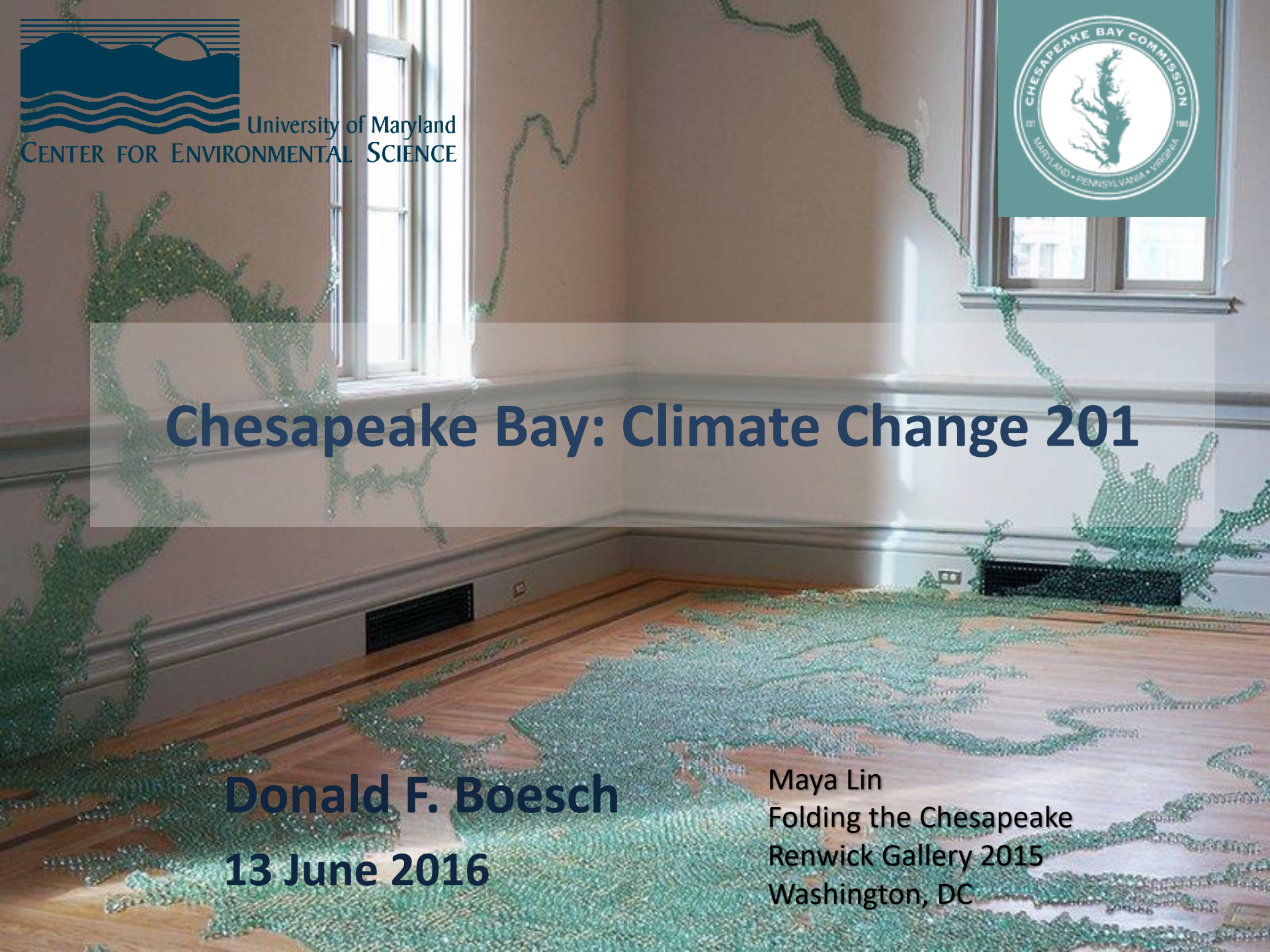
University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Chesapeake Bay: Climate Change 201

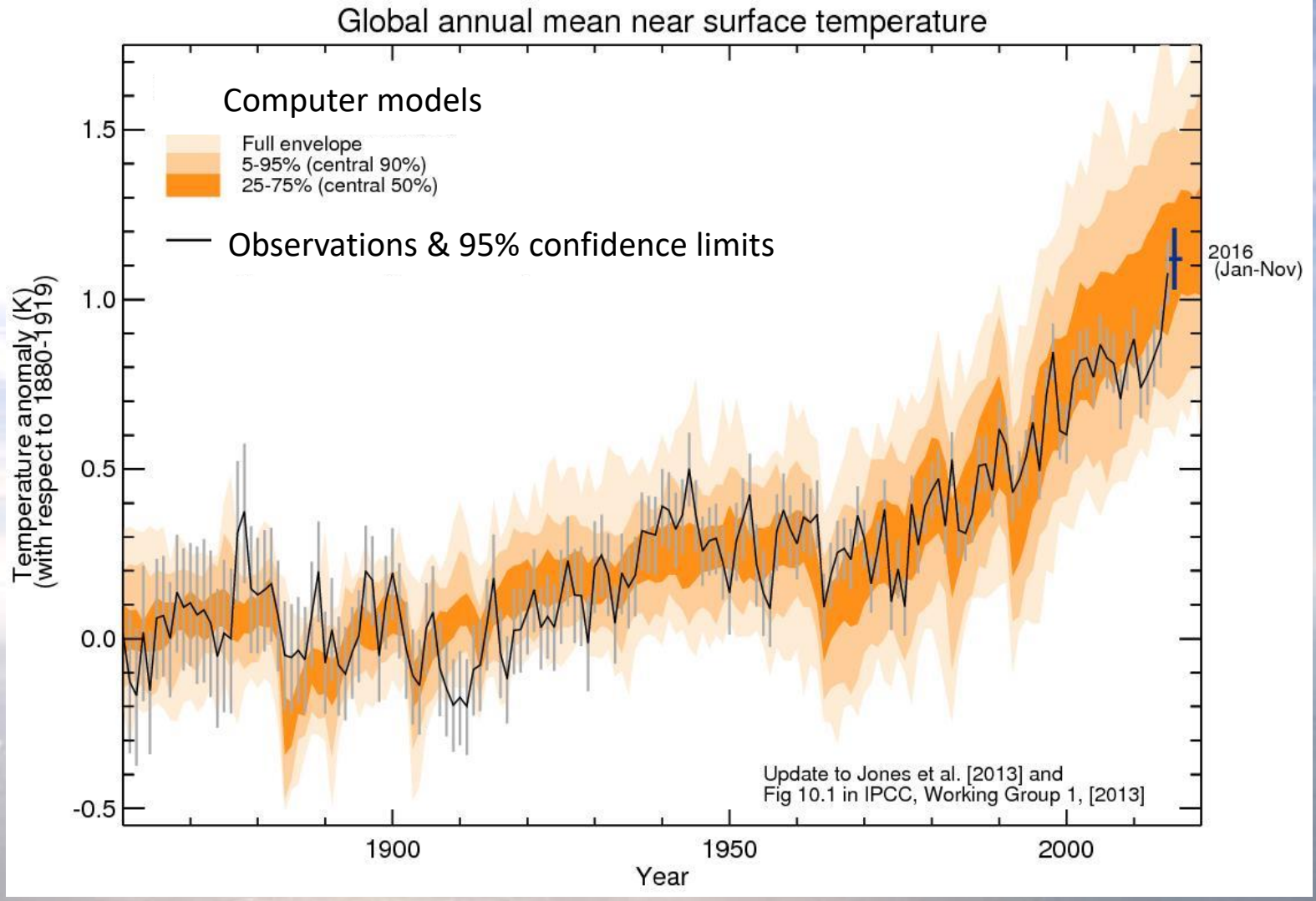
Donald F. Boesch

13 June 2016



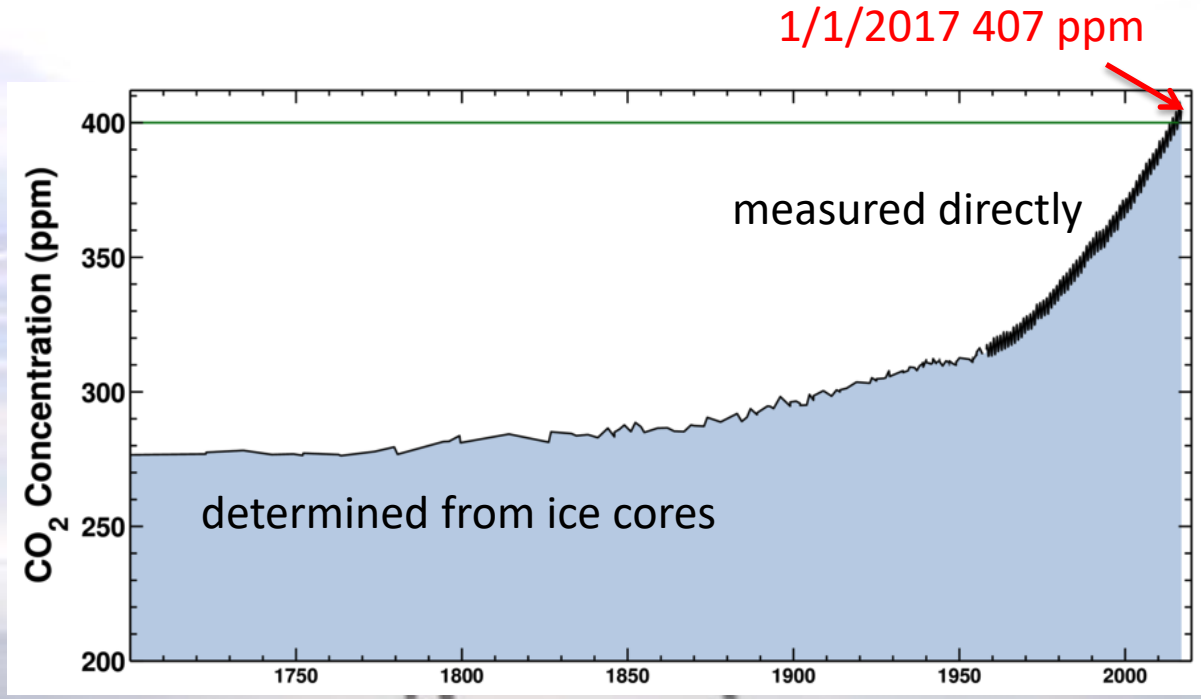
Maya Lin
Folding the Chesapeake
Renwick Gallery 2015
Washington, DC

