	4.7	55.4
Tieton River at Canal Headworks near Naches (TIECH)	102.0	4.5	-27.9	2.7	68.6
Yakima River near Parker (PARW)	106.4	9.2	-44.9	9.5	68.8
Wenatchee River near Plain (WENPL)	99.0	20.0	-27.6	6.7	49.4
Stehekin River at Stehekin (STEHE)	15.9	60.9	12.0	7.2	4.7
Methow River at Twisp (METTW)	4.4	59.5	-4.8	-22.6	0.3
GFDL-ESM2M Streamflow Minimum					
American River Near Nile (AMRW)	-12.2	56.7	-33.6	-34.0	-12.6
Yakima River at Cle Elum (YUMW)	-2.2	118.1	-51.0	-42.5	-2.3
Yakima River at Umtanum (UMTW)	-5.3	100.8	-39.3	-28.4	-5.5
Tieton River at Canal Headworks near Naches (TIECH)	-3.4	15.0	-2.3	-3.5	-3.4
Yakima River near Parker (PARW)	-3.2	87.7	-29.4	-21.0	-3.2
Wenatchee River near Plain (WENPL)	11.7	88.5	-28.5	-26.9	12.0
Stehekin River at Stehekin (STEHE)	4.5	9.4	-0.3	0.5	4.6
Methow River at Twisp (METTW)	-78.2	-44.6	-98.1	-105.4	-85.6
CanESM2 Streamflow Maximum					
American River Near Nile (AMRW)	159.1	-3.7	-78.0	62.3	103.0
Yakima River at Cle Elum (YUMW)	109.8	3.2	-69.0	7.5	65.2
Yakima River at Umtanum (UMTW)	119.2	18.3	-63.0	39.3	76.4
Tieton River at Canal Headworks near Naches (TIECH)	107.9	13.8	-34.1	43.4	80.7
Yakima River near Parker (PARW)	113.1	11.7	-68.5	49.6	82.9
Wenatchee River near Plain (WENPL)	134.8	3.1	-64.8	49.0	82.7
Stehekin River at Stehekin (STEHE)	27.9	46.9	-33.9	22.7	9.3
Methow River at Twisp (METTW)	76.8	17.4	-56.5	23.6	6.7
CanESM2 Streamflow Minimum					
American River Near Nile (AMRW)	5.4	126.1	-59.9	-40.0	5.5
Yakima River at Cle Elum (YUMW)	6.0	133.7	-79.2	-66.8	6.7
Yakima River at Umtanum (UMTW)	14.7	116.9	-53.2	-42.6	15.7
Tieton River at Canal Headworks near Naches (TIECH)	2.1	24.5	-3.5	-3.7	2.1
Yakima River near Parker (PARW)	16.9	89.8	-39.8	-29.6	17.7
Wenatchee River near Plain (WENPL)	9.3	119.9	-48.8	-39.7	9.6
Stehekin River at Stehekin (STEHE)	1.8	14.9	-4.8	-7.0	1.8
Methow River at Twisp (METTW)	-88.5	-4.7	-167.3	-184.4	-109.3

