

sylvania - NetCam SC IR - Fri Sep 25 2020 11:30:06 CST - UTC-6

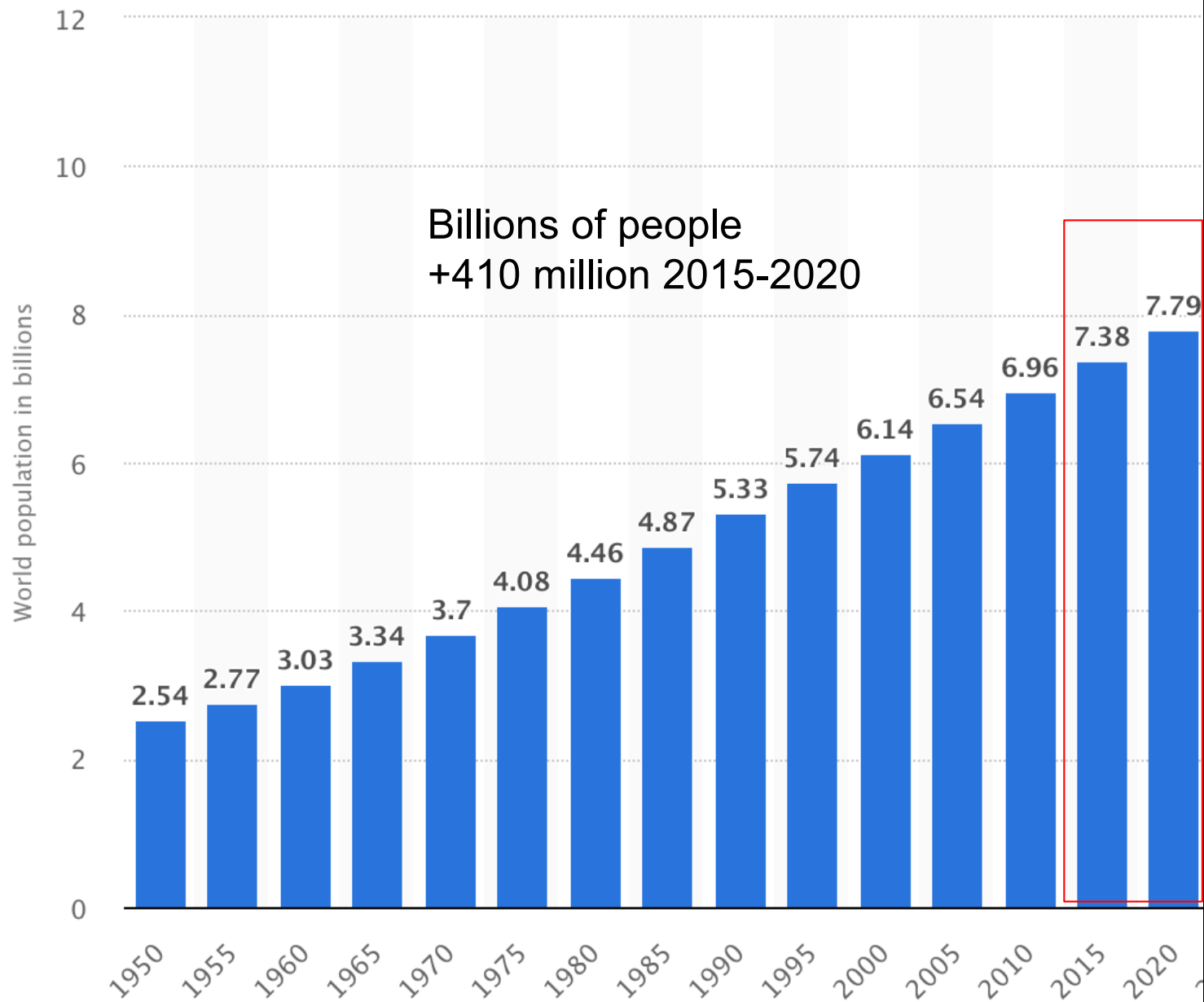
Camera Temperature: 42.5

Exposure: 85

# Climates Change, Can People?

**Ankur Desai**  
**Dept of Atmospheric & Oceanic Sciences**  
**University of Wisconsin-Madison**

**Nov 16, 2020**  
**PLATO**  
**VIRTUAL EDITION**



# Annual Fossil CO<sub>2</sub> Emissions and 2019 Projections

16 Gt  
CO<sub>2</sub>

Projected global emissions growth: +0.6% (-0.2% to +1.5%)

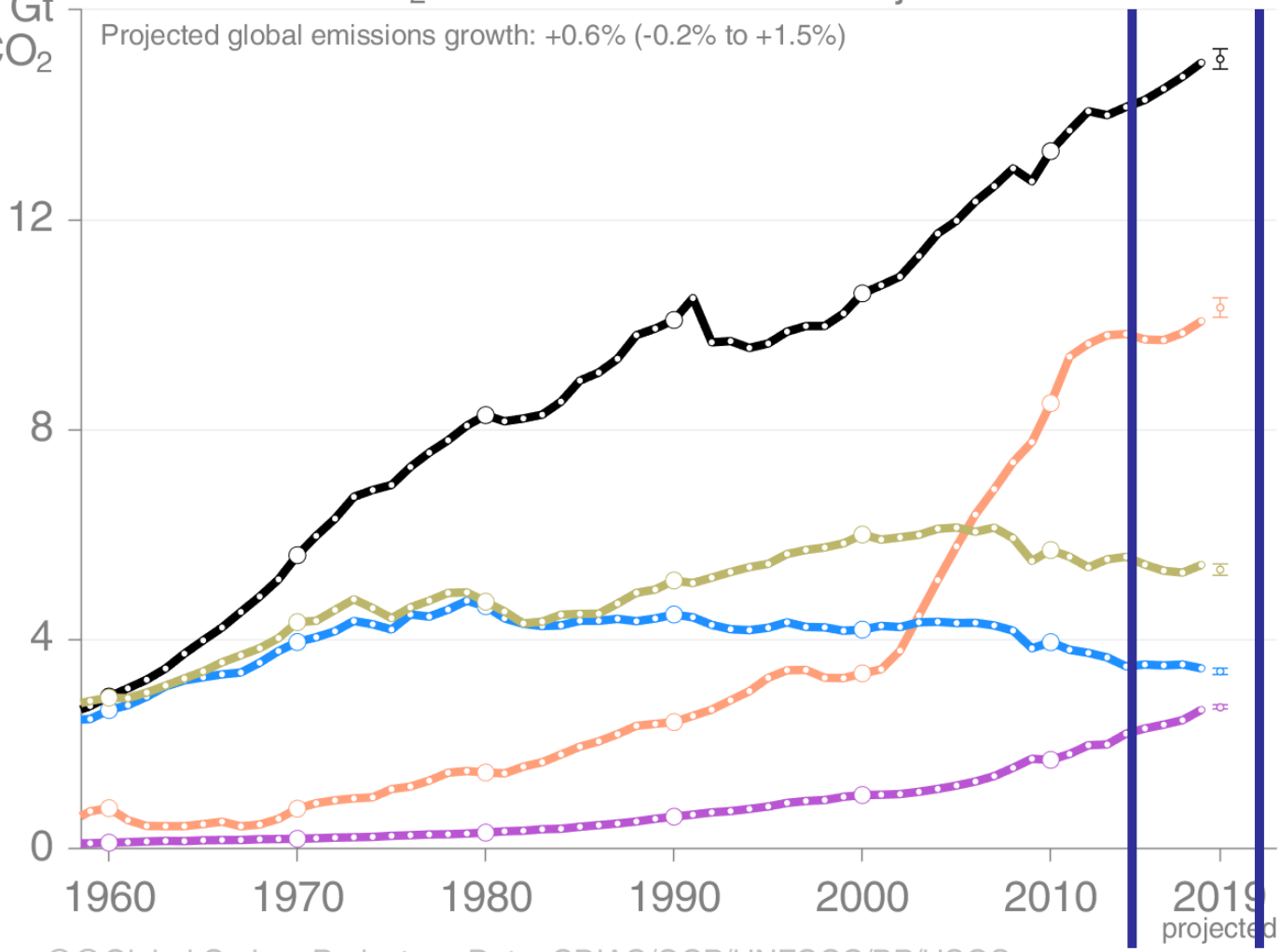
Projected Gt CO<sub>2</sub> in 2019  
**All others 15.1**  
 ▲ 0.5% (-0.8% to +1.8%)

**China 10.3**  
 ▲ 2.6% (+0.7% to +4.4%)

**USA 5.3**  
 ▼ 1.7% (-3.7% to +0.3%)

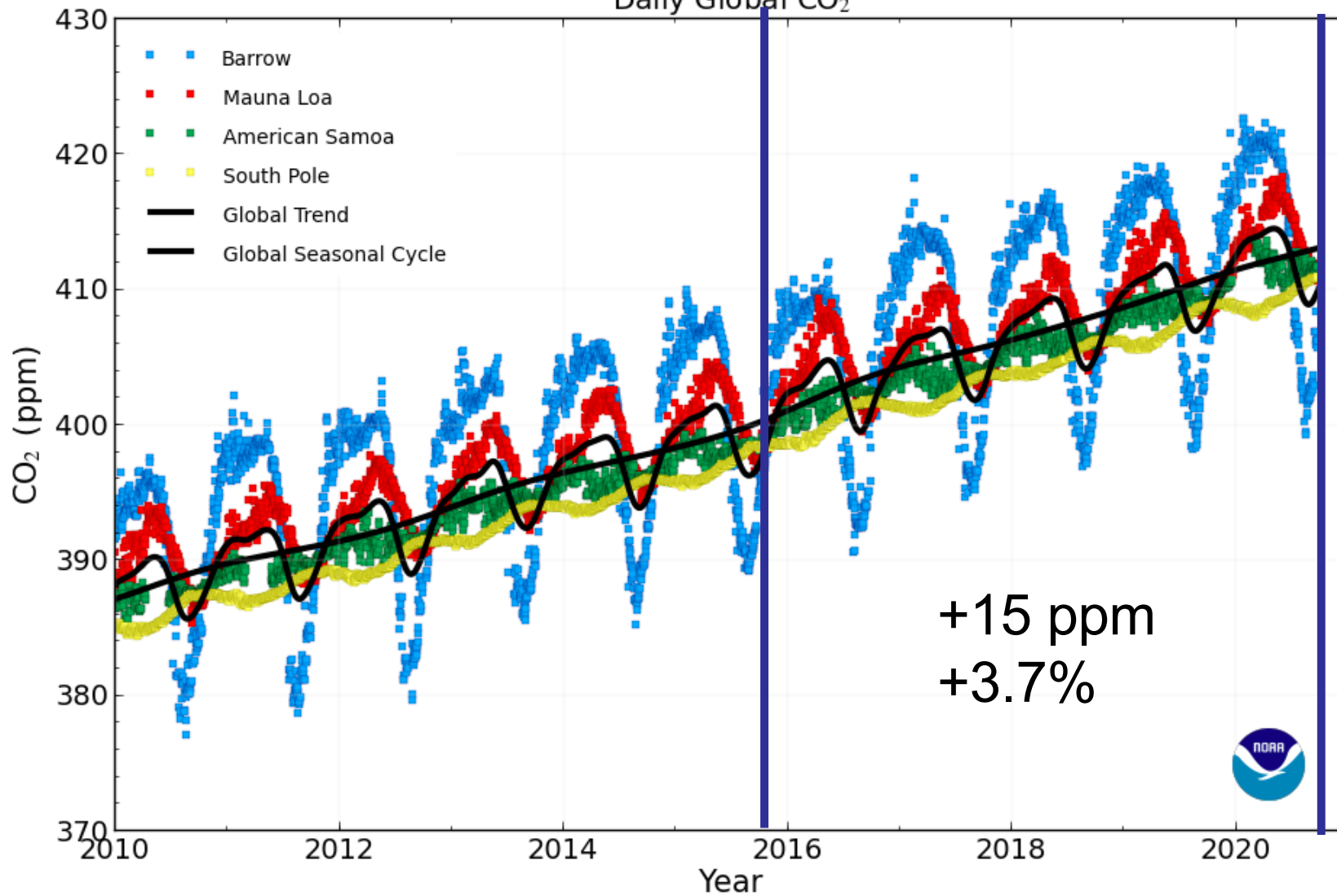
**EU28 3.4**  
 ▼ 1.7% (-3.4% to +0.1%)

**India 2.7**  
 ▲ 1.8% (+0.7% to +3.7%)

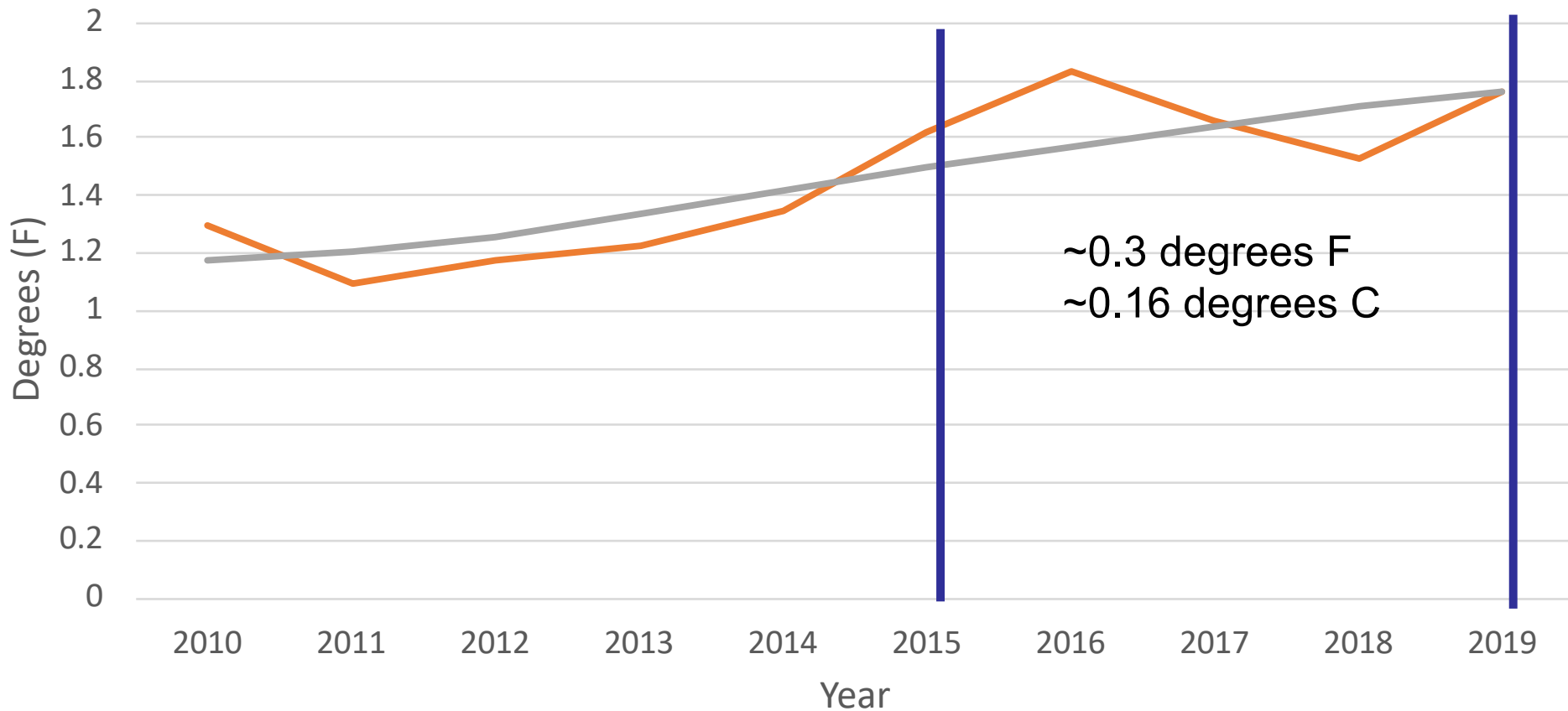


© Global Carbon Project • Data: CDIAC/GCP/UNFCCC/BP/USGS

# Daily Global CO<sub>2</sub>



## Global Temperature Difference from 1950-1980 (NASA GISS)



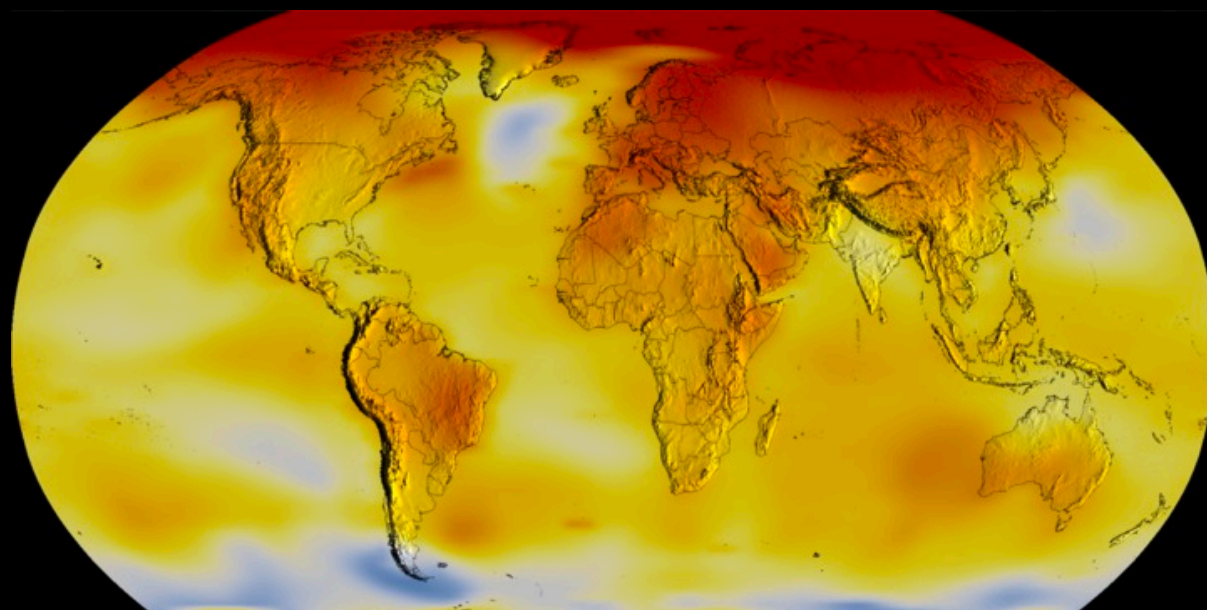
1.8 degree F per  
100 ppm (20 yrs emissions)

