What Can YOU do about Climate Change?

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

Milwaukee Public Library

Three things about me

Three things about me

- I was born and raised in New Jersey

PHILLYSKYLINE.COM : ATLANTIC CITY FRO

Three things about me

- I was born and raised in New Jersey
- I live in Madison with my wife and three daughters

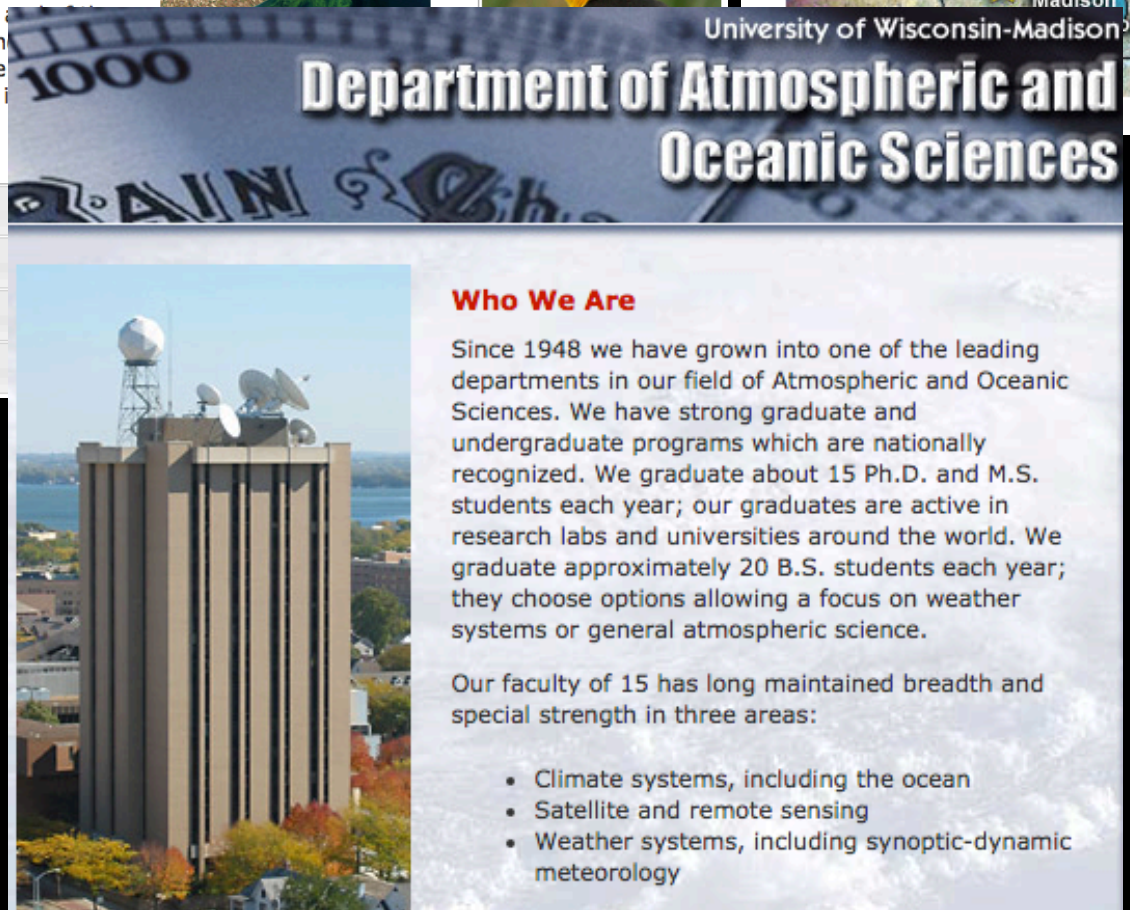

SEVER
RIP

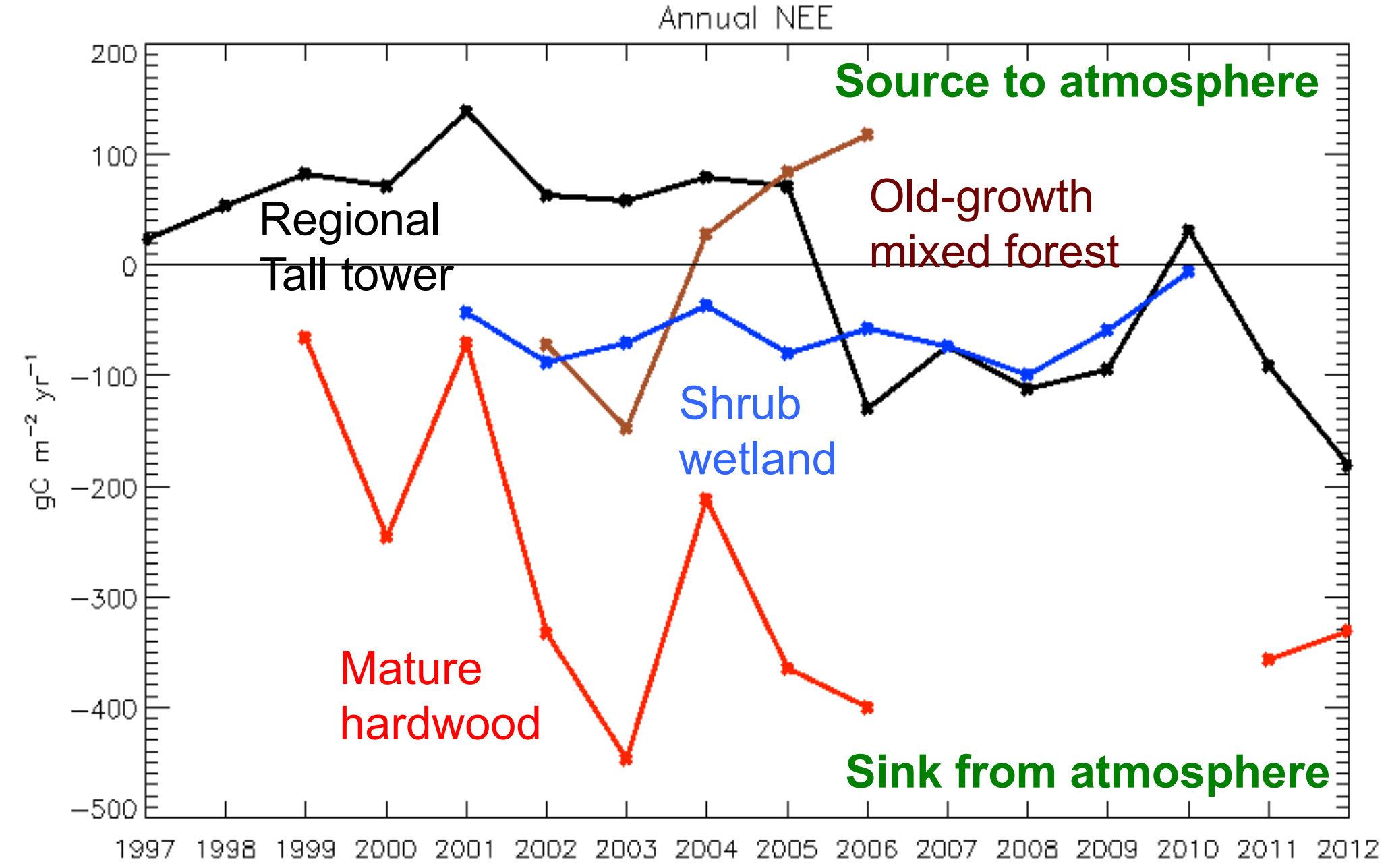
Three things about me

- I was born and raised in New Jersey
- I live in Madison with my wife and three daughters
- I am a climate scientist who has spent that past 2 decades studying how plants, climate, and weather all influence each other


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 an
elucidate natural carbon fluxes and the
controlling them, and work to use this
improve predictive models.
Climate Impacts
Land Surface Processes
Oceanography and Limnology
Past Climates


North Temperate Lakes
Long Term Ecological Resear
Member of the US LTER Network
Welcome to NTL-LTER
Trout Lake
Region
Madison
North Temperate Lak
sites established by
and changing land us
present, future).
Our primary study si
their surrounding lan
Limnology at the Uni


University of Wisconsin-Madison
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

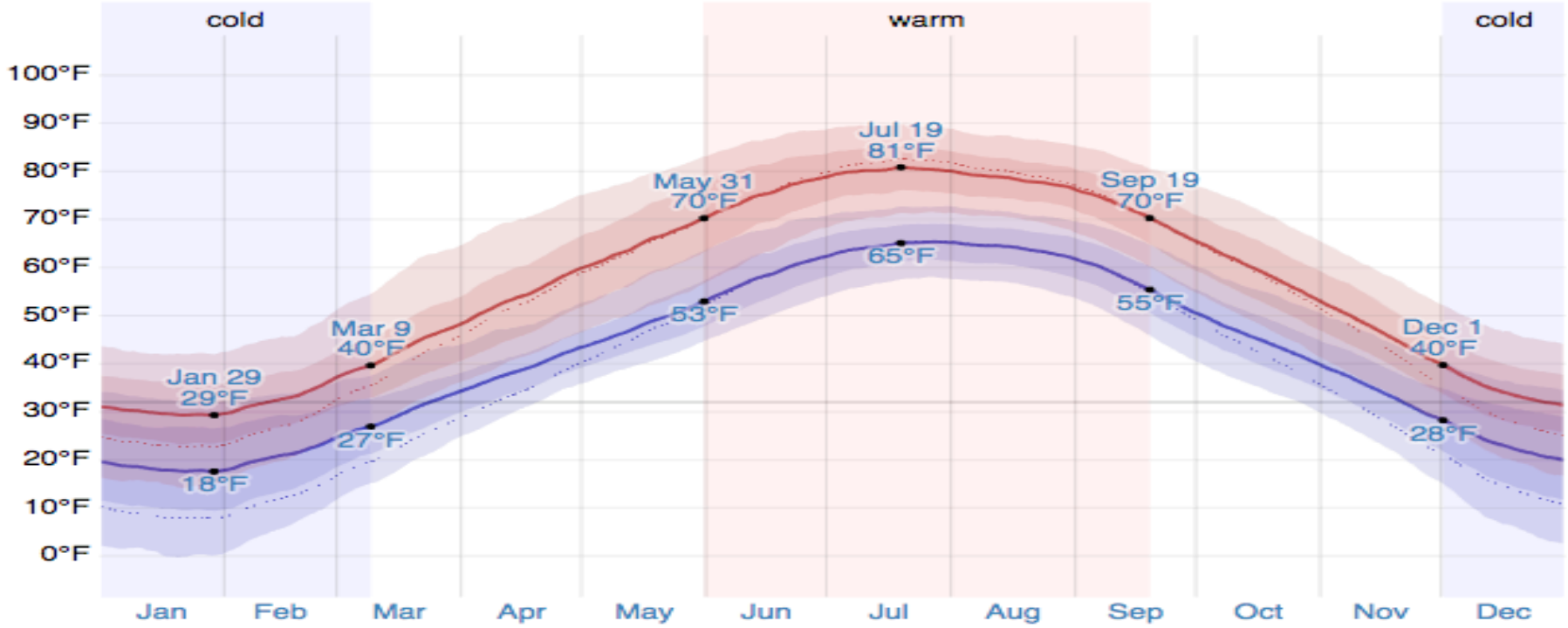

Annual NEE
Source to atmosphere
Regional
Tall tower
Old-growth
mixed forest
Shrub
wetland
Mature
hardwood
Sink from atmosphere
gC m^{-2} yr^{-1}
200
100
0
−100
−200
−300
−400
−500
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Three things about climate

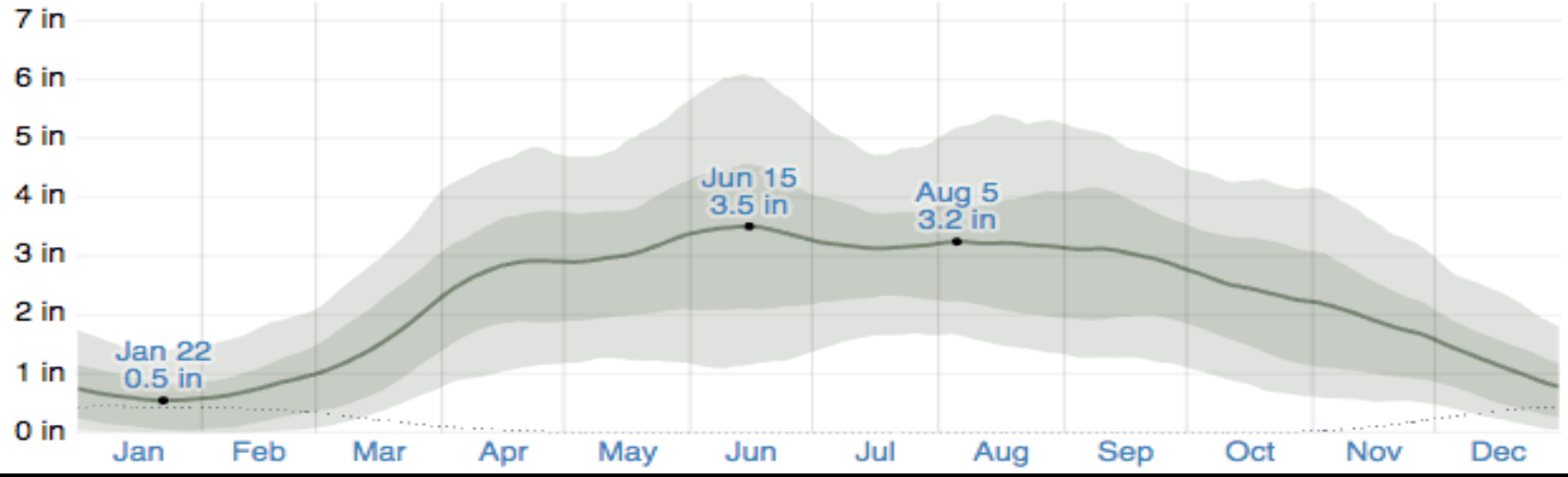
Three things about climate

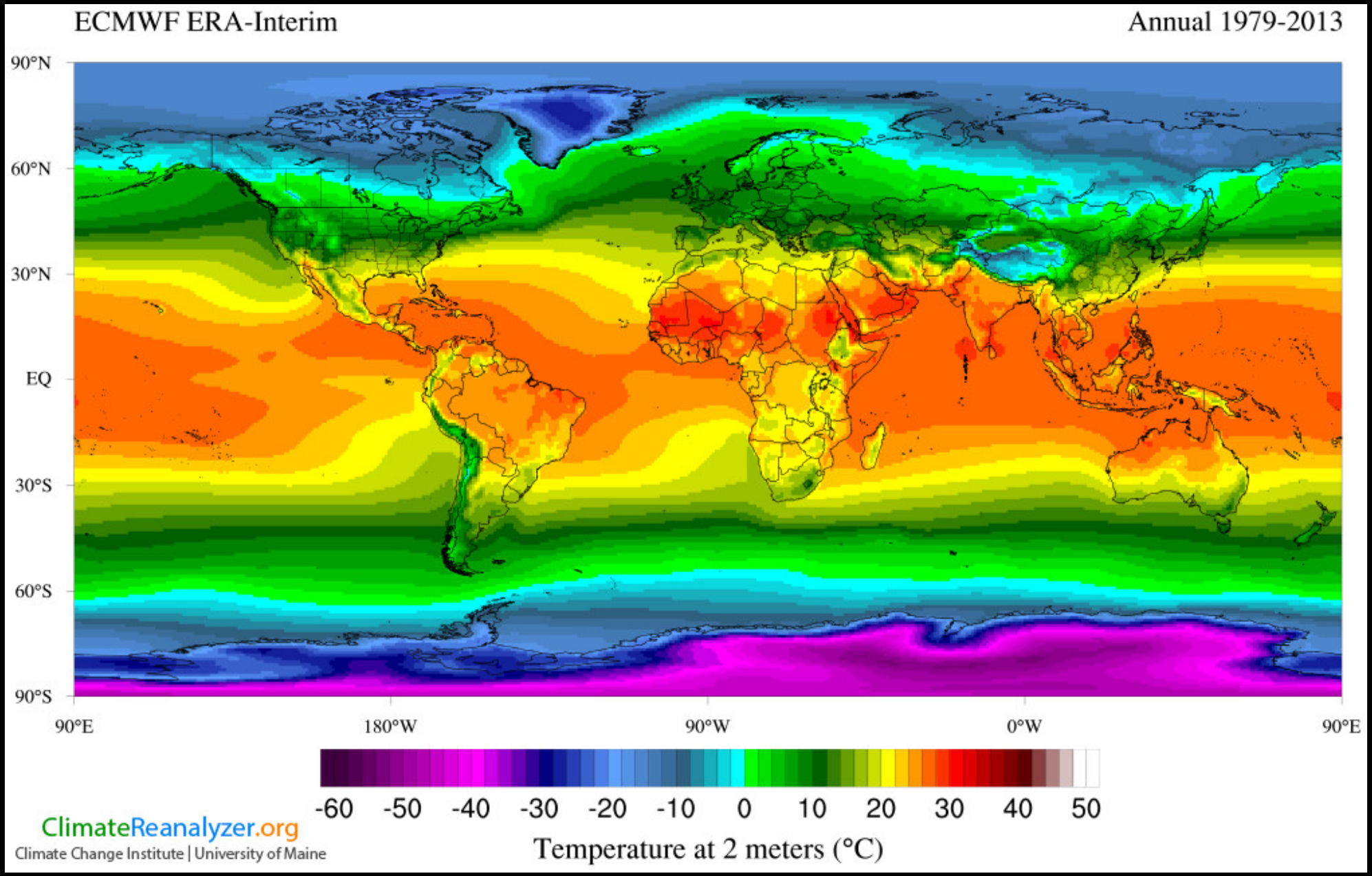
- Climate is the average of weather

Average High and Low Temperature

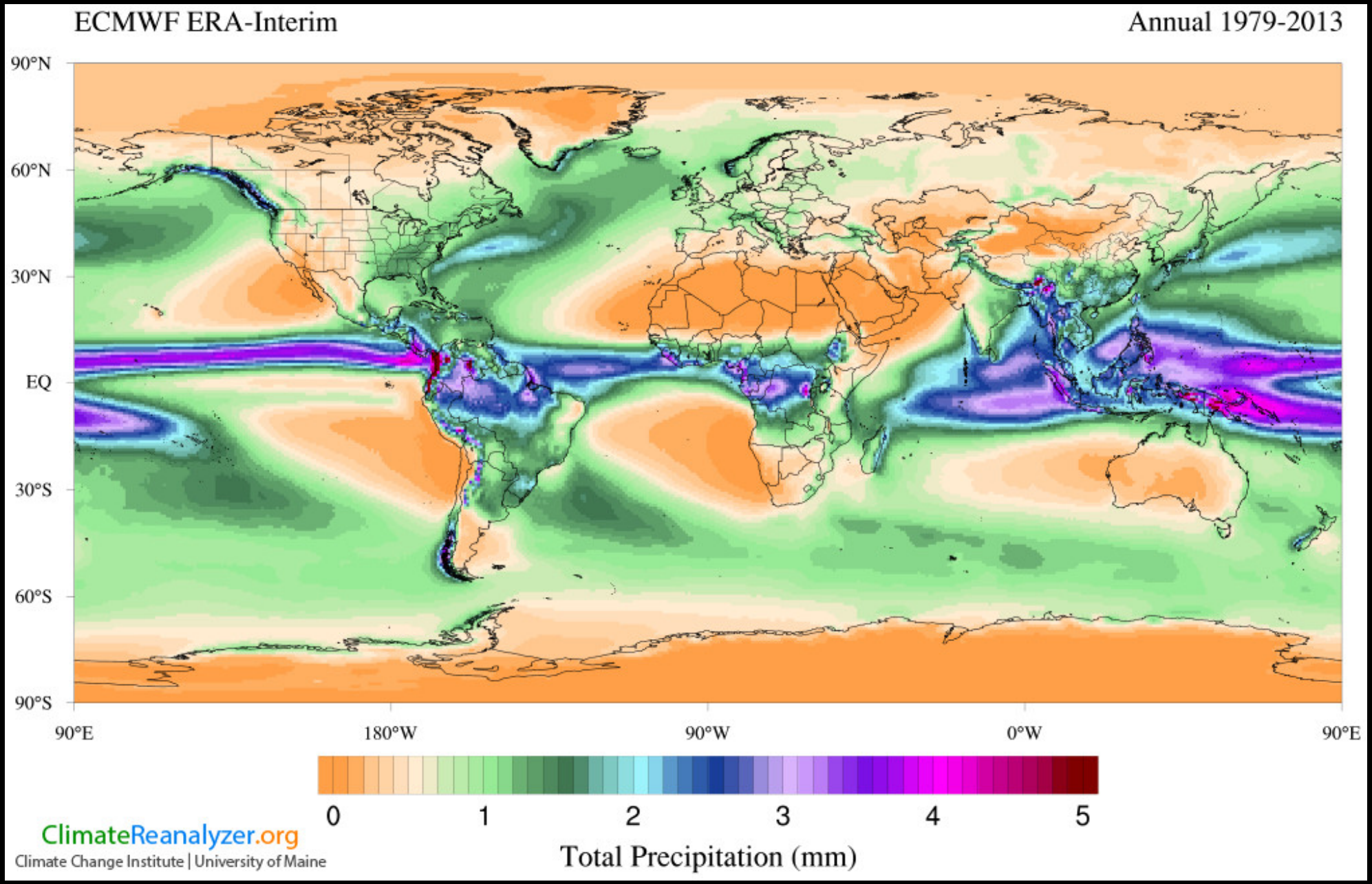


Average Monthly Rainfall





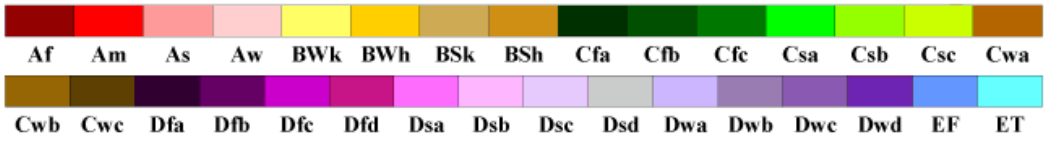
http://cci-reanalyzer.org/



http://cci-reanalyzer.org/

World Map of Köppen−Geiger Climate Classification

updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000



Main climates
- A: equatorial
- B: arid
- C: warm temperate
- D: snow
- E: polar

Precipitation
- W: desert
- S: steppe
- f: fully humid
- s: summer dry
- w: winter dry
- m: monsoonal

