A Sea Level Rise Update

KEEPING HISTORY ABOVE WATER

ANNAPOLIS, MD

Oct 30, 2017

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NOAA CO-OPS Oceanographer

Talking Heads sang “This must be the place” decades ago …then came sea level rise (SLR) flooding

NOAA Technical Report NOS CO-OPS 083

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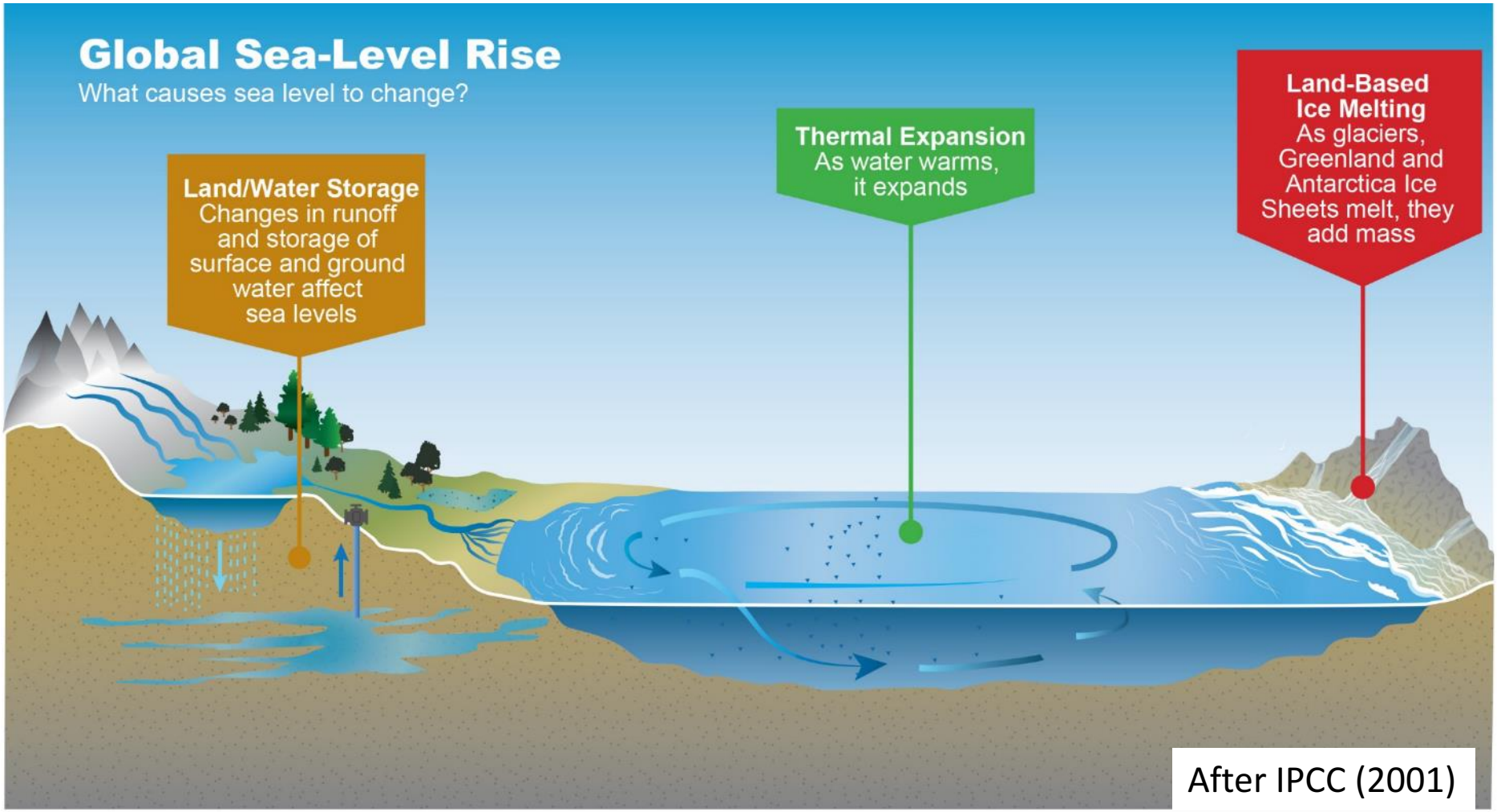
GLOBAL AND REGIONAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES

Photo: Ocean City, Maryland

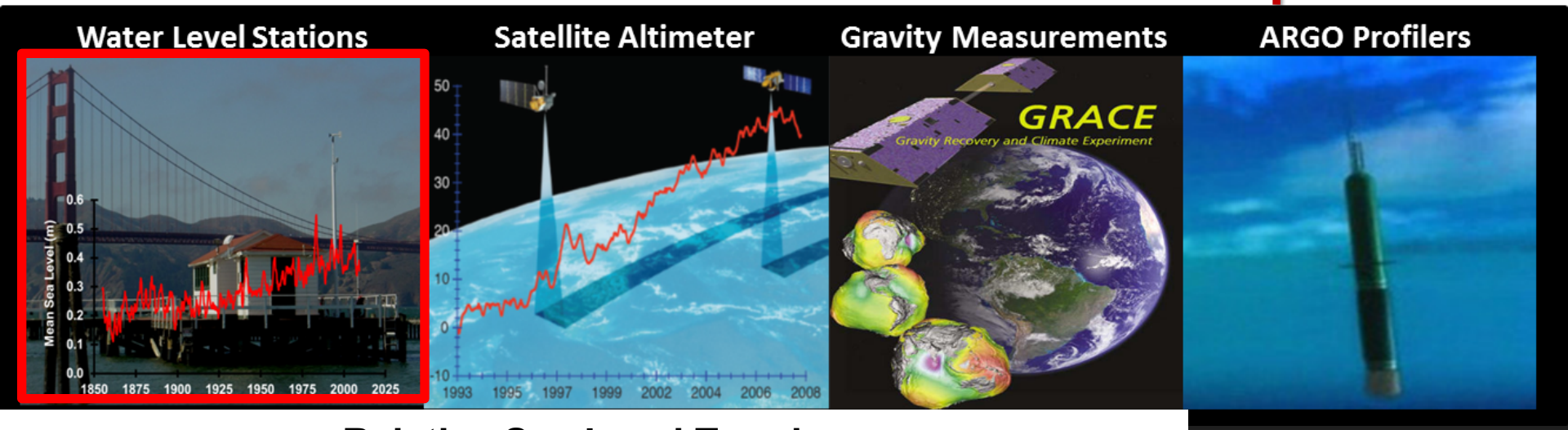
Silver Spring, Maryland
January 2017

City Dock in Ann

Global mean sea level rise

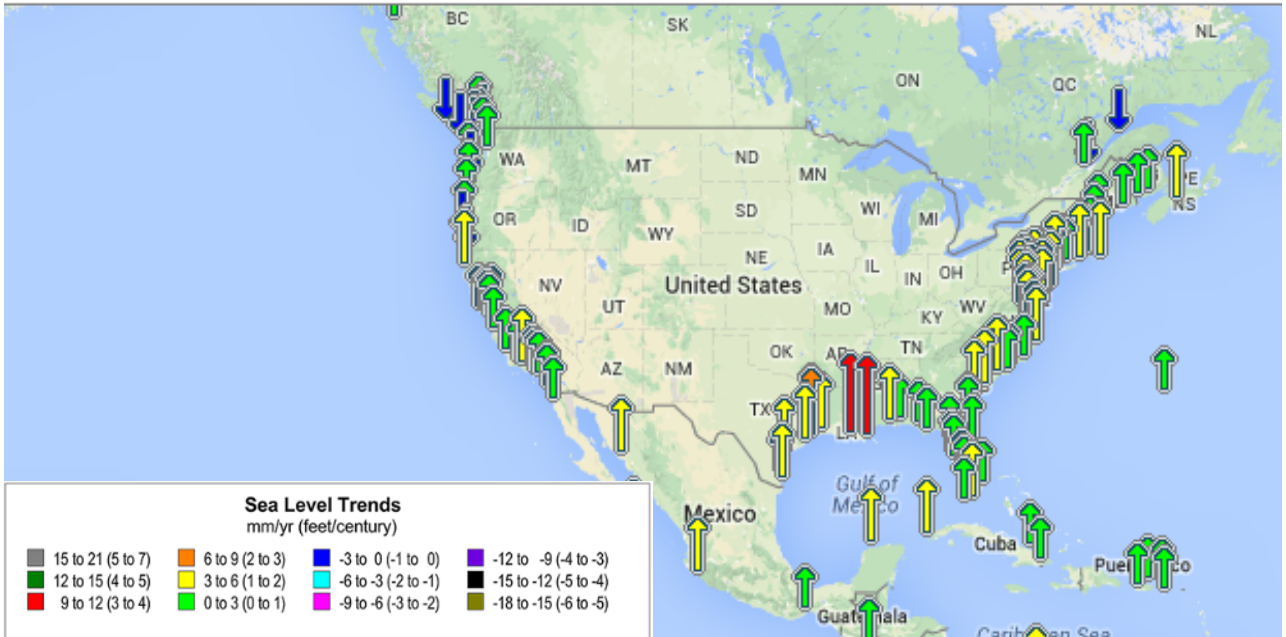


Global/Local sea level rise and measurement platforms



Relative Sea Level Trends
(tidesandcurrents.noaa.gov/sltrends)