— Anomaly — Smoothed

~3 C for doubling of CO<sub>2</sub>

~0.3 degrees F  
~0.16 degrees C

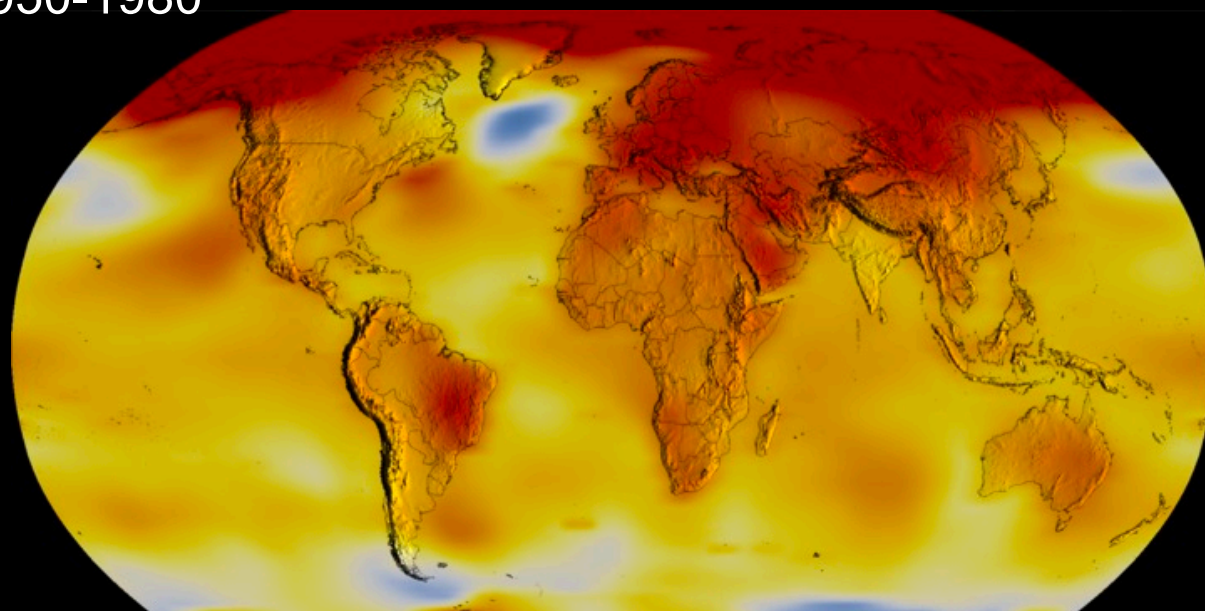
2015



Temperature Difference (Fahrenheit)  
versus 1950-1980



2020



NASA GISS



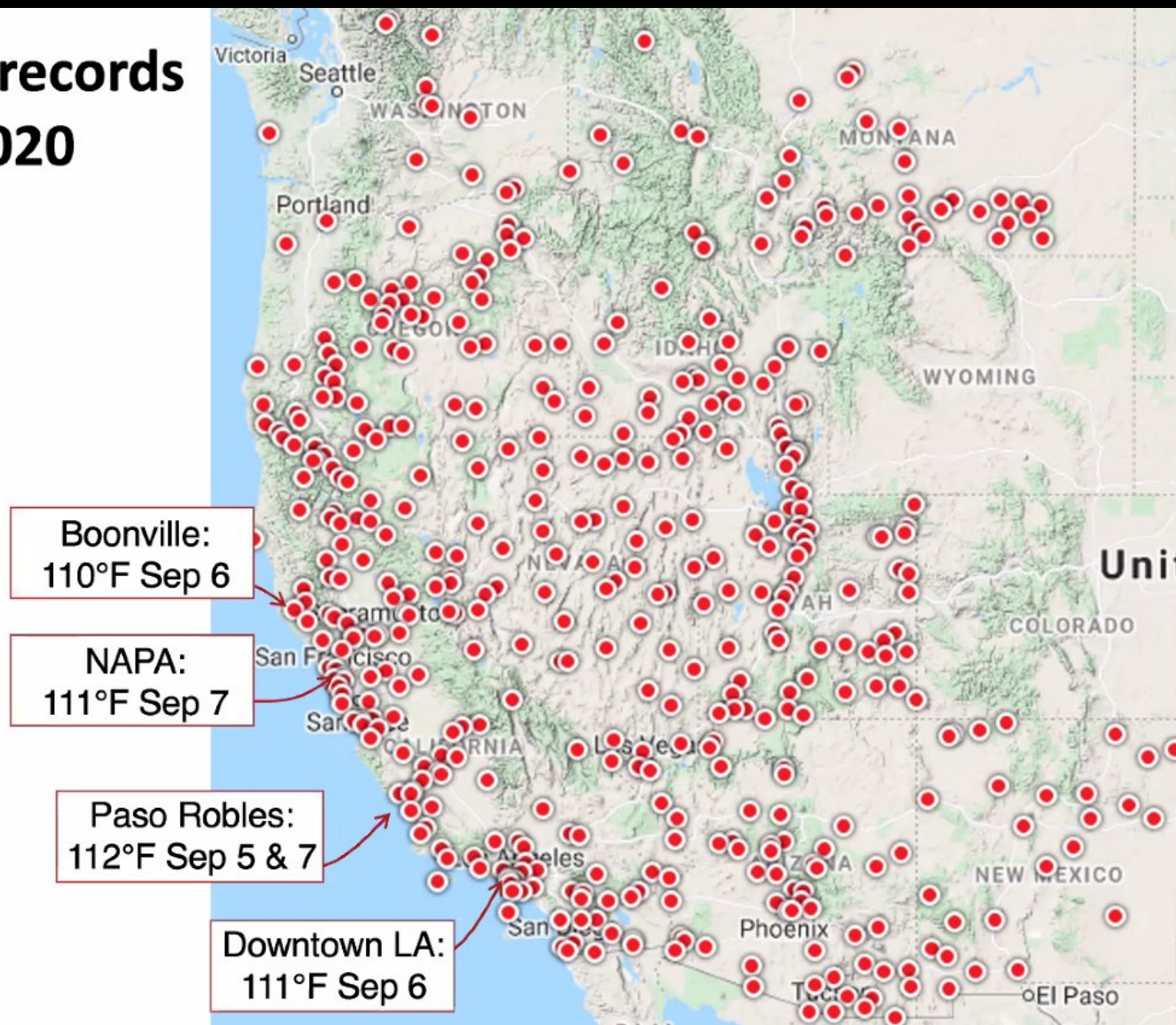
REUTERS



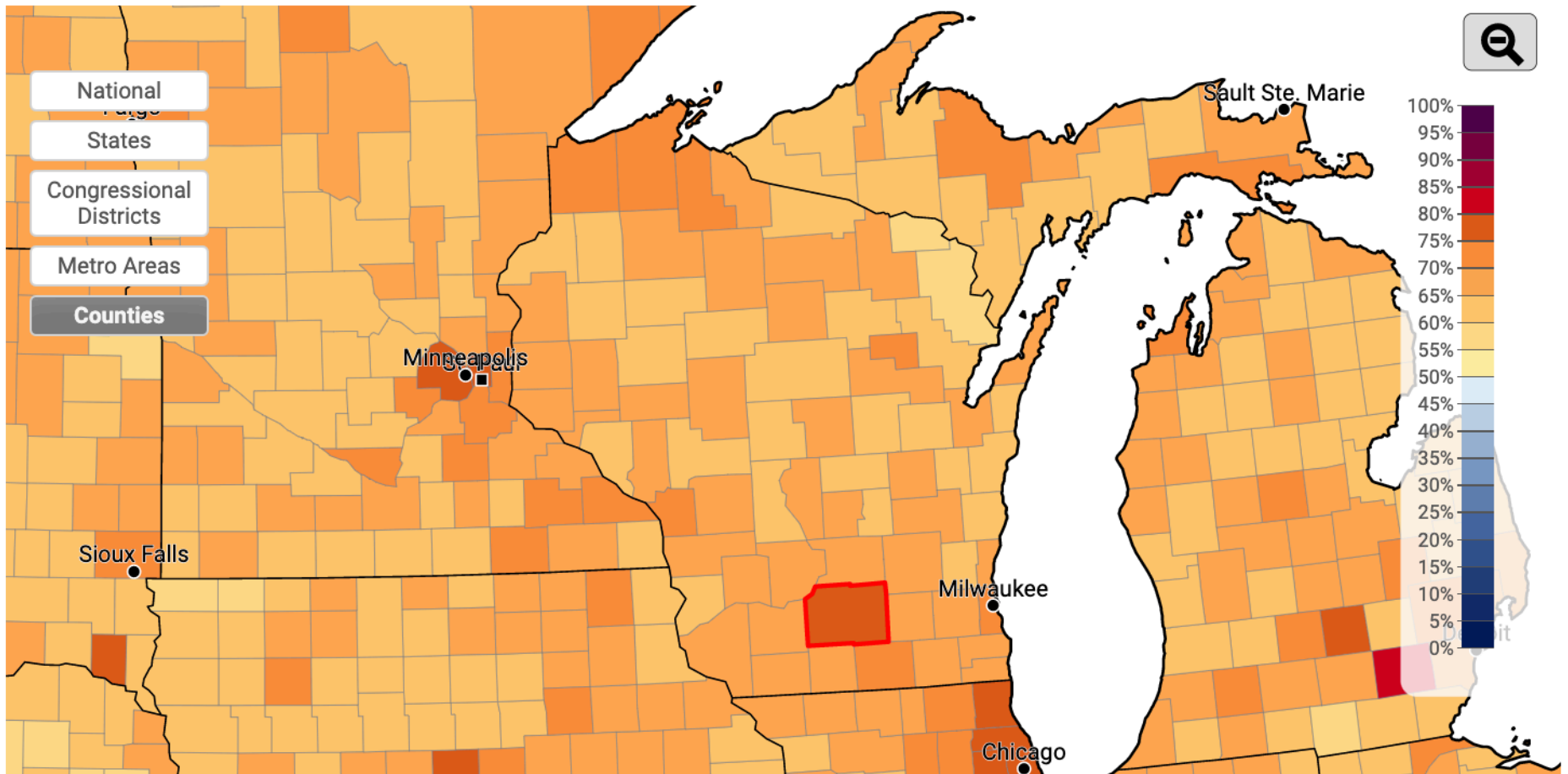
<https://www.nytimes.com/2020/01/10/world/australia/australia-wildfires-photos.html>



# New daily temperature records September 1–19, 2020







## Is climate change occurring?



Dane County, Wisconsin

50%



Yes No

Wisconsin



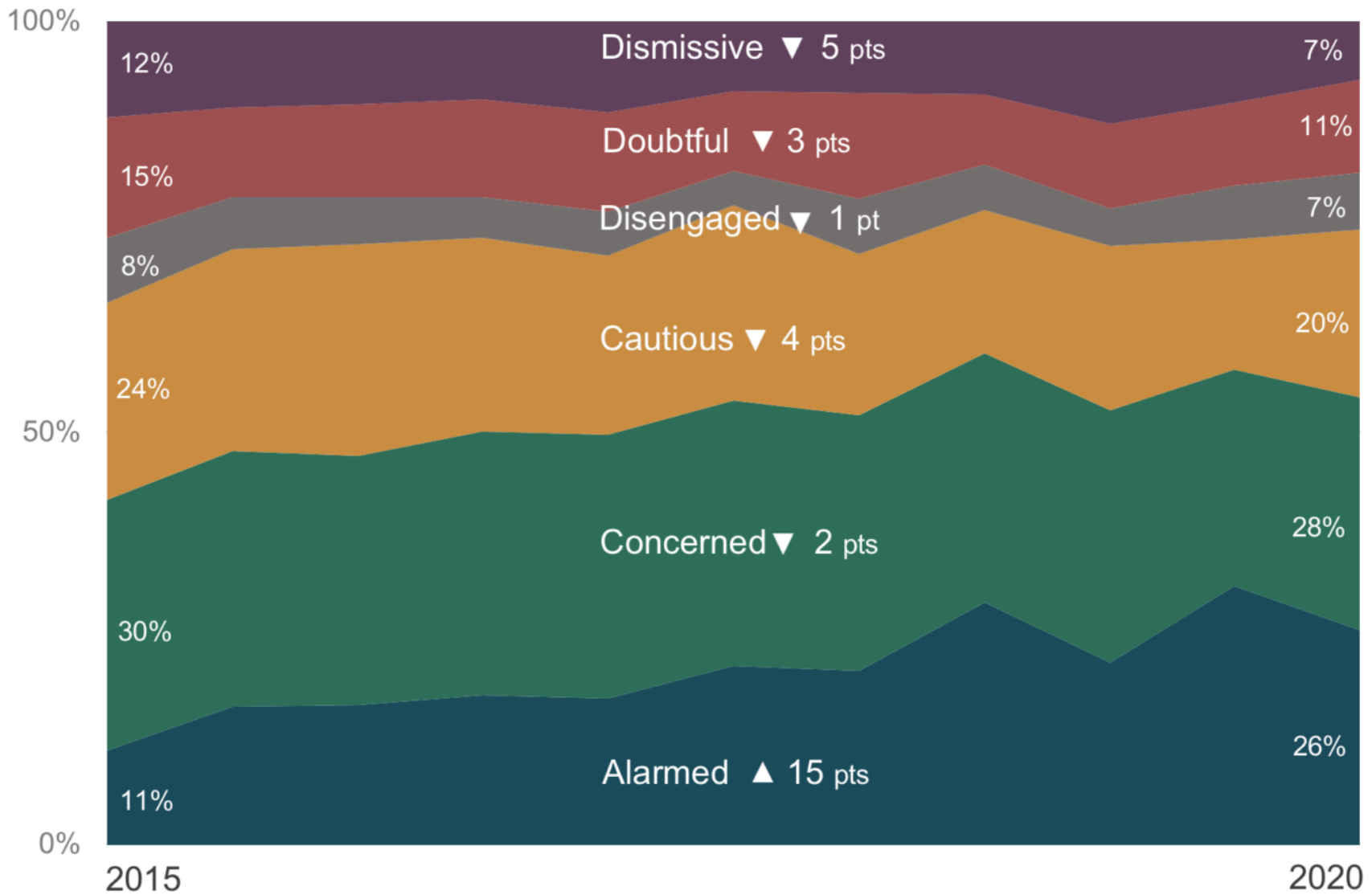
Yes No

United States



Yes No

# Global Warming's Six Americas: Five Year Trend



Data from 11 national surveys ( $N = 13,609$ ) from March 2015 to April 2020.



YALE PROGRAM ON  
Climate Change  
Communication



GEORGE MASON UNIVERSITY  
CENTER for CLIMATE CHANGE  
COMMUNICATION

# Climate change: US formally withdraws from Paris agreement

## FOURTH NATIONAL CLIMATE ASSESSMENT

Volume II: Impacts, Risks, and Adaptation in the United States



**OFFICE OF THE GOVERNOR**

**EXECUTIVE ORDER #52**

**Relating to the Creation of the Governor's Task Force on Climate Change**



**WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS**

Nelson Institute for Environmental Studies | Wisconsin Department of Natural Resources

[WORKING GROUPS](#) ▾

[TRENDS AND PROJECTIONS](#)

[IMPACTS AND ADAPTATION](#)

[EDUCATION AND OUTREACH](#)

[ABOUT](#) ▾

[CONTACT US](#)

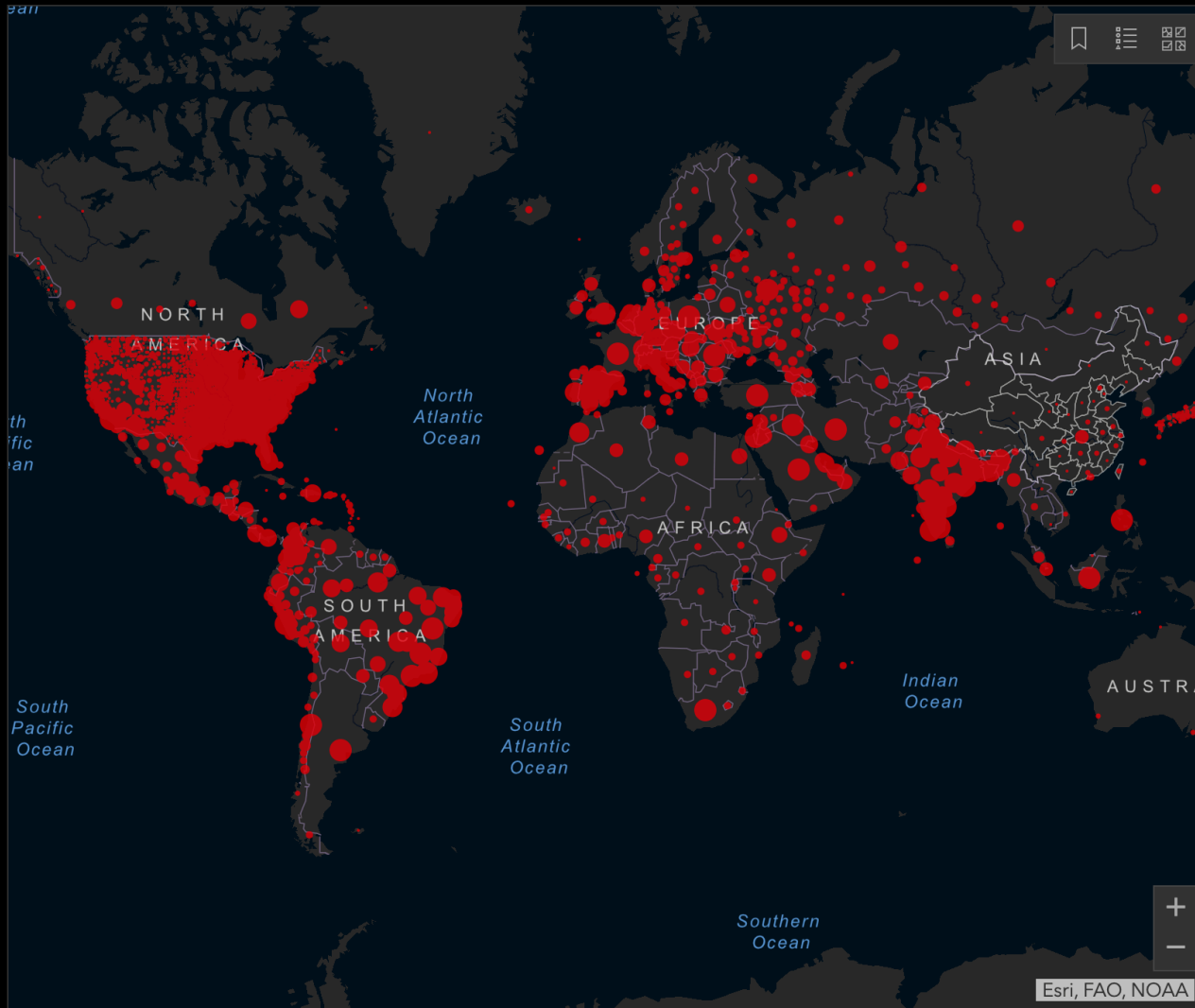


### Global Cases

**53,126,651**

#### Cases by Country/Region/Sovereignty

10,642,218	US
8,728,795	India
5,781,582	Brazil
1,915,428	France
1,865,395	Russia
1,458,591	Spain
1,321,031	United Kingdom
1,284,519	Argentina
1,174,012	Colombia
1,107,303	Italy
991,835	Mexico
930,237	Peru
772,428	Germany
744,732	South Africa
738,322	Iran
665,547	Poland



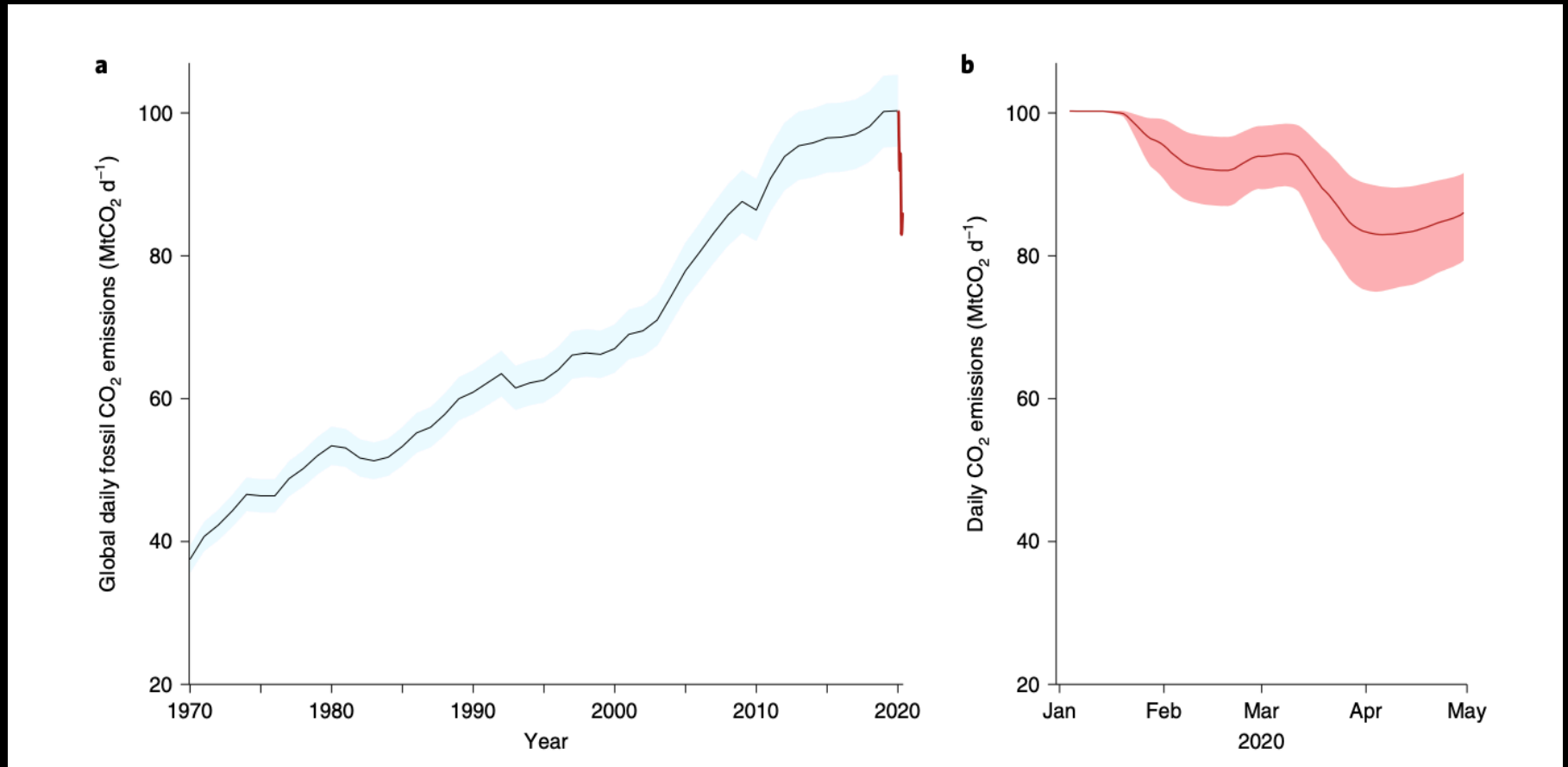
### Global Deaths

**1,312,339**

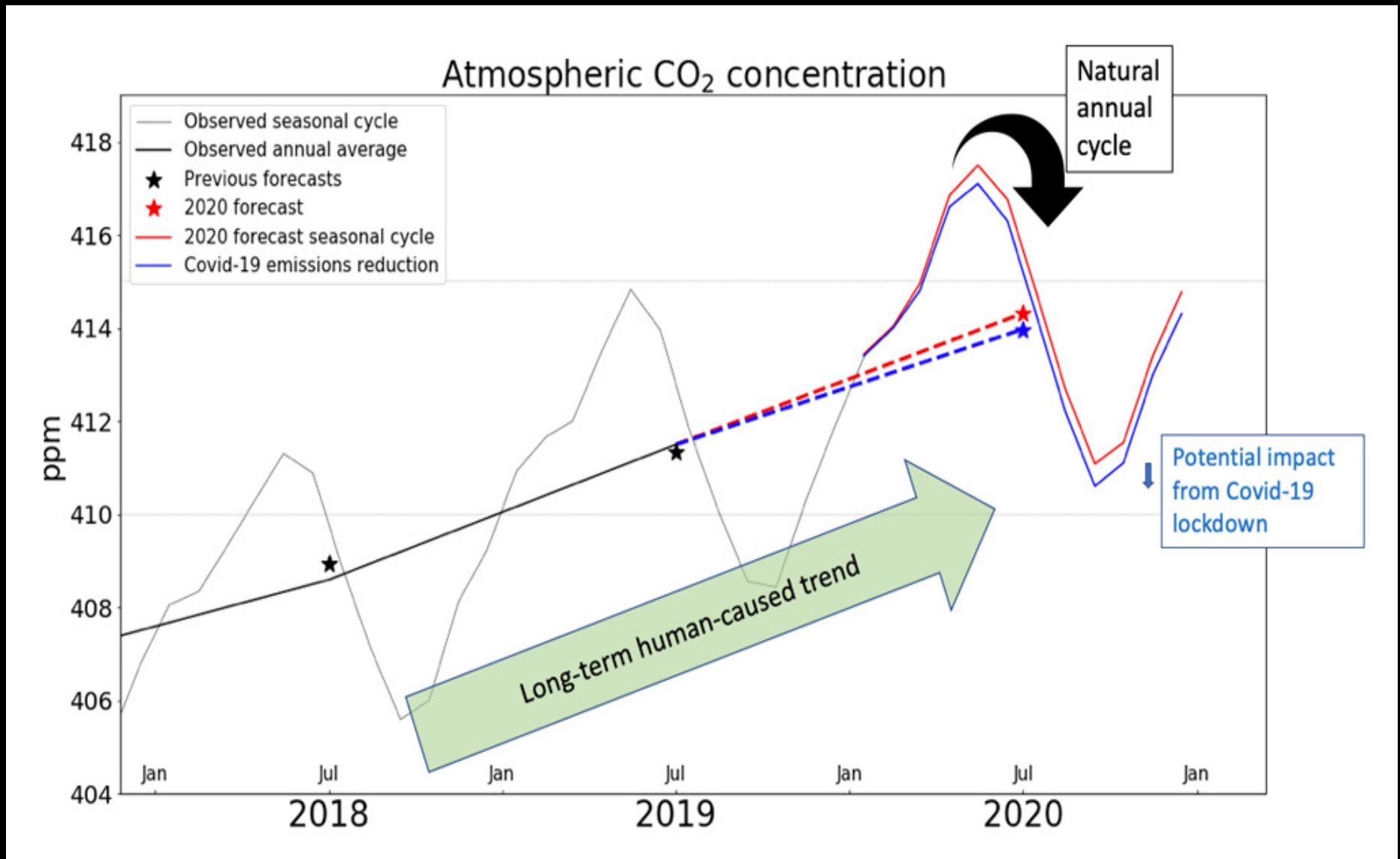
243,044	deaths	US
164,281	deaths	Brazil
128,668	deaths	India
97,056	deaths	Mexico
51,396	deaths	United Kingdom
44,139	deaths	Italy
42,599	deaths	France
40,769	deaths	Spain

