Extreme Weather Events + Climate Change: Making the Connections

Portsmouth, March 2, 2018

Deerfield, March 13, 2018

Monadnock Region, August 18, 2018

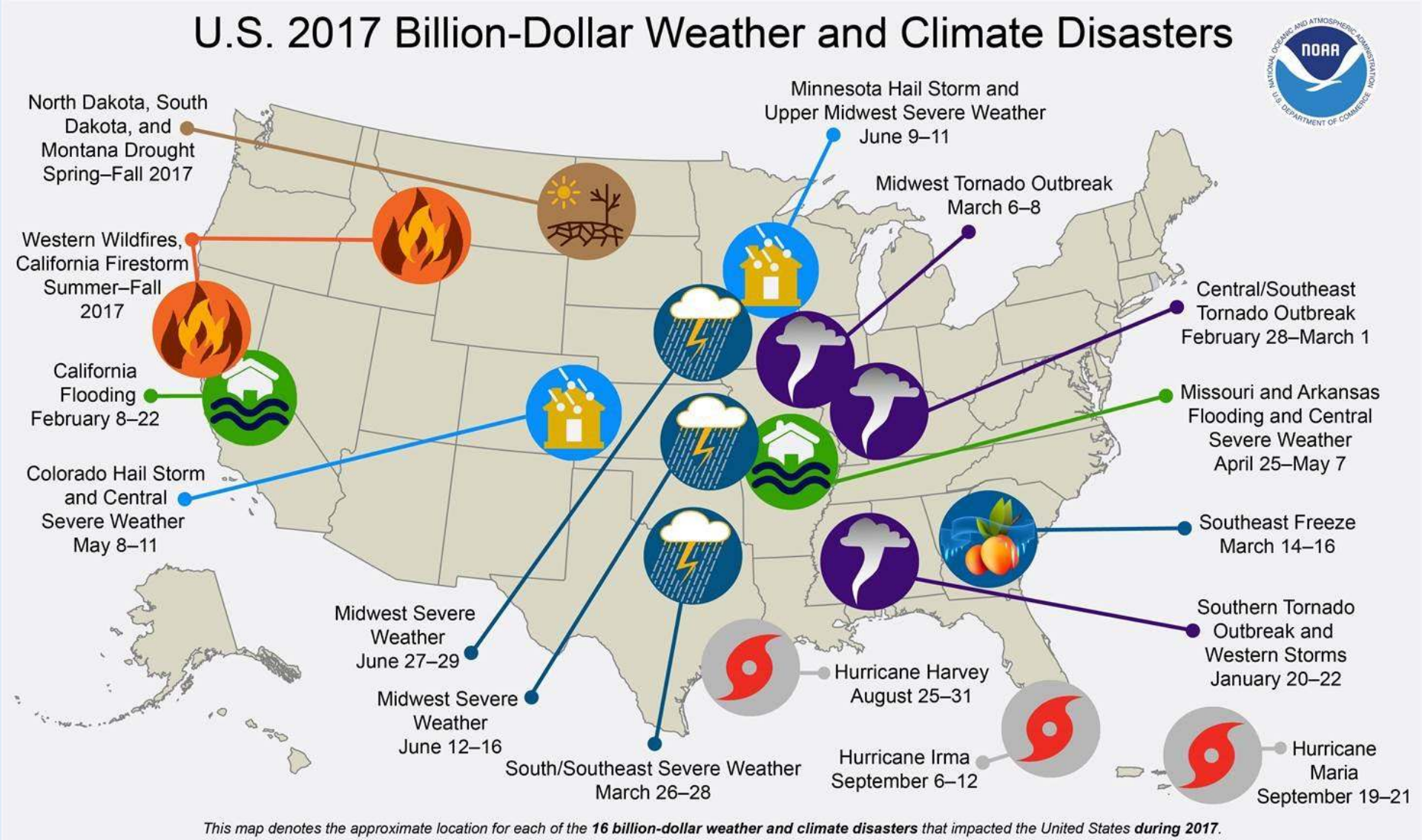
Business and Industry Association
September 11, 2019

Sherry Godlewski
NH Department of Environmental Services
Sherry.godlewski@des.nh.gov

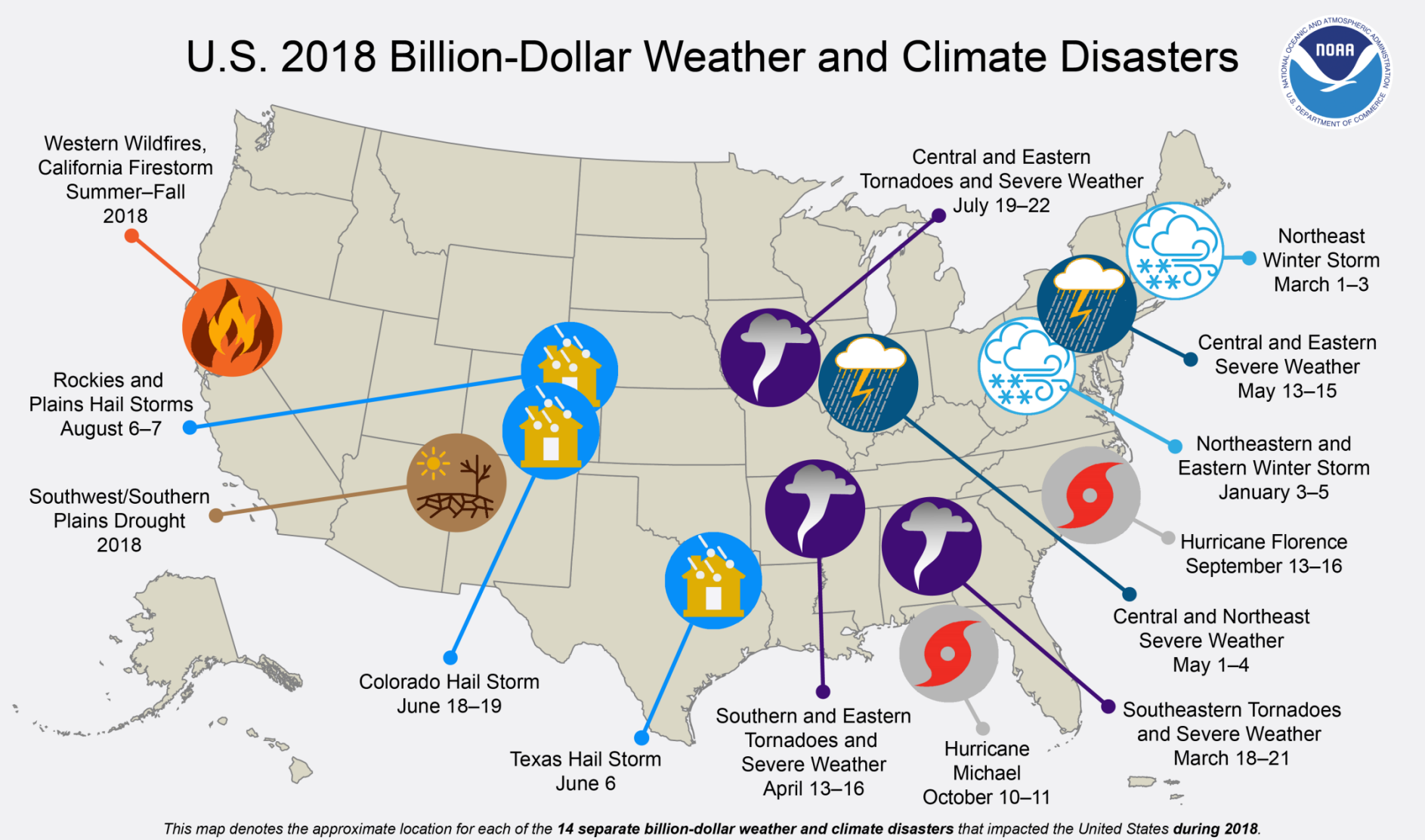
NEW HAMPSHIRE DEPARTMENT OF Environmental Services

Hurricanes, wildfires, flooding made 2017 the most costly U.S. disaster year on record

$306 billion



$ 91 Billion



4th highest total cost & # of events behind the years 2017, 2011 & 2016

https://www.ncdc.noaa.gov/billions/

NH Presidentially-Declared Extreme Weather Events

- 1953-2002 (**50 Years**)
  - 15 Disaster Declarations
  - 3 Emergency Declarations

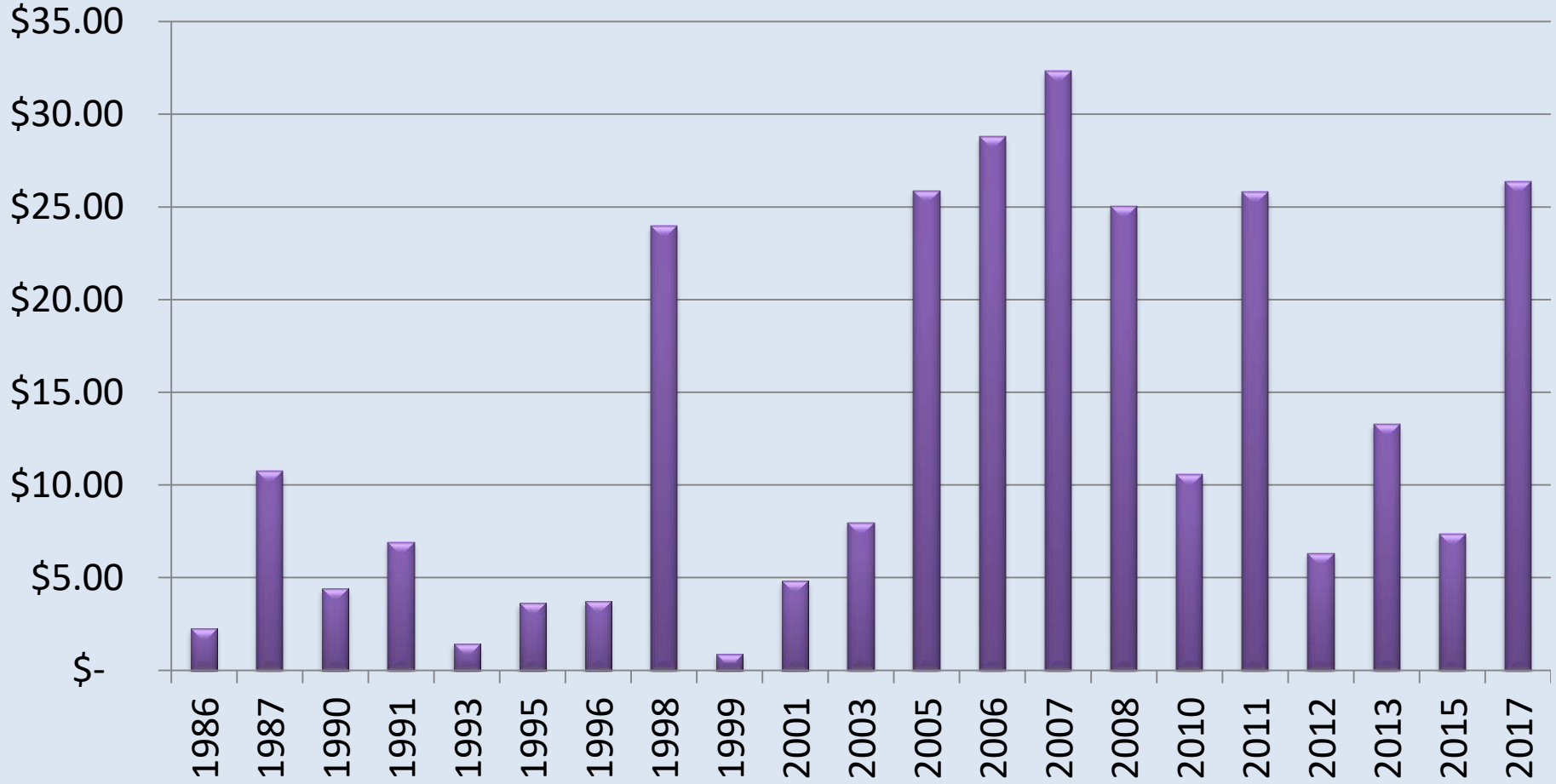
- 2003-2018 (**16 Years**)
  - 21 Disaster Declarations
    - Hurricane
    - Tropical Storm
    - Severe Storms
      - Fall Snow Storm
      - Flooding events
    - Winter Storms
    - Landslide
    - Tornado
  - 10 Emergency Declarations

Axe Handle Brook, Rochester, NH, May 2006

Source: FEMA.gov

Federal Reimbursement for Extreme Weather in NH

(millions $ 2017)



1998: Ice Storm
2005: Alstead/Keene Floods (Oct)
2006: Mother's Day Flood (May)
2007: Patriots Day Flood (April)
2008: Tornado; Floods; Ice Storm
2010: Windstorm; Floods
2011: Irene
2012: Sandy; Flooding
2013: Severe Winter Storm; Landslide; Flooding
2015: Severe Winter Storm
2017: Severe Winter Storm; Severe Storm; Flooding

BUSINESSNH
MAGAZINE

FEMA Assistance Tops $1 Million for NH

Published Tuesday Sep 25, 2018

The Federal Emergency Management Agency (FEMA) has obligated more than $1.13 million in federal assistance to the state to help cover the cost of recovery following the Oct. 29-Nov. 1, 2017 severe storm and flooding. The disaster impacted six of the state's 10 counties.

President Trump approved Gov. Chris Sununu's request for federal assistance, signing a major disaster declaration on Jan. 2. Since then, FEMA has been working with state and local officials providing grants under its Public Assistance (PA) program to eligible entities in Belknap, Carroll, Coos, Grafton, Merrimack and Sullivan counties.

