Implications of Climate Change for Chesapeake Bay Restoration

Science • Consequences • Policy Opportunities

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Opinions Don't Differ Across Region

Fundamentals of climate change	PA	DE	MD	VA
Global warming is happening	79%	85%	82%	81%
Warming will continue in future	69%	71%	79%	65%
Past warming caused by humans	76%	73%	84%	77%
Warming will be serious US problem	77%	85%	83%	76%
5°F warming in 75 years will be bad	44%	54%	52%	60%

Source: Jon Krosnick, Stanford University climatepublicopinion.stanford.edu

Opinions of Virginians

<1 in 20 chance that most warming not caused by human activities - IPCC

Climate change cause	Total	Democrat	Independent	Republican
Mostly by human activities	31%	43%	29%	18%
Mostly by natural changes	22%	16%	20%	33%
More or less equally by both	36%	32%	40%	32%
By other things	2%	2%	1%	4%
Global warming isn't happening	7%	4%	8%	12%
Don't know	2%	2%	2%	2%

Based on survey of Virginians who watch TV news at least once a week
Source: George Mason University www.climatechangecommunication.org

Opinions of Virginians

~97% of climate scientists agree human-induced climate change is occurring

Scientific consensus	Total	Democrat	Independent	Republican
Most scientists: climate change happening	43%	51%	40%	33%
Most scientists: climate change NOT happening	<1%	0%	1%	1%
Lot of scientific disagreement	34%	21%	39%	43%
Don't know enough to say	23%	27%	19%	23%

Based on survey of Virginians who watch TV news at least once a week
Source: George Mason University www.climatechangecommunication.org

Public Opinions on Global Warming

Alarmed **Concerned** **Cautious** **Disengaged** **Doubtful** **Dismissive**

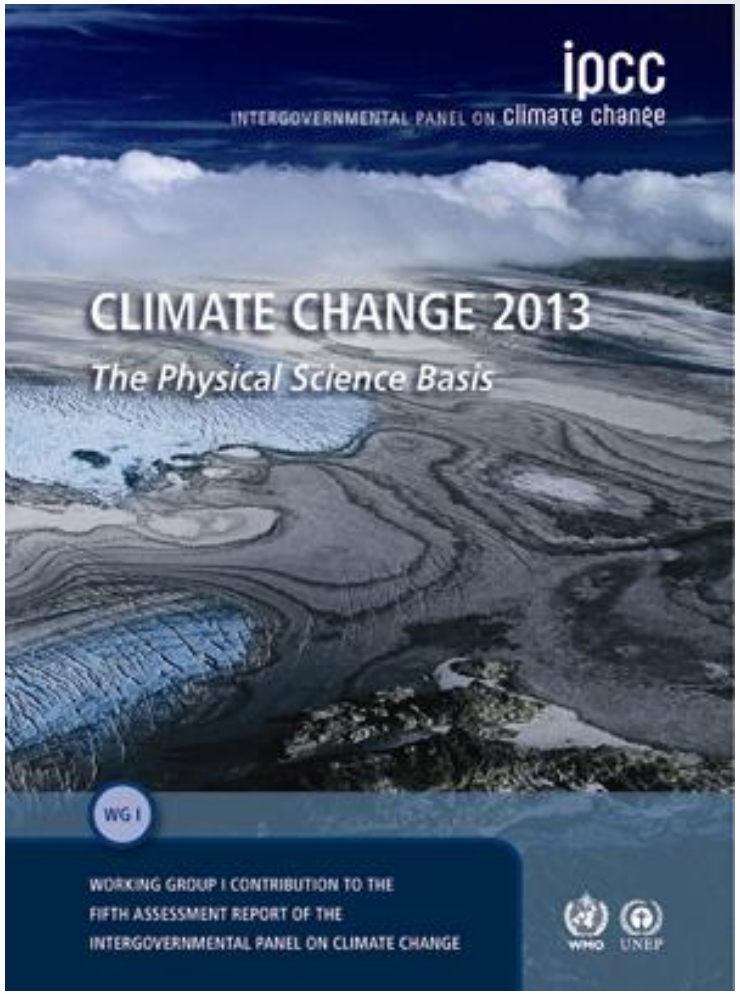
Highest Belief in Global Warming
Most Concerned
Most Motivated

Lowest Belief in Global Warming
Least Concerned
Least Motivated

US	**16%**	**26%**	**25%**	**5%**	**15%**	**13%**
MD	**23%**	**39%**	**19%**	**5%**	**10%**	**5%**
ES	**21%**	**35%**	**24%**	**4%**	**11%**	**6%**

George Mason University
www.climate changecommunication.org

Intergovernmental Panel on Climate Change 5th Assessment



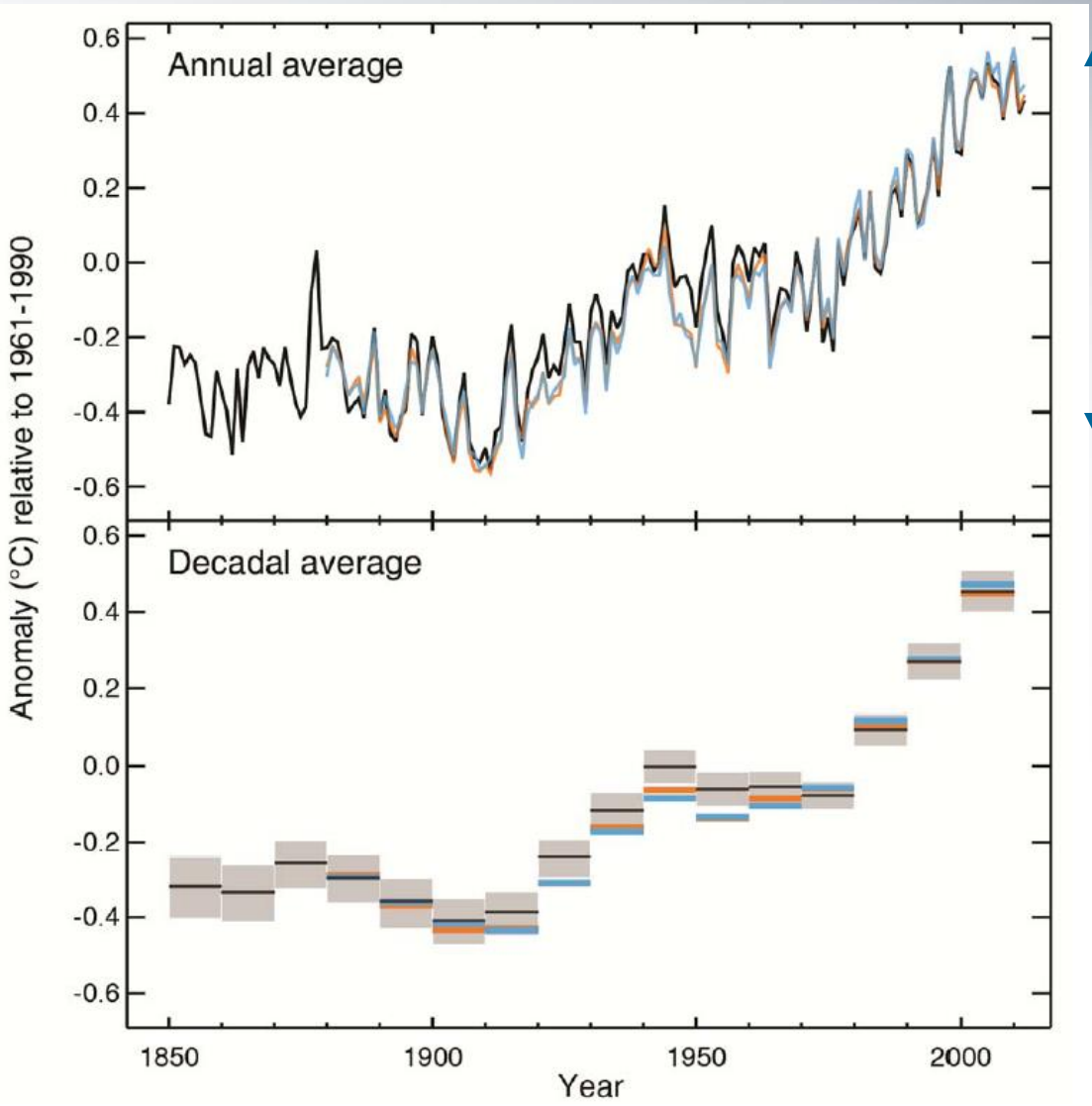
It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.

Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

www.ipcc.ch

How Much Has It Warmed?

