Supporting Information for Observed Changes in Daily Precipitation Intensity in the United States

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This document contains ten figures and three tables which are supplementary to the main text.

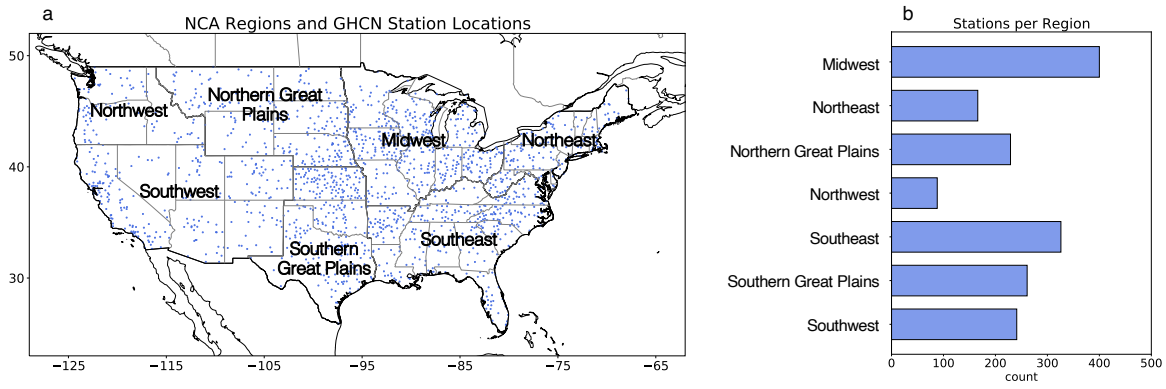


Figure S1*: Station Locations and NCA Region Station Counts. (a) Map of qualifying GHCN-D stations (blue dots) overlaid on the United States with U.S. National Climate Assessment (NCA) region boundaries in thick black and state borders in thin grey. (b) Histogram of the number of qualifying stations within each NCA region.*

Station ID	NEON Domain	NCA Region	Station-Block Years Removed	Outlier Values (mm)
USC00164700	Southeast	Southeast	1955-1956	764.5, 527.3, 791.5
USC00253185	Central Plains	Northern Great Plains	1963-1964	1524.5, 1778.8, 762.5, 1526.5, 2286, 1524.3, 1778, 2286, 1016, 1016, 2286, 508.5, 762, 763.8, 2286
USC00210287	Northern Plains	Midwest	1951-1952	290.8
USC00353604	Great Basin	Northwest	1951-1952	261.6
USW00003904	Southern Plains	Southern Great Plains	1971-1972	1016
USW00024284	Pacific Northwest	Northwest	1957-1958	283.7
USC00177479	Northeast	Northeast	1999-2000	584.2, 2006.6
USC00303346	Northeast	Northeast	1951-1952	1796.5
USC00200230	Great Lakes	Midwest	1953-1954	1286.3
USC00204090	Great Lakes	Midwest	1959-1960	2032.3
USC00335718	Appalachians and Cumberland Plateau	Midwest	1963-1964	457.2
USC00335747	Appalachians and Cumberland Plateau	Midwest	1965-1966	1017.3
USC00034562	Ozarks Complex	Southeast	1951-1952	1524.3
USC00422057	Southern Rockies and Colorado Plateau	Southwest	1973-1974	1524
USW00024057	Great Basin	Northern Great Plains	1967-1968	254.3

***Table S1**: List of Manually Identified Unverifiable Outliers. Outlying observations were compared against appropriate verified state and station records, etc. to determine validity; unverifiable records are listed here. Two-year station-blocks containing unverifiable records are removed from our analysis.*

	Mean	Standard Deviation	Median	Skew	Kurtosis
Northeast*	**5.4**	**7.0**	**5.7**	-0.3	-2.6
Mid Atlantic*	**2.5**	**6.3**	0.0	**17.6**	**11.1**
Southeast*	**5.2**	**8.8**	3.7	**11.3**	8.6
Atlantic Neotropical#	2.3	-0.4	7.0	-17.7	**-20.2**
Great Lakes*	**5.3**	**6.4**	6.3	-0.3	-0.4
Prairie Peninsula*	**5.6**	**6.7**	**5.2**	-0.2	0.5
Appalachians and Cumberland Plateau*	**5.1**	**5.2**	**4.5**	-5.1	-2.5
Ozarks Complex*	**4.9**	**6.0**	**3.5**	2.5	1.3
Northern Plains*	**5.8**	**7.1**	7.9	2.6	1.6
Central Plains*	**4.6**	**4.4**	5.7	-2.9	-1.1
Southern Plains*	**8.0**	**7.1**	**7.0**	-3.7	-1.2
Northern Rockies*	0.8	-1.3	0.0	-4.2	-1.2
Southern Rockies and Colorado Plateau*	1.7	1.2	**0.0**	4.9	7.5
Desert Southwest*	3.6	3.8	4.2	9.0	10.8
Great Basin*	2.5	3.4	0.0	**12.6**	**13.4**
Pacific Northwest*	-0.9	1.4	0.0	**10.4**	3.3
Pacific Southwest*	-0.6	-3.3	0.0	**-8.4**	**-5.3**
Tundra*	4.7	-1.4	7.1	**-14.0**	-4.8

