Trendy Perspectives in Coastal Water Level and Hazard Implications

Len Pietrafesa[1]
&
Tom Karl[2]
Margaret Davidson[3]
Dave Dickey[1]
Lian Xie[1]

[1]North Carolina State University
[2]NOAA NESDIS National Climatic Data Center
[3] NOAA NOS Coastal Services Center

Issues

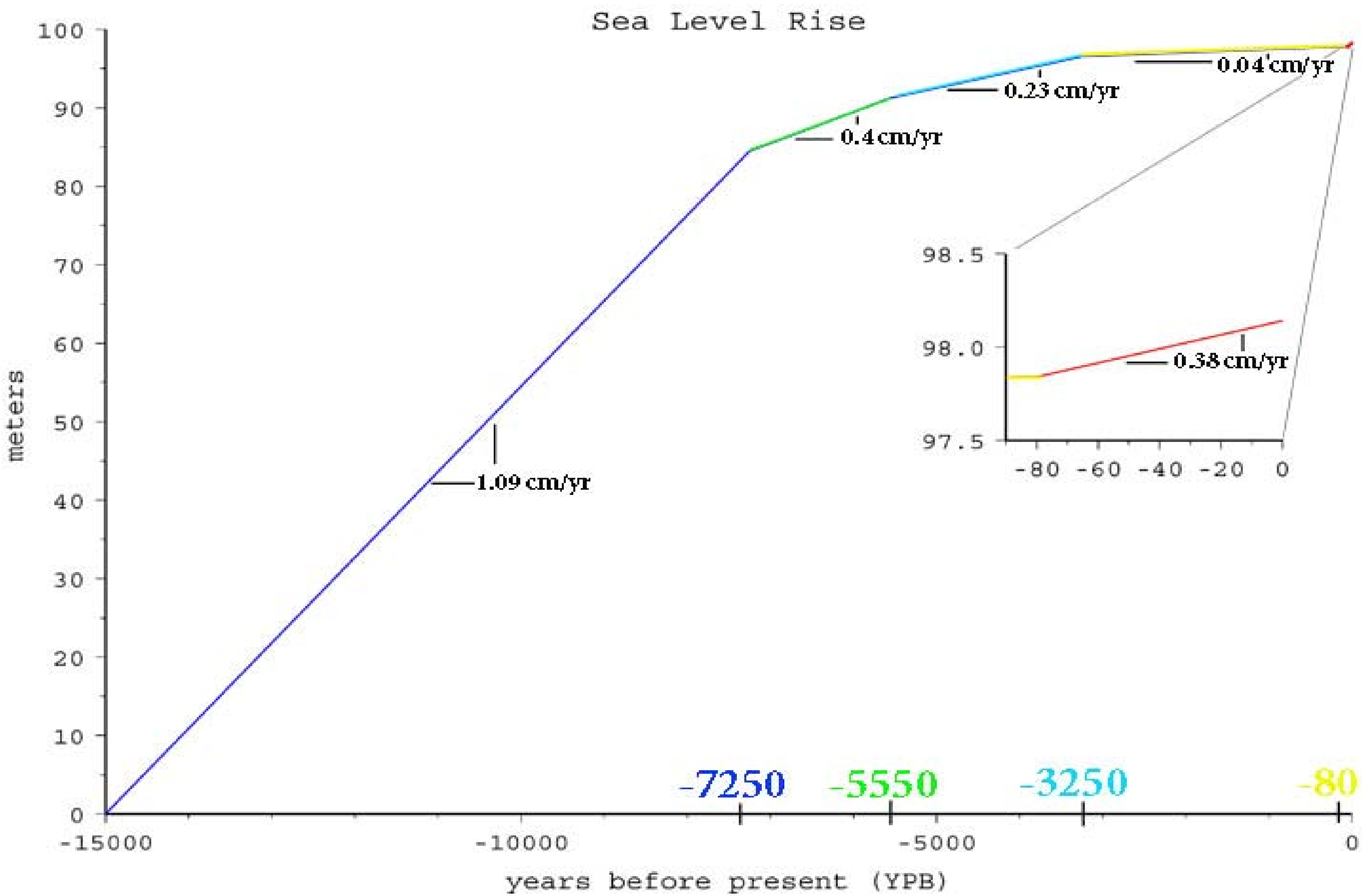
- US coastal regions have experienced enormous growth and development
- And are at great risk due to exposure to the impacts of present and future climate factors and weather events and rising SL
- Potential impacts include: erosion of beaches; mass wasting of coastal bluffs; higher surge and increased property damage; increased inundation of low lying areas, particularly during storms; salt water intrusion into aquifers; etc.
- Alaska has significant coastal exposure to not only storm induced waves but sea ice as well

But, what are the facts? Is sea level really rising along the coastlines of the US? If so, by how much? What are the trends?