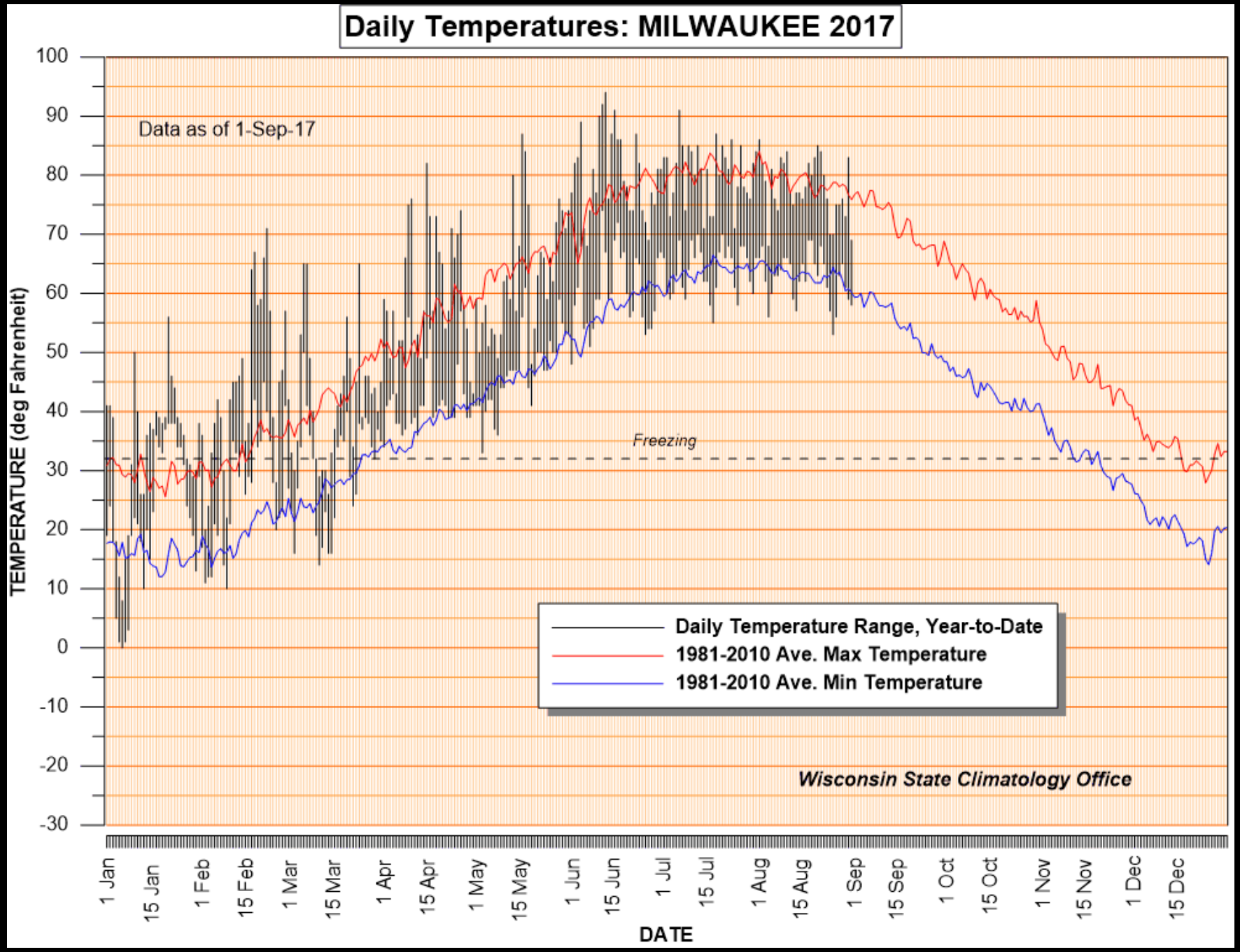
Temperature
- h: hot arid
- k: cold arid
- a: hot summer
- b: warm summer
- c: cool summer
- d: extremely continental
- F: polar frost
- T: polar tundra

Resolution: 0.5 deg lat/lon

Version of April 2006

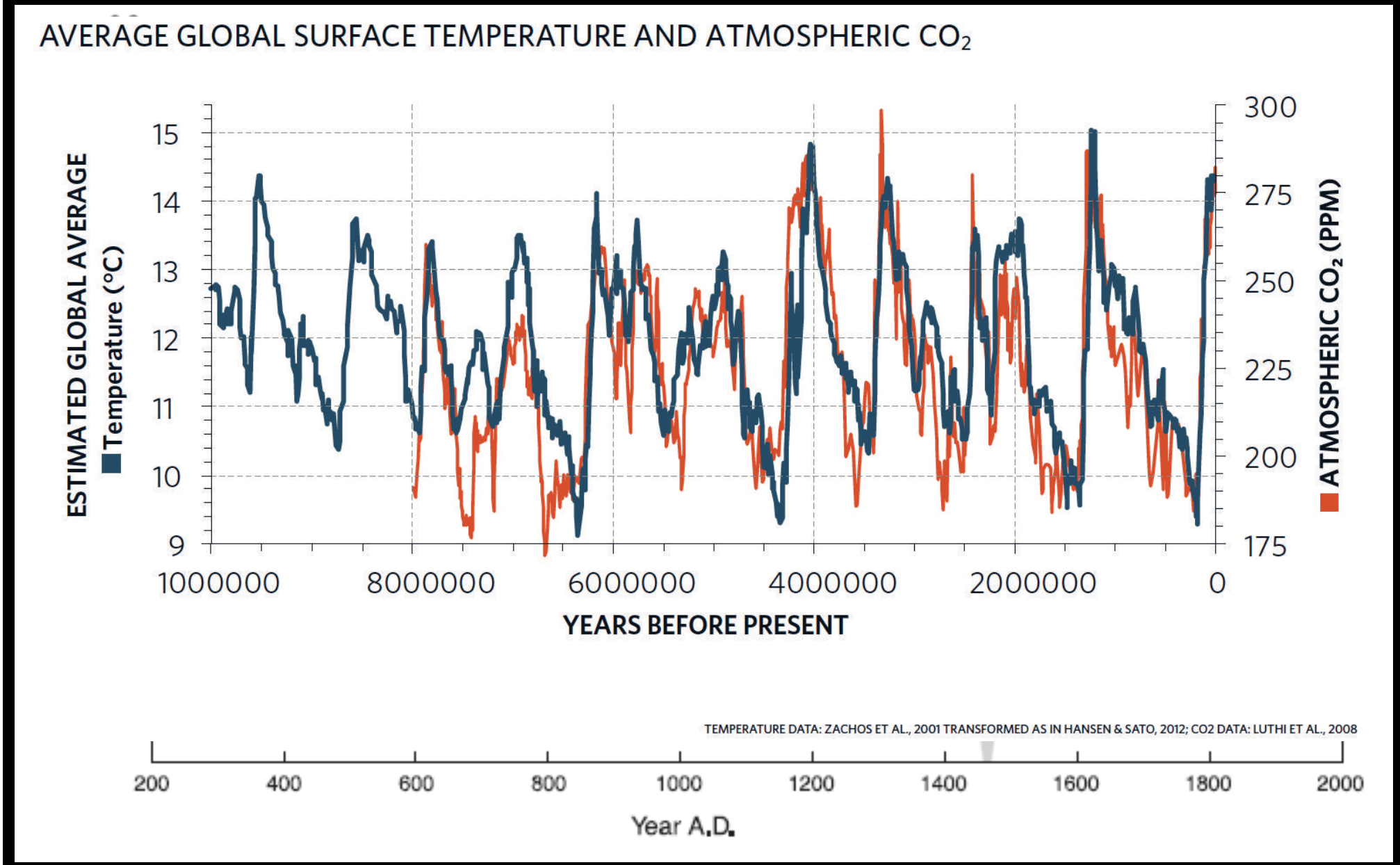
http://gpcc.dwd.de
http://koeppen-geiger.vu-wien.ac.at

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006: World Map of Köppen-Geiger Climate Classification updated. *Meteorol. Z.*, **15**, 259-263.


Daily Temperatures: MILWAUKEE 2017
Data as of 1-Sep-17
TEMPERATURE (deg Fahrenheit)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
Freezing
Daily Temperature Range, Year-to-Date
1981-2010 Ave. Max Temperature
1981-2010 Ave. Min Temperature
Wisconsin State Climatology Office
1 Jan
15 Jan
1 Feb
15 Feb
1 Mar
15 Mar
1 Apr
15 Apr
1 May
15 May
1 Jun
15 Jun
1 Jul
15 Jul
1 Aug
15 Aug
1 Sep
15 Sep
1 Oct
15 Oct
1 Nov
15 Nov
1 Dec
15 Dec
DATE

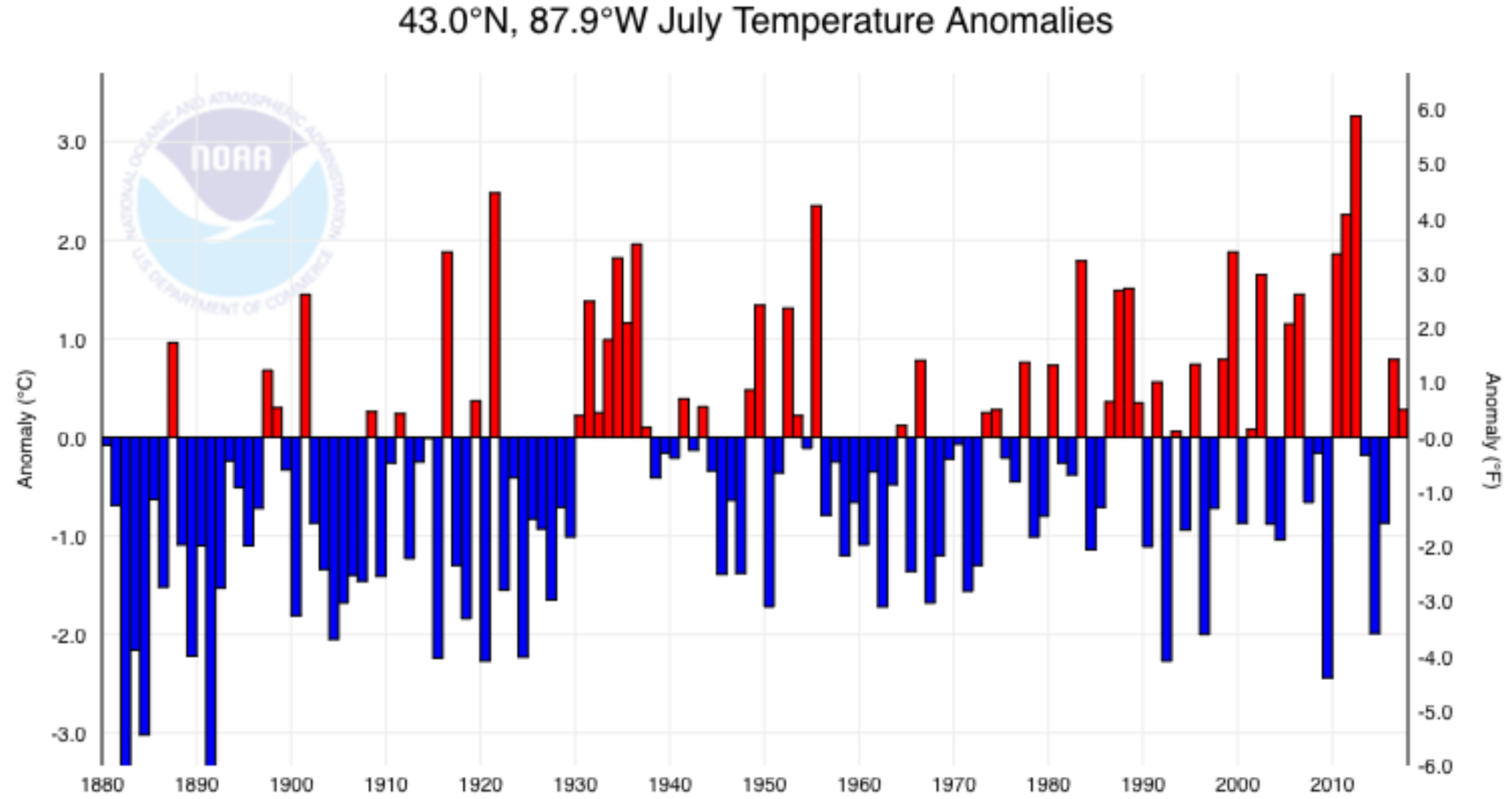
Three things about climate

- Climate is the average of weather
- Climate changes naturally

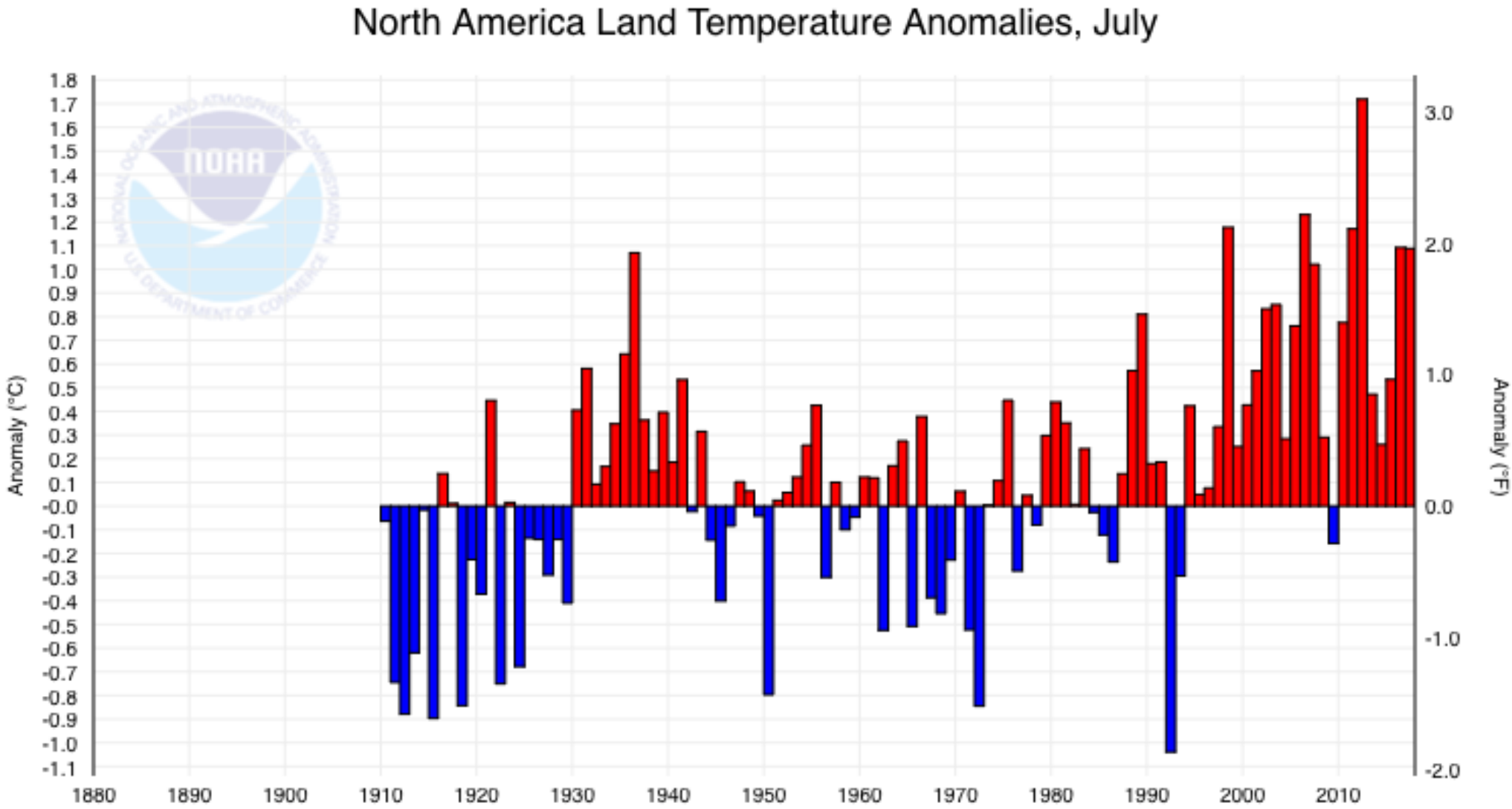


Mann et al., 2003, EOS

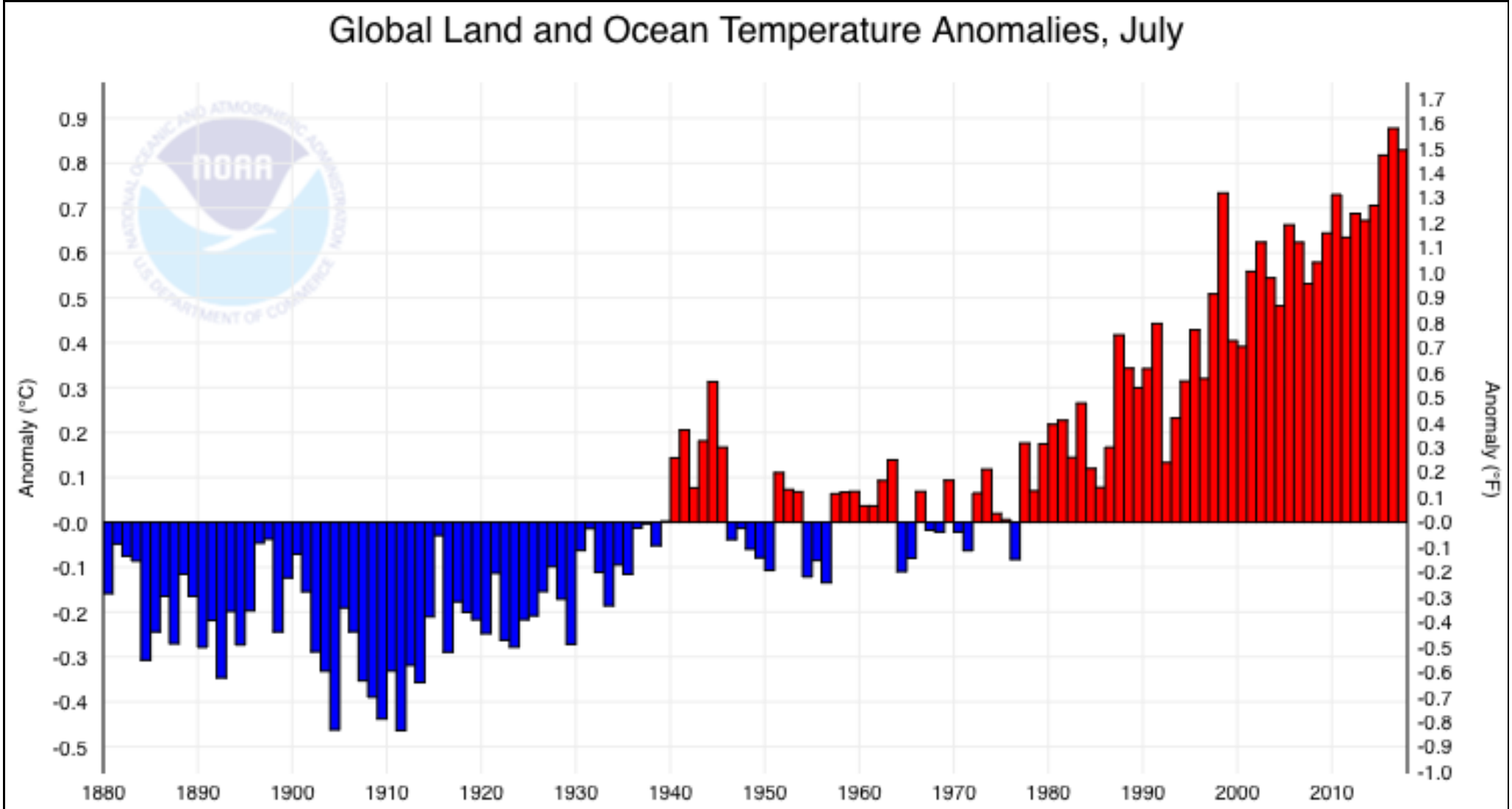
MKE

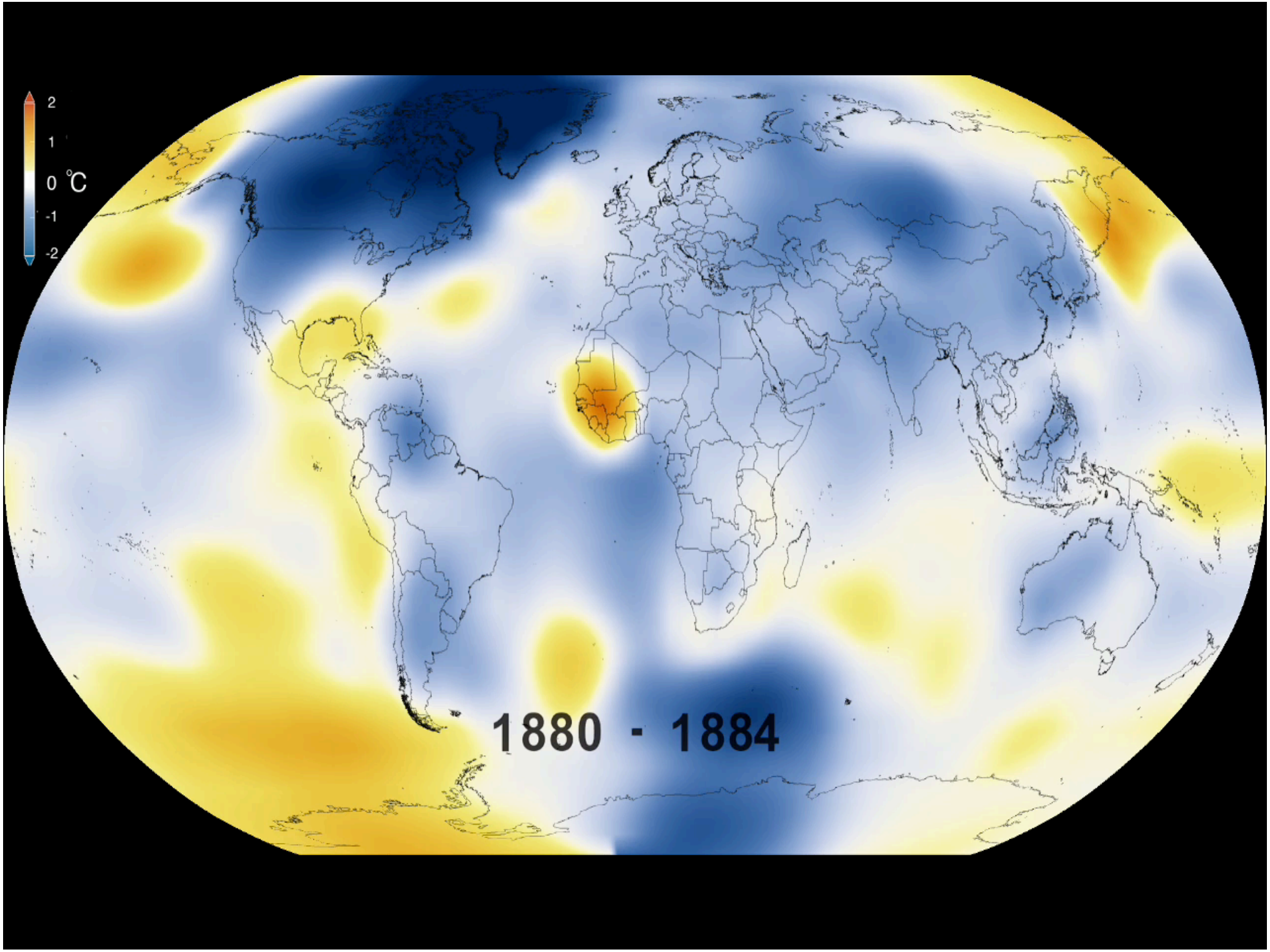

43.0°N, 87.9°W July Temperature Anomalies
Anomaly (°C)
Anomaly (°F)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
6.0
5.0
4.0
3.0
2.0
1.0
-0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