East Coast | West Coast | Gulf Coast | Alaska | Hawaii | Global



Local SLR

=

Global

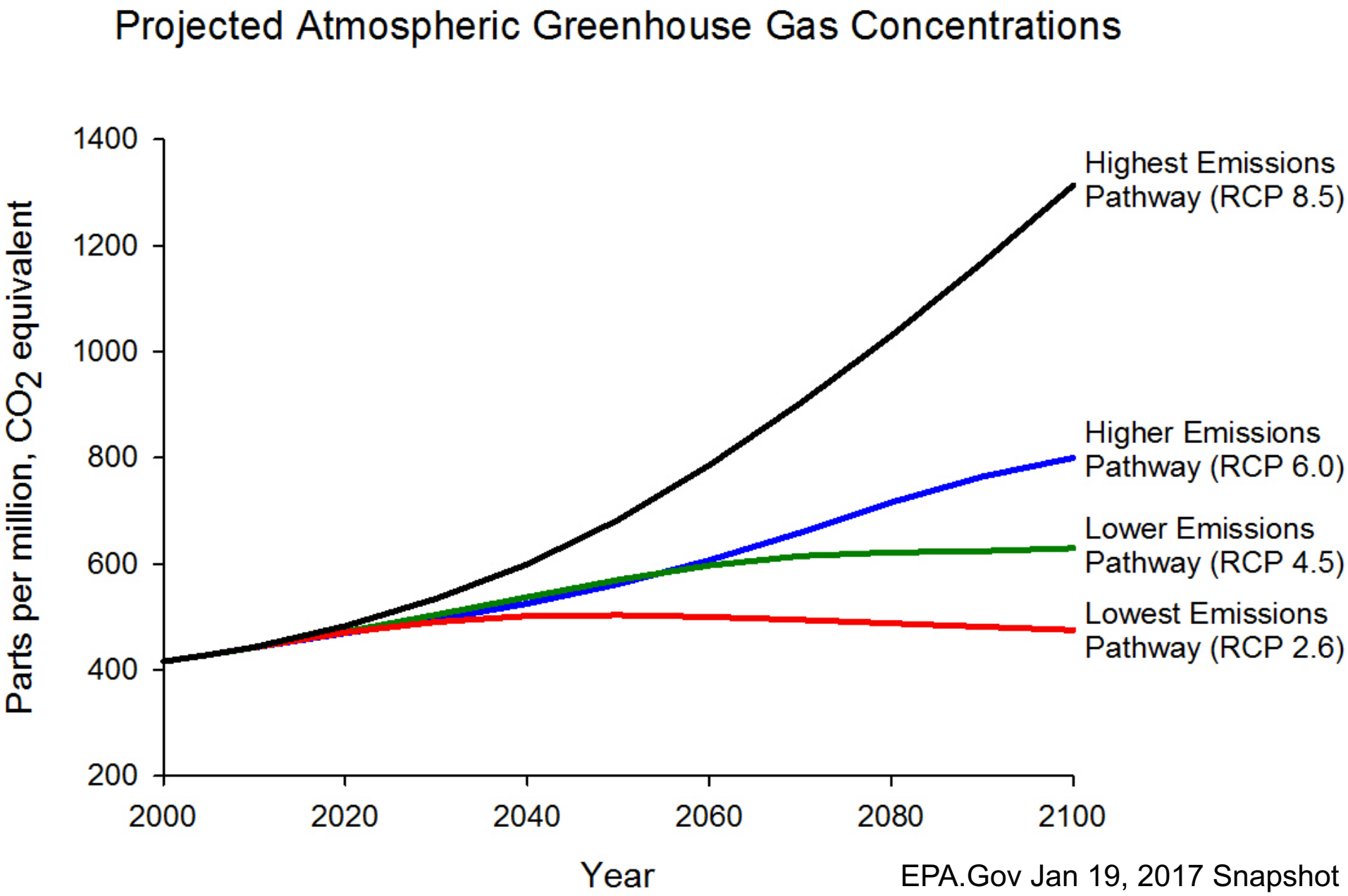
+

Regional

+

Local

The Past & our Future: The CO2, Temp & SLR Connection



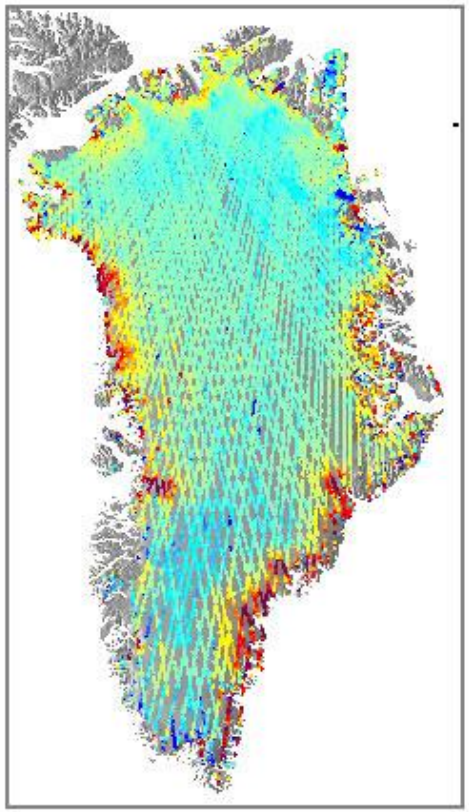
EPA.Gov Jan 19, 2017 Snapshot

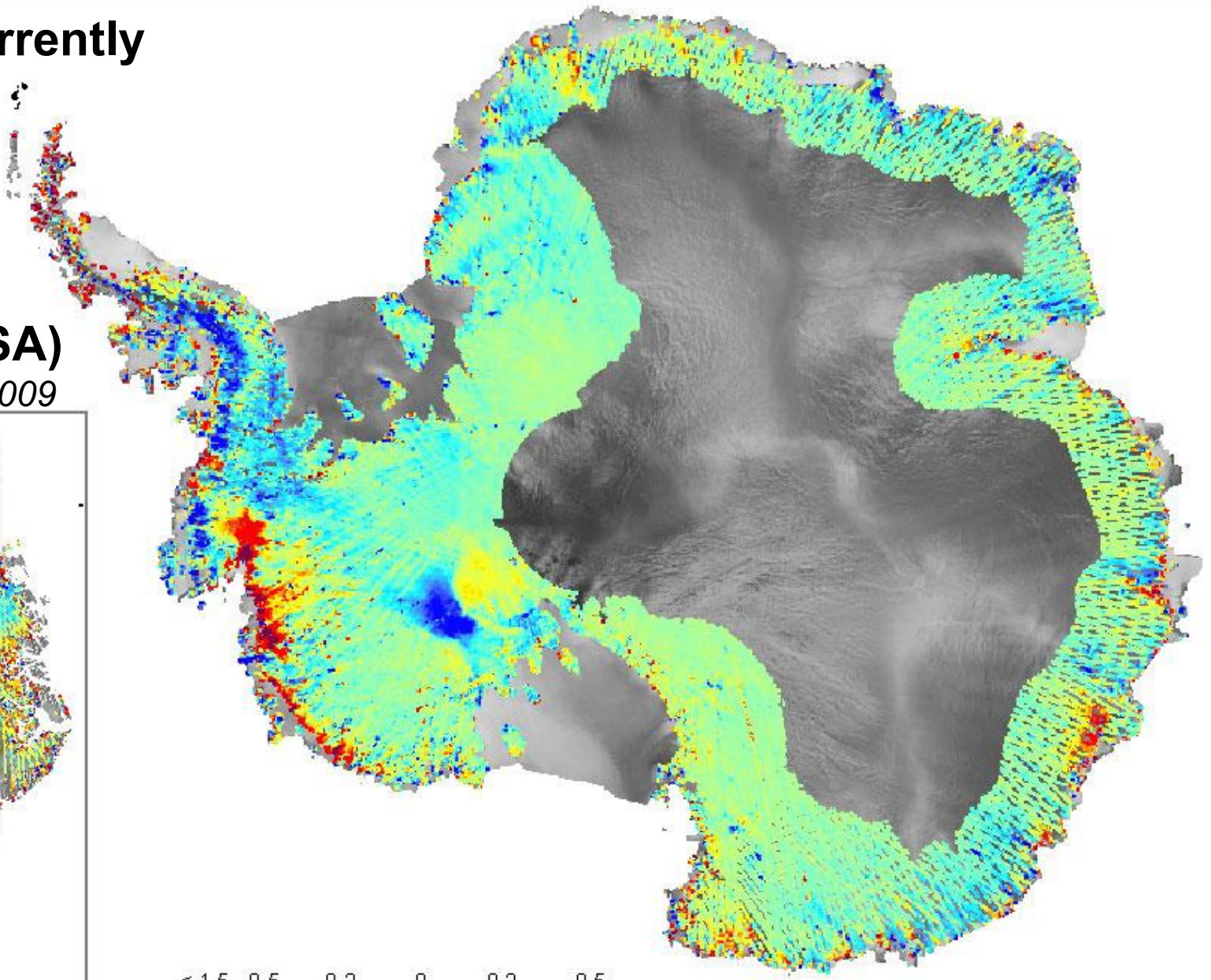
The Past & our Future: The CO2, Temp & SLR Connection

Regions currently thinning (red).

(British Antarctic Survey/NASA)

Pritchard *et al. 2009*





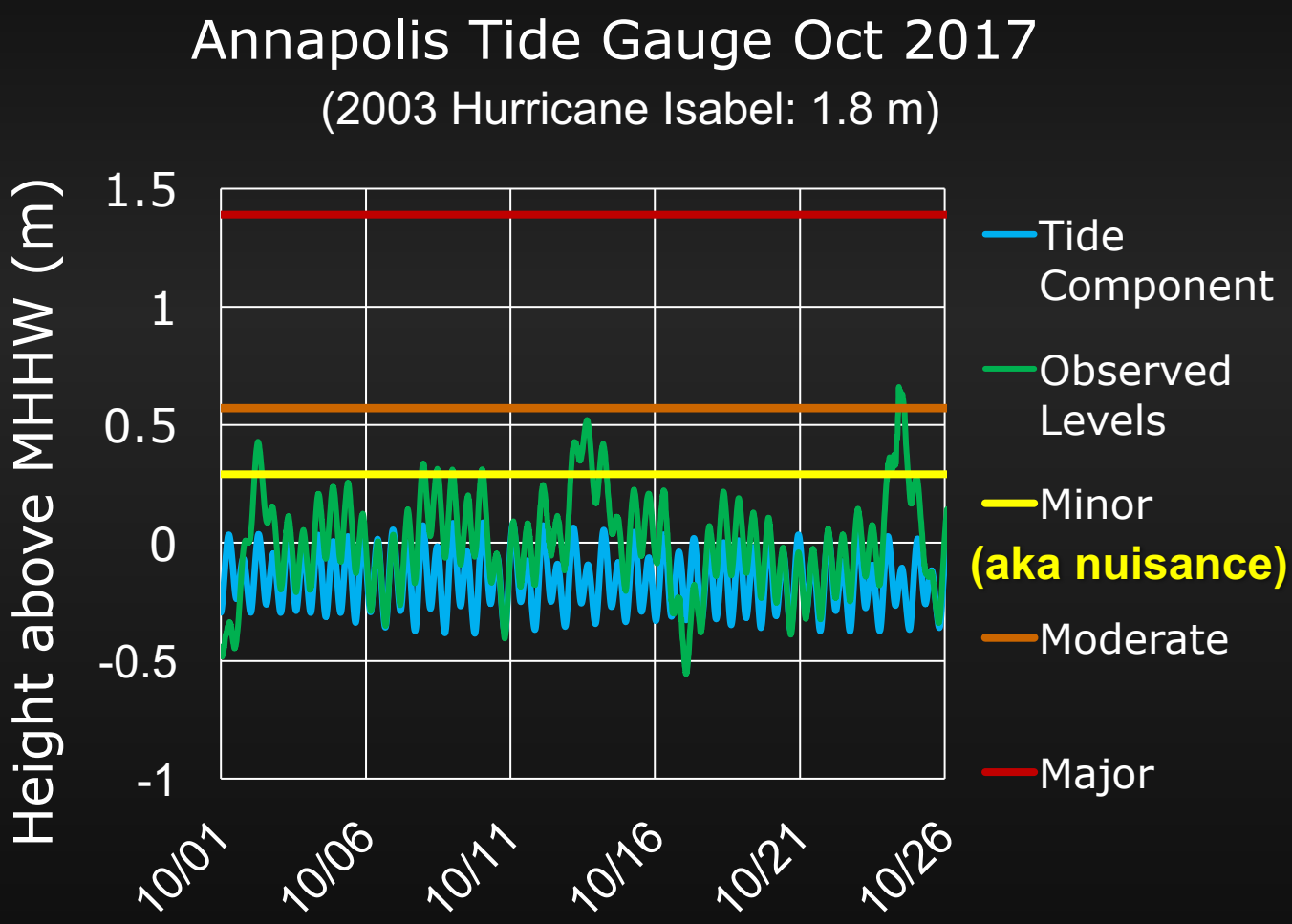
Future Sea Level Scenarios

Global Sea Level Rise Scenario by 2100	RCP2.6 dramatic reduction of carbon emissions	RCP4.5 some reduction in carbon emissions	RCP8.5 no change in carbon emissions
Low (0.3 m)	94%	98%	100%
Intermediate-low (0.5 m)	49%	73%	96%
Intermediate (1.0 m)	2%	3%	17%
Intermediate-high (1.5 m)	0.4%	0.5%	1.3%
High (2.0 m)	0.1%	0.1%	0.3%
Extreme (2.5 m)	0.05%	0.05%	0.1%

