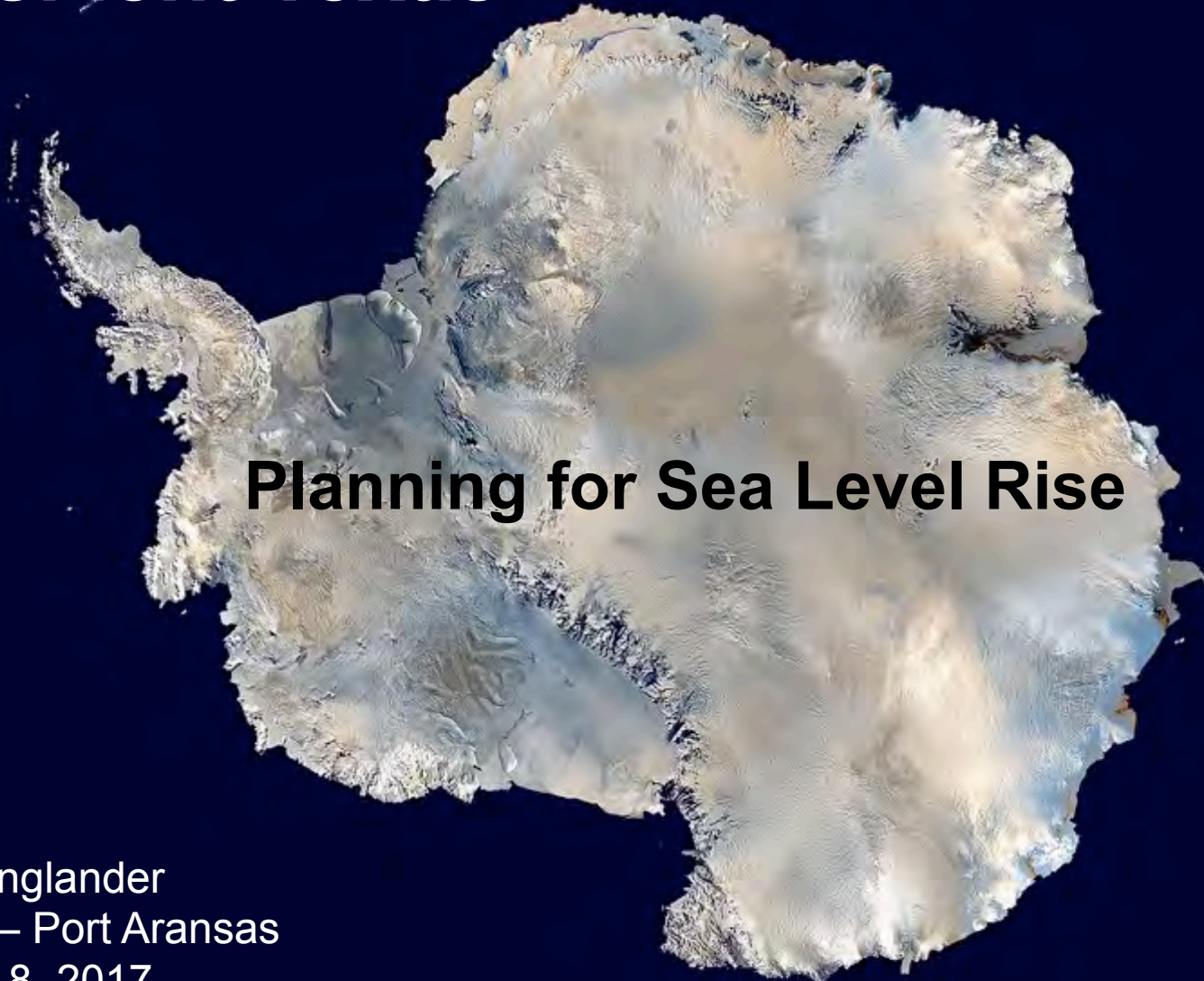


# Resilient Texas

## Planning for Sea Level Rise

John Englander  
UTMSI– Port Aransas  
August 8, 2017



Greenland =  
24 feet of SLR



Antarctica =  
186 feet of SLR



# **“Green” = 5 very different things**

- 1. Energy related: Reduction of GHG through renewables, conservation and lower carbon**
- 2. Reduced materials: recycling & waste reduction**
- 3. Ecological and animal related issues**
- 4. Effects of the warming, including changing weather patterns, diseases, heat, drought, ocean acidification**
- 5. Rising sea level**

# To cover

- Review the science of sea level globally
- How SLR intersects with the local issues
- Challenge to plan ahead and think bigger
- Questions

**Twitter: @johnenglander**

# Climate Change

```
graph TD; A[Energy Aspects: Carbon Emissions, GHG Reduction] --> B[Prepare for Broad Effects. e.g. Increased temperatures, Changing Weather patterns, More precipitation, Increased Fires, Ocean Acidification]; B --> C[Rising Sea Level: Can slow, but not stop, Quasi permanent, Move shorelines, Increases short term flooding];
```

Energy Aspects:  
Carbon Emissions  
GHG Reduction

Prepare for Broad Effects. e.g

- Increased temperatures
- Changing Weather patterns
- More precipitation
- Increased Fires
- Ocean Acidification

## Rising Sea Level

- Can slow, but not stop
- Quasi permanent
- Move shorelines
- Increases short term flooding

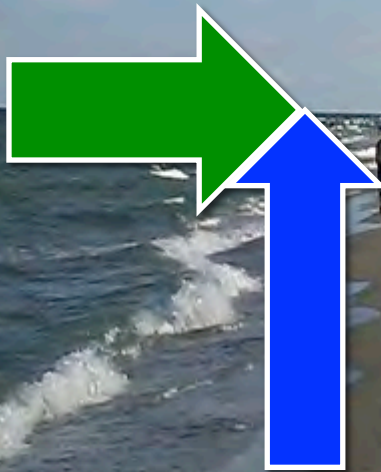
## Flooding due to:

- Rising Sea Level
- Storms – waves & surge
- Rainfall & Runoff
- Topographic forcing
- Extreme Tides
- Subsidence
- [Erosion]

## Different

- Drivers
- Predictability
- Magnitude
- Permanence
- Impact areas

Global average ratio is 300 feet of shoreline change for each foot of sea level rise



