

Adapting to Climate Change for Natural Resources, Food & Fiber



3rd Annual BA-UMD Fall Symposium
Trends in Agriculture
January 23, 2014



Donald F. Boesch



University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE



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%

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.

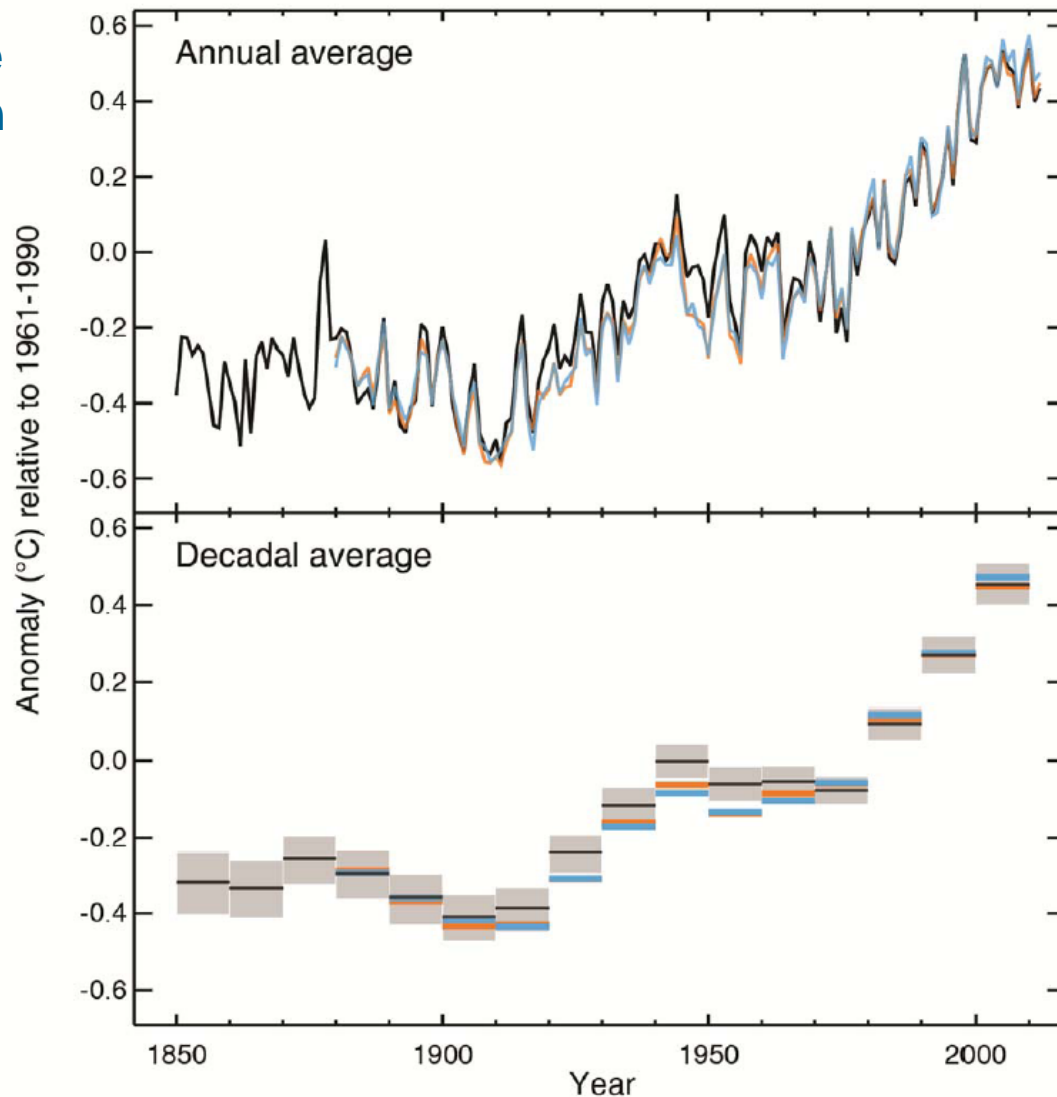
Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

www.ipcc.ch

How Much Has It Warmed?