Taiga	-0.2	-0.6	0.0	1.1	0.6
Pacific Tropical*	0.6	-3.3	0.0	-4.0	-1.2

***Table S2**: Percent Change in Wet Day Precipitation Intensity Distribution Moments. Bolded values denote statistical significance at the $p < 0.05$ level. Domains denoted with * observed statistically significant ($p < 0.05$) differences in early and late distributions from both the Kolmogorov-Smirnov and Anderson-Darling two-sample tests (# denotes statistically significant differences in Anderson-Darling two-sample test only).*

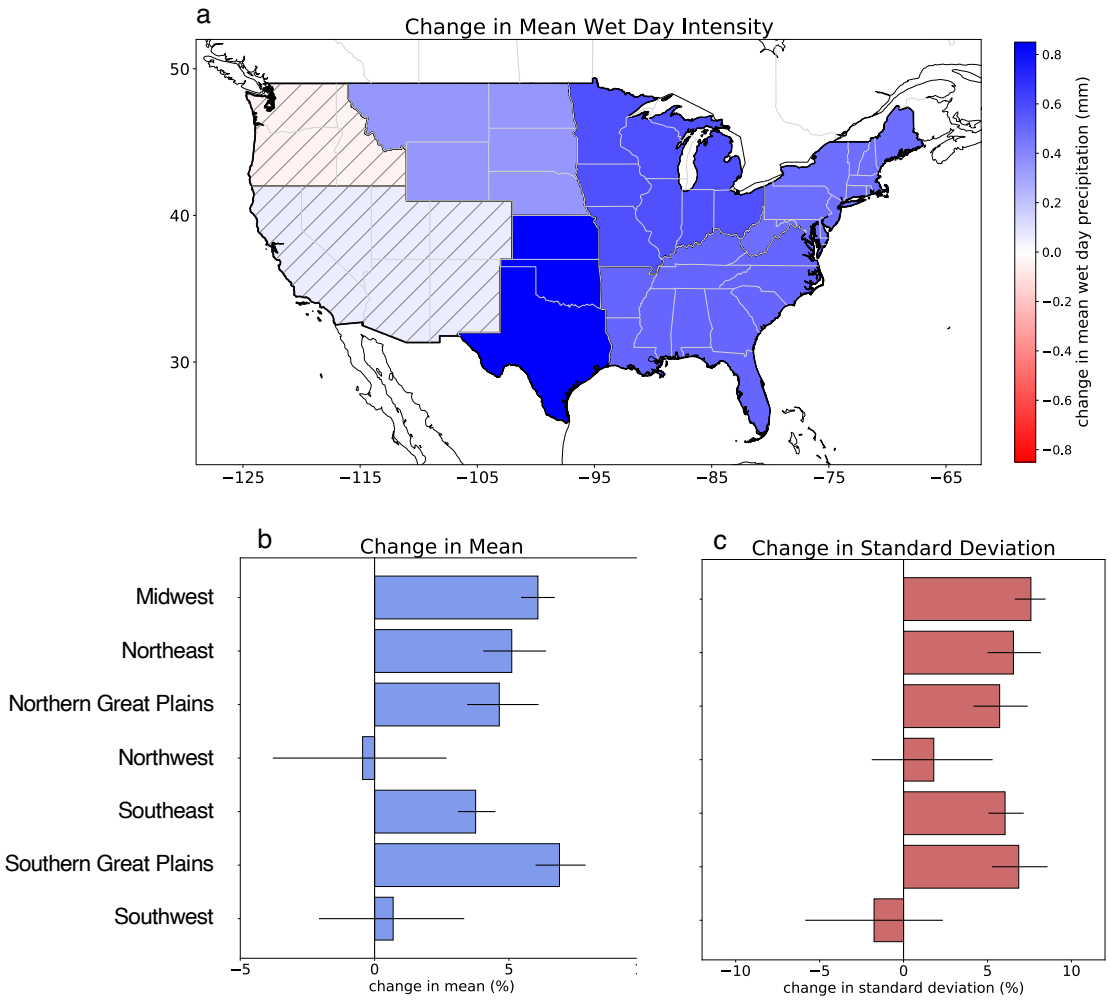


***Figure S2**: Changes in Wet Day Precipitation Intensity Between Early (1951-1980) and Late (1991-2020) Periods for NCA Regions. (a) Map of changes in mean wet day precipitation for NCA regions. Red-blue fill indicates change in precipitation intensity (mm/day) within domains (dark grey borders) on top of state boundaries (light grey borders). Hatching denotes domains without a statistically significant change in mean wet day precipitation intensity. (b) Percentage changes in mean wet day precipitation for NCA domains. Blue bars show percentage change of mean and horizontal black line shows 95% confidence interval. (c) Same as (b) but for standard deviation of wet day precipitation and with red bars.*

