DECADAL SEA LEVEL VARIABILITY ALONG THE UNITED STATES EAST COAST

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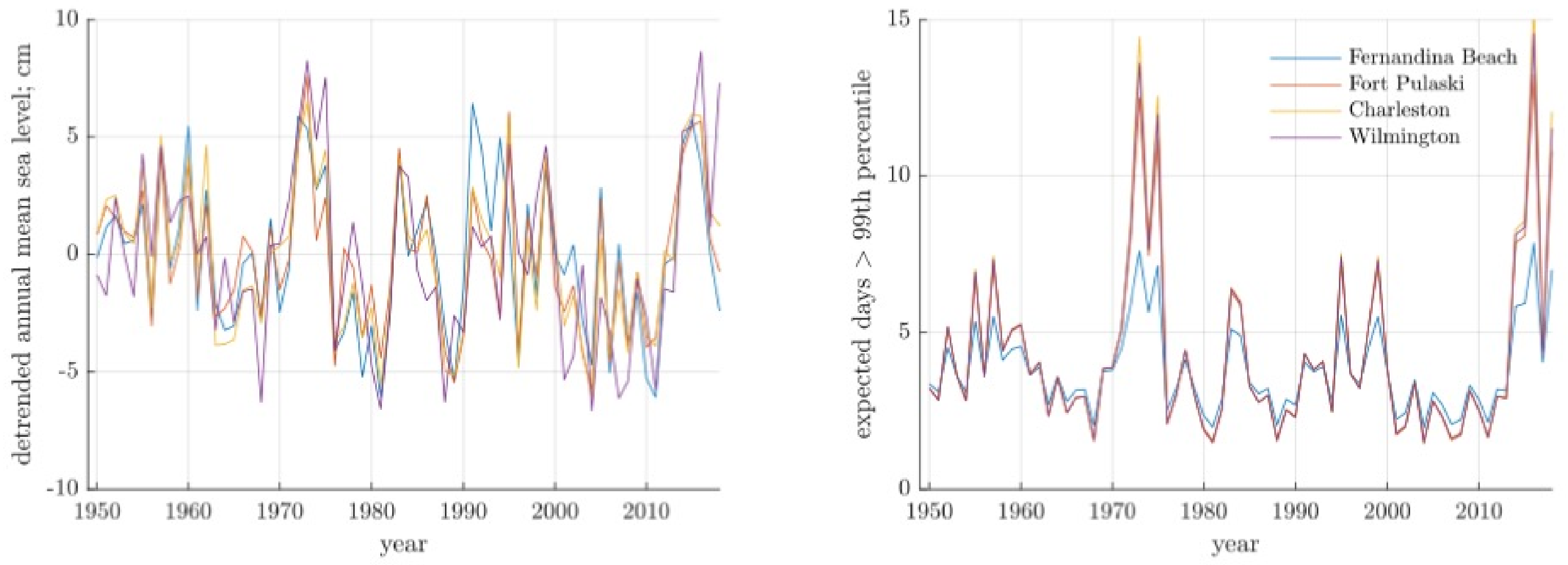
Summary and Motivation

Interannual to multi-decadal fluctuations in coastal (relative) sea level often overwhelm long-term secular trends, driving changes in the frequency and severity of coastal flooding, saltwater intrusion and coastal erosion, along large sections of coastline (see below for an example along the southeastern United States coast).