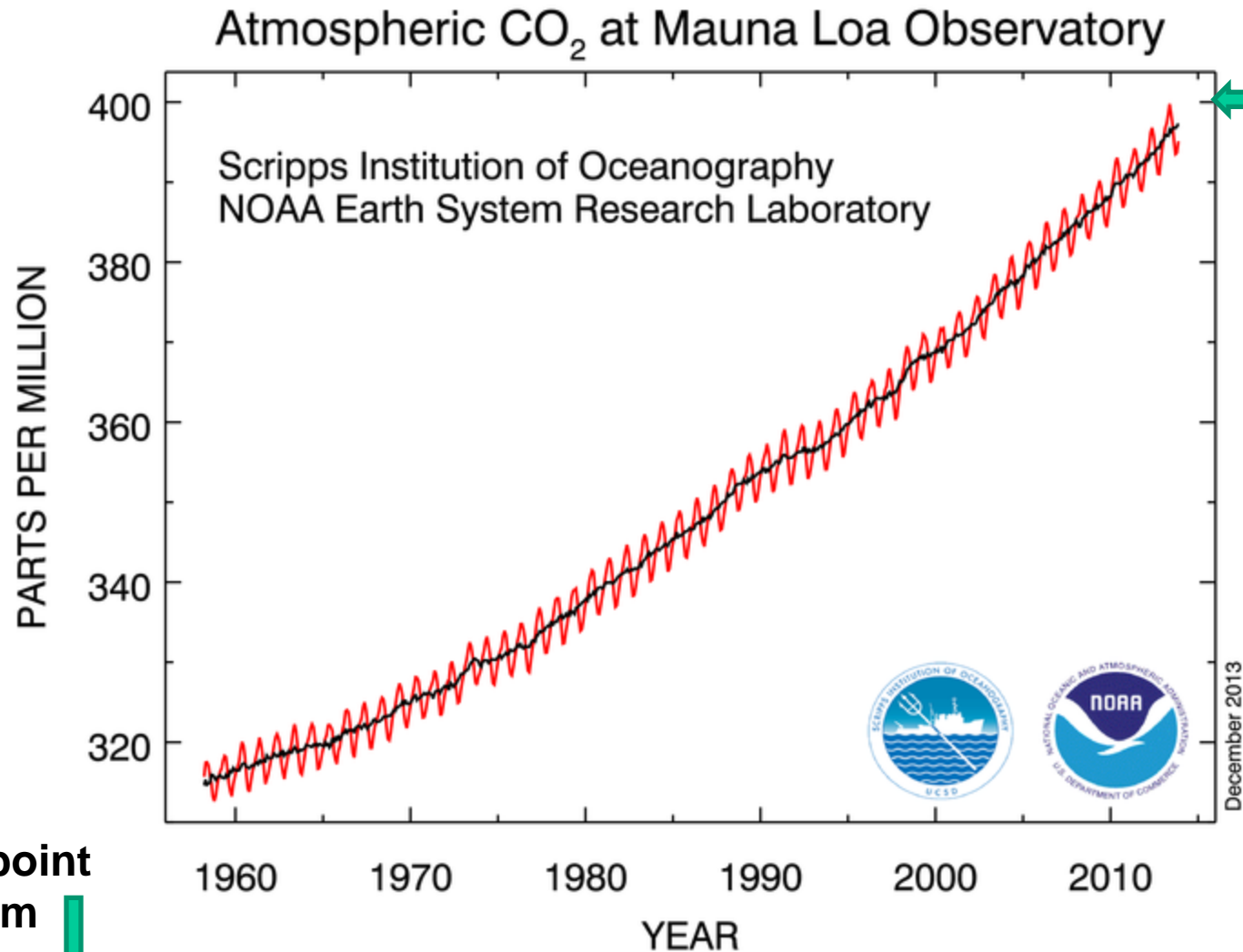


**Global average
land and ocean
temperature**



**about 0.9 C
or 1.6 F**

Increase in Atmospheric CO₂

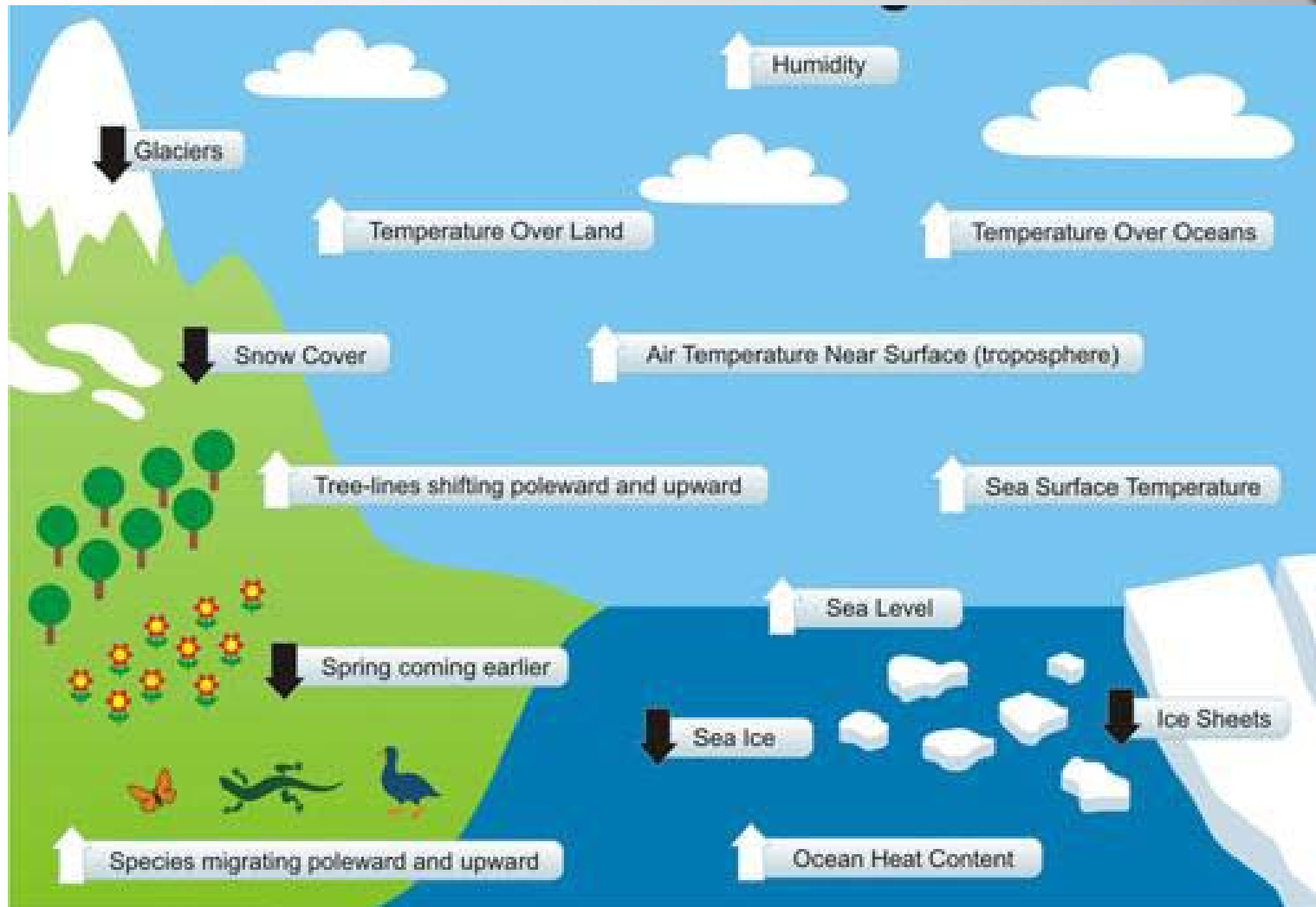


**Crossed
400 ppm
this May**

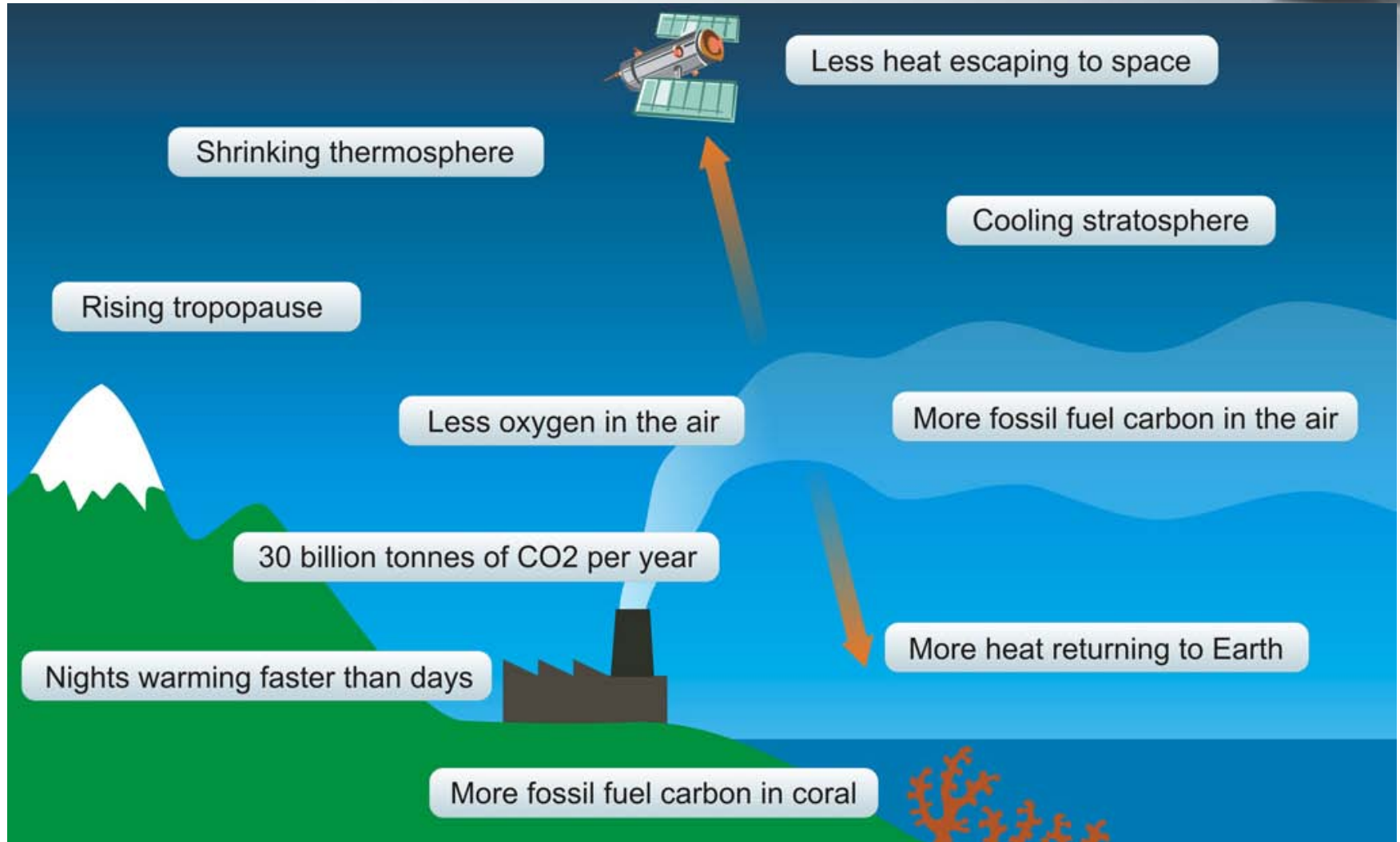
**Today
398.8 ppm**

**Starting point
280 ppm**

Indicators of a Warming World



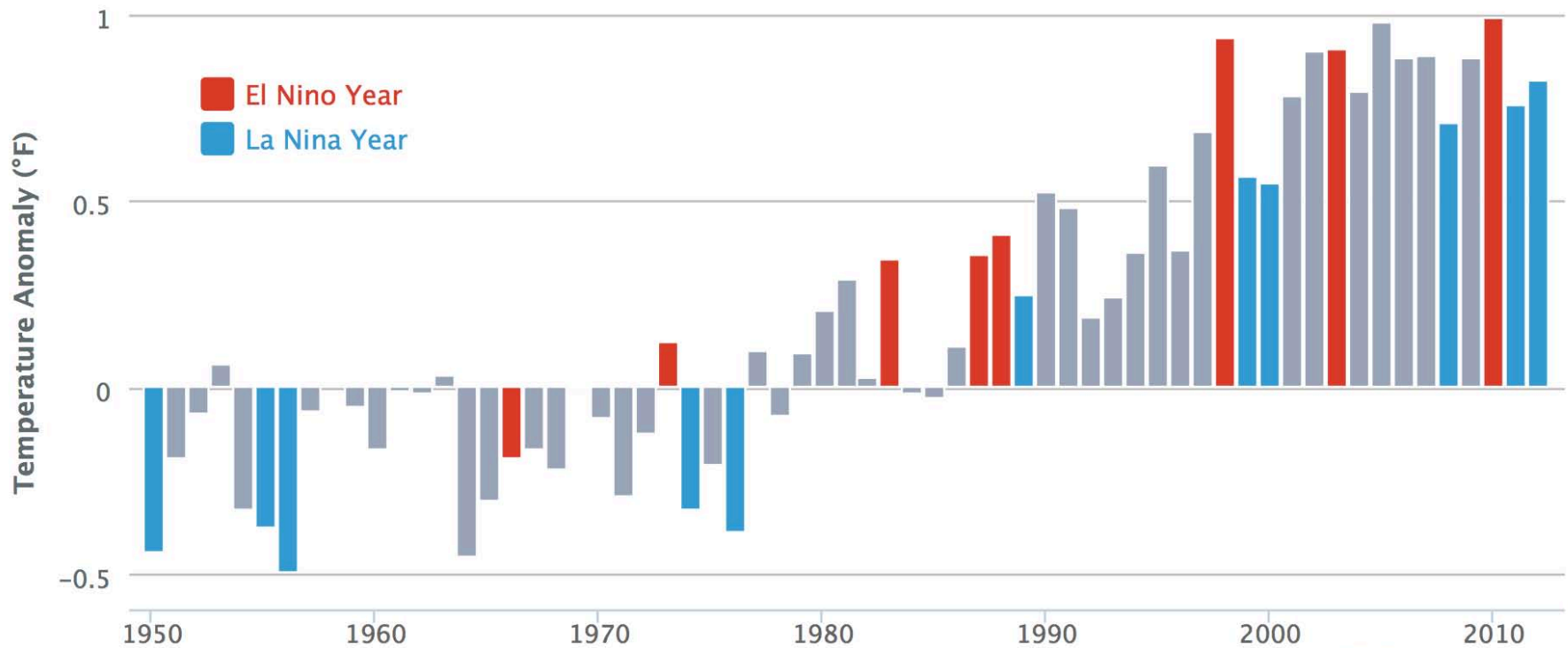
Fingerprints Confirming Human Cause



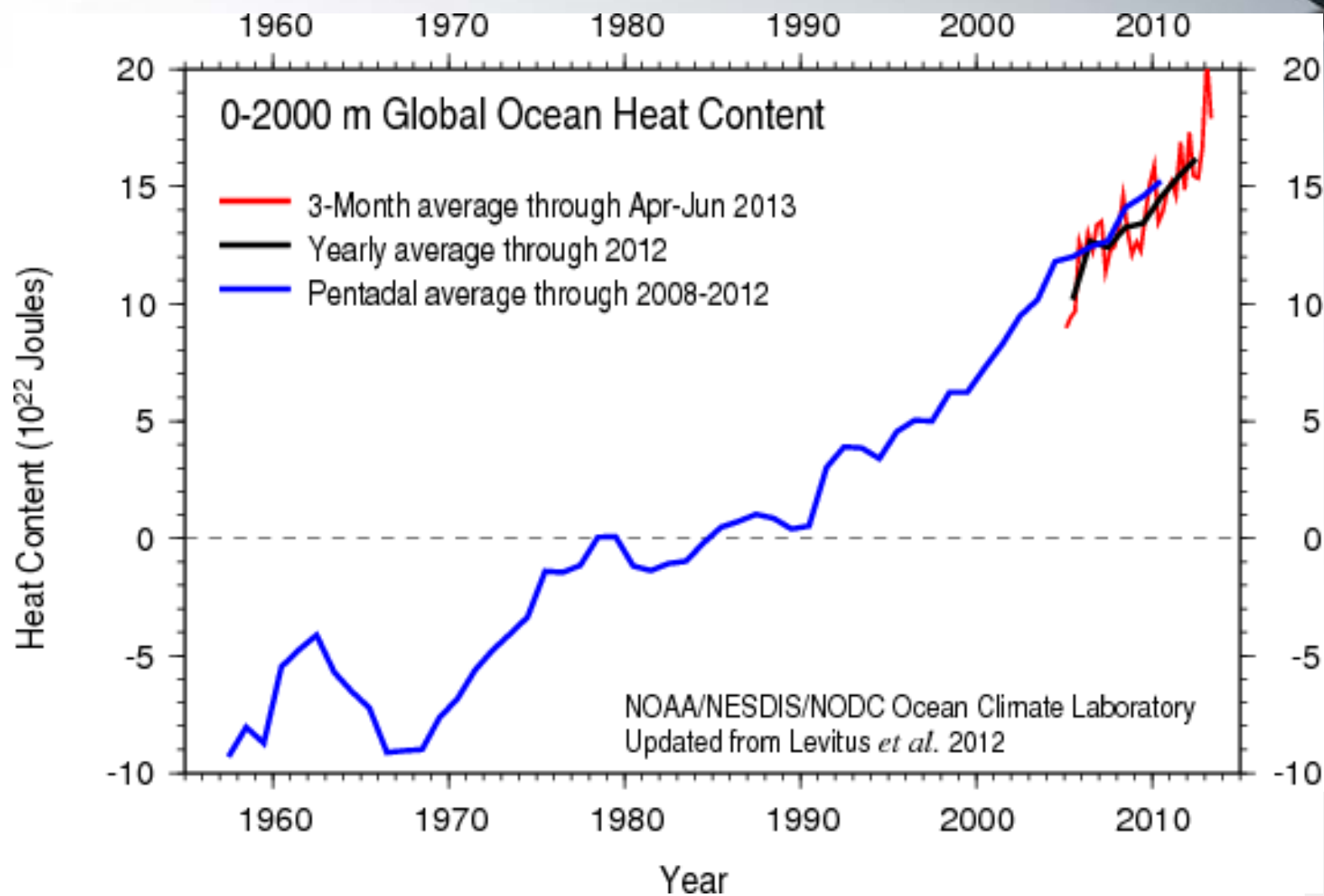
Has Global Warming Paused?



