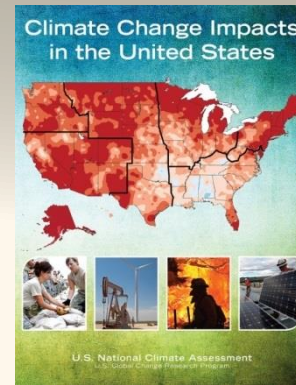


UC Irvine  
April 14, 2016



# Climate Impacts, Water and Adaptation: Findings of the Third National Climate Assessment

Kathy Jacobs

University of Arizona

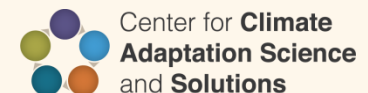
Director, Center for Climate Adaptation

Science and Solutions

Department of Soil, Water and Environmental Science



COLLEGE OF AGRICULTURE  
AND LIFE SCIENCES



# US Global Change Research Program

Global Change Research Act (1990):

“To provide for development and coordination of a comprehensive and integrated United States research program which will assist the Nation and the world to **understand, assess, predict, and respond** to human-induced and natural processes of global change.”



United States  
Global Change  
Research Program

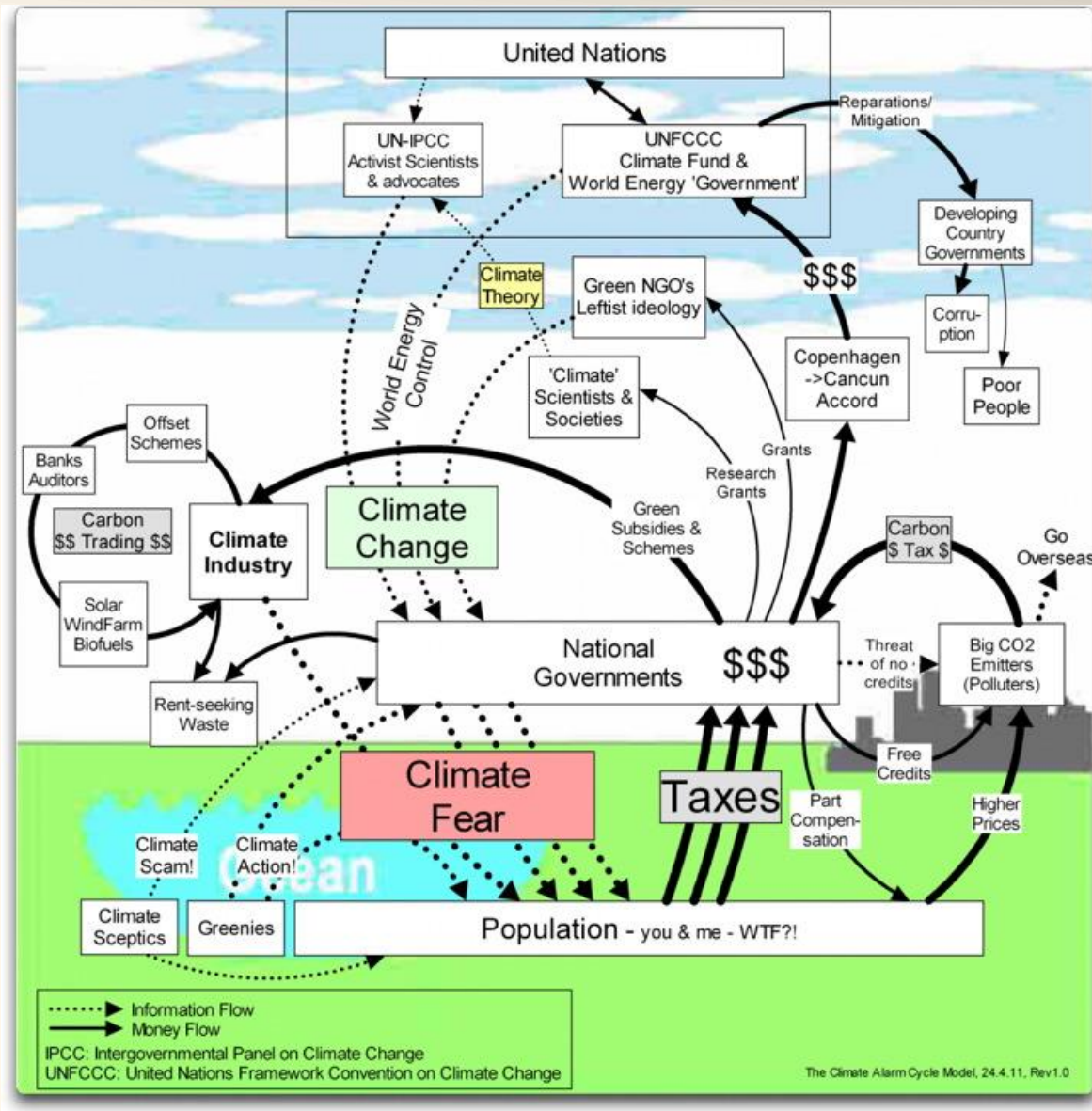


13 Federal Departments & Agencies +  
Executive Office of the President

More information at

<http://www.globalchange.gov><sup>2</sup>

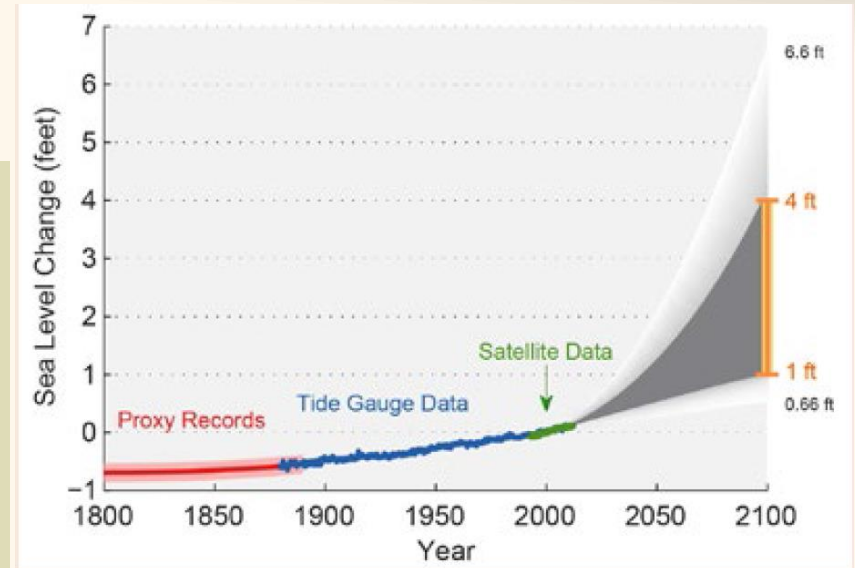
# The Third National Climate Assessment



Scientific assessments are a critical foundation for climate policy and for adaptation efforts

# Assessments, Adaptation, Science and Policy

Adaptation is iterative risk management, requiring identification of current and anticipated impacts and vulnerabilities, and responses to changes in fundamental scientific understanding and associated uncertainties...



# The Third National Climate Assessment (NCA3)

GCRA (1990), Section 106

...not less frequently than every 4 years, the Council shall prepare... an assessment



## Goal

- Enhance the ability of the United States to **anticipate, mitigate, and adapt** to changes in the global environment.

## Vision

- Advance an **inclusive, broad-based, and sustained process** for assessing and communicating scientific knowledge of the impacts, risks, and vulnerabilities associated with a changing global climate in support of decision-making across the US.

# What is new about the Third NCA?

- Broad engagement strategy, 300 authors, 60 member advisory committee
- Traceable accounts – “line of sight” between data and conclusions
- Decision-making support in a “risk-based” framework
- Assesses progress in response activities
- Fosters sustained scientific process
- Electronic delivery: Web-based and transparent



# NCA Risk & Decision-Support Framing

- Importance of underlying vulnerabilities
  - Inter-sectoral links and cascading effects
    - Water, Energy & Land
    - Biogeochemical Cycles
    - Tribal Resources
    - Land Use & Land Cover
    - Rural Communities
    - Urban Systems, Infrast
    - Coastal Zones, Develop
    - Oceans and Marine Re
- NCA
- Intersecting systems can either increase resilience or result in catastrophic failure - cascading effects through systems

# Acknowledging legitimate differences in perspective and training

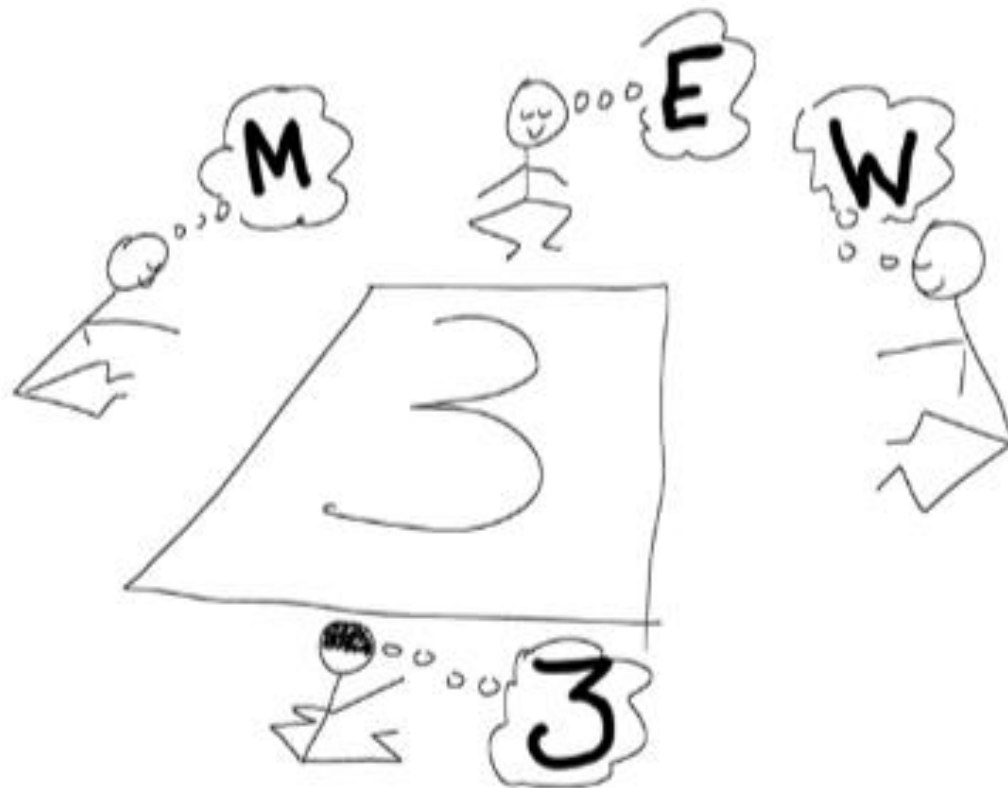
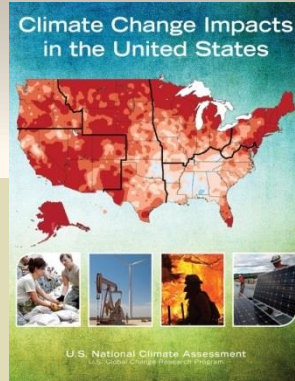