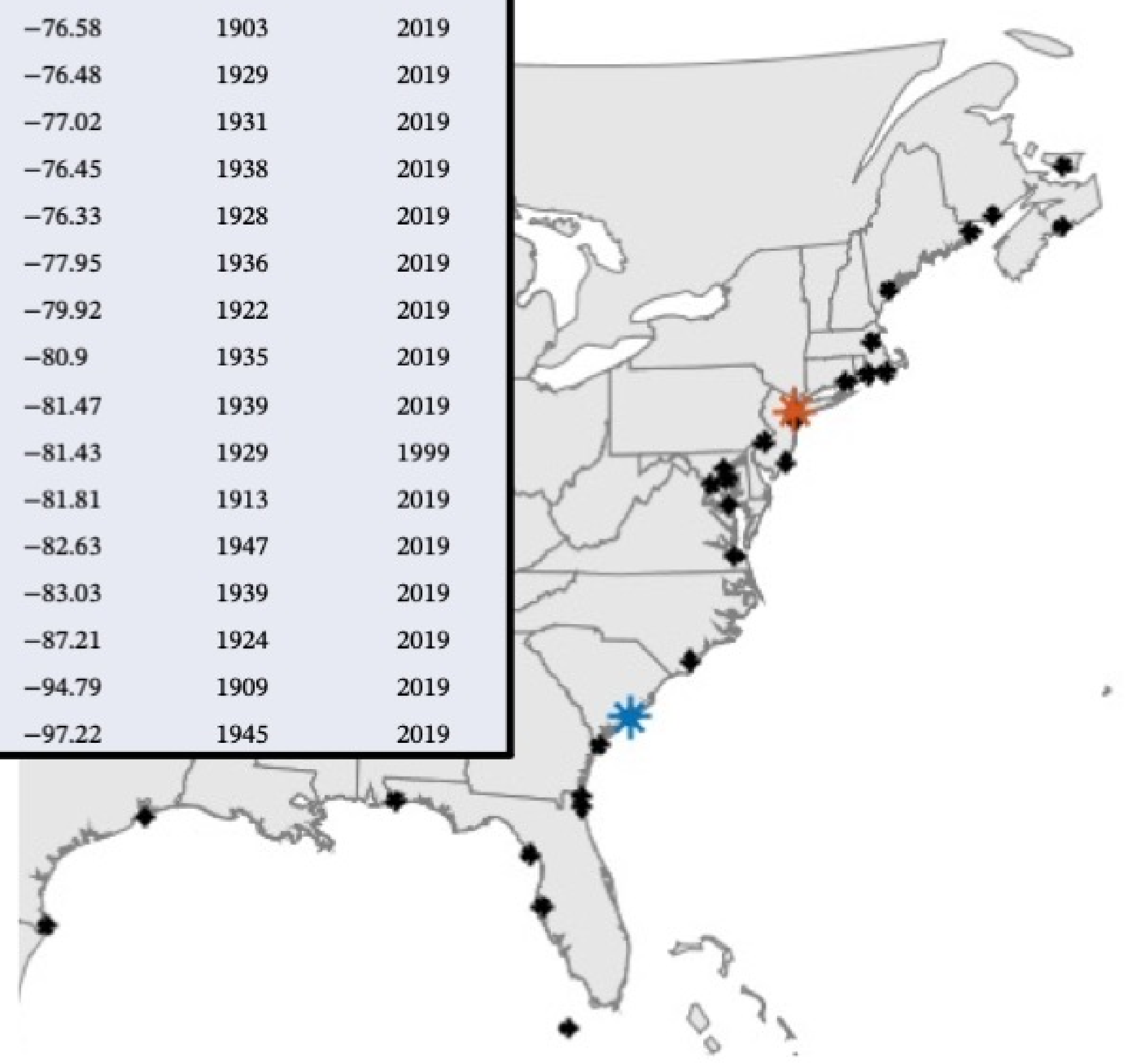
(Left) Detrended relative sea level from four tide gauges along the southeastern United States coast over the 1950-2018 period. (Right) Number of days per year with water levels exceeding the 99th percentile value at each tide gauge location (calculated using data and equation (2) from Buchanan et al., 2017). Data from Permanent Service for Mean Sea Level.

Predictions of large-scale, sustained, sea level anomalies along the densely-populated United States East Coast are thus of considerable societal value. However, robust predictions require additional efforts to: 1) characterize the nature of observed sea level variability; 2) identify key underlying physical processes; and 3) assess the predictability of key processes. This poster summarizes a recent paper (Little et al. 2021) pursuing the first objective. It is intended to inspire discussion of the climate and ocean dynamics underlying sea level variability at this frequency band.