N America


North America Land Temperature Anomalies, July
Anomaly (°C)
Anomaly (°F)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
3.0
2.0
1.0
0.0
-1.0
-2.0
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

WORLD

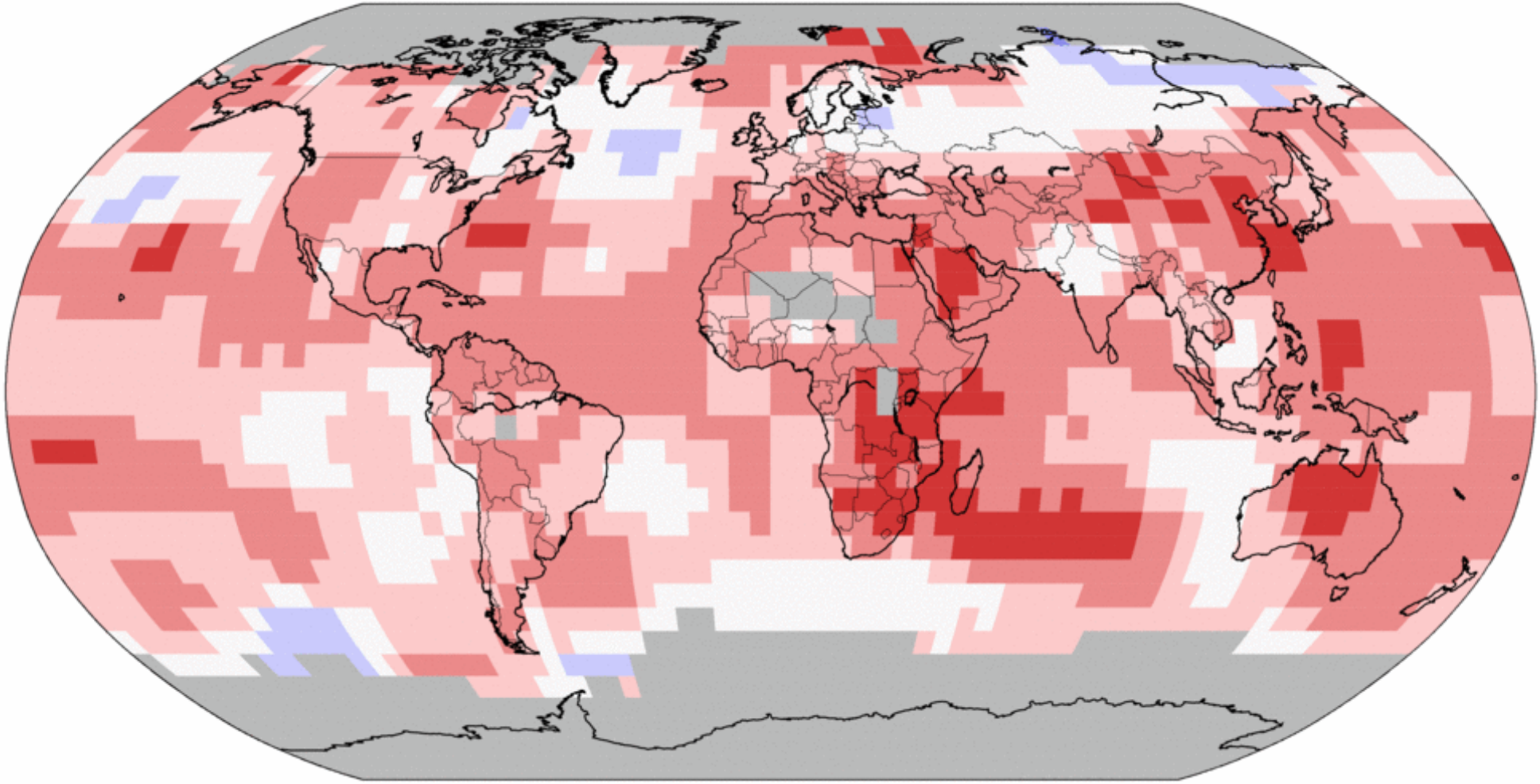

Global Land and Ocean Temperature Anomalies, July
Anomaly (°C)
Anomaly (°F)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.0
-0.1
-0.2
-0.3
-0.4
-0.5
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010


2
1
0 °C
-1
-2
1880 - 1884

Land & Ocean Temperature Percentiles Jul 2017

NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0



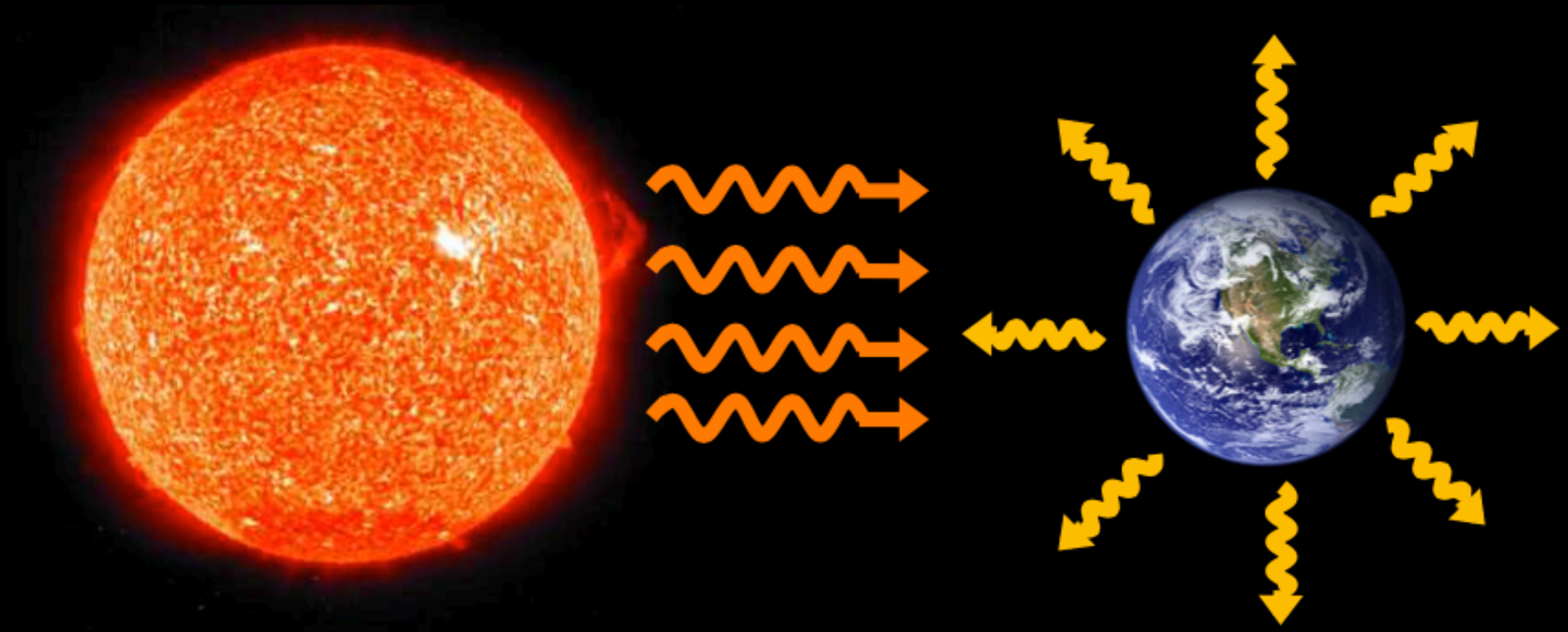
Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

Mon Aug 14 07:08:00 EDT 2017

Three things about climate

- Climate is the average of weather
- Climate changes naturally
- The study of climate change is well-established. We know how climate changes and what's is mostly causing current change

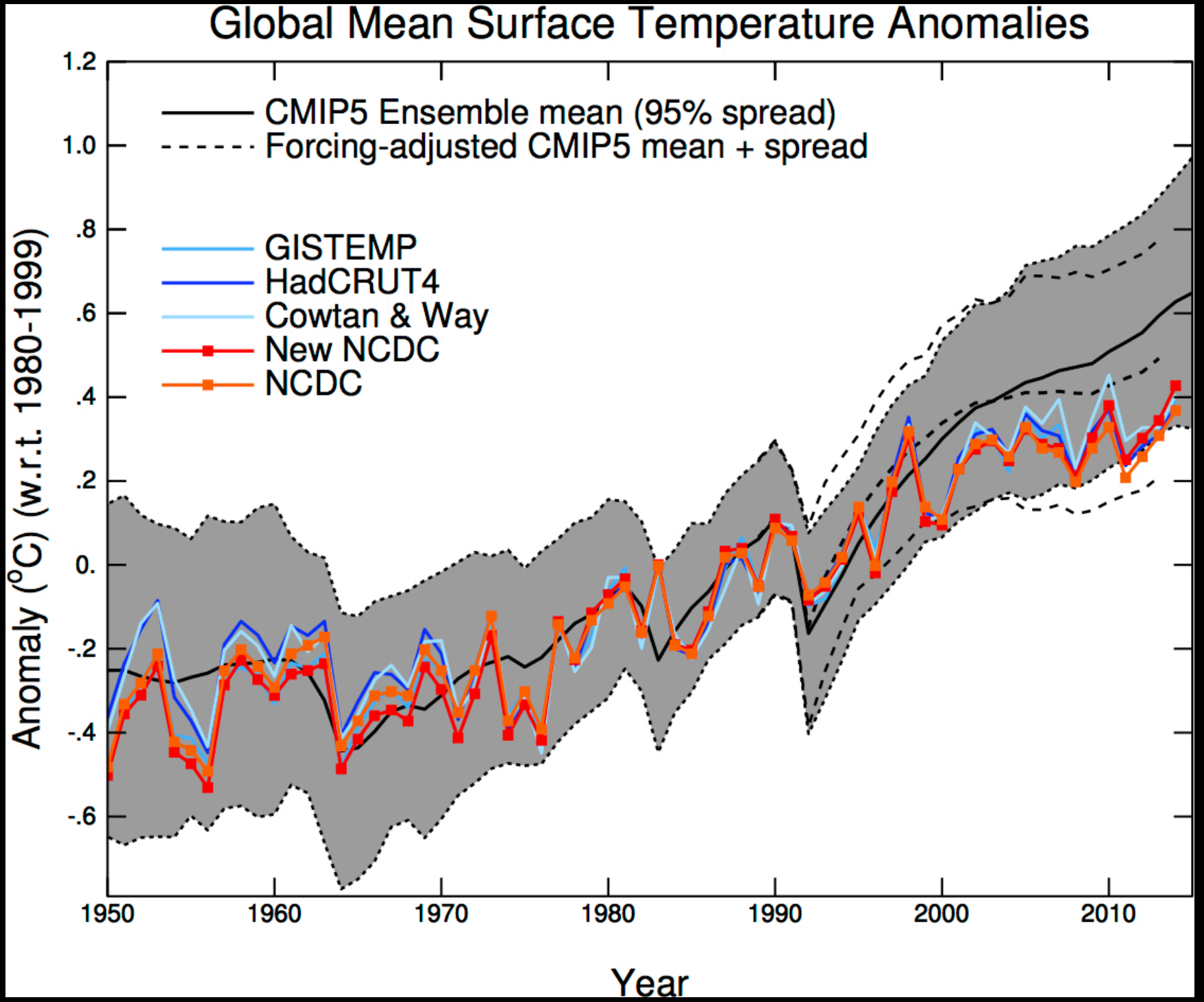
Planetary Radiation Balance

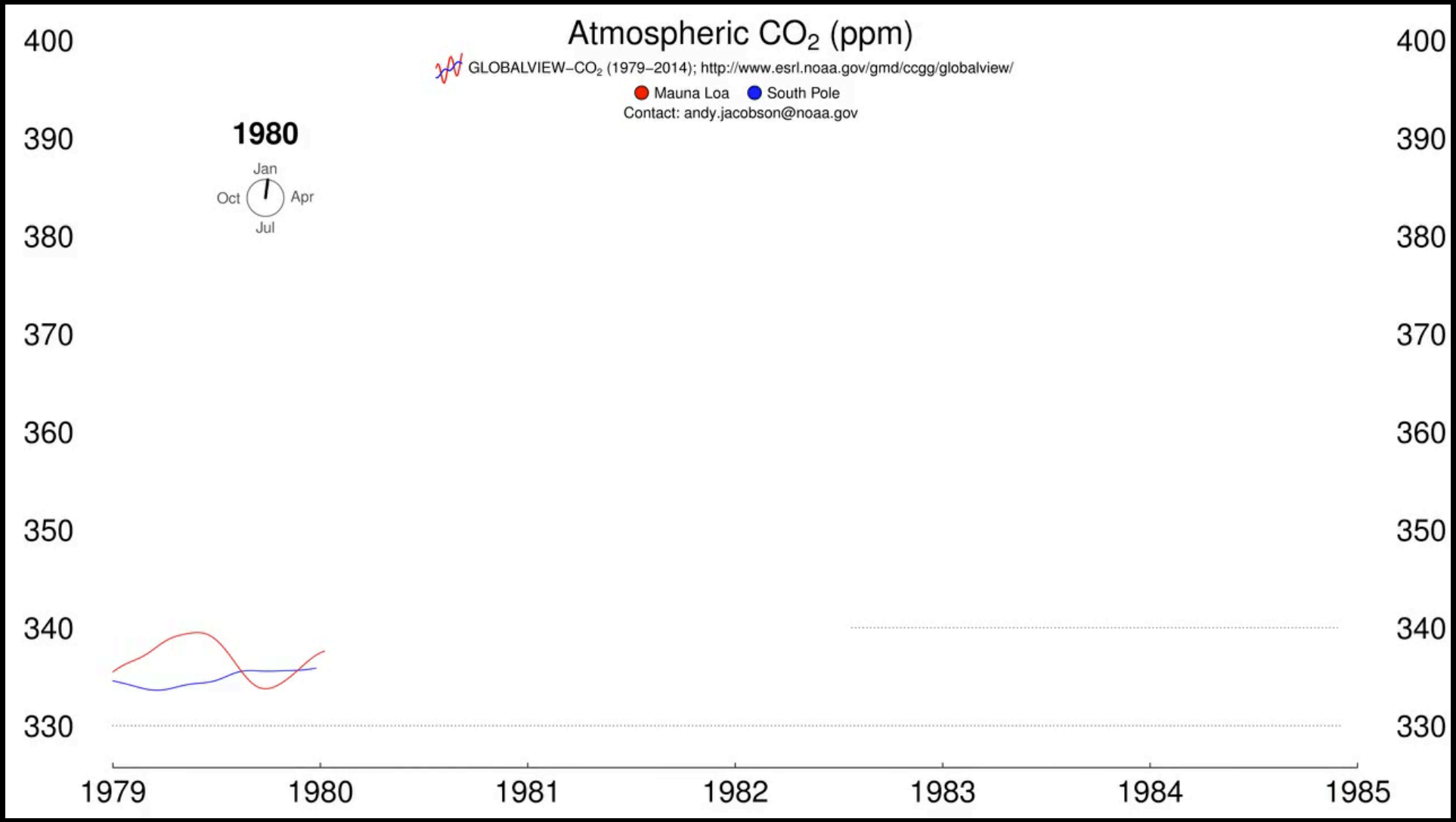


In most general terms, the Earth's temperature is determined by the balance between incoming energy from the sun and the heat it radiates back to space.


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.
1880
1880
2014
Colder
Based on an interactive by Bloomberg

Bloomberg


Global Mean Surface Temperature Anomalies
CMIP5 Ensemble mean (95% spread)
Forcing-adjusted CMIP5 mean + spread
GISTEMP
HadCRUT4
Cowtan & Way
New NCDC
NCDC
Anomaly (°C) (w.r.t. 1980-1999)
1.2
1.0
.8
.6
.4
.2
0.
-.2
-.4
-.6
1950
1960
1970
1980
1990
2000
2010
Year

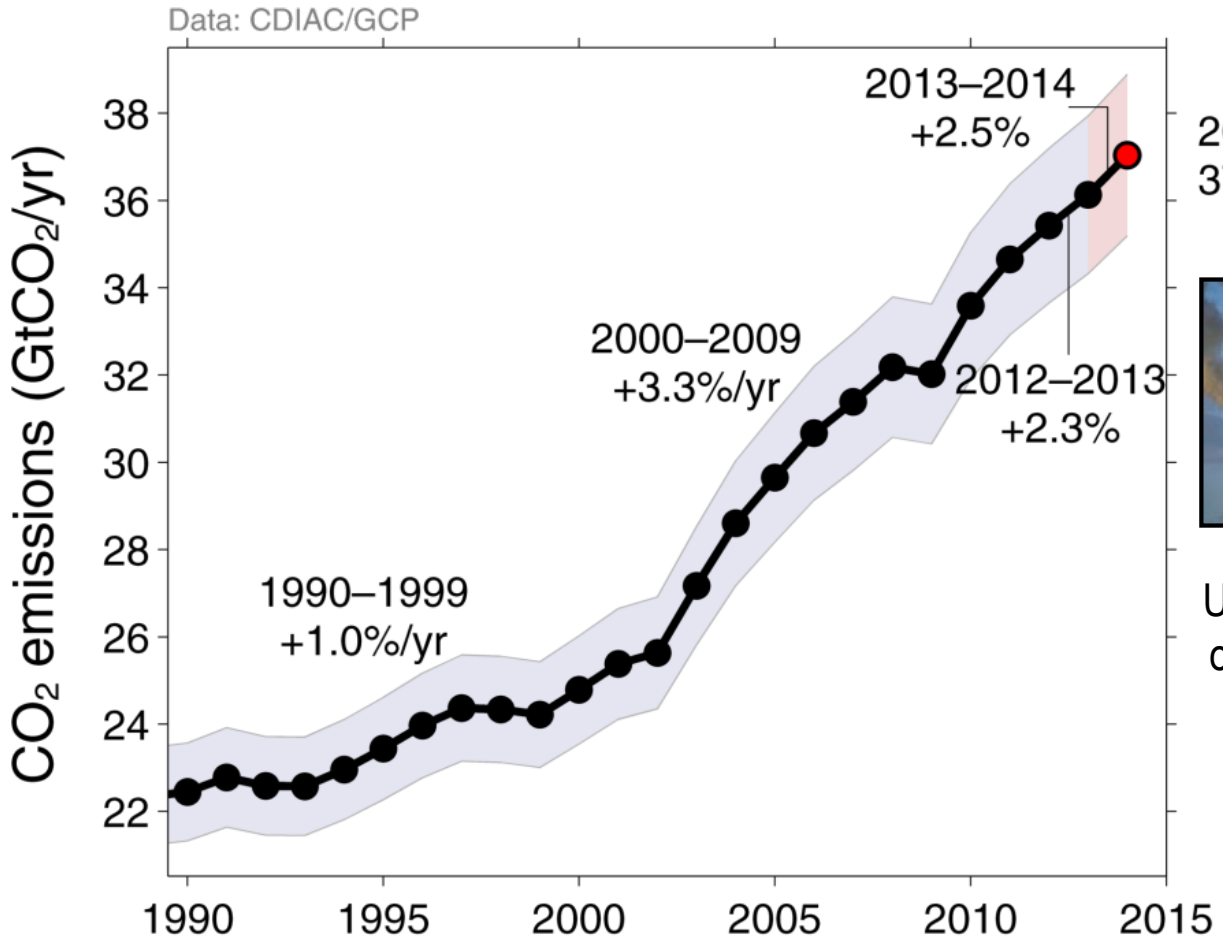


Other evidence: decreasing radiocarbon content of atmosphere, acidification of ocean, increased water use efficiency of plants, concentrations tracks emissions

