Adaptation Planning: Ideas from Annapolis

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October 10, 2018

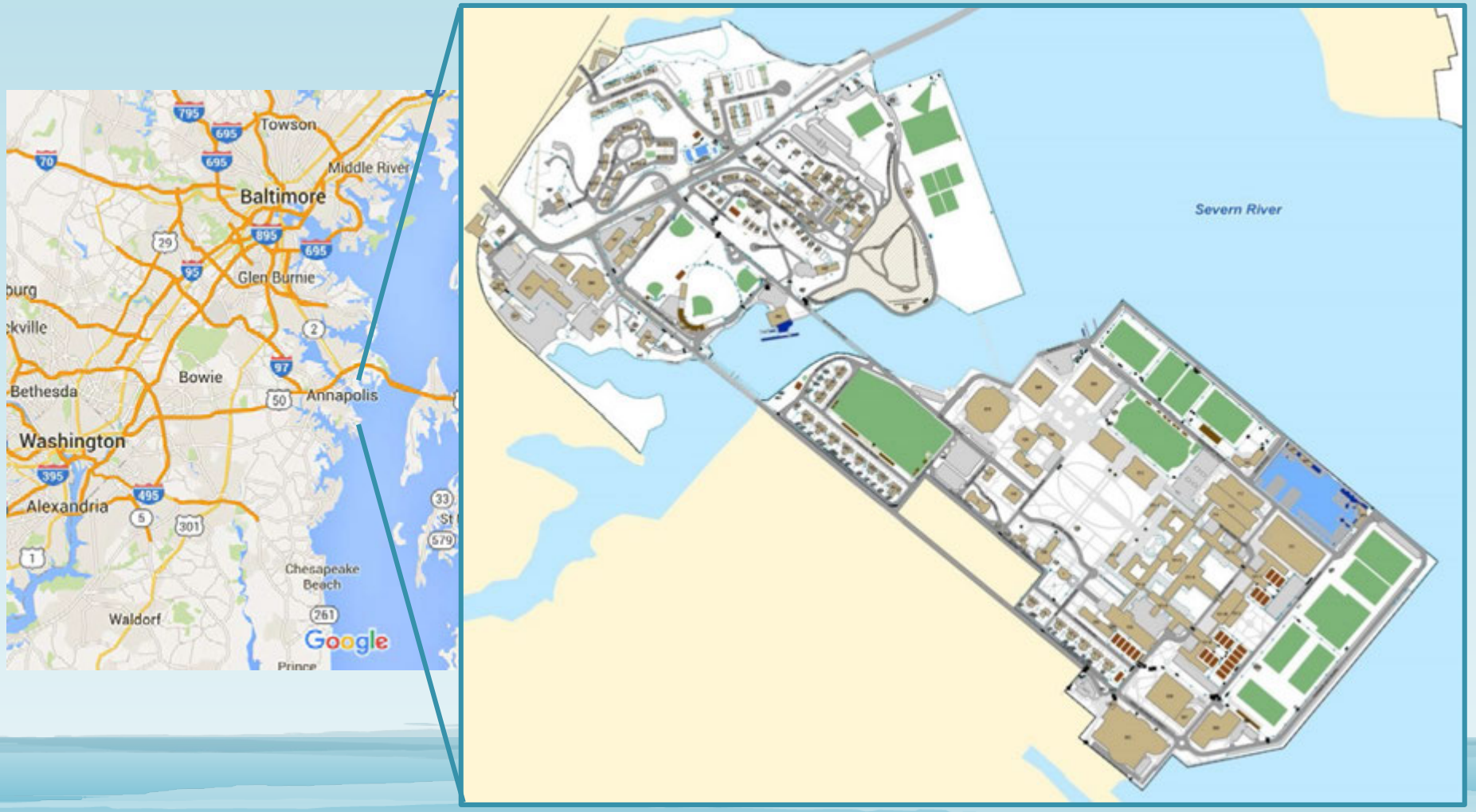
The Roadmap

- Why Annapolis?
- What is the sea level rise trend?
- How to adapt to sea level rise?
- Where do we go from here?



Source: USA Today

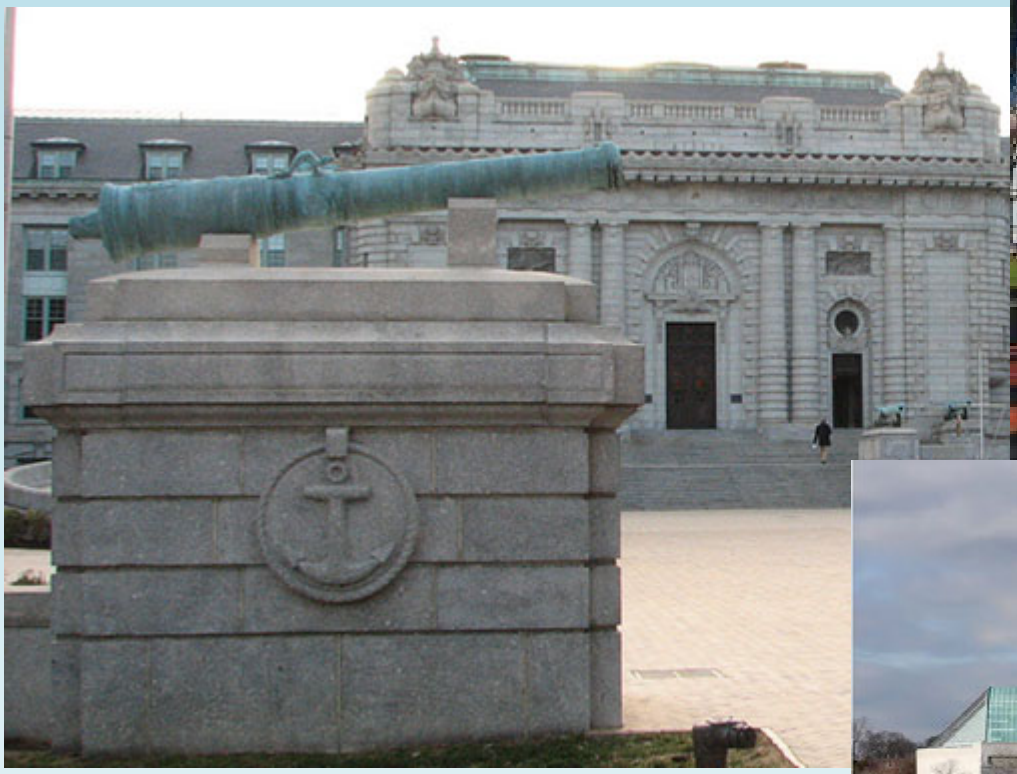
Location, Location, Location



Historic Annapolis



United States Naval Academy







Land Acquisition





Storm Surge Flooding



Storm Surge Flooding



Downtown, City of Annapolis flooded in Tropical Storm Isabel, Sep. 2003

Storm Surge Flooding



Homemade flood barrier and pump during Hurricane Sandy, October 30, 2012.

