Supplement of Nat. Hazards Earth Syst. Sci., 26, 391–409, 2026
https://doi.org/10.5194/nhess-26-391-2026-supplement

Natural Hazards and Earth System Sciences
Open Access
EGU

Supplement of

Assessing the spatial correlation of potential compound flooding in the United States

Huazhi Li et al.

Correspondence to: Huazhi Li (huazhi.li@vu.nl)

Table S1: Summary of location information for the 41 station combinations of NOAA tidal gauges and USGS river stations.

Coast	Location number	Tidal Gauge	Lat	Long	River Station	USGS Station Number	Lat	Long	Distance Between Paired Stations (km)
West	1	Friday Harbor	48.5	-123.0	Nooksack River	12213100	48.8	-122.6	44.5
	2	Seattle	47.6	-122.3	Green River	12113000	47.3	-122.2	34.2
	3	Toke Point	46.7	-124.0	Willapa River	12013500	46.7	-123.7	22.9
	4	Astoria	46.2	-123.8	Cowlitz River	14243000	46.3	-122.9	70.1
	5	South Beach	44.6	-124.0	Siletz River	14305500	44.7	-123.9	13.6
	6	Charleston 2	43.3	-124.3	Umpqua River	14321000	43.6	-123.6	65.6
	7	Crescent City	41.7	-124.2	Klamath River	11530500	41.5	-124.0	27.8
	8	North Spit	40.8	-124.2	Mad River	11481000	40.9	-124.1	13.9
	9	San Francisco	37.8	-122.5	Castro Valley Channel	11181008	37.7	-122.1	34.3
	10	Port San Luis	35.2	-120.8	Cuyama River	11136800	35.0	-120.2	55.7
	11	Santa Monica	34.0	-118.5	Rio Hondo	11101250	34.1	-118.1	40.0
	12	Los Angeles	33.7	-118.3	San Gabriel River	11087020	34.0	-118.0	43.4
	13	La Jolla	32.9	-117.3	Los Penasquitos Channel	11023340	32.9	-117.1	17.3
Gulf	14	Rock Port	28.0	-97.0	Mission River	08189500	28.3	-97.3	44.5
	15	Pier 21	29.3	-94.8	Whiteoak Bayou	08074500	29.8	-95.4	80.4
	16	Pensacola	30.4	-87.2	Escambia River	02375500	31.0	-87.2	61.7
	17	Panama City	30.2	-85.7	Choctawhatchee River	02366500	30.5	-85.9	33.7
	18	Apalachicola	29.7	-85.0	Apalachicola River	02359170	29.9	-85.0	22.2
	19	Cedar Key	29.1	-83.0	Suwannee River	02323500	29.6	-82.9	56.4
	20	St Petersburg	27.8	-82.6	Little Manatee River	02300500	27.7	-82.4	22.6
East	21	Fernandina Beach	30.7	-81.5	Saint Marys River	02231000	30.4	-82.1	66.4
	22	Fort Pulaski	32.0	-80.9	Savannah River	02198500	32.5	-81.3	67.1
	23	Charleston	32.8	-79.9	Edisto River	02175000	33.0	-80.4	51.7
	24	Wilmington	34.2	-78.0	Cape Fear River	02105769	34.4	-78.3	34.0
	25	Beaufort	34.7	-76.7	Neuse River	02091814	35.3	-77.3	86.2
	26	Duck	36.2	-75.7	Blackwater River	02049500	36.8	-76.9	126.3
	27	Sewell point	36.9	-76.3	James River	02037500	37.6	-77.5	131.7
	28	Washington	38.9	-77.0	Potomac River	01646500	38.9	-77.1	8.7
	29	Baltimore	39.3	-76.6	Susquehanna River	01578310	39.7	-76.7	40.5
	30	Annapolis	39.0	-76.5	Patuxent River	01594440	39.0	-76.7	18.2
	31	Reedy Point	39.6	-75.6	Brandywine Creek	01481500	39.8	-75.6	22.2
	32	Atlantic City	39.4	-74.4	Tuckahoe River	01411300	39.6	-74.4	22.2

	33	Sandy Hook	40.5	-74.0	Swimming River	01407500	40.3	-74.1	22.3
	34	Battery	40.7	-74.0	Saddle River	01391500	40.9	-74.1	23.8
	35	Bridge Port	41.2	-73.2	Housatonic River	01205500	41.4	-73.2	22.2
	36	New London	41.4	-72.1	Shetucket River	01122500	41.7	-72.2	34.4
	37	Newport	41.5	-71.3	Pawtuxet River	01116500	41.8	-71.4	30.1
	38	Boston	42.4	-71.1	Charles River	01104500	42.4	-71.2	8.2
	39	Portland	43.7	-70.2	Saco River	01066000	43.8	-70.8	49.5
	40	Bar Harbor	44.4	-68.2	Penobscot River	01034500	45.2	-68.7	99.6
	41	Eastport	44.9	-67.0	St. Croix River	01021000	45.1	-67.3	32.4

Table S2: Summary of information on the marginal thresholds and specified thresholds used for identifying compound flooding potential.