◀ Global Deaths ▶

# Global lockdowns led to a 17% drop in April CO<sub>2</sub> emissions, ~5-8% for the year

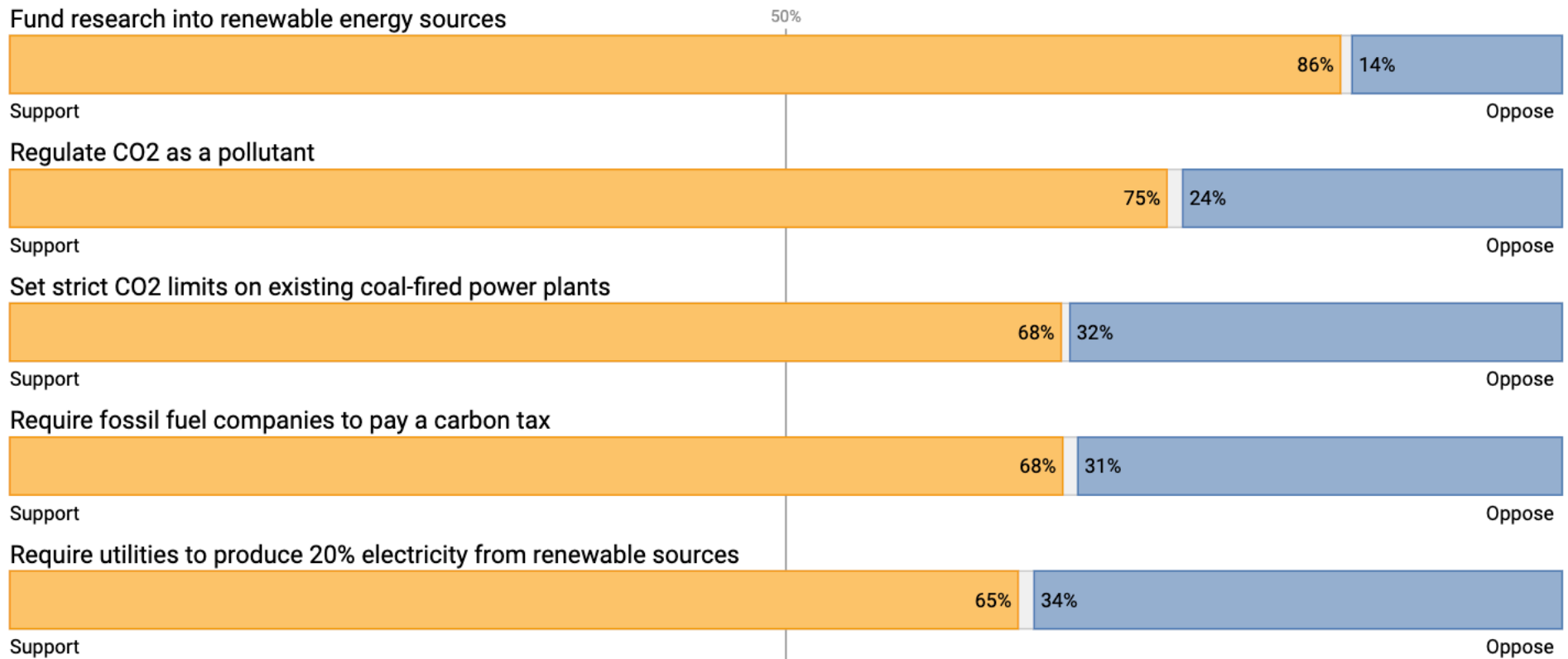


# Lockdowns are not the solution to our environmental challenges

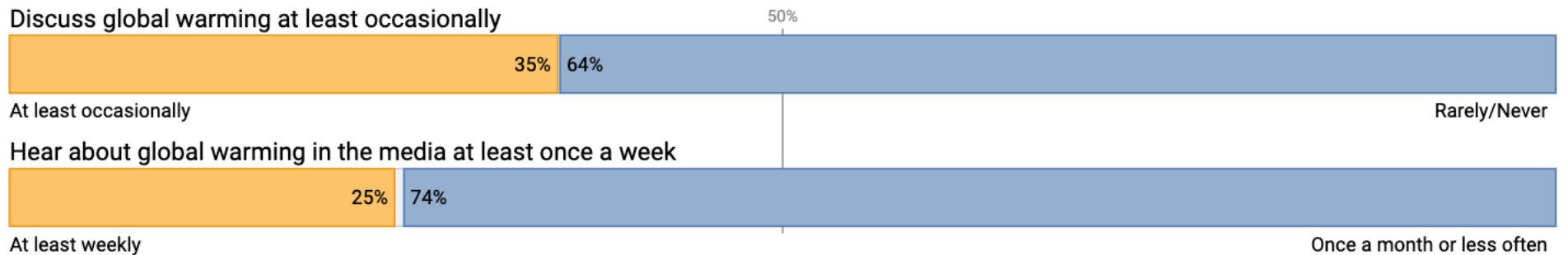




## POLICY SUPPORT



## BEHAVIORS







# THE CENTER FOR CLIMATIC RESEARCH

THE NELSON INSTITUTE FOR ENVIRONMENTAL STUDIES | UNIVERSITY OF WISCONSIN-MADISON

ABOUT

CCR NEWS

RESEARCH

RESOURCES

SUPPORT CC

## Welcome to CCR

### Biogeochemistry

CCR researchers are investigating global and regional biogeochemistry, with a particular focus on the carbon cycle of the land biosphere, oceans and Great Lakes. Using data and models to elucidate natural carbon fluxes and the factors controlling them, and work to use this information to improve predictive models.



### Climate Impacts

### Land Surface Processes

### Oceanography and Limnology

### Past Climates



## Department of Atmospheric and Oceanic Sciences

### Who We Are

Since 1948 we have grown into one of the leading departments in our field of Atmospheric and Oceanic Sciences. We have strong graduate and undergraduate programs which are nationally recognized. We graduate about 15 Ph.D. and M.S. students each year; our graduates are active in research labs and universities around the world. We graduate approximately 20 B.S. students each year; they choose options allowing a focus on weather systems or general atmospheric science.

Our faculty of 15 has long maintained breadth and special strength in three areas:

- Climate systems, including the ocean
- Satellite and remote sensing
- Weather systems, including synoptic-dynamic meteorology

## North Temperate Lakes Long Term Ecological Research

Member of the US LTER Network

### Welcome to NTL-LTER




North Temperate Lakes sites established by the University of Wisconsin-Madison (and changing land use in the present, future).

Our primary study site is the University of Wisconsin-Madison Limnology at the University of Wisconsin-Madison.

# What is Climate?

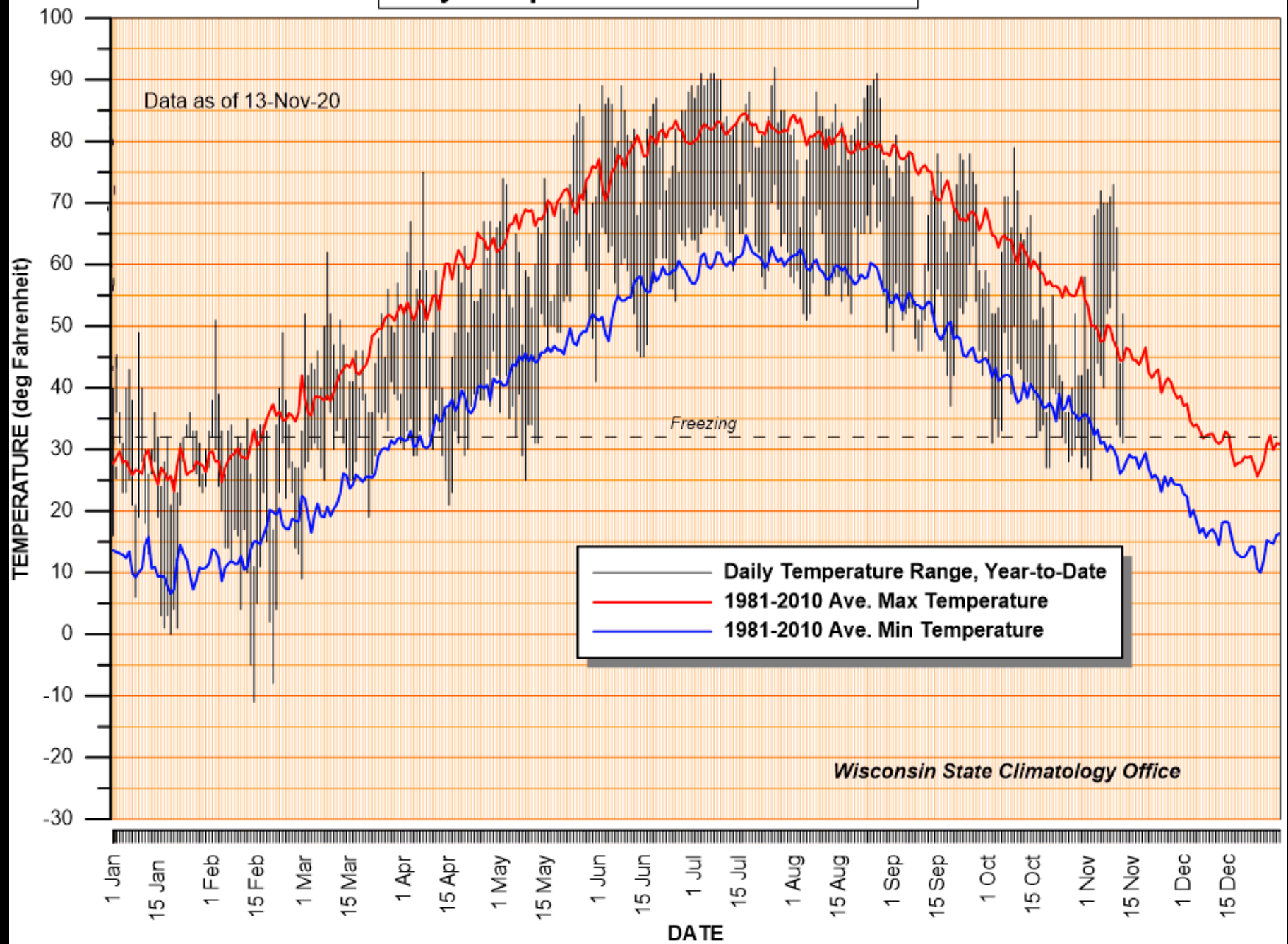
- Climate is the average of weather
  - “Climate is what you expect, weather is what you get” –Andrew John Herbertson
- Climate changes naturally (over eons) and by humans (over centuries)

Climate is your  
personality  
Weather is your  
mood

A professional portrait of Prof. J. Marshall Shephard, a Black man with a receding hairline, smiling. He is wearing a dark suit jacket, a white dress shirt, and a red patterned tie. The background is a soft-focus outdoor scene with a blue sky and greenery.

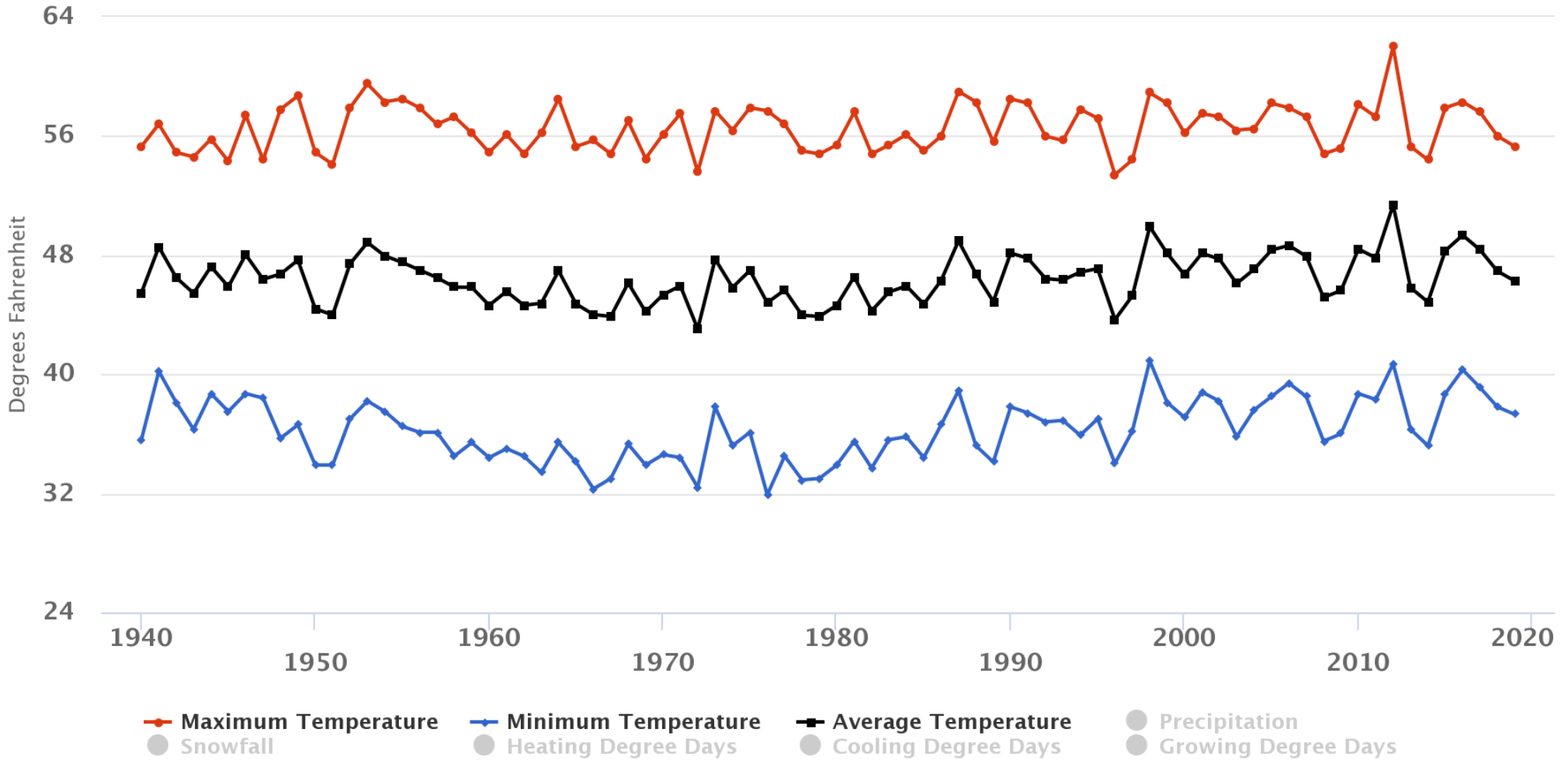
Prof. J. Marshall Shephard  
U. Georgia

# Daily Temperatures: MADISON 2020



# Annual Values at MADISON DANE COUNTY REGIONAL AP (WI) USW00014837

Midwestern Regional Climate Center

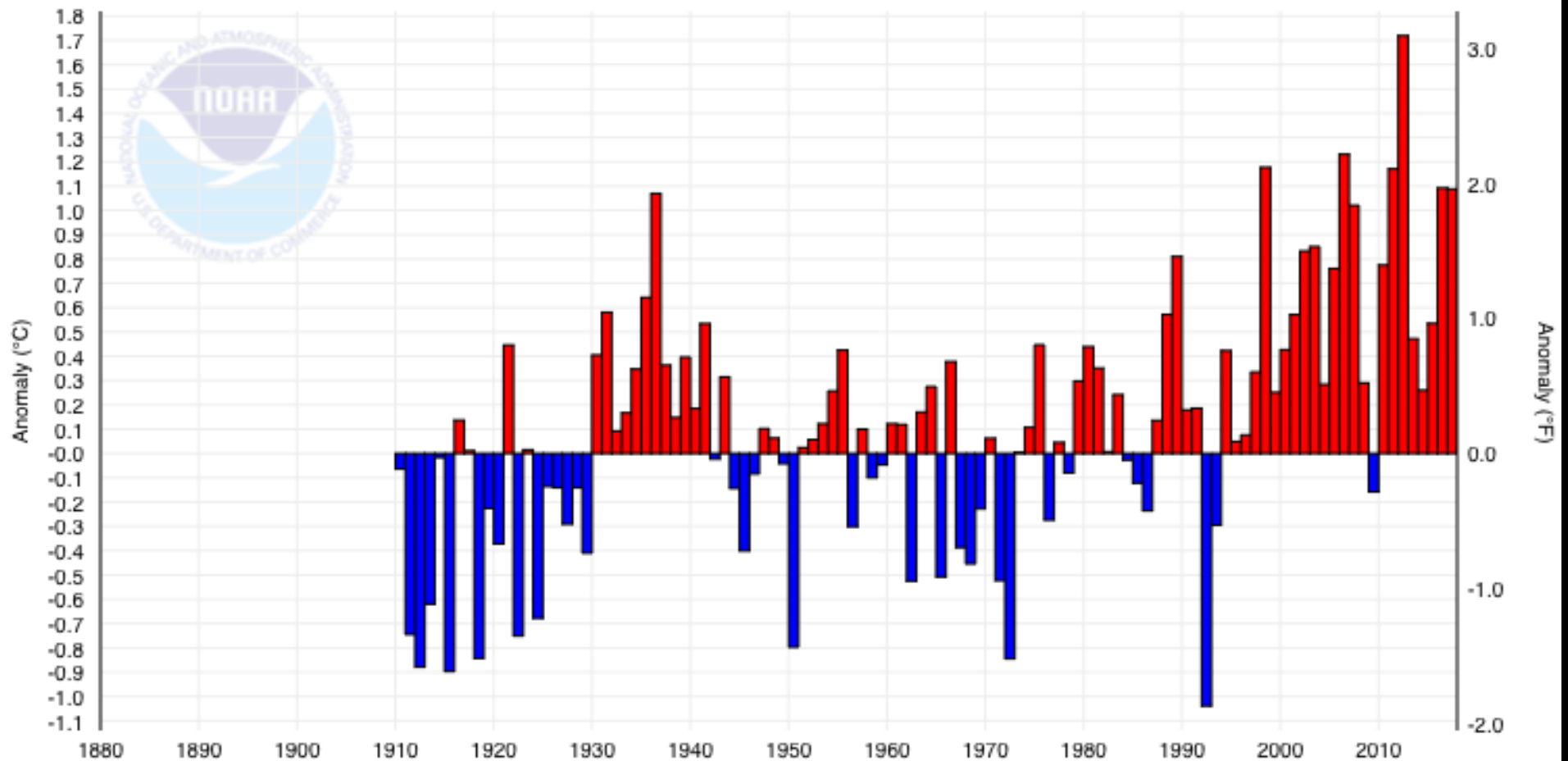


Click and drag to zoom.



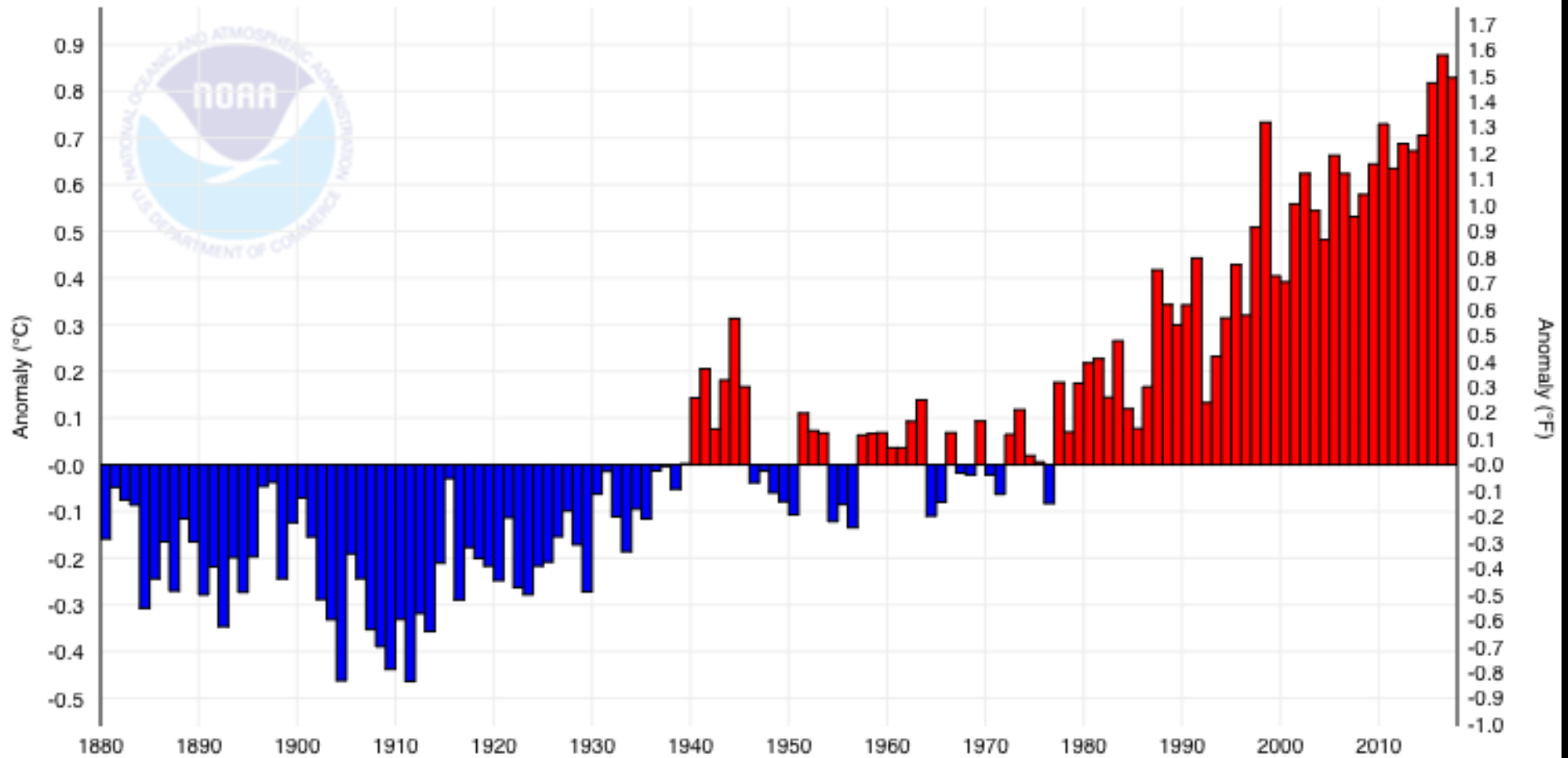
# N America

North America Land Temperature Anomalies, July

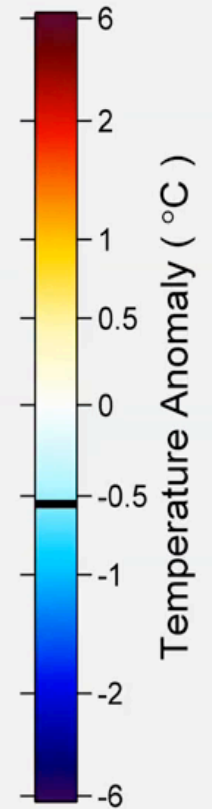
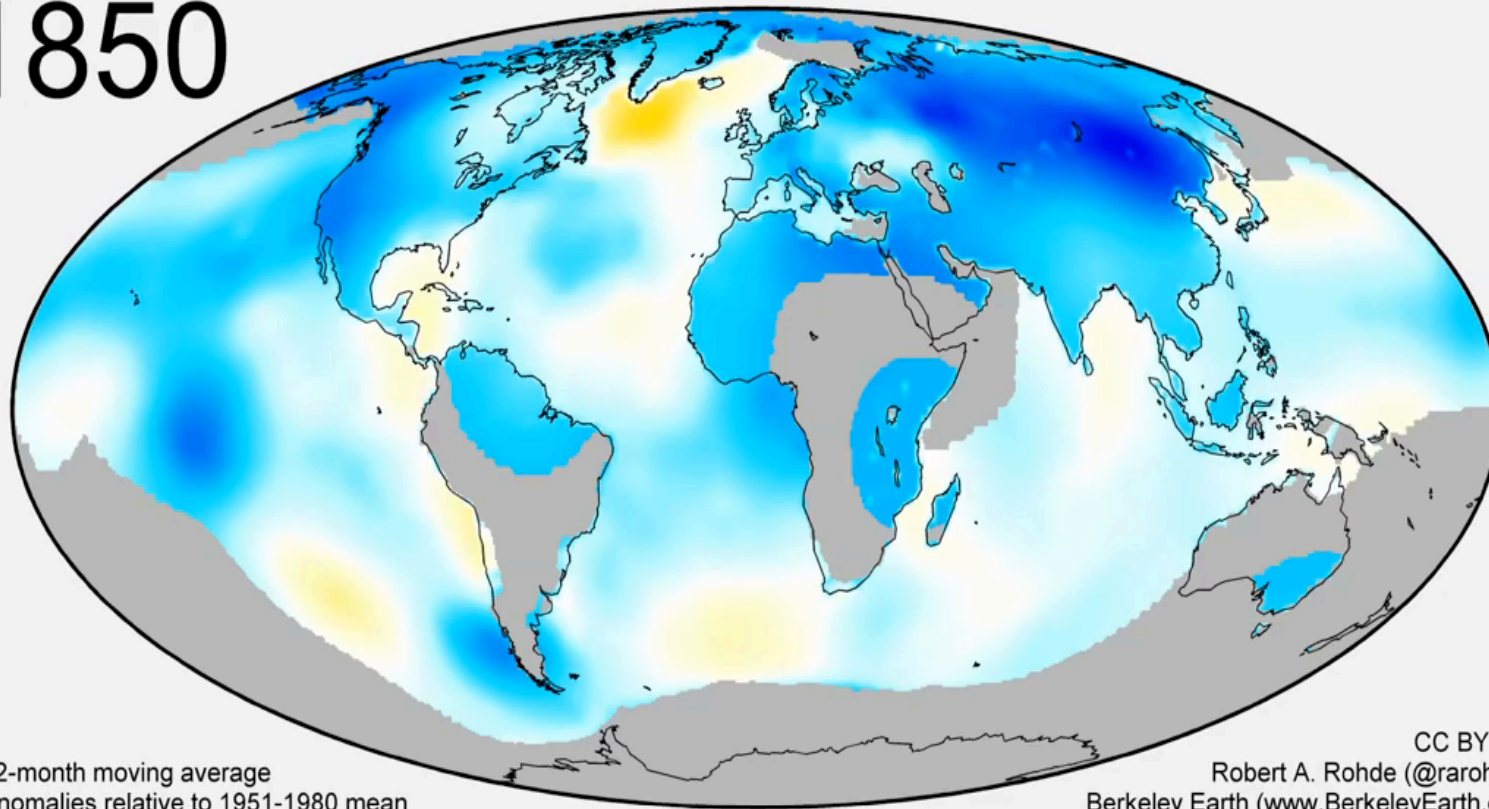


