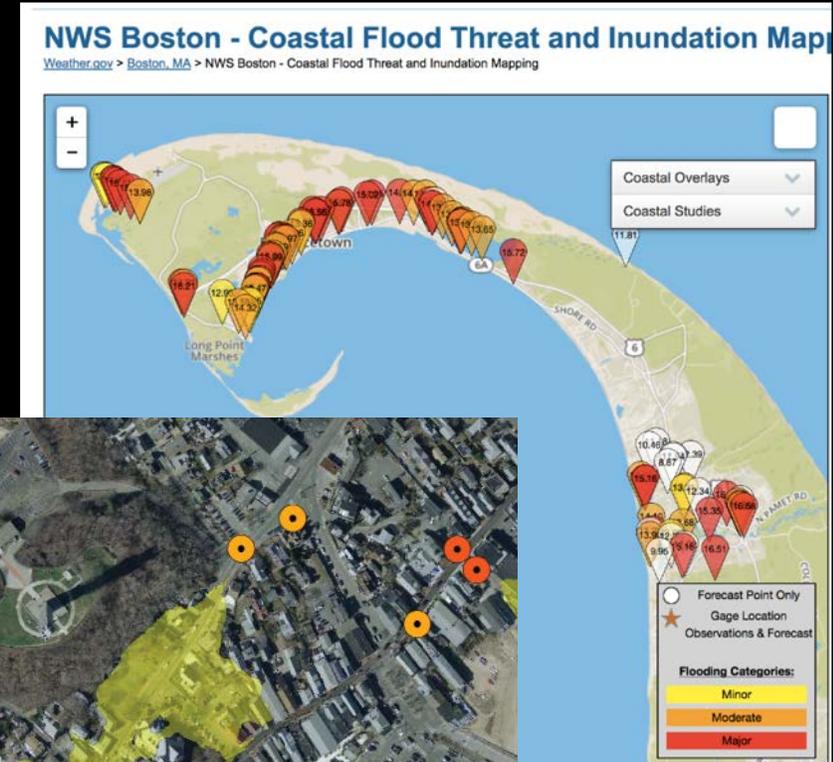
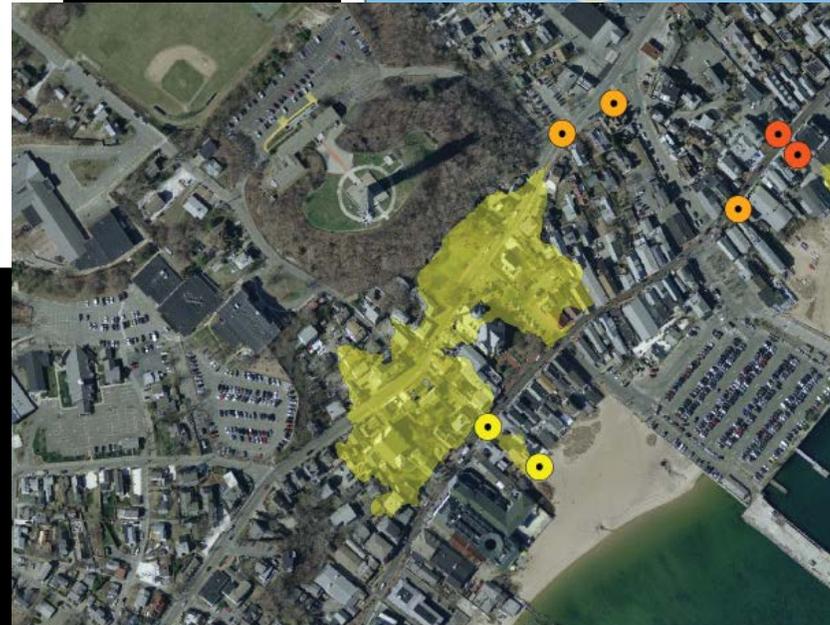
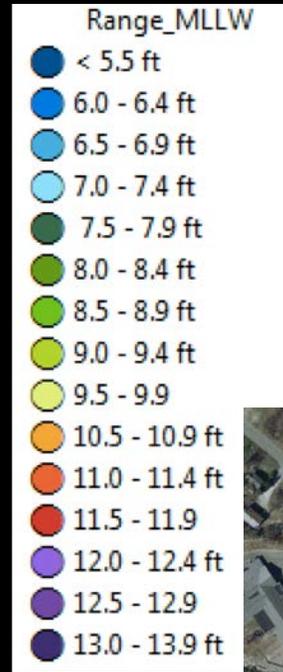
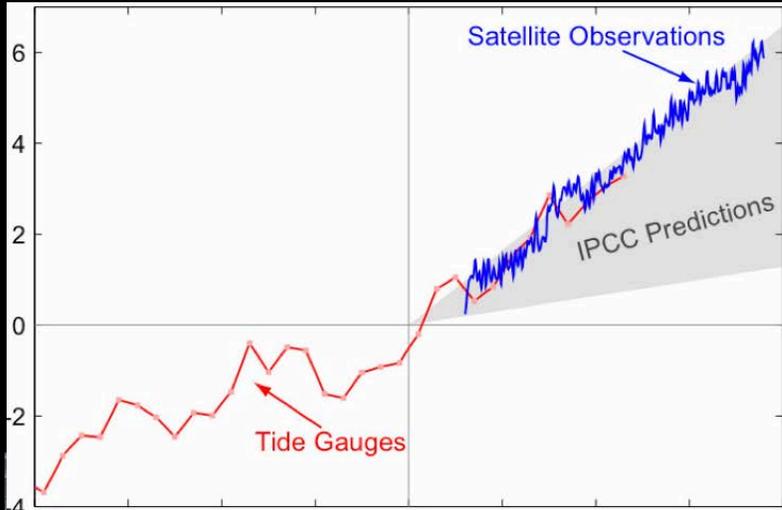


# Community Resiliency Building Workshop: Provincetown, MA

## Storms, Sea Level Rise and Mapping Inundation Pathways



# Talk Outline

- Tidal Flooding: '*Nuisance Flooding*' '*Sunny Day Flooding*'
- Storms
- Sea Level Rise
- Mapping Storm Tide Pathways



Nov 3, 2015

**"King Tide" Brings  
Record Sea Level Rise  
to Boston's Waterfront**  
<http://www.climatesignals.org>



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October 24, 2016  
**King Tide's Gift:  
Gentle Awakenings to  
a Rapidly Changing  
World**  
Union of Concerned  
Scientists



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Dec 05 2017  
Perigean tide flooding  
the Chart House patio  
on Long Wharf in  
Boston, WBZ, Boston



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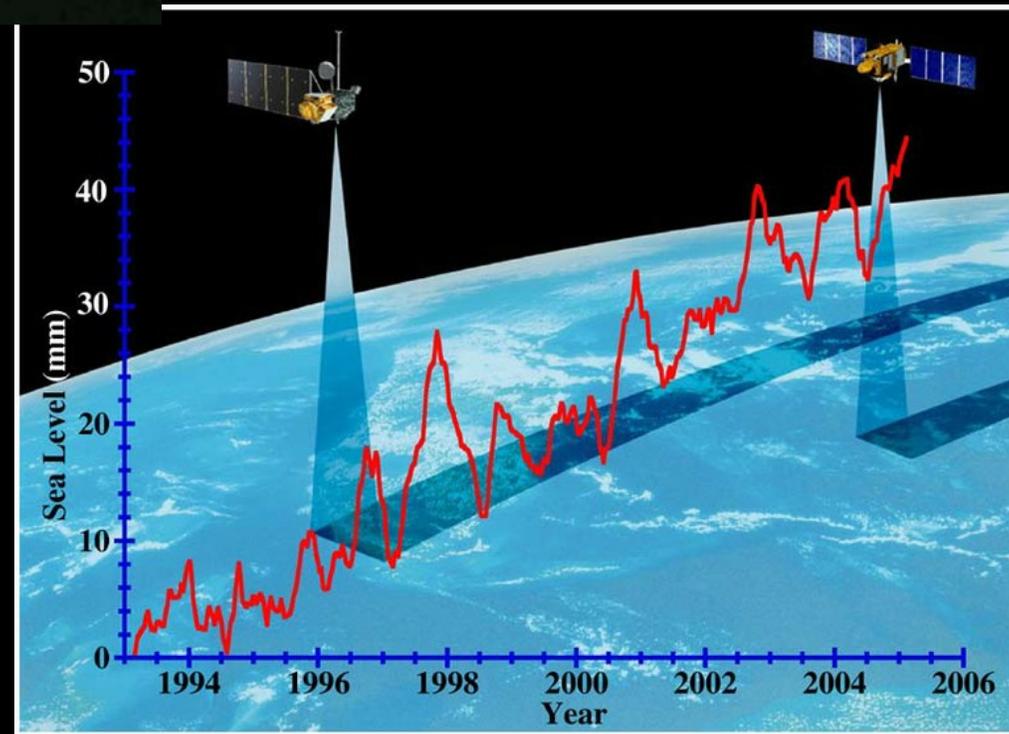
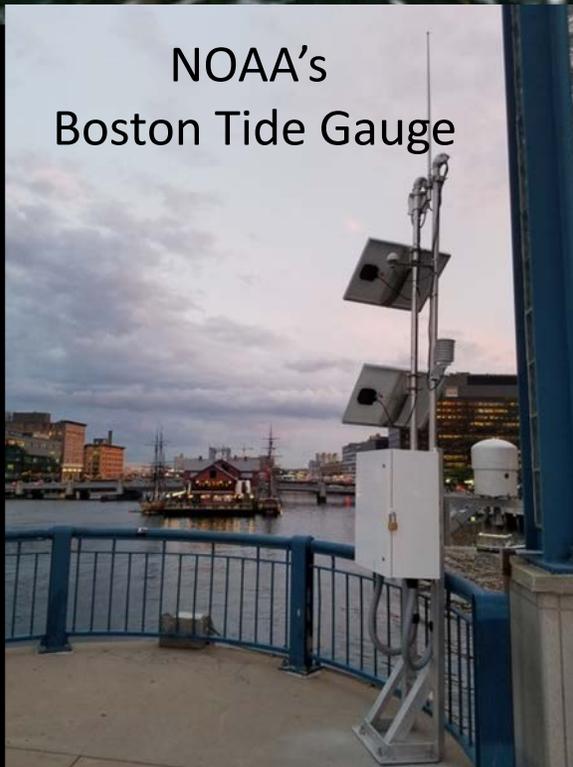


