The Science of Climate Change : Why We All Should Care

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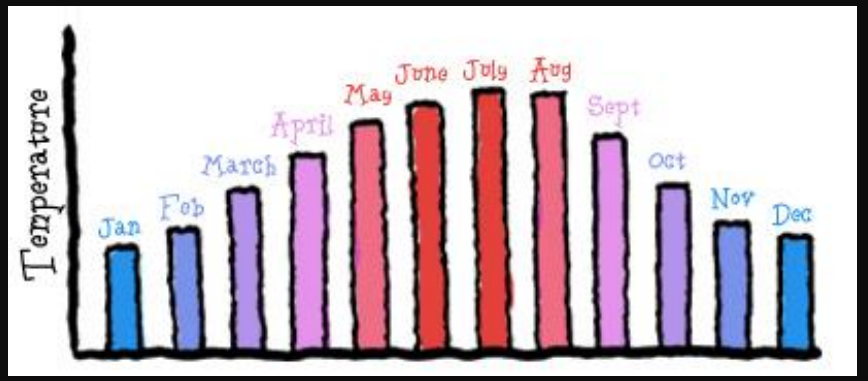
Future Values symposium, Depaul Univ. November 1, 2018

Climate Change: Long-Term Changes in Weather

Weather: State of the atmosphere at a given time.

Climate: Averages and statistics of the weather over long time periods (20-30 years).



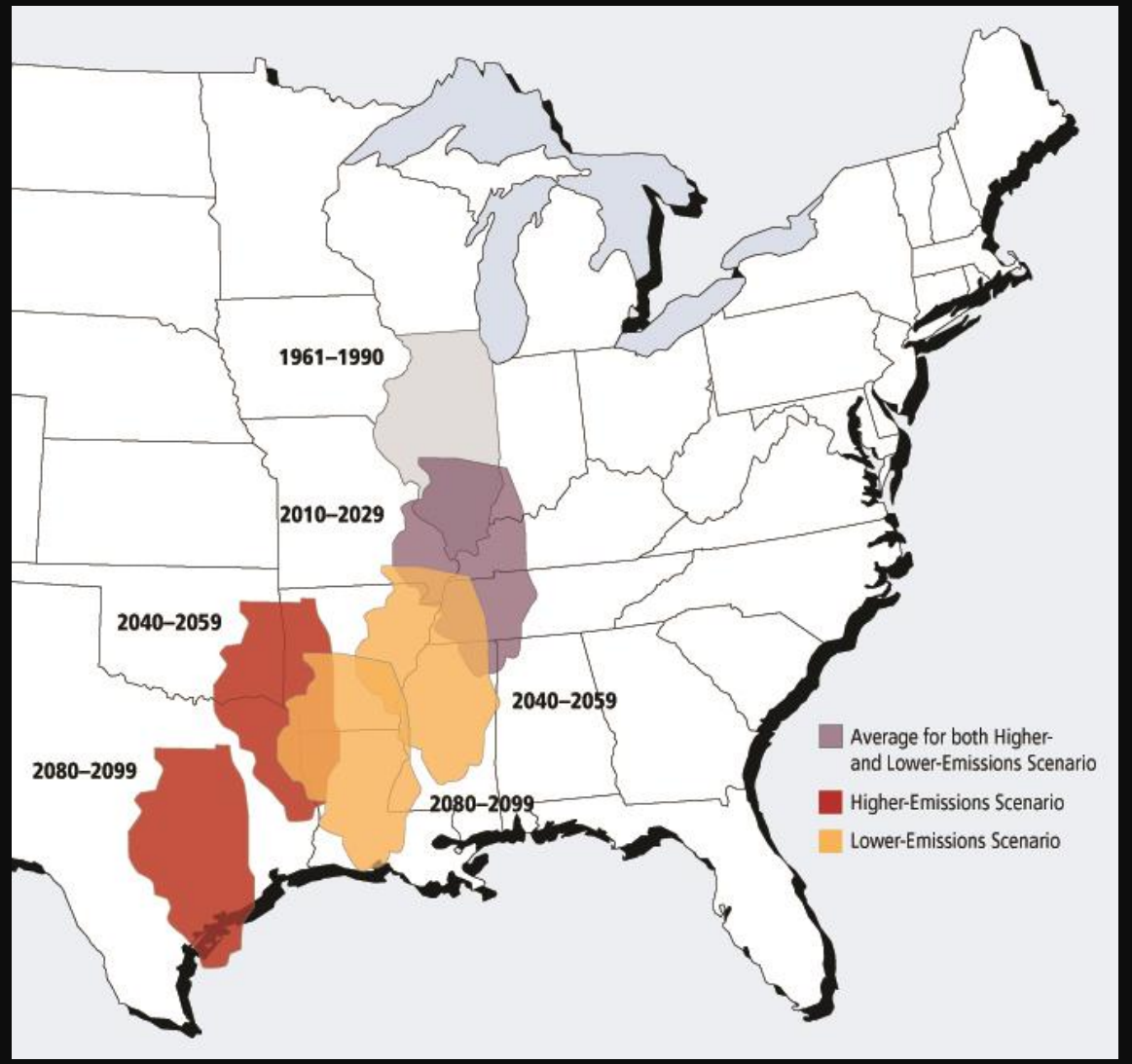
Climate is what you expect, weather is what you get.

Attributed to Mark Twain

Why Care about Climate and Climate Change?

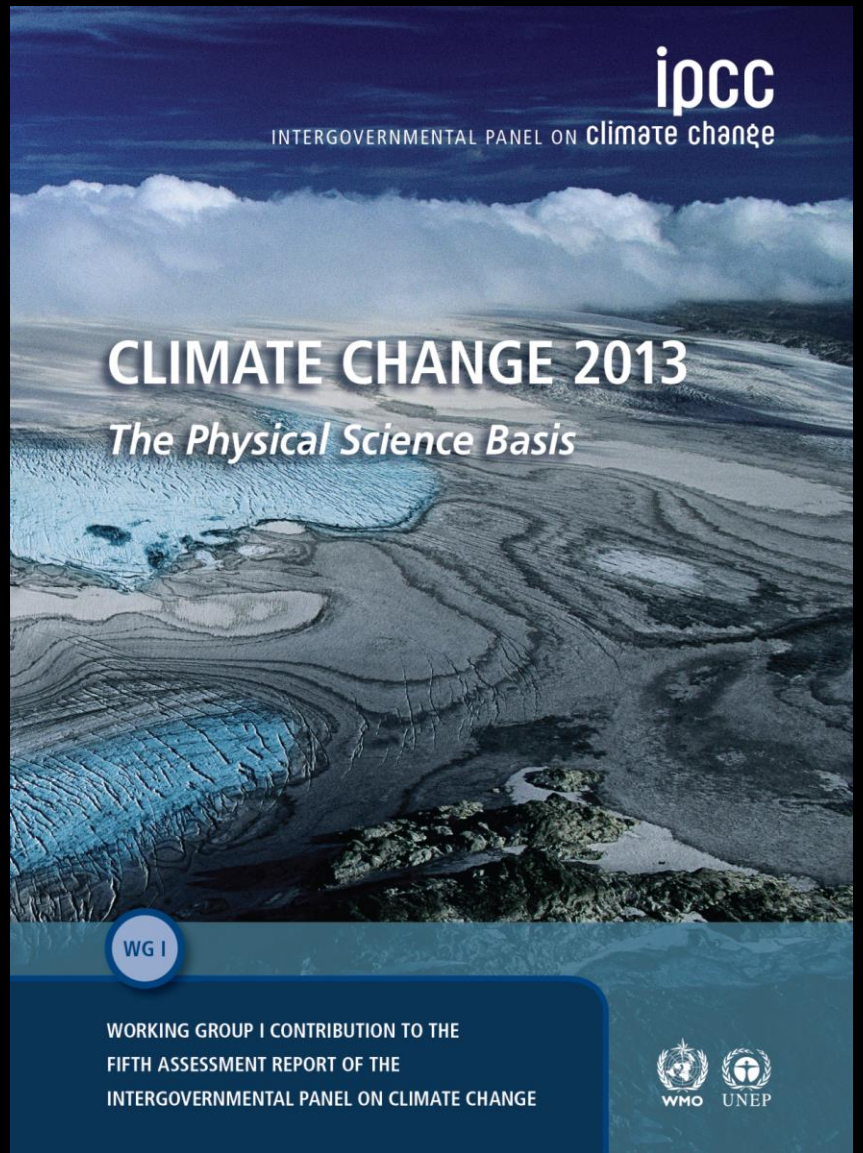
Climate affects the well-being where you live

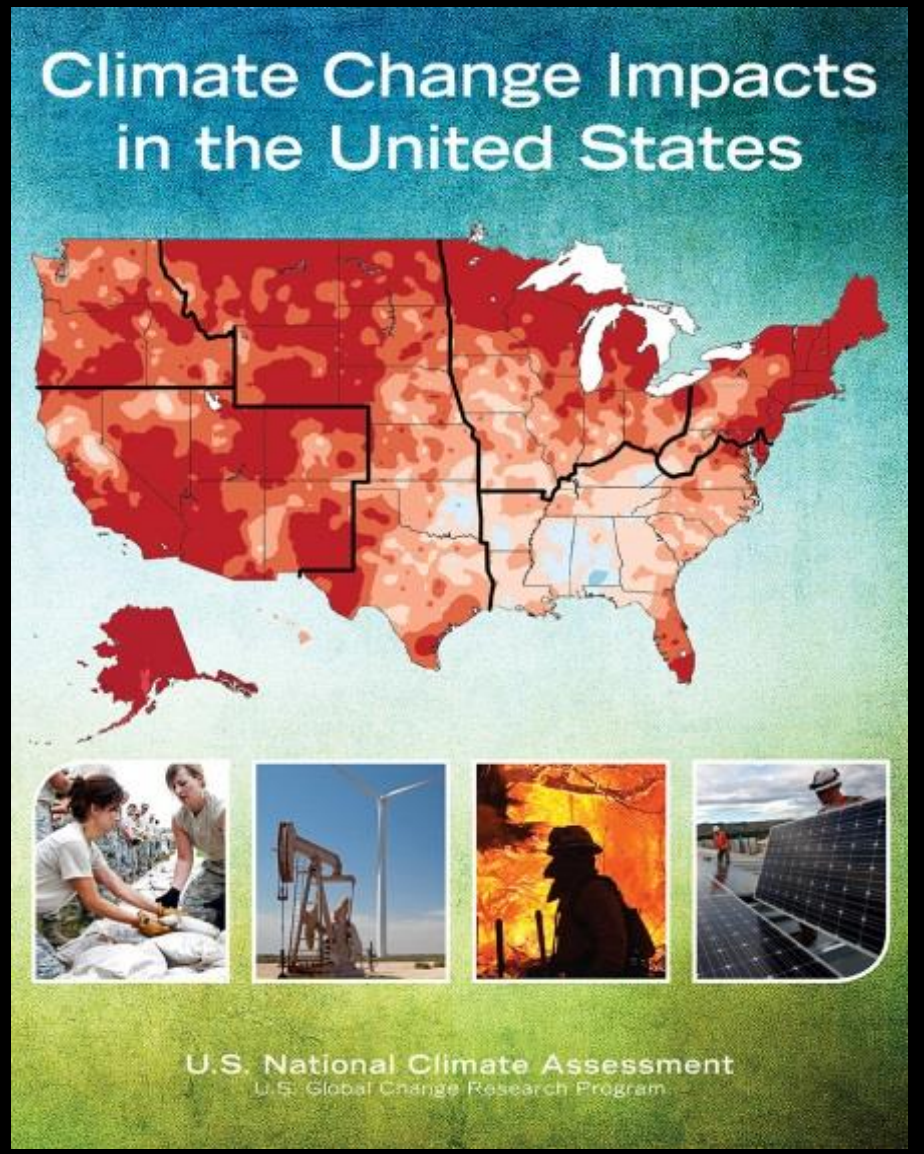
- The landscape
- Severity of the weather,
- Food availability,
- Water availability
- Ecosystems,
- Health risks



Suppose a summer in Illinois was more like a current summer in Texas?