# WORLD

Global Land and Ocean Temperature Anomalies, July



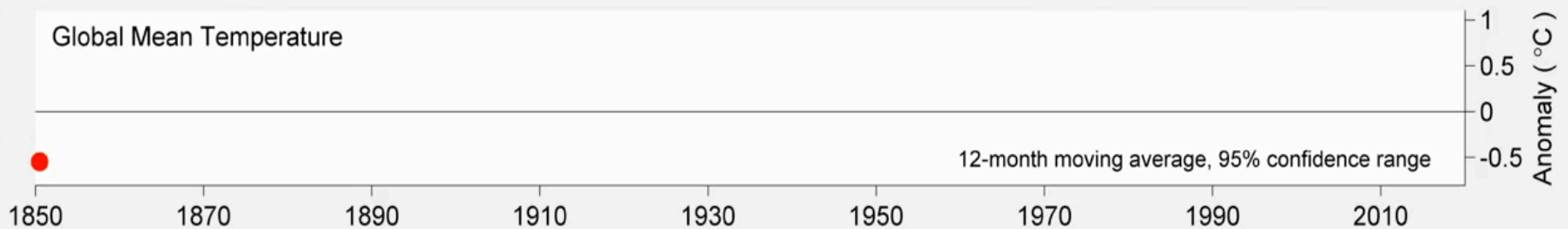
# 1850



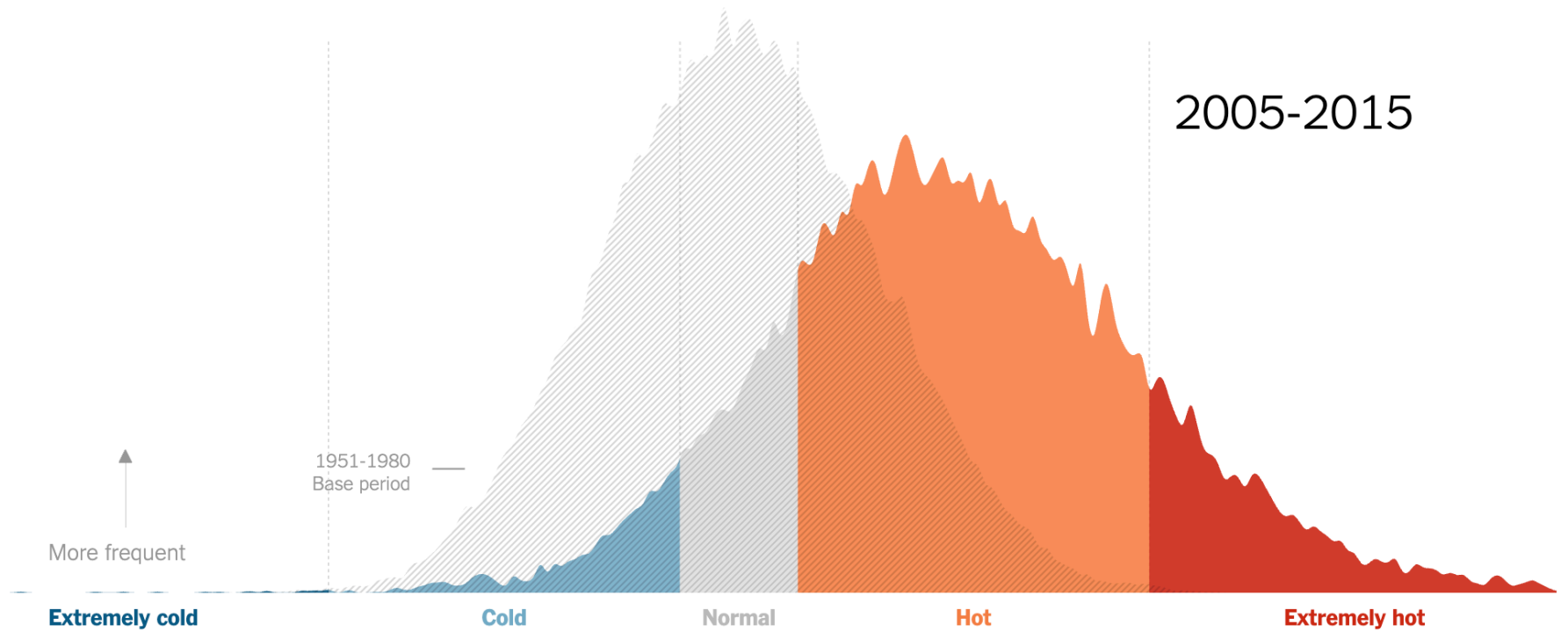
12-month moving average  
Anomalies relative to 1951-1980 mean

CC BY-4.0  
Robert A. Rohde (@rarohde)  
Berkeley Earth ([www.BerkeleyEarth.org](http://www.BerkeleyEarth.org))

Global Mean Temperature



**Summer temperatures**  
in the Northern Hemisphere



# The Rodney & Otamatea Times

WAITEMATA & KAIPARA GAZETTE.

PRICE—10s per annum in advance

WARKWORTH, WEDNESDAY, AUGUST 14, 1912.

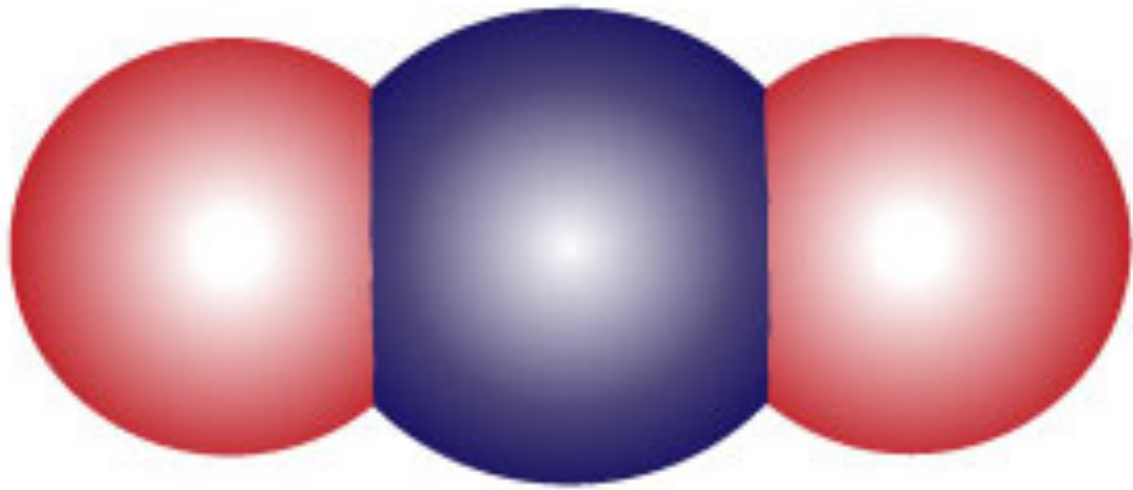
3d per Copy.

## Science Notes and News.

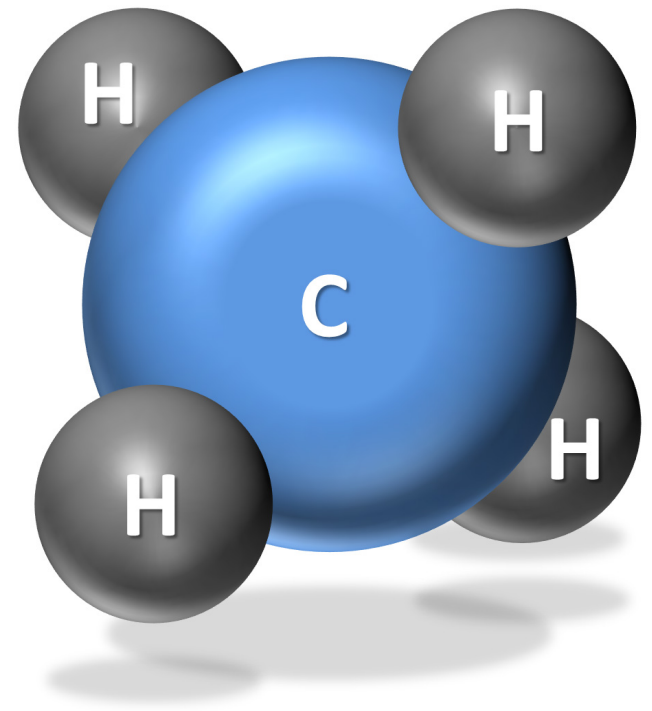
### COAL CONSUMPTION AFFECTING CLIMATE.

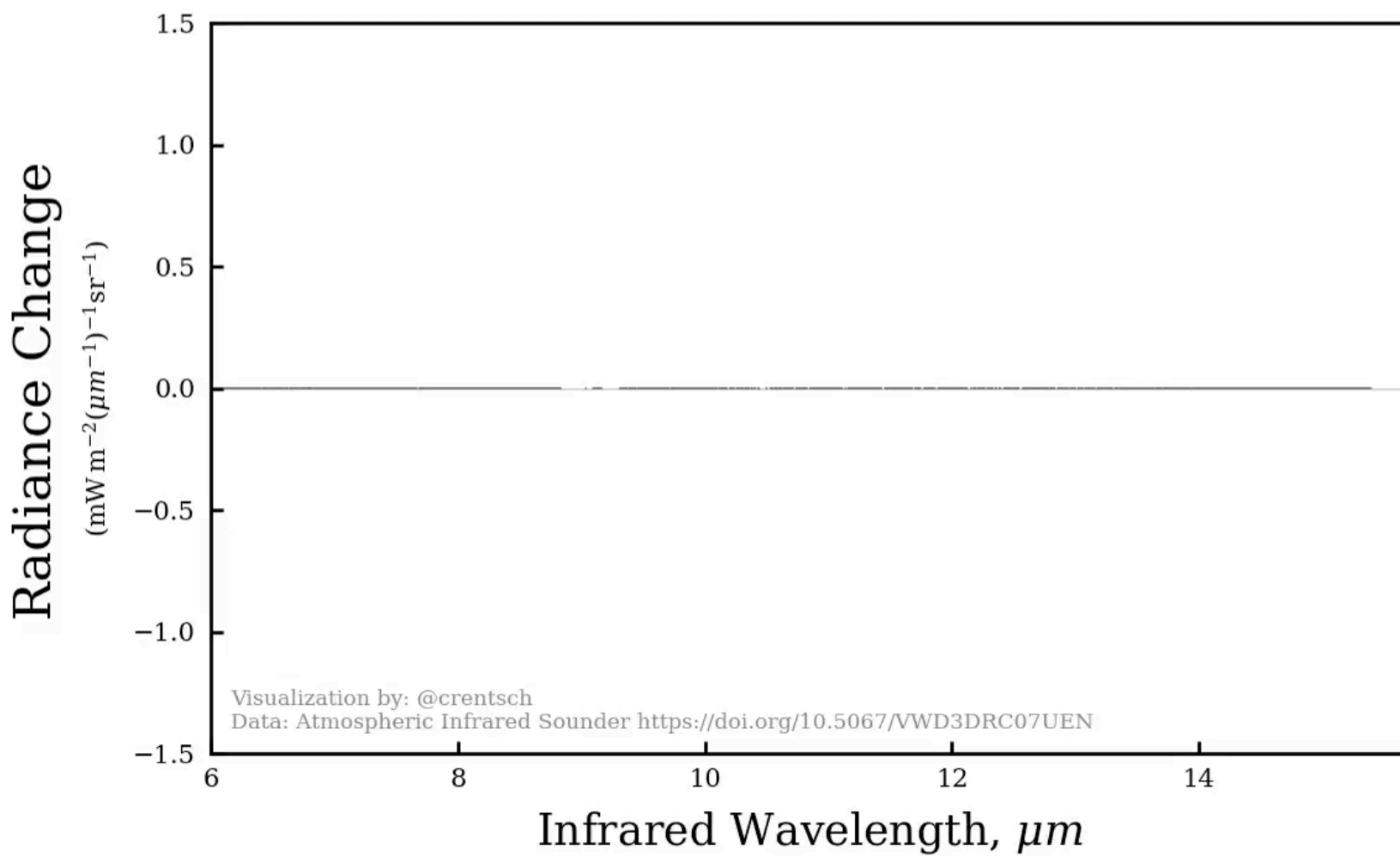
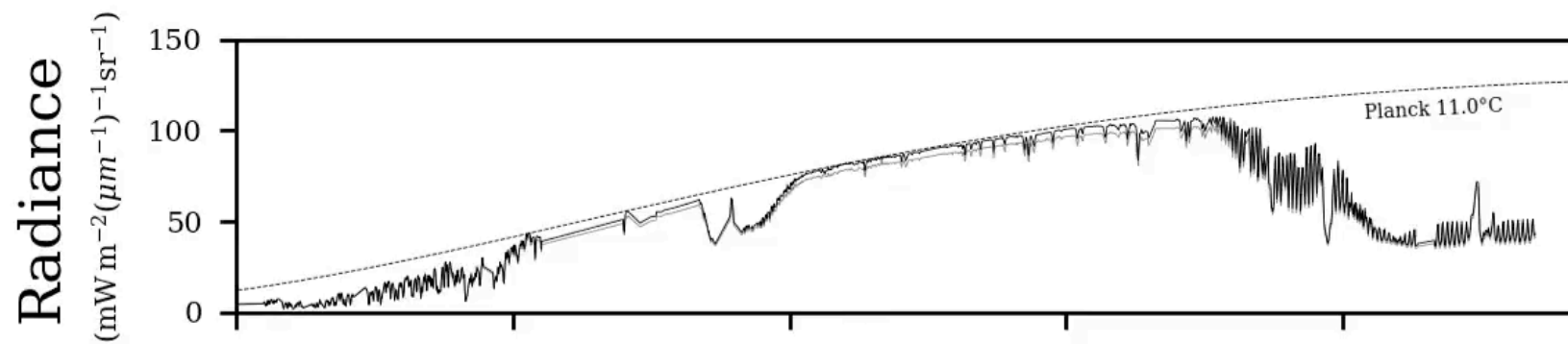
The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.



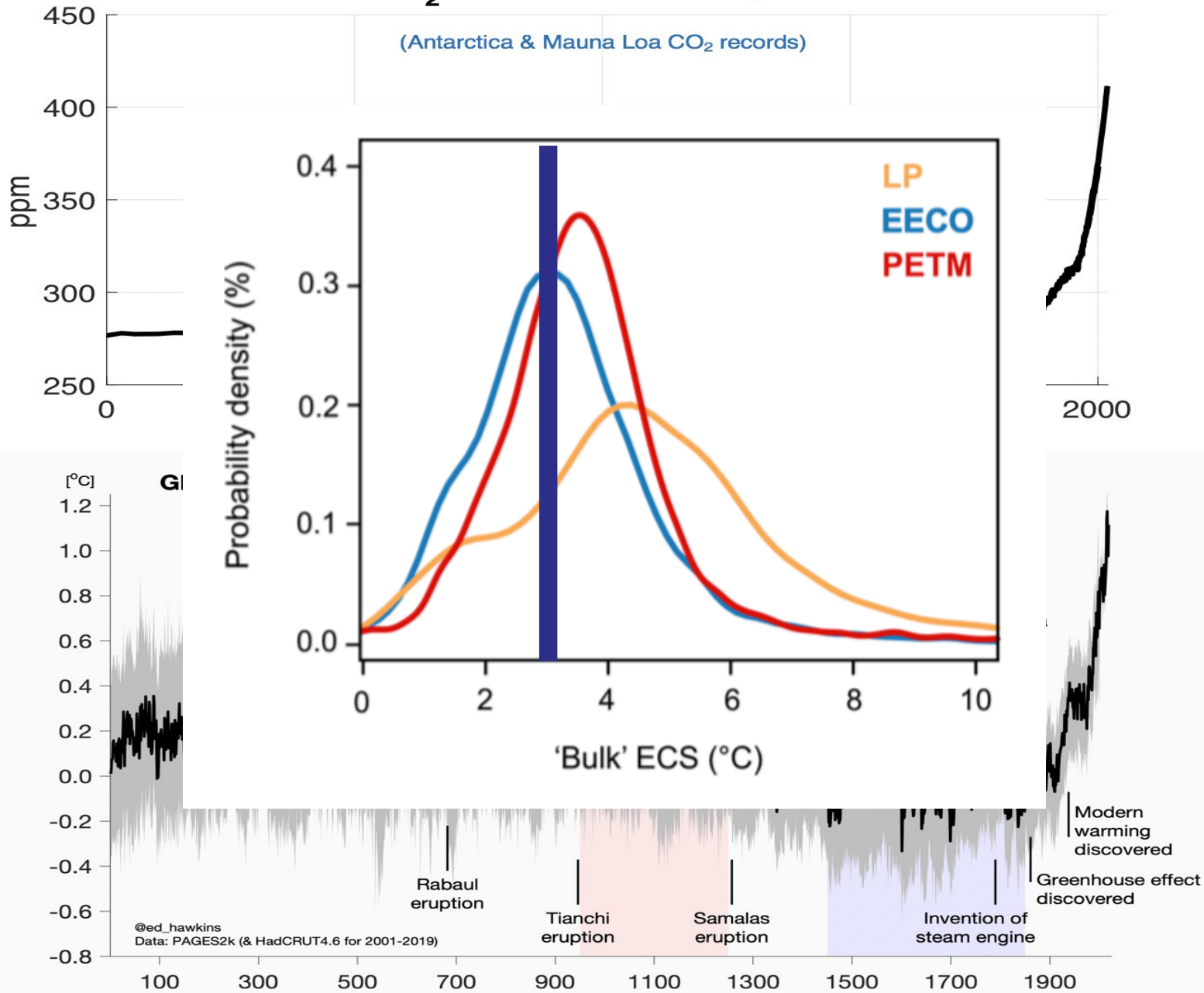


Greenhouse  
Gases





# CO<sub>2</sub> over the last 2019 years





“CO<sub>2</sub> is to climate what steroids was to baseball...” –Jason Samenow

Hotter

### What's Really Warming the World?

Skeptics of manmade climate change offer various natural causes to explain why the Earth has warmed 1.4 degrees Fahrenheit since 1880. But can these account for the planet's rising temperature? Watch to see how much different factors, both natural and industrial, contribute to global warming, based on findings from NASA's Goddard Institute for Space Studies.

