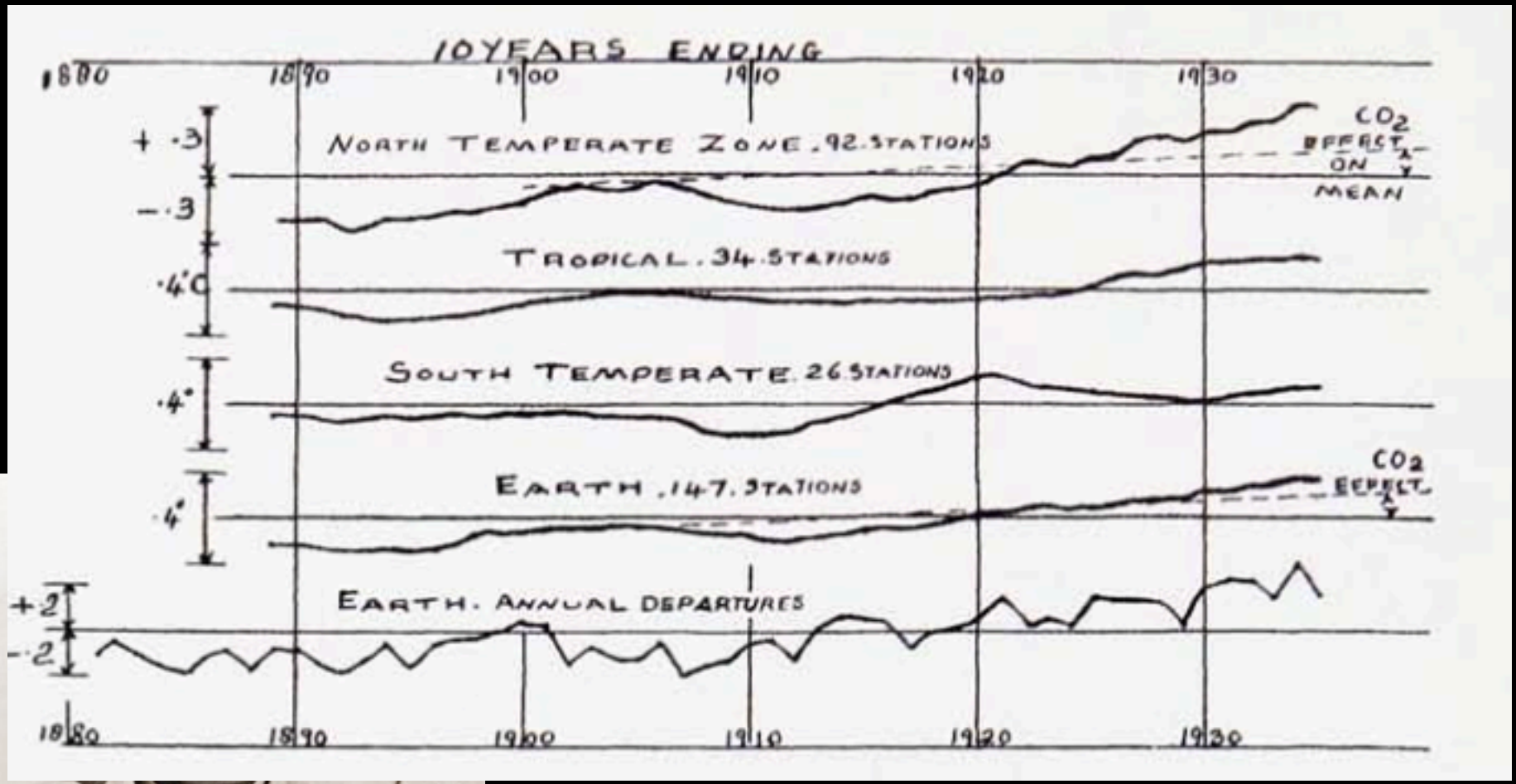
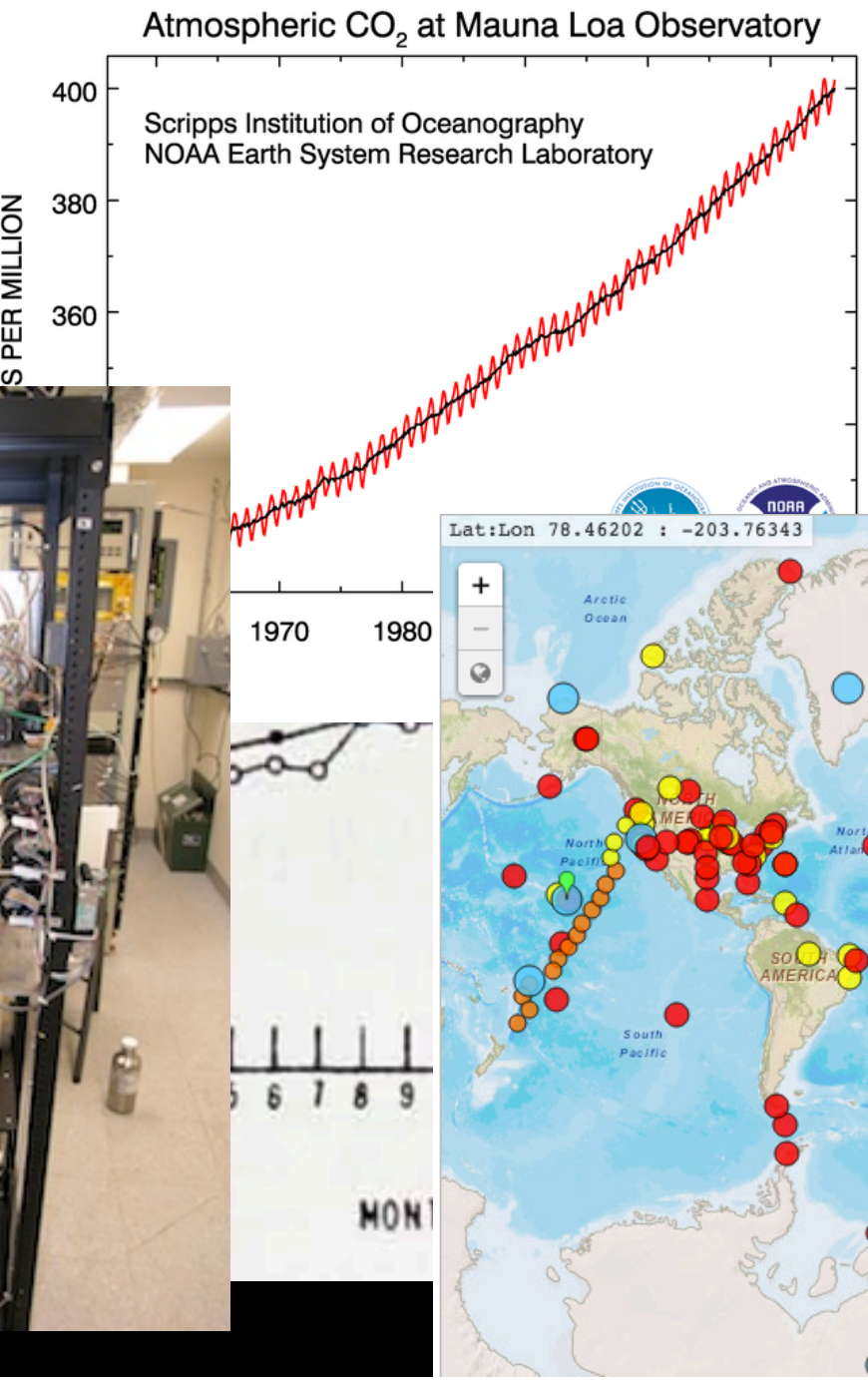
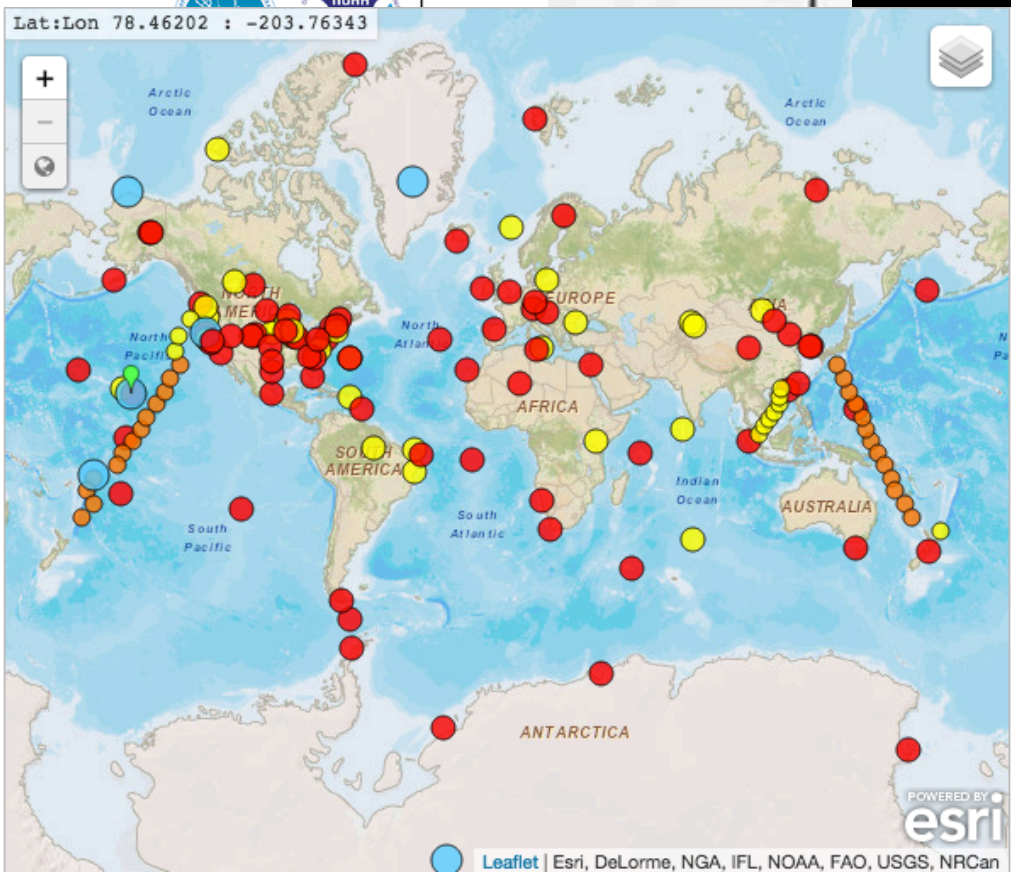