Fossil Fuel and Cement Emissions

Global fossil fuel and cement emissions: 36.1 ± 1.8 $GtCO_2$ in 2013, 61% over 1990

- Projection for 2014 : 37.0 ± 1.9 $GtCO_2$, 65% over 1990

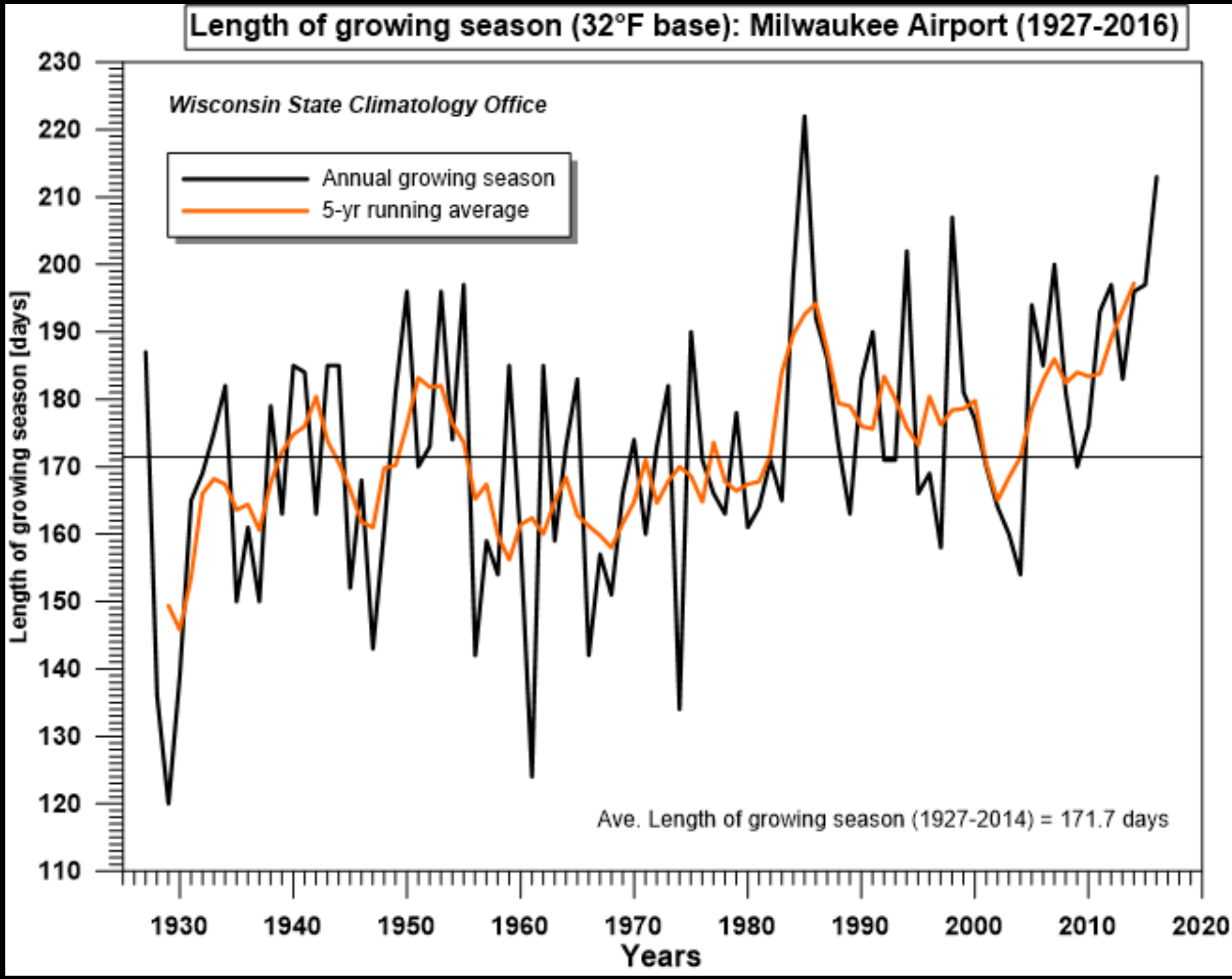


Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

Estimates for 2011, 2012, and 2013 are preliminary

Source: CDIAC; Le Quéré et al 2014; Global Carbon Budget 2014

So what’s the big deal?


Length of growing season (32°F base): Milwaukee Airport (1927-2016)
Wisconsin State Climatology Office
Annual growing season
5-yr running average
Length of growing season [days]
230
220
210
200
190
180
170
160
150
140
130
120
110
Ave. Length of growing season (1927-2014) = 171.7 days
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Years

Earlier arrival of spring in Wisconsin

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


Nina Leopold Bradley

Photo: Jeffrey Phelps, Milw. Journal Sentinel


Leopold Shack

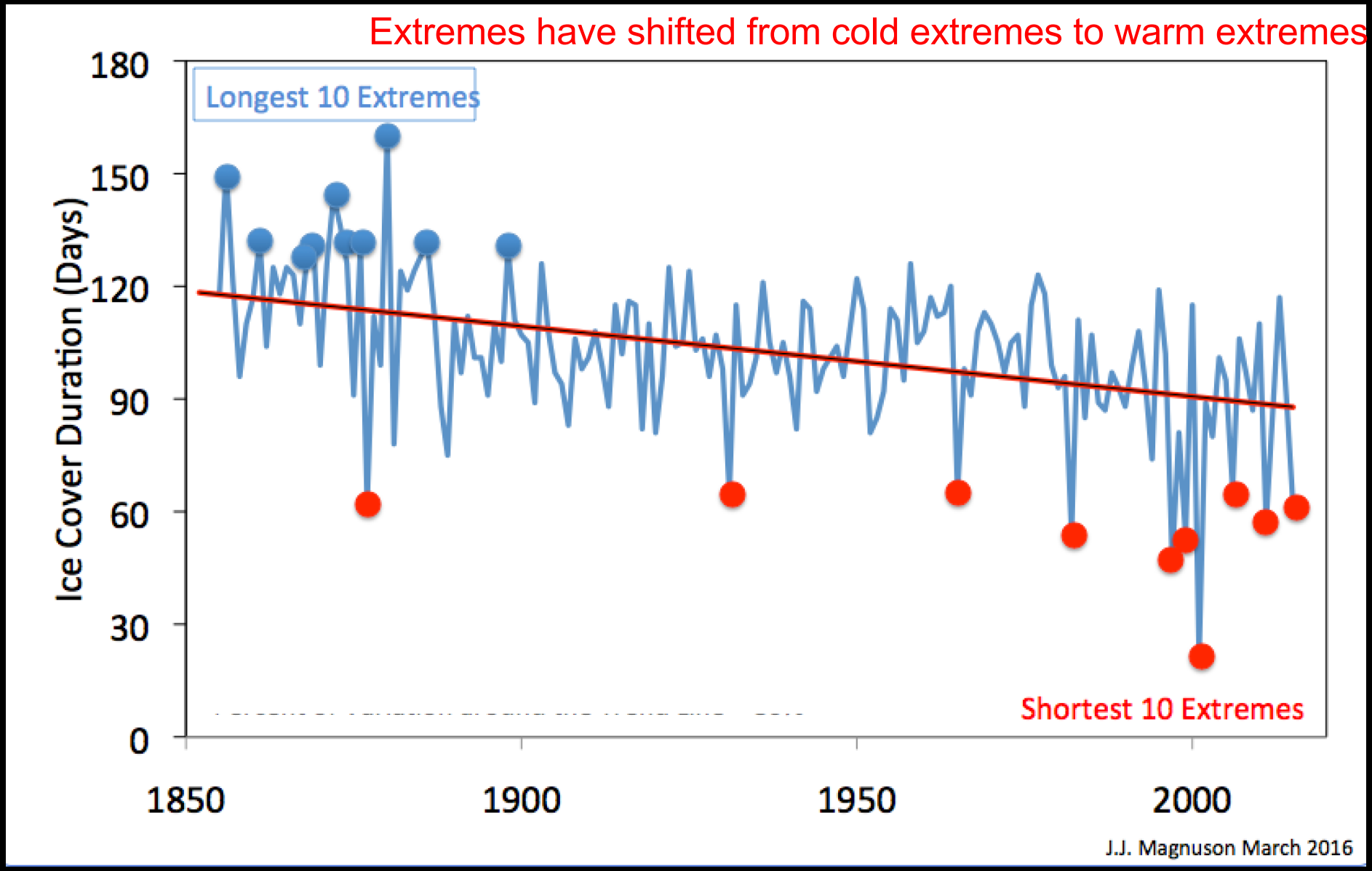
Photo: Aldo Leopold Foundation

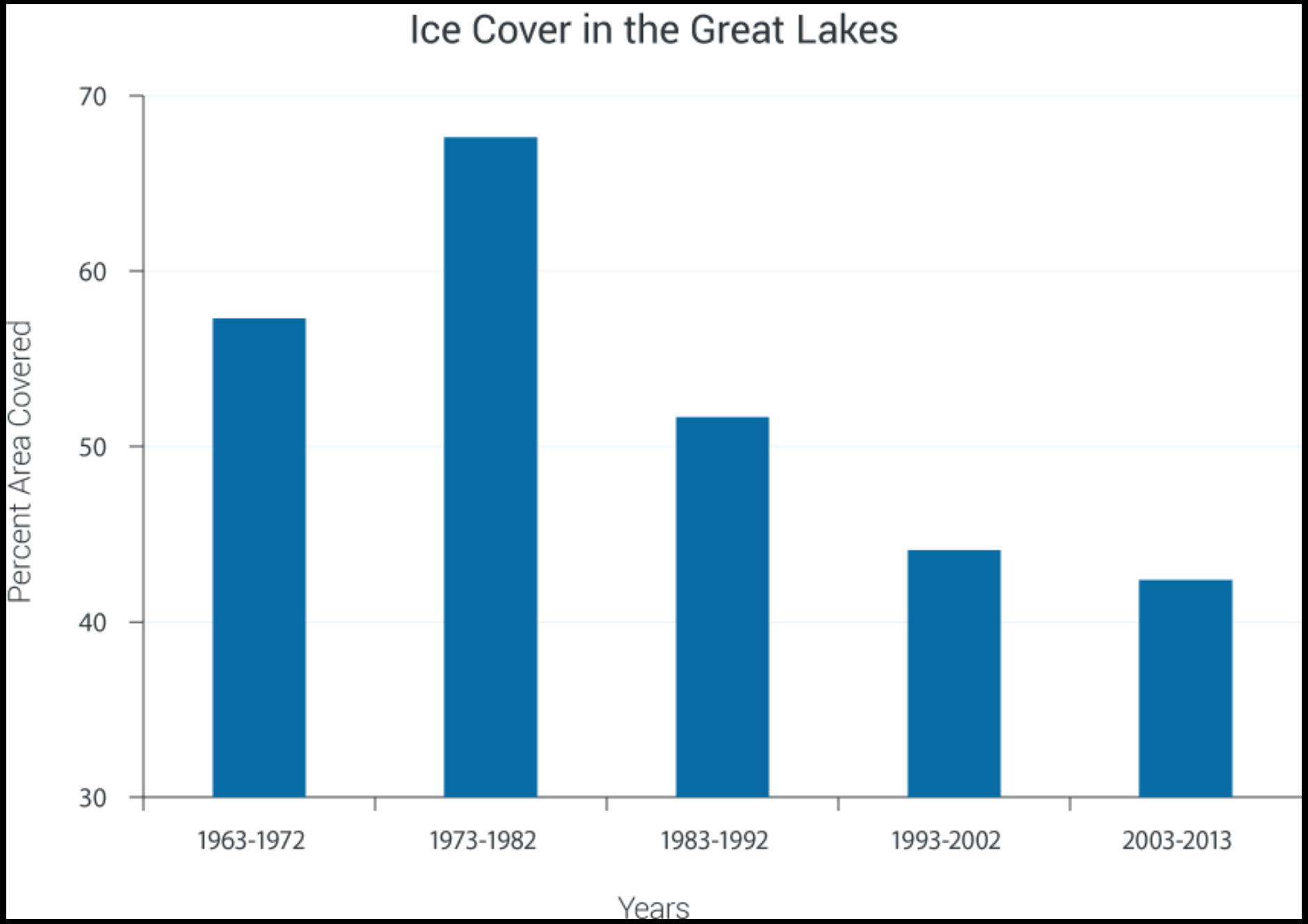
55 ecological indicators of spring occurred on average 1.2 days earlier per decade from 1936 to 1998.

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

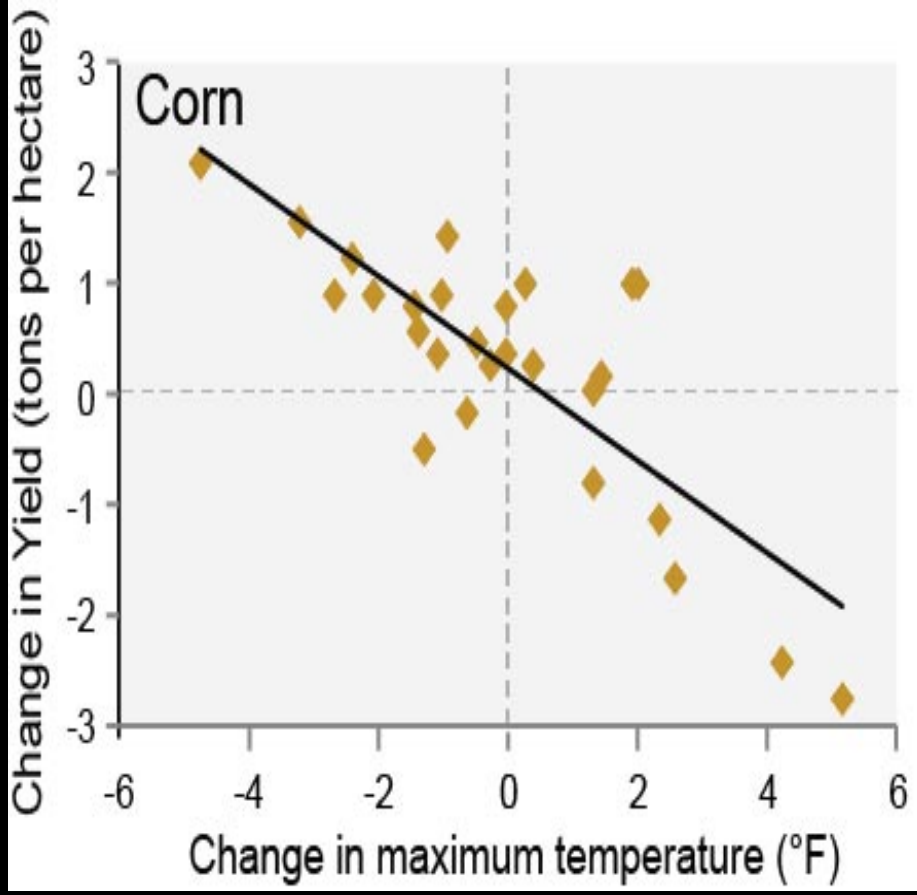
Slide adapted from C. Kucharik, UW-Madison

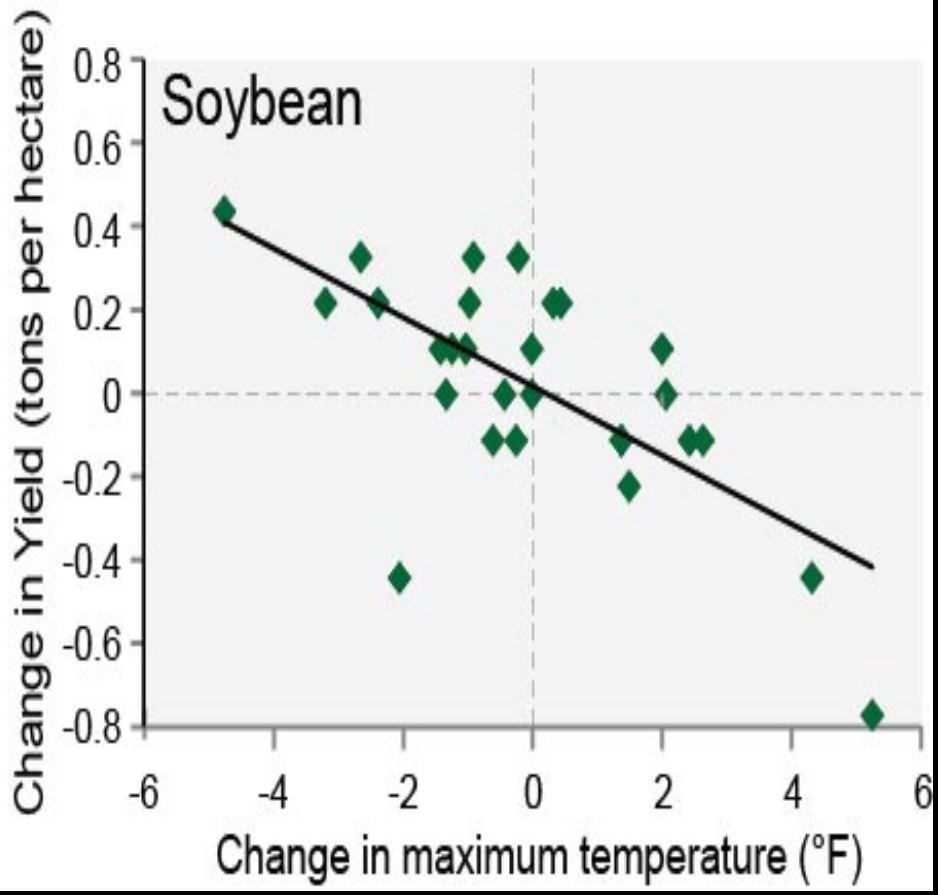
A change in Extreme Winters for Lake Mendota, Wisconsin