Data and Methods

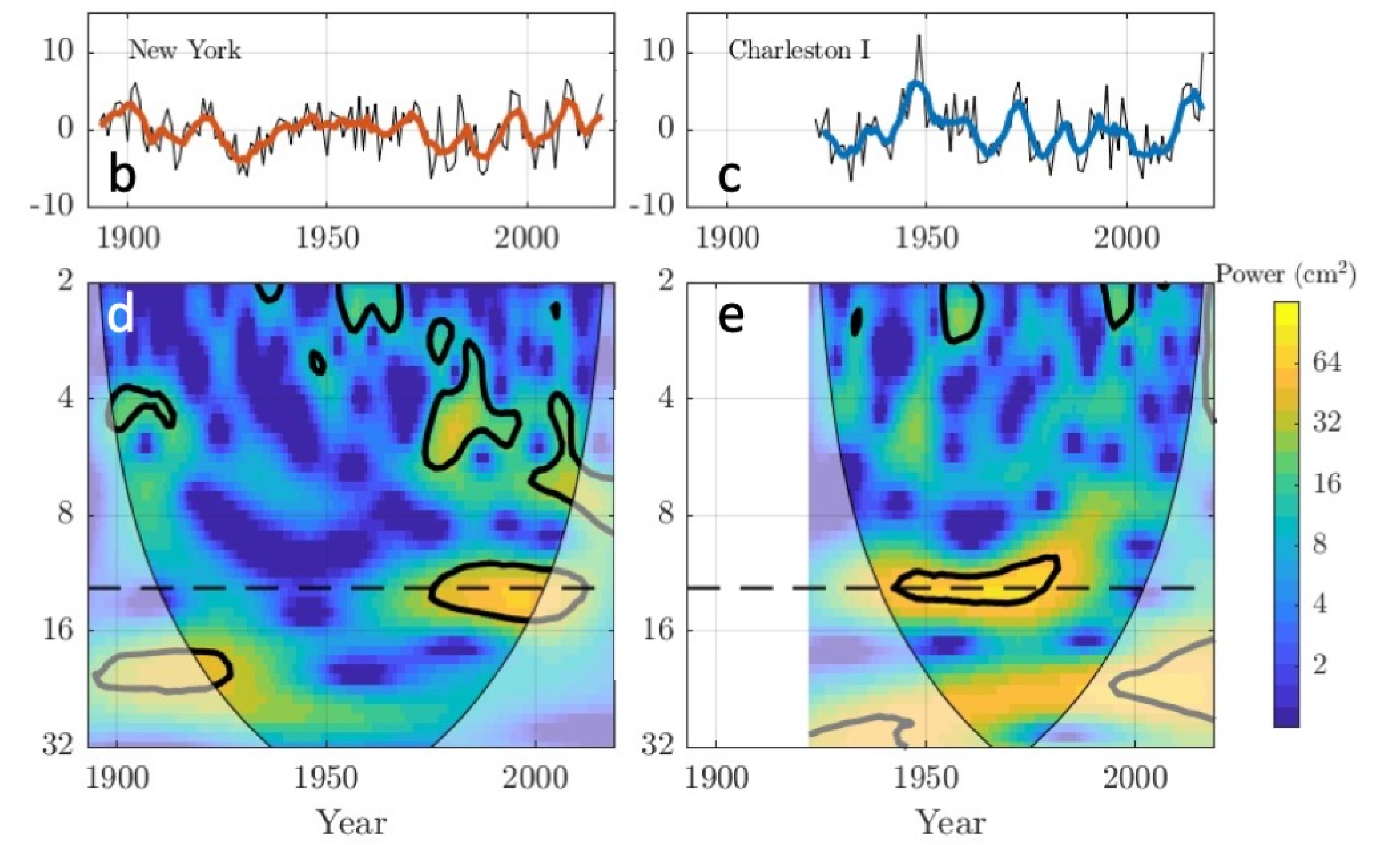
Tide gauge	Latitude	Longitude	First full year	Last full year
Charlottetown	46.23	−63.12	1938	2018
Halifax	44.67	−63.58	1941	2013
Saint John, N.B.	45.27	−66.07	1941	2018
Eastport	44.9	−66.98	1930	2019
Portland (Maine)	43.66	−70.25	1912	2019
Boston	42.35	−71.05	1921	2019
Woods Hole (Ocean. Inst.)	41.52	−70.67	1933	2019
Newport	41.51	−71.33	1931	2019
New London	41.36	−72.09	1939	2019
New York (The Battery)	40.7	−74.01	1893	2019
Sandy Hook	40.47	−74.01	1933	2019
Philadelphia (Pier 9N)	39.93	−75.14	1901	2019
Atlantic City	39.35	−74.42	1912	2019
Baltimore	39.27	−76.58	1903	2019
Annapolis (Naval Academy)	38.98	−76.48	1929	2019
Washington DC	38.87	−77.02	1931	2019
Solomon's Island (Biol. Lab.)	38.32	−76.45	1938	2019
Sewells Point, Hampton Roads	36.95	−76.33	1928	2019
Wilmington	34.23	−77.95	1936	2019
Charleston I	32.78	−79.92	1922	2019
Fort Pulaski	32.03	−80.9	1935	2019
Fernandina Beach	30.67	−81.47	1939	2019
Mayport	30.39	−81.43	1929	1999
Key West	24.55	−81.81	1913	2019
St. Petersburg	27.76	−82.63	1947	2019
Cedar Key II	29.14	−83.03	1939	2019
Pensacola	30.4	−87.21	1924	2019
Galveston II, Pier 21, TX	29.31	−94.79	1909	2019
Port Isabel	26.06	−97.22	1945	2019