Every 4-6 Years Scientists Assess the Science of the Changing Climate and its Societal Impacts





science2017.globalchange.gov

NCA Volume II on impacts expected to be published in Dec. 2018

The Science: The Bottom Line

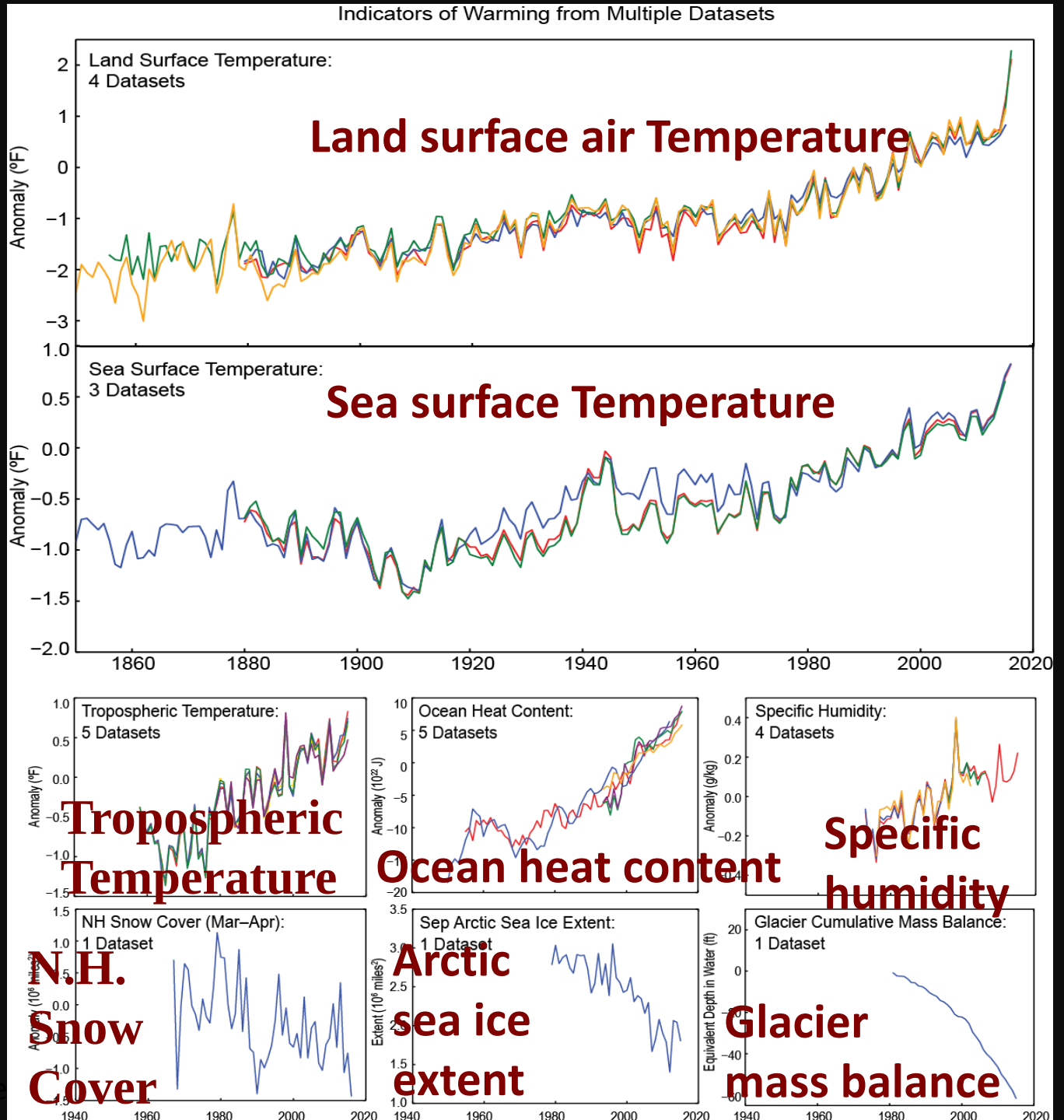
- Our climate is changing,
  - It is happening now;
  - It is happening extremely rapidly;
- Severe weather is becoming more intense;
- Sea levels are rising;
- It is largely happening because of human activities and associated pollution;
- The climate will continue to change over the coming decades.

The Bottom Line (in 10 words)

Anthony Leiserowitz, Yale University

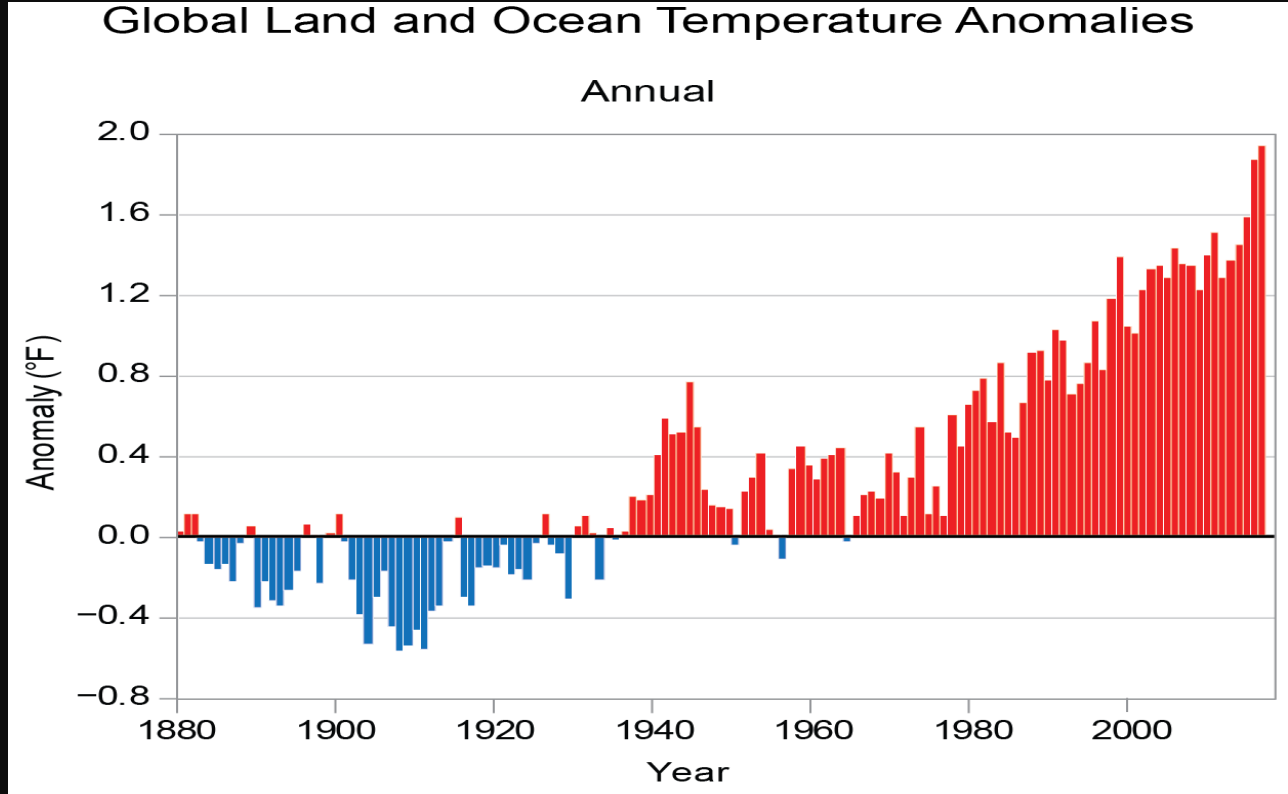
- It's Here
- It's Us
- It's Serious
- Scientists Agree
- There's Hope

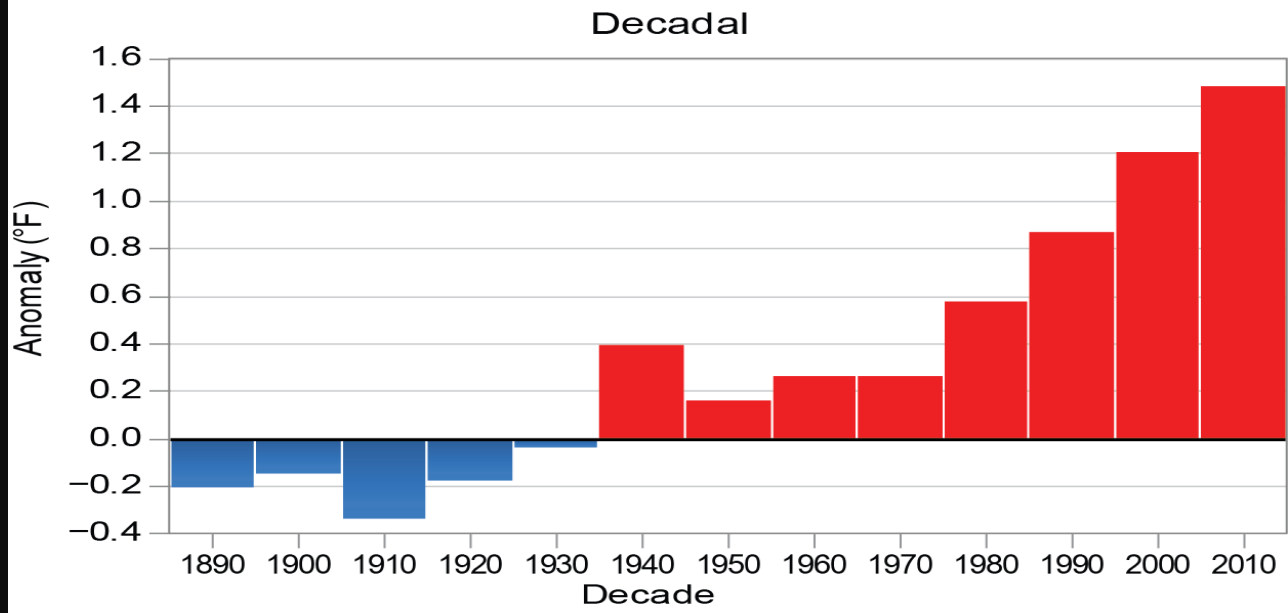
Many Different Observations Show a Changing Climate



Global Annually-Averaged Temperature Record (NOAA, through 2016)