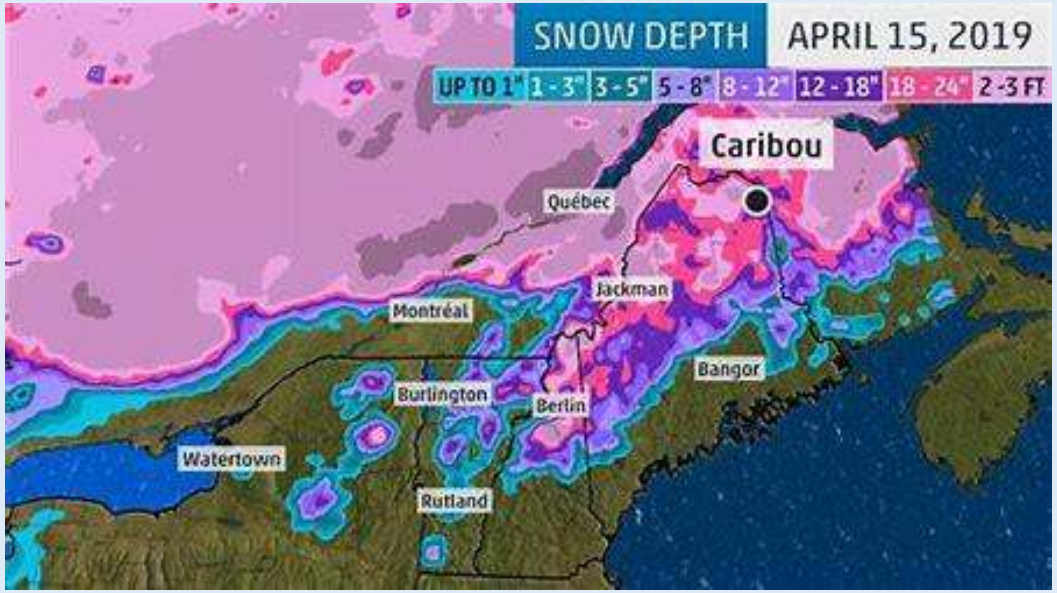
Additional Stories You Might Be Interested In

Franklin: From Troubled Waters to Whitewater Park

FEMA offers grants to eligible applicants by reimbursement through cost sharing.
FEMA typically covers no less than 75 % of the eligible costs of putting a community back on its feet.
The remaining 25 % comes from non-federal sources, such as state and local funds.

2019 Weather

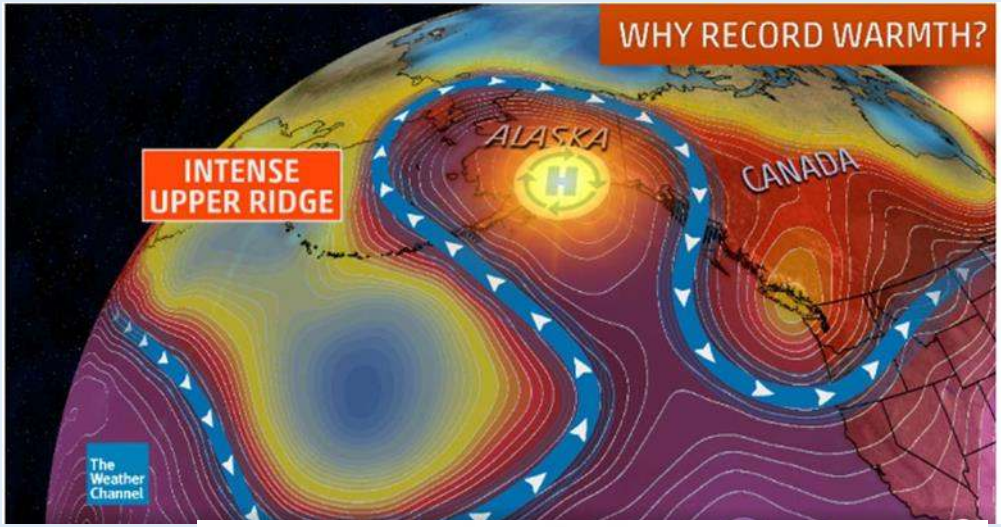
- Northern NH cold + snowy winter
- Southern NH inconsistent snow; periods of cold
- Caribou, ME set a 163 day record of at least 1” of snow
- February had above average temps
- Spring slow to start

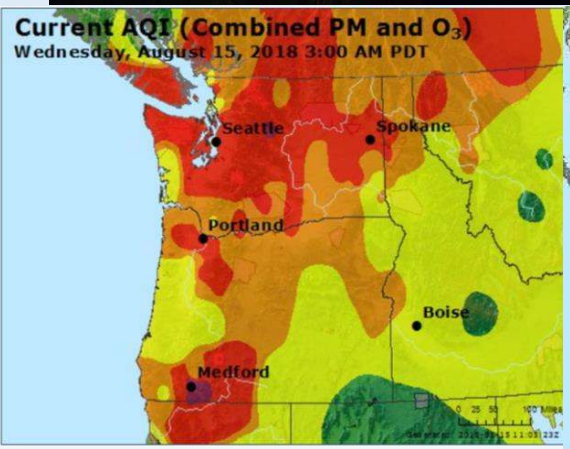


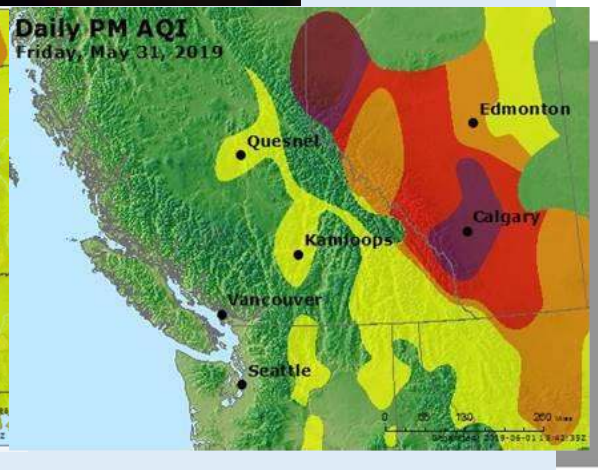
weather.com

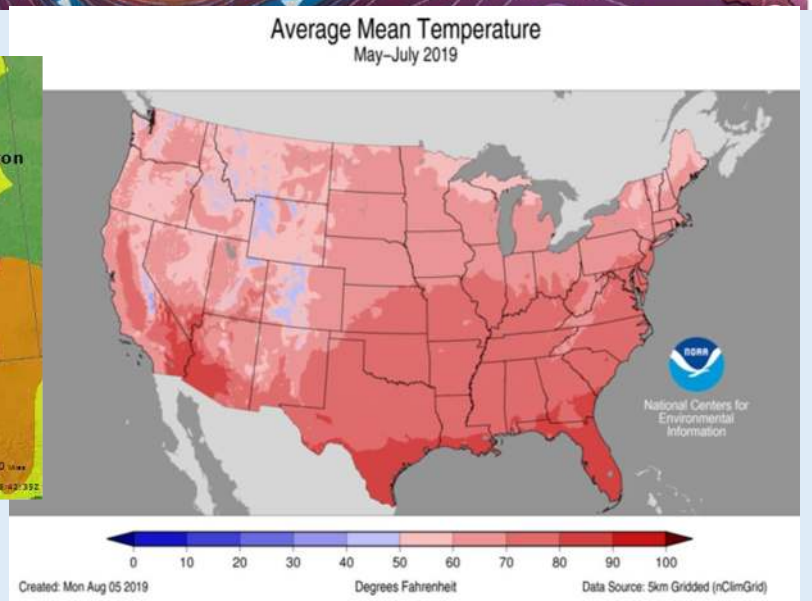
Portland Press Herald

A troubling summer of devastating wildfires, record-breaking heat … each of which, federal scientists say, signals a warming world



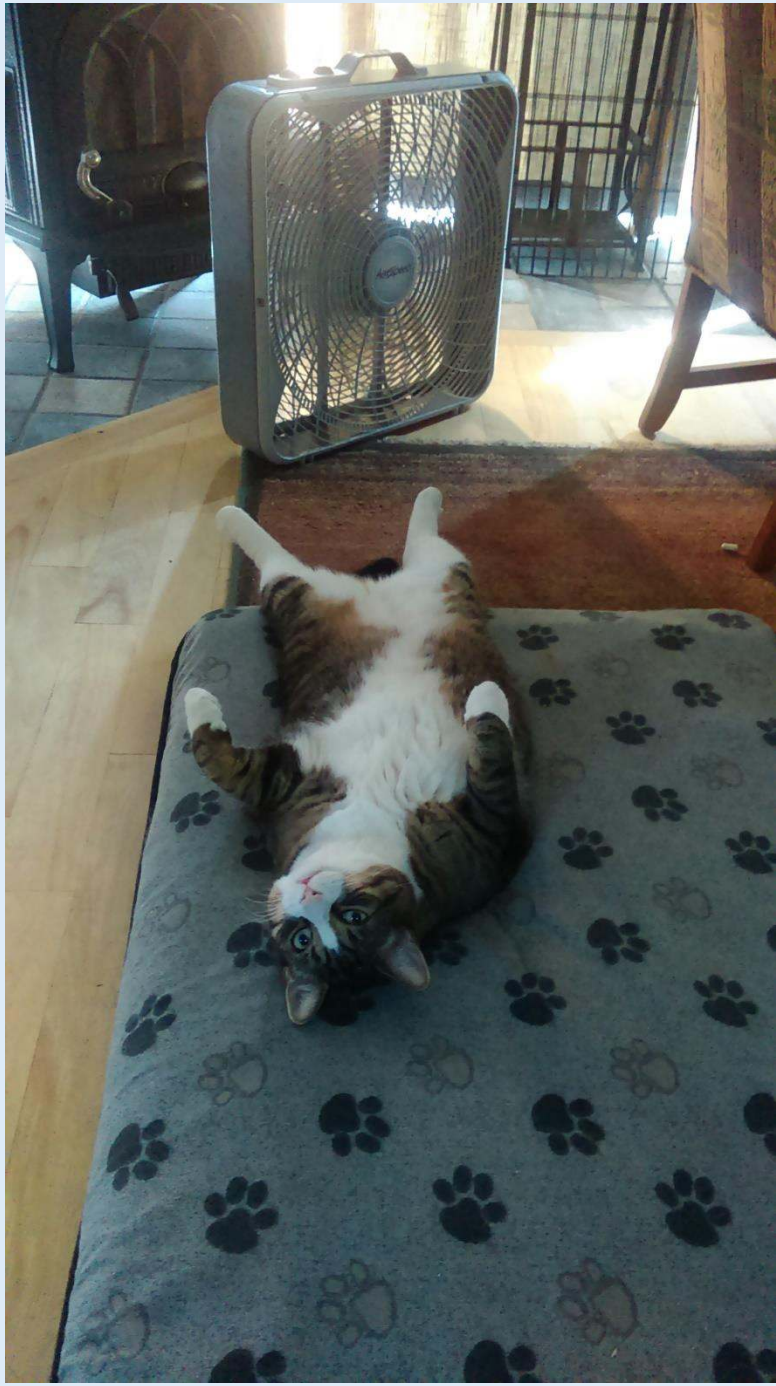






Summer's Heat

- Increasing days over 90 degrees are happening, but more significantly
- Nighttime temps are increasing at a faster rate
- From 1940-2017 minimum temperatures have increased by 2.5 degrees F (statistically significant)
- Reduced nighttime cooling has serious health effects
- Concord's minimum air temperature didn't get down to 60 degrees from June 27- July 10, 2018
- Mt. Washington's low on July 1, 2018 was 69 degrees; Burlington VT's low was 80 breaking its warmest nighttime temp record
- Not going to change – will continue to move in this warmer + more humid than average direction