Nuisance Flooding



Parking lot in downtown Annapolis flooded to heavy rain and high tide, October 2010.

Nuisance Flooding



Sunny day high-tide flooding caused by backflowing stormwater drains, Feb. 2016.

Nuisance Flooding



Downtown flooding caused by several days of rain **last month**, September 9, 2018.

Nuisance Floods in Annapolis

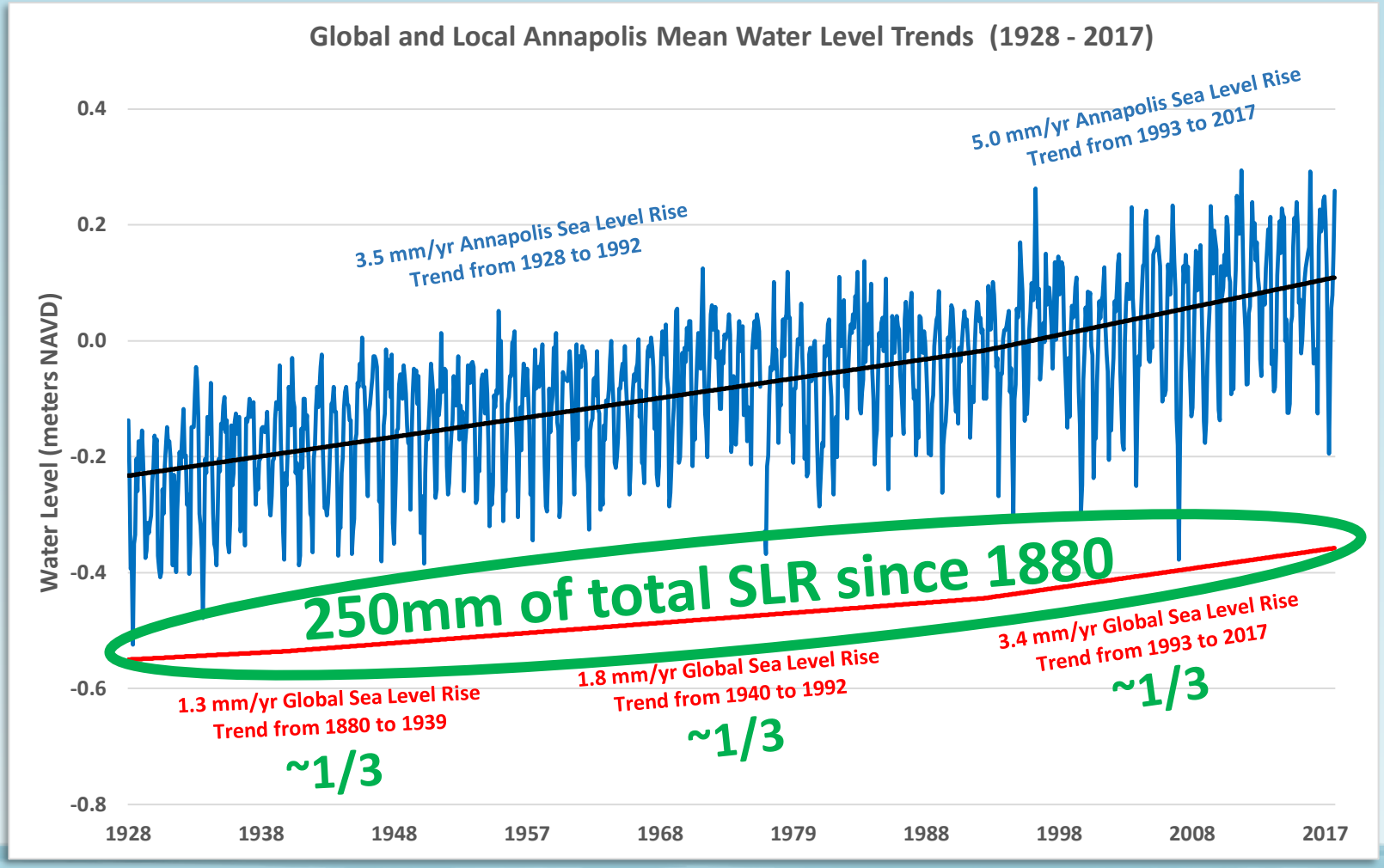
- Averaged 3.6 minor flood days per year during 1957-1963
- ~ 34 days per year during 2006-2010
- ~ 40 days per year during 2010-2016 (max of 66 in 2011)