It's Warming and We Know Why



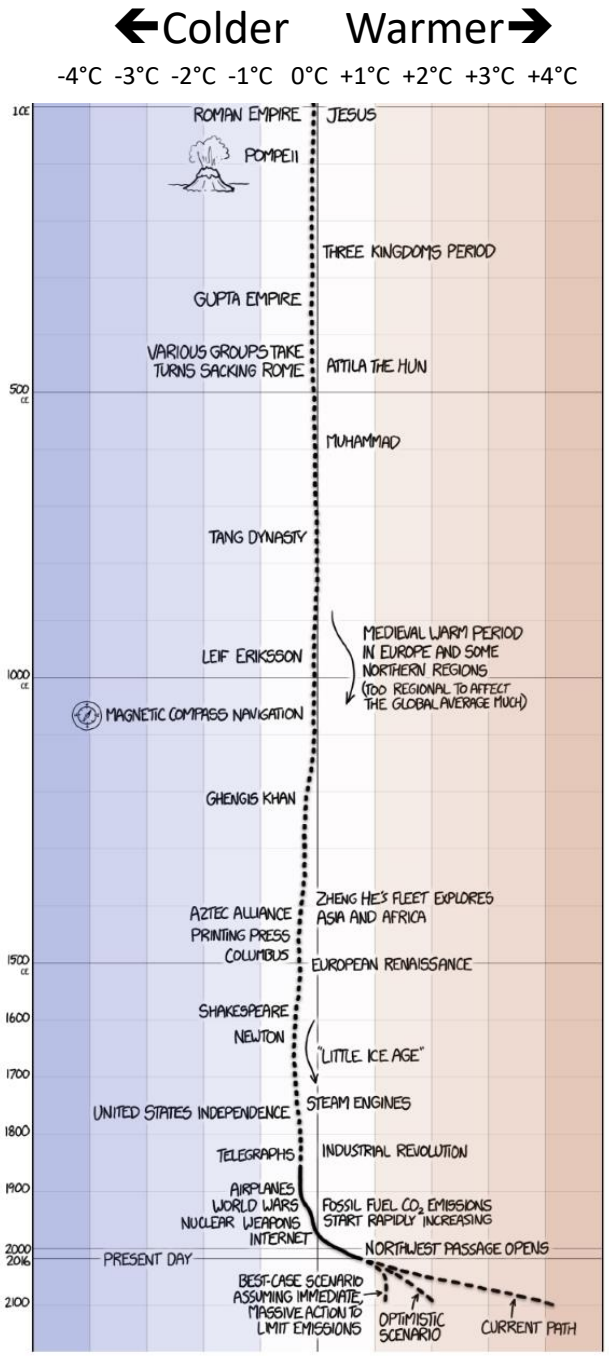
Source: Gareth Jones

Global Warming in Human History



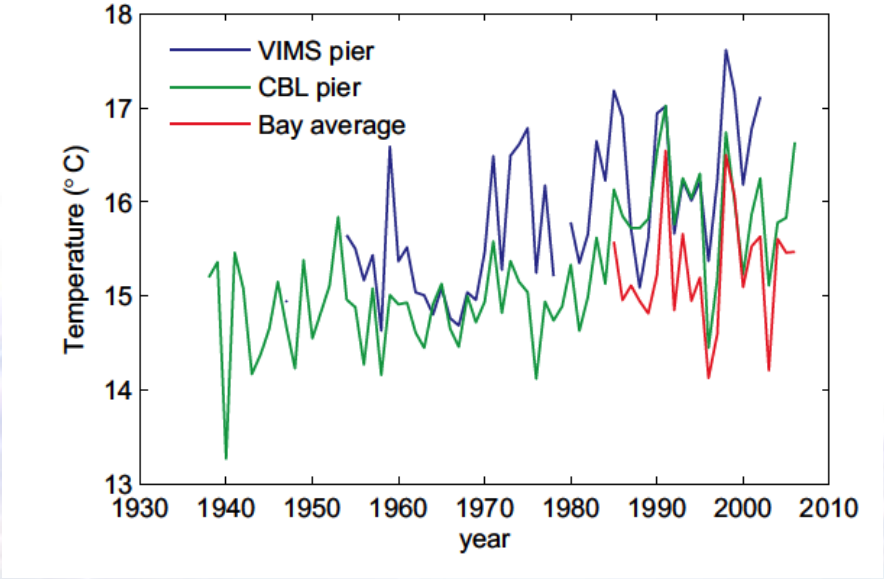
Warming from mid-19th century has been predominantly due to increased concentration of CO_2 and other greenhouses in the atmosphere.

This has been understood and predicted by scientists since 1896.



Bay Waters Have Been Warming

Average annual temperature

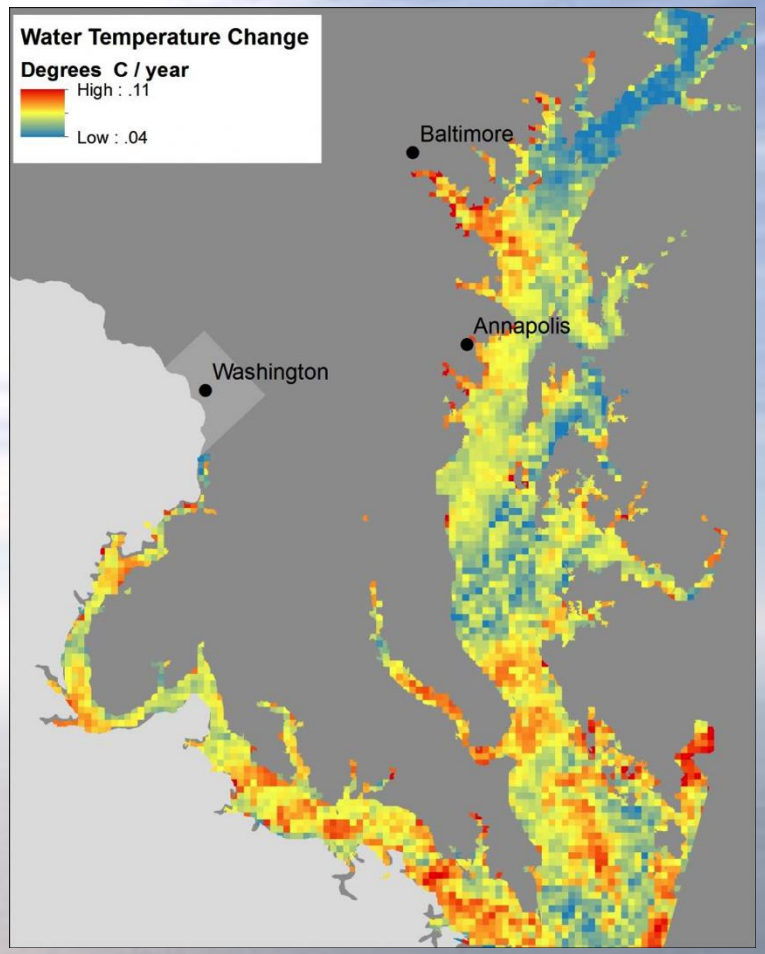


(almost 3° F since 1940s)