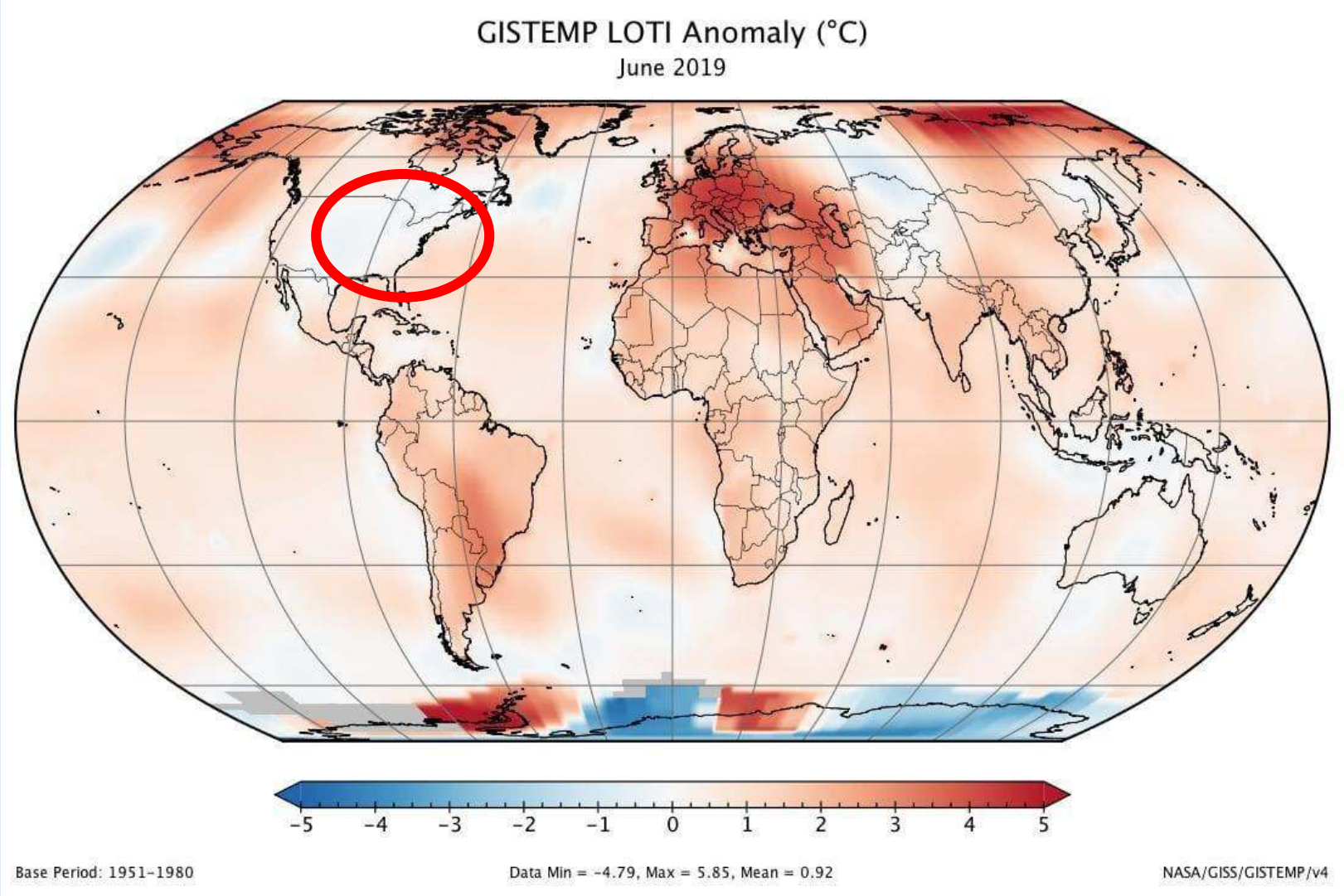


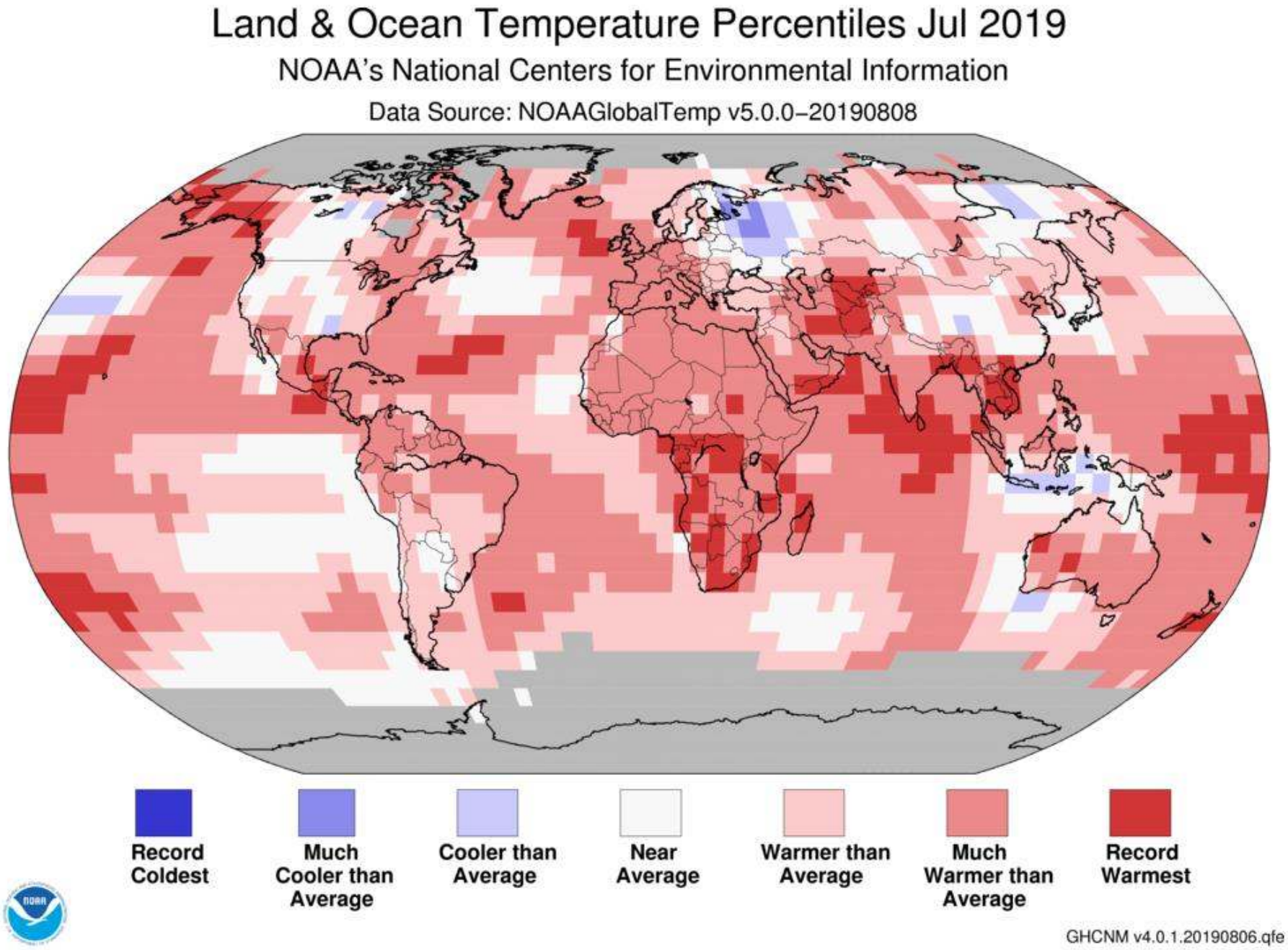
NOAA

July 11 and 12

Severe Storms and Flooding in Grafton County

Earth just had its hottest June on record, on track for warmest July





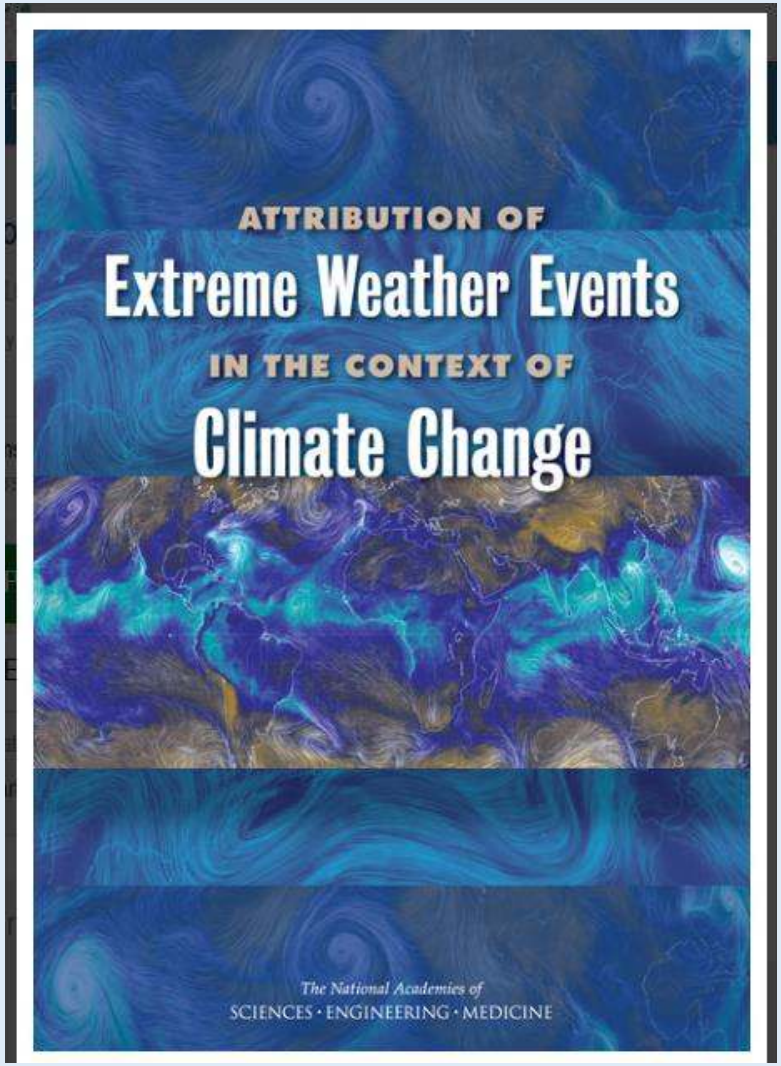
Hottest month ever on record and hottest July ever

- July 31, biggest melt day
- 56% of the ice sheet had at least 1 mm of water on it
- More than 11 billion tons of ice melted into the sea

More CO_2 = More Extreme Weather

Scientists now link extreme weather events to carbon dioxide in the air from the burning of fossil fuels.

More atmospheric CO_2 has boosted the odds of extreme heat, extreme cold, drought, + punishing rain/snow storms….



The National Academies Press. 2016 https://doi.org/10.17226/21852

Extreme Weather:
What's climate change got to do with it?

"As the climate has warmed over the years, a new pattern of more frequent and more intense weather events is unfolding in the U.S. and across the globe. Because of a rapidly advancing new area of science called 'event attribution,' we can now estimate how climate change increases the risk to society of some types of extreme events."

Marcia McNutt, President, National Academy of Sciences

A new pattern of more frequent and more intense weather events….

new area of science called 'Event Attribution'

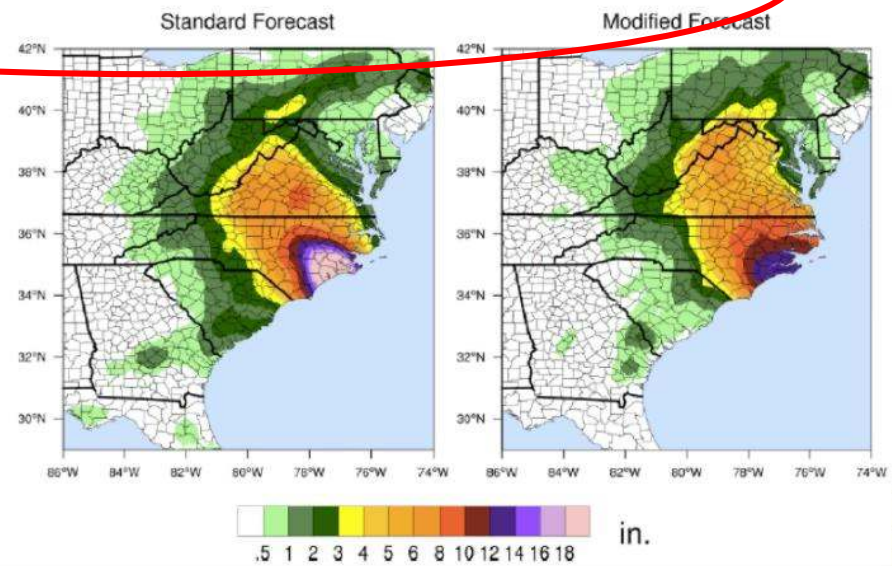
…we can now estimate how climate change increases the risk to society of some types of extreme events

The National Academies Press. 2016 https://doi.org/10.17226/21852

Hurricane Florence forecasted attribution statement

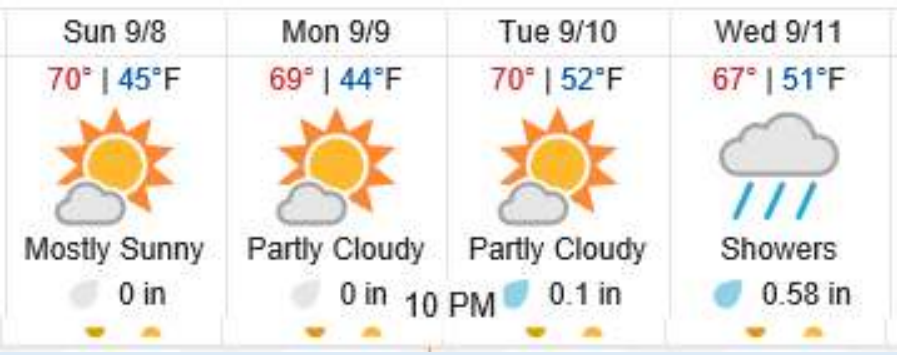
- "We find that rainfall will be significantly increased by over 50% in the heaviest precipitating parts of the storm."
- "…and that the storm will be approximately 80 km in diameter larger at landfall because of the human interference in the climate system."
- The first attribution statement made in advance of a storm.
- These statements are holding up in the retrospective analysis since the storm.
- Much public interest.

Kevin A. Reed
Alyssa M. Stansfield
Michael Wehner
Colin Zarzycki



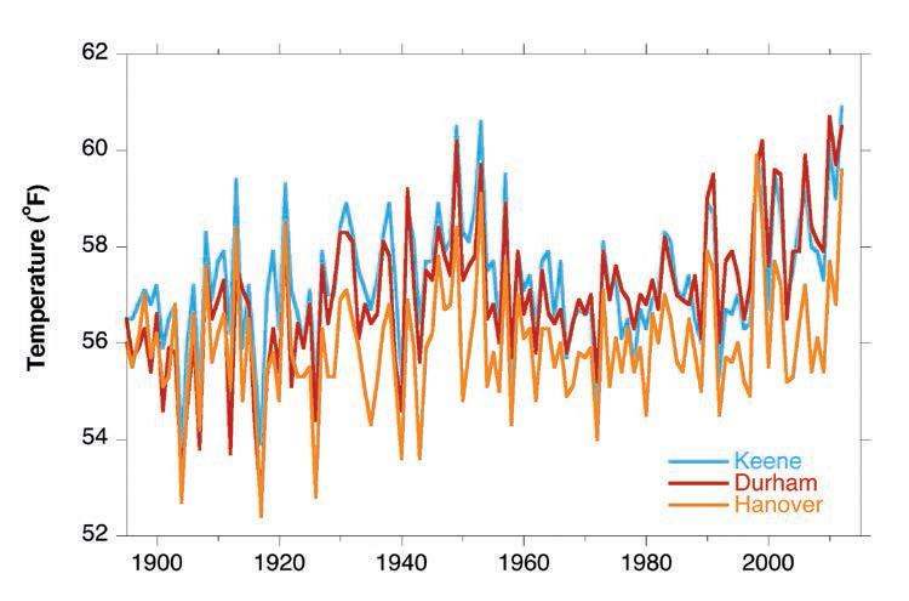
Kevin A. Reed, Stony Brook University
Alyssa M. Stansfield, Stony Brook University
Michael F. Wehner, Lawrence Berkeley National Laboratory
Colin M. Zarzycki, National Center for Atmospheric Research
Center for Climate and Energy Solutions November 2018 webinar