Global average land and ocean temperature



about 0.9°C or 1.6°F

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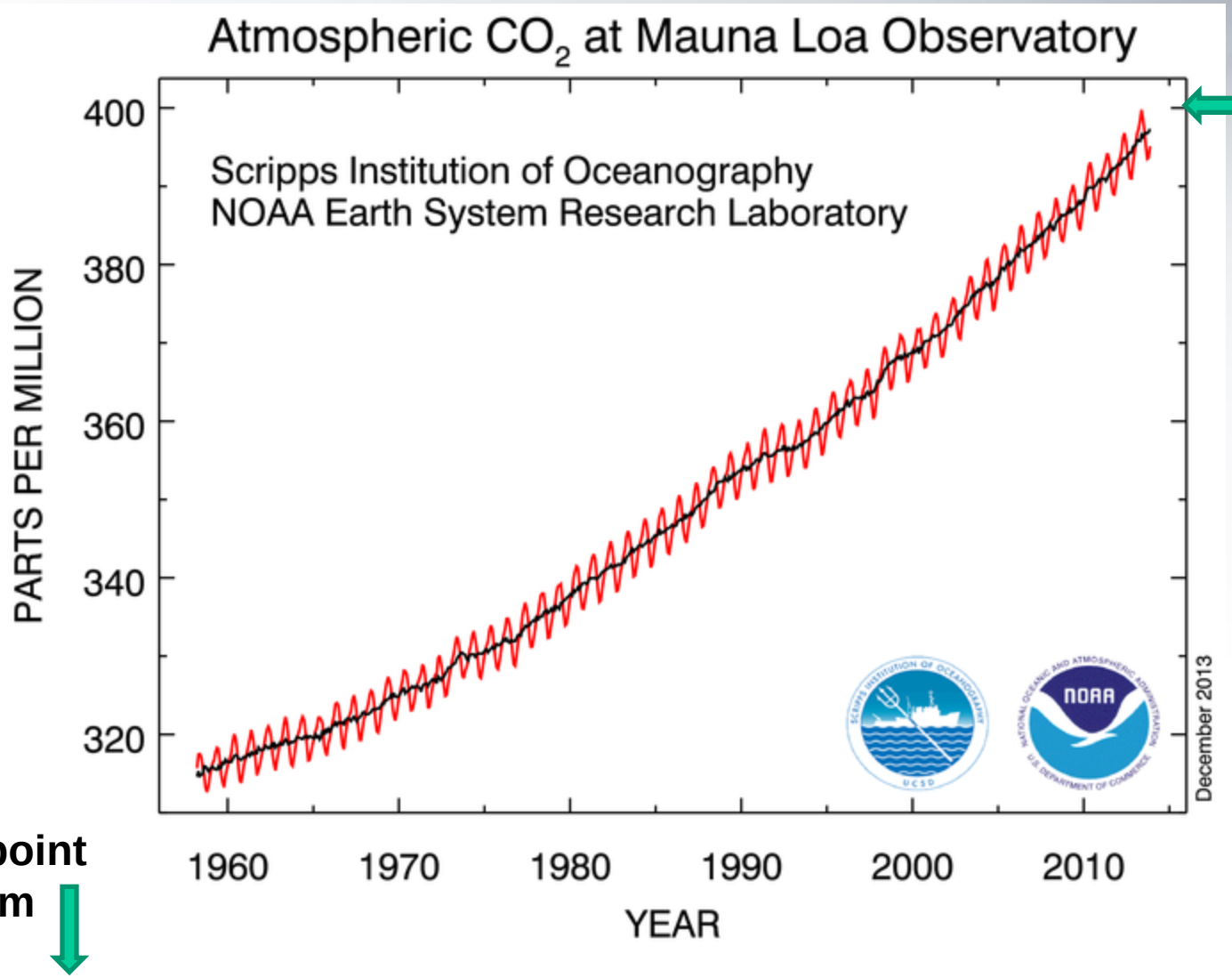
Increase in Atmospheric CO_2