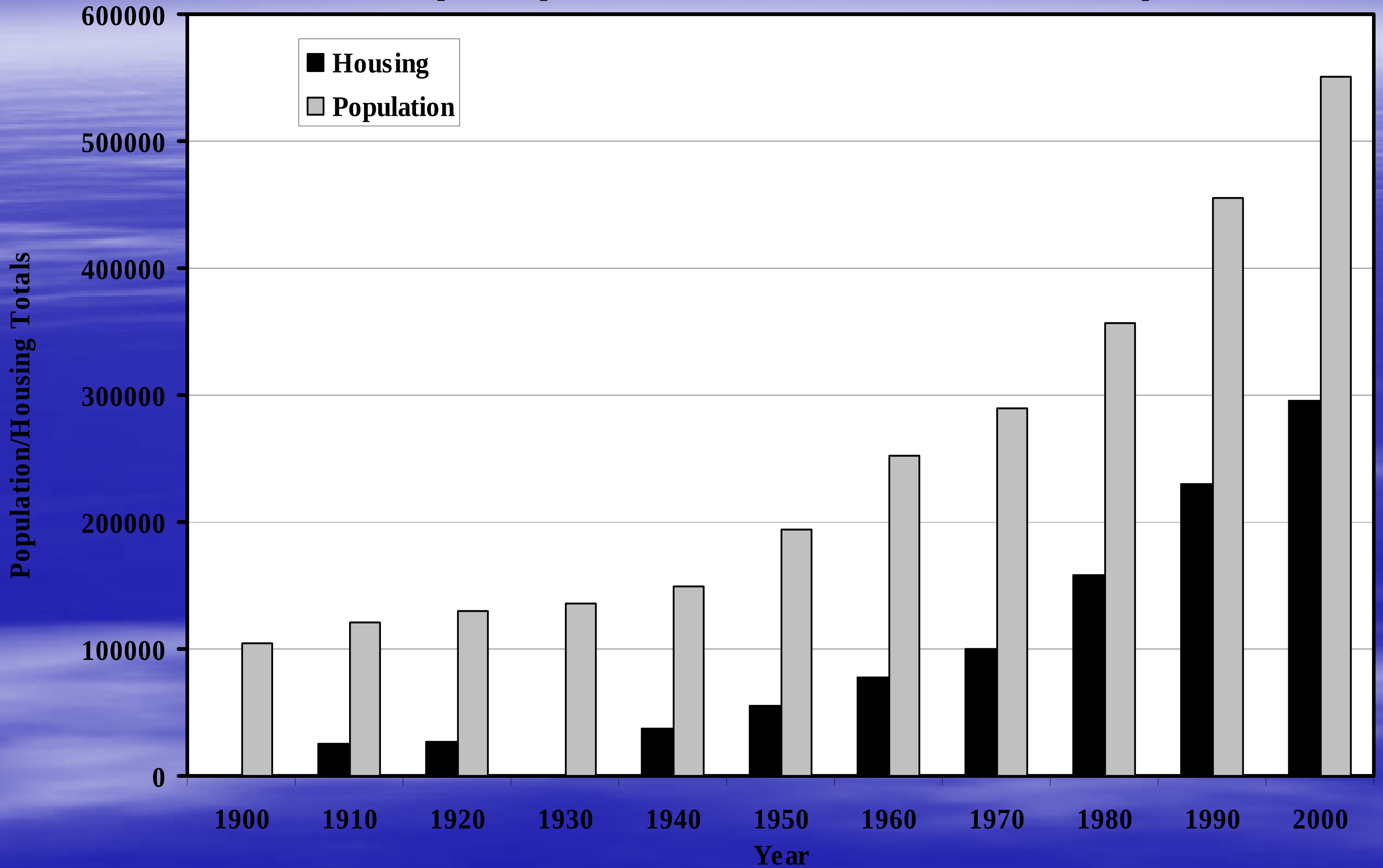
But 1st , some historical perspective

- Modern Sea Level is believed to be rising globally at ~ 0.2 cm/yr or = to the 3rd to 4th fastest rate in 18K years, but US sites show .16 to .44 cm/yr or up to the 2nd fastest rate
- 21,000 years before the present (YBP), glacial ice sheets covered Canada and much of the US. As a consequence of the fresh water sequestration, global sea level was > 100 meters lower than it is at present
- Then, 18,000YBP, the planetary climate system switched from cool to warm; the ocean and atmosphere began to heat up
- Subsequently the glaciers receded, the ice sheets broke up and melted and the ocean expanded due to the increased heat content
- And sea level began to march upward, in five discernable epochs: I) very aggressive; II) aggressive; III) modest; IV) quiet; and V) the modern, which is purported to be between modest to aggressive, depending on location

The Documented Time History of Global Sea Level with a ballpark number for the past 85 years: But, so what?



This is "so what". People & Property = Fn(X, t) in coastal zones. Example: NC



North Carolina coastal population and housing trends from 1900-2000 based on U.S. Census data. Housing data for 1900 and 1930 were not available. Coastal counties included in the study are Brunswick, Carteret, Currituck, Dare, Hyde, New Hanover, Onslow, Pamlico, and Pender.

Now, back to SL. So, what affects coastal water level variability?
14 of the many suspects include:

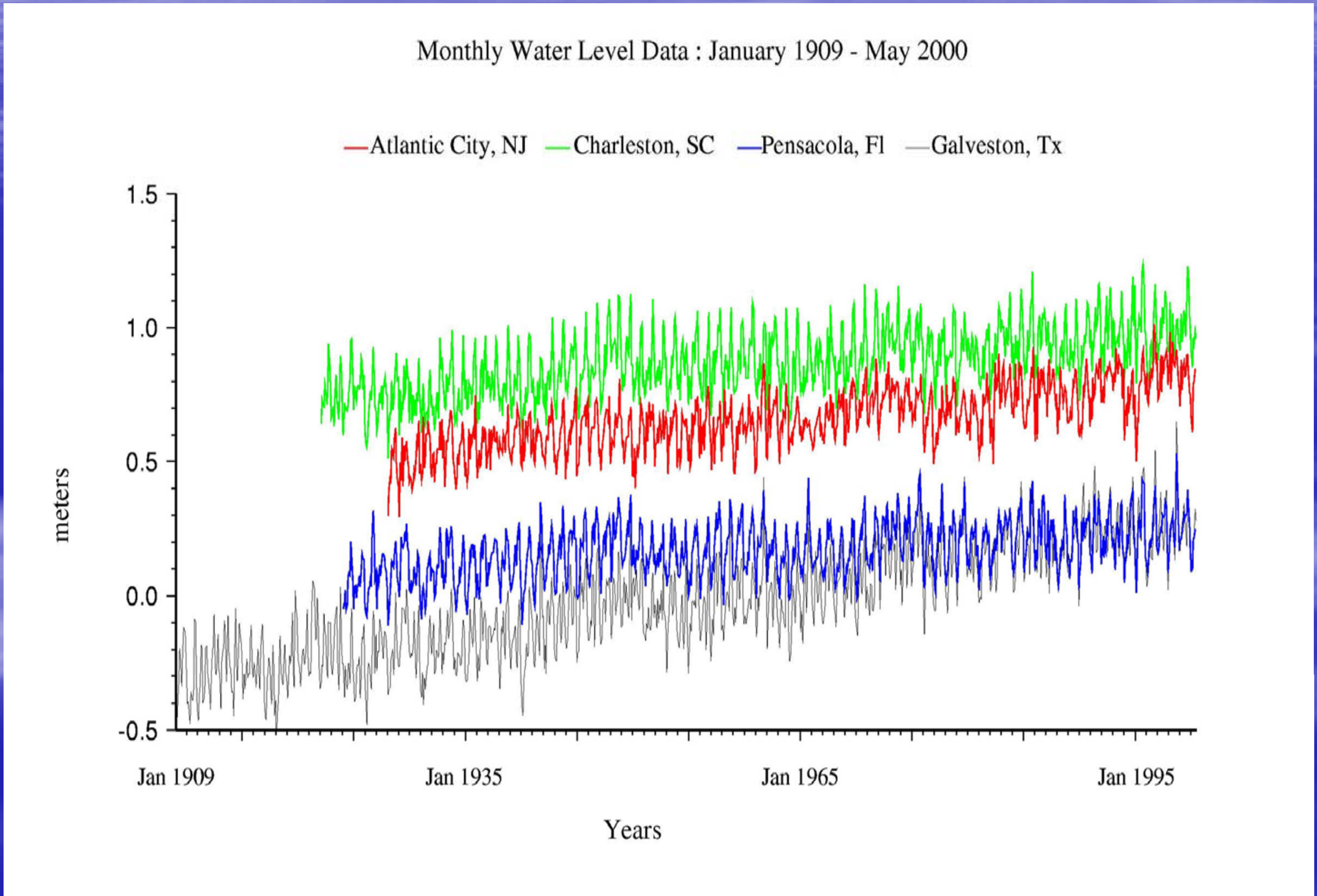
- addition of fresh water due to melting of Alpine Glaciers & Polar Ice Sheets (+)
- auto-compaction of ancient sediments (+)
- compaction of deep sediments, particularly in deltaic environments (+)
- regional to local isostatic rebound from the last period of glacial loading (-)
- local to regional slumps in coastal areas due to sediment discharge loading (+)
- slumping due to drainage of local ground-water, i.e. subsurface fluvial withdrawal (+)
- excess precipitation (drought) and coupled watershed responses + (-)
- steric rises (falls) of the water levels of adjacent ocean basin(s) water masses due to increases (decreases) in the heat storage of these water masses + (-)
- mesoscale to synoptic scale to longer period coastal winds (coast to right +, left -)
- ocean basin long waves (+ or -)
- changes in the coastal wave field (seasonal)
- management practices such as dikes and impoundments (-)
- climate variability (+ or -)
- climate change (+)