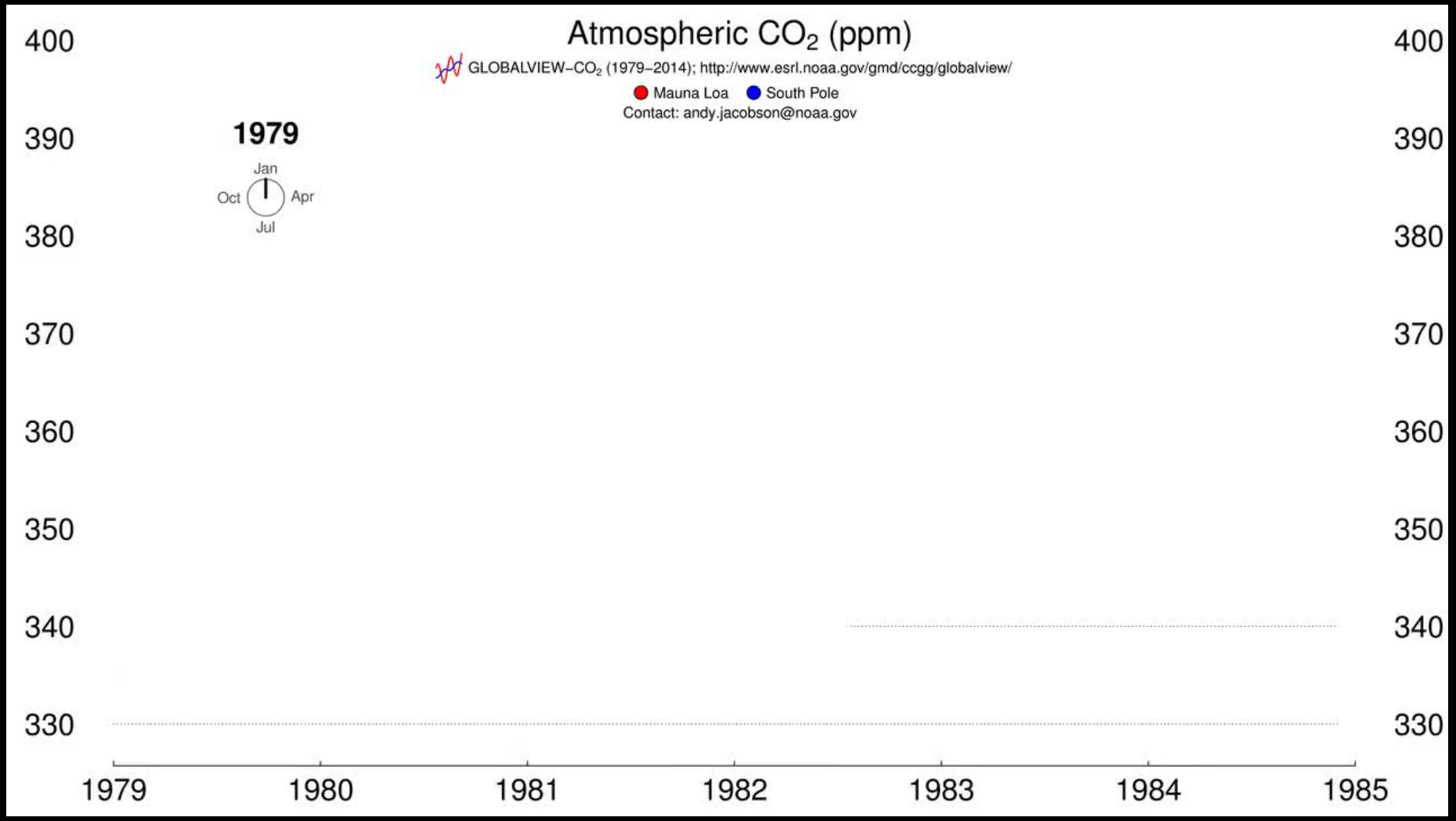
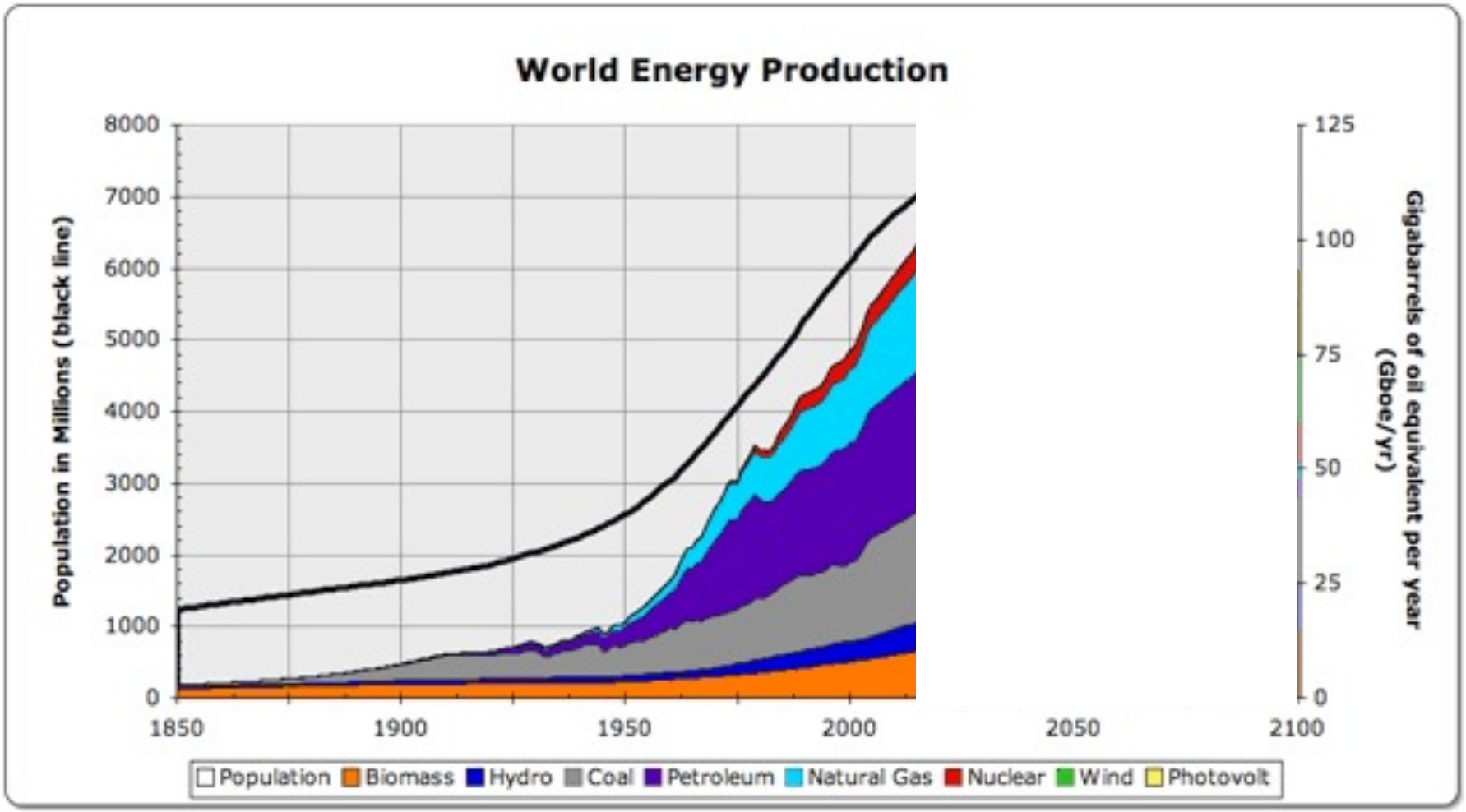