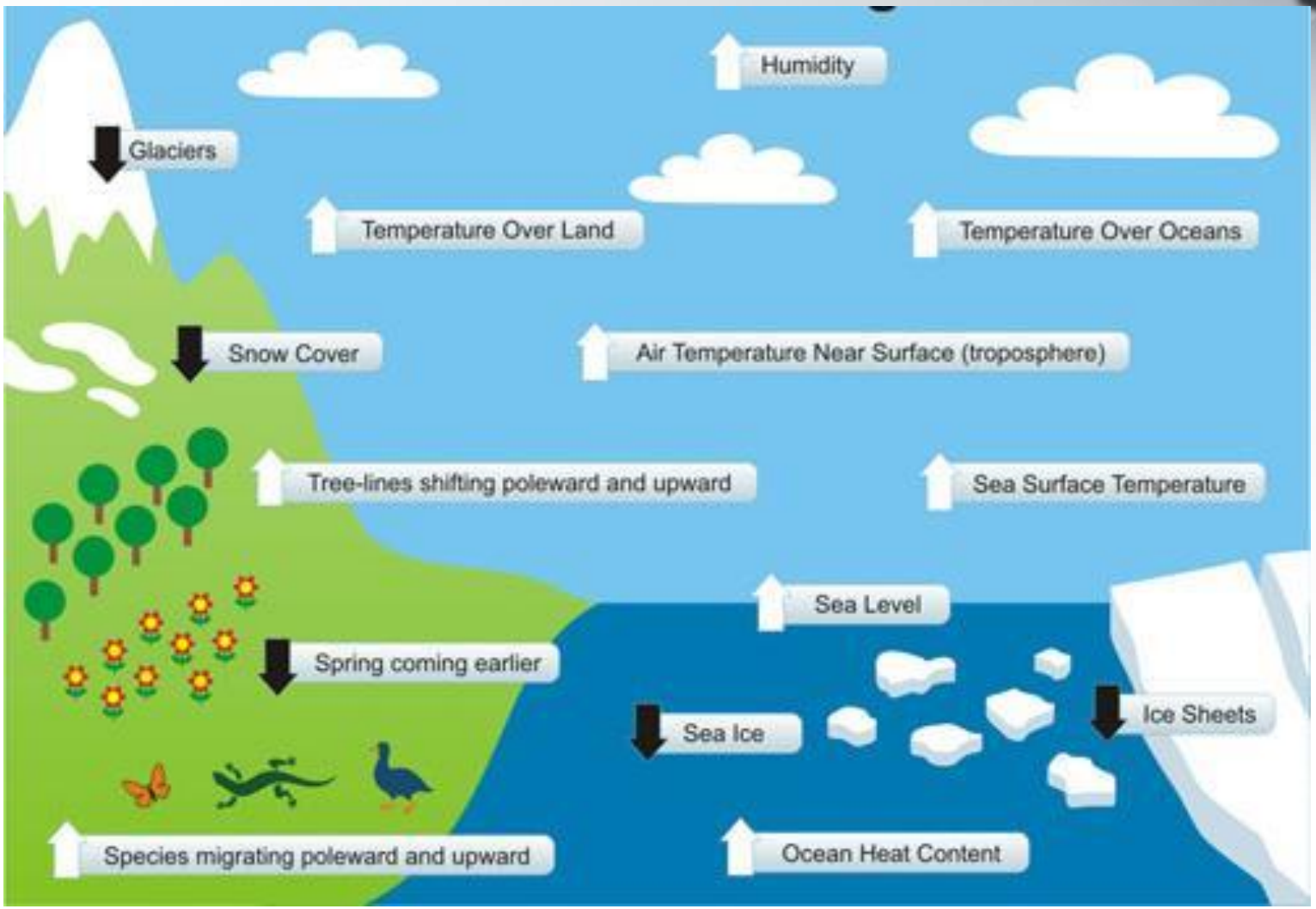


Crossed 400 ppm this May

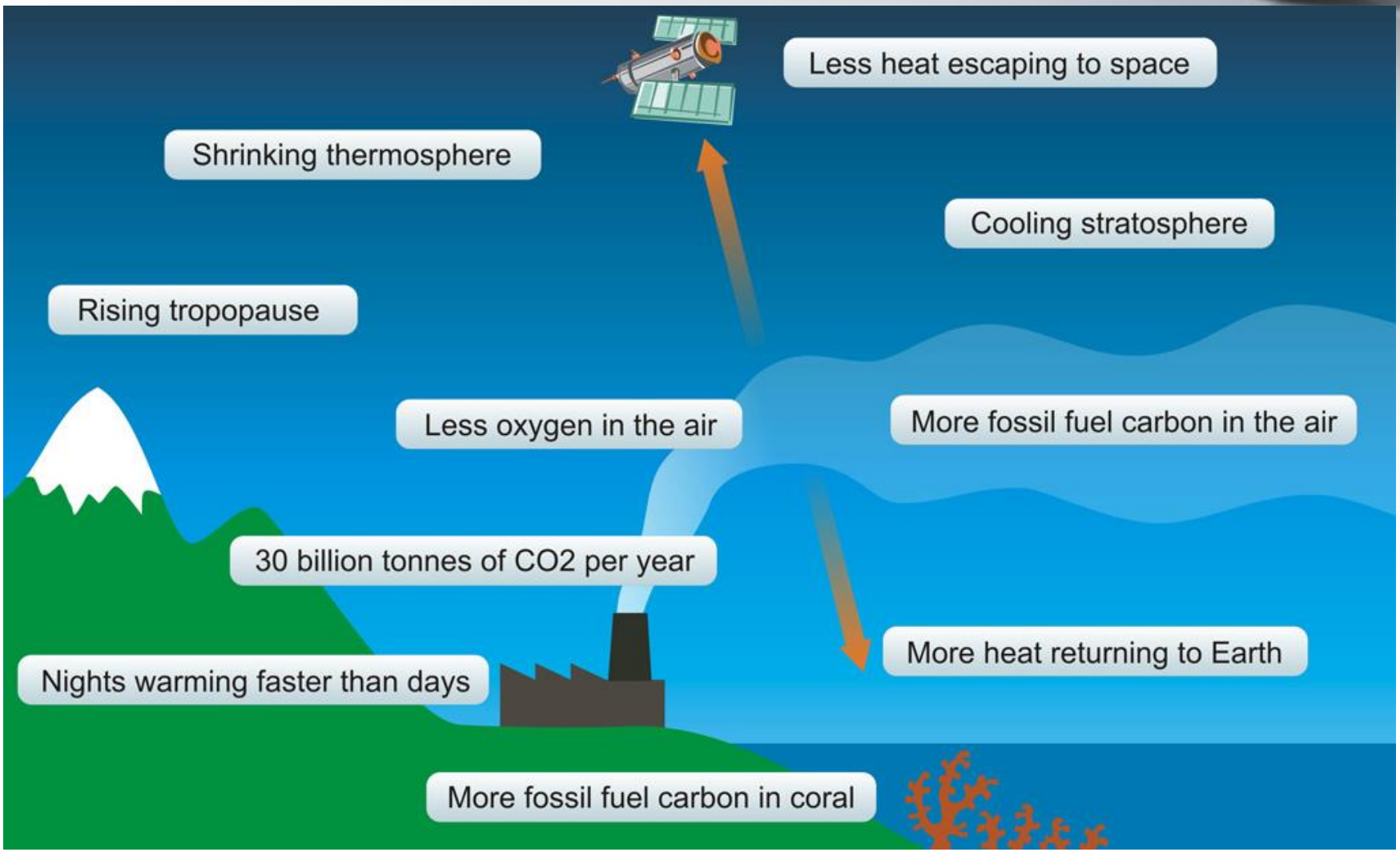
Today 397.6 ppm

Starting point 280 ppm

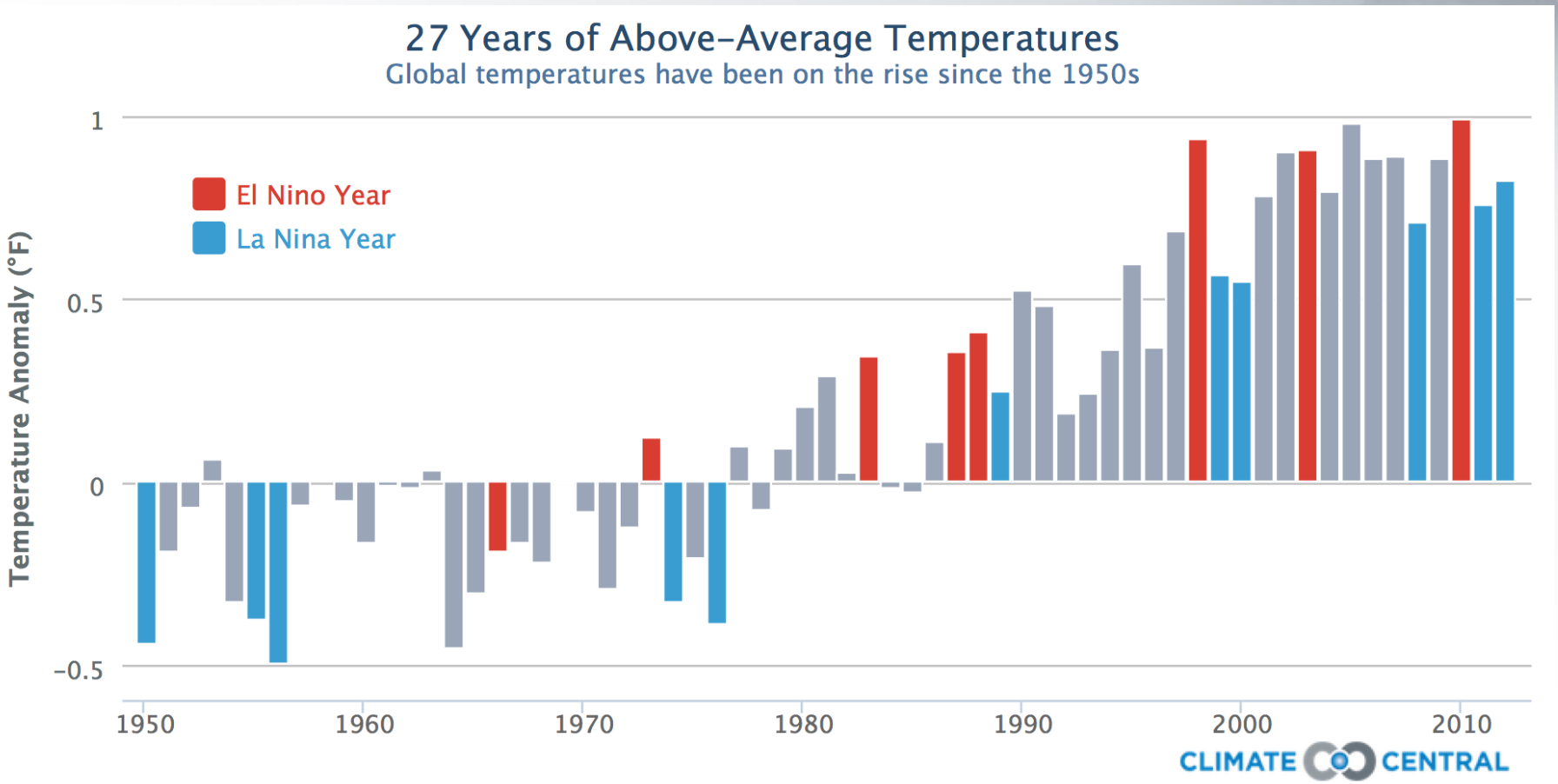
Indicators of a Warming World



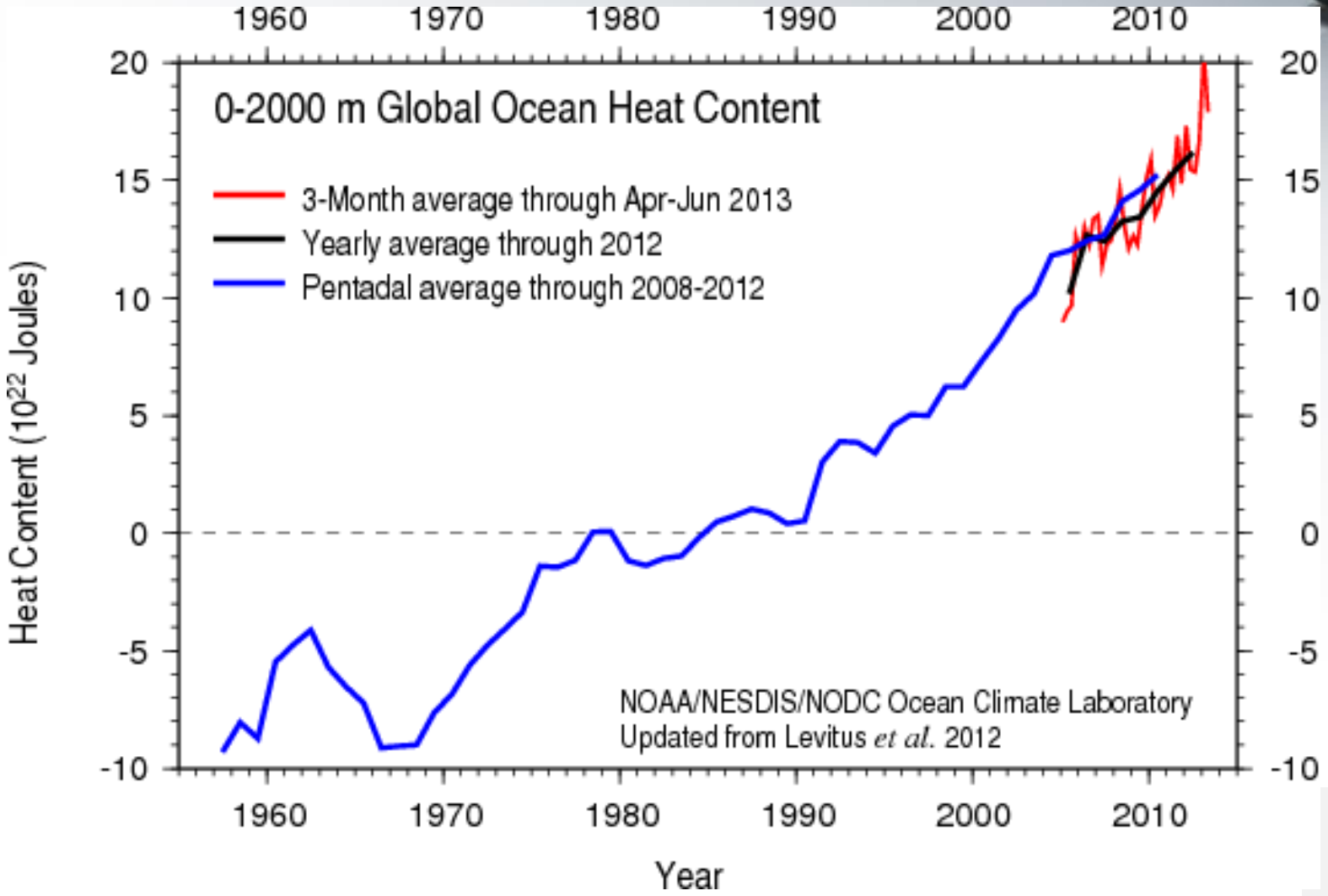
Fingerprints Confirming Human Cause



Has Global Warming Paused?



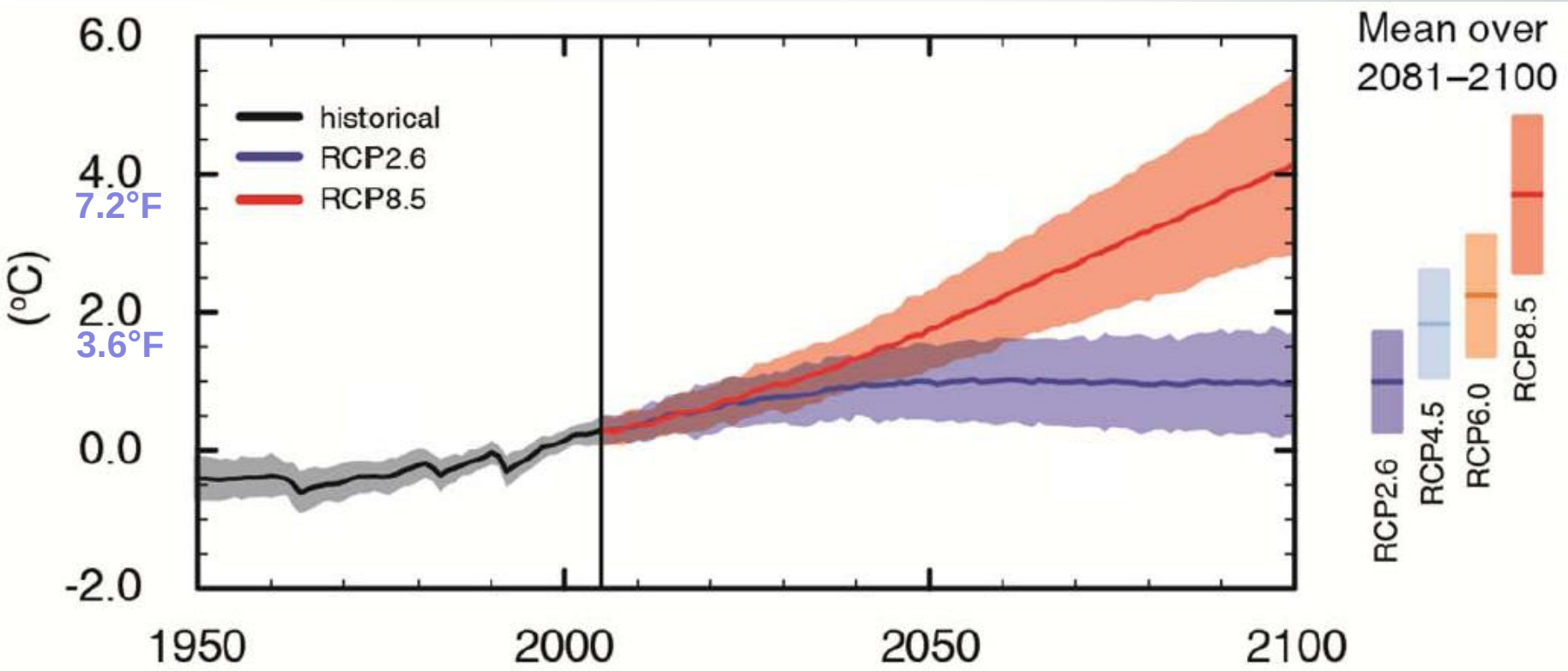
Heating Has Continued in Ocean



How Much Will it Warm?