# Sea Level Rise



Direct vs. Proxy  
measurements

NOAA's  
Boston Tide Gauge

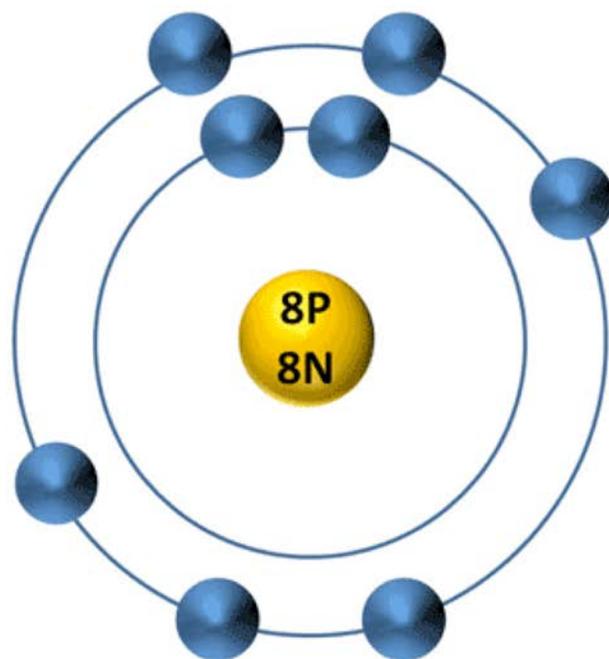


RICHARD B. ALLEY

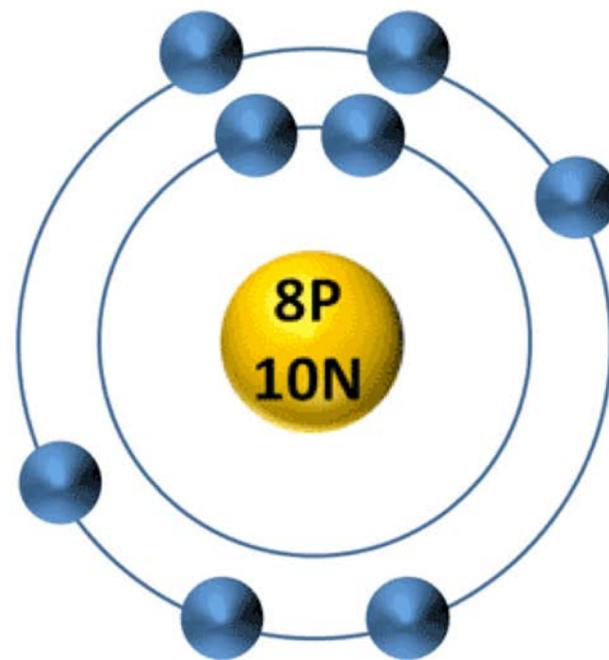
THE  
TWO-MILE  
TIME MACHINE

ICE CORES, ABRUPT CLIMATE  
CHANGE, AND OUR FUTURE

# Oxygen Isotopes



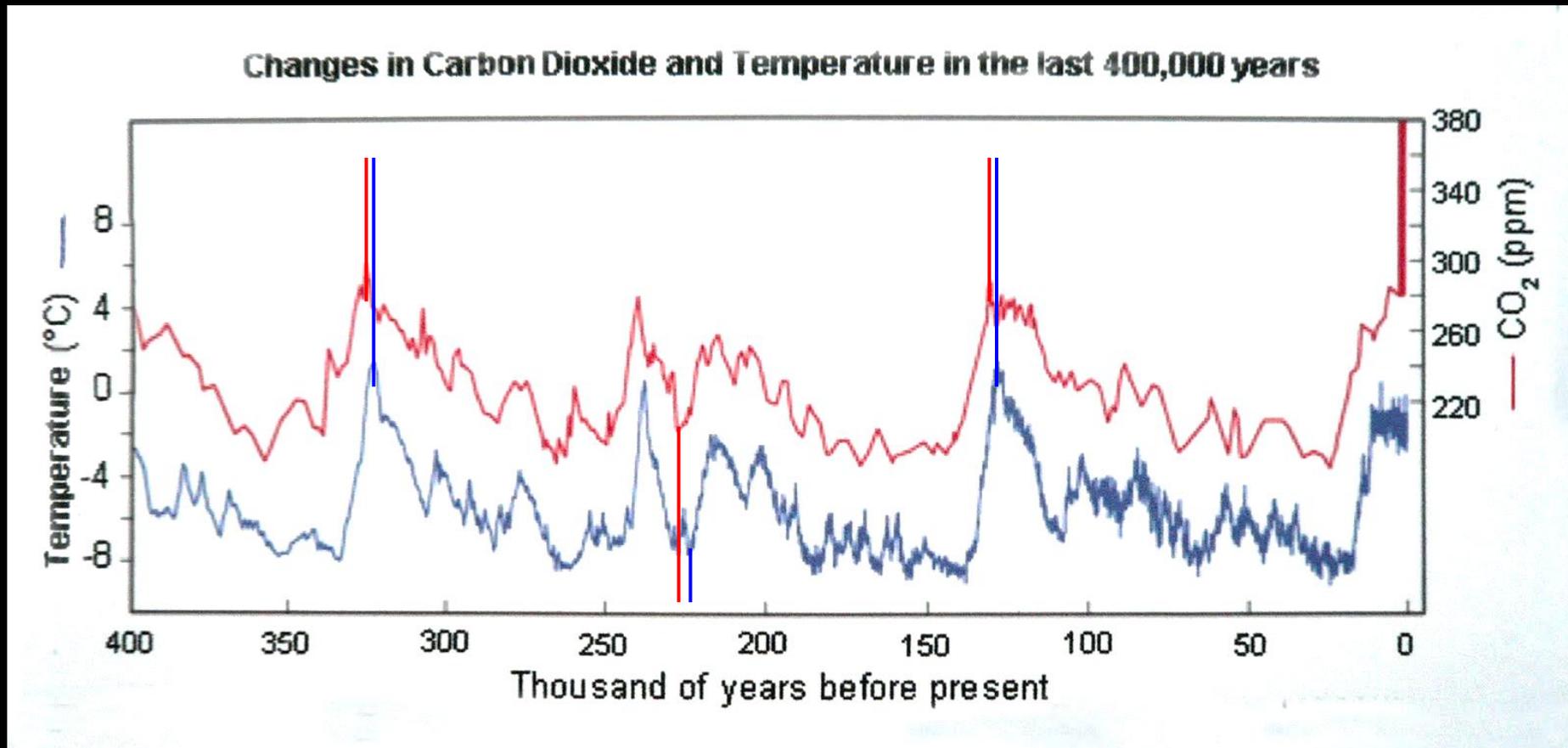
$^{16}\text{O}$  Isotope

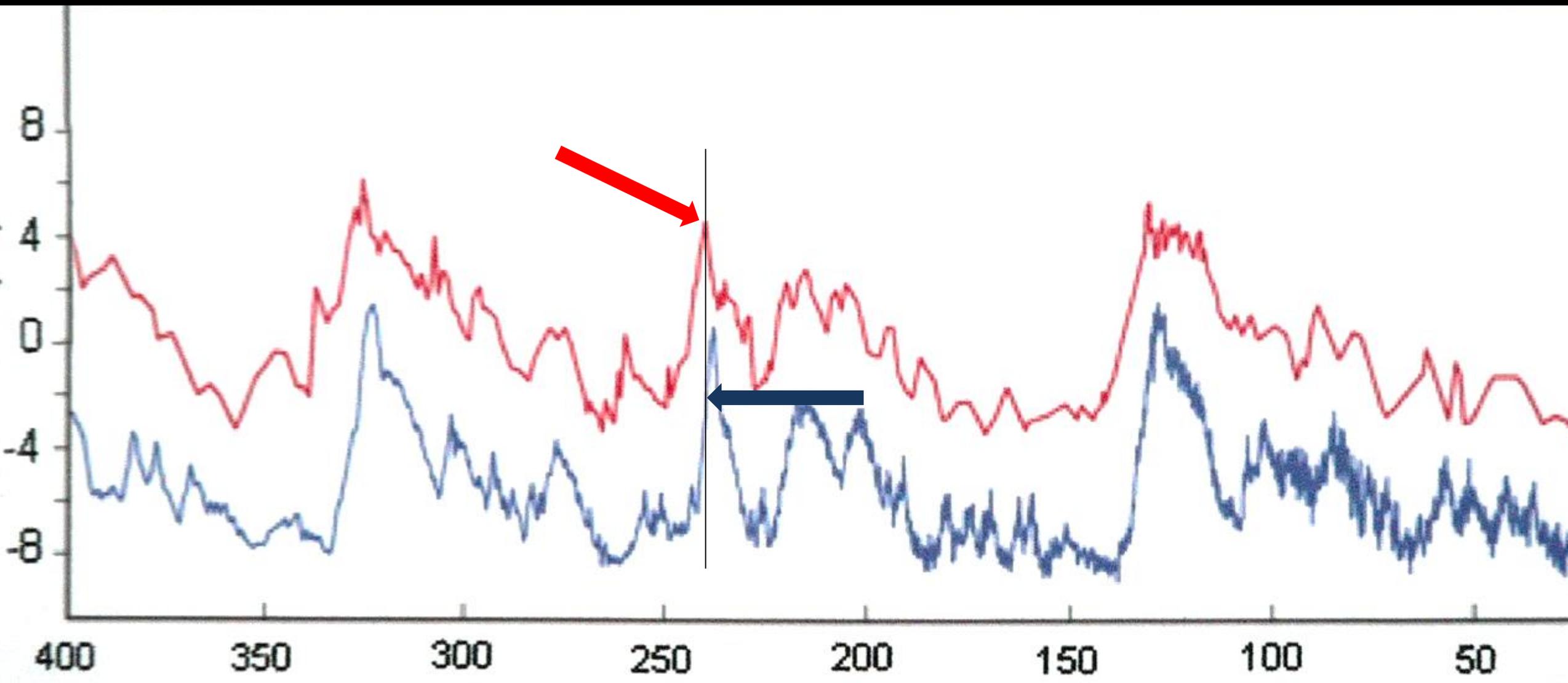


$^{18}\text{O}$  Isotope

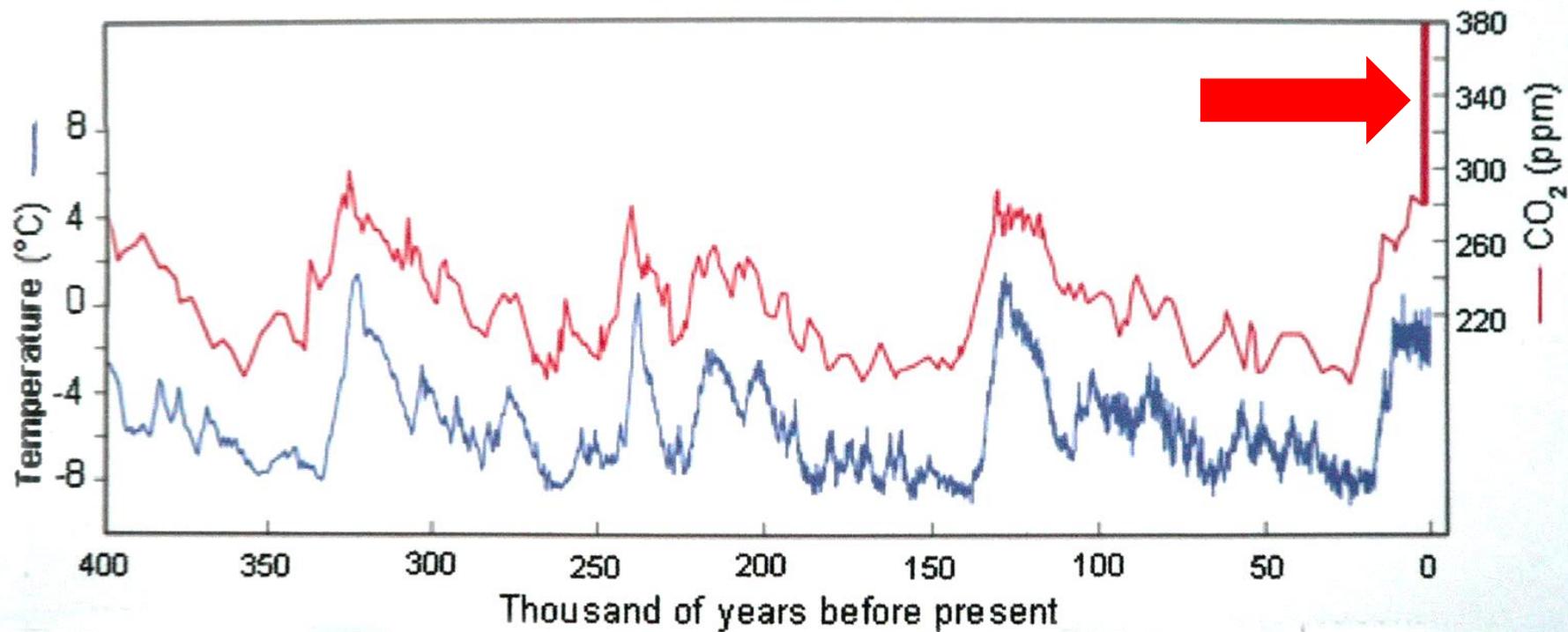