Annapolis City Dock September 19, 2017

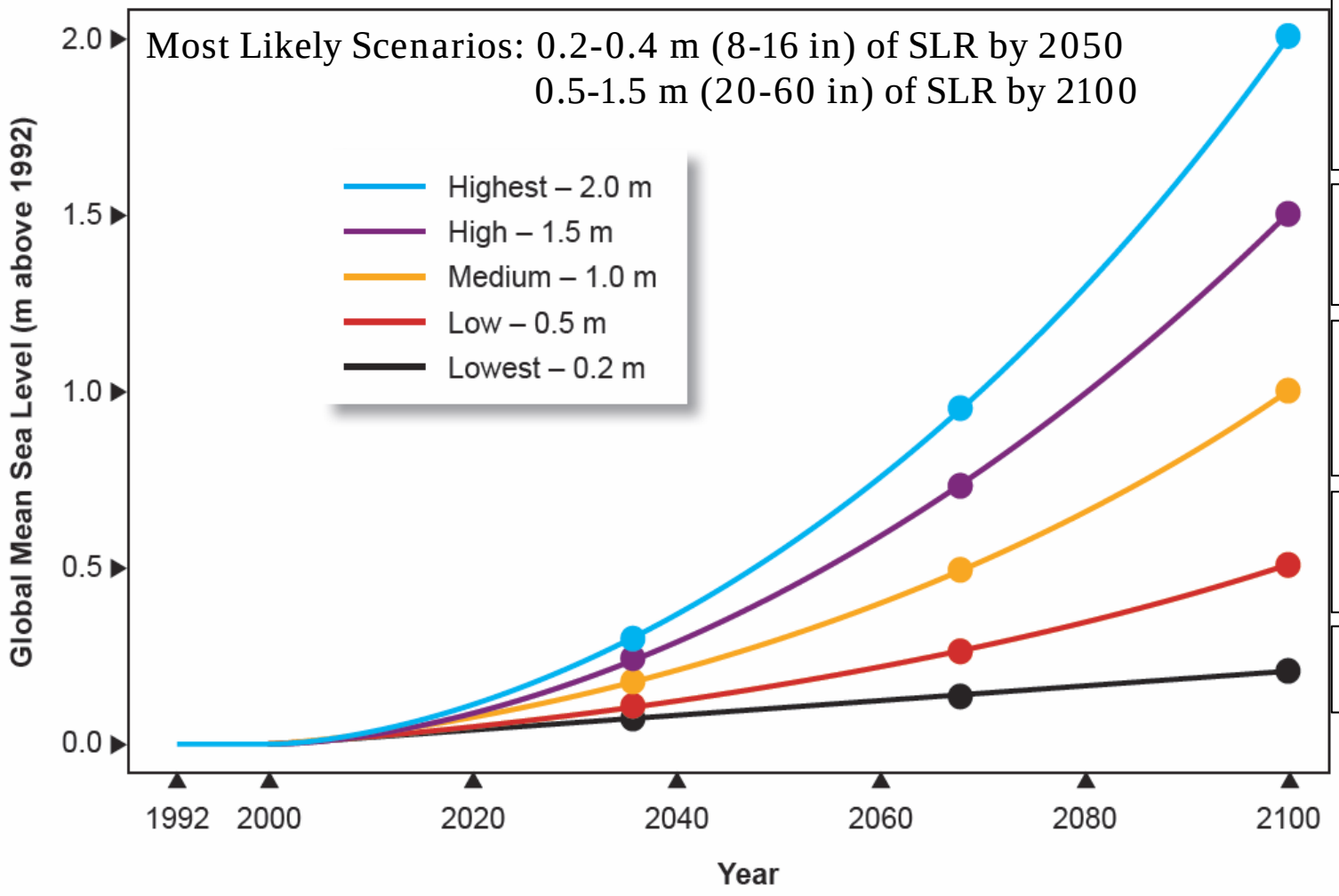
Source: Sweet et al. (2014), NOAA (2017)

What is the Sea Level Rise Trend?



Sources: Adapted from National Climate Assessment (2014), Church & White (2011), NOAA tidesandcurrents.noaa.gov

What is the Sea Level Rise Forecast?



Maximum physically plausible land ice loss by 2100, with warming from unchecked carbon emissions

Upper limit mandated by USACE (2013)

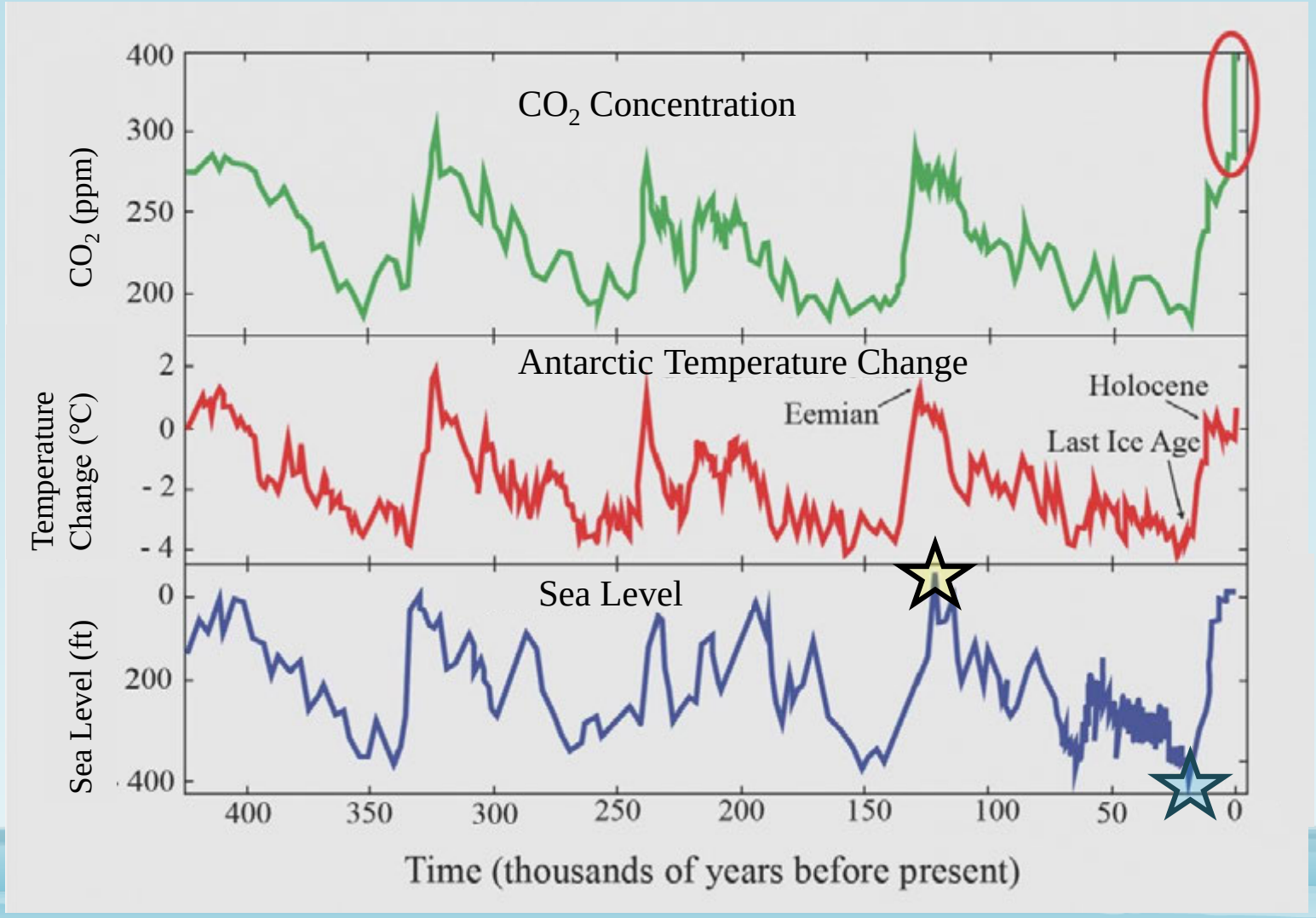
Upper limit in IPCC 2013 report (small contribution from land ice)

Moderate - major carbon cuts (Paris Accord goal)

Linear extrapolation of tidal gauge trend

Source: Adapted from Hall et al (2016)