27 Years of Above-Average Temperatures
Global temperatures have been on the rise since the 1950s



Heating Has Continued in Ocean

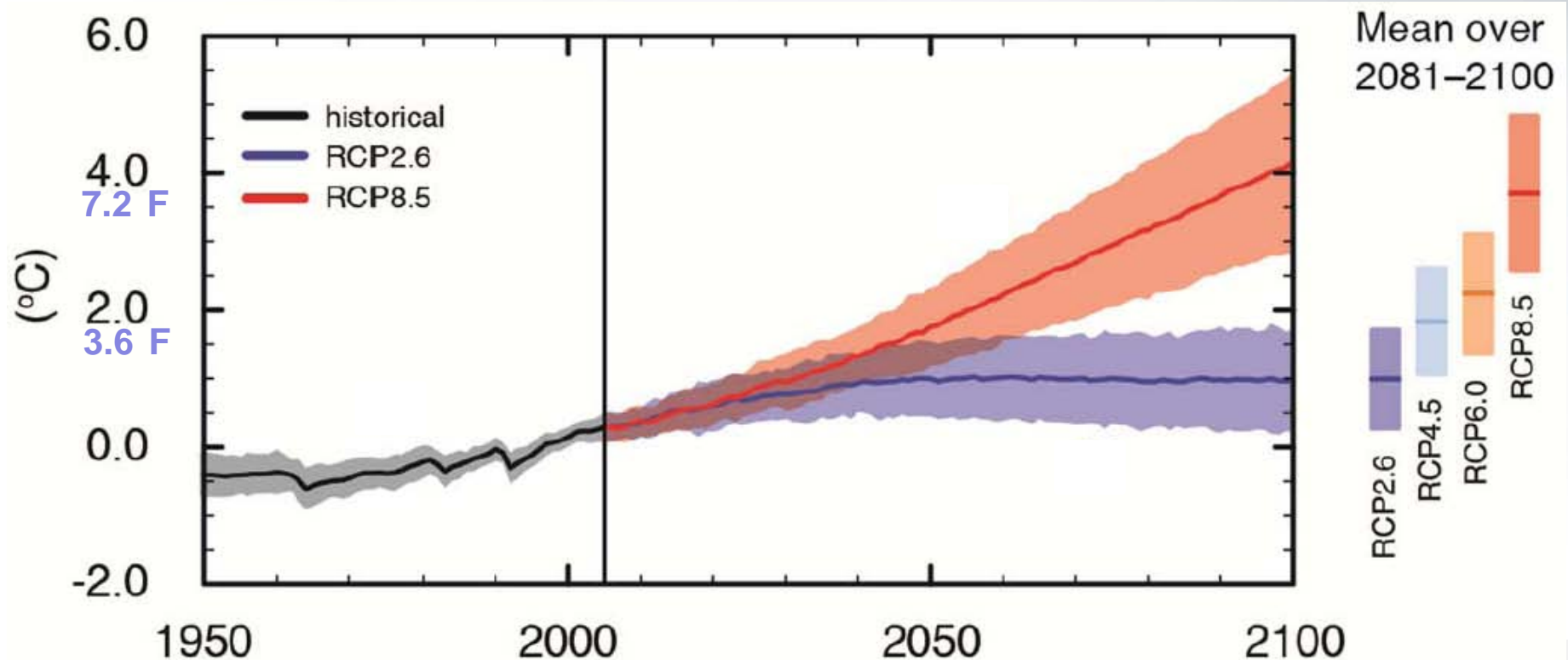


How Much Will it Warm?

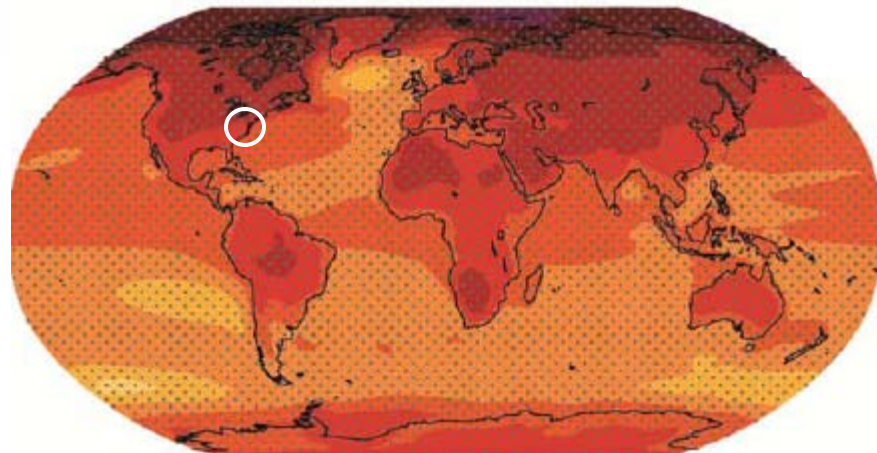


It mainly depends on how much greenhouse gases we emit.

Global average surface temperature

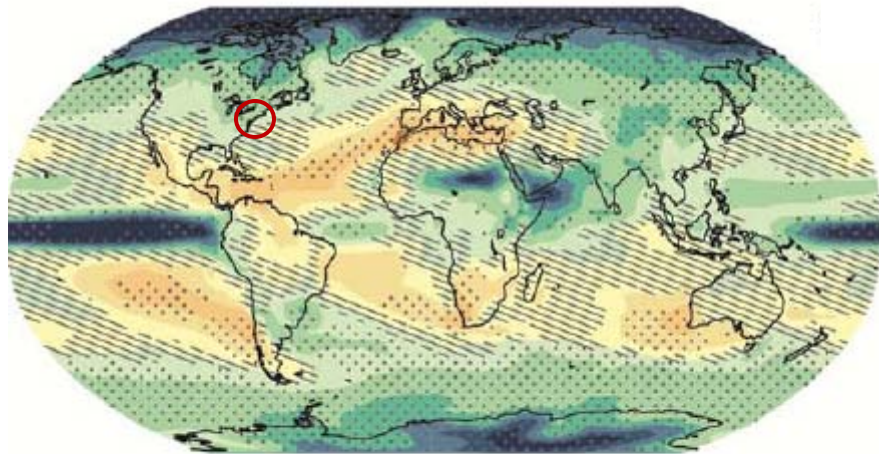


Changes Will Vary Greatly



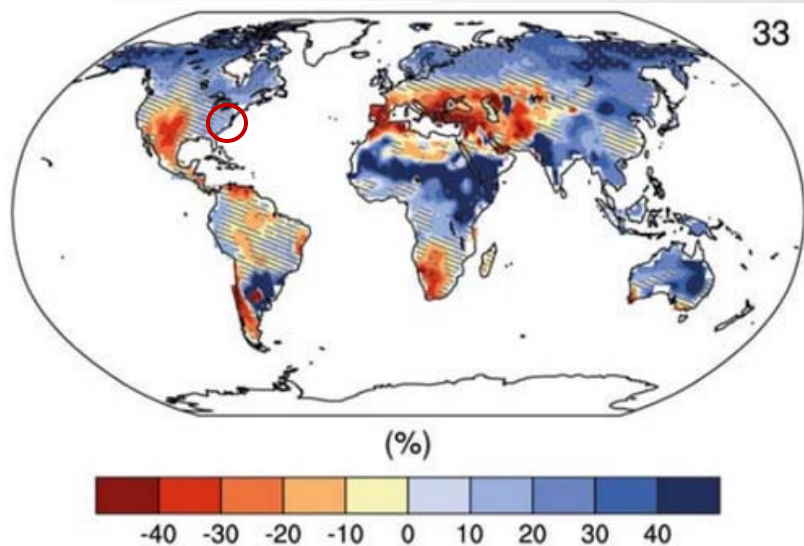
RCP8.5 Scenario for 2081-2100

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



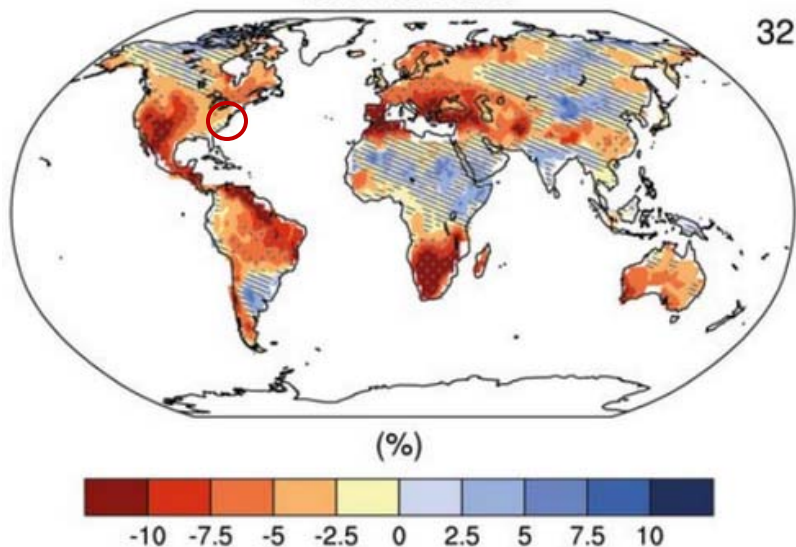
**Average percent change in annual
mean precipitation
[~10% increase in Chesapeake region,
mainly winter-spring]**