It mainly depends on how much greenhouse gases we emit.

Global average surface temperature



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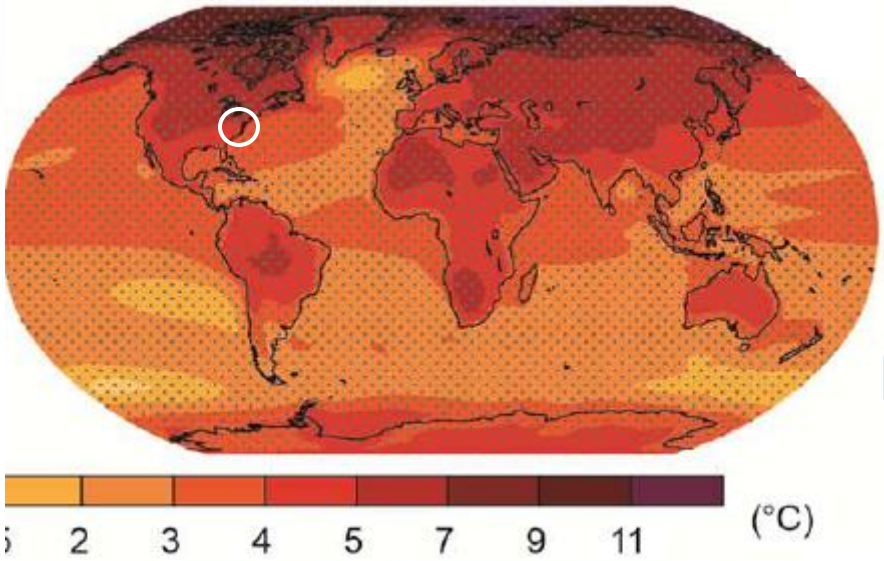
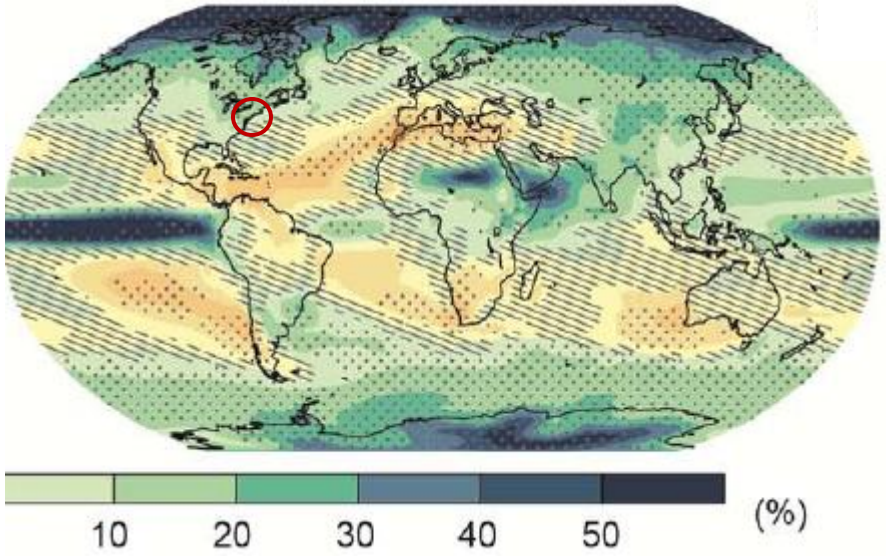
RCP8.5 = 'business as usual' continued growth in emissions

RCP2.6 = rapid reductions in GHG emissions to 0 by 2070

Changes Will Vary Greatly





RCP8.5 Scenario for 2081-2100

Annual mean surface temperature
[Chesapeake region warms more than global average]

Average percent change in annual mean precipitation
[~10% increase in Chesapeake region, mainly winter-spring]

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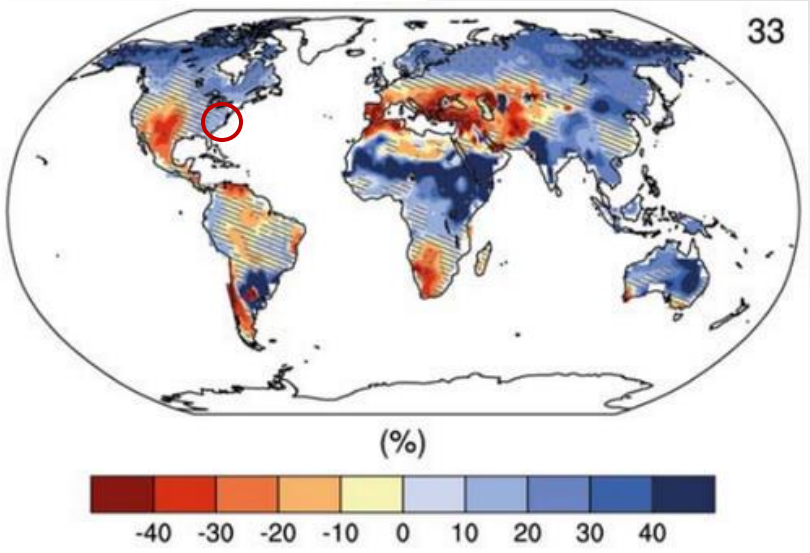
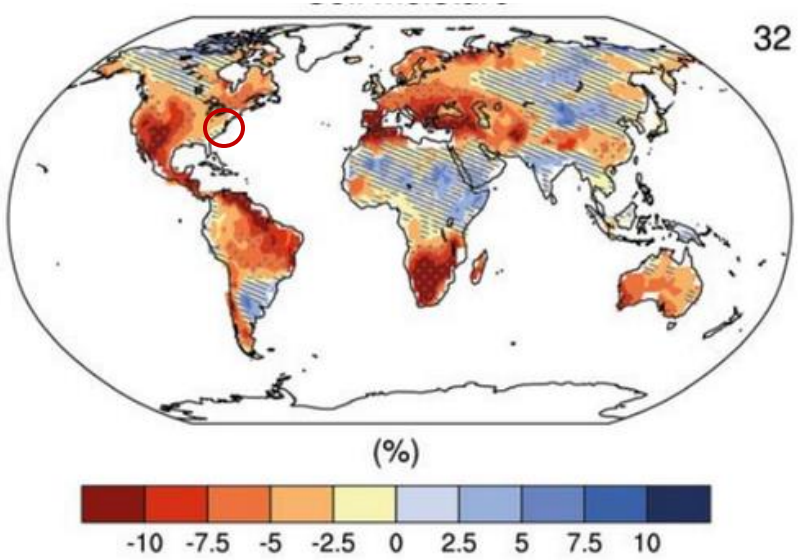
Changes Will Vary Greatly





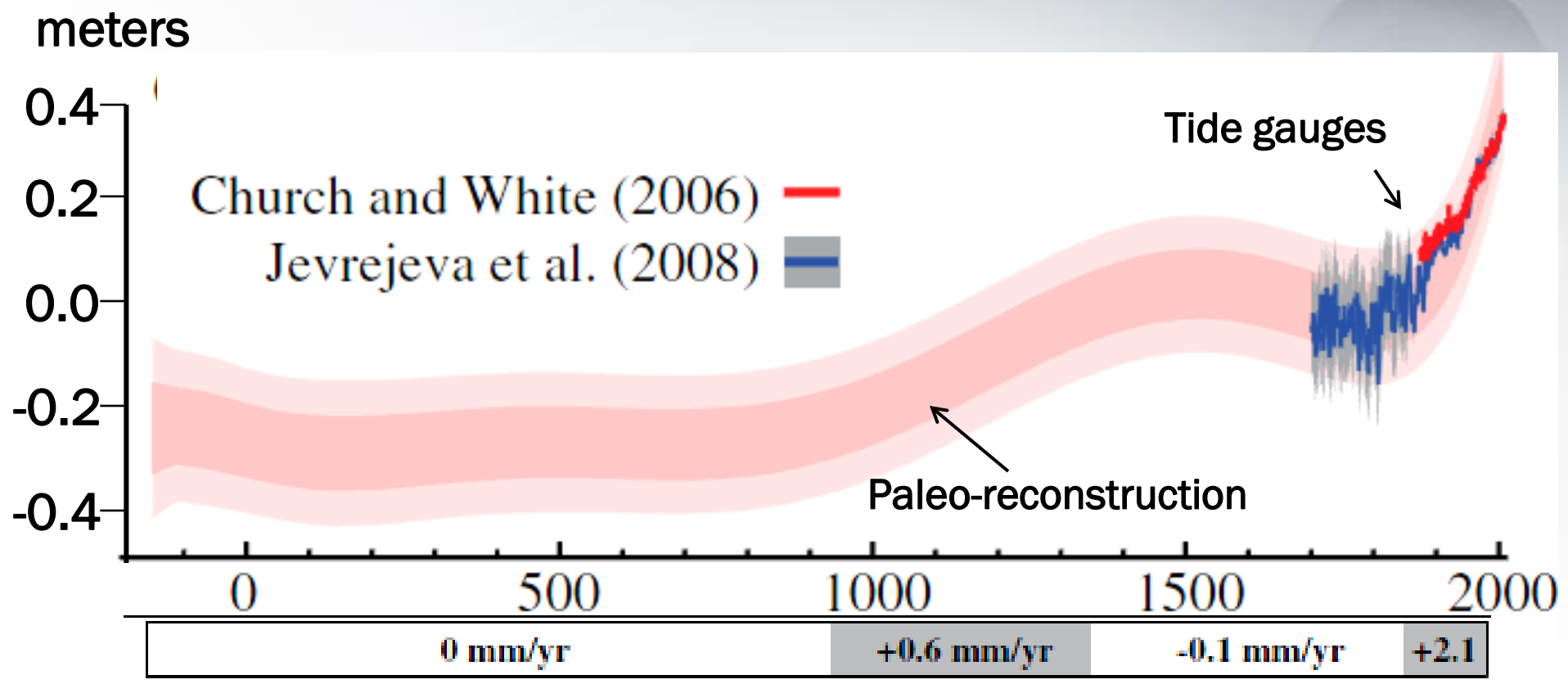
RCP8.5 Scenario for 2081-2100

Average percent change in runoff
[some increase in runoff to Chesapeake Bay, but models don't agree]

Average percent change in soil moisture
[drier conditions in growing season in Chesapeake basin]

