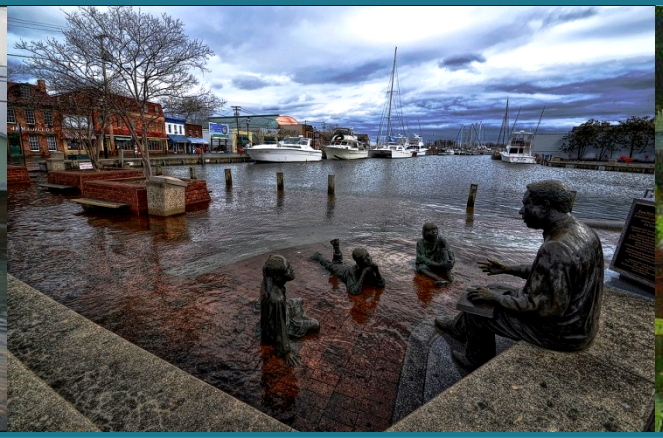
From the Extreme to the Mean: Effects of Sea Level Rise on Coastal Flooding

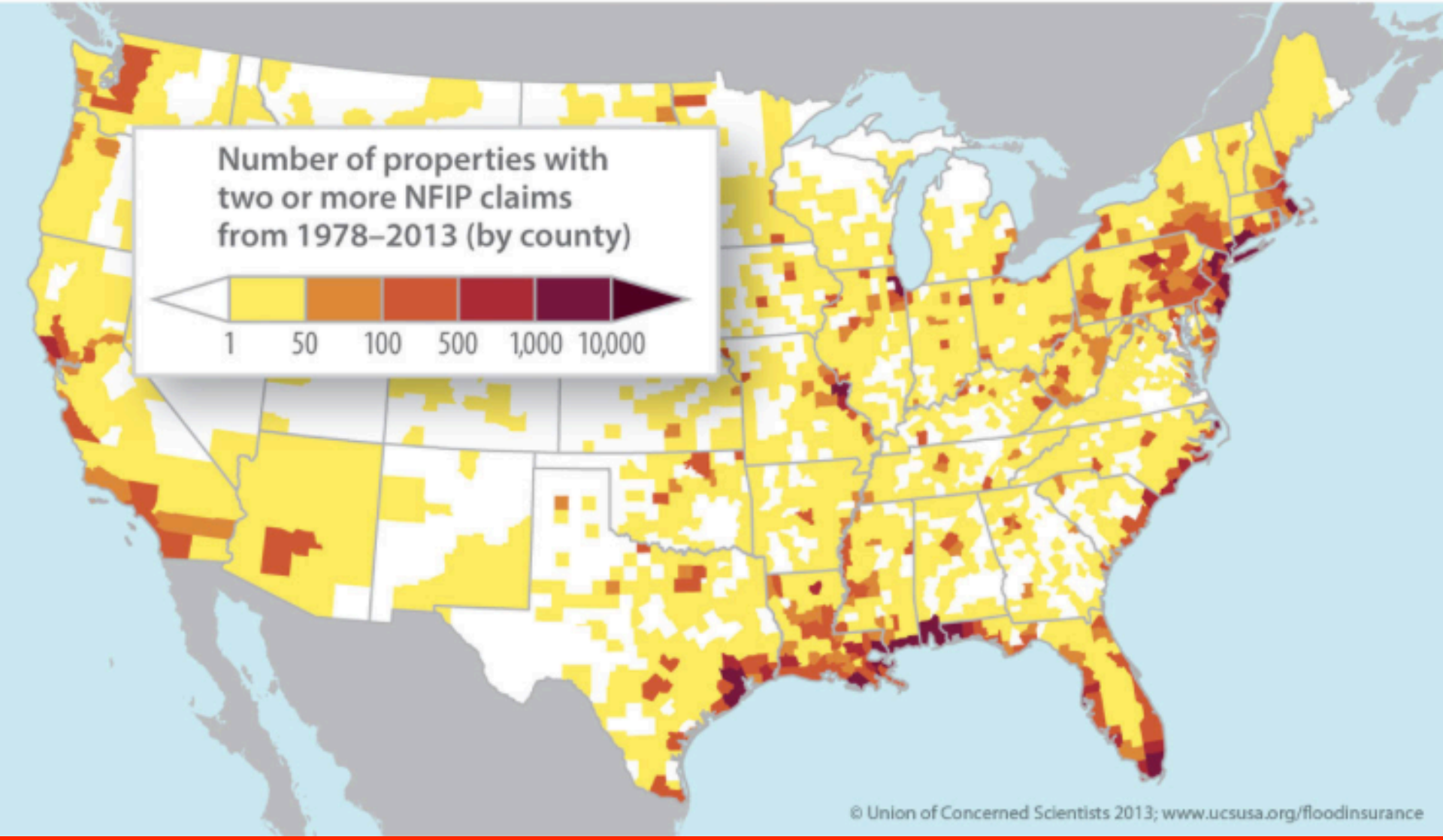


Integrating Coastal Flood Research, Modeling and Monitoring to Improve Coastal Resiliency in the Mid-Atlantic

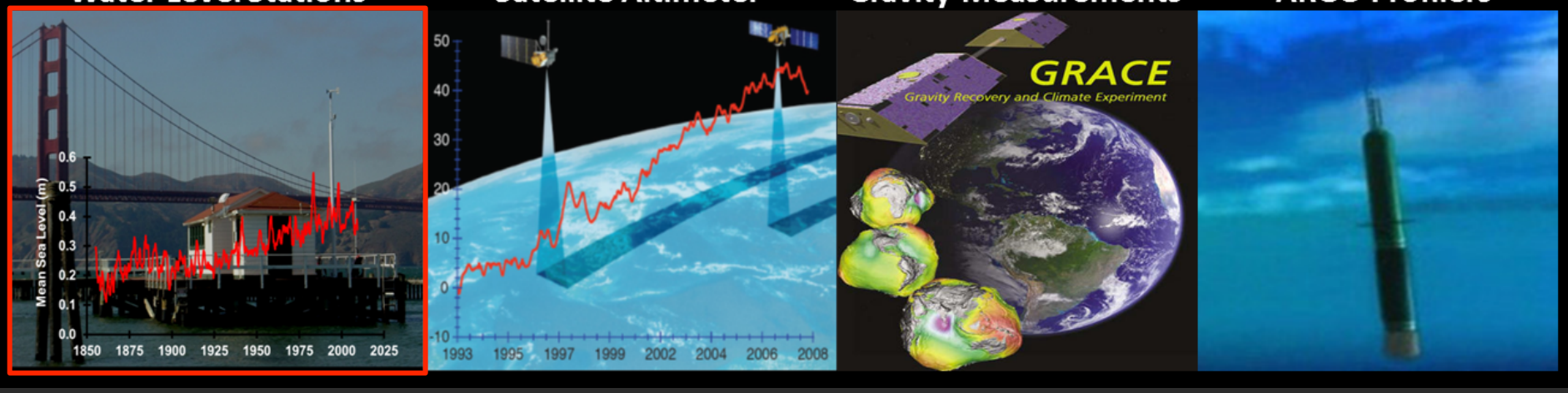
September 16, 2015

Dr. William Sweet
NOAA CO-OPS Oceanographer

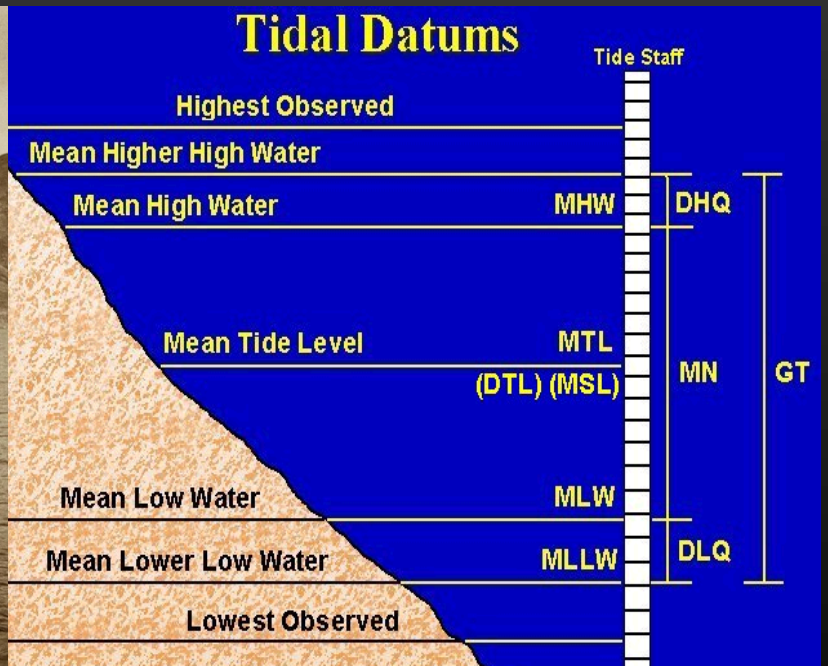
Repetitive-Loss Properties by U.S. County