- **29 tide gauges with 70+ year records (from Permanent Service for Mean Sea Level)**
- **Linear trends over period of record removed**
- **Uncertainty assessed using Monte-Carlo techniques and an AR(1) assumption**



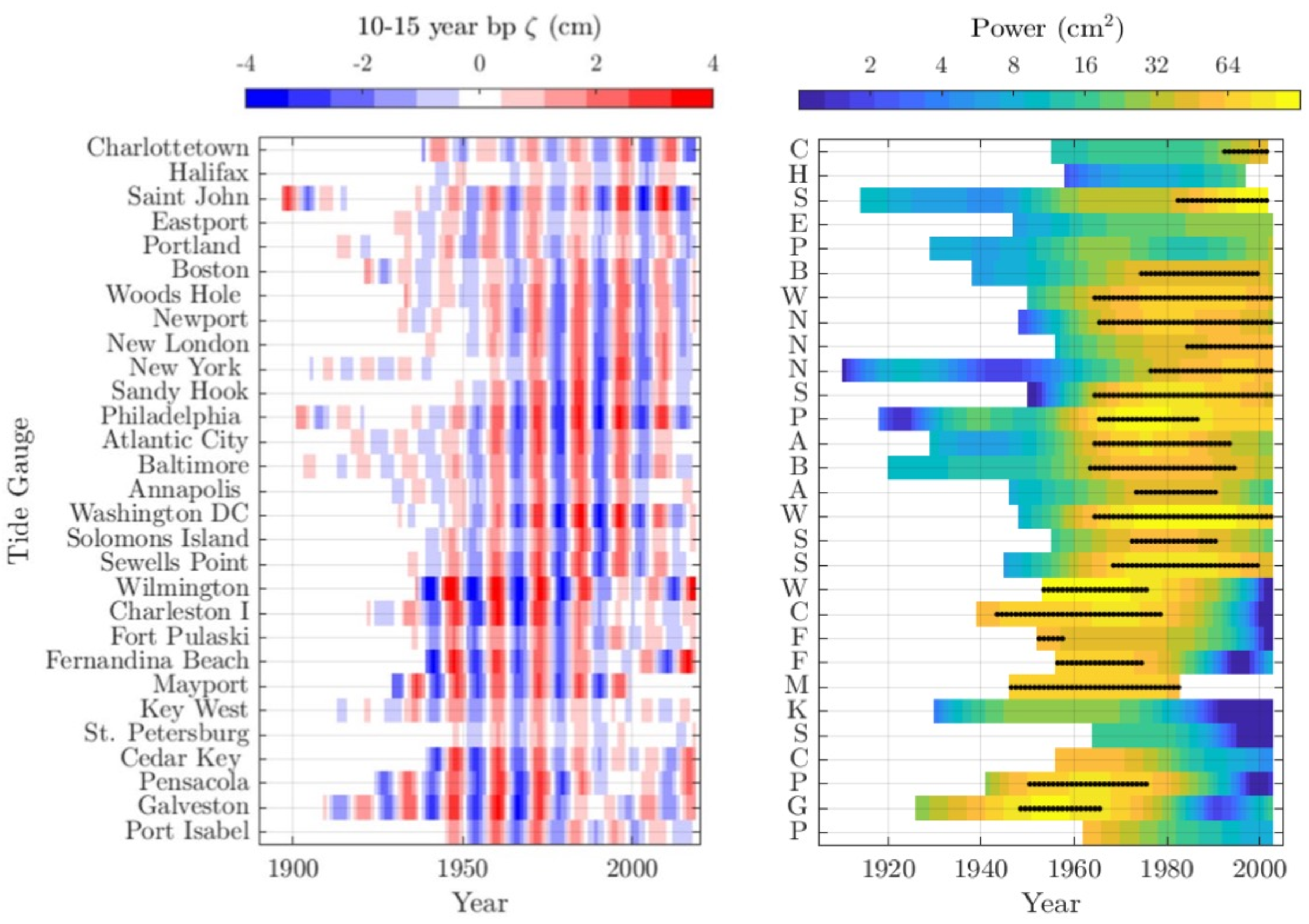
Location of 29 tide gauges employed in this analysis, with colors indicating the two highlighted tide gauges (Charleston I, blue; the Battery/New York City, orange).