Location number	Tidal Gauge	River Station	Marginal threshold		Compound threshold (99th)	
			Water level (m)	Discharge (m^3/s)	Water level (m)	Discharge (m^3/s)
1	Friday Harbor	Nooksack River	4.09 (98.5)	210.39 (92.0)	4.13	450.24
2	Seattle	Green River	6.31 (95.2)	162.82 (98.1)	6.49	212.16
3	Toke Point	Willapa River	4.53 (91.5)	83.53 (96.5)	4.91	146.54
4	Astoria	Cowlitz River	3.36 (90.7)	504.04 (91.6)	3.69	911.8
5	South Beach	Siletz River	4.34 (90.3)	99.68 (90.0)	4.64	283.17
6	Charleston 2	Umpqua River	3.82 (90.5)	1266.68 (98.7)	4.11	1434.25
7	Crescent City	Klamath River	3.51 (91.9)	2732.58 (98.7)	3.76	2944.95
8	North Spit	Mad River	6.97 (92.0)	106.58 (90.4)	7.18	343.34
9	San Francisco	Castro Valley Channel	4.04 (98.3)	0.96 (97.6)	4.08	1.81
10	Port San Luis	Cuyama River	3.38 (97.9)	3.33 (97.1)	3.43	12.74
11	Santa Monica	Rio Hondo	2.94 (98.6)	8.19 (95.6)	2.96	29.8
12	Los Angeles	San Gabriel River	3.33 (97.3)	13.28 (95.8)	3.39	76.81
13	La Jolla	Los Penasquitos Channel	3.4 (96.4)	4.15 (98.4)	3.49	6.45
14	Rock Port	Mission River	2.46 (94.7)	80.09 (98.9)	2.6	87.07
15	Pier 21	Whiteoak Bayou	2.23 (94.3)	56.63 (98.9)	2.41	59.75
16	Pensacola	Escambia River	3.4 (97.4)	368.12 (90.1)	3.56	996.75
17	Panama City	Choctawhatchee River	1.89 (98.6)	447.07 (93.2)	1.91	962.77
18	Apalachicola	Apalachicola River	2.28 (98.3)	1180.81 (90.7)	2.33	2368.87
19	Cedar Key	Suwannee River	2.19 (97.2)	540.85 (92.6)	2.27	914.63
20	St Petersburg	Little Manatee River	2.09 (96.1)	10.34 (90.1)	2.19	39.08
21	Fernandina Beach	Saint Marys River	3.09 (98.7)	38.51 (90.3)	3.11	144.13
22	Fort Pulaski	Savannah River	3.99 (98.9)	1125.59 (99.0)	4	1125.59

23	Charleston	Edisto River	3.2 (98.7)	298.25 (98.7)	3.22	311.49
24	Wilmington	Cape Fear River	2.59 (96.2)	504.04 (94.6)	2.7	725.62
25	Beaufort	Neuse River	2.09 (97.4)	302.99 (92.7)	2.15	591.82
26	Duck	Blackwater River	7.19 (91.3)	46.16 (90.3)	7.44	114.75
27	Sewell point	James River	2.56 (90.1)	458.73 (90.0)	2.88	1365.58
28	Washington	Potomac River	2.92 (98.3)	923.13 (92.3)	2.97	2331.18
29	Baltimore	Susquehanna River	2.32 (98.8)	2772.22 (92.6)	2.33	5889.9
30	Annapolis	Patuxent River	2.37 (98.6)	30.58 (94.2)	2.4	71.43
31	Reedy Point	Brandywine Creek	2.65 (97.5)	32.0 (93.6)	2.72	81.91
32	Atlantic City	Tuckahoe River	3.5 (97.7)	2.21 (90.8)	3.59	4.93
33	Sandy Hook	Swimming River	3.01 (98.5)	3.06 (90.5)	3.06	13.39
34	Battery	Saddle River	3.2 (98.9)	5.72 (90.4)	3.21	19.16
35	Bridge Port	Housatonic River	3.38 (97.5)	201.74 (94.2)	3.47	379.45
36	New London	Shetucket River	2.42 (96.3)	54.65 (92.1)	2.54	119.78
37	Newport	Pawtuxet River	2.28 (98.3)	21.72 (90.0)	2.31	48.21
38	Boston	Charles River	4.9 (98.4)	20.78 (90.4)	4.94	39.64
39	Portland	Saco River	6.23 (97.4)	170.18 (90.0)	6.31	382.28
40	Bar Harbor	Penobscot River	5.16 (97.1)	763.0 (90.2)	5.24	1722.37
41	Eastport	St. Croix River	8.35 (98.7)	144.13 (90.3)	4.13	450.24

**numbers in the brackets showing the corresponding marginal quantile*

Table S3: Comparison of data lengths (years) between original data with removed gaps and complete data with infilled gaps for the West and the combined Gulf and East coasts. Numbers in the brackets show the average percentage of infilled data across all stations.

Method	**West**	**Gulf + East**
Constrained to commonly available events (excluding missing values)	11.4 years	3.2 years
Complete time series (infilling missing values)	41 years (1.73%)	41 years (1.73%)