Monitoring Global SLR and Relative Impacts from Tide Gauges

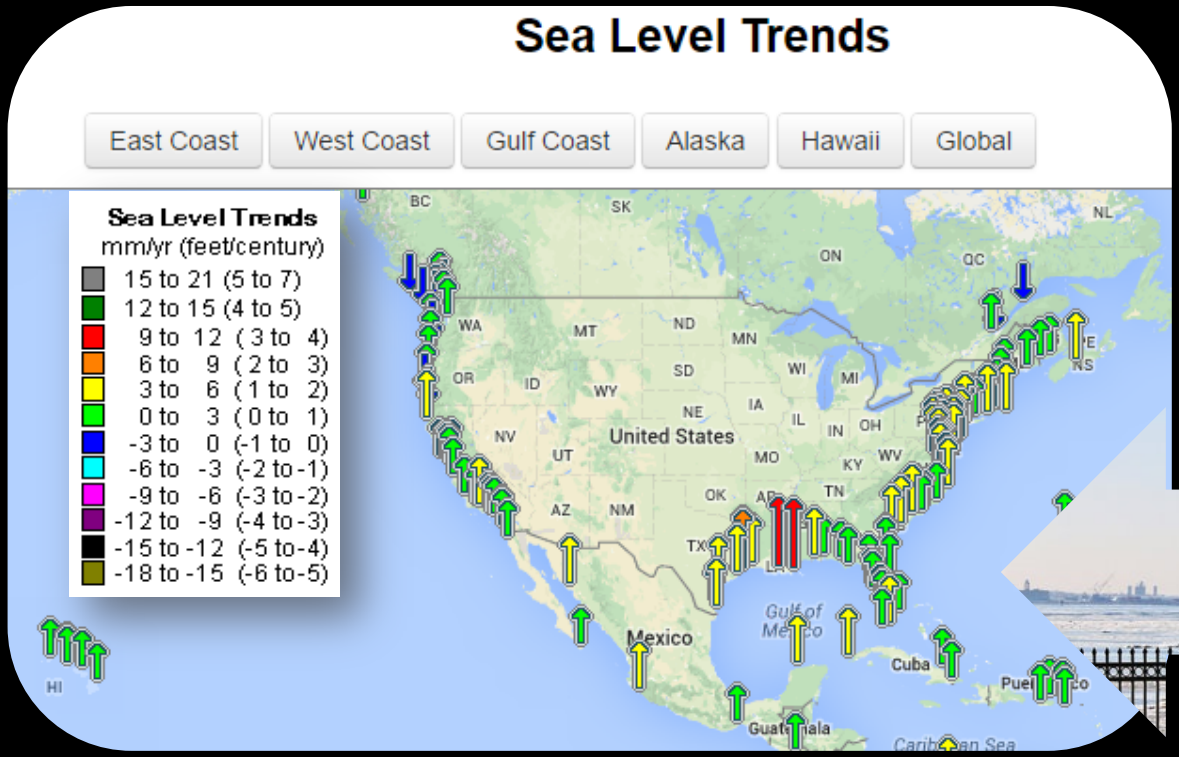


NOAA tide gauges provide local coastal flood information



- Benchmark network and tidal-geodetic connection
- Relative SLR trends
- Vertical land motion
- Extremes and Impacts

Relative Sea Level Rise (SLR_{rel})



http://tidesandcurrents.noaa.gov/sltrends

- The seas are rising
- The land is sinking in many locations

http://tidesandcurrents.noaa.gov/publications/Technical_Report_NOS_CO-OPS_065.pdf

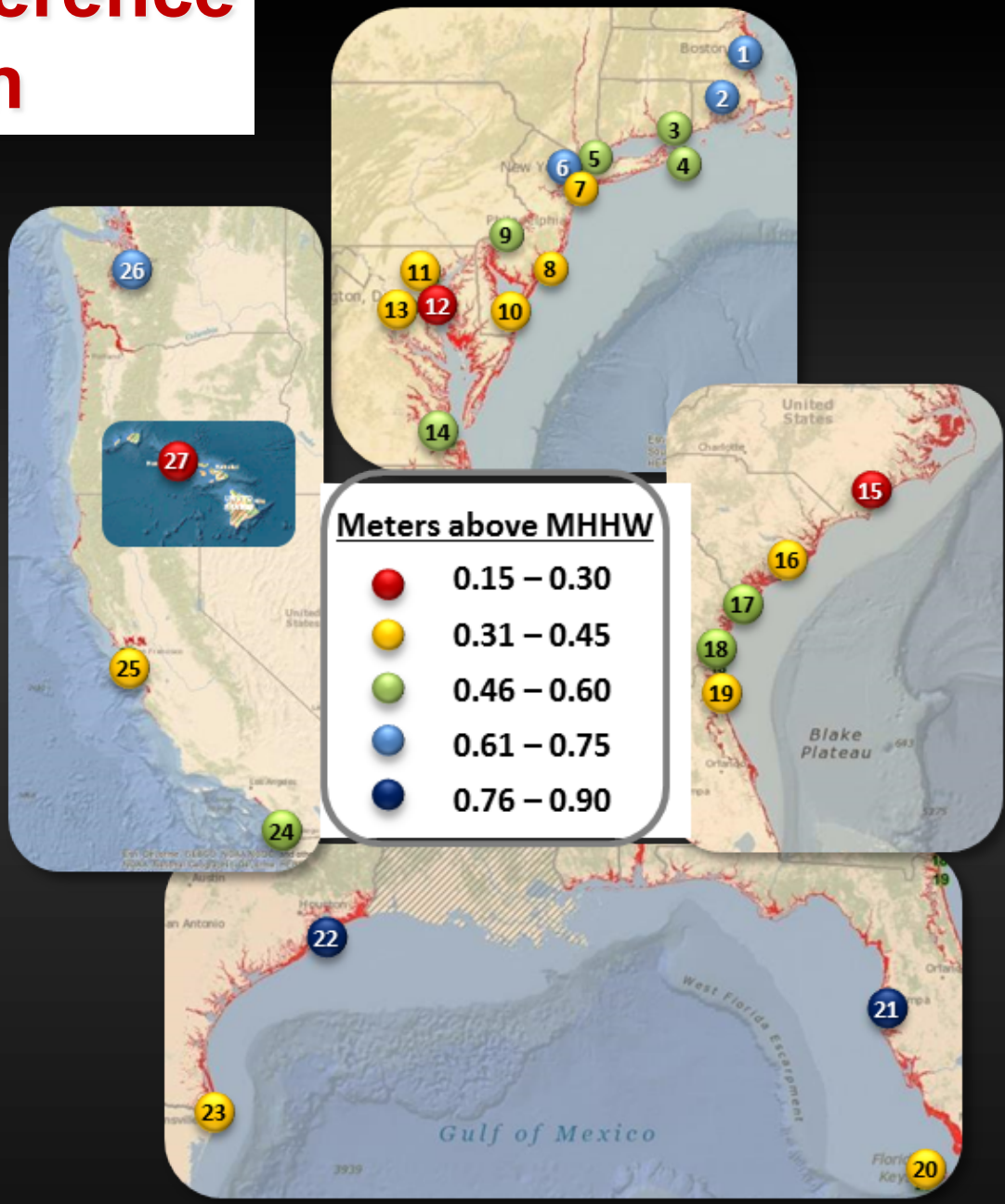
Thresholds of “Concern”

Exposure thresholds of systems to flooding at which functional degradation occurs...

