11-16-2012

Sea Level Rise (SLR) Acceleration in the Hampton Roads: A Scientific Perspective

Tal Ezer
Old Dominion University

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Old Dominion University

ODU Climate Change and Sea Level Rise Initiative

Sea Level Rise (SLR) Acceleration in the Hampton Roads: a Scientific Perspective

Tal Ezer and Larry Atkinson
Center for Coastal Physical Oceanography
Old Dominion University (ODU)

Hampton Roads Sea Level Rise Adaptation Forum
VMASC, Friday, November 16, 2012

The New York Times , November, 2010

Front-Line City in Virginia Tackles Rise in Sea

Matthew Eich for The New York

The city of Norfolk, Va., is spending a lot of money to raise Richmond Crescent by 18 inches to avert routine flooding a high tide.

By LESLIE KAUFMAN
Published: November 25, 2010

The Washington Post , June, 2012

Built on sinking ground, Norfolk tries to hold back tide amid sea-level rise

Norfolk in the News

need to know on PBS

PBS, April, 2012

Rising tide in Norfolk, Va.

By William Brangham
April 27, 2012

When the presidential candidates talk about the long-term economic security of the US, they often talk about the national debt, the viability of Medicare and Social Security, and the rise of China.

CLIMATE DESK

But there's another issue that could have major implications for the nation's economy, and it's barely mentioned at all: the soaring costs Americ might face in generations to come from climate change. More specifically, the very damaging and very costly effects of sea level rise.

According to recent research put out by Climate Central, close to four million Americans now live in coastal communities that could see increase flooding caused by sea-level rise. The kind of flooding that was once considered extremely rare could happen more and more often, with devastating economic consequences.

The city of Norfolk, Va., is getting an early look at what sea-level rise means for a big coastal community. The city is experiencing sea-level rise earlier than most because not only are the seas around the city going up, but much of the land beneath Norfolk is going down. This one-two punc means the city is seeing today the kind of flooding that many cities could experience down the road if the scientific projections of sea-level rise pl out.

PilotOnline.com

NEWS | OPIN

Virginian Pilot, February, 2012

HOME » NEWS

Norfolk asks state to study fixes to flooding problem

Posted to: Environment | Local Government | News | Norfolk | State Government

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1 OF 5 PHOTOS: A minor tide floods a bench in Ghent on Monday, Feb. 17, 2003. (Virginian-Pilot file photo)

By Harry Minium
The Virginian-Pilot
© February 18, 2012

RICHMOND

A full moon, a high tide and a brief downpour can be disastrous for many residents in Norfolk's East Ocean View. Rising water from Pretty Lake, a tributary of the Chesapeake Bay, often overwhelms the storm sewer system and overflows the inlet's banks, flooding streets, homes and cars.

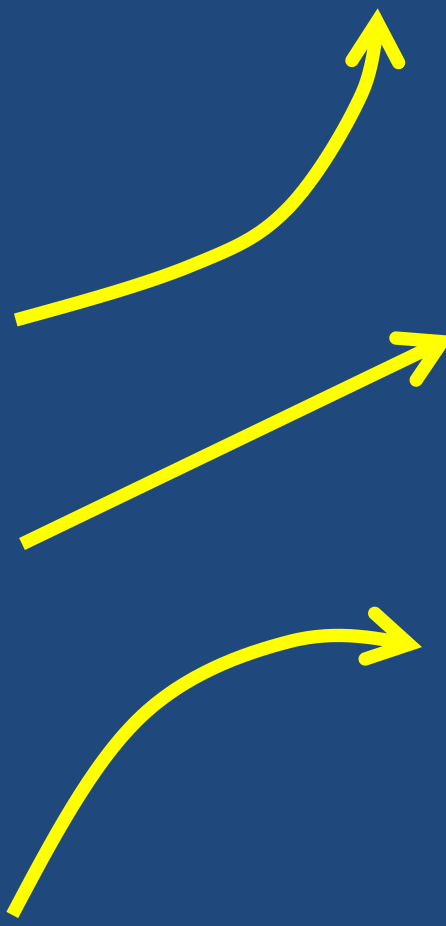
Much the same is true in Ghent, where the Hague often spills into the neighborhood.

Questions:

- Is the Hampton Roads region at a higher flood risk than other areas? and if so why?
- What is the future projection of sea level rise in the area?
- What can we do about it?

To prepare for consequences of sea level rise and be able to project future changes we need to know if:

- SLR rates are increasing?
  (SLR acceleration)
- SLR rates remain unchanged?
- SLR rates are decreasing?
  (SLR deceleration)



Three separate studies published within the past 5 months all indicate an **acceleration** of Sea Level Rise in the mid-Atlantic coast

nature climate change

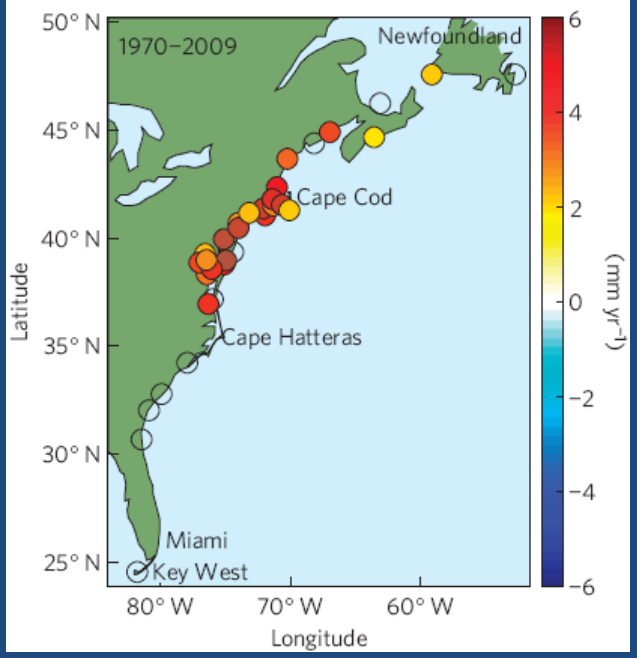
LETTERS

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

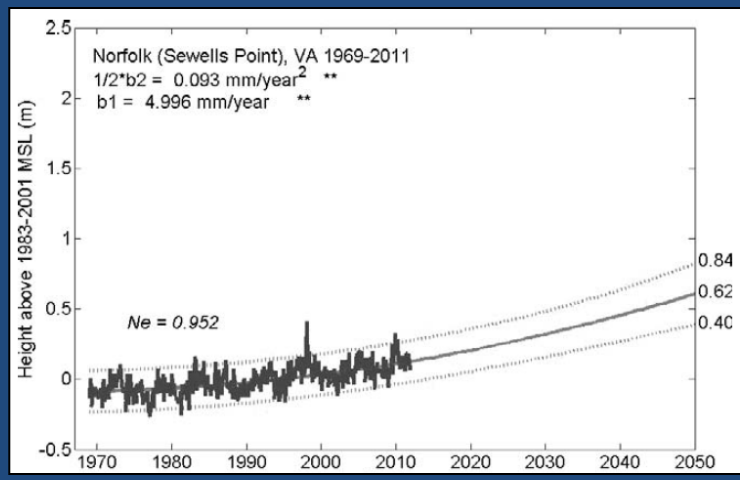
John D. Boon

Virginia Institute of Marine Science
College of William and Mary
P.O. Box 1346
Gloucester Point, VA 23062, U.S.A.
boon@vims.edu

www.cerf-jcr.org

J. Coastal Res. 2012

VIMS



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

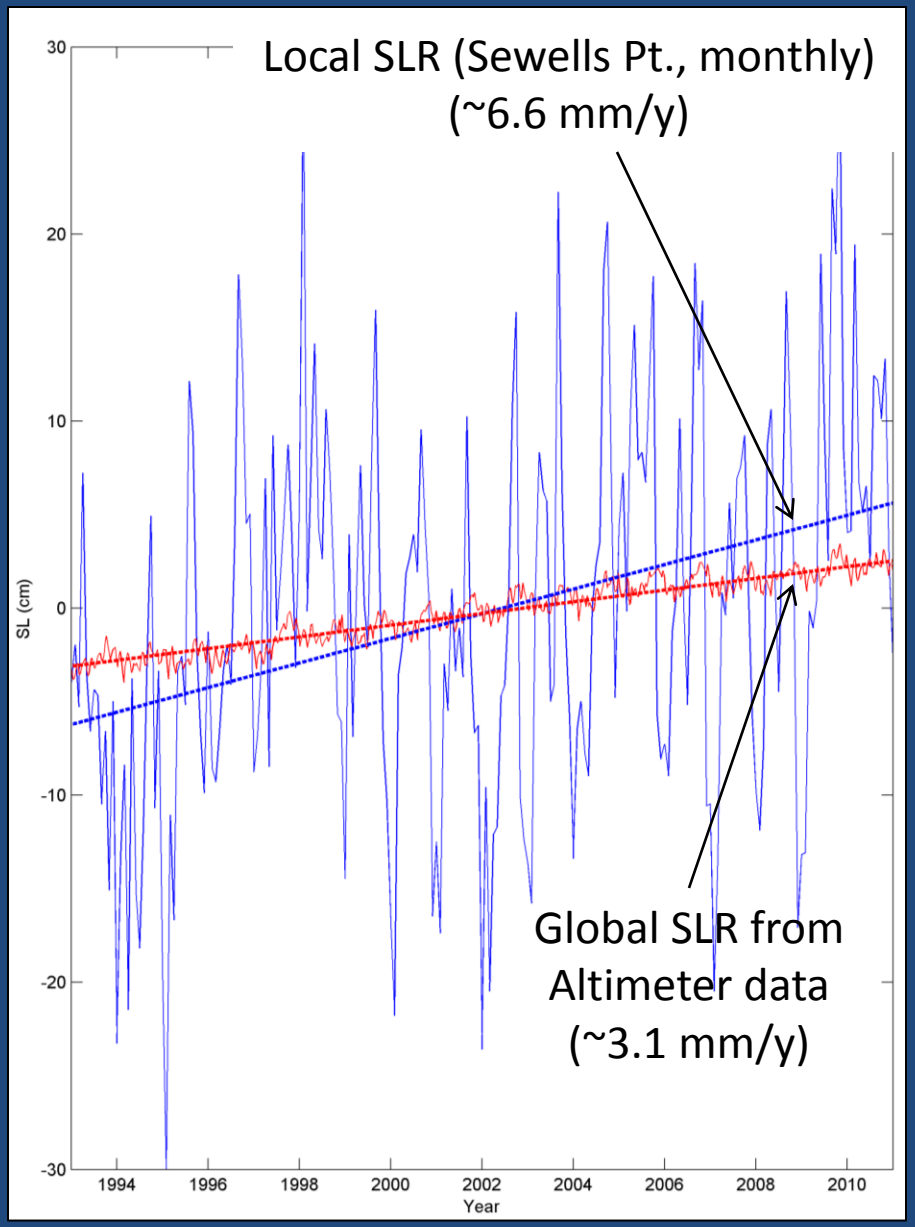
Is sea level rise accelerating in the Chesapeake Bay? A demonstration of a novel new approach for analyzing sea level data

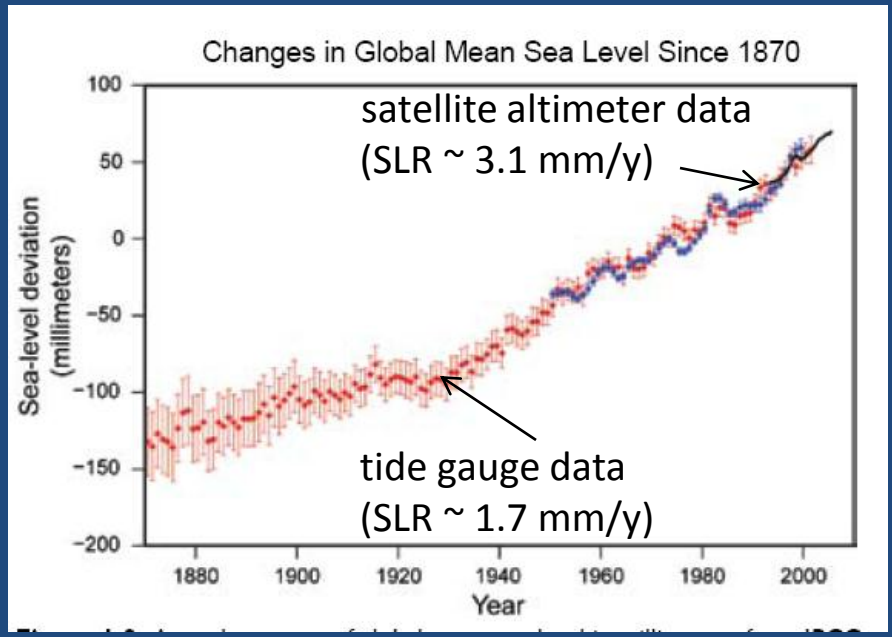
Tal Ezer[1] and William Bryce Corlett[1,2]

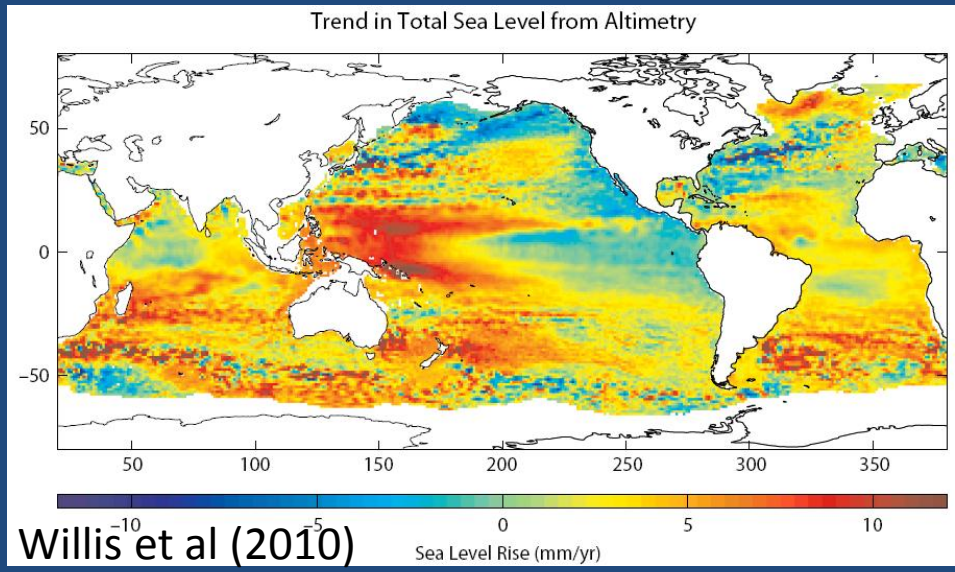
ODU

Global Sea Level Rise is different than local:

Local (relative) SLR = Global SLR ± Land Subsidence/Uplift ± Ocean Dynamics

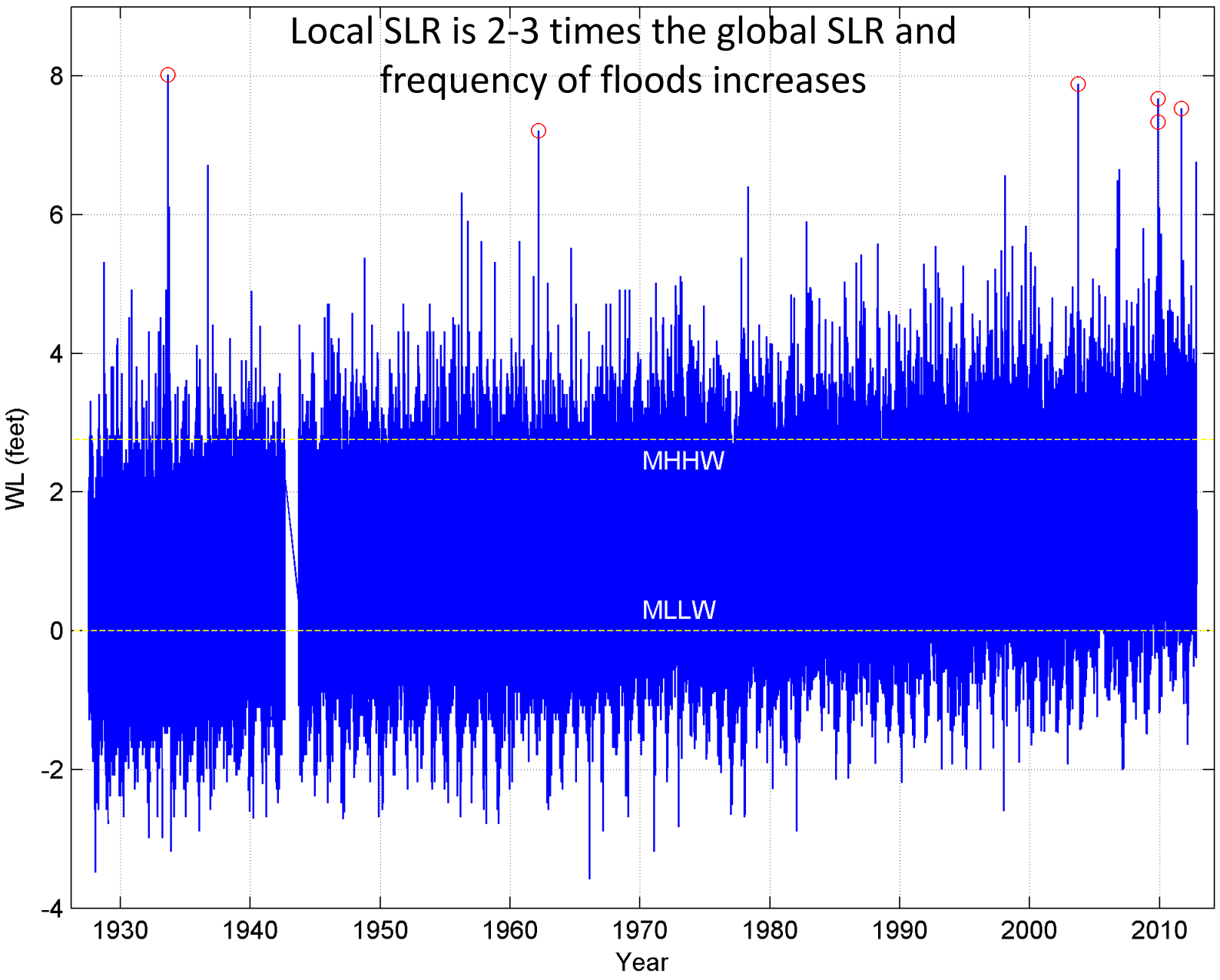




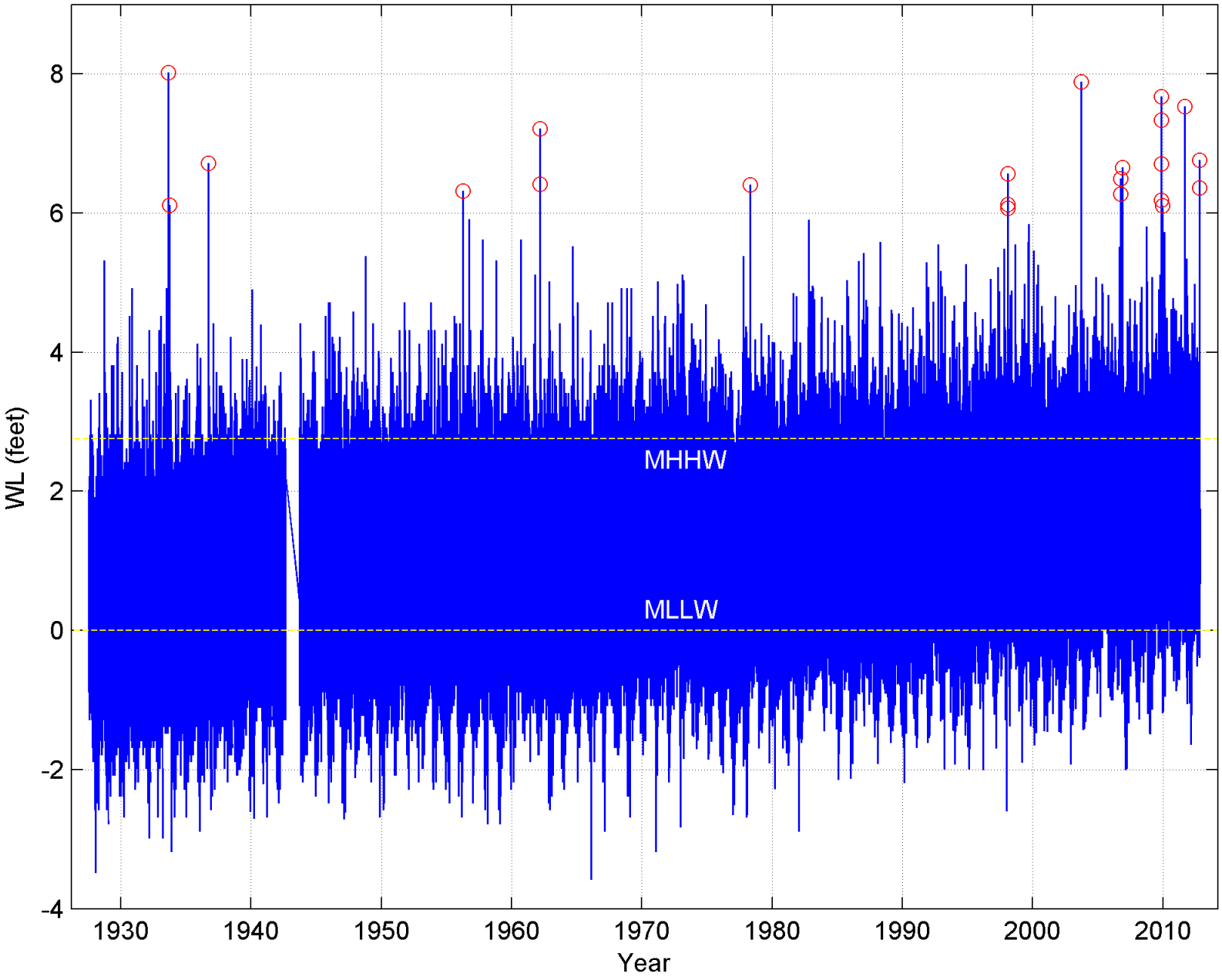


Willis et al (2010)

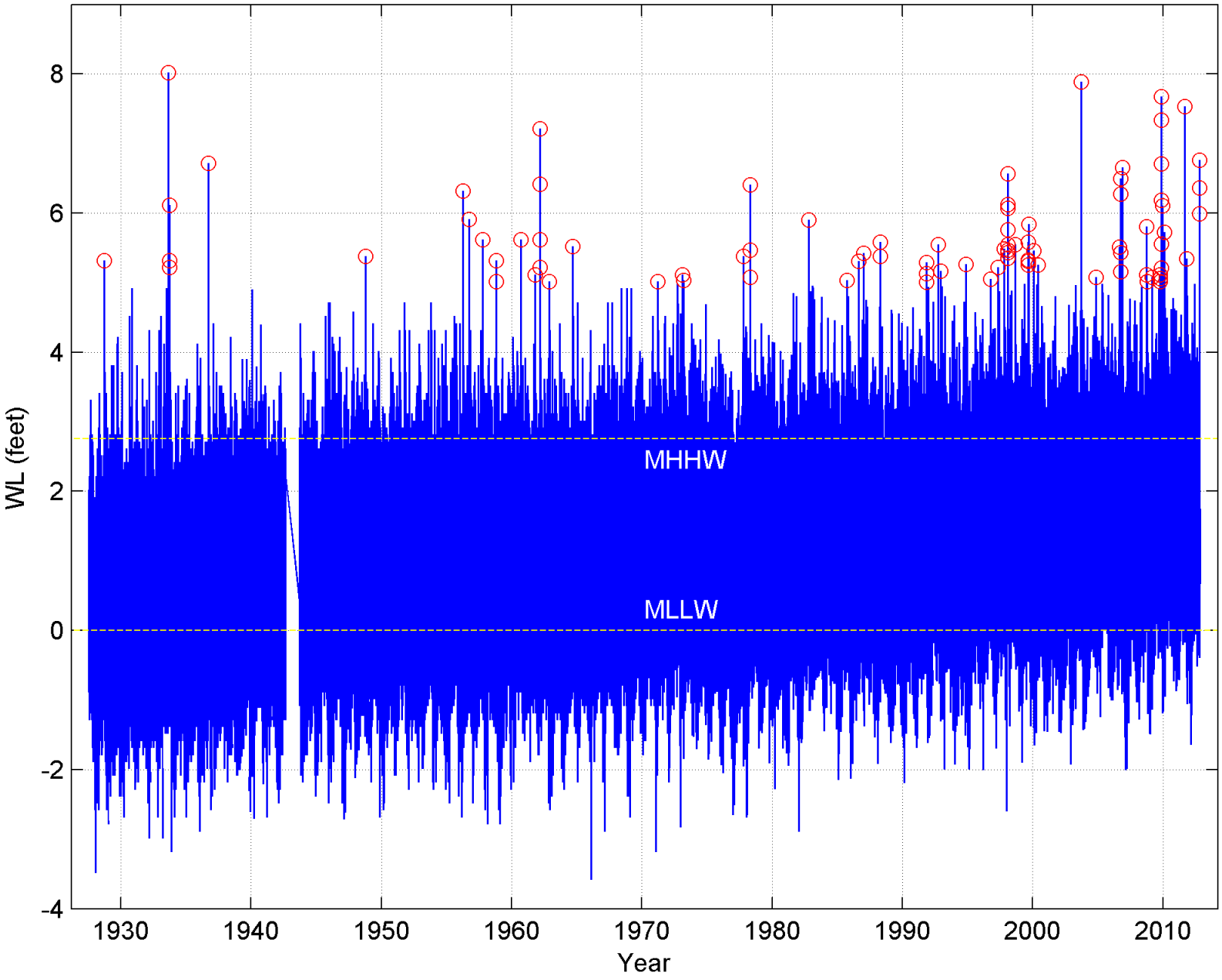
7-foot flood


Sewells Pt. Hourly Water Level and flood > 7 ft
Local SLR is 2-3 times the global SLR and frequency of floods increases
MHHW
MLLW
WL (feet)
Year
8
6
4
2
0
-2
-4
1930
1940
1950
1960
1970
1980
1990
2000
2010

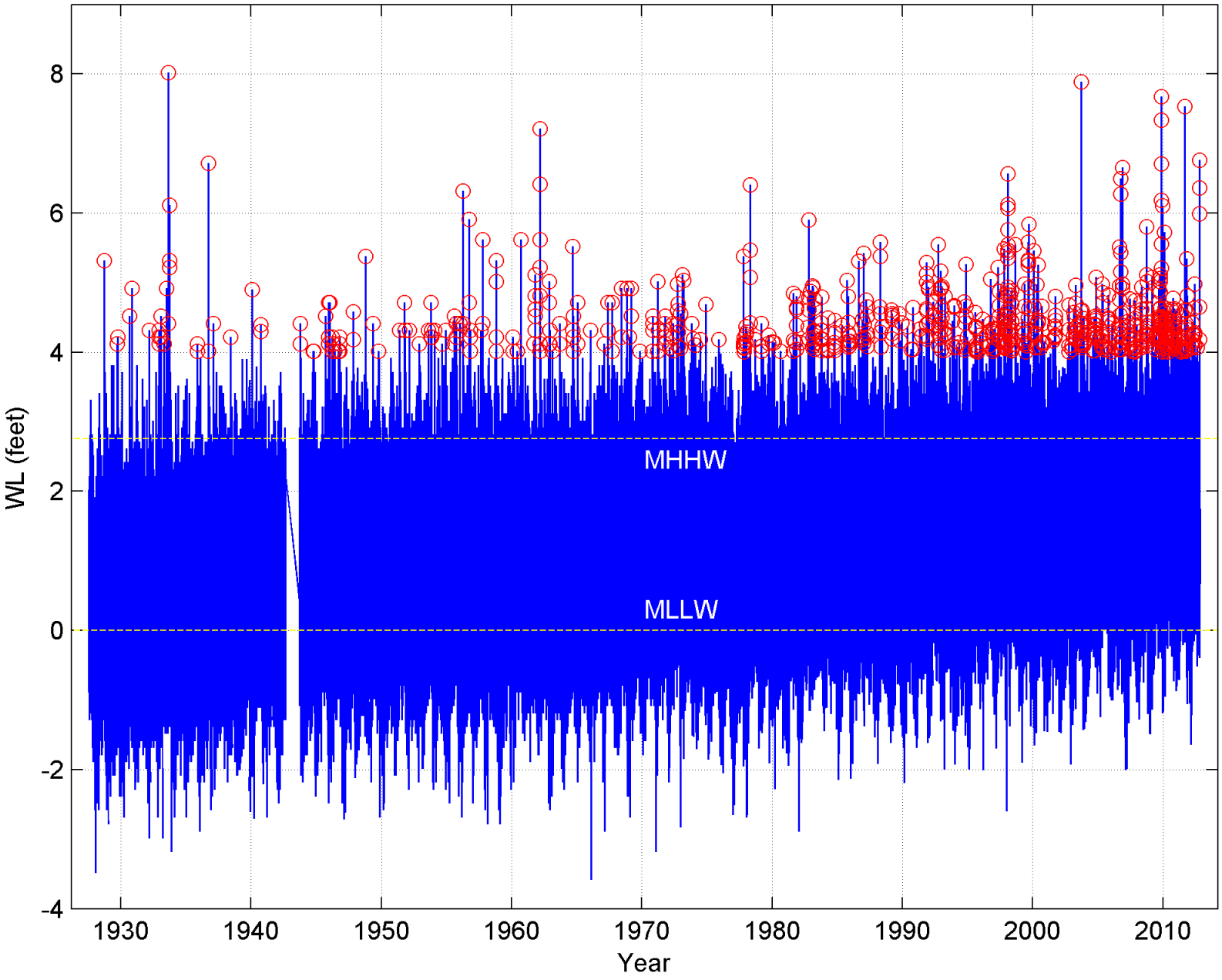
6-foot flood


Sewells Pt. Hourly Water Level and flood > 6 ft
WL (feet)
Year
MHHW
MLLW
8
6
4
2
0
-2
-4
1930
1940
1950
1960
1970
1980
1990
2000
2010

5-foot flood

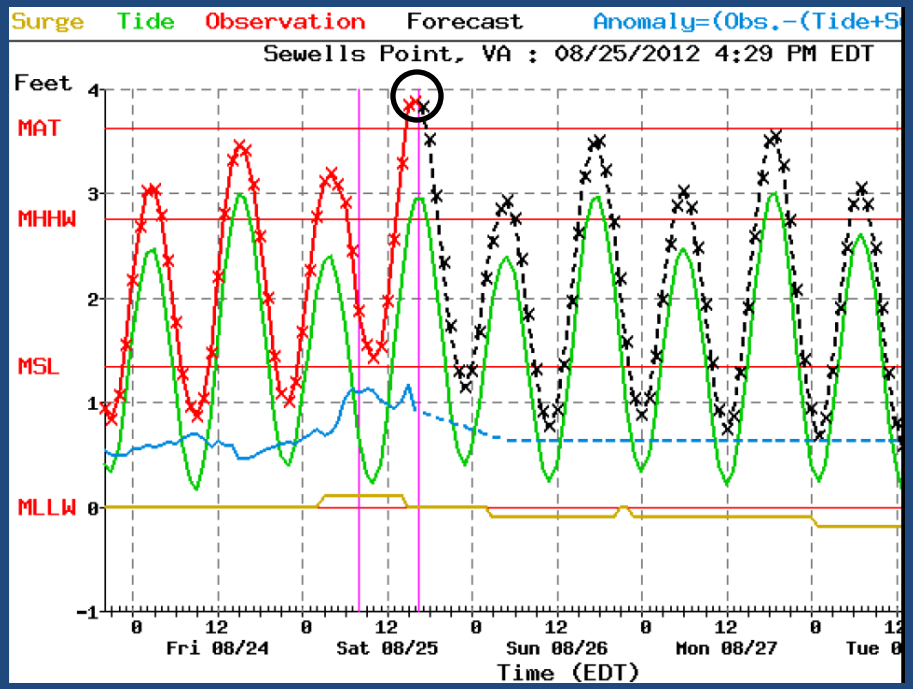

Sewells Pt. Hourly Water Level and flood > 5 ft
WL (feet)
Year
MHHW
MLLW
8
6
4
2
0
-2
-4
1930
1940
1950
1960
1970
1980
1990
2000
2010

4-foot flood

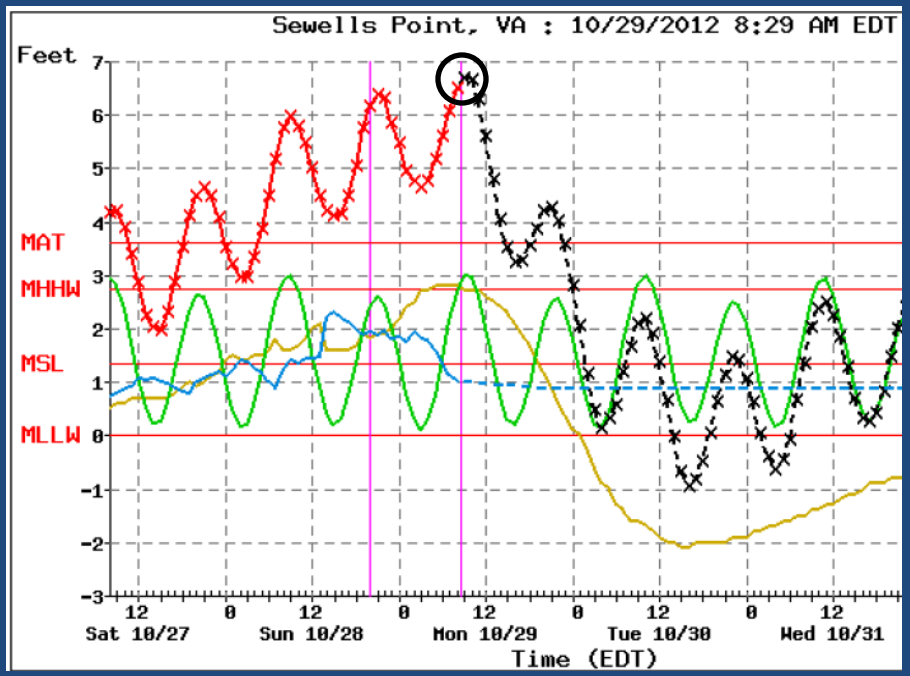

Sewells Pt. Hourly Water Level and flood > 4 ft
WL (feet)
8
6
4
2
0
-2
-4
MHHW
MLLW
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

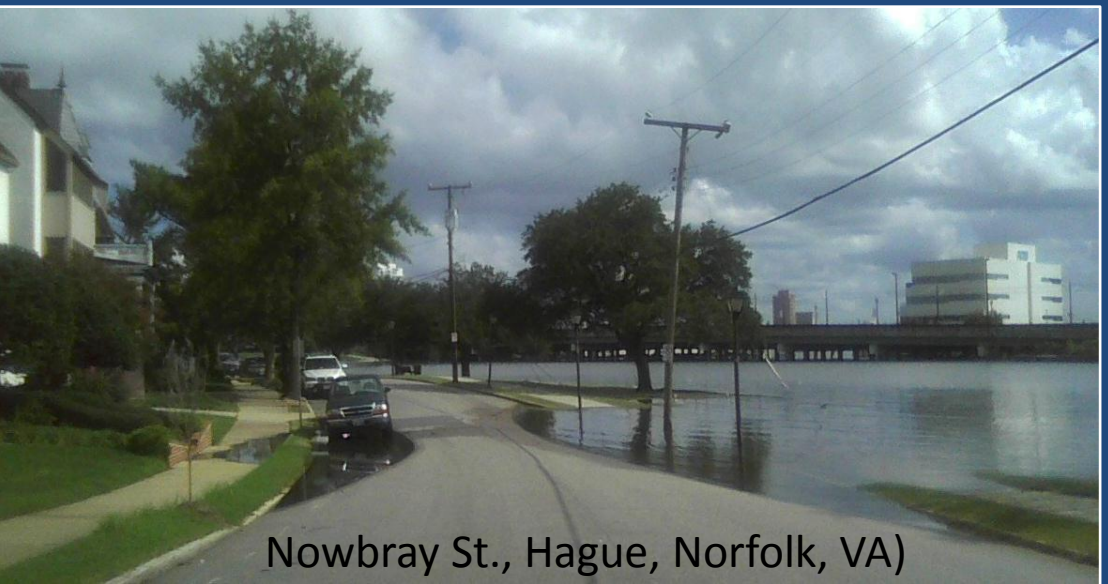
What does a 4-foot or 7-foot flood mean for Norfolk?

Minor flood: high tide (~4ft; 8-25-2012)

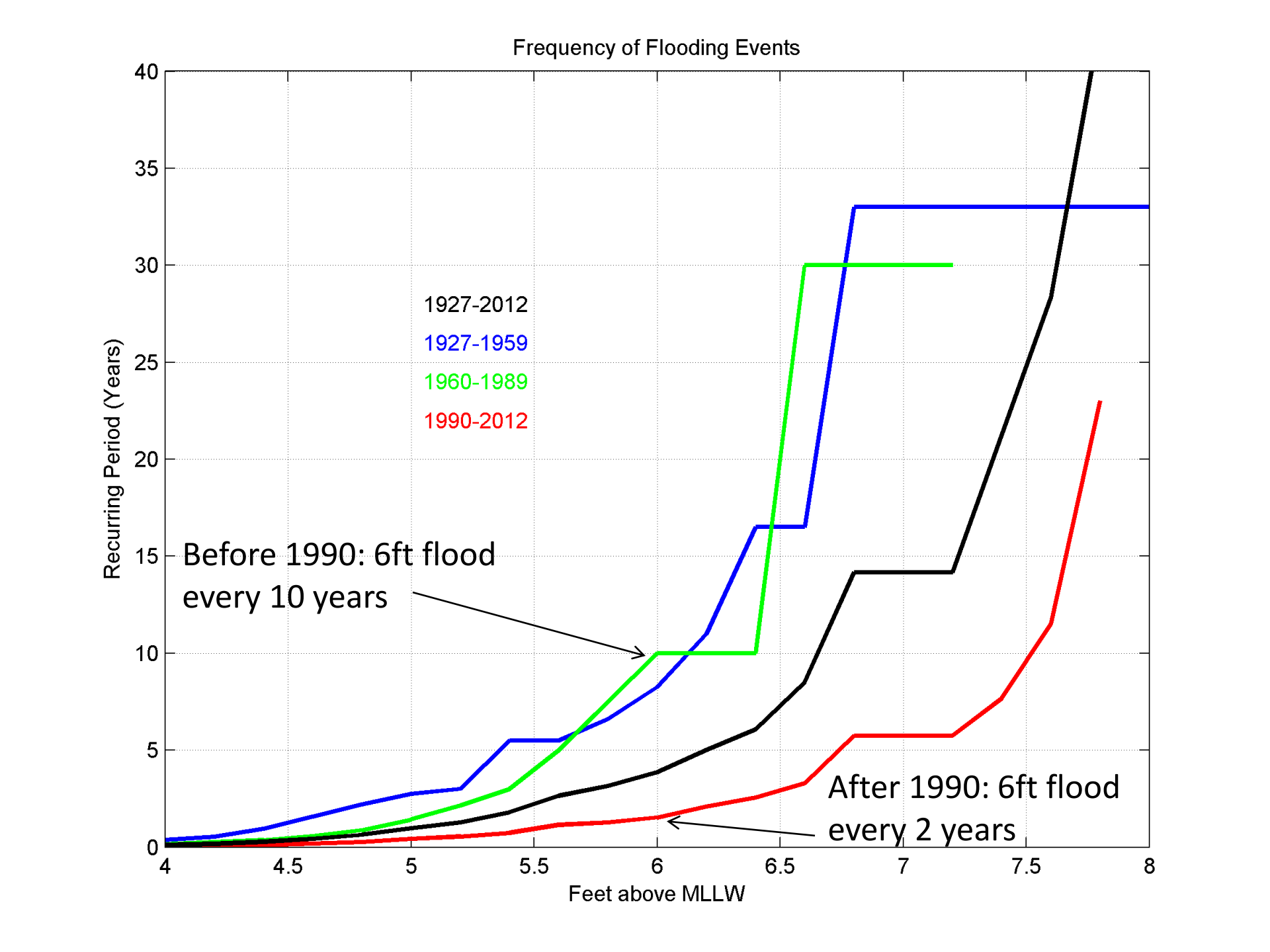


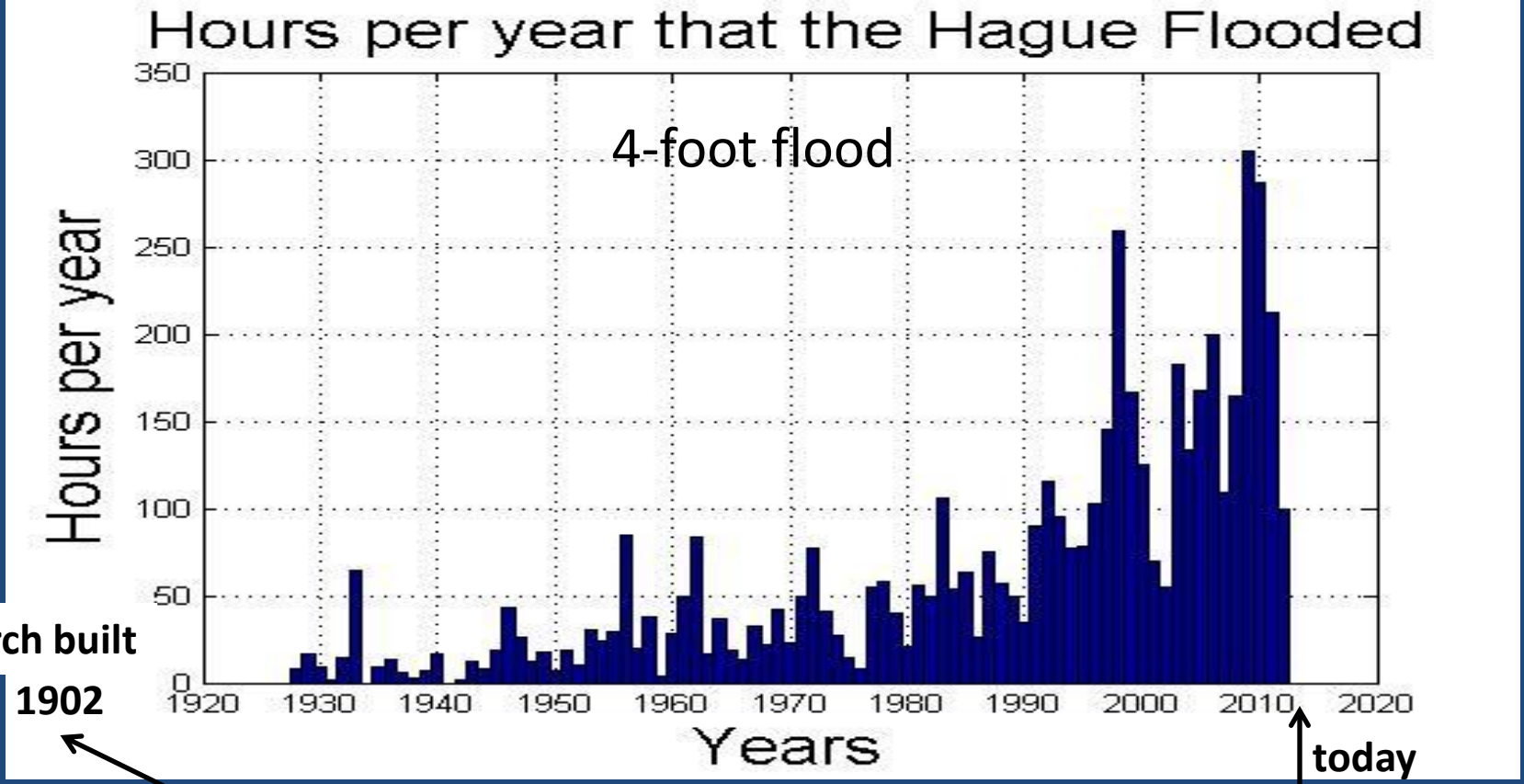
Major flood: Hurricane Sandy (~7ft; 10-29-2012)





Nowbray St., Hague, Norfolk, VA)


Frequency of Flooding Events
Recurring Period (Years)
Feet above MLLW
0
5
10
15
20
25
30
35
40
4
4.5
5
5.5
6
6.5
7
7.5
8
1927-2012
1927-1959
1960-1989
1990-2012
Before 1990: 6ft flood every 10 years
After 1990: 6ft flood every 2 years

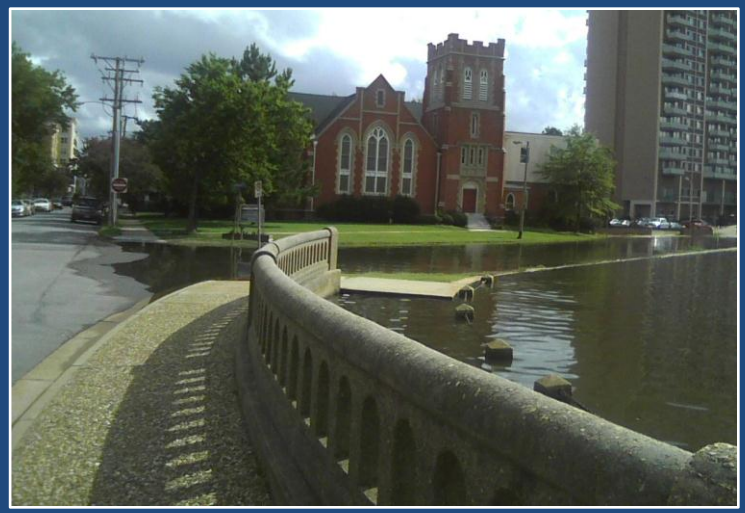


church built

1902

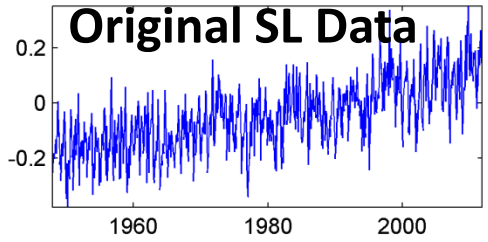
today

picture taken: 1935

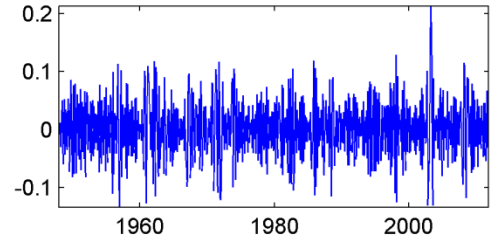


Sewells Pt. SL Mode-0

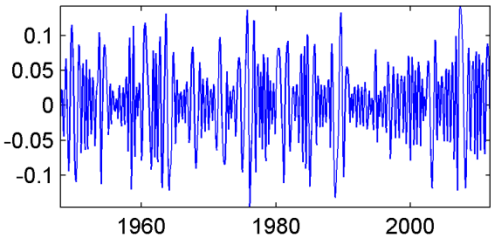
Original SL Data



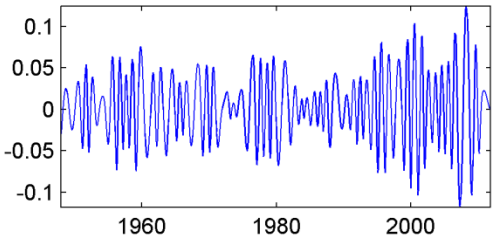
Sewells Pt. SL Mode-1



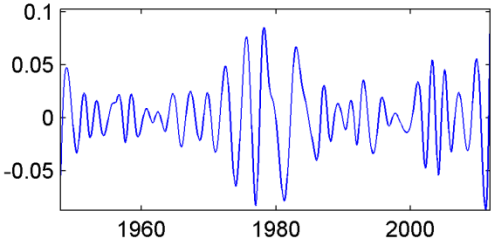
Sewells Pt. SL Mode-2



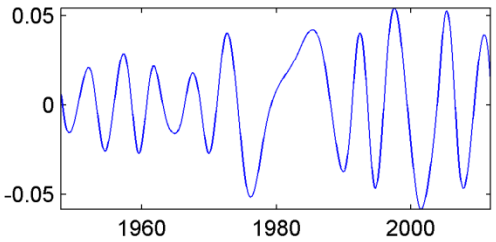
Sewells Pt. SL Mode-3



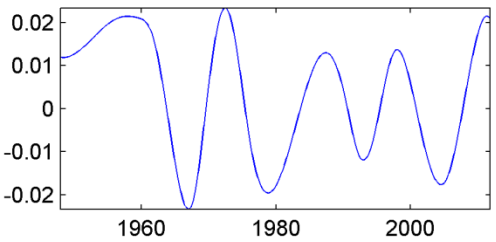
Sewells Pt. SL Mode-4



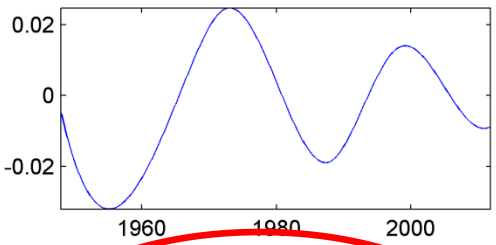
Sewells Pt. SL Mode-5



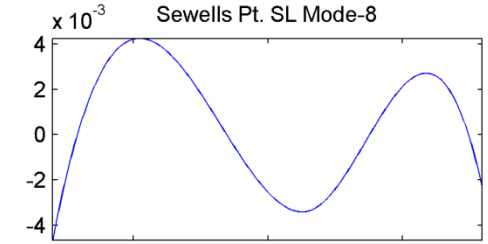
Sewells Pt. SL Mode-6



Sewells Pt. SL Mode-7

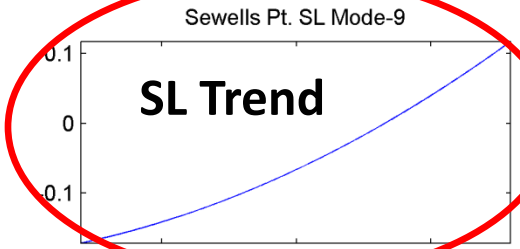


Sewells Pt. SL Mode-8

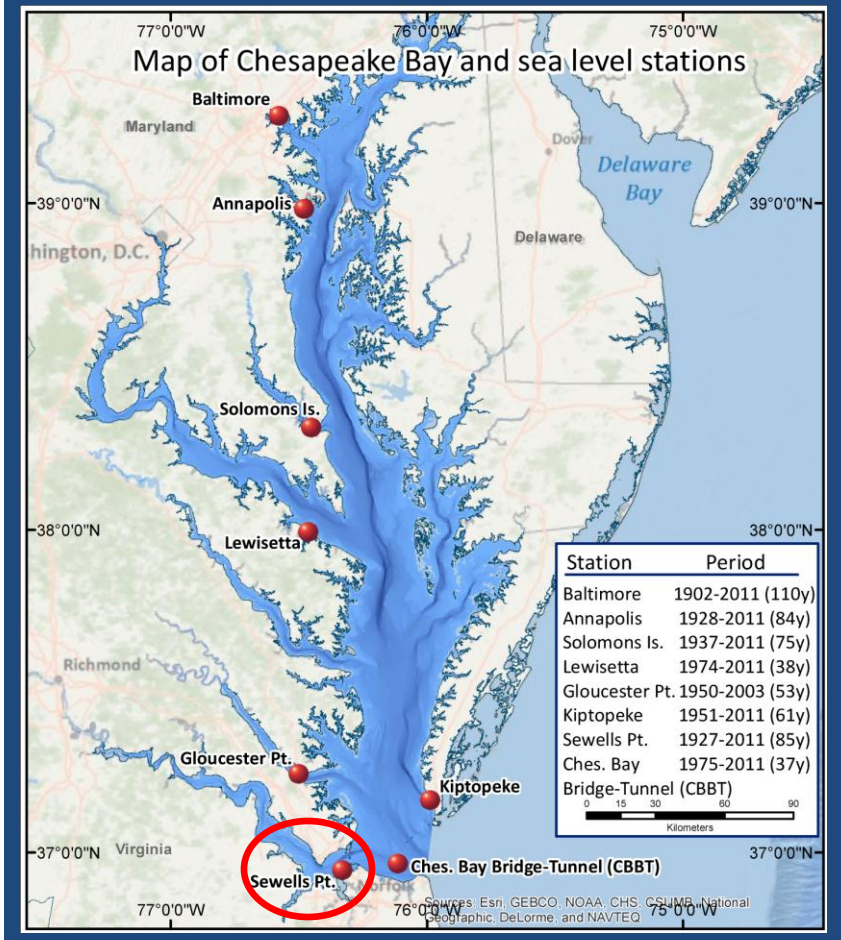


Sewells Pt. SL Mode-9

SL Trend



Sea Level Analysis in Chesapeake Bay



Analysis Method:

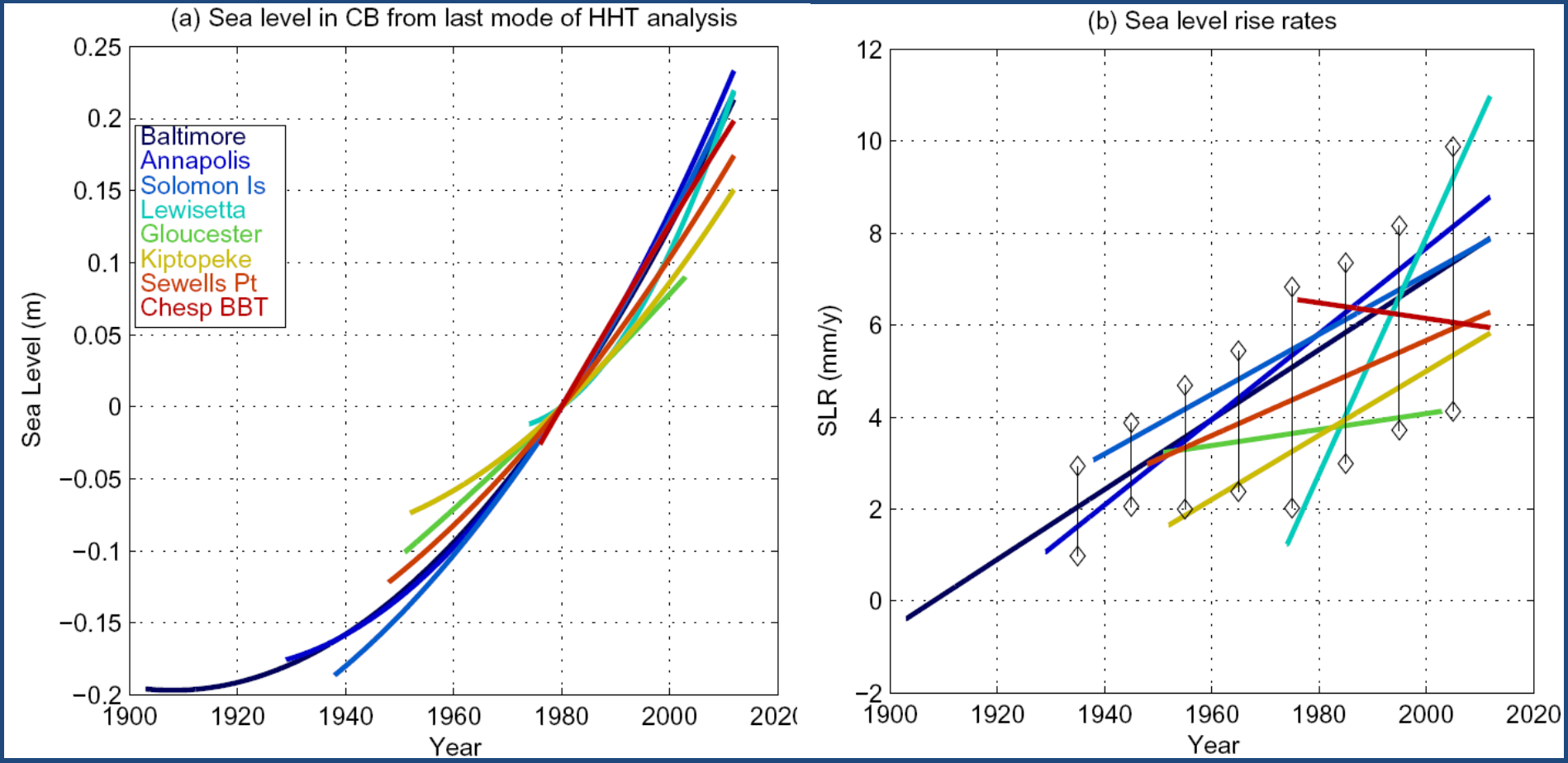
Empirical Mode Decomposition-Hilbert-Huang Transformation (EMD/HHT)

[Ezer & Corlett 2012a,b]

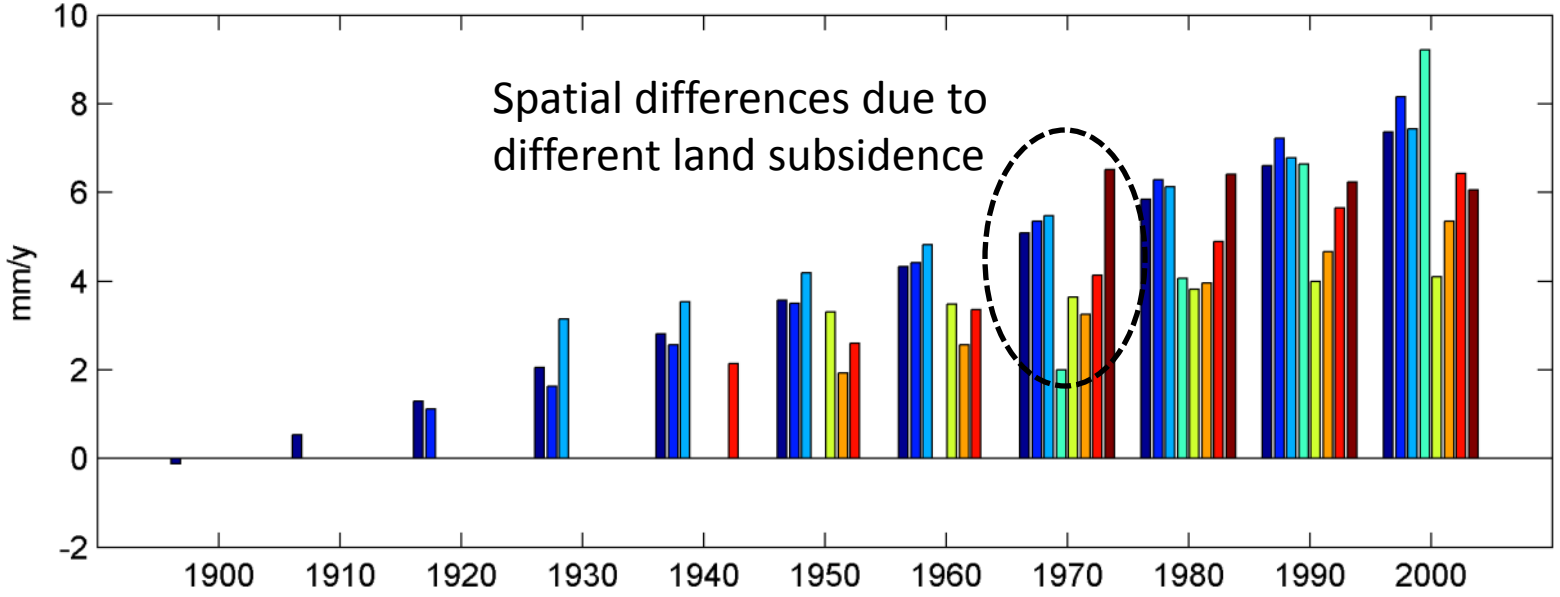
- All the stations with long records (60-110y) show similar SLR trend
- SLR rates significantly changed from:

  1-3 mm/y in the 1930s to 4-10 mm/y in the 2010s

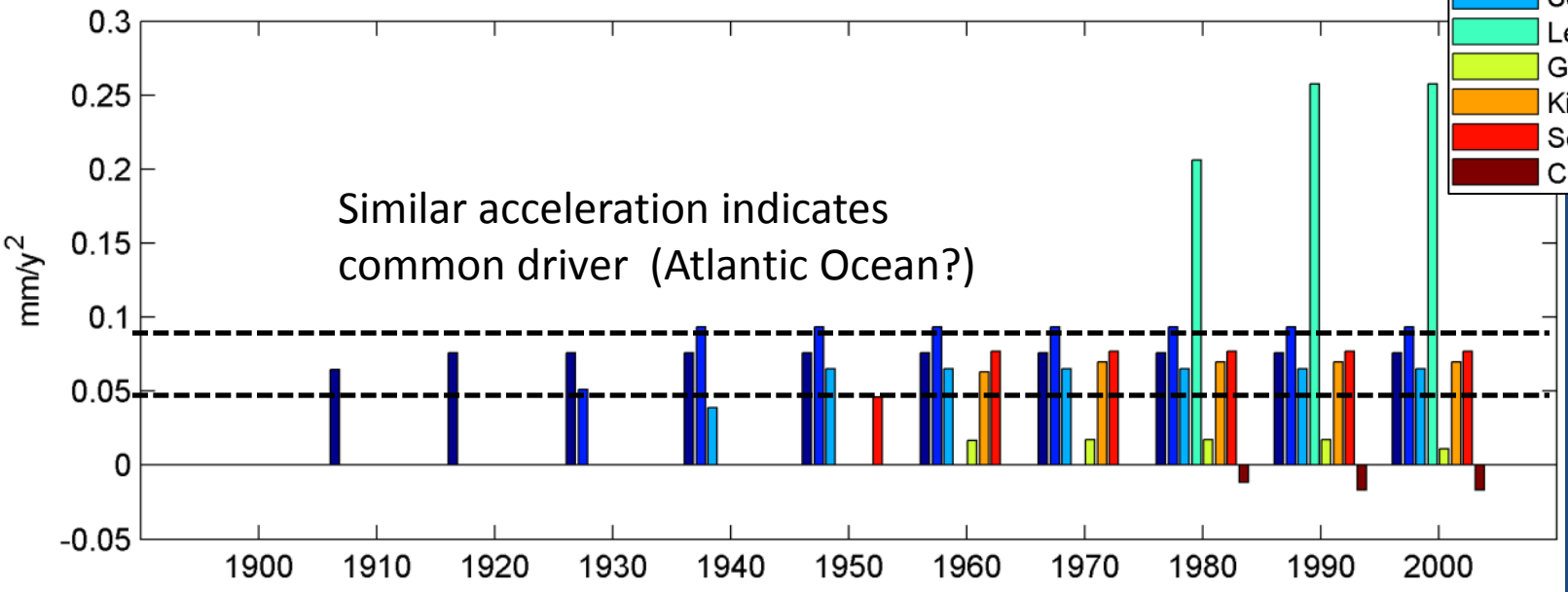
SLR is clearly accelerating in the Chesapeake Bay



Decadal Averaged Sea-Level Rise Rates



Decadal Averaged Sea-Level Rise Acceleration



← Similar acceleration as Sallenger-2012 Boon-2012

So what is a possible reason for the acceleration in sea level rise along the mid-Atlantic coast in recent years?

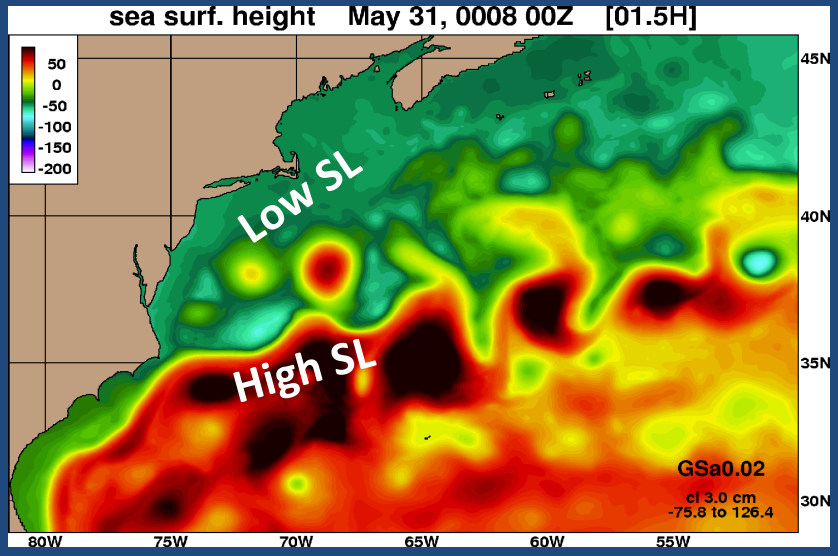
Note: land subsidence is a slow process that can not cause acceleration!

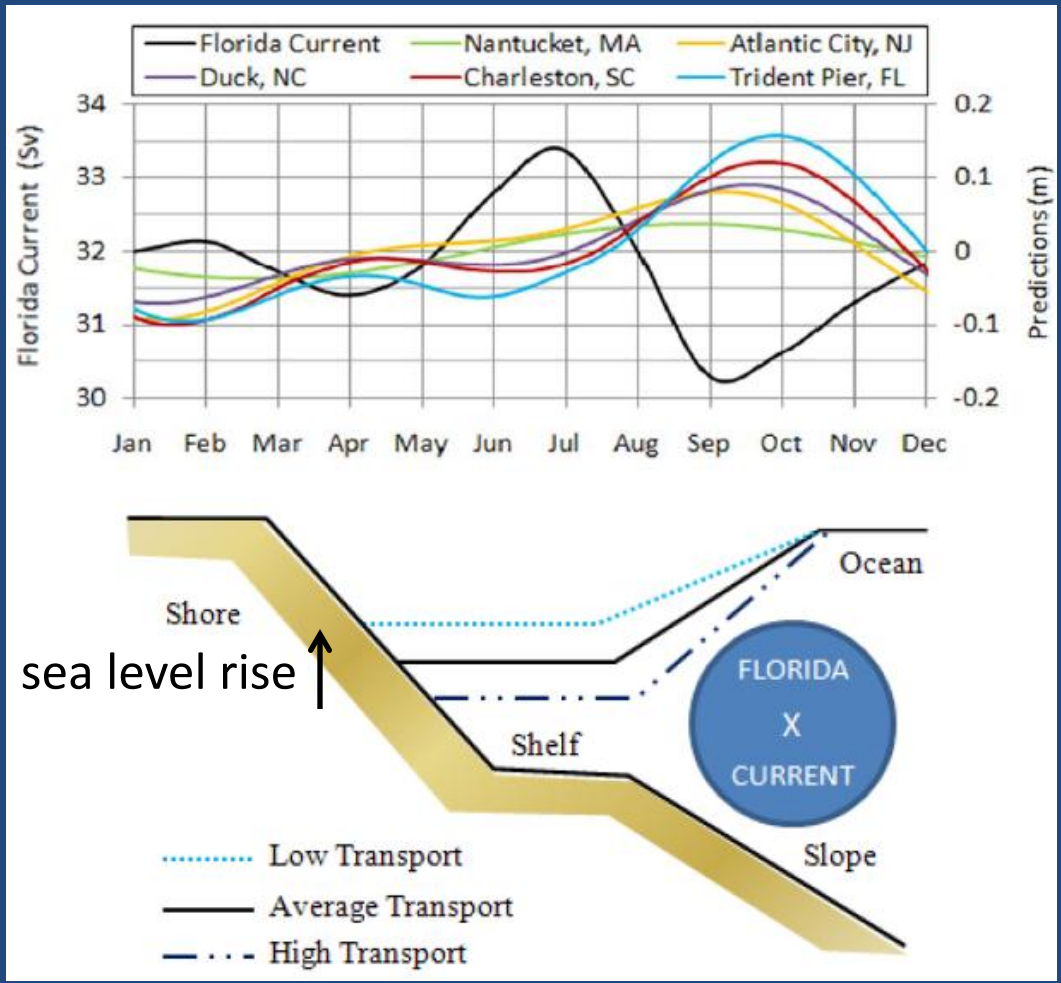
NOAA Technical Report NOS CO-OPS 051

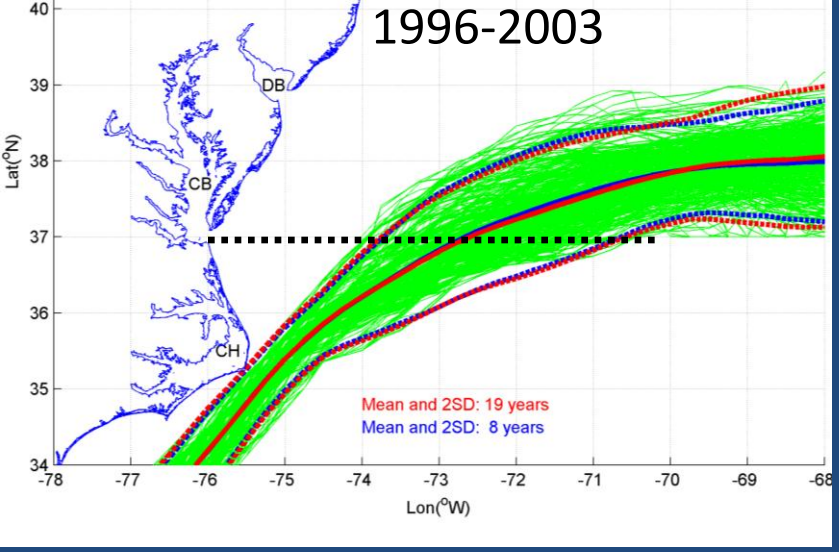
ELEVATED EAST COAST SEA LEVEL ANOMALY: June – July 2009

Sweet et al., 2009

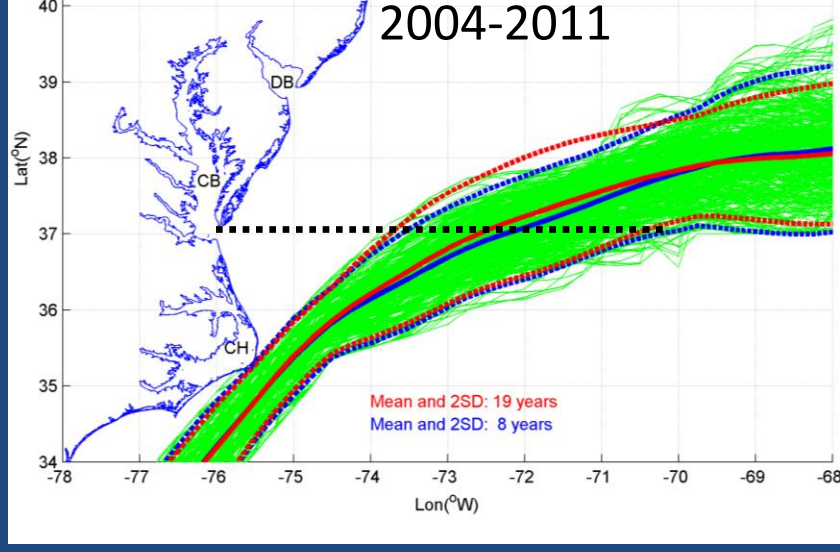
Hypothesis:
Climate-related weakening of the Gulf Stream raises coastal sea level





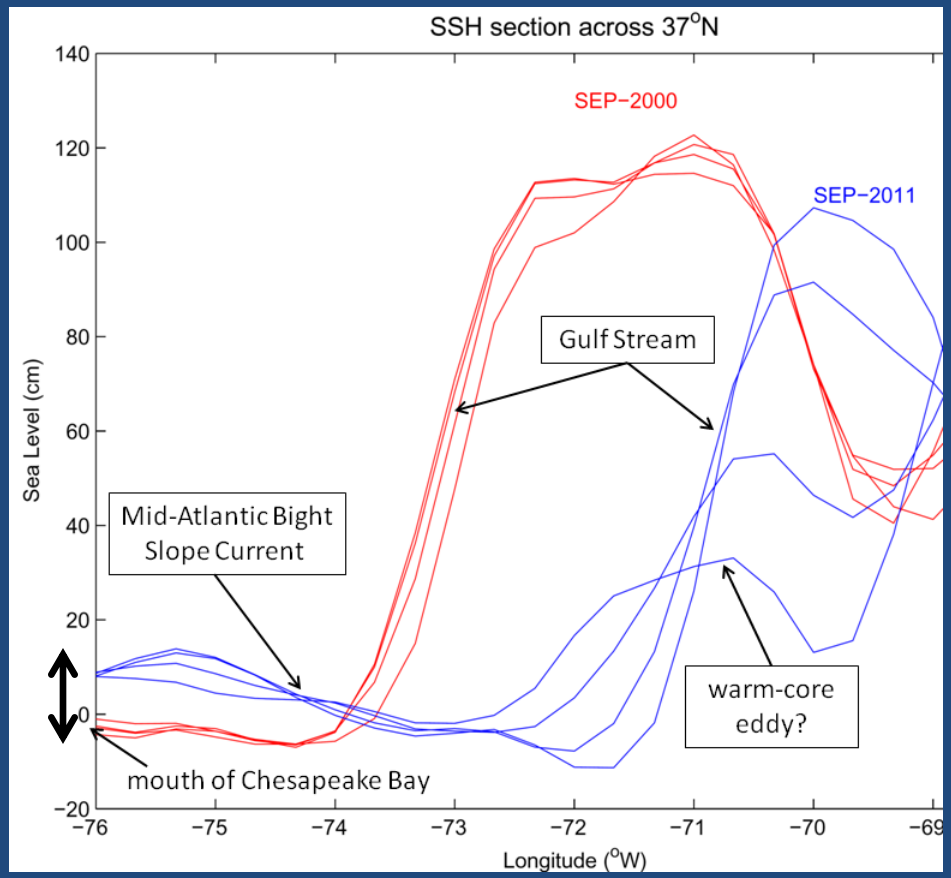


Weakly Gulf Stream path from satellite altimeter data

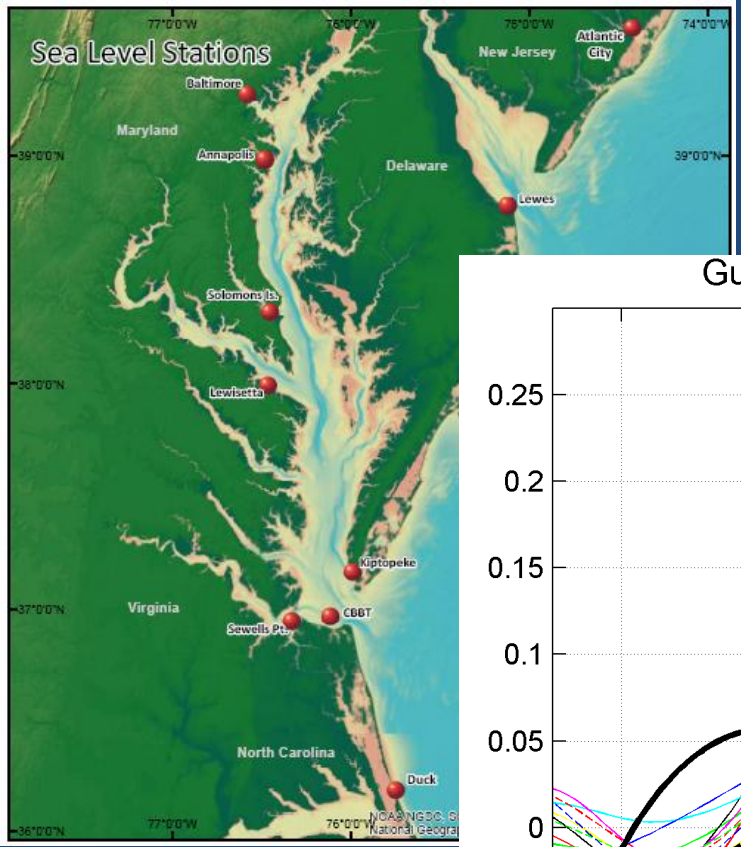


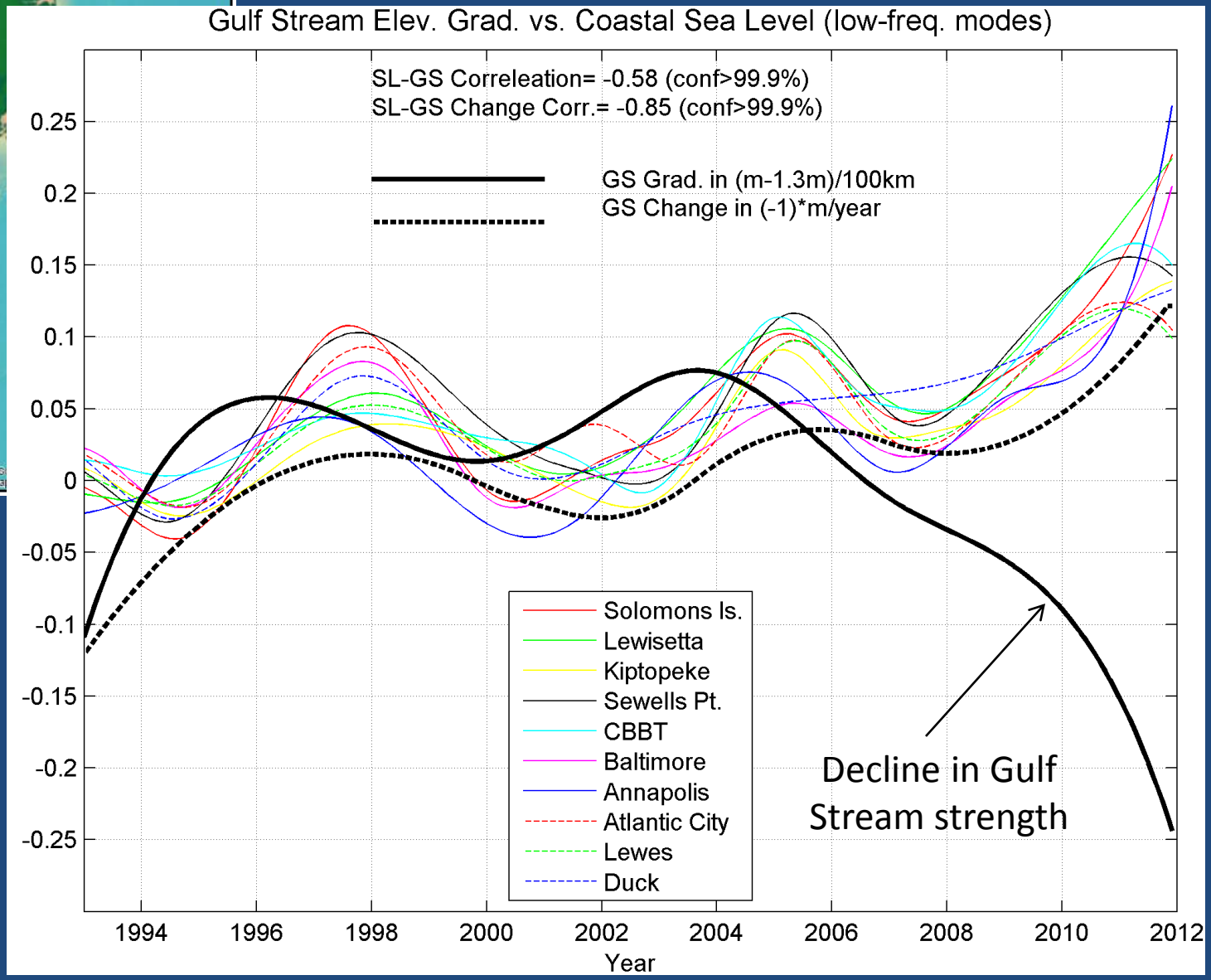
There is evidence that in recent years the Gulf Stream is weakening and potentially shifting offshore

Change of 12 cm over 10 years →



All sea level records from Atlantic City (NJ) to Duck (NC) show similar long-term pattern driven by the Gulf Stream

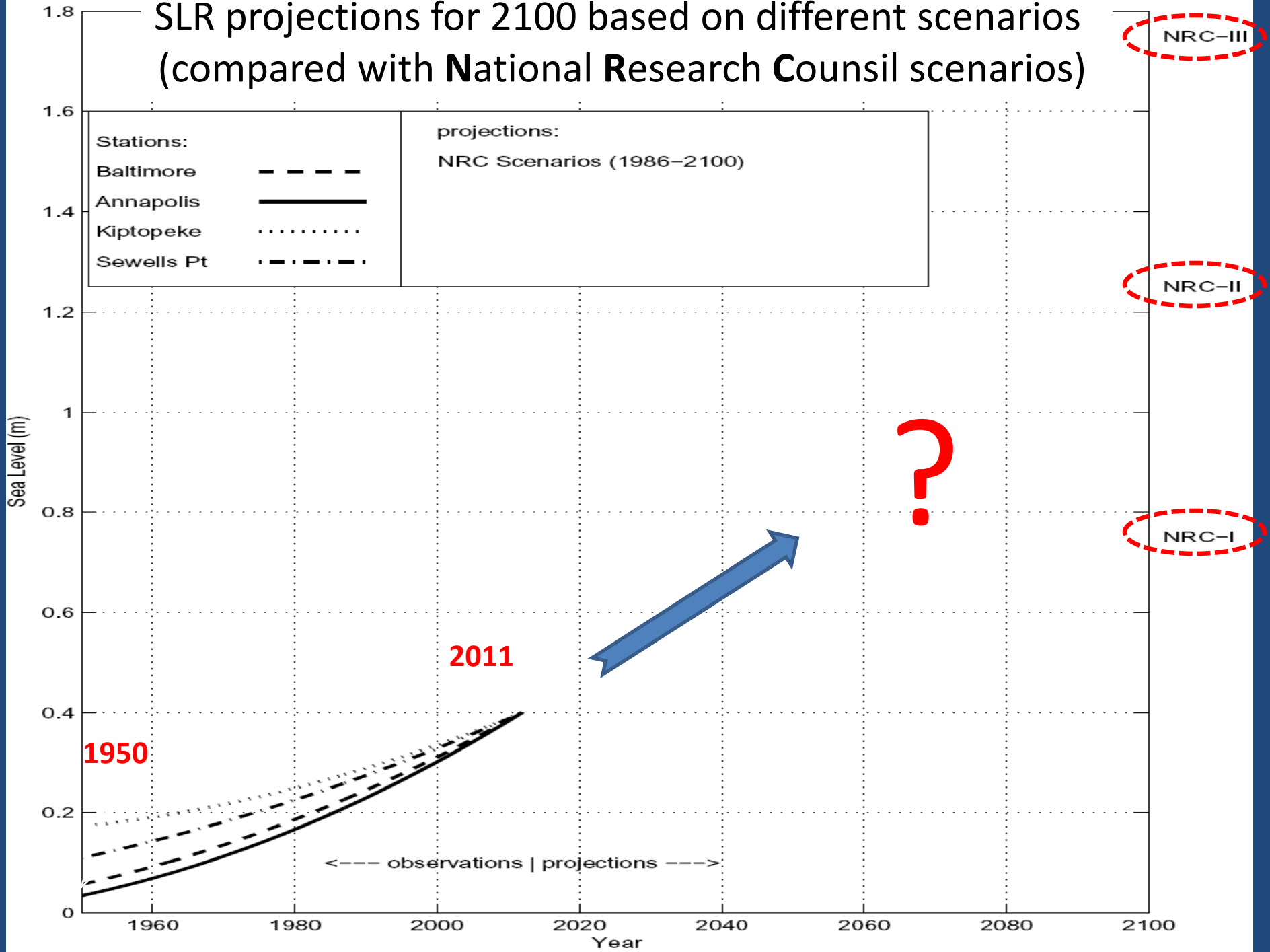


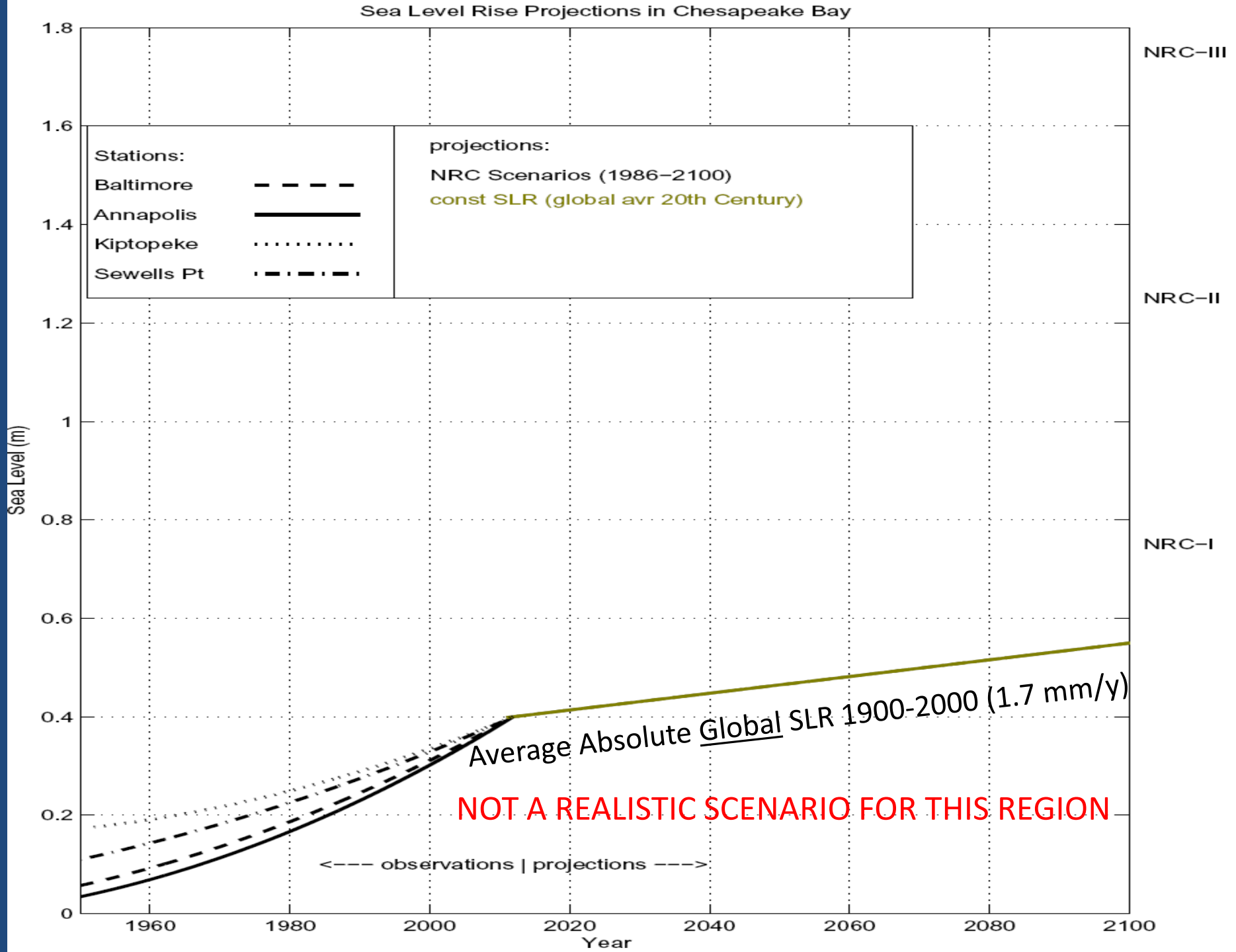


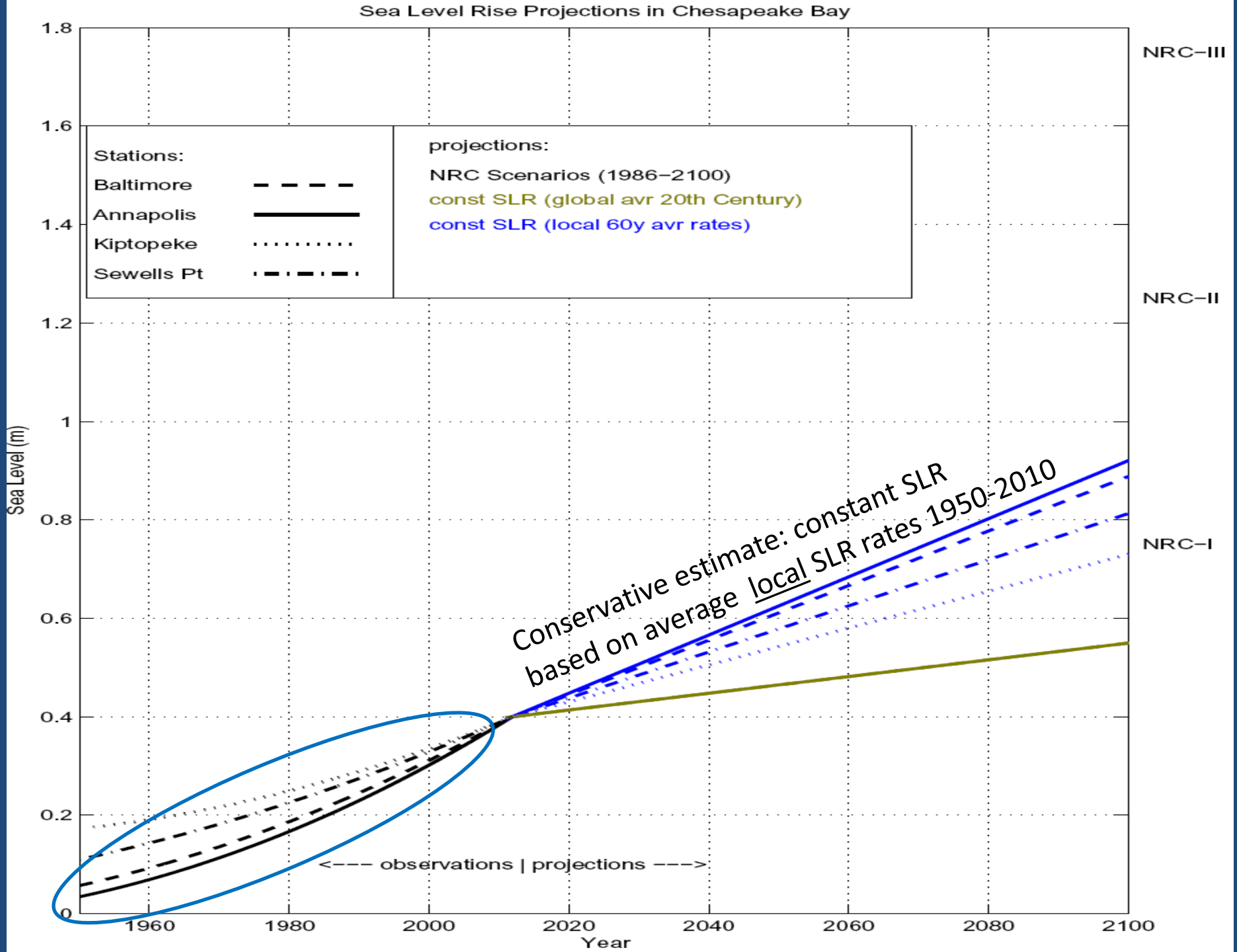
So how will sea level change in the future?

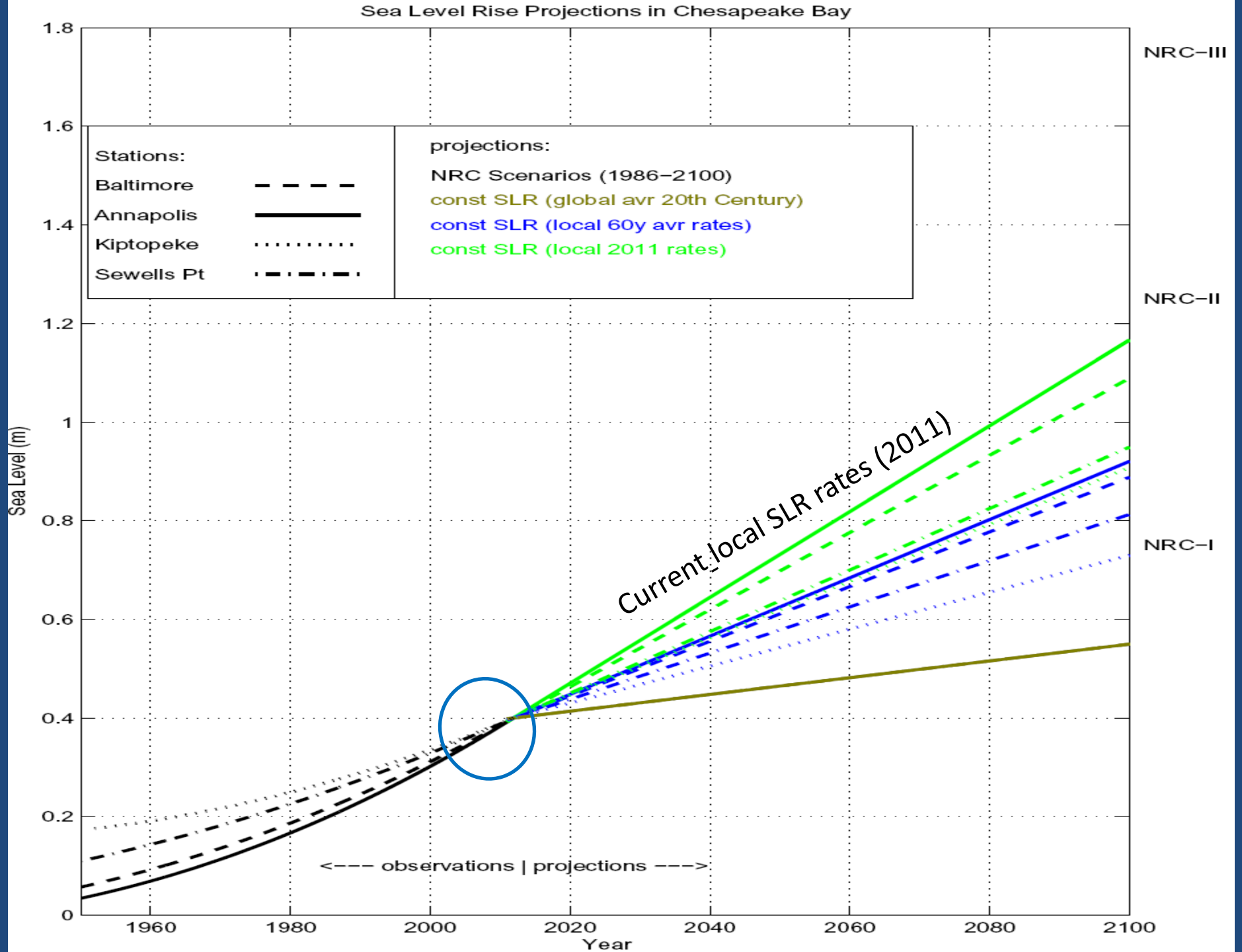
→make projections based on our analysis of local SL data

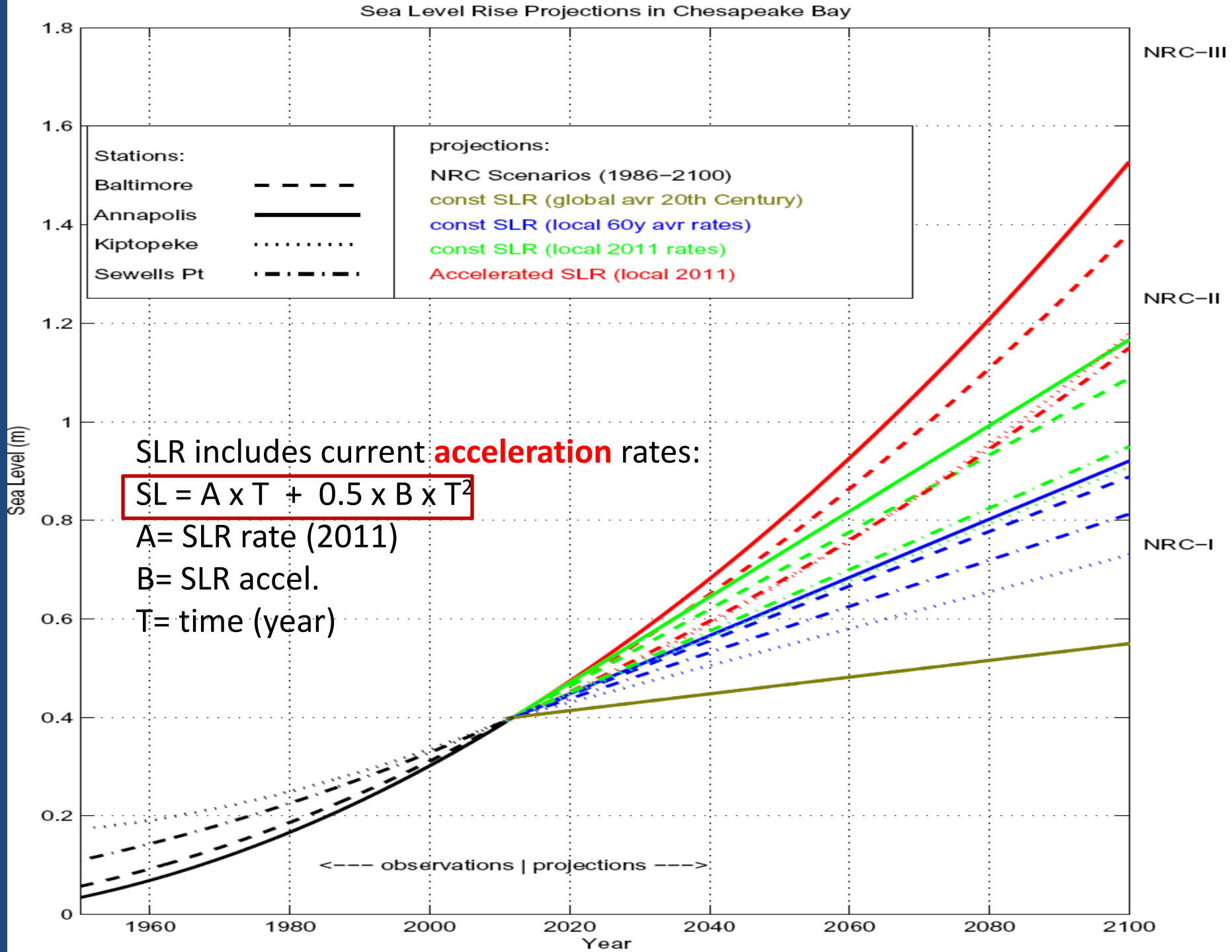
SLR projections for 2100 based on different scenarios (compared with **N**ational **R**esearch **C**ounsil scenarios)




Sea Level Rise Projections in Chesapeake Bay
Stations:
Baltimore
Annapolis
Kiptopeke
Sewells Pt
projections:
NRC Scenarios (1986–2100)
const SLR (global avr 20th Century)
NRC–III
NRC–II
NRC–I
Sea Level (m)
Year
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1960
1980
2000
2020
2040
2060
2080
2100
Average Absolute Global SLR 1900-2000 (1.7 mm/y)
NOT A REALISTIC SCENARIO FOR THIS REGION
<--- observations | projections --->
Sea Level Rise Projections in Chesapeake Bay


Sea Level Rise Projections in Chesapeake Bay
Stations:
Baltimore
Annapolis
Kiptopeke
Sewells Pt
projections:
NRC Scenarios (1986–2100)
const SLR (global avr 20th Century)
const SLR (local 60y avr rates)
NRC–III
NRC–II
NRC–I
Conservative estimate: constant SLR
based on average local SLR rates 1950-2010
<--- observations | projections --->
Sea Level (m)
Year
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1960
1980
2000
2020
2040
2060
2080
2100


Sea Level Rise Projections in Chesapeake Bay
Stations:
Baltimore
Annapolis
Kiptopeke
Sewells Pt
projections:
NRC Scenarios (1986–2100)
const SLR (global avr 20th Century)
const SLR (local 60y avr rates)
const SLR (local 2011 rates)
NRC–III
NRC–II
NRC–I
Current local SLR rates (2011)
<--- observations | projections --->
Sea Level (m)
Year
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1960
1980
2000
2020
2040
2060
2080
2100


Sea Level Rise Projections in Chesapeake Bay
Stations:
Baltimore
Annapolis
Kiptopeke
Sewells Pt
projections:
NRC Scenarios (1986–2100)
const SLR (global avr 20th Century)
const SLR (local 60y avr rates)
const SLR (local 2011 rates)
Accelerated SLR (local 2011)
NRC–III
NRC–II
NRC–I
SLR includes current acceleration rates:
SL = A x T + 0.5 x B x T²
A= SLR rate (2011)
B= SLR accel.
T= time (year)
<--- observations | projections --->
Sea Level (m)
Year
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1960
1980
2000
2020
2040
2060
2080
2100

Summary:

- Sea level is likely to continue to rise at increasing rates during the next decades
- Thus need to develop adaptation strategies to mitigate increasing flooding in the Hampton Roads

Hague area

Larchmont