	Mean	Standard Deviation	Median	Skew	Kurtosis
Alaska	-0.1	-0.1	0.0	5.3	14.7
U.S. Caribbean	-	-	-	-	-
Hawaii and Pacific Islands#	-4.9	-7.9	0.0	2.5	11.4
Midwest*	**6.1**	**7.6**	0.0	0.9	4.5
Northeast*	**5.2**	**6.5**	**3.6**	1.3	0.3
Northern Great Plains*	**4.7**	**5.7**	4.9	2.2	7.4
Northwest*	-0.5	1.8	0.0	**10.3**	18.9
Southeast*	**3.8**	**6.1**	2.5	**6.8**	**18.9**
Southern Great Plains*	**6.9**	**6.9**	**7.6**	1.6	16.9
Southwest*	0.7	-1.7	4.3	-5.8	**-16.8**

Table S3*: Percent Change in Wet Day Precipitation Intensity Distribution Moments for NCA regions. Bolded values denote statistical significance at the $p < 0.05$ level. Domains denoted with * observed statistically significant ($p < 0.05$) differences in early and late distributions from both the Kolmogorov-Smirnov and Anderson-Darling two-sample tests (# denotes statistically significant differences in Anderson-Darling two-sample test only). Note that the U.S. Caribbean region does not contain any qualifying stations.*

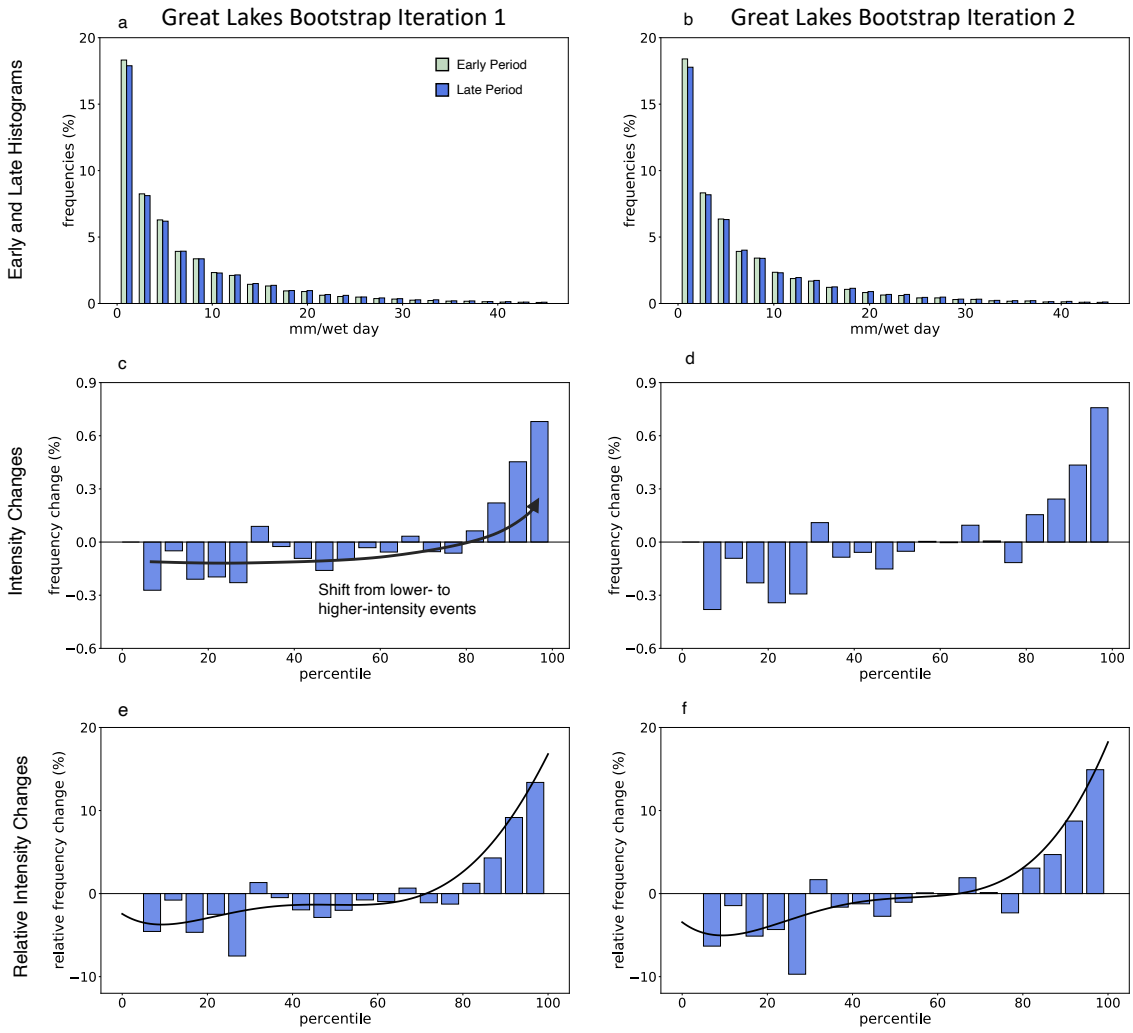


Figure S3*: Bootstrapped Change in Precipitation Intensity between Early and Late Periods. (a) Histograms of wet day precipitation intensity in the Great Lakes domain for the early (light green; 1951-1980) and late (dark blue; 1991-2020) period. Histogram values represent the percentage of all wet-day events within the binned intensity. (b) Absolute difference in wet day precipitation intensity frequency between the late and early periods for the Great Lakes NEON domain over five percentile increments. (c) Same as (b) but the change is normalized by the early period frequency. Thick black line represents a fifth-*

degree polynomial fit over a three bin smoothing. (d-f) Same as (a-c) but for a second iteration of the block bootstrapping methodology.