Today's Frame of reference …looking down

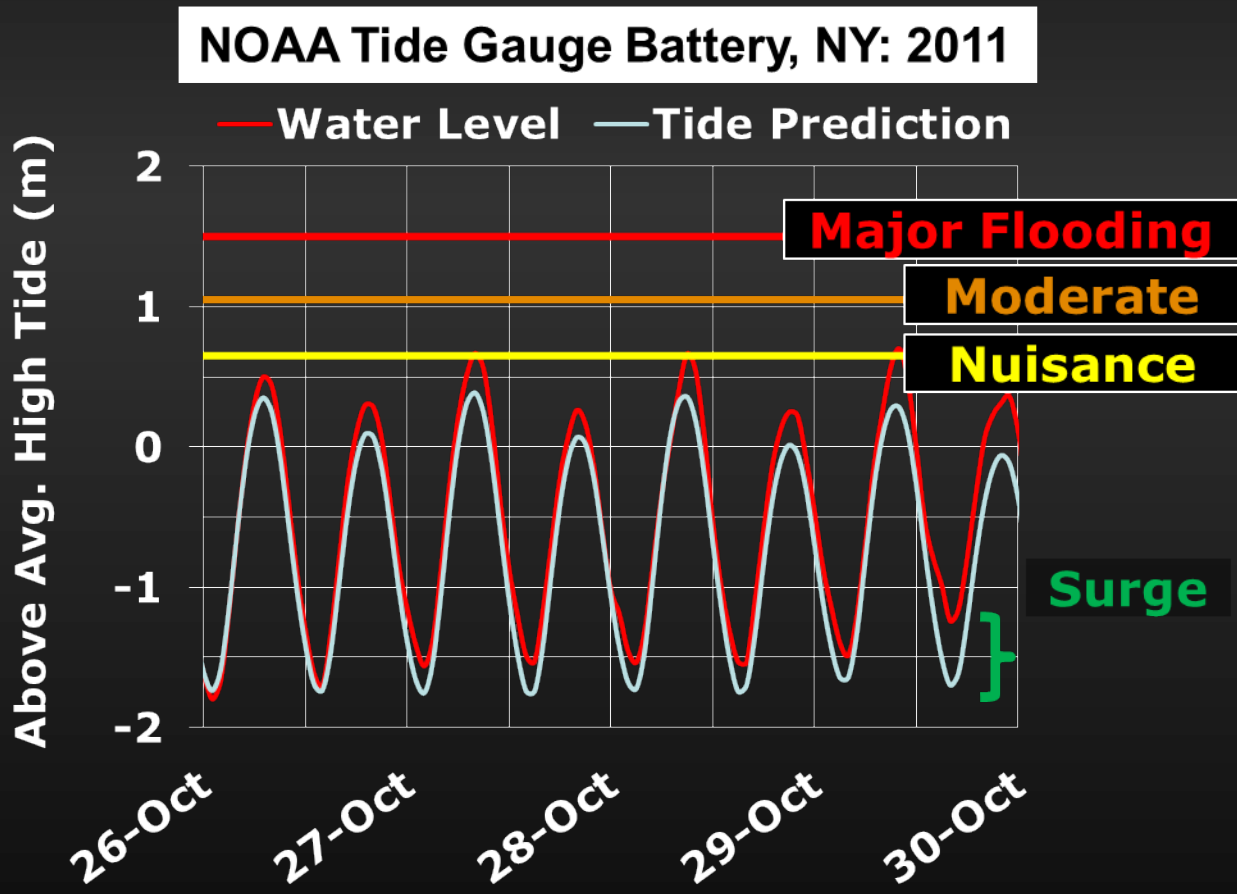
Today's infrastructure:

Vulnerable to minor nuisance flooding 1-2' above avg. highest tide

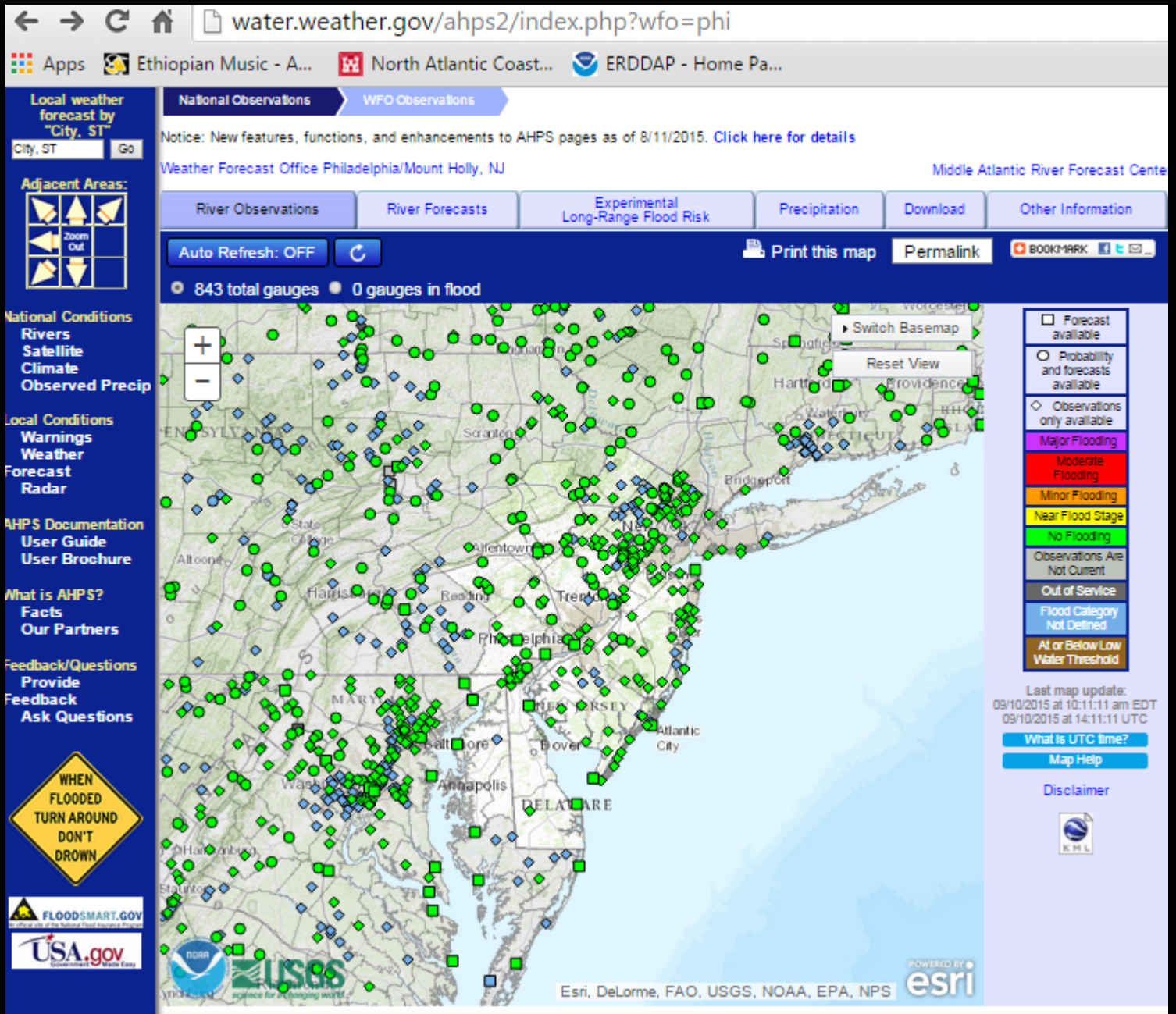


NOAA Tide Gauges and Coastal Flooding

Tide gauges provide long records of high-water events whose impacts are defined by NOAA NWS