Image source:<http://ch301.cm.utexas.edu/learn/>Credit: John Rowley



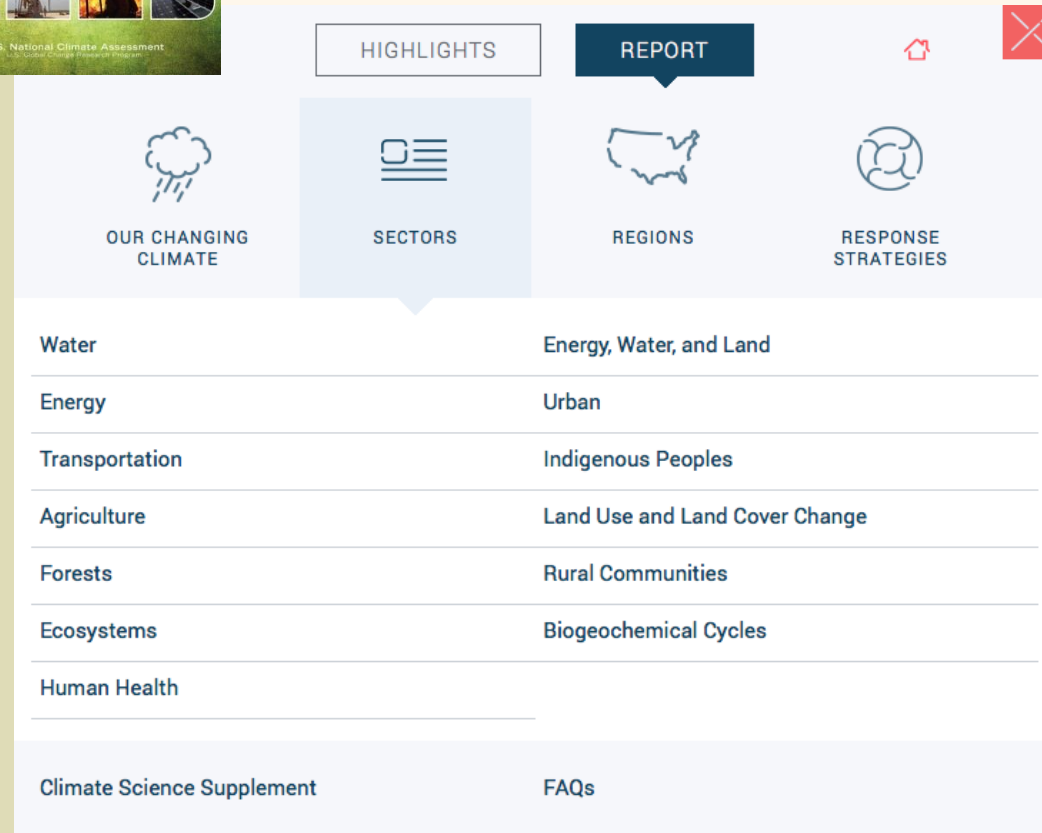
# NCA Products

- Full synthesis document
- Stand alone chapters
- Highlights document
- Multiple 2-4 page handouts
- Spanish language versions
- Dynamic website



<https://nca2014.globalchange.gov>

Released May 6, 2014



The screenshot shows the NCA website interface. At the top, there are buttons for 'HIGHLIGHTS' and 'REPORT' (which is highlighted). Below these are four main navigation icons: 'OUR CHANGING CLIMATE' (cloud with rain), 'SECTORS' (American flag), 'REGIONS' (map of the US), and 'RESPONSE STRATEGIES' (circular arrows). Below the navigation is a list of report sections:

Water	Energy, Water, and Land
Energy	Urban
Transportation	Indigenous Peoples
Agriculture	Land Use and Land Cover Change
Forests	Rural Communities
Ecosystems	Biogeochemical Cycles
Human Health	
Climate Science Supplement	FAQs

# NCAnet: Partners in Assessment

## 180+ partner organizations

- Professional societies
- Academic institutions and consortia
- Non-governmental organizations
- Local and state government departments
- Private sector

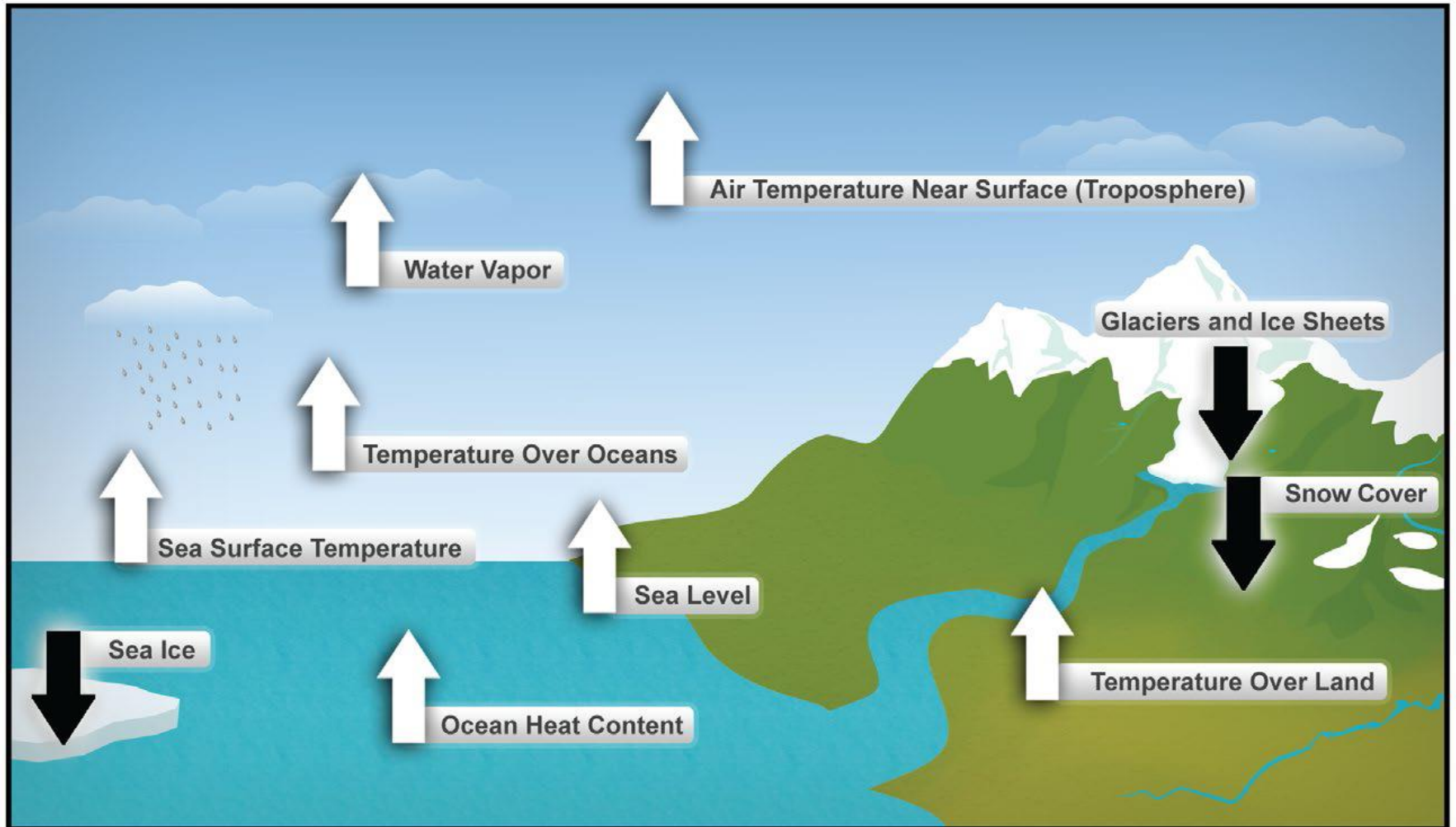
## Online at

<http://ncanet.usgcrp.gov>

- List of partners' NCA-related activities
- Monthly conversations among existing partners
- “Affinity groups” model for collaboration on activities
- Toolkit of materials related to USGCRP and the NCA