Changes Will Vary Greatly



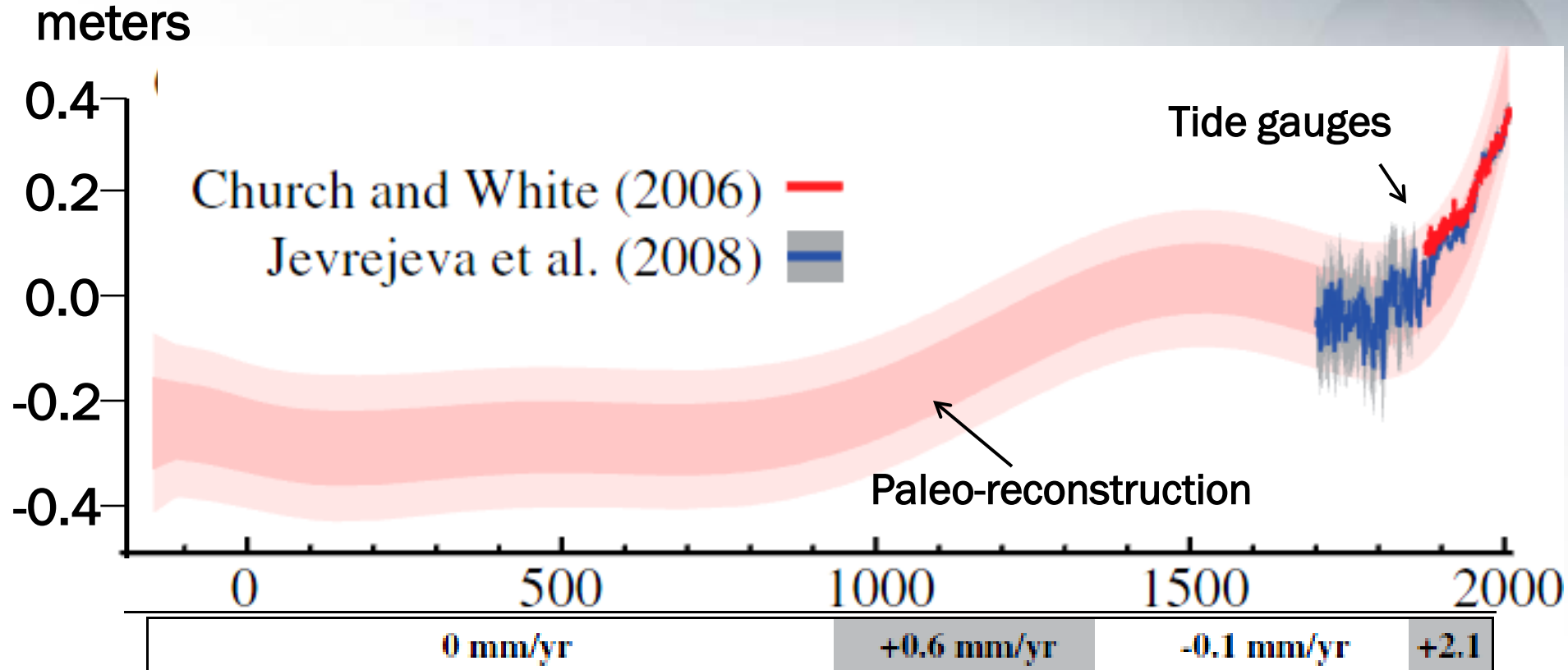
RCP8.5 Scenario for 2081-2100

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



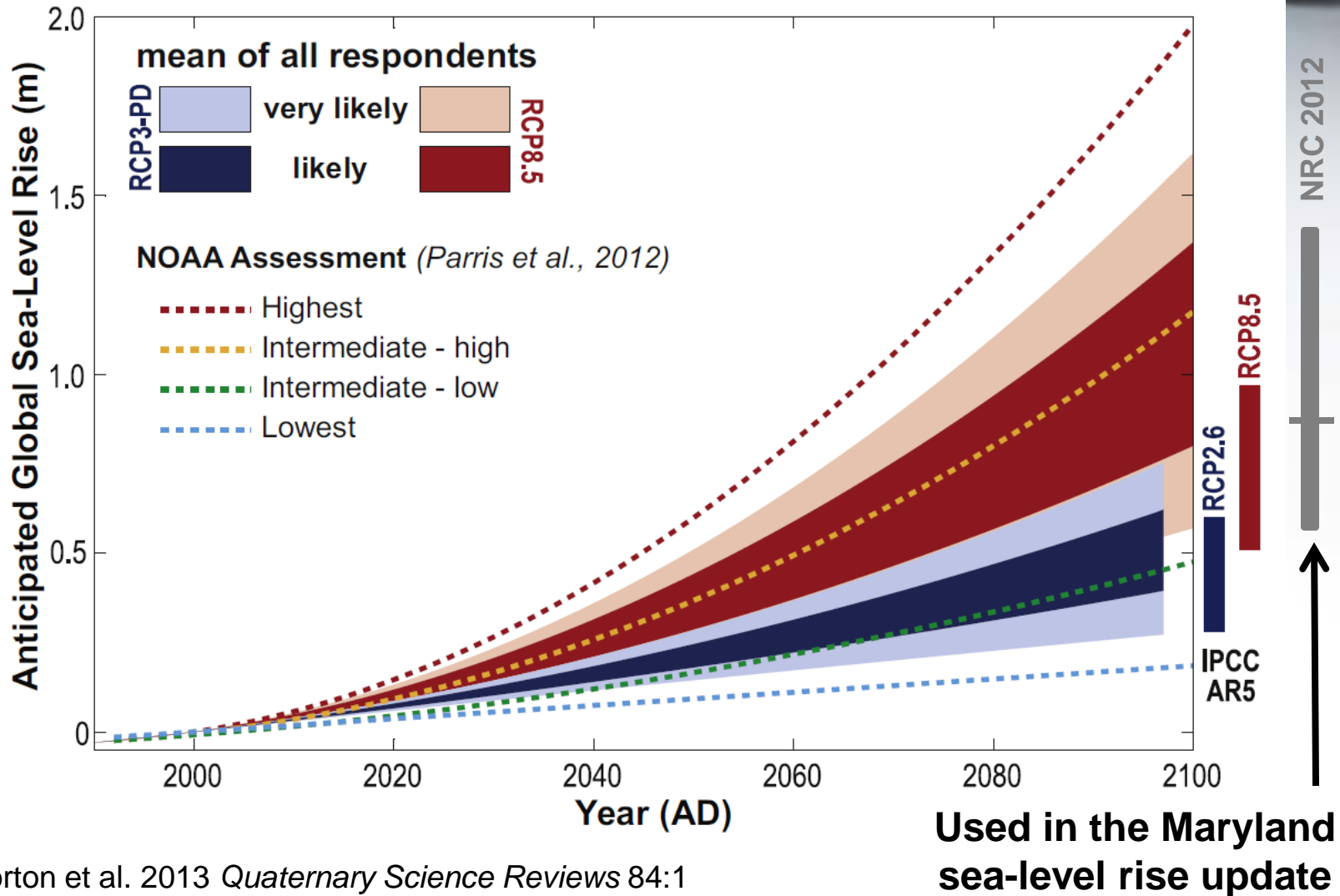
Average percent change in soil moisture
[drier conditions in growing season in Chesapeake basin]

Sea Level Had Been Stable 2000 Years

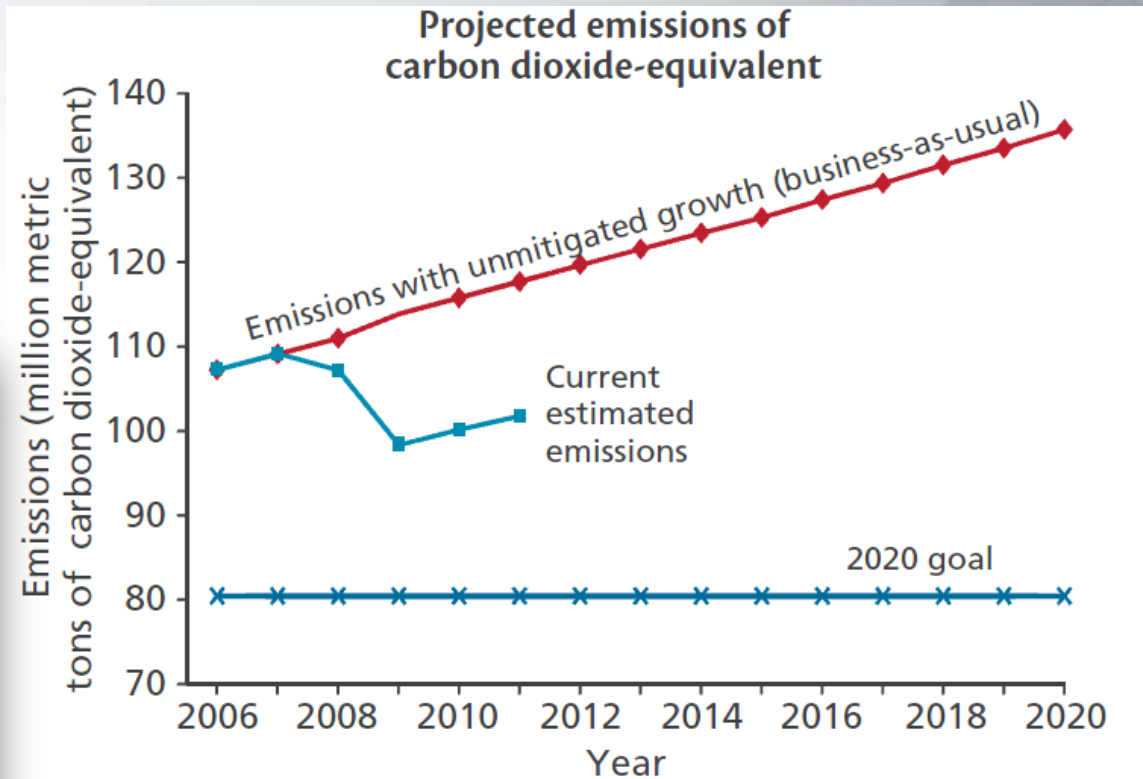
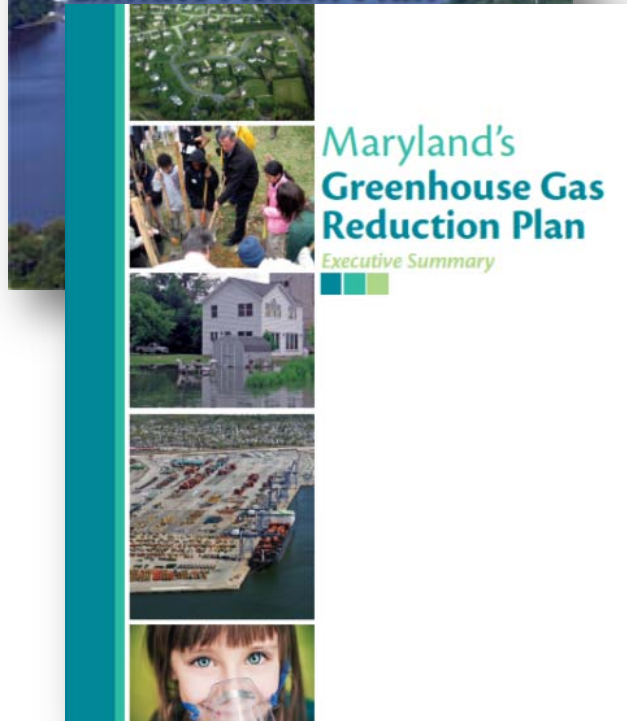


Kemp et al. 2011. *Proc. National Acad. Sci*

How Much Will the Seas Rise?