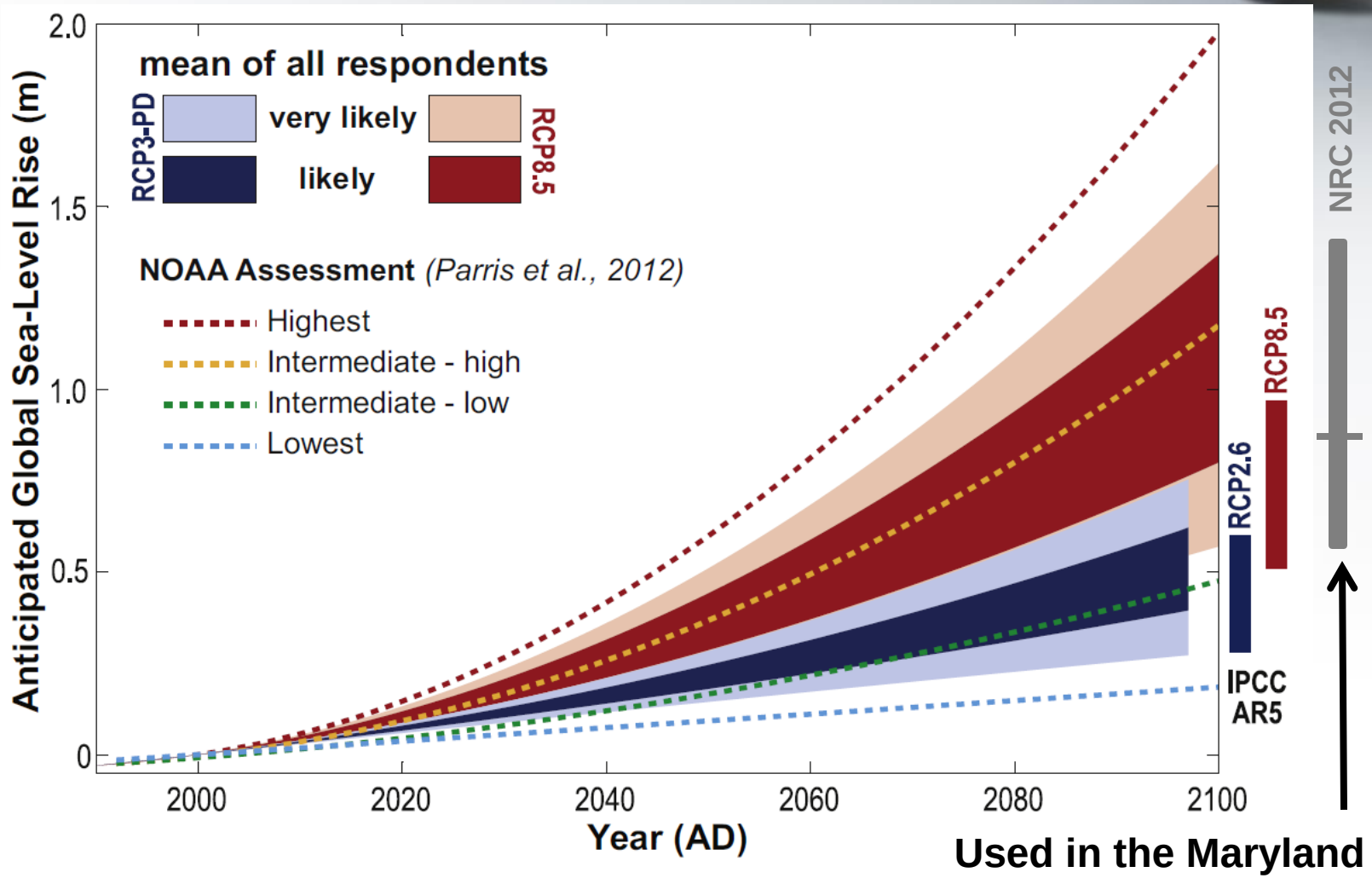
www.ipcc.ch

Sea Level Had Been Stable 2000 Years



Kemp et al. 2011. *Proc. National Acad. Sci*

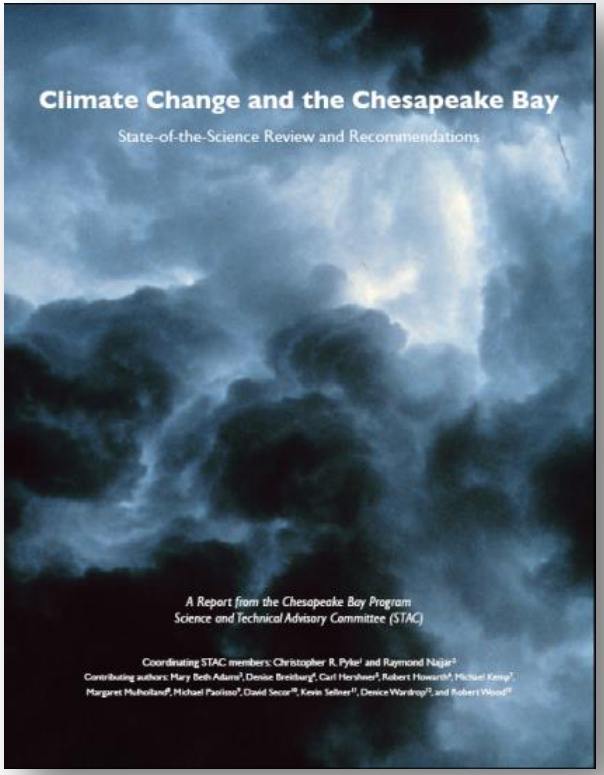
How Much Will the Seas Rise?

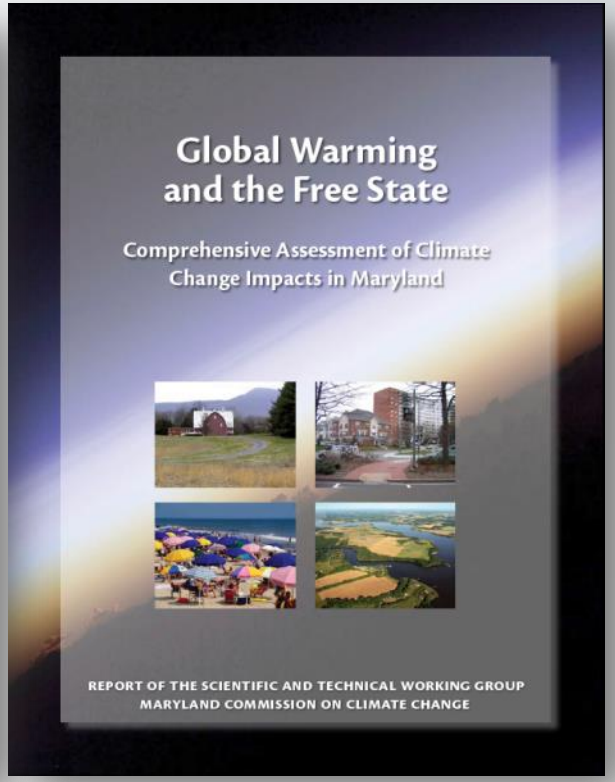


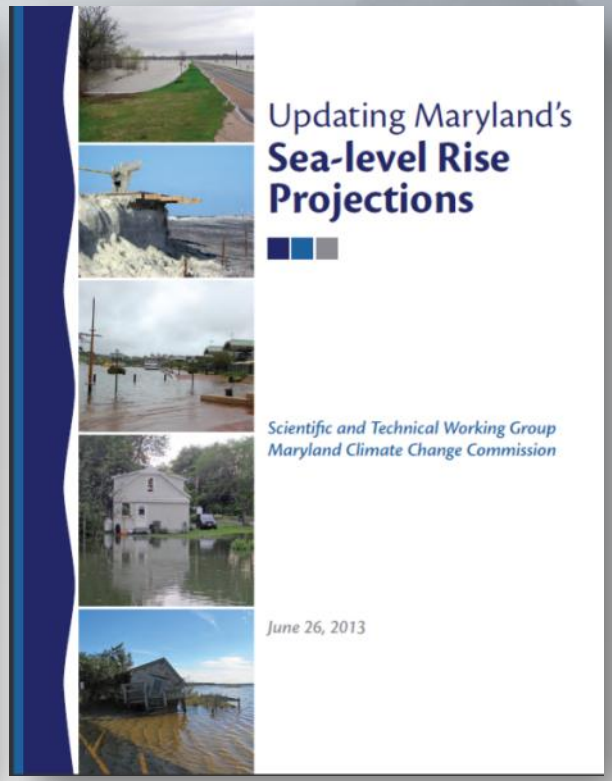
Used in the Maryland sea-level rise update