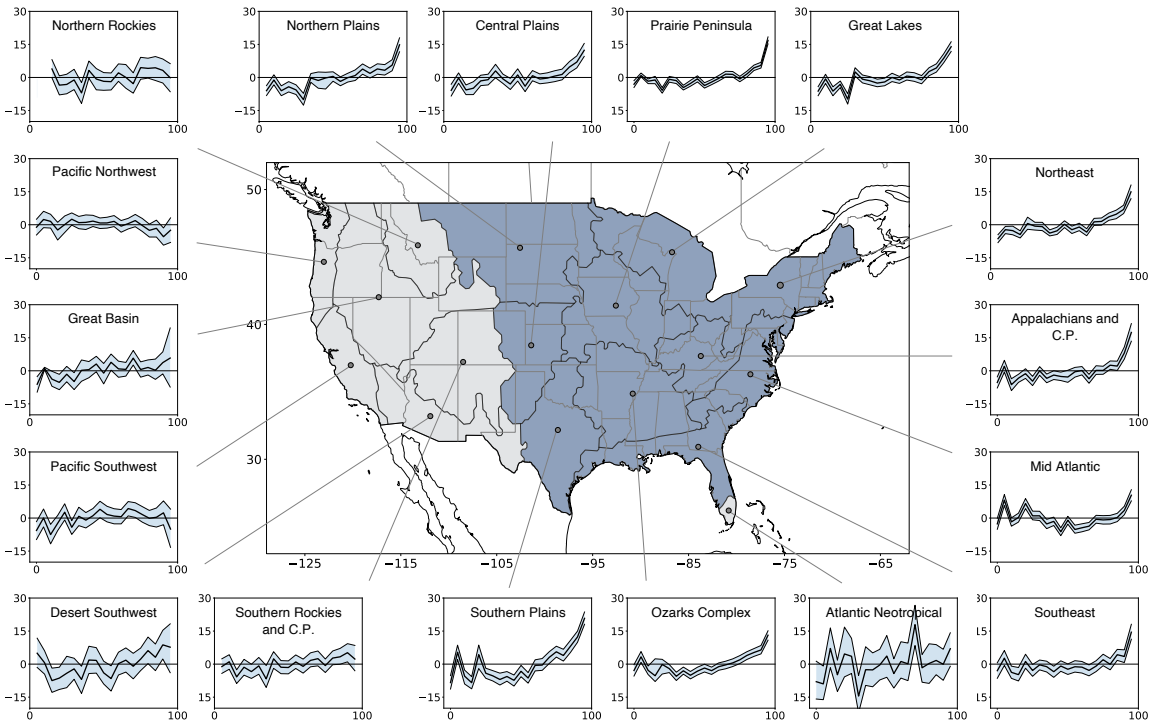


***Figure S4**: Raw Relativized Frequency Change for Each Domain. (map) The United States with NEON domain boundaries (thick dark grey) and state borders (thin light grey). Blue fill denotes the cluster of central and eastern domains with a predominantly consistent significant change in frequency across intensities. Conversely, grey fill denotes the cluster of western domains with inconsistent or non-significant changes in frequency across intensities. (domain subplots) Raw change in frequency of intensity for each domain across the 0th-100th percentile of wet day intensities at five percentile increments. This is illustrated for both the median (thick black) and 90% confidence bounds as determined by block bootstrapping (thin black line and light blue shading).*