Weather and Climate



Weather – the set of conditions at any given point in time

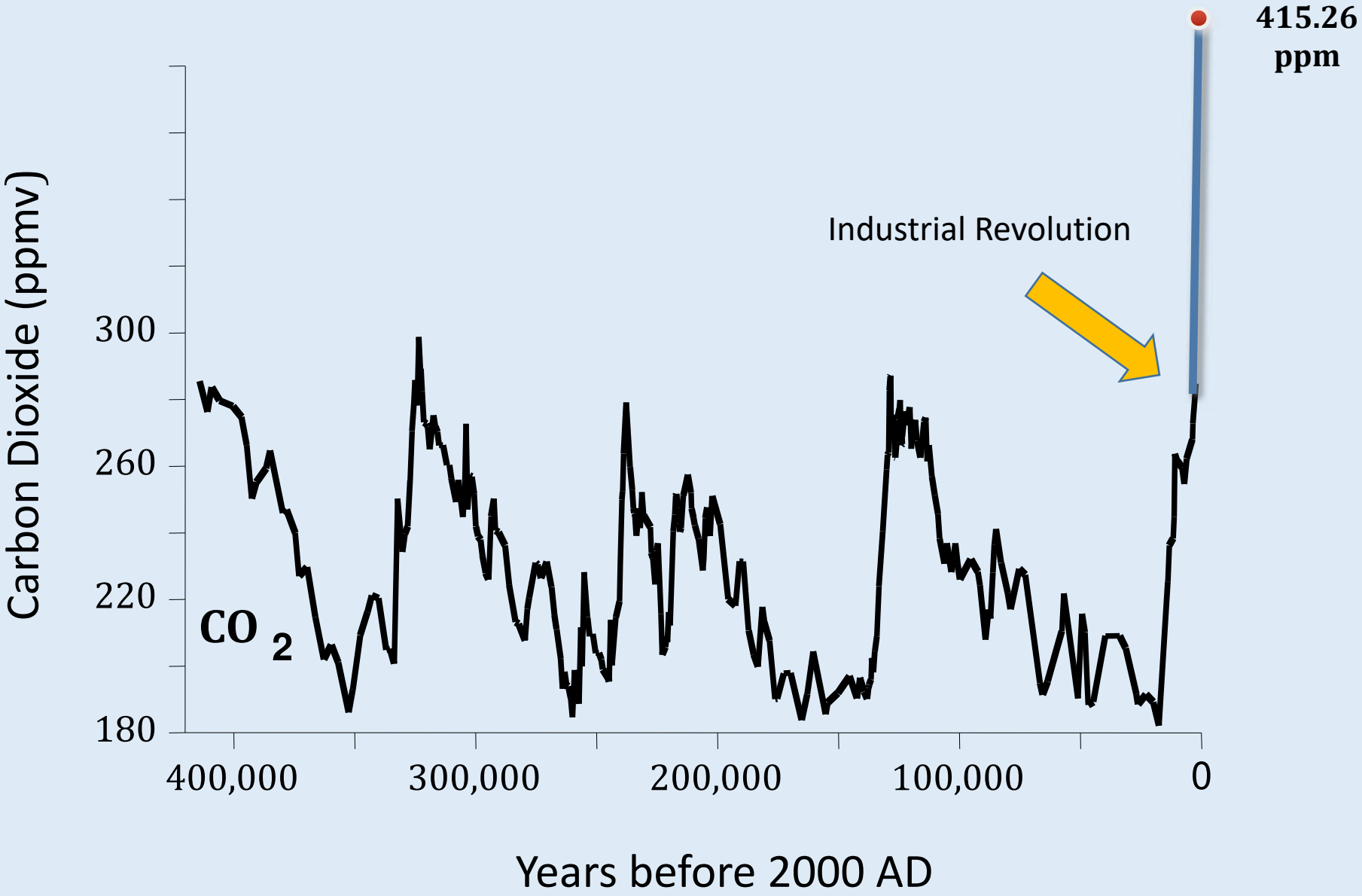
- today, tomorrow, this week



Climate - the average set of conditions over a period of decades

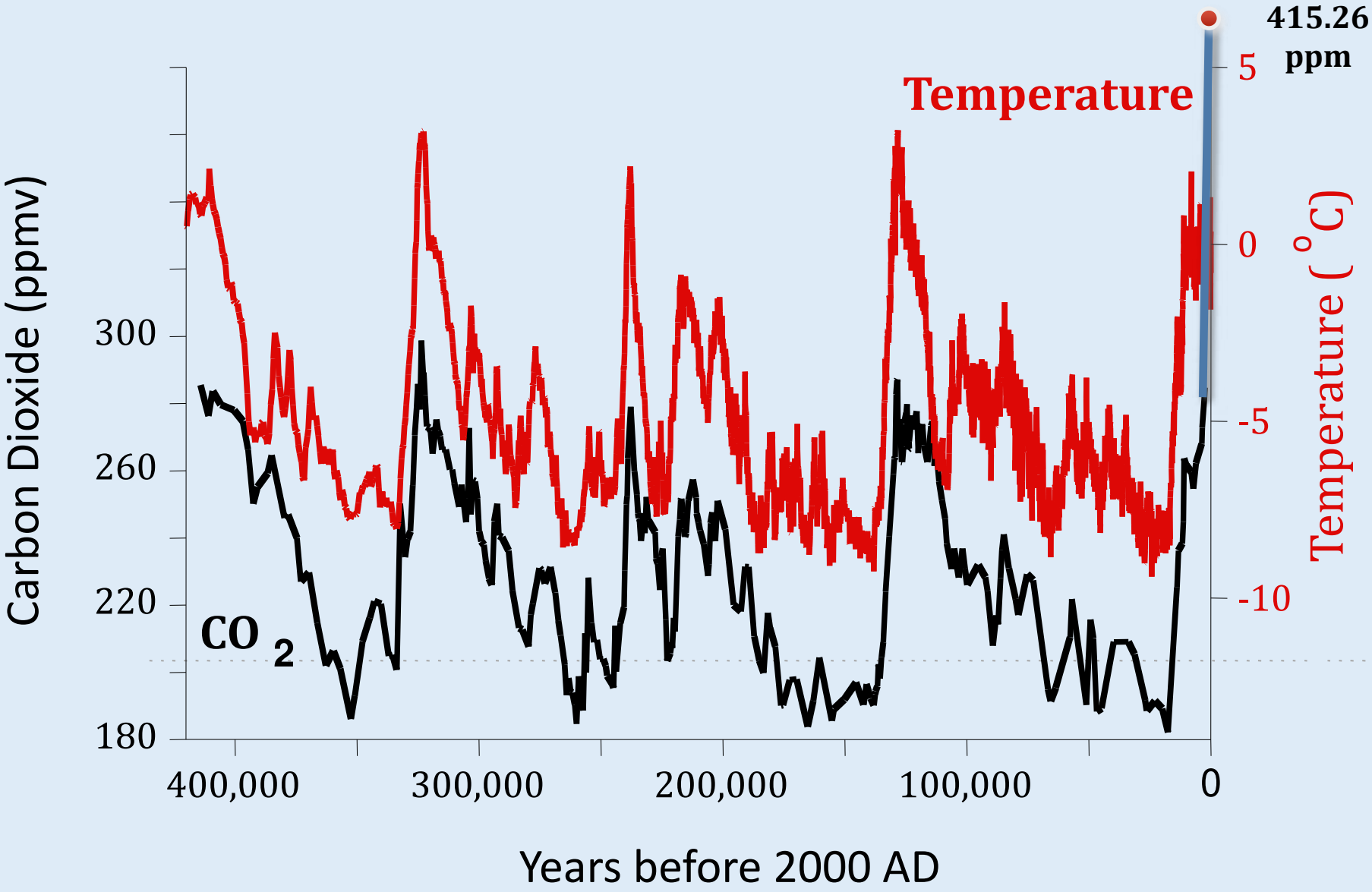
- 30 year averages

Atmospheric Carbon Dioxide Record

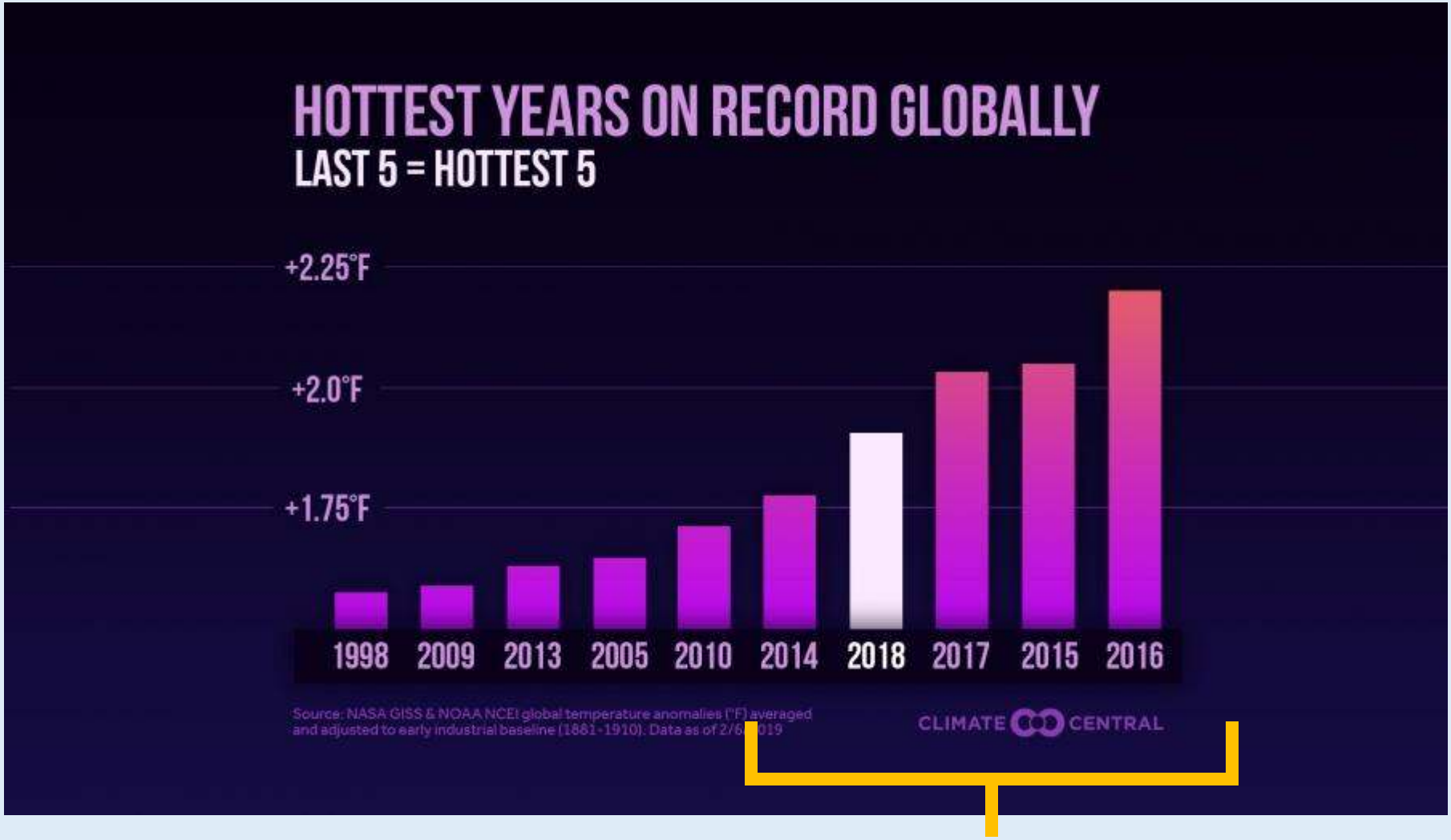


Petit et al., 1999

Atmospheric Carbon Dioxide & Temperature Record



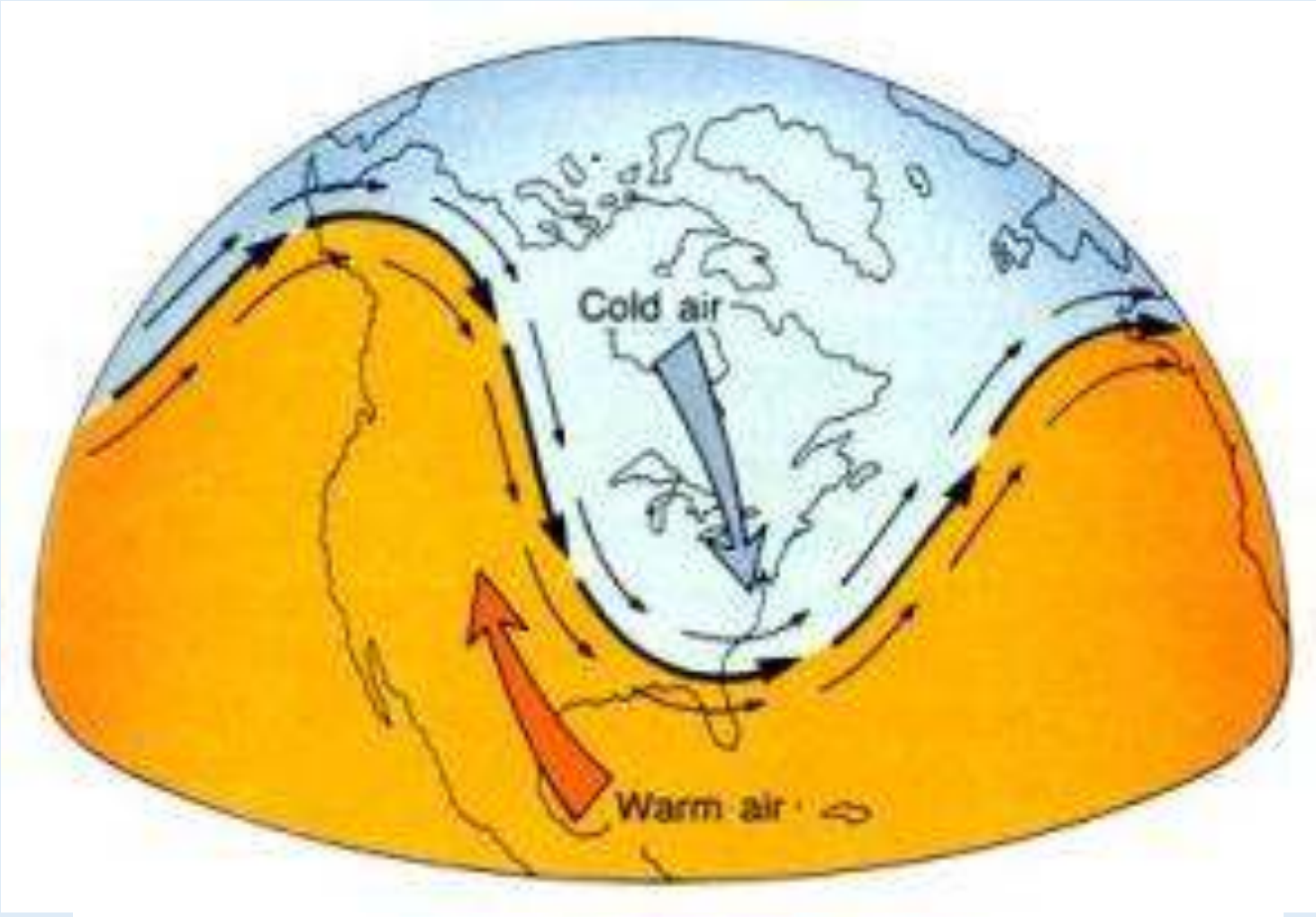
Petit et al., 1999



Records date back 138 years to 1880

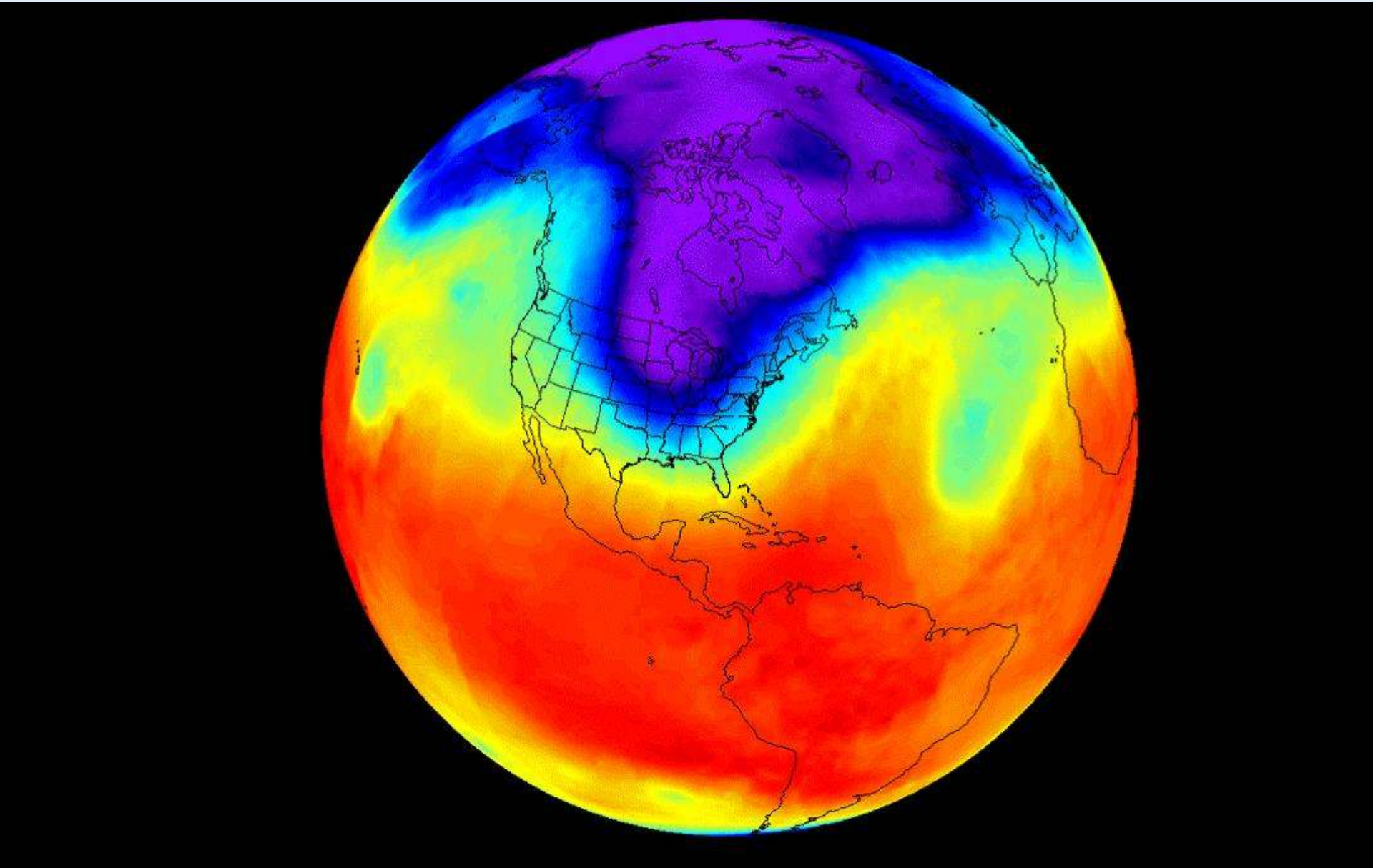
Climate Central February 2019

Wobbly Jet Stream



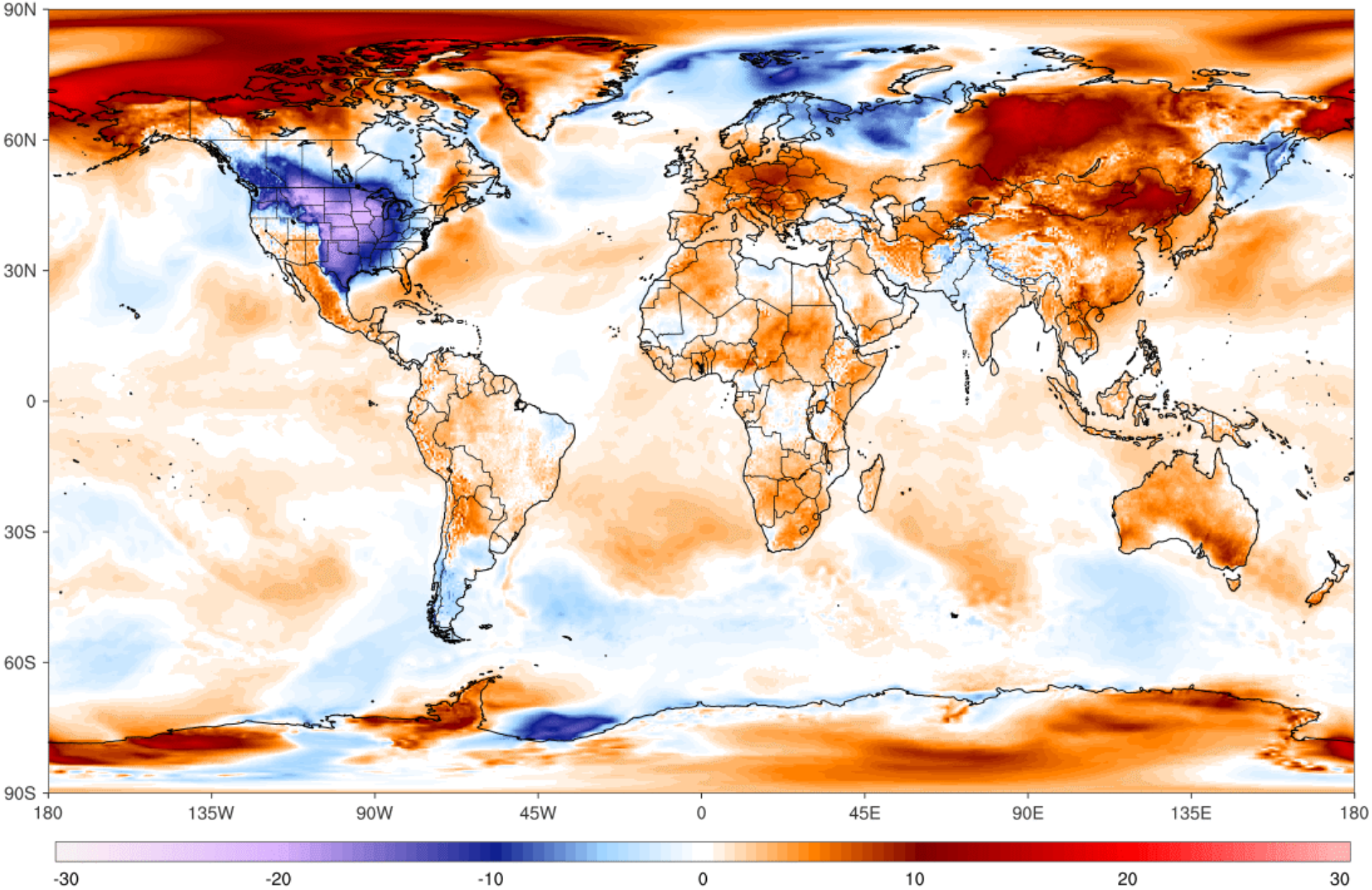
Source: R. Barry & R. Chorley (2009). Atmosphere, Weather and Climate.

January 20-29, 2019 Polar Vortex



ClimateReanalyzer.org
Climate Change Institute | University of Maine

GFS/CFSR 1-day Avg 2m T Anomaly (°C) [1979-2000 base]
Monday, Mar 04, 2019



World	NH	SH	Arctic	Antarctic	Tropics
+ 0.8 °C	+ 1.1 °C	+ 0.6 °C	+ 4.9 °C	+ 2.4 °C	+ 0.6 °C

Quasi-resonant Amplification

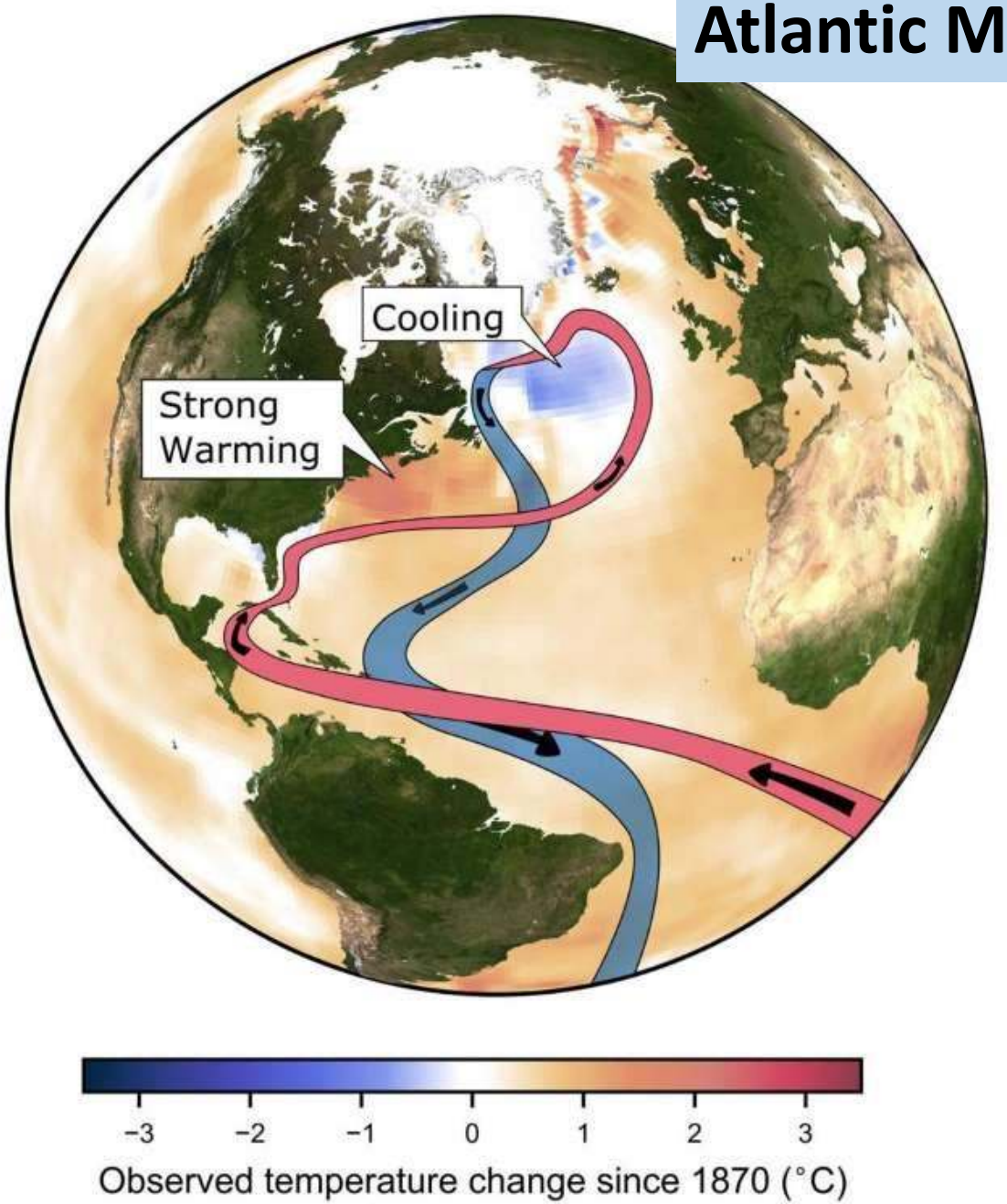
The jet stream exhibits extreme behavior during the summer

… warm air holds more moisture + when stirred by a hurricane, the moisture manifests as intense rainfall