# Size matters



Antarctica and Greenland are covered by ice averaging more than a mile high







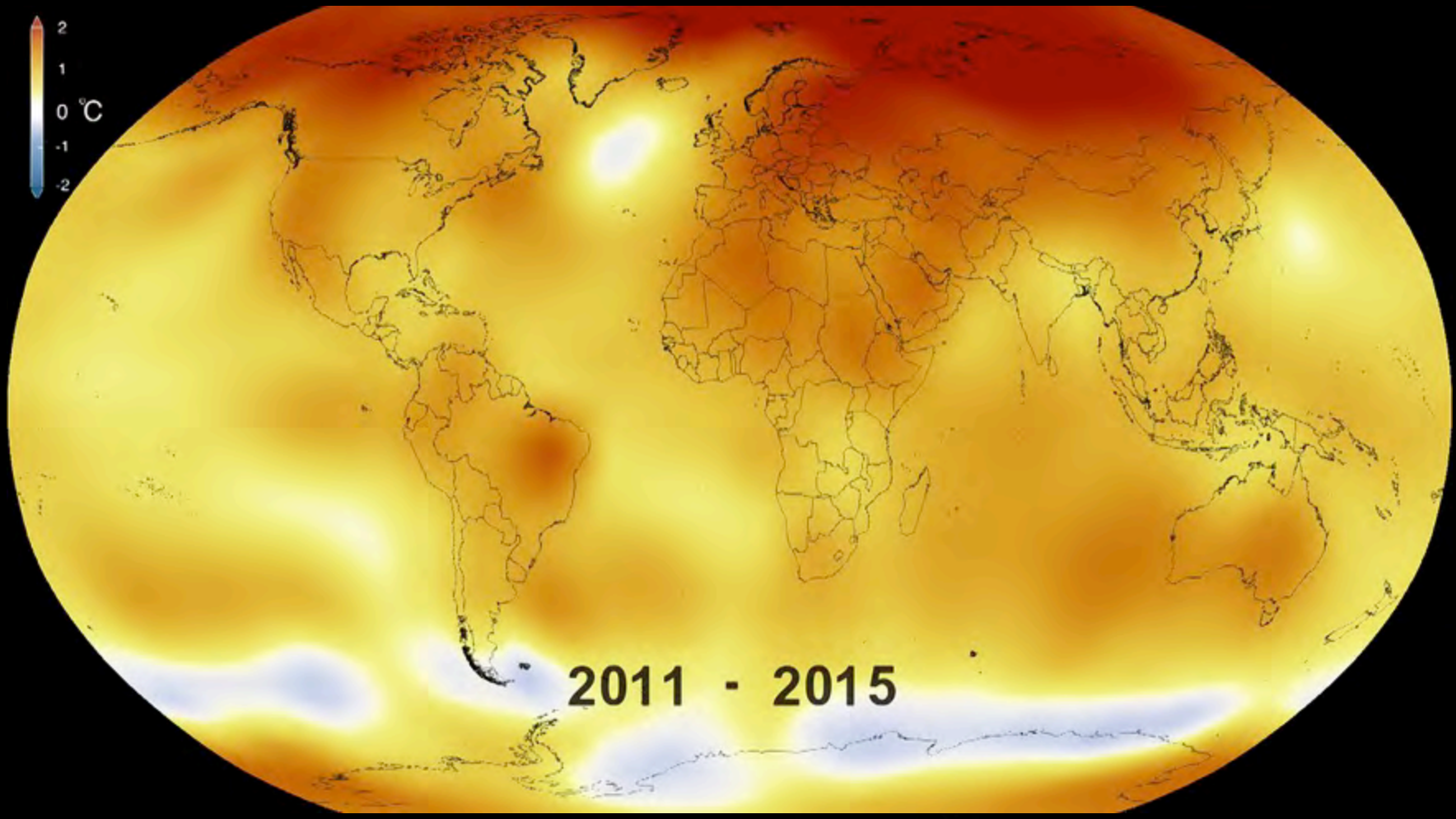


© Clemens Van der Werf

@johnenglander

# Earth is Warming, but Arctic is Warming Twice Global Average

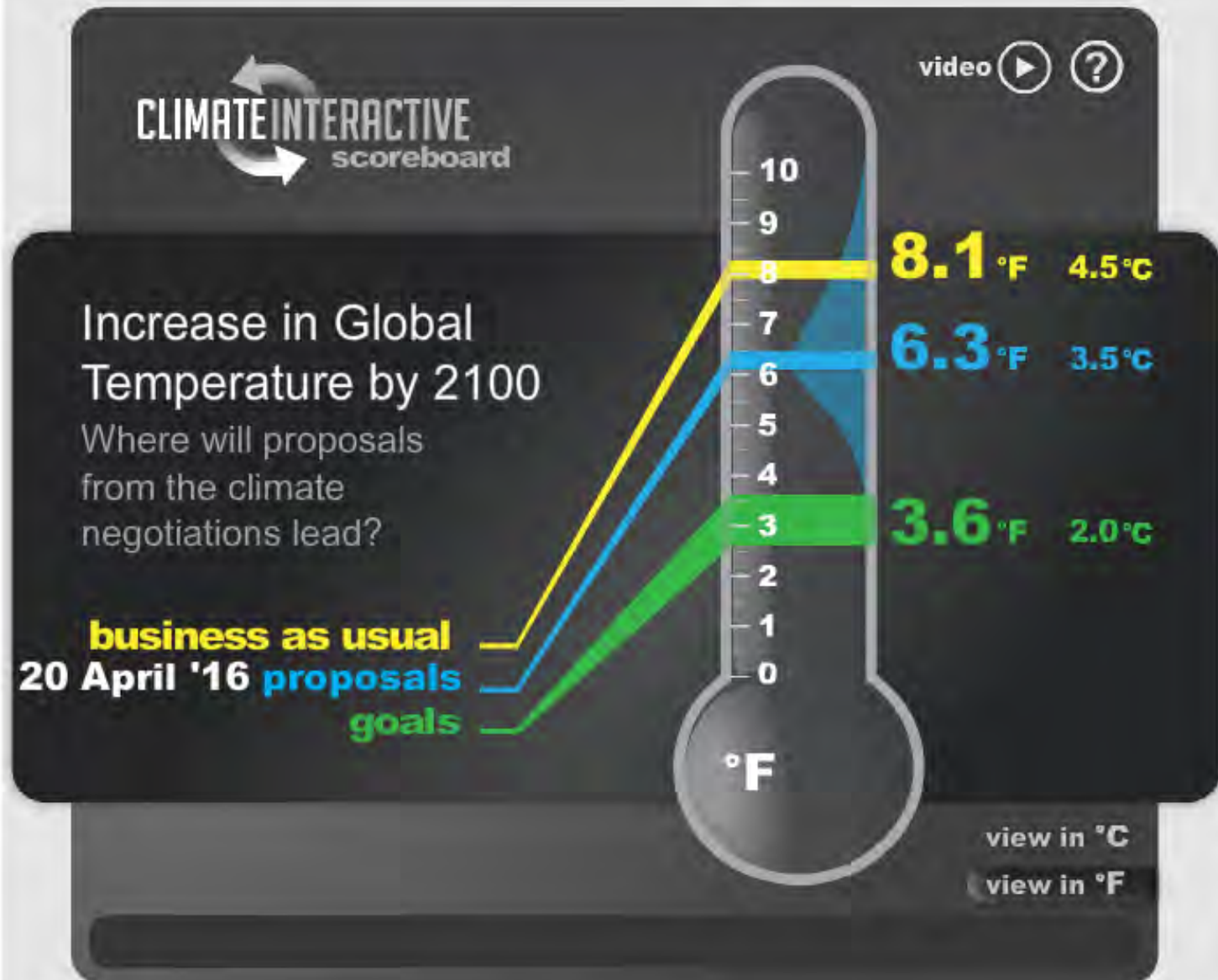
Observed Temperature Increase from 1880 to 2015

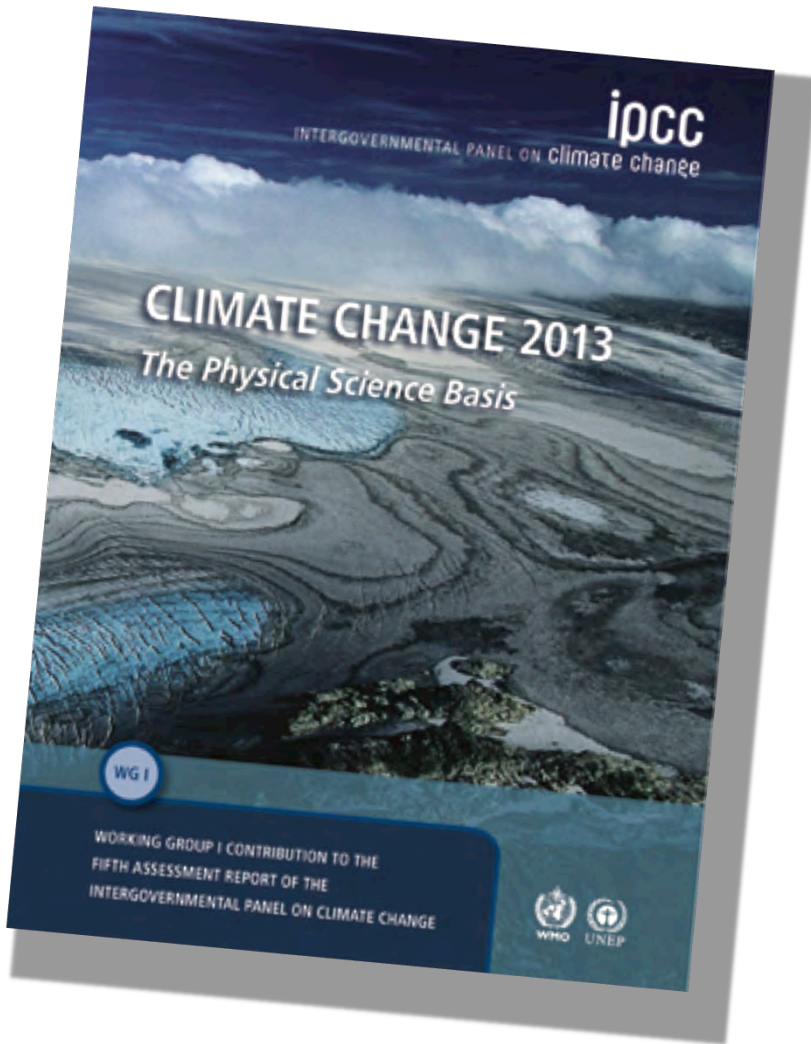


# UN Climate Pledge Analysis



COP21 • CMP11  
**PARIS 2015**  
UN CLIMATE CHANGE CONFERENCE





Most recent IPCC  
Projections (2013):

**“10 – 32 Inches of SLR by  
end of century”**

**But largely excludes  
“wild card” amplifiers:**

- **Antarctic glaciers**
- **Methane**

Actual Table below from the IPCC is shown just to establish authenticity. On the following slides, we group and present this data at simply stacked bar graphs to illustrate that the ice sheets and glaciers from Greenland and Antarctica are largely under-represented in the current projections, though they do acknowledge the “uncertainty” essentially as footnotes (MISI – marine ice sheet instability)

**Table 13.5** | Median values and *likely* ranges for projections of global mean sea level (GMSL) rise and its contributions in metres in 2081–2100 relative to 1986–2005 for the four RCP scenarios and SRES A1B, GMSL rise in 2046–2065 and 2100, and rates of GMSL rise in mm yr<sup>-1</sup> in 2081–2100. See Section 13.5.1 concerning how the *likely* range is defined. Because some of the uncertainties in modelling the contributions are treated as uncorrelated, the sum of the lower bound of contributions does not equal the lower bound of the sum, and similarly for the upper bound (see Supplementary Material). Because of imprecision from rounding, the sum of the medians of contributions may not exactly equal the median of the sum. The net contribution (surface mass balance (SMB) + dynamics) for each ice sheet, and the contribution from rapid dynamical change in both ice sheets together, are shown as additional lines below the sum; they are not contributions in addition to those given above the sum. The contributions from ice-sheet rapid dynamical change and anthropogenic land water storage are treated as having uniform probability distributions, uncorrelated with the magnitude of global climate change (except for the interaction between Antarctic ice sheet SMB and outflow), and as independent of scenario (except that a higher rate of change is used for Greenland ice sheet outflow under RCP8.5). This treatment does not imply that the contributions concerned will not depend on the scenario followed, only that the current state of knowledge does not permit a quantitative assessment of the dependence. Regional sea level change is expected in general to differ from the global mean (see Section 13.6).