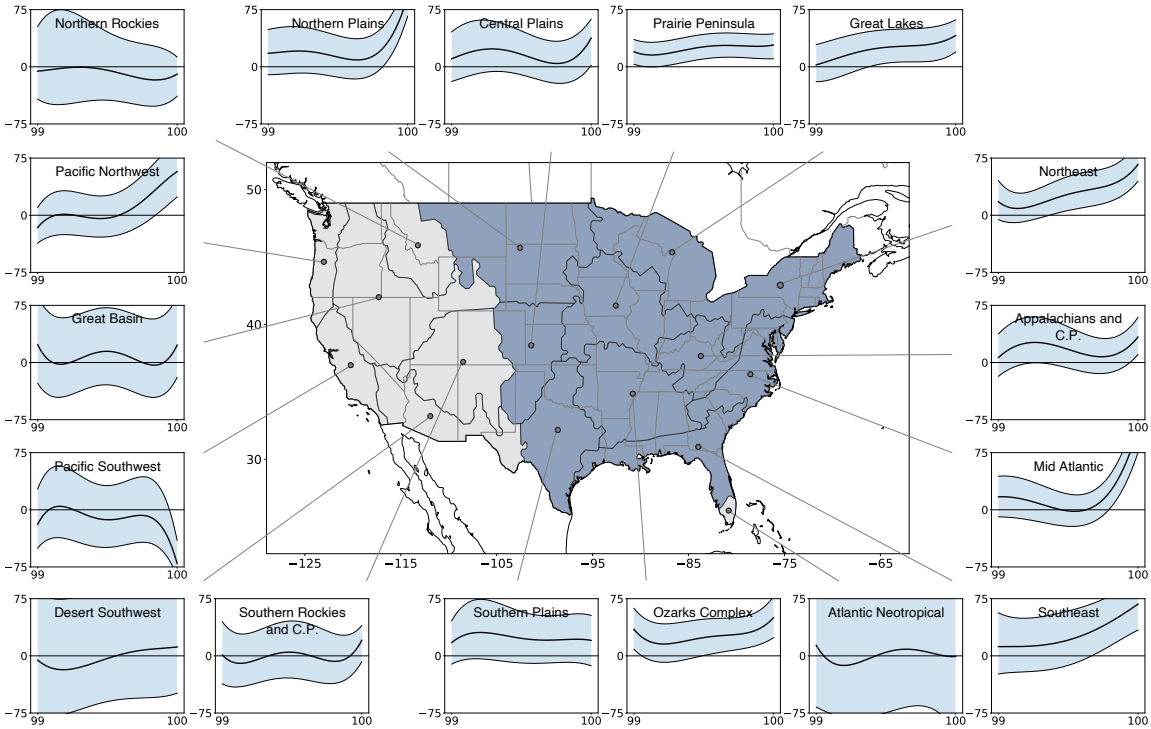


***Figure S5**: Smoothed Relativized Frequency Change for Each Domain for Extreme Precipitation. Same as Figure 3 but