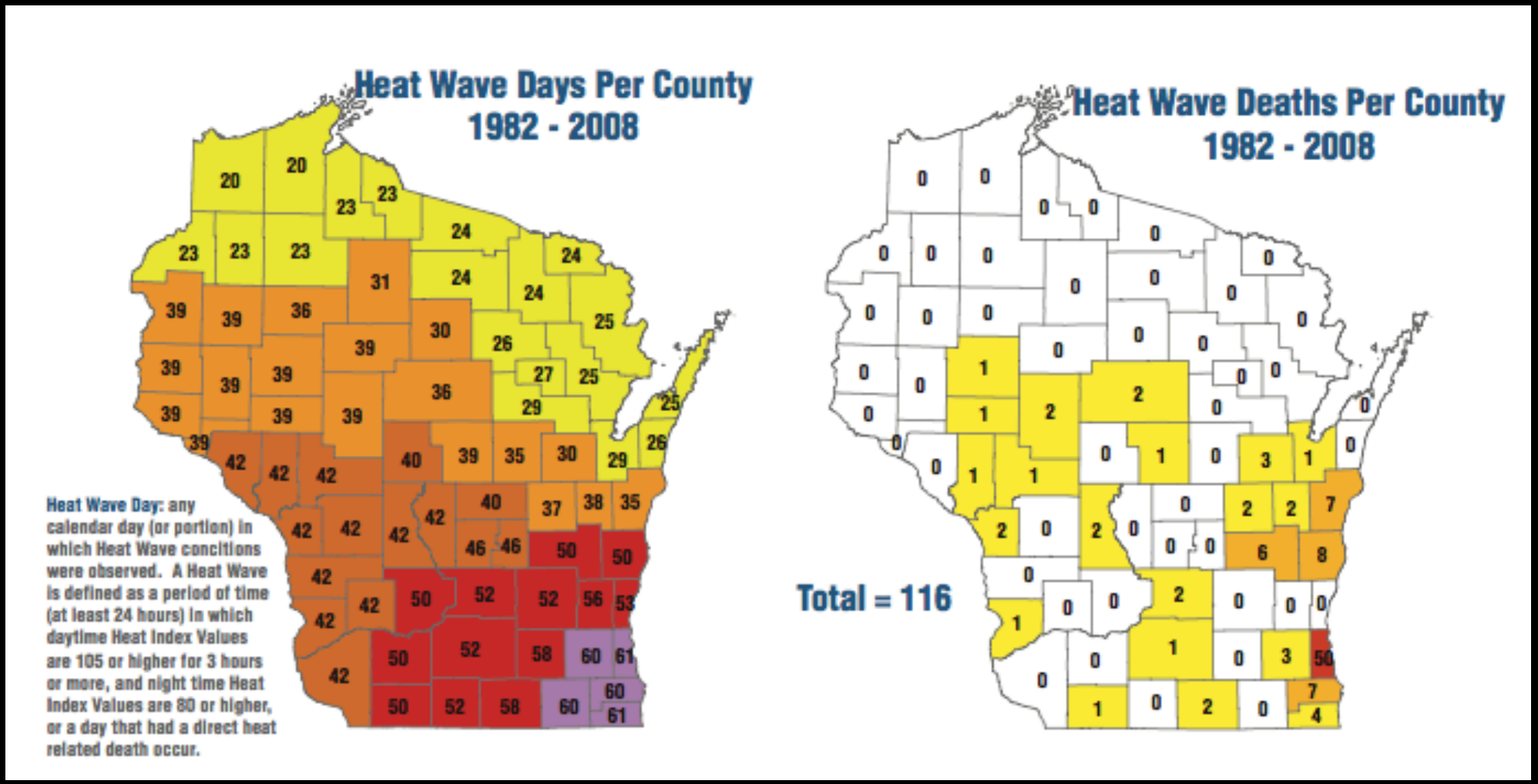


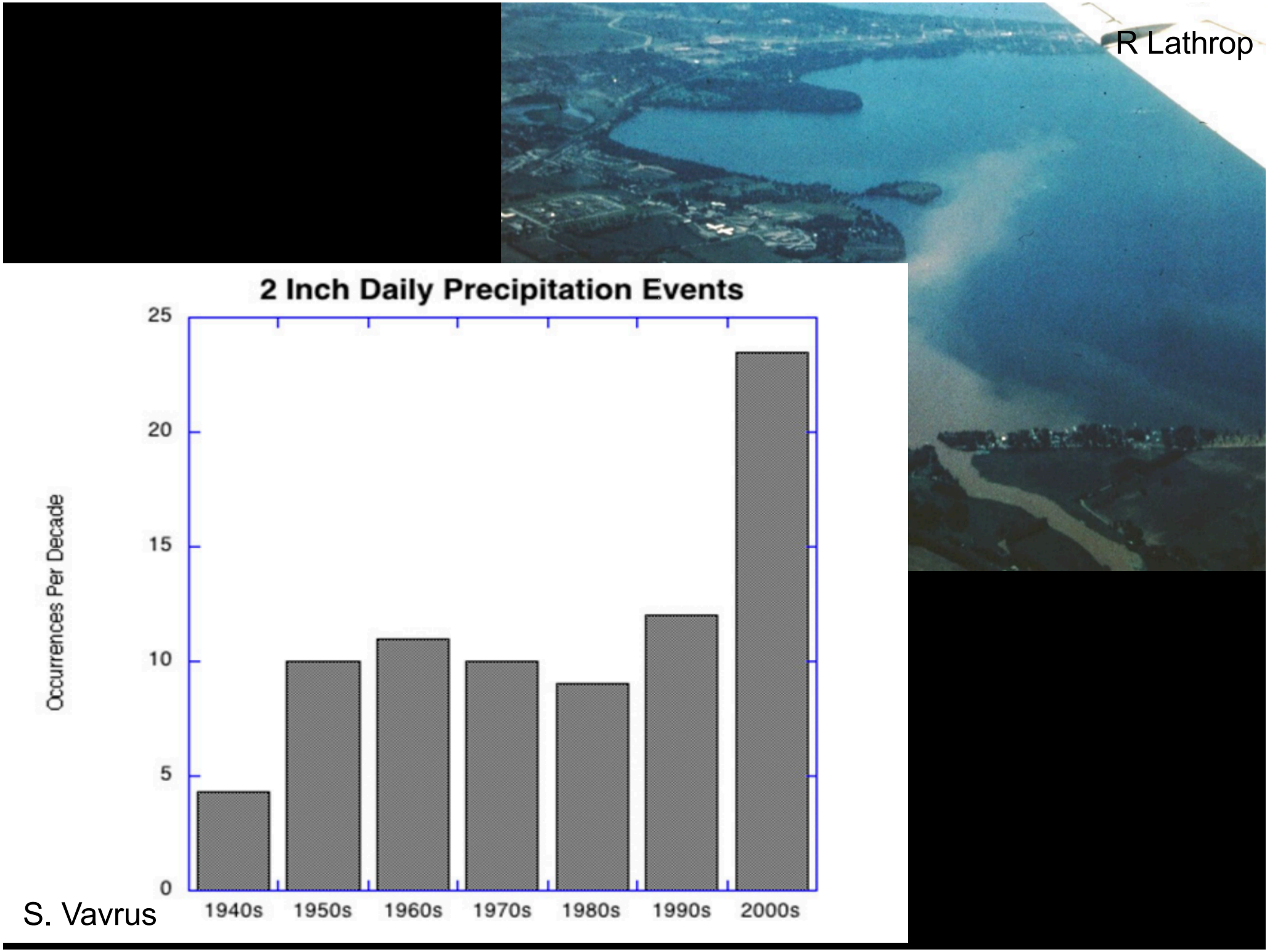

Ice Cover in the Great Lakes
70
60
50
40
30
Percent Area Covered
1963-1972
1973-1982
1983-1992
1993-2002
2003-2013
Years

Crop Yields Decline under Higher Temperatures



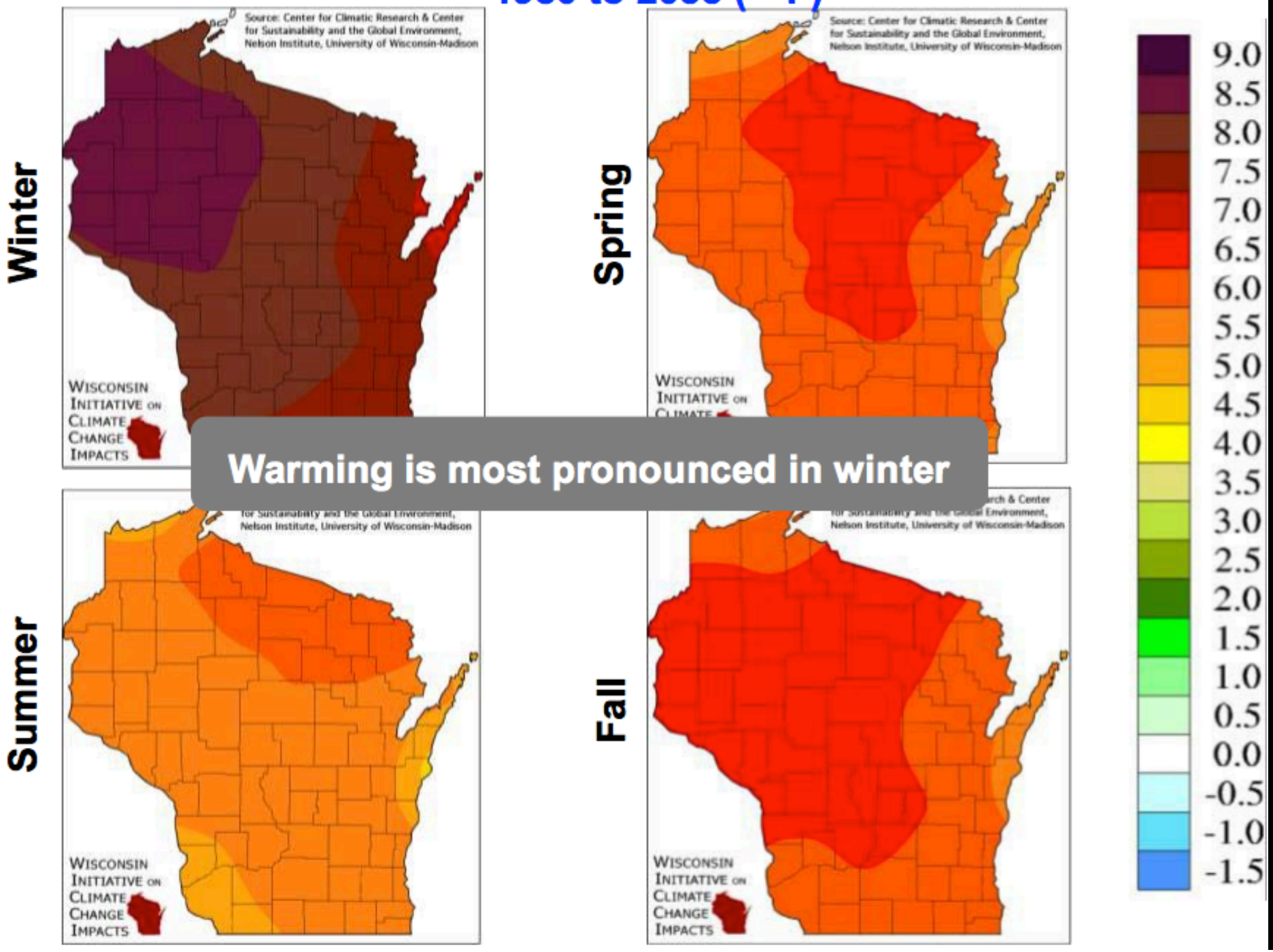



Heat Wave Days Per County
1982 - 2008
Heat Wave Day: any calendar day (or portion) in which Heat Wave concitions were observed. A Heat Wave is defined as a period of time (at least 24 hours) in which daytime Heat Index Values are 105 or higher for 3 hours or more, and night time Heat Index Values are 80 or higher, or a day that had a direct heat related death occur.
Heat Wave Deaths Per County
1982 - 2008
Total = 116

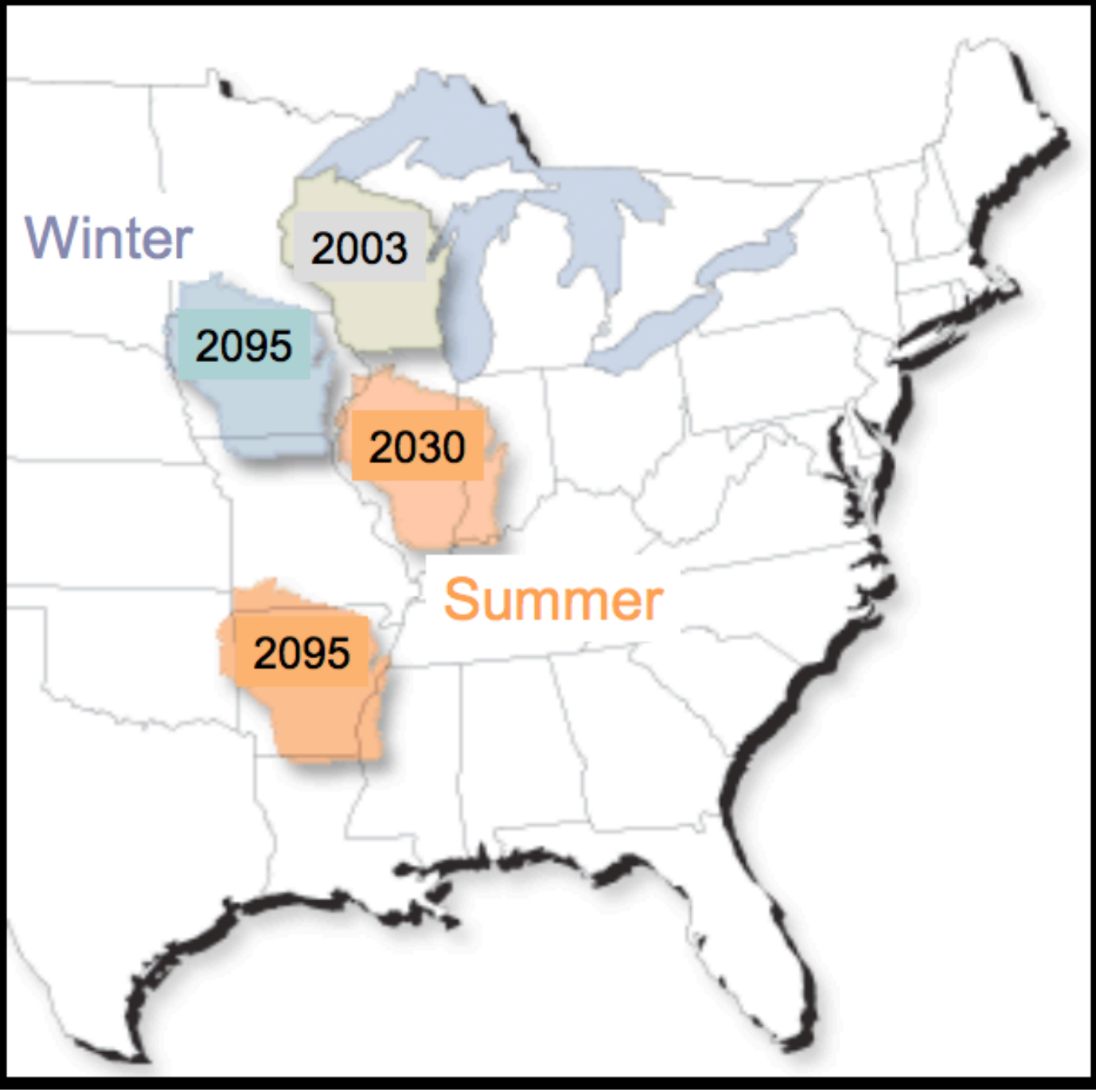

R Lathrop
2 Inch Daily Precipitation Events
Occurrences Per Decade
25
20
15
10
5
0
1940s
1950s
1960s
1970s
1980s
1990s
2000s
S. Vavrus

Projected Change in Seasonal Temperatures

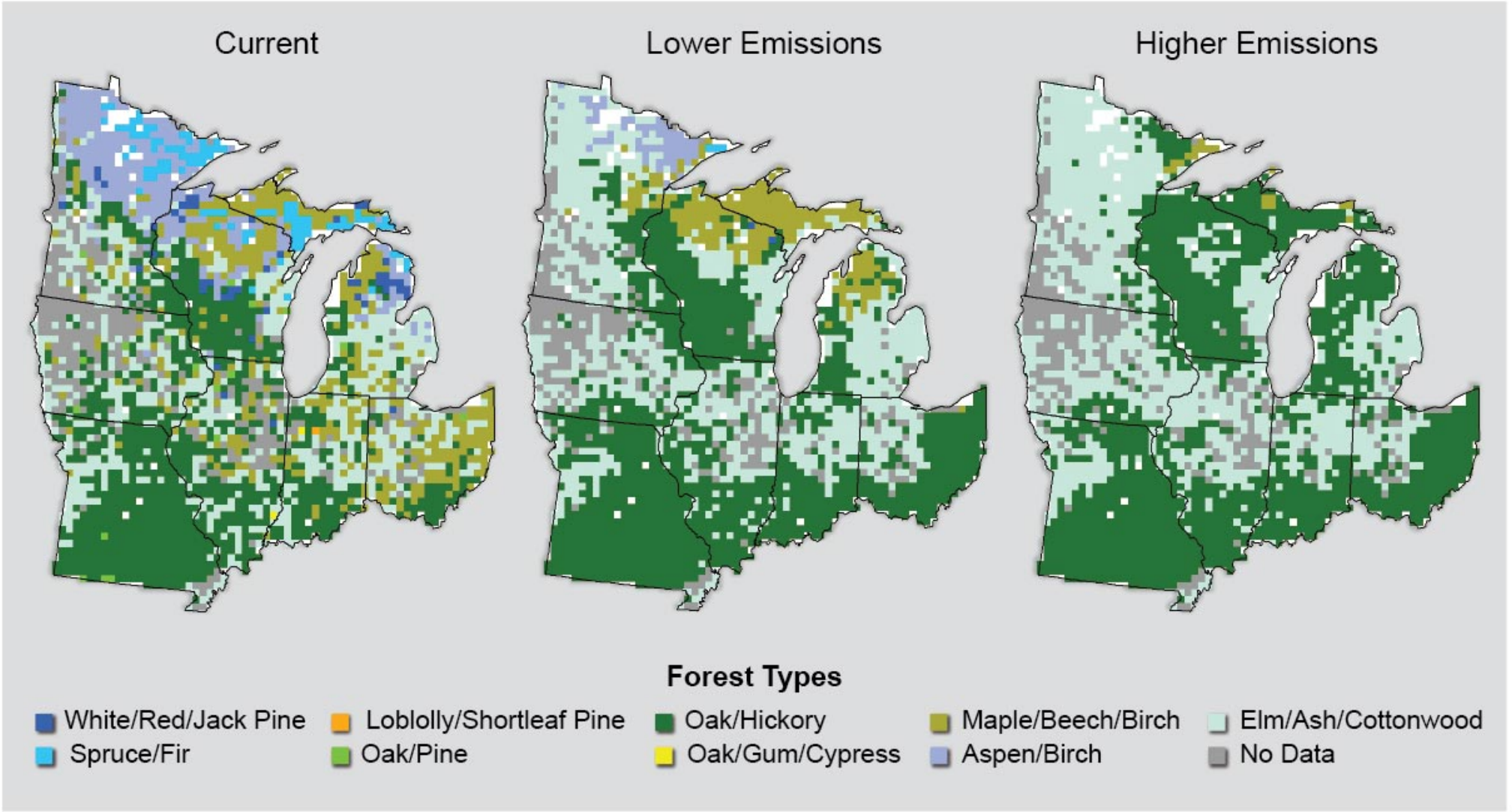
1980 to 2055 (° F)



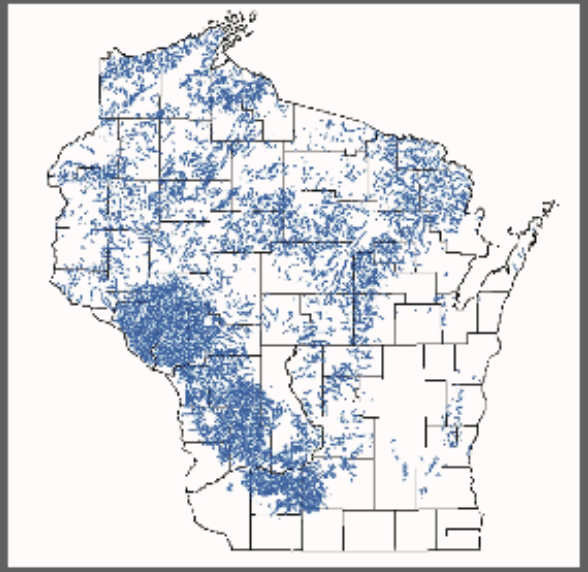
Wisconsin Migrating Climate



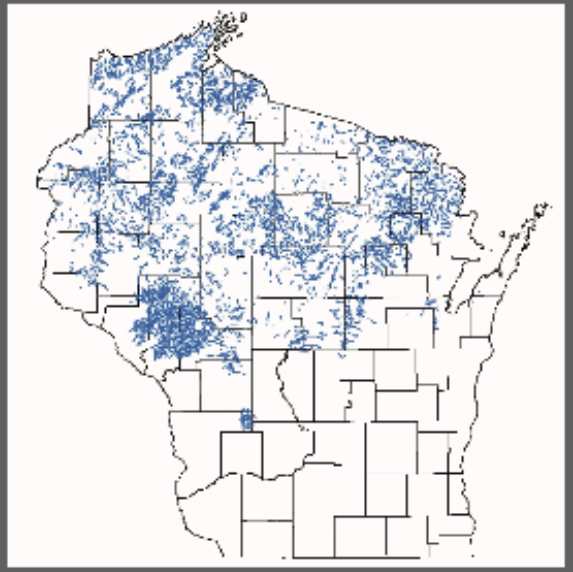
Forest Composition Shifts



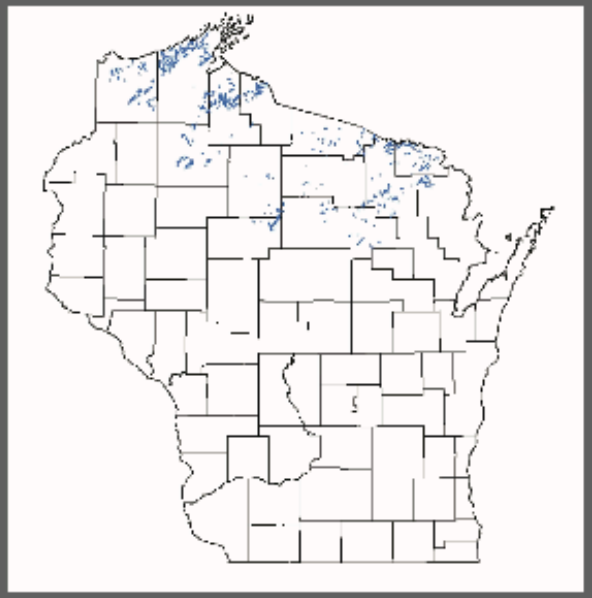
Brook trout streams
Source: WICCI



Current climate



Best case
+1.4°F = 44% loss

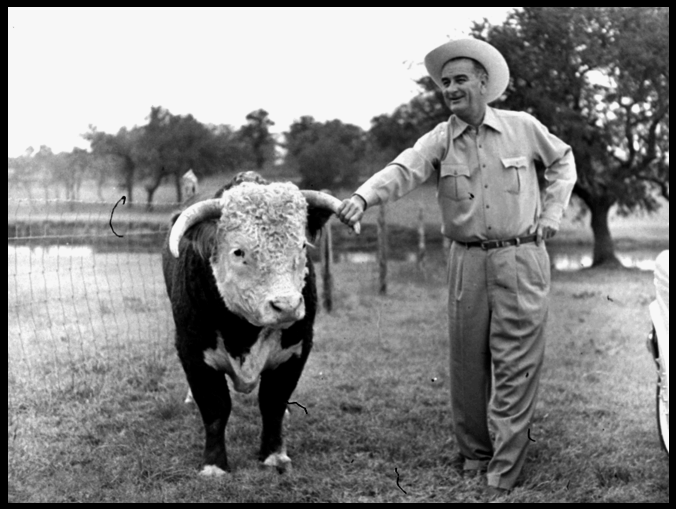


Moderate case
+4.3°F = 94% loss

Worst case
+7.2°F = total loss

Why aren’t we doing something about it then?

The continued release of CO_2 to the atmosphere from burning fossil fuels would "almost certainly cause significant changes" and "could be deleterious from the point of view of human beings […] and marked changes in climate, not controllable through local or even national efforts.