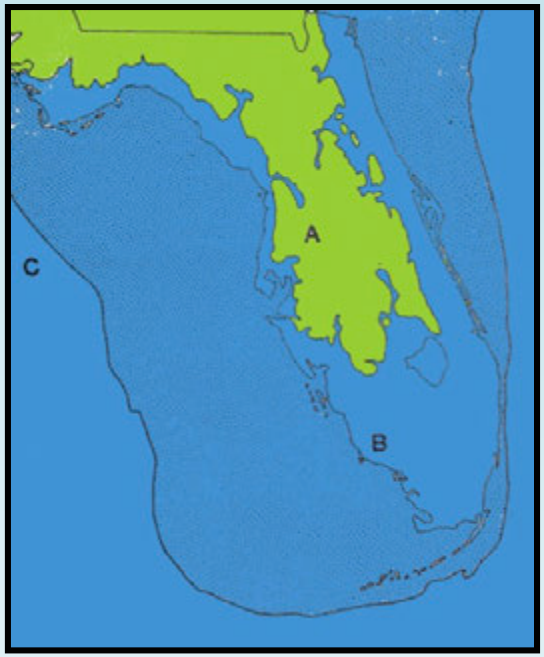
“Show Me the Data!”



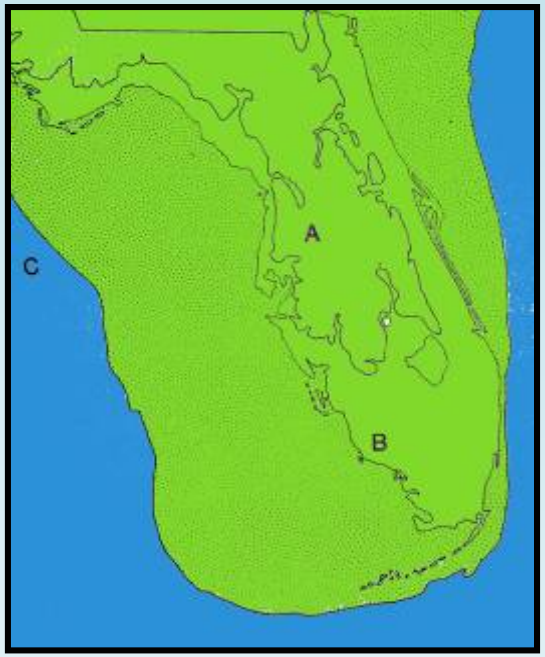
Source: Adapted from Hansen et al. (2008)

“Show Me the Data!”