# CO<sub>2</sub> and Global Temperatures

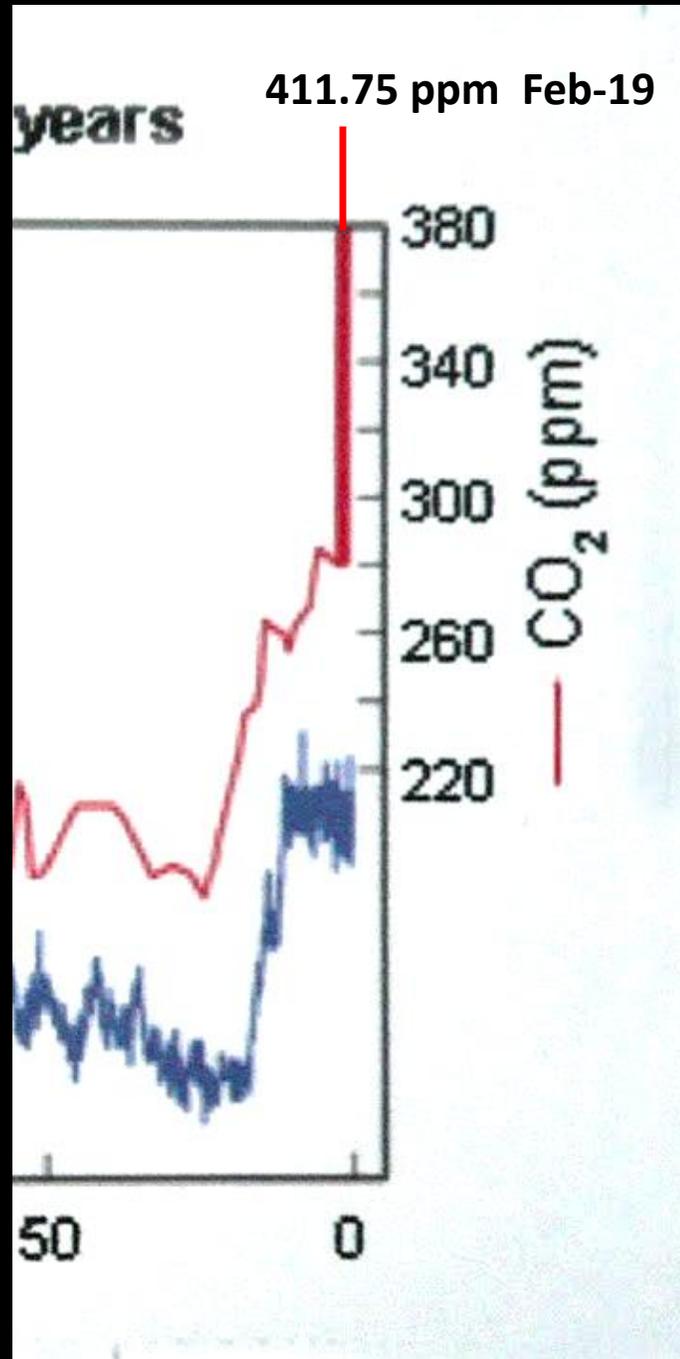




Changes in Carbon Dioxide and Temperature in the last 400,000 years



NOAA Earth System  
Research Laboratory



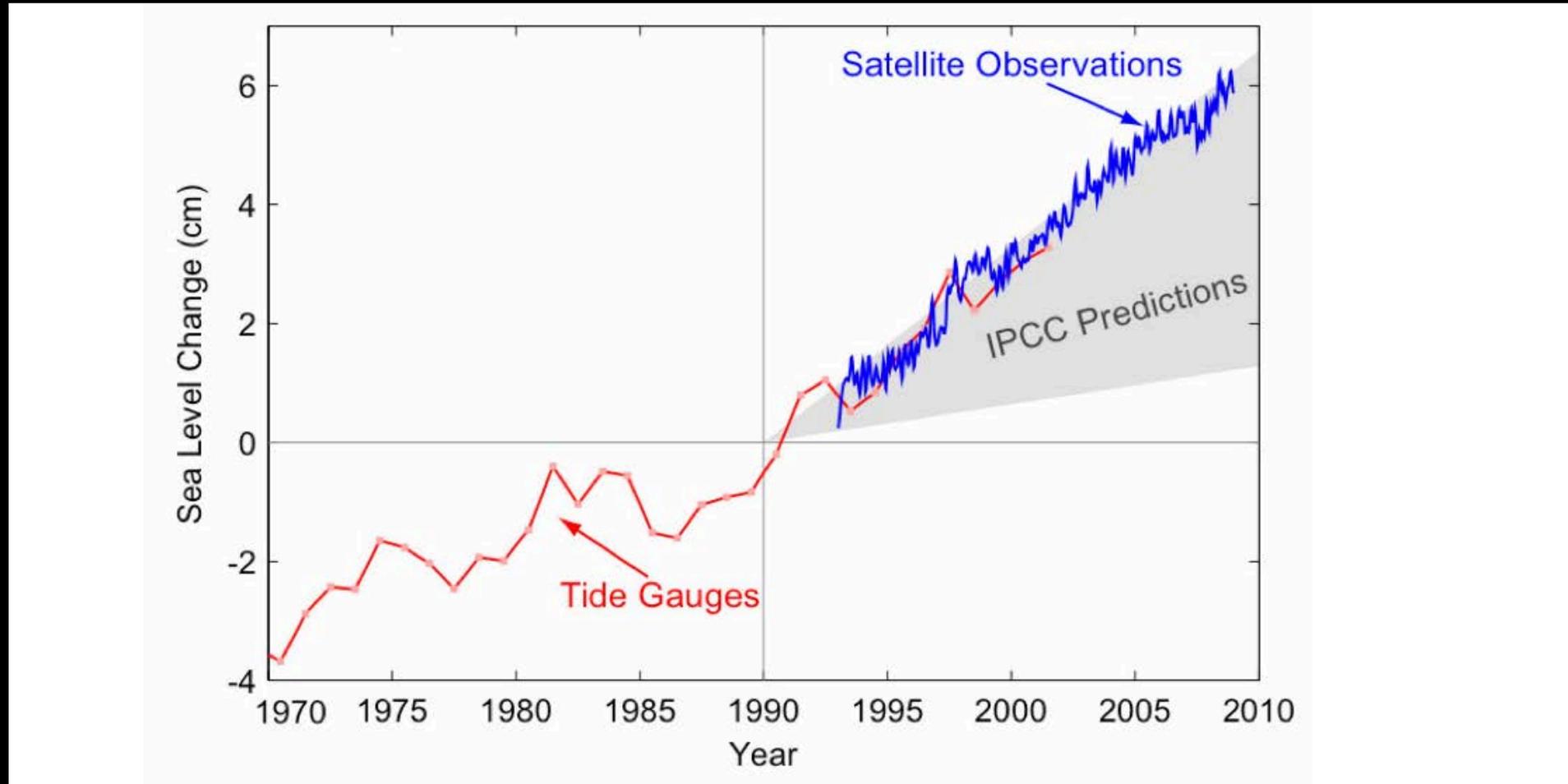
Center for Coastal Studies  
Marine Geology

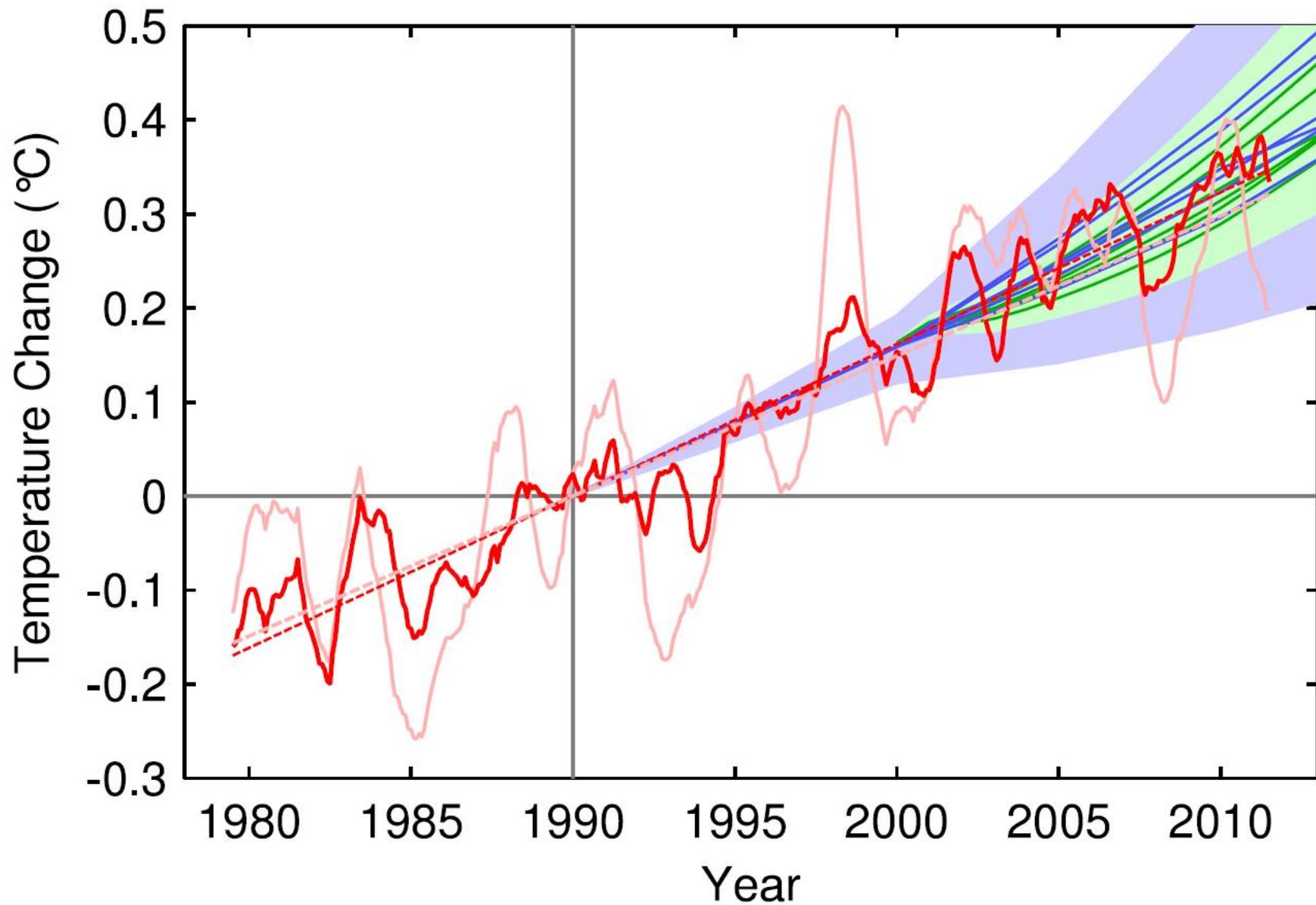
The Coastal Processes and Ecosystems Laboratory

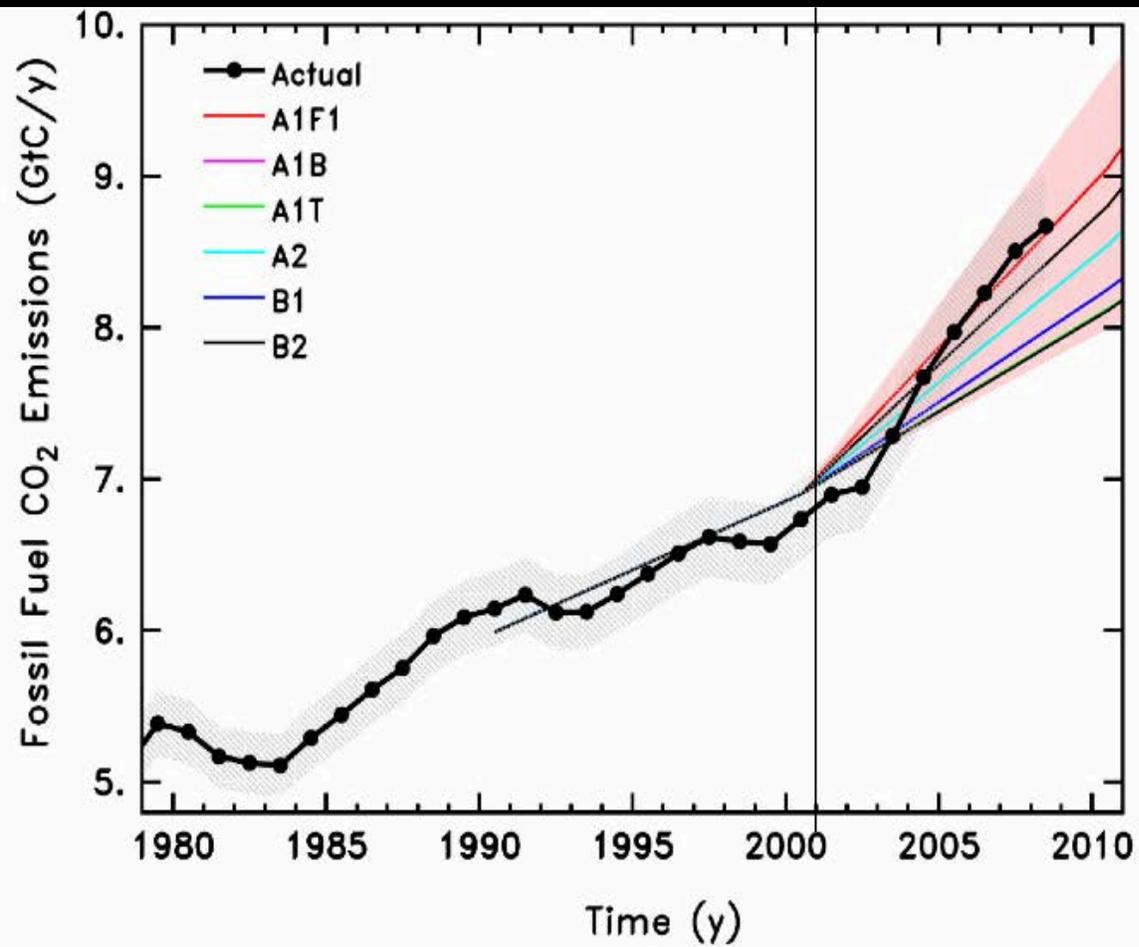
The University of Massachusetts, Boston  
School for the Environment