Najjar et al. 2010. *Estuarine, Coastal, Shelf Science* 86:1

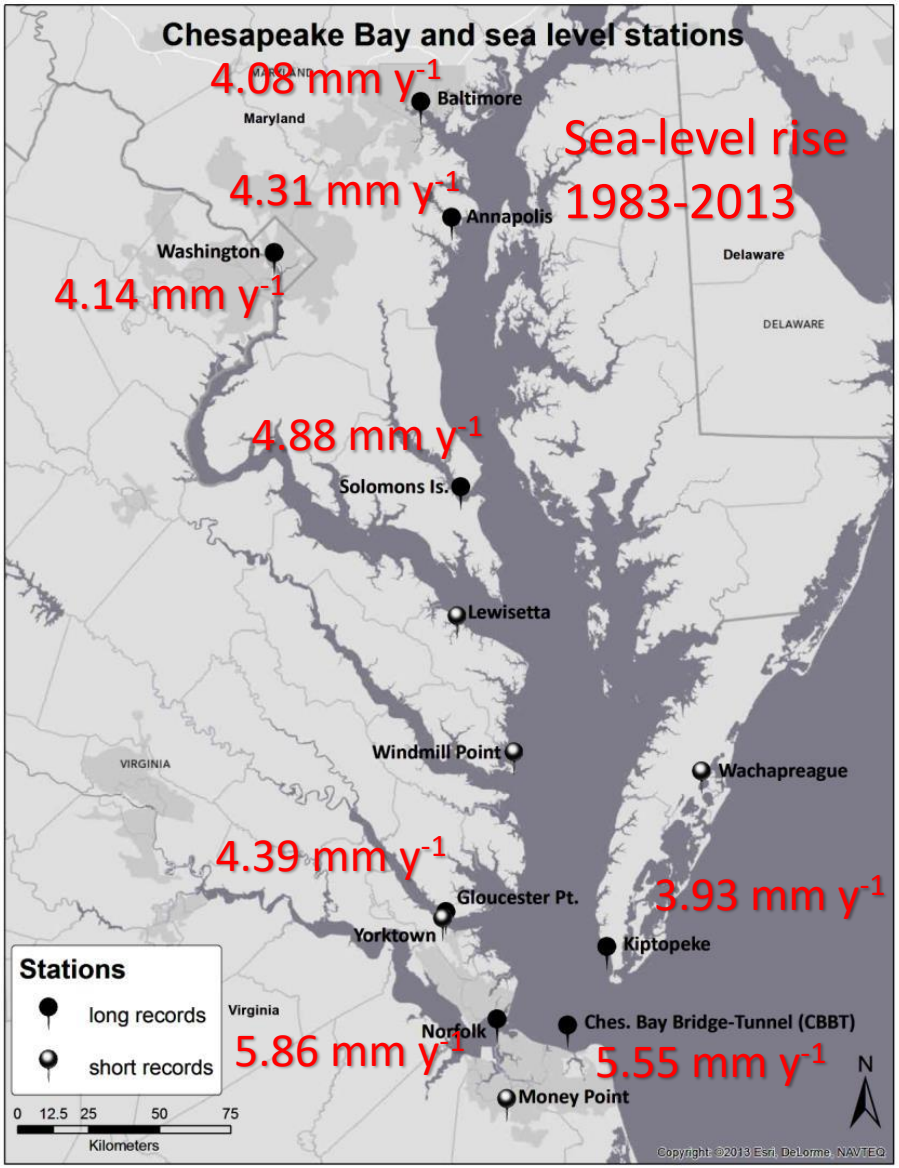
Landsat satellite records: surface water warming 0.05 to 0.10° C per year, 1985-2012

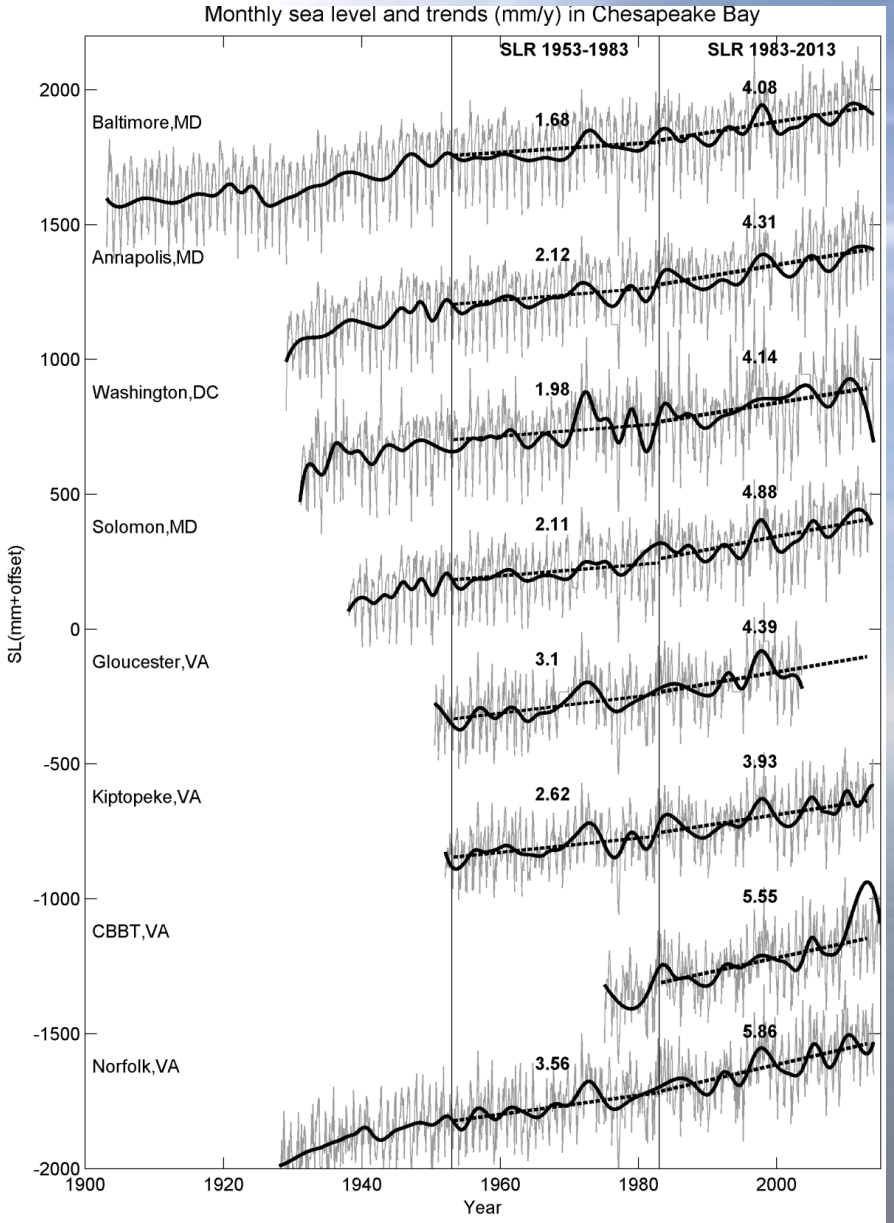
(since 1985 about 0.14° F per year on average)



Ding & Elmore 2015. *Remote Sensing of Environment* 168: 335

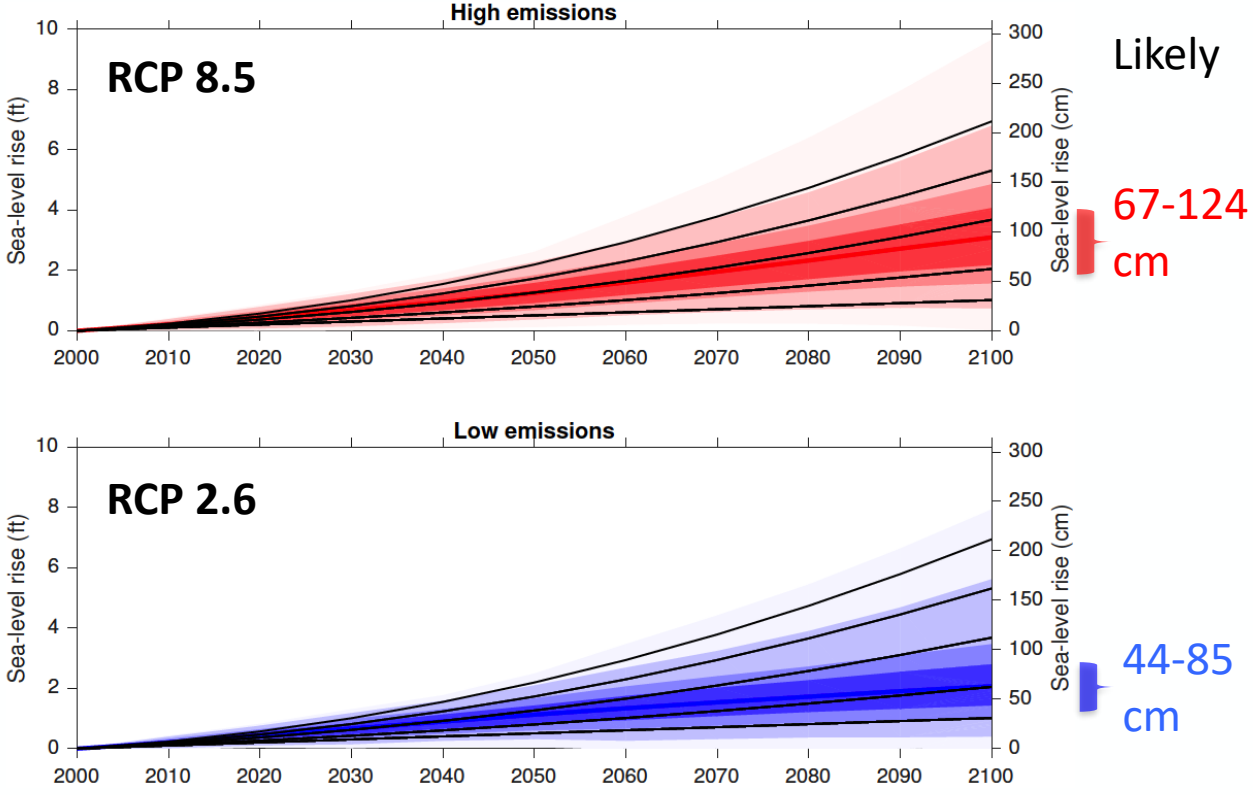
Sea-level Rising Faster than Global Mean