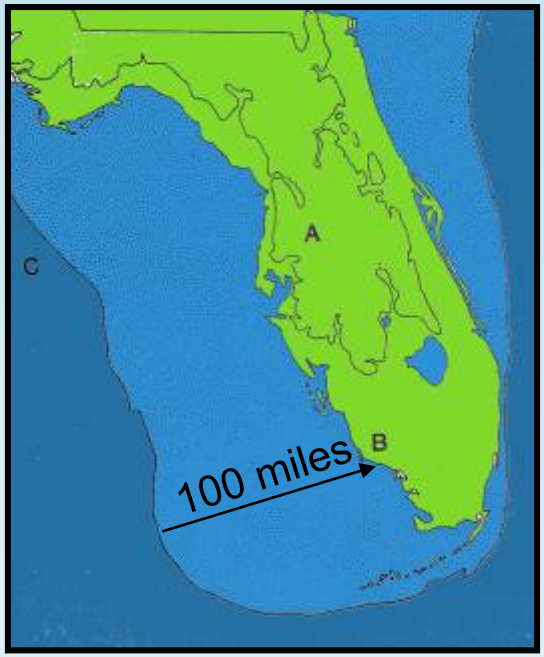
120,000 yrs ago
20 ft higher



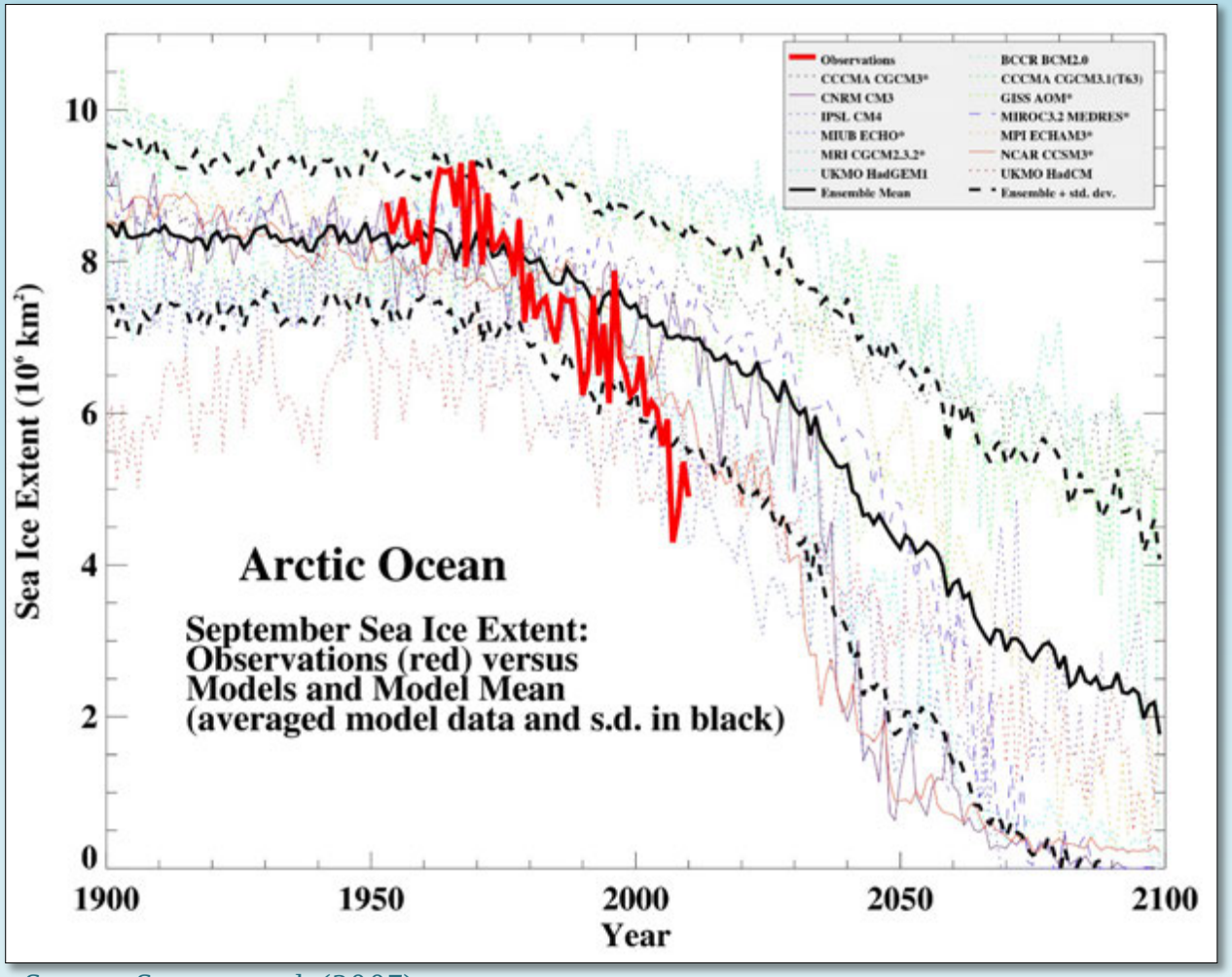
18,000 yrs ago
420 ft lower



Today



Source: Adapted from Dr. Wanless presentation to Miami-Dade County Board of Commissioners (2008)

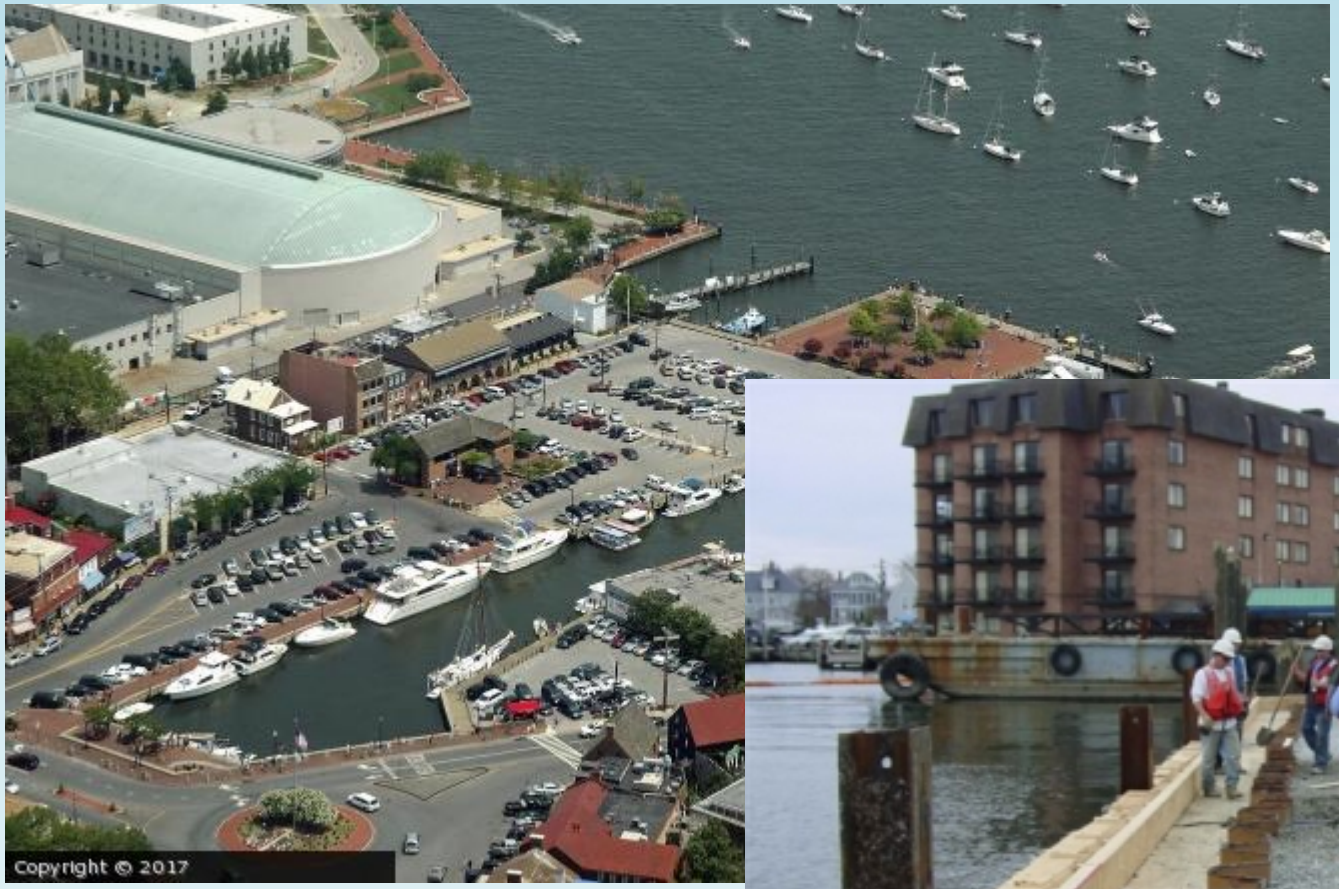


Climate Models vs. Actual

Source: Stroeve et al. (2007)