for 99th-100th percentile precipitation and 0.05 percentile increments.*

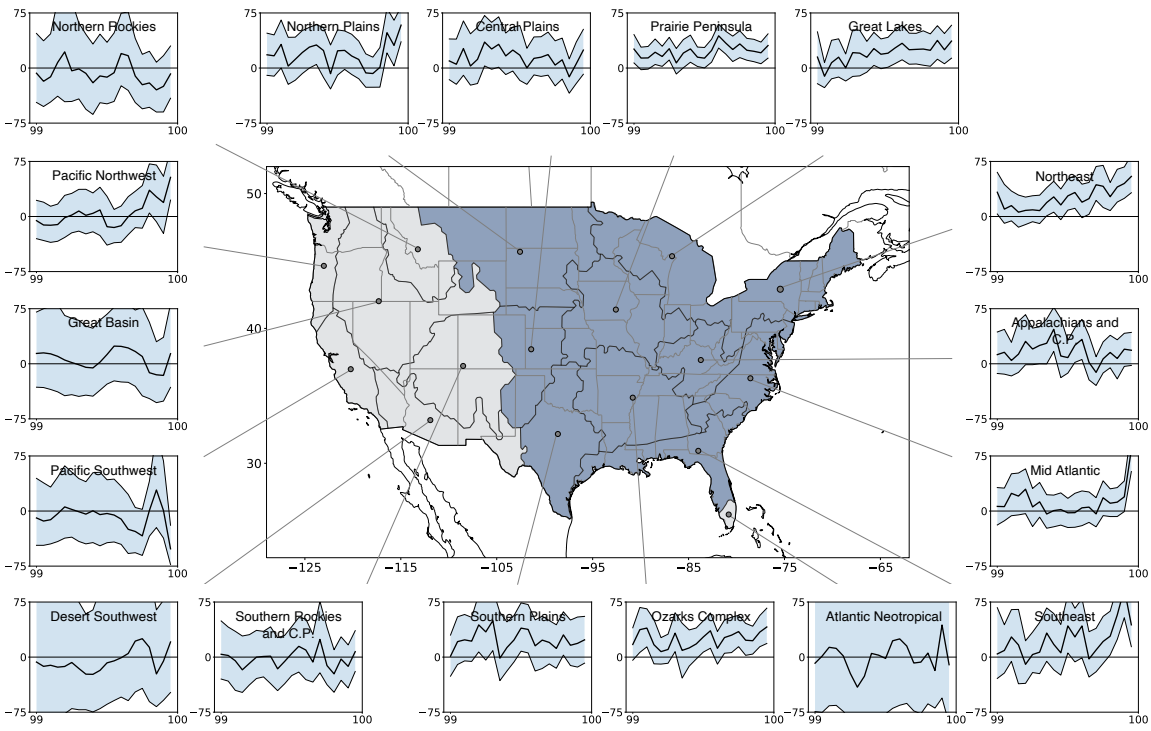
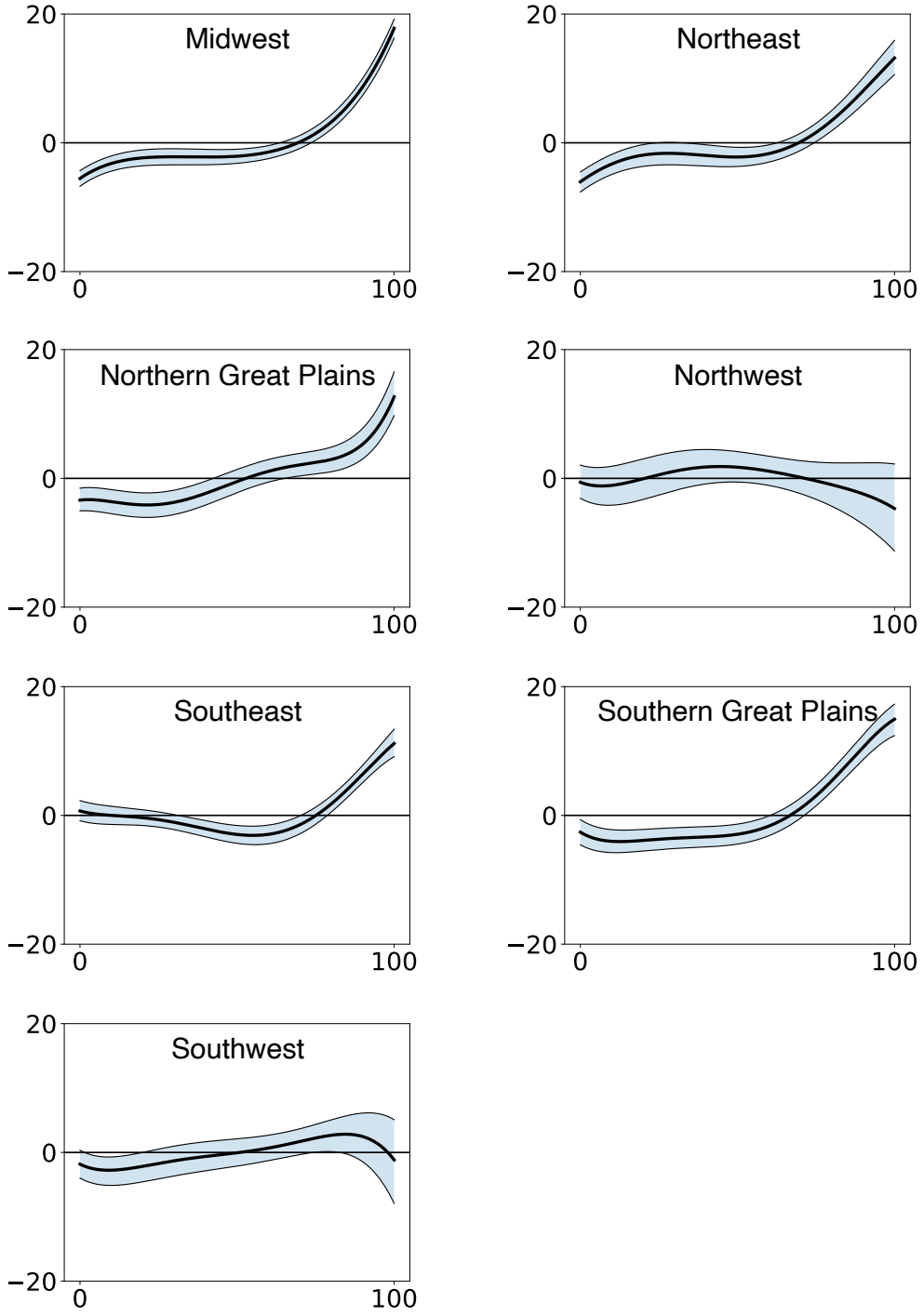