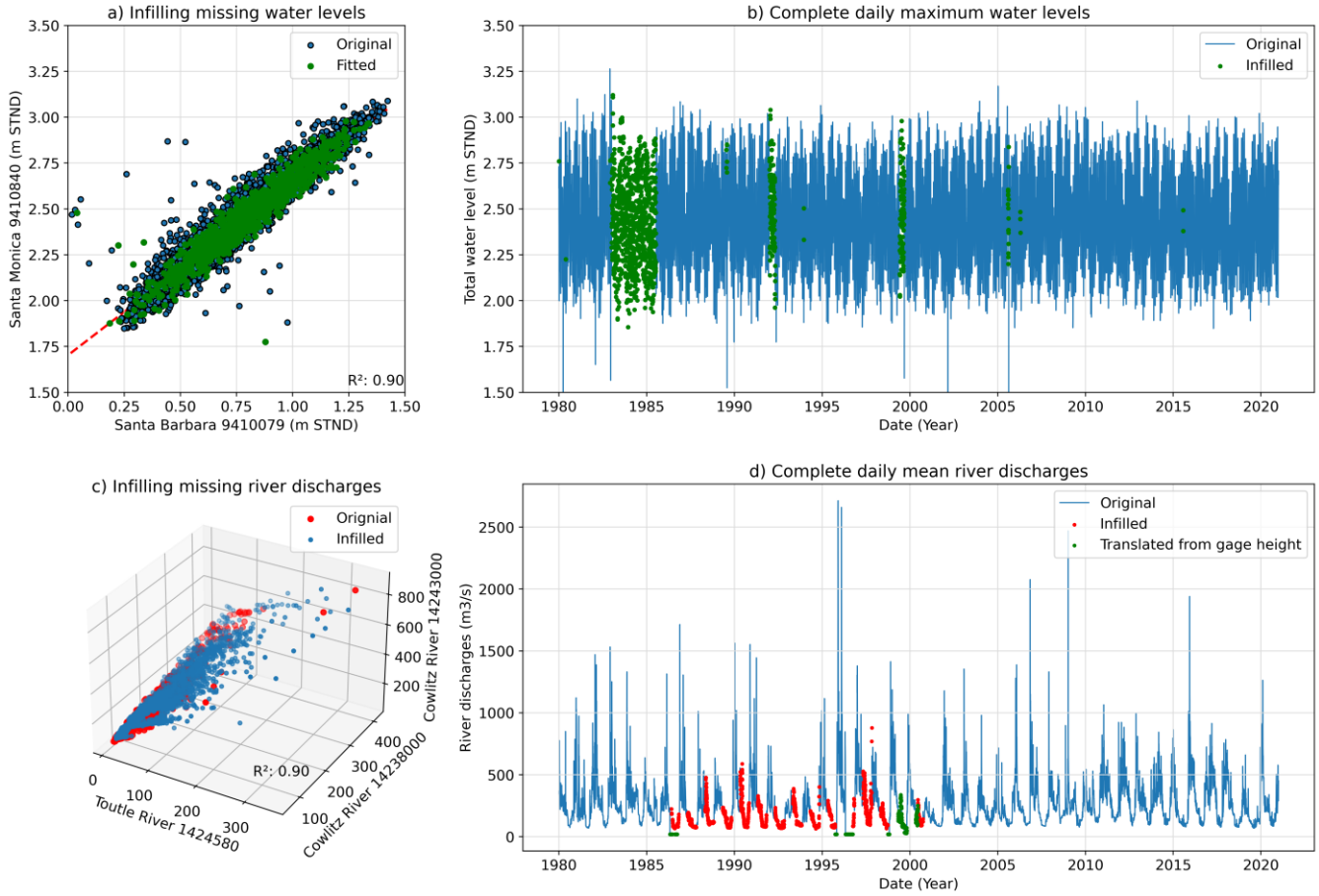

Figure S1: Exemplary infilling results for the tidal gauge Santa Monica and the river station Cowlitz River. Panel a) shows the infilled water levels from the simultaneous values at the gauge Santa Barbara, while Panel b) shows the complete time series after infilling. Panel c) shows the infilled daily mean discharges from the simultaneous data at two upstream river stations and Panel d) shows the complete time series after the infilling process.

Section S1: Evaluation of the sampled historic spatially joint events of total water level and river discharge

Two measures are applied to evaluate these spatially joint events. First, we assess how many de-clustered peaks are captured, missed or double counted per variable in the sampled events. Fig. S1 shows that these identified joint events can sufficiently capture the de-clustered peaks. While only very few peaks are doubled counted, these events are found to miss a certain amount of peaks. This is probably due to the applied window for time lags between locations is relatively long, during which only the maximum peak is retained.

The second evaluation analysis is done by assessing the number of extremes as well as non-extremes including true and false non-extremes for each variable from all sampled events. We define extremes of individual variables using the corresponding 99th thresholds. True non-extremes are the sampled values below this threshold, while false non-extremes refer to those

above the threshold but they are not the identified peaks. The false non-extremes are the cases where the variable value exceeds the threshold but is not one of the de-clustered peaks. False non-extremes are sampled when the peak of a particular variable falls outside the lag window of the peak of the primary variable. Evaluation results can be found in Fig. S2. The numbers of sampled historic events are the same for the Gulf and East coasts as the model was applied for a large area combining these two coasts.

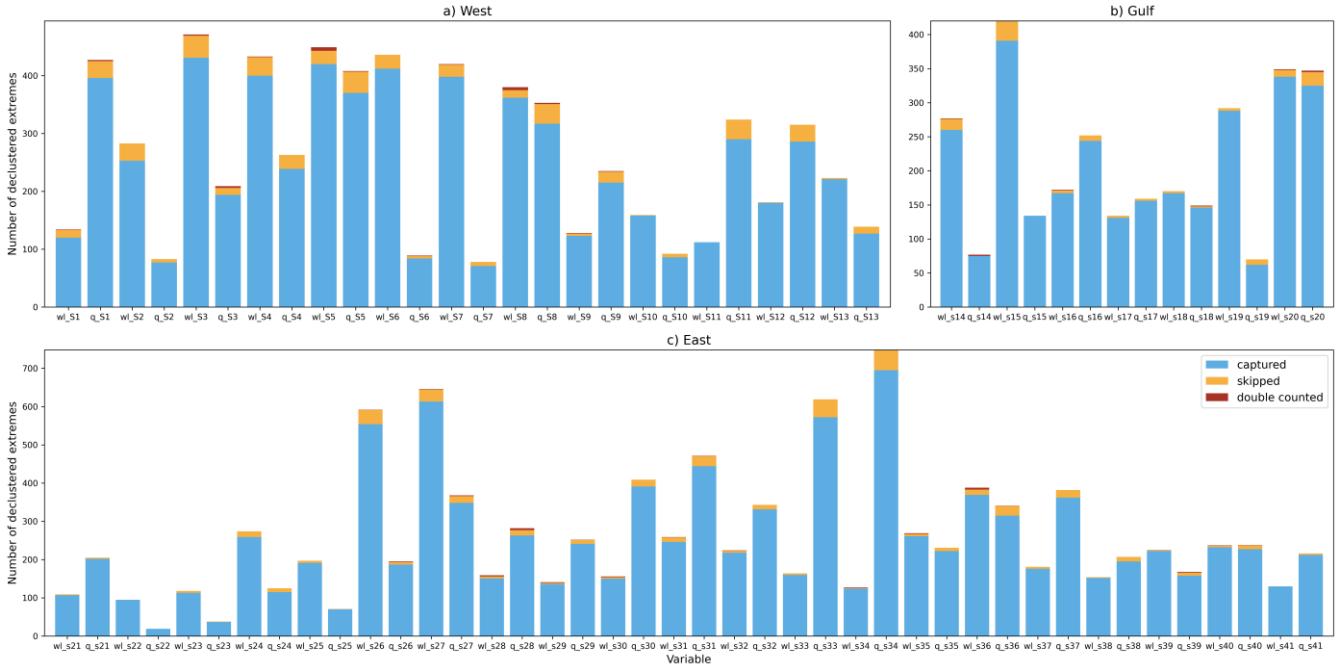

Figure S2: Evaluation of the sampled historic spatially joint events. The numbers of captured, skipped, and double counted peaks for the West, Gulf, and East coasts are represented by the blue, yellow, and red bars, respectively. The location numbers correspond to those in Table S1.