Colder

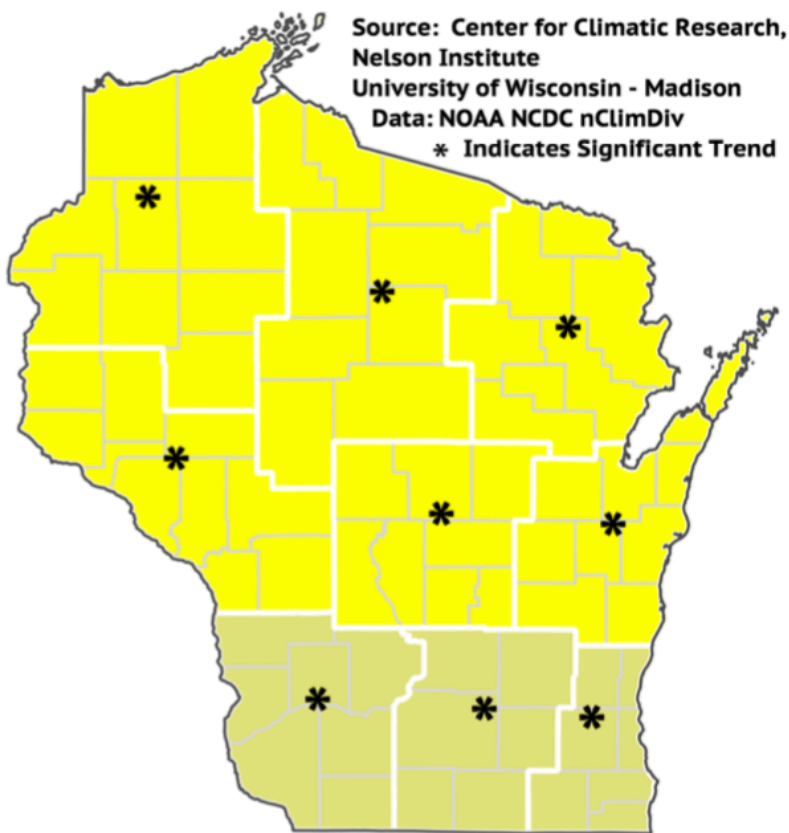


Based on an interactive by Bloomberg

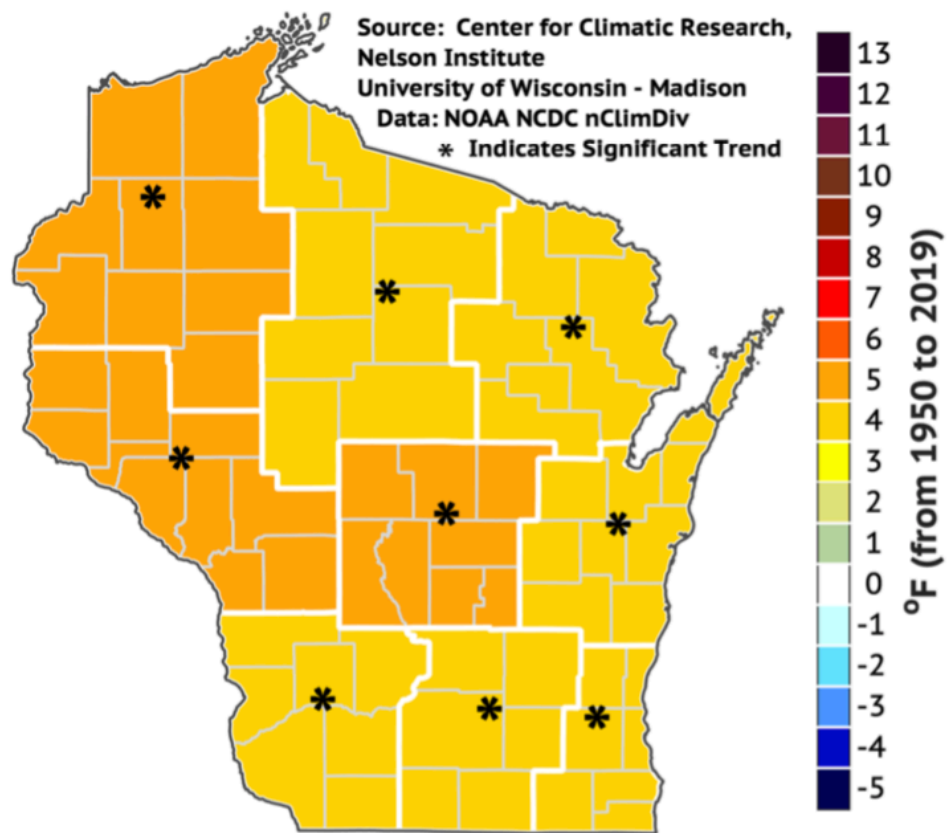
<https://www.bloomberg.com/graphics/2015-whats-warming-the-world/>

# Wisconsin is getting less cold

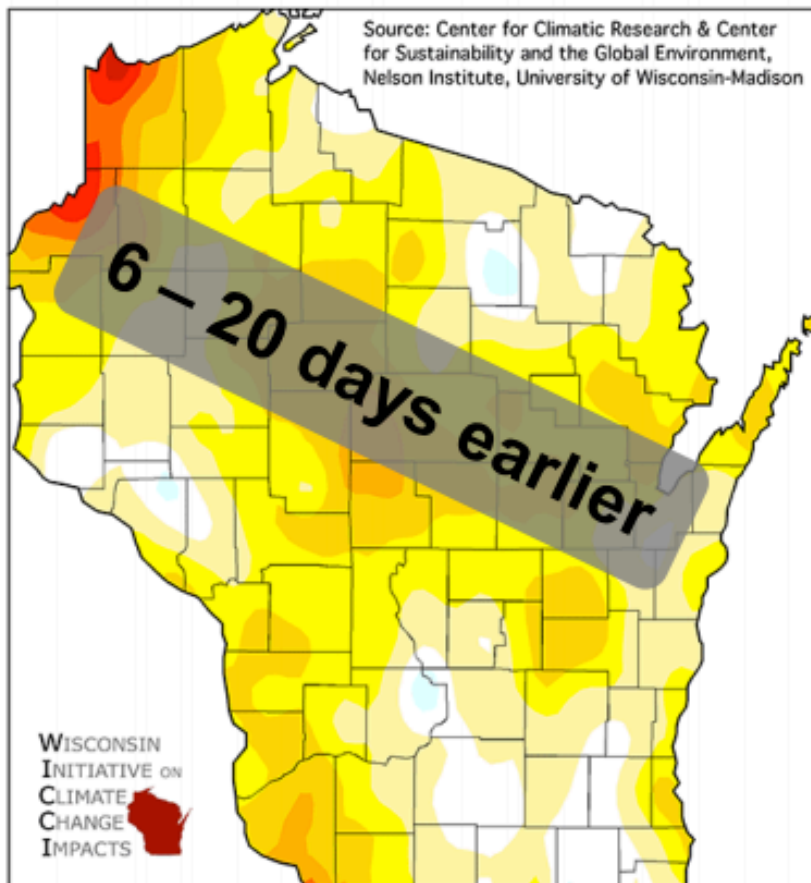
## Historical Change in Annual TMEAN from 1950 to 2019



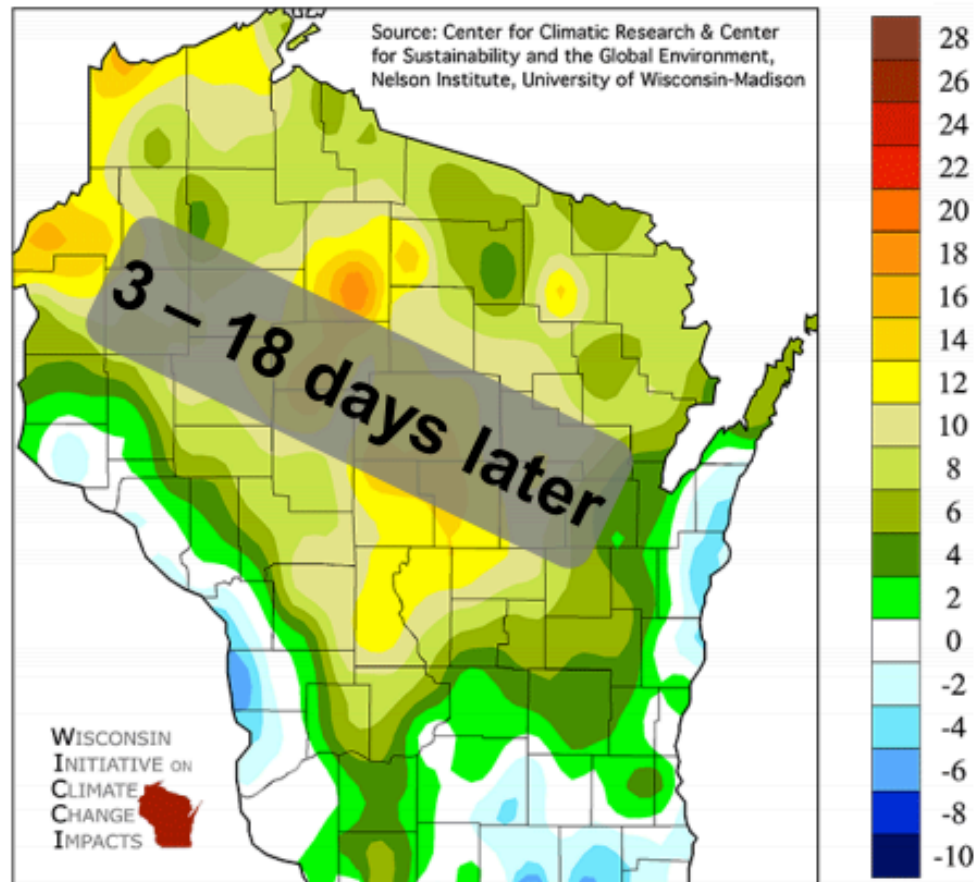
## Historical Change in DJF TMEAN from 1950 to 2019



## Change in Date of Last Spring Freeze from 1950 to 2006



## Change in Date of First Fall Freeze from 1950 to 2006



(from Serbin and Kucharik 2009)

# Earlier arrival of spring in Wisconsin

Bird migration	Vegetation
Geese Arrival: 29 days	<i>Baptista</i> first bloom: 18 days
Cardinal first song: 22 days	<i>Butterfly weed</i> first bloom: 18 days
Robin arrival: 9 days	<i>Marsh milkweed</i> first bloom: 13 days



**Nina Leopold Bradley**

Photo: Jeffrey Phelps, Milw. Journal Sentinel



**Leopold Shack**

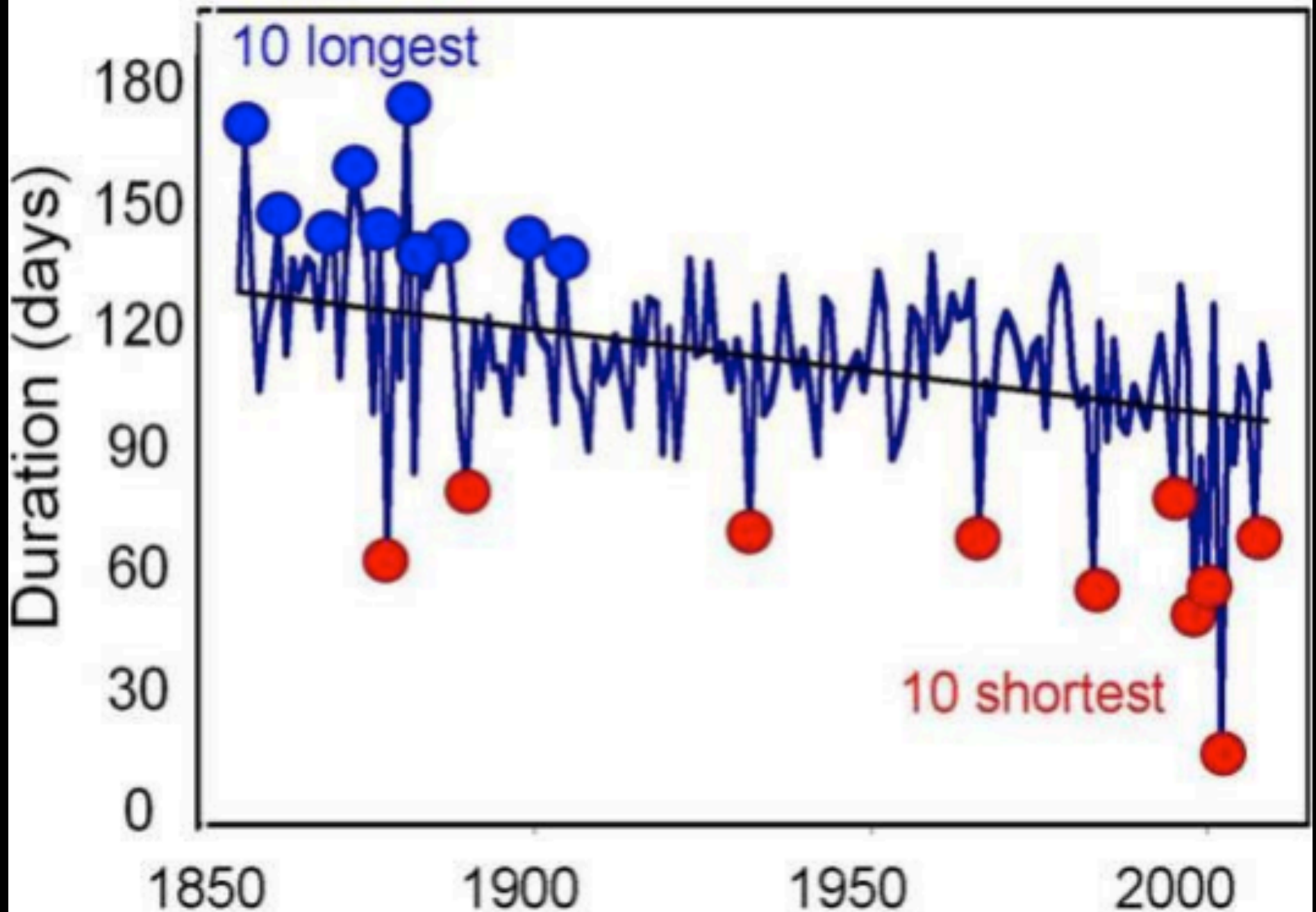
Photo: Aldo Leopold Foundation

**55 ecological indicators of spring occurred on average 1.2 days earlier per decade from 1936 to 1998.**

Source: Bradley et al., 1999. Phenological changes reflect climate change in Wisconsin. Proc. Natl. Acad. Sci., 96: 9701-9704.

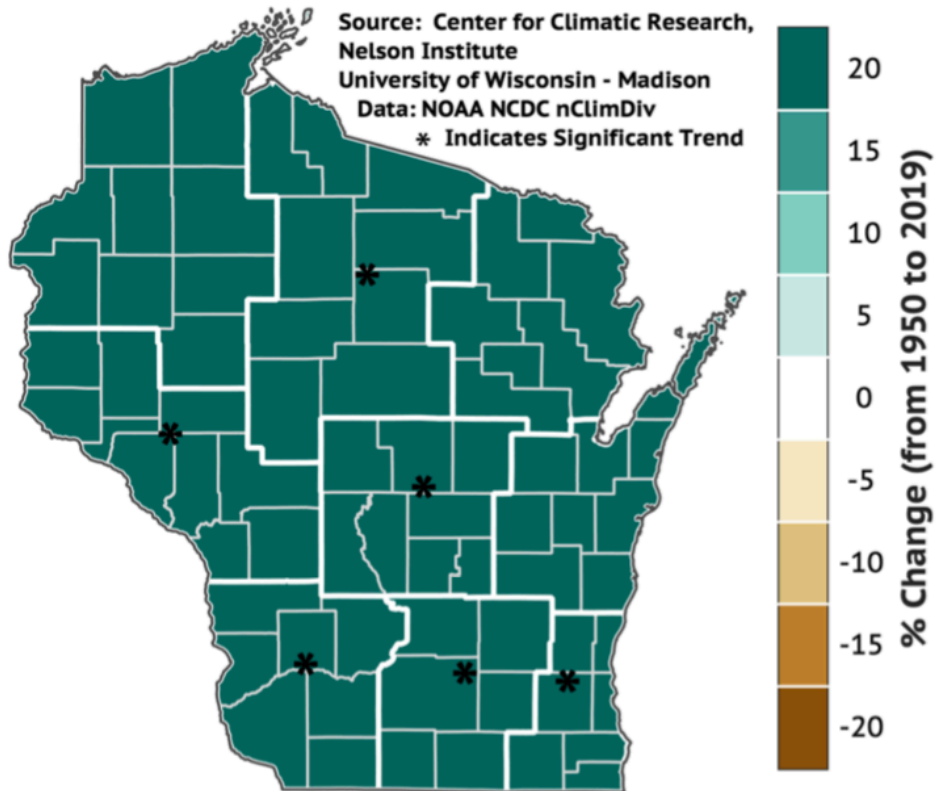
Slide adapted from C. Kucharik, UW-Madison

# Lake Mendota Ice Duration 1855-6 to 2008-9

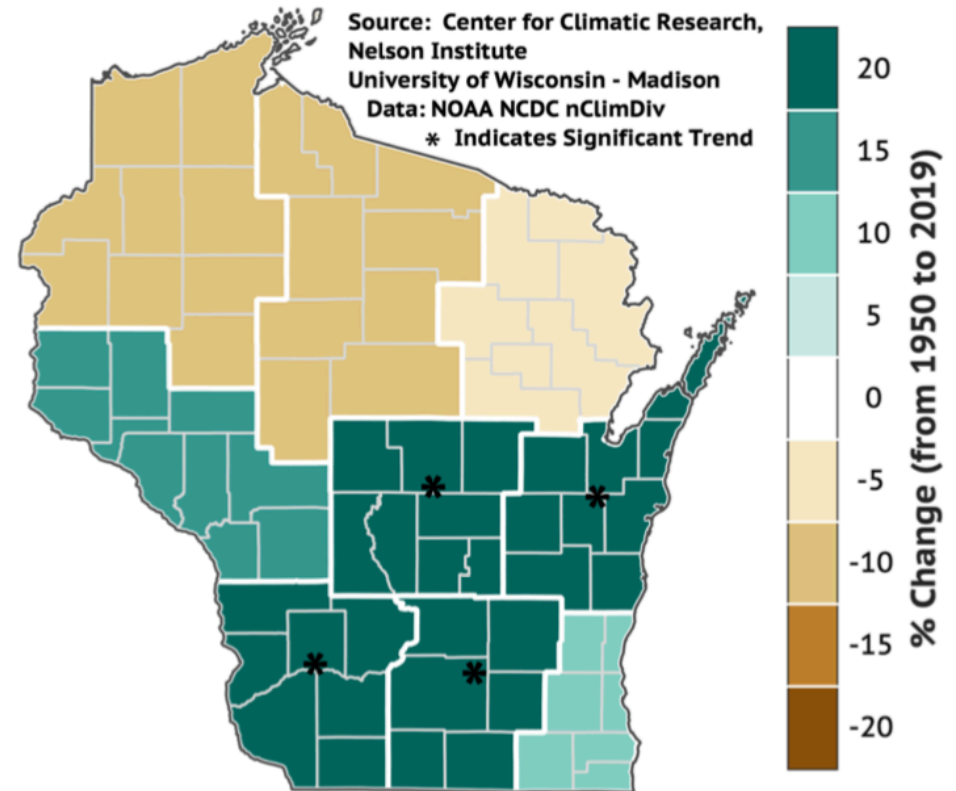


# Wisconsin is wetter

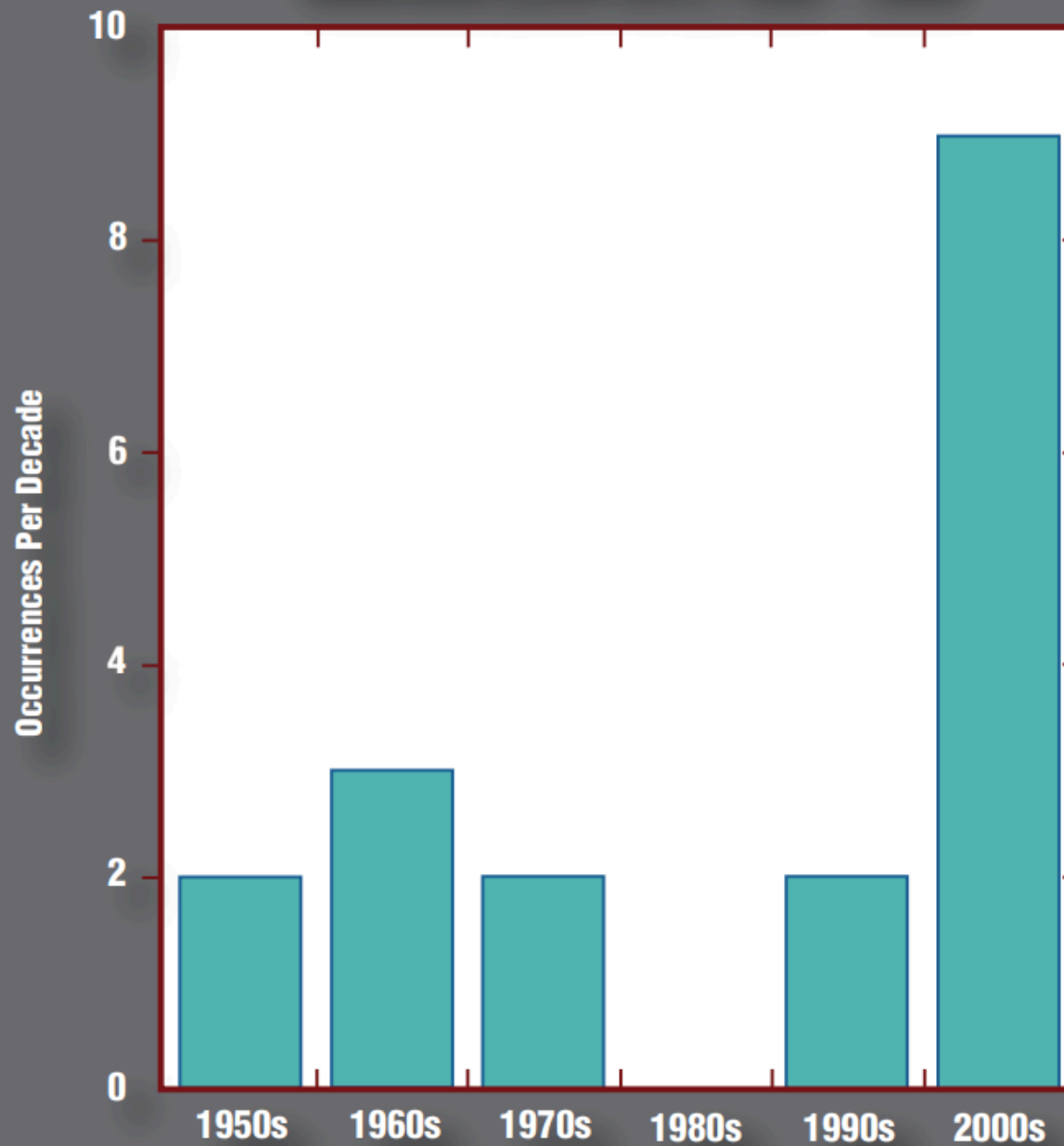
**Historical Change in DJF PRECIP (%)  
from 1950 to 2019**



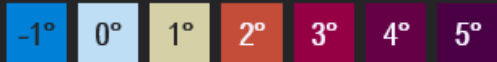
**Historical Change in JJA PRECIP (%)  
from 1950 to 2019**