- Predicted to increase by 50 % this century if emissions of carbon dioxide + other GHG continue unchecked
- Same phenomena as the polar vortex in winter

Michael Mann, climate scientist at Pennsylvania State University

Atlantic Meridional Overturning



The oceans' circulation hasn't been this sluggish in 1,000 years

AMO circulation has declined in strength by 15% since the mid-20th century

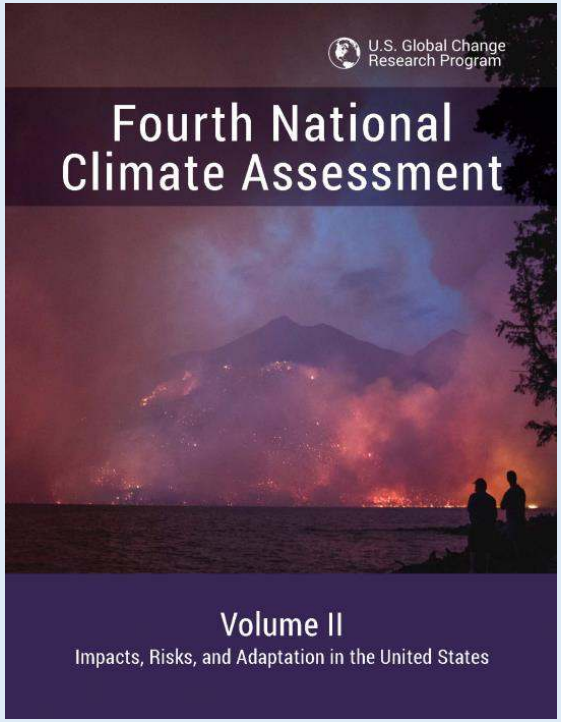
This is a new record low

Over the past 15 years the Gulf of Maine has warmed 7 times faster than the rest of the ocean

Potsdam Institute for Climate Impact Research
April 11, 2018
Gulf of Maine Research Institute

The **Global Change Research Act of 1990** mandates that the U.S. Global Change Research Program (USGCRP) deliver a report to Congress and the President no less than every four years that:

1**) integrates, evaluates, and interprets** the findings of the Program . . .;
2) **analyzes the effects of global change** on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and
3) **analyzes current trends in global change**, both human-induced and natural, and **projects major trends** for the subsequent 25 to 100 years."