	SRES A1B	RCP2.6	RCP4.5	RCP6.0	RCP8.5
Thermal expansion	0.21 [0.16 to 0.26]	0.14 [0.10 to 0.18]	0.19 [0.14 to 0.23]	0.19 [0.15 to 0.24]	0.27 [0.21 to 0.33]
Glaciers*	0.14 [0.08 to 0.21]	0.10 [0.04 to 0.16]	0.12 [0.06 to 0.19]	0.12 [0.06 to 0.19]	0.16 [0.09 to 0.23]
Greenland ice-sheet SMB <sup>b</sup>	0.05 [0.02 to 0.12]	0.03 [0.01 to 0.07]	0.04 [0.01 to 0.09]	0.04 [0.01 to 0.09]	0.07 [0.03 to 0.16]
Antarctic ice-sheet SMB <sup>c</sup>	-0.03 [-0.06 to -0.01]	-0.02 [-0.04 to -0.00]	-0.02 [-0.05 to -0.01]	-0.02 [-0.05 to -0.01]	-0.04 [-0.07 to -0.01]
Greenland ice-sheet rapid dynamics	0.04 [0.01 to 0.06]	0.04 [0.01 to 0.06]	0.04 [0.01 to 0.06]	0.04 [0.01 to 0.06]	0.05 [0.02 to 0.07]
Antarctic ice-sheet rapid dynamics	0.07 [-0.01 to 0.16]	0.07 [-0.01 to 0.16]	0.07 [-0.01 to 0.16]	0.07 [-0.01 to 0.16]	0.07 [-0.01 to 0.16]
Land water storage	0.04 [-0.01 to 0.09]	0.04 [-0.01 to 0.09]	0.04 [-0.01 to 0.09]	0.04 [-0.01 to 0.09]	0.04 [-0.01 to 0.09]
Global mean sea level rise in 2081–2100	0.52 [0.37 to 0.69]	0.40 [0.26 to 0.55]	0.47 [0.32 to 0.63]	0.48 [0.33 to 0.63]	0.63 [0.45 to 0.82]
Greenland ice sheet	0.09 [0.05 to 0.15]	0.06 [0.04 to 0.10]	0.08 [0.04 to 0.13]	0.08 [0.04 to 0.13]	0.12 [0.07 to 0.21]
Antarctic ice sheet	0.04 [-0.05 to 0.13]	0.05 [-0.03 to 0.14]	0.05 [-0.04 to 0.13]	0.05 [-0.04 to 0.13]	0.04 [-0.06 to 0.12]
Ice-sheet rapid dynamics	0.10 [0.03 to 0.19]	0.10 [0.03 to 0.19]	0.10 [0.03 to 0.19]	0.10 [0.03 to 0.19]	0.12 [0.03 to 0.20]
Rate of global mean sea level rise	8.1 [5.1 to 11.4]	4.4 [2.0 to 6.8]	6.1 [3.5 to 8.8]	7.4 [4.7 to 10.3]	11.2 [7.5 to 15.7]
Global mean sea level rise in 2046–2065	0.27 [0.19 to 0.34]	0.24 [0.17 to 0.32]	0.26 [0.19 to 0.33]	0.25 [0.18 to 0.32]	0.30 [0.22 to 0.38]
Global mean sea level rise in 2100	0.60 [0.42 to 0.80]	0.44 [0.28 to 0.61]	0.53 [0.36 to 0.71]	0.55 [0.38 to 0.73]	0.74 [0.52 to 0.98]

Only the collapse of the marine-based sectors of the Antarctic ice sheet, if initiated, could cause GMSL to rise substantially above the *likely* range during the 21st century. This potential additional contribution cannot be precisely quantified but there is *medium confidence* that it would not exceed several tenths of a meter of sea level rise.

# Sea Level Rise median values in inches 2081-2100

relative to 1986-2005 per IPCC AR5 Table 13-5





# Global Sea Level Rise Scenarios for the United States National Climate Assessment

December 6, 2012

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 (6.6 feet) by 2100.



US Army Corps of Engineers.

NOAA Technical Report NOS CO-OPS 083

# GLOBAL AND REGIONAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES



Silver Spring, Maryland  
January 2017

*Photo: Ocean City, Maryland*



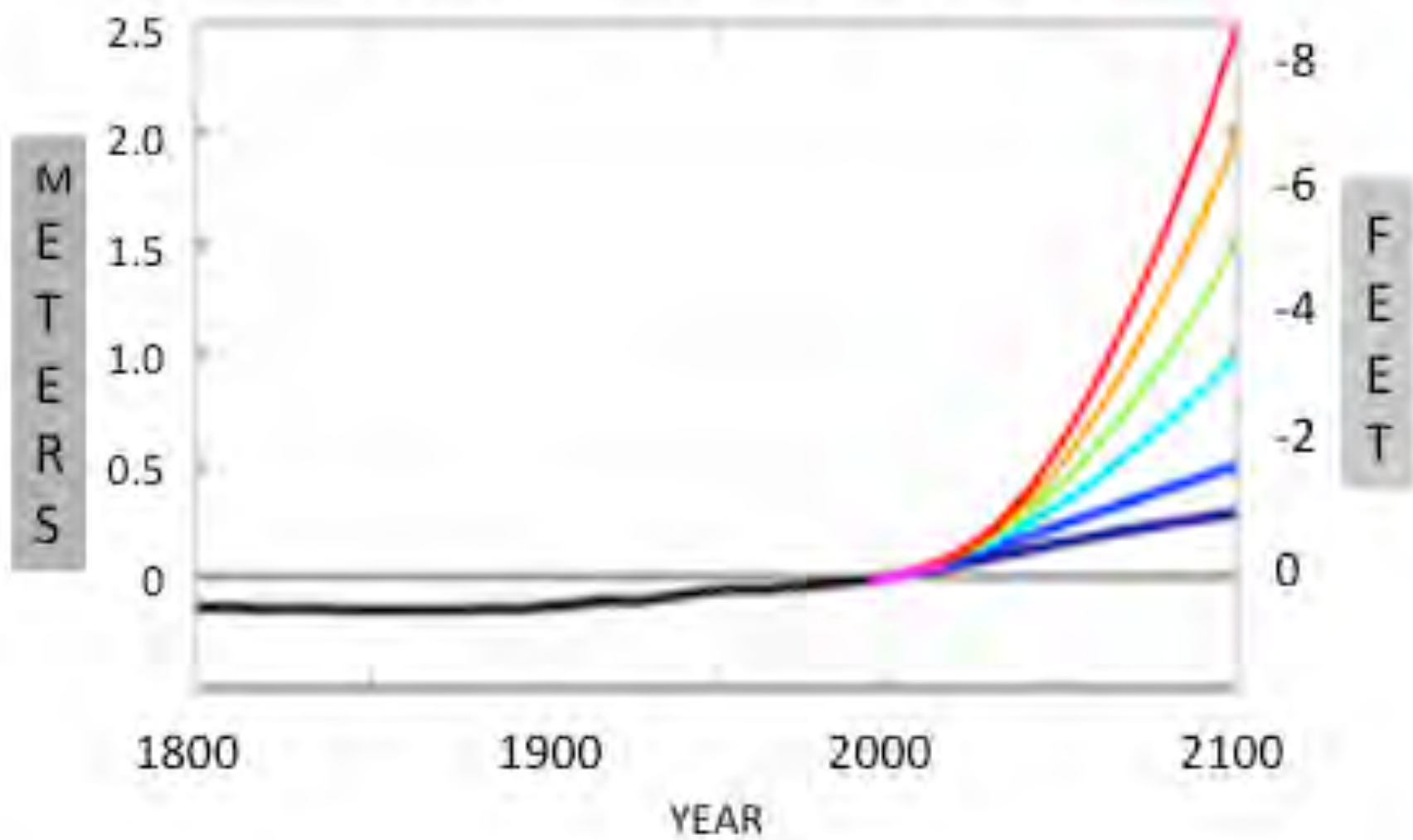
**noaa**

National Oceanic and Atmospheric Administration  
U.S. DEPARTMENT OF COMMERCE  
National Ocean Service

Center for Operational Oceanographic Products and Services

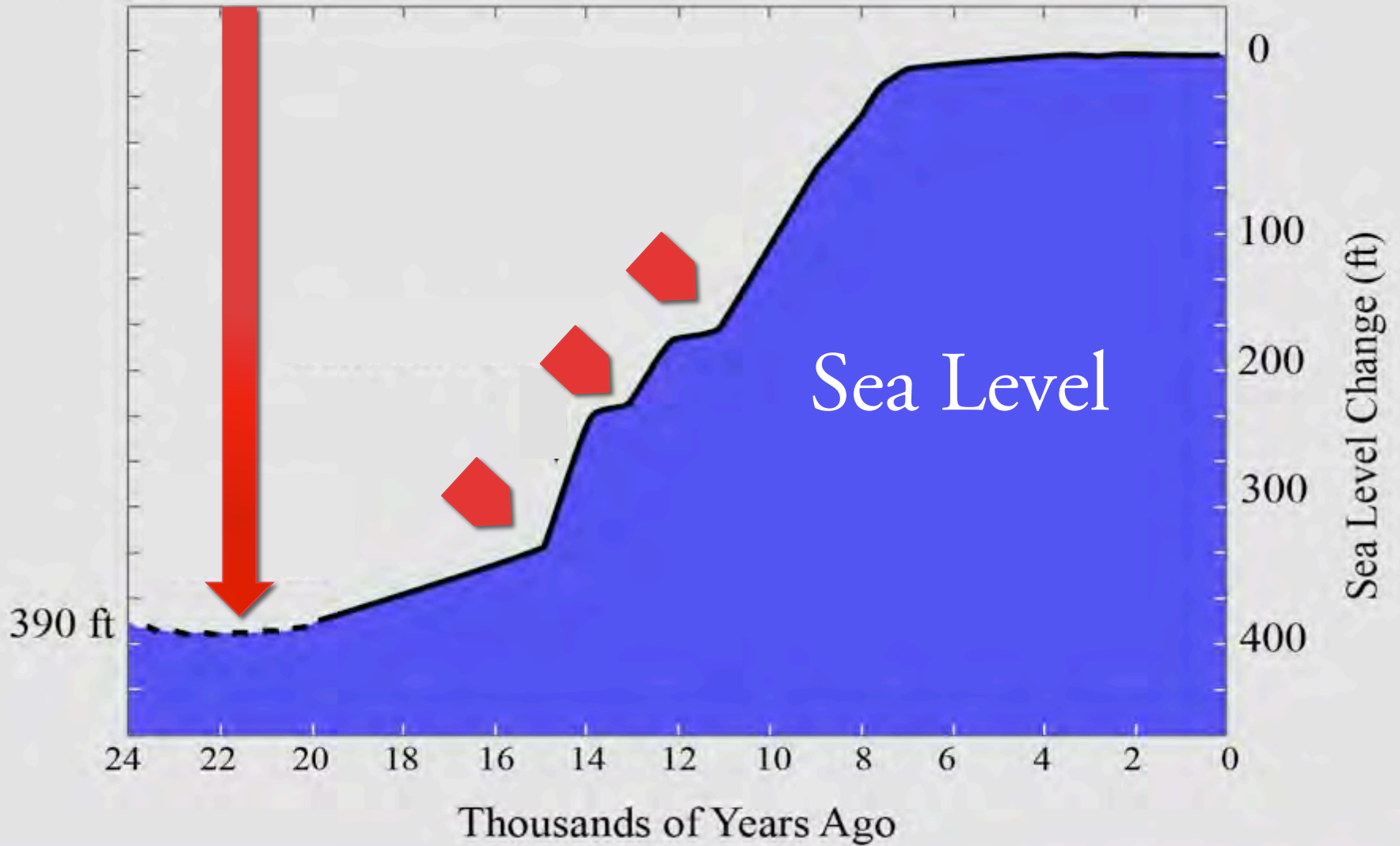
January 19, 2017  
Latest US Government  
Report about sea level  
Rise scenarios