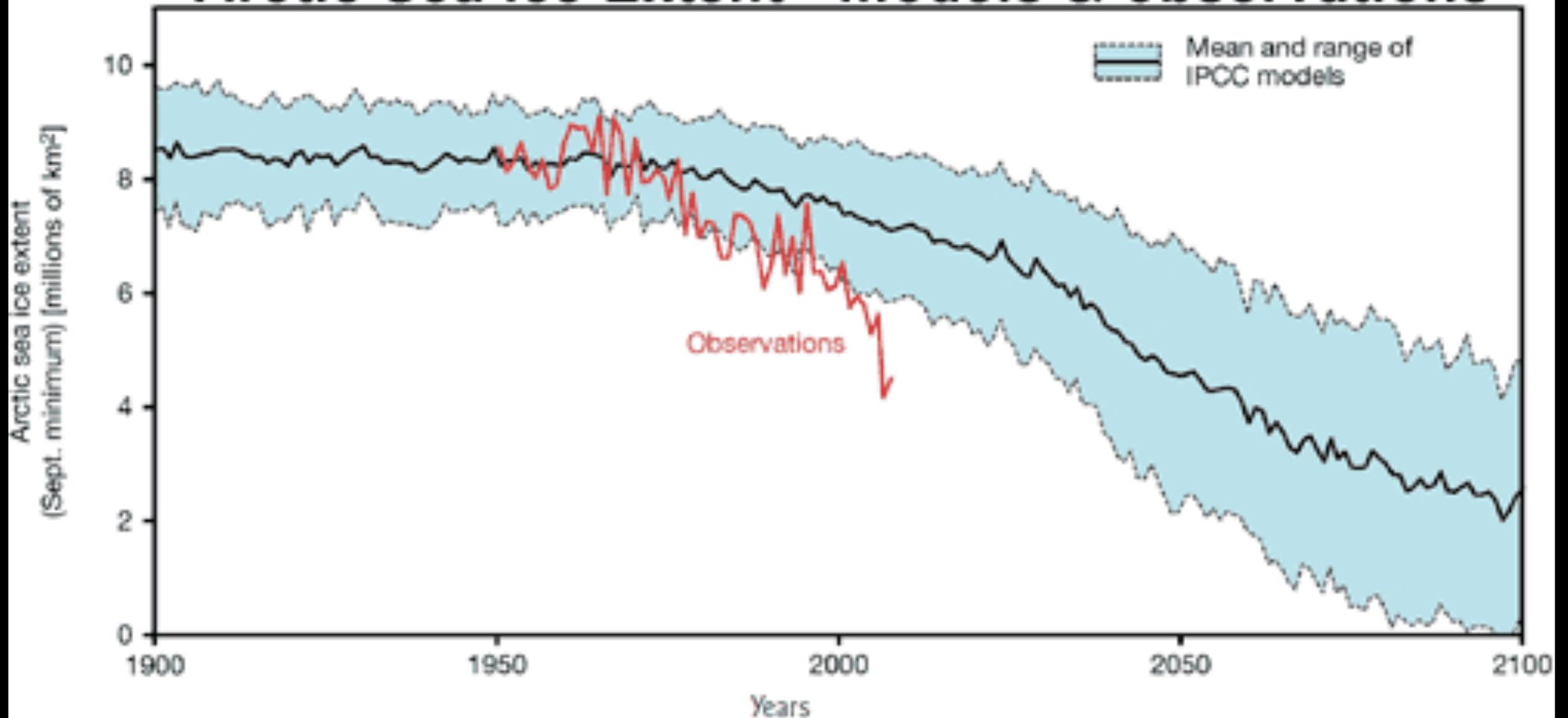
‘They can’t predict the weather next week what do they know about the climate in 20 years’