BUT the peer reviewed literature including recent publications claim that establishing definitive trends of SL rise is problematic because it is very-difficult-to-determine initial and end points of observation

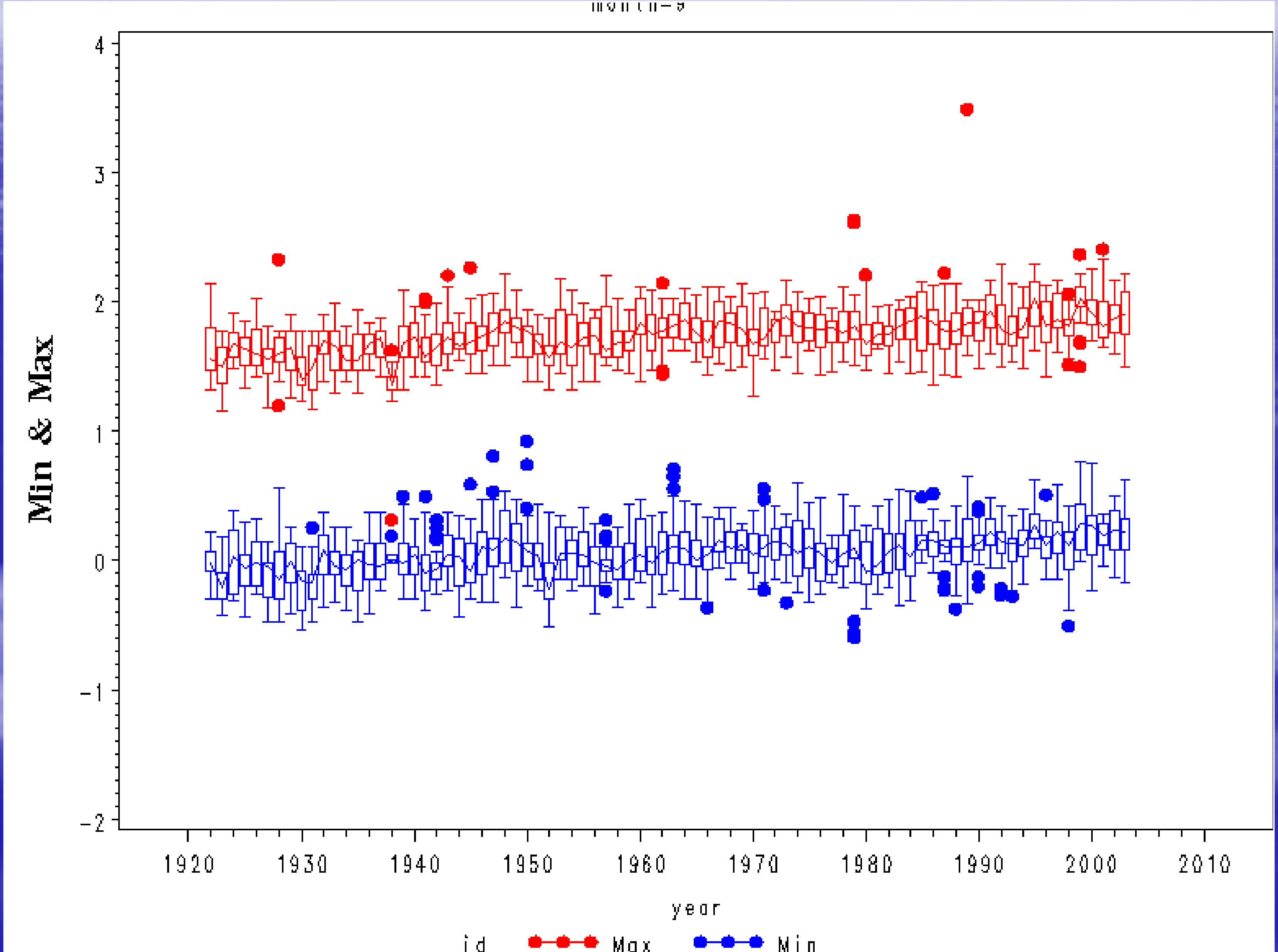
Lets consider Representative Monthly records of Sea Level Extrema.

Q: “Trends” clearly could change as a function of time window.

How about the Extrema or on an Annual Ave.?