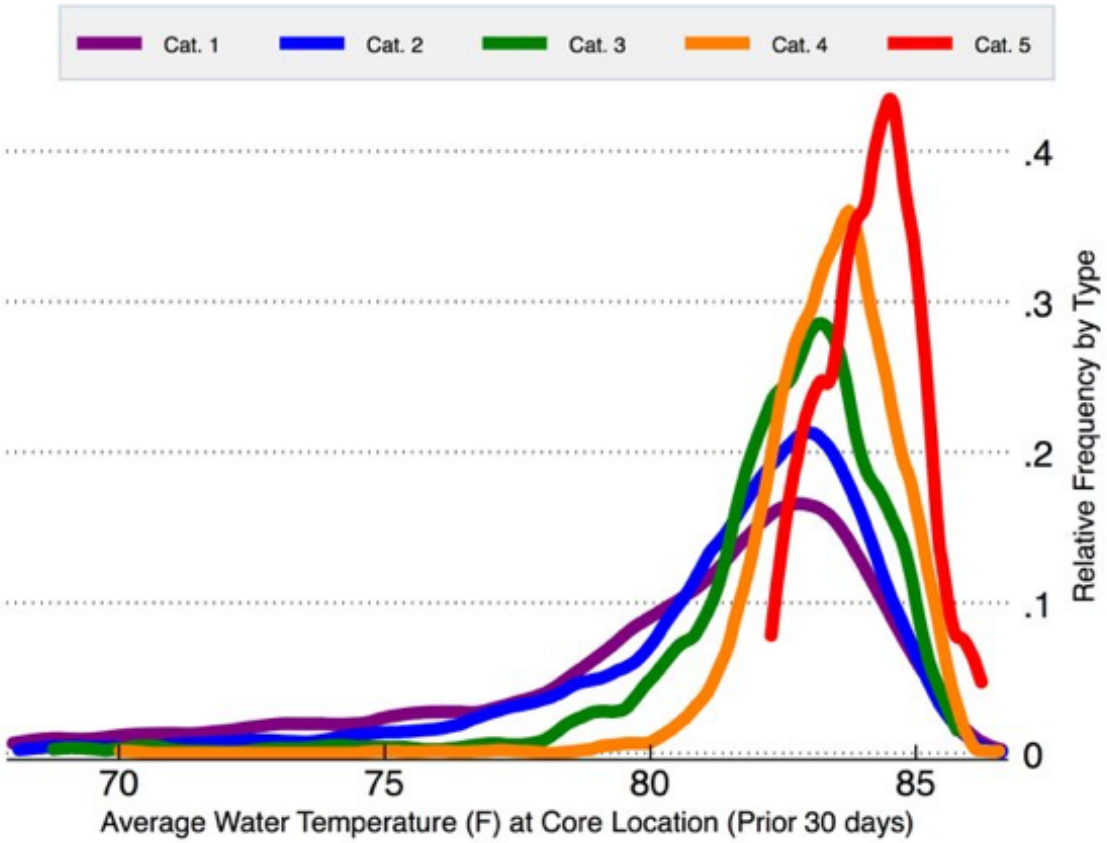
U.S. President's Science Advisory to President Lyndon B. Johnson 1966

DOOMSDAY Thinking

- The imagery of the impossible leads to the art of the no deal

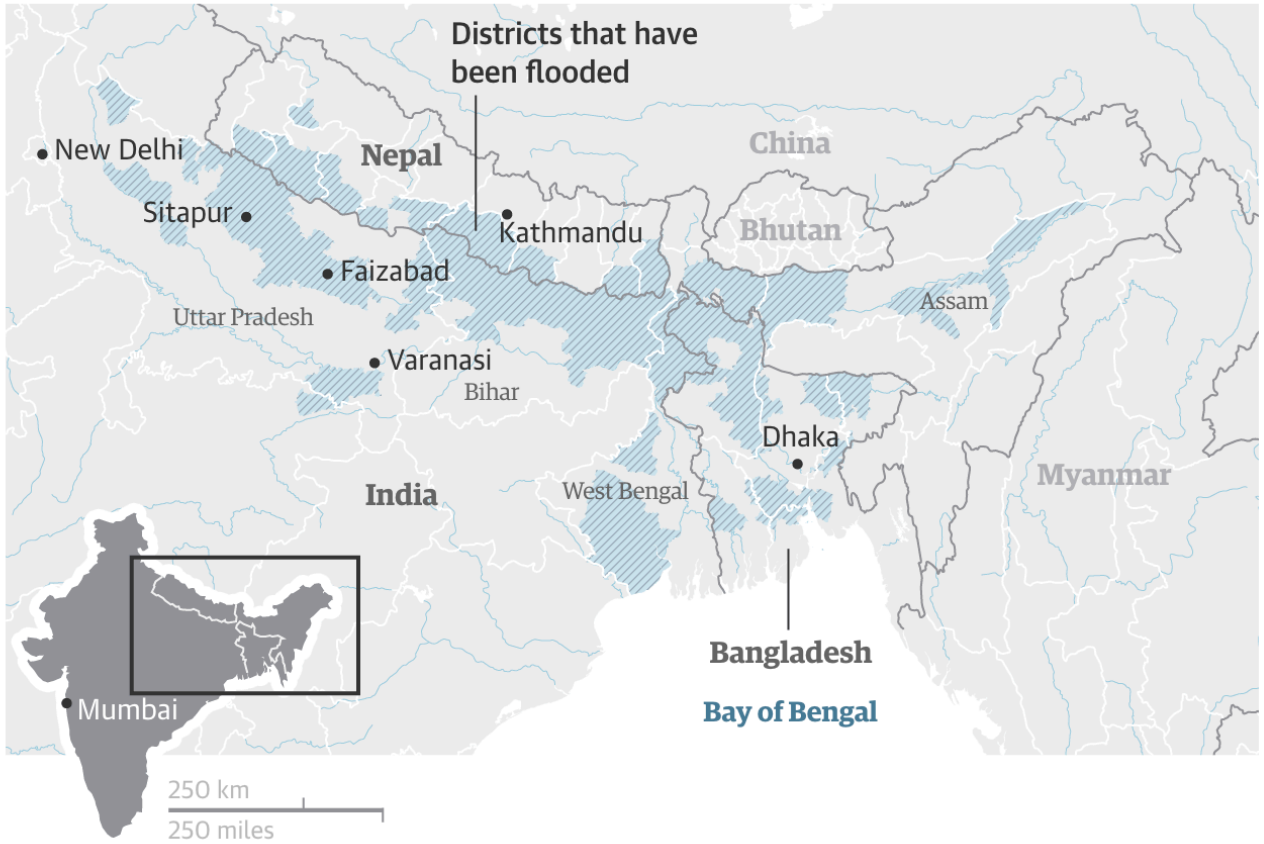

outnow.ch

Hurricane Strength and Ocean Temperatures



Kernal density functions of SSTs by hurricane category. Area under each curve represents 100% of hurricanes of that type. Hurricane wind speeds via HURDAT.

More than 1,200 people have died across India, Bangladesh and Nepal as a result of flooding



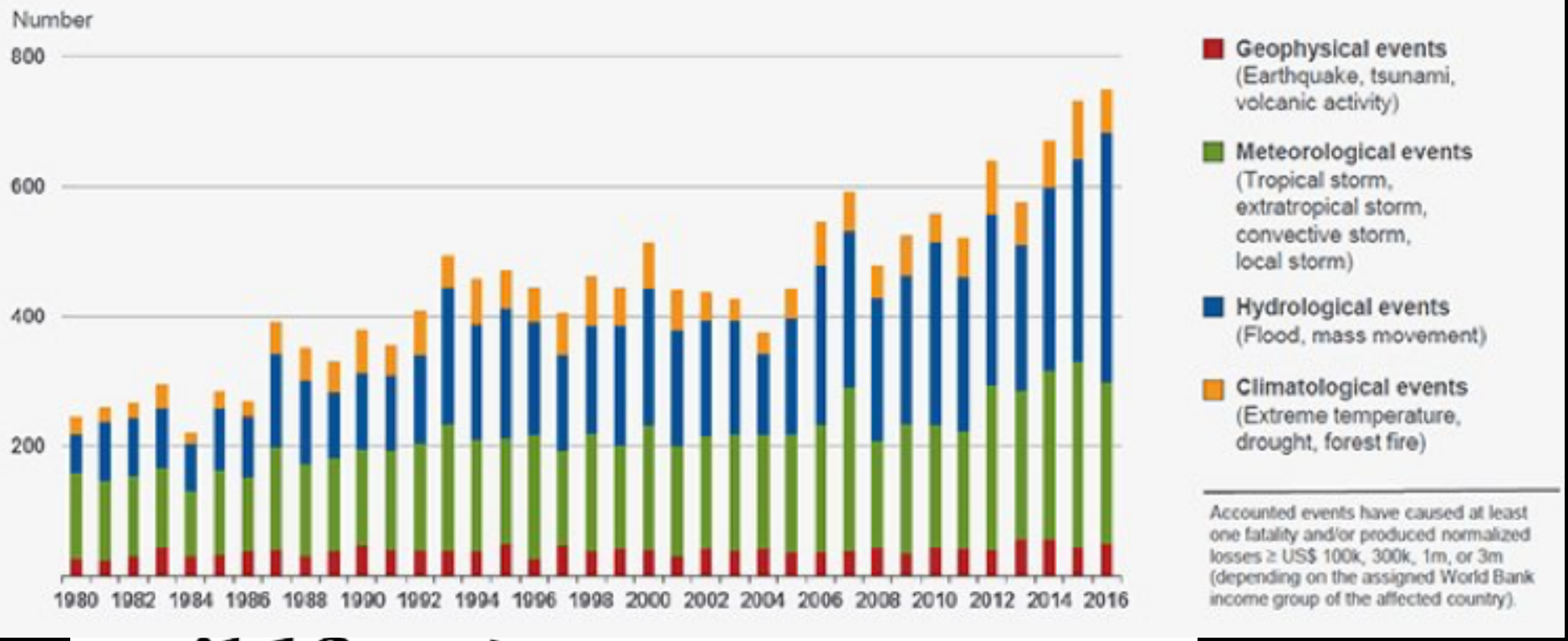
LA Times

Fires, droughts and hurricanes: What's the link between climate

Number Of Natural Catastrophes

Global - 1980-2016

Source: Munich Re, Geo Risks Research



Wildfires?

It was supposed to be a quiet year.

●●○○○ CC 6:56 PM 48%

cnn.com

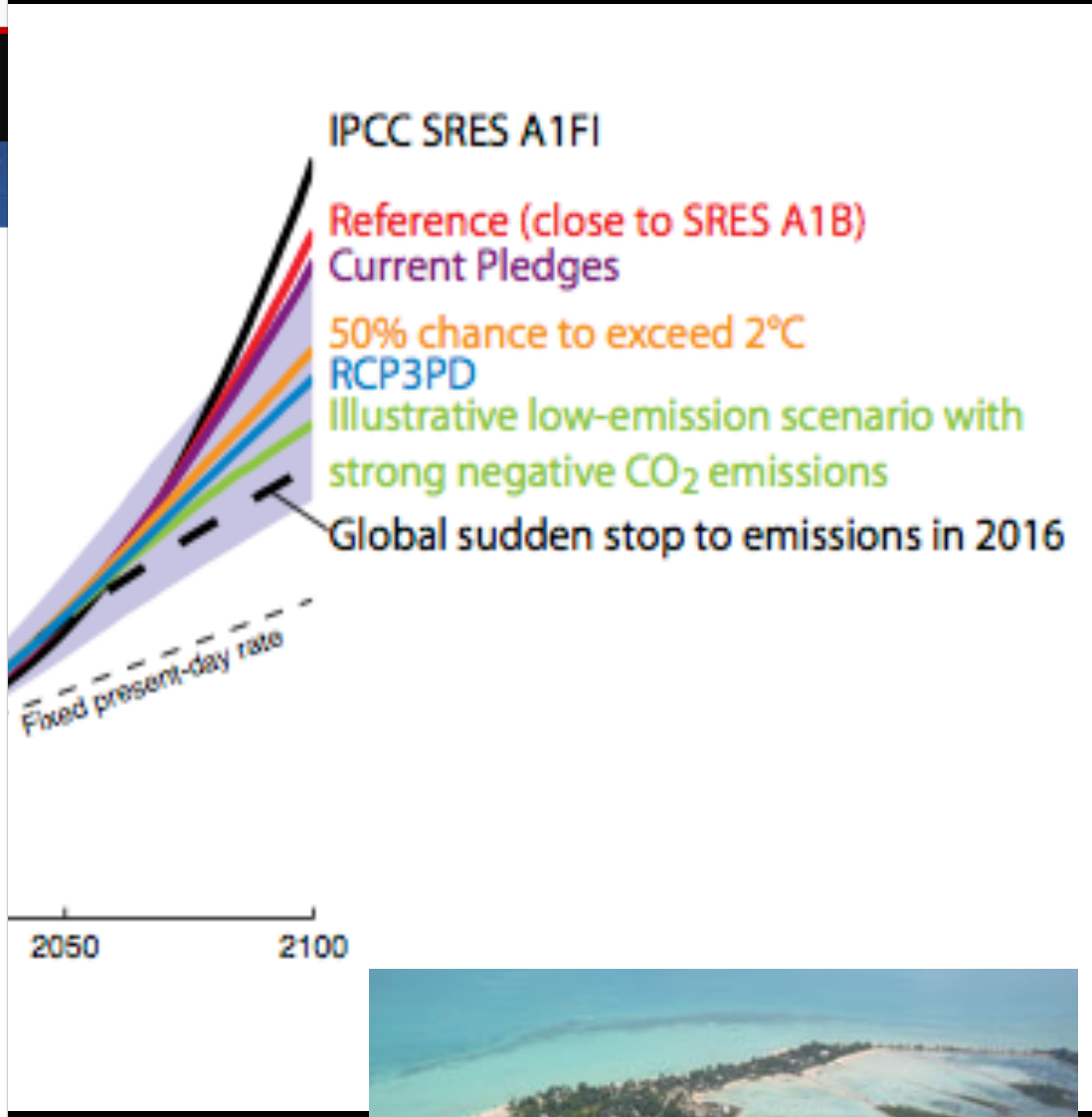
CNN U.S. + Live TV

ZAKARIA

Neil deGrasse Tyson says it might be 'too late' to recover from climate change

By **Alexandra King**, CNN

Updated 4:18 PM ET, Sun September 17, 2017



Maarten van Aalst / World Bank

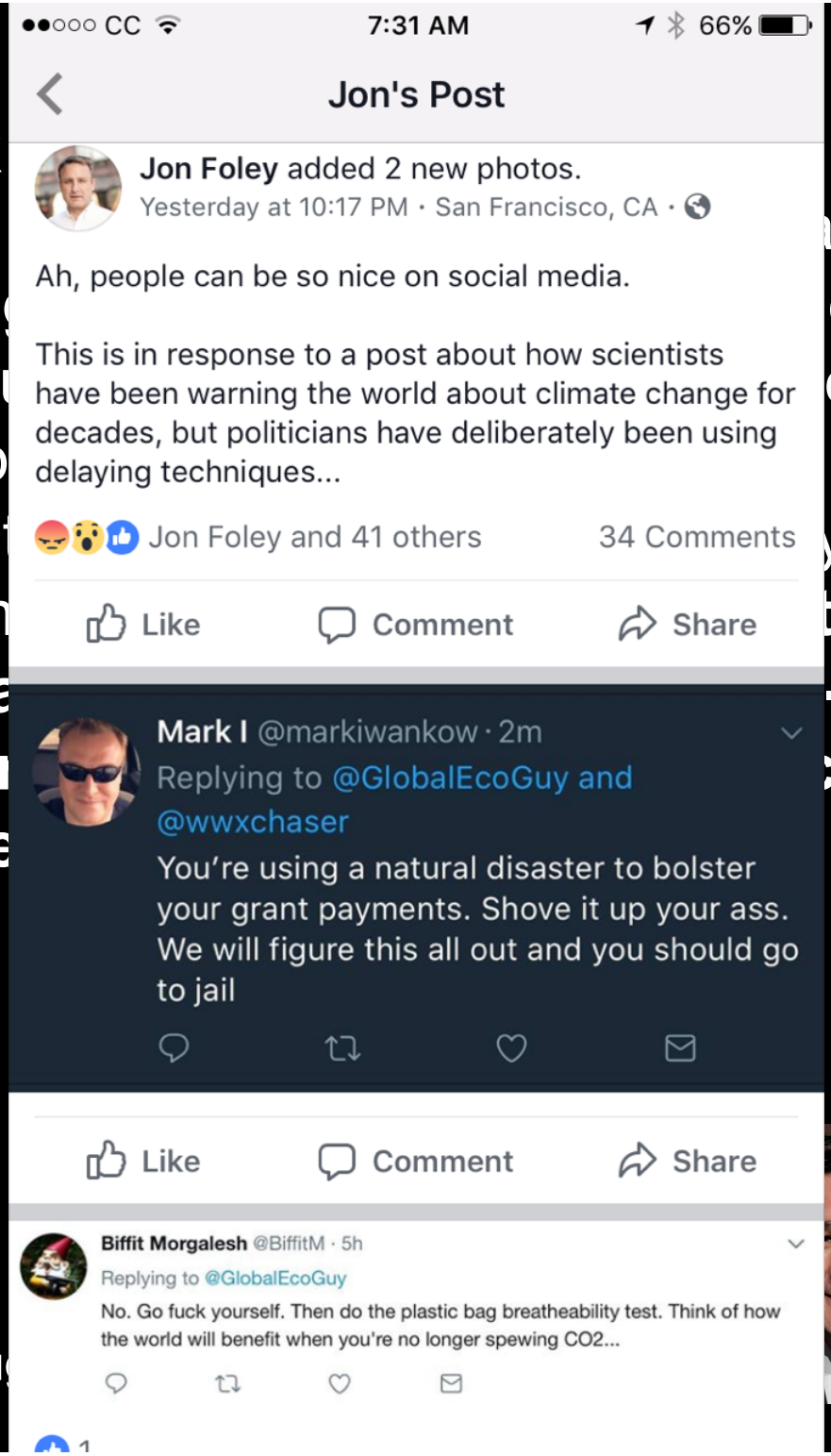
So what do you do about climate change?

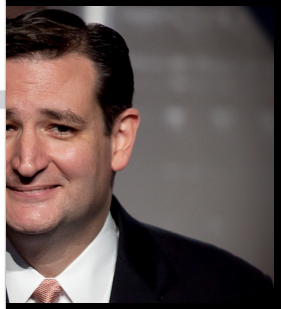
- Denialism is a normal doomsday response
- So is alarmism. Trying an “all of the above” solution is paralyzing
- But, there are some levers we know work:
  - Rethinking agriculture
  - Reducing deforestation
  - Expanding our energy choices
  - Providing incentives to change

We do and believe like our neighbors

- Or at least, what we think are neighbors do and believe…

- “If you look … they don't like to look … ata. […] I read this morning … e 1970s talking abou… e data proved to b… So then all the advocat… y shifted to global warn… **terestingly enough wa… -- governmen… ctor and every aspe…**





Washington Post, 2 Au…

We do and believe like our neighbors

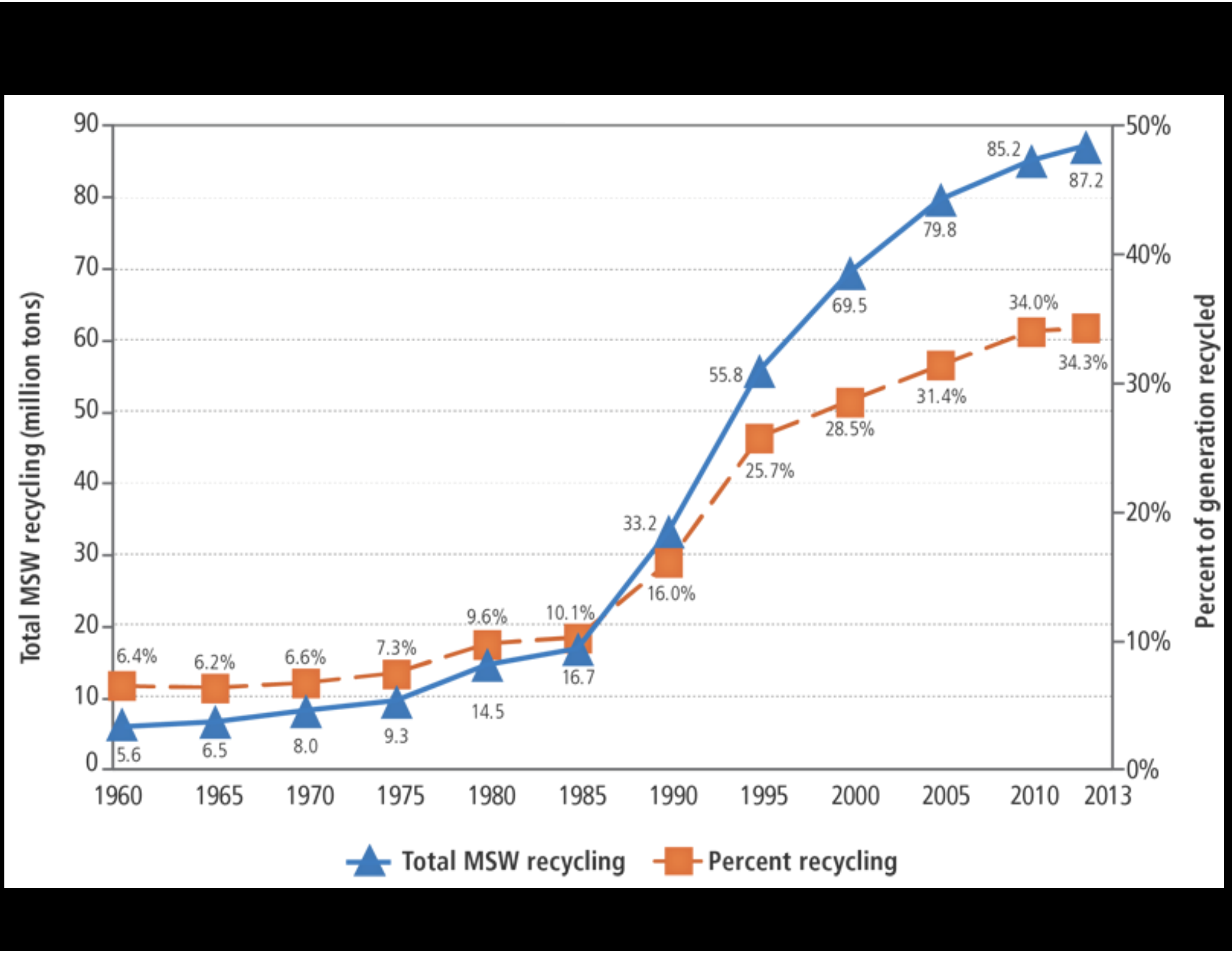
- Or at least, what we think are neighbors do and believe…