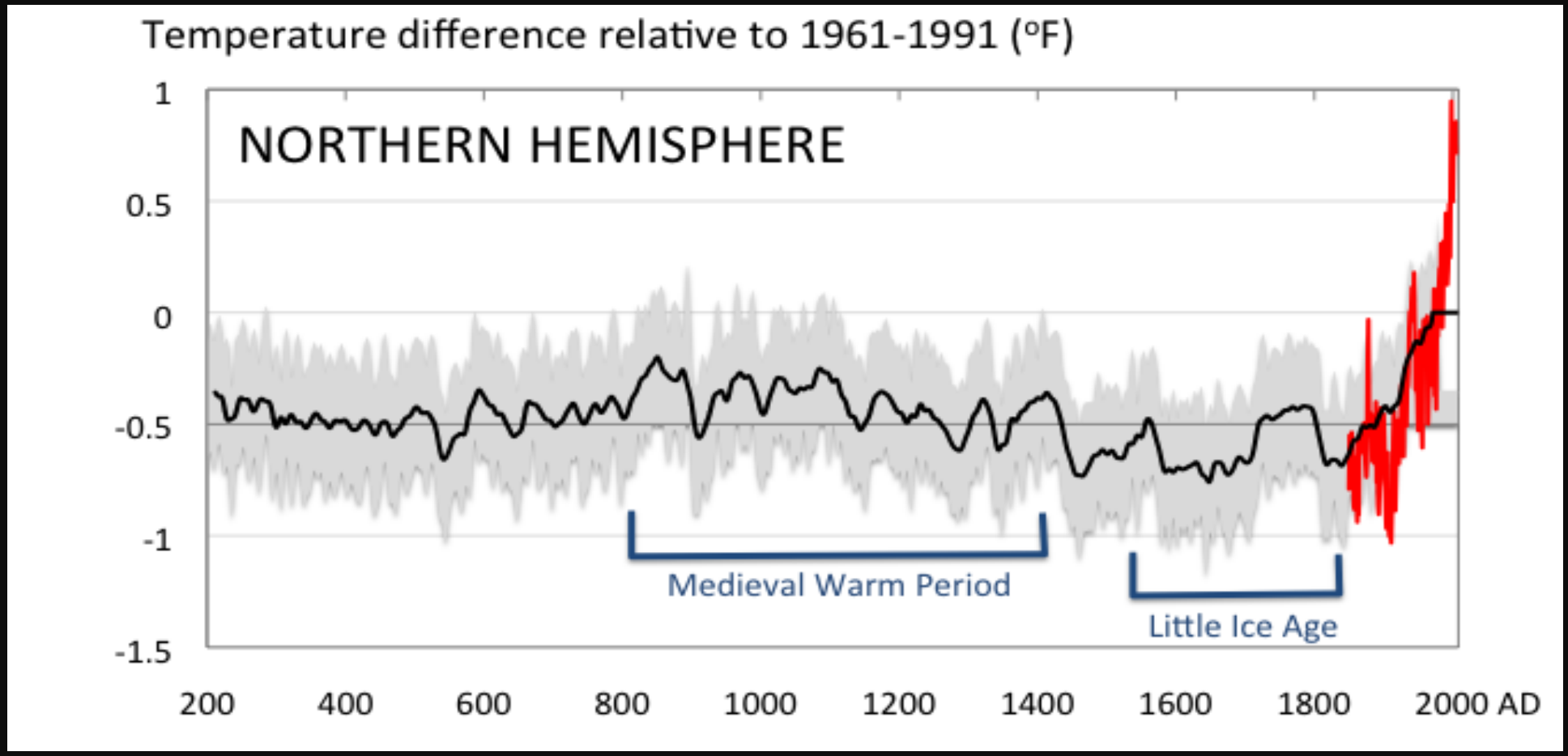
Globally, annually-averaged temperature has increased by 1.8 °F from 1901-2016





Graphs are relative to 1901-1960

Conditions today appear to be unusual in the context of the last 2,000 years …



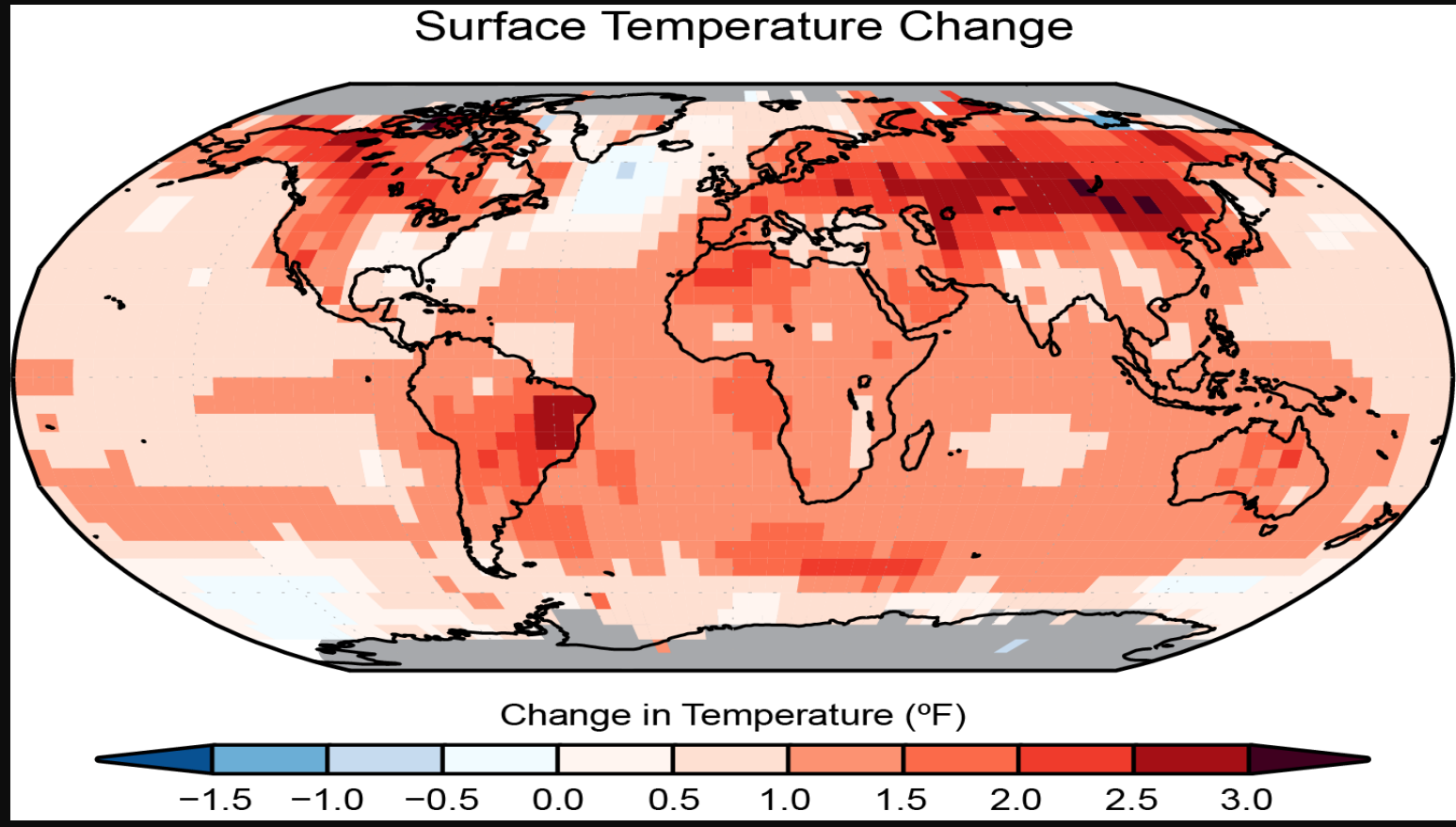
Updated from Mann et al., 2008 PNAS

Our Climate Continues to Change Rapidly

The global long-term warming trend is continuing.

2016 was the warmest year on record, 2015 is 2nd and far surpassed 2014, which is 3rd.

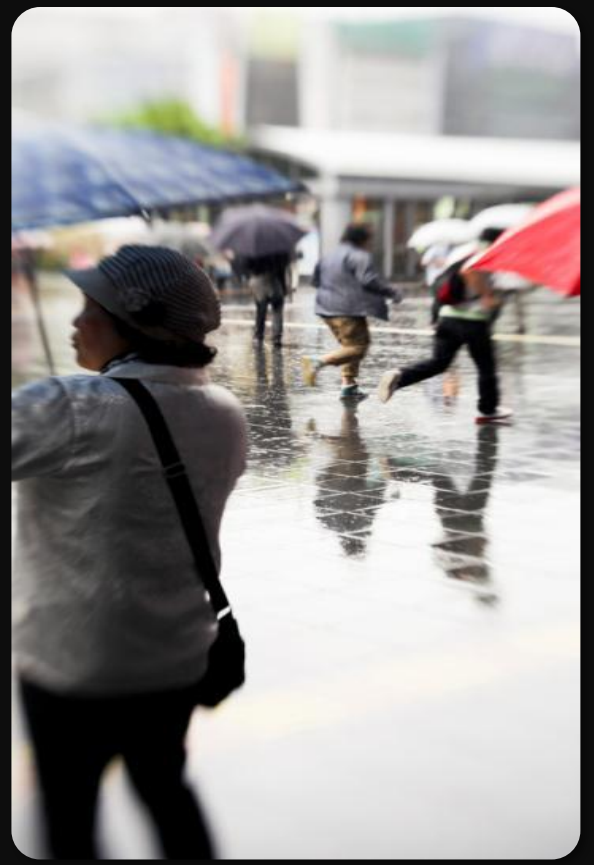
Sixteen of the last 17 years are the warmest years on record for the globe.



Temperature trends (change in ° F) for the period 1986-2015 relative to 1901-1960

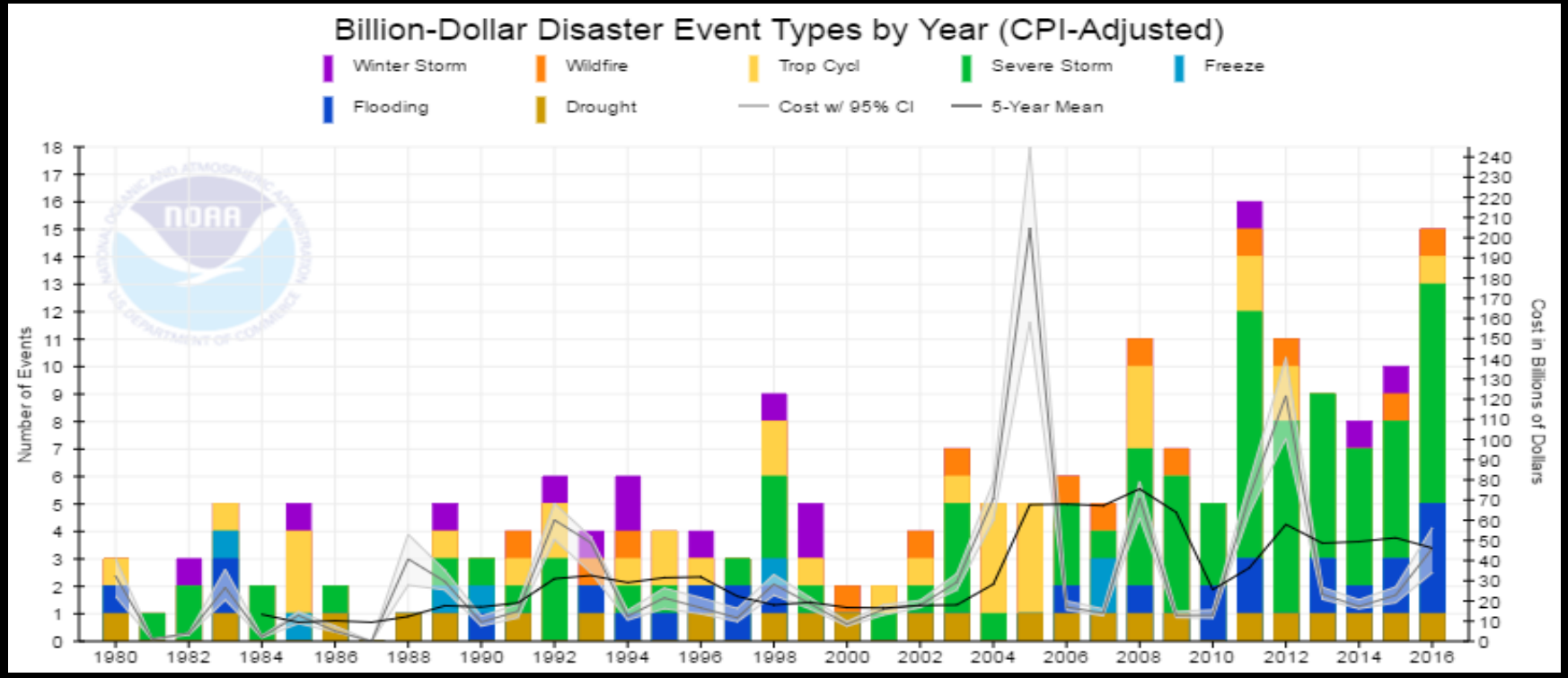
We are seeing changing trends in extreme weather and climate events



NOAA analyses show increasing effects of Severe Weather on U.S. economy: Total of $1.5 trillion since 1980

Every U.S. region has been affected by this growing trend.