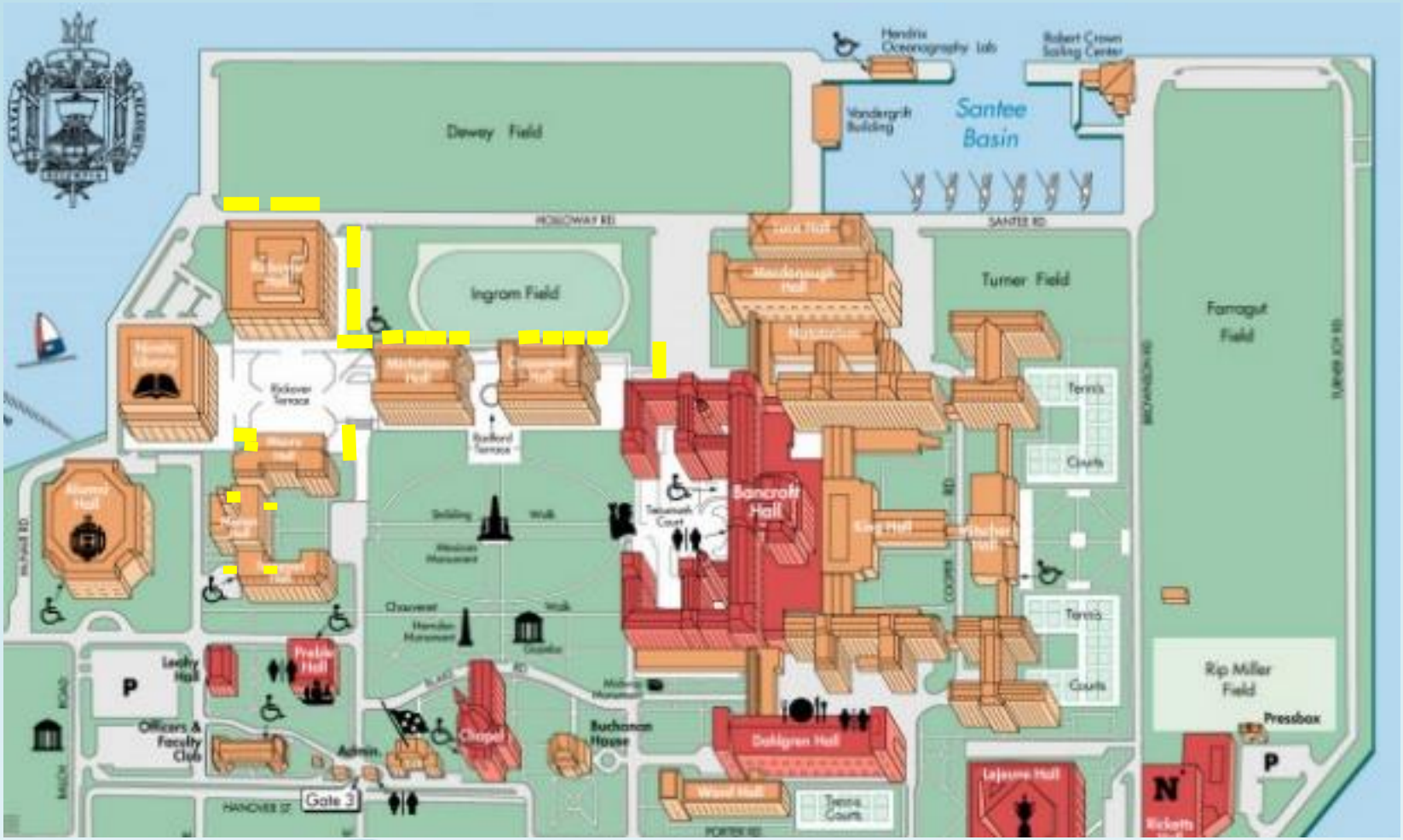
"There's still a lot about the rapid rate of Arctic change that we don't understand." - Mark Serreze, director of the National Snow and Ice Data Center.

Armor, Adapt, or Abandon?