Horton et al. 2013 *Quaternary Science Reviews* 84:1

Chesapeake Climate Change Assessments



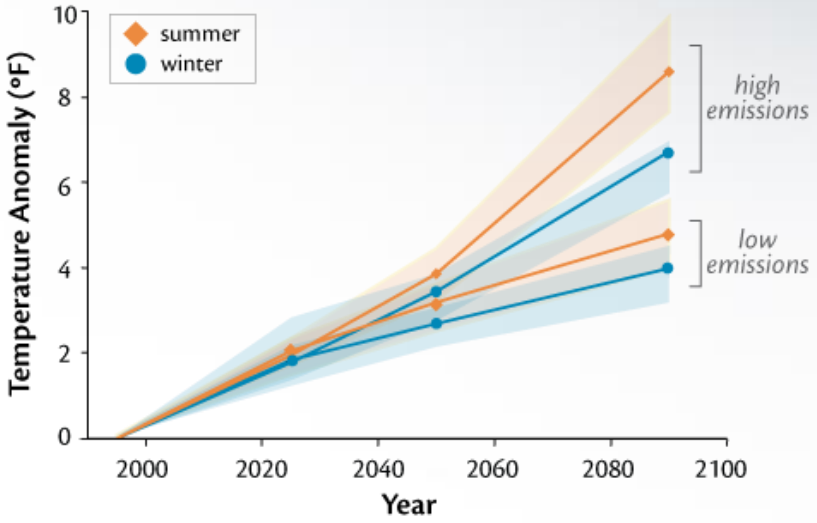


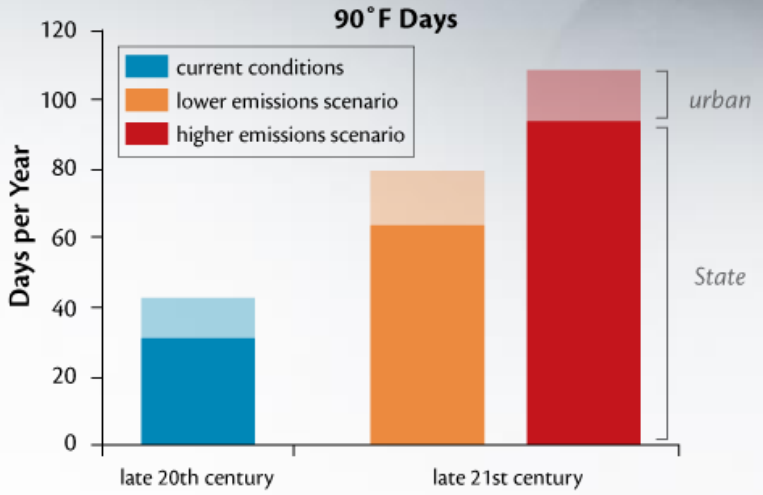


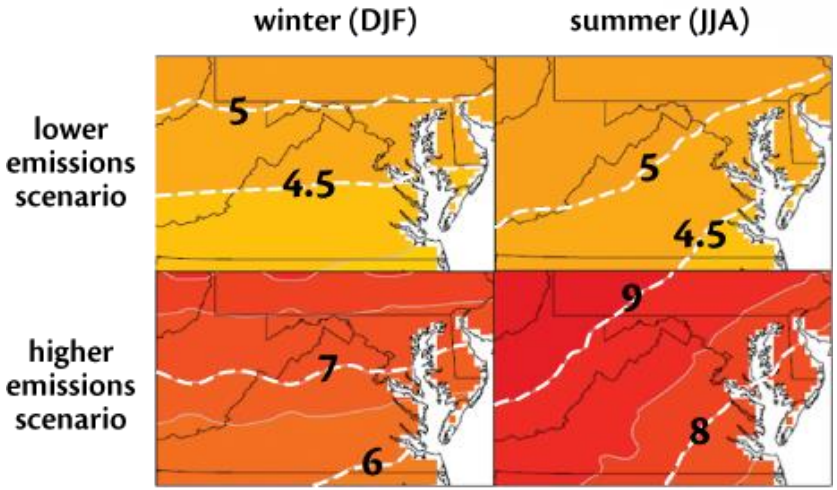
www.chesapeake.org/stac/Pubs/climchangereport.pdf

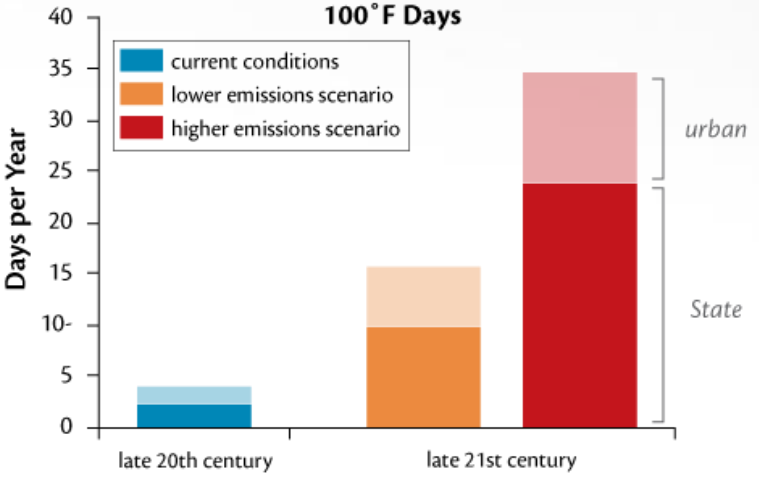
climatechange.maryland.gov

Milder Winters, Hotter Summers



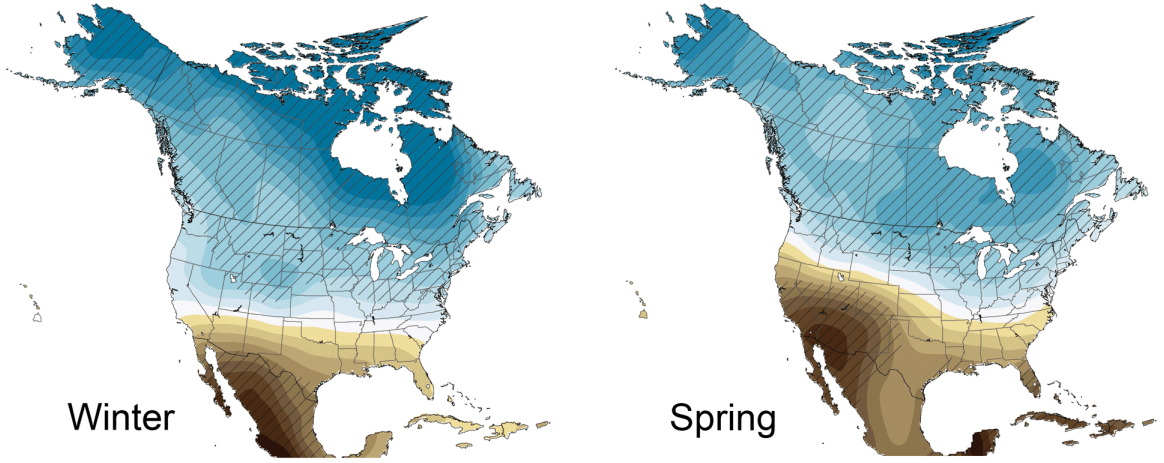




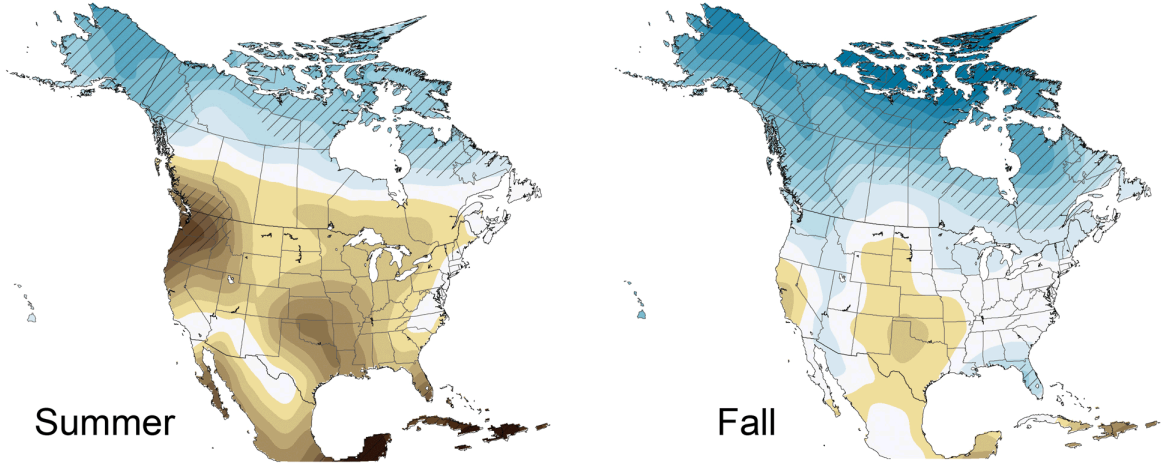


www.umces.edu/applying-science/global-warming-free-state-highlights

Projected Changes in Precipitation



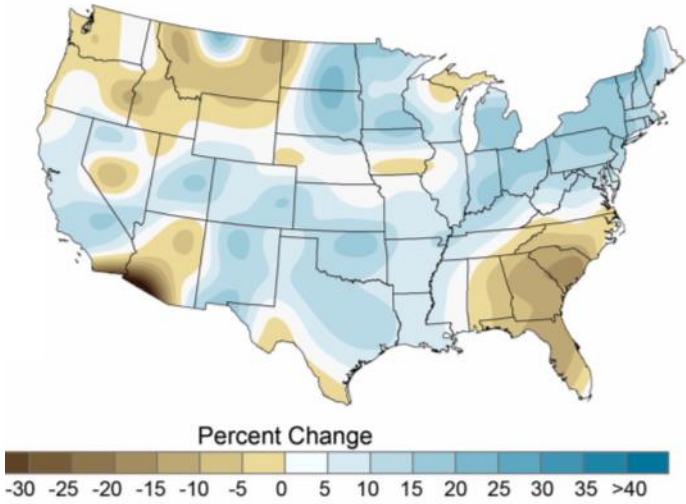
by 2080-90s



Percent Change

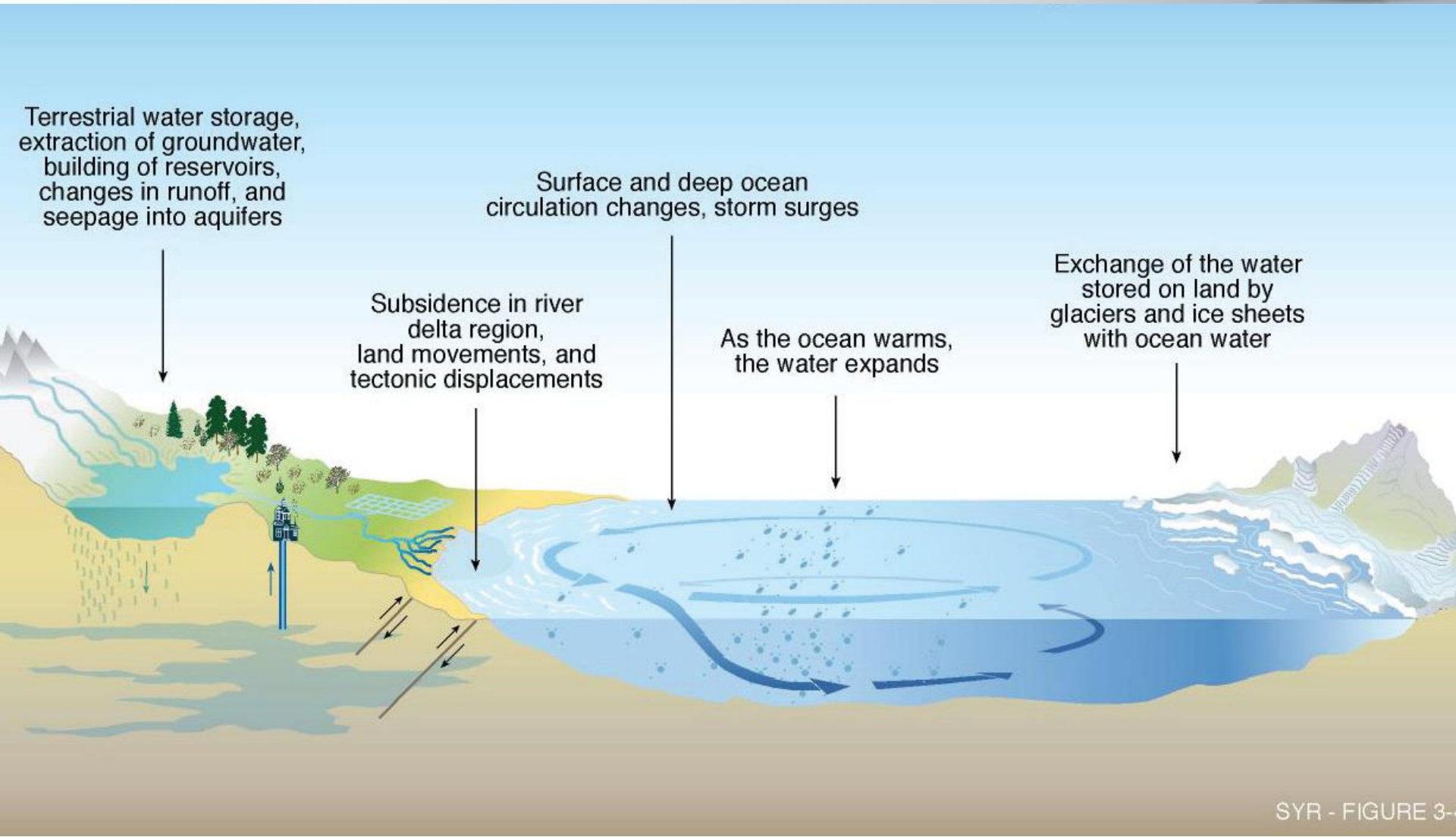
<-40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 >40