- BUT

Community standards can change

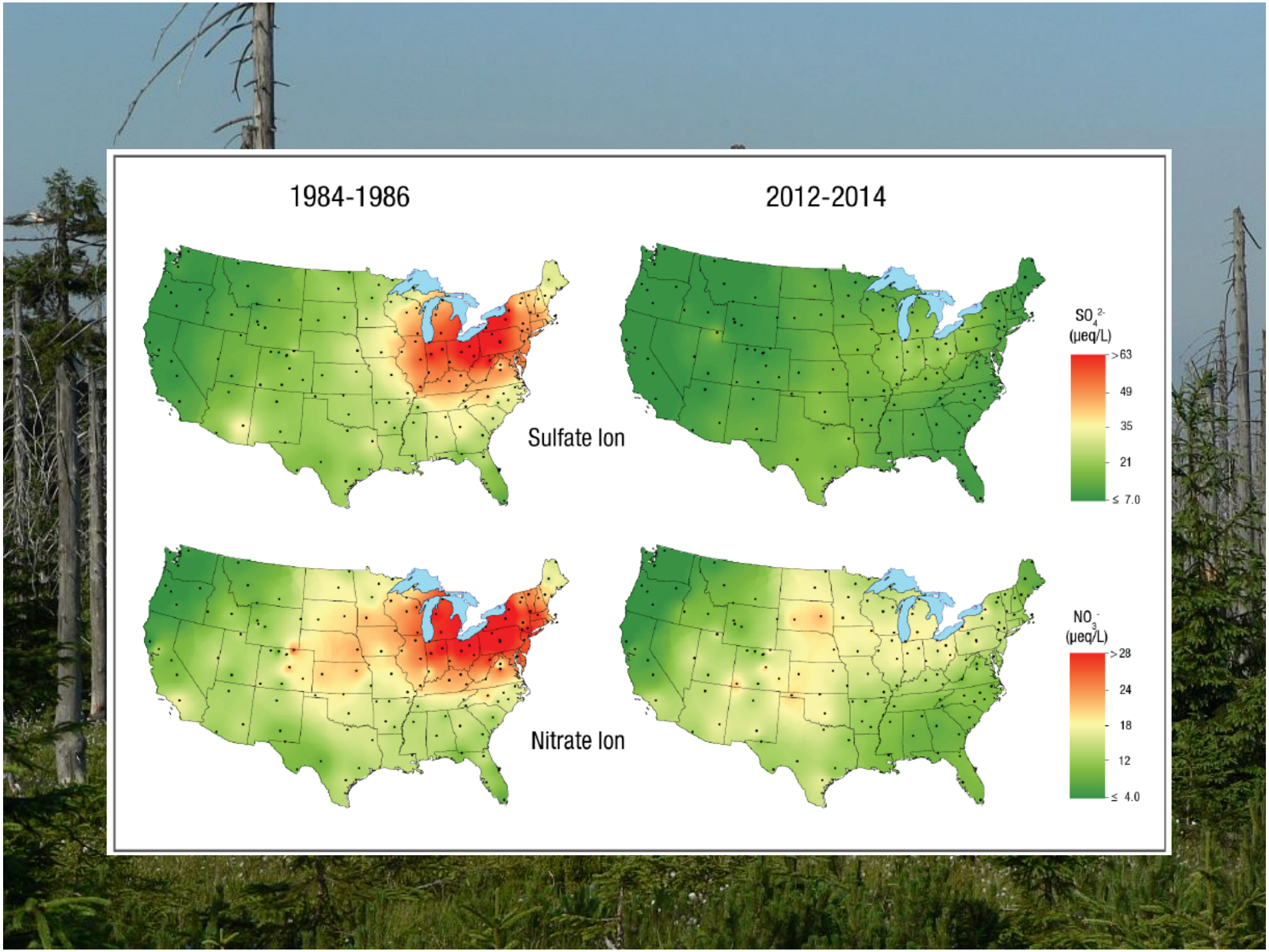
Community standards can change

- Education and generational change
  - Recycling


Total MSW recycling (million tons)
Percent of generation recycled
90
80
70
60
50
40
30
20
10
0
50%
40%
30%
20%
10%
0%
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2013
5.6
6.5
8.0
9.3
14.5
16.7
33.2
55.8
69.5
79.8
85.2
87.2
6.4%
6.2%
6.6%
7.3%
9.6%
10.1%
16.0%
25.7%
28.5%
31.4%
34.0%
34.3%
Total MSW recycling
Percent recycling

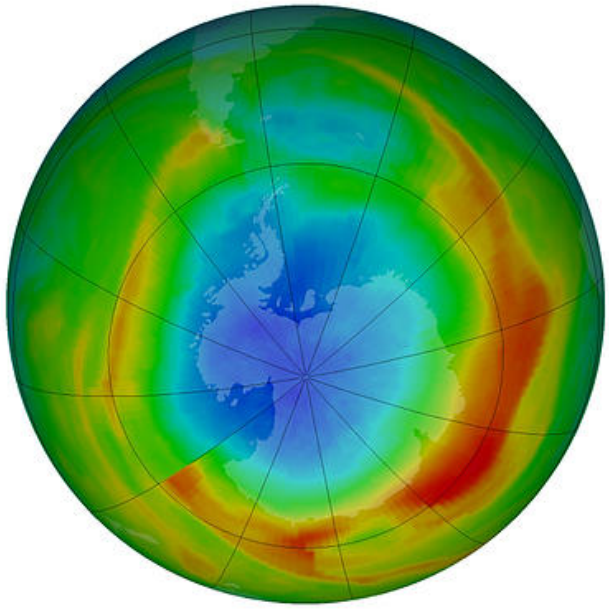
Community standards can change

- Education and generational change
  - Recycling
- Regulation
  - Acid rain

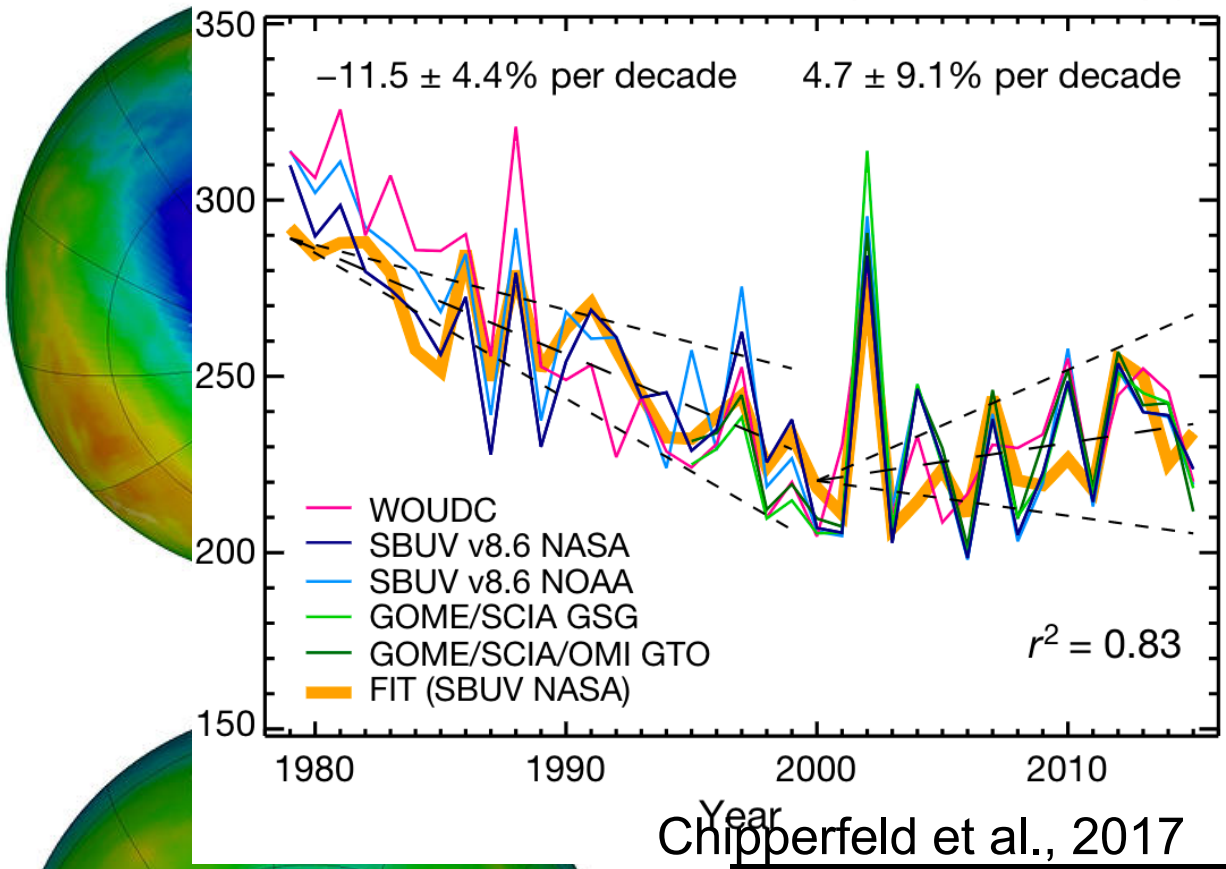

1984-1986
2012-2014
Sulfate Ion
Nitrate Ion
SO_4^{2-} (µeq/L)
>63
49
35
21
≤ 7.0
NO_3^- (µeq/L)
>28
24
18
12
≤ 4.0

Community standards can change

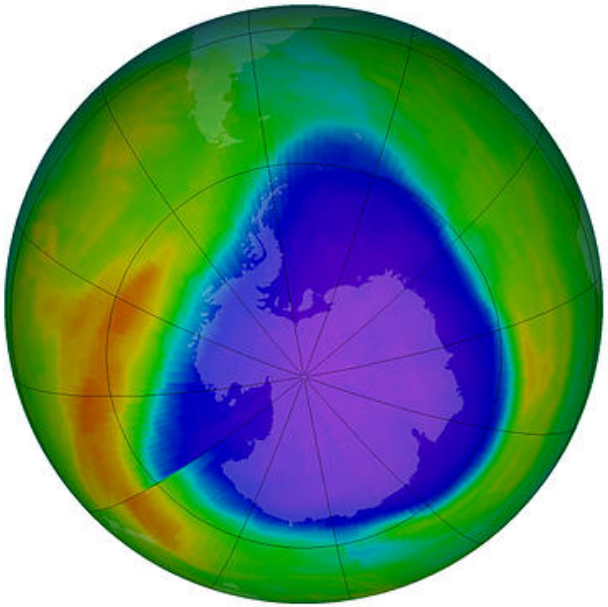
- Education and generational change
  - Recycling
- Regulation
  - Acid rain
- Innovation
  - The Ozone Hole



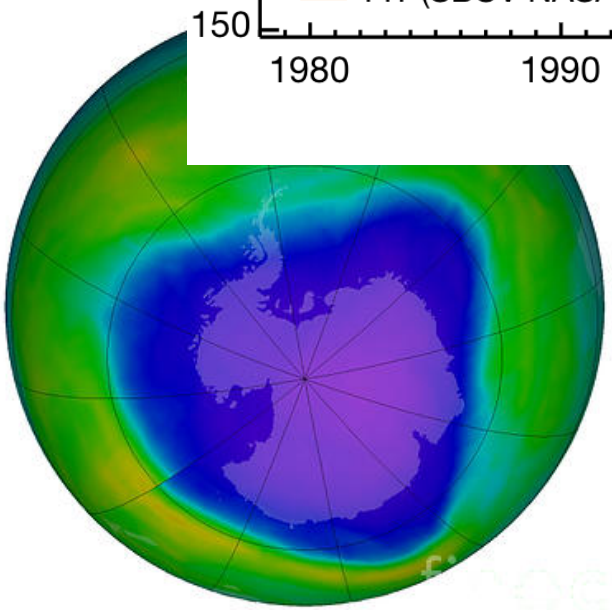
1980



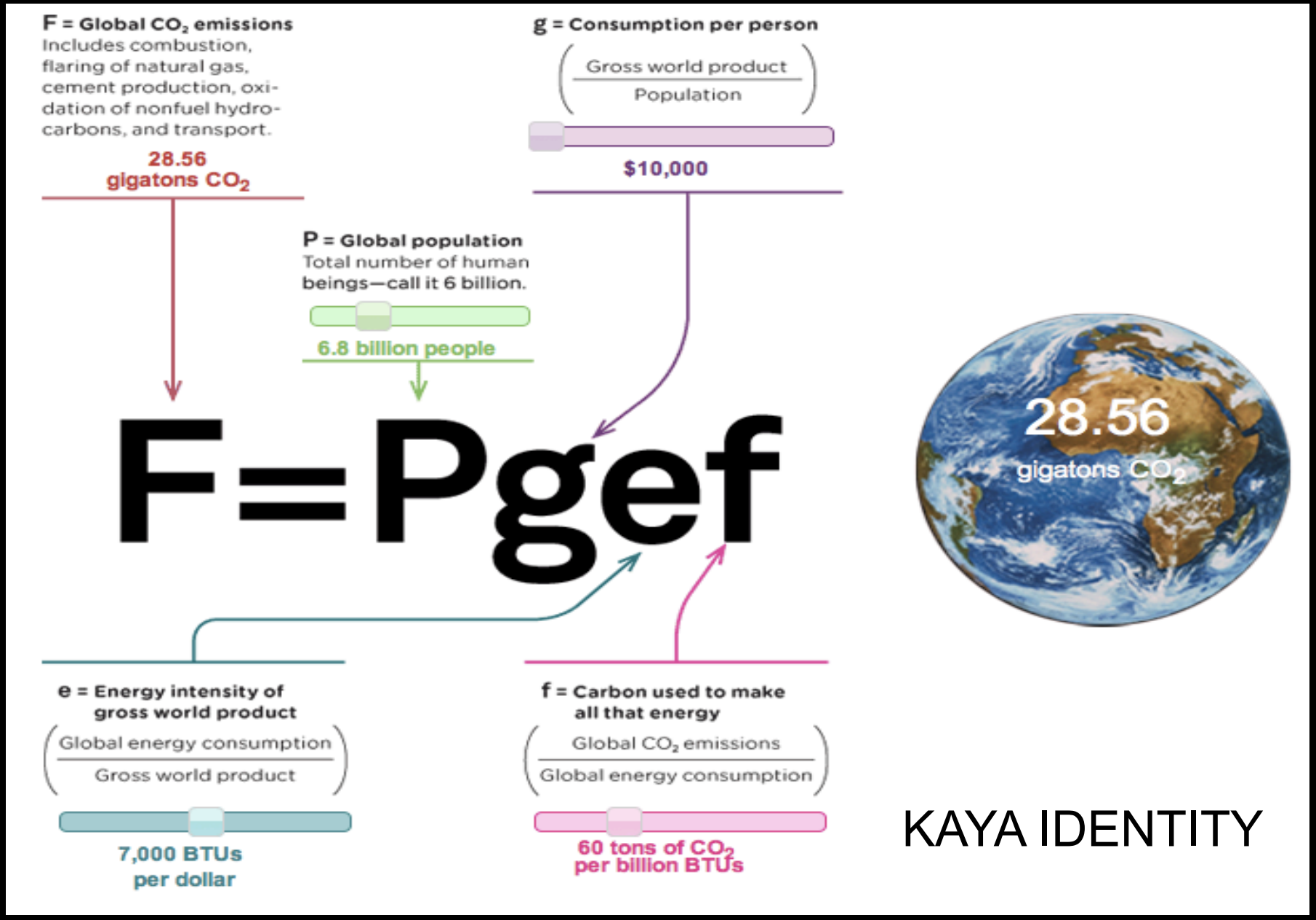
Chipperfeld et al., 2017



2000



2015

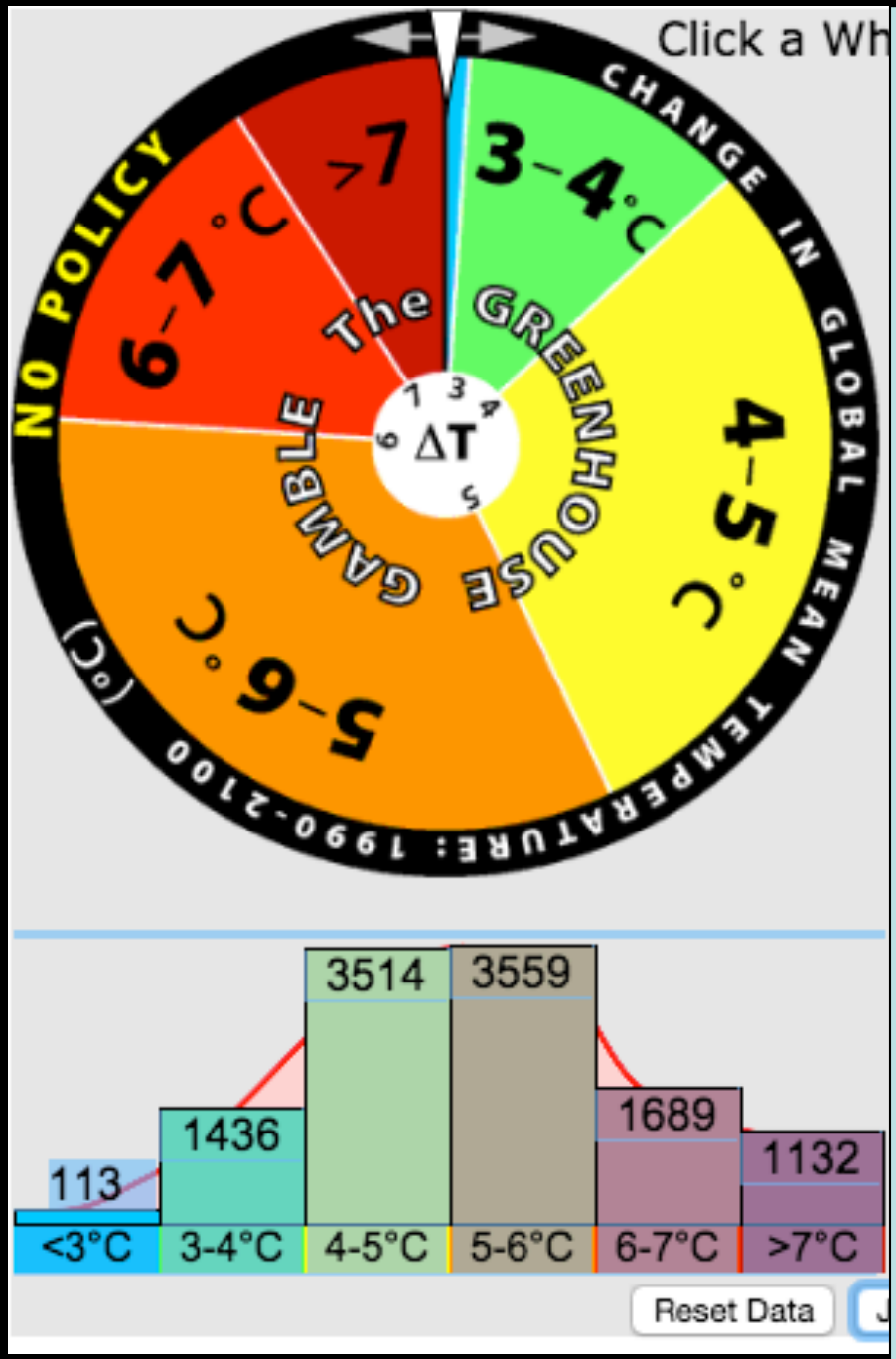


KAYA IDENTITY

http://climatemodels.uchicago.edu/kaya/

- “I am not a scientist myself, but my best assessment of the data is that the world is getting warmer, that human activity contributes to that warming, and that policymakers should therefore consider the risk of negative consequences.”
  – Sept. 2012