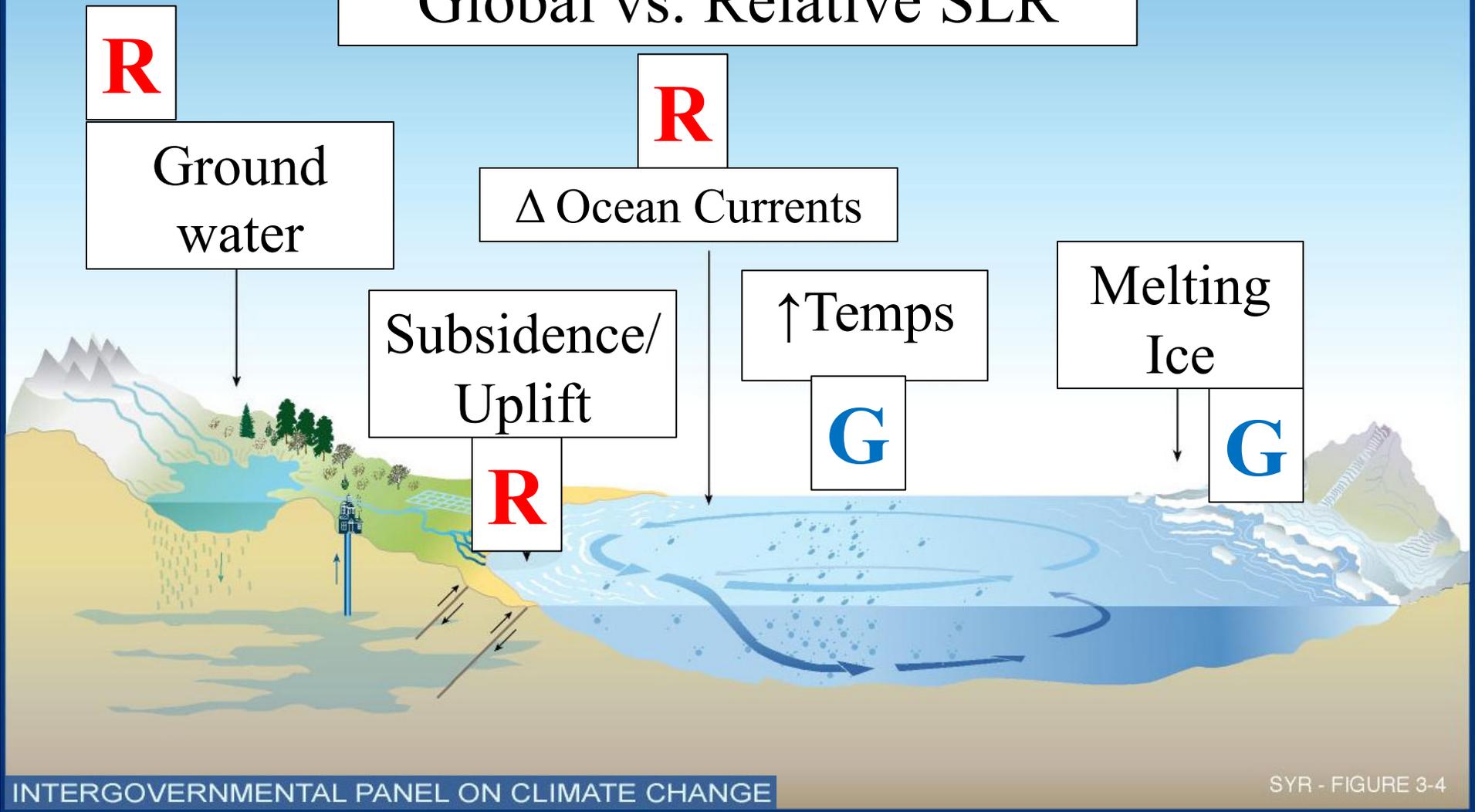




# Arctic Sea Ice Extent - models & observations



# Global vs. Relative SLR

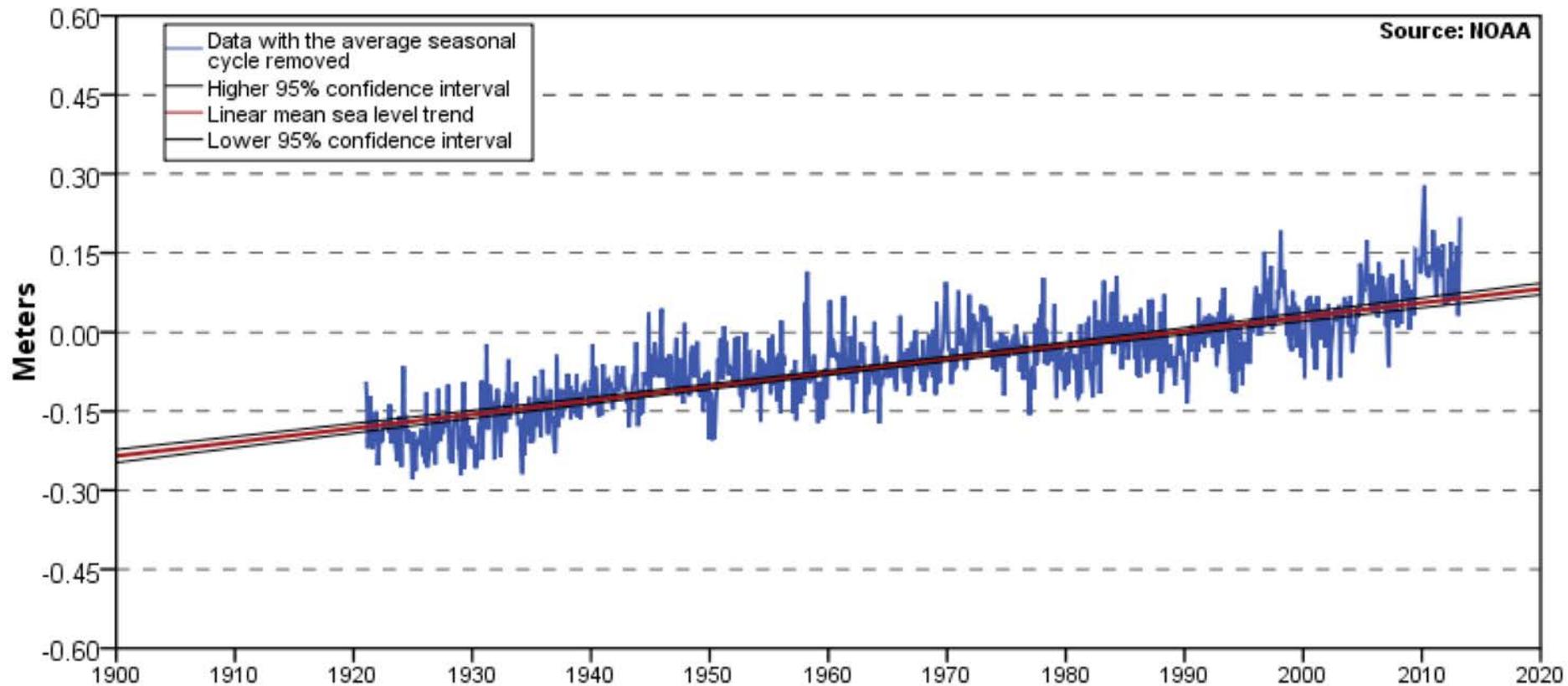


INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

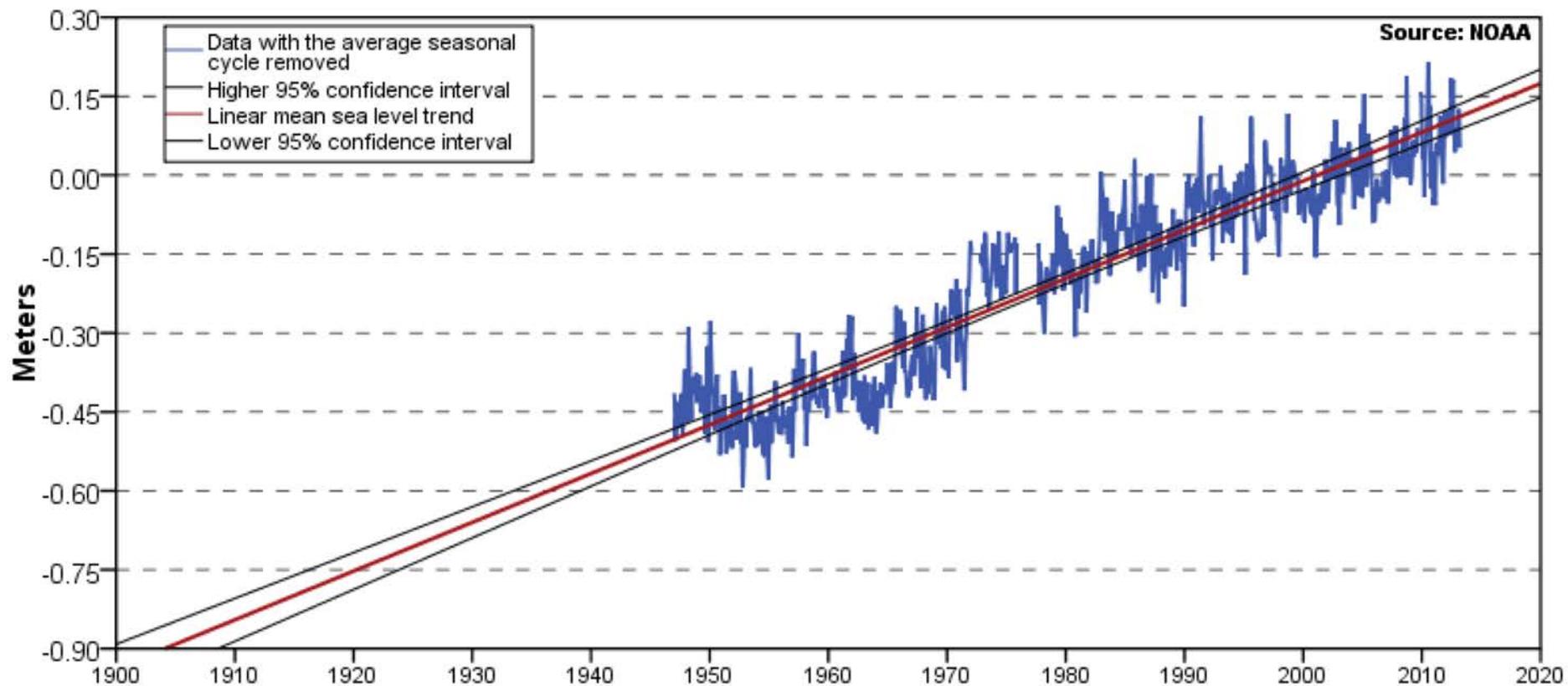
SYR - FIGURE 3-4



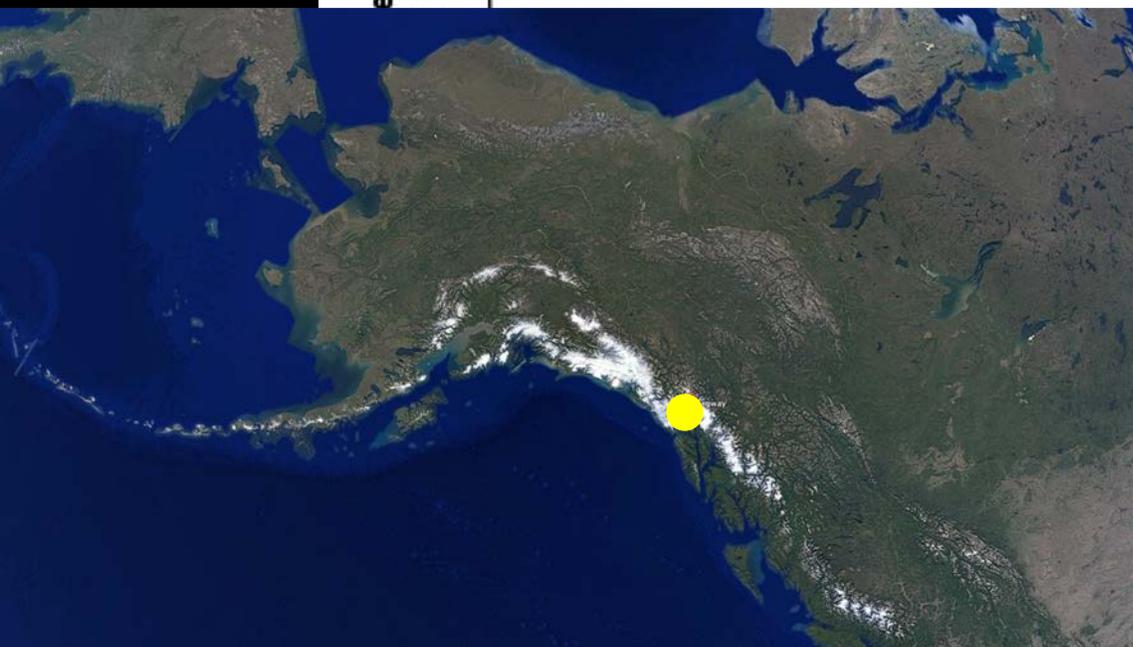
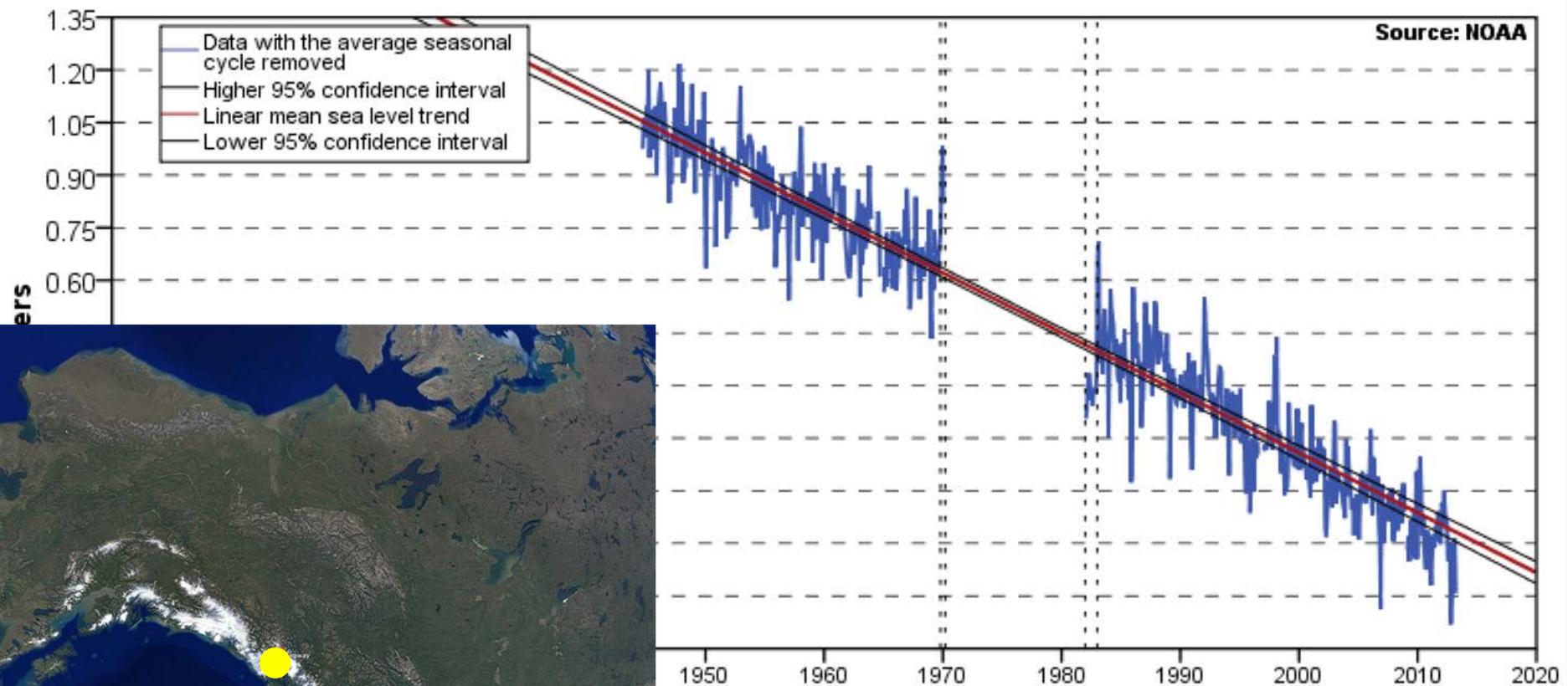
Boston, MA 2.63 +/- 0.18 mm/yr



Grand Isle, LA 9.24 +/- 0.59 mm/yr

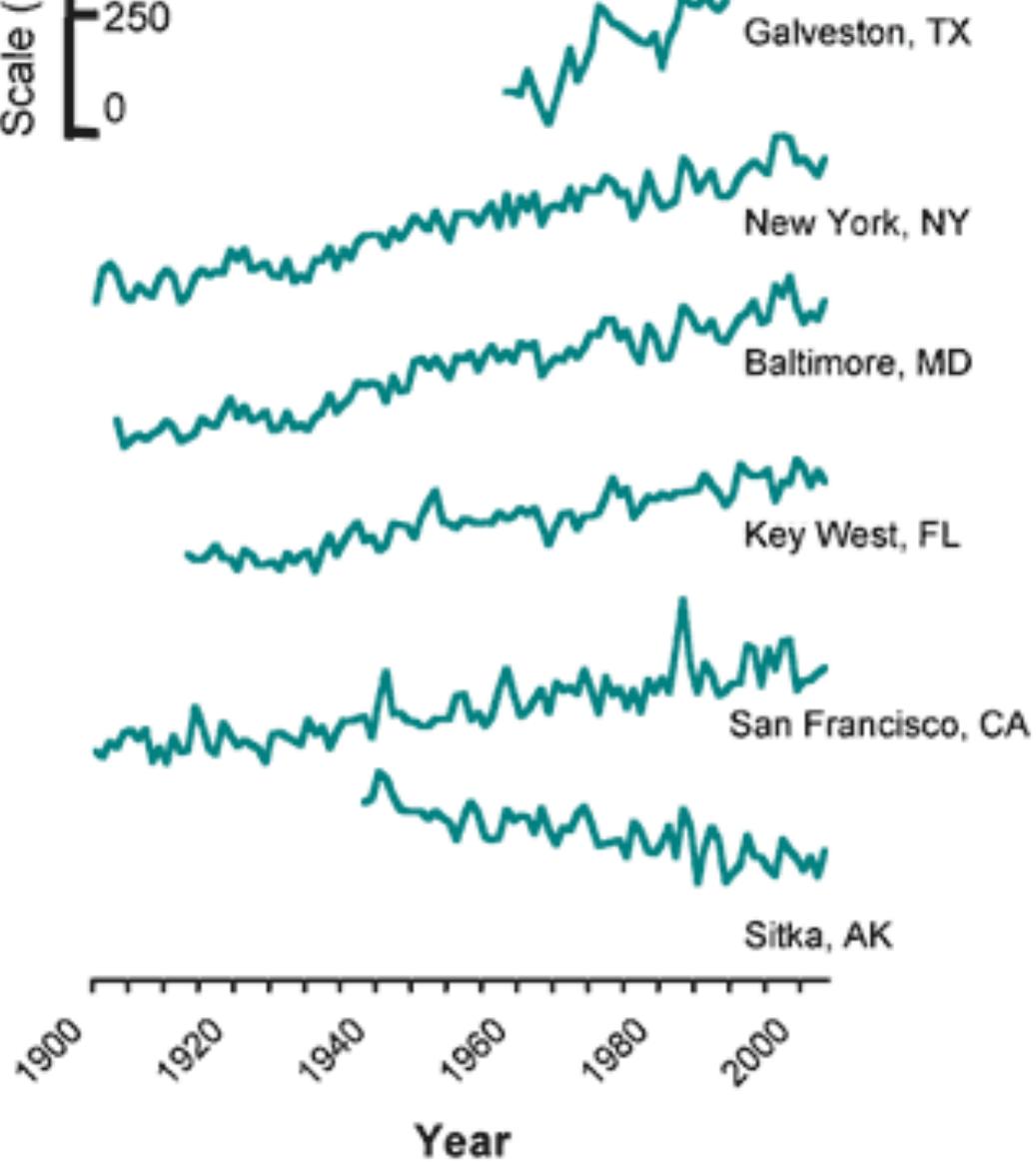
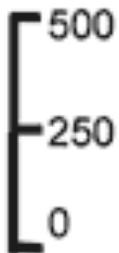


# Skagway, AK $-17.12 \pm 0.65$ mm/yr



# U.S. Sea Level Trends (1900-2003)

Scale (mm)



# US northeast coast is hotspot for rising sea levels

Report comes after North Carolina senate proposes bill to ban predictions of increase in rates of sea-level rise.

Leigh Phillips

## Regional sea-level scenarios: Helping US Northeast plan for faster-than-global rise

Global sea level could rise by **as much as 8 feet by 2100** in a worst-case scenario

*Date:* January 19, 2017

*Source:* Rutgers University



# Quick Quiz

A \_\_\_\_\_ ft rise in MSL would enable a 10-year storm to flood areas that today are only flooded by a 100-year storm.

a) 1

b) 1.5

c) 2

d) 2.5

e) 3



A 100-year storm...  
 A 100-year return frequency event  
 1% return frequency event

Return Frequency	10-yr	100 - yr	$\Delta$ 10 v 100	500 - yr	$\Delta$ 100 v 500
Elevation (ft)	8.6	9.5	~1.0	10.20	0.70

Center for International Earth  
 Science Information Network  
 EARTH INSTITUTE | COLUMBIA UNIVERSITY

Orton, P., et al., Boston Coastal Flooding Analysis and Mapping



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**Back to back nor'easter  
storms slam  
Massachusetts  
March 08, 2018, Boston  
Globe**