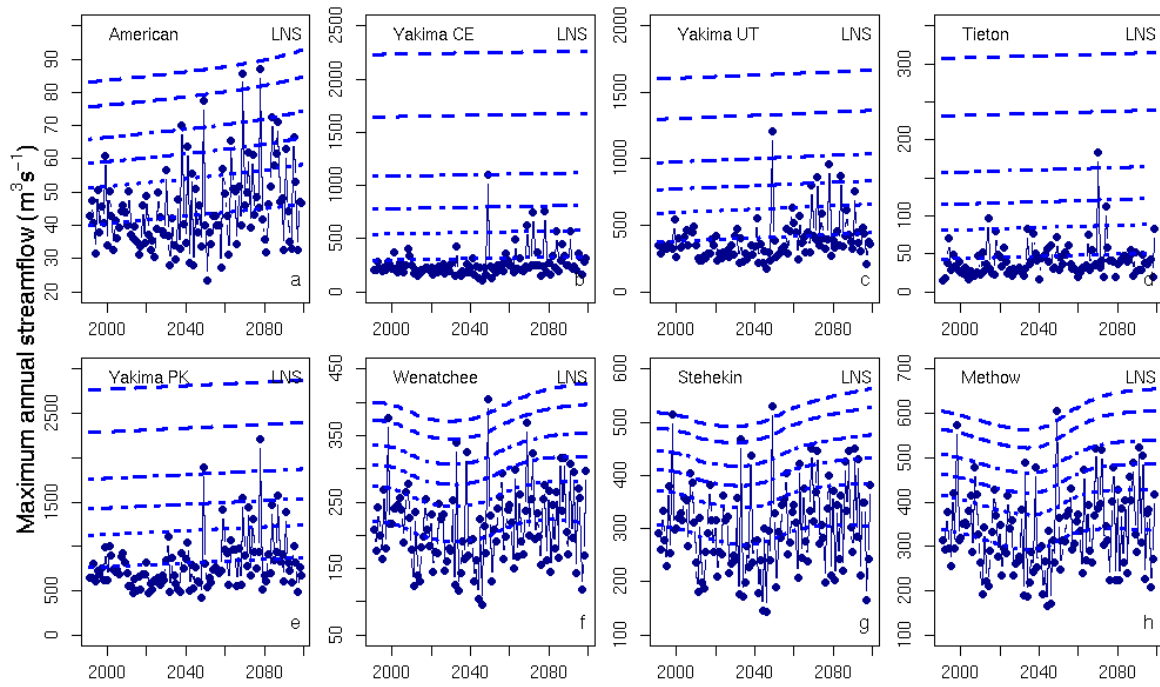


Figure S4. GEV results for eight stations for the maximum annual streamflow from 1991-2099 for the GFDL- ESM2M model.

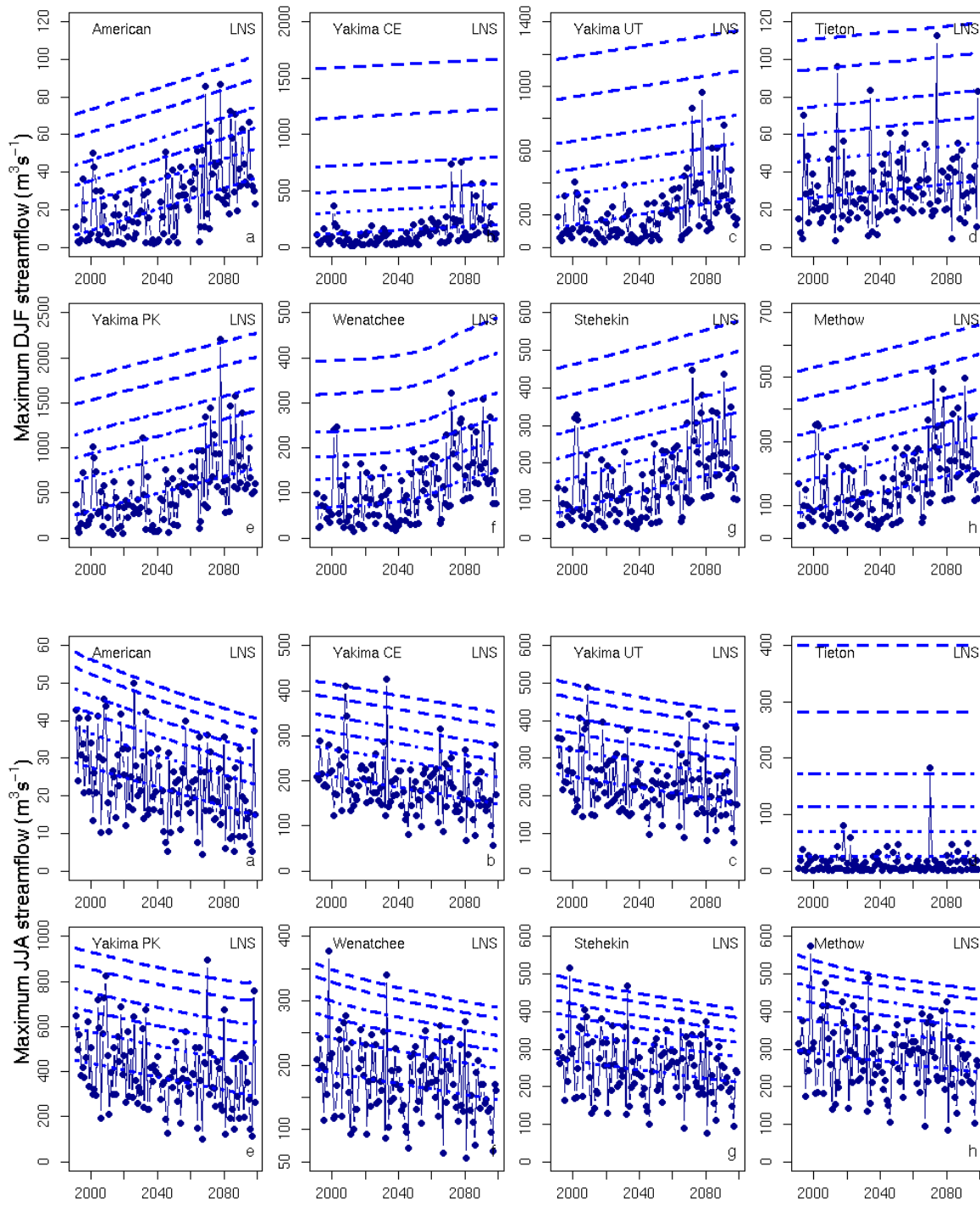


Figure S5. GEV results for eight stations for the maximum DJF (top) and JJA (bottom) streamflow from 1991-2099 for the GFDL-ESM2M model.