10 YEARS ENDING
1880
1890
1900
1910
1920
1930
+ ·3
− ·3
NORTH TEMPERATE ZONE. 92. STATIONS
CO_2 EFFECT ON MEAN
·4°C
TROPICAL. 34. STATIONS
·4°
SOUTH TEMPERATE. 26 STATIONS
·4°
EARTH. 147. STATIONS
CO_2 EFFECT
+2
−2
EARTH. ANNUAL DEPARTURES


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
S PER MILLION
400
380
360
1970
1980
MON


Lat:Lon 78.46202 : -203.76343
Arctic Ocean
EUROPE
AFRICA
AUSTRALIA
ANTARCTICA
Indian Ocean
South Pacific
South Atlantic
Leaflet | Esri, DeLorme, NGA, IFL, NOAA, FAO, USGS, NRCan


Atmospheric CO_2 (ppm)
GLOBALVIEW–CO_2 (1979–2014); http://www.esrl.noaa.gov/gmd/ccgg/globalview/
Mauna Loa
South Pole
Contact: andy.jacobson@noaa.gov
1979
Jan
Oct
Apr
Jul
400
390
380
370
360
350
340
330
1979
1980
1981
1982
1983
1984
1985



http://www.iceuls.com/_photo/b.jpg

THE GREAT ACCELERATION

SOCIO-ECONOMIC TRENDS

EARTH SYSTEM TRENDS

REFERENCE: Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney and C. Ludwig (2015), The Trajectory of the Anthropocene: the Great Acceleration, Submitted to *The Anthropocene Review.*

MAP & DESIGN: Félix Pharand-Deschênes / Globaïa

Global Carbon Budget

The cumulative contributions to the Global Carbon Budget from 1870
Contributions are shown in parts per million (ppm)

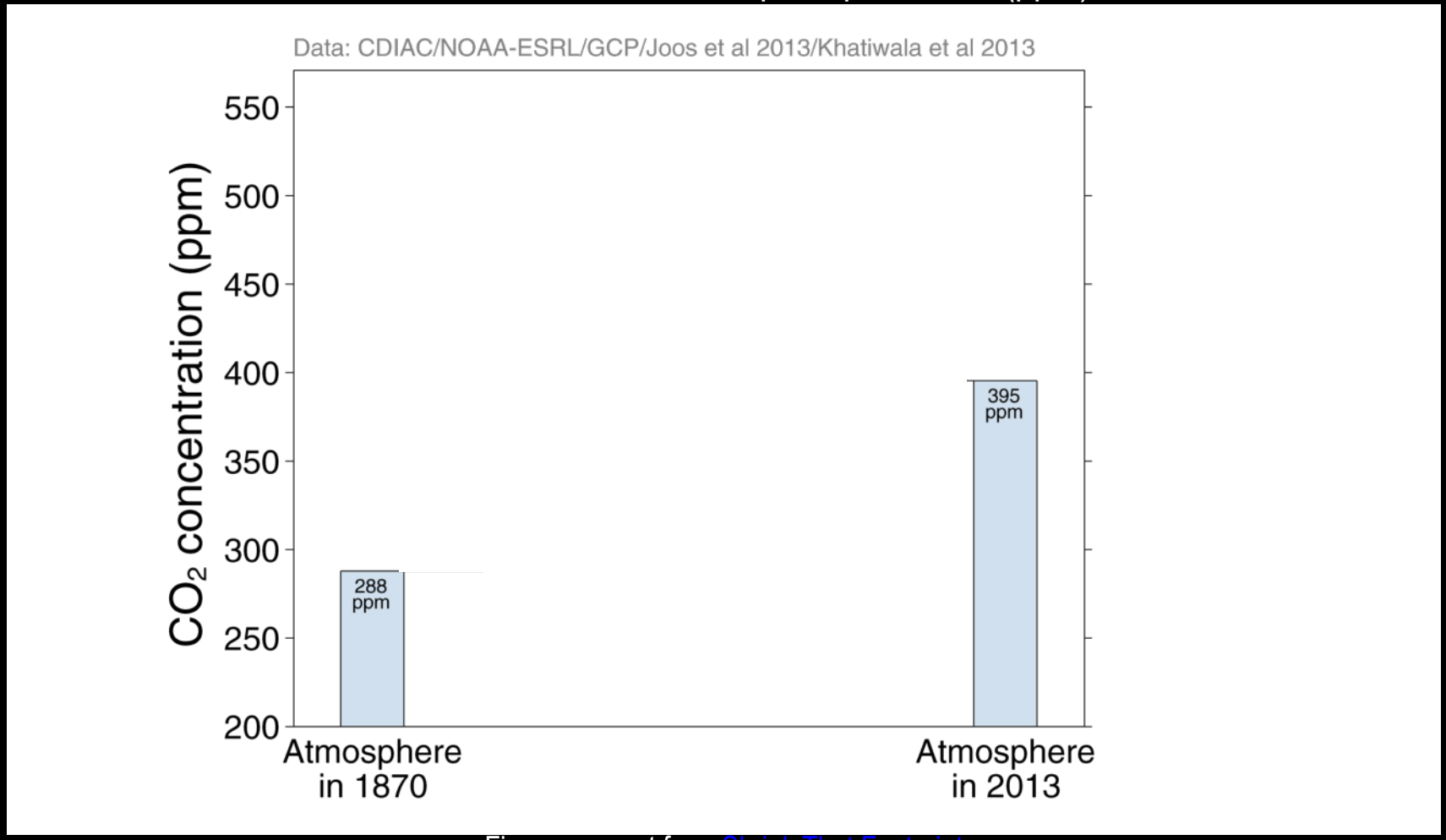
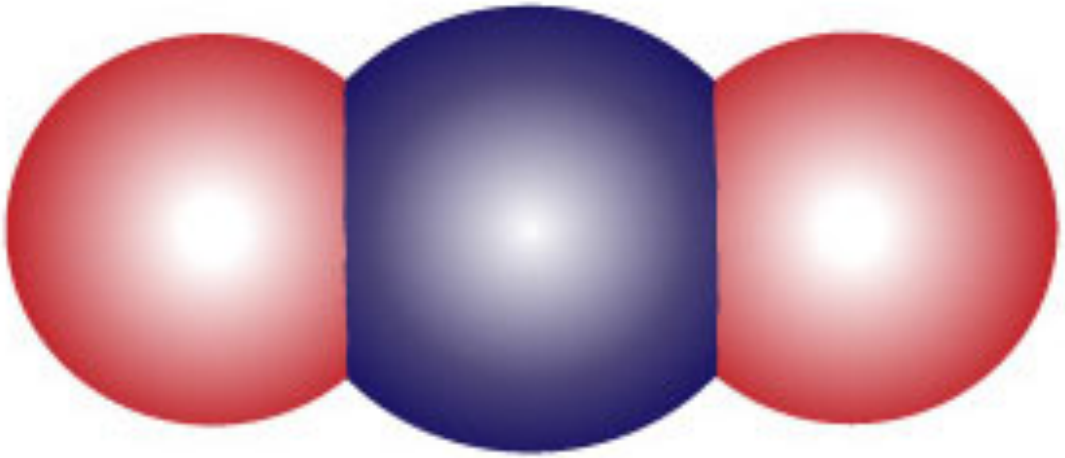
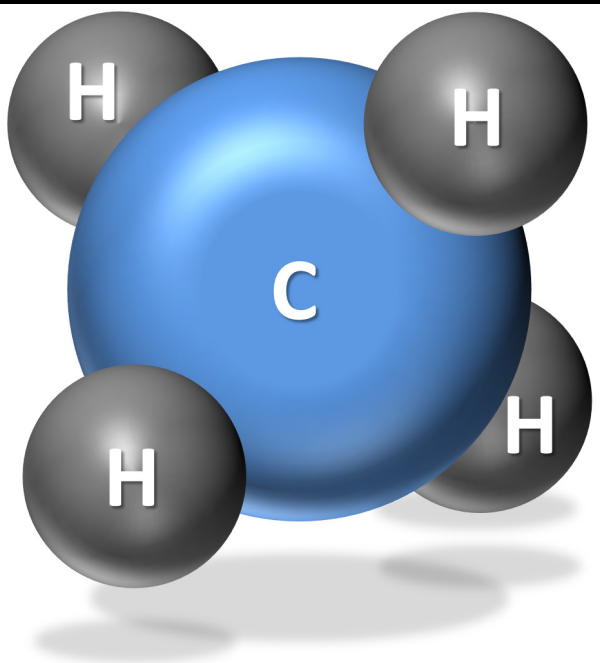


Figure concept from Shrink That Footprint

Source: CDIAC; NOAA-ESRL; Houghton et al 2012; Giglio et al 2013; Joos et al 2013; Khatiwala et al 2013; Le Quéré et al 2014; Global Carbon Budget 2014



O=C=O



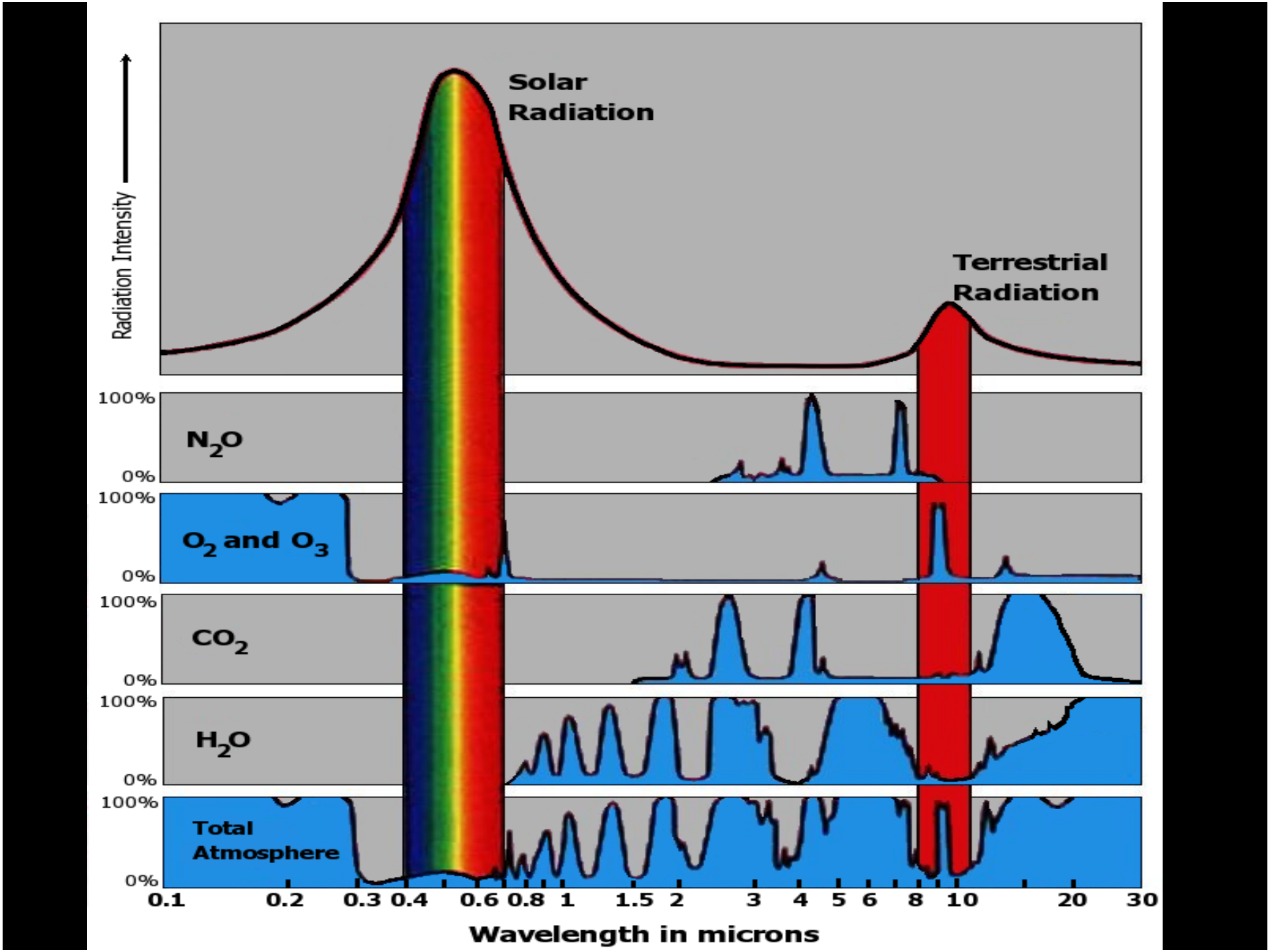
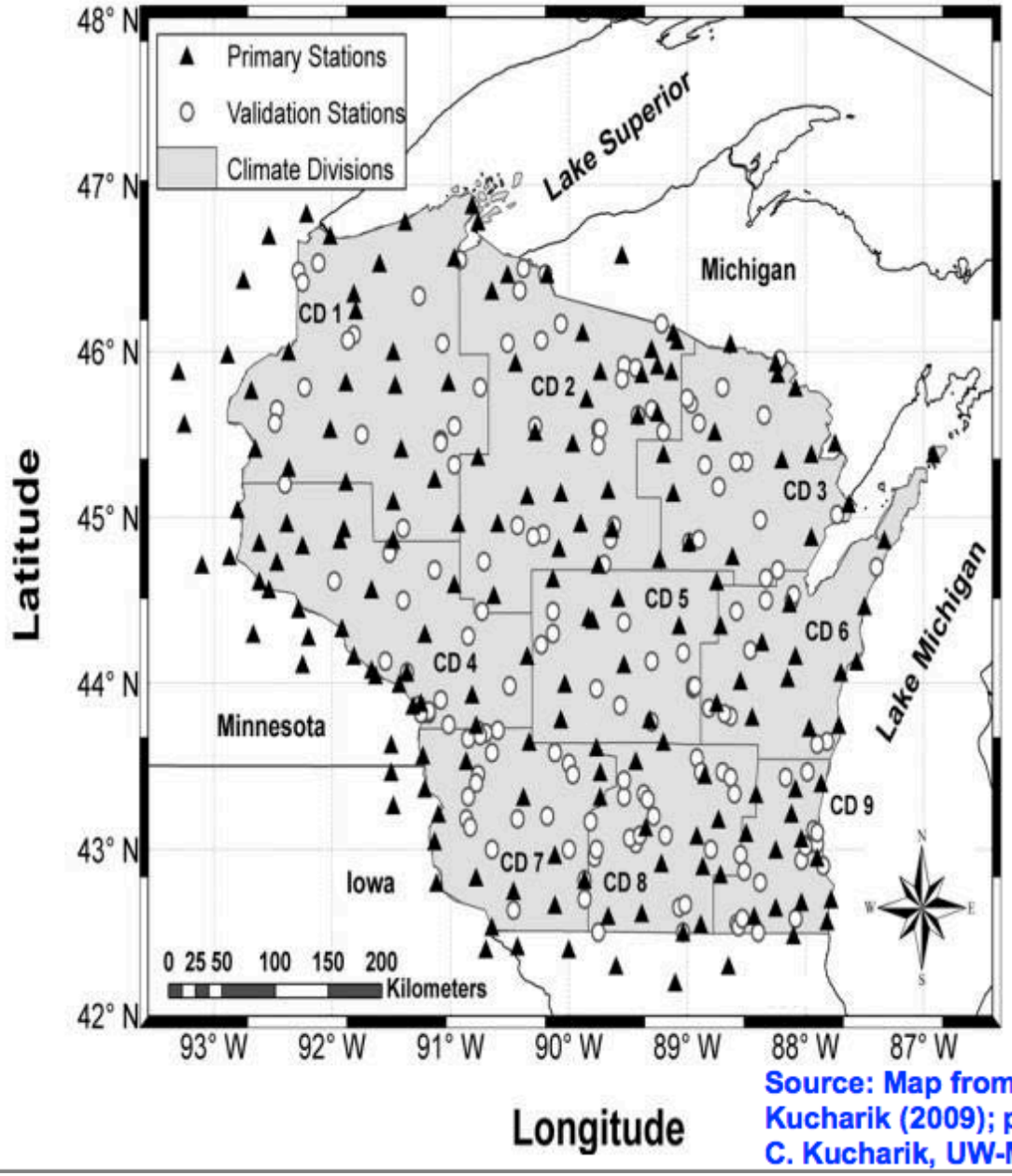