Likelihood of exceeding the global rise amount under the probabilistic construct of Kopp et al. (2014)

NOAA Tide Gauge Annapolis and Coastal Flooding

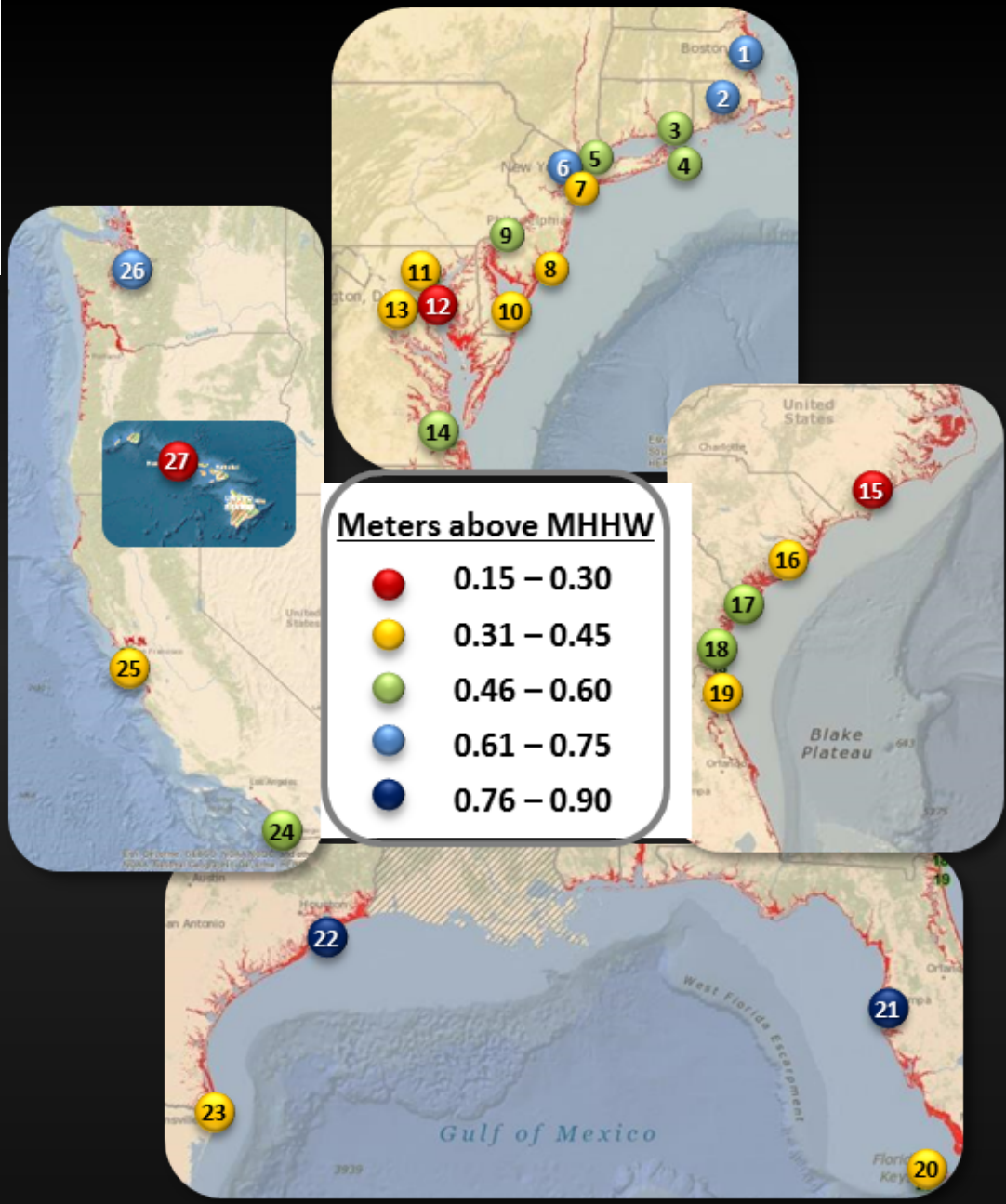
Tide gauges provide long records of high-water events whose impacts are defined by NOAA NWS



Frame of reference: Losing freeboard… taking on water

<u>Today's infrastructure:</u>

Vulnerable to minor nuisance flooding 1-2' above avg. highest tide

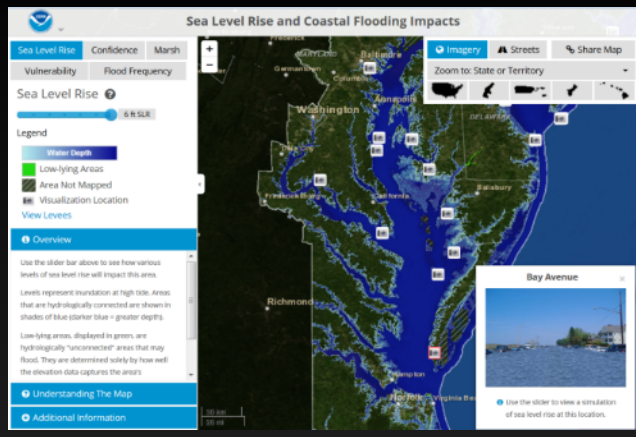


NOAA Tide Gauge Annapolis and Coastal Flooding

Moderate Flooding: Oct 24, 2017

What are the effects of SLR?

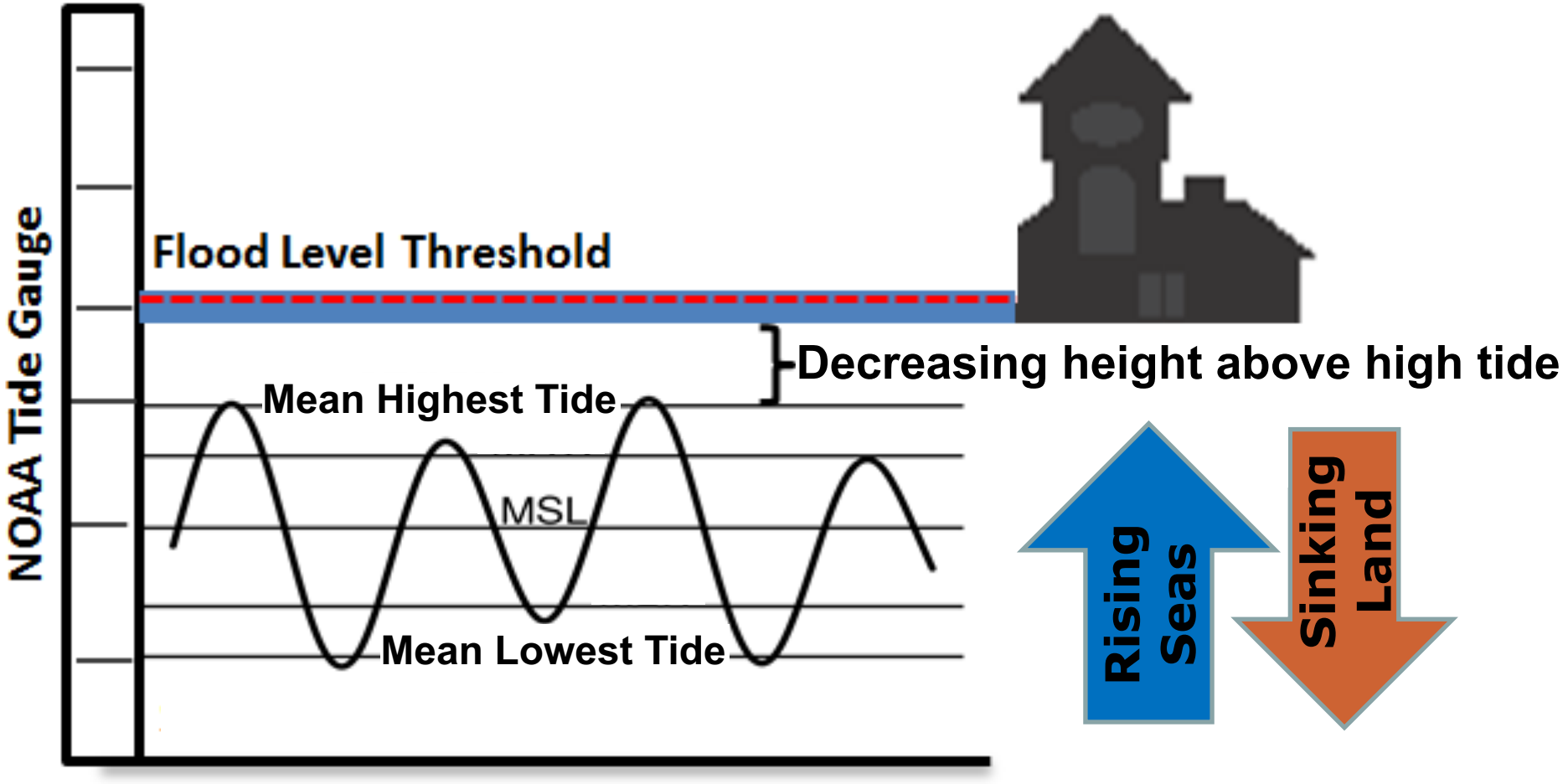
1. SLR_{rel} increases perennial inundation
   - difficult to sense "mean" changes … tides and storms dominate



2. Exacerbates extreme probabilities
   - obscured by rarity of events

3. Exacerbates high tide (nuisance) flooding
   - more tangible indicator of climate change-related SLR

Dylan's B-side hit: the tides…they are a changing



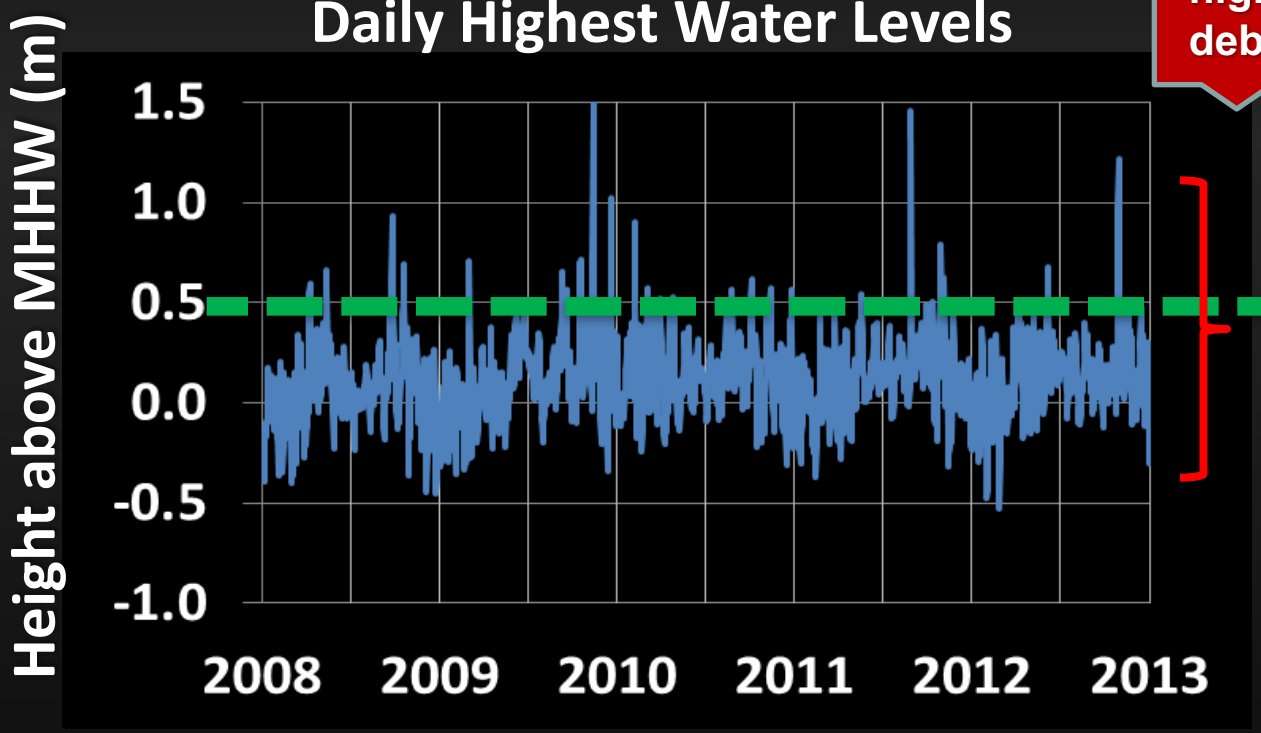
"Then" flooding occurred during big storms.

"Now" sunny-day nuisance urban flooding is common.

Bob Dylan…the (high) tides, they are a changing!

Years ago, flooding occurred during big storms.

Now, sunny-day tidal flooding is rather common.

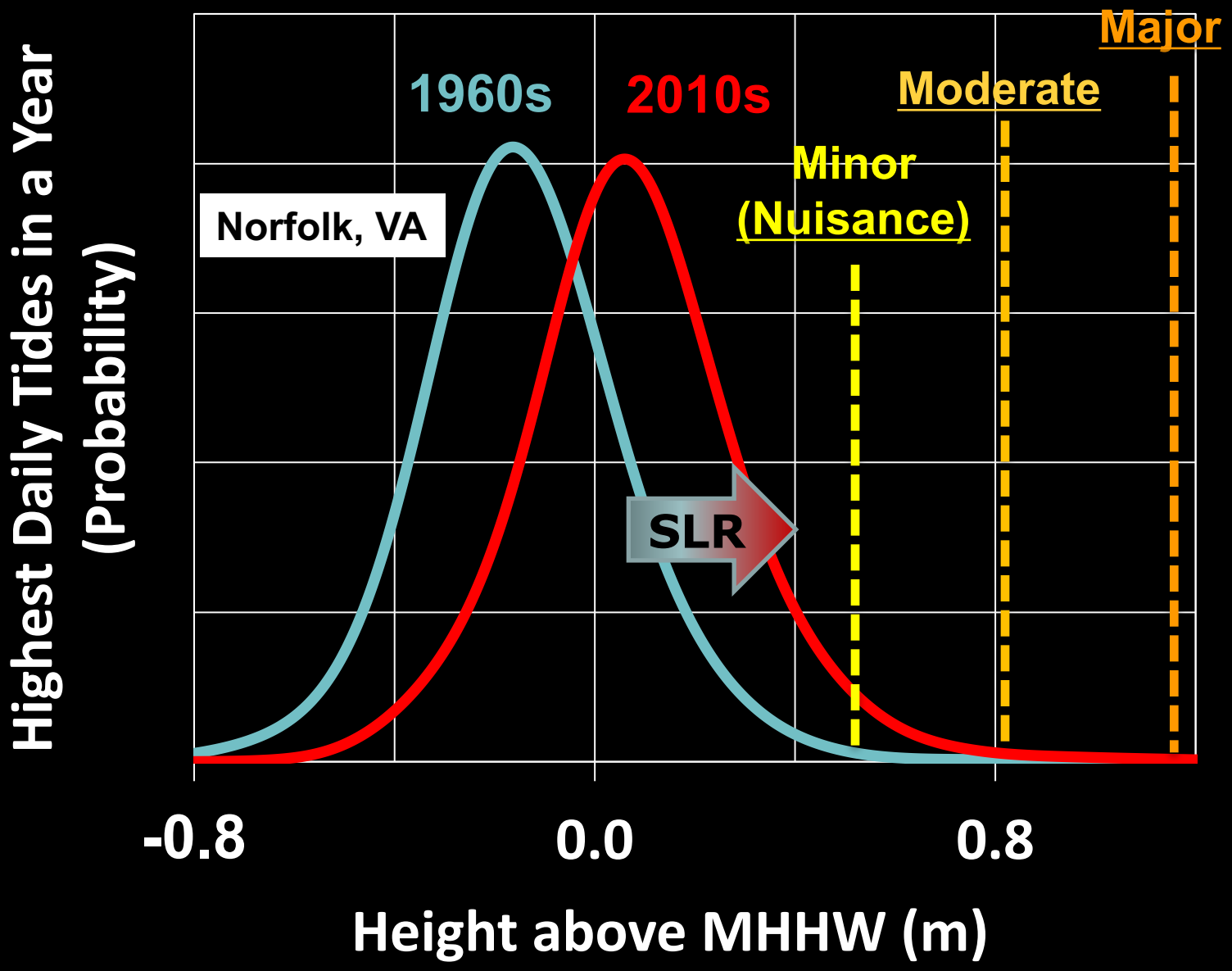


Think: high water debris line

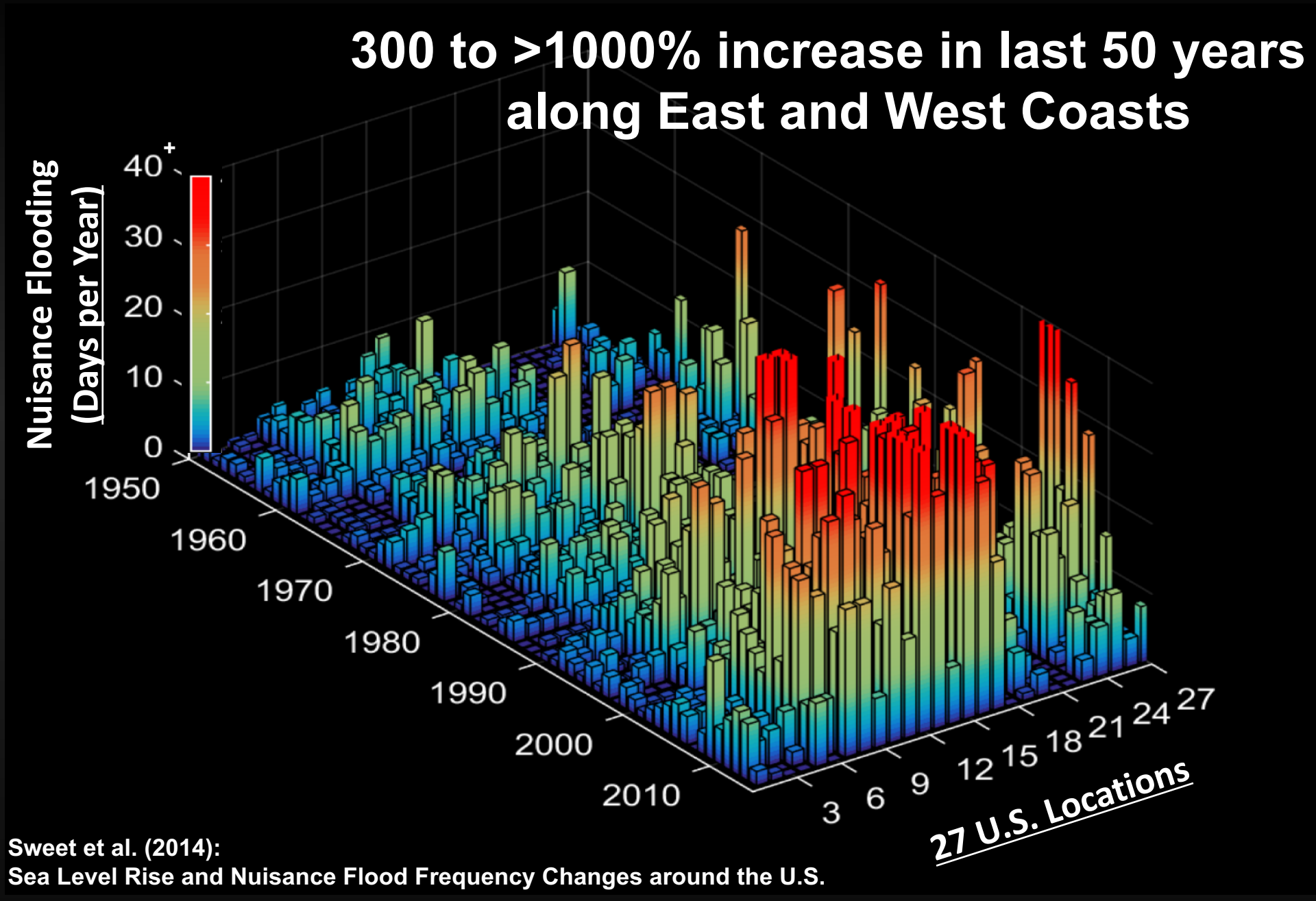
Nuisance Flood Level

Example from Norfolk, VA

The Accelerating Threat of Tidal Flooding



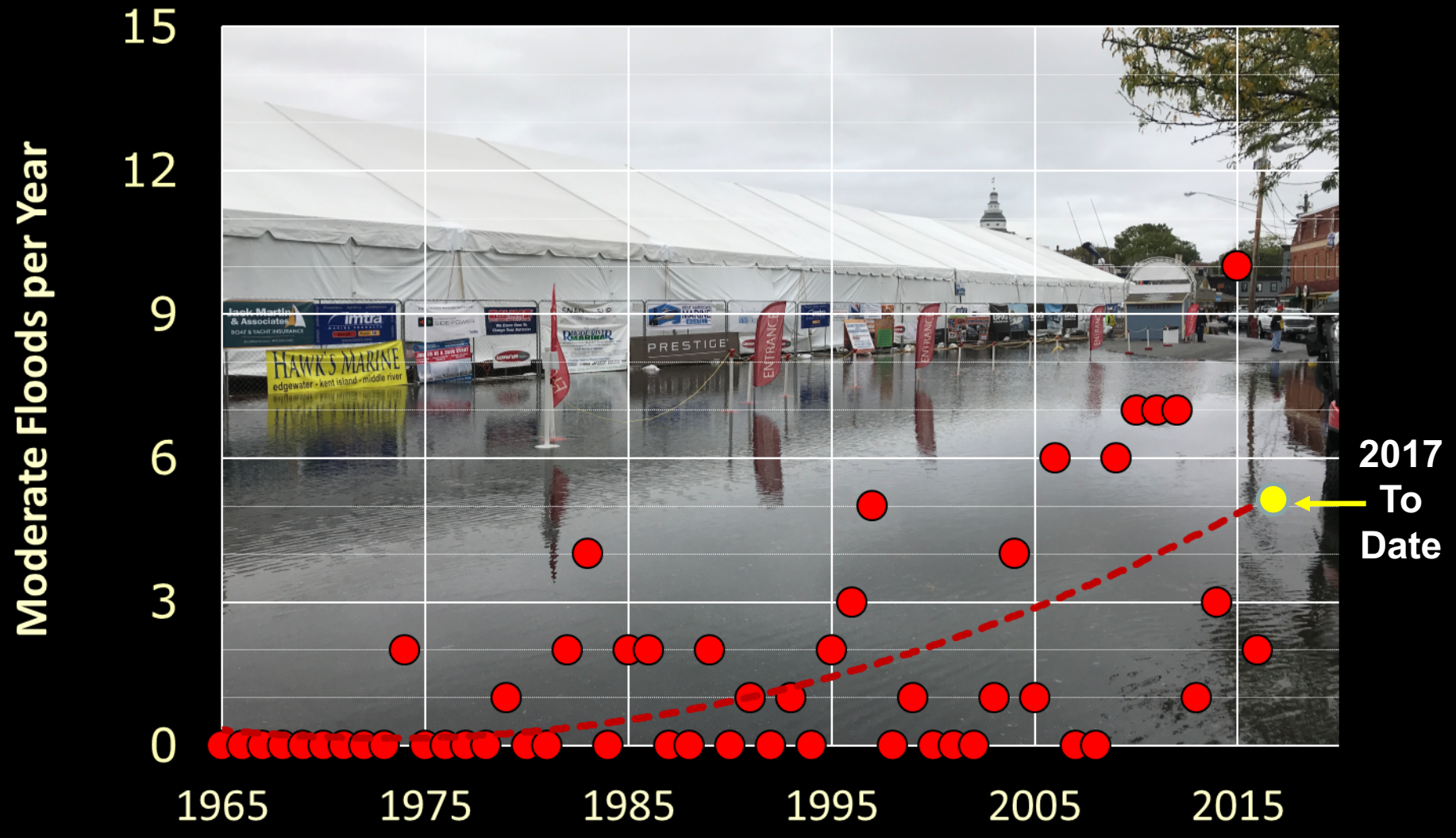
Tidal Flooding Trends: A Growing National Problem



Sweet et al. (2014):
Sea Level Rise and Nuisance Flood Frequency Changes around the U.S.

An Accelerating Trend of Tidal Flooding

Annapolis, MD: Moderate Floods per Year (year: May-April)

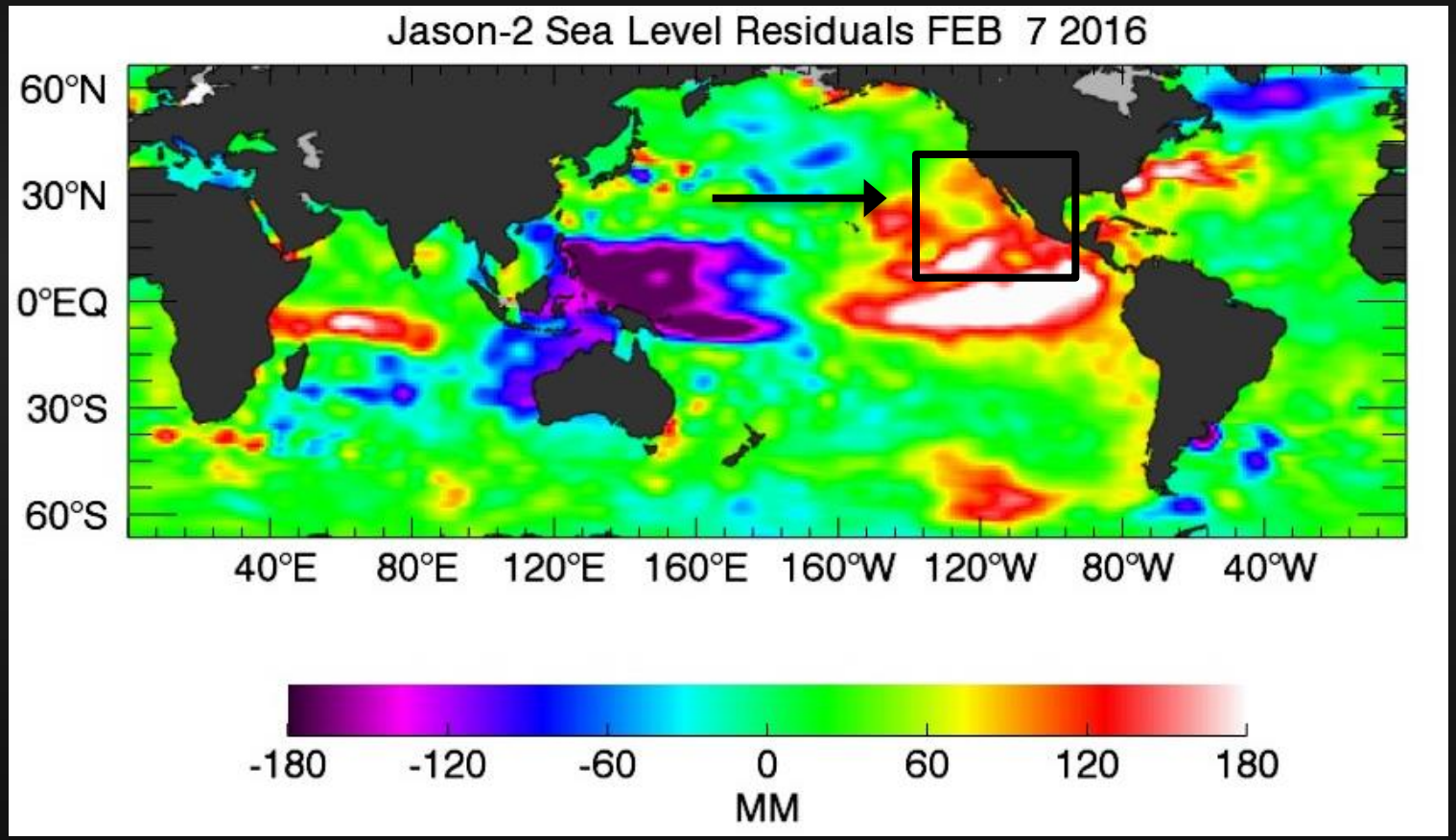


Sweet et al. (In Prep)

Bouncing about the Trend: Effects of El Nino

West Coast:

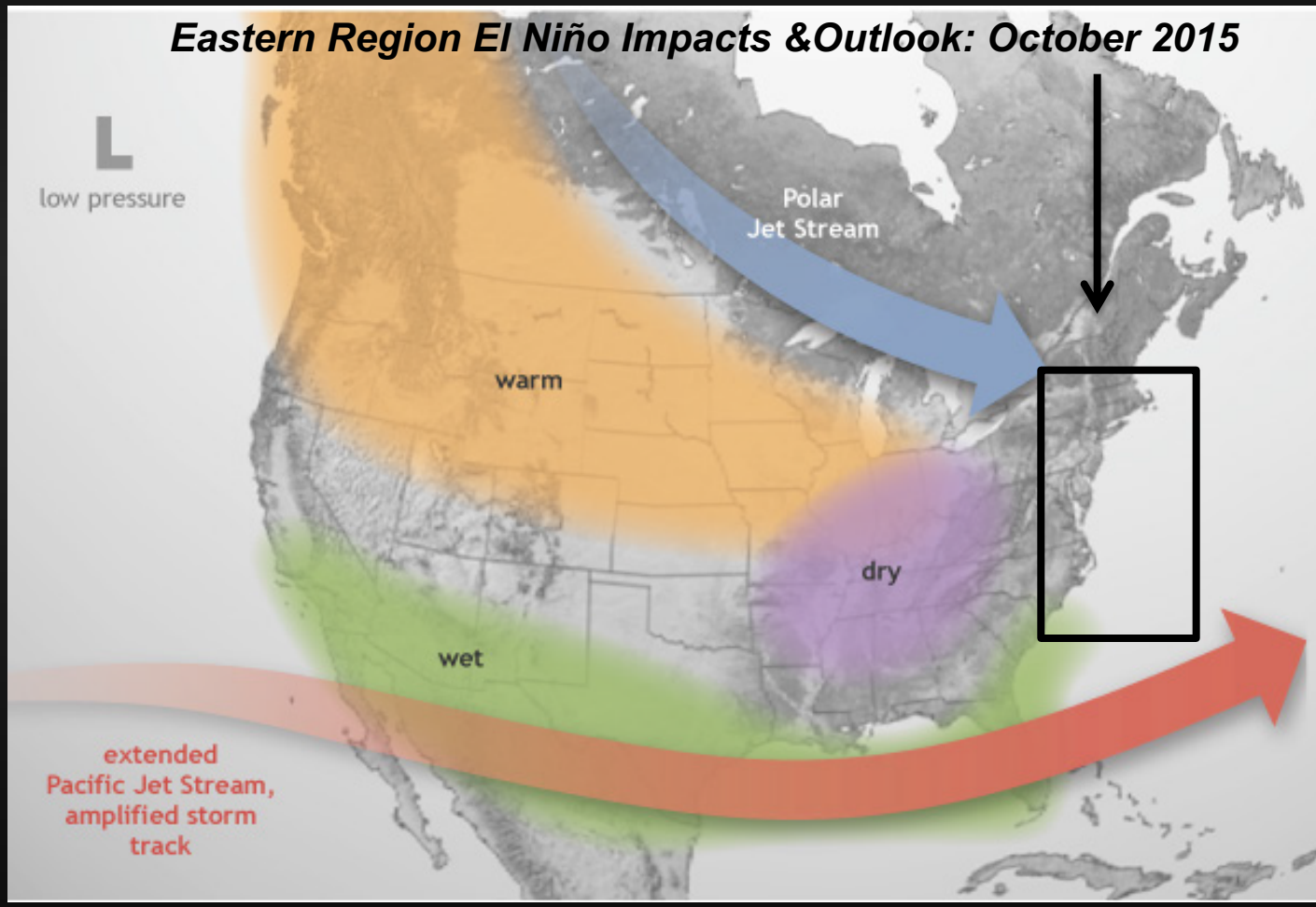
High ocean temperatures, sea levels for months increase the reach of (sometimes more) storms and tides



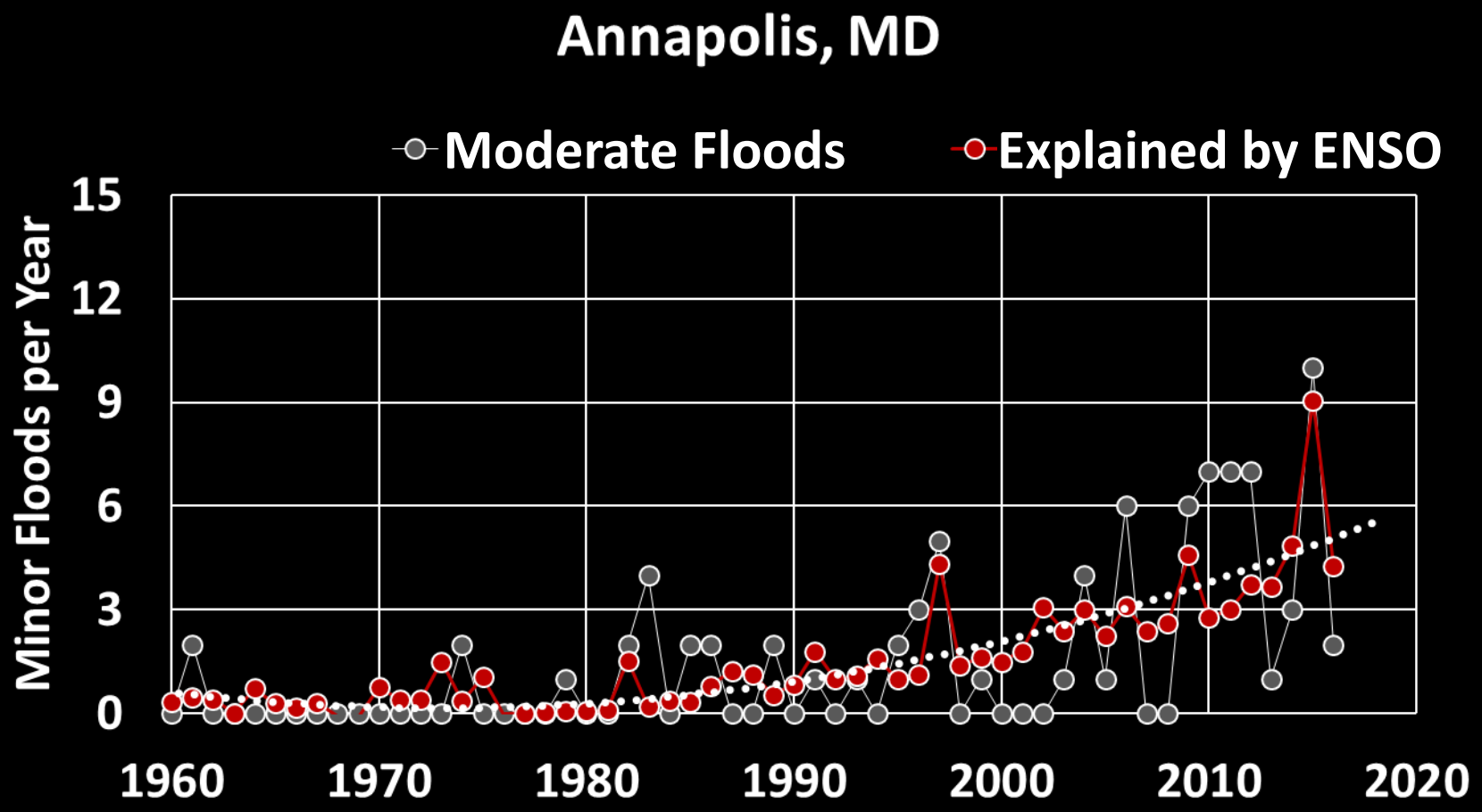
El Niño Pattern: More West & East Coast Tidal Flooding

East Coast:

More northerly wind forcing with more frequent storm surges and/or (quiet) anomalies



Moderate Flooding in Annapolis is Accelerating and further Compounded during El Nino



Sweet et al. (In Prep)

What Might the Future Look Like:
Future Rise Scenarios and their regional projections

NOAA Technical Report NOS CO-OPS 083

GLOBAL AND REGIONAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES

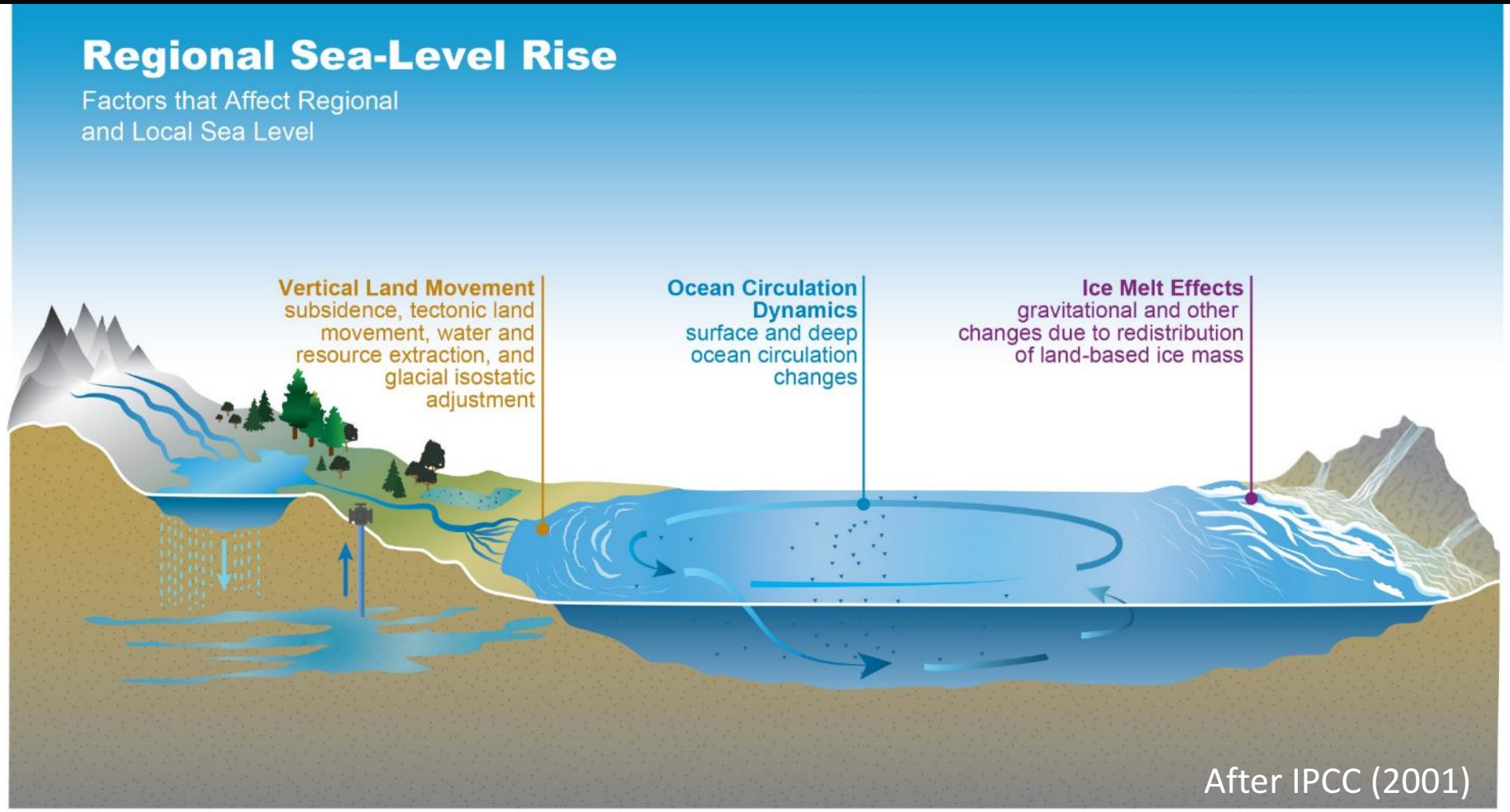
Photo: Ocean City, Maryland

Silver Spring, Maryland
January 2017

USGS science for a changing world

RUTGERS UNIVERSITY | NEW BRUNSWICK

Global - regional - local change



Future SLR_Annapolis

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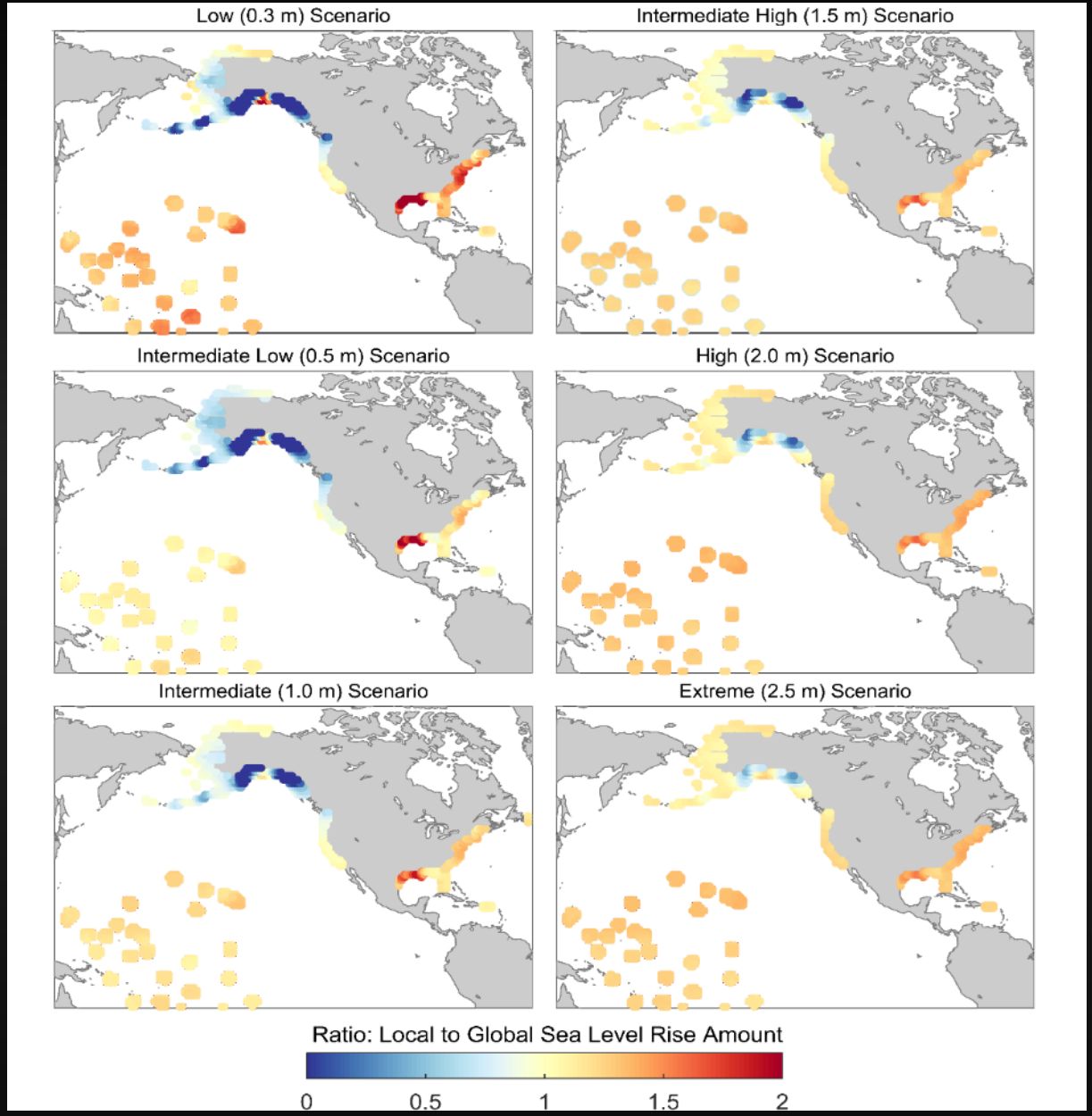
Global SLR scenario + changes (land elevation, circulation, Earth gravity/rotation)

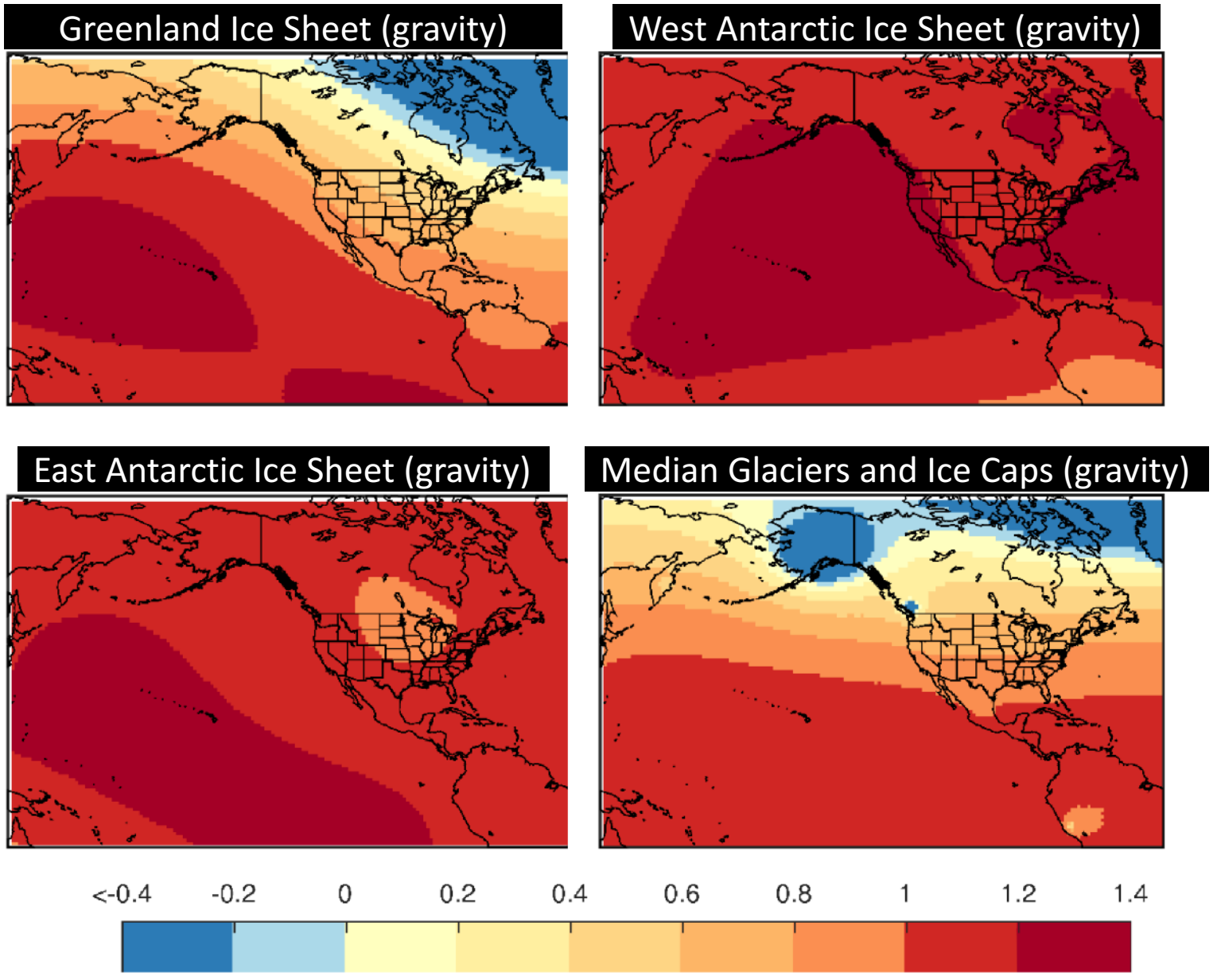
Total RSL change (1-degree grids) for 2100

(ratio: local to the GMSL rise amount for that scenario)



From
Sweet et al. (2017)

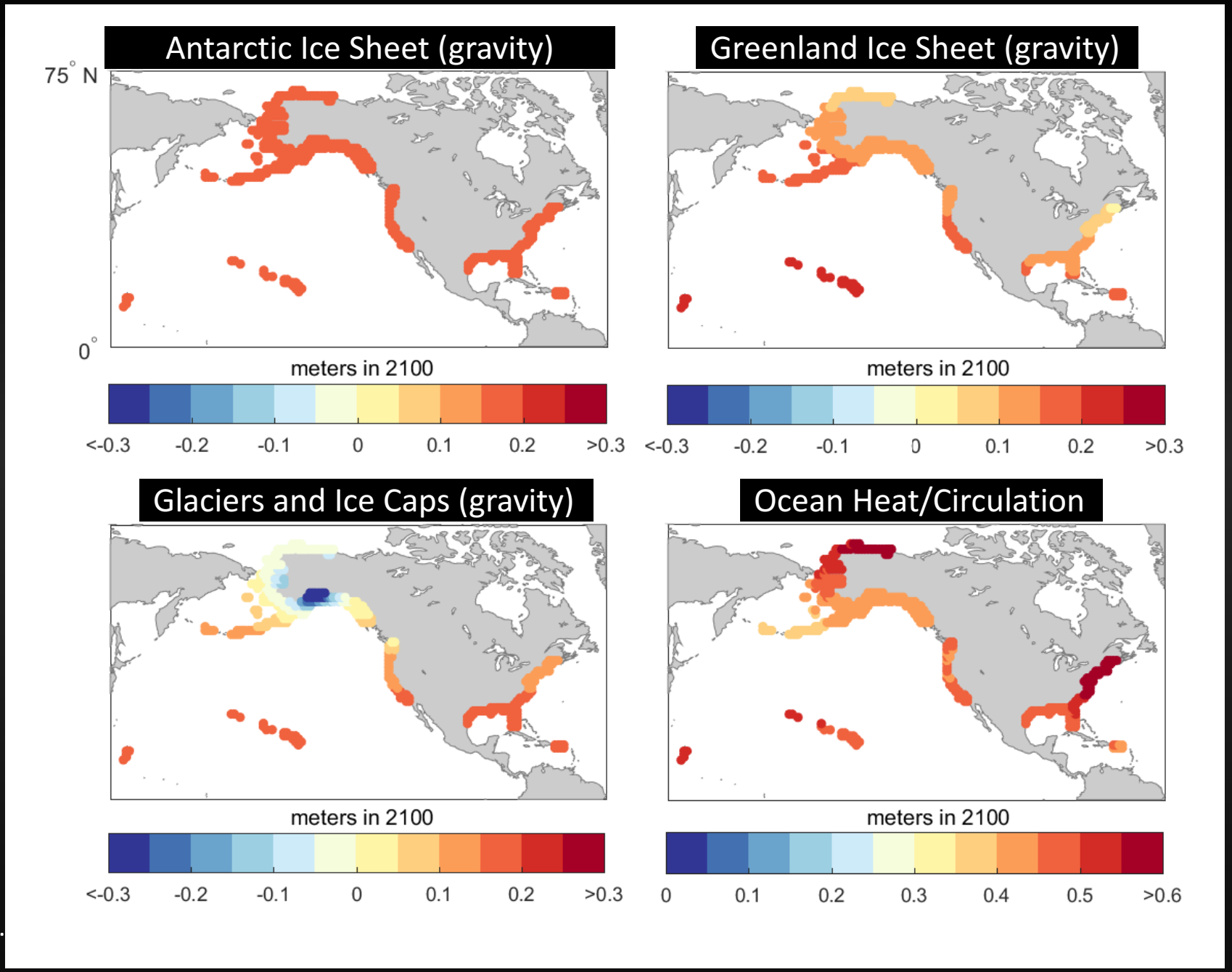
Regional SLR from changes in gravity/rotation



From Sweet et al. (2017)