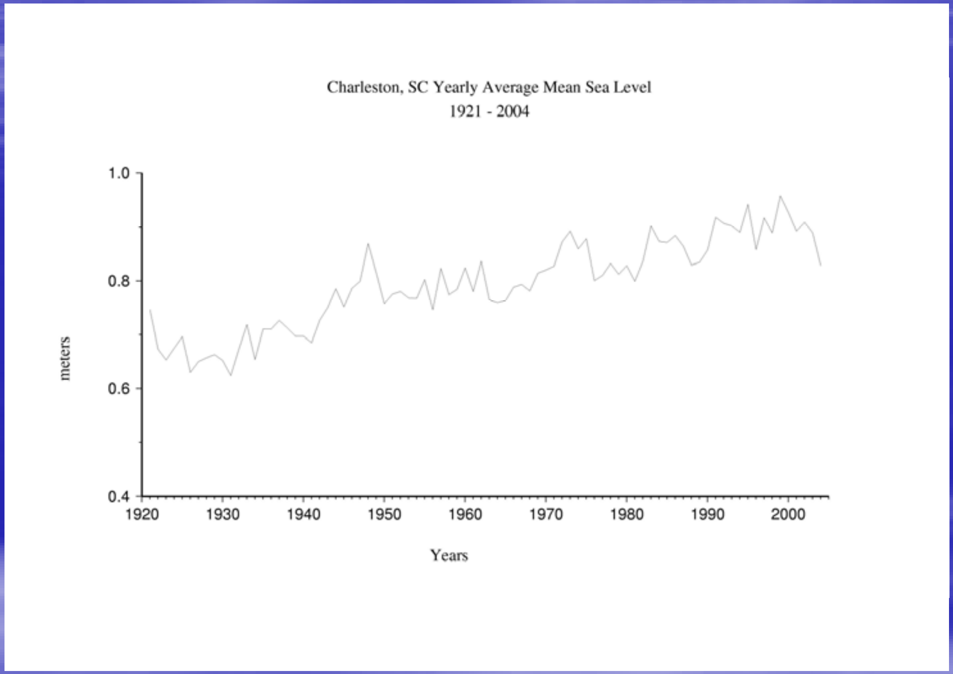


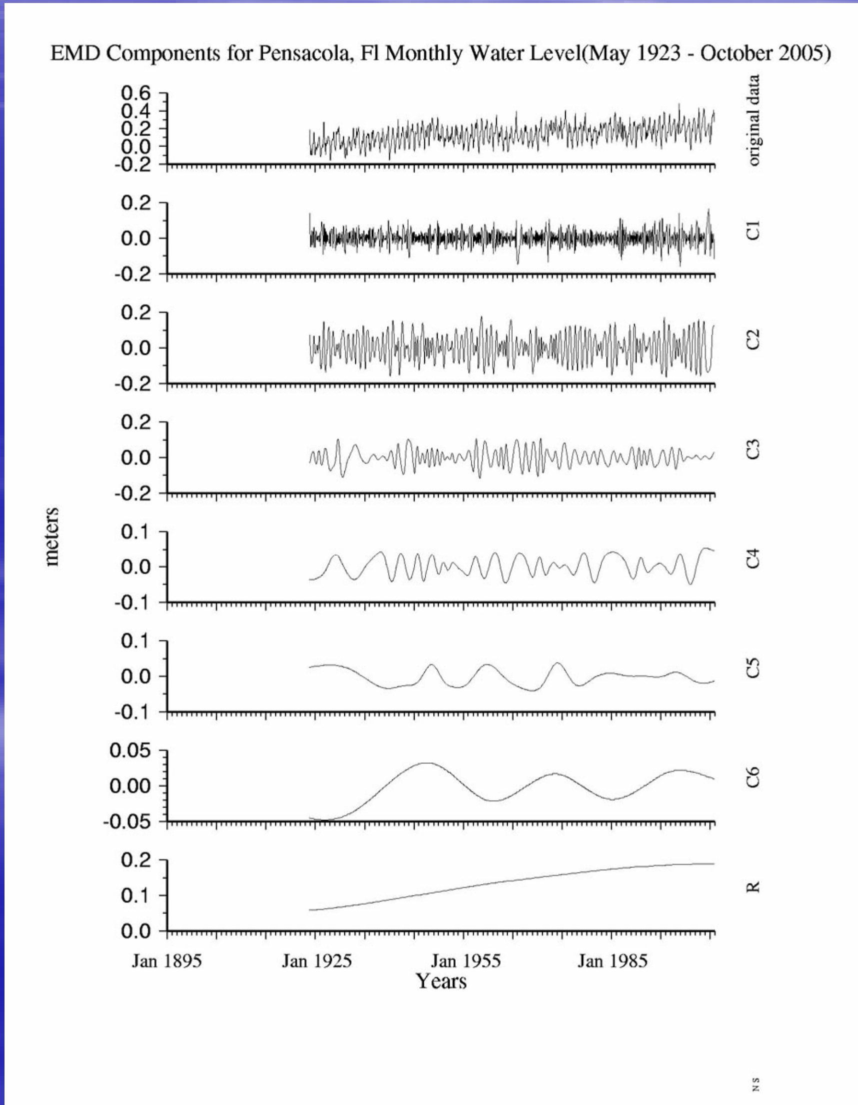
In the Charleston time series of all September water level data, Maxima and Minima are rising but not diverging; as shown in this "box and whiskers" plot.



In the Charleston SL time series (left) on a yearly average basis, we note fluctuations of 20-30 cm over periods of several years to decades. Still no trend other than “up overall”, is identifiable and thus difficult to define.

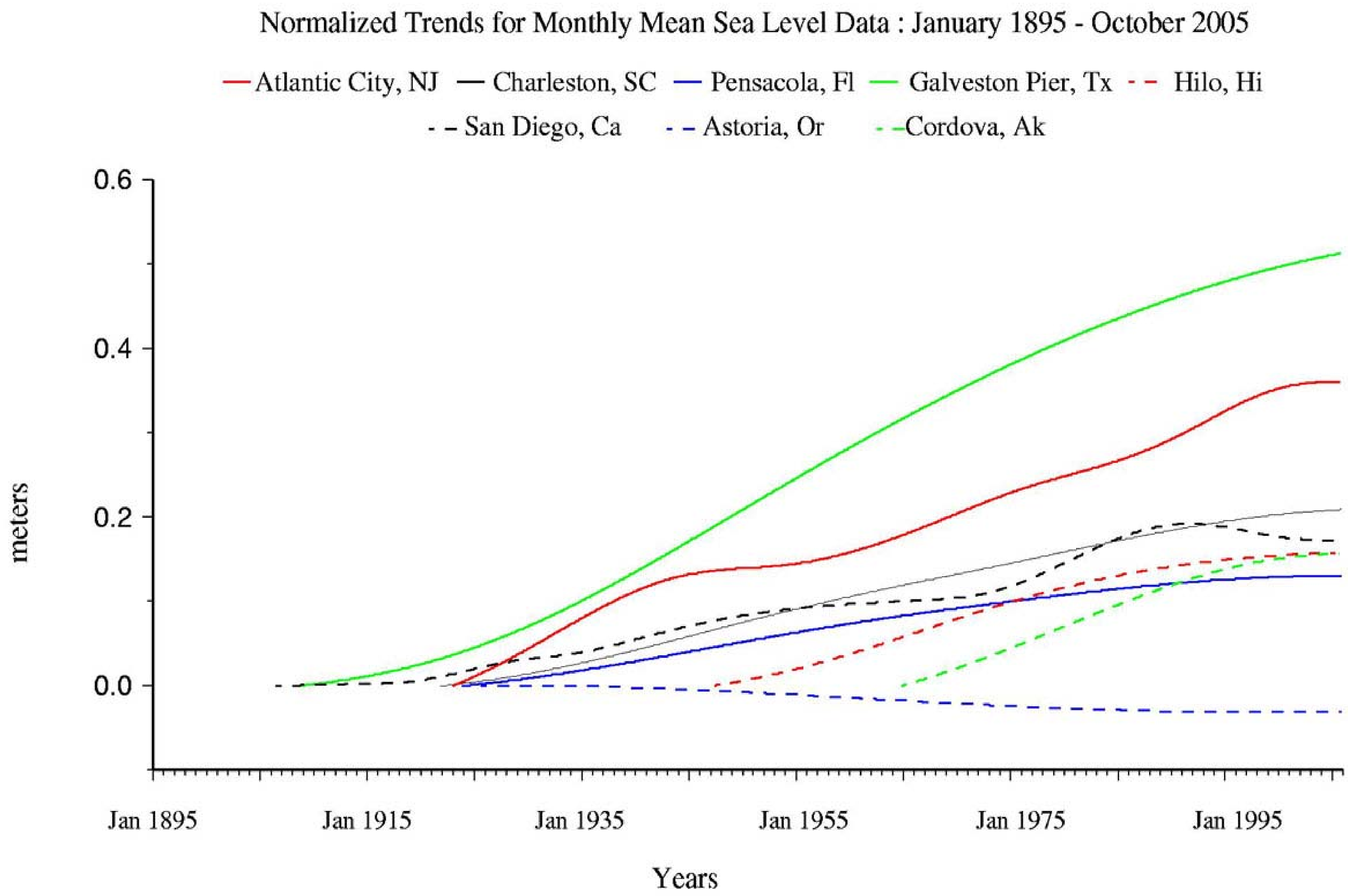
So we perform a modal decomposition on the time series of SL of Pensacola (right). Note there are 7 modes with the gravest the “trend”.