Climate Action Plan



climatechange.maryland.gov

Climate Change Assessments



climatechange.maryland.gov




The screenshot shows the homepage of the Maryland Climate Change website. The header features the Maryland logo and the slogan "Smart, Green & Growing". Navigation links include PLAN, ADAPTATION, BENEFITS, SCIENCE, ACTIONS, GALLERY, NEWS & EVENTS, PRESS, and ABOUT. A search bar and links for Email Friend and print page are also present.

The main content area is titled "CLIMATE CHANGE MARYLAND" and includes a summary: "Maryland's Climate Change plan will reduce greenhouse gases 25 percent by 2020, improve public health and have economic benefits". Below this is a video player featuring Dr. Donald Boesch, President of the University of Maryland Center for Environmental Science, discussing the history and science of climate change. The video title is "Climate change is real. It's happening. It's hu..." and the video player shows a play button and a progress bar.

On the right side, there is a section for "E-NEWS SIGNUP" with a "SUBSCRIBE" button. Below this is a "LATEST TWEET" section featuring a tweet from @MDMEMA about energy saving tips. Further down is a "DO YOU PARTICIPATE IN ANY ENERGY EFFICIENCY PROGRAMS?" section with checkboxes for various programs: EmPOWER Maryland, Energy Star, Utility-based program, Energy Efficiency Contractor did work on my home/business, and I installed solar panels on my home/business. A "submit" button and a "more polls >" link are at the bottom of this section.

The left sidebar contains icons and labels for "PUBLICATIONS", "EDUCATE", "WHAT CAN YOU DO?", and "PROGRESS".

At the bottom of the page, there is a footer with the website address "climatechange.maryland.gov" and contact information: "Contact the Office | Accessibility | Privacy Notice", "1800 Washington Boulevard, Baltimore, MD 21230 | (410) 537-3000".

Communicating Adaptation



CLIMATE CHANGE IMPACT PLANNING

TAKE ACTION NOW TO PROTECT YOUR CO

In order to protect local citizens from public health and safety risks and to protect public and private investments, coastal state is experiencing now and will continue to experience in the future.

Climate change will affect communities and local economies in a variety of ways. Likely impacts include an increase in the frequency and severity of extreme weather events, such as drought, storms, flooding, and sea level rise. These impacts will be felt most acutely in coastal areas, but they will also be felt in inland areas. For example, drought can lead to water shortages, which can affect agriculture and industry. Sea level rise can lead to flooding, which can damage property and infrastructure.

When assessing the future climate risks to your community, it is important to consider both the direct and indirect impacts of climate change. Direct impacts are those that are caused by climate change itself, such as drought, storms, and sea level rise. Indirect impacts are those that are caused by climate change through other factors, such as changes in land use and population growth.

Local citizens can take many steps to protect themselves and their communities from the impacts of climate change. These steps include:

- Reducing greenhouse gas emissions by conserving energy and using public transportation.
- Preparing for emergencies by having a disaster plan and emergency kit.
- Protecting coastal areas by planting trees and creating buffer zones.
- Supporting local businesses and industries that are resilient to climate change.

RESILIENCY AND WATER RESOURCES MANAGEMENT

WATER SUPPLY IN A CHANGING CLIMATE

Maryland citizens are blessed with an abundance of water resources. However, as climate change impacts our water cycle, we must take steps to ensure that we have enough water to meet our needs. This includes protecting our watersheds, improving water efficiency, and developing new water sources.

One of the most significant impacts of climate change on water resources is the changing timing and amount of precipitation. In Maryland, this can lead to both drought and flooding. Drought can reduce the amount of water available in rivers and streams, while flooding can contaminate water supplies and damage infrastructure.

To address these challenges, Maryland has implemented a variety of water conservation programs. These programs include:

- Installing water-saving devices in homes and businesses.
- Protecting watersheds by reducing pollution and deforestation.
- Developing new water sources, such as desalination and water recycling.

BEST MANAGEMENT PRACTICES

PRESERVING CLEAN WATER IN A CHANGING CLIMATE

REDUCING RISKS WITH STORMWATER BEST MANAGEMENT PRACTICES TO SAVE MONEY AND THE ENVIRONMENT

Risk management is critical in any restoration project. Risks include those associated with climate patterns, such as more intense storms, as well as those associated with land use change, site selection, and design. Addressing these risks with ongoing restoration efforts will prepare communities for greater variability and may result in cost savings and reduced risk.

A Changing Climate
One hundred years of data shows that Maryland is getting warmer on average by 1.8°F and by as much as 3.6°F in the winter. Warmer air holds more moisture, leading to more frequent and intense storms. Over the last century, Maryland has experienced a significant increase in the number of days with heavy rain. This has led to increased flooding and damage to property and infrastructure.

Best Management Practices (BMPs) should be used and designed with the goal of reducing runoff and improving water quality. BMPs include:

- Increased flooding may overwhelm water infiltration, conveyance, and storage capacity.
- Flooding and inundation will increase nutrient transport and impact ecosystems.
- Greater storm frequency and intensity can increase shoreline and bank erosion.
- Rising temperatures may harm vegetation and aquatic ecosystems.

MARYLAND AT RISK

SEA-LEVEL RISE ADAPTATION & RESPONSE

Action is needed now to stem not only the drivers of sea-level rise but also to prepare for the inevitable consequences of climate change. Maryland is extremely vulnerable to sea-level rise. Historic tide-gauge records show that sea levels in Maryland have risen by an average of 1.5 feet since 1900. Projections indicate that sea levels could rise by 3 to 6 feet by 2100, depending on the rate of global warming.

The Chesapeake Bay is the largest estuary in the United States. It is a vital source of food and income for Marylanders. Sea-level rise threatens the Bay's health and the livelihoods of those who depend on it. Rising sea levels can lead to saltwater intrusion, which can damage crops and infrastructure. It can also lead to the loss of wetlands, which are important for filtering pollutants and protecting the shore.

WATERSHED MANAGEMENT

CONSERVATION AND RESTORATION IN A CHANGING CLIMATE

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Watershed management is a key strategy for protecting the Bay and other important water resources. Watershed management involves protecting the land and water resources that feed into a body of water. This includes reducing pollution, conserving water, and restoring natural habitats.

MARYLAND'S PEOPLE, PROPERTY, AND POTENTIAL

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Who should adapt?
A changing climate will mean positive and negative impacts for all Marylanders. However, some groups are more vulnerable than others. These groups include:

- Low-income and minority communities.
- People living in coastal areas.
- People who rely on agriculture and fishing for their livelihoods.
- People who have limited resources to adapt to climate change.

EXISTING PRACTICES PROVIDE A VALUE

Management Practice	Nutrient Benefit	Temperature Reduction	Storm Reduction
Wastewater Treatment Plant	●	●	●
Stream Restoration	●	●	●
Forest Buffer	●	●	●
Wetlands	●	●	●
Infiltration	●	●	●
Shoreline Erosion Control	●	●	●
Vegetated Open Channel	●	●	●

* Practices designated with a ● potentially buffer against climate impacts and could be enhanced through modifications suggested in the report.

LAND MANAGEMENT

FARMING IN A CHANGING CLIMATE

The importance of farming in Maryland
Agriculture is the largest commercial industry in Maryland, employing about 300,000 people on almost 1,000 farms covering 10 million acres.

What is changing?
Over the past century, both minimum and maximum temperatures have been increasing. In the future, Maryland should expect higher temperatures, more intense precipitation in the fall and winter, and an increase in short-term droughts in the summer. The eastern shore is more vulnerable to sea level rise, drought, and flooding. Because of its location, the eastern shore is also one of the most vulnerable to the impacts of climate change. The eastern shore is home to many important agricultural products, including seafood and poultry. Rising sea levels and drought can damage these products and the livelihoods of those who produce them.

Who should be concerned?
At the climate change, farmers, the farm credit industry and regulators of agricultural management practices will likely face a number of challenges. These challenges include:

- Increased costs for insurance and disaster relief.
- Reduced yields due to drought and flooding.
- Increased competition from other countries.
- Reduced demand for certain products.

Extreme Events

In 2013, the Maryland Department of Agriculture received a federal disaster assistance for drought, severe heat, and flooding. This assistance was used to help farmers and ranchers cope with the impacts of these extreme events. The assistance included:

- Providing technical assistance and training.
- Providing financial assistance for emergency repairs and recovery.
- Providing information and resources for disaster preparedness.

Extreme events are becoming more frequent and severe. This is due to climate change. Extreme events can cause significant damage to property and infrastructure. They can also lead to the loss of lives and livelihoods. It is important to take steps to reduce the risk of extreme events. These steps include:

- Reducing greenhouse gas emissions.
- Preparing for emergencies by having a disaster plan and emergency kit.
- Protecting coastal areas by planting trees and creating buffer zones.
- Supporting local businesses and industries that are resilient to climate change.

Local Solutions

Anyone in need for horses
A horse owner's dream is to have a horse. However, owning a horse can be a costly endeavor. It requires a lot of money for feed, vet care, and equipment. It also requires a lot of time and space. For many people, owning a horse is not a realistic option.

One solution is to join a horse club or association. These organizations provide a variety of services to their members, including:

- Providing access to riding facilities.
- Providing information and resources for horse care.
- Providing a sense of community and support.

Another solution is to adopt a horse. Many rescue organizations have horses that are in need of homes. These horses are often rescued from neglect or abuse. They need a loving home and a good owner. Adopting a horse can be a rewarding experience. It can also help to reduce the number of horses in rescue.