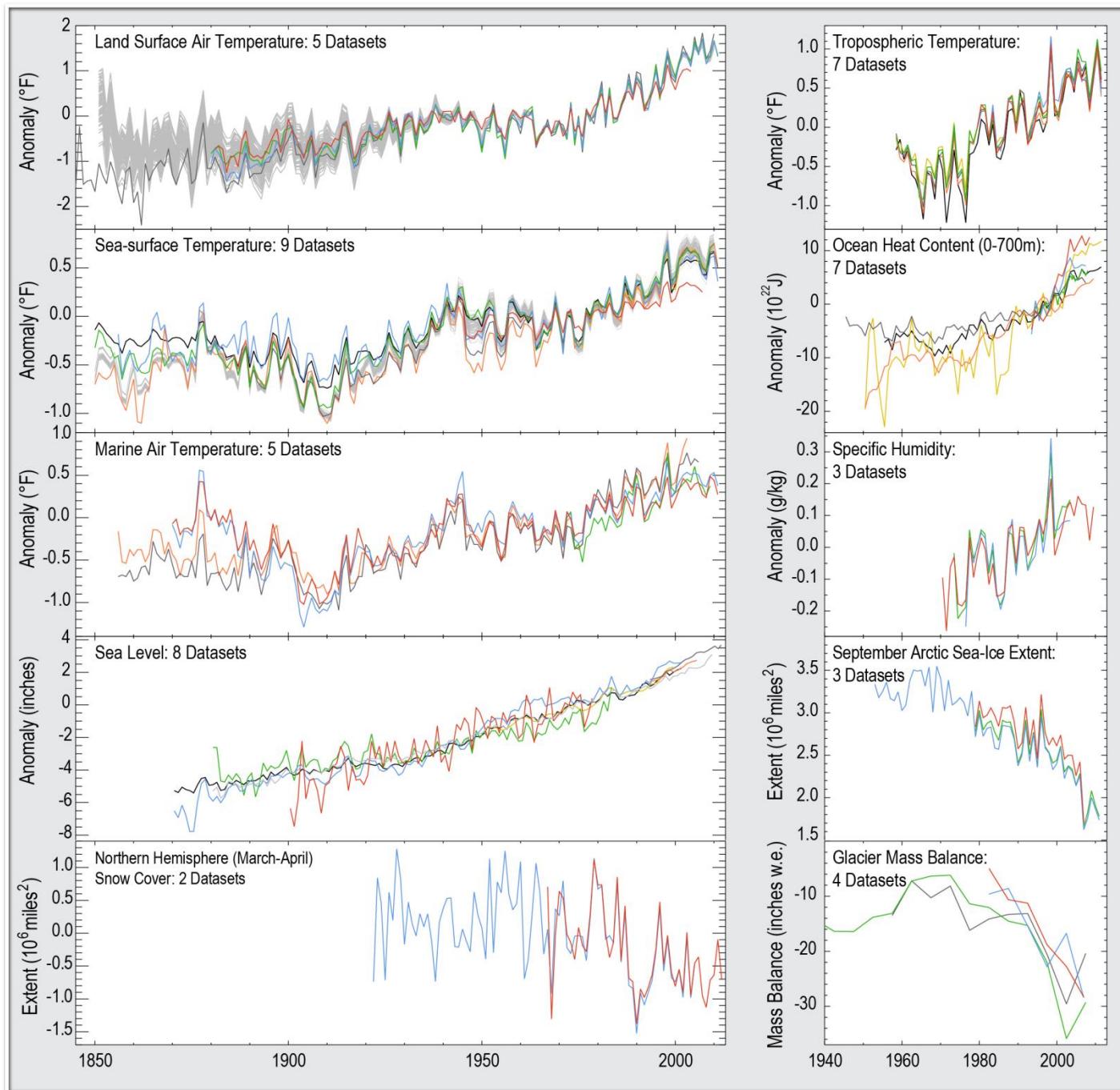
# Ten Indicators of a Warming World

## NCA3, Climate Chapter

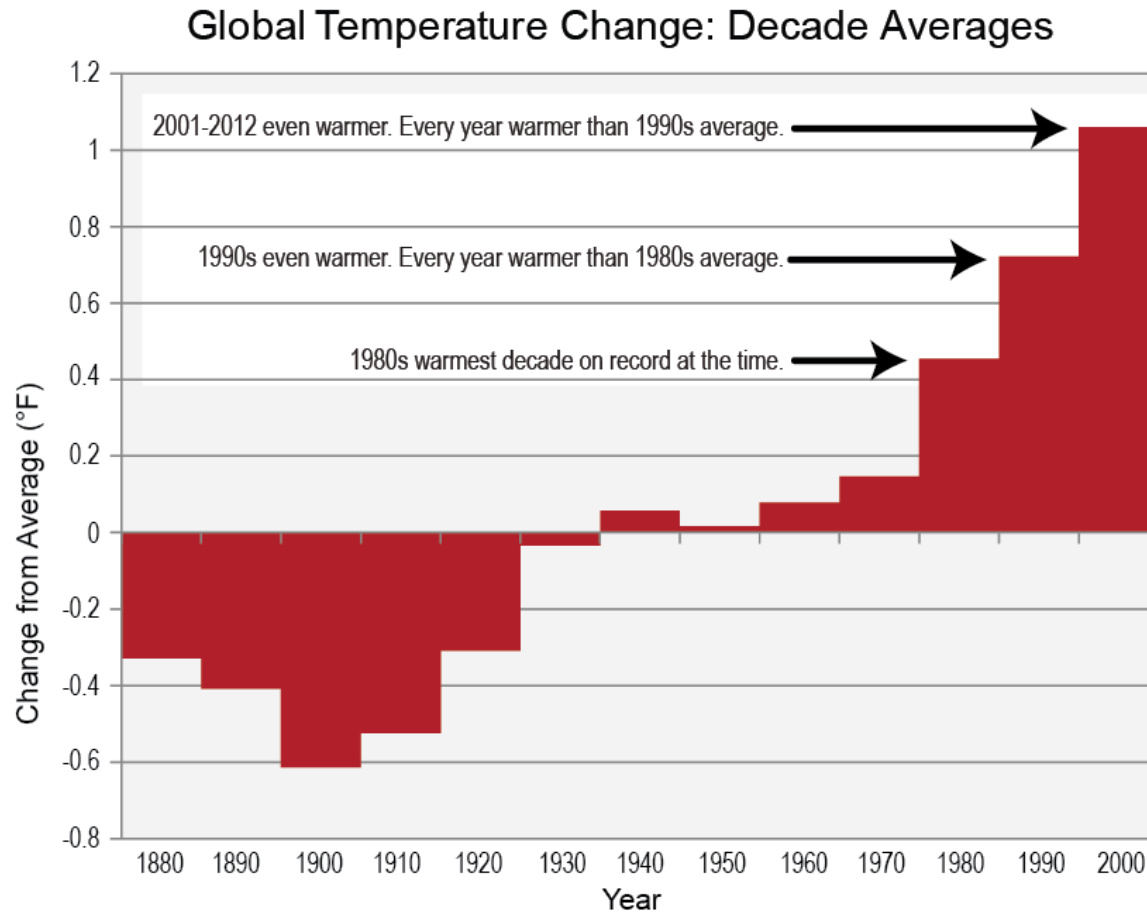


# Ten Indicators of a Warming World

Data since 1850 (left) and 1940 (right) show clear trends for each indicator



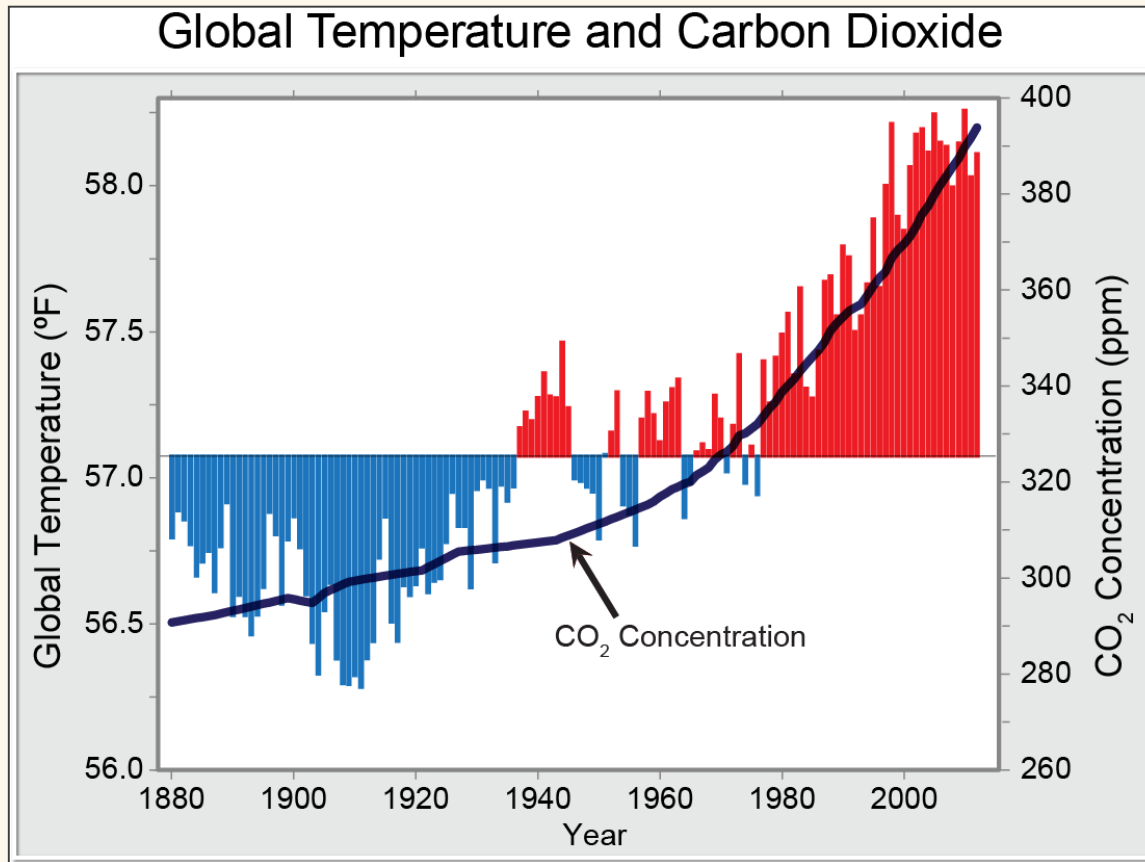
# Global Temperature Increases



NCA3 (Figure source: NOAA NCDC).

# Global Temperature Change and Attribution

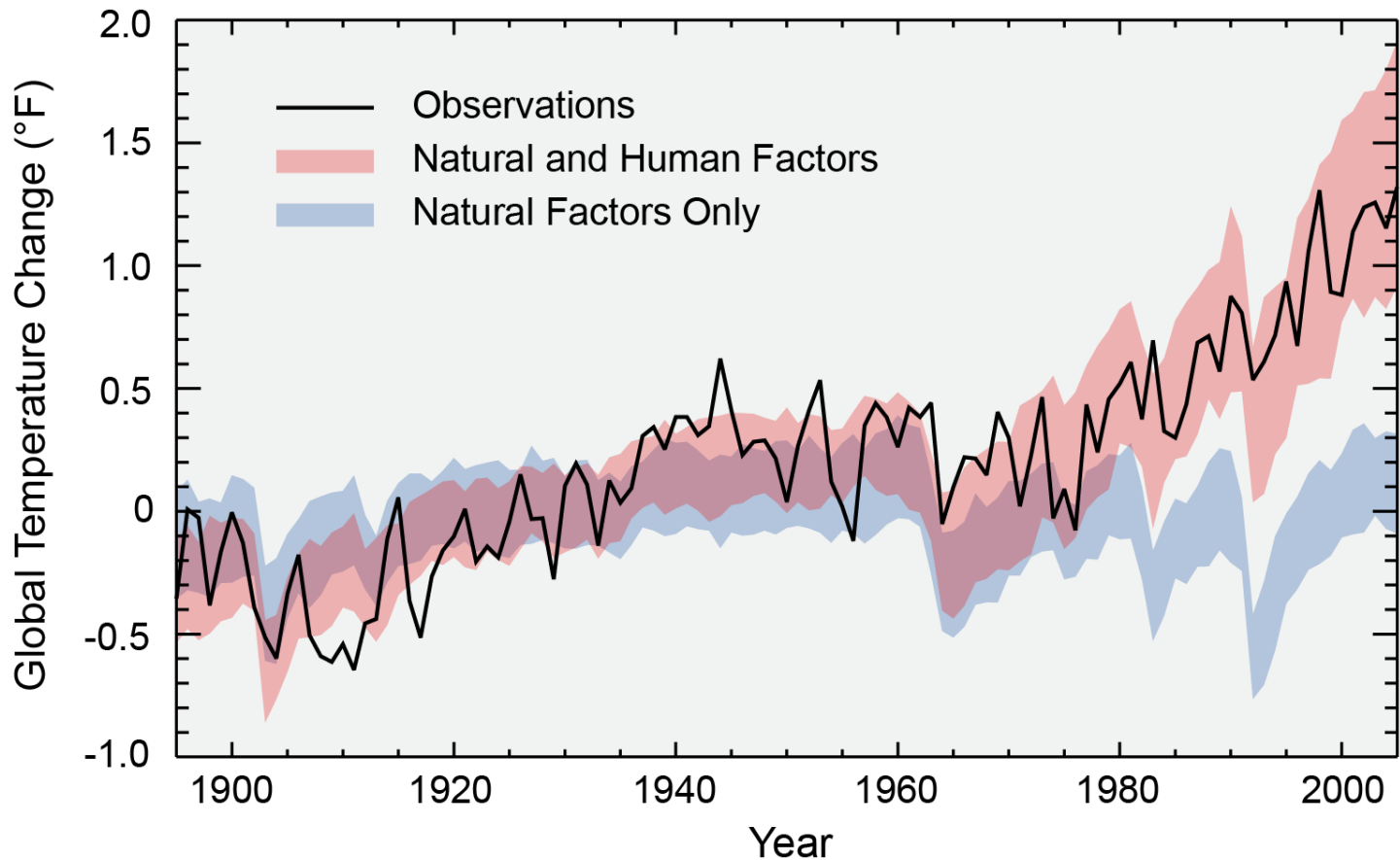
## NCA3, Climate Chapter



**2000-2009 was the warmest decade in at least 1300 years.**

# Human Influence on Climate

## Separating Human and Natural Influences on Climate

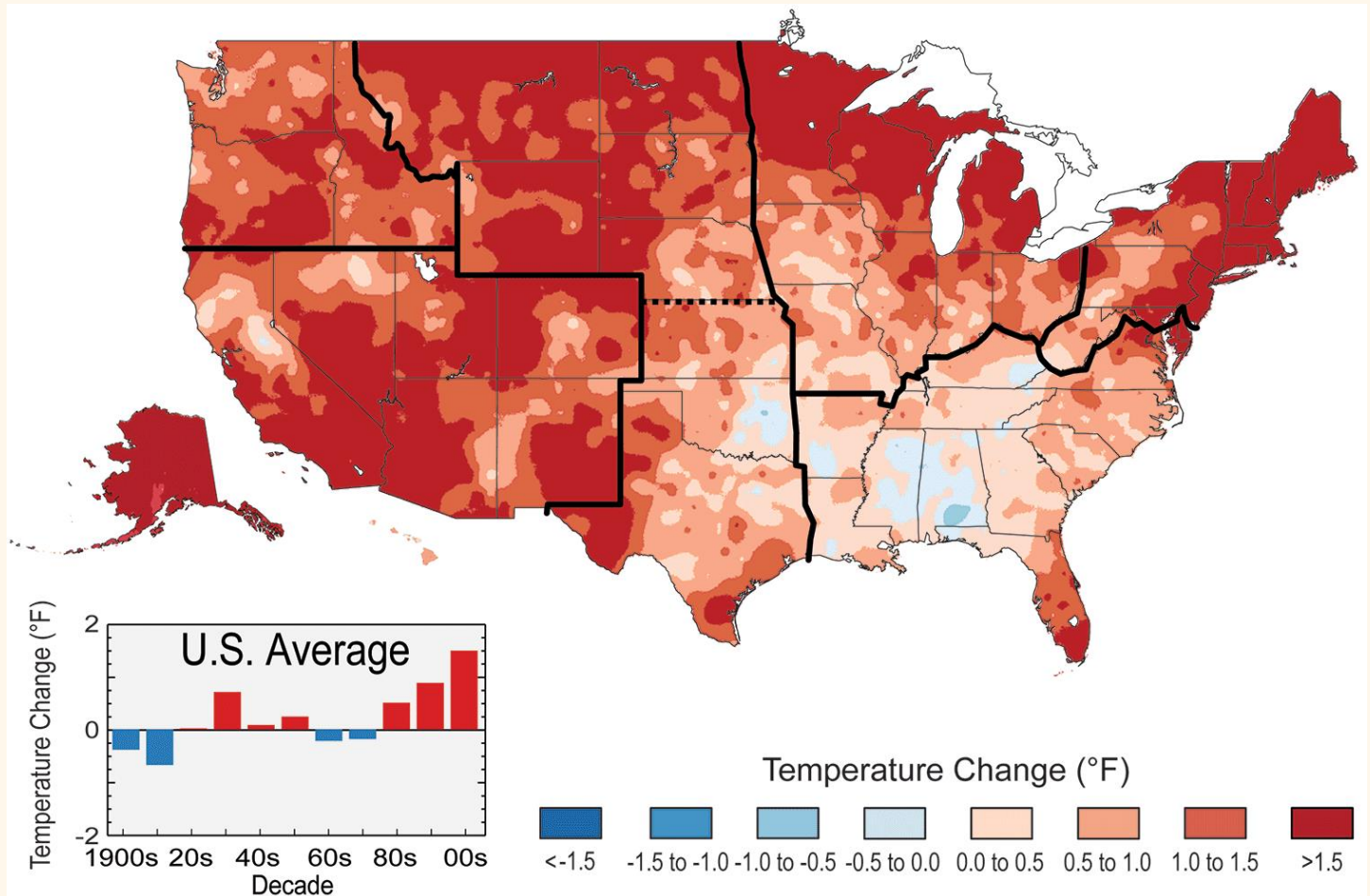


(Source: adapted from Huber and Knutti, 2012)

# Report Findings

*Our changing climate:* Global climate is changing and this is apparent across the United States in a wide range of observations.

Observed  
U.S.  
Temperature  
Change





# Report Findings

*Our changing climate:* The global warming of the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels.



©Tom Mihalek/Reuters/Corbis

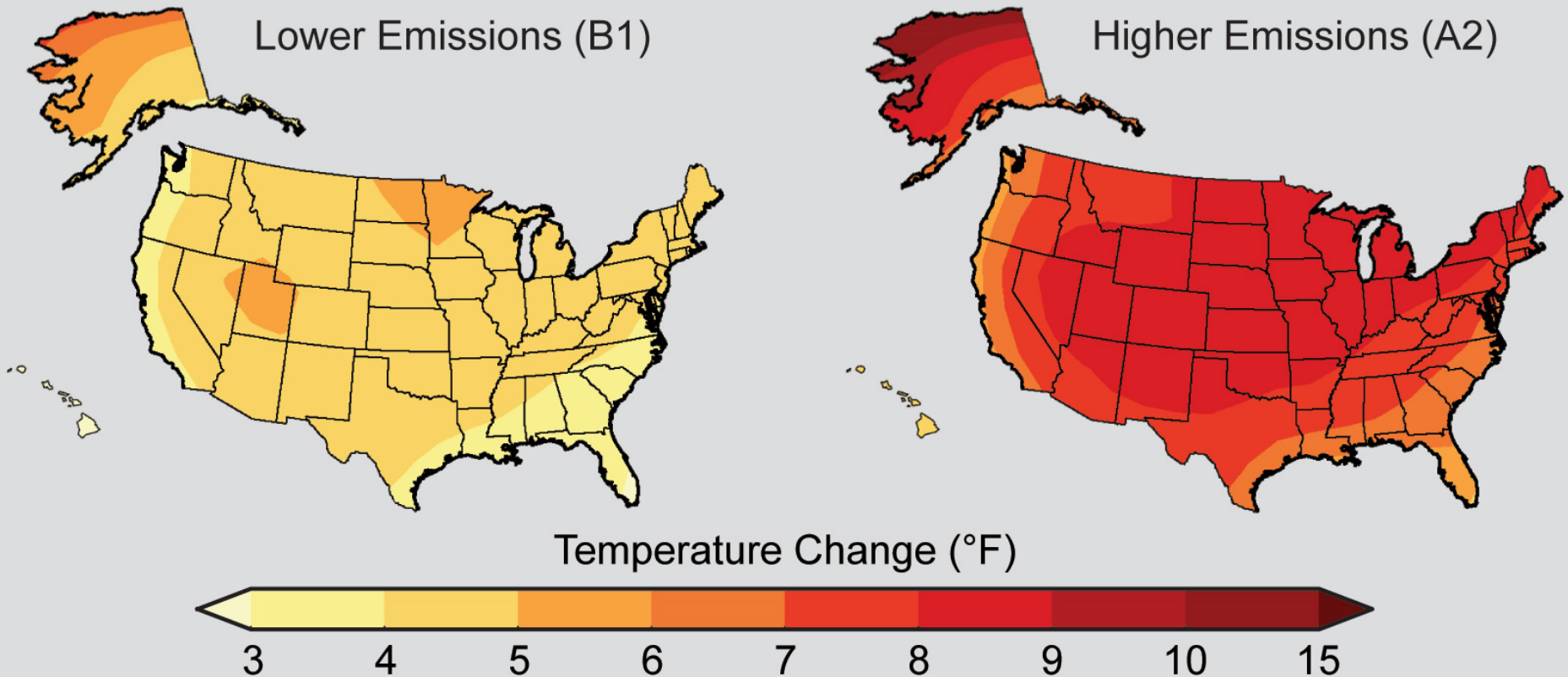


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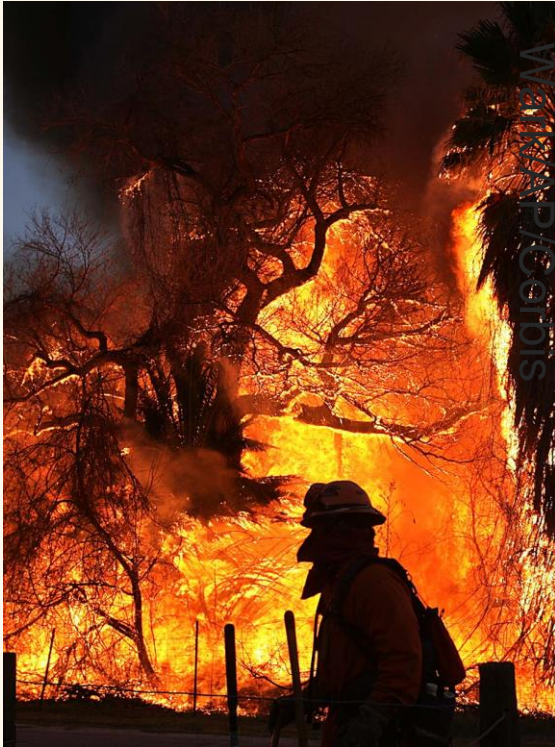
# Report Findings

*Future climate:* Human-induced climate change is projected to continue, and it will accelerate significantly if global emissions of heat-trapping gases continue to increase.



# Report Findings

*Widespread impacts:* Impacts related to climate change are already evident in many sectors and are expected to become increasingly disruptive across the nation throughout this century and beyond.



©AP Photo/The Press-Enterprise, Terry Pierson

© John



© Dave Martin/AP/Corbis



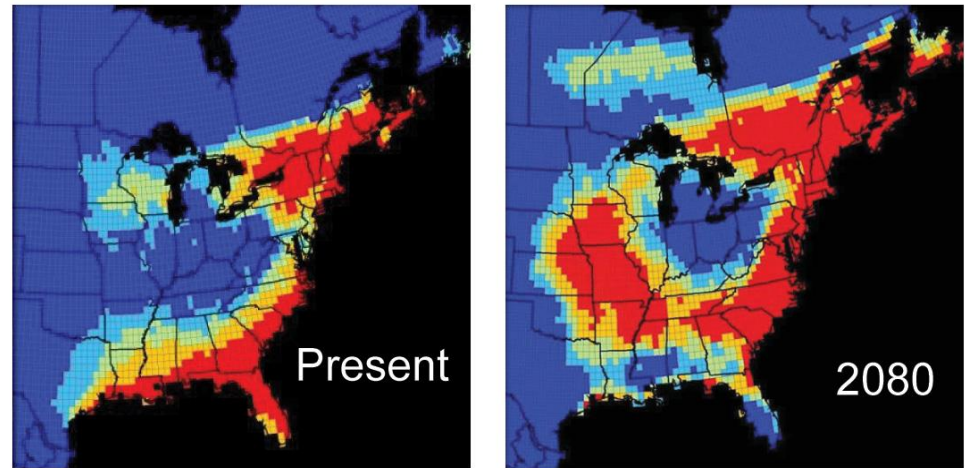
# Report Findings

*Human health:* Climate change threatens human health and well-being in many ways, including through more extreme weather events and wildfire, decreased air quality, and diseases transmitted by insects, food, and water.



**Wildfire smoke has widespread health effects**

**Projected changes in Tick Habitat**



Tick Establishment Probability (%)



# Report Findings

*Infrastructure:* Infrastructure is being damaged by sea level rise, heavy downpours, and extreme heat; damages are projected to increase with continued climate change.



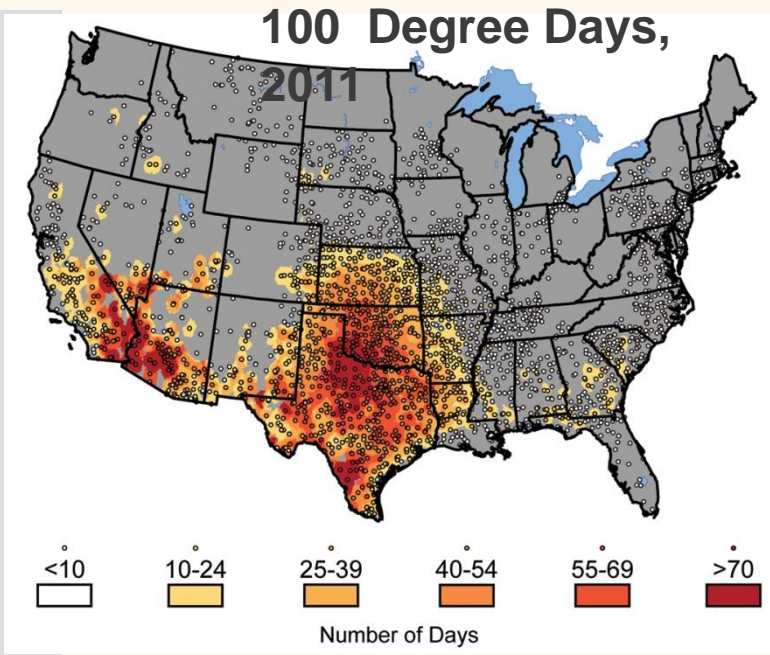
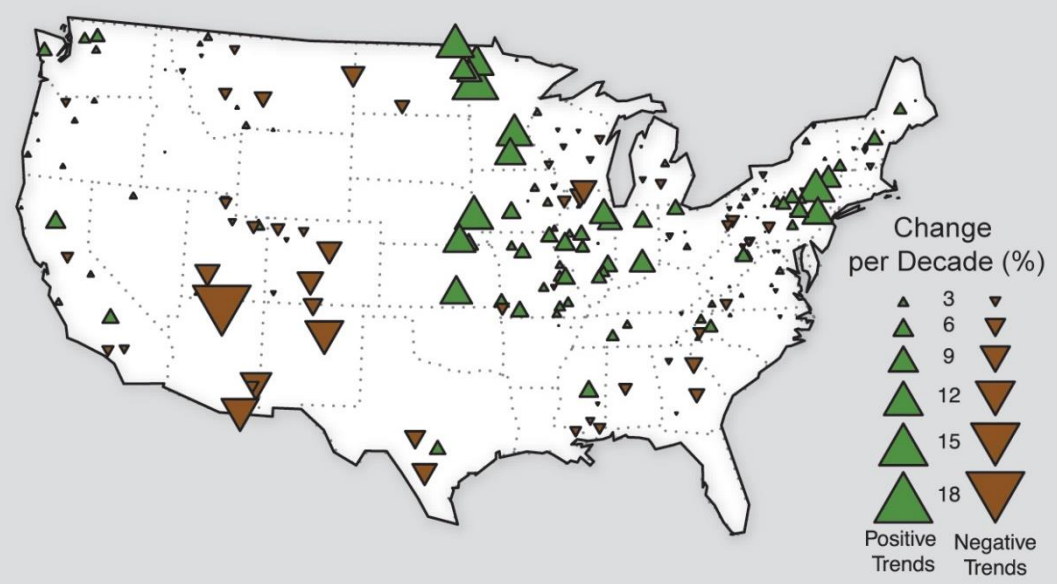
# Report Findings

*Water:* Water quality and water supply reliability are jeopardized by climate change in a variety of ways that affect ecosystems and livelihoods.



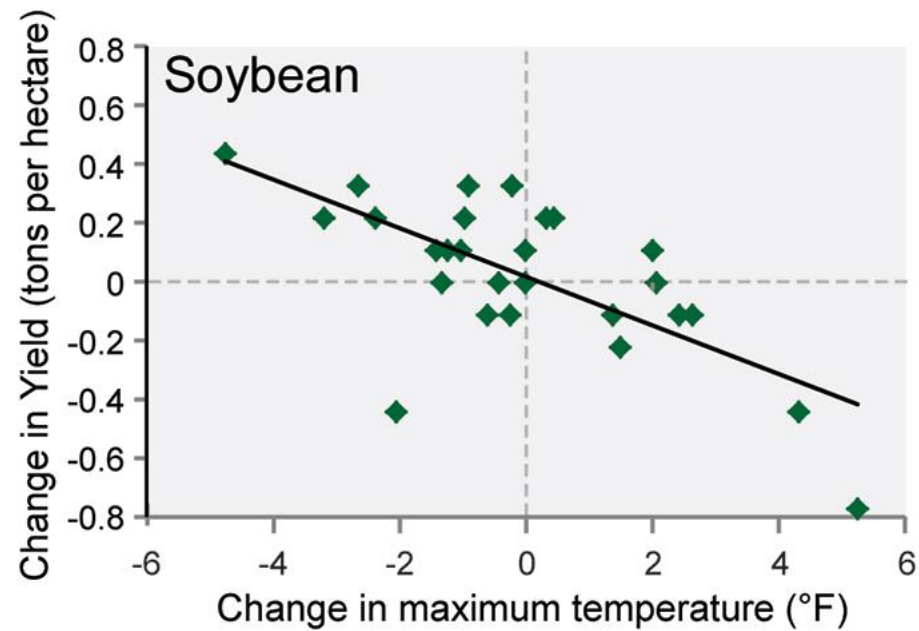
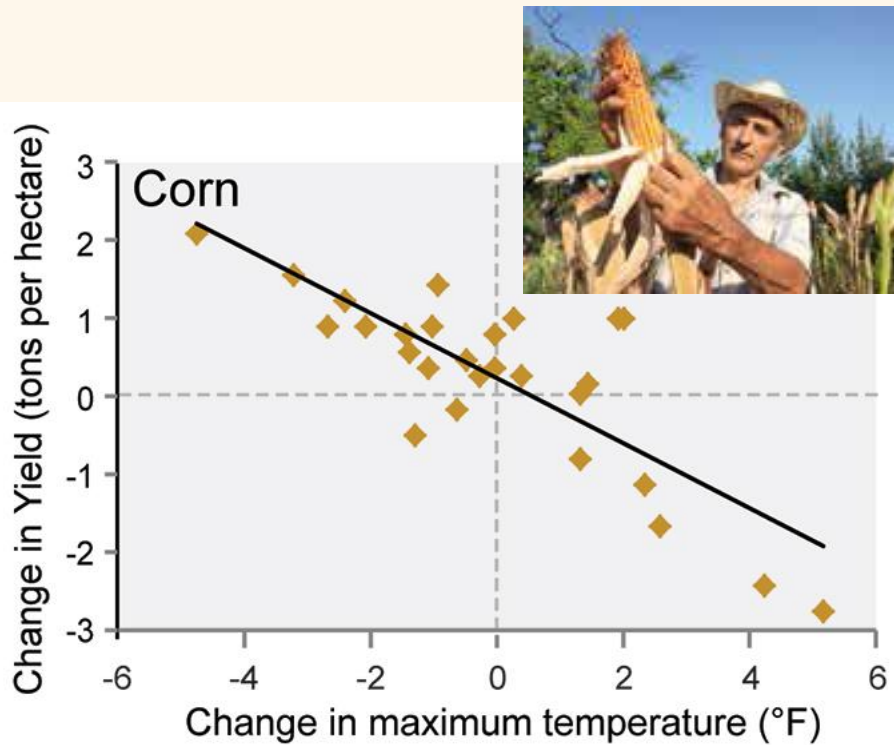
© Scott Olson/Getty Images

## Trends in Flood Magnitude per Decade



# Report Findings

*Agriculture:* Climate disruptions to agriculture have been increasing and are projected to become more severe over this century.



**Crop Yields Decline Under Higher Temperatures**



# Report Findings

*Indigenous peoples:* Climate change poses particular threats to Indigenous Peoples' health, wellbeing, and ways of life.



**Wild rice is unable to grow in its traditional range**



**Impacts in Alaska include damage to infrastructure due to melting permafrost**

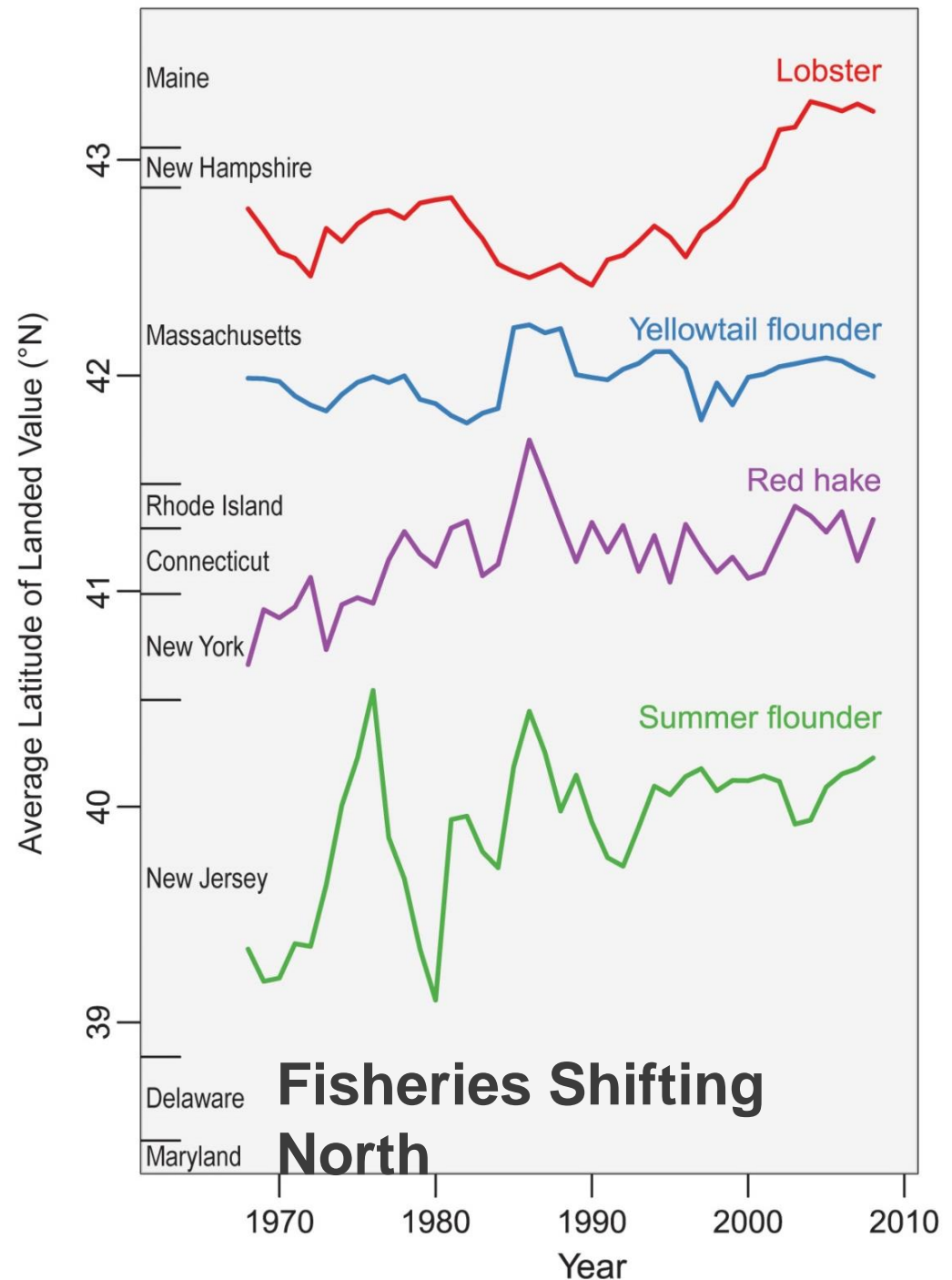
**Chronic stresses such as extreme poverty are exacerbated by heat and drought**



# Report Findings

## *Ecosystems:*

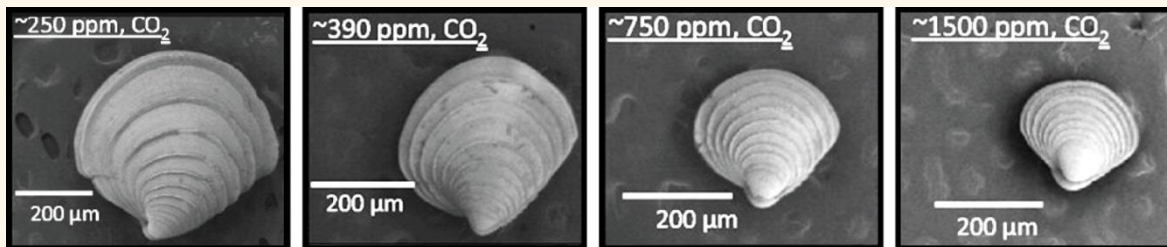
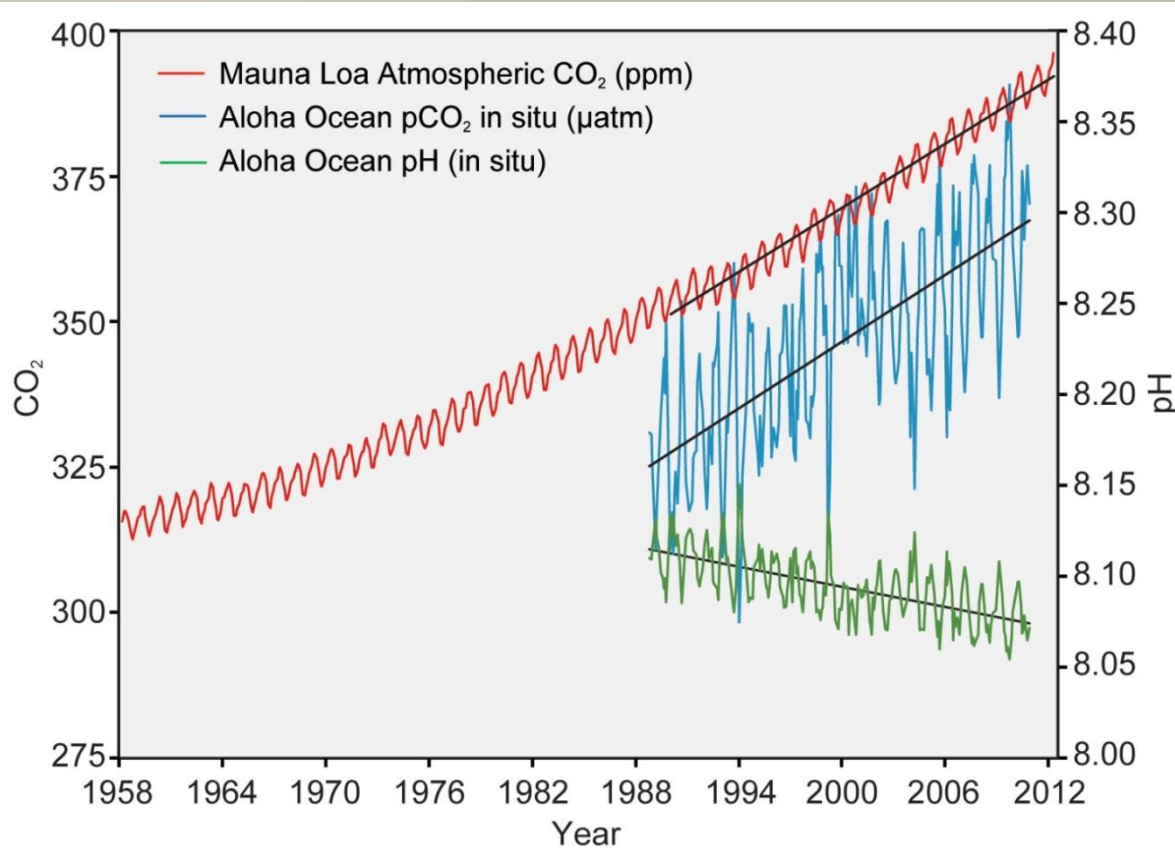
Ecosystems and the benefits they provide to society are being affected by climate change. The capacity of ecosystems to buffer the impacts of extreme events like fires, floods, and severe storms is being overwhelmed.



# Report Findings

## *Oceans:*

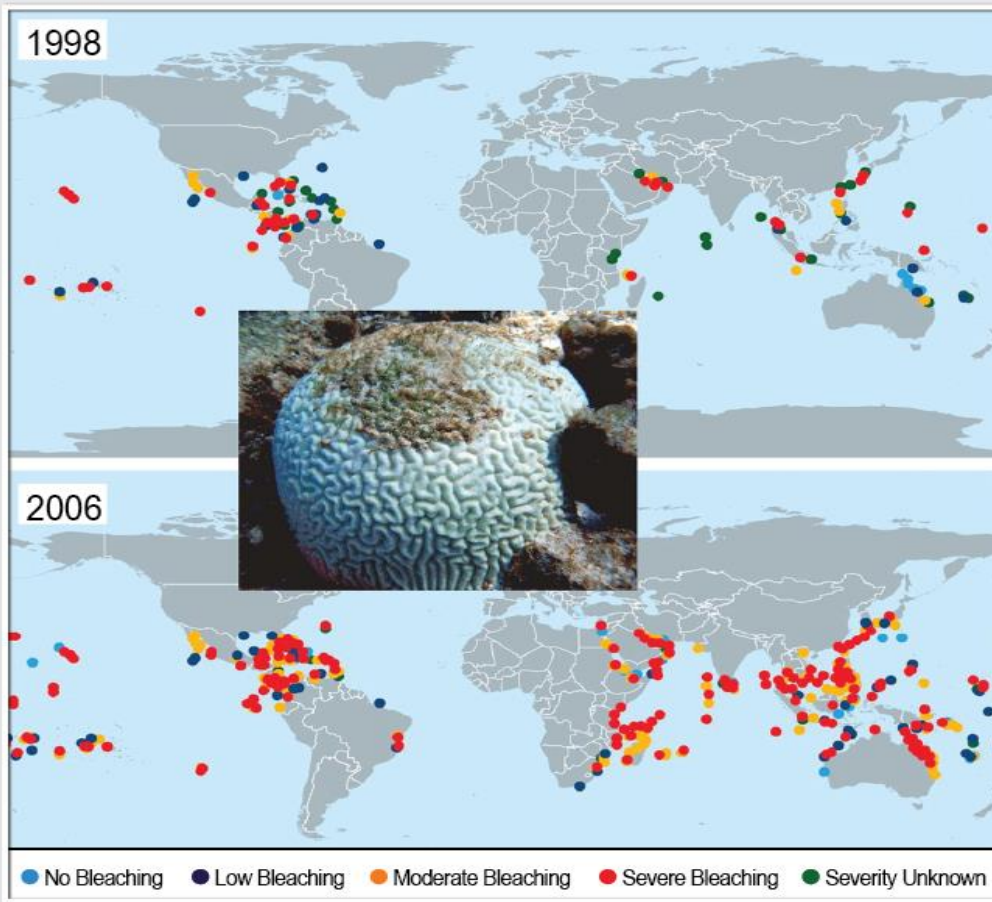
Ocean waters are becoming warmer and more acidic, broadly affecting ocean circulation, chemistry, ecosystems, and marine life.



**Ocean Acidification Reduces the Size of Clams**

# Climate Effects on Oceans

## Coral Bleaching

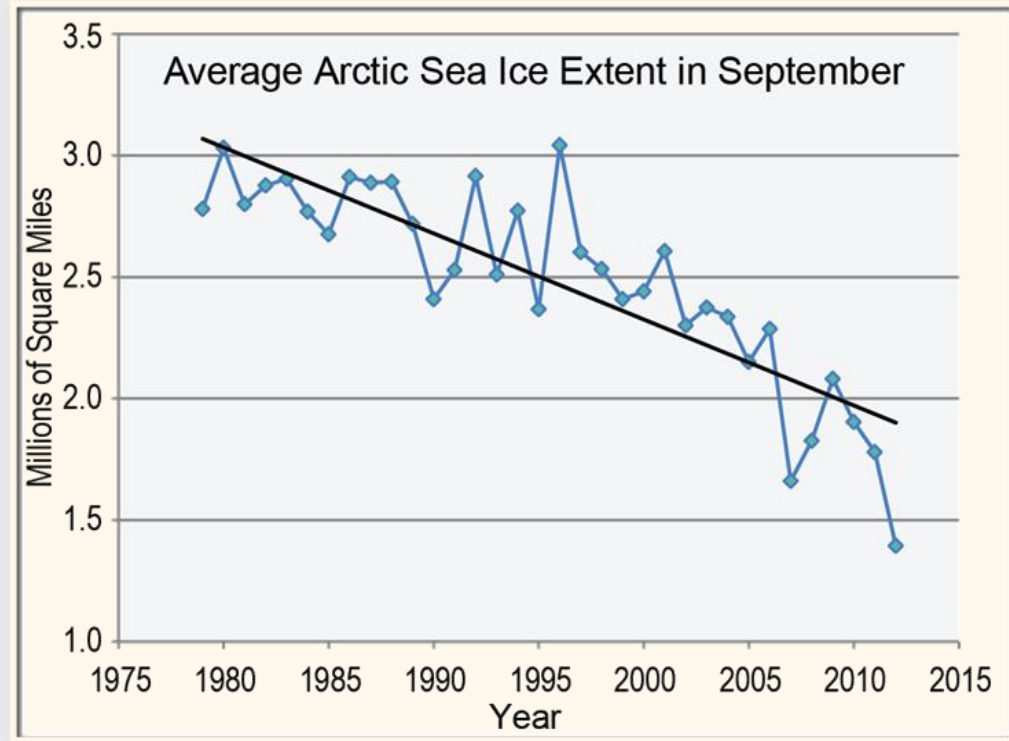
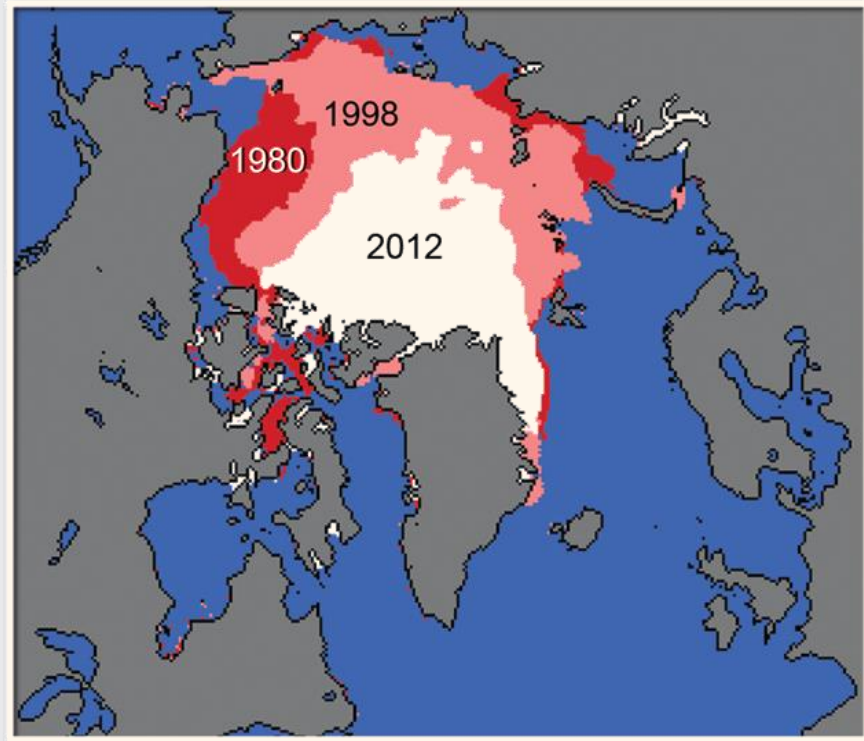


Today, the world's oceans absorb more than 90% of the energy captured by human-emitted carbon dioxide and other heat-trapping gases. This extra energy warms the ocean, causing it to expand. This in turn causes sea level to

**rise.** (Source: NOAA) (Figure source: Marshall and Schuttenberg 2006)

# Climate Effects Across the Arctic

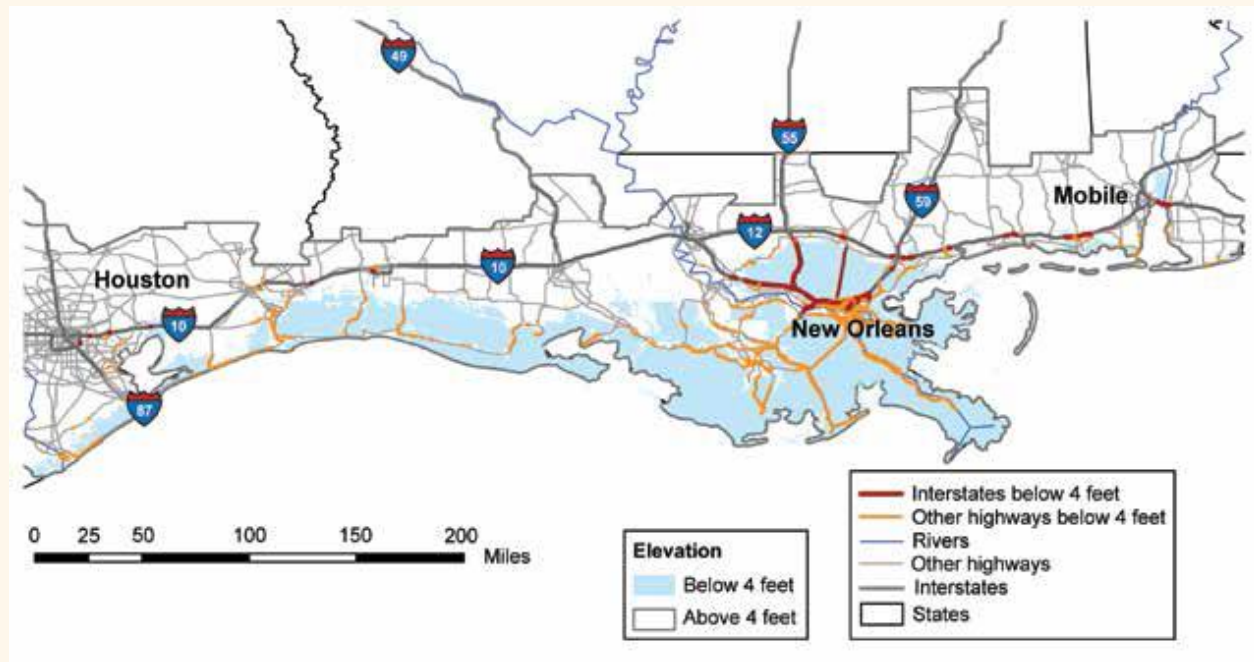
## Arctic Sea Ice Decline



Sea ice extent in 2012 was 40% below recent median.

# Report Findings: Coasts

Coastal lifelines, such as water supply infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, and other climate-related changes.



## Gulf Coast Transportation Hubs at Risk

# Report Findings

*Responses:* Planning for adaptation (to address and prepare for impacts) and mitigation (to reduce future climate change, for example by cutting emissions) is becoming more widespread, *but current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences.*



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# Projected Precipitation by Season (CMIP 5)

## Continued Emissions Increases (RCP 8.5)

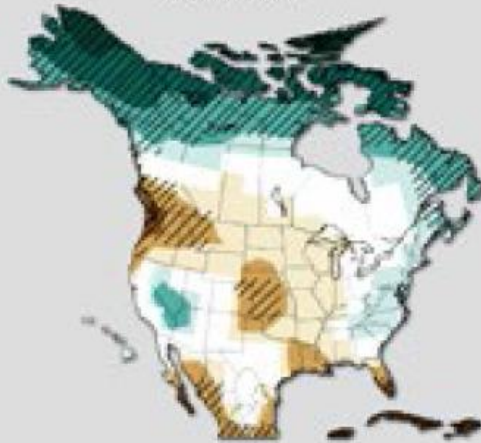
Winter



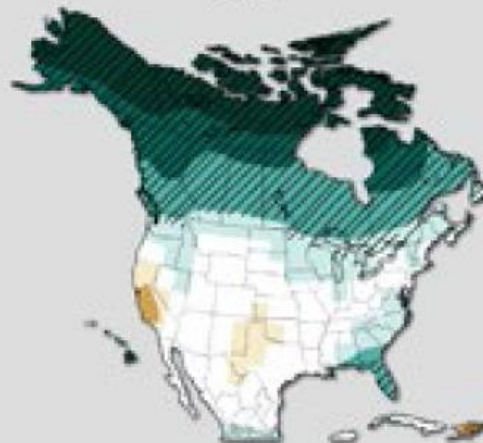
Spring



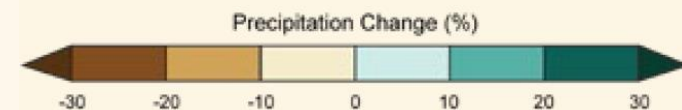
Summer



Fall

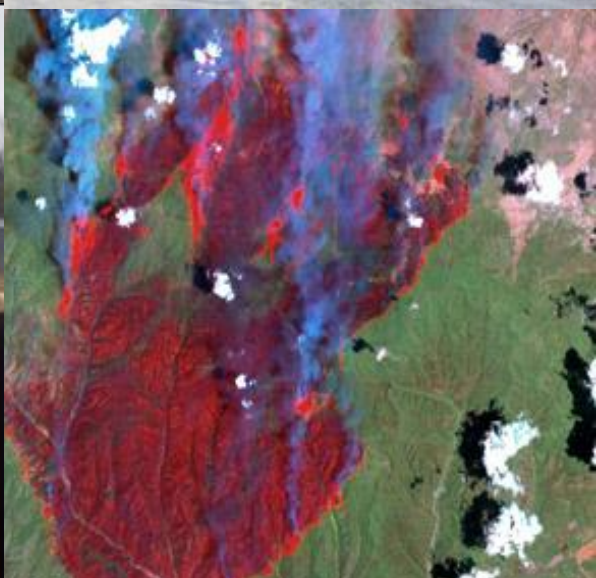
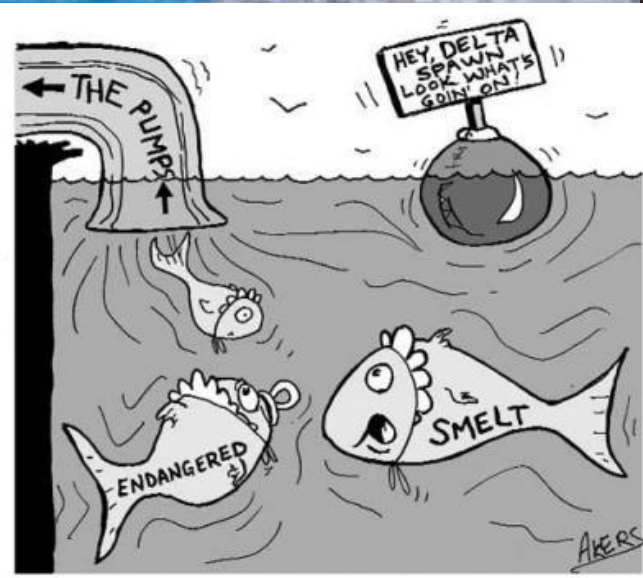


The wet areas  
will get wetter,  
The dry areas  
will get drier...





# Most of the impacts of climate change are felt through changes in the water cycle



"IF ONLY THEY COULD JUST BYPASS US"



## **NCA3 CHAPTER 3: WATER RESOURCES**

### **Convening Lead Authors**

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Paul Fleming, Seattle Public Utilities

### **Lead Authors**

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Christa Peters-Lidard, National Aeronautics and Space Administration

Terese (T.C.) Richmond, Van Ness Feldman, LLP

Ken Reckhow, Duke University

Kathleen White, U.S. Army Corps of Engineers

David Yates, University Corporation for Atmospheric Research

# Impacts of Climate Change on Water Sector

Climate change will affect

- Snowpack, rain vs. snow (esp at lower elevations)
- Timing and seasonality of surface water runoff (depending on basin storage)
- Groundwater-surface water interactions (gaining and losing stream segments affected)
- Water temperature and quality
- Extreme events (floods and droughts)

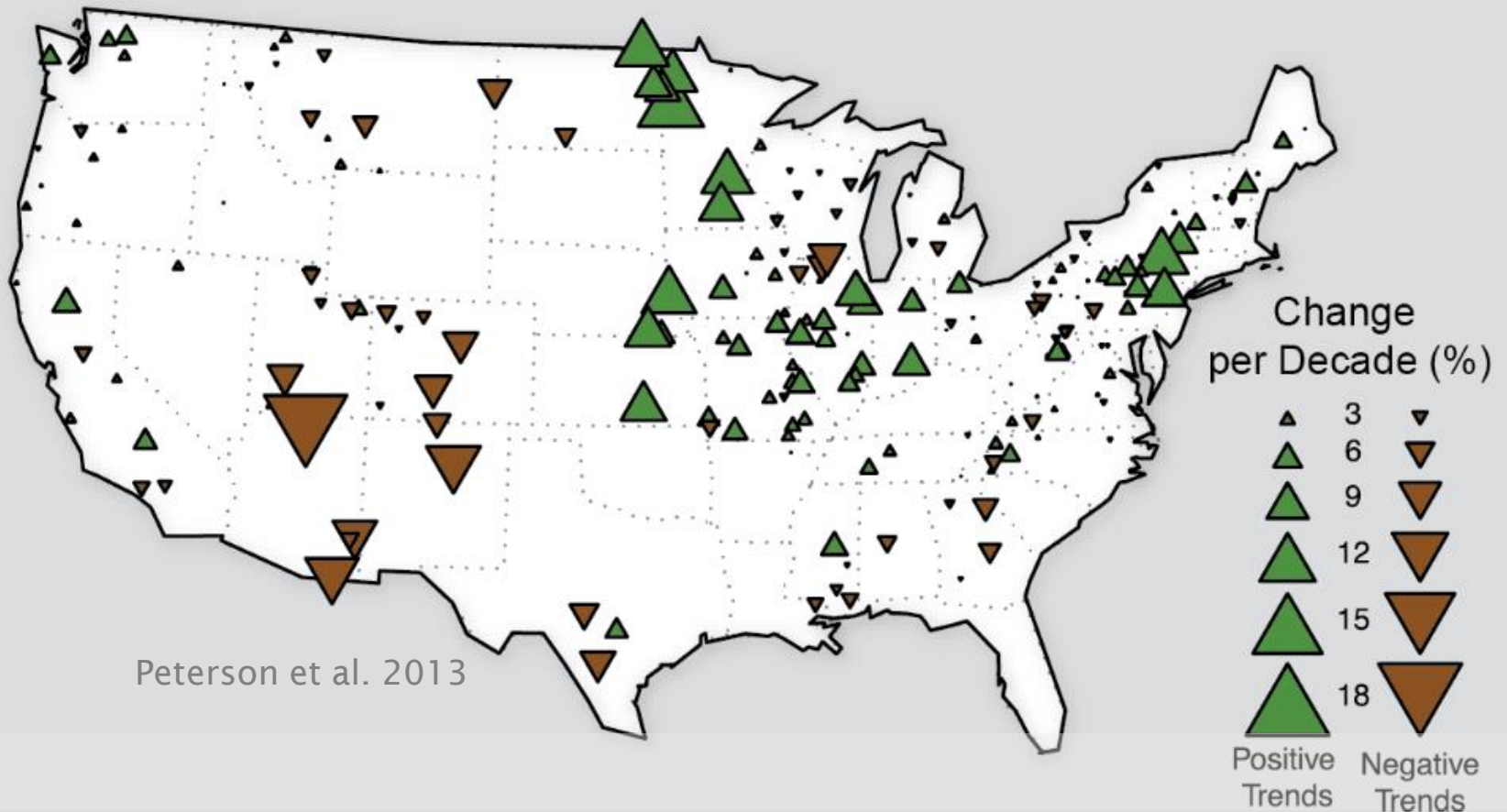
# Flood Factors and Expected Trends

- Flash and Urban Flooding - expected to Increase
- Riverine Flooding - uncertain, as it depends on several factors (basin extent, precipitation, soil moisture, time of year, snow cover, land use, terrain, etc.)
- Coastal Flooding - expected to increase in many coastal areas.



- In the US, from 1959 to 2005, floods caused 4,585 deaths and property and crop damage averaging \$8.22 billion per year