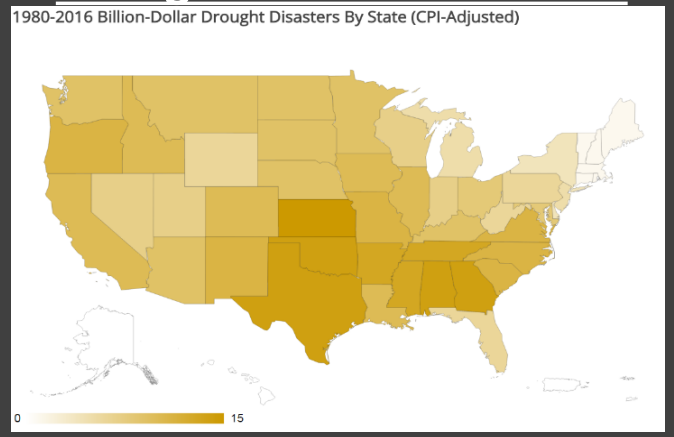
Billion-dollar weather and climate disasters frequency: 1980-2016 (accounts for inflation)

Similar trend globally

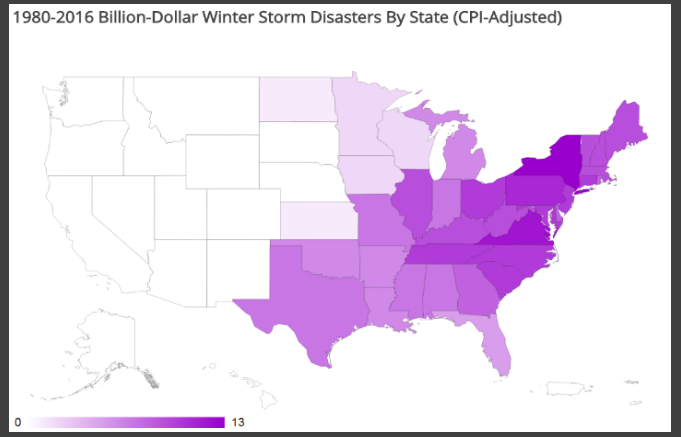
The Nation is Climate Conscious…for Good Reason

Billion-dollar weather and climate disasters frequency mapping: 1980-2016*

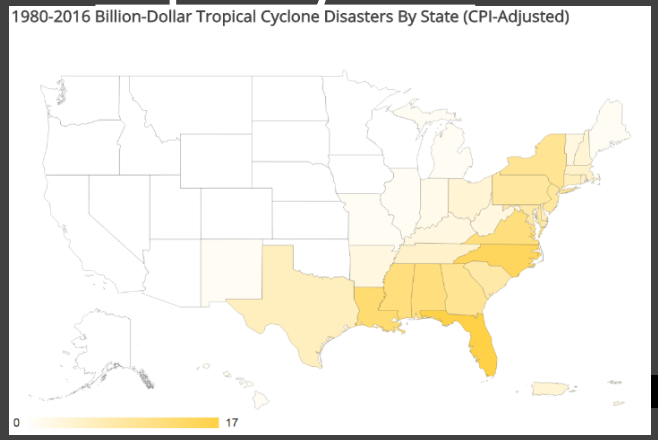
Droughts and Heat Waves



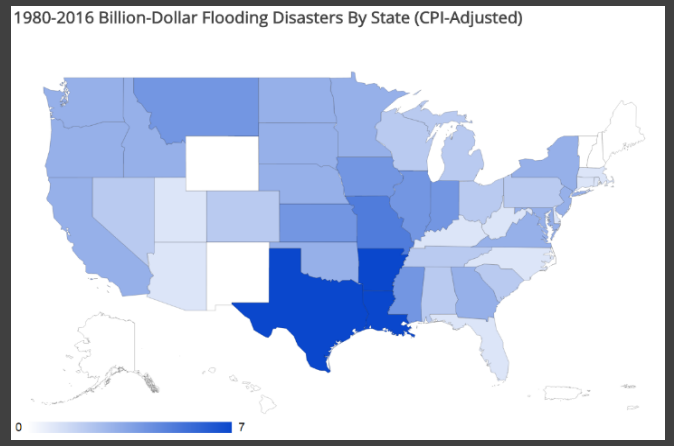
Winter Storms



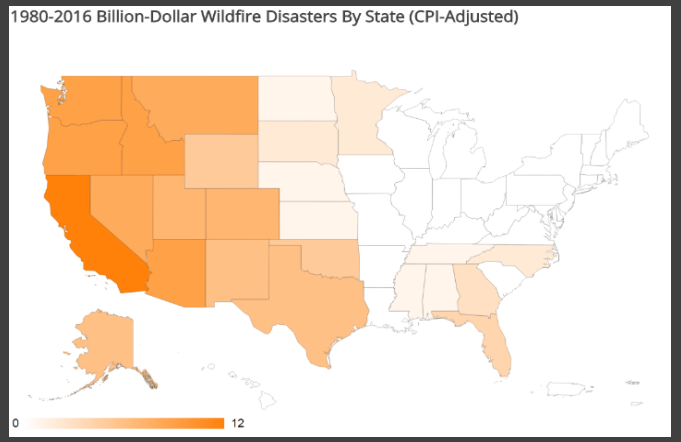
Tropical Cyclones



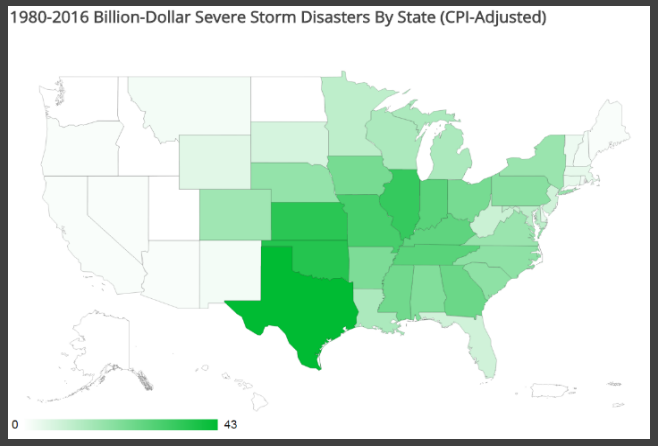
Flooding



Wildfires



Severe Local Storms



*203 weather and climate disasters reached or exceeded $1 billion during this period (CPI-adjusted)

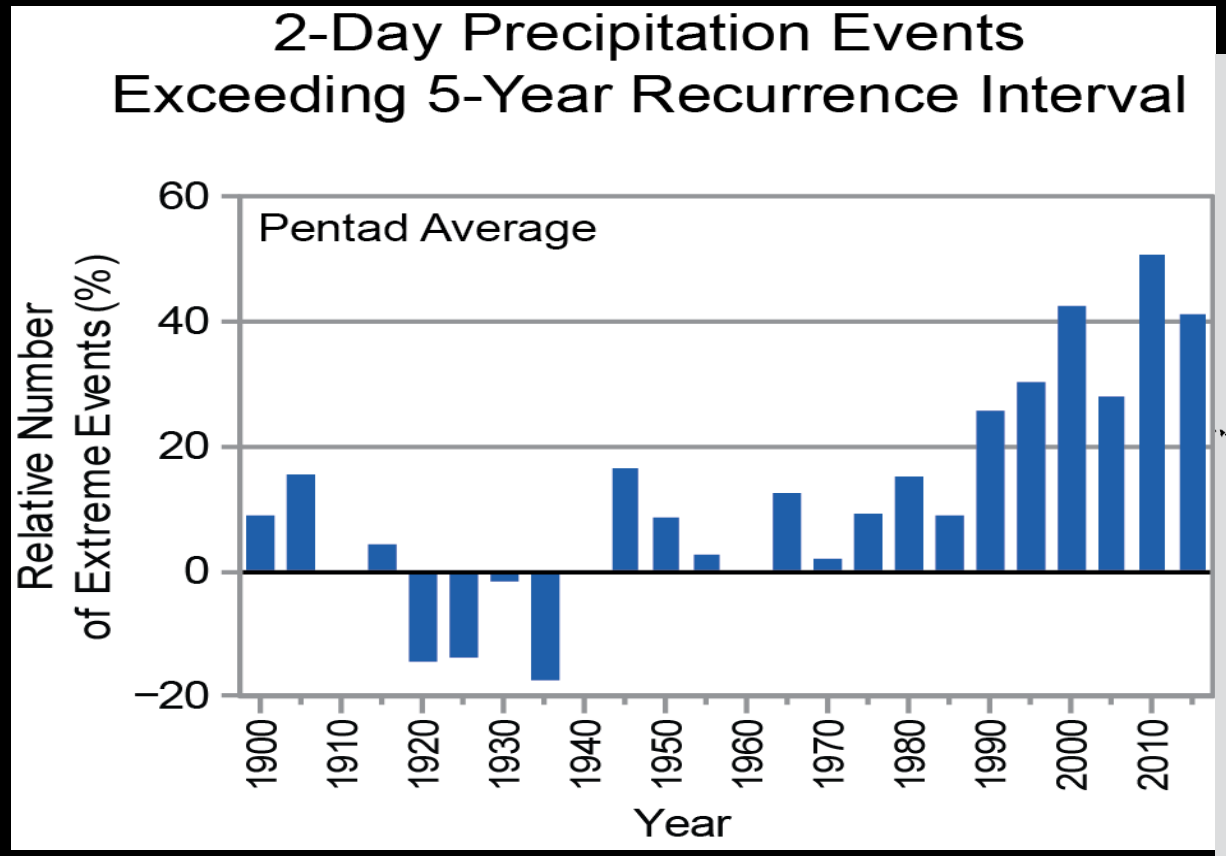
Please note that the map reflects a summation of billion-dollar events for each state affected (i.e., it does not mean that each state shown suffered at least $1 billion in losses for each event).

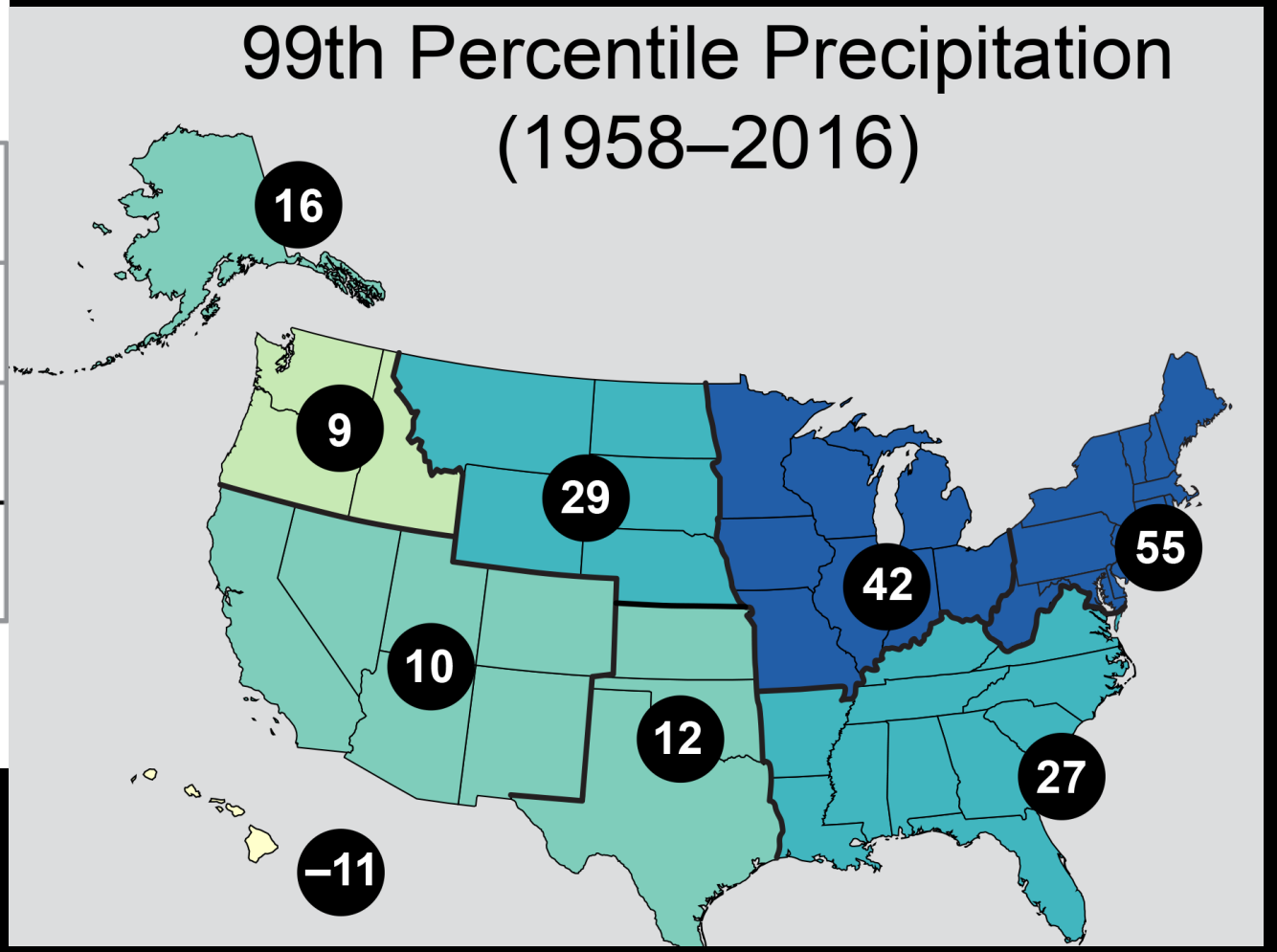
Certain Types of Extreme Events Show Important Trends Globally and in United States

- Heat waves are generally increasing in number and intensity; Cold waves are decreasing.
- More precipitation coming as larger events.
- Increasing risk of floods in some regions (NE, MW).
- Increasing intensity of droughts in some regions (SW, SE).
- Incidence of large wildfires has increased (West, Alaska)
- Increasing intensity of hurricanes are expected.
- Tornado activity more variable – increase in outbreaks.
- Hail may be coming more intense also

These trends are expected to continue.