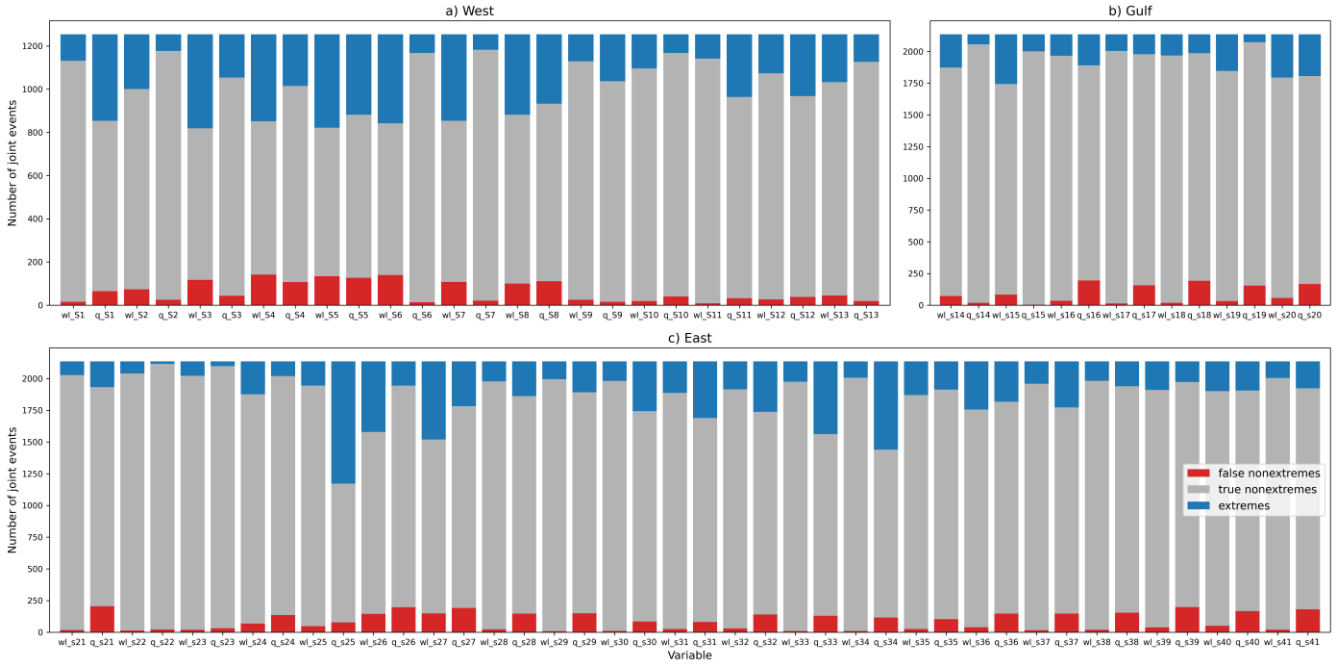

Figure S3: Evaluation of the sampled historic spatially joint events. The numbers of extremes, true non-extremes, false non-extremes in the sampled joint events for the West, Gulf, and East coasts are represented by the blue, grey, and red bars, respectively. The location numbers correspond to those in Table S1.

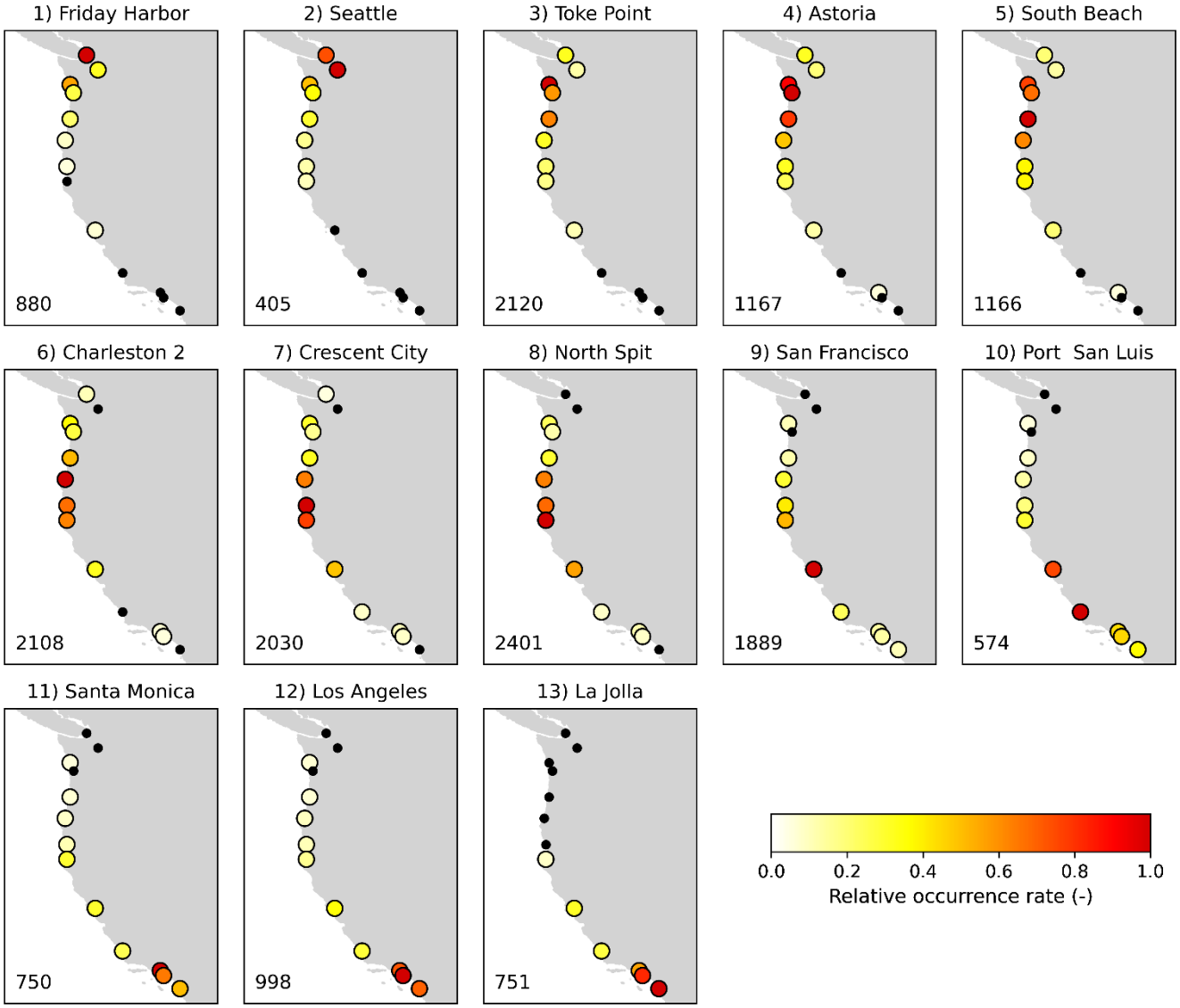

Figure S4: Joint occurrence rate of potential compound flooding at remaining locations given potential compound flooding occurs at a primary location for the West coast. Potential compound flooding is defined by events with both total water levels and river discharges exceeding the 1-year return level. Small black solid circles refer to the joint occurrence rate lower than 0.05.

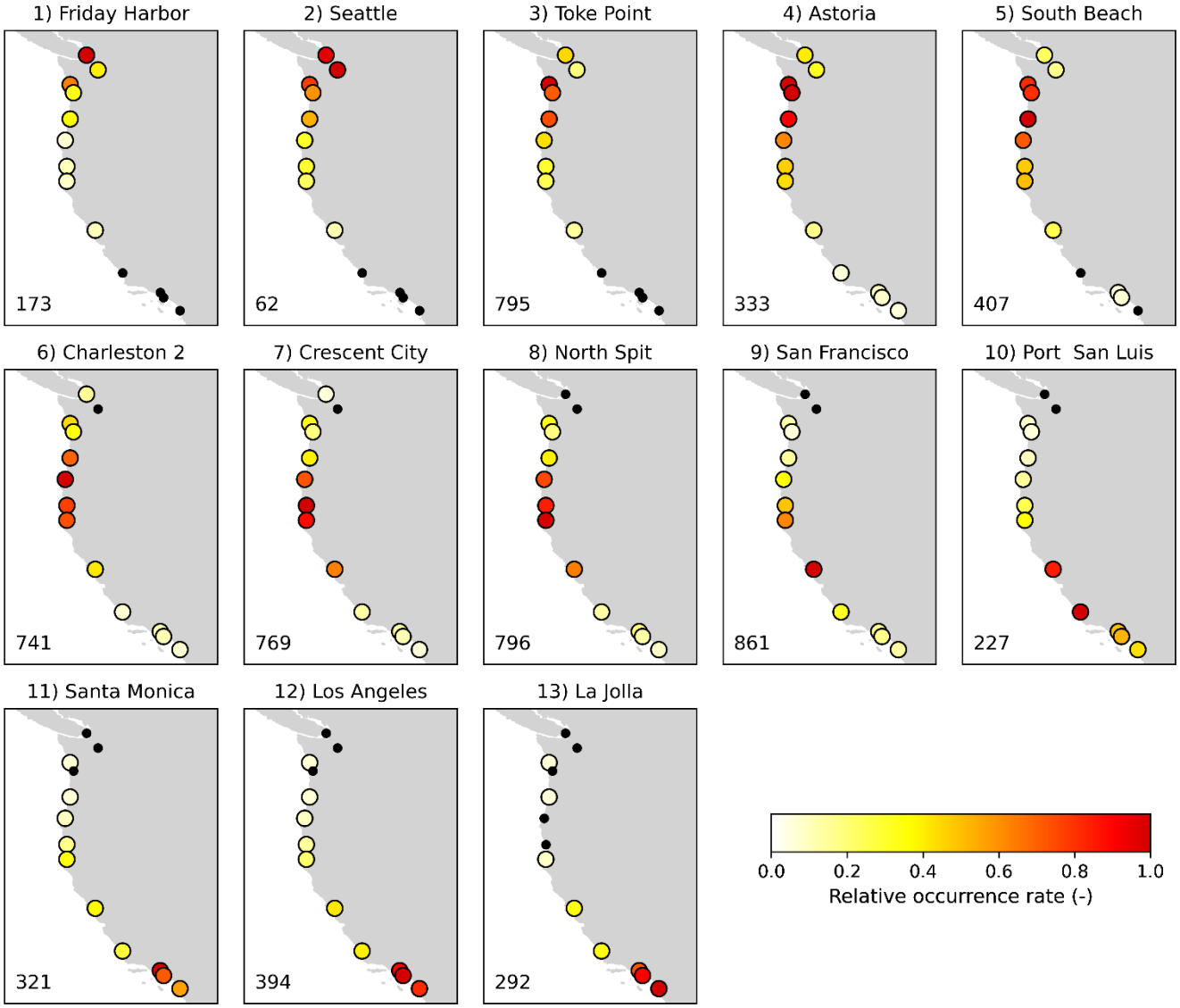

Figure S5: Joint occurrence rate of potential compound flooding at remaining locations given potential compound flooding occurs at a primary location for the West coast. Potential compound flooding is defined by events with both total water levels and river discharges exceeding the 2-year return level. Small black solid circles refer to the joint occurrence rate lower than 0.05.