***Figure S6**: Raw Relativized Frequency Change for Each Domain for Extreme Precipitation. Same as Figure S4 but for 99th-100th percentile precipitation and 0.05 percentile increments.*



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93 ***Figure S7****: Smoothed Relativized Frequency Change for Each NCA Region. Same as Figure 2 but for*

94 *NCA regions and without underlying map.*

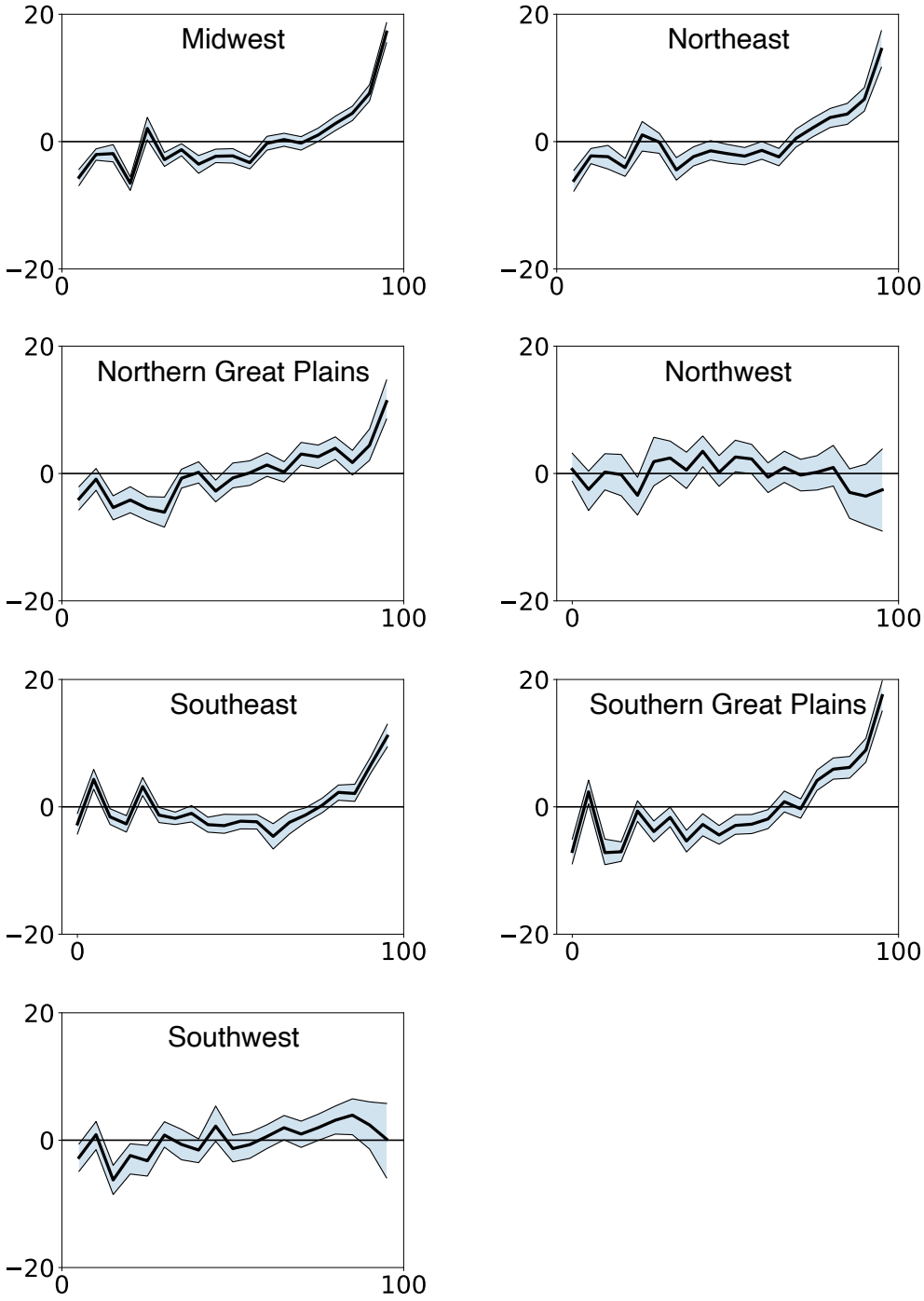

***Figure S8**: Raw Relativized Frequency Change for Each NCA Region. Same as Figure S4 but for NCA regions and without underlying map.*

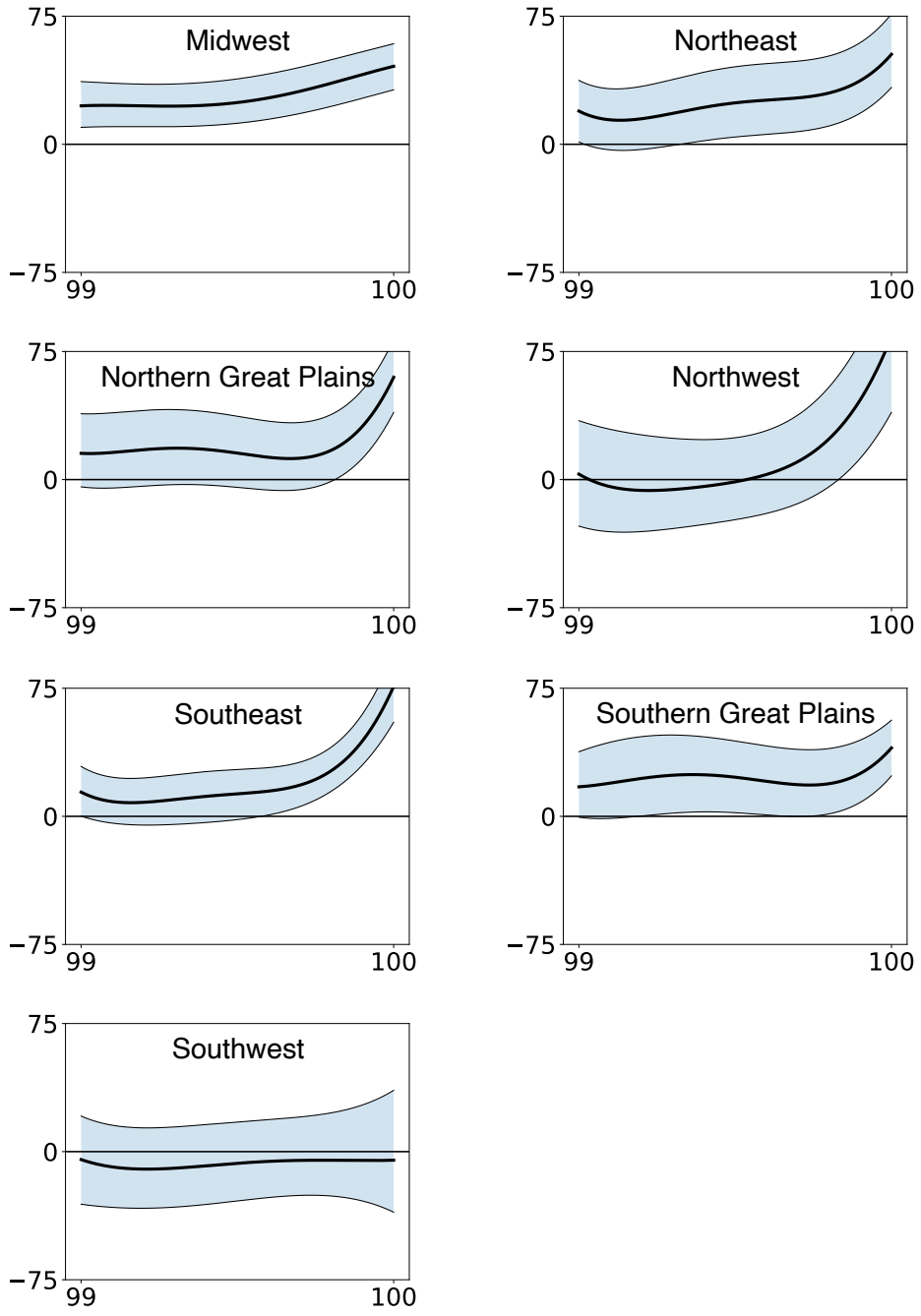

***Figure S9**: Smoothed Relativized Frequency Change for Each NCA Region for Extreme Precipitation.*

Same as Figure S5 but for NCA regions and without underlying map.

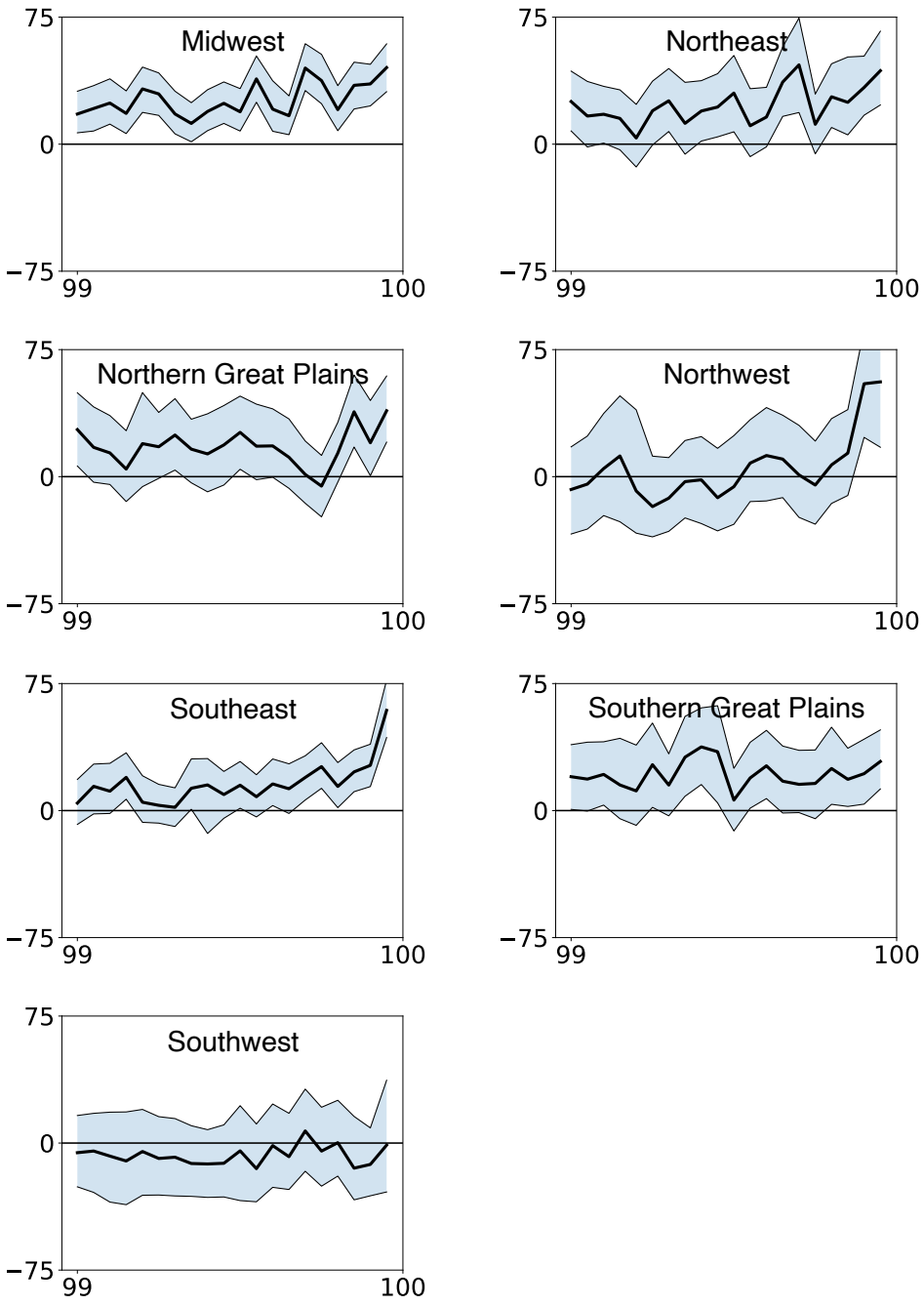

***Figure S10**: Raw Relativized Frequency Change for Each NCA Region for Extreme Precipitation. Same as Figure S6 but for NCA regions and without underlying map.*