Radiation Intensity
Solar Radiation
Terrestrial Radiation
100%
N_2O
0%
100%
O_2 and O_3
0%
100%
CO_2
0%
100%
H_2O
0%
100%
Total Atmosphere
0%
0.1
0.2
0.3
0.4
0.6
0.8
1
1.5
2
3
4
5
6
8
10
20
30
Wavelength in microns

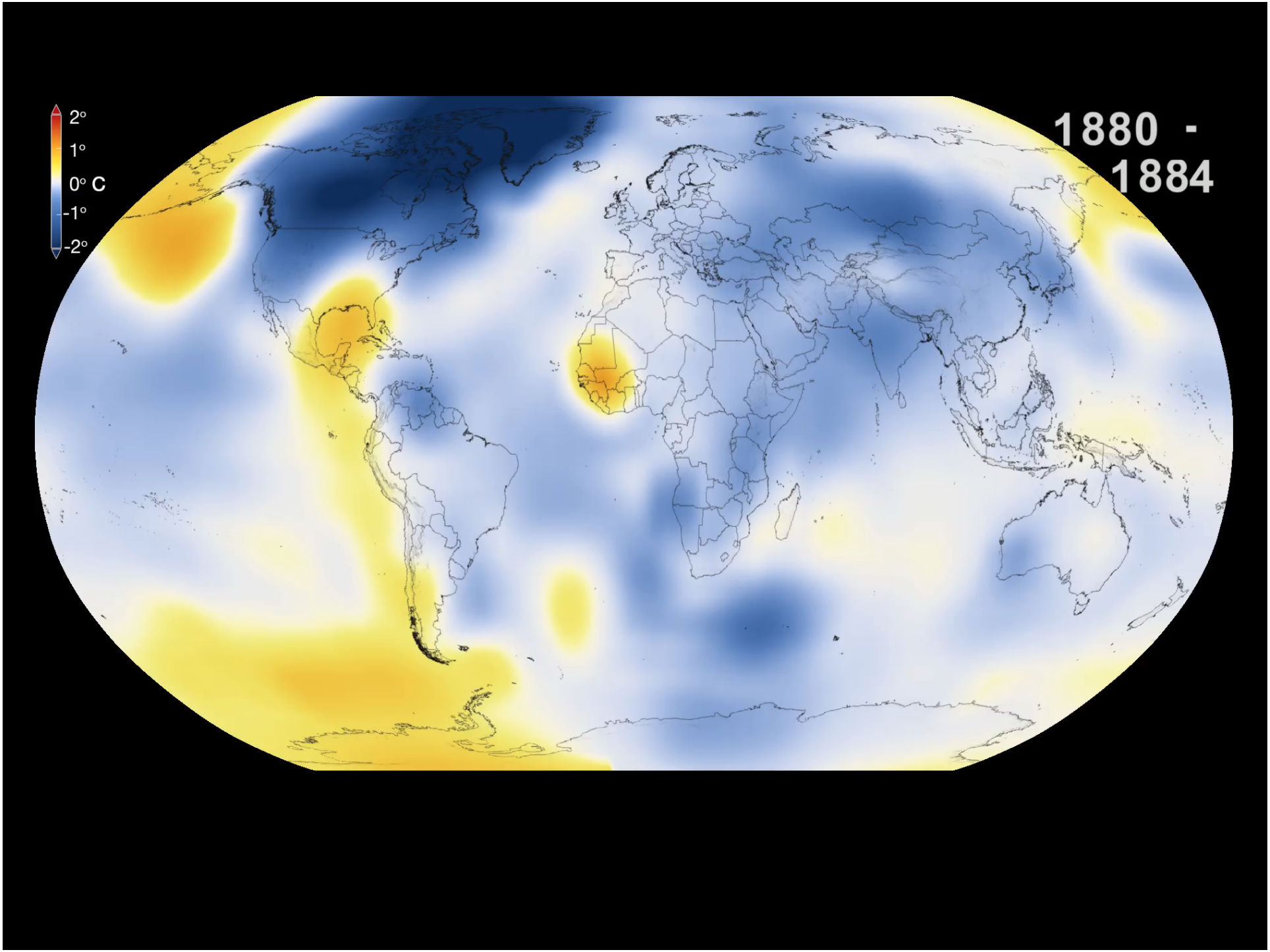
Photo credit: NOAA

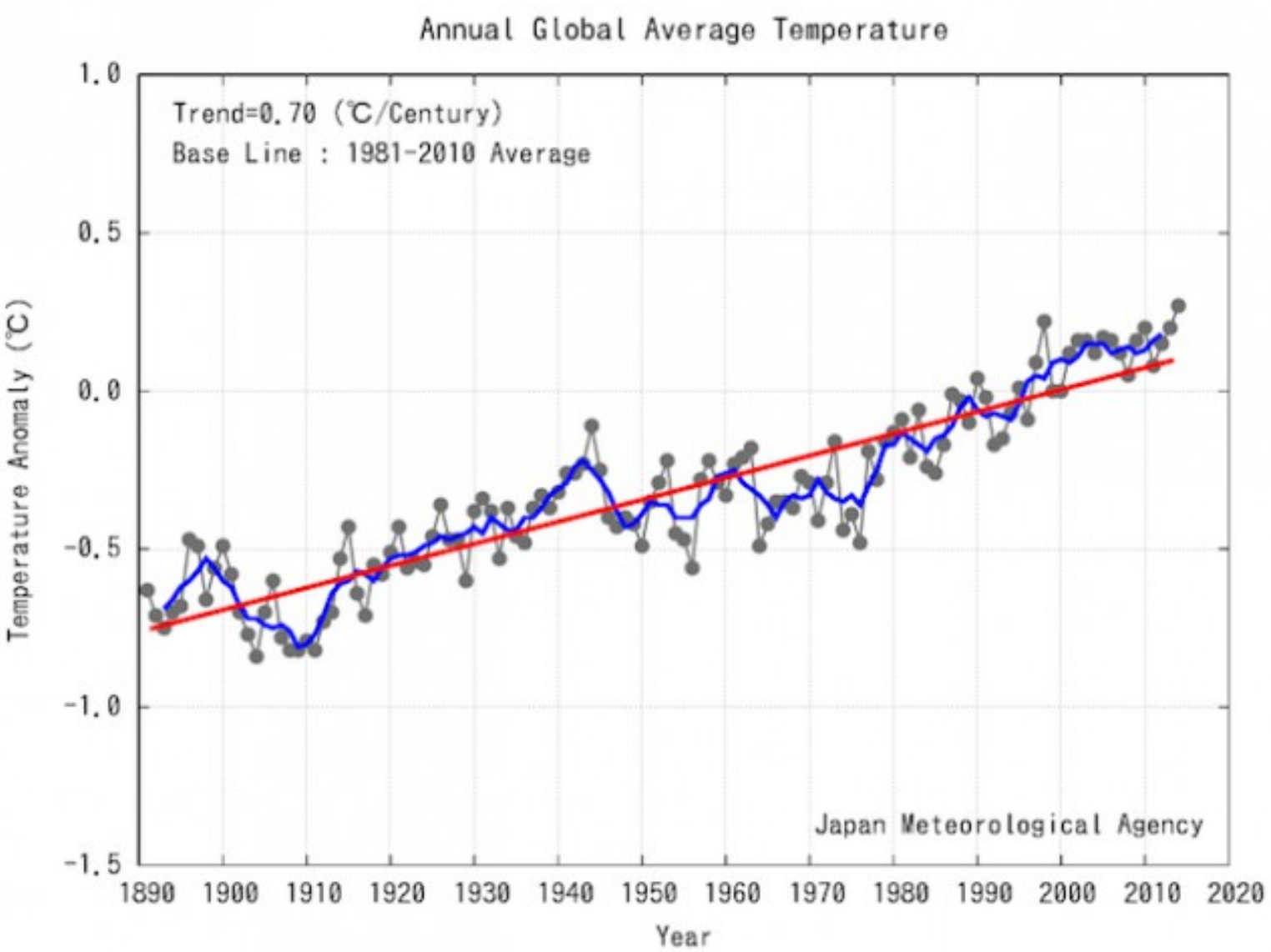
Weather Station Network for Wisconsin

(Daily temperature and precipitation data since 1950)