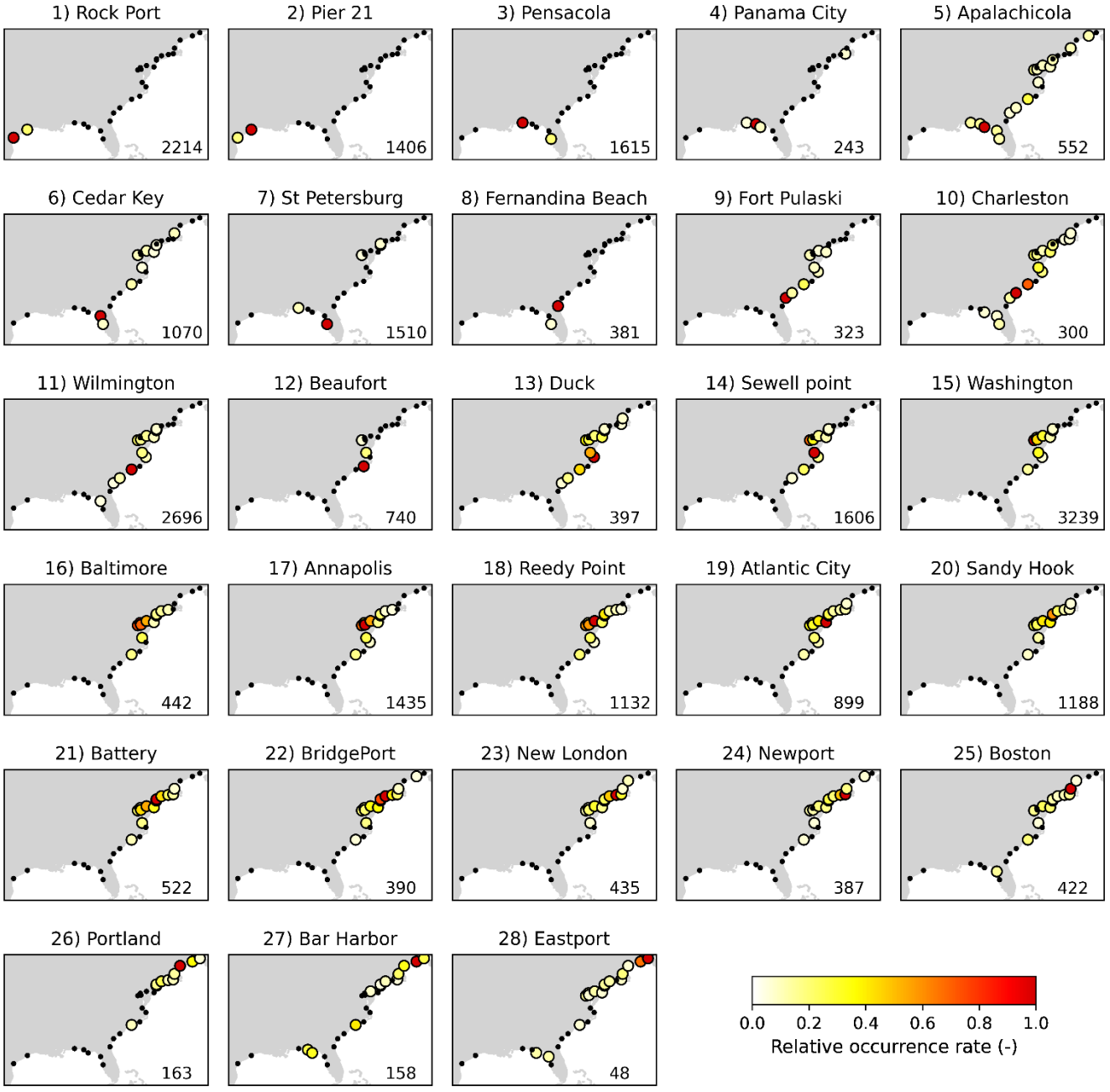

Figure S6: Joint occurrence rate of potential compound flooding at remaining locations given potential compound flooding occurs at a primary location for the Gulf and East coasts. Potential compound flooding is defined by events with both total water levels and river discharges exceeding the 1-year return level. Small black solid circles refer to the joint occurrence rate lower than 0.05.