Extreme Events

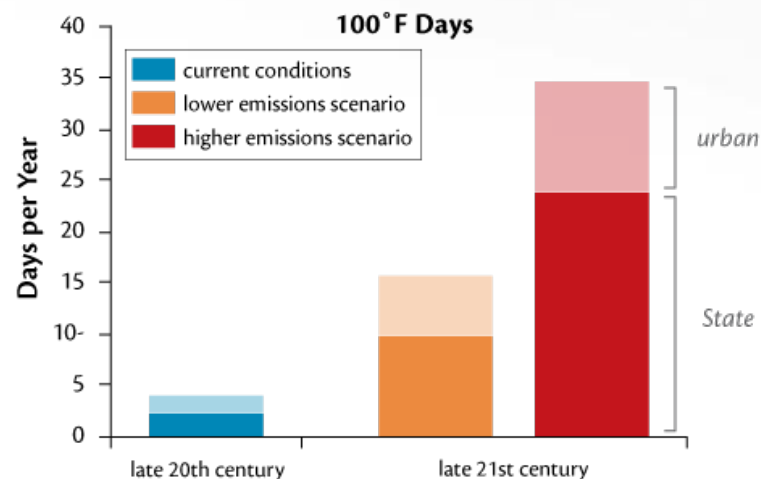
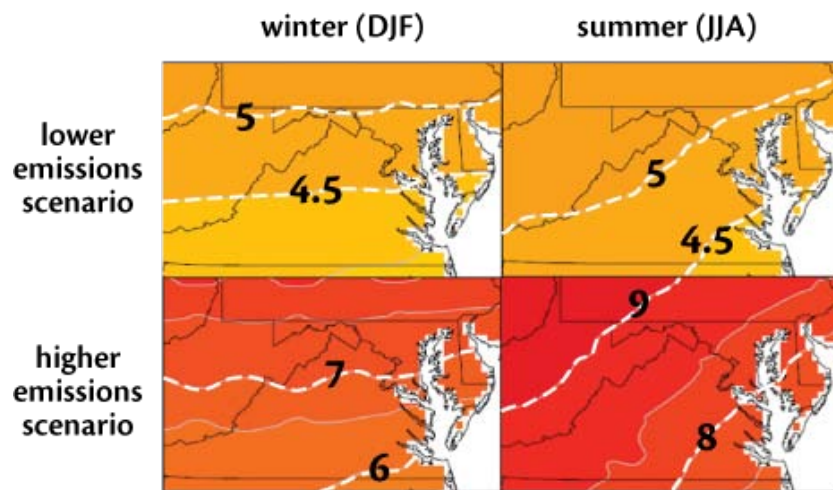
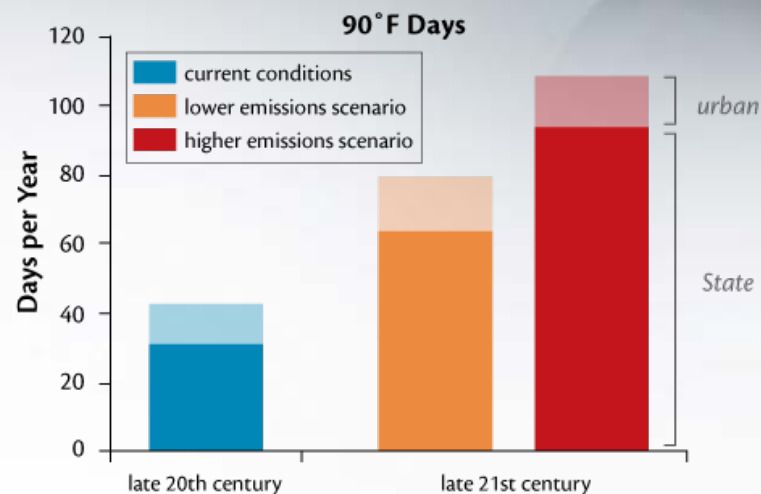
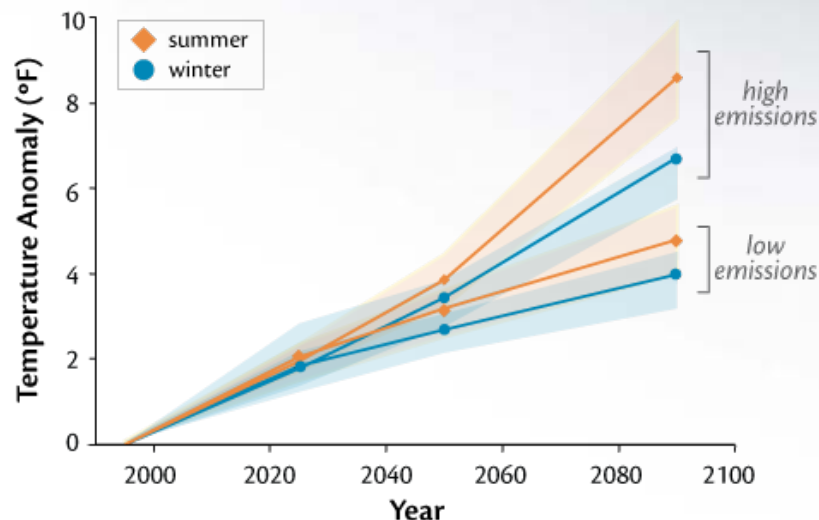
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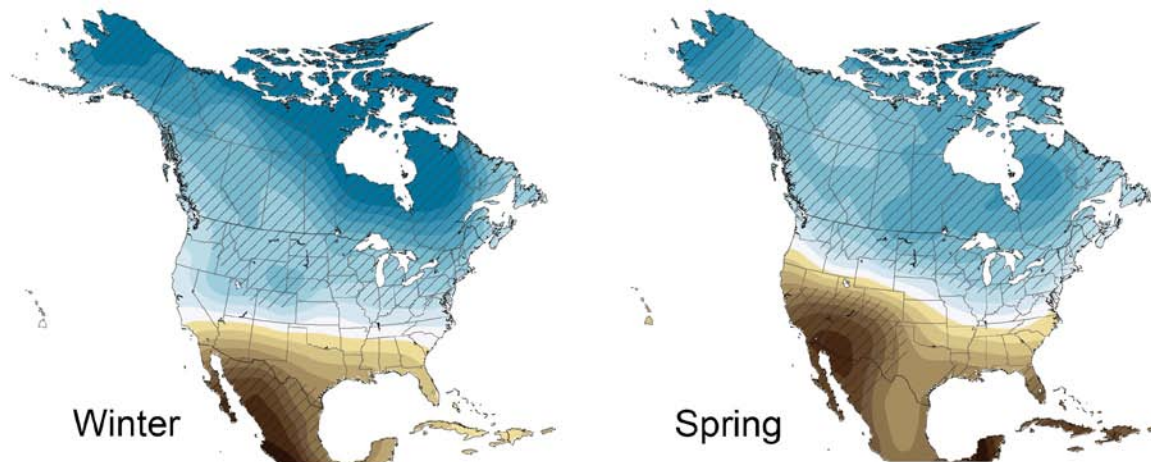
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Milder Winters, Hotter Summers