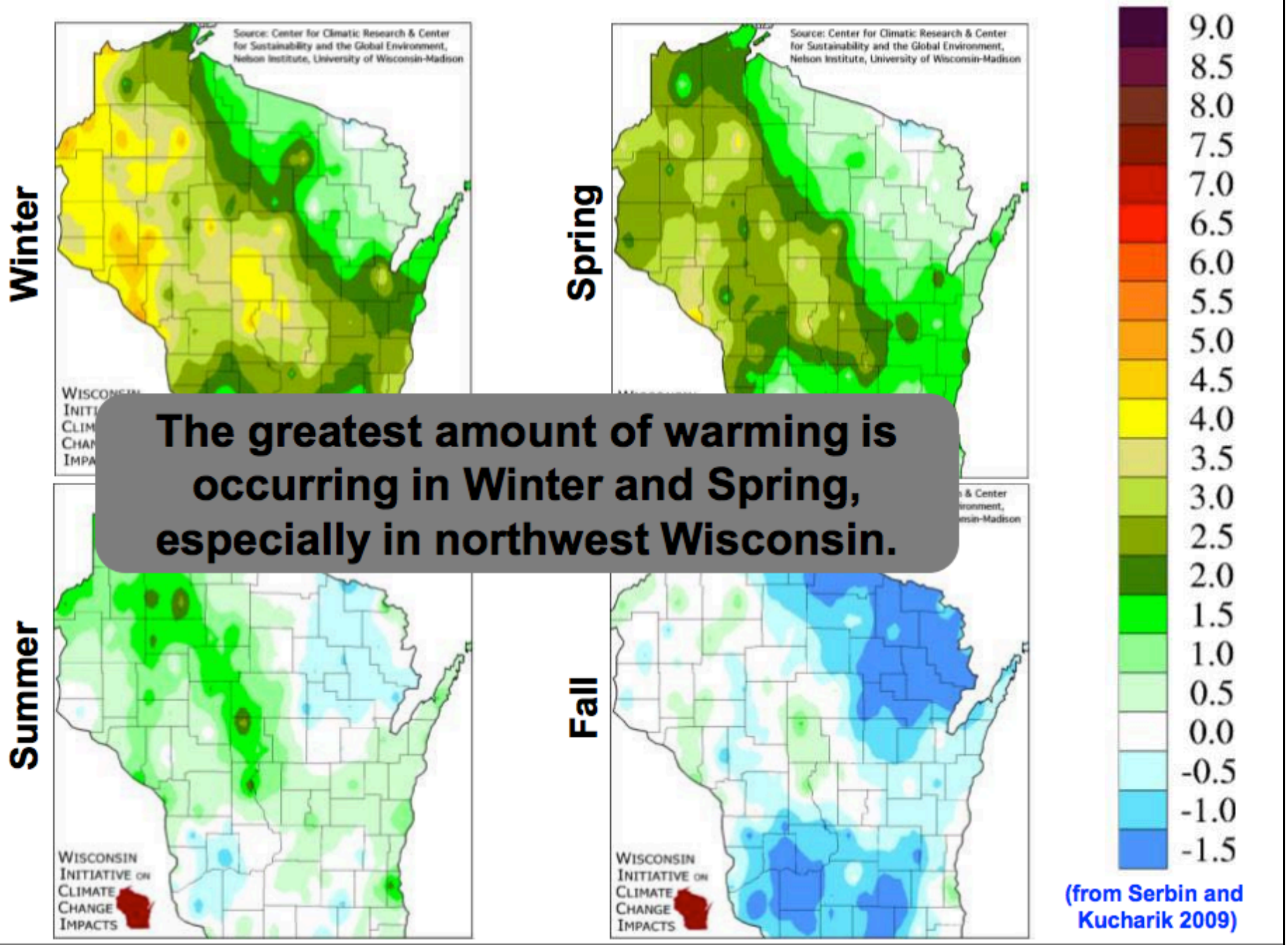
Source: Map from Serbin and Kucharik (2009); photos from C. Kucharik, UW-Madison


2°
1°
0° C
-1°
-2°
1880 -
1884



Anonalies are deviation from baseline (1981-2010 Average).
The black thin line indicates surface temperature anomaly of each year.
The blue line indicates their 5-year running mean.
The red line indicates the long-tern linear trend.