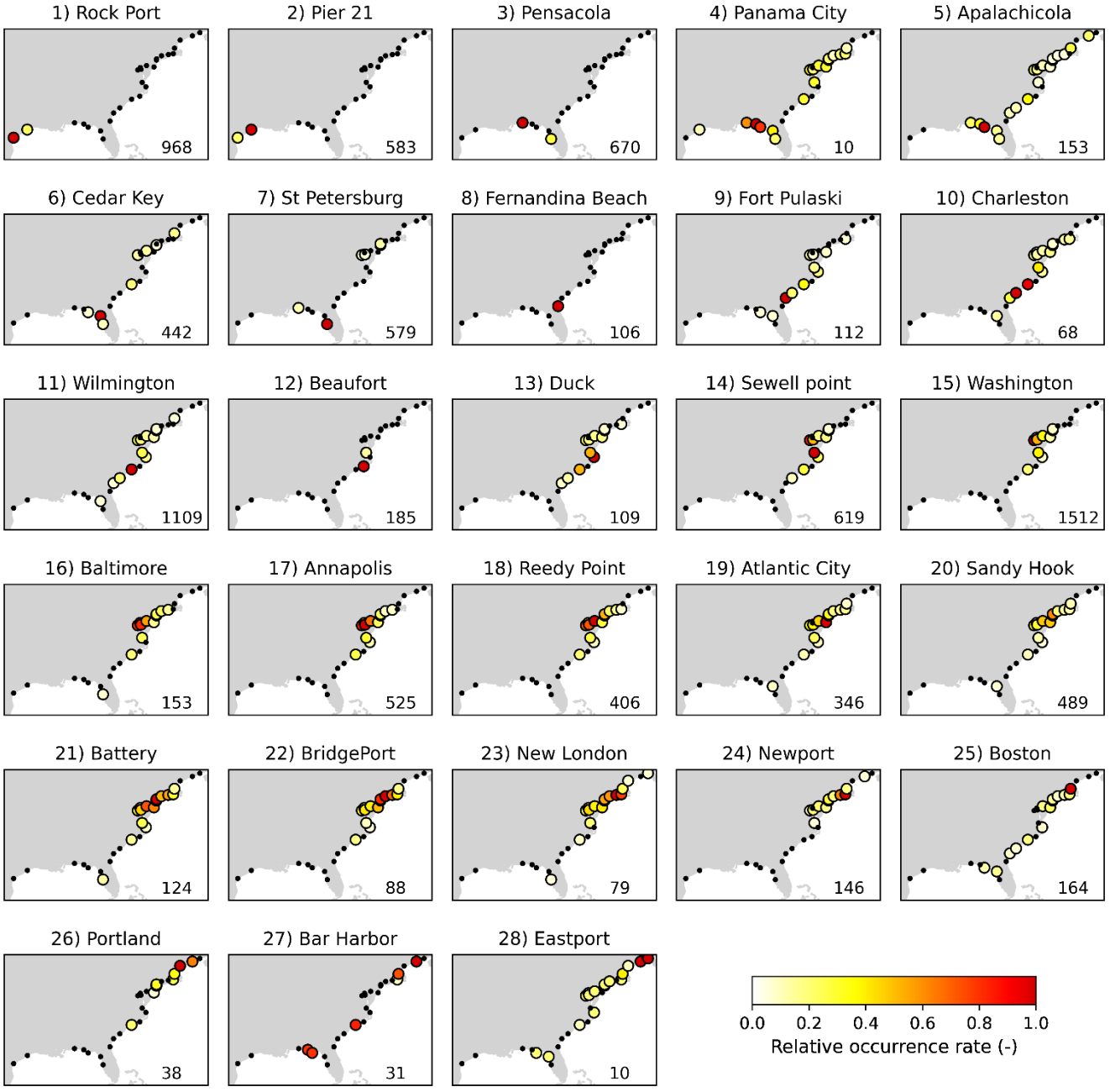

Figure S7: Joint occurrence rate of potential compound flooding at remaining locations given potential compound flooding occurs at a primary location for the Gulf and East coasts. Potential compound flooding is defined by events with both total water levels and river discharges exceeding the 2-year return level. Small black solid circles refer to the joint occurrence rate lower than 0.05.