# Observed Flood Magnitude Trends [1920 - 2008]

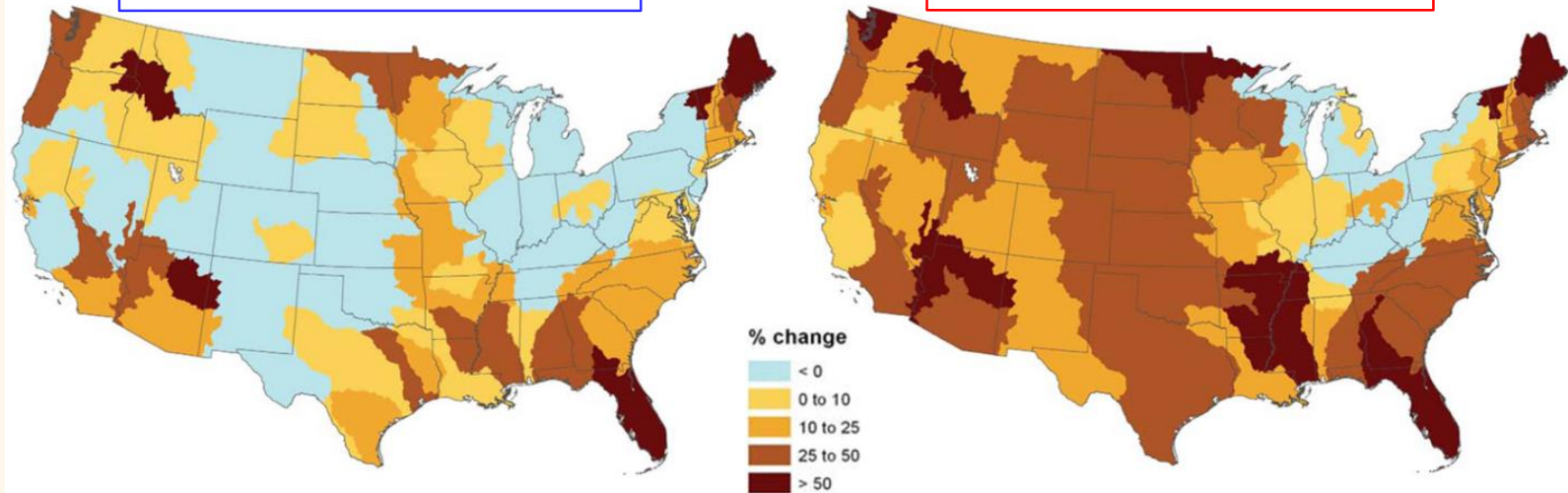


# Climate Change Impacts on Water Use

## Projected Changes in Water Withdrawals

(a) Without Climate Change

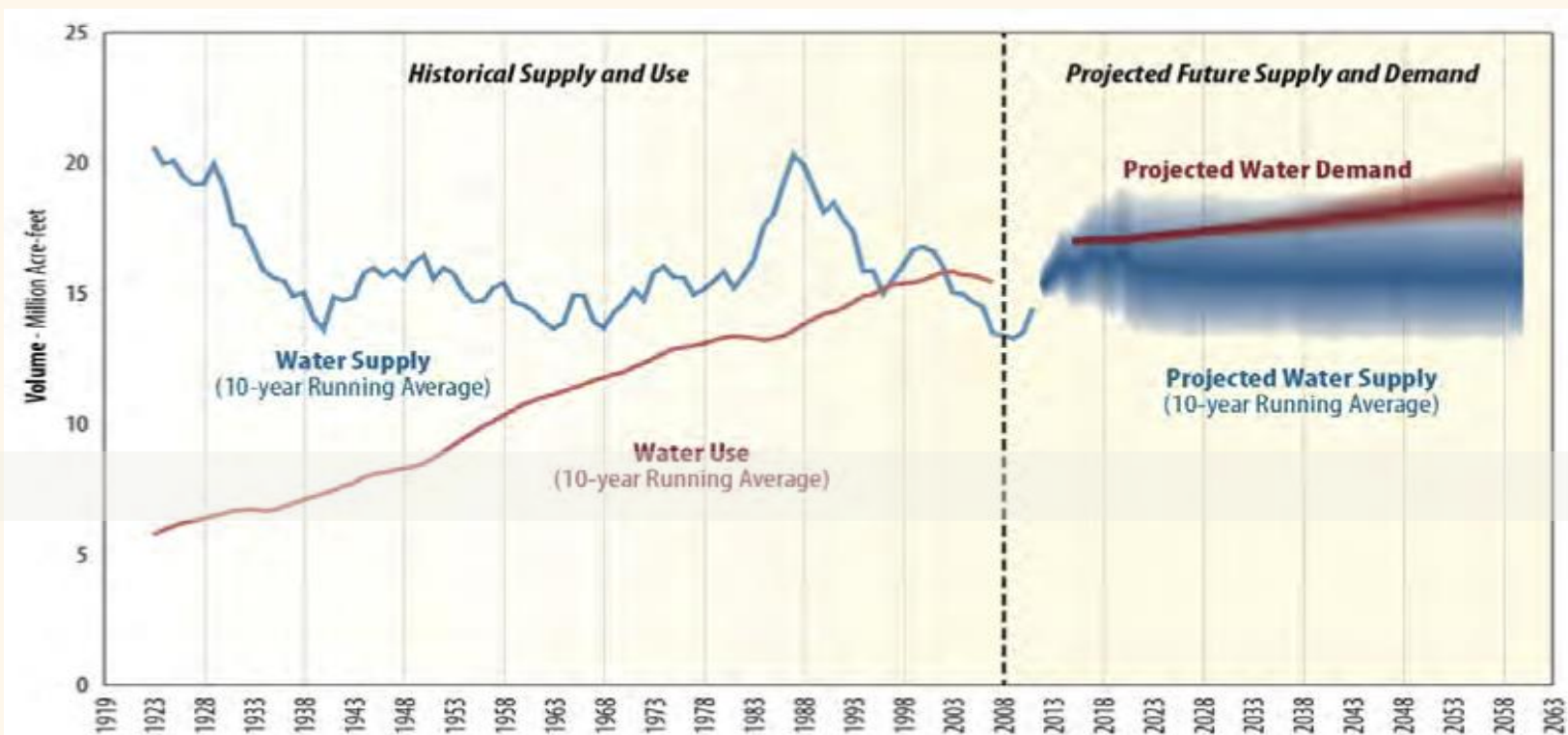
(b) With Climate Change



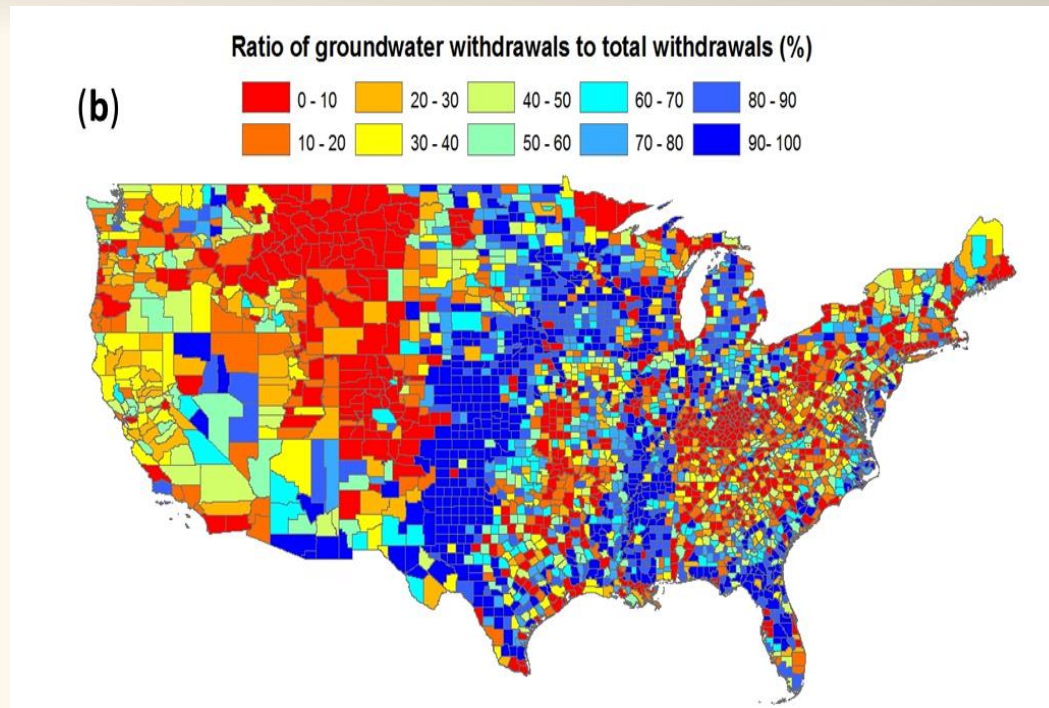
% change from 2005 to 2060 in projected demand assuming (a) change in population and socioeconomic conditions of A1B, but no change in climate, and (b) combined changes in population, socioeconomic conditions, *and* climate

# Climate Change Impacts on Water Management

## Historical and Projected Water Supply and Demand for the Colorado River Basin



# Groundwater Availability



- Groundwater is the main water supply source for many US regions
- GW is susceptible to the combined stresses of climate change (slow to manifest) and water use changes (more immediate impacts).



# Conclusions

- *The question for water managers is no longer whether climate change is happening.*
- *The question is what are we going to do about it?*

# Water/Climate Adaptation options

- Drought planning and conservation are no-regrets strategies
  - Conjunctive management offers multiple benefits
- However,** water either comes from the environment or from a current use (no free lunch!)
- Effects on groundwater of drought and climate change need more analysis



# Adaptation options: Expand the solution set to include new technologies and practices

Expand portfolio of technology solutions:

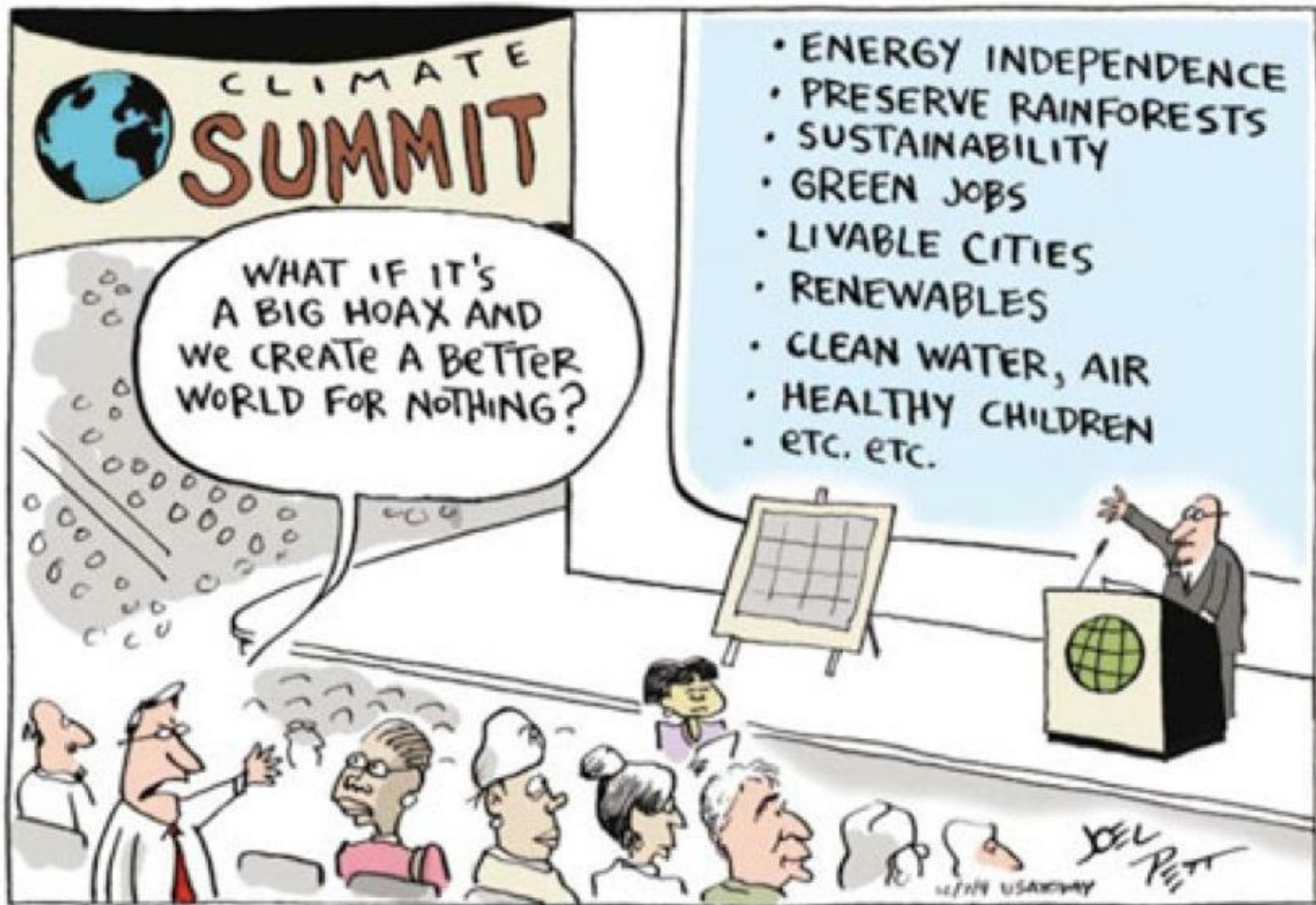
- desalination,
- reuse and recharge of municipal wastewater,
- rainwater harvesting,
- improved management of floodflows,
- integration/redundancy of delivery systems for reliability
- green infrastructure



# Adaptation Options: More Flexible Water Rights



- Reservoir reoperation
- Conditional water rights;
- Trigger-mechanisms for alternative allocation schemes based on monitoring of key species, drought conditions, flow volumes, demand levels, reservoir elevations;
- Dry-year options to ensure municipal supply and instream flow needs are met;
- Unit shares of basin water rights, with or without replenishment obligations.



- ENERGY INDEPENDENCE
- PRESERVE RAINFORESTS
- SUSTAINABILITY
- GREEN JOBS
- LIVABLE CITIES
- RENEWABLES
- CLEAN WATER, AIR
- HEALTHY CHILDREN
- ETC. ETC.

WHAT IF IT'S  
A BIG HOAX AND  
WE CREATE A BETTER  
WORLD FOR NOTHING?

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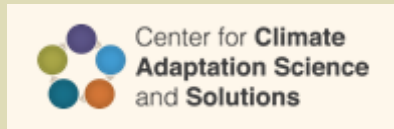
# CCASS Themes/Grand Challenges



- *Bridging the gap between science and decision making*
- *Managing risk in a complex, interdisciplinary and multi-sectoral context*
- *Supporting transformational adaptation and preparing for extreme climate and weather events*
- *Finding synergies among adaptation and mitigation strategies to promote sustainability*

# CCASS Core Leadership Team

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<http://nca2014.globalchange.gov/report>