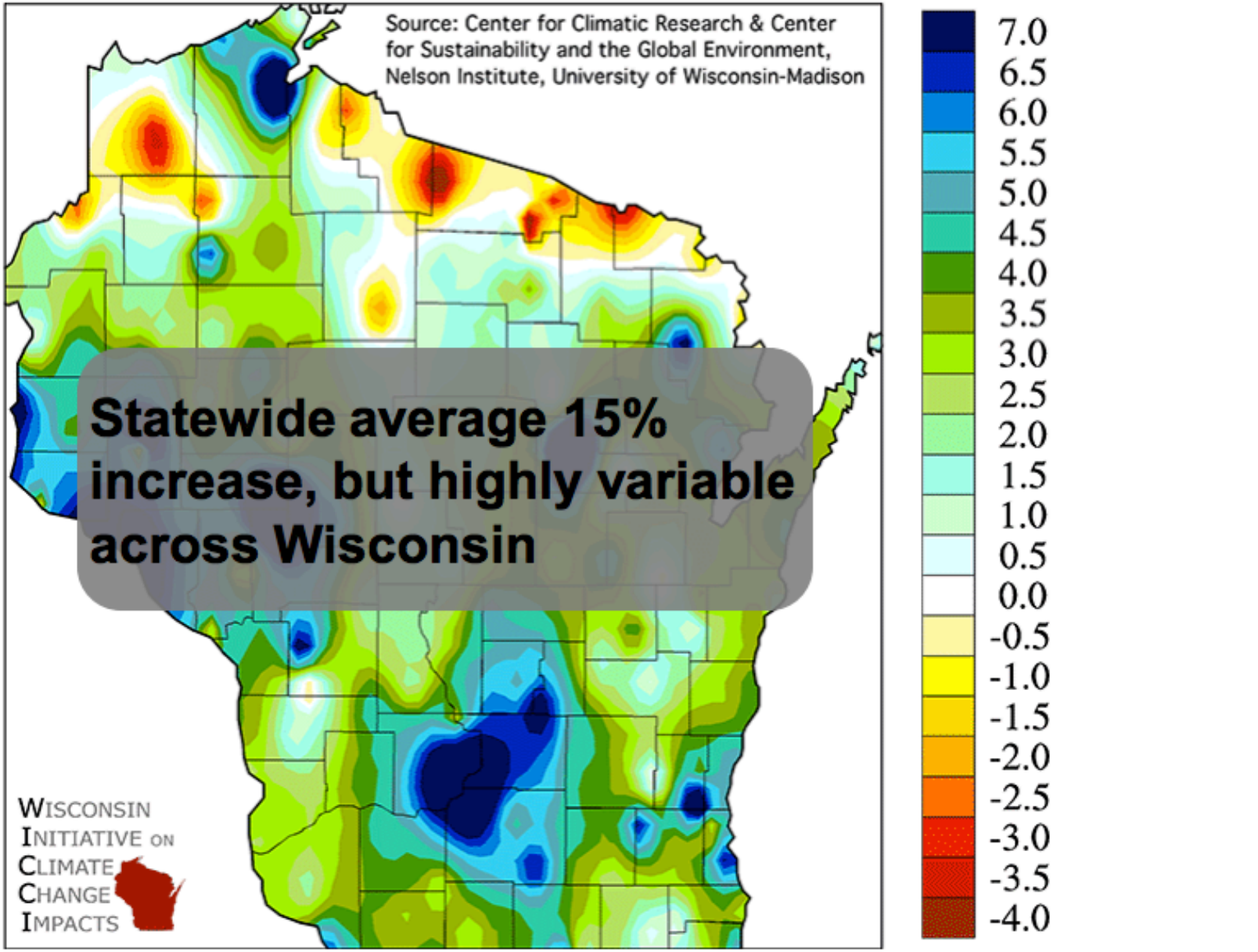
Change in Average Temperature (° F) from 1950 to 2006



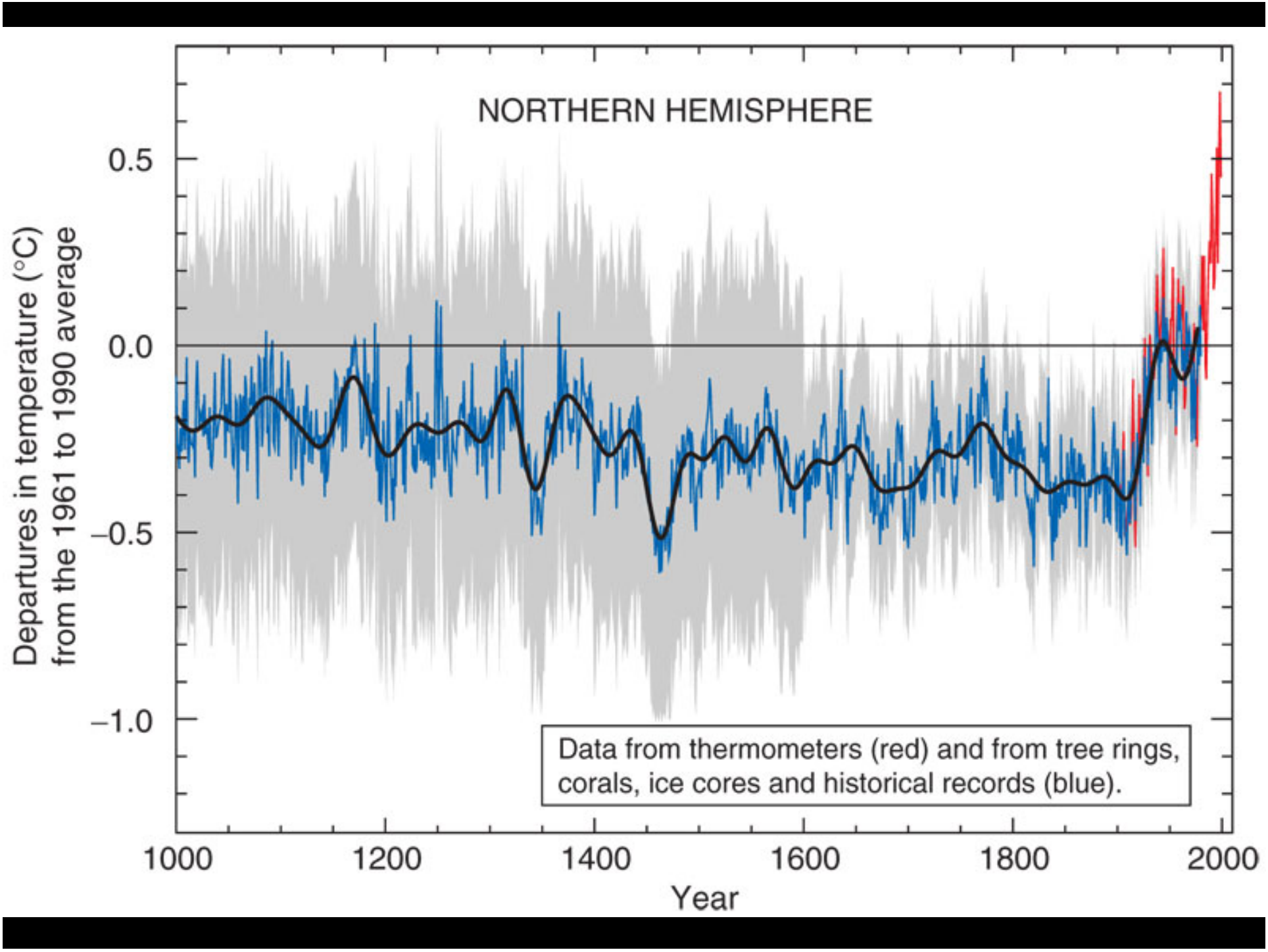
The greatest amount of warming is occurring in Winter and Spring, especially in northwest Wisconsin.