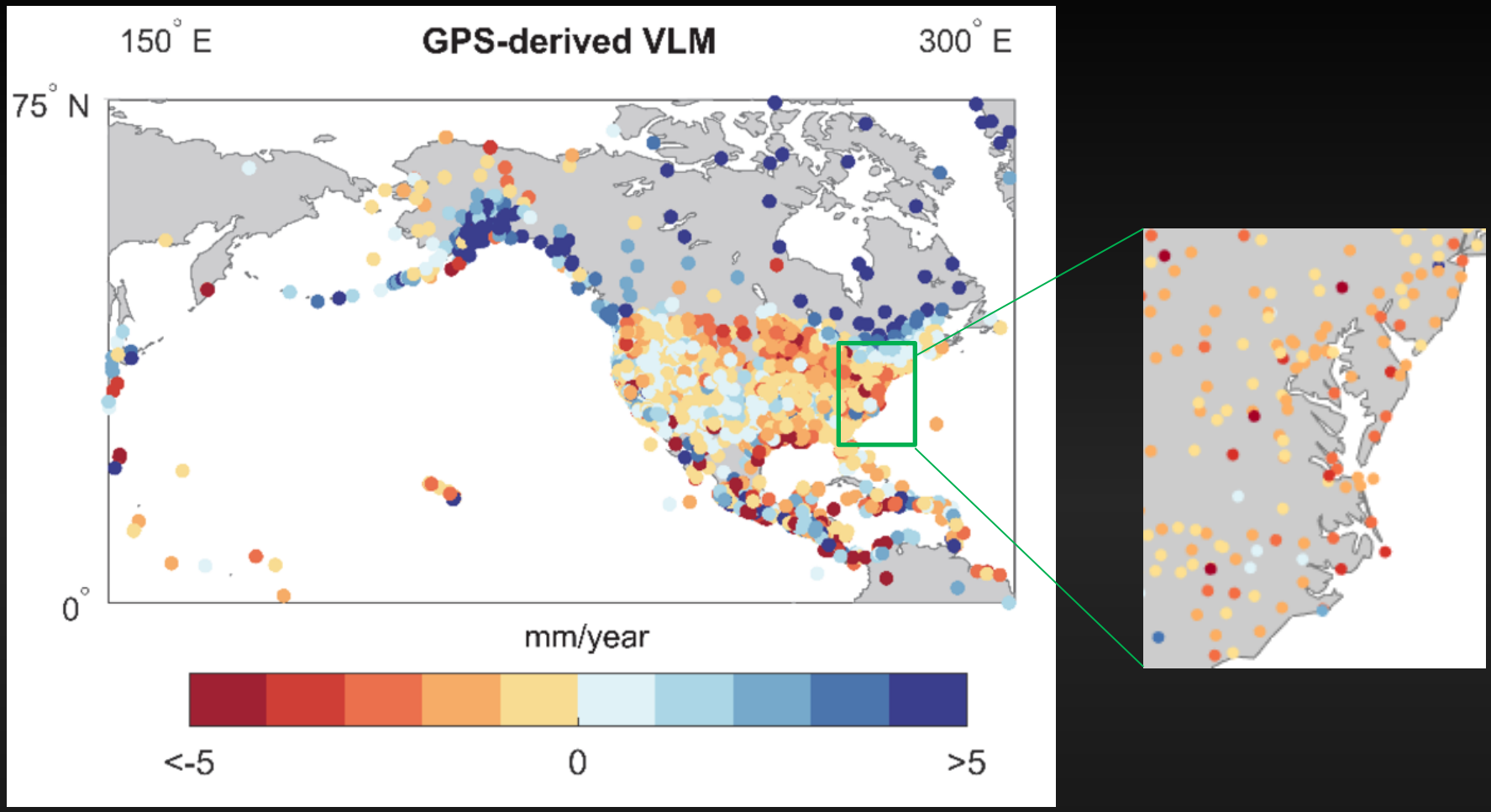
Ratio of regtional rise associated with global contribution (e.g., meters)

Components inherent to the Intermediate Scenario (1 m by 2100)



From Sweet et al. (2017)

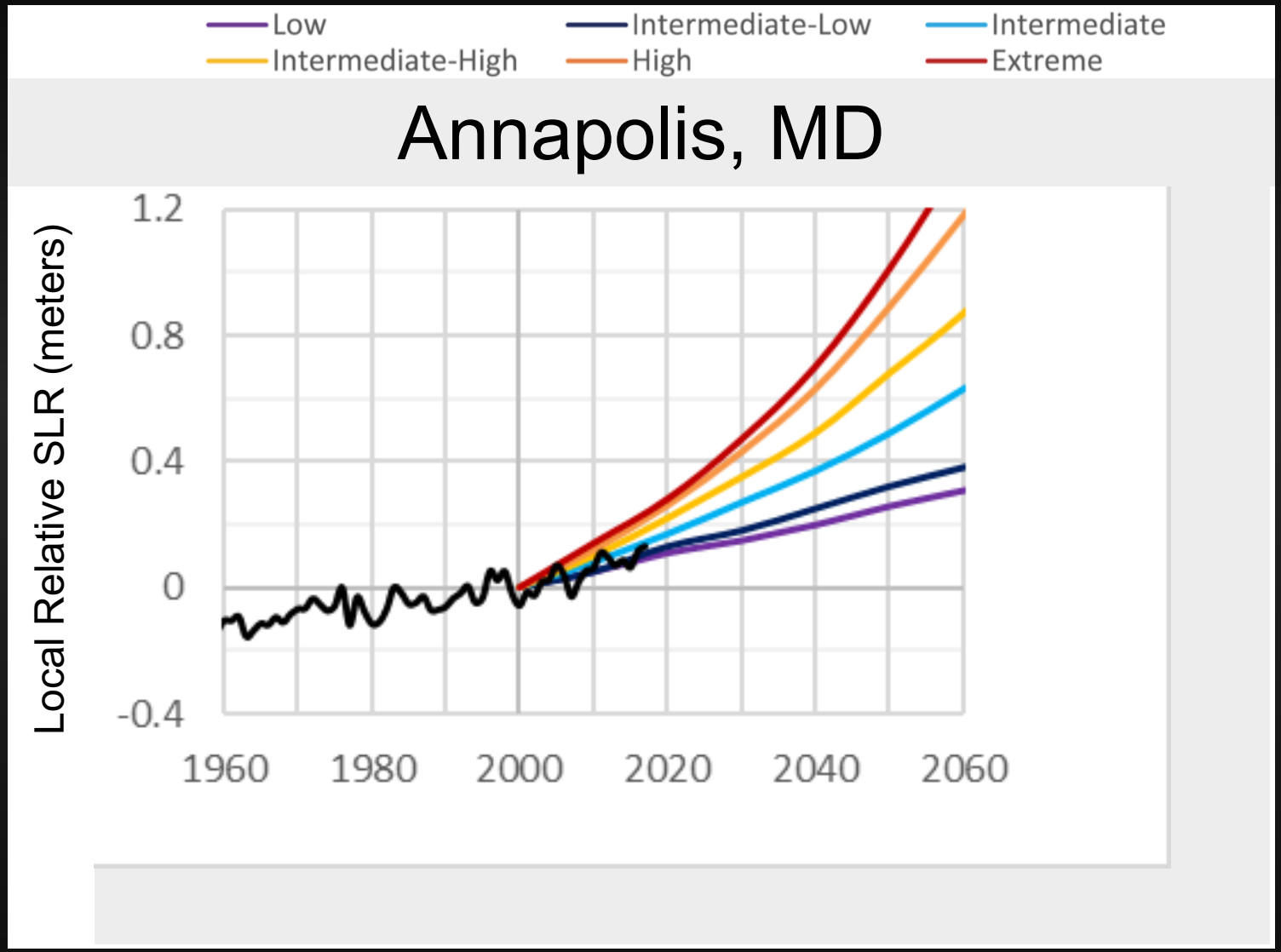
Vertical Land Motion



VLM trend estimates (mm/year) derived from GPS platforms

From Sweet et al. (2017)

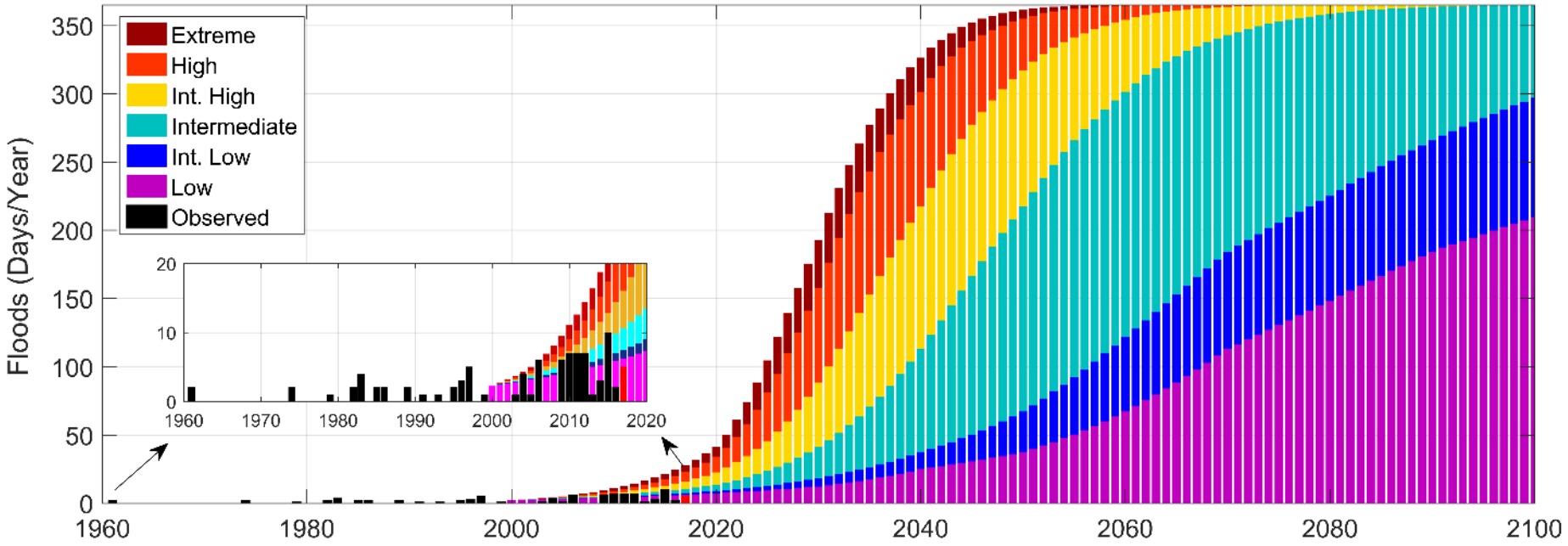
Future Trajectory of Sea Level and the Scenarios



From Sweet et al. (2017)

Future of High Tide Flooding w/ Moderate Impacts

High Tide Floods for Annapolis, MD based upon sea level rise futures of the U.S. Federal Interagency Sea Level Rise Taskforce
(about 1.75 feet above highest average tide)



Sweet et al., (In Prep)

Concluding Remarks

- Local SLR is likely to be about 25 to 40% greater than global average: subsidence, Gulf Stream slow-down, Antarctic ice loss (higher scenarios)

- Moderate (~damaging) flooding of about 30, 50 and 170 days per year by 2050 under the Low, Int. Low and Int. Scenarios

- By 2100, SLR in Annapolis and Bay Region of about **1.3 m (4.3 feet) under the Intermediate scenario** and **3.4 meters (11.2 feet) under the Extreme Scenario**.
  - **100-year event becomes close to average high tide**
  - **High Tide is about 1.6 m above Hurricane Isabel levels**

- Reducing emissions lessens future SLR. Low Scenario is likely inevitable…need to plan to live with higher seas: nature-based flood protection that promotes outside/bayside activities?

Questions?

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