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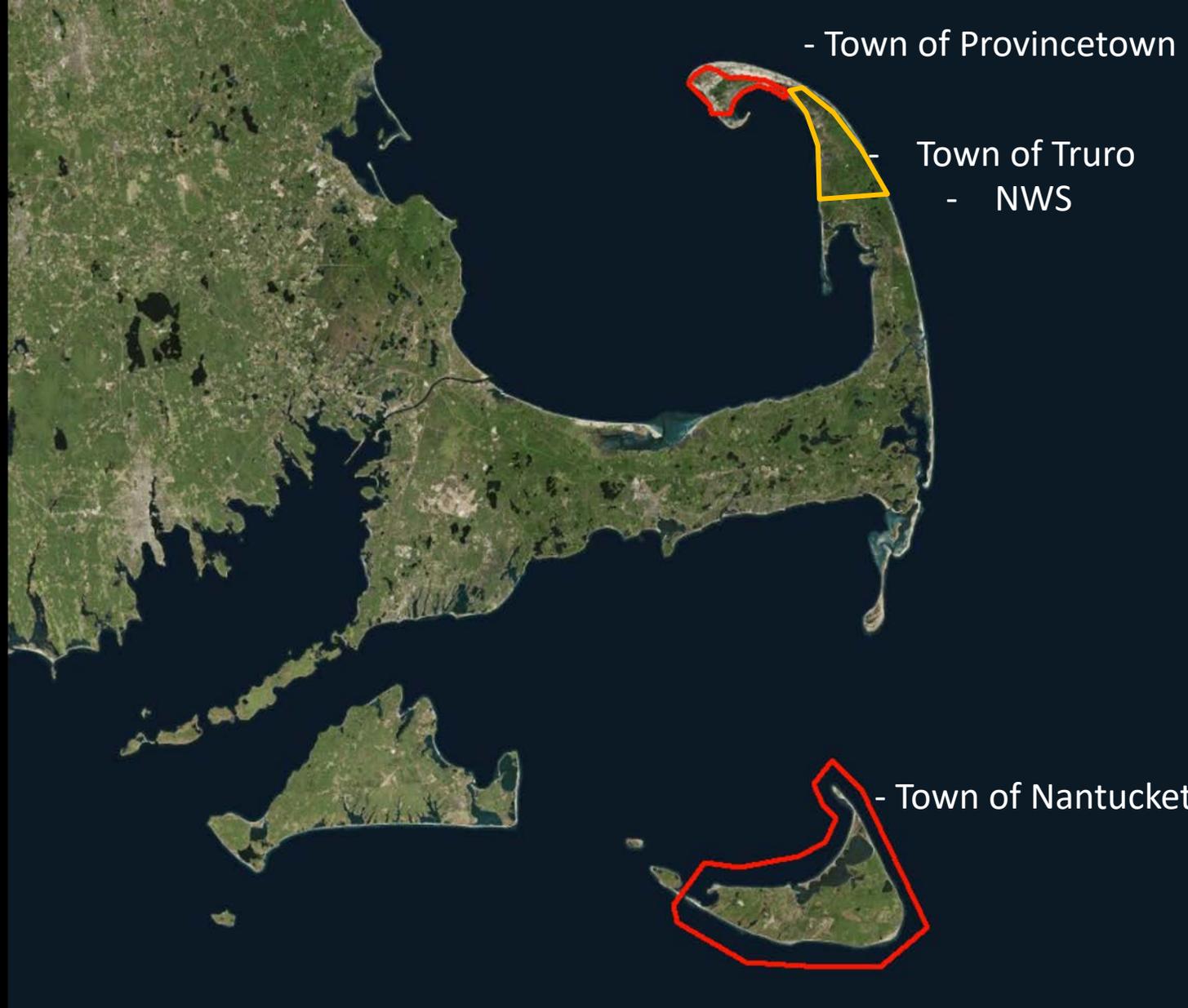
# Mapping Storm-Tide (Inundation) Pathways



## MAPPING & MODELING

1. Useful AND usable to local entities/managers
2. Address current and future concerns
3. Little, to no, computing resources
4. Increase resiliency and autonomy





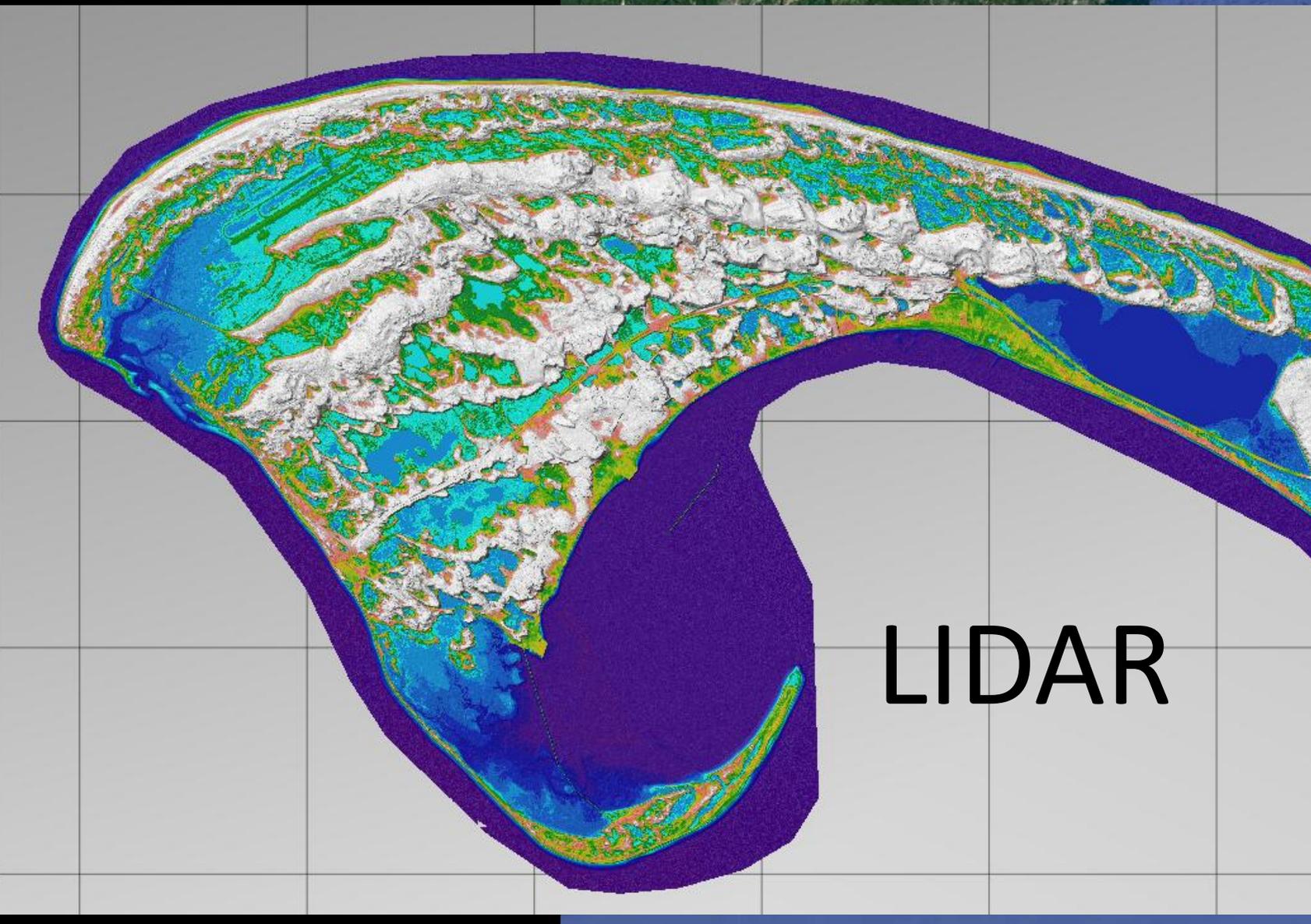
- Town of Provincetown

- Town of Truro  
- NWS

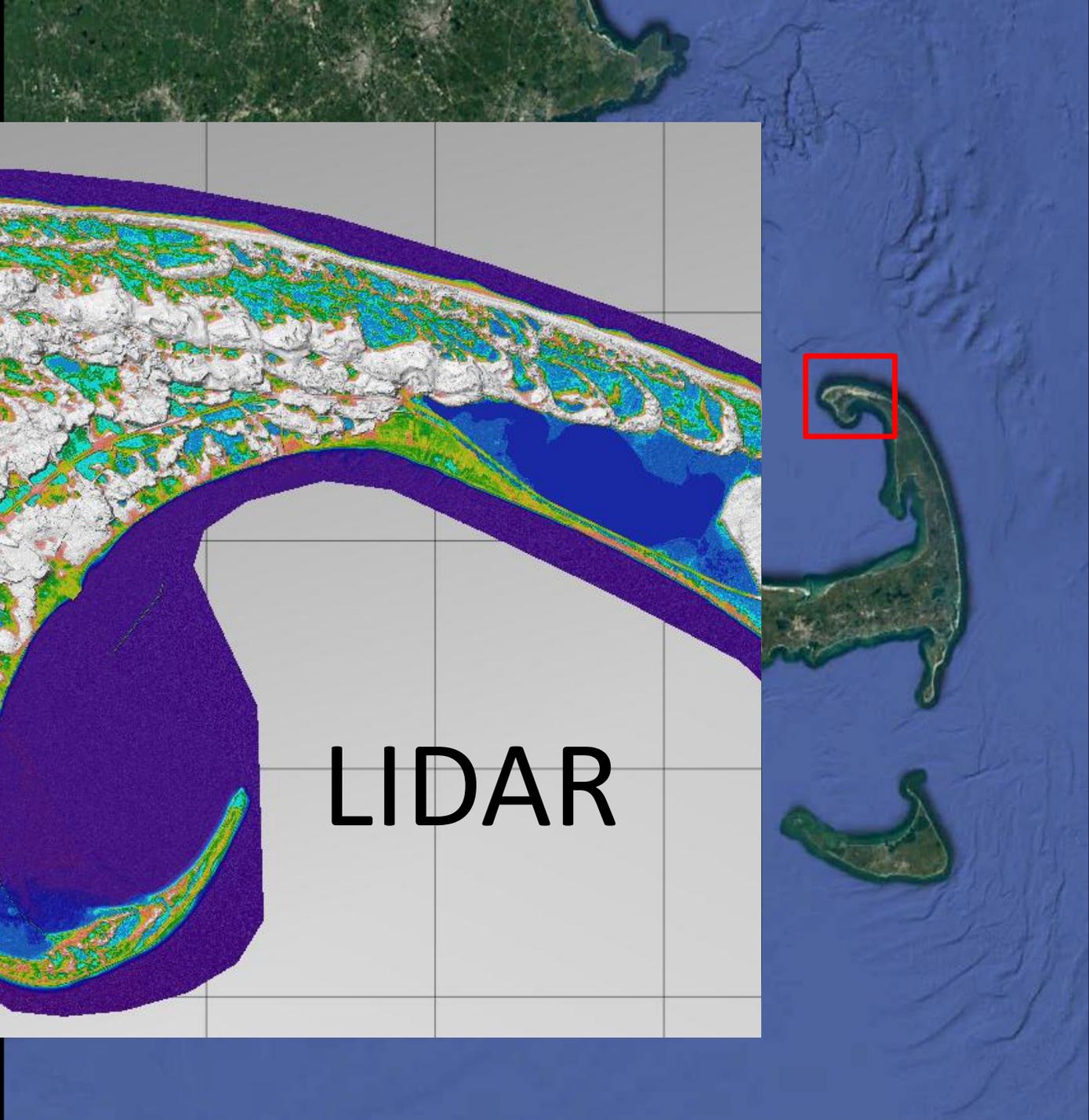
- Town of Nantucket



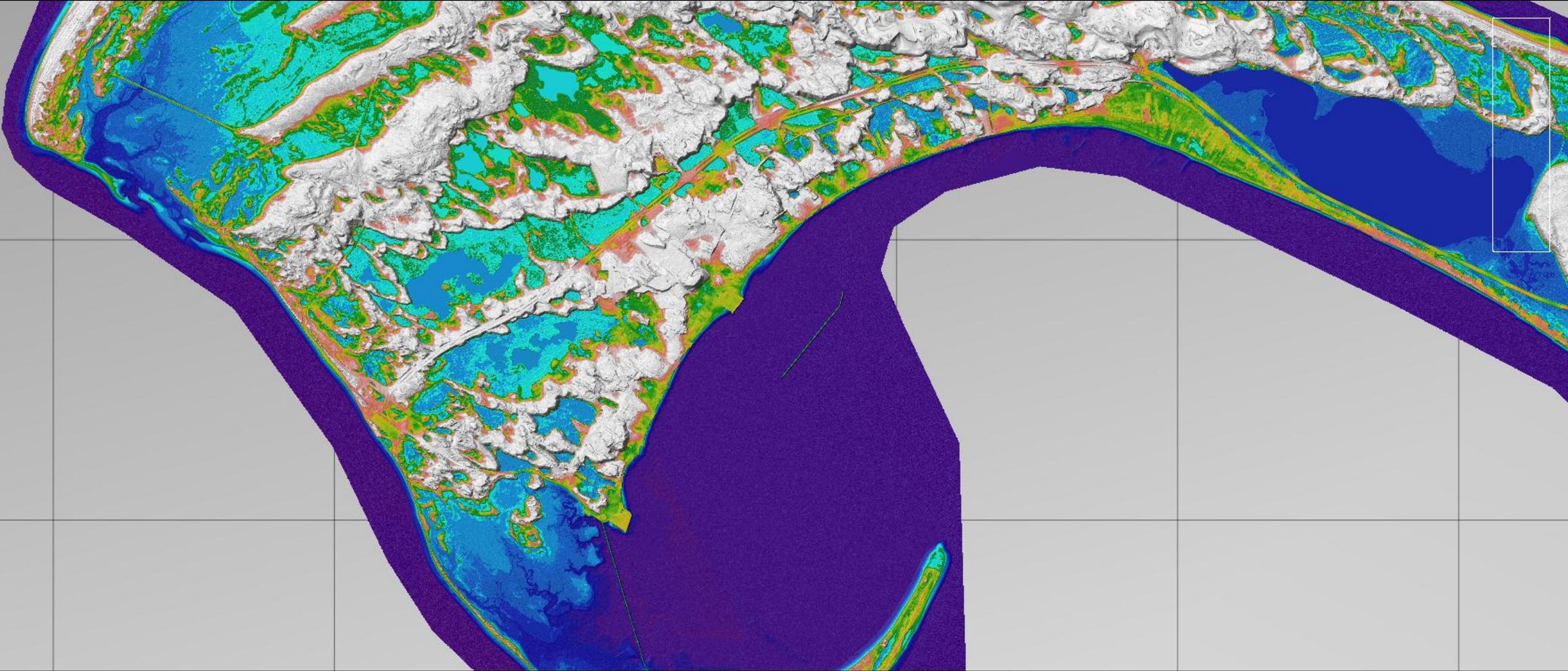
864000.0 866000.0 868000.0 870000.0 E



LIDAR

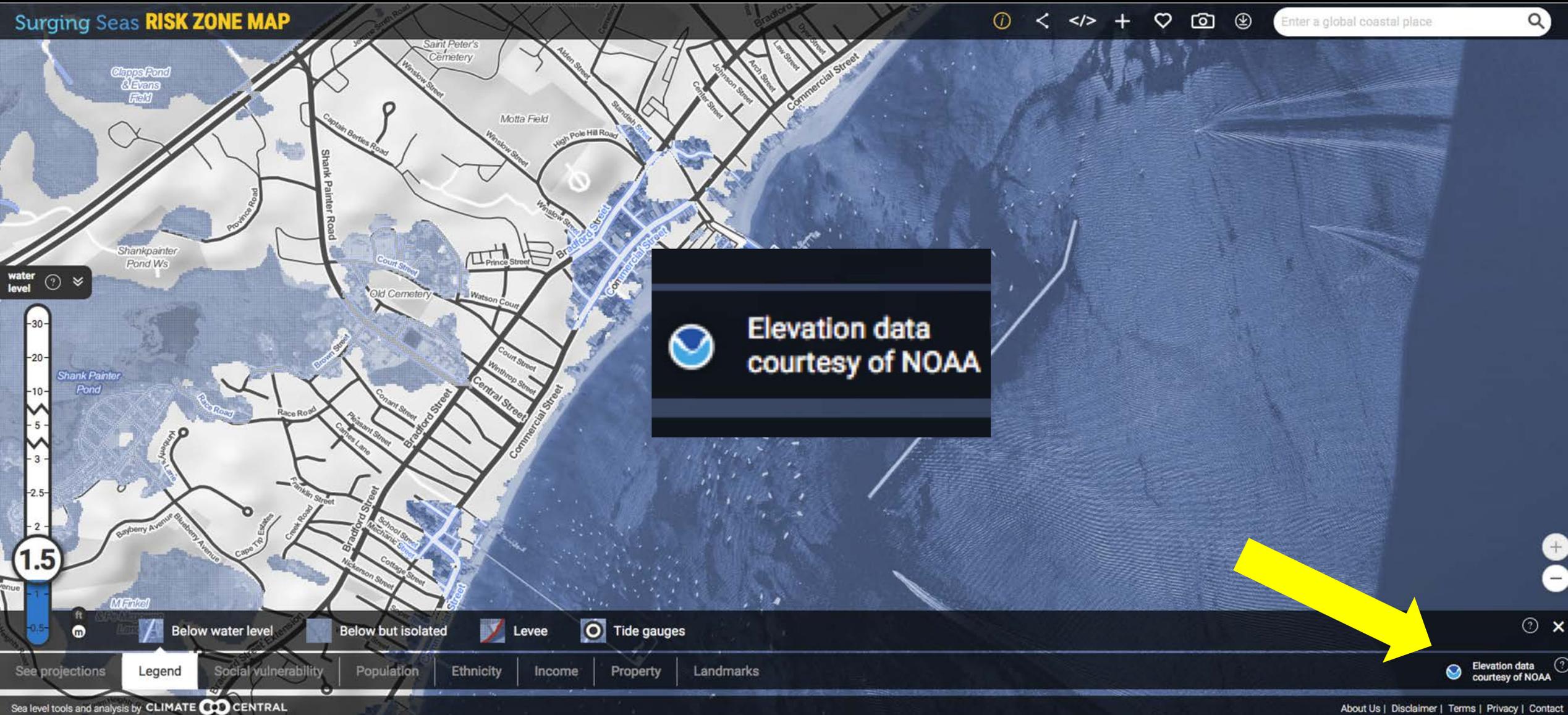


# Downtown Provincetown

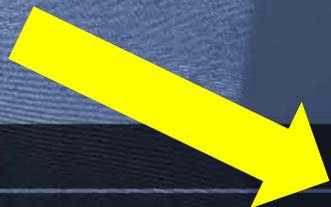


# Surging Seas (<http://sealevel.climatecentral.org/>)

## Surging Seas RISK ZONE MAP

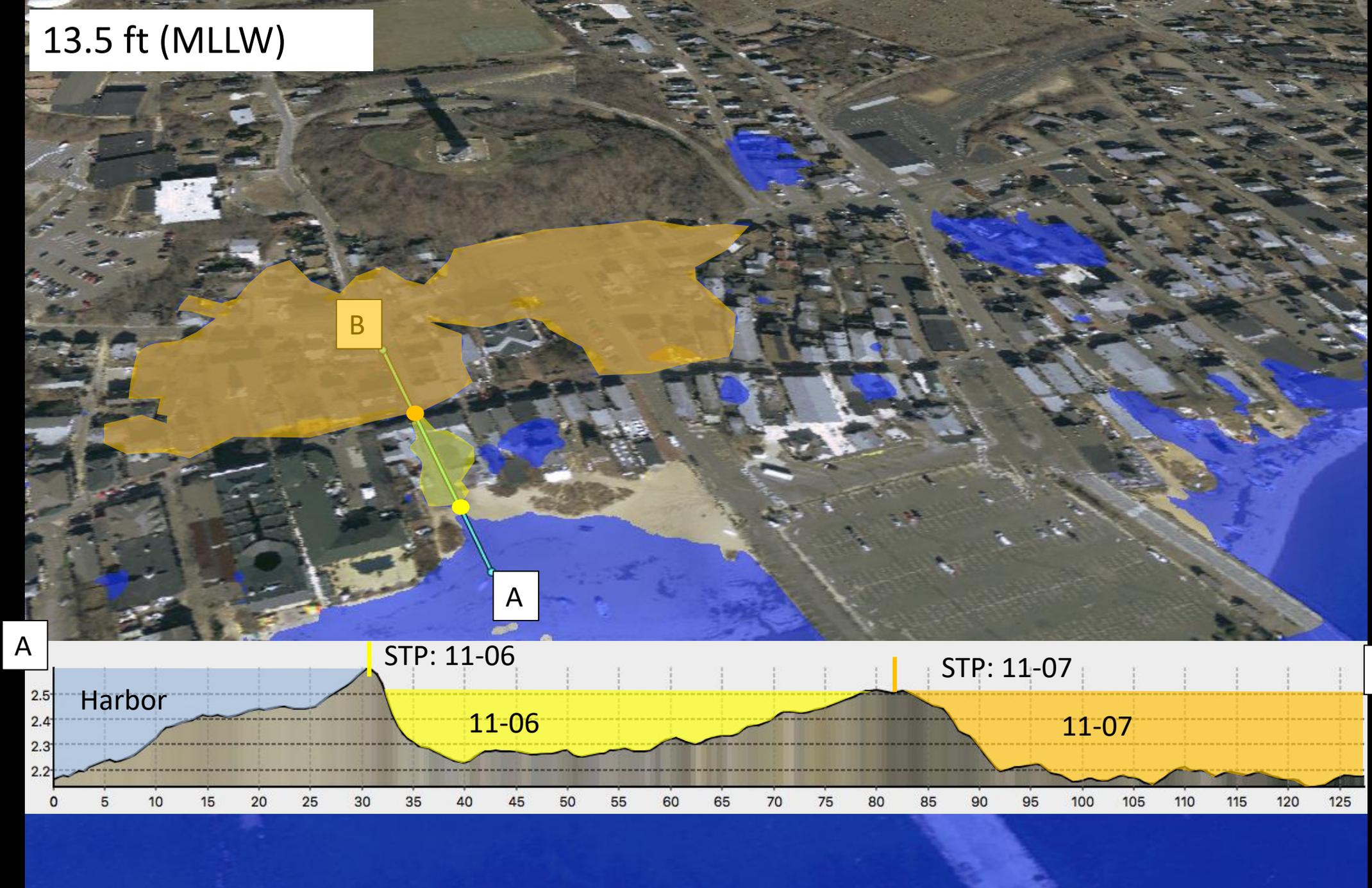


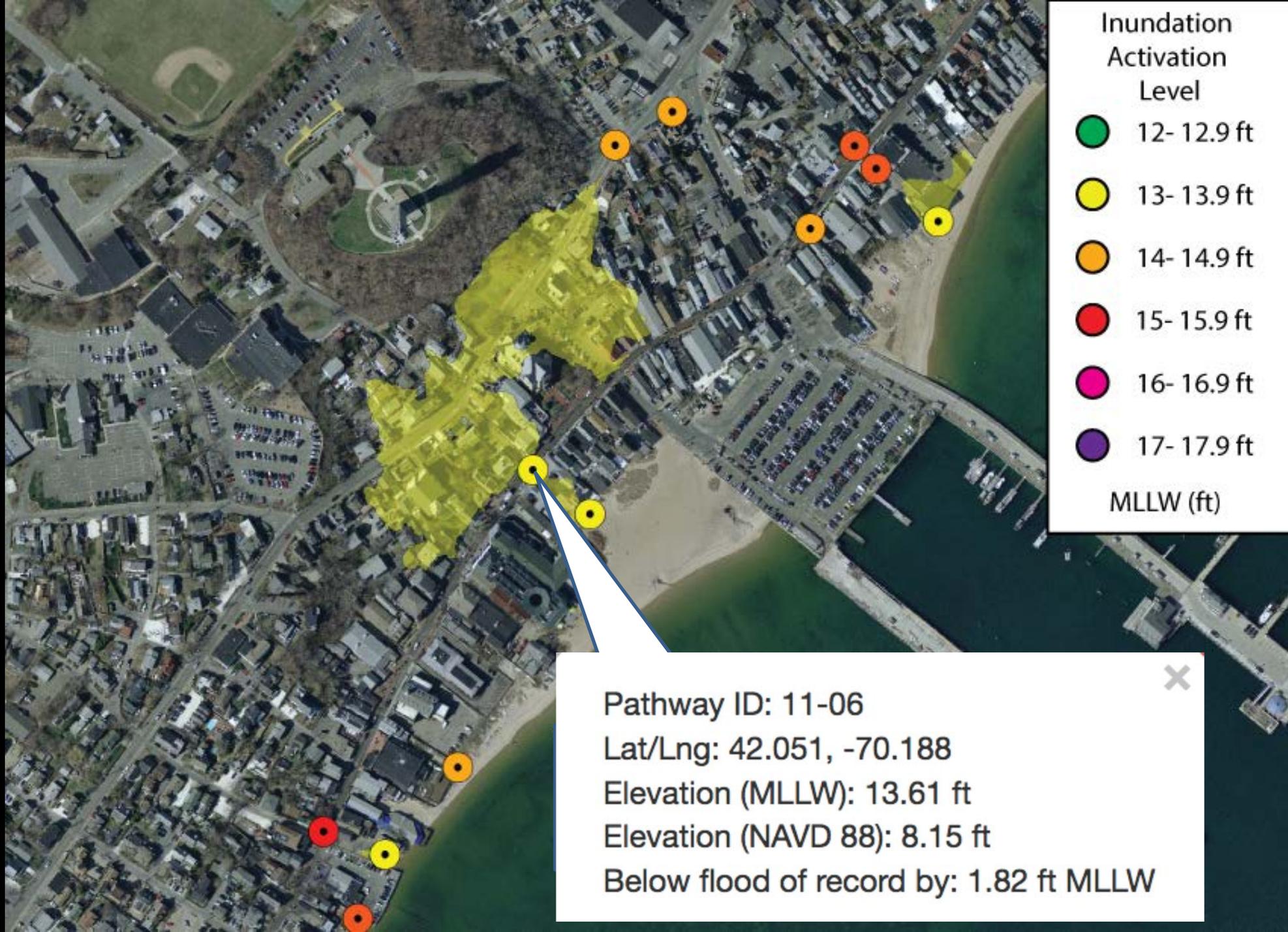
 Elevation data  
courtesy of NOAA



 Elevation data  
courtesy of NOAA

13.5 ft (MLLW)