Wavelet spectra at two tide gauges



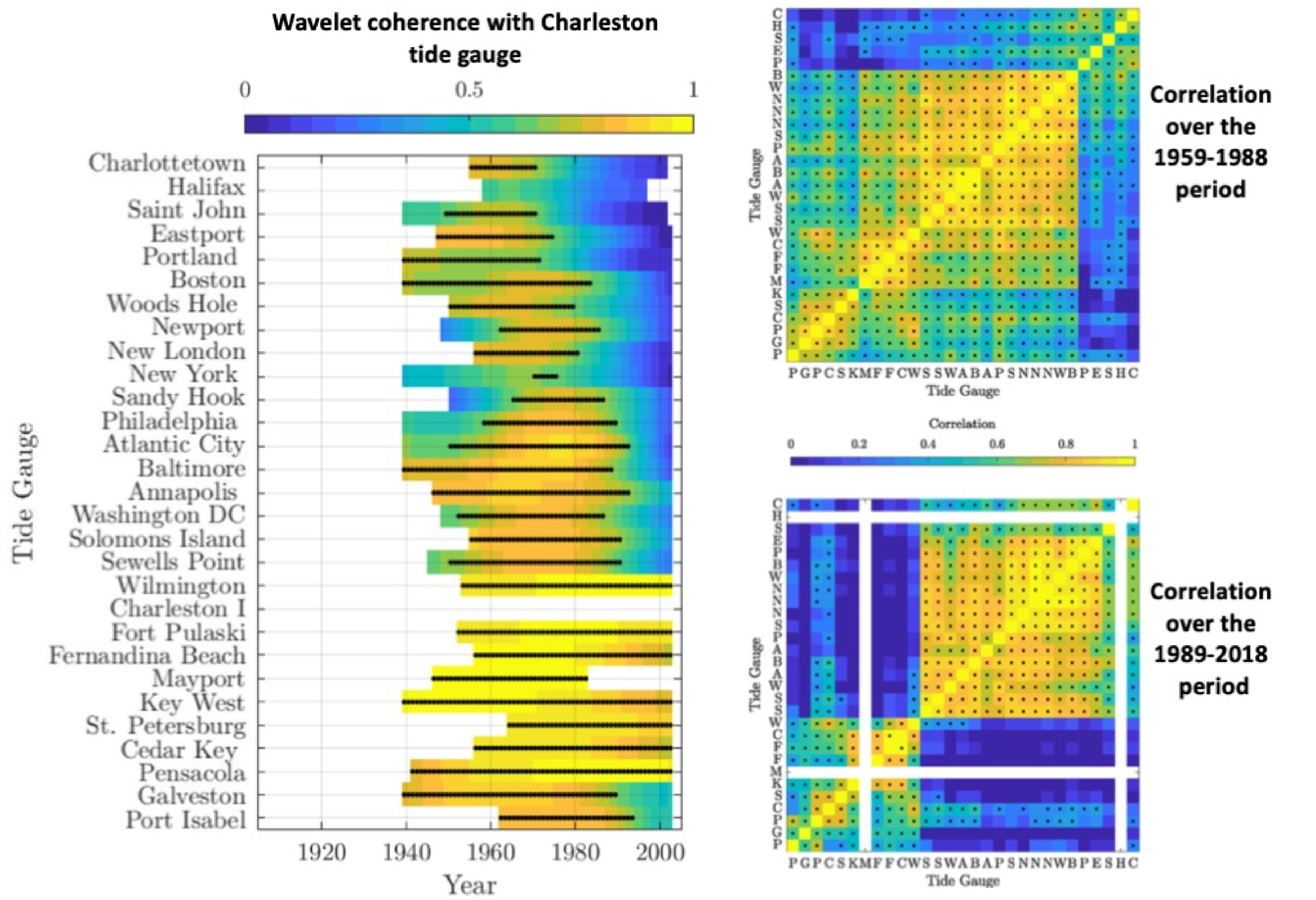
(Top) Detrended, infilled, annual mean relative sea level (in cm) at the Battery (New York City, left) and (right) Charleston, South Carolina tide gauges. 5-year smoothed timeseries at each tide gauge are shown with thick colored lines. (Bottom left) Continuous wavelet power spectra (in cm^2, on a $\log_2$ scale) of relative sea level at the Battery (left) and (right) Charleston tide gauges. Transparent mask indicates the cone of influence. Solid black lines denote significance at the $p < 0.1$ level relative to 300 resampled time series with the same AR(1) coefficients. Black dashed line indicates a period of 12.4 years.