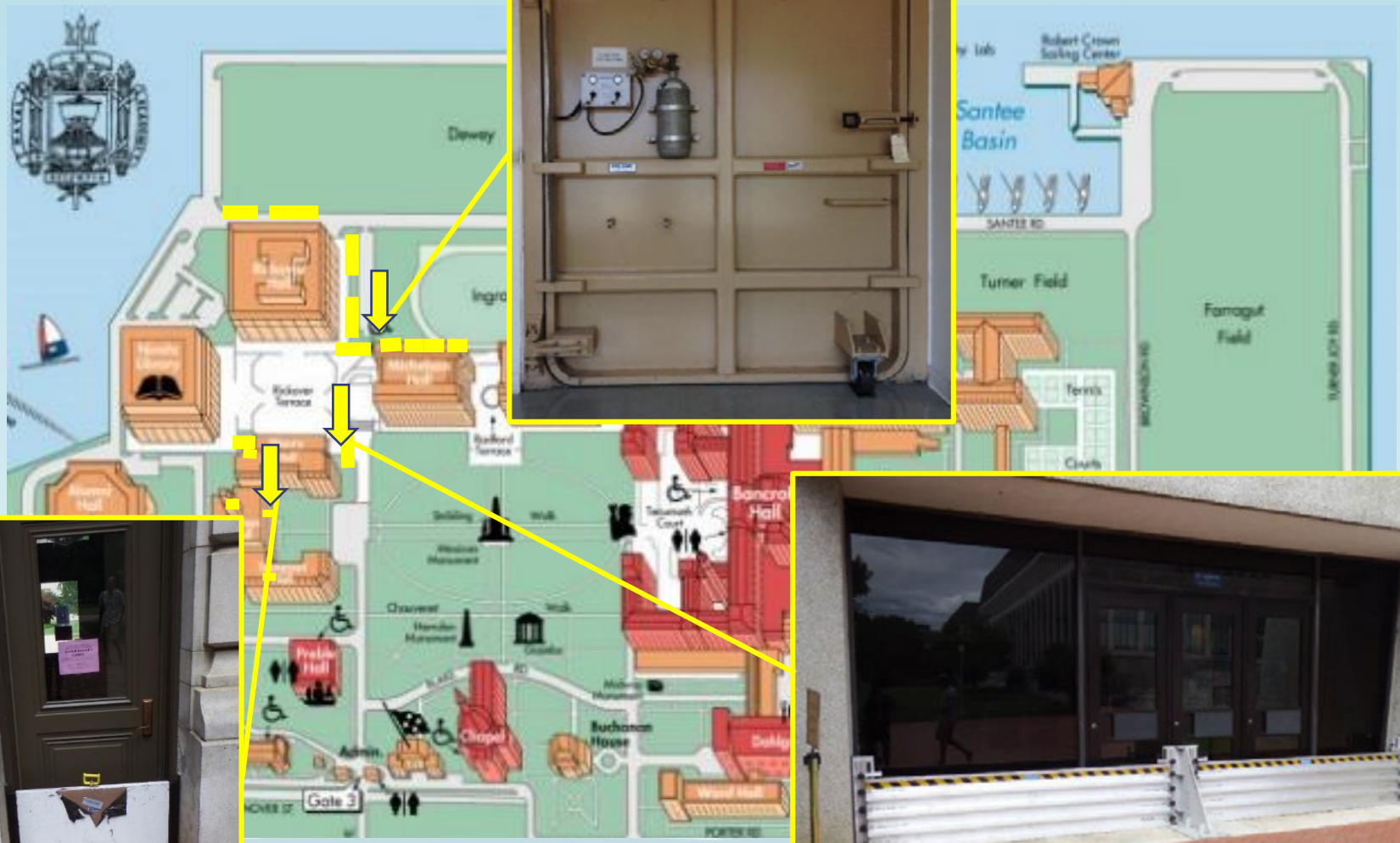




U.S. Naval Academy Flood Protection



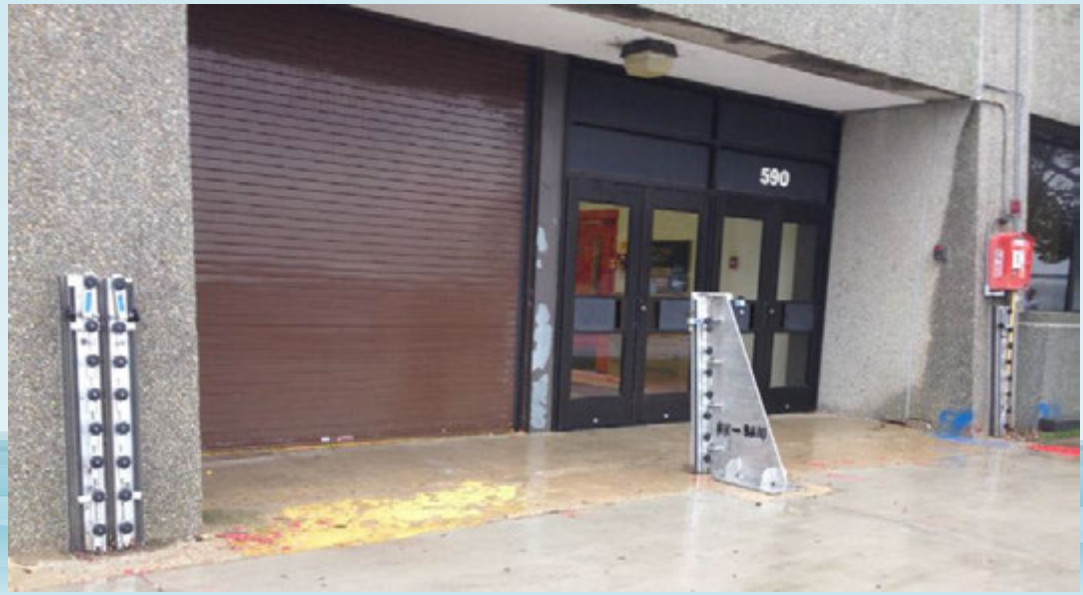
Examples of USNA Flood Protection



Some Assembly Required







Some Assembly Required



Off the Shelf Products





Homemade “Armor”



Homemade “Armor”



Adaptation Options







Adaptation Options

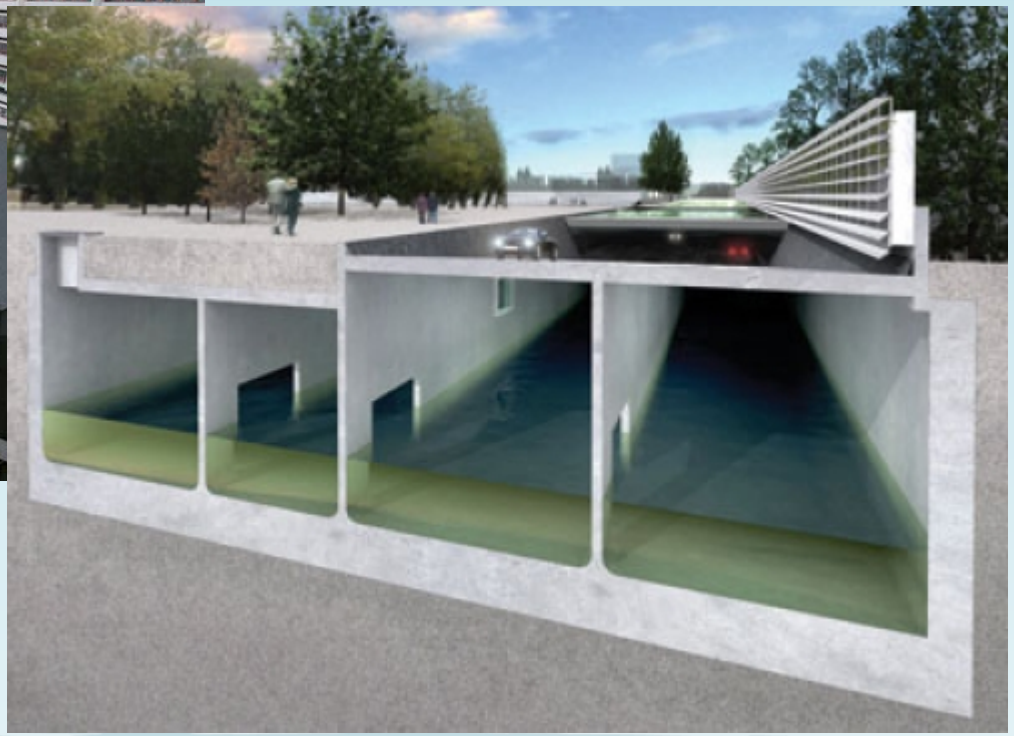






Adaptation Options





Adaptation Options





Raise or Raze?



Which options to choose?

Economics is a driving factor, also consider:

- Practicality
- Timeline
- Modularity
- Risk Calculus
- Economy of Scale
- Collective Benefits



What can you do?

- Be informed about sea level rise and tell others
- Learn from other region's experiences
- Look for your vulnerabilities
- Take action, as needed, to Adapt, Armor, or Abandon