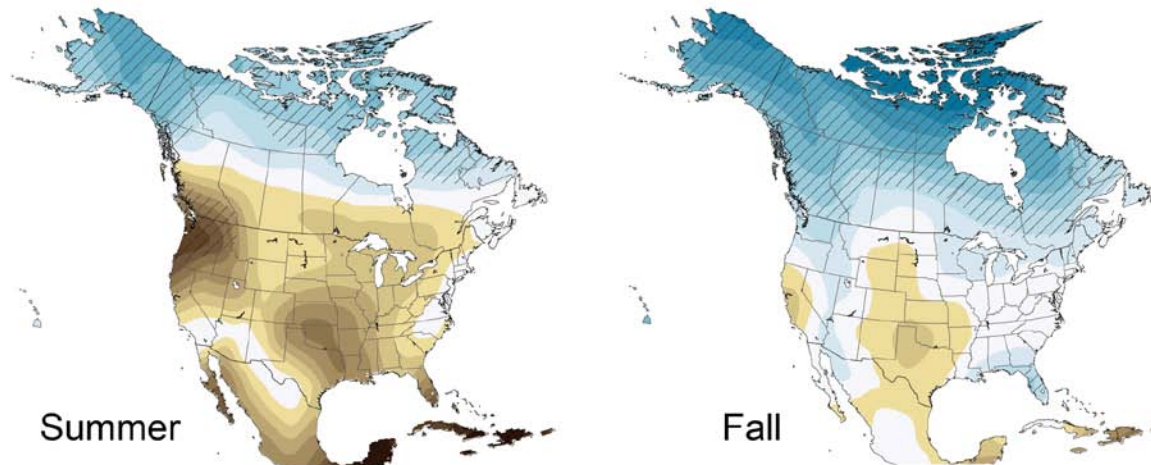
Projected Changes in Precipitation



Winter

Spring

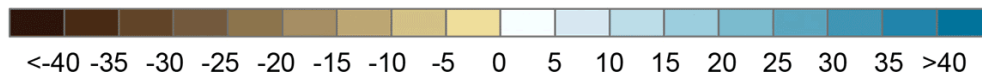
by 2080-90s



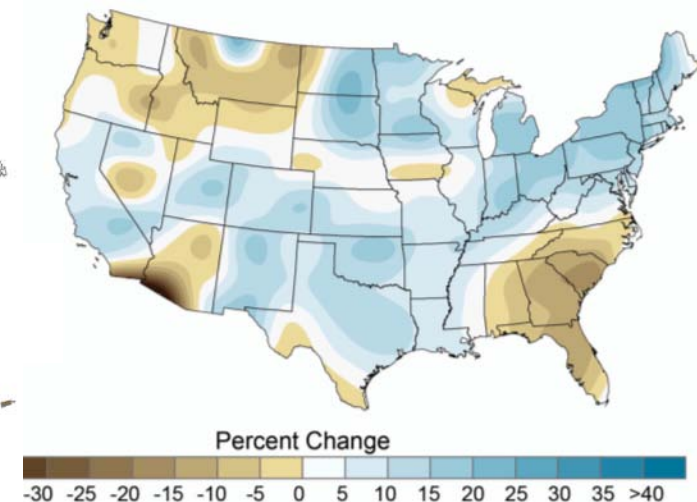
Summer

Fall

Percent Change



**Observed annual change
1950-2008**

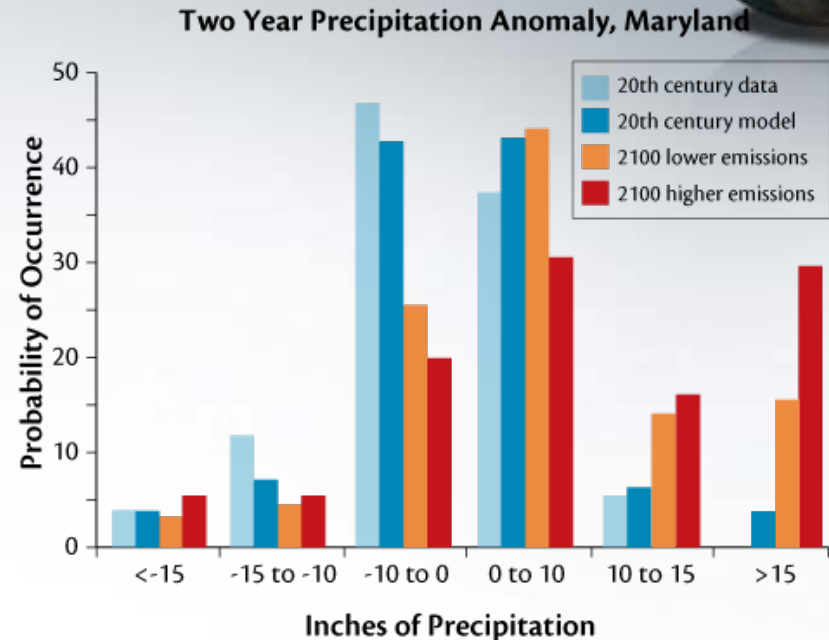


www.globalchange.gov/

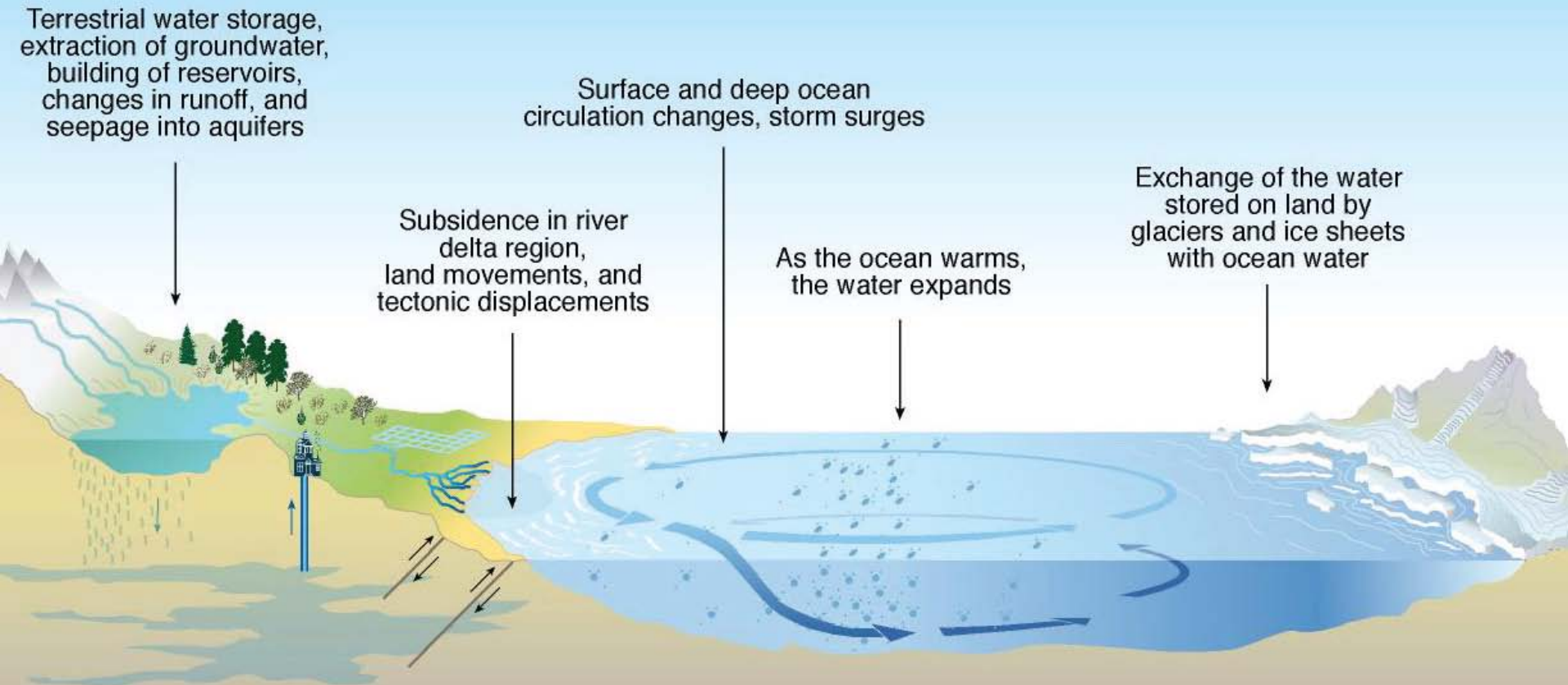
Consequences for Water Resources



- ❁ Somewhat more precipitation overall but mostly in winter & spring
- ❁ Summer droughts and downpours more frequent
- ❁ Soil moisture limiting agriculture; increased irrigation demand
- ❁ Baltimore supplies safe, Potomac River uncertain
- ❁ Will not alleviate overdraw of ground water



Factors Influencing Sea-Level

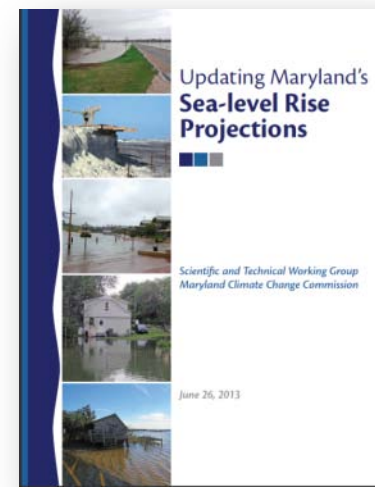


How Much Will Sea Level Rise in the Maryland?

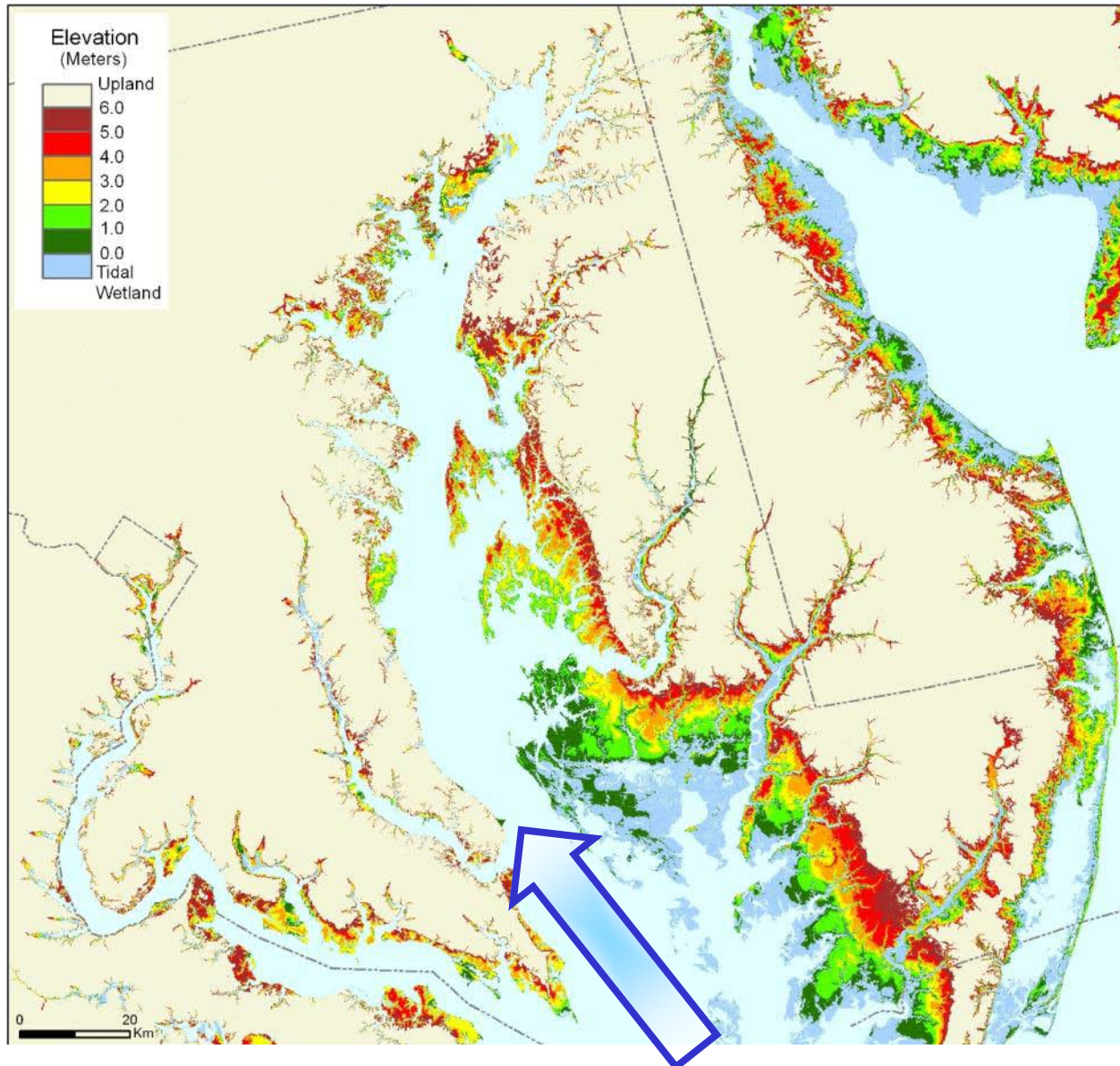


Maryland Relative Sea-level Rise	Thermal (m)	Glaciers (m)	Greenland (m)	Antarctica (m)	Dynamic (m)	VLM (m)	Relative SLR	
							meters	feet
2050 best	0.10	0.05	0.03	0.09	0.09	0.075	0.4	1.4
2050 low	0.04	0.05	0.02	0.04	0.07	0.065	0.3	0.9
2050 high	0.19	0.06	0.05	0.16	0.10	0.085	0.7	2.1
2100 best	0.24	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 inundation