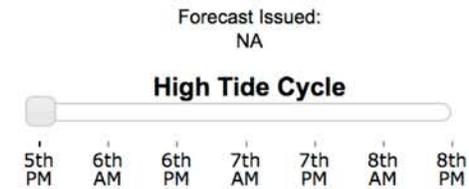
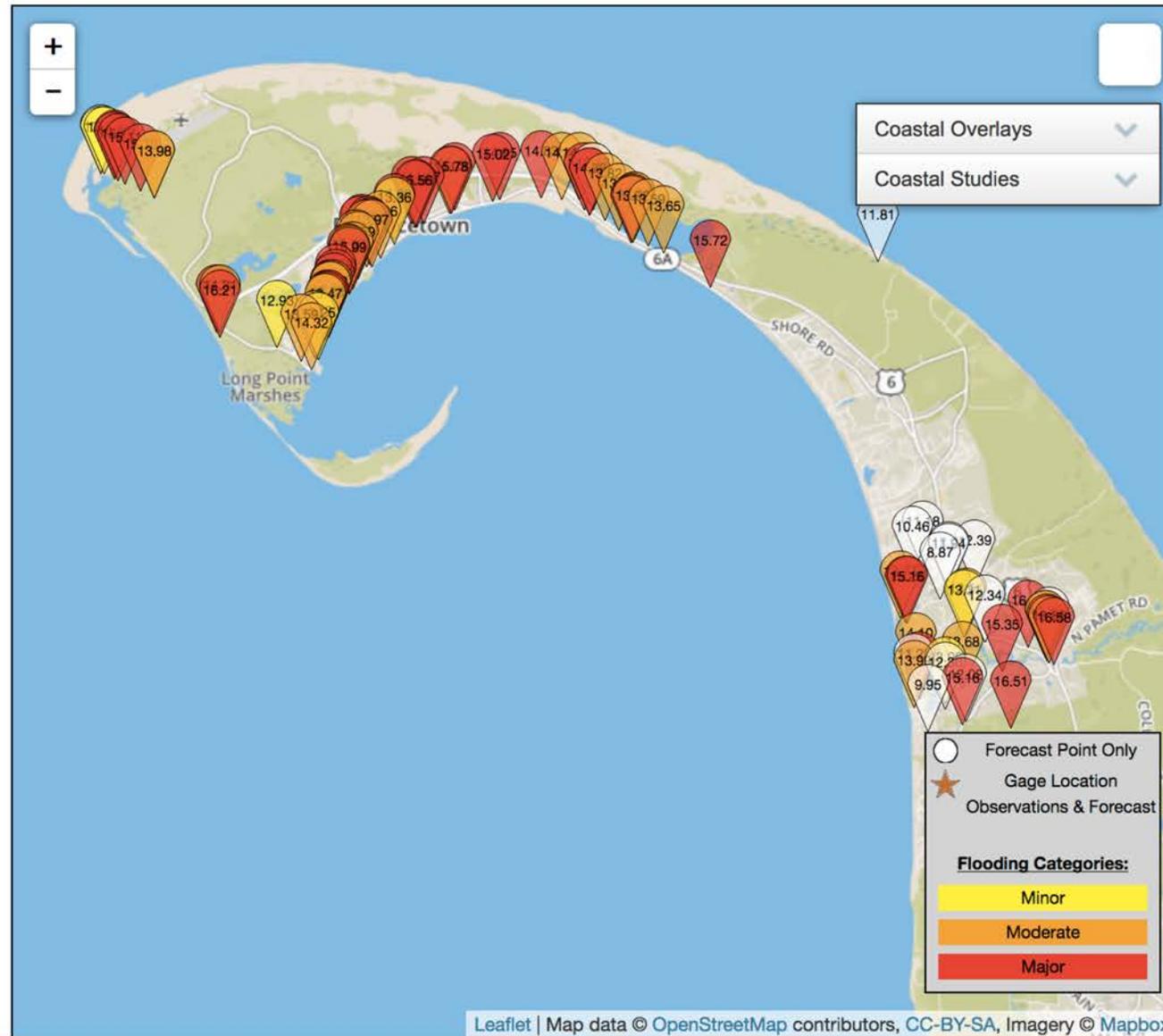




# NWS Boston - Coastal Flood Threat and Inundation Mapping

[Weather.gov](#) > [Boston, MA](#) > NWS Boston - Coastal Flood Threat and Inundation Mapping

Boston, MA  
Weather Forecast Office



- Inundation Overlay -  
Total Water Level Height  
(ft MLLW)

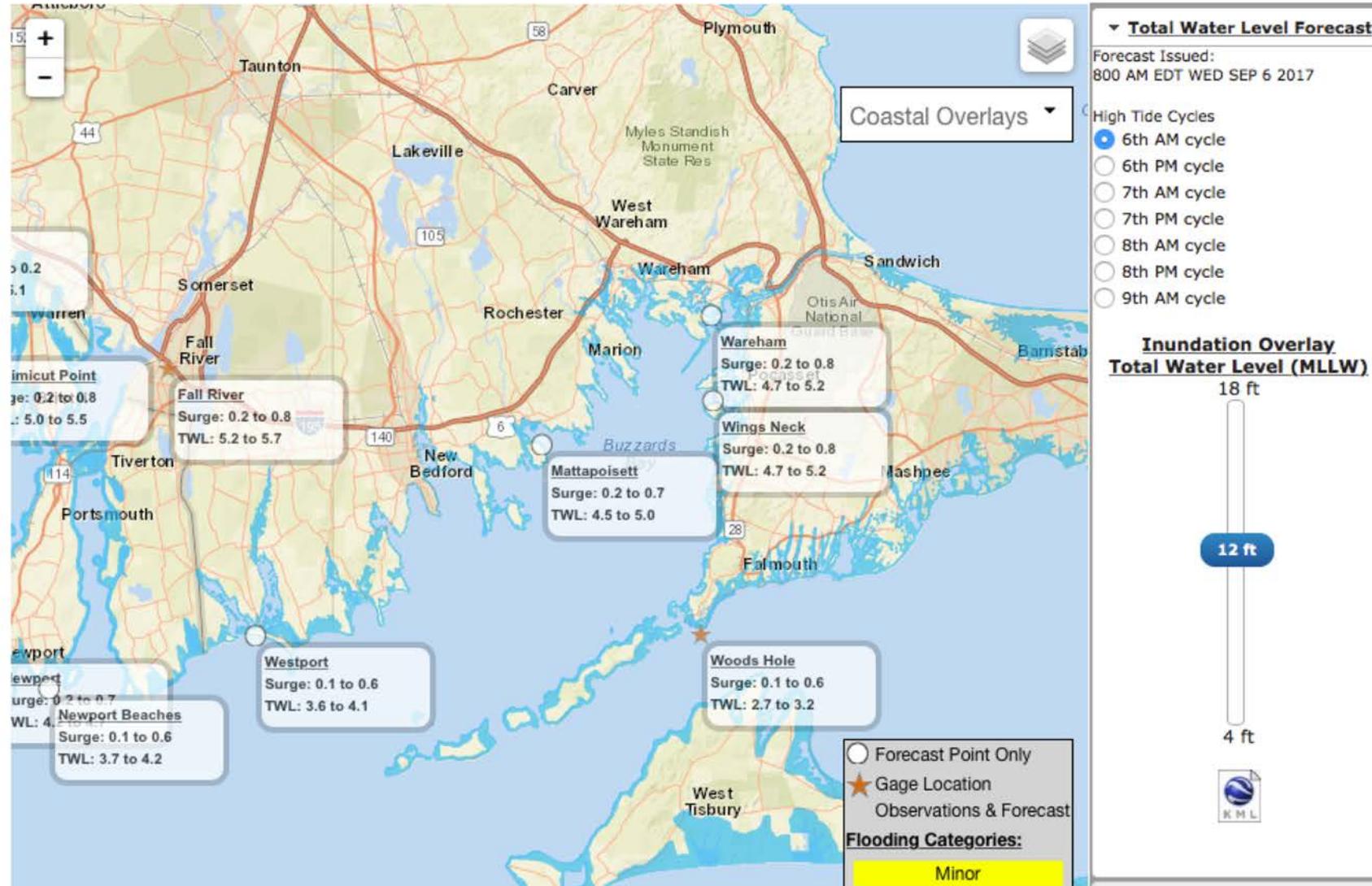


# NWS Boston - Coastal Flood Threat and Inundation Mapping

Weather.gov > Boston, MA > NWS Boston - Coastal Flood Threat and Inundation Mapping

Boston, MA

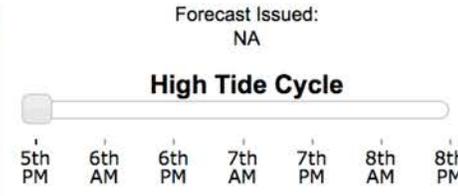
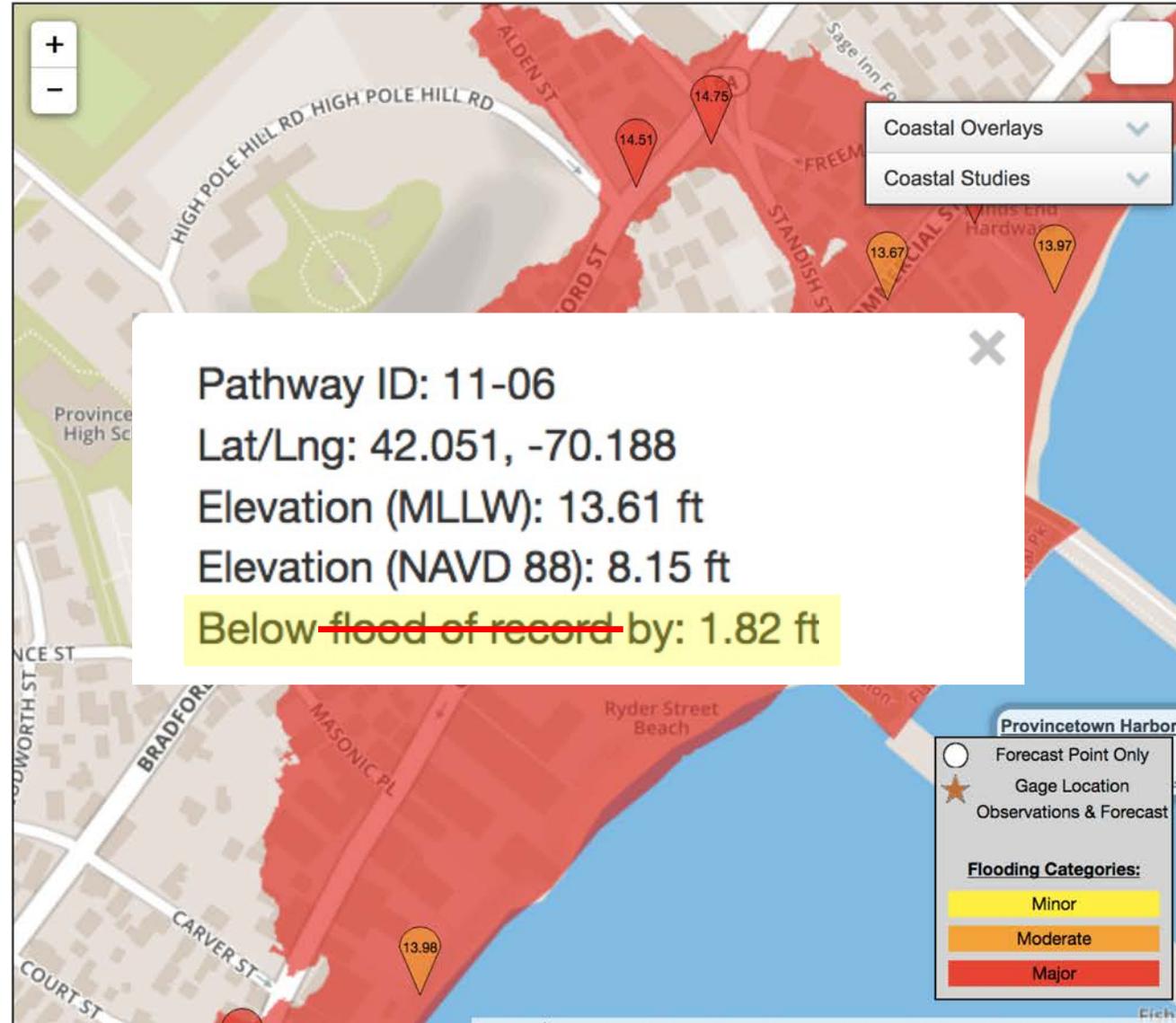
Weather Forecast Office



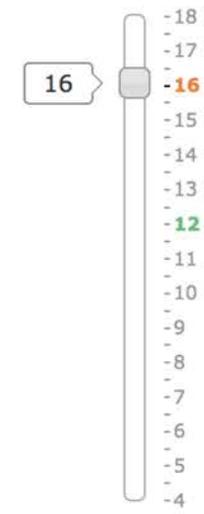
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Boston, MA  
Weather Forecast Office



- Inundation Overlay -  
Total Water Level Height  
(ft MLLW)



**Storm of Record**

**Provincetown**

**11 Feb 78 15.1 ft**

**04 Jan 18 15.6 ft**

**~ +0.5 ft**



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# QUESTIONS?



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