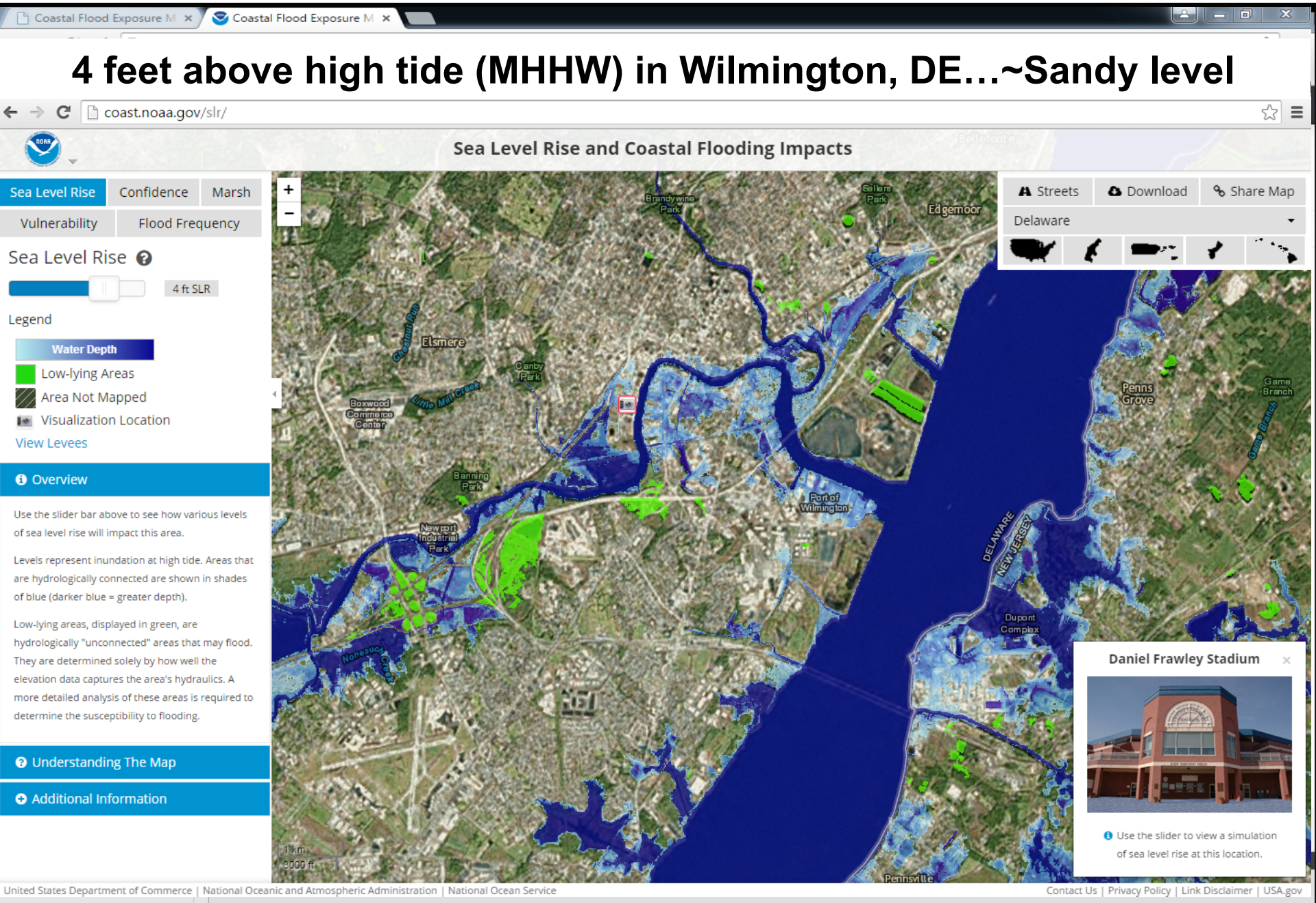


What is “Nuisance” Tidal Flooding?



At Risk from Nuisance+ Level Flooding

4 feet above high tide (MHHW) in Wilmington, DE…~Sandy level



What Does Nuisance Flooding Look Like?

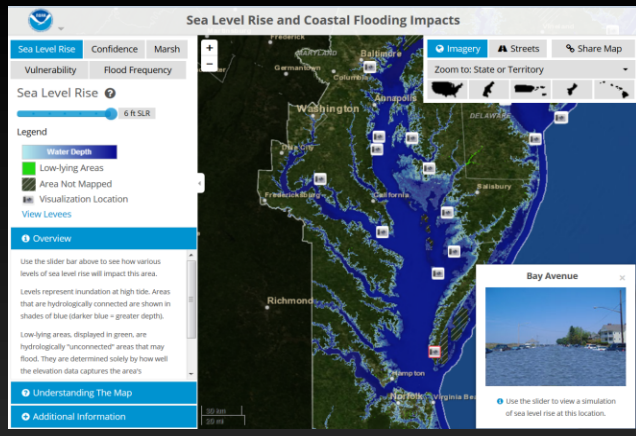
(From: Picasa, King Tide in the NY-NJ Harbor Estuary)

What are the effects of SLR?

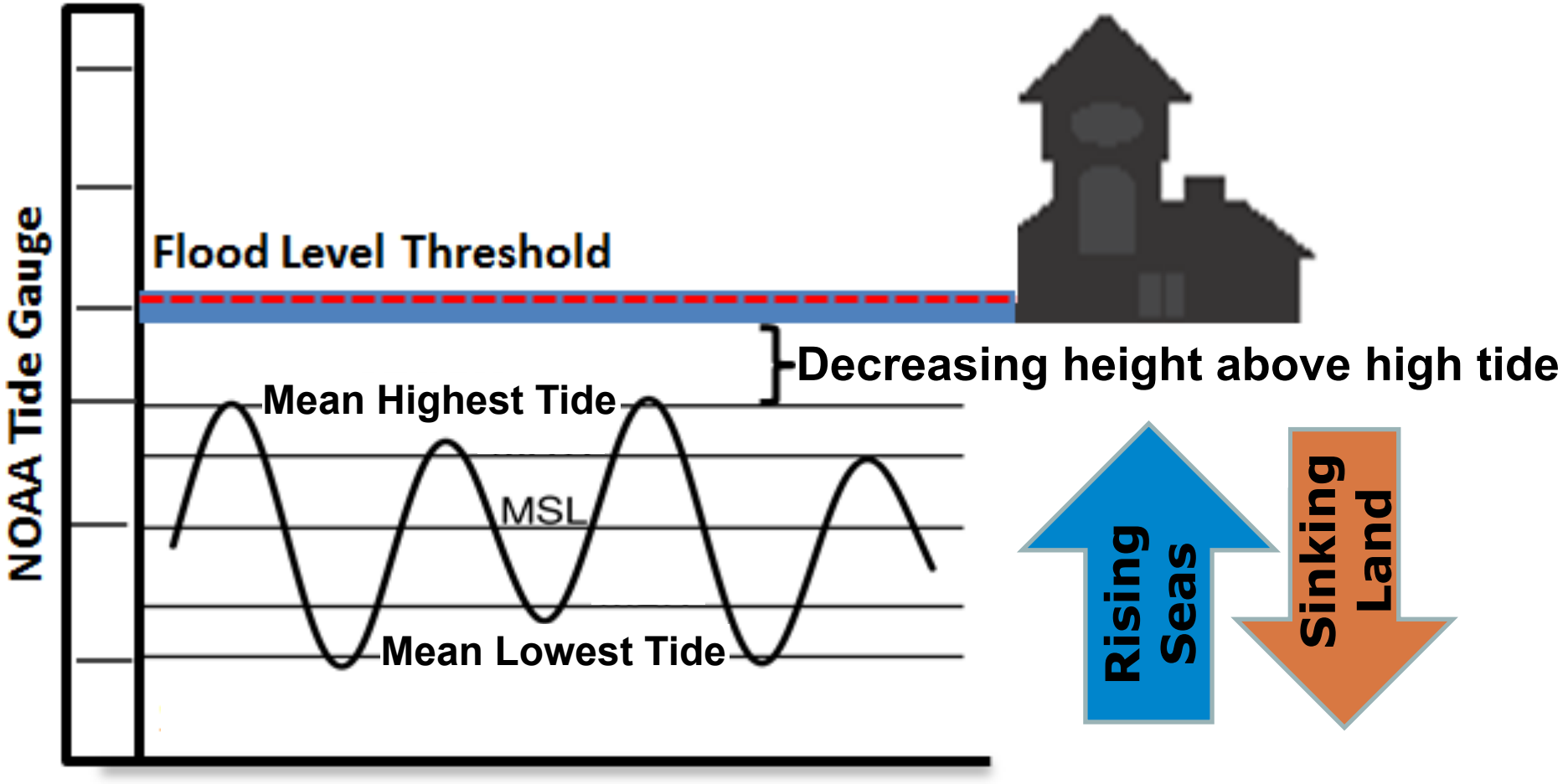
1. SLR_{rel} increases perennial inundation
   - difficult to sense "mean" changes … tides and storms dominate

2. Exacerbates extreme probabilities
   - obscured by rarity of events

3. Exacerbates nuisance flooding
   - more tangible indicator of climate change-related SLR



Dylan's B-side hit: the tides…they are a changing

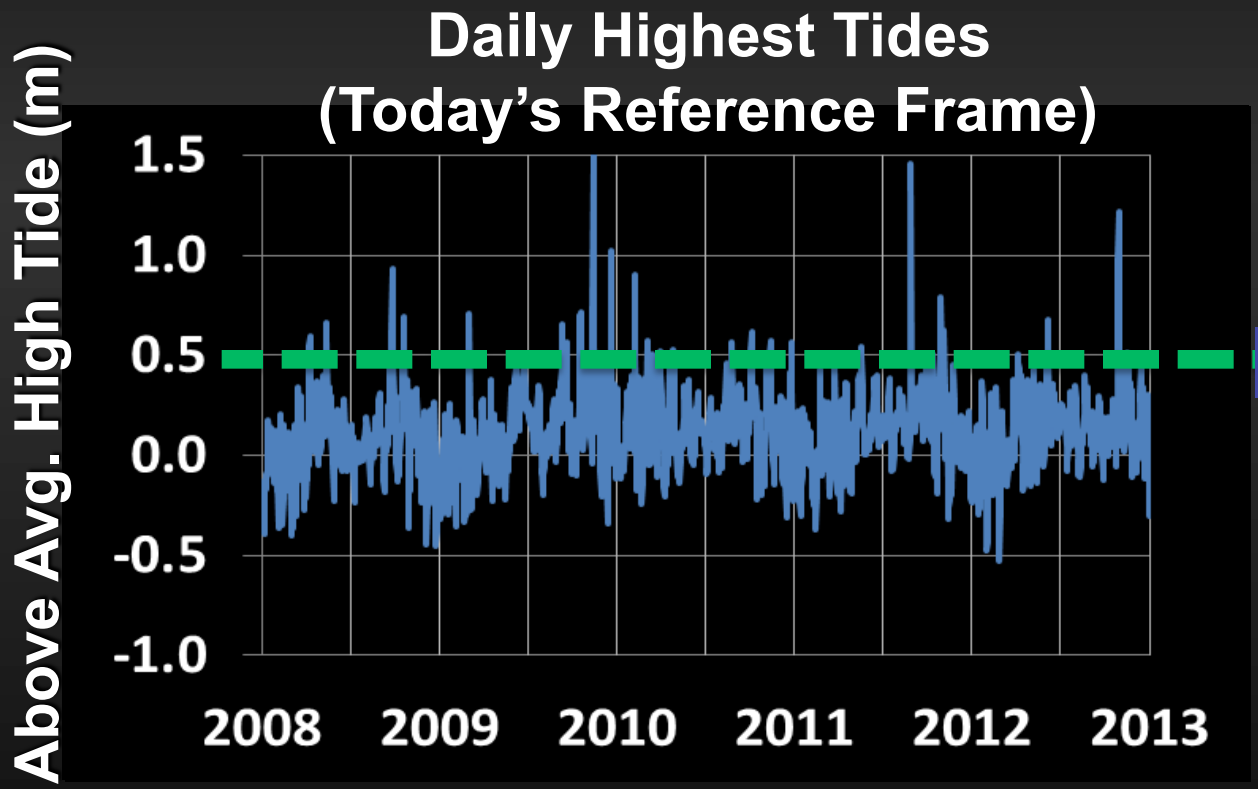


"Then" flooding occurred during big storms.

"Now" sunny-day nuisance urban flooding is common.

NOAA Tide Gauges and Nuisance Coastal Flooding

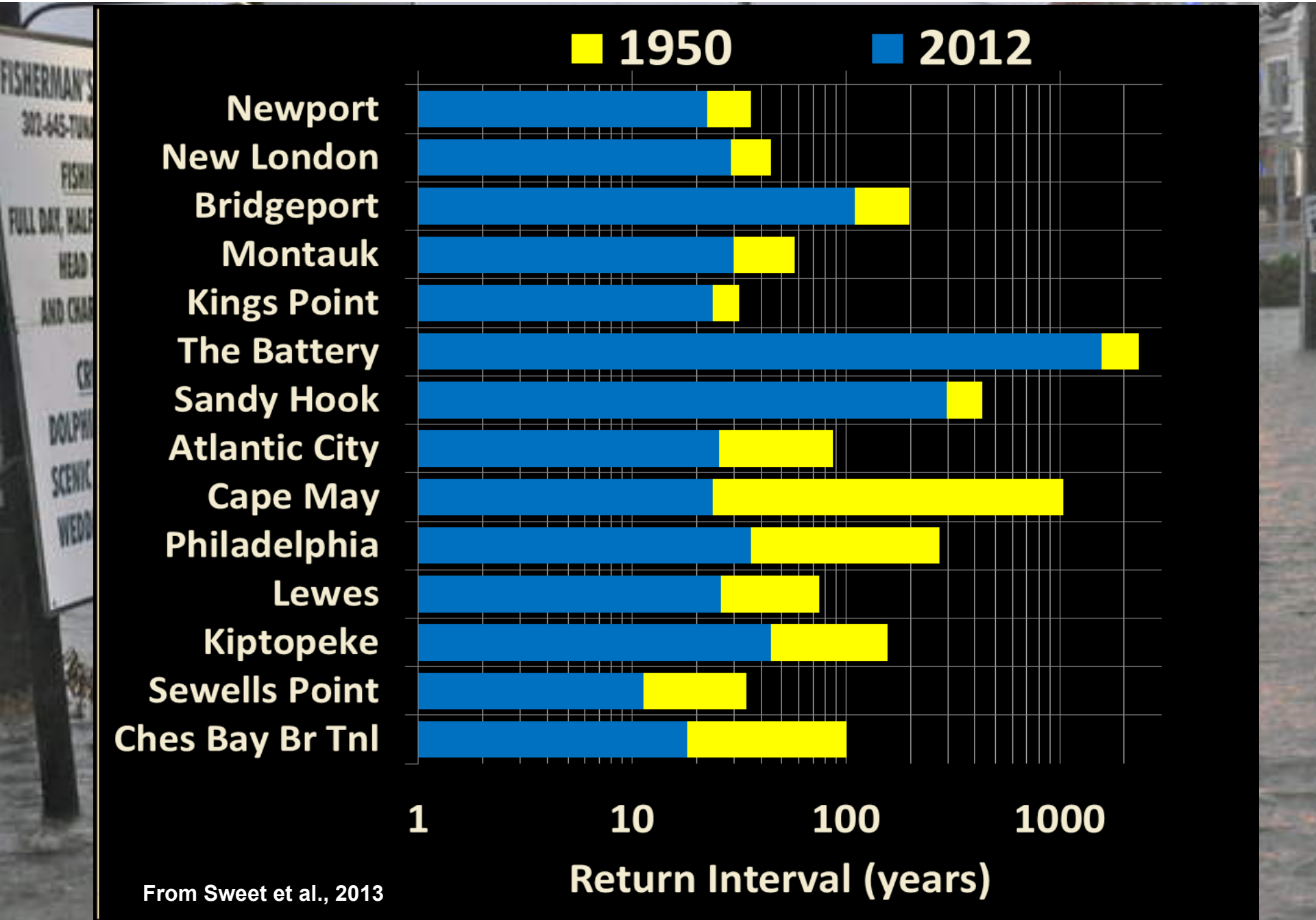
Steady sea level rise ~ accelerated impacts (East & Gulf Coasts)



Nuisance Flood Level

Example from
Norfolk, VA

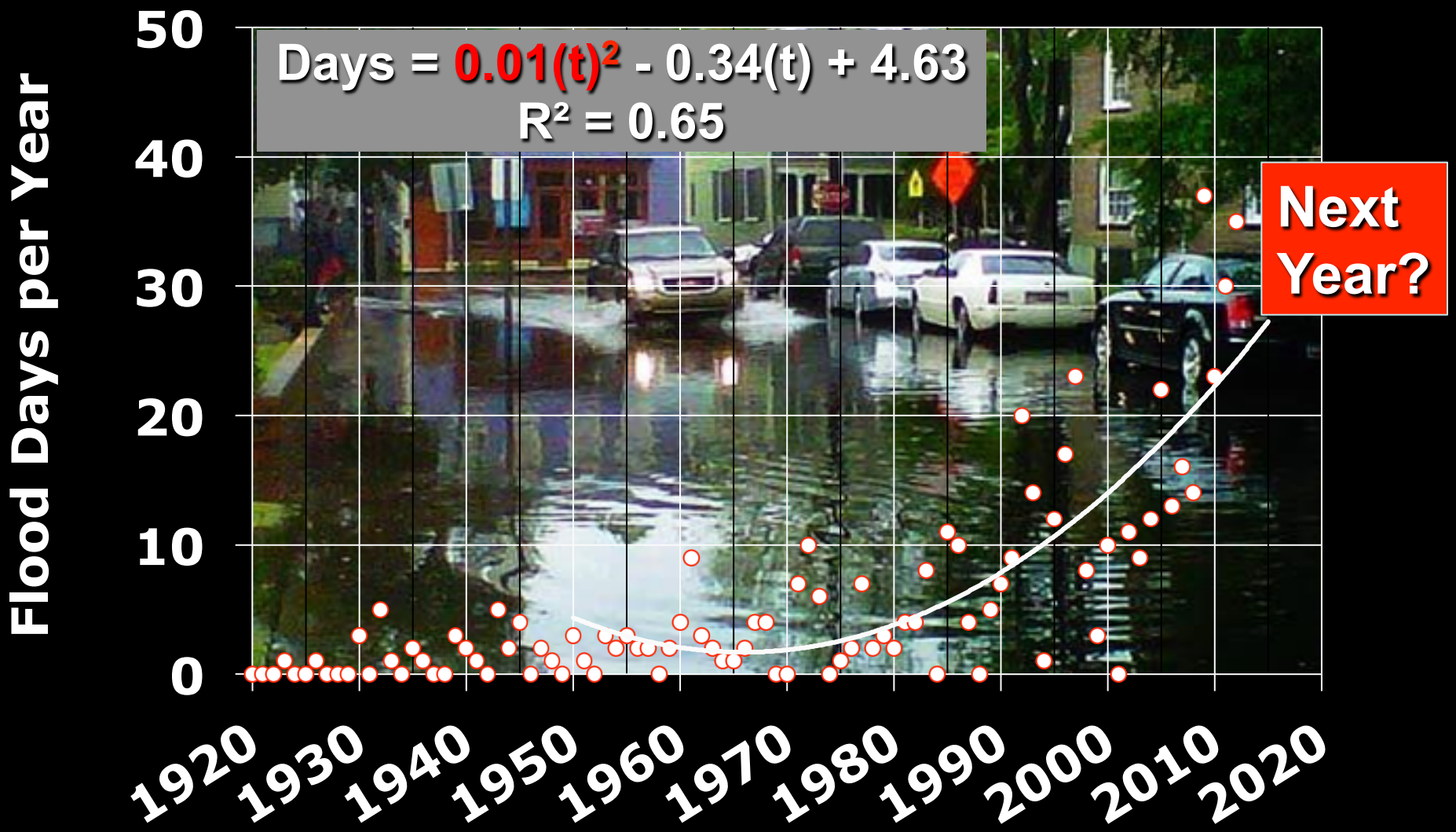
General Nature of the Problem: Shifting Geometry



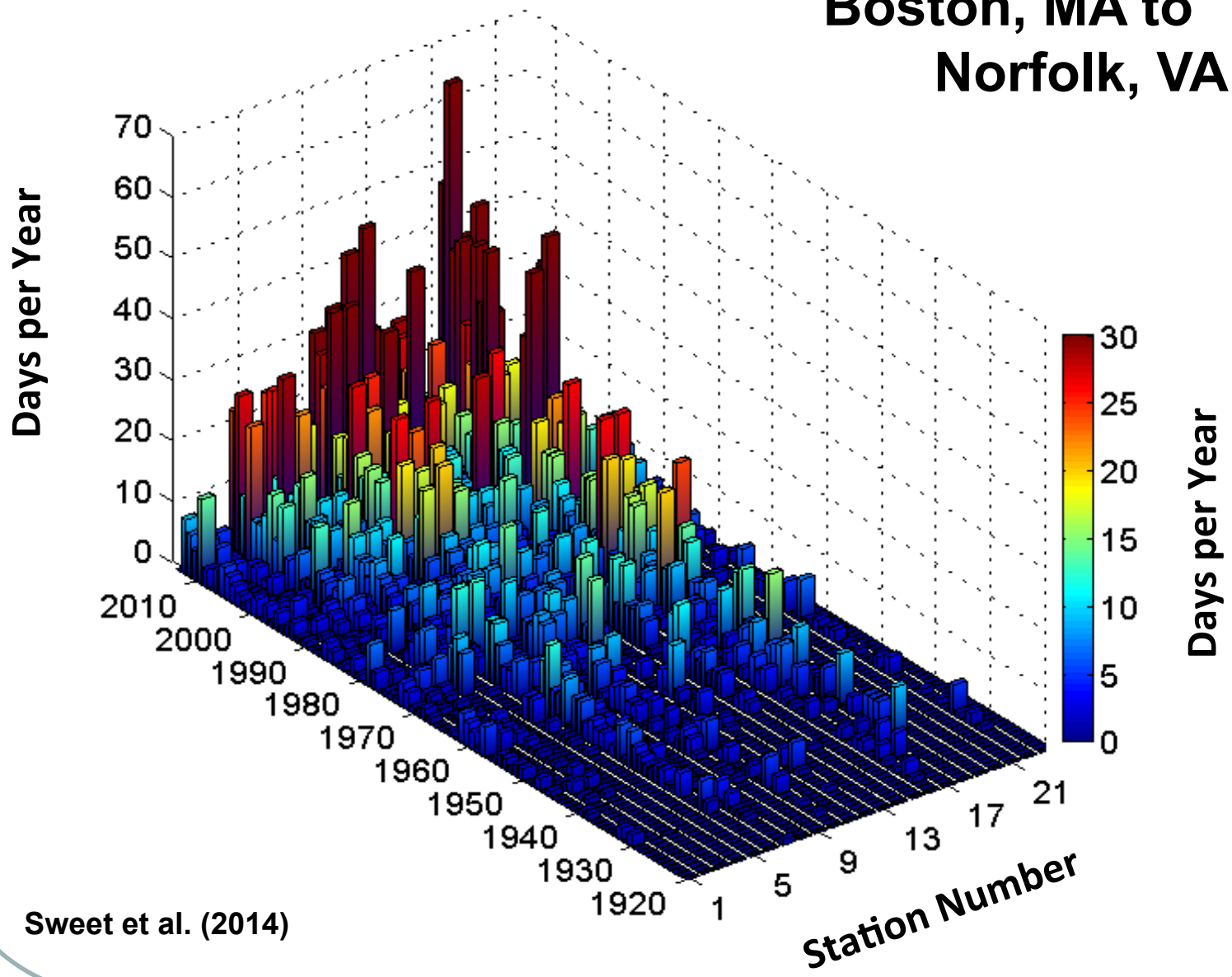
From Sweet et al., 2013

Atlantic City, NJ: Days with Nuisance Level Flooding

Accelerated Impacts

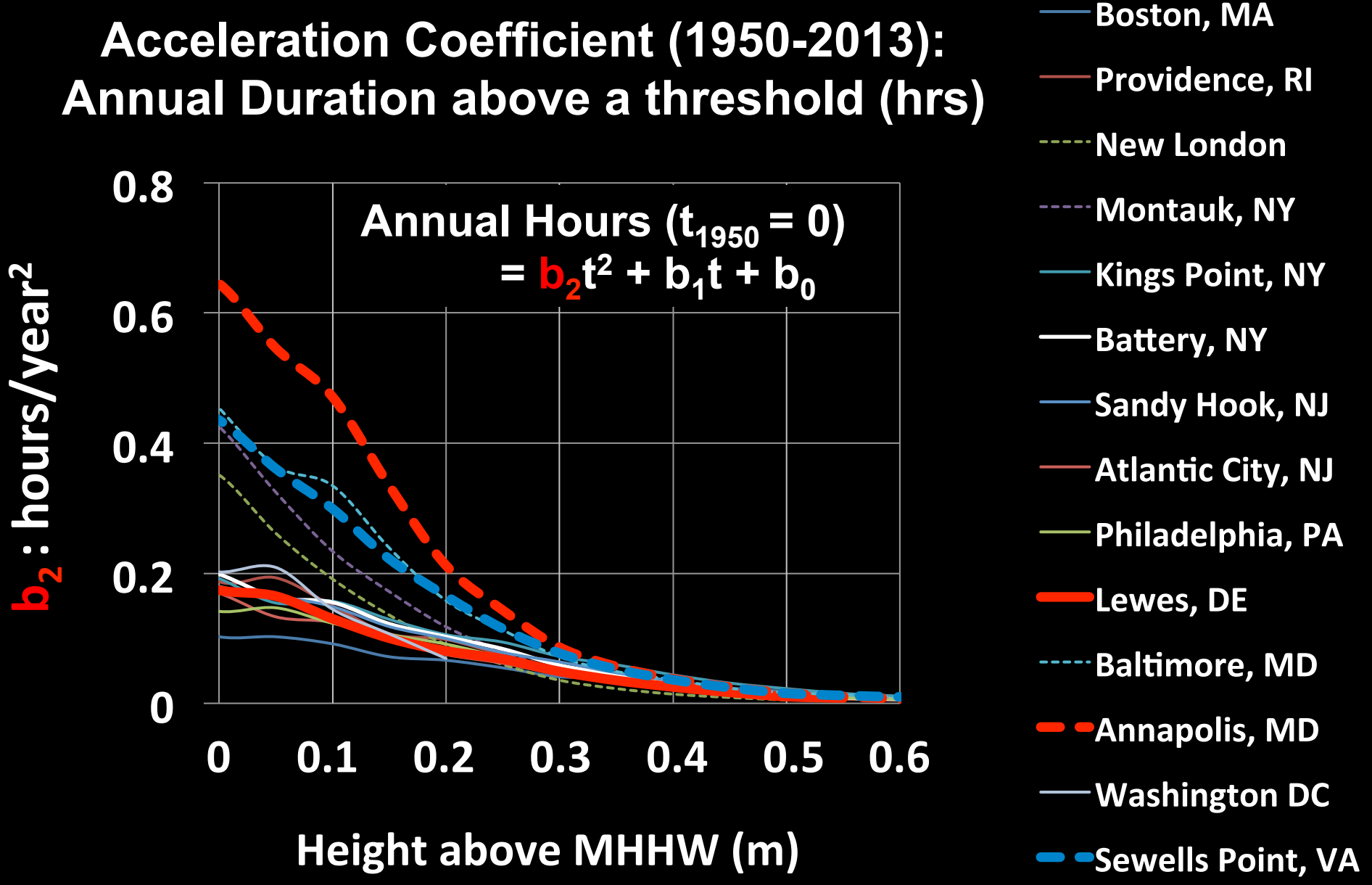


Effects of Relative SLR



Sweet et al. (2014)

Accelerated Flooding: SLR Rates & Tide Range



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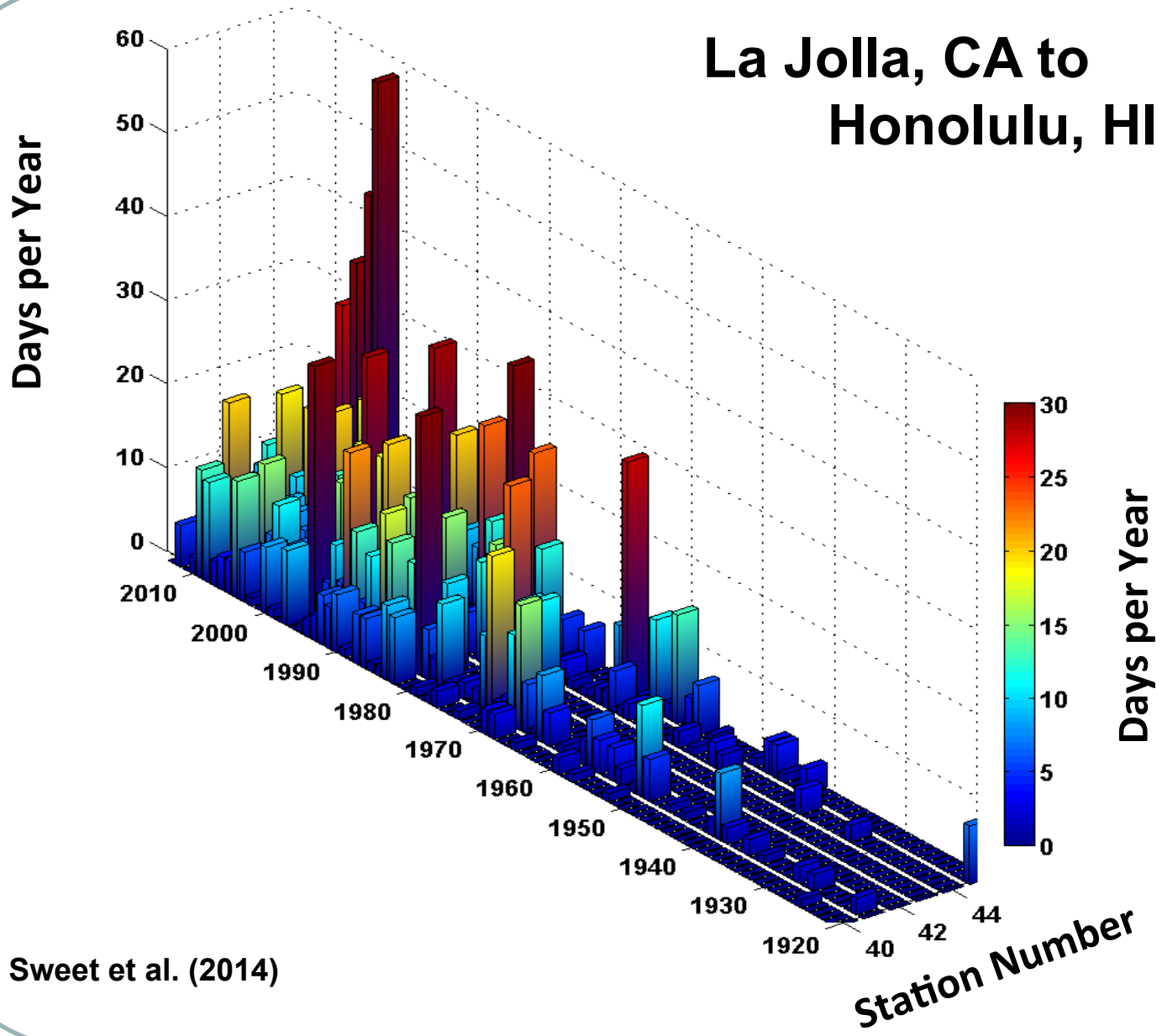
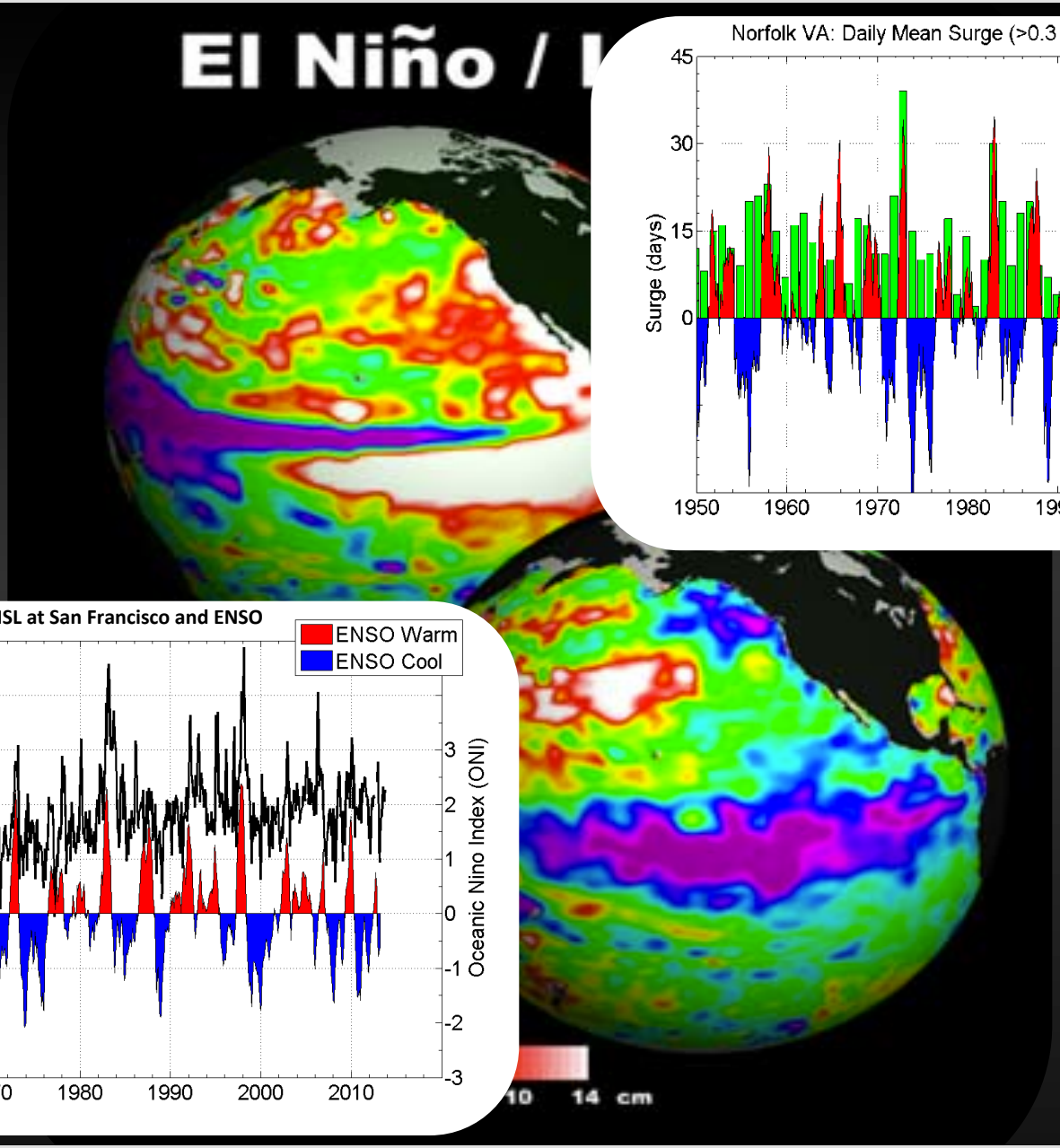
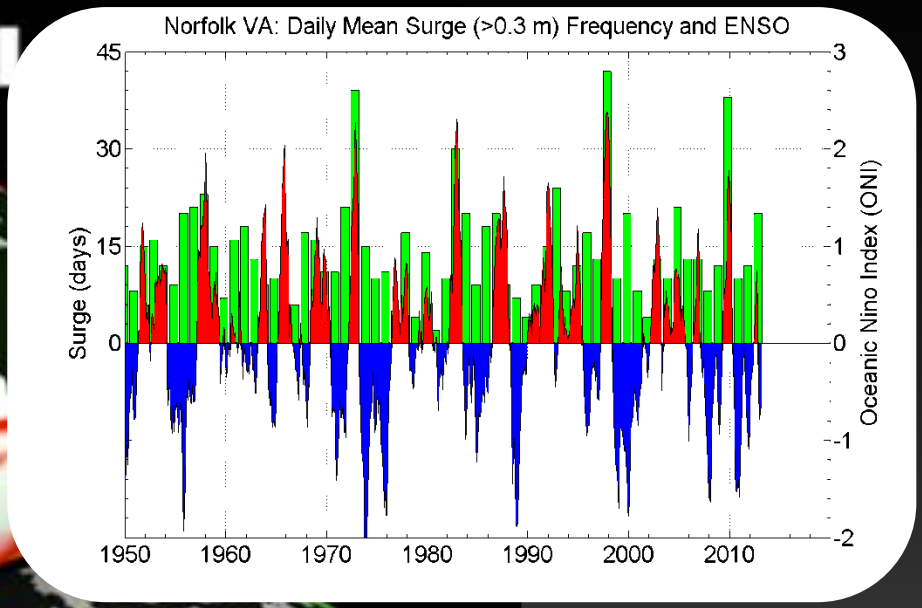


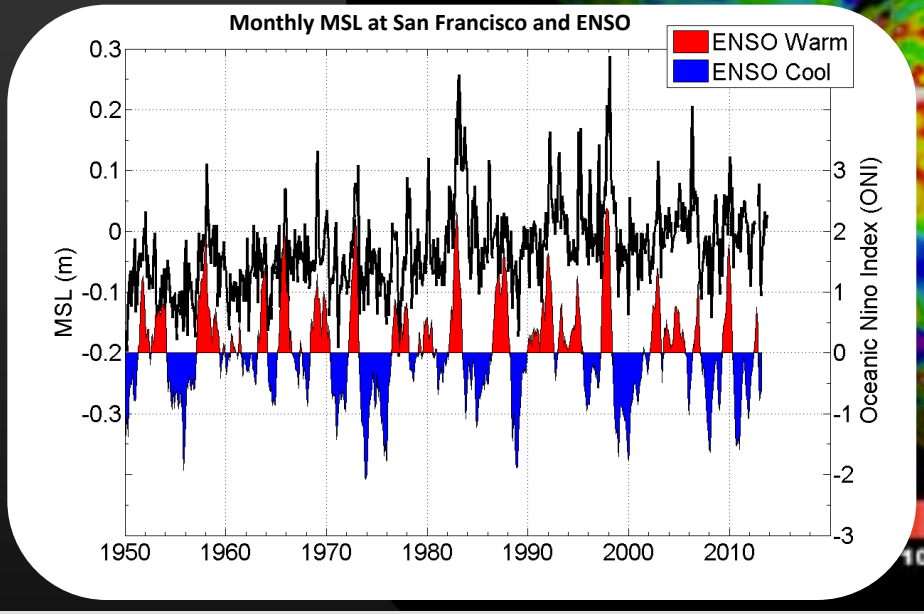
Sweet et al. (2014)

East Coast: Higher storm surge frequency during El Nino





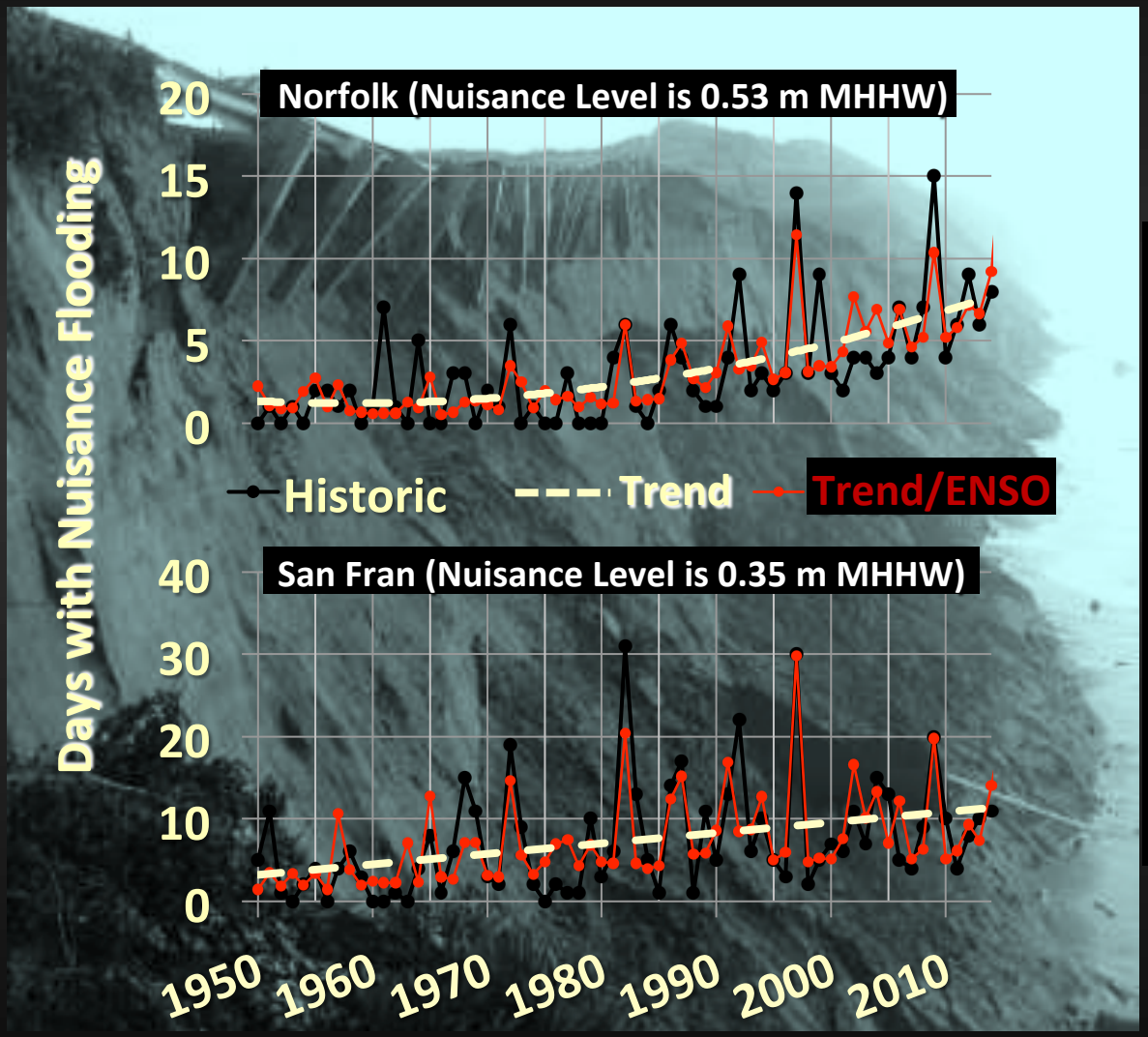
Sweet and Zervas (2011)



West Coast: + (-) MSL anomalies during El Nino (La Nina)

Climate Patterns and Nuisance Flooding

Yearly differences (from trend) in nuisance flood frequency are driven by El Nino Southern Oscillation (Sweet and Park, 2014)



Historical record is better characterized with an ENSO proxy

RESILIENCE MEANS BOUNCING BACK

Resiliency: community's ability to "bounce back" after an event, like a hurricane, coastal storm, or flooding…

but sea level rise is an on-going process, whose impacts are growing in severity.

RESILIENCE MEANS *BOUNCING BACK*

SLR is a slow-motion disaster affecting public-serving systems, and resiliency will require continuous maintenance and mitigation over planning horizons.

Decade(s) of Tipping Point Crossing under 4 Projections (0.5, 0.6, 0.8, 1.2 m) of Global Sea Level Rise by 2100*		
Location	Nuisance Flood Level (meters above MHHW)	>30 days/year with Nuisance Flooding
Wilmington, NC	0.25	Past
Annapolis, MD	0.29	Past
Washington D.C.	0.31	Past
Lewes, DE	0.41	By 2020
Baltimore, MD	0.41	By 2020
Atlantic City, NJ	0.43	By 2020
Sandy Hook, NJ	0.45	By 2020
Kings Point, NY	0.52	By 2020
Philadelphia, PA	0.49	By 2030
Norfolk, VA	0.53	2021-2040
Boston, MA	0.68	2021-2040
Montauk, NY	0.60	2021-2050
The Battery, NY	0.65	2021-2050
New London, CT	0.60	2031-2060
Providence, RI	0.66	2031-2060

30 days/year with nuisance flooding…

System tipping points – functional or economic – are dependent upon sensitivities to event magnitudes, frequencies or durations.

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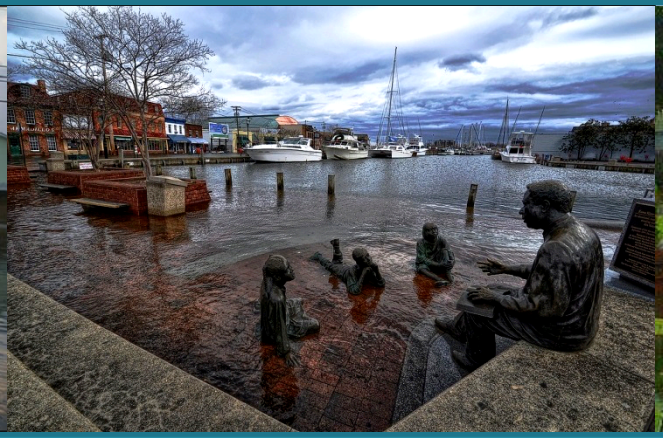

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