Sea-level Rise Projections for Baltimore
with polar ice melt & vertical land motion

Compared with 5 DoD scenarios adjusted for subsidence

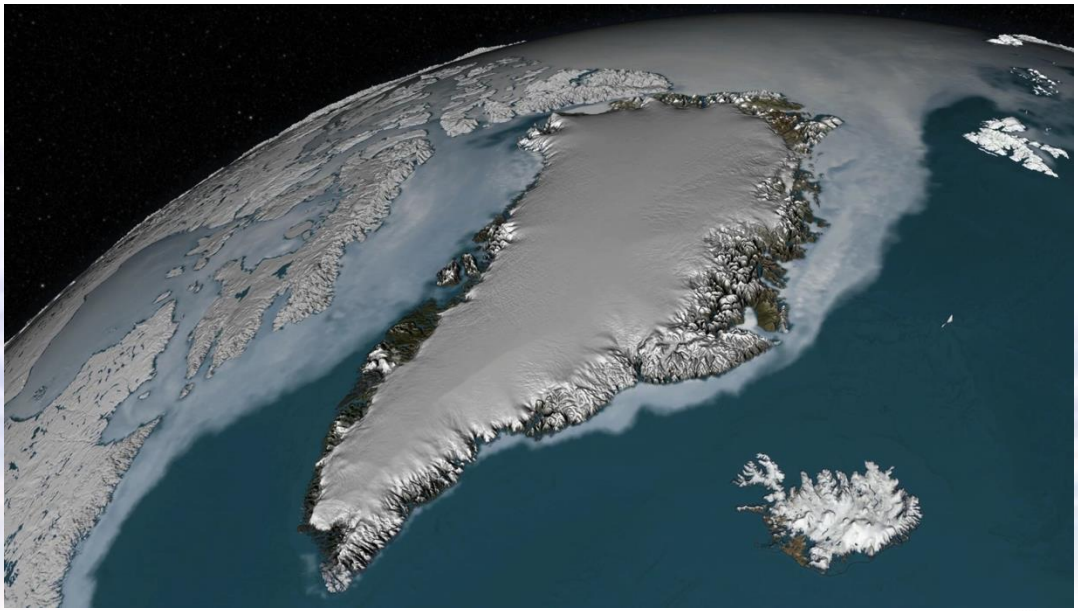


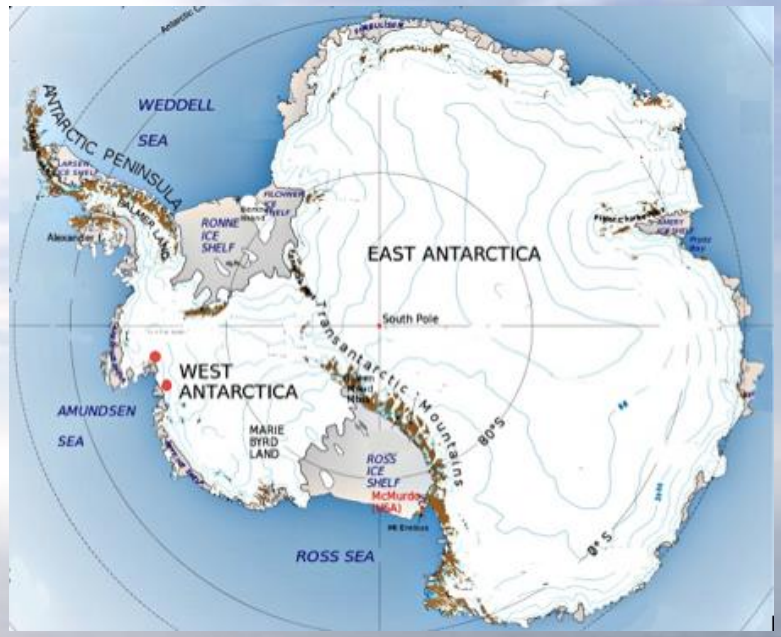
Dark = likely (17th-83rd percentile range)
Medium = 5th-95th percentile range
Medium-Light = 0.5th-99.5th percentile range
Very light = 0.1st-99.9th percentile range

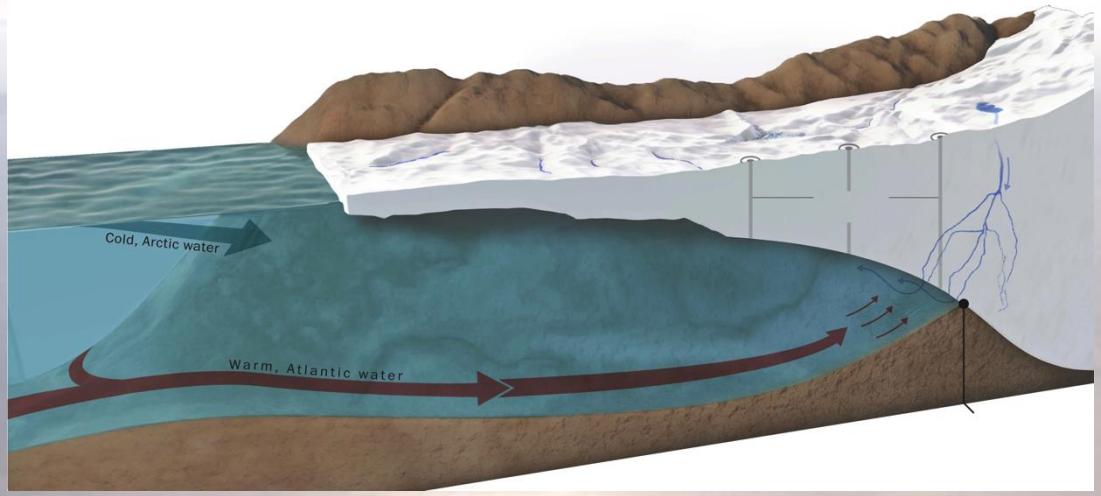
Robert Kopp, Rutgers University, unpublished based on Kopp et al. 2016 *PNAS*

Rutgers Earth System Science & Policy Lab

Wild Card: Polar Ice Sheets

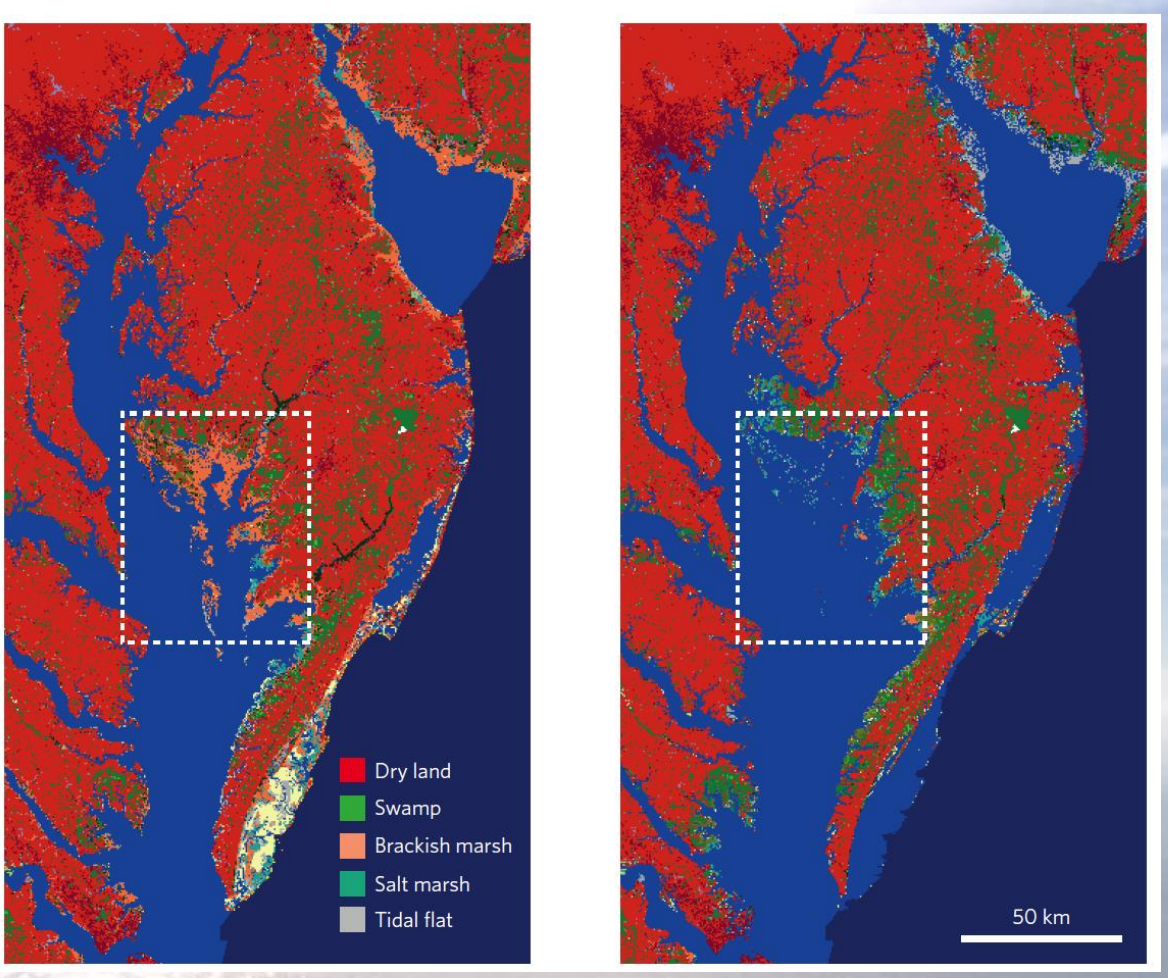






Tidal Marshes Under Sea-Level Rise

landscape models may overestimate vulnerability

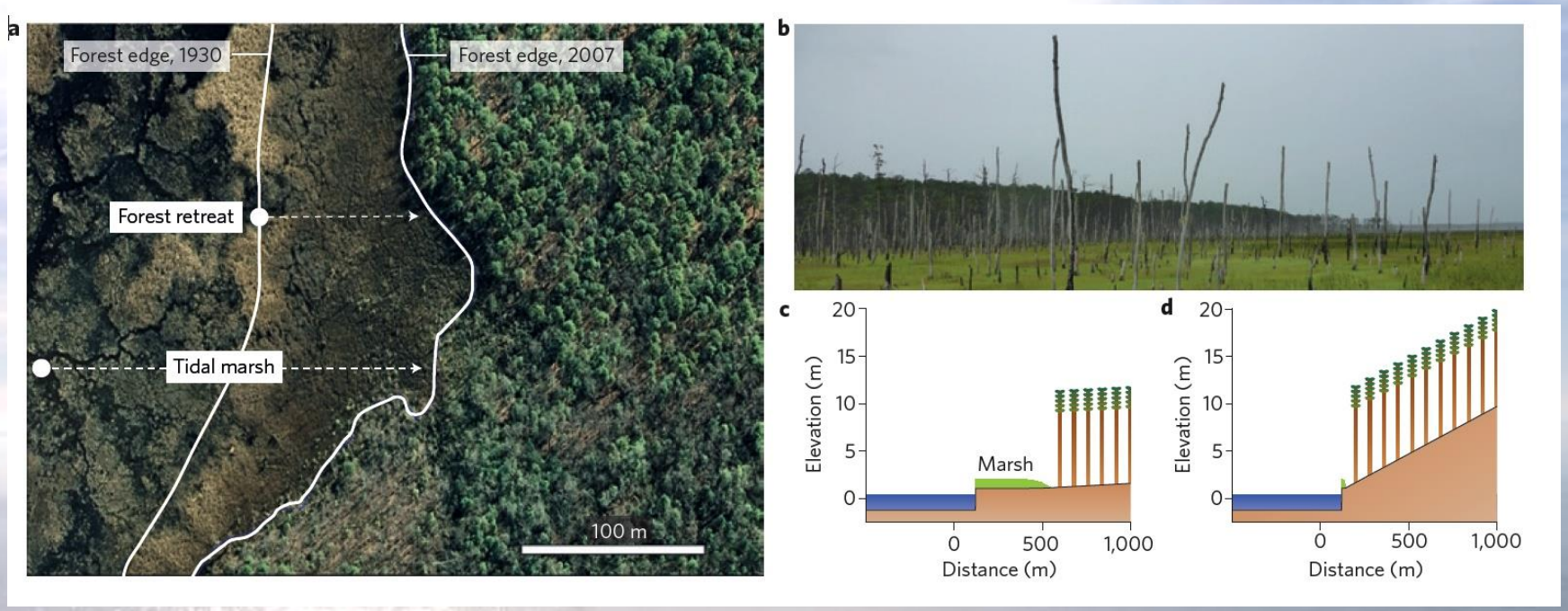


Initial **2100**

Kirwan et al. 2016. *Nature Climate Change*

Tidal Marshes Under Sea-Level Rise

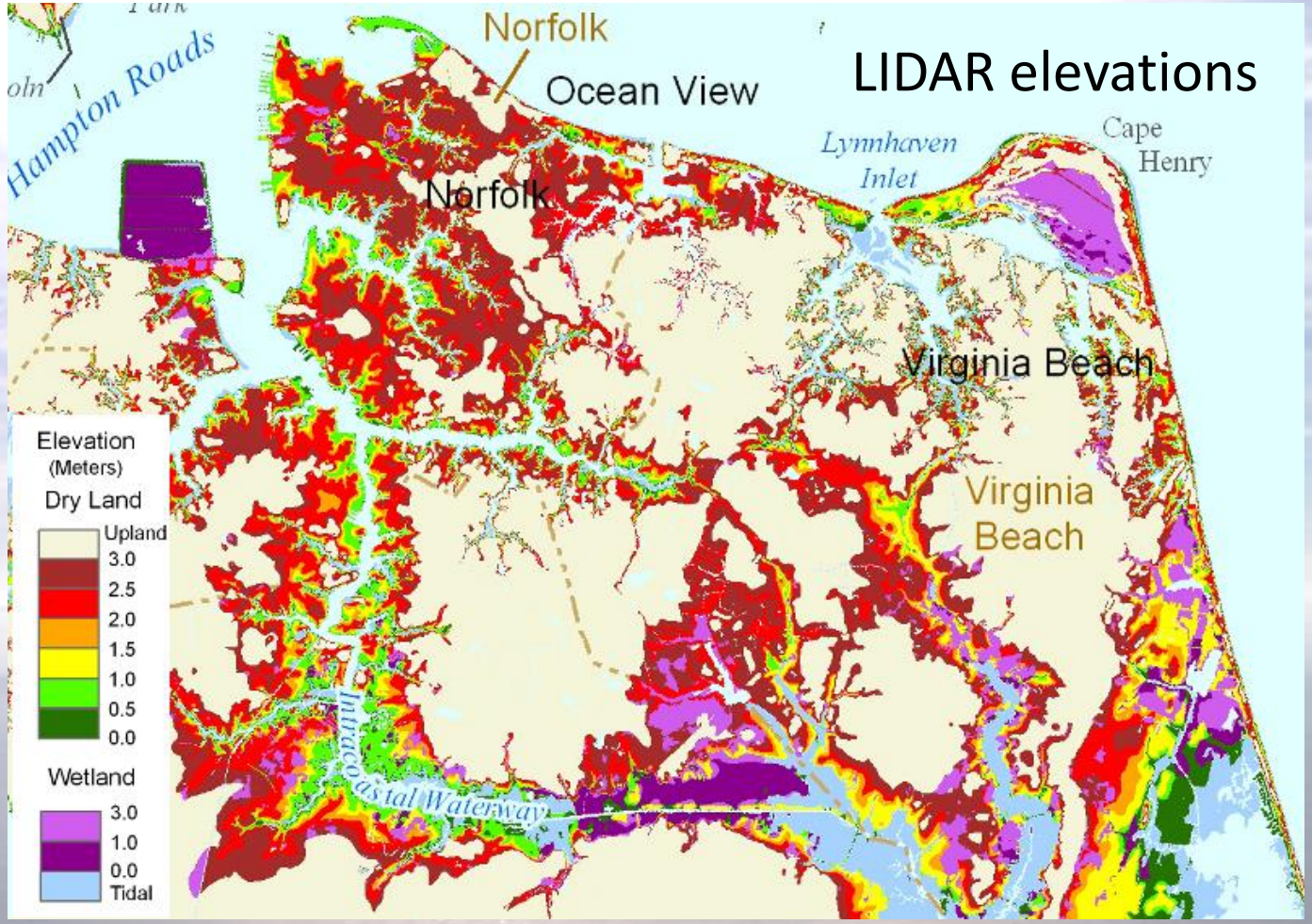
unknowns regarding aggradation and retreat



Kirwan et al. 2016. *Nature Climate Change*

Vulnerability to Sea-Level Rise

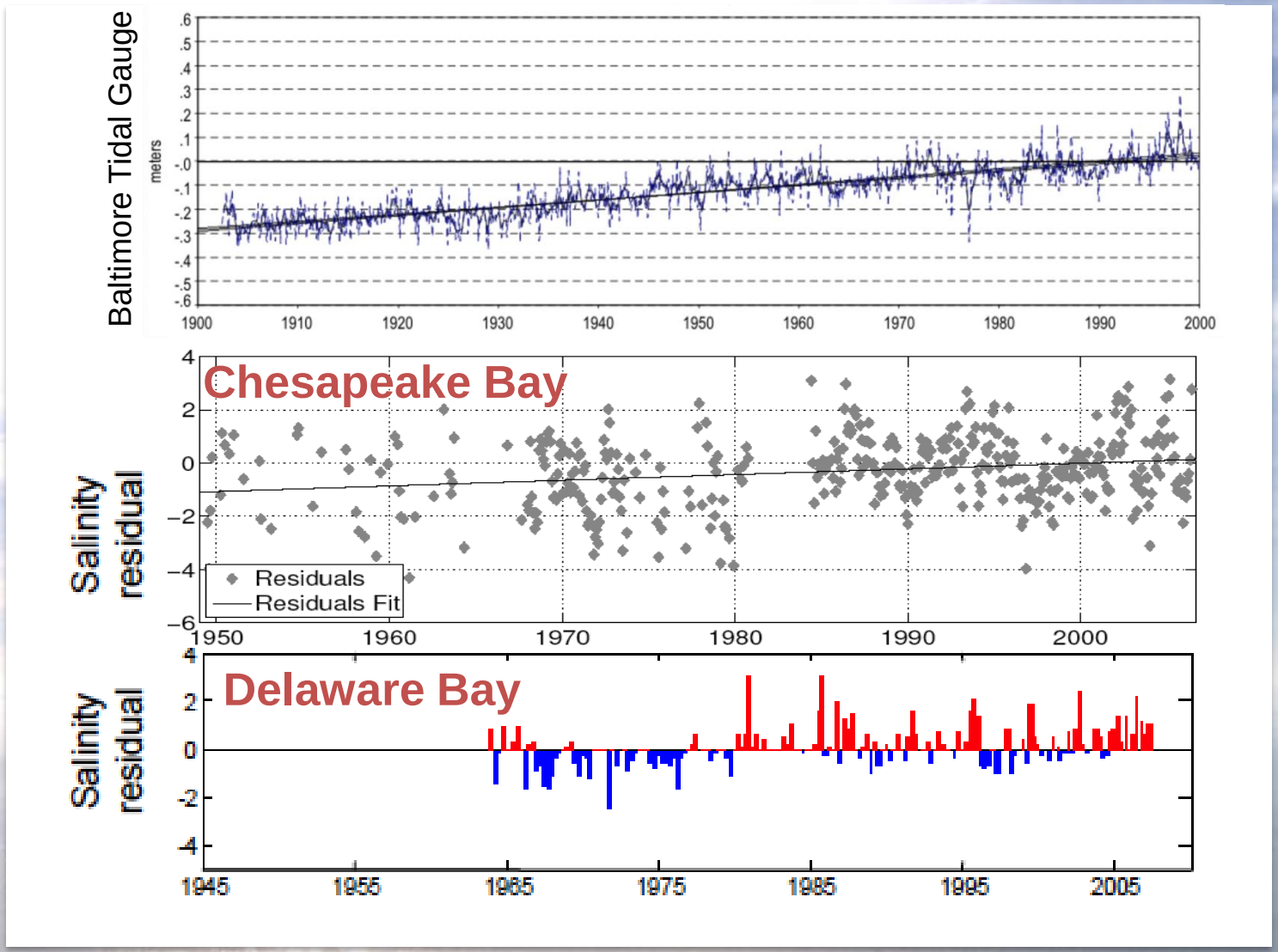
Norfolk-Virginia Beach region



Tidal range 0.9 m
Storm surge up to 3 m

Inundation ~1 m under RCP 8.5

Salinity Is Increasing With Sea-Level

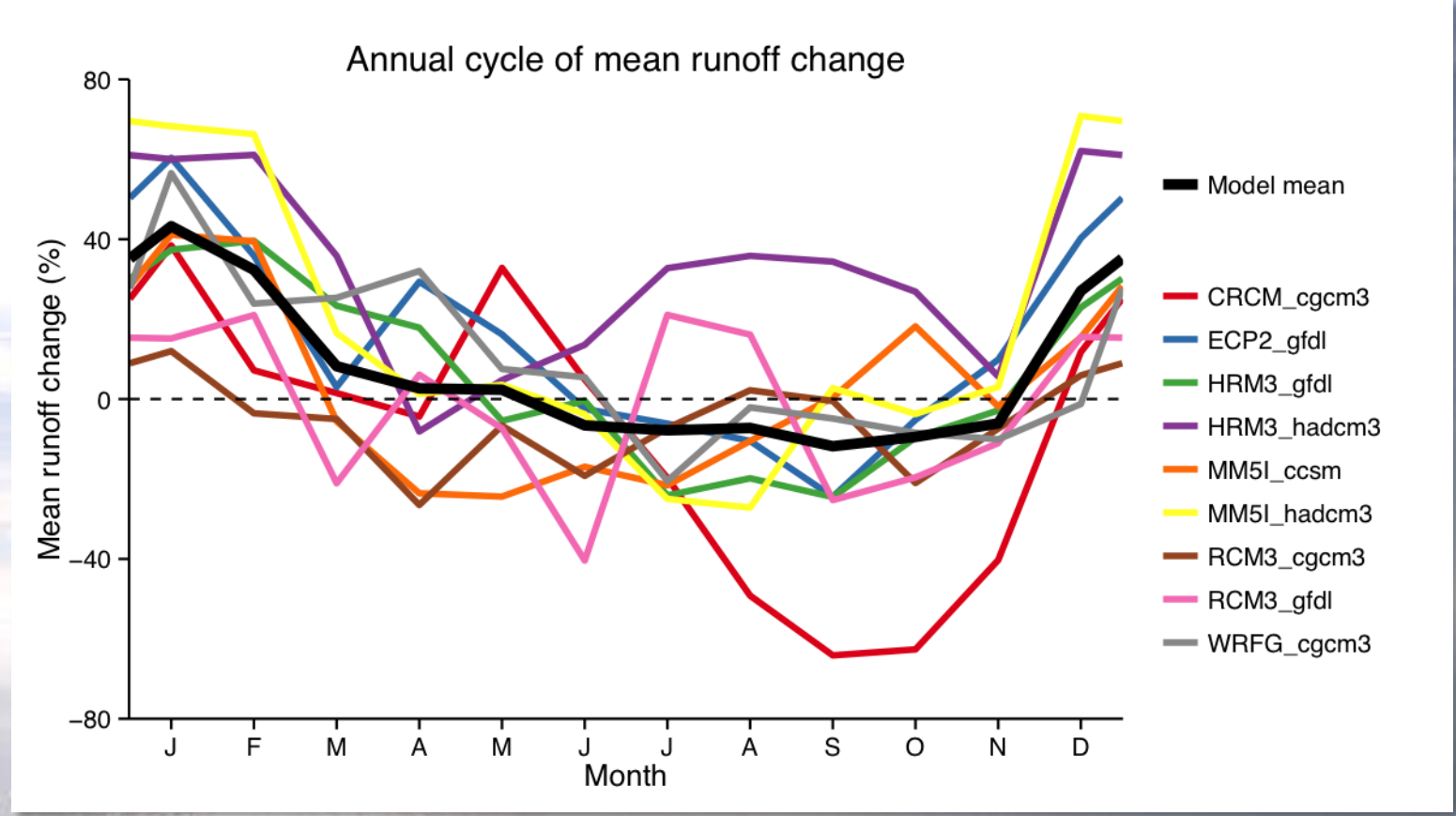


Increased by 1-2 psu over past 50 years with sea-level rise of 20 cm

Hilton et al. 2008, *JGR Oceans*; Ross et al. 2015, *Estuar. Coast. Shelf Sci*.

Projecting Changes in River Flow

regionally downscaled from CMIP-4 models, A2 scenario

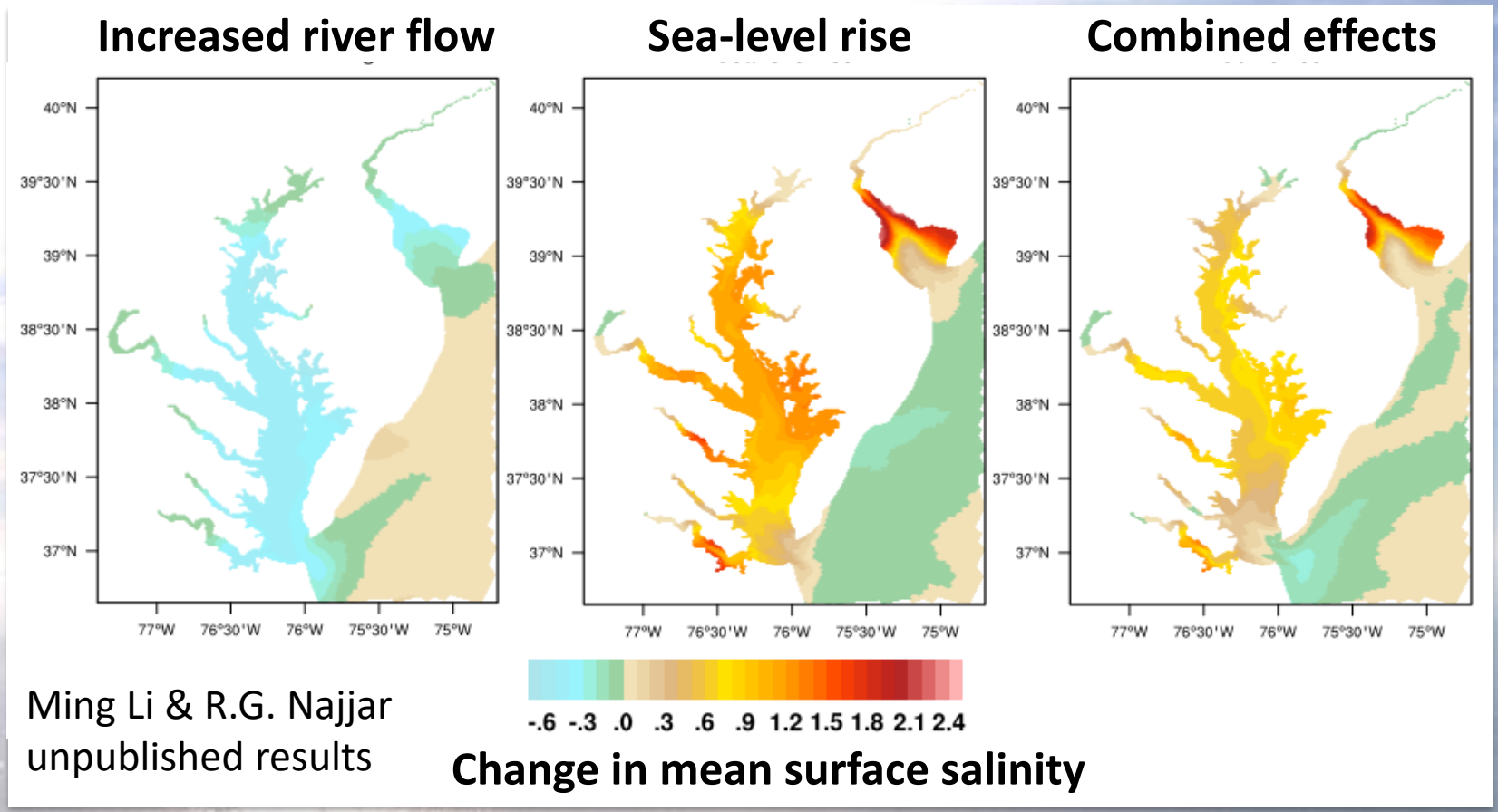


Ensemble-mean projections :

- **winter-spring river increase of 34%**
- **summer flow decrease of 7%**

Ming Li & R.G. Najjar, unpublished results

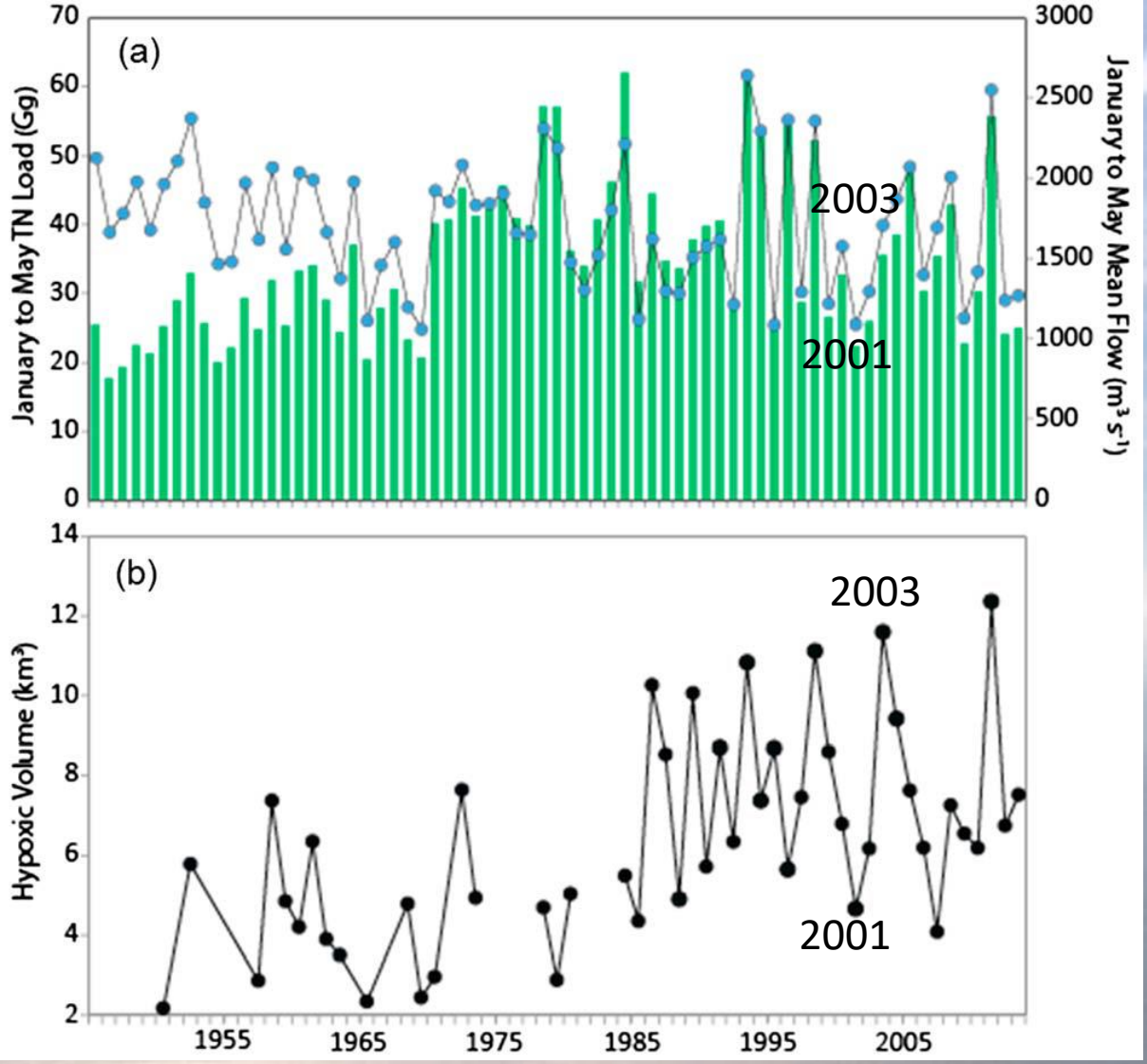
Climate Change Effects on Salinity
downscaled precipitation & ROMS model



- **Salinity decreases by ~ 0.5 psu due to larger winter-spring river flow**
- **Salinity increases by 1-2 psu due to sea level rise**

River Flow & N Loading Affect Hypoxia

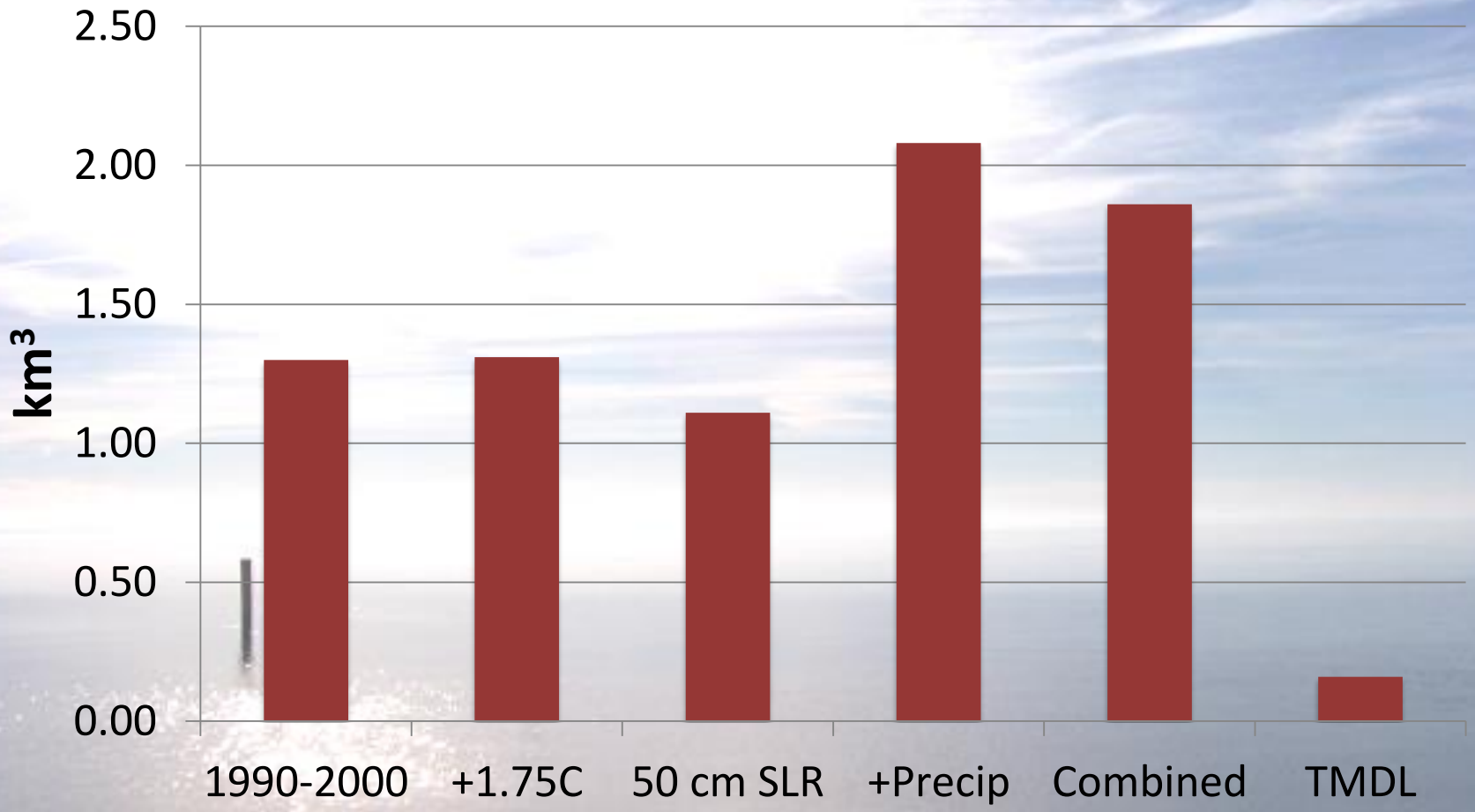
July hypoxic (<2 mg l^{-1}) volume



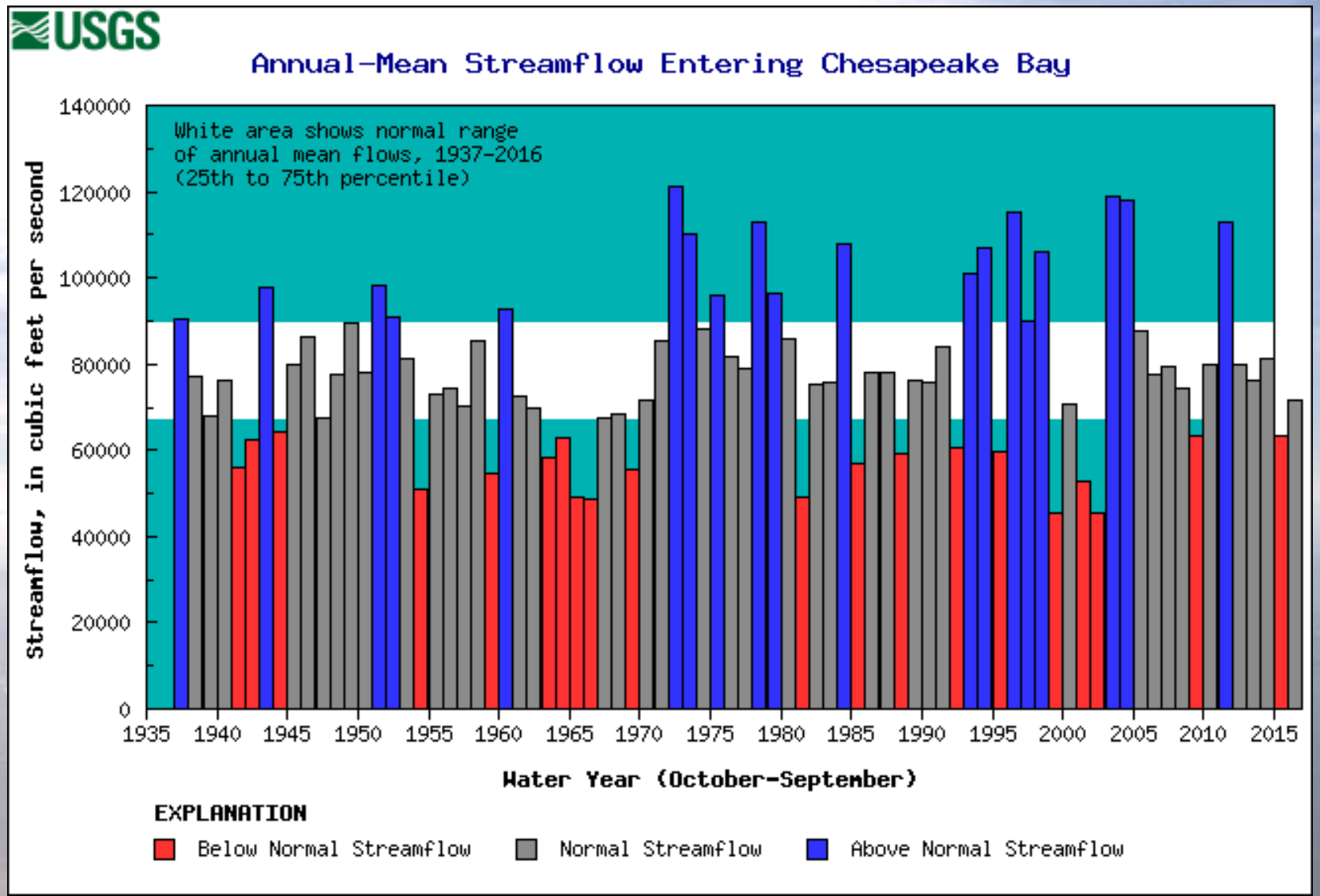
Li et al. 2016. Geophys. Res. Lett. 43, 2127-2134

CBP Management Model Projections

average summer anoxic volume

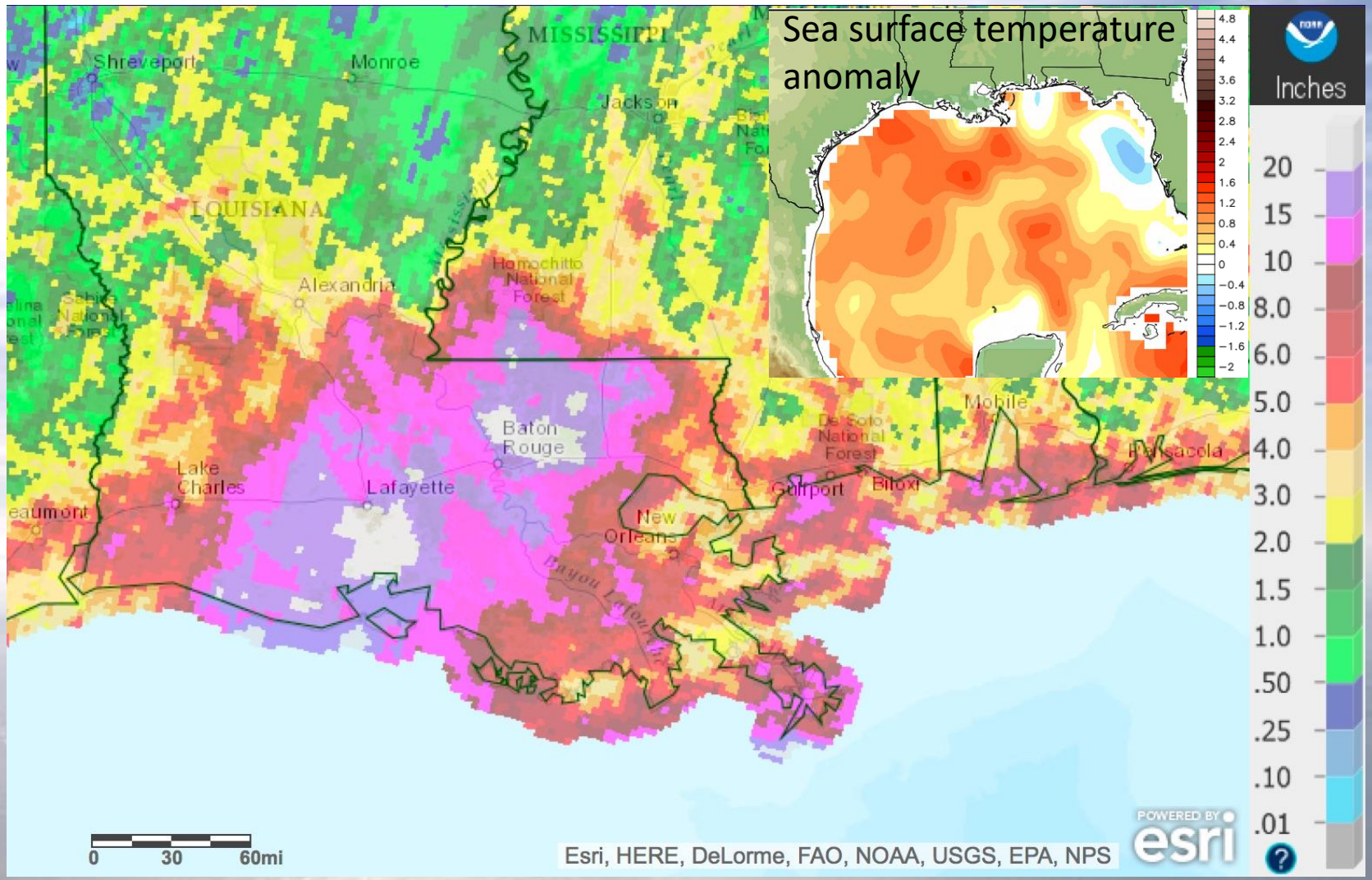


Changes in Streamflow the Wild Card
influenced by decadal climate cycles



Extreme Events Linked to Climate Change

August 2016 Louisiana floods



Maryland's Climate Change Strategy
manage unavoidable, avoid unmanageable

- **Mitigation**
  - Greenhouse Gas Reduction Act- 40% reduction by 2030
  - Regional Greenhouse Gas Initiative, EmPOWER, RPS, etc.
- **Adaptation and Response**
  - Coast Smart
  - Sector strategies, incl. Chesapeake Bay
- **Education, Communications and Outreach**
  - MADE CLEAR – climate change education
- **Science and Technology**
  - Impact assessment and sea-level rise projections
  - Green Energy Institute

boesch@umces.edu
www.umces.edu/people/president
@DonBoesch