## Six Projections for Rising Sea Level 2017 NOAA Technical Paper 083



20,000 Years Ago

Last Ice Age

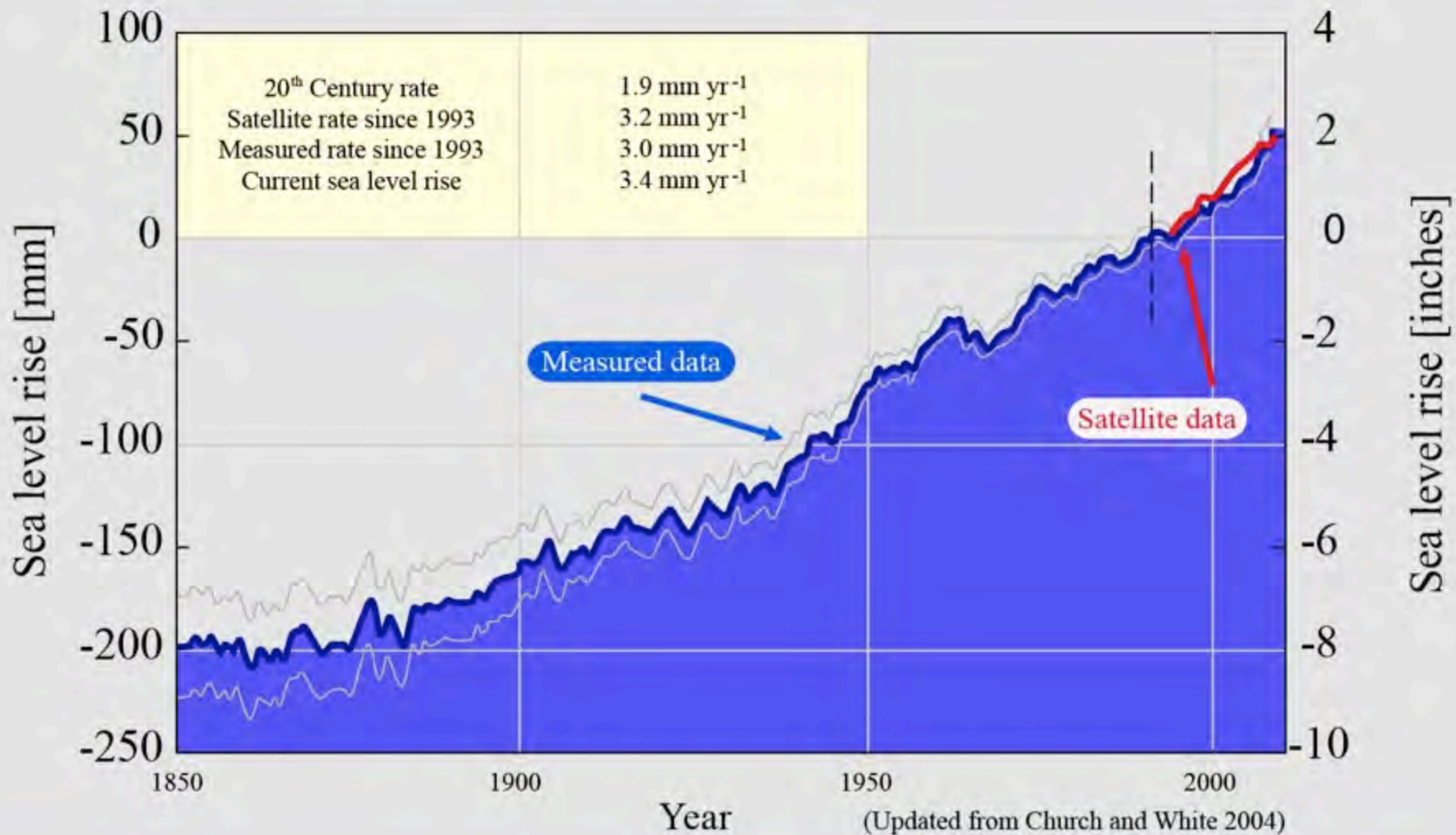


@johnenglander



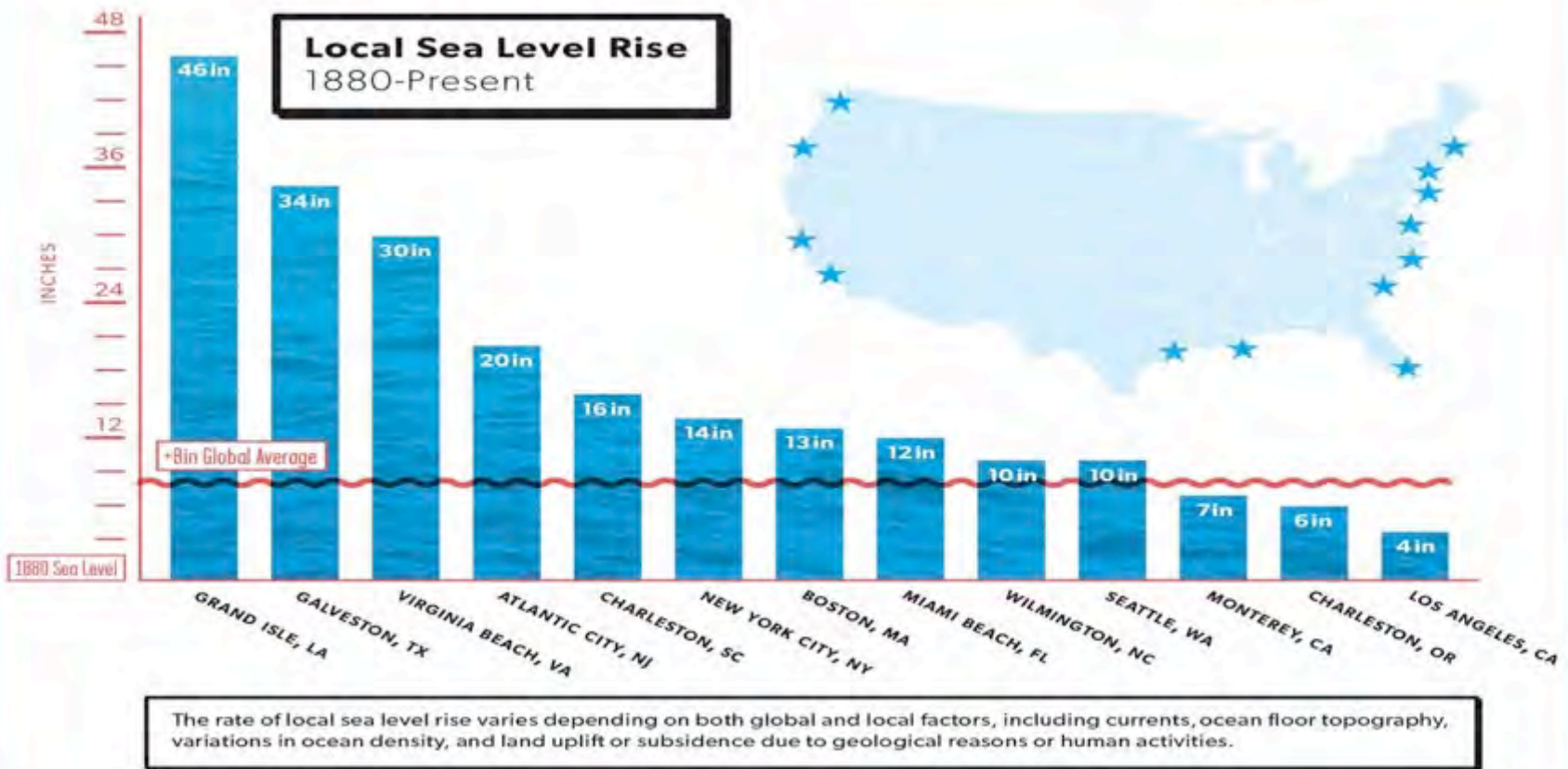
**ICE  
AGE**  
THE MELTDOWN

# Sea Level Rise: 20<sup>th</sup> Century

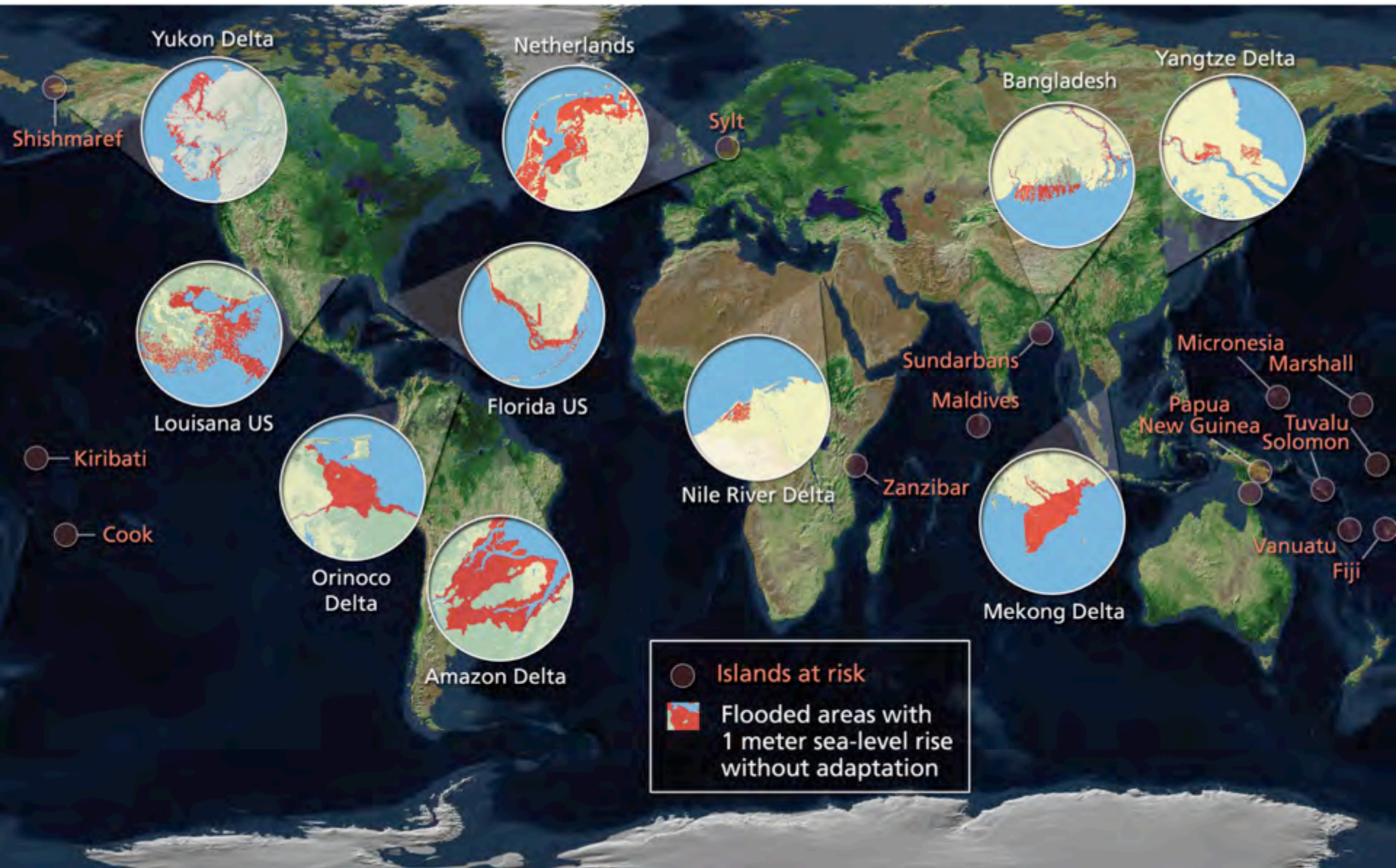