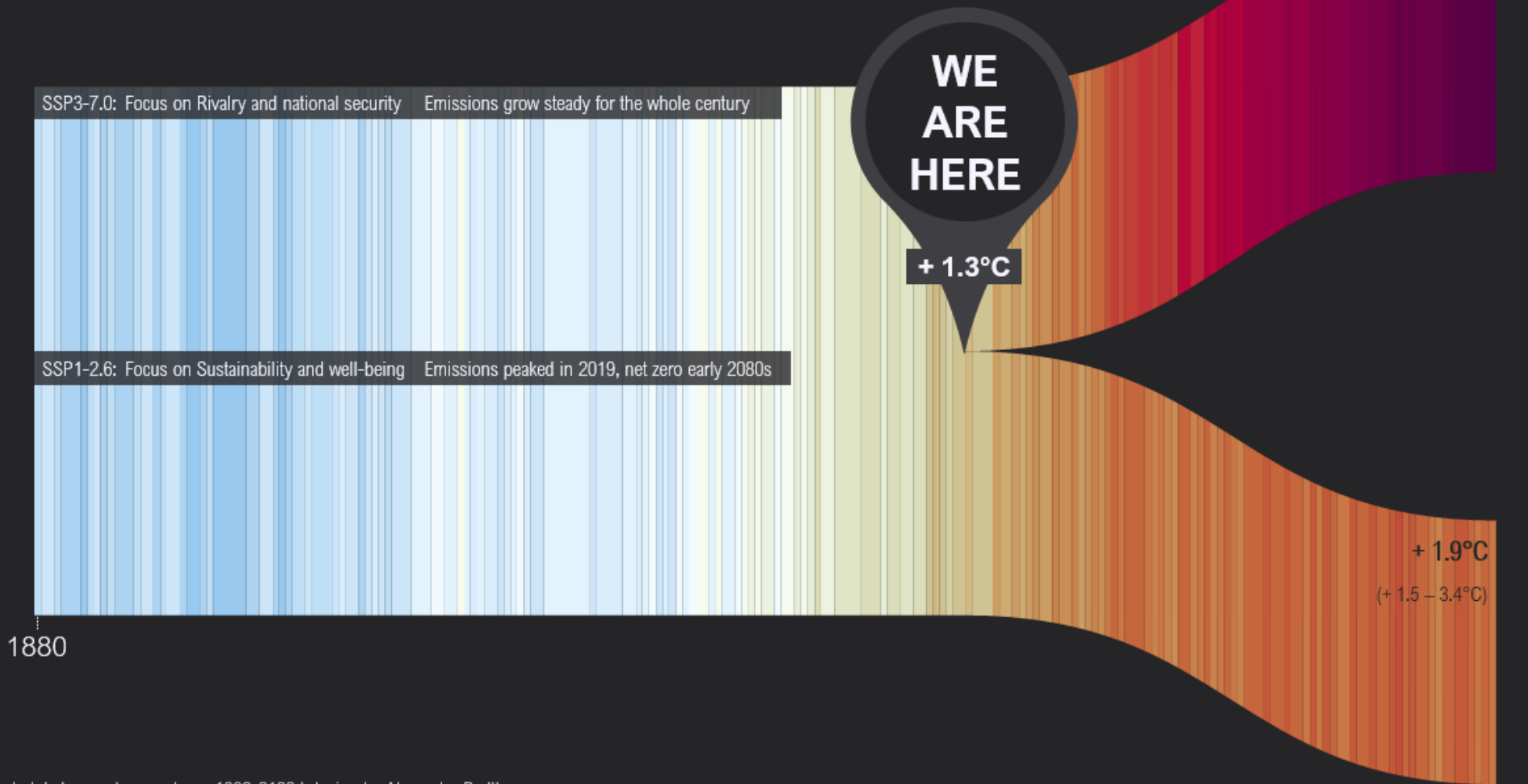
# OCCURRENCES OF 3"+ DAILY PRECIPITATION MADISON (AIRPORT) 1950 - 2009



# Where are we headed?

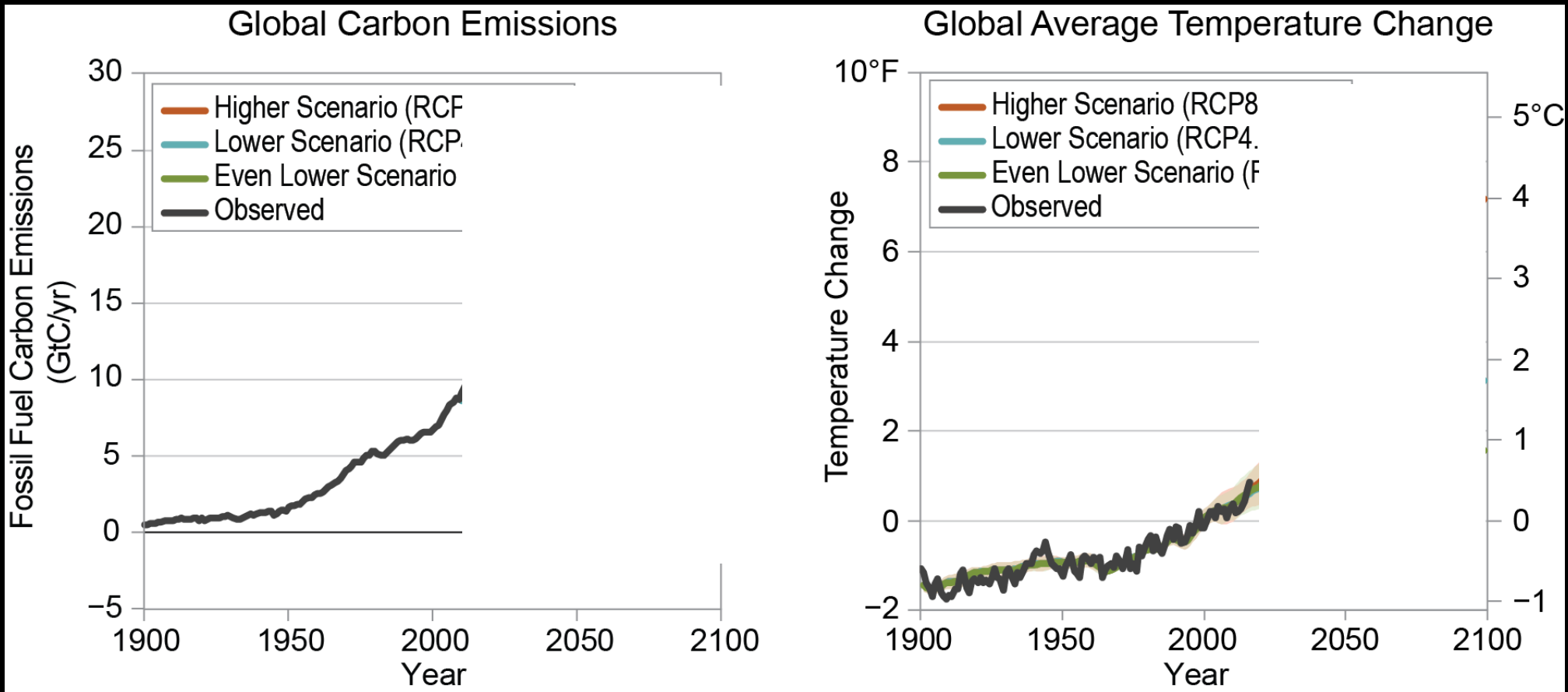


temperatures relative to 1850-1900 mean





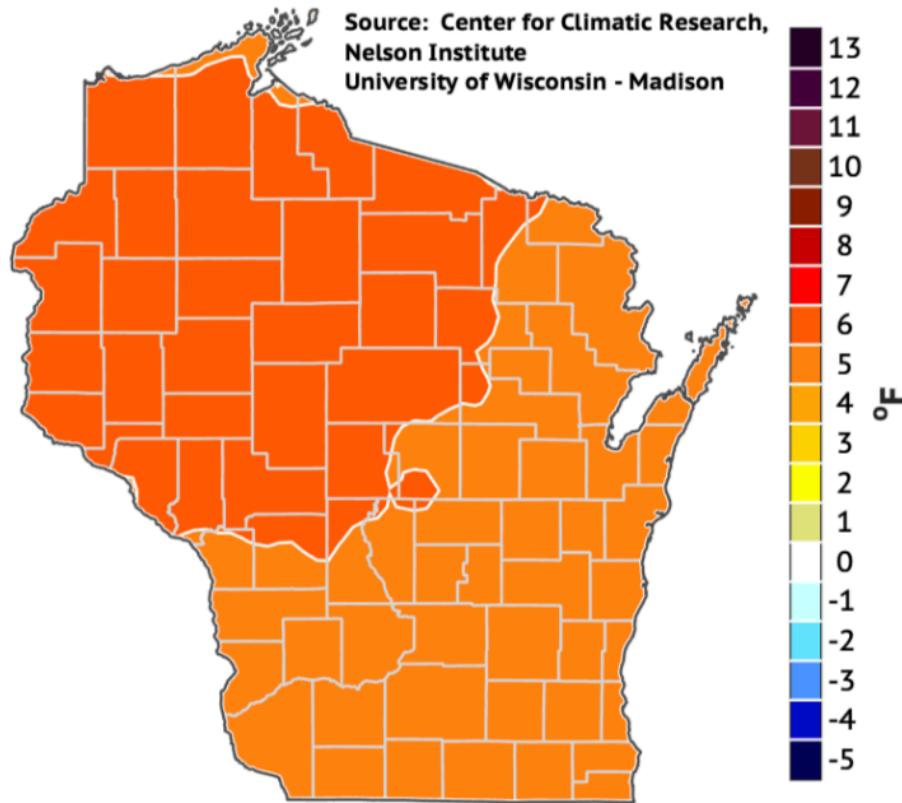
# Projecting into the future



# Projecting into Wisconsin's future

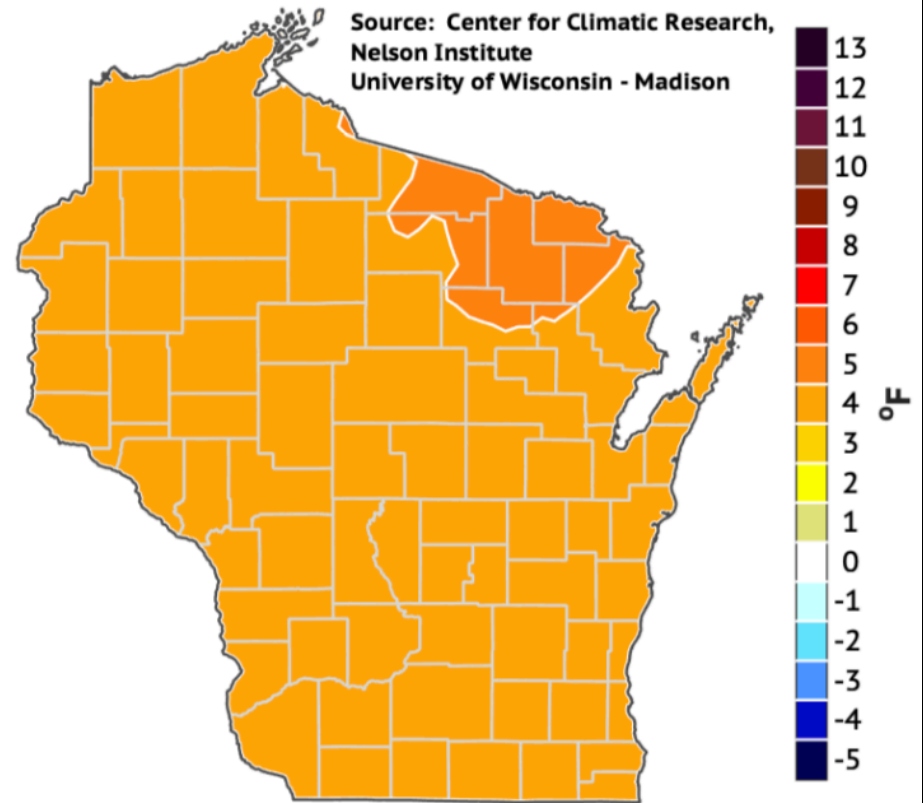
2050

Change in DJF TMEAN, RCP45:  
2041-2060 minus 1981-2010



Winter

Change in JJA TMEAN, RCP45:  
2041-2060 minus 1981-2010



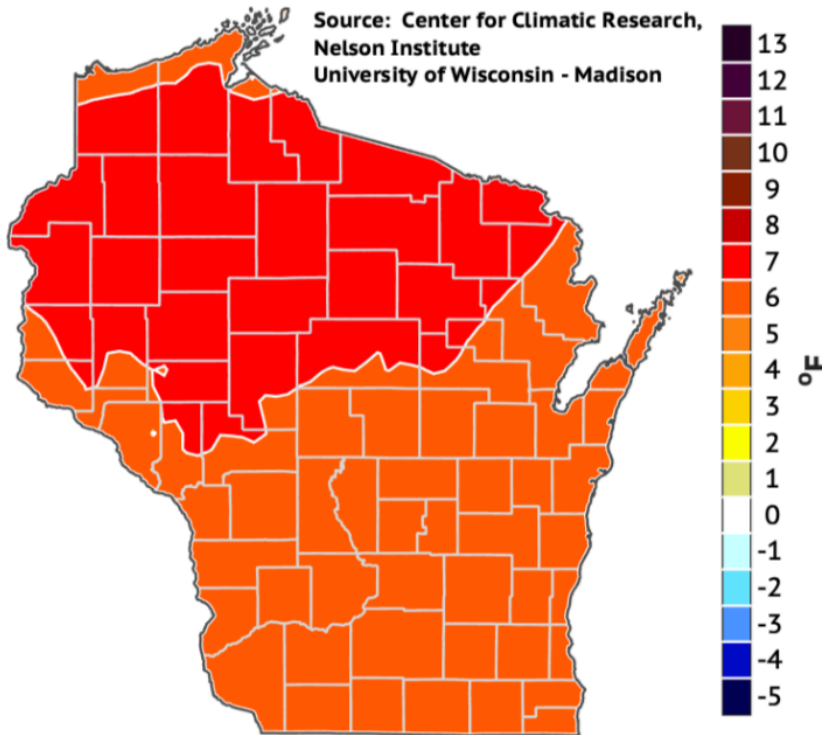
Summer

# Future emissions makes a big difference

## 2100

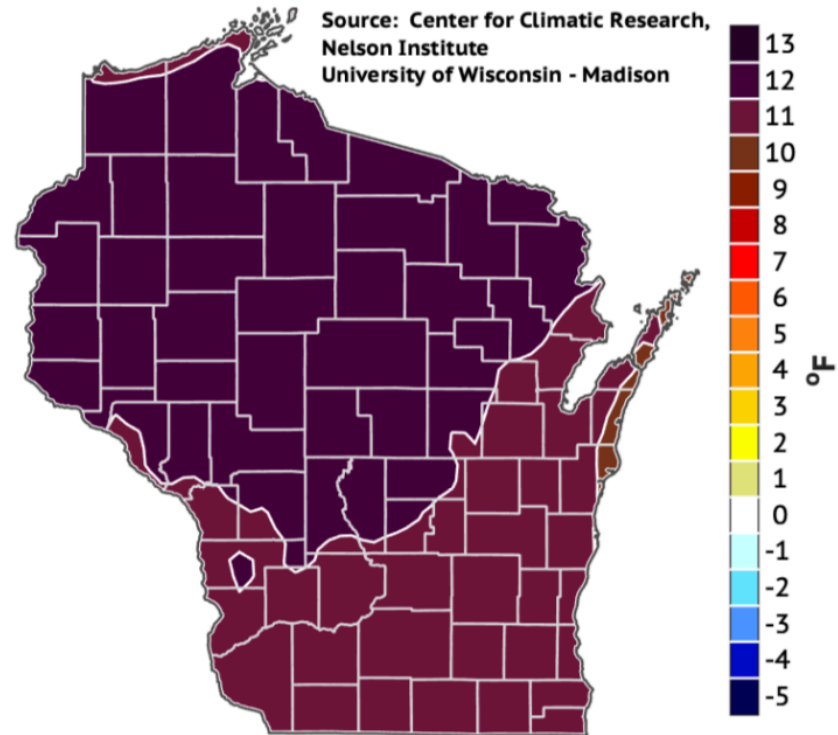
**Change in Annual TMEAN, RCP45:  
2081-2100 minus 1981-2010**

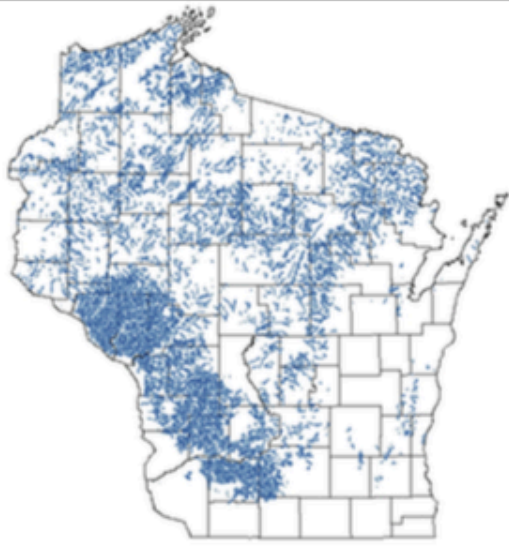
Source: Center for Climatic Research,  
Nelson Institute  
University of Wisconsin - Madison



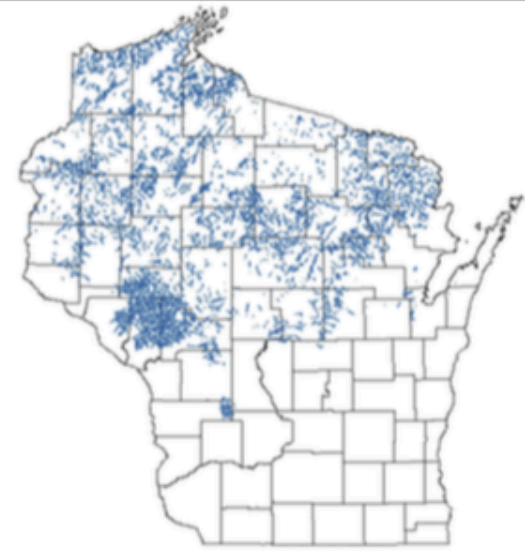
**Change in Annual TMEAN, RCP85:  
2081-2100 minus 1981-2010**

Source: Center for Climatic Research,  
Nelson Institute  
University of Wisconsin - Madison





**Current climate**



**Best case  
+1.4°F = 44% loss**

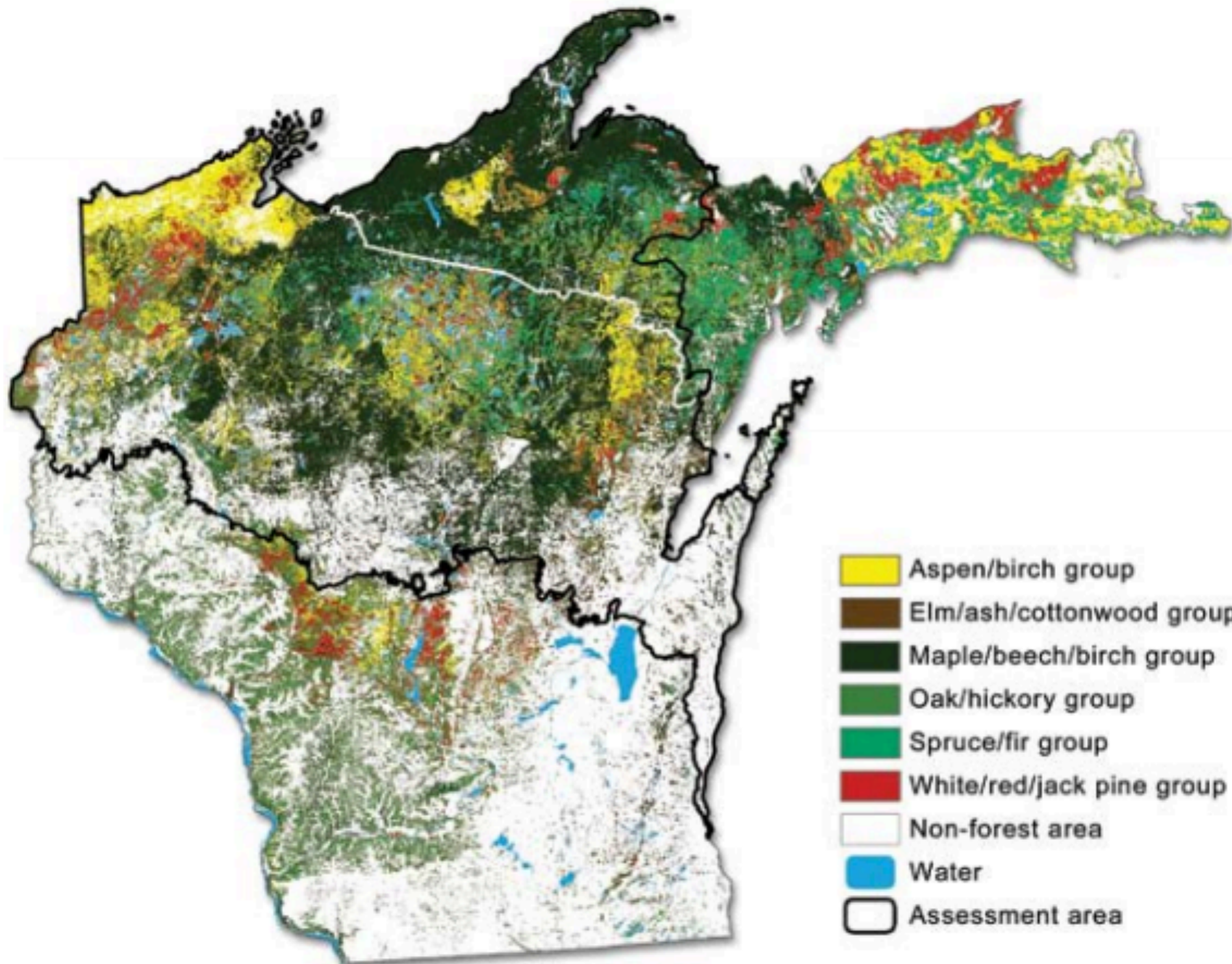


**Moderate case  
+4.3°F = 94% loss**



**Worst case  
+7.2°F = total loss**

*Predicted distribution of brook trout in Wisconsin streams under current climate conditions and predicted losses under three climate-warming scenarios for Wisconsin by mid-century.*

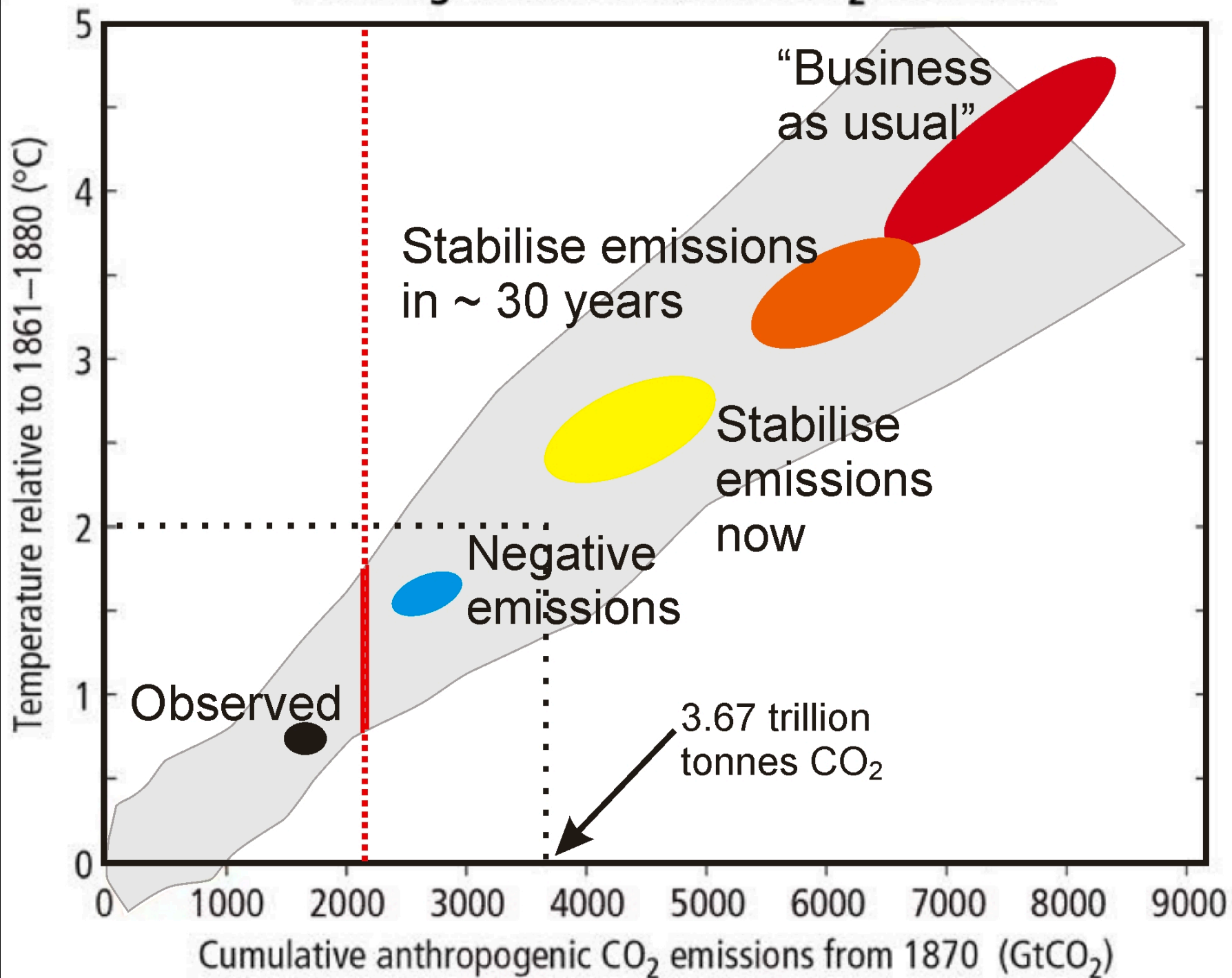


- Growing seasons across northern Wisconsin could increase by 14 to 49 days by the end of the century
- Even if total rainfall increases, these factors may lead to net drier conditions for Wisconsin's forests
- Frozen ground duration is expected to shrink by another 1–2 months by the end of the century
- Invasive plants will “disproportionally benefit” under climate change
- Deer benefit from climate change over the 21st century and could have even greater impacts on forests