Observed annual change 1950-2008



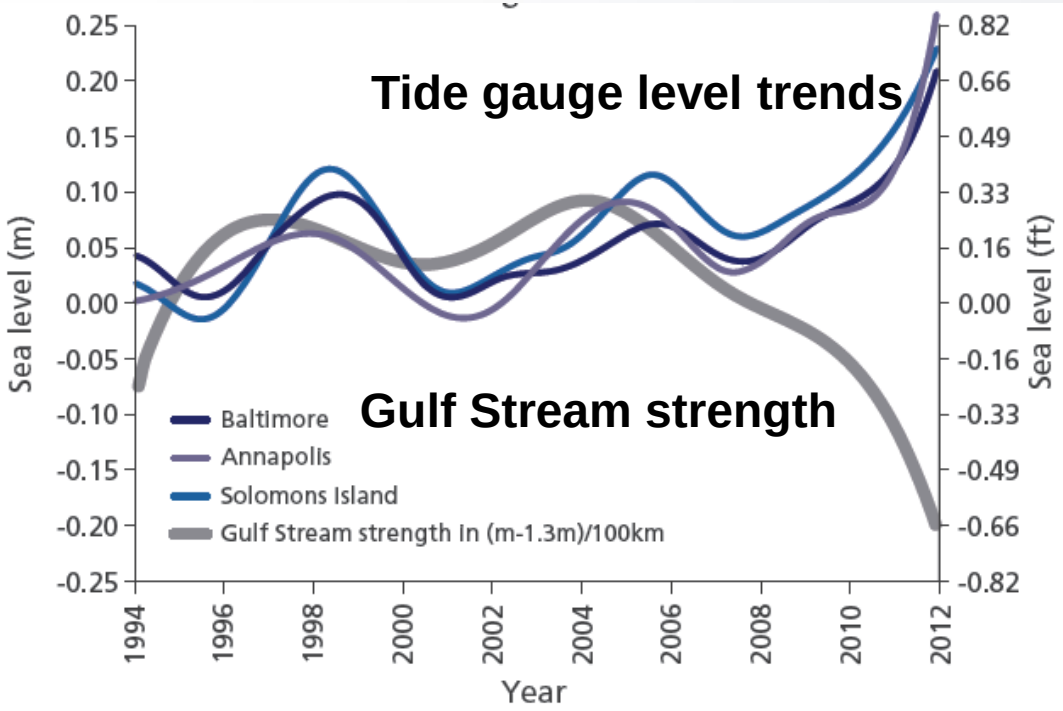
www.globalchange.gov/

Factors that Influence Sea-Level Changes



SYR - FIGURE 3-

Slowing of Gulf Stream Raises Sea Level

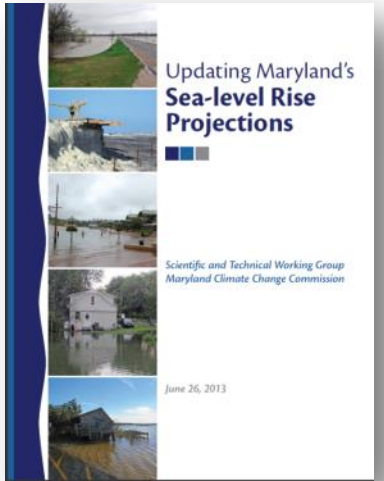


Based on work of Tal Ezer and colleagues, Old Dominion University

J. Geophysical Research 118:685

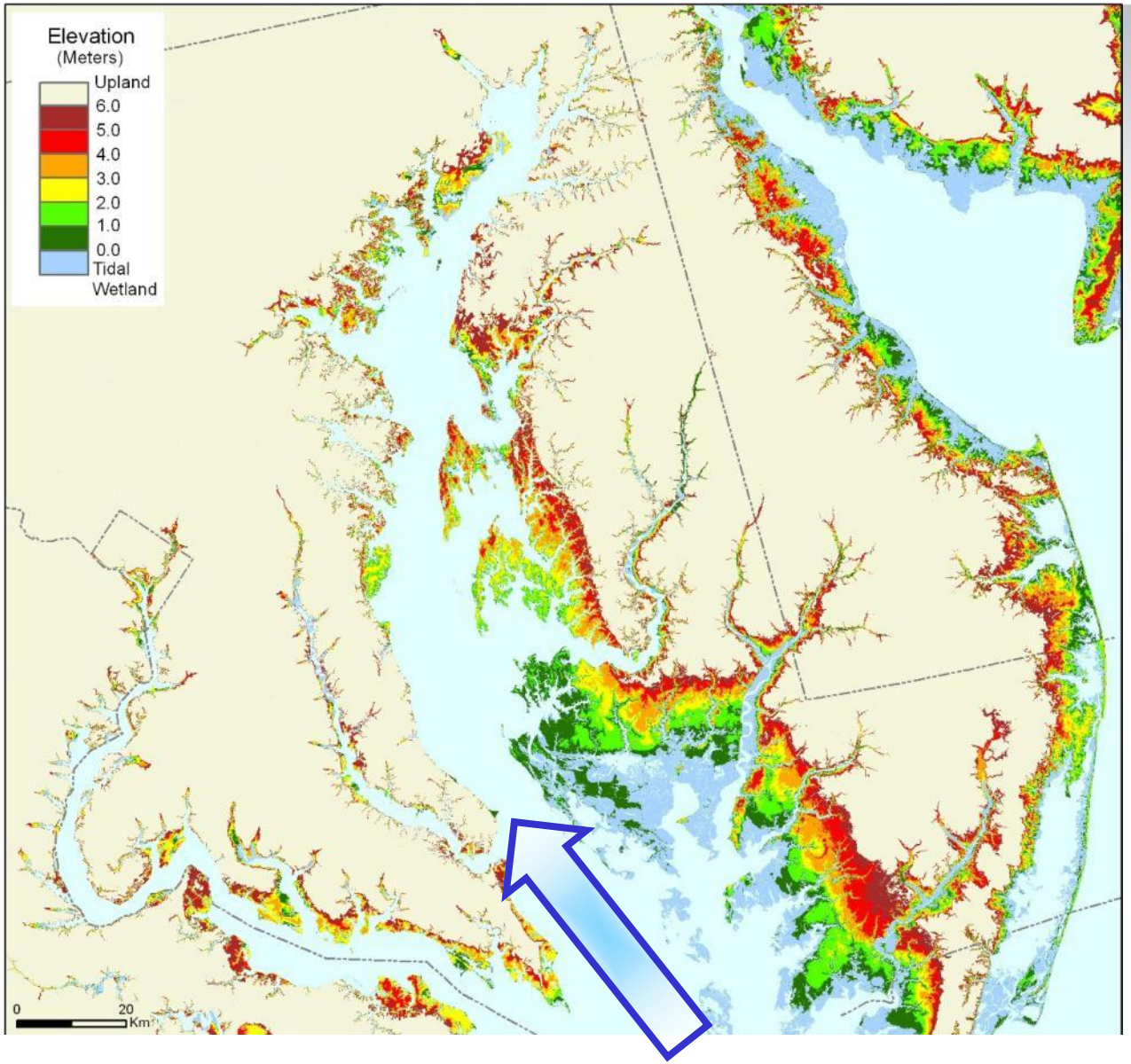
How Much Will Sea Level Rise in the Chesapeake Bay?