# Sea level rise varies greatly by location.

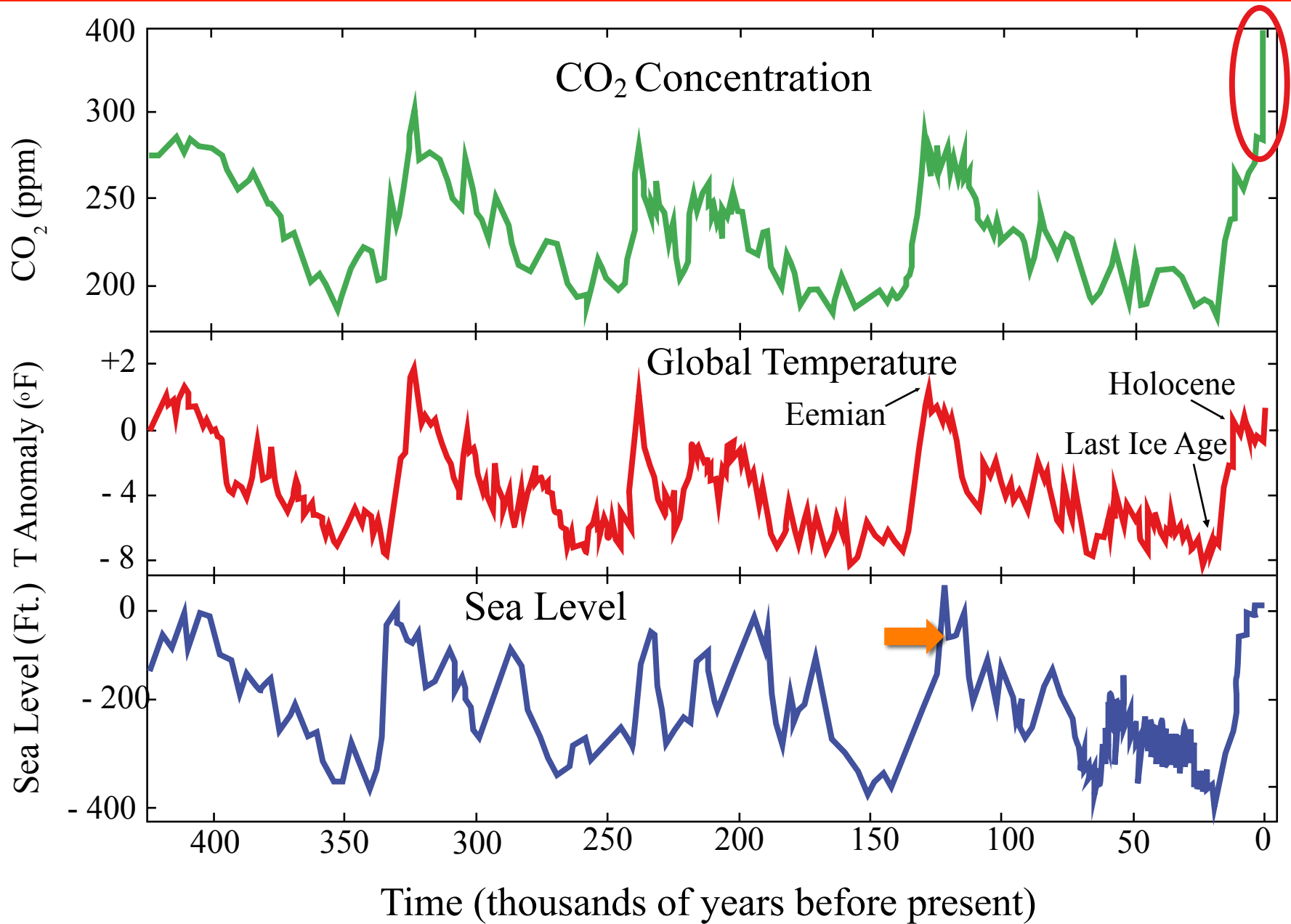
Global average sea level has increased 8 inches since 1880. Sea levels along the U.S. East Coast and Gulf of Mexico are rising **much faster**.



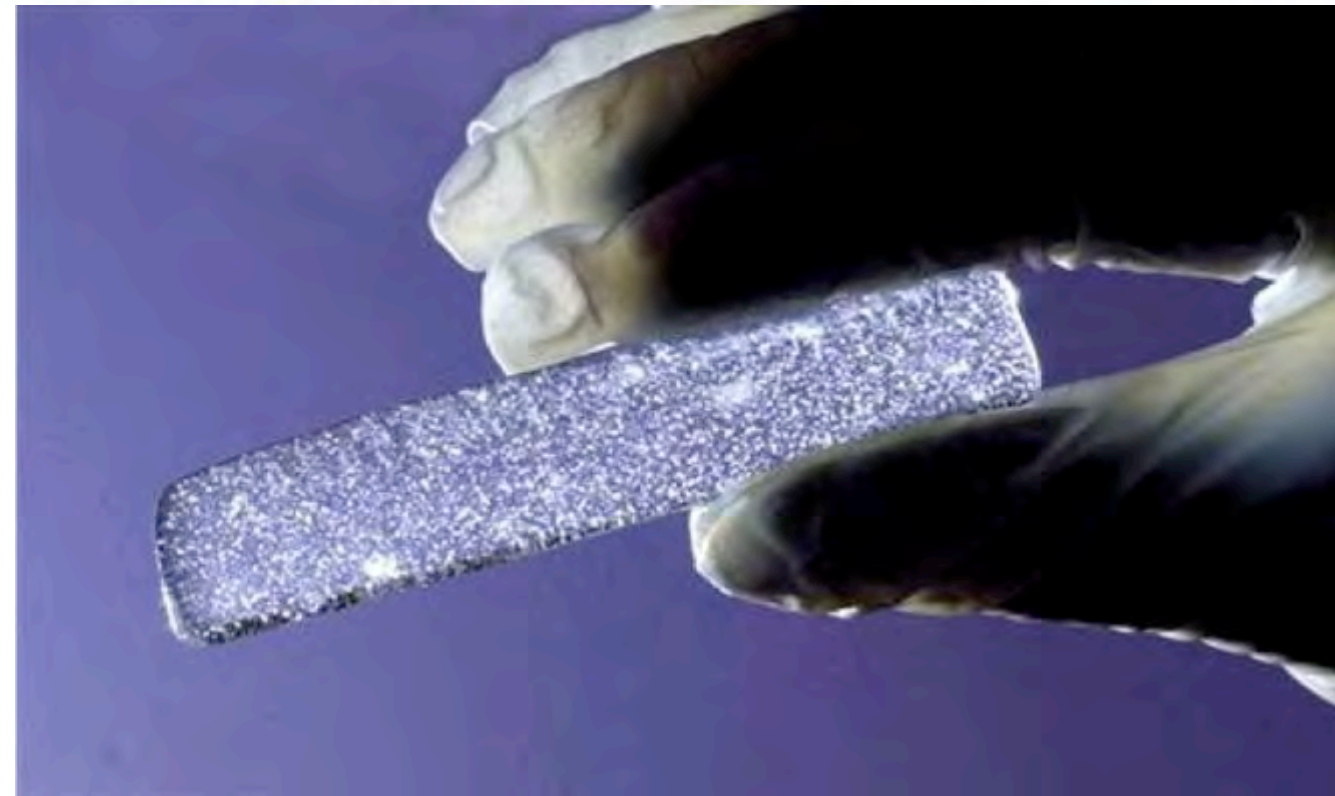
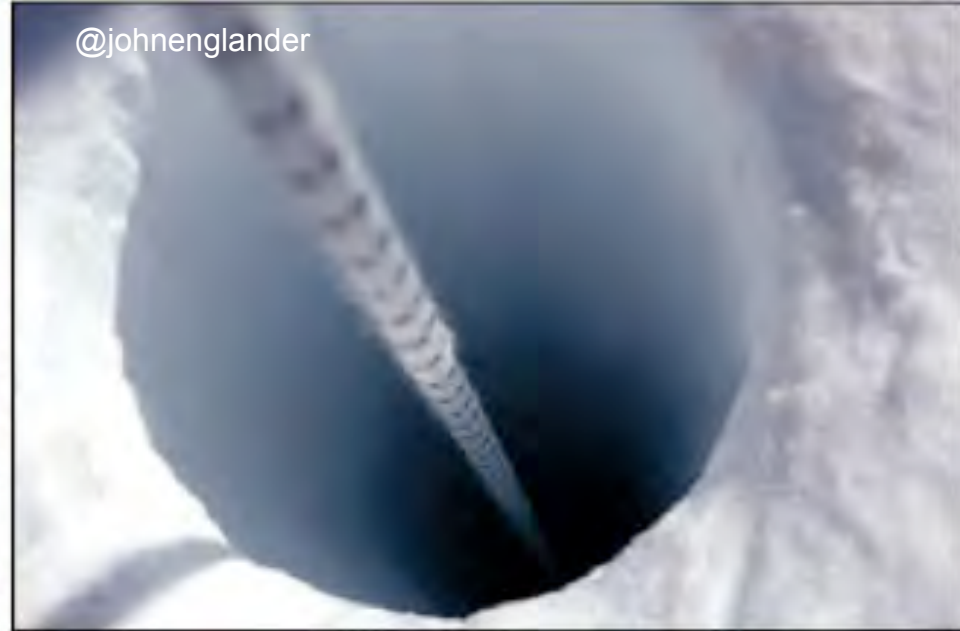
# 1 meter SLR = different impacts in different places