# What Are The Options?

- Adaptation
- Mitigation

# Warming versus cumulative CO<sub>2</sub> emissions

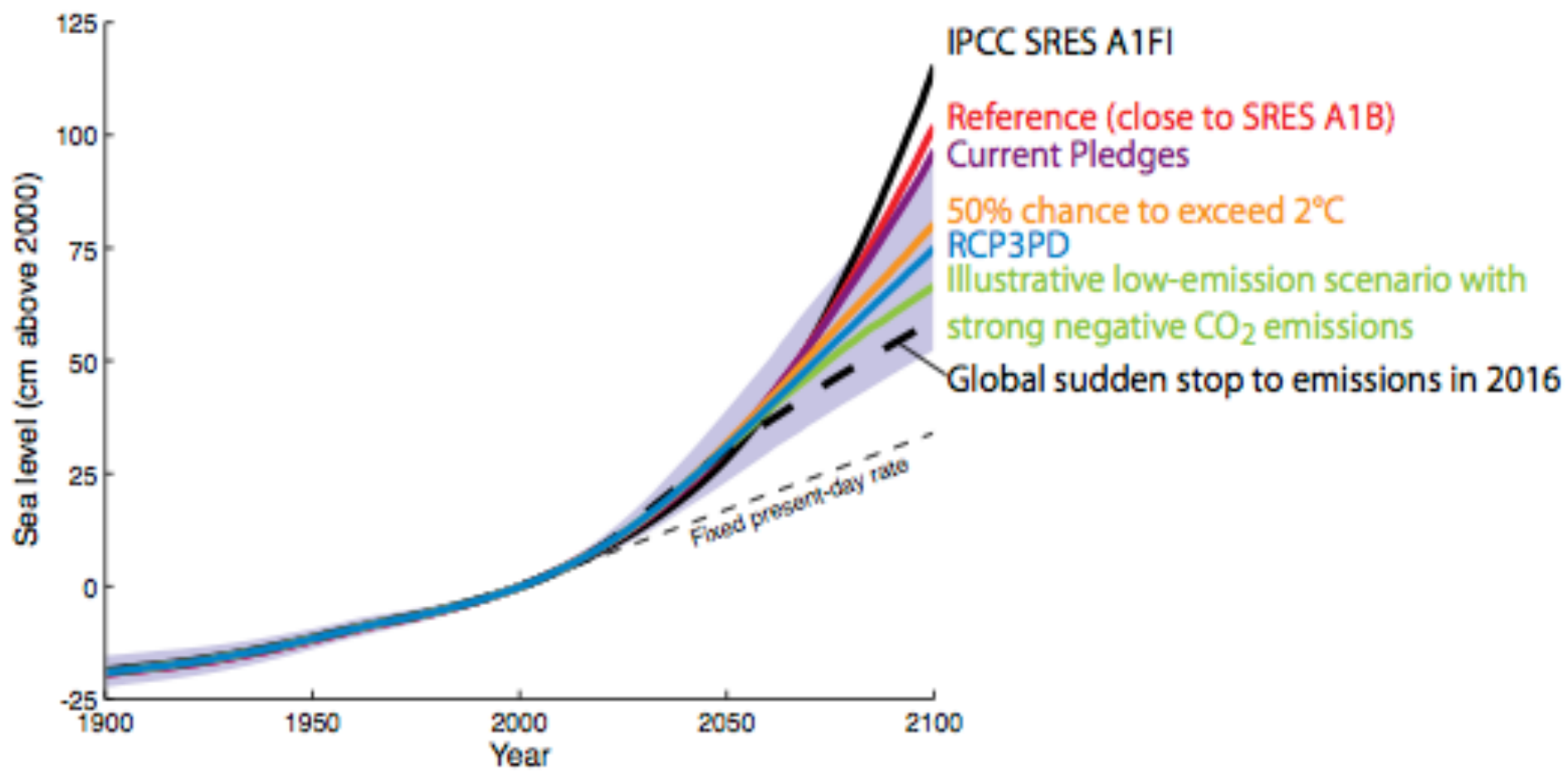




# What Are The Options?

- Adaptation
  - Economic/political
  - Technological
- Mitigation

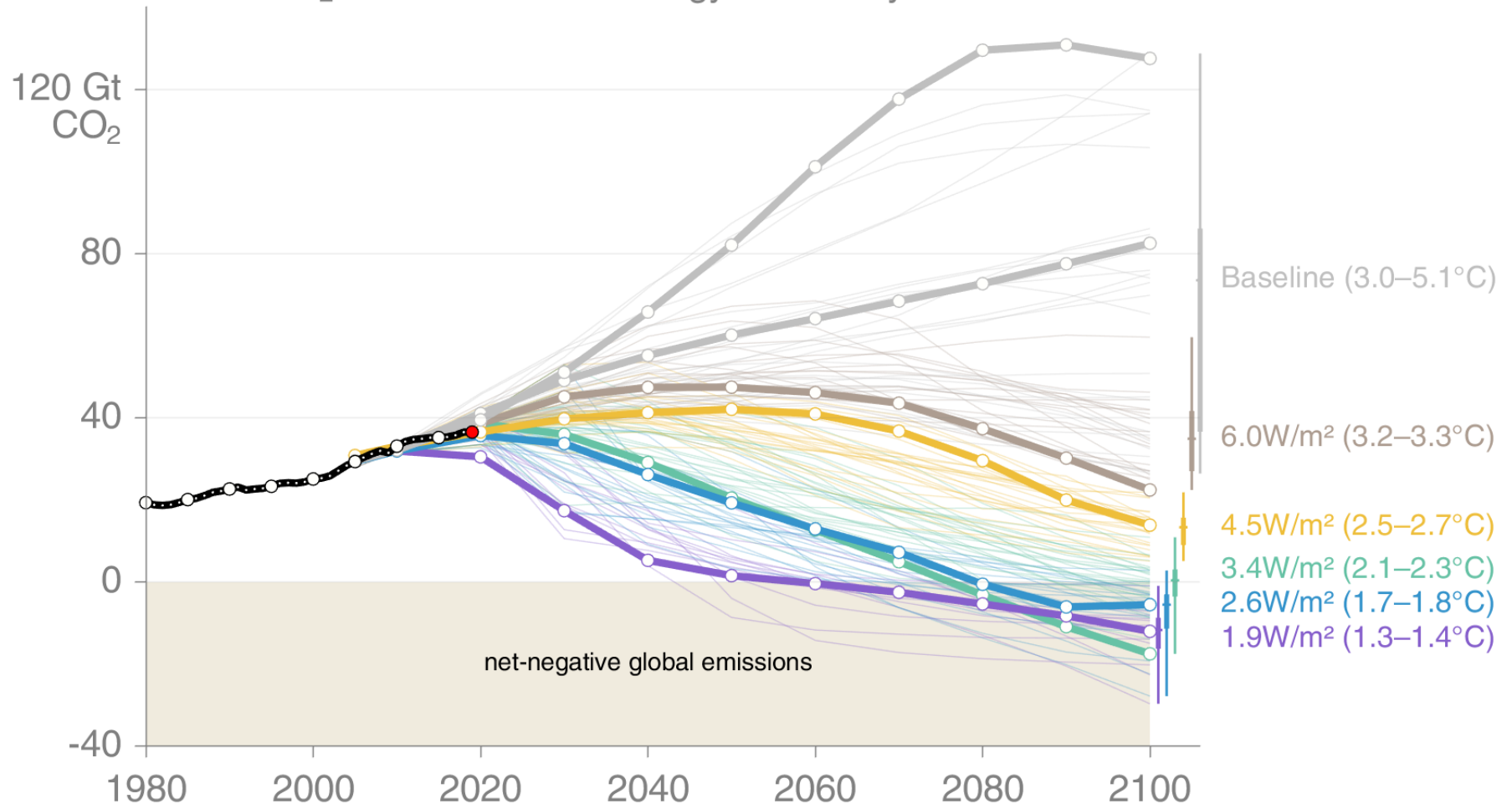




# What Are The Options?

- Adaptation
  - Economic/political
  - Technological
- Mitigation
  - Economic
  - Regulatory
  - Societal
  - Technological

# Global CO<sub>2</sub> Emissions from Energy & Industry



# Nuclear, renewable, or something else?

- Our power grid energy future is only one piece of the puzzle (~20%)
- There are pros and cons of all energy options including solar, wind, nuclear, hydro, geothermal, tidal, etc...
- Fossil fuels are being phased out rapidly, coal plants are not economical to operate, solar is now the cheapest energy to produce in most places

# Dane County to go all-renewable with help of proposed Alliant solar farm

Chris Hubbuch | Wisconsin State Journal | Nov 6, 2020

# We Energies to retire 1.8 gigawatts of fossil fuel; utility adding solar, wind, battery storage

Chris Hubbuch | Wisconsin State Journal | Nov 6, 2020

## Biden Wants to Be the Climate President. He'll Need Some Help From China.

The U.S.-China relationship is at its lowest point in a half century, but there are also converging interests on global

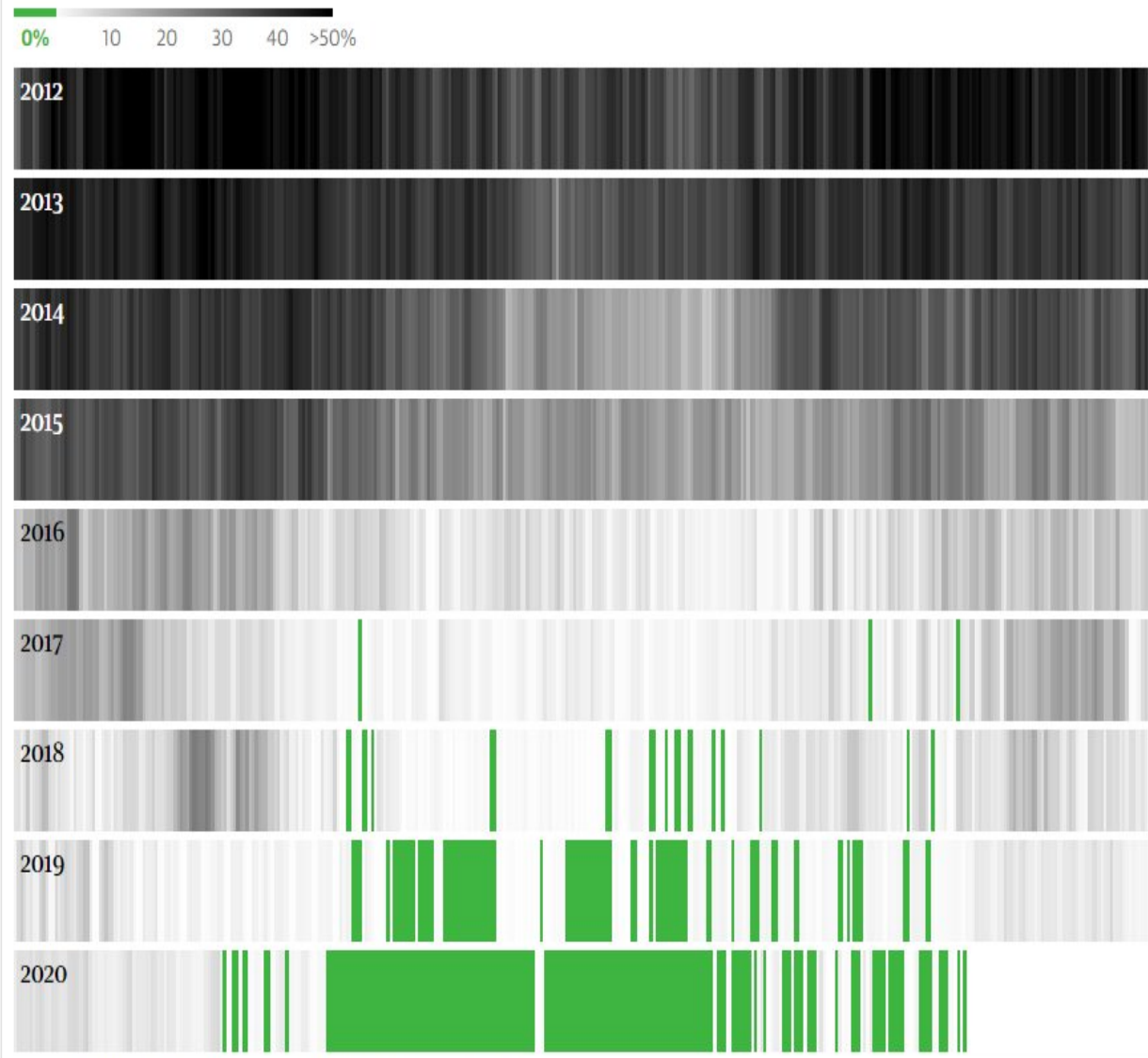
**All of South Australia's power comes from solar panels in world first for major jurisdiction**

# Rolls-Royce plans 16 mini-nuclear plants for UK

By Justin Rowlett  
Chief environment correspondent

## Britain is rapidly phasing out coal

Daily share of Britain's power generated by burning coal

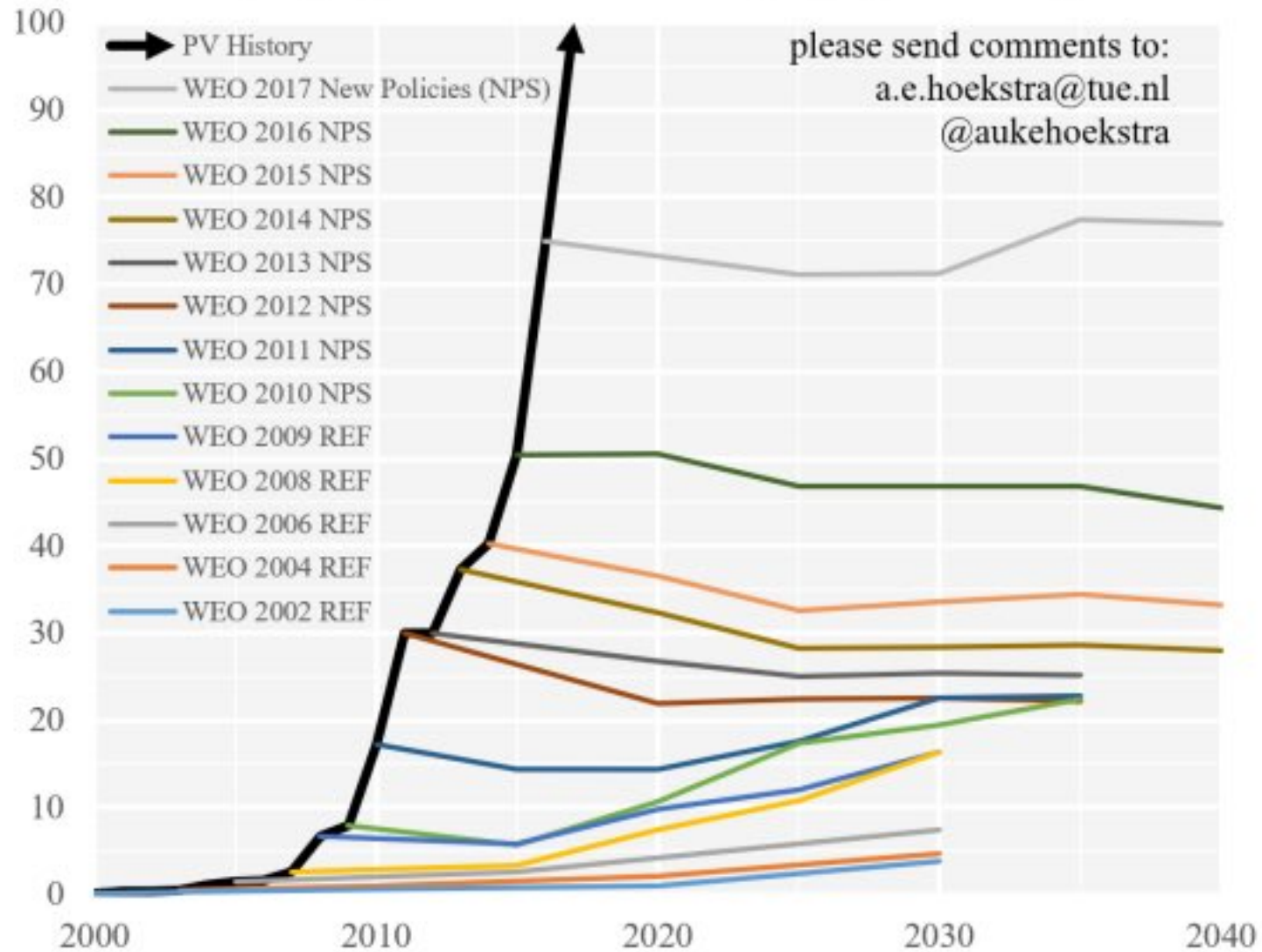


Source: Drax Electric Insights. Last updated at 5:55pm on 31 October



# Annual PV additions: historic data vs IEA WEO predictions

In GW of added capacity per year - source International Energy Agency - World Energy Outlook

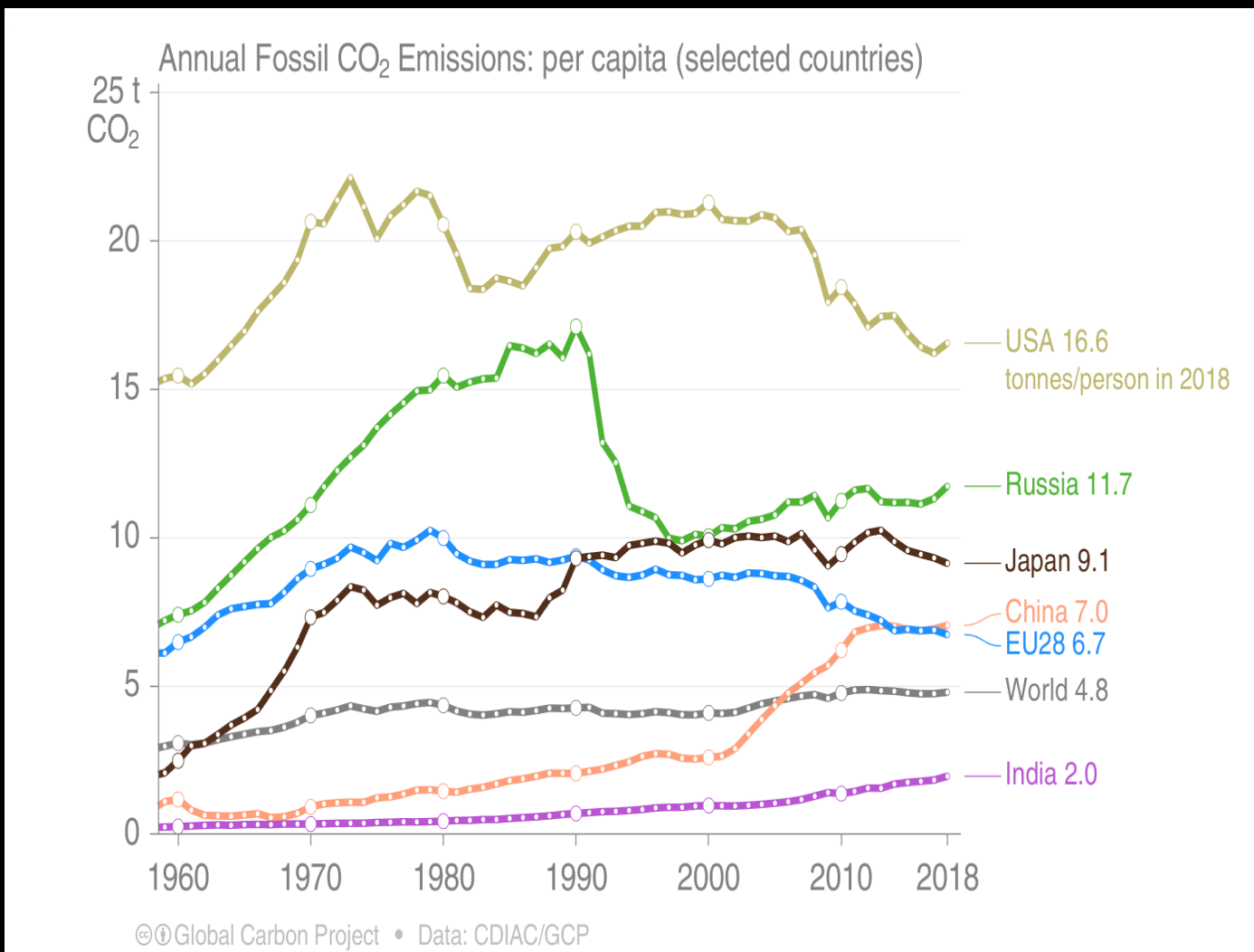


IEEFA update: Renewables surpass coal in U.S. power generation throughout the month of April 2020

Utility-scale solar, wind, and hydro exceeded coal-generated power every single day

## Top emitters: Fossil CO<sub>2</sub> Emissions per capita

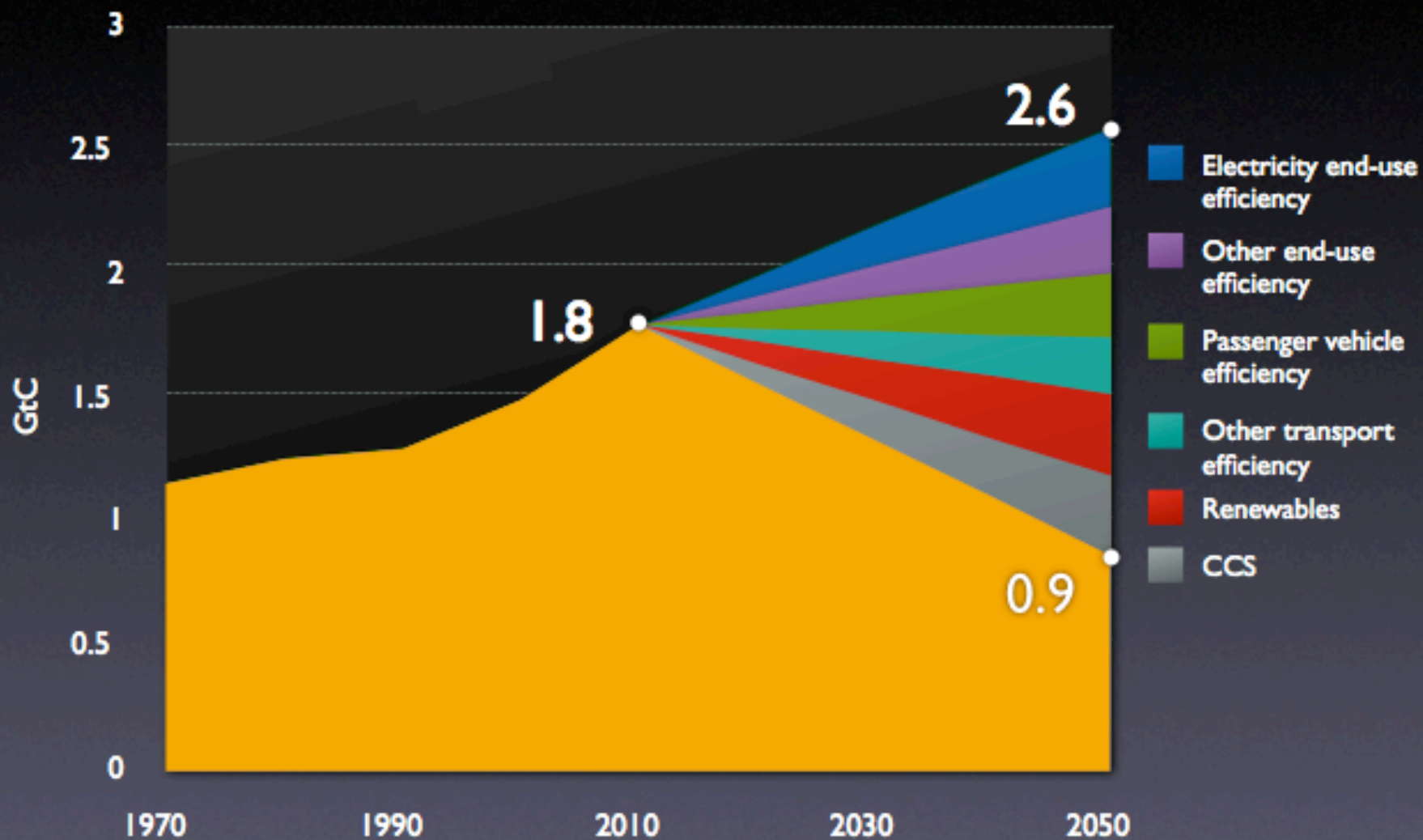
Countries have a broad range of per capita emissions reflecting their national circumstances