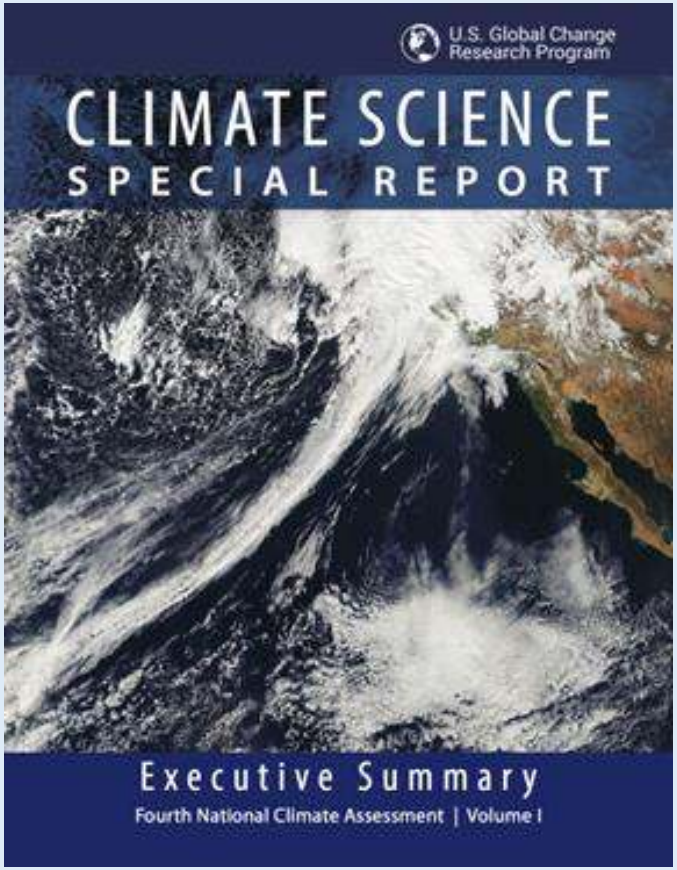


Fulfills that mandate in two volumes. This report, Volume II, draws on the foundational science described in Volume I, the *Climate Science Special Report (CSSR).*

- More than 300 federal and non-federal experts
- 13 Federal Agencies
- Regional engagement workshops reached more than 1,000 individuals in over 40 cities

Full report: nca2018.globalchange.gov

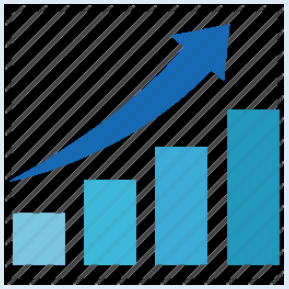
Climate Science Special Report



- Published in 2017, serves as the first volume of NCA4
- Integrates and evaluates current findings on climate science + discusses the uncertainties
- Analyzes trends in climate change
- Projects major trends to the end of this century
- Provides important input to the development of other parts of NCA4

full report: science2017.globalchange.gov.

Climate Science Special Report
National Climate Assessment



Global atmospheric carbon dioxide (CO_2) concentration has now passed 400 parts per million (ppm).

That last occurred about 3 million years ago, when both global average temperature and sea level were significantly higher than today.

The observed increase in global carbon emissions over the past 15–20 years has been consistent with higher scenarios (e.g., RCP8.5) (*very high confidence*)

https://science2017.globalchange.gov/chapter/executive-summary/

Climate Science Special Report
National Climate Assessment 2017

Annual average temperature over the contiguous US has increased by 1.8°F (1.0°C) over the last 115 years (1901–2016) and is projected to continue to rise. (*Very high confidence*)

This period is now the warmest in the history of modern civilization

https://science2017.globalchange.gov/chapter/executive-summary/

Climate Science Special Report
National Climate Assessment

Annual average US temperature is projected to rise (*very high confidence*)

- Increases of about 2.5°F (1.4°C) are projected for the period 2021–2050 relative to the average from 1976–2005 in all RCP scenarios

Recent record-setting years may be "common" in the next few decades (*high confidence*)

Much larger rises are projected by late century (2071–2100) (*high confidence)*:

2.8°–7.3°F (1.6°– 4.1°C) in a lower scenario (RCP4.5)

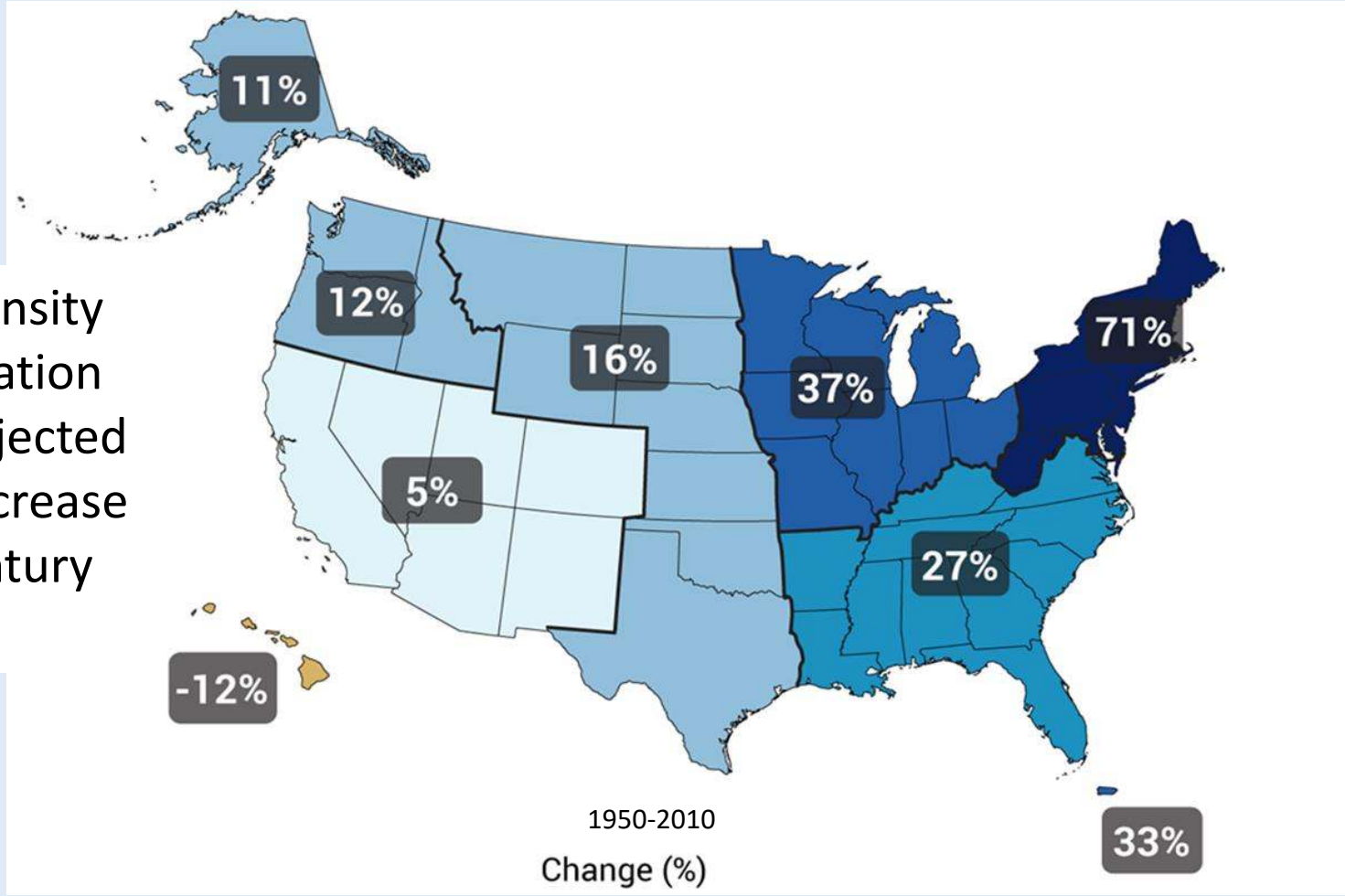
5.8°–11.9°F (3.2°– 6.6°C) in a higher scenario (RCP8.5)

https://science2017.globalchange.gov/chapter/executive-summary/

Heavy precipitation events in most parts of the US have increased in both intensity & frequency since 1901 (*high confidence*)

Regional differences in trends, the largest increases occurring in the northeastern US (*high confidence*)

Frequency & intensity of heavy precipitation in the US are projected to continue to increase over the 21st century (*high confidence*)



Oceans Are Rising, Warming, and Becoming More Acidic

Global mean sea level (GMSL) has risen by about **7–8 inches** (about 16–21 cm) **since 1900**, with about **3 of those inches** (about 7 cm) **occurring since 1993** (*very high confidence*)

Human-caused climate change has made a substantial contribution to GMSL rise since 1900 (*high confidence*), **contributing to a rate of rise that is greater than during any preceding century in at least 2,800 years** (*medium confidence*)

https://science2017.globalchange.gov/chapter/executive-summary/

Oceans Are Rising, Warming, and Becoming More Acidic

Relative to the year 2000, GMSL is *very likely* to rise by:

- **0.3–0.6 feet** (9–18 cm) **by 2030**
- **0.5–1.2 feet** (15–38 cm) **by 2050**
- **1.0–4.3 feet** (30–130 cm) **by 2100**

(*very high confidence* in lower bounds*; medium confidence* in upper bounds for 2030 and 2050*; low* confidence in upper bounds for 2100*)*

Emerging science regarding Antarctic ice sheet stability suggests that, for higher scenarios, a GMSL rise exceeding 8 feet (2.4 m) by 2100 is physically possible, although the probability of such an extreme outcome cannot currently be assessed.

It is *extremely likely* that GMSL rise will continue beyond 2100 (*high confidence*)

https://science2017.globalchange.gov/chapter/executive-summary/

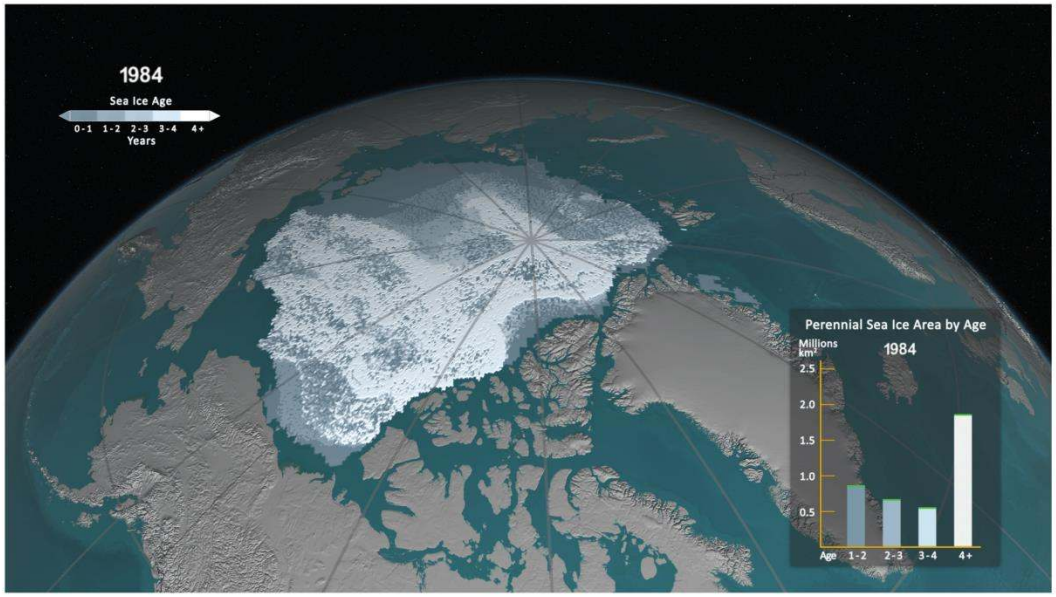
Oceans Are Rising, Warming, and Becoming More Acidic

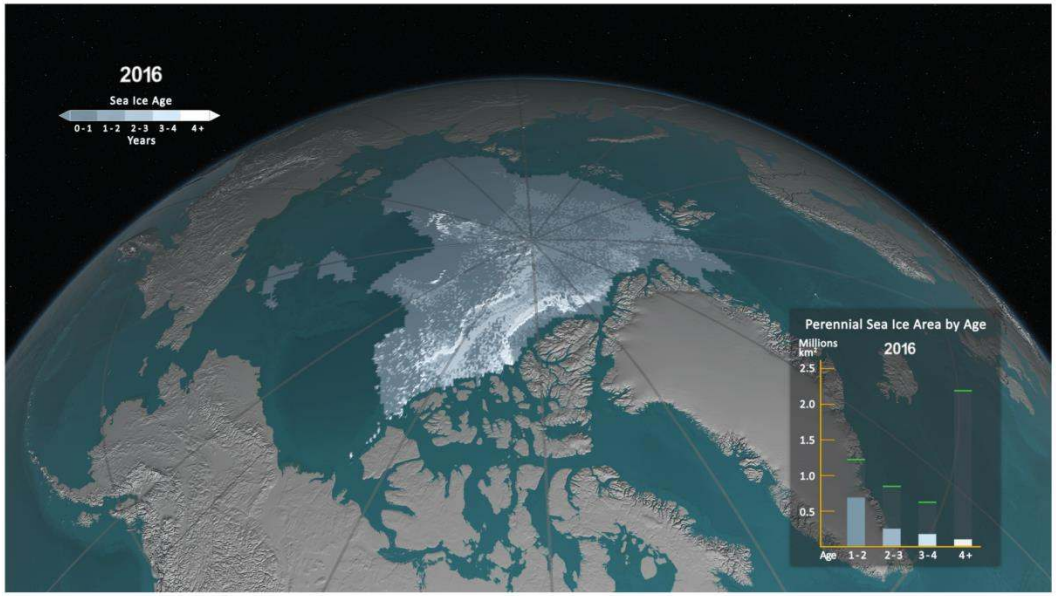
The world's **oceans have absorbed about 93% of the excess heat** caused by GHG warming since the mid-20th century, making them warmer + altering global & regional climate feedbacks. (*very high confidence*)

The world's **oceans are currently absorbing more than a quarter of the CO_2** emitted to the atmosphere annually from human activities, making them more acidic (*very high confidence*), with potential detrimental impacts to marine ecosystems

https://science2017.globalchange.gov/chapter/executive-summary/

Arctic Sea Ice Loss





Arctic sea ice loss is expected to **continue through the 21st century**, *very likely* resulting in **nearly sea ice-free late summers by the 2040s** (*very high confidence*)

It is *very likely* that **human activities have contributed** to observed arctic surface temperature warming, sea ice loss, glacier mass loss, + northern hemisphere snow extent decline (*high confidence*)

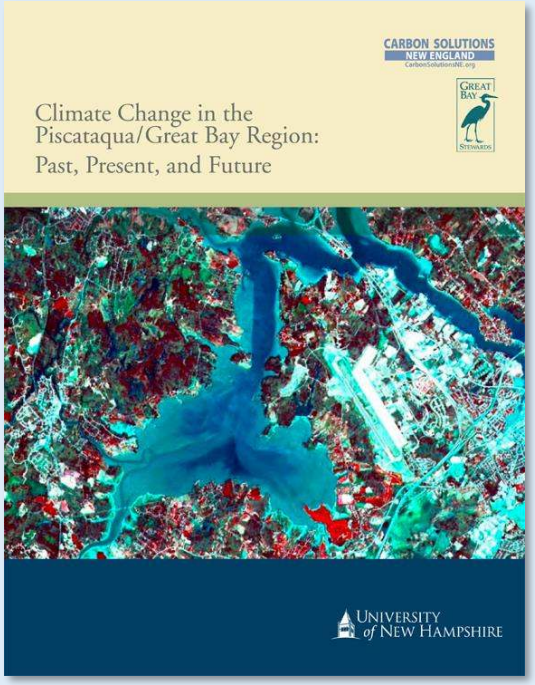
https://science2017.globalchange.gov/chapter/executive-summary/

Choices made today will determine the magnitude of climate change risks beyond the next few decades

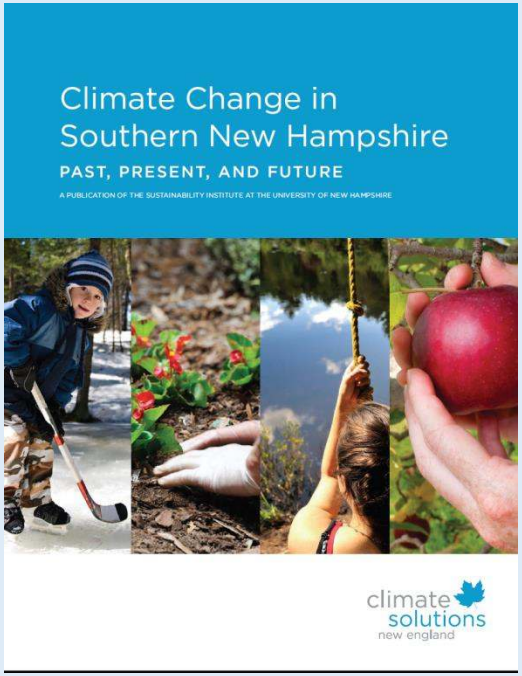
Unanticipated and difficult or impossible-to-manage changes in the climate system are possible throughout the next century as critical thresholds are crossed and/or multiple climate-related extreme events occur simultaneously (**surprises or tipping points**)

Seabrook
Jan 23, 2019

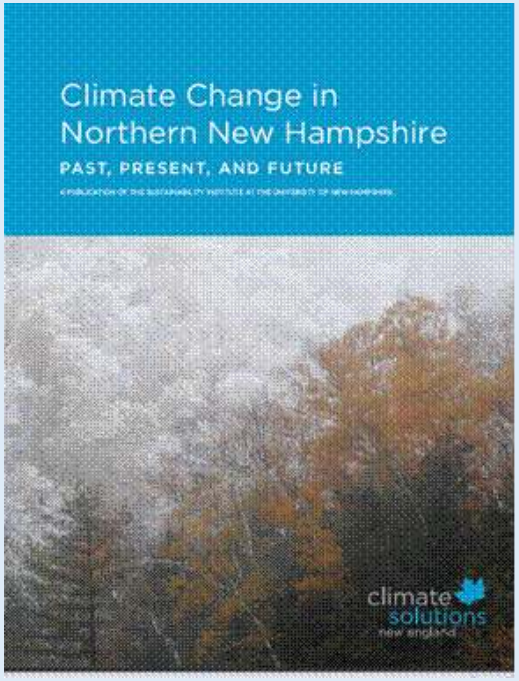
Local and Regional Climate Assessments



Seacoast



Southern NH

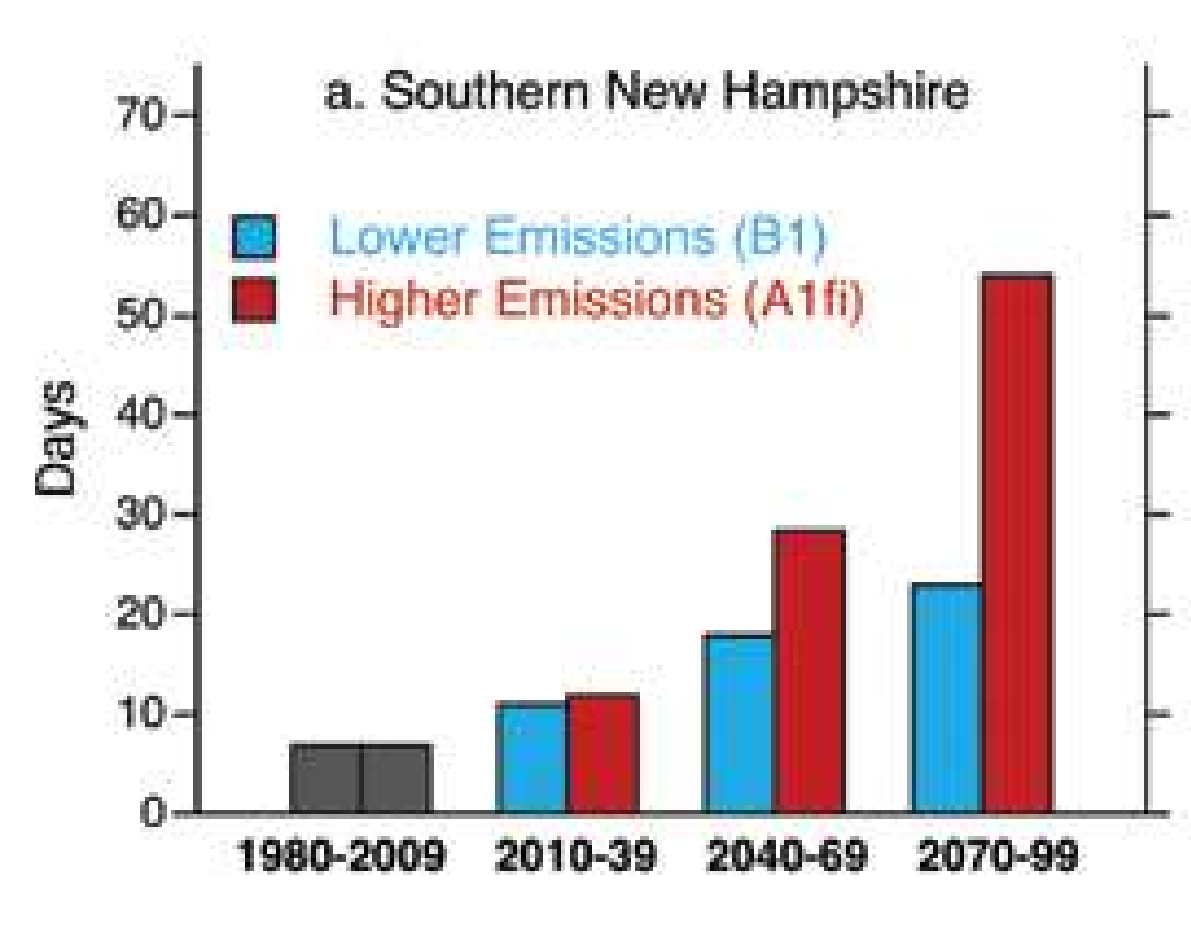


Northern NH

Local Data!

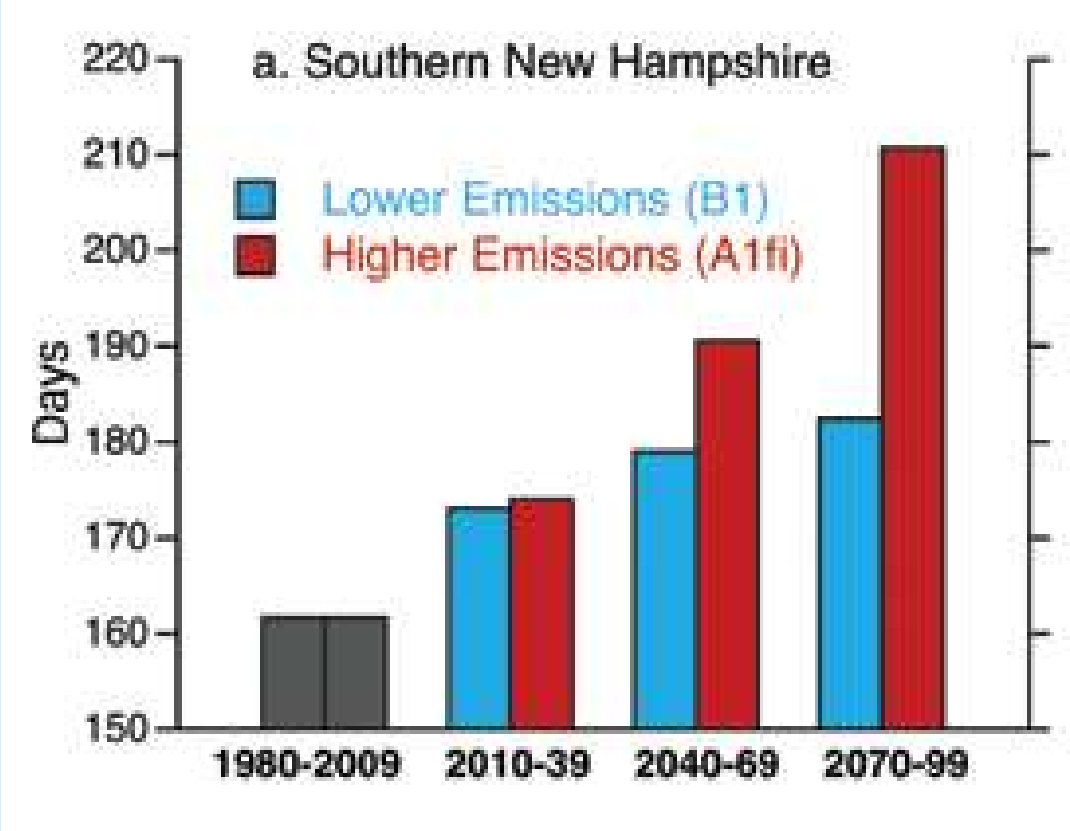
http://sustainableunh.unh.edu/csne-climate-assessments-new-england#map

Extreme Heat



Average number of days over 90 degrees per year

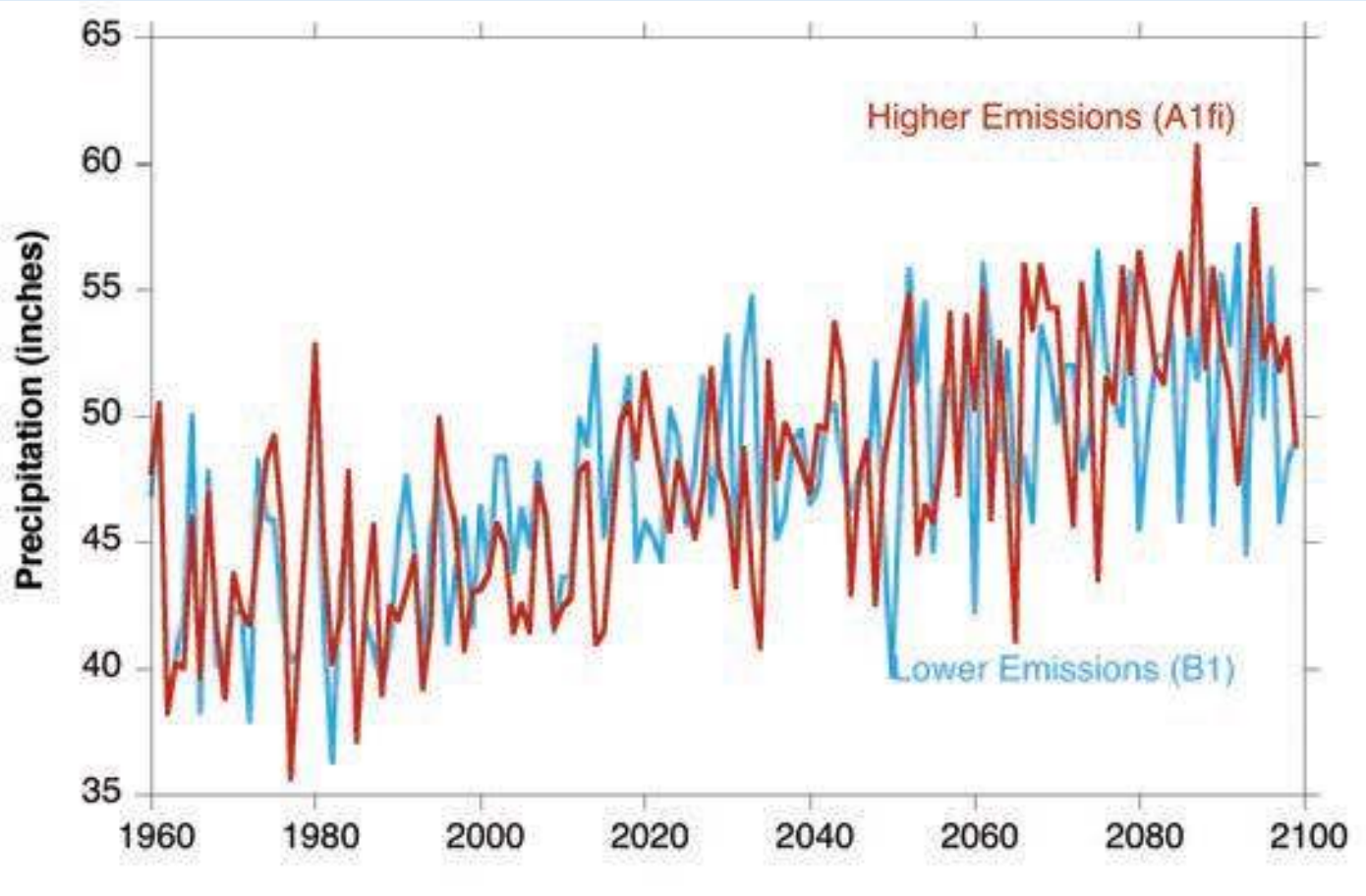
Future Growing Season



The growing season is projected to lengthen by about two weeks (lower emission scenario) or five weeks (higher emission scenario)

Hotter temperatures, reduced chilling hours, enhanced evapotranspiration, and more extreme precipitation will likely result in a decrease in crop yields.

