The Latest on Sea Level Rise

Dr. Larry Atkinson
Slover Professor of Oceanography
Old Dominion University
Norfolk, Virginia

http://www.nytimes.com/2014/01/14/science/earth/grappling-with-sea-level-rise-sooner-not-later.html?_r=0

Hours per year that Norfolk streets started to flood

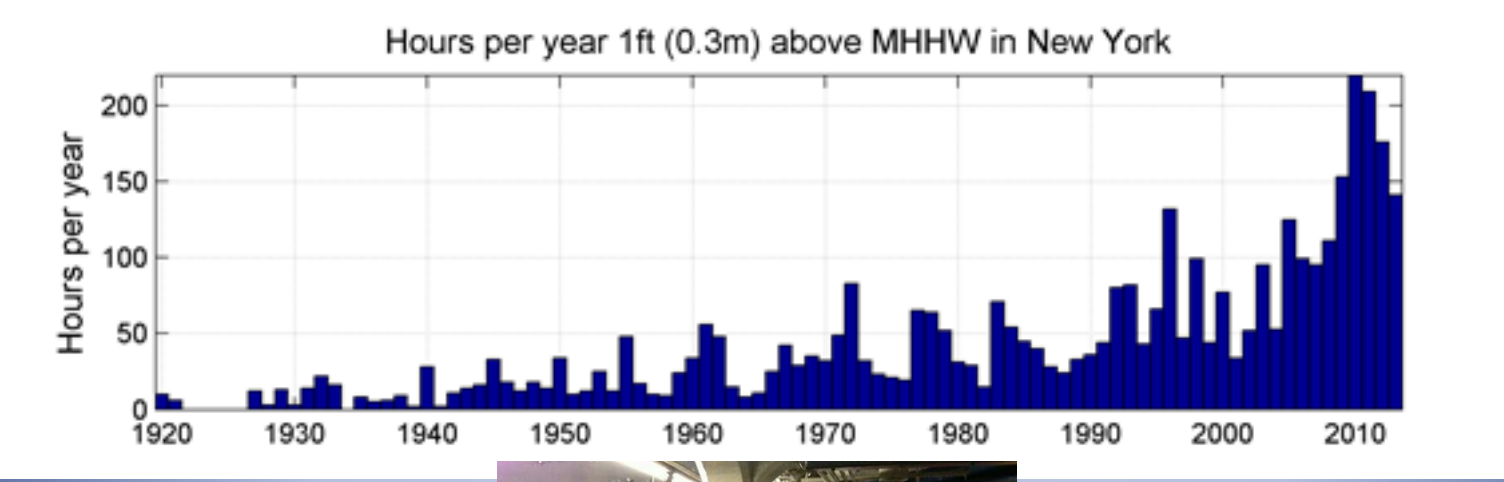
Hours per year

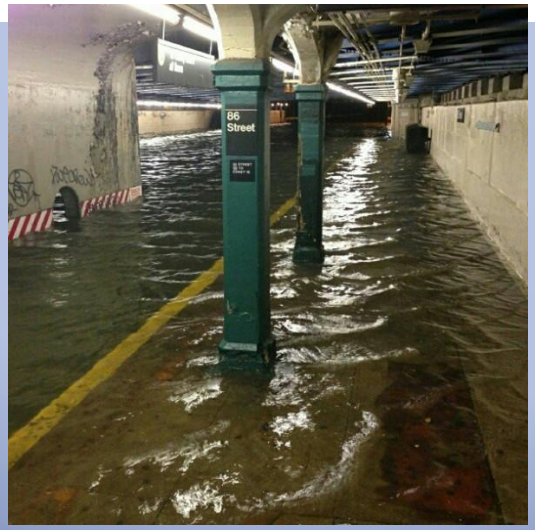
350
300
250
200
150
100
50
0

1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

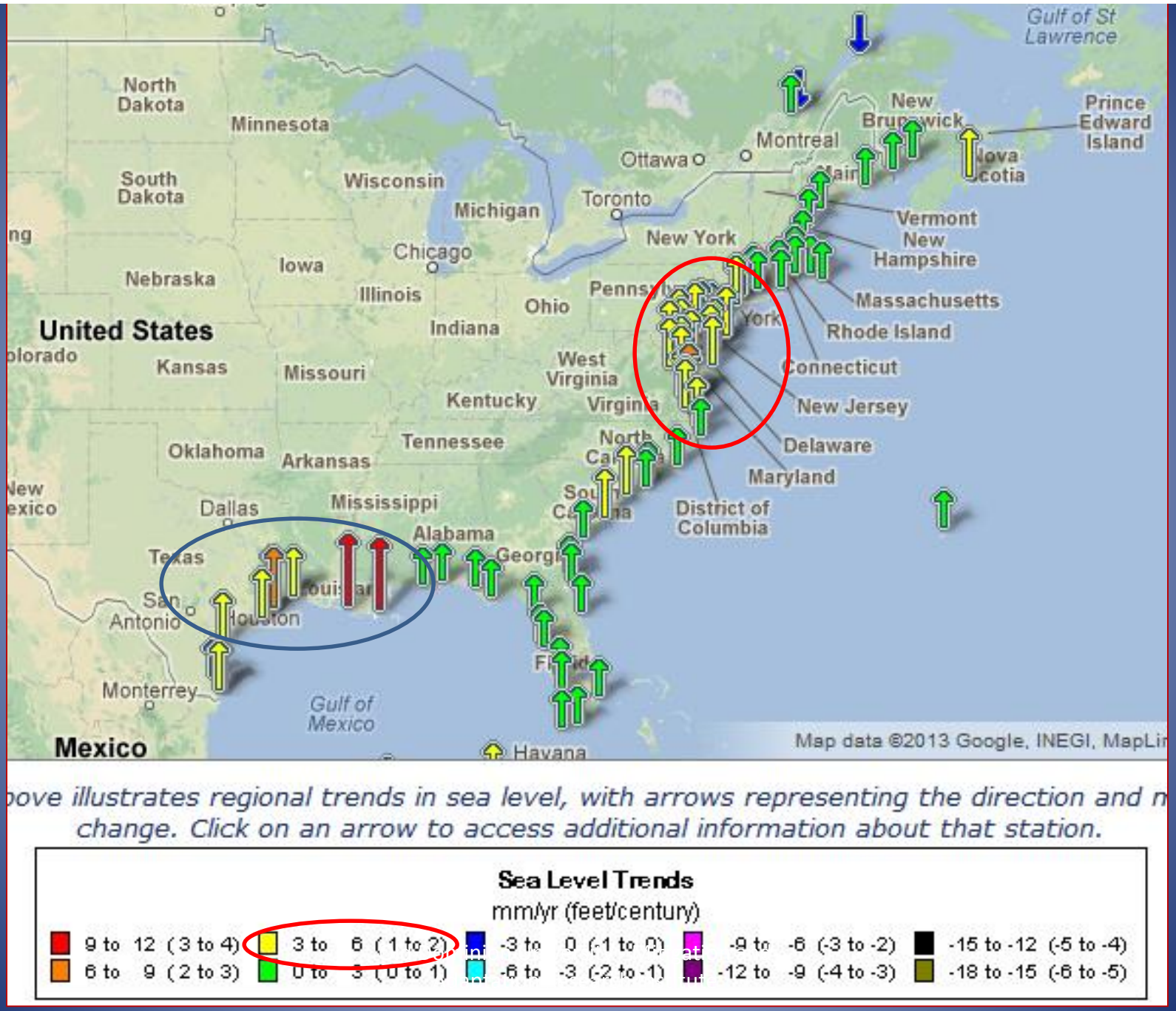
Years

We are not alone - NYC





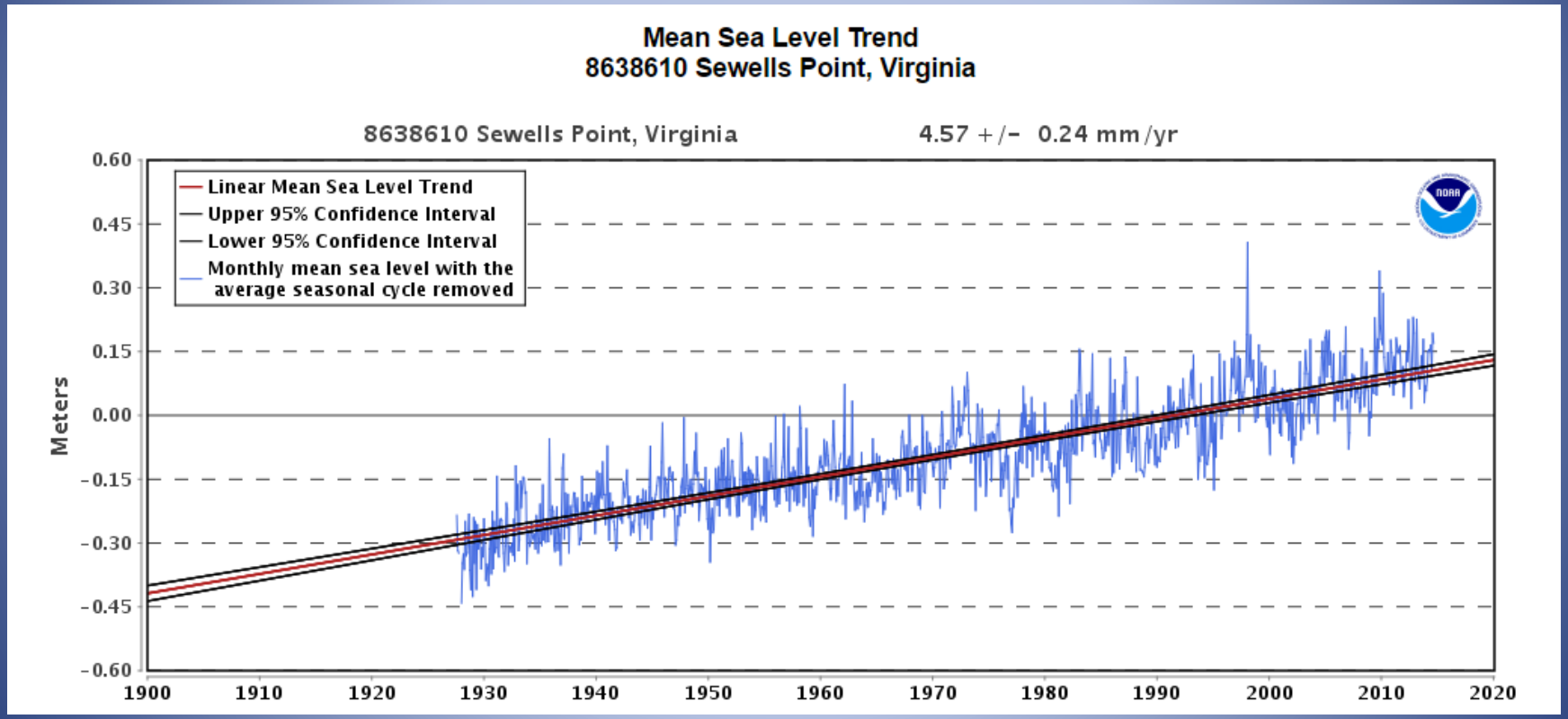
Sea level rise rates at points along the US East Coast are relatively higher than in other places



NOAA Water Level Station at the Navy Base

- 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

1.5 feet per 100 years at Navy Base



So we know about whole oceans

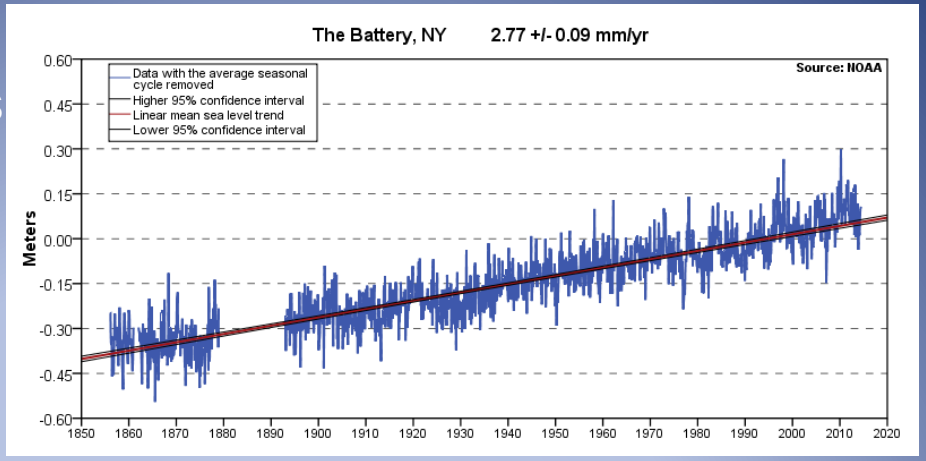
Regional SLR is different

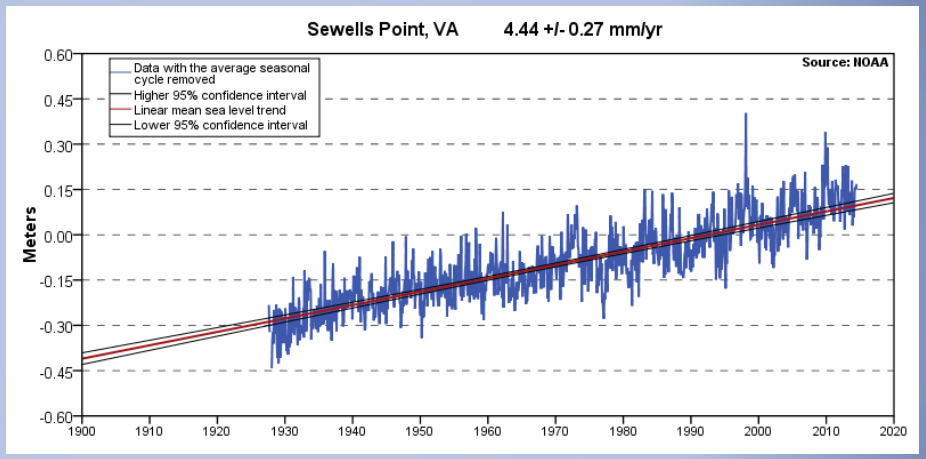
The Battery, NYC
0.9 feet per century

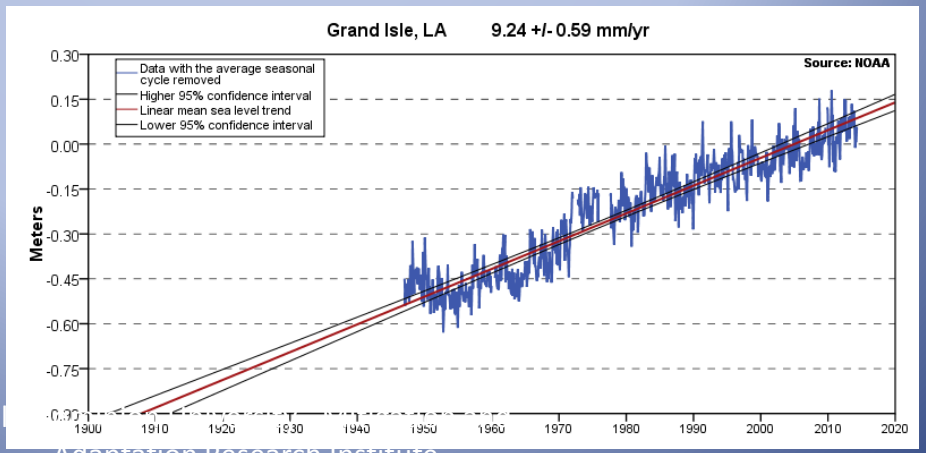
Norfolk Virginia
1.5 feet per century

Coastal Louisiana
3.0 feet per century

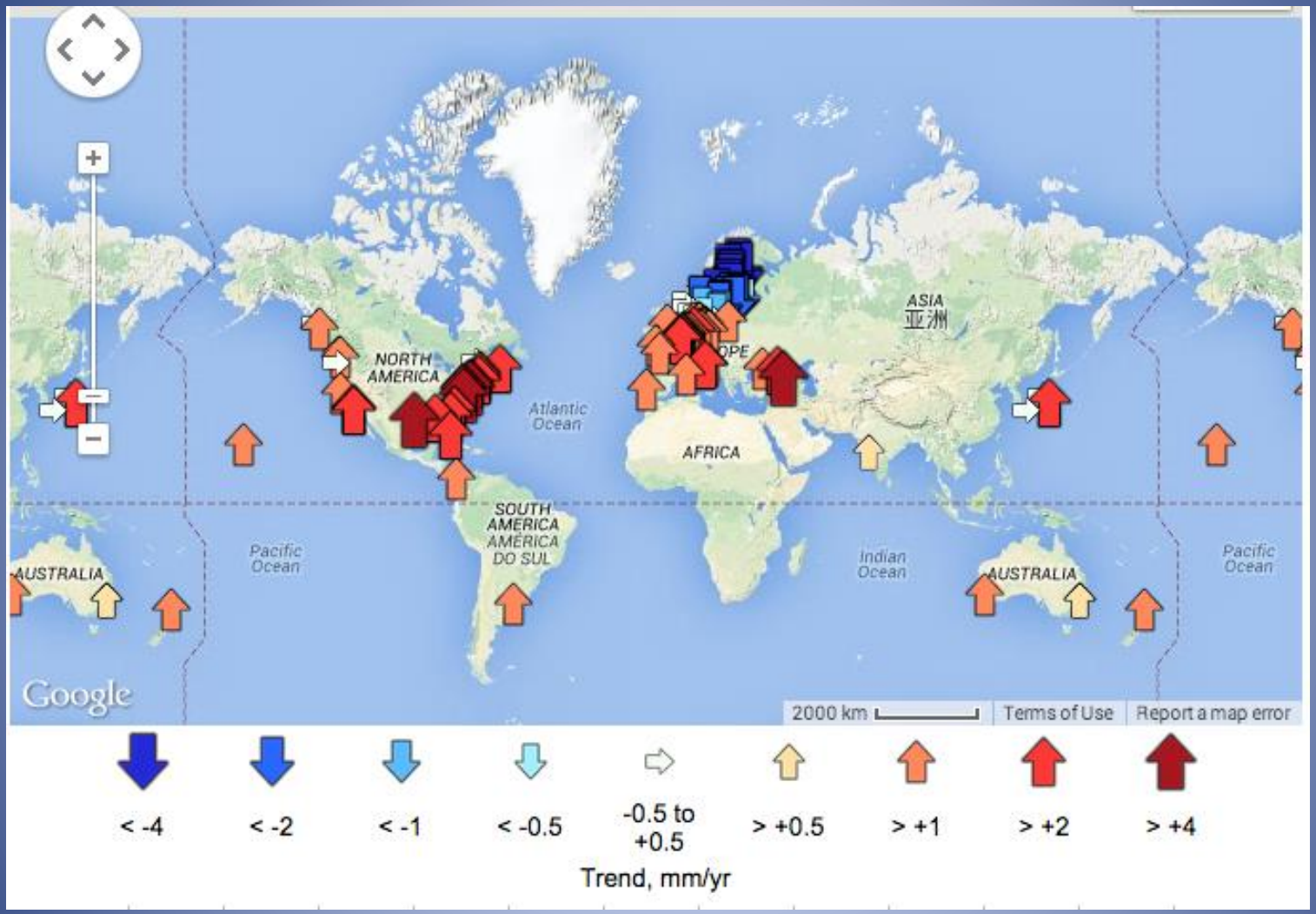
WHY?







And Globally



Data http://www.psmsl.org/

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

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

Land Ice is melting ‘filling the global bathtub’ – the ocean

If all ice melted

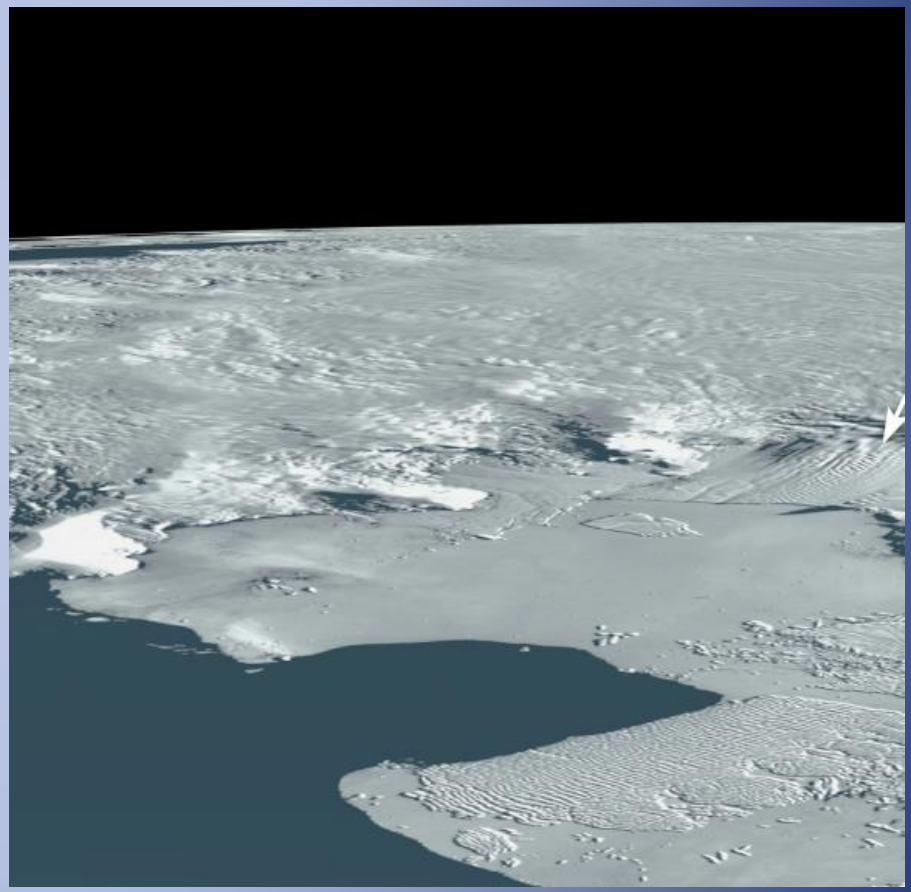
Antarctic – 200 foot sea level rise

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

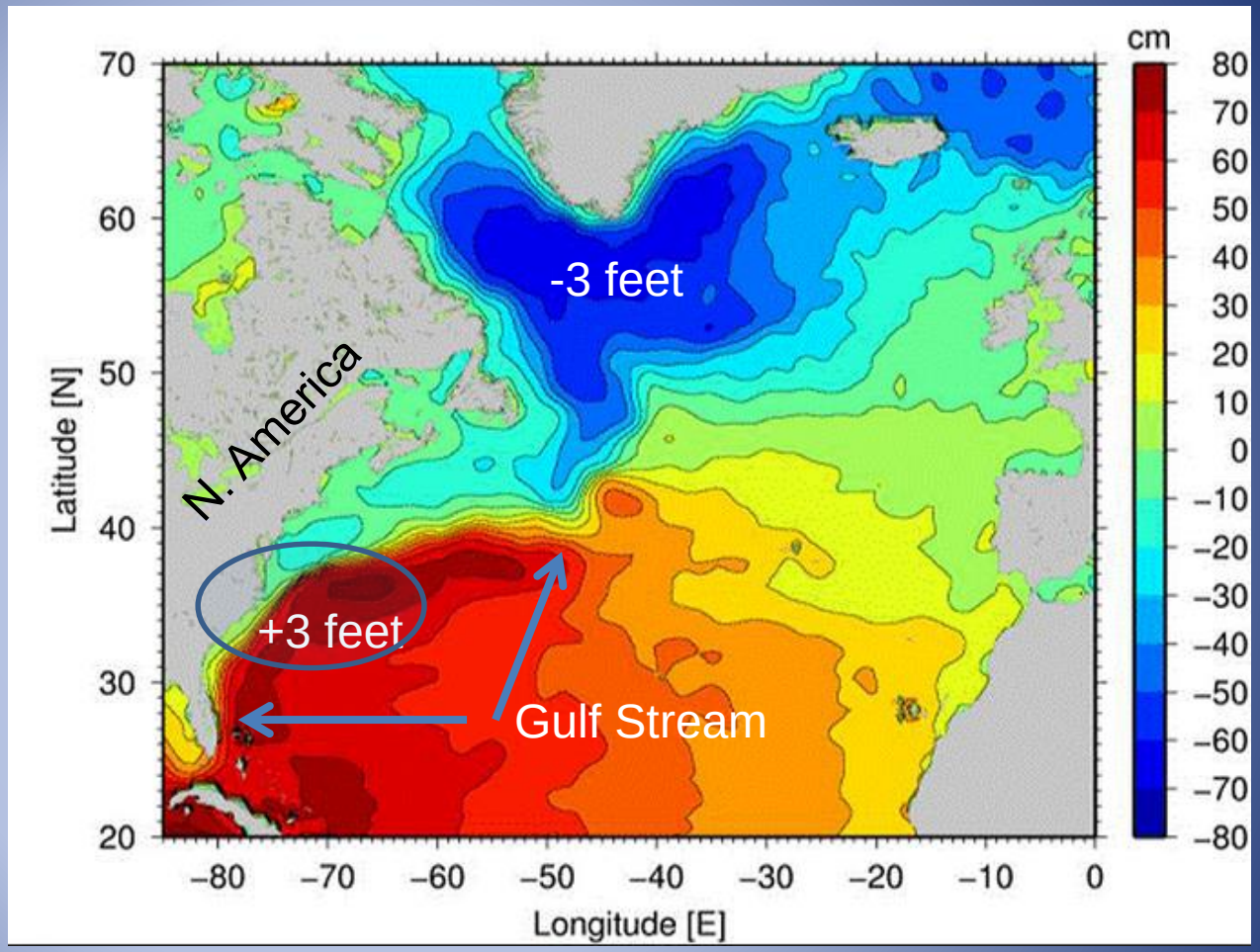


The Ocean is not flat

The red is 6 feet higher than the blue area.

Small changes in ocean currents cause **big changes in coastal sea level**

Topography of the ocean surface



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

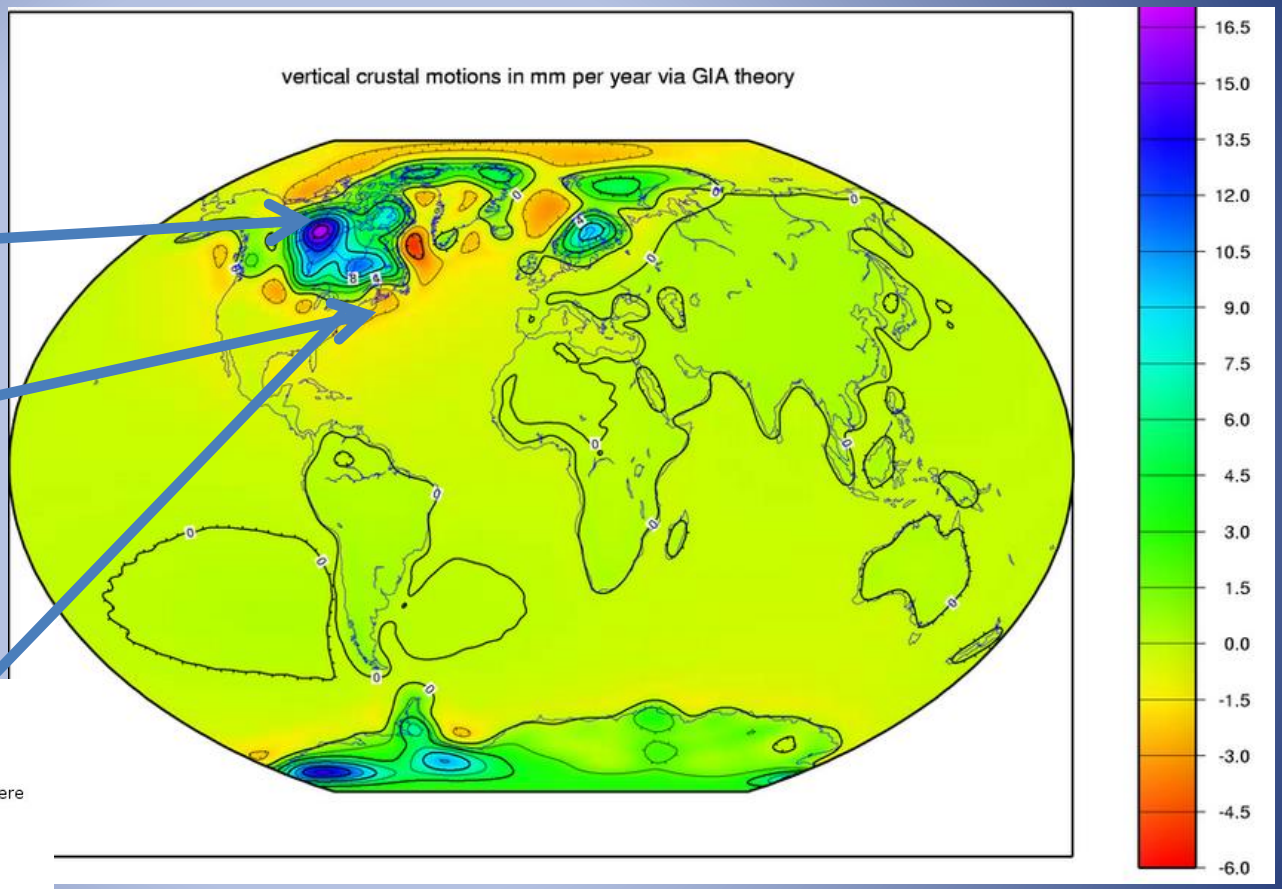
But we care about changes in coastal flooding exacerbated by local SLR

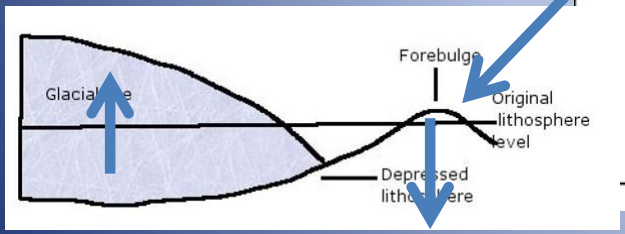
Annapolis – photo by Amy McGovern

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

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.

Case Study- ground water withdrawal in coastal Virginia

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

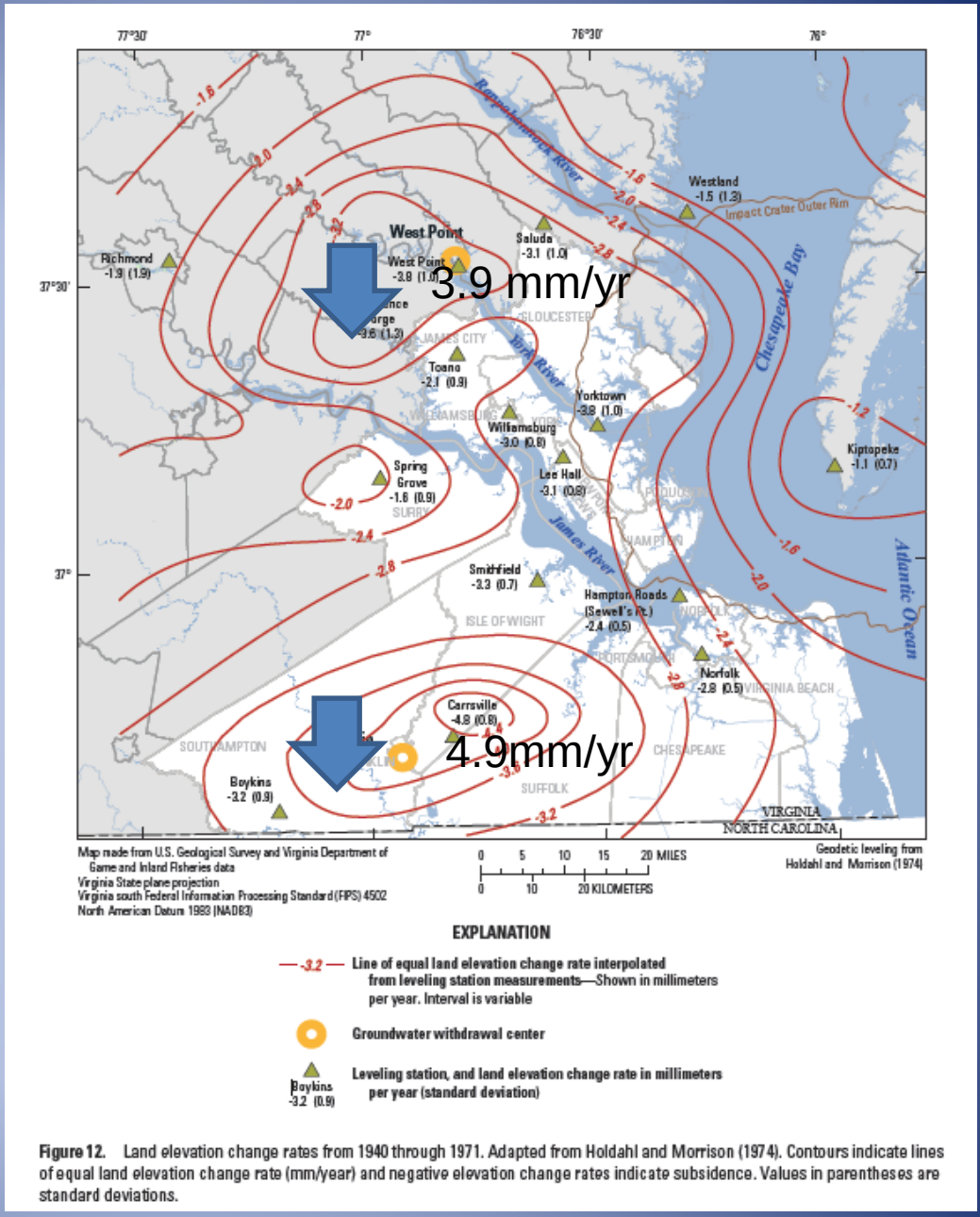


Figure 12. Land elevation change rates from 1940 through 1971. Adapted from Holdahl and Morrison (1974). Contours indicate lines of equal land elevation change rate (mm/year) and negative elevation change rates indicate subsidence. Values in parentheses are standard deviations.

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

‘Nuisance Flooding’

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

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Regional downscaling and its applications to sea-level rise impacts

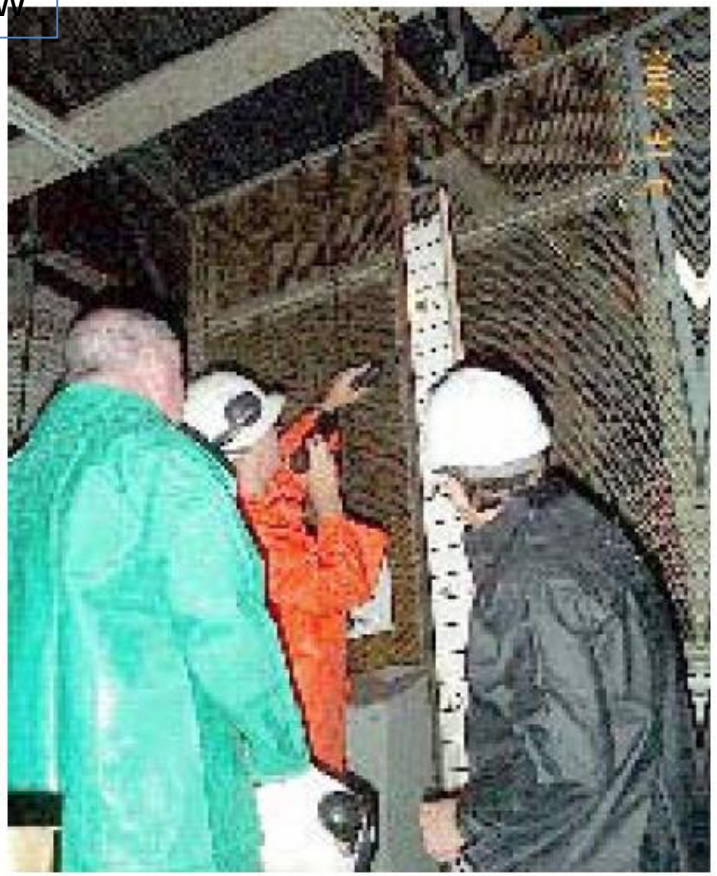
NORTHROP GRUMMAN

Impacts of Hurricane Isabel on the Northrop Grumman Ship Yard

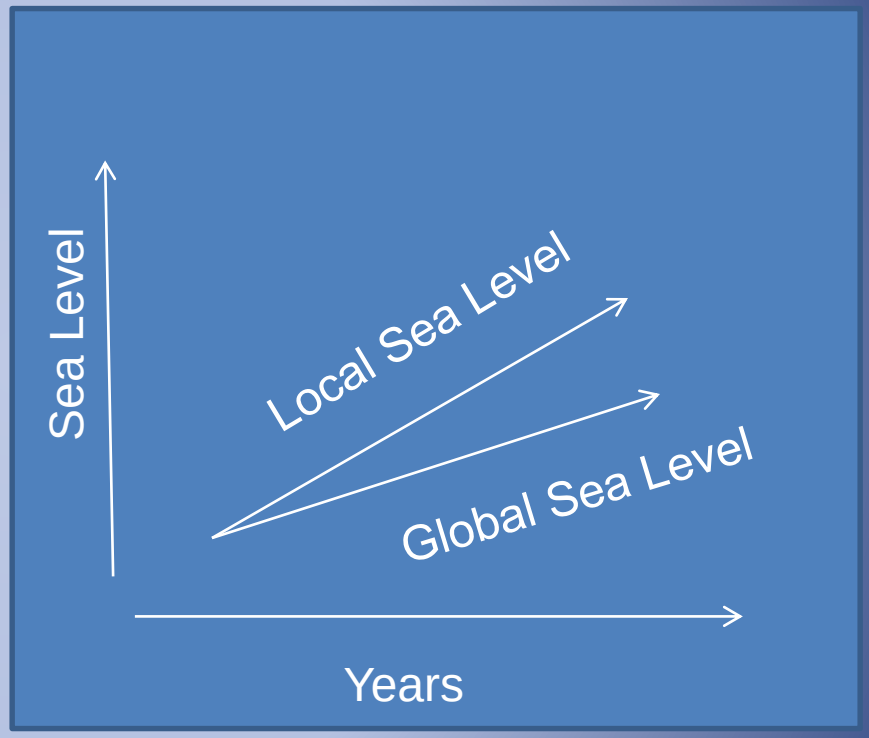
Flooding that might occur every 80 years
Will occur every 2 years 50 to 100 years from now

James River spilling into dry dock #1

Record high water level at the Shipyard



- 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.



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 Sea Level related to

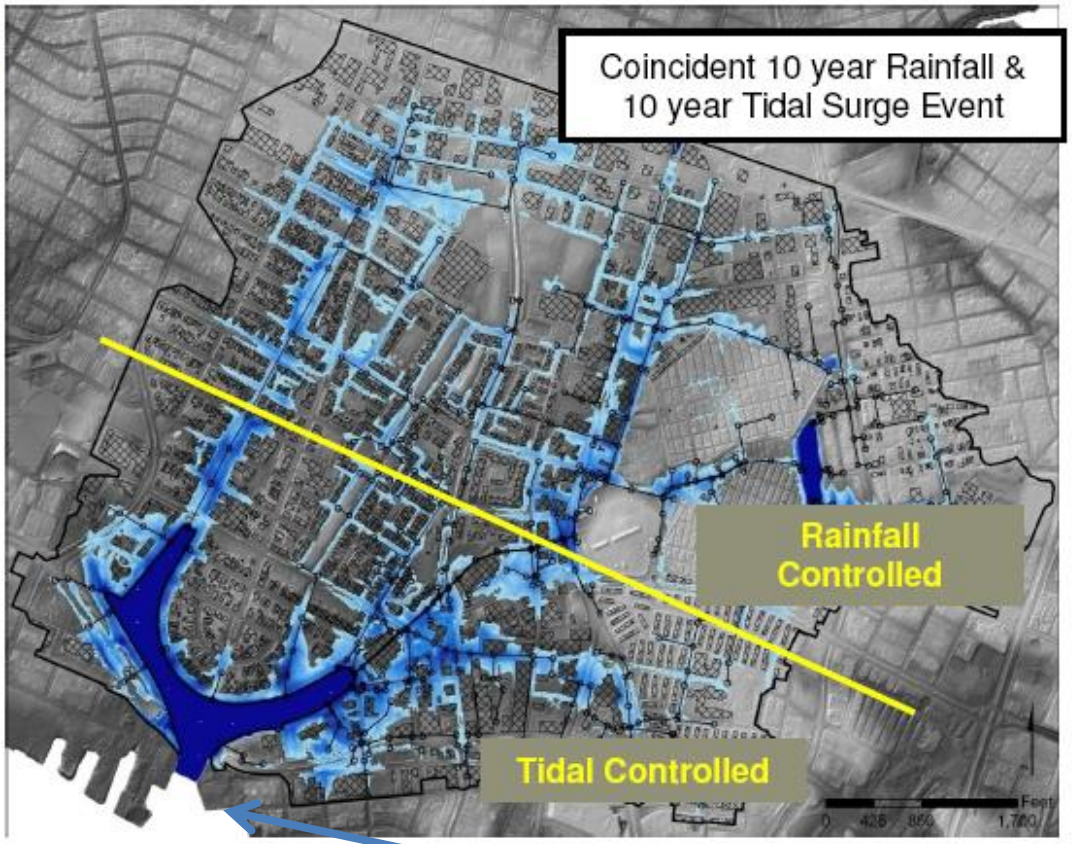
- slowing of Gulf Stream,
- coastal wind direction, and
- possible strength of coastal currents.
- ODU has experts working on this

Regional Response

- Hampton Roads Planning District Commission – Formed - Special Committee
  - Plan for both recurrent flooding
  - developing policy
  - Advocating for state and federal support
  - Primary regional contact for coordinating efforts
  - Members of the Committee - local government staff from across Hampton Roads representing various departments (such planning, public works, and economic development) and military.

Flooding Mitigation and Insurance is at City Level

Storm water Infrastructure Model



Tidal surge:
1) Increases area of rainfall flooding
2) Increases depth of rainfall flooding and
3) Holds water upstream longer and increases duration of flooding

City of Norfolk and Fugro Atlantic

Light Rail extensions can also be flood structures

Adapting to Flooding

By Sarah Hutchins
The Virginian-Pilot
© August 22, 2011
Photos by D Miller

Relevance to your business

- Water level (sea level) is rising at most locations in the lower 48 – we can measure it
- There will be more ‘nuisance flooding’ and more severe storm flooding
- There will be more rain water flooding
- New regulations will require more storm water management.

Thanks

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And colleague

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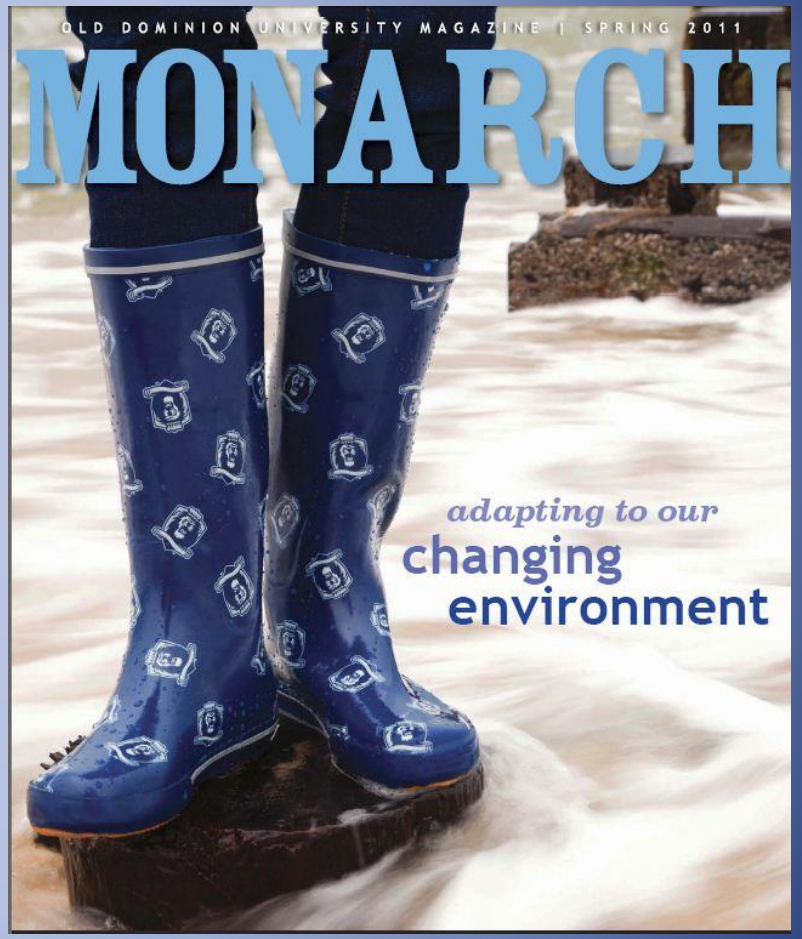
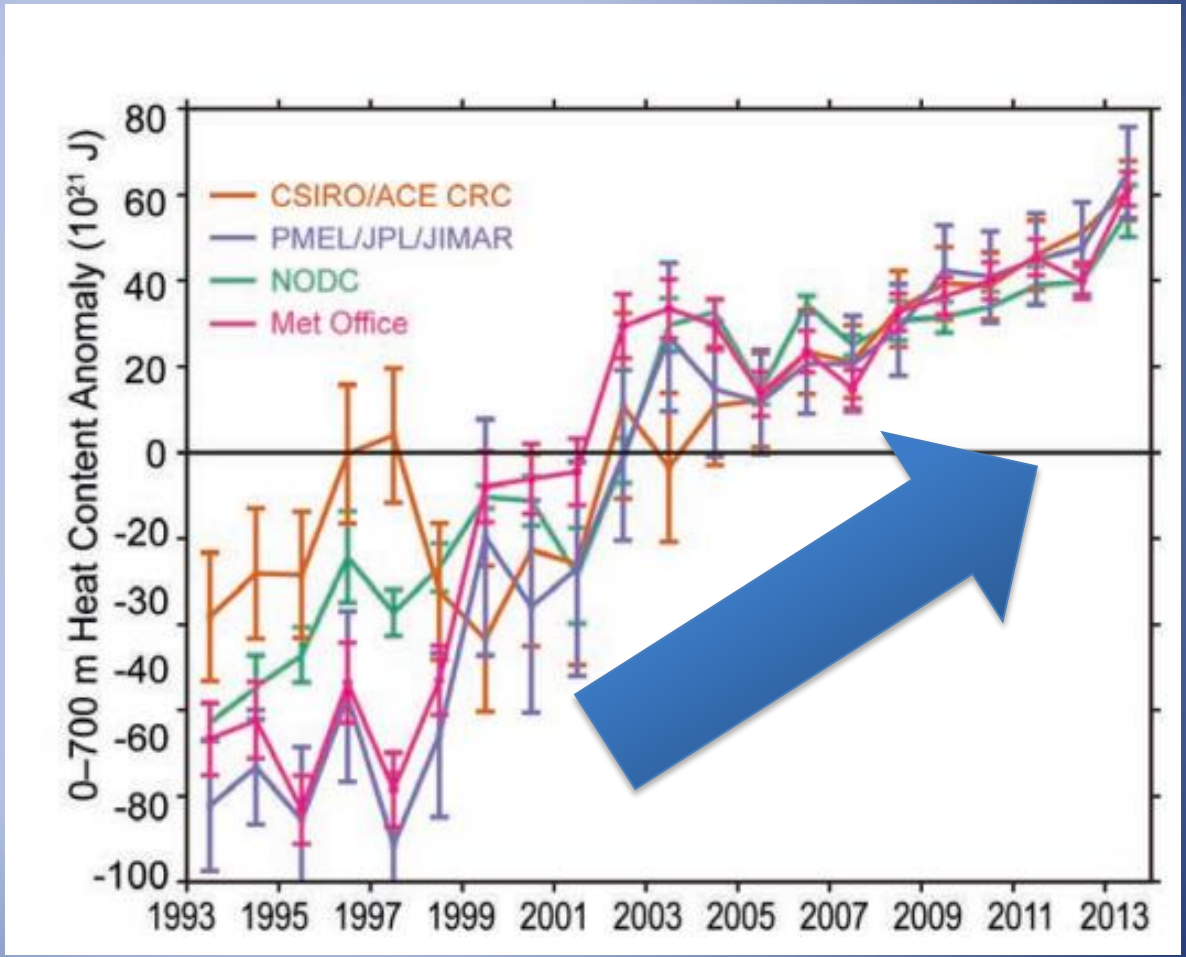


- Flooding more
- We measure it
- Why
- Rain flooding and tidal flooding
- What state and region is doing – needs fed/state/regional approach but it is all local/city by city – make sure one project doesn't cause harm elsewhere.
- Relevance to Ready Mix – more surface flooding – part of CRS (flooding) – more stormwater management - opportunities

The Ocean is Warming – and expanding

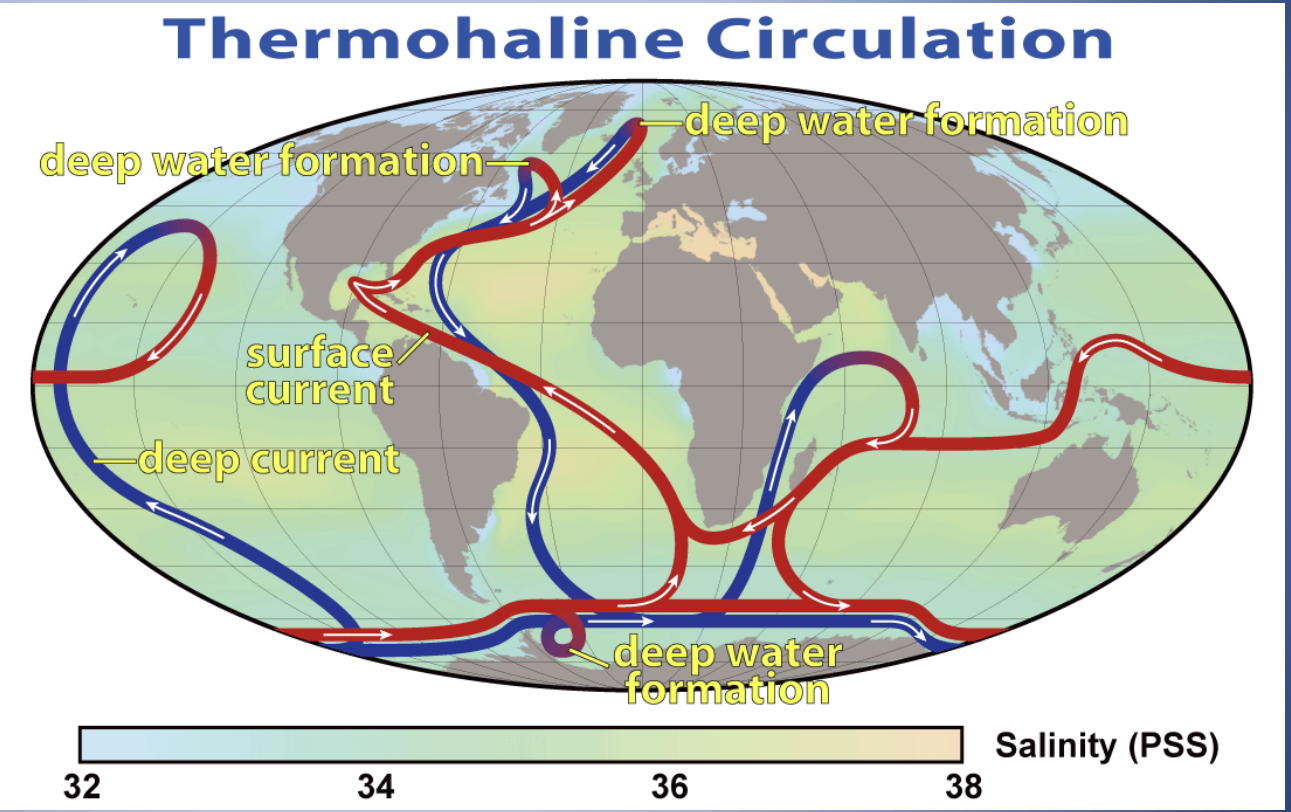
Increasing heat content of the global ocean

As the ocean heats up it expands



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

This is a very active area of research right now.



Flood Insurance will make decisions for us

PilotOnline.com

Cost of flood insurance poised to rise for thousands

By Sarah Kleiner Varble
The Virginian-Pilot
© September 24, 2013

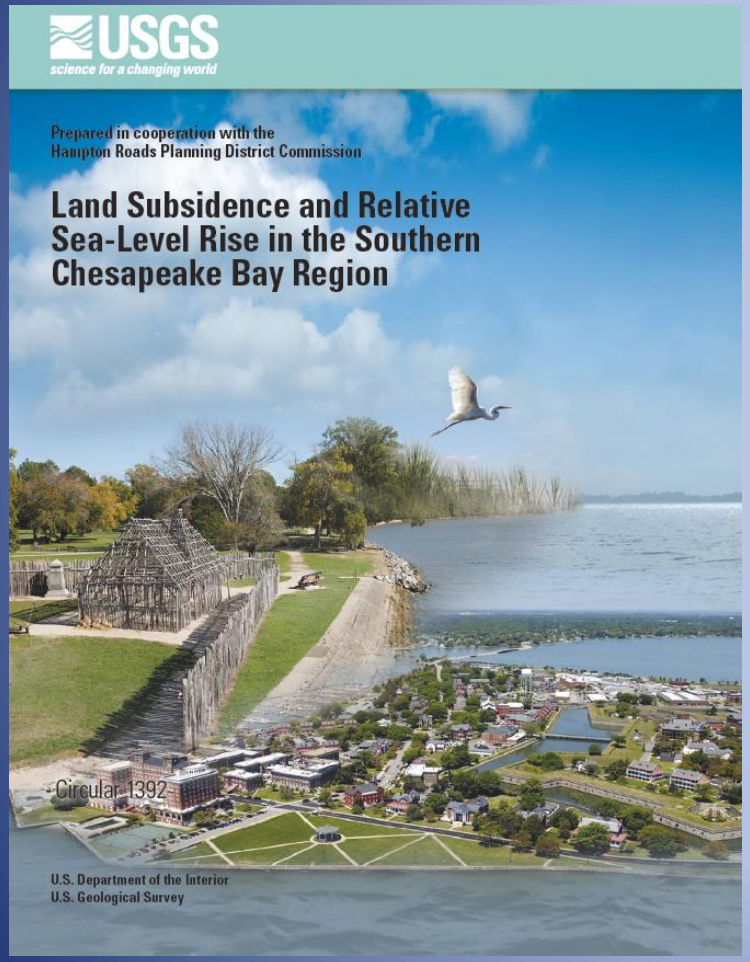
Mother Nature has spared U.S. coastal cities from devastating hurricanes this season, but some local homeowners should brace themselves nonetheless.

The cost of flood insurance for thousands of properties in South Hampton Roads soon could go up - significantly in some cases.

Subsidies that have kept insurance costs down for many homeowners across the country will be phased out beginning Oct 1. And those discounts no longer will be transferable from owner to owner, which will add hundreds or thousands of dollars to the annual out-of-pocket costs for buyers of such homes.

On top of that, the Federal Emergency Management Agency is redrawing flood zone boundaries. Houses that aren't in a flood zone now might find themselves on the riskier side of the line once the maps are finalized in 2014. Those homes will have to be insured against flooding.

To sum up – subsidence is important



Glacial adjustment 1 mm/yr

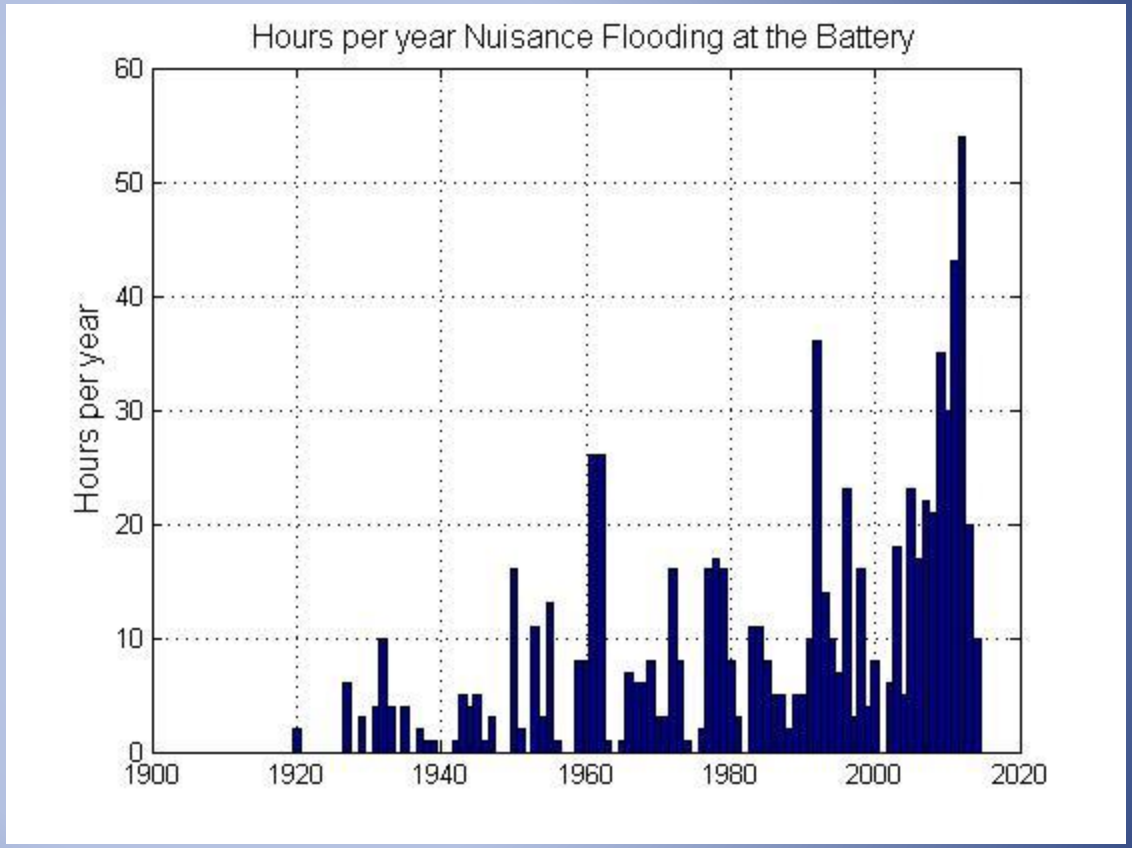
Land subsidence 1.1 to 4.8 mm/yr

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

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).



RISK&INSURANCE

Emerging Strategies for Risk

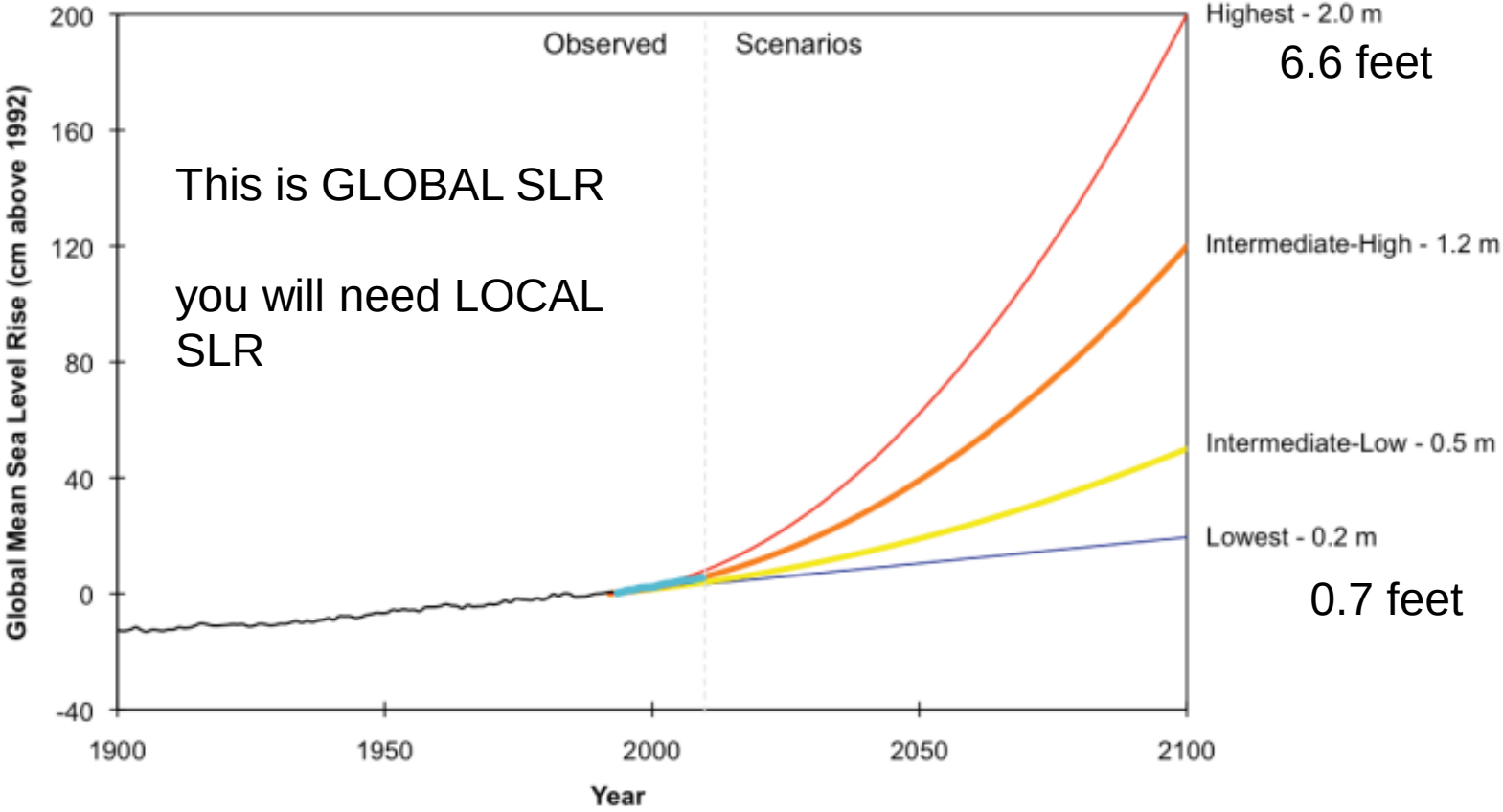
CLIMATE: The Slowing Gulf Stream

Coastal events like Superstorm Sandy will become more problematic due to higher sea levels from a slowing Gulf Stream.

By Gregory Morris

Scenario: *For most of the U.S. the iconic image from Superstorm Sandy was the beloved roller coaster at Seaside Heights, NJ, half submerged in the Atlantic Ocean after the pier upon which it stood collapsed. For New Yorkers, however, the images seared in mind from the super storm were from Breezy Point, at the very tip of the Rockaway Peninsula, which became practically an island. Hurricane, tidal surge, and raging fires literally levelled the community. When federal and state aid began flowing to repair the Sandy damage, local and city entities at all levels mobilized. Coney Island, at the south end of Brooklyn, had already had its renaissance, and now it was the turn of the Rockaways.*

"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