# U.S. Emissions

After Pacala and Socolow, 2004;  
ARI CarBen3 Spreadsheet

- Carbon Capture & Storage



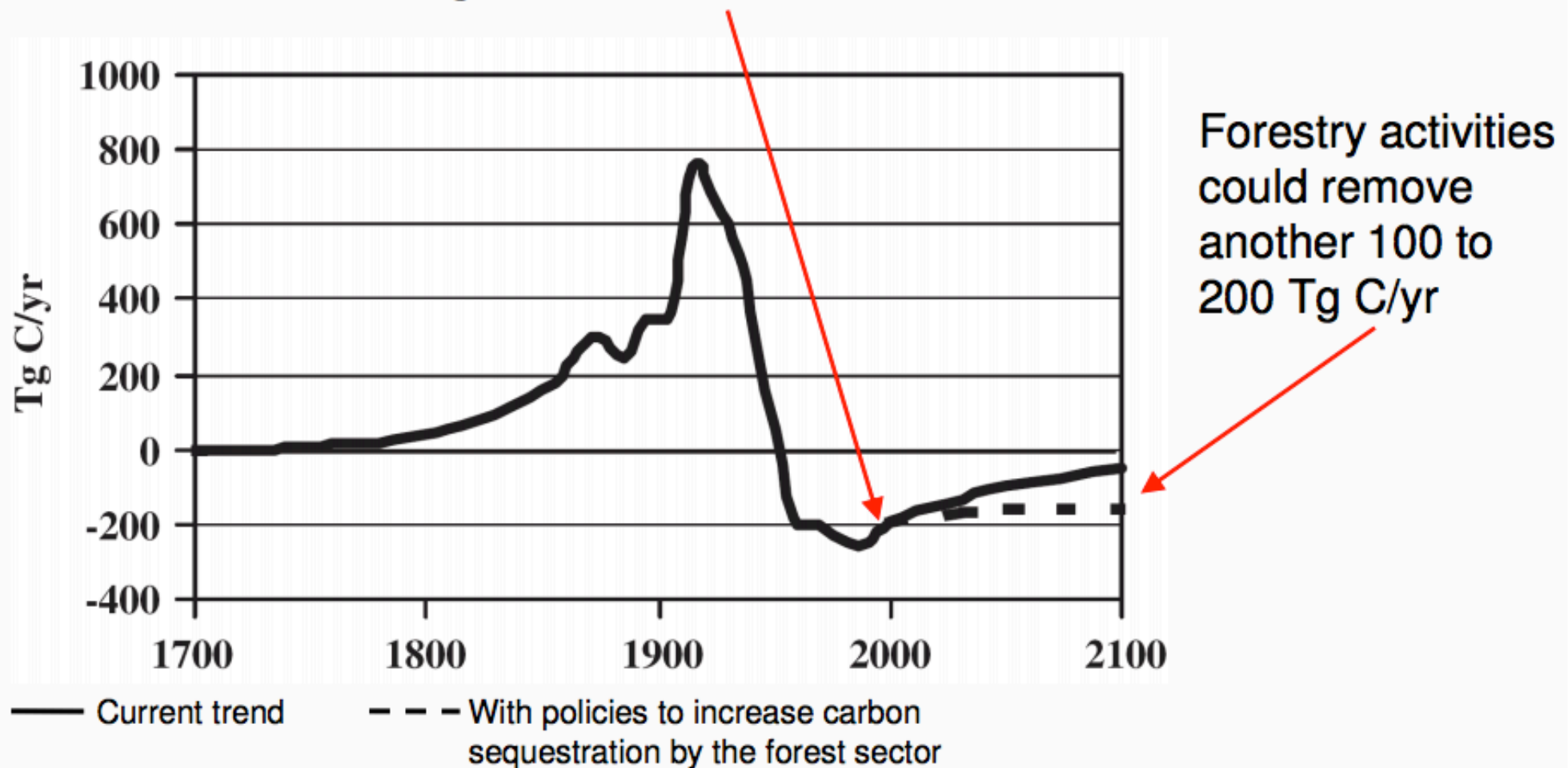
# Solutions are abundant

- <https://www.drawdown.org/solutions>

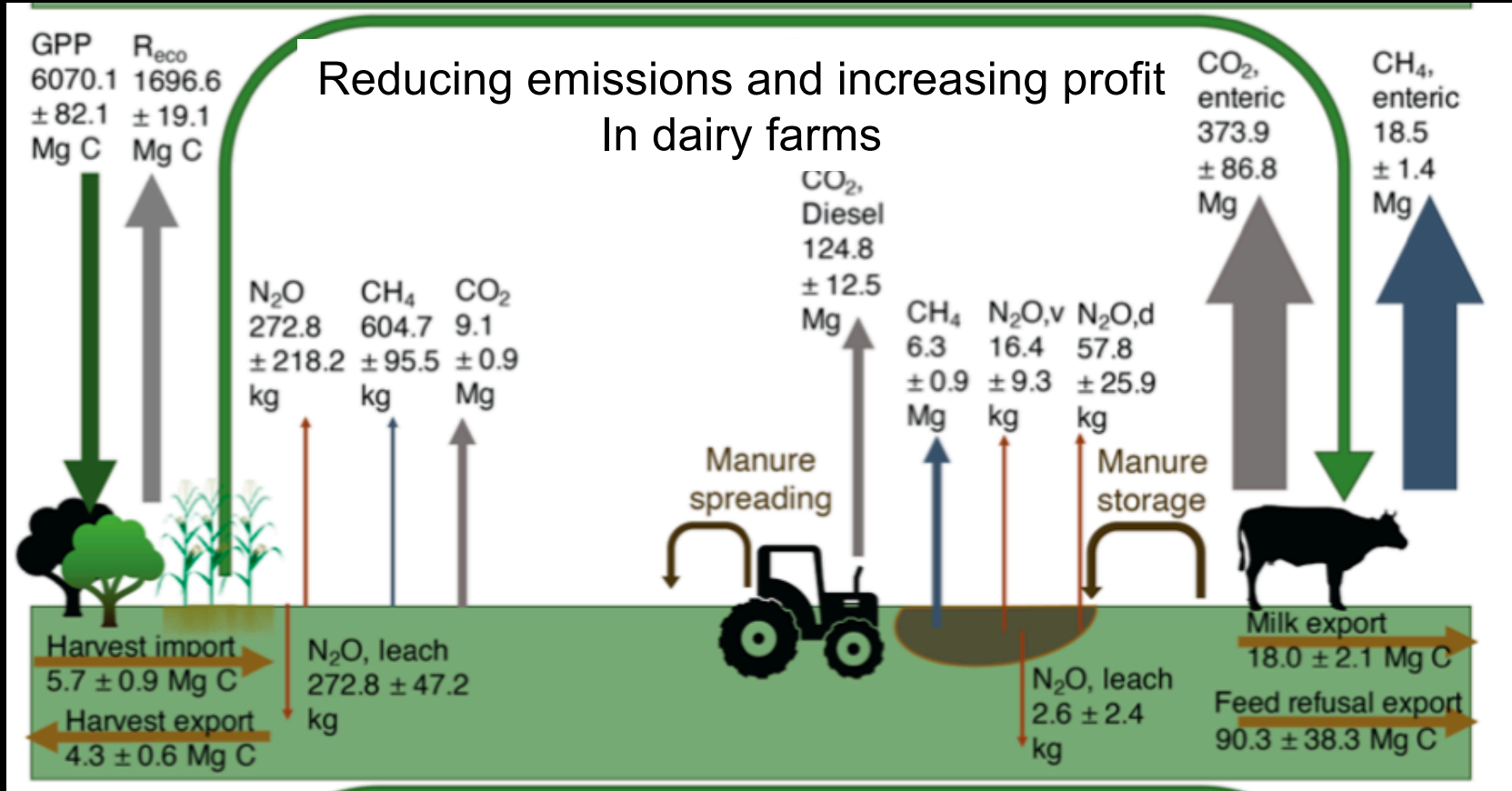
\* Gigatons CO2 Equivalent Reduced / Sequestered (2020–2050)

◆ SOLUTION	◆ SECTOR(S)	▼ SCENARIO 1*	◆ SCENARIO 2*
Reduced Food Waste	Food, Agriculture, and Land Use / Land Sinks	87.45	94.56
Health and Education	Health and Education	85.42	85.42
Plant-Rich Diets	Food, Agriculture, and Land Use / Land Sinks	65.01	91.72
Refrigerant Management	Industry / Buildings	57.75	57.75
Tropical Forest Restoration	Land Sinks	54.45	85.14
Onshore Wind Turbines	Electricity	47.21	147.72
Alternative Refrigerants	Industry / Buildings	43.53	50.53
Utility-Scale Solar Photovoltaics	Electricity	42.32	119.13
Improved Clean Cookstoves	Buildings	31.34	72.65
Distributed Solar Photovoltaics	Electricity	27.98	68.64
Silvopasture	Land Sinks	26.58	42.31
Peatland Protection and Rewetting	Food, Agriculture, and Land Use / Land Sinks	26.03	41.93
Tree Plantations (on Degraded Land)	Land Sinks	22.24	35.94
Temperate Forest Restoration	Land Sinks	19.42	27.85
Concentrated Solar Power	Electricity	18.60	23.96

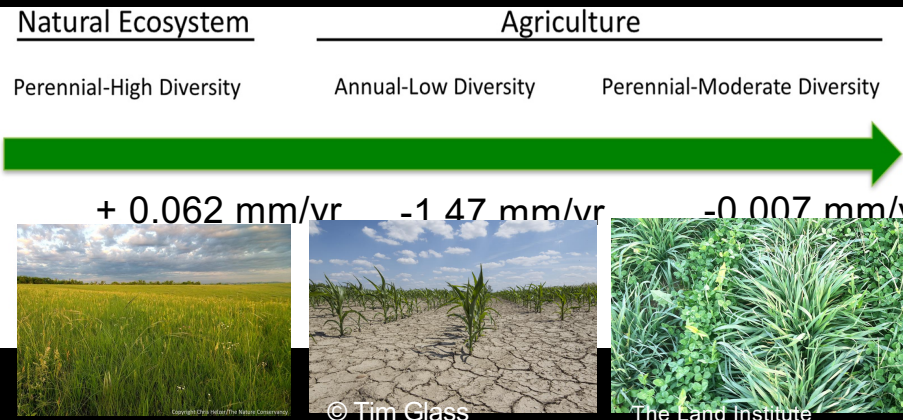
US forests annually sequester the equivalent of 10% of US carbon dioxide emissions from burning fossil fuels



*Smith and Heath 2004, EPA 2005, Birdsey et al. 2006*



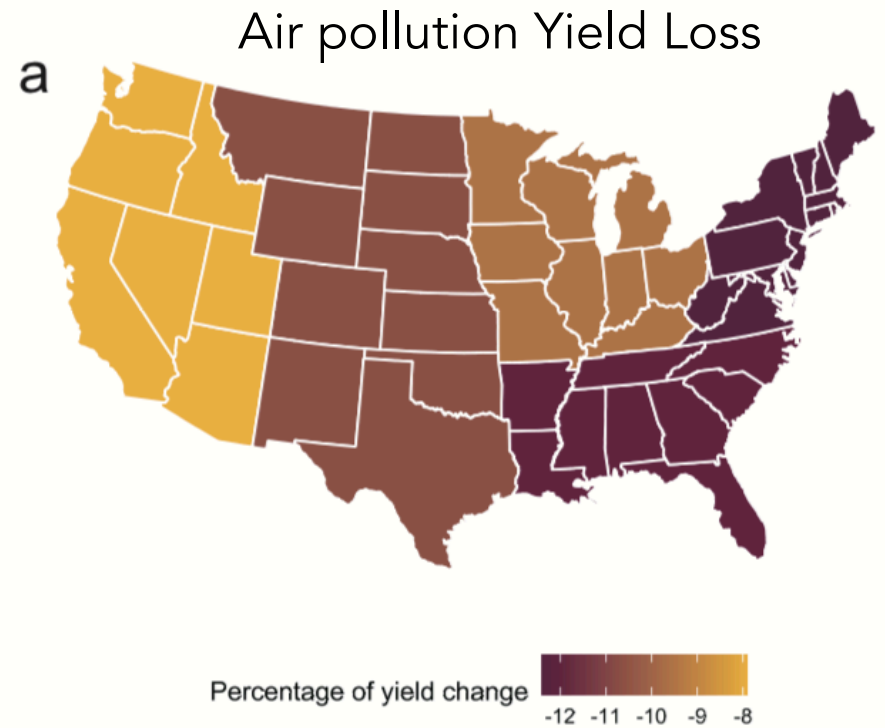
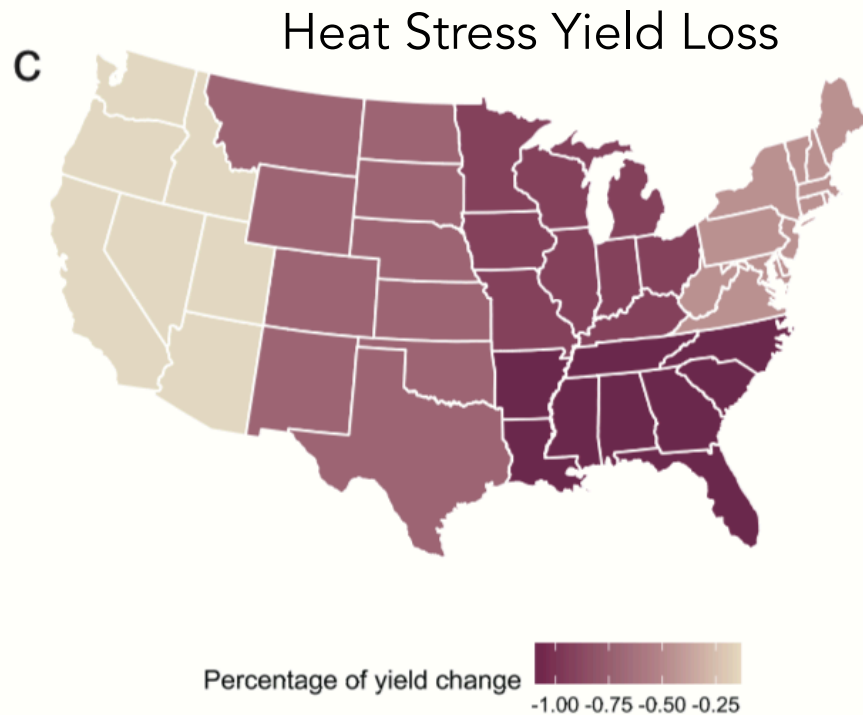
## Natural Climate Solutions





# Improving air quality has more than offset heat/drought related yield losses

*We can further improve food security through air quality regulation*







<https://globalclimatestrike.net/>



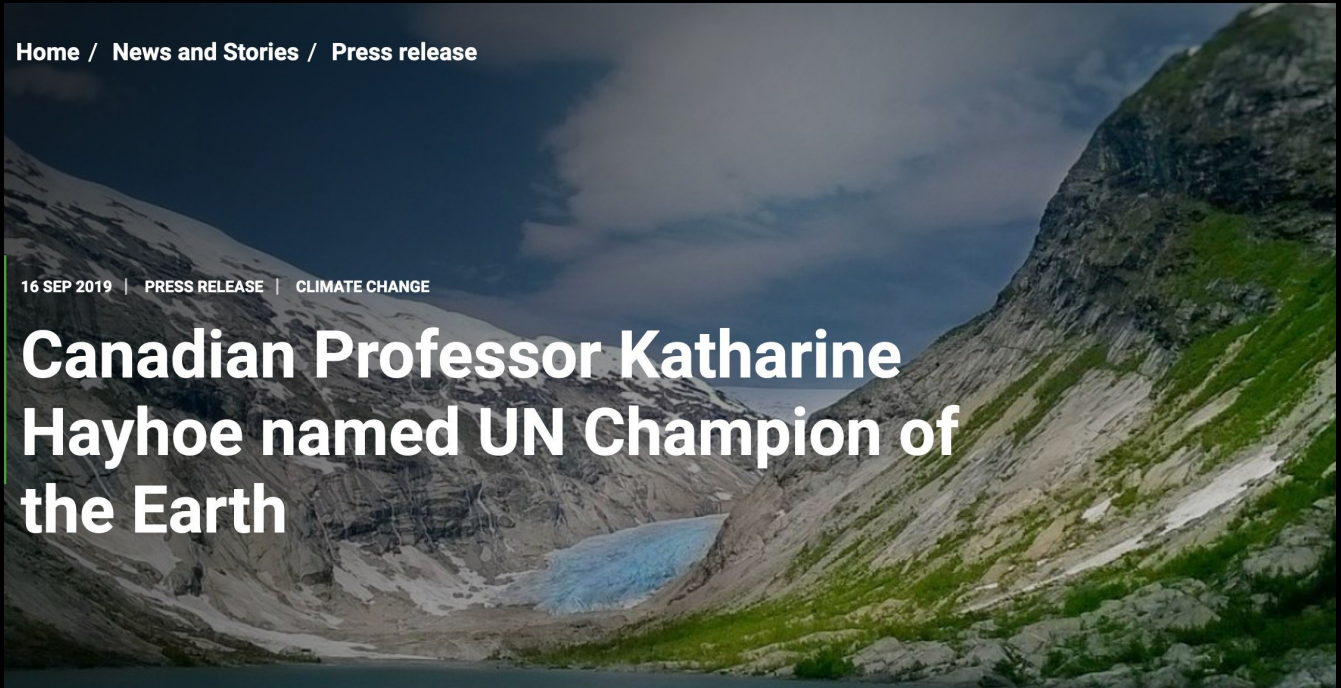
<http://katharinehayhoe.com>

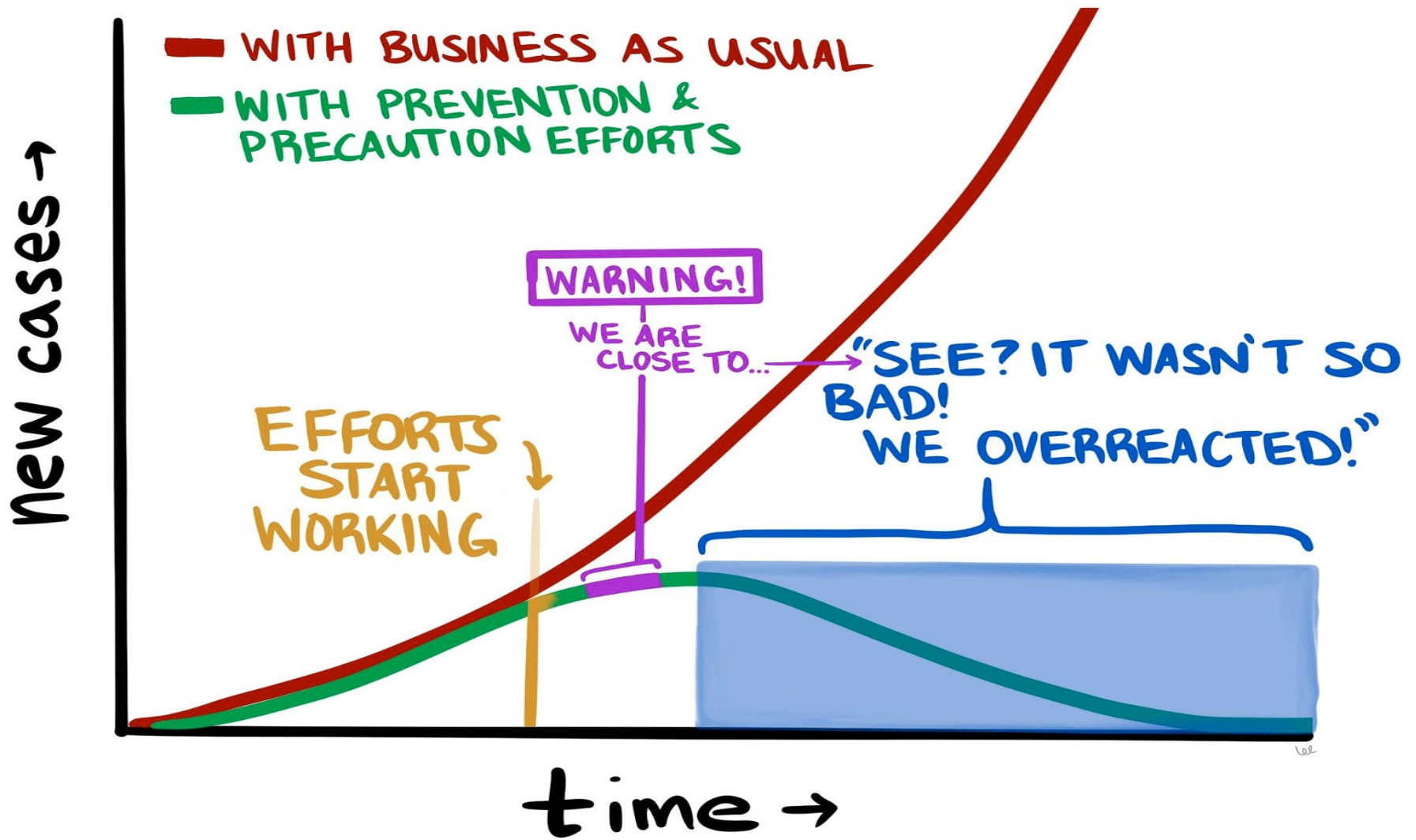
GLOBAL WEIRDING  
YouTube Channel

Home / News and Stories / Press release

16 SEP 2019 | PRESS RELEASE | CLIMATE CHANGE

## Canadian Professor Katharine Hayhoe named UN Champion of the Earth







*How a Handful of Scientists  
Obscured the Truth on  
Issues from Tobacco  
Smoke to Global  
Warming*

# Merchants of DOUBT

Naomi Oreskes  

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 & Erik M. Conway

Terrorism

Lack of  
Education

Wealth  
Inequality

**Climate Change  
Makes These**

Water scarcity &  
pollution

Land  
Degradation

Rapid  
Urbanization

Natural  
Disasters

**Harder or More Expensive  
to Solve**

Oppression of  
minorities

Inadequate  
public health

Food  
Insecurity

Species  
Loss



DOWNTOWN MADISON  
INFORMATION

Love  
is greater than  
fear.



Please Respect  
This Space  
Reserved





**Thank you!**

Ankur Desai

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Photo: A. Desai