Extreme Precipitation Events are Increasing in Frequency and Intensity





More Drought and More Floods

As temperatures rise, **both drought** and **heavy rains** are increasing in many areas

How can this be?

Over the oceans: **more water evaporates into warmer air, helping increase precipitation intensity worldwide**

Over land: **warmer air sucks moisture from dry land, intensifying drought**

Many Studies Are Examining Detection and Attribution

Climate change likely affected Hurricane Harvey:

- Occurrence 3 to 3.5 times more likely
- Rainfall 15 to 38% greater

Now, it's a 1% chance per year. Before end of century, 18% chance each year.

Major journal papers: Emanuel 2017; Risser & Wehner 2017; van Oldenberg et al. 2017

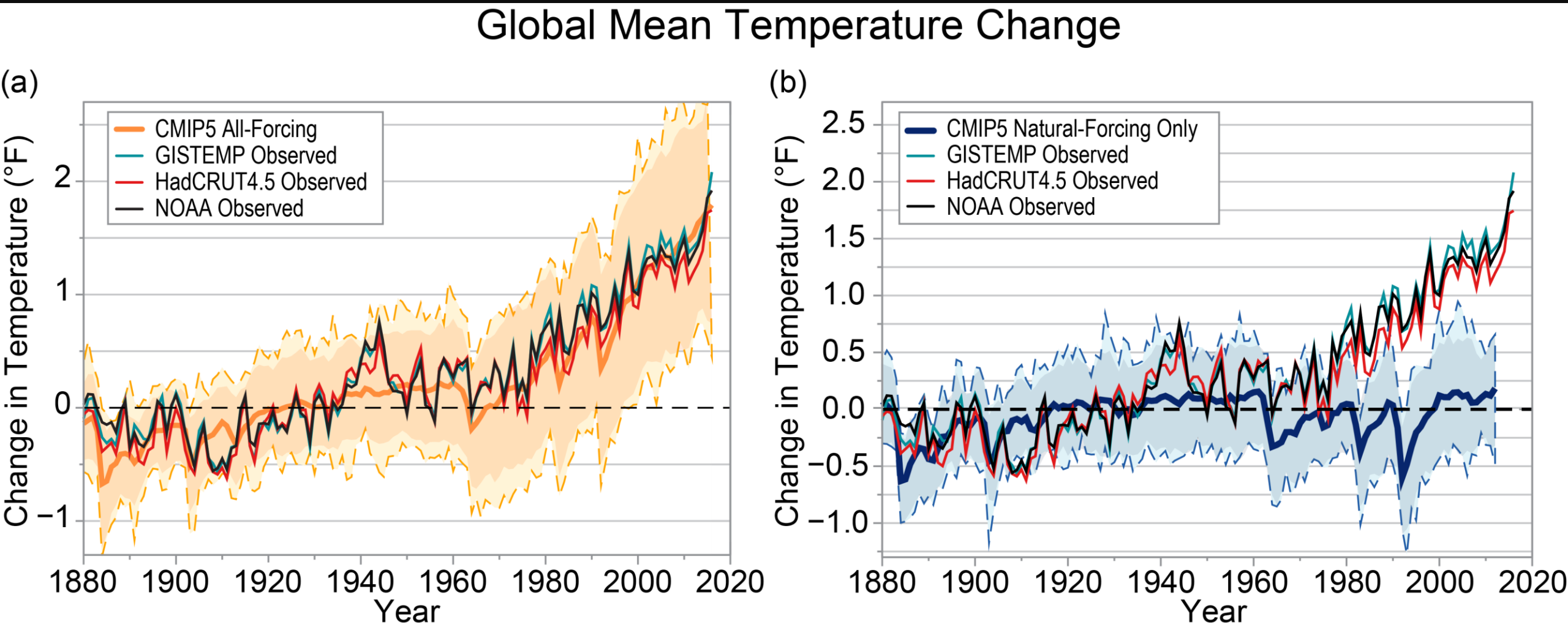
CO2: Ice Core from Antarctica

The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years.

What is Causing Observed Changes in Climate

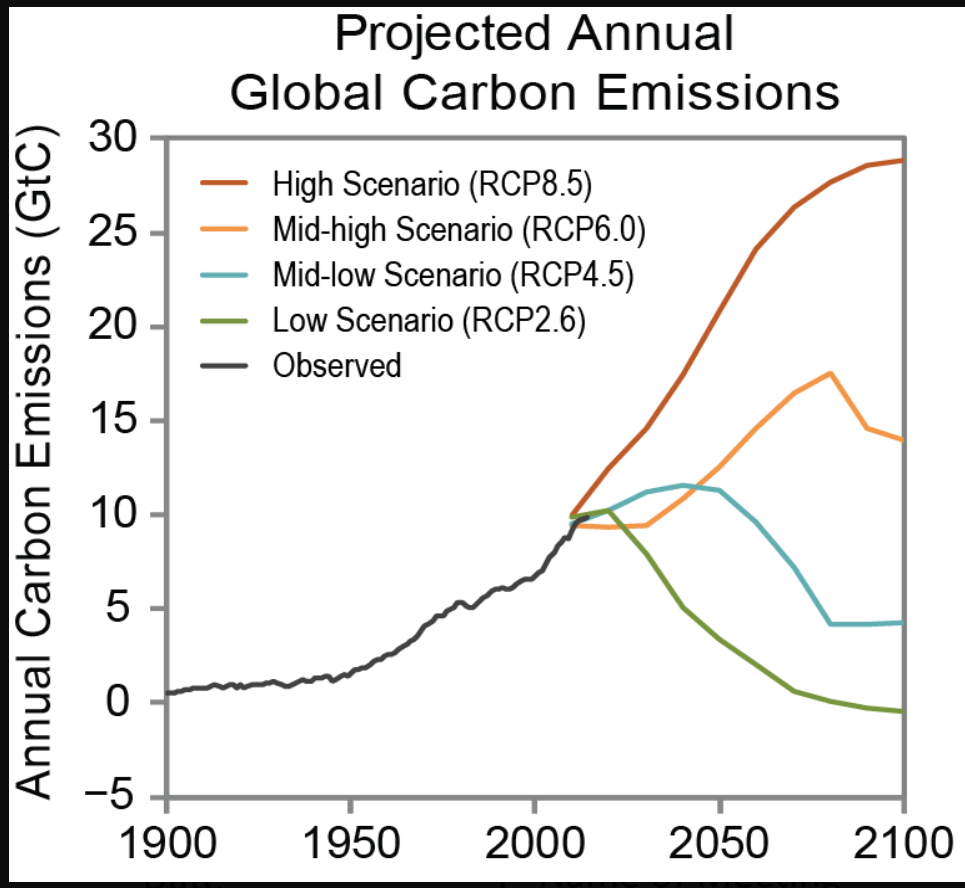
- **Many lines of evidence demonstrate that human activities, especially emissions of greenhouse gases, are primarily responsible for the observed climate changes.**
- **For the period extending over the last century, there are no credible alternative explanations supported by the extent of the observational evidence.**
  - Solar output changes and natural variability can only contribute marginally to the observed changes in climate over this time period.
  - No natural cycles are found in the observational record that can explain the observed changes in climate.

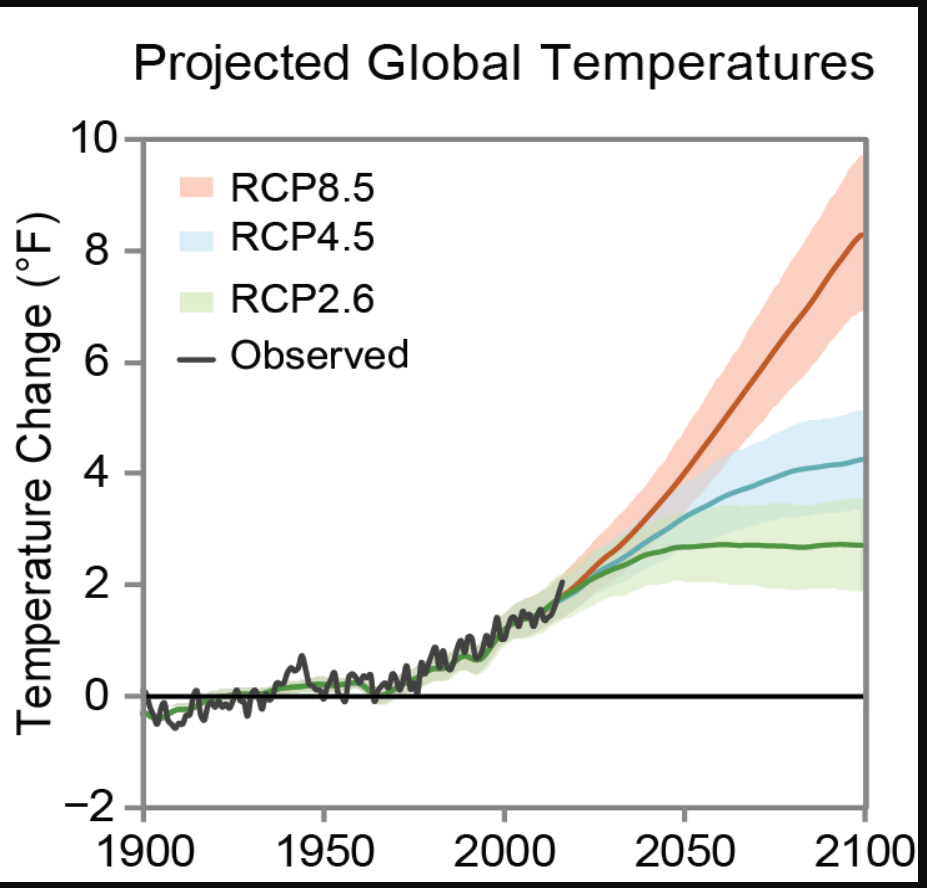
Observed Temperature Trends Only Explained by Human Emissions



The Forecast: Climate will Continue to Change

Climate change beyond the next few decades depends primarily on the **heat-trapping gases emitted** and the remaining uncertainty in the **sensitivity of Earth's climate** to those emissions.

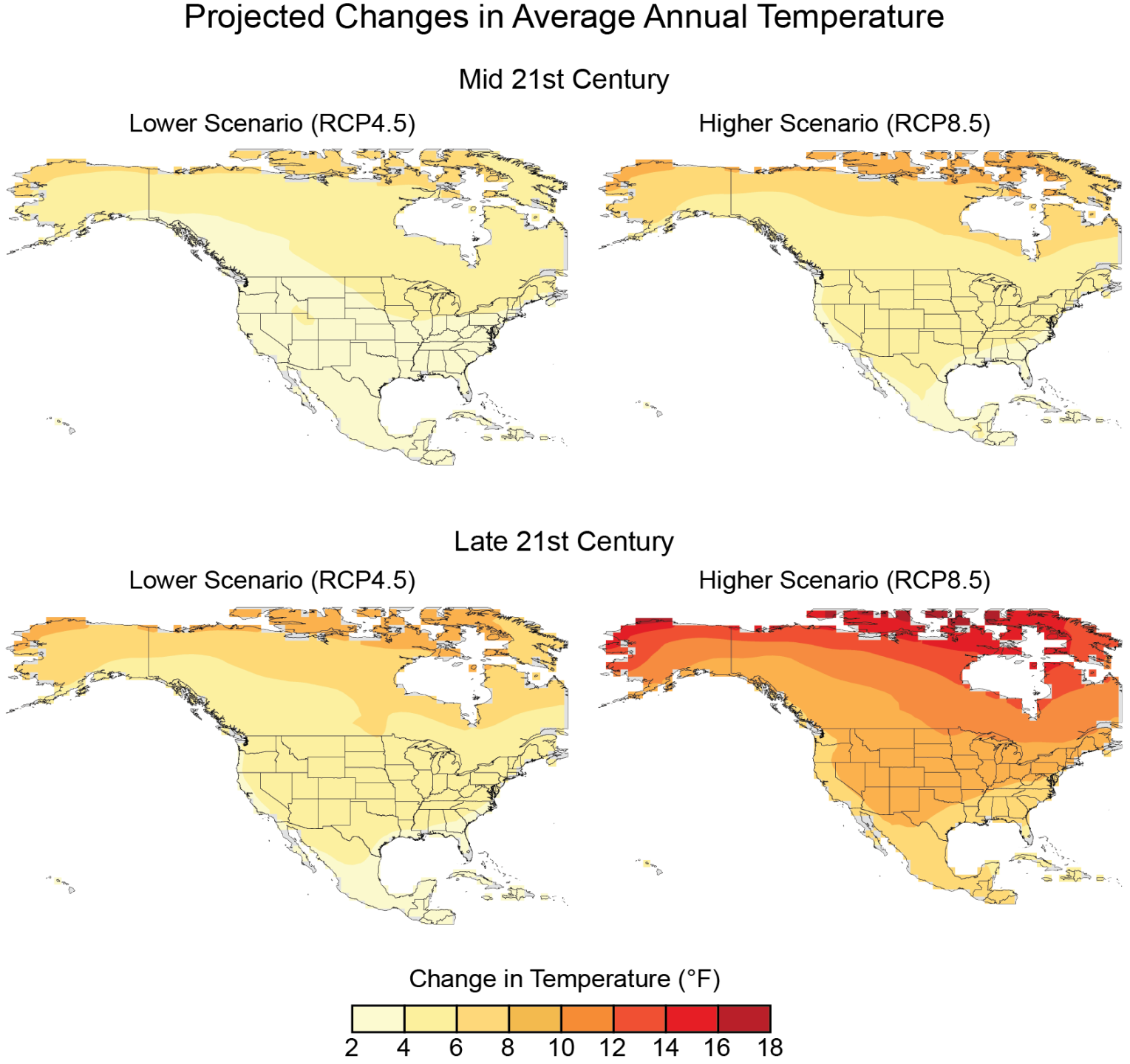




Projected U.S. Temperature Change

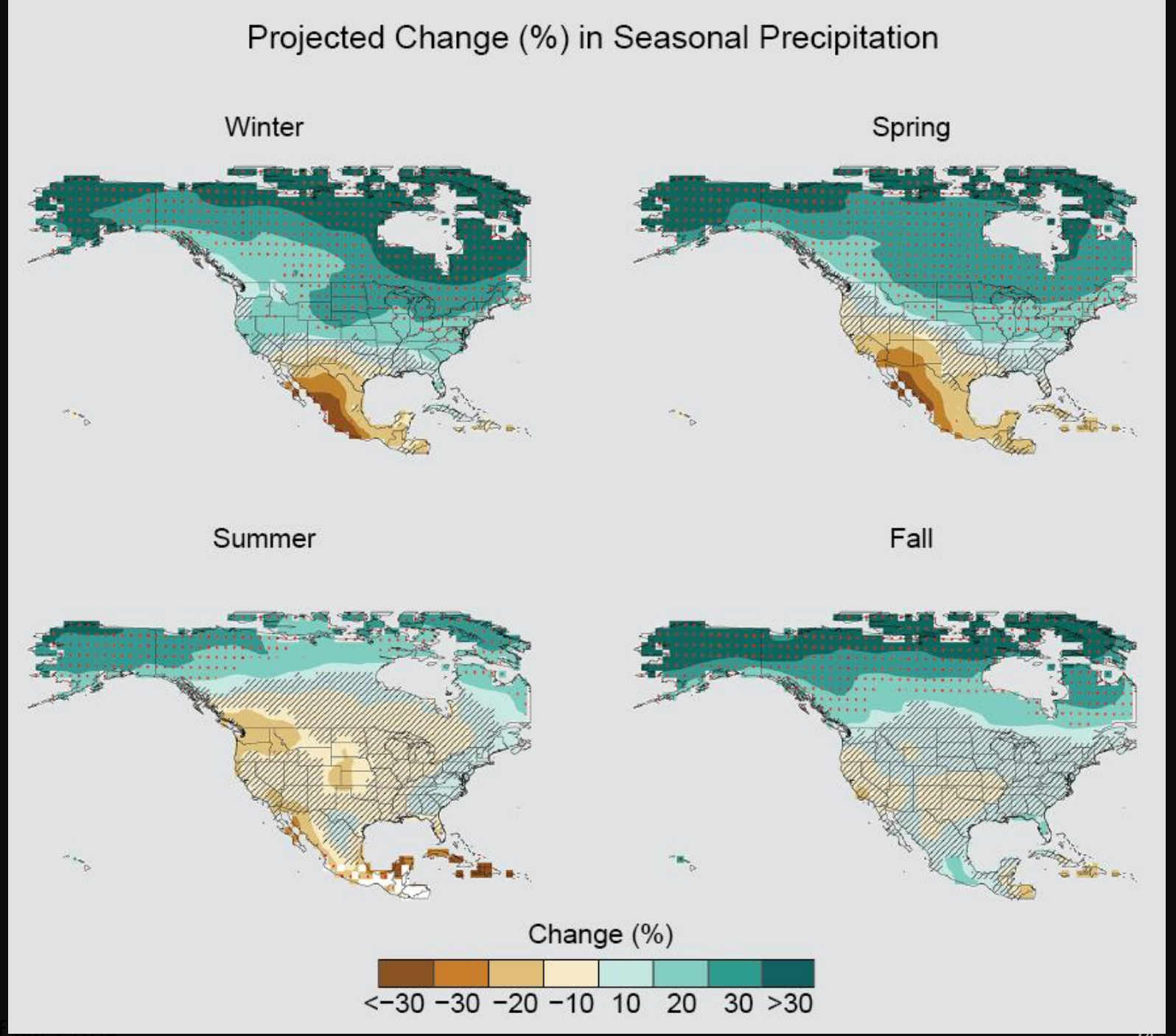
Projected changes in average annual temperatures (°F)

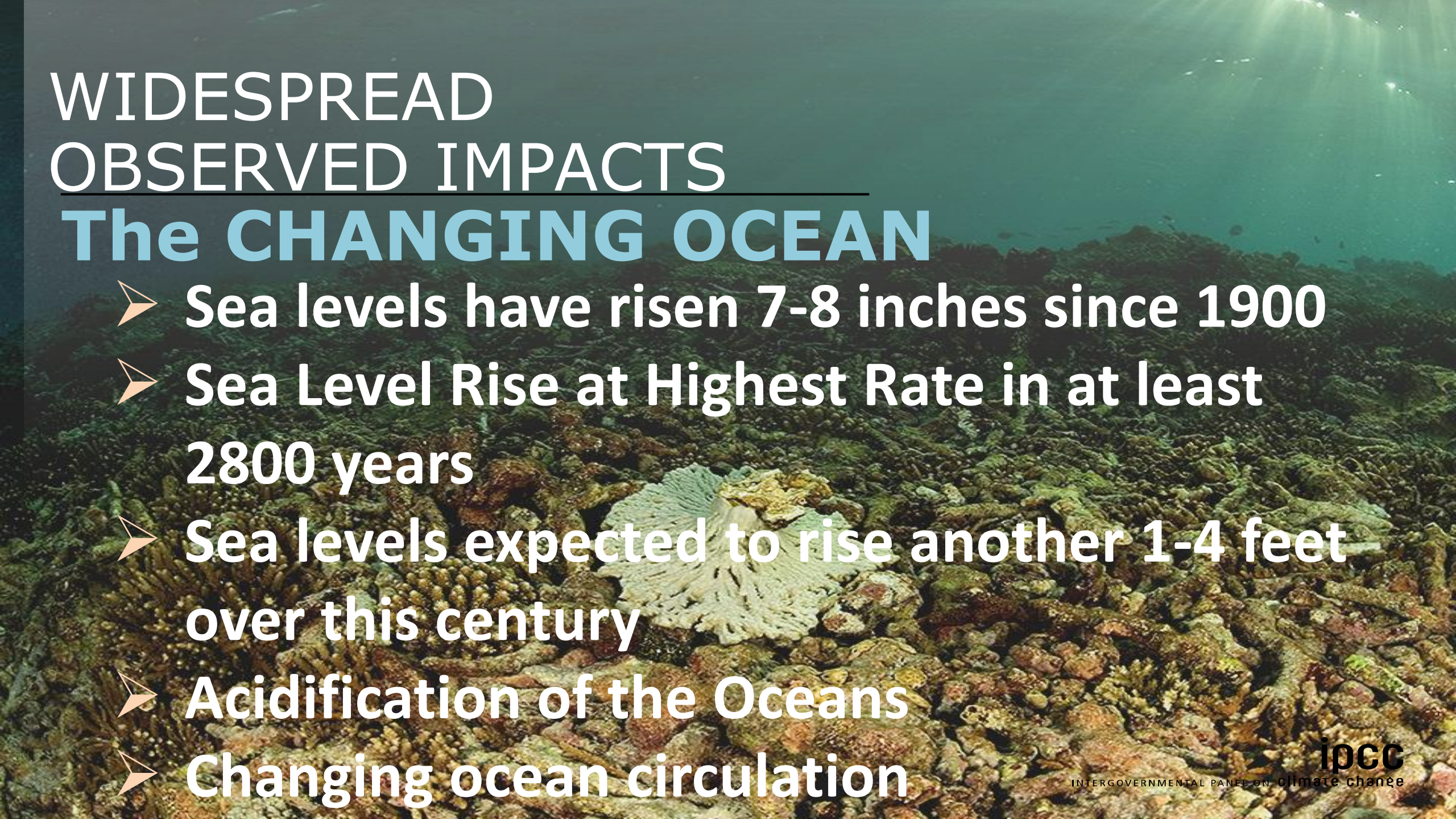
Relative to 1976–2005



Projected U.S. Precipitation Change

2070-2099 relative to 1975-2005
For RCP8.5 (High scenario)





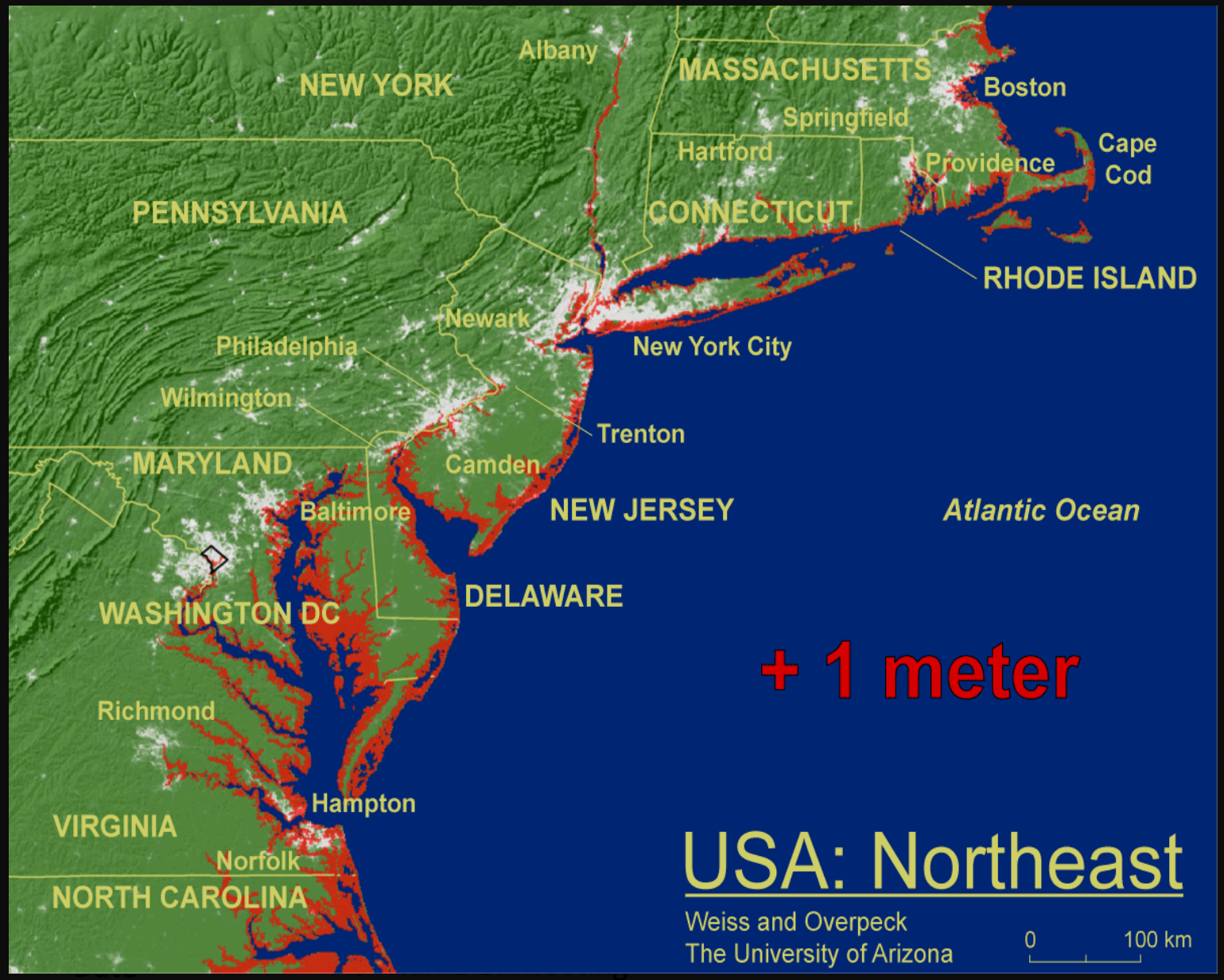
WIDESPREAD OBSERVED IMPACTS

The CHANGING OCEAN

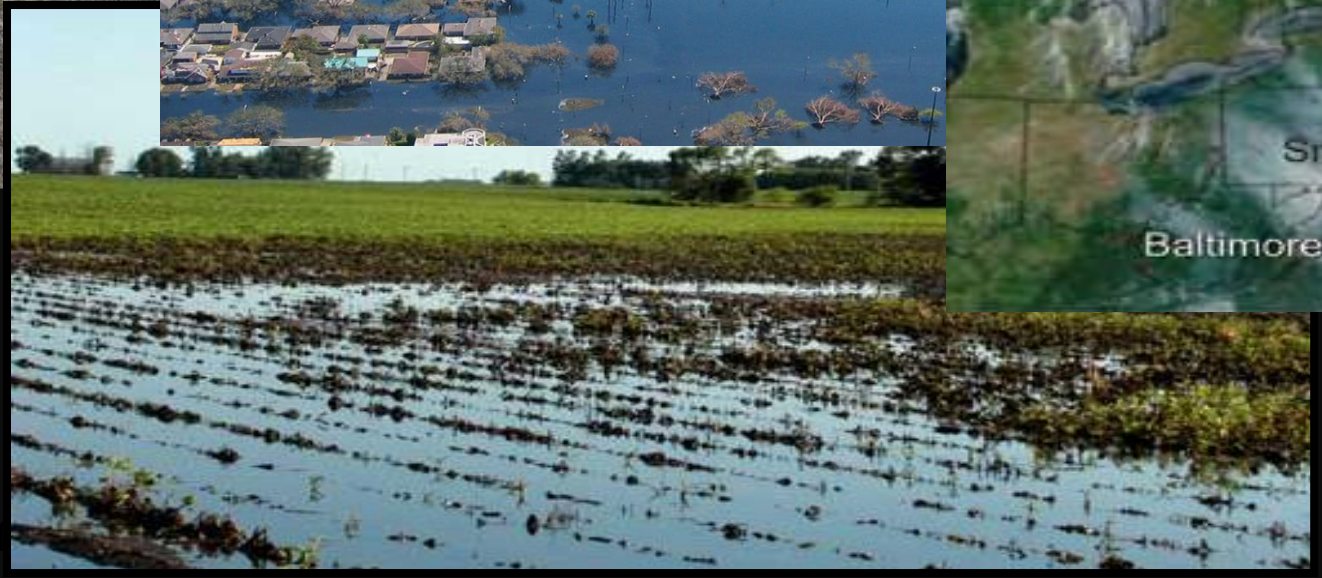
- Sea levels have risen 7-8 inches since 1900
- Sea Level Rise at Highest Rate in at least 2800 years
- Sea levels expected to rise another 1-4 feet over this century
- Acidification of the Oceans
- Changing ocean circulation

ipcc
INTERGOVERNMENTAL PANEL ON climate change

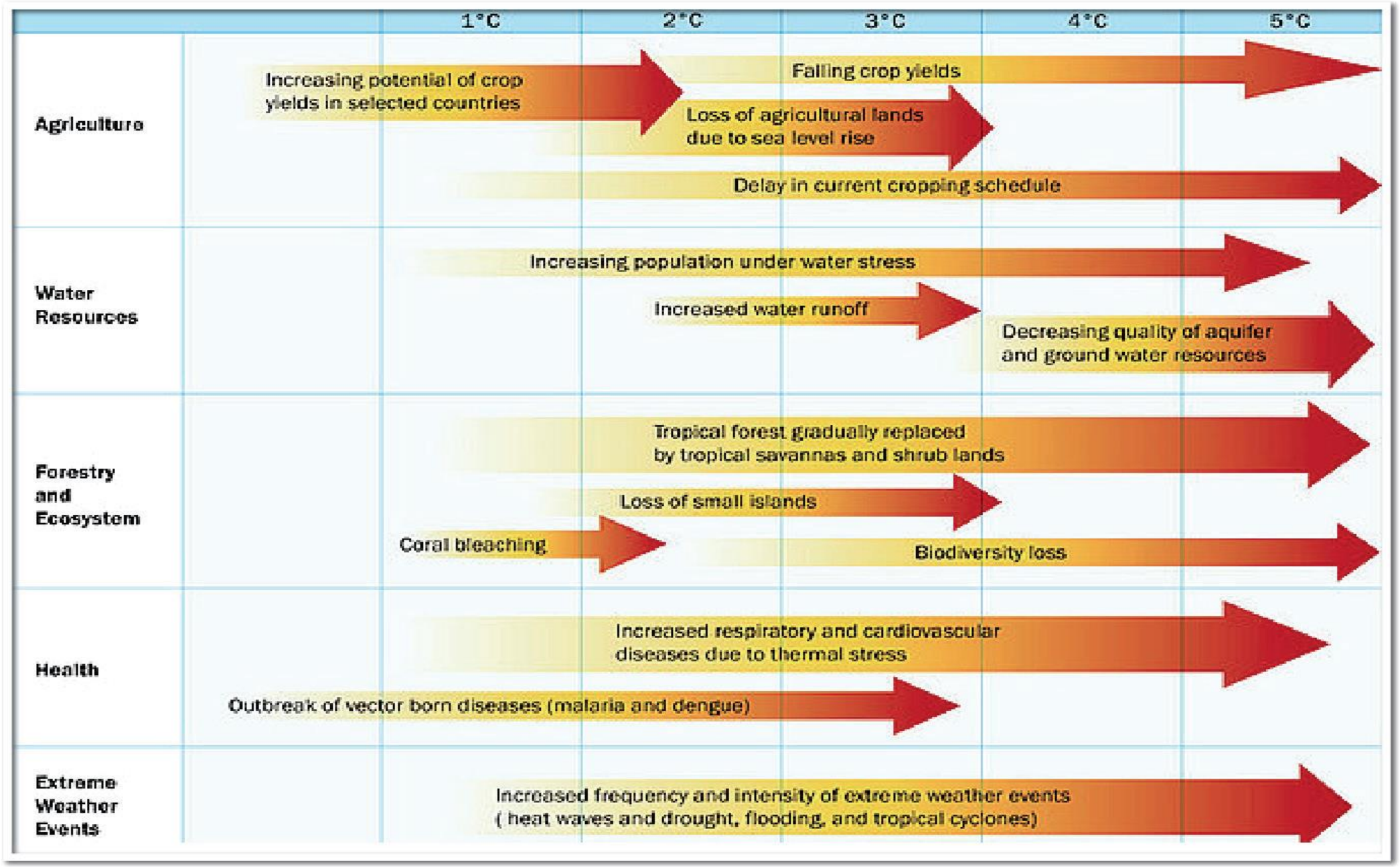
Sea level: Flooded area with 1 meter rise



Impacts are already apparent in every region and in important sectors, e.g., health, water, agriculture, energy, and more.



Risks Increase with More Climate Change



What should we do?

There are only three options:

- **Mitigation**: measures to reduce the pace & magnitude of the changes in climate.
- **Adaptation**: measures to reduce the adverse impacts on human well-being resulting from climate change.
- **Suffering**: the adverse impacts and societal disruption not avoided by mitigation or adaptation.

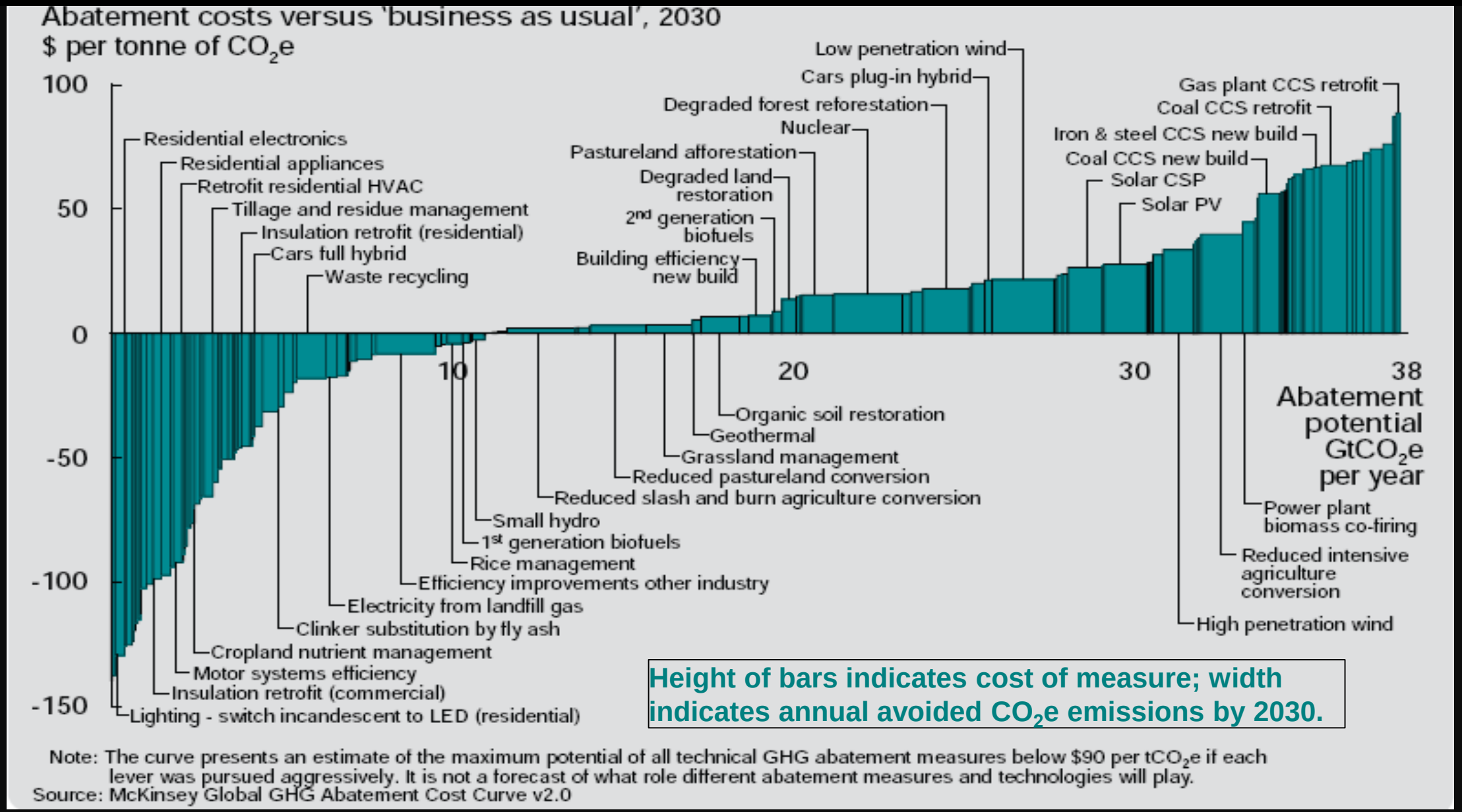
Concerning the three options…

- Right now we are doing some of each.
- What's up for grabs is the future mix.
- Minimizing suffering can only be achieved by doing a lot of mitigation and a lot of adaptation.
  - Mitigation alone inadequate
  - Adaptation alone inadequate

We need enough mitigation to avoid the unmanageable, enough adaptation to manage the unavoidable.

Mitigation Pathways

Mitigation supply curve for 2030: aiming for 450 ppm CO2e



Maintaining a Sense of Hope

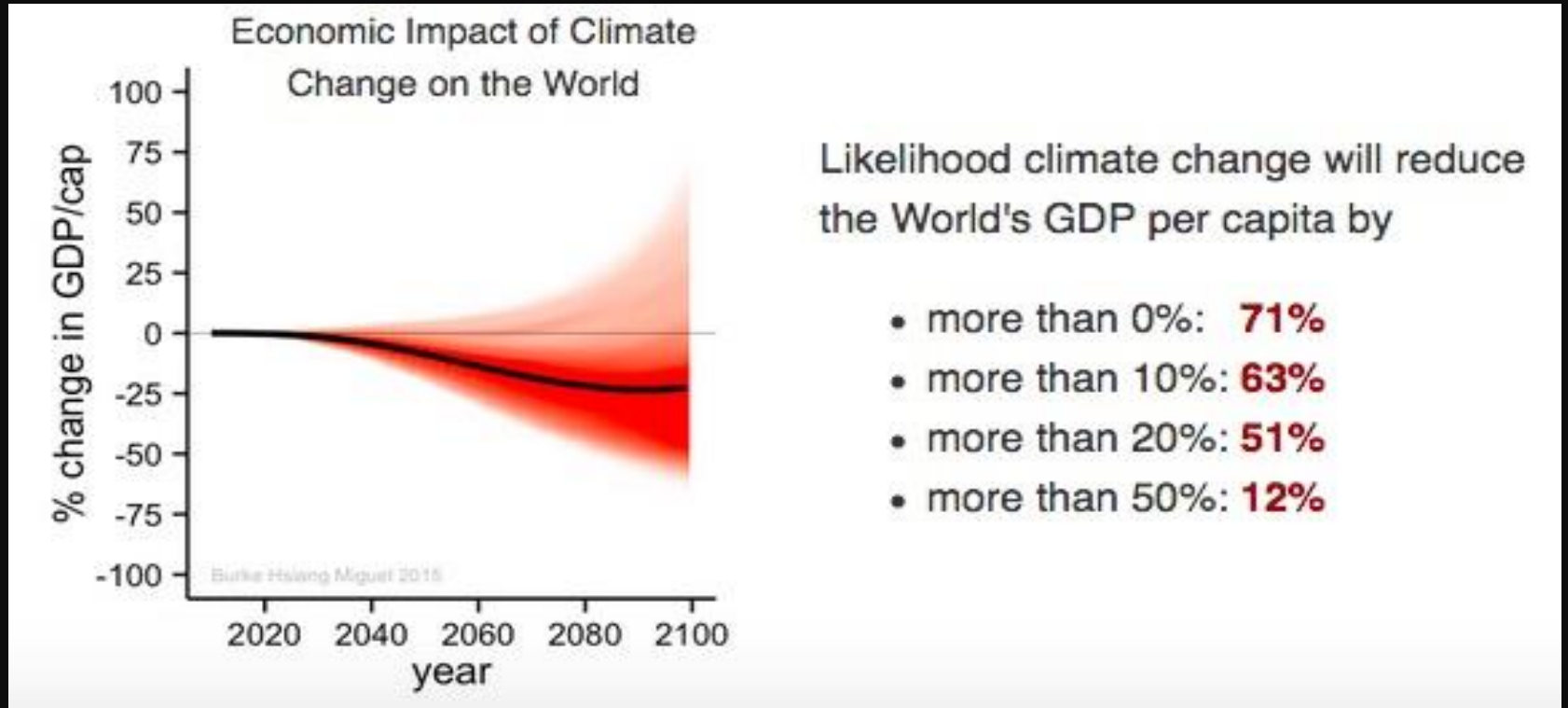
- Our future depends on how we act to limit climate change.
- Adaptation is not a choice – our choice is whether to adapt proactively or respond to the consequences.
- Adaptation requires focusing on managing risks.
- We must draw on our long history of responding to changing conditions on our planet in facing the challenges of climate change.

We Have Solved Difficult Problems Before!

The cost of inaction

GDP reductions for a 4°C warming by 2100 range from -0.3% per year for rich northern countries like Canada and Finland to over 20% per year for many poor countries in Africa and Southeast Asia (Kompas et a. 2018).

There is a 51% chance that it will reduce per capita global GDP by over 20% by 2100.



Hsiang et al. 2015

So where does that leave us?

Sir David King:
Science Advisor to two U.K. Prime Ministers; previously head of Chemistry Dept. at the University of Cambridge

"Climate change is not the biggest challenge of our time, it's the biggest challenge of all time"

April 29, 2014

Letter | Published: 21 October 2015

Global non-linear effect of temperature on economic production

Marshall Burke ✉, Solomon M. Hsiang & Edward Miguel

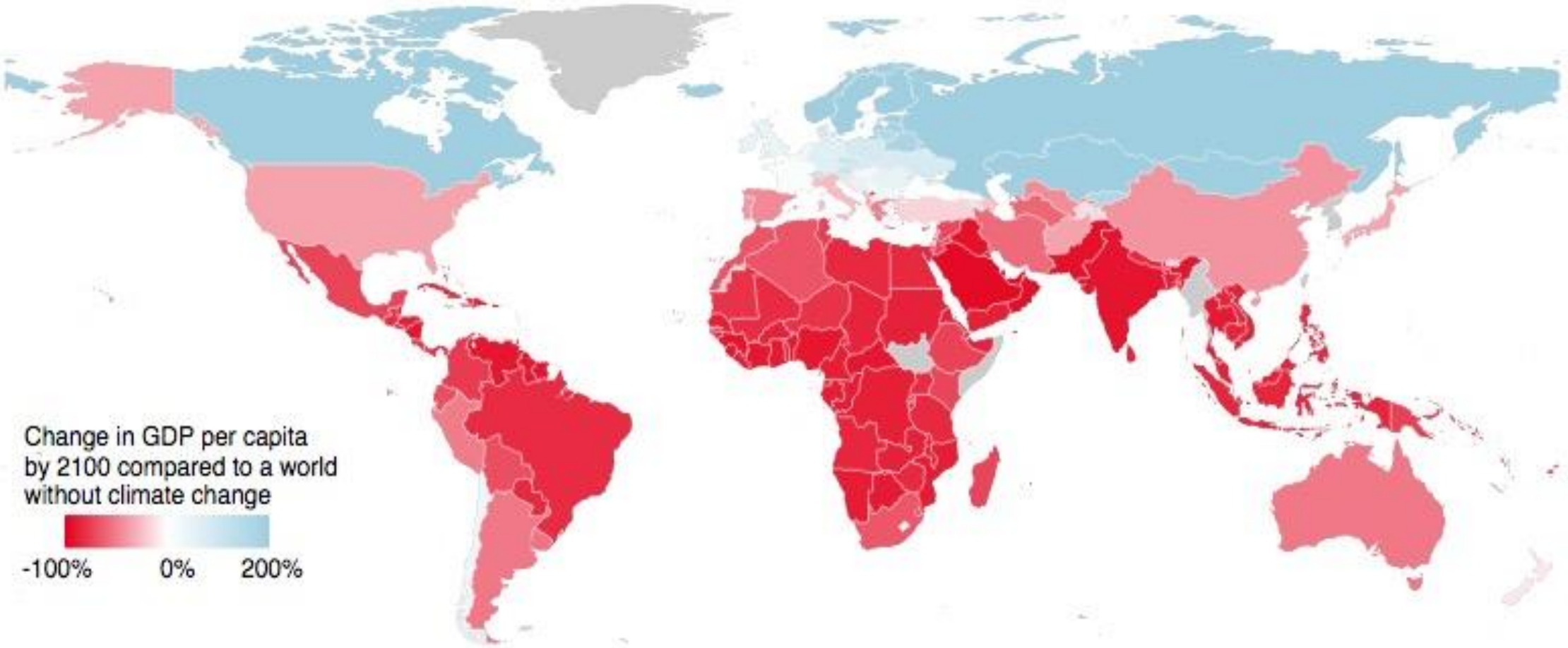
Nature **527**, 235–239 (12 November 2015) | Download Citation ⬇

Unmitigated warming is expected to reshape the global economy by reducing average global incomes roughly 23% by 2100 and widening global income inequality, relative to scenarios without climate change.

In contrast to prior estimates, expected global losses are approximately linear in global mean temperature, with median losses many times larger than leading models indicate.

Economic Impact of Climate Change on The World

Select a country/region or click on the map to get estimates of how climate change will affect GDP per capita as calculated in Burke, Hsiang, and Miguel (2015) Back to main page



RESEARCH ARTICLE | CLIMATOLOGY

Climate models predict increasing temperature variability in poor countries

Sebastian Bathiany[1,*], Vasilis Dakos[2], Marten Scheffer[1] and Timothy M. Lenton[3]

+ See all authors and affiliations

Science Advances 02 May 2018:
Vol. 4, no. 5, eaar5809
DOI: 10.1126/sciadv.aar5809

The countries that have contributed least to climate change, and are most vulnerable to extreme events, are projected to experience the strongest increase in variability. These changes would therefore amplify the inequality associated with the impacts of a changing climate.

Earth's Future
AN OPEN ACCESS AGU JOURNAL

Research Article | Open Access

The Effects of Climate Change on GDP by Country and the Global Economic Gains From Complying With the Paris Climate Accord

Tom Kompas, Van Ha Pham, Tuong Nhu Che

First published: 13 July 2018 | https://doi.org/10.1029/2018EF000922

The potential economic gains from complying with the Paris Accord are also estimated, showing that even with a limited set of possible damages from global warming, these gains are substantial. For example, with the comparative case of Representative Concentration Pathway 8.5 (4°C), the global gains from complying with the 2°C target are approximately US$17.5 billion per year by 2100. The relative damages from not complying to Sub-Sahara Africa, India, and Southeast Asia, across all temperature ranges, are especially severe.

Comparing the costs of action vs. inaction

GDP = 80 trillion dollars per year.

Estimated economic impact of unchecked climate change = 20% of GDP or 16 trillion dollars per year

Estimated cost of meeting the Paris Agreement world-wide: between 40 to 175 billion per year

That’s 0.005 to 0.2% of global GDP per year.