Monthly, seasonal, annual, 2-5 yrs, 10-12 yrs, 25-30 yrs and the gravest Mode => a “trend”

Trends for a representative sampling of US SL stations



SL Trends and Lateral Erosion Implications

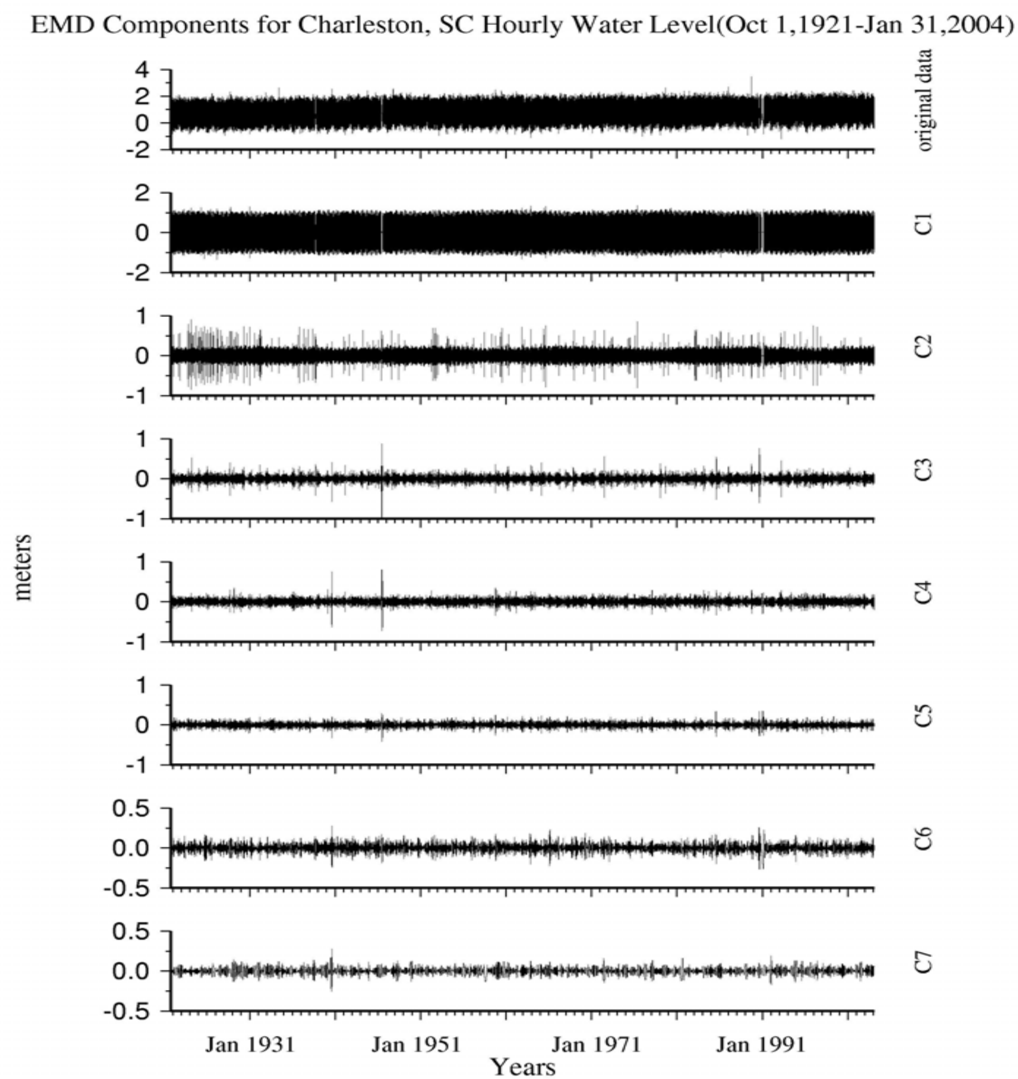
	SLR	Time to 1 Foot Up & 100 feet of Erosion
Atlantic City	= .44 cm/yr	=> 1 foot in 70 yrs => 100 ft in ~46yrs
Charleston	= .29 cm/yr	=> 1 foot in 105 yrs => 100 ft in ~70 yrs
Pensacola	= .16 cm/yr	=> 1 foot in 192 yrs => 100 ft in ~128 yrs
Galveston	= .88 cm/yr	=> 1 foot in 34 yrs => 100ft in ~ 22 yrs
Hilo	= .27 cm/yr	=> 1 foot in 112 yrs=> 100ft in ~ 74 yrs
San Diego	= .17 cm/yr	=> 1 foot in 177 yrs=> 100 ft in ~ 118 yrs
Cordova	= .38 cm/yr	=> 1 foot in 80 yrs=> 100 ft in ~ 53 yrs

- Note, there are East coast, GoM and West coast high SLR and lateral erosion locales.

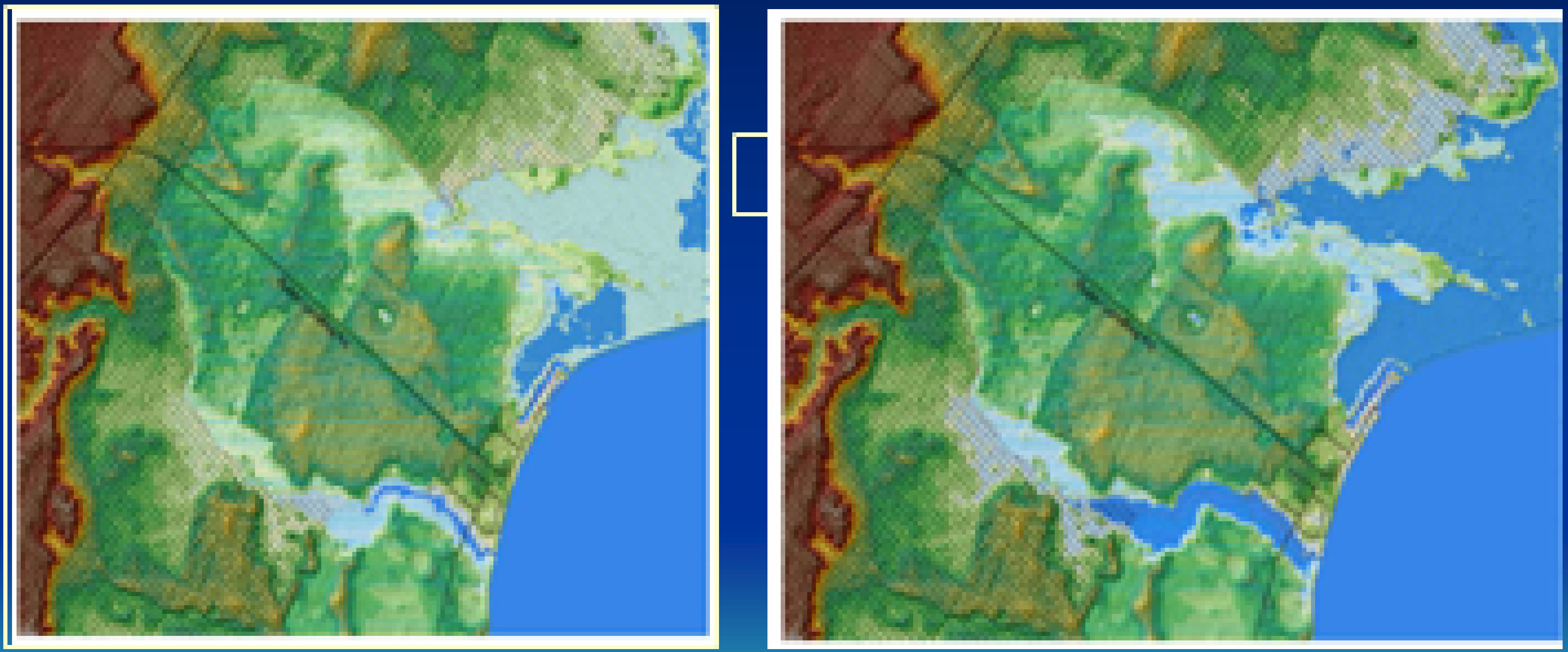
Note, the Metonic Cycle, a 19 YR period over which all 235 lunations (or phase relations between the moon, earth, sun, etc.) will reoccur on the same day of the year is missing.

But, if we redo the modal decomposition, using hourly water level data, then the 19 YR Epoch shows up as the modulating envelope of Mode 2.

This says that to properly measure SL at a coastal point, you need to have hourly data. A sampling message.

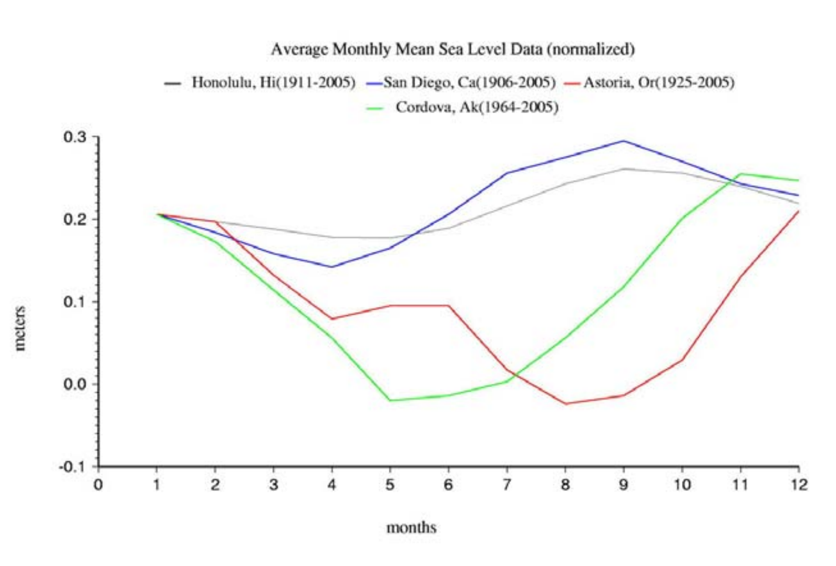


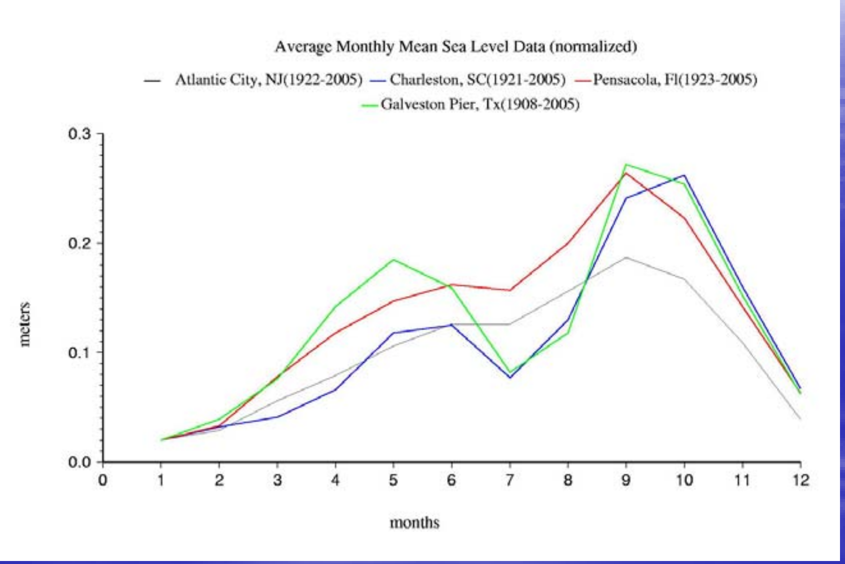
Sea Level Rise: Public Landing, MD: presently left, in 75 years right, assuming .4 cm/year

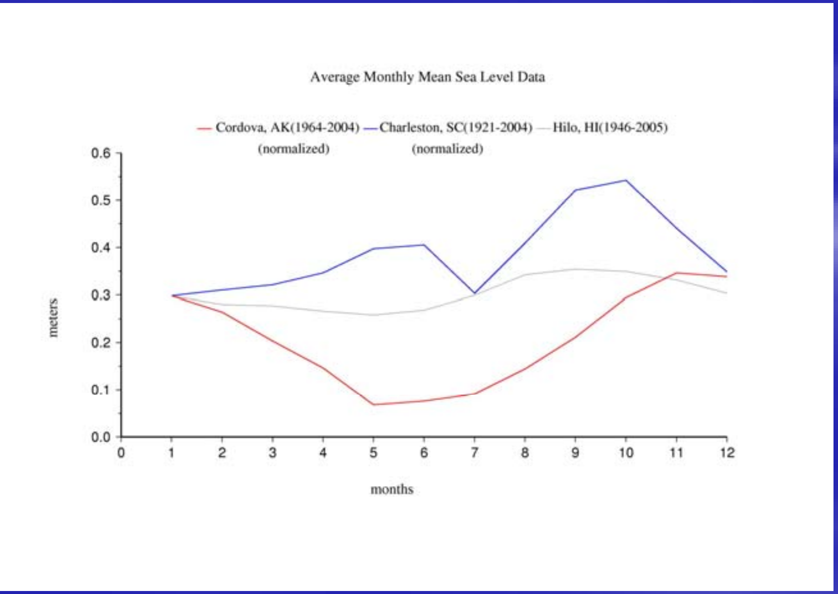


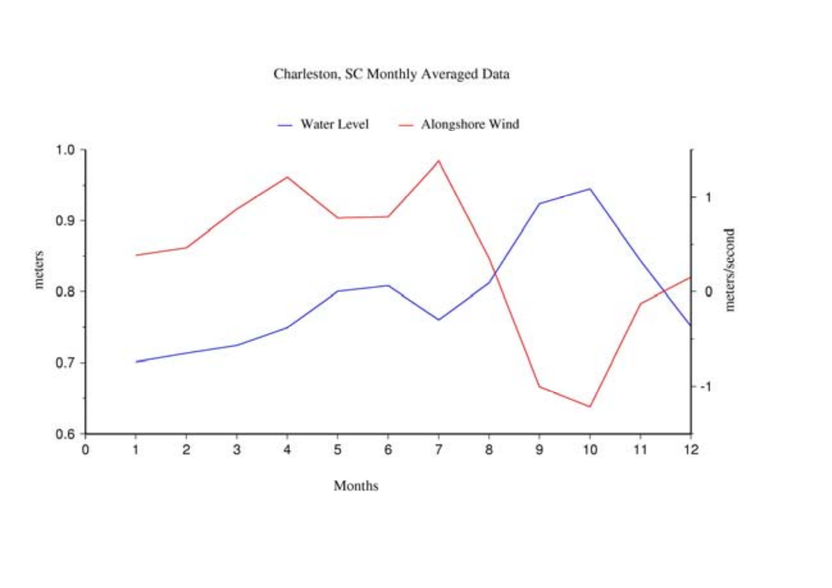
Society is very concerned about 1 foot rises over the lifetime of some evolving, ill-defined trend. But actually sea level rises and falls annually the order of a foot or more. So the future is already present.

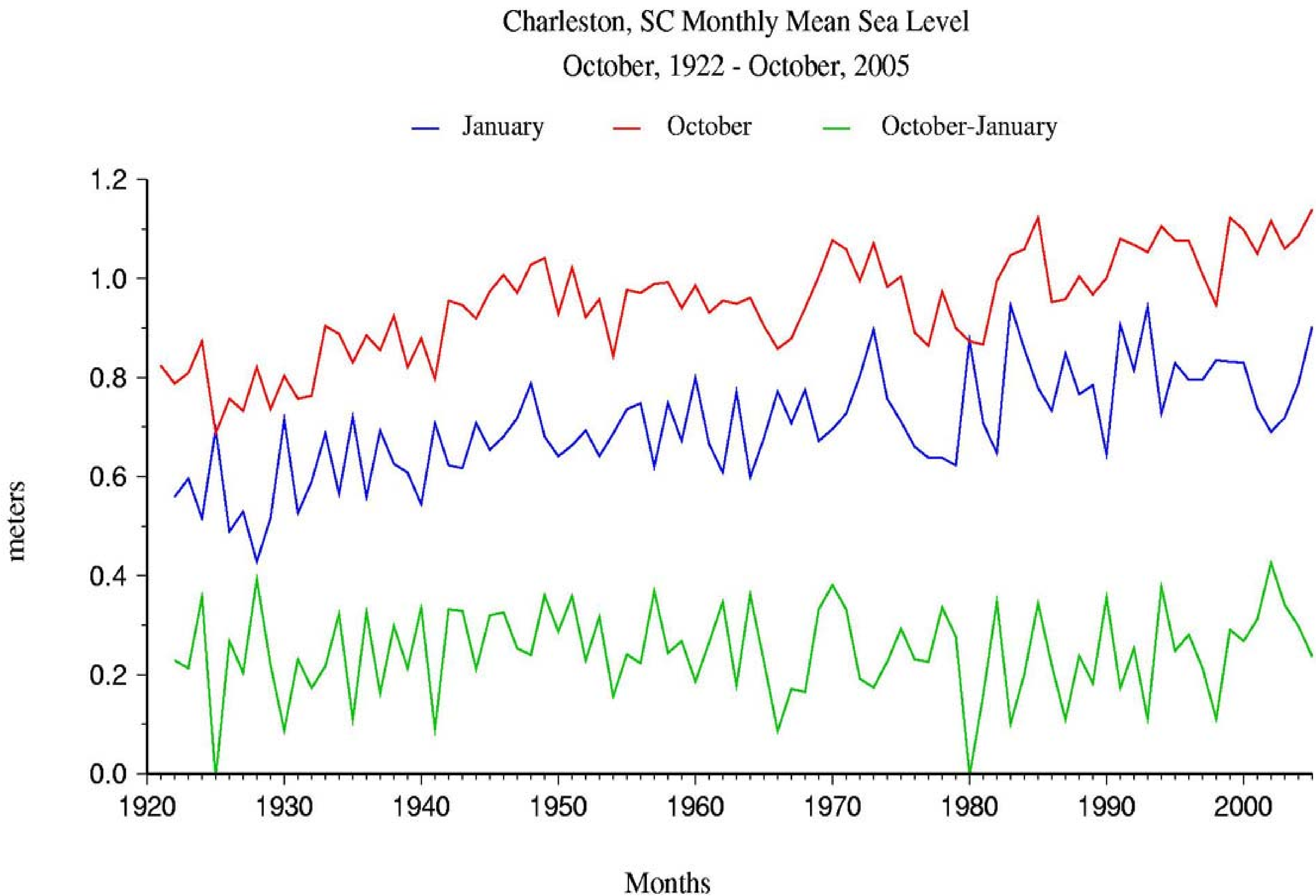
As shown in these representative (record length) Annual Monthly Values of SL





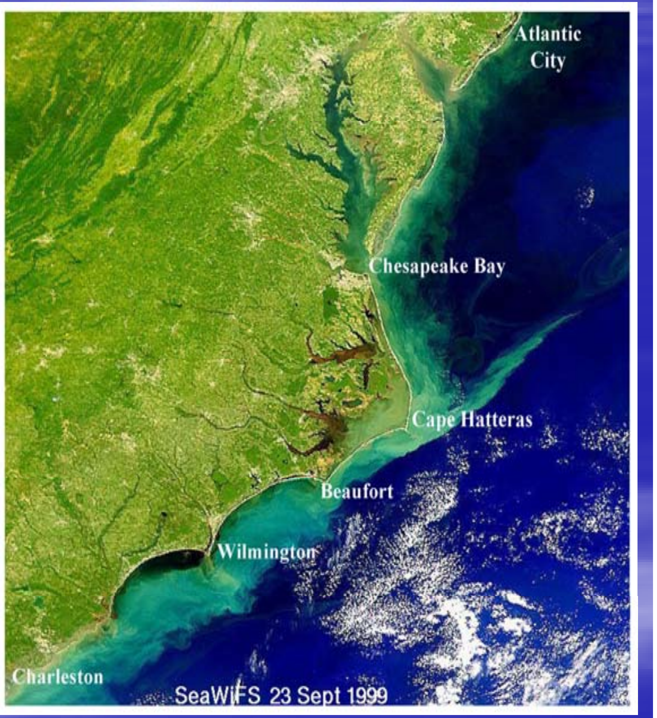


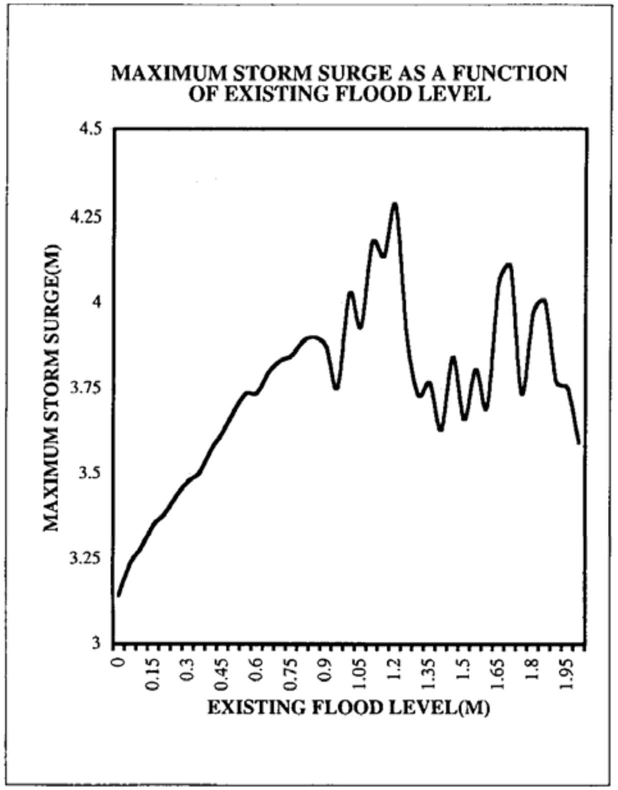


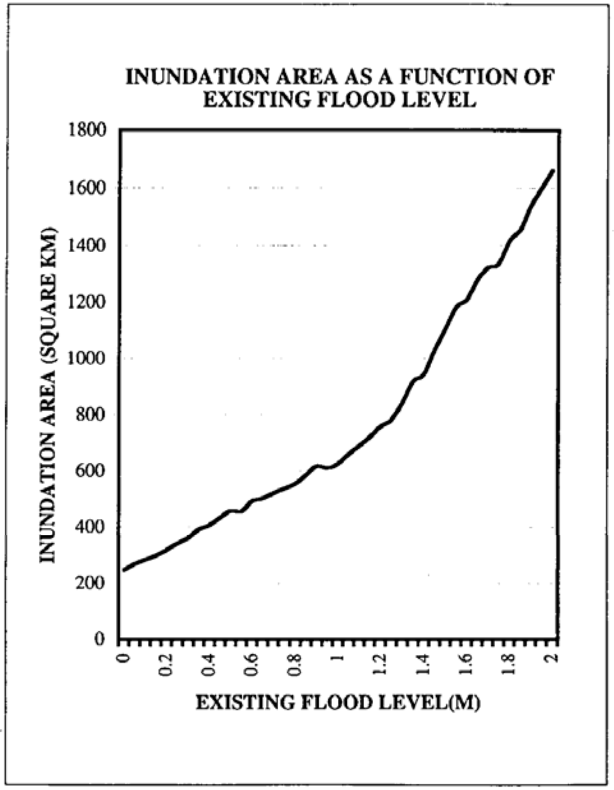


Charleston, SC Monthly Mean Sea Level
October, 1922 - October, 2005
January
October
October-January
meters
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1920
1930
1940
1950
1960
1970
1980
1990
2000
Months

We must properly initialize Water level in surge & inundation models
For example: how the initial water level will effect the ultimate height of surge and distance of inundation in the Pamlico Sound, NC system







Some Lessons Learned:

1) Present rates of SLR in US coastal waters may, overall, be 2nd in rate, retrospectively to 21,000 to 15,000 YBP
2) Hourly data are required to properly resolve all tidal constituents
3) Rates of WLR vary significantly over periods of days to weeks to months to seasons to years to multiple years to multiple decades; the maximum length of time for which we have continuous records
4) Maxima , Means and Minima of WL are rising but not diverging
5) WLs generally stand 10-50 cm higher because of ocean basin scale steric effects during different seasons of the yea
6) Basin scale waves contribute to SL multi-year variability
7) Coastal water levels are required to initialize coastal surge and inundation models; especially during storm conditions
8) The existing national water level monitoring network needed to properly assess water levels locally, either over long or short time scales, cannot be compromised
9) Water impoundment and sequestration are a cause of underestimation of true SLR
10) Coastal Buyer beware

Funding agencies

- NOAA NOS Coastal Services Center
- NOAA NESDIS National Climatic Data Center

Via the

Climate & Weather Impacts

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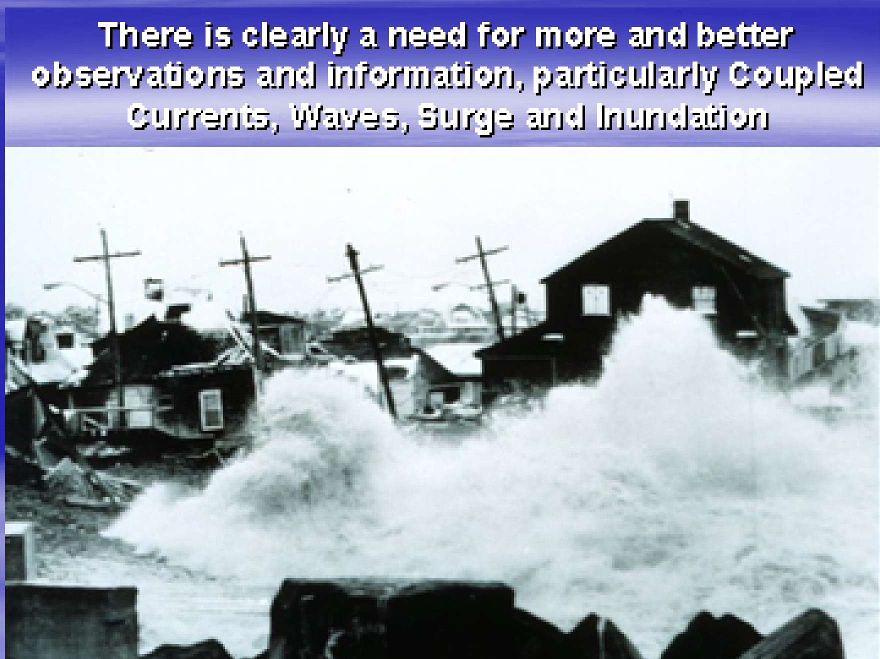
Thank You


There is clearly a need for more and better observations and information, particularly Coupled Currents, Waves, Surge and Inundation