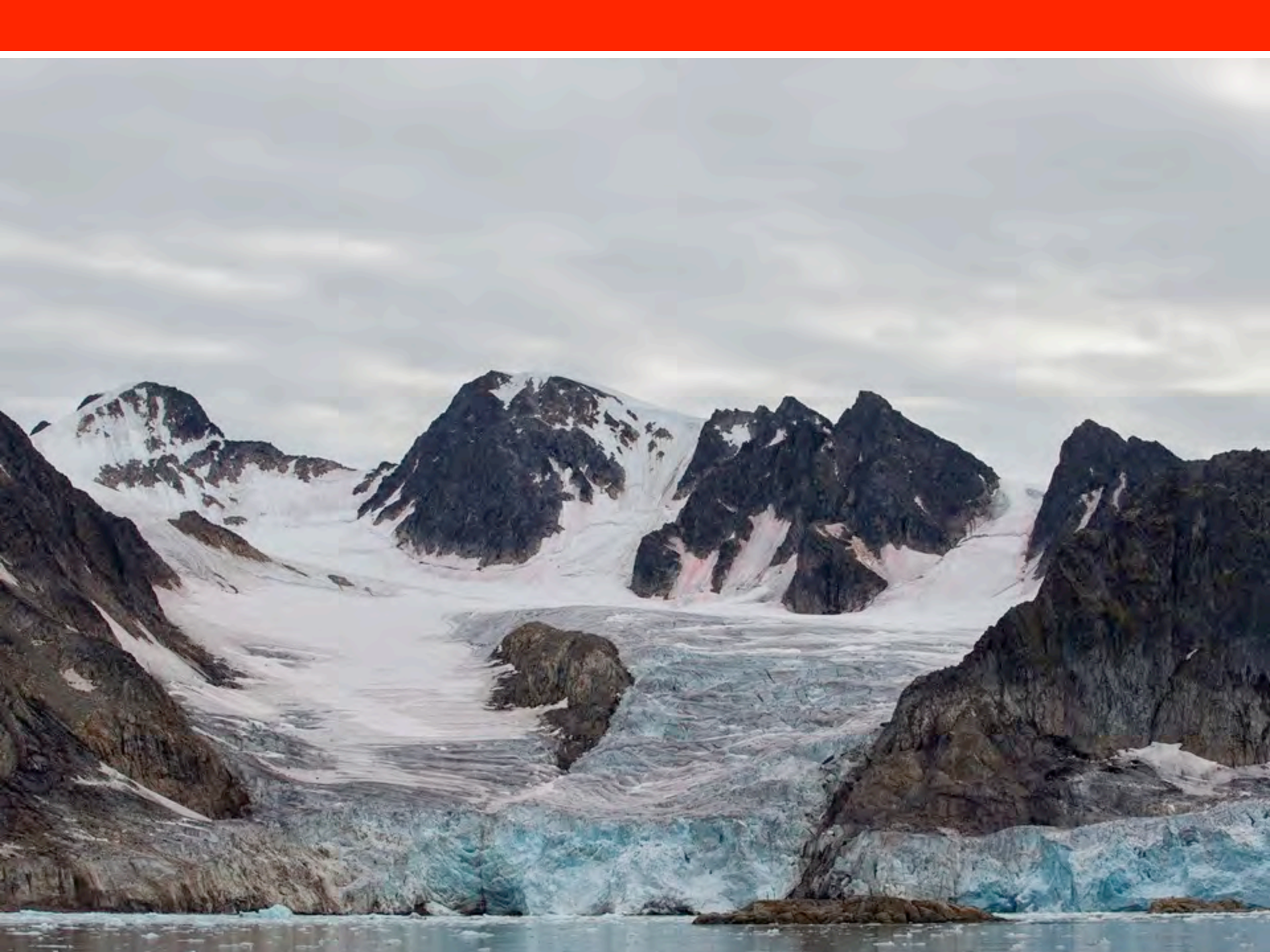






Adapted from Hansen & Sato





Greenland =  
24 feet of SLR



Antarctica =  
186 feet of SLR



# Melting of Greenland Ice Sheet Much More Advanced than Antarctica







Glacier Watching Day 17

From "Chasing Ice" movie showing massive glacier collapse 4:41 seconds  
NOTE: If video link fails, go to <http://youtu.be/hC3VTgIPoGU>

Jacobshavn Glacier, Greenland 5-28-08

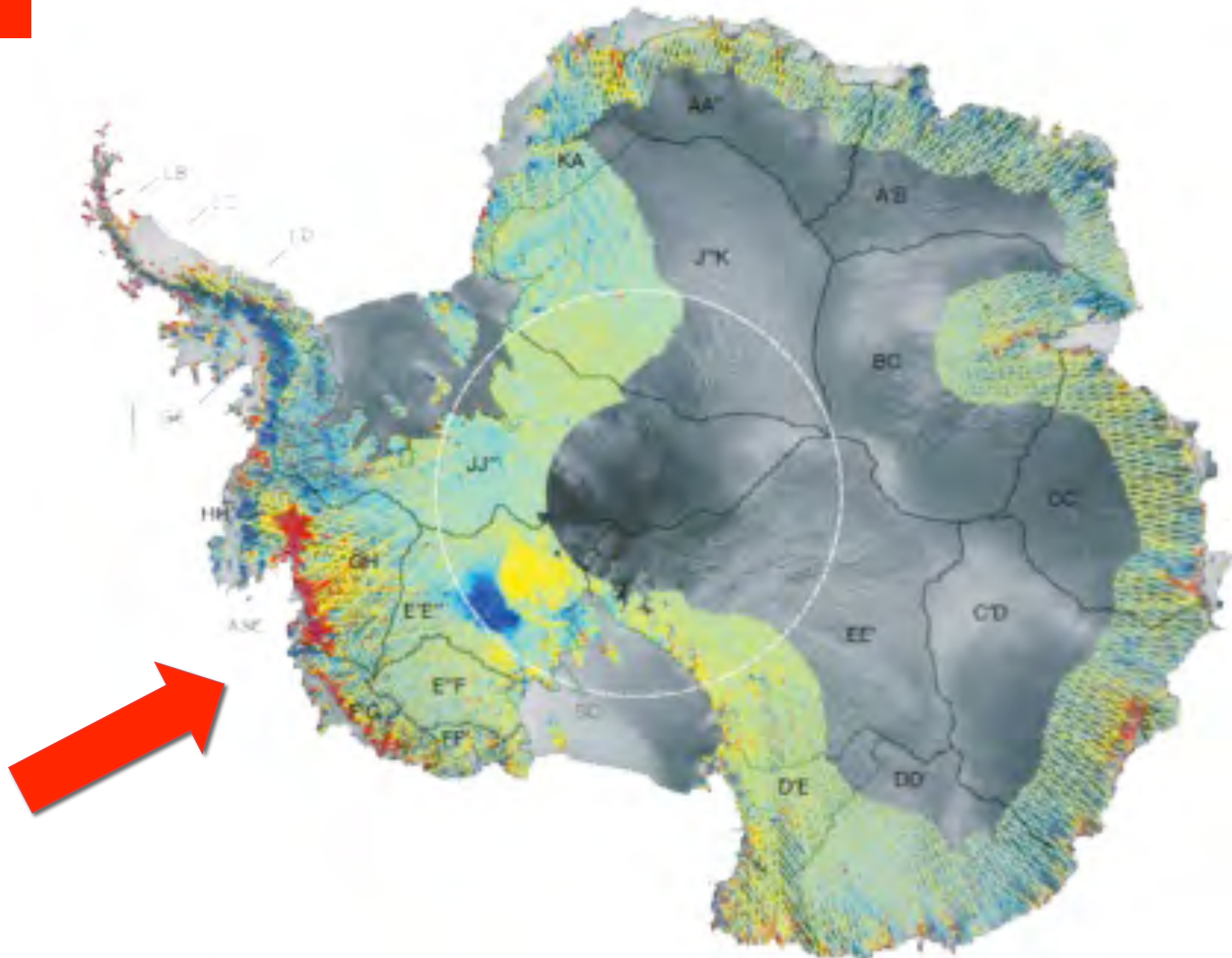
Antarctica has 7 times more ice than Greenland