http://www.sciencedebate.org/debate12/

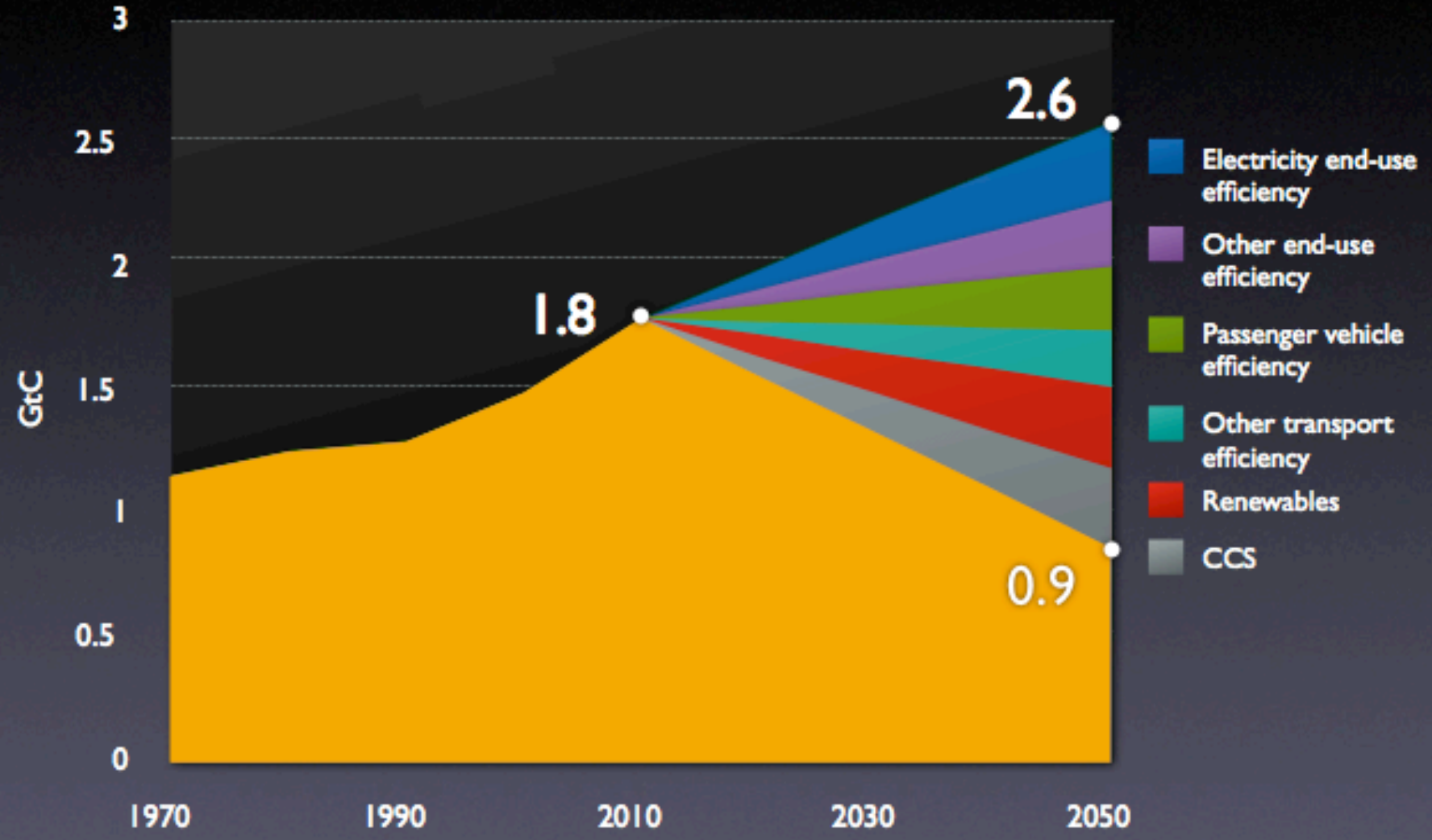


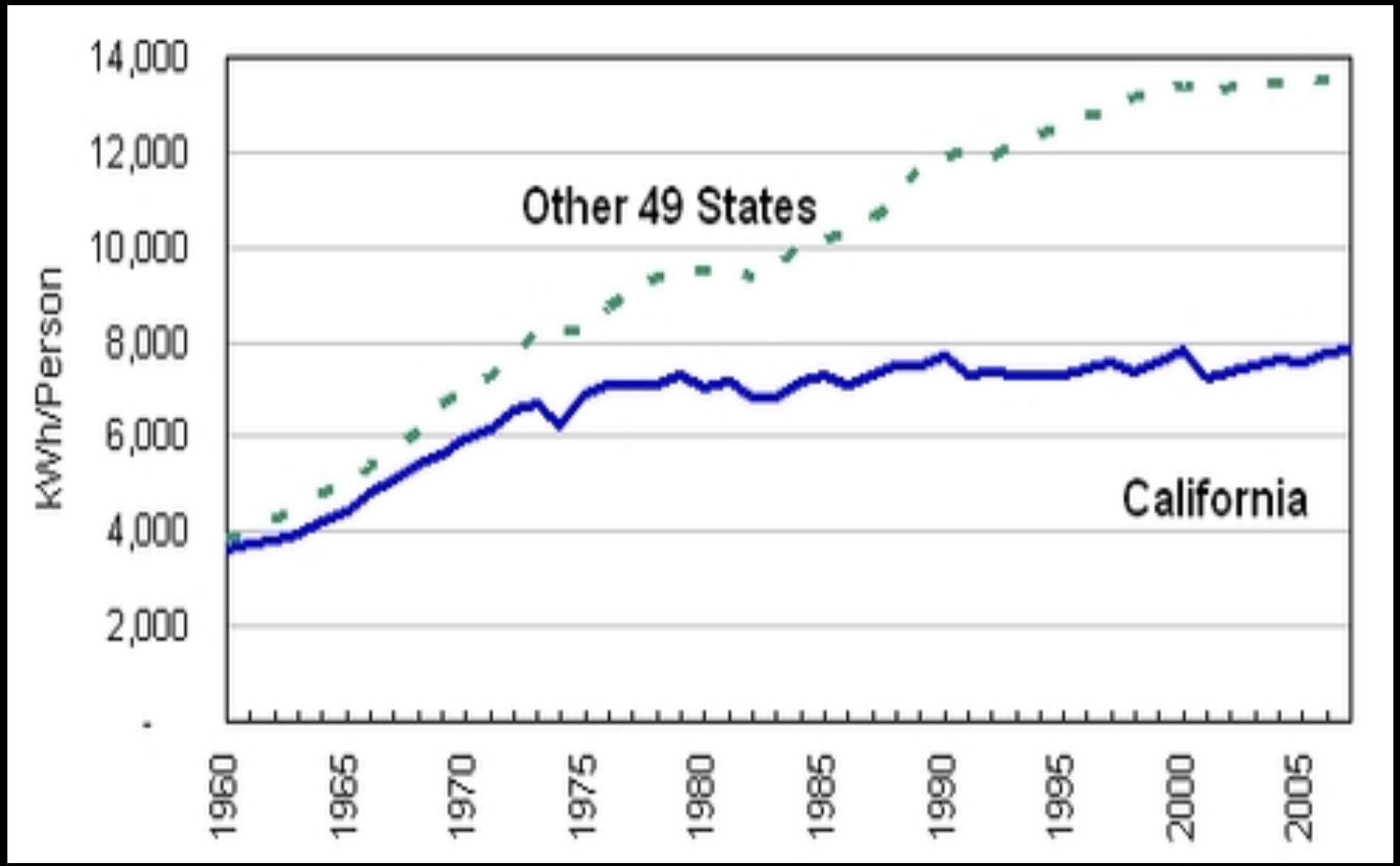
http://globalchange.mit.edu/focus-areas/uncertainty/gamble

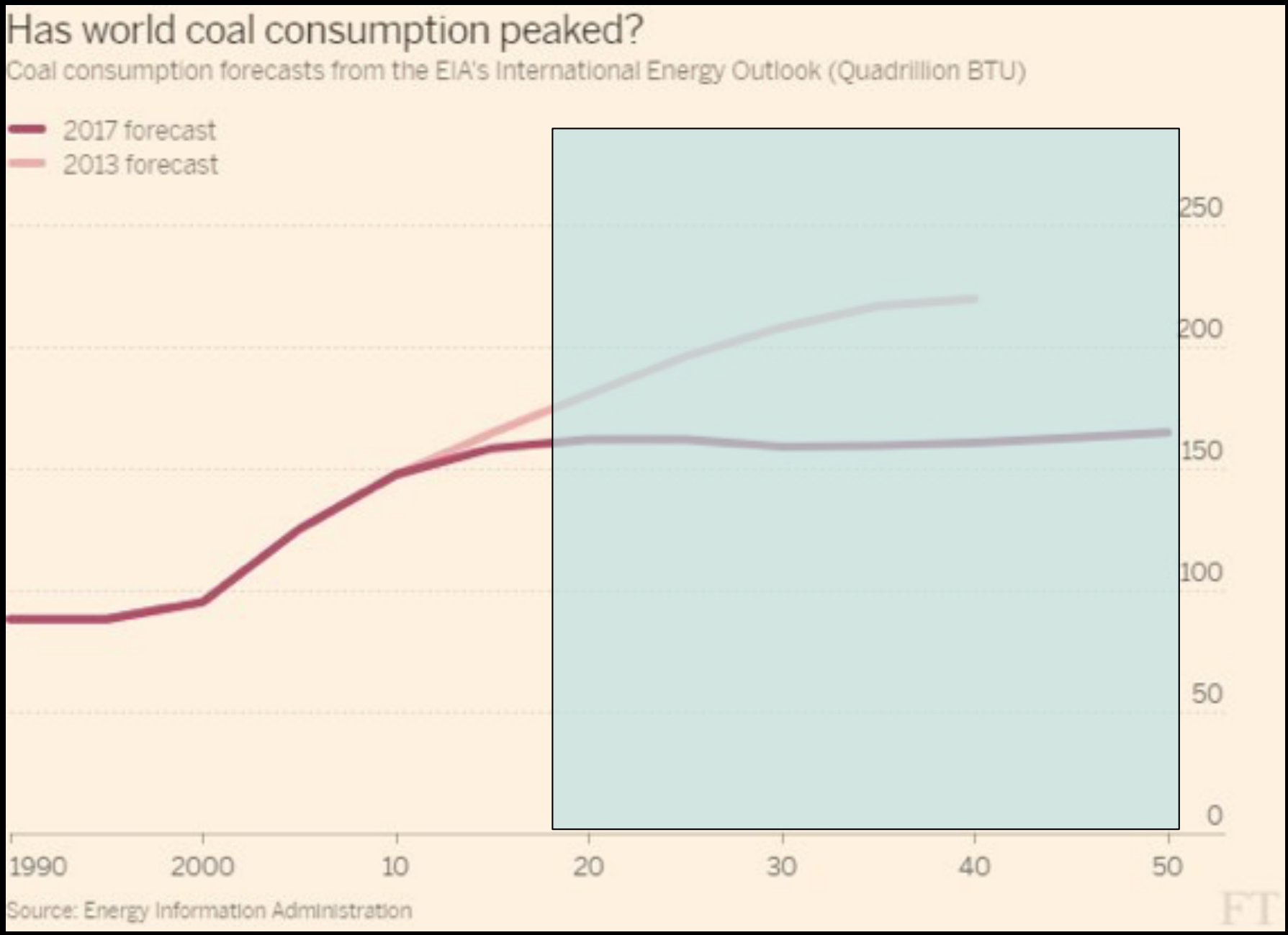
U.S. Emissions

After Pacala and Socolow, 2004;
ARI CarBen3 Spreadsheet

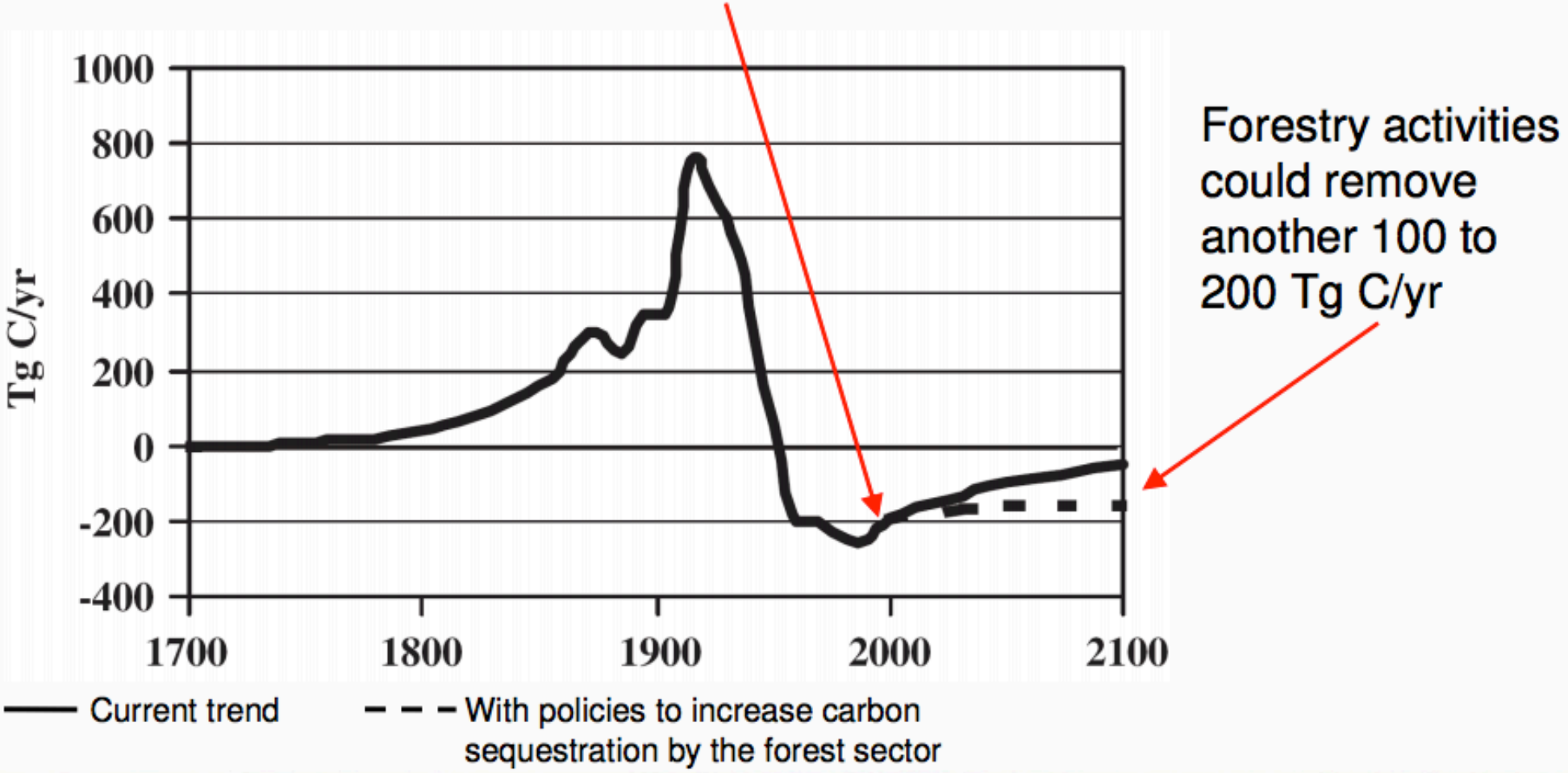
- Carbon Capture & Storage




14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
KWh/Person
Other 49 States
California
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005


Has world coal consumption peaked?
Coal consumption forecasts from the EIA's International Energy Outlook (Quadrillion BTU)
2017 forecast
2013 forecast
250
200
150
100
50
0
1990
2000
10
20
30
40
50
Source: Energy Information Administration
FT

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

- “Higher temperatures and less-predictable weather would hurt poor farmers […] It would be a terrible injustice to let climate change undo any of the past half-century’s progress against poverty and disease—and doubly unfair because the people who will be hurt the most are the ones doing the least to cause the problem.”

Linkedin.com

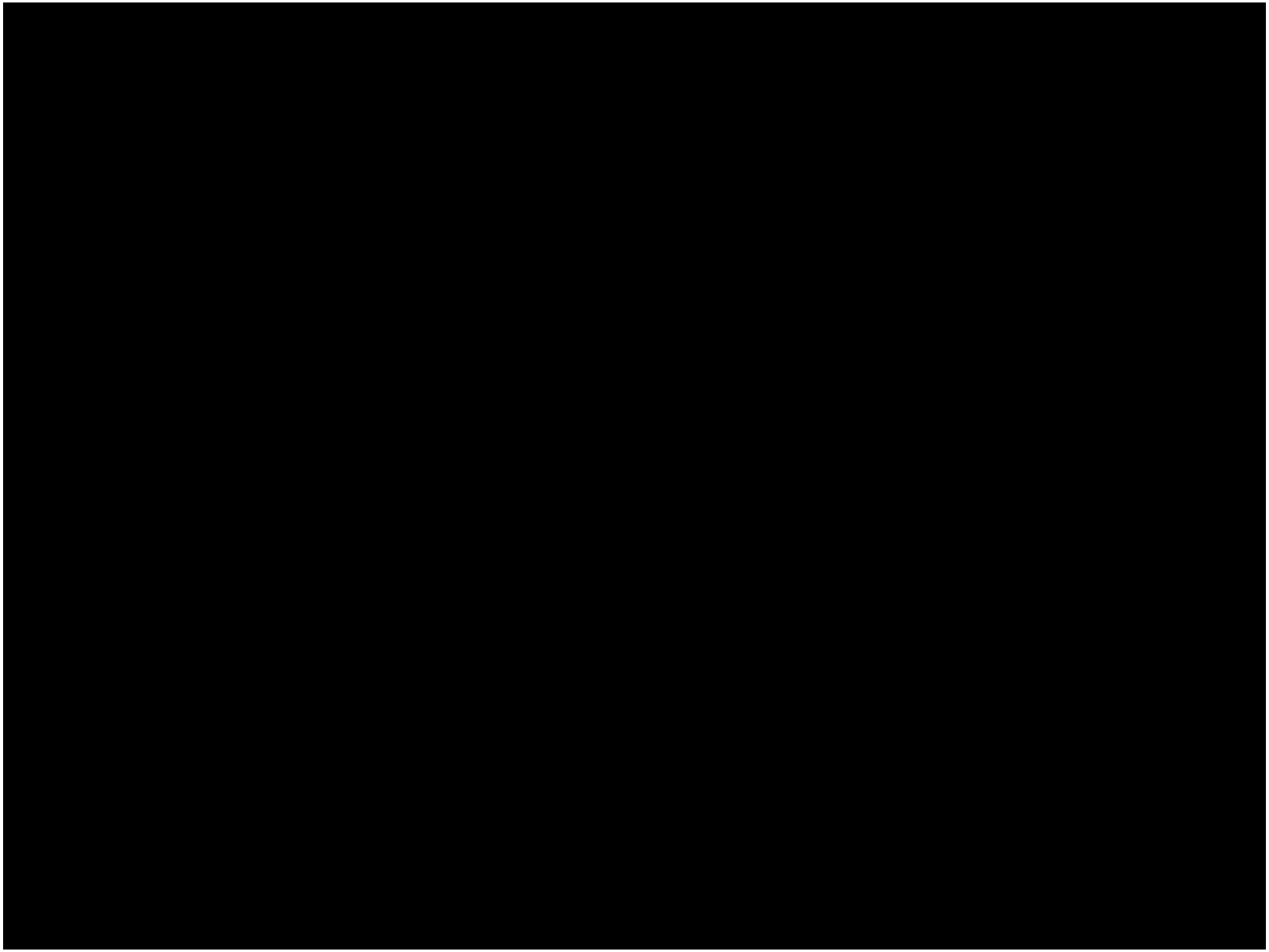
What can you do?

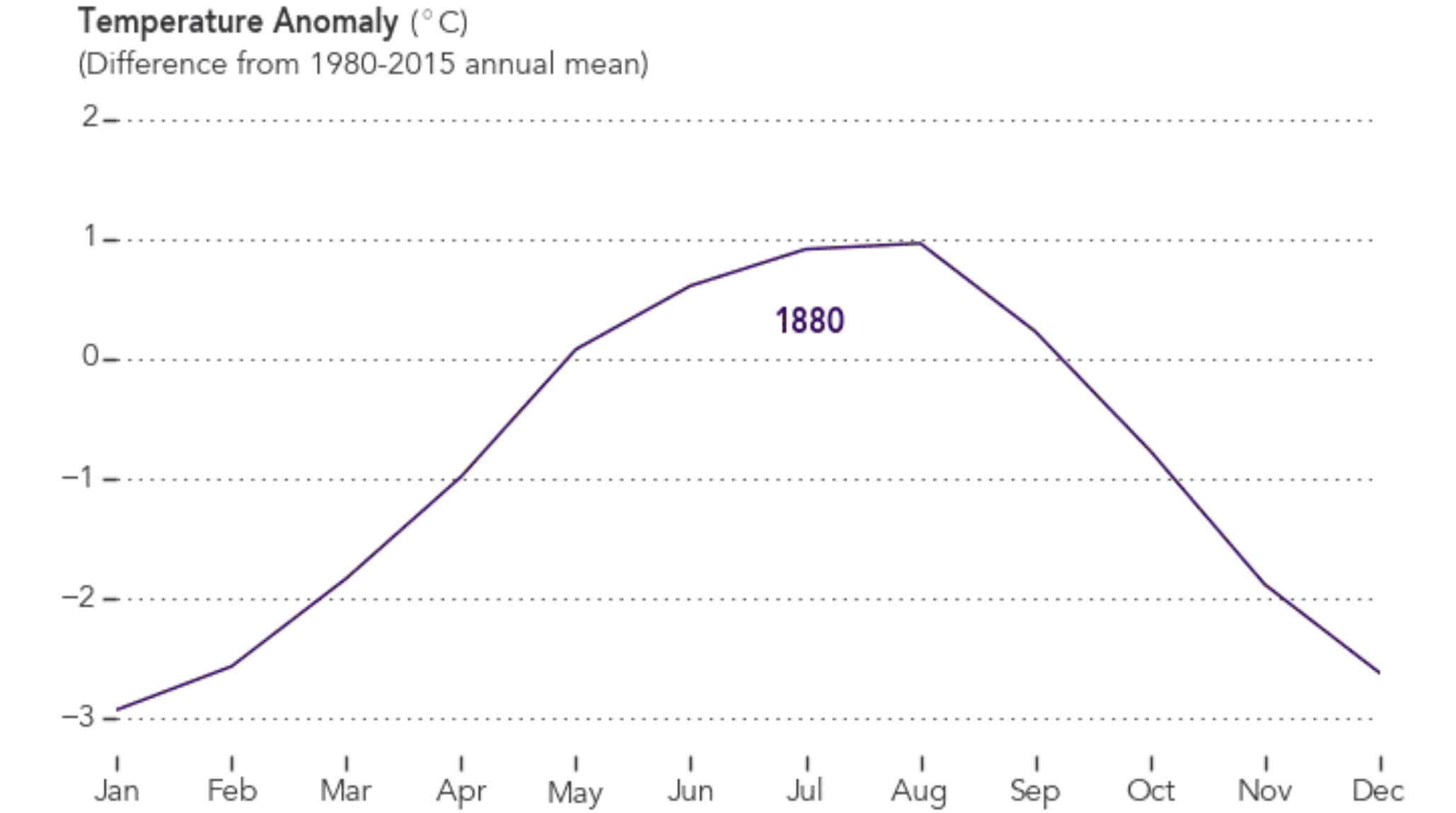
- Be mindful of how choices you make today influence the lives for your and other folks' grandchildren
- Denialism and alarmism are both symptoms of doomsday thinking, be wary of either position
- Seemingly small changes in habits of transportation, energy use, efficiency, many of which require limited government role, can influence your community, might even save money, & make a big impact
- Some level of climate change is inevitable, so local adaptation to flooding, extreme heat, sea level are an essential role for local governments

THANKS!

- desai@aos.wisc.edu

Don’t be afraid, be curious




Temperature Anomaly (°C)
(Difference from 1980-2015 annual mean)
2
1
0
−1
−2
−3
1880
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec