The Latest on Sea Level Rise

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Norfolk, Virginia
ACCO 2014

Science of Sea Level Rise

- We can measure it – easily it turns out
- It is rising along our coasts
- And appears to be rising faster (accelerating)
- Reasons
  - Geology – glaciers gone, ground water withdrawal
  - Global Sea Level Rise and movements of the ocean
- Take home – understand your specific situation

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NOAA Water Level Station at the Battery NYC

- Stations like these provide water levels real time
- From these we know how often there is flooding
- NOAA surveys these regularly so we know the measurements are good

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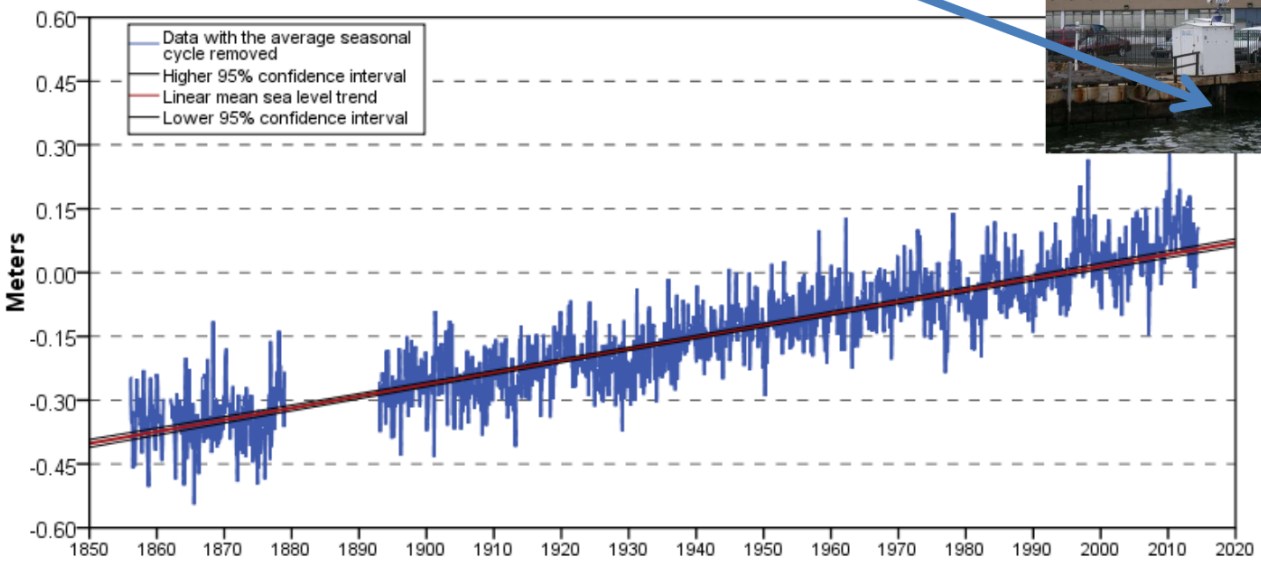
So what do we see – Sea level is rising right there



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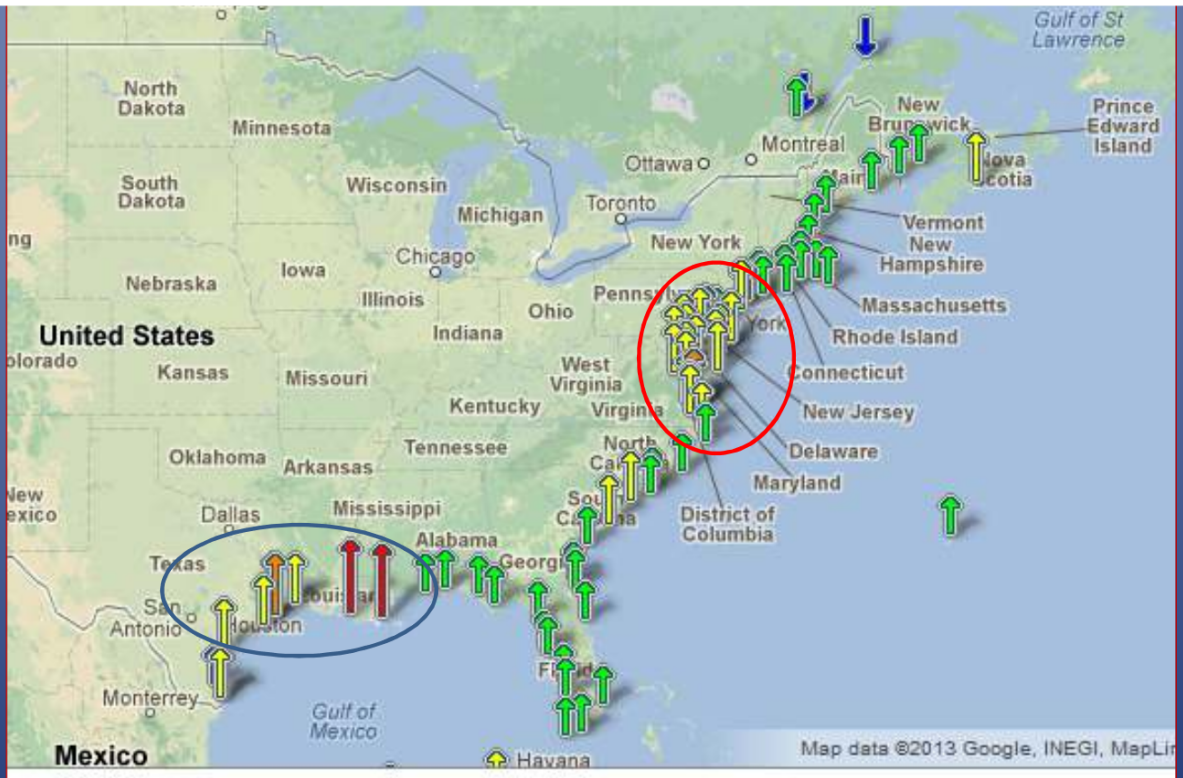
Sea level rise rates at points along the US East Coast are relatively higher than in other places

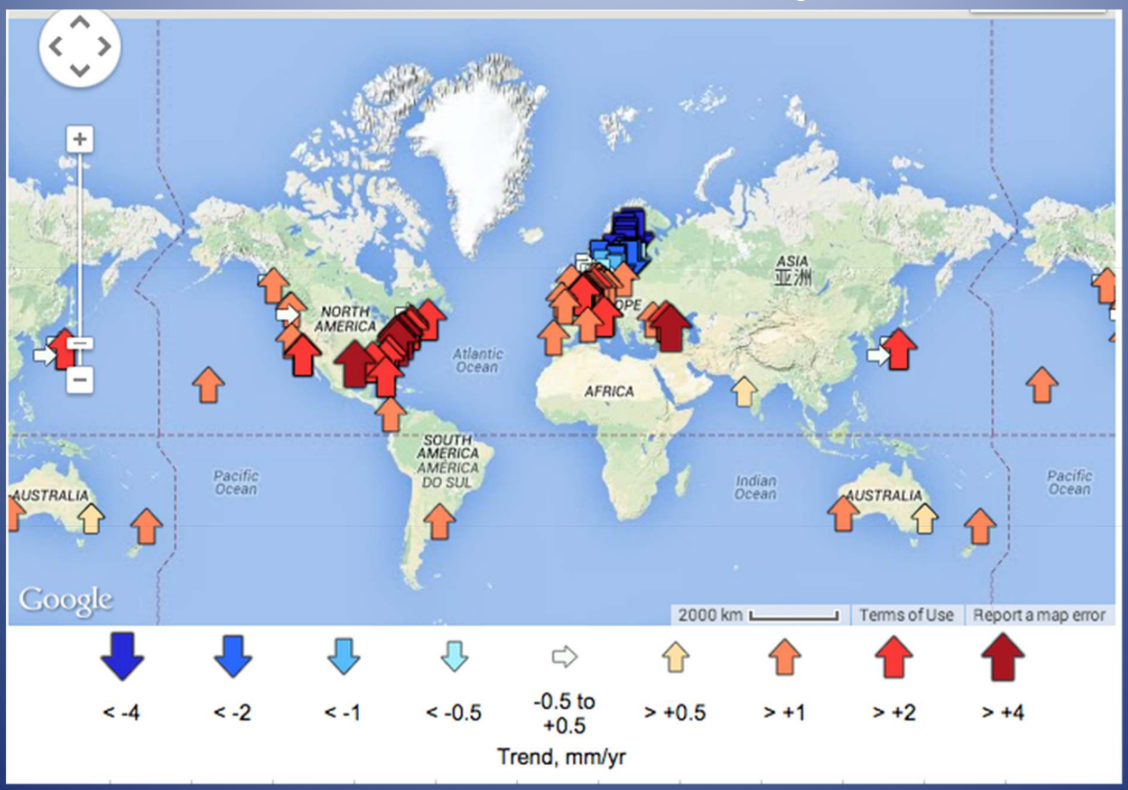


bove illustrates regional trends in sea level, with arrows representing the direction and r change. Click on an arrow to access additional information about that station.

Sea Level Trends
mm/yr (feet/century)

9 to 12 (3 to 4)	3 to 6 (1 to 2)	-3 to 0 (-1 to 0)	-9 to -6 (-3 to -2)	-15 to -12 (-5 to -4)
6 to 9 (2 to 3)	0 to 3 (0 to 1)	-6 to -3 (-2 to -1)	-12 to -9 (-4 to -3)	-18 to -15 (-6 to -5)

And Globally



Data http://www.psmsl.org/

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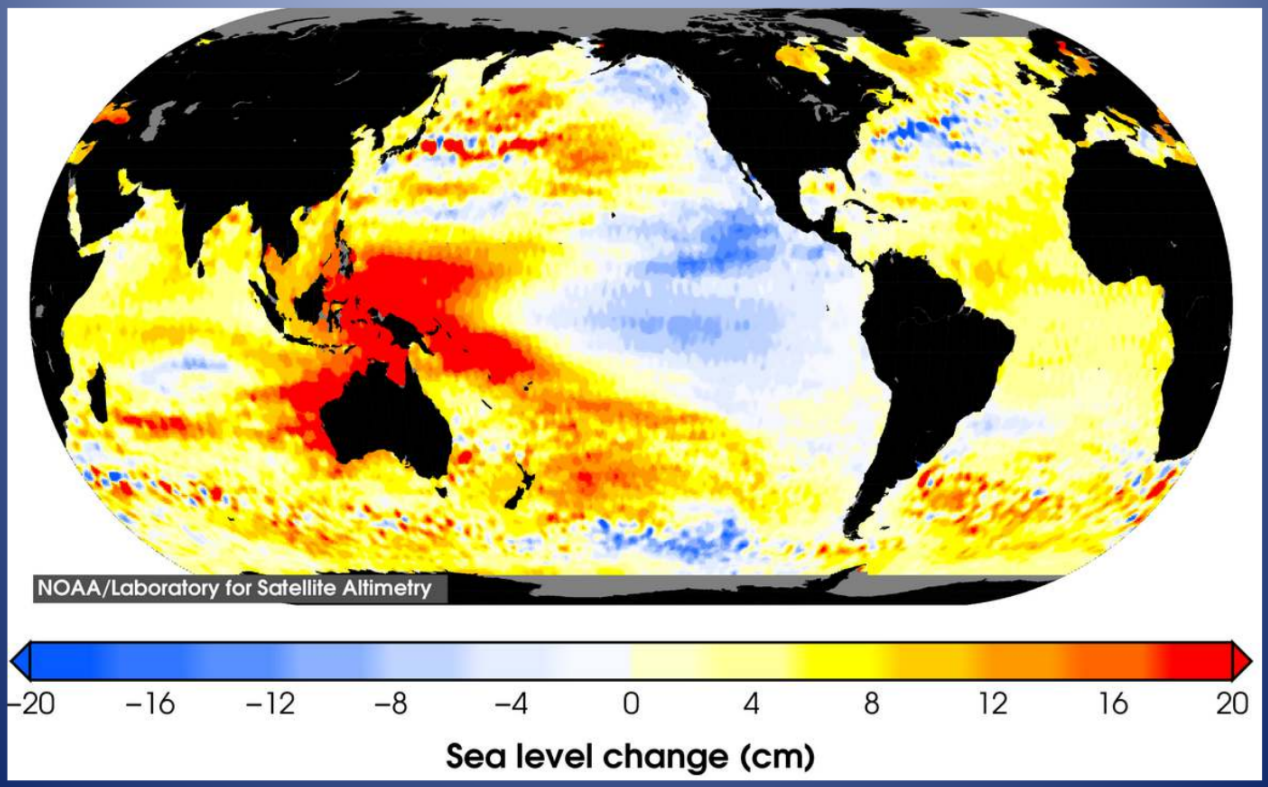
Satellites measure global sea level



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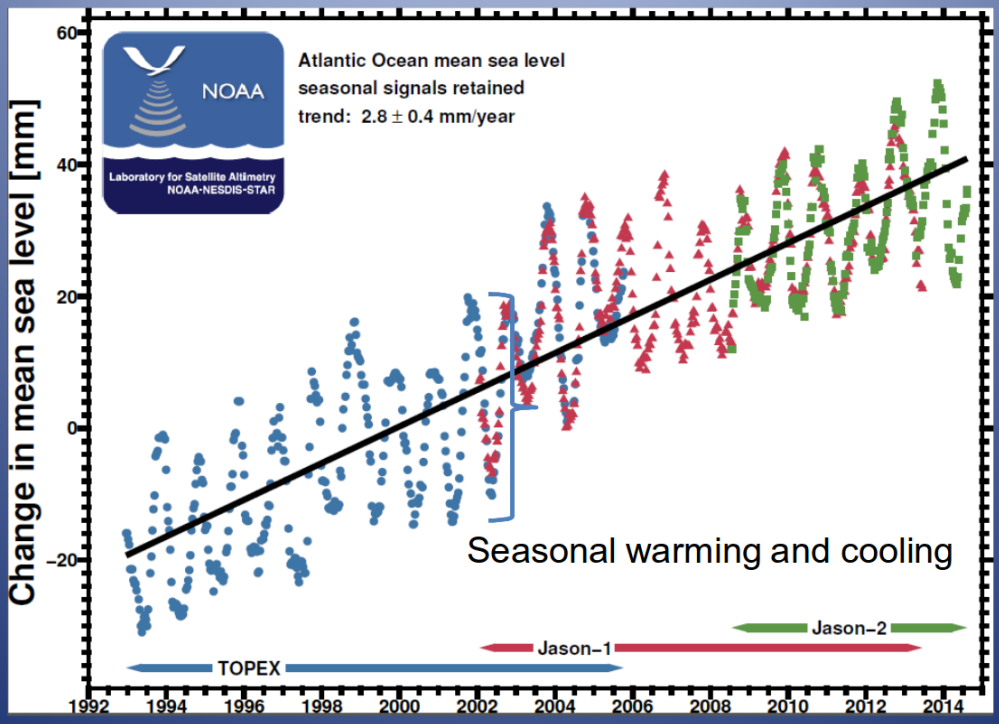
The Atlantic Ocean surface is rising (and warming and cooling every year)



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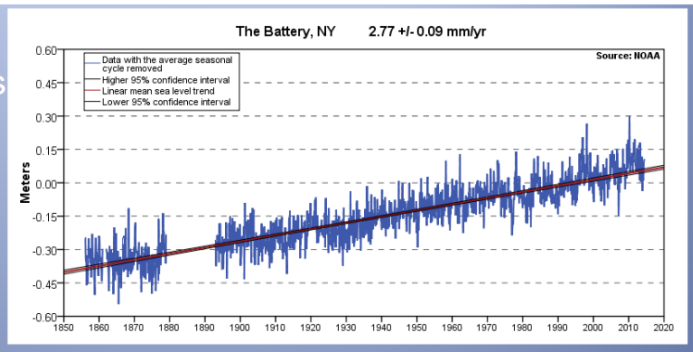
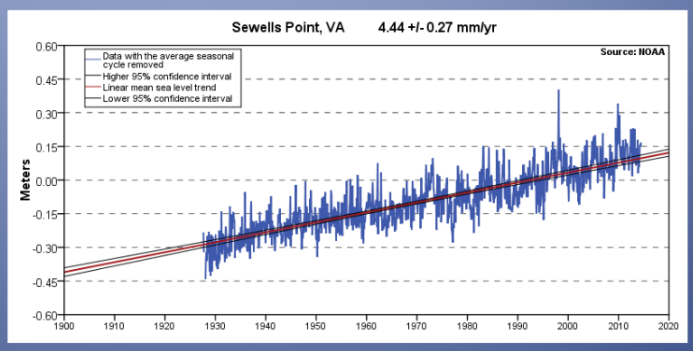
So we know about whole oceans

Regional SLR is different

The Battery, NYC
0.9 feet per century

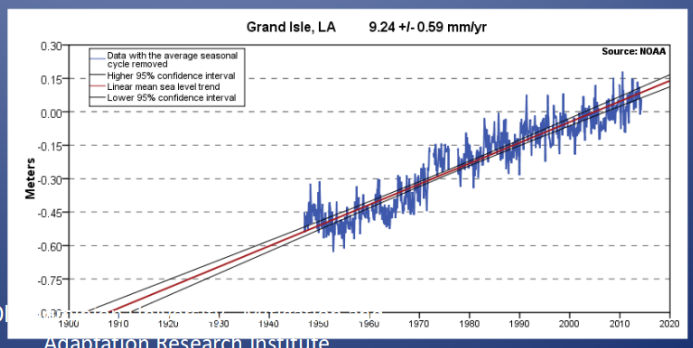


Norfolk Virginia
1.5 feet per century



Coastal Louisiana
3.0 feet per century

WHY?



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Two ways we think about SLR

- The global ocean is filling and warming and moving around
- Locally at your coastal region other things are happening.
- So let's quickly look at global then to regional/local

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Land Ice is melting 'filling the global bathtub' – the ocean

If all ice melted

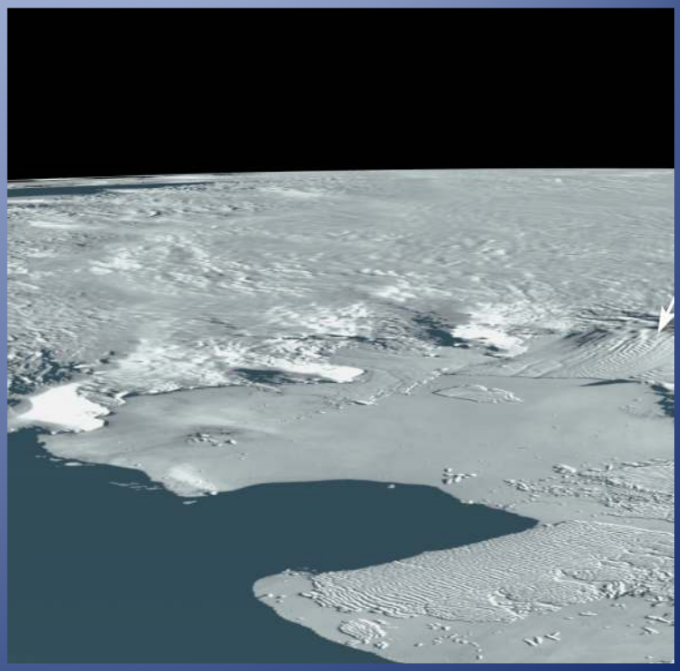
Antarctic – 200 foot sea level rise

Greenland – 20 foot rise

That will not happen for centuries

Small ice melt can lead to significant SLR – and that will (with very high certainty) happen.

This is why you hear so much in the news about ice sheets in Greenland and the Antarctic



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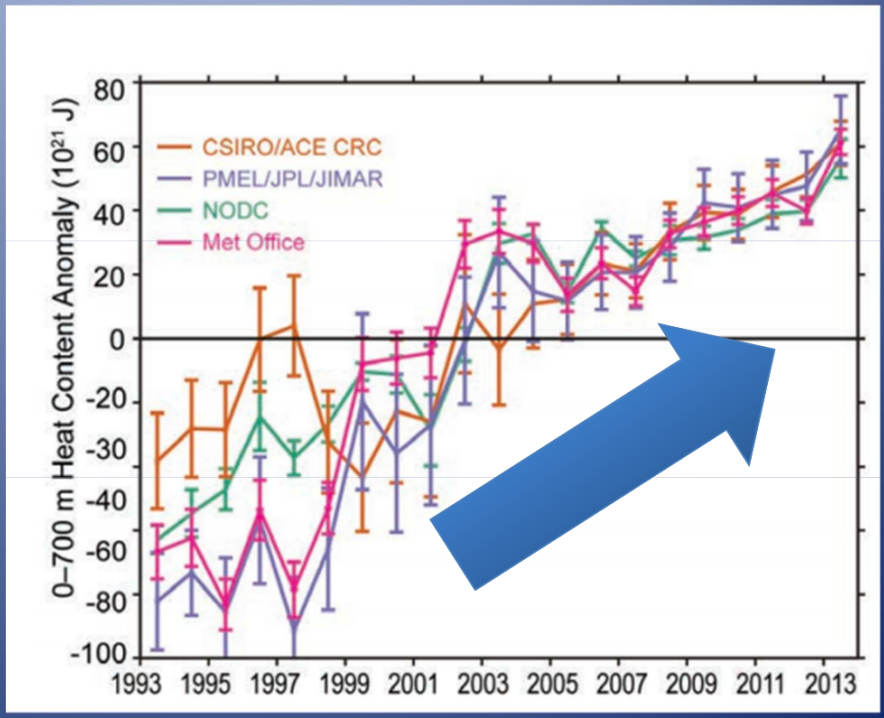
The Ocean is Warming – and expanding

ncreasing heat content of the global ocean

As the ocean heats up it expands



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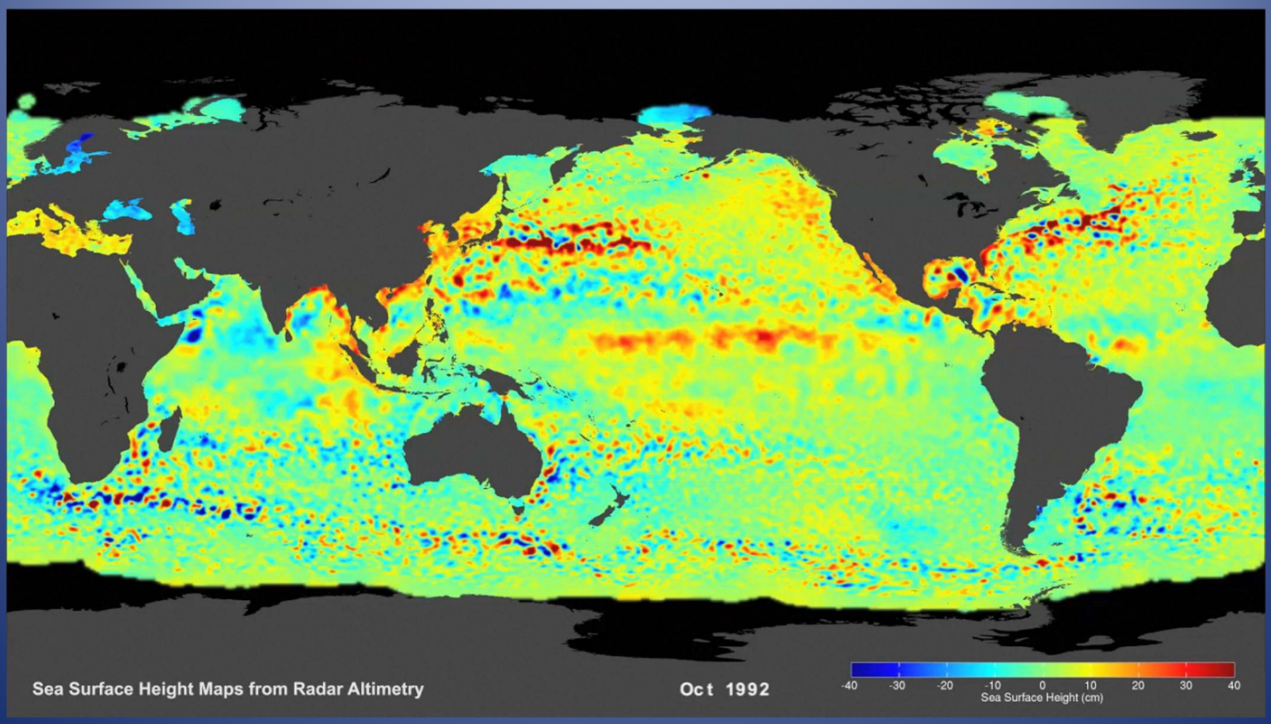
And it is moving



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The Ocean is not flat

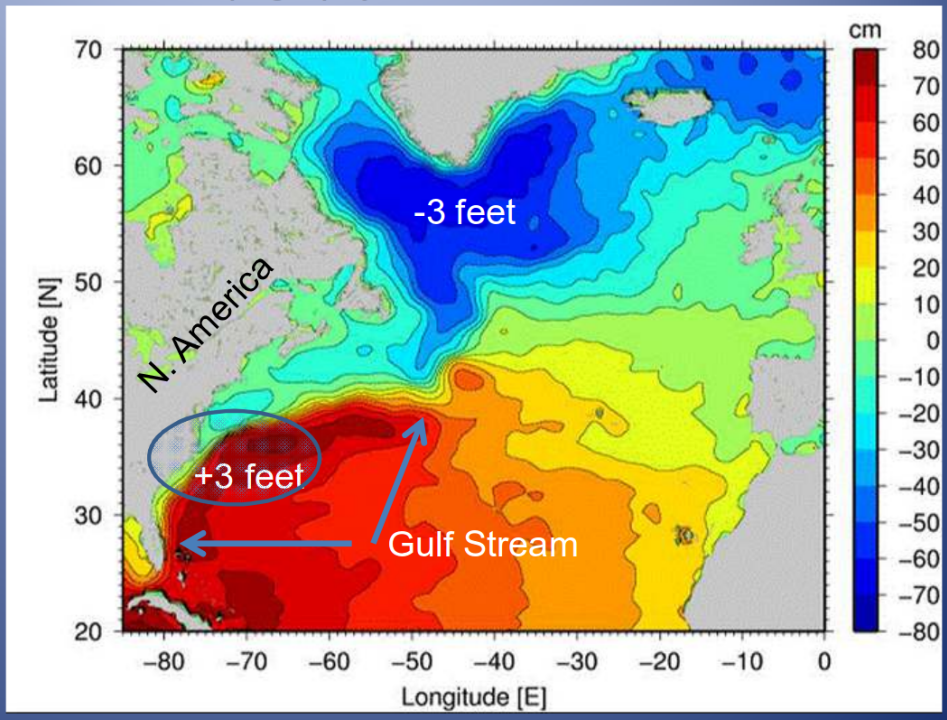
The red is 6 feet higher than the blue area.

Small changes in ocean currents cause ___

_____

_____

Topography of the ocean surface



http://blogs.nature.com/news/2011/03/goce_mission_reveals_the_true.html

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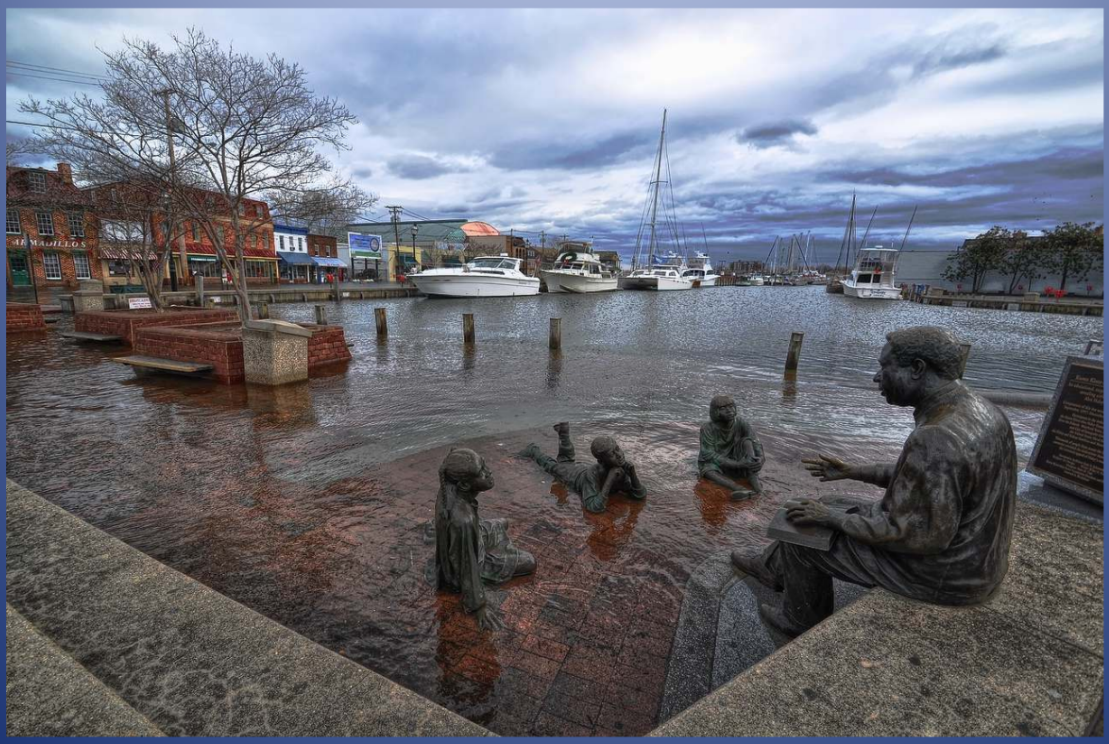
But we care about changes in coastal flooding exacerbated by local SLR



Annapolis – photo by Amy McGovern

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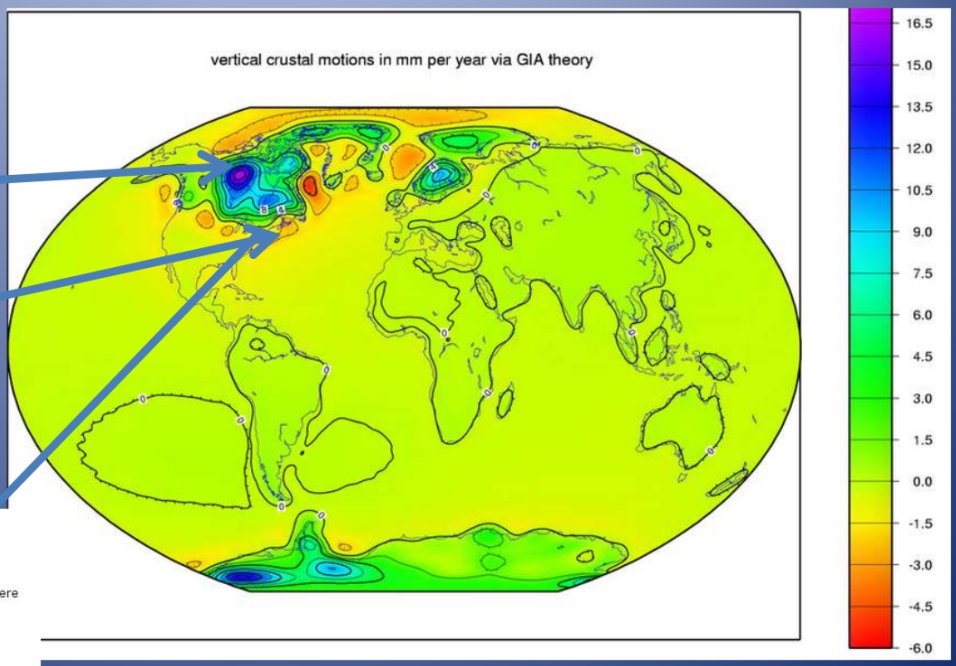
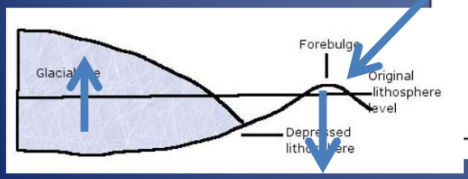
The land is moving - adjustment to last glaciation – mid-Atlantic sinking a bit

Rising where glaciers are gone

Sinking where glacial forebuldge was





Wadoski UMaine

ftp://podaac.jpl.nasa.gov/allData/tellus/L3/pgr/browse/PGR_Paulson2007_Rate_of_Lithospheric_Uplift_due_to_PGR.png

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Subsidence (land sinking) causes

- Aquifer-system compaction from groundwater withdrawals
  - water-level decline,
  - sediment compressibility, and
  - sediment thickness

Photograph from Galloway and others (1999), USGS.

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Case Study- ground water withdrawal in coastal Virginia

Two large pulp mills draw water from aquifer causing land to subside around the wells.

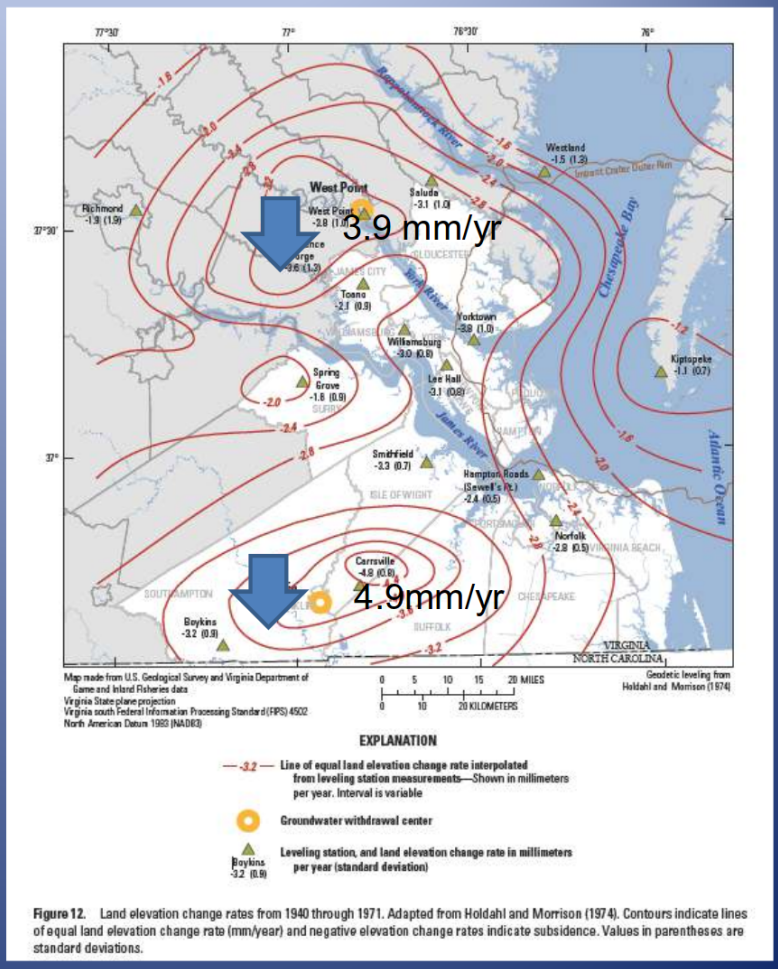

Figure 12. Land elevation change rates from 1940 through 1971. Adapted from Holdahl and Morrison (1974). Contours indicate lines of equal land elevation change rate (mm/year) and negative elevation change rates indicate subsidence. Values in parentheses are standard deviations.

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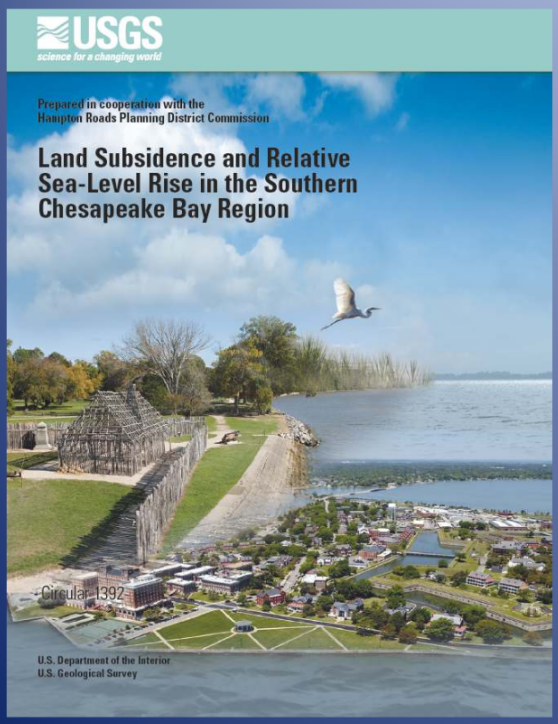
To sum up – subsidence is important



Glacial adjustment 1 mm/yr

Land subsidence 1.1 to 4.8 mm/yr

Cities in my region are installing their own water level gauges to get better resolution of subsidence rates

3 mm/year = about 1 foot per century

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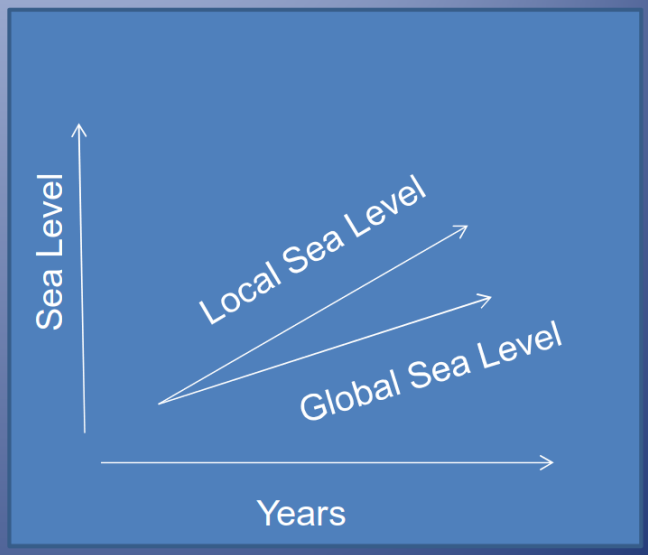
- So now we know
  - Local SL rising faster than global in many cases
  - Subsidence is causing part of this but apparently not all.
  - The ocean is not flat so the added water and expansion does not necessarily lead to equal rise along the coasts.



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NOAA Technical Report NOS CO-OPS 051

ELEVATED EAST COAST SEA LEVEL ANOMALY:
June – July 2009

Silver Spring, Maryland
August 2009

noaa National Oceanic and Atmospheric Administration

U.S. Department Of Commerce
National Ocean Service
Center for Operational Oceanographic Products and Services

Elevated SL related to
- slowing of Gulf Stream,
- coastal wind direction, and
- possible strength of coastal currents.

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NOAA Technical Report NOS CO-OPS 073

Sea Level Rise and Nuisance Flood Frequency Changes around the United States

City Dock in Annapolis, Maryland. Photo Credit: Amy McGovern.

Silver Spring, Maryland

June 2014

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

Sea level rise and these anomalies related to Gulf Stream slowing was topic of reports and papers.

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stitute

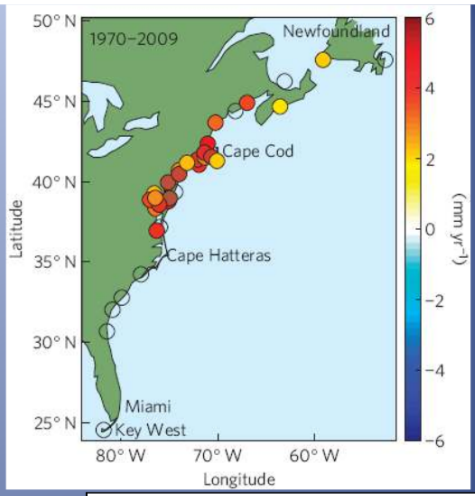
Then three separate studies published within months in 2012 all indicate a **hotspot of accelerated SLR** in the mid-Atlantic coast

nature climate change
LETTERS
PUBLISHED ONLINE: 24 JUNE 2012 | DOI: 10.1038/NCLIMATE1597

Hotspot of accelerated sea-level rise on the Atlantic coast of North America

Asbury H. Sallenger Jr*, Kara S. Doran and Peter A. Howd

USGS



Evidence of Sea Level Acceleration at U.S. and Canadian Tide Stations, Atlantic Coast, North America

John D. Boon

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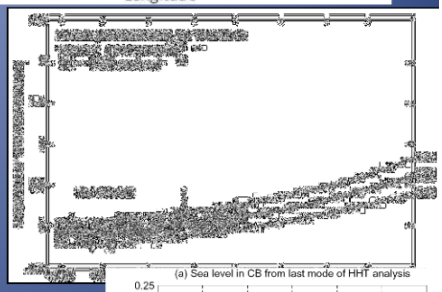
VIMS

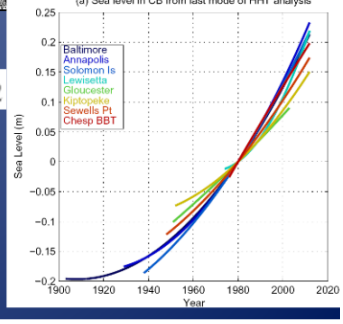


GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L19605, doi:10.1029/2012GL053435, 2012

Is sea level rise accelerating in the Chesapeake Bay? A demonstration of a novel new approach for analyzing sea level data

Tal Ezer[1] and William Bryce Corlett[1,2]

ODU



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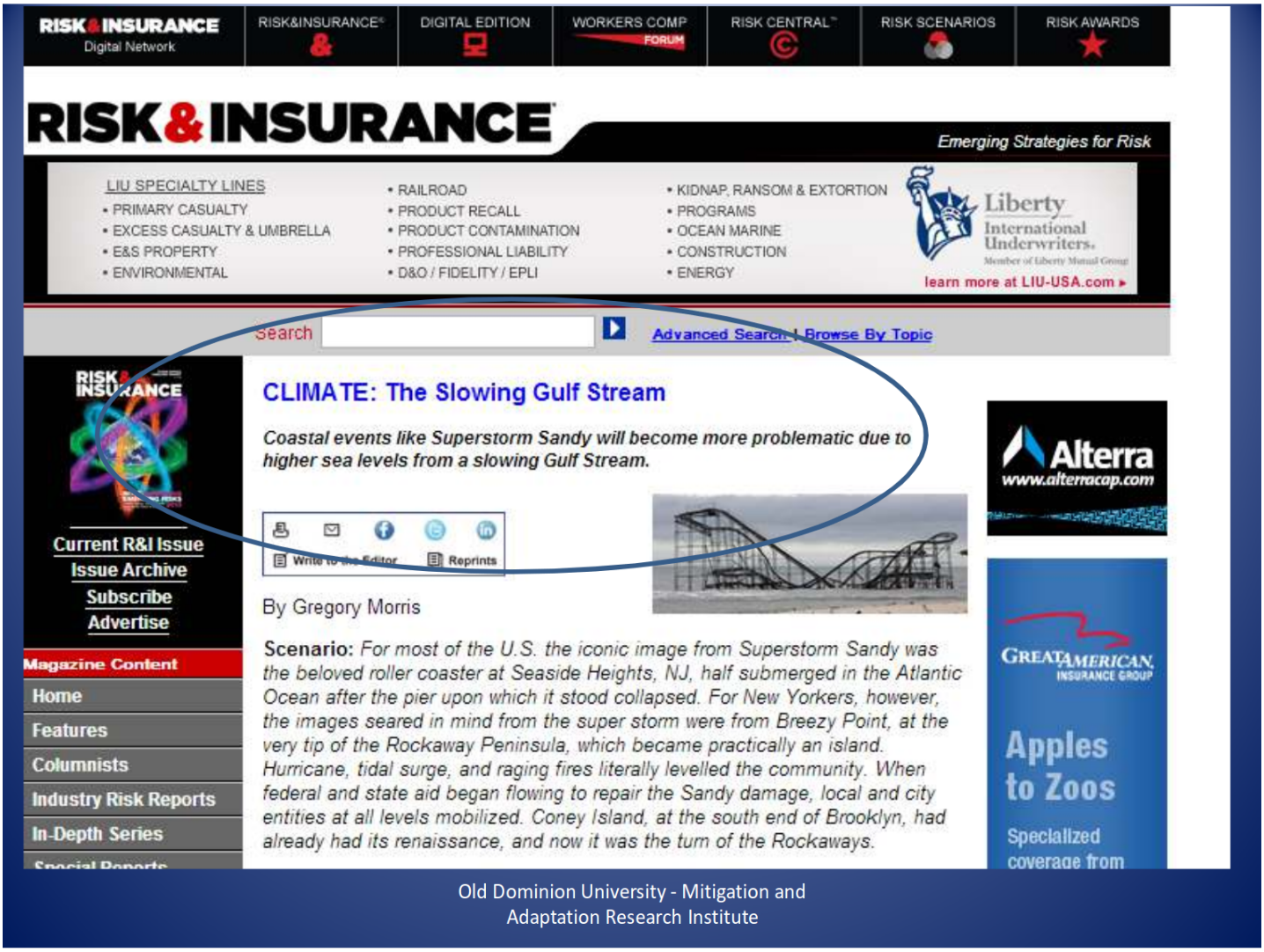

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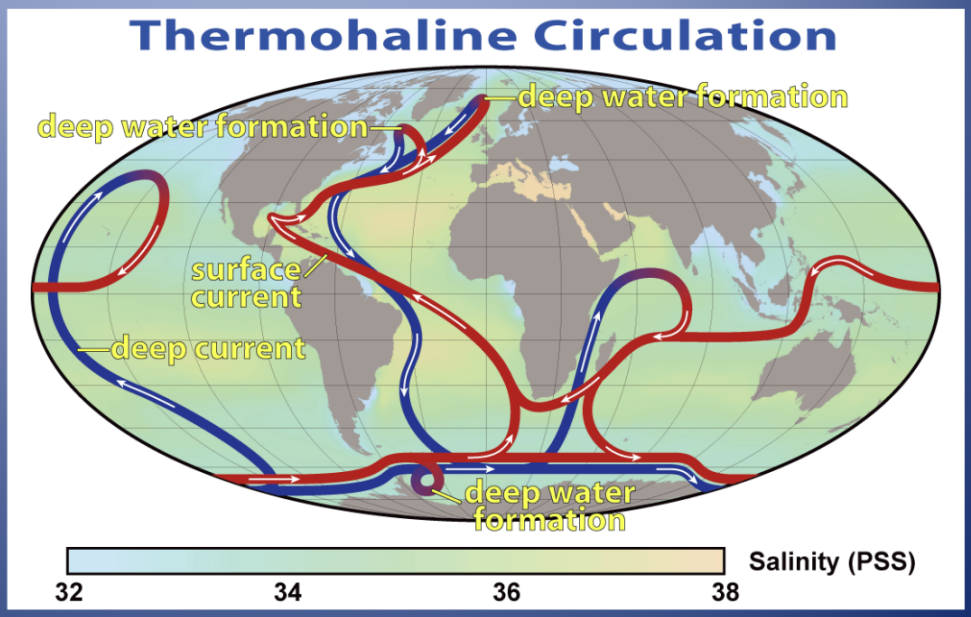
Or the global conveyor belt slowing down – affecting coastal sea level

This is a very active area of research right now.



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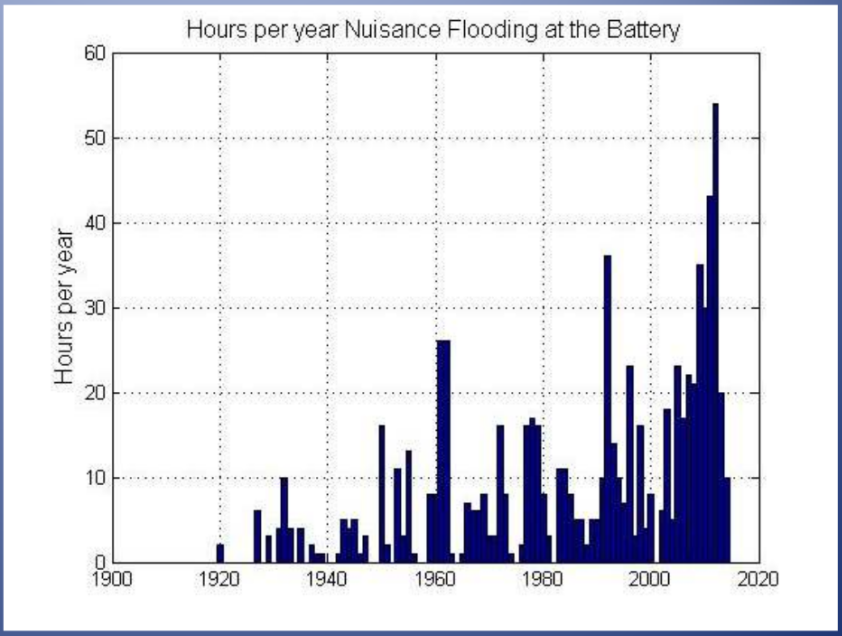
Regardless of cause we are seeing more flooding

To predict future sea level we need to understand what the ocean is going to do in response to increased GHG's (the elephant in the room).



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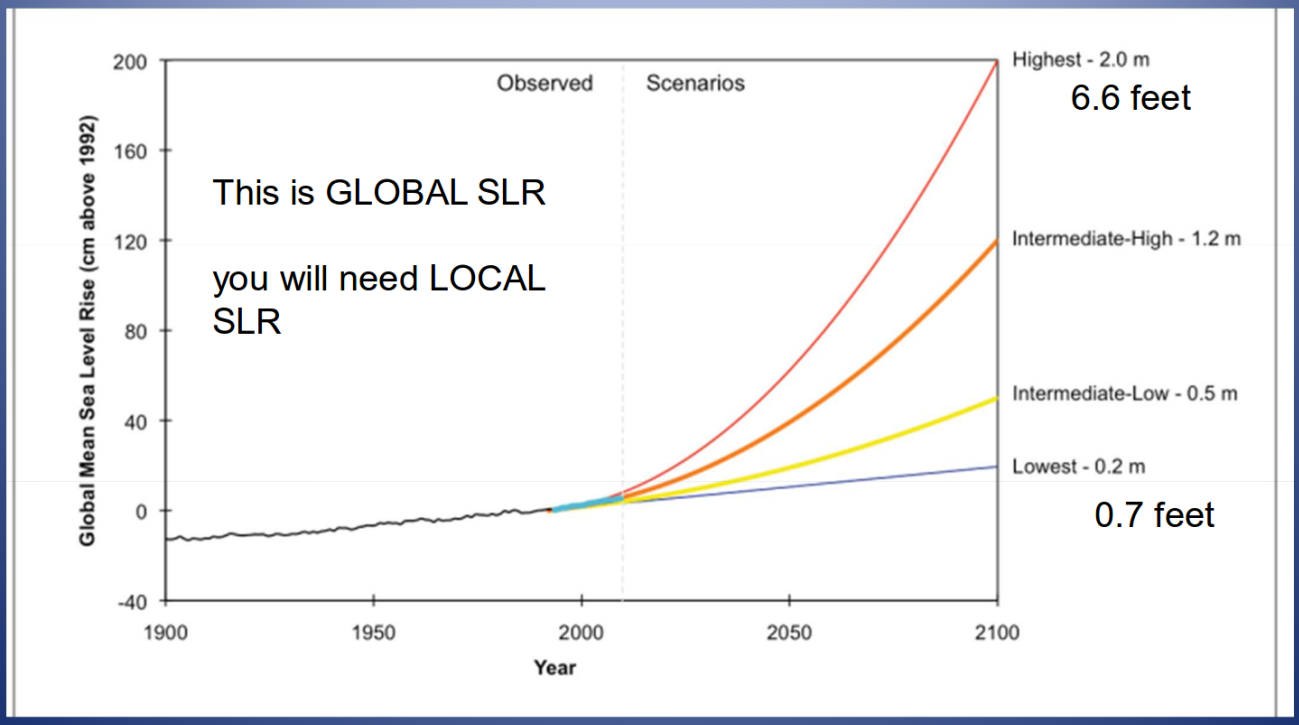
We have very high confidence (>9 in 10 chance) that **global mean sea level** will rise at least 0.2 meters (8 inches) and no more than 2.0 meters" Recent US Assessment



Parris, A., et al. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp

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Learning Points

- Water level (sea level) is rising at most locations in the lower 48 – we can measure it
- It appears to be accelerating along the coasts
  - Global sea level rise
  - Local subsidence
  - Regional ocean circulation
- Get accurate water level measurements locally for your needs and link to nearby accurate water level gauge.

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Thanks

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And colleague

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