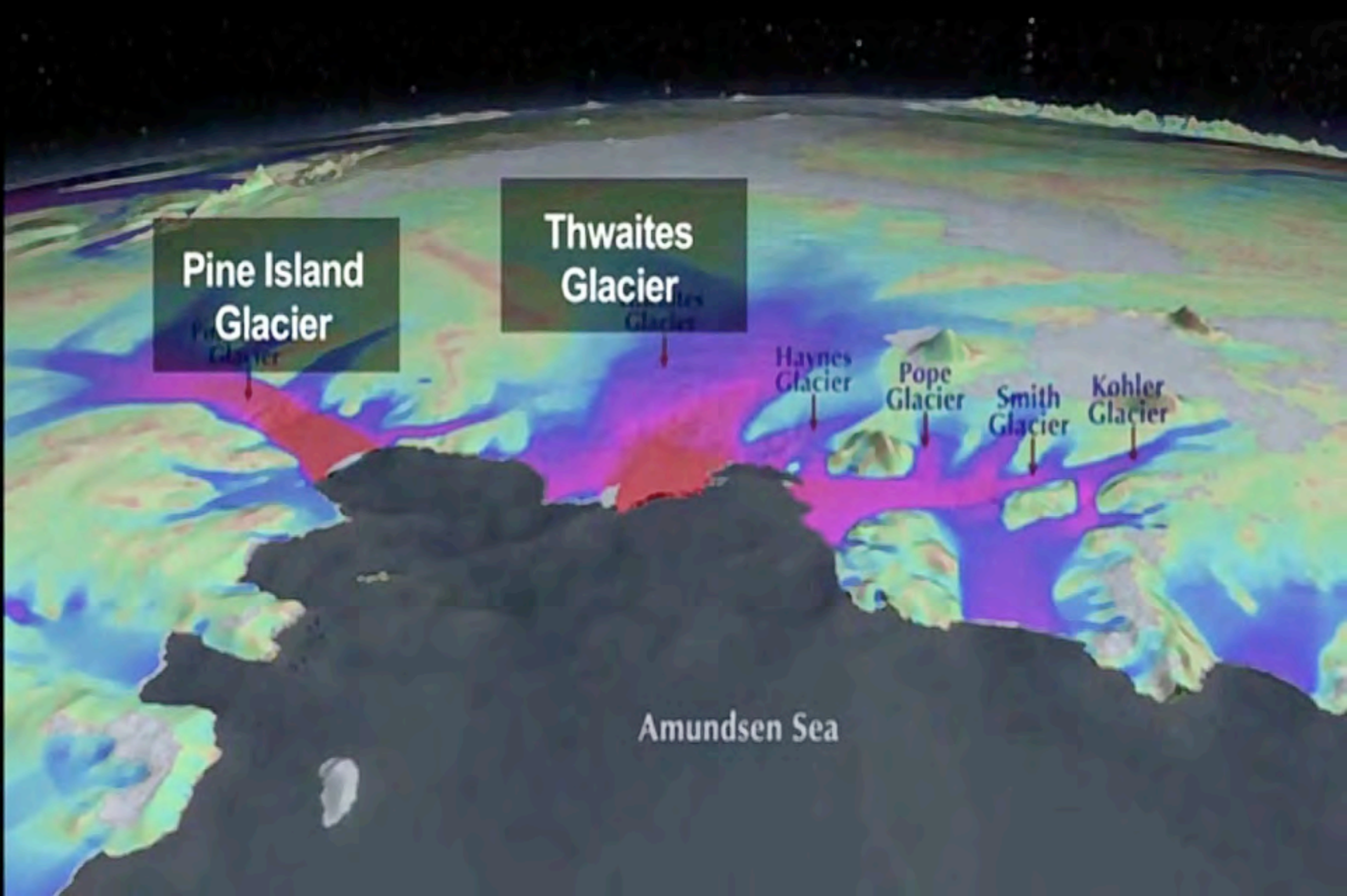




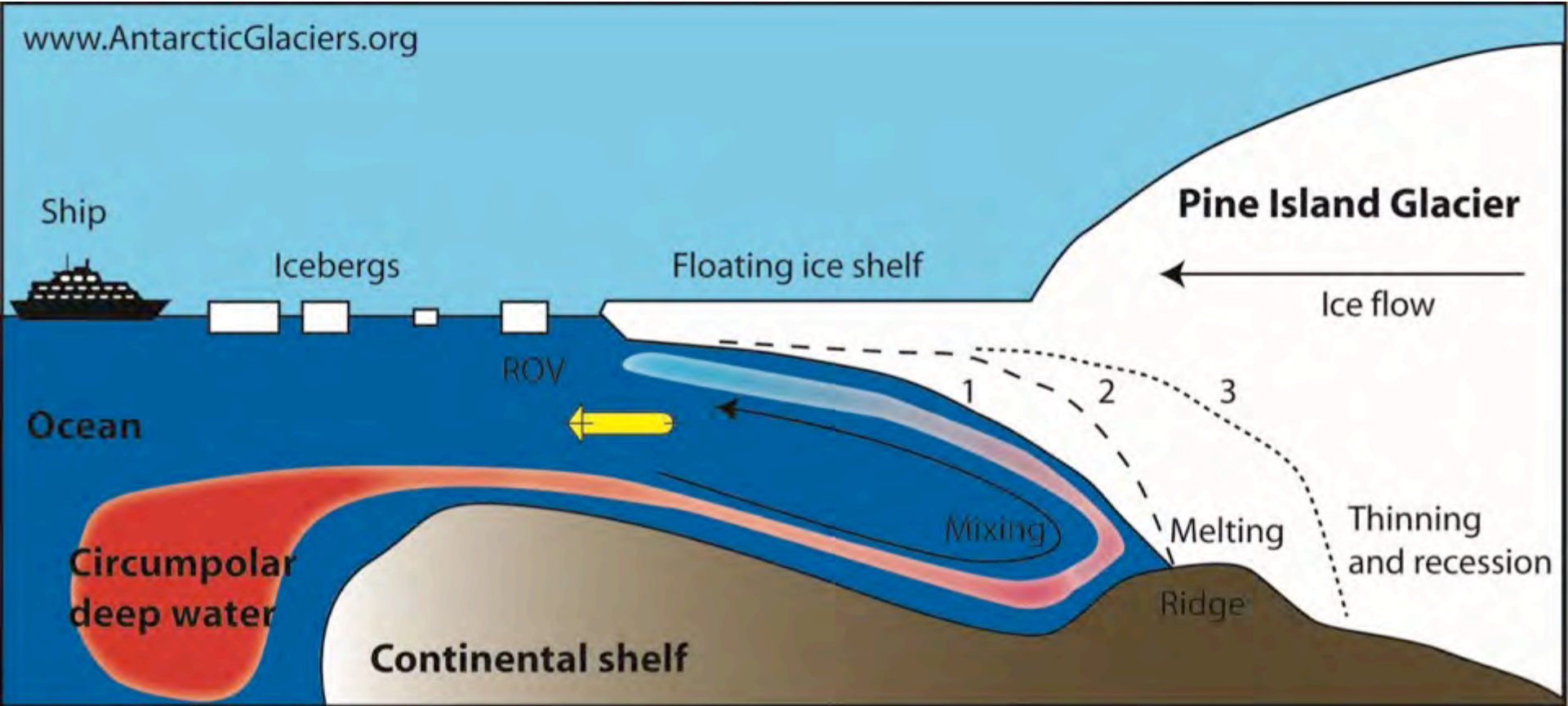




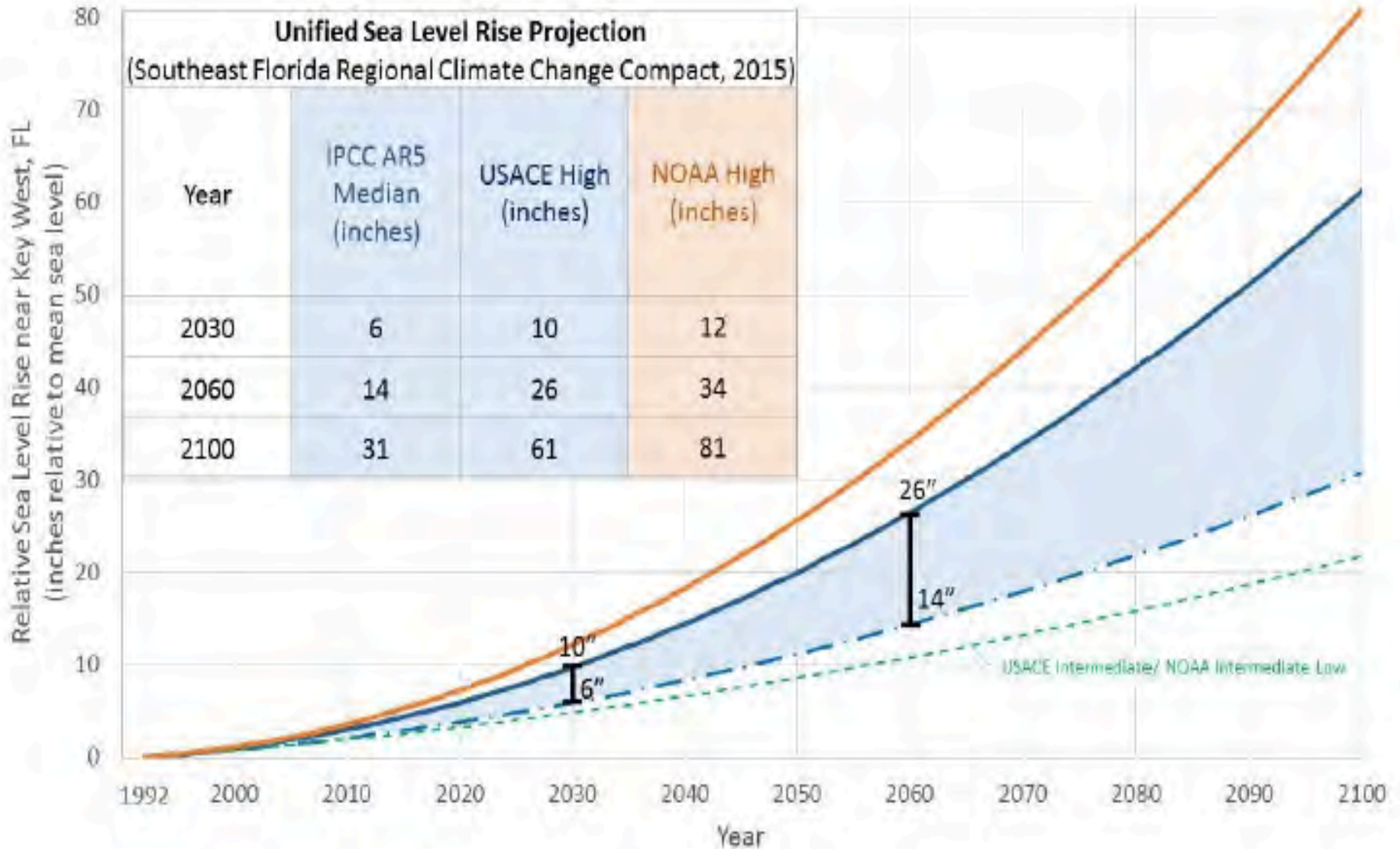
# The West Antarctic Icesheet



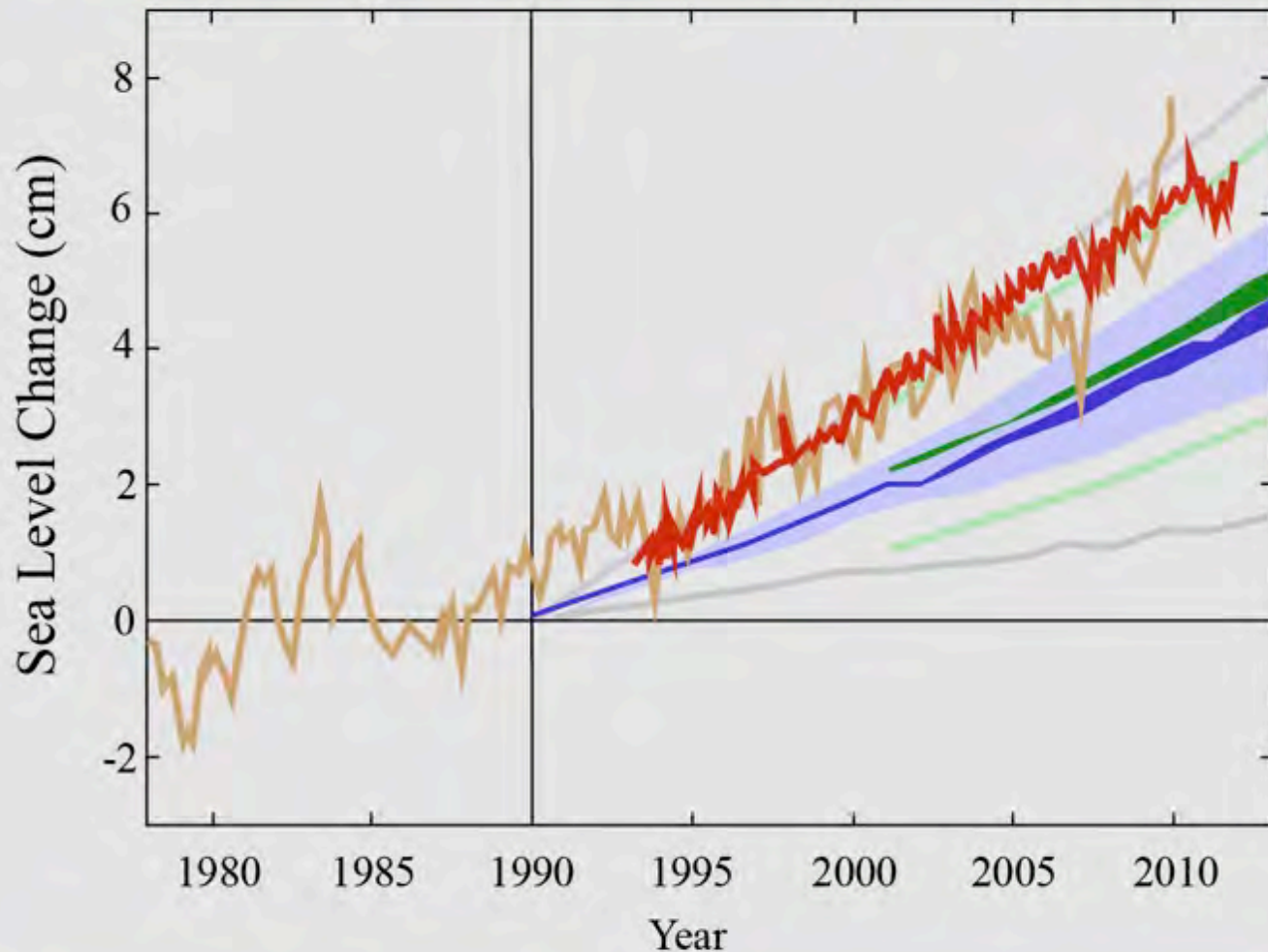
www.AntarcticGlaciers.org



# SE Florida Regional Climate Change Compact 2015



# Actual SL Exceeding Projections



Rahmstorf et al 2012

Blue – 1990 Projections

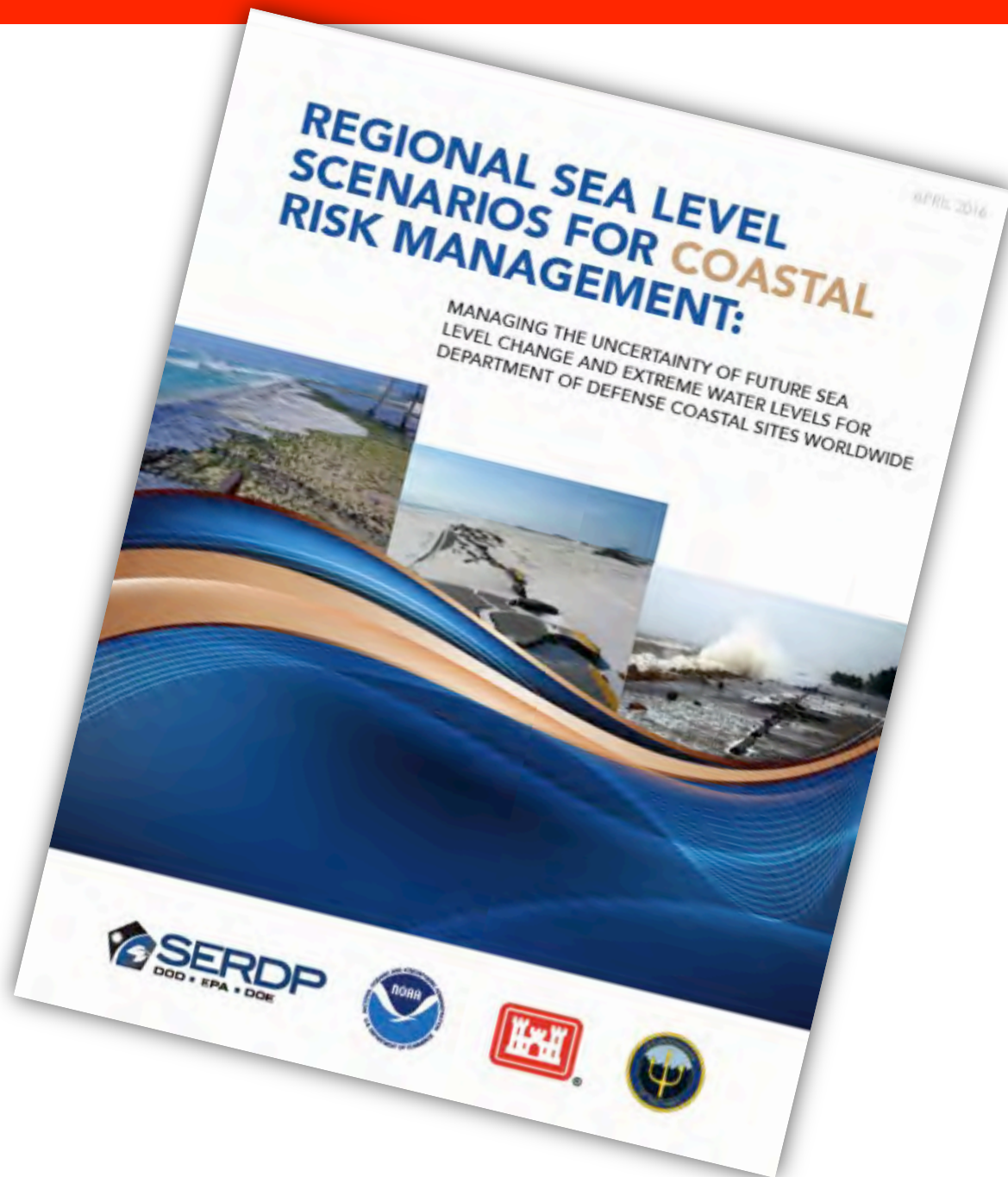
Gold – Actual Sea level

Green – 2002 Projections

Red - SL with trend line smoothing







April 2016

Good position:

Due to uncertainty,  
plan with multiple  
scenarios.

[\[Link\]](#)



# It is time to consider our future....



There is risk...



**...but there is huge opportunity to plan  
and adapt over the coming decades**



[www.johnenglander.net](http://www.johnenglander.net)

“Sea Level Rise Now” weekly digest

[www.sealevelrisenow.com](http://www.sealevelrisenow.com)

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