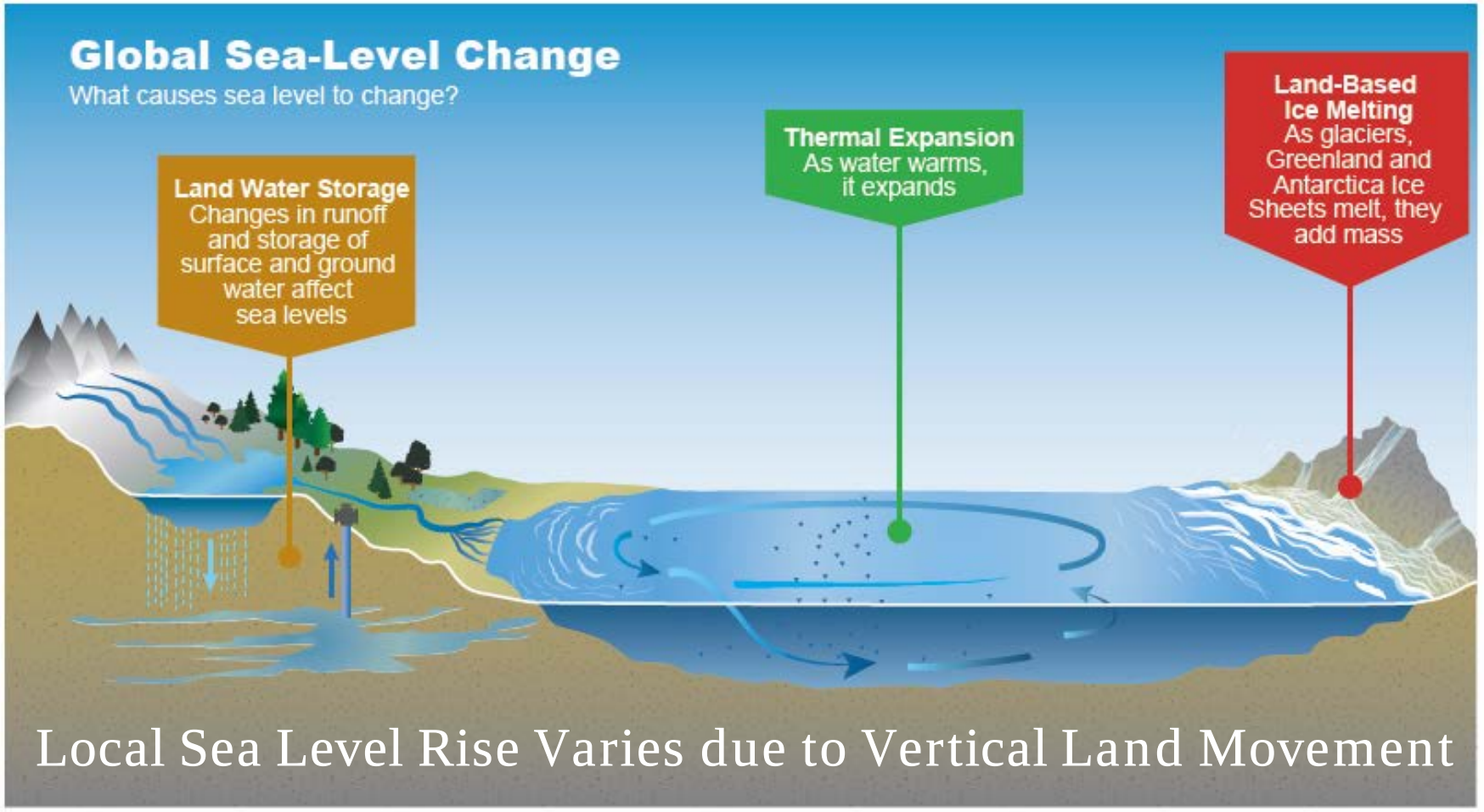
Questions?





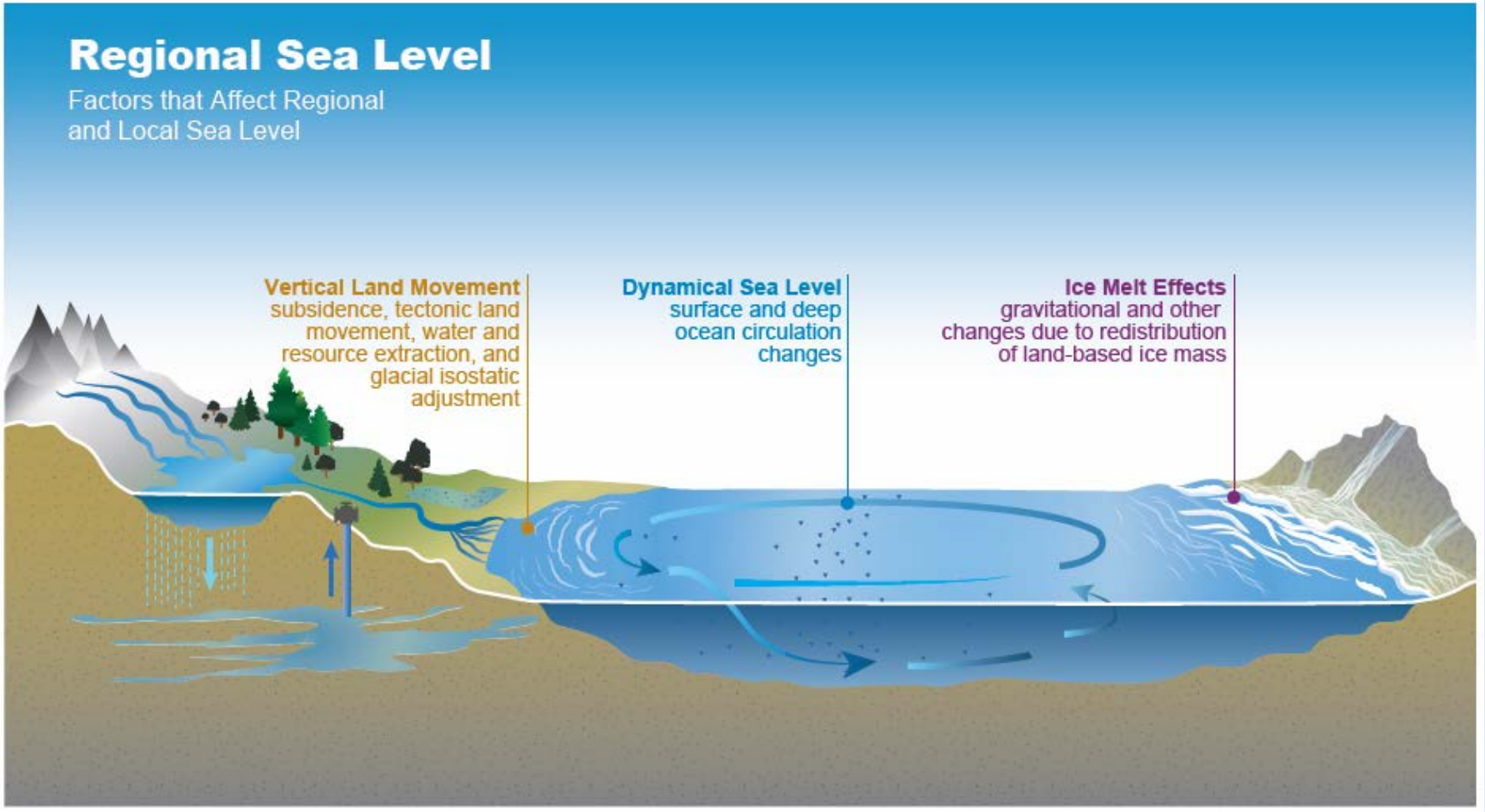
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How Much More Will Sea Level Rise?



Source: Hall et al. (2016), IPCC AR5 (2013)

Causes of Local Sea Level Rise vs. Global Sea Level Rise Trend



Source: Hall et al. (2016), IPCC AR5 (2013)