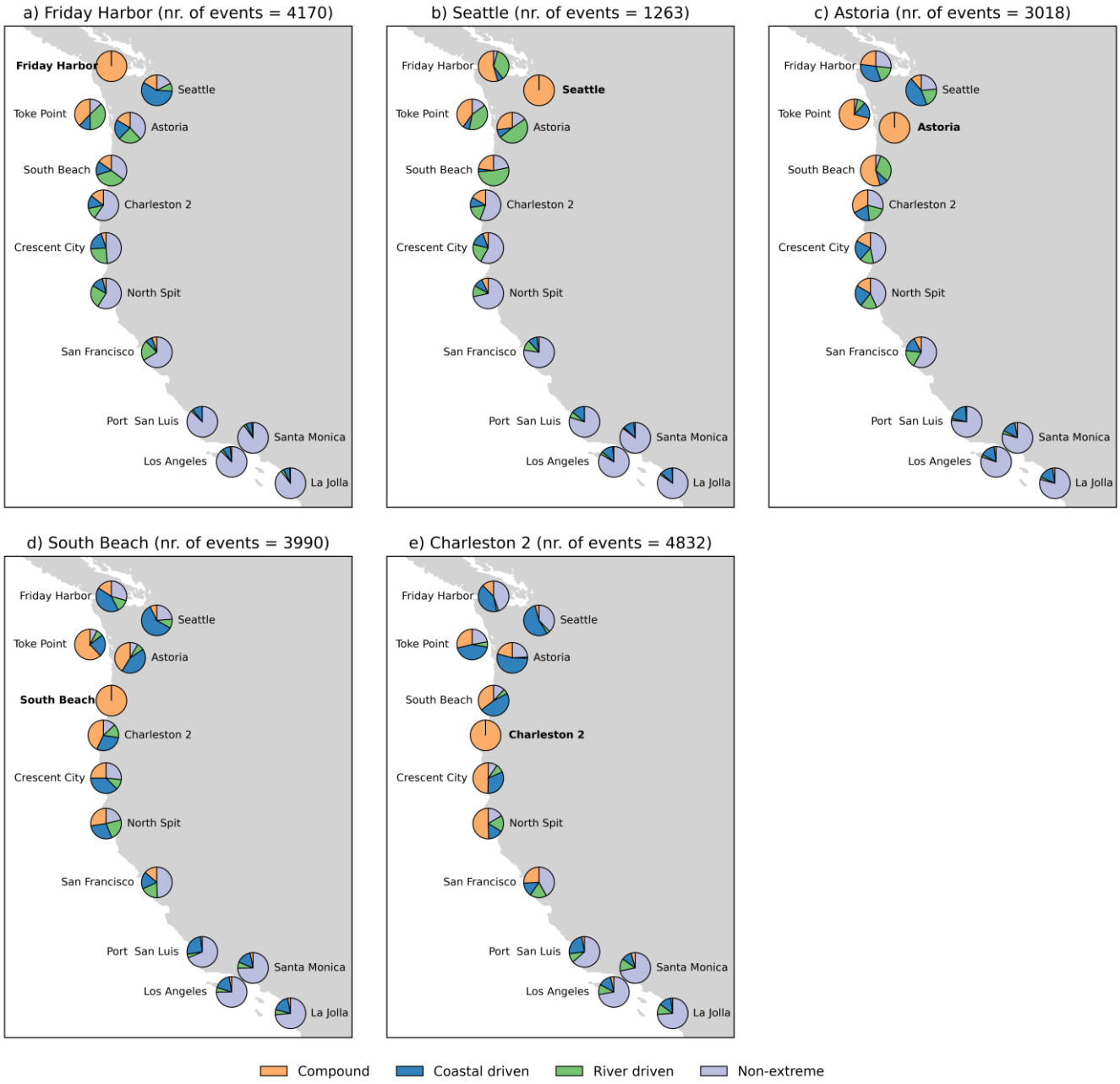

Figure S8: Relative frequency of different types of events given potential compound flooding occurs at a primary location for a) Friday Habor, b) Seattle, c) Astoria, d) South Beach, and e) Charleston on the U.S. West Coast. Potential compound flood event (orange) is defined for events with both total water levels and river discharges exceeding the 99th percentile. Blue refers to coastal driven events where only the total water level exceeds the 99th threshold, while green refers to river driven events where only the river discharge exceeds the 99th threshold. Purple refers to non-extreme events where none of the drivers exceed the threshold.

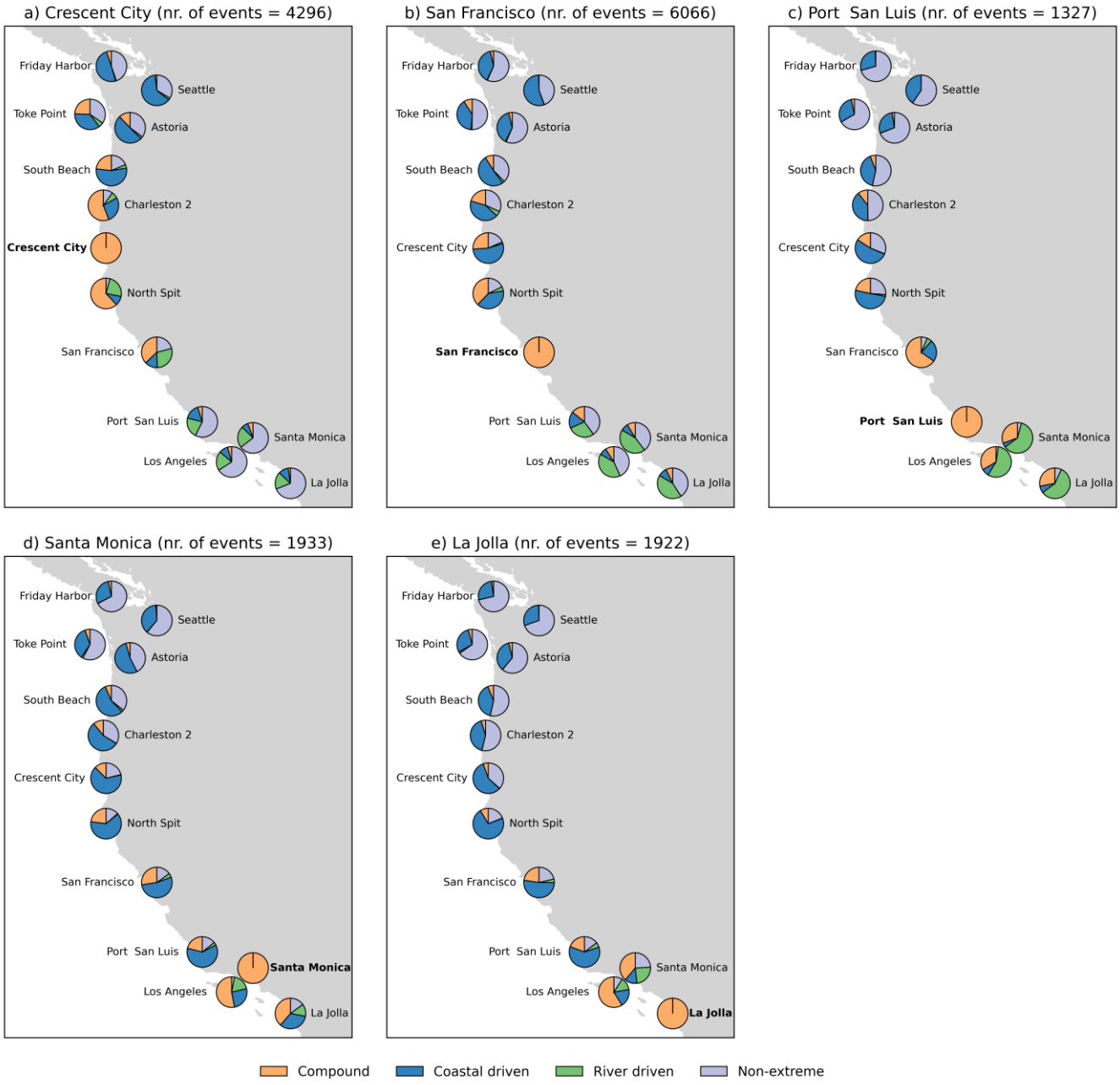

Figure S9: Relative frequency of different types of events given potential compound flooding occurs at a primary location for a) Cresent City, b) San Francisco, c) Port San Luis, d) Santa Monica, and e) La Jolla on the U.S. West Coast. Potential compound flood event (orange) is defined for events with both total water levels and river discharges exceeding the 99th percentile. Blue refers to coastal driven events where only the total water level exceeds the 99th threshold, while green refers to river driven events where only the river discharge exceeds the 99th threshold. Purple refers to non-extreme events where none of the drivers exceed the threshold.