Maryland Relative Sea-level Rise	Thermal (m)	Glaciers (m)	Greenland (m)	Antarctica (m)	Dynamic (m)	VLM (m)	Relative SLR meters	Relative SLR feet
2050 best	0.10	0.05	0.03	0.09	0.09	0.075	0.4	1.4
2050 low	0.04	0.05	0.02	0.04	0.07	0.065	0.3	0.9
2050 high	0.19	0.06	0.05	0.16	0.10	0.085	0.7	2.1
2100 best	0.24	0.13	0.10	0.30	0.17	0.15	1.1	3.7
2100 low	0.10	0.12	0.08	0.10	0.13	0.13	0.7	2.1
2100 high	0.46	0.17	0.17	0.58	0.19	0.17	1.7	5.7
Land ice change fingerprint scale factors		0.9	0.5	1.25				



climatechange.maryland.gov

Consequences of Sea-Level Rise



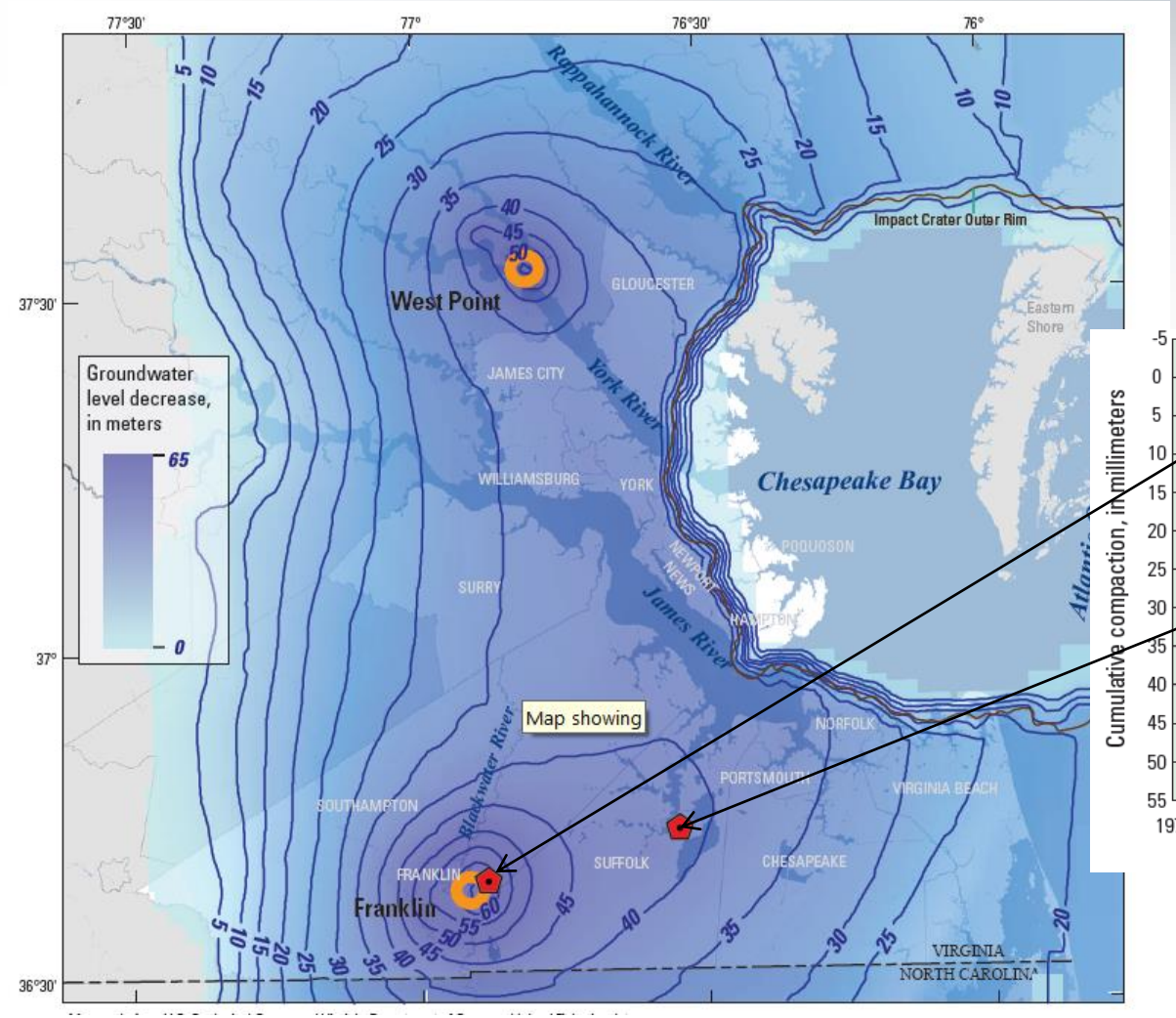
Light blue: salt marshes

Greens: < 2 m, susceptible to innundation

Orange-yellow: 2-4 m, susceptible to storm surge

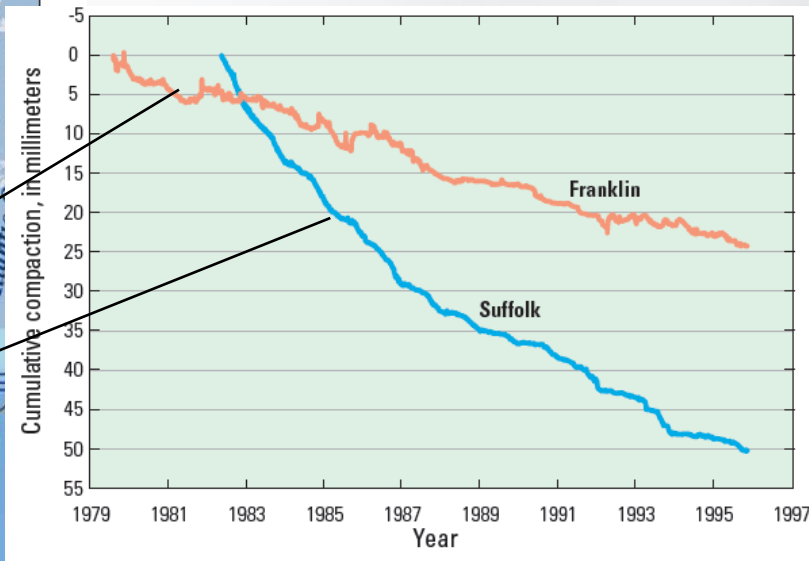
Greater Bay volume, ocean influence

Human-Induced Subsidence Exacerbates Relative Sea-Level Rise in Virginia



Groundwater level decrease (m) 1900-2008

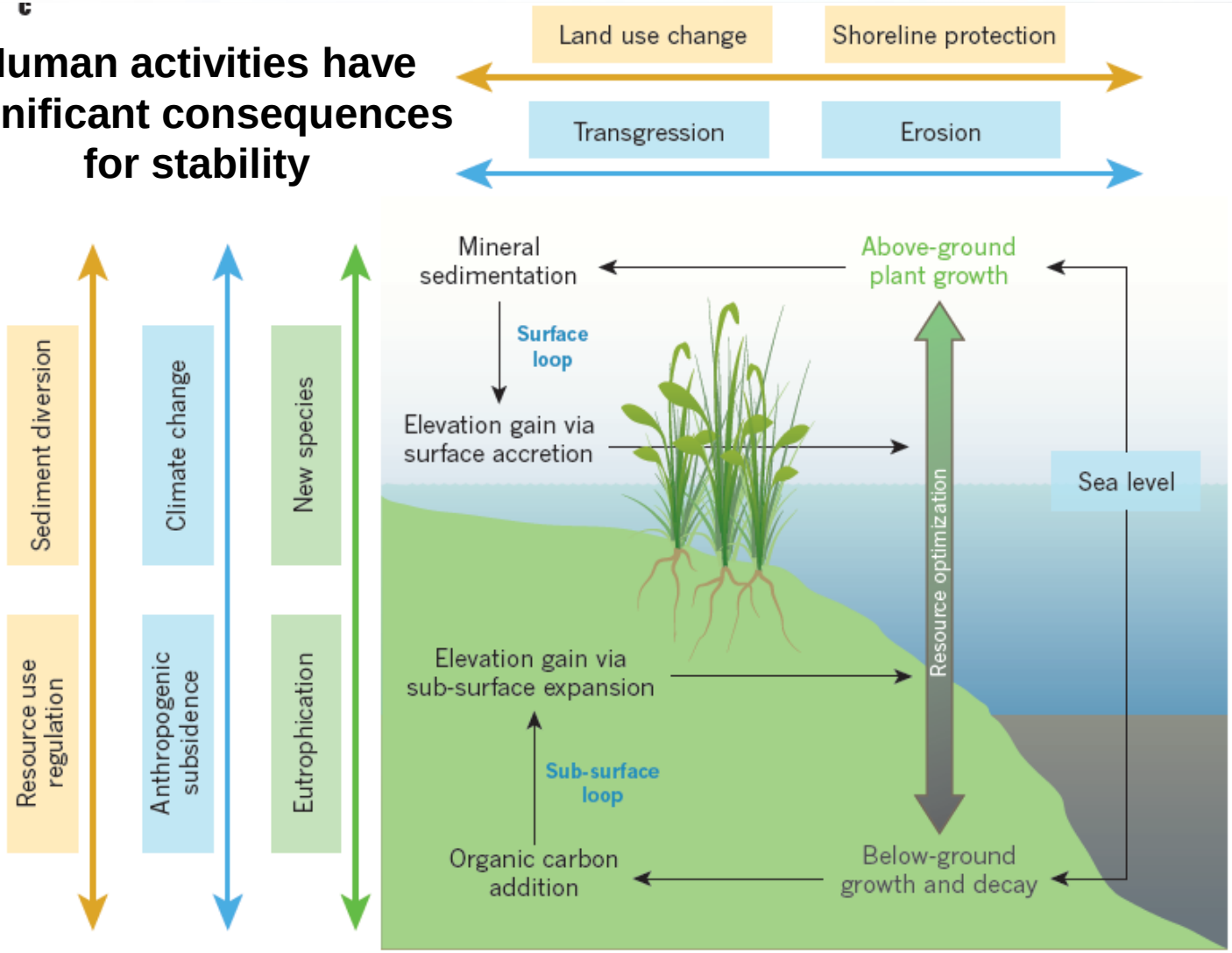
Cumulative compaction within 20 years



Eggleston & Pope 2013
USGS Circular 1392

Tidal Wetlands and Sea-Level Rise

Human activities have significant consequences for stability



Kirwan & Megonigal *2013. Nature* 404:53

Should TMDL Be Adjusted?

- Increased winter-spring runoff & warmer temperatures could exacerbate water quality problems, requiring greater nutrient reductions.
- However, there are lots of unknowns regarding precipitation, evapotranspiration & consequences of greater estuary volume, particularly <2025.
- So, stay the course with WIPs based on present TMDL estimates.
- In the longer term, maintaining water quality will always require adapting for growth, climate change, etc.

Some Policy Opportunities

- Increased sea-level rise is virtually certain, so:
  - improve resilience of coastal infrastructure, including defend and retreat options, with ecosystem services in mind;
  - sustain tidal wetlands through sediment management & facilitating transgression.
- Precipitation events are highly likely to intensify, so:
  - design stormwater management improvements to handle larger volumes.
- Actions to reduce greenhouse gas emissions will increasingly be taken, so:
  - look for Bay-restoration options that emerge, e.g. limiting sprawl.

Climate Change Education

Maryland and Delaware Climate Change Education Assessment and Research

- K-12 Education (integrated with Next-Generation Science Standards, and Environmental Literacy Requirements)
- Higher Education (sustainability literacy, teacher preparation, pipeline)
- Informal Education (museums, aquaria, outdoor centers, media)

www.madeclear.org/

Questions or Comments?

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- www.umces.edu/people/president