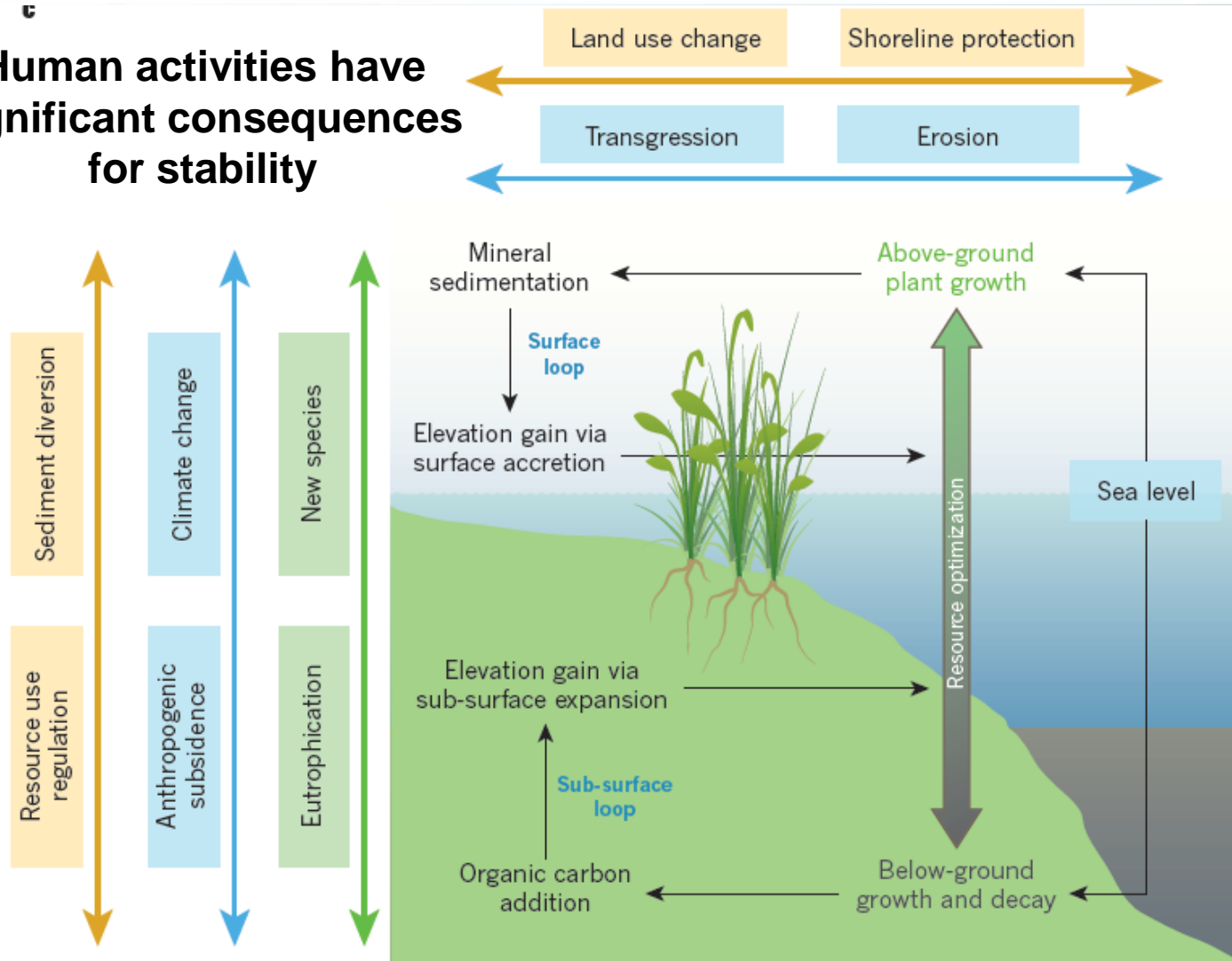
Orange-yellow: 2-4 m, susceptible to storm surge

Greater Bay volume, ocean influence

Tidal Wetlands and Sea-Level Rise



Human activities have significant consequences for stability



National Assessment Key Messages



Agriculture

1. Climate disruptions increasingly negative by mid-century.
2. Declines in crop & livestock productivity due to weeds, diseases, insects & other stresses.
3. Degradation of soil & water assets by increasing extremes in precipitation challenges rain-fed and irrigated agriculture w/o innovative conservation.
4. Rising incidence of weather extremes increasingly have negative effects on productivity
5. Increase innovation needed to ensure pace of adaptation.
6. Consequences for food security in US and globally.

From public review draft, subject to change. www.globalchange.gov

National Assessment Key Messages



Forestry

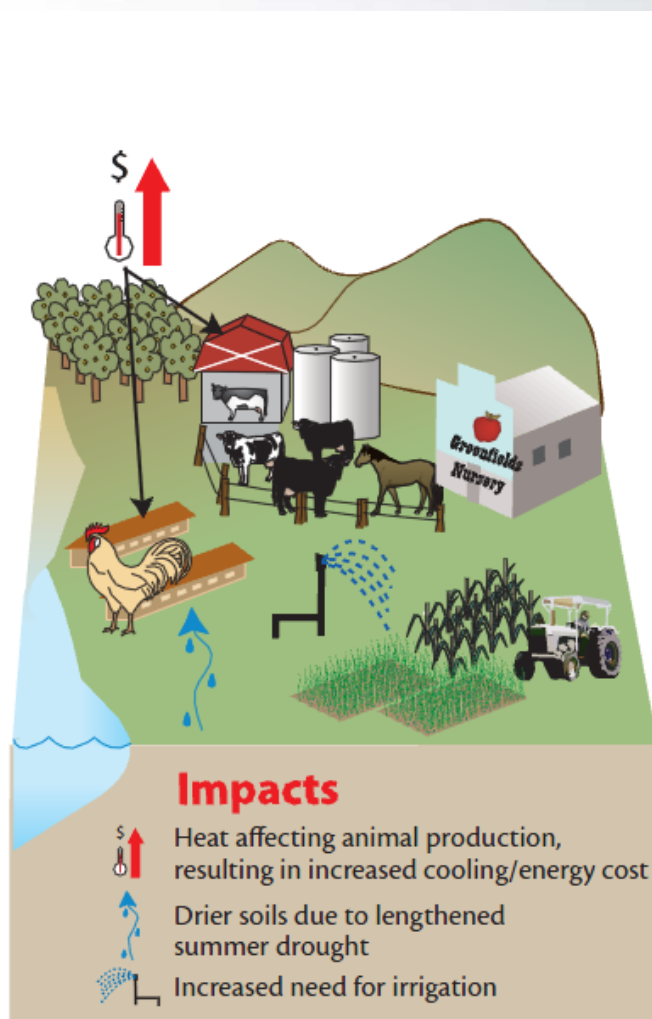
1. Climate change increasing vulnerability through fire, insect infestations, drought & disease outbreaks.
2. US forests absorb 13% of CO₂ emitted in US, but reductions projected.
3. Bioenergy is emerging new market, could finance salvage & restoration.
4. Changes in ownership, globalization, bioenergy markets and US climate change policy will influence forest management.

Limiting Climate Change & Agriculture



- ❖ Reduce GHG emissions related to production & transportation.
- ❖ Waste reduction.
- ❖ Generate renewable energy.
- ❖ Carbon sequestration.
- ❖ Food security.

Impacts & Adaptation for MD Agriculture



**Product
(ranked by 2007
market value, USDA
Census)**

Climate impact

Adaptation strategy

Poultry

Increased cooling costs;
decreased production;
changing disease presence

Improve energy efficiency of
housing; bioenergy use; improve
ability to monitor disease and
quarantine

Grains, oilseeds,
dry beans, peas

Water stress: increased irrigation
use; winter flooding; changes in
crop yield quantity and quality

Diversify cultivar and crop types;
improve water management
systems; improve pest forecasting

Nursery,
greenhouse,
floriculture, sod

Increased cooling costs;
water stress

Establish emergency response
systems; improve energy
efficiency of housing

Milk and dairy

Decreased milk productivity;
changing disease presence;
low-quality pasture during
drought

Increase shade and cooling;
improve ability to monitor
disease and quarantine; manage
pastures for drought

Cattle and
calves

Changing disease presence;
heat stress; low-quality pasture
during drought

Increase shade and cooling; improve
ability to monitor disease and
quarantine; manage pastures for
drought; farm heat-tolerant breeds

Vegetables,
melons, potatoes,
other crops, hay

Water stress: increased irrigation
use; winter flooding; changes in
crop yield quantity and quality

Diversify cultivar and crop types;
improve water management
systems; improve pest forecasting

Horses, ponies,
mules, burros,
donkeys

Heat stress; low-quality pasture
during drought

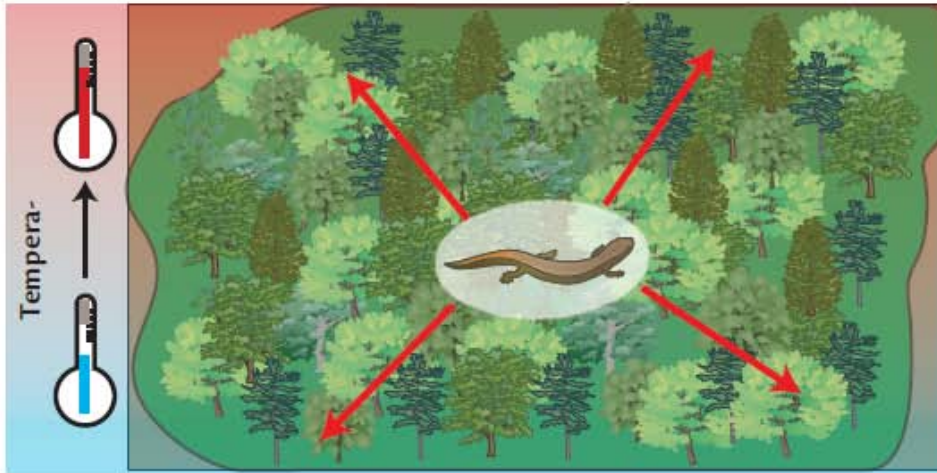
Increase shade and cooling;
manage pastures for drought
education about heat stress

Fruit trees, nuts,
berries

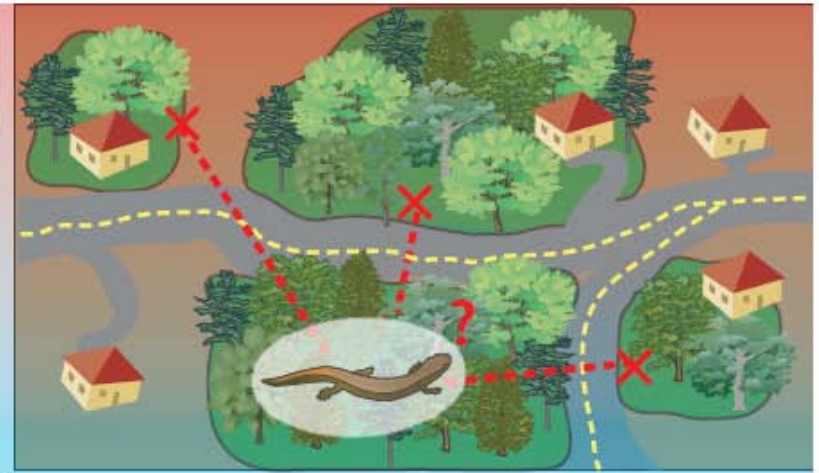
Water stress: increased irrigation
use; increased pest damage

Diversify cultivar and crop types;
improve water management
systems; improve pest forecasting

Managing Forests for Migration



Contiguous Forested Landscape



Fragmented Forested Landscape

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)

Questions or Comments?

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