Along-coast power at 10-15 year periods



(Left) 10-15 year bandpass filtered detrended relative sea level (in cm) at all tide gauges. (Right) Power centered on a period of 12.4 years for all tide gauges, only shown for times outside the cone of influence. Significance at the $p < 0.1$ level is shown with stippling.

Time-dependent alongcoast coherence



(Left) Wavelet coherence of east coast tide gauges with the Charleston I tide gauge centered on a period of 12.4 years. (Right) Cross-correlation of detrended relative sea level between pairs of tide gauges over the (top) 1959-1988 and (bottom) 1989-2018 epoch. Significance at the $p < 0.1$ level is shown with stippling.

Conclusions

- ☆ **Multidecadal epochs of enhanced (up to ~10 cm) decadal sea level variability, explaining a significant fraction of overall sea level variance, are evident at most tide gauges along the United States East Coast.**
- ☆ **Decadal sea level variability was coherent across Cape Hatteras from approximately 1960 to 1990, but has since been incoherent.**
- ☆ **Previous interpretations of alongcoast covariance, and its underlying physical drivers, are clouded by time- and frequency-dependence.**
- ☆ **This understanding of the spatiotemporal covariance *should* help clarify the relevant mechanisms, and their predictability!**

Questions for discussion

1. **What are the key processes underlying 10-15 year period relative sea level variability, and are they predictable?**
2. **Is the same process responsible for sea level variability in this frequency band in coastal sectors north and south of Cape Hatteras?**
3. **Does the tide gauge record capture a multidecadal-to-centennial modulation or the emergence of a secular trend?**
4. **If it is a modulation, is it related to multidecadal variability (e.g. AMV/AMOC) or closely-spaced "interfering modes" of decadal variability?**
5. **How do longer-term changes influence variability at decadal periods (e.g. stratification, Gulf Stream and/or westerly position)?**

Acknowledgments

- **NSF grant OCE-1805029**
- **Permanent Service for Mean Sea Level (http://www.psmsl.org/data/obtaining/).**
- **Cross-wavelet and wavelet coherence toolbox for MATLAB (http://grinsted.github.io/wavelet-coherence/)**
- **Christopher Piecuch (WHOI) and Rui Ponte (AER)**

Geophysical Research Letters
RESEARCH LETTER
10.1029/2021GL093675

North American East Coast Sea Level Exhibits High Power and Spatiotemporal Complexity on Decadal Timescales

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