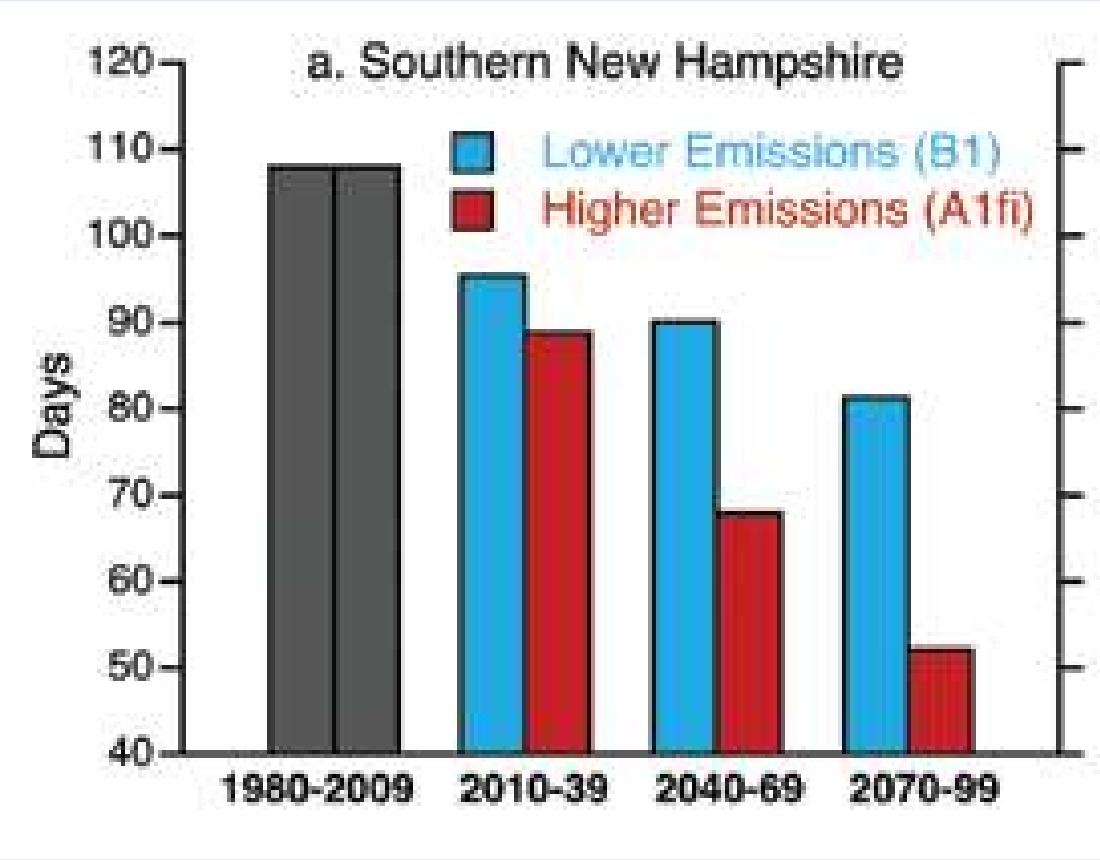
Future Precipitation



Annual precipitation is projected to increase 17 to 20% (both emission scenarios) by the end of the century

Increase in extreme precipitation events, results in excessive runoff, flooding, damage to critical infrastructure (buildings, roads, dams, bridges, culverts), increased erosion & degradation of water quality…

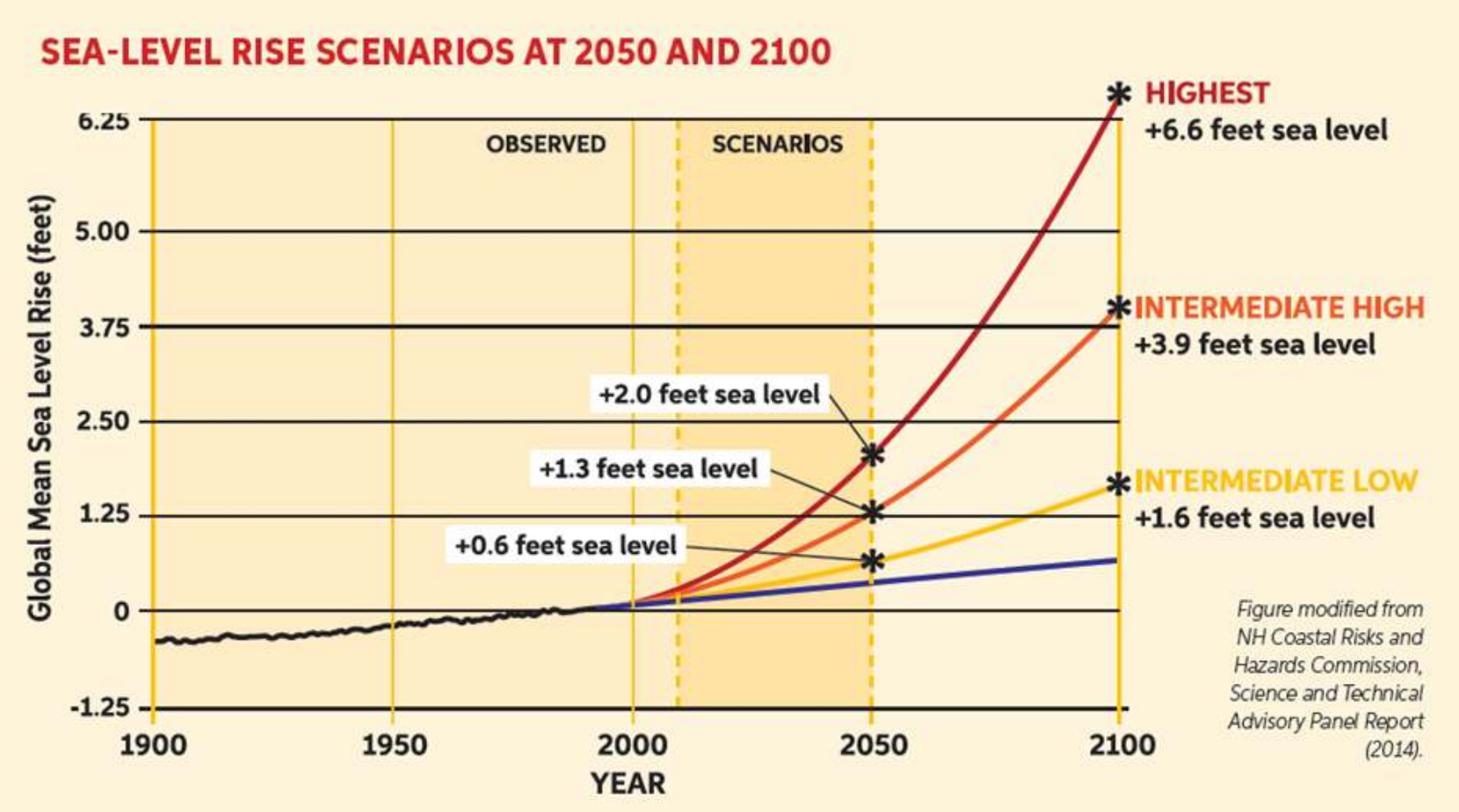
Snow Covered Days



Historically we had 105 days per year with snow cover

By the end of the century (high emissions scenario), we could have only 52 days

Sea Level Rise



Projections:

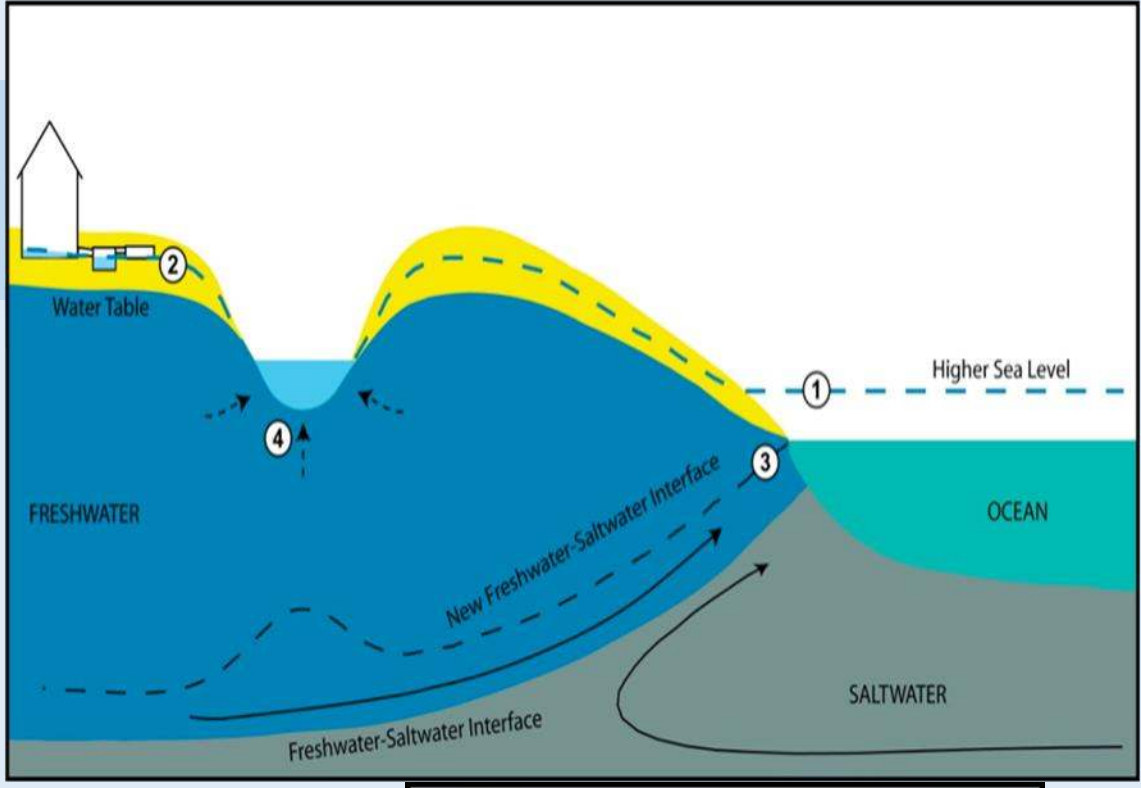
0.6 – 2.0 ft. by 2050

1.6 – 6.6 ft. by 2100

… and our coast is significantly impacted by both **Nor'easters & hurricanes**. Winds from these storms drive ocean water towards the land, resulting in the short-term rise in water levels called **storm surge**.

NH Coastal Risk and Hazards Commission - 2016

Groundwater will rise with sea level



Groundwater rise will extend farther inland than sea level rise

From 1-5 ft. of ground water rise is predicted as far as 3 mi. the inland from tidal shorelines

The amount of groundwater rise is not uniform and linear with distance from the coast

Depends on:

- local hydrogeology
- proximity of streams or wetlands
- distance from the coast
- groundwater pumping

Will impact roads, underground storage tanks, drinking water wells, septic systems, landfills…

Knott J., M. Elshaer, J. Sias Daniel, J.M. Jacobs, P. Kirshen 2017

Exacerbating Issues

- Population increase
  - Displaced people
- Development increases – more pavement
- More homes built in risky areas
- Old infrastructure - undersized
- Federal funding decreases
- Politics
- Other?

Your Job?

More Heat

- Design Parameters
- Energy use for Cooling
- Remedial Strategies
- Field Staff

More Precipitation

- USTs | ASTs
- HW Storage
- Landfills
- Spill Prevention Control, Countermeasures

Above ground + Underground Storage Tanks	• Impacts from GW rise + flooding • Appropriate drainage? • Proximity to floodplains?
Hazardous Waste Storage Facilities	• Impacts from more frequent + intense storms • Appropriate drainage? • Can floodwaters enter the building?
Landfills	• Increased leachate production? • Stormwater runoff and erosion? • Revise closure/capacity plans to address projected frequency + intensity of storms
Spill Prevention Control, Countermeasures Plan	• Review + revise to address projected frequency + intensity of storms • Sampling after storms may need to increase

Design Parameters	• Plan for temperatures above 90º F • Longer heat waves
Energy use for Cooling	• Buildings • Grid Demand | Peak Demands
Remedial Strategies	• Excessive heat impacts to infrastructure • Effects of heat + humidity on instruments
Field Staff	• High heat + humidity • Ticks | Mosquitos | vector born disease

Need to do both!

Mitigation

- Saves money – now and into the future
- Reduces the amount we will have to adapt to

Adaptation

- Proactive adaptation—including changes to policies, business operations, capital investments, and other steps—**yields benefits in excess of their costs** now and into the future.

We Have Met Environmental Challenges in the Past!

40 years ago – Smog

- Solution: Catalytic converters
- Smog reduced by 30% to 50%

We Have Met Environmental Challenges in the Past!

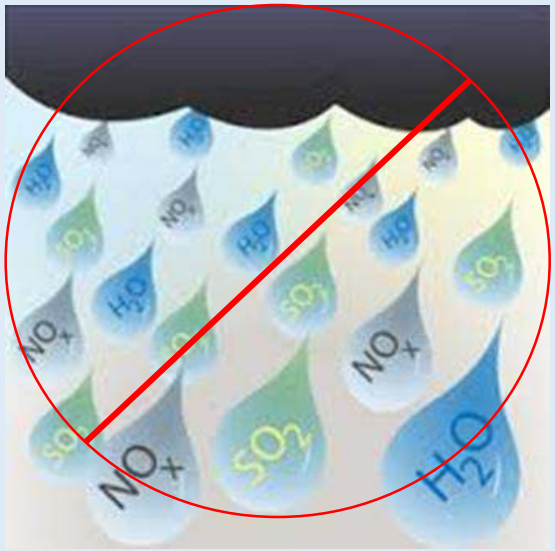
35 years ago – Ozone layer destruction

- Solution: Chlorofluorocarbon (CFC) phase out
- CFCs all but eliminated, ozone layer (slowly) rebounding

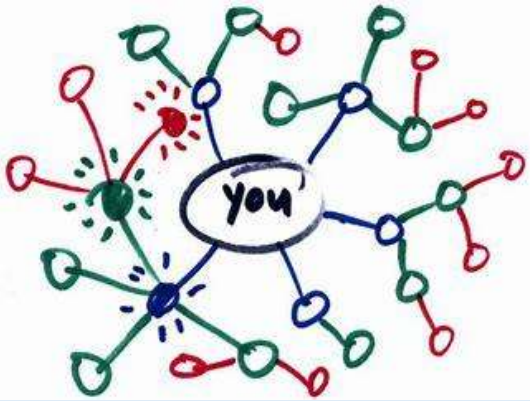
We Have Met Environmental Challenges in the Past!

30 years ago – Acid Rain

- Solution: market-based program for regulating utility sulfur dioxide emissions
- Acid rain emissions cut by 50%; forests rebounding, lakes (slowly) recovering



Making the Connections



- Climate change will cost taxpayers more than a half a trillion dollars this decade, and trillions more in the future unless we mitigate the impacts. (Government Accountability Office)
- We cannot ignore the impact of climate change on our public health, our environment, and our economy.
- The lessons will continue to be taught until they are learned.
- We've got to connect the dots!

Questions?

Thank You

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