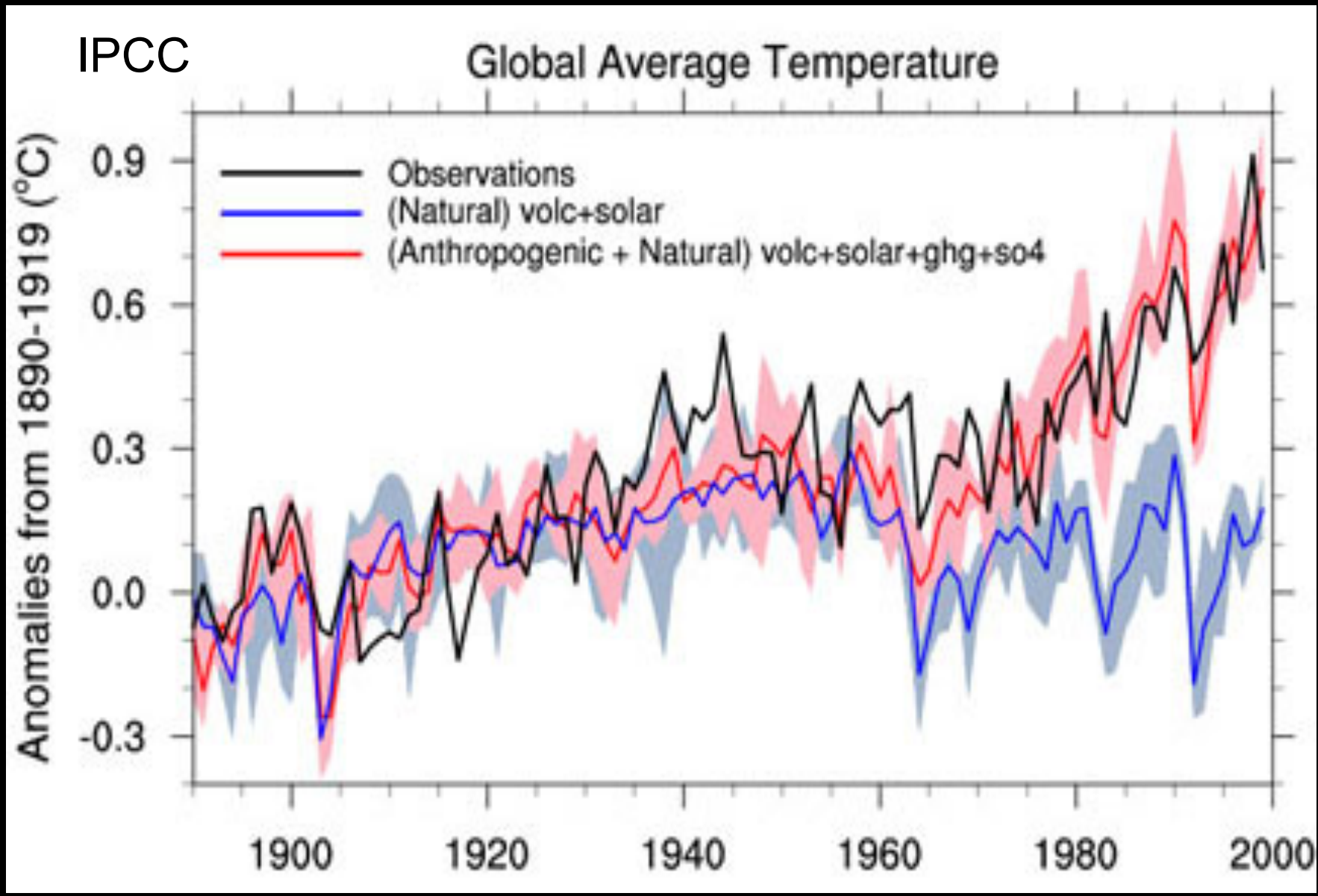
(from Serbin and Kucharik 2009)

Change in Annual Average Precipitation (inches) from 1950 to 2006



(from Serbin and Kucharik 2009)

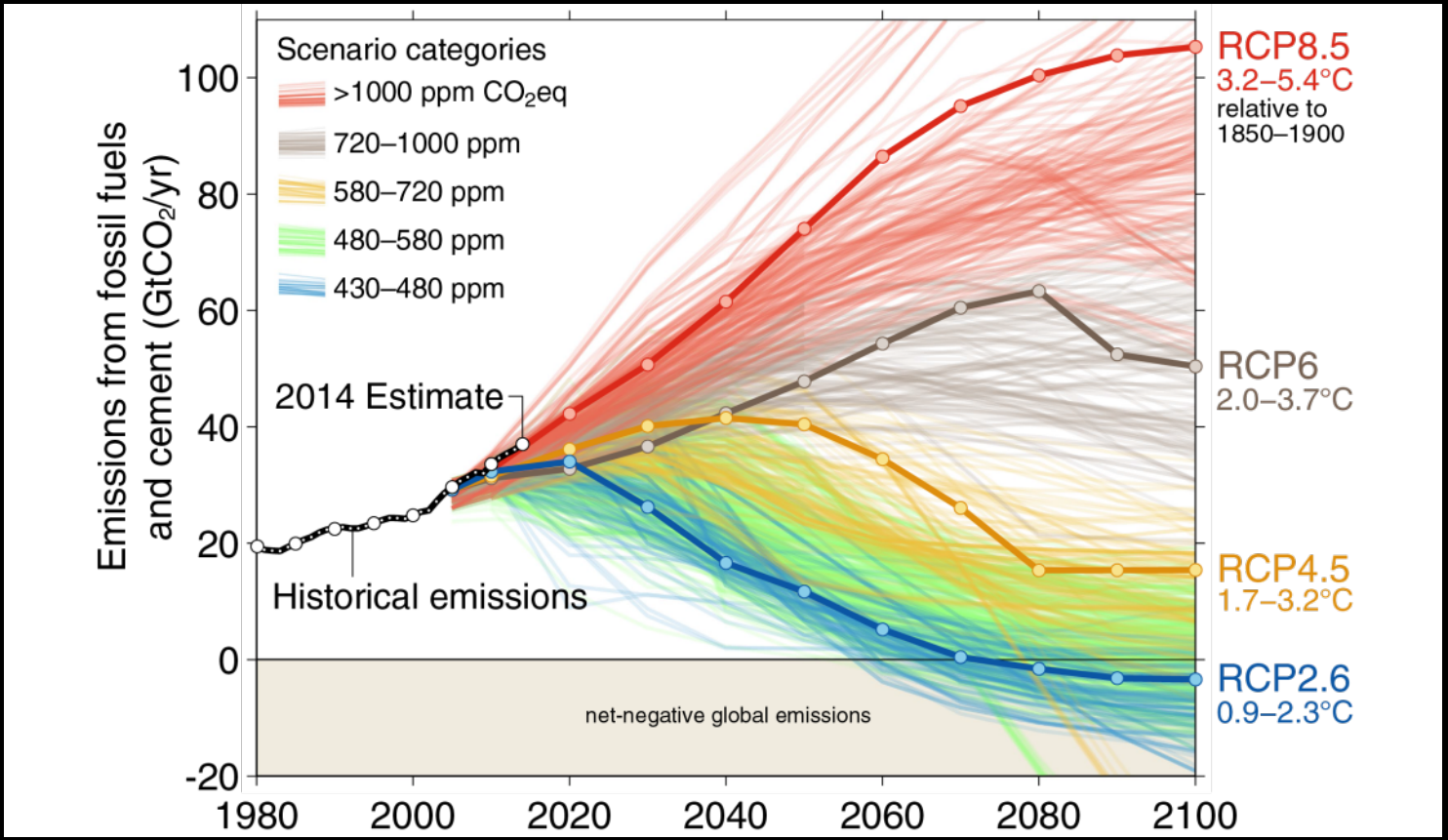

NORTHERN HEMISPHERE
Departures in temperature (°C)
from the 1961 to 1990 average
0.5
0.0
−0.5
−1.0
1000
1200
1400
1600
1800
2000
Year
Data from thermometers (red) and from tree rings,
corals, ice cores and historical records (blue).


IPCC
Global Average Temperature
Anomalies from 1890-1919 (°C)
0.9
0.6
0.3
0.0
-0.3
Observations
(Natural) volc+solar
(Anthropogenic + Natural) volc+solar+ghg+so4
1900
1920
1940
1960
1980
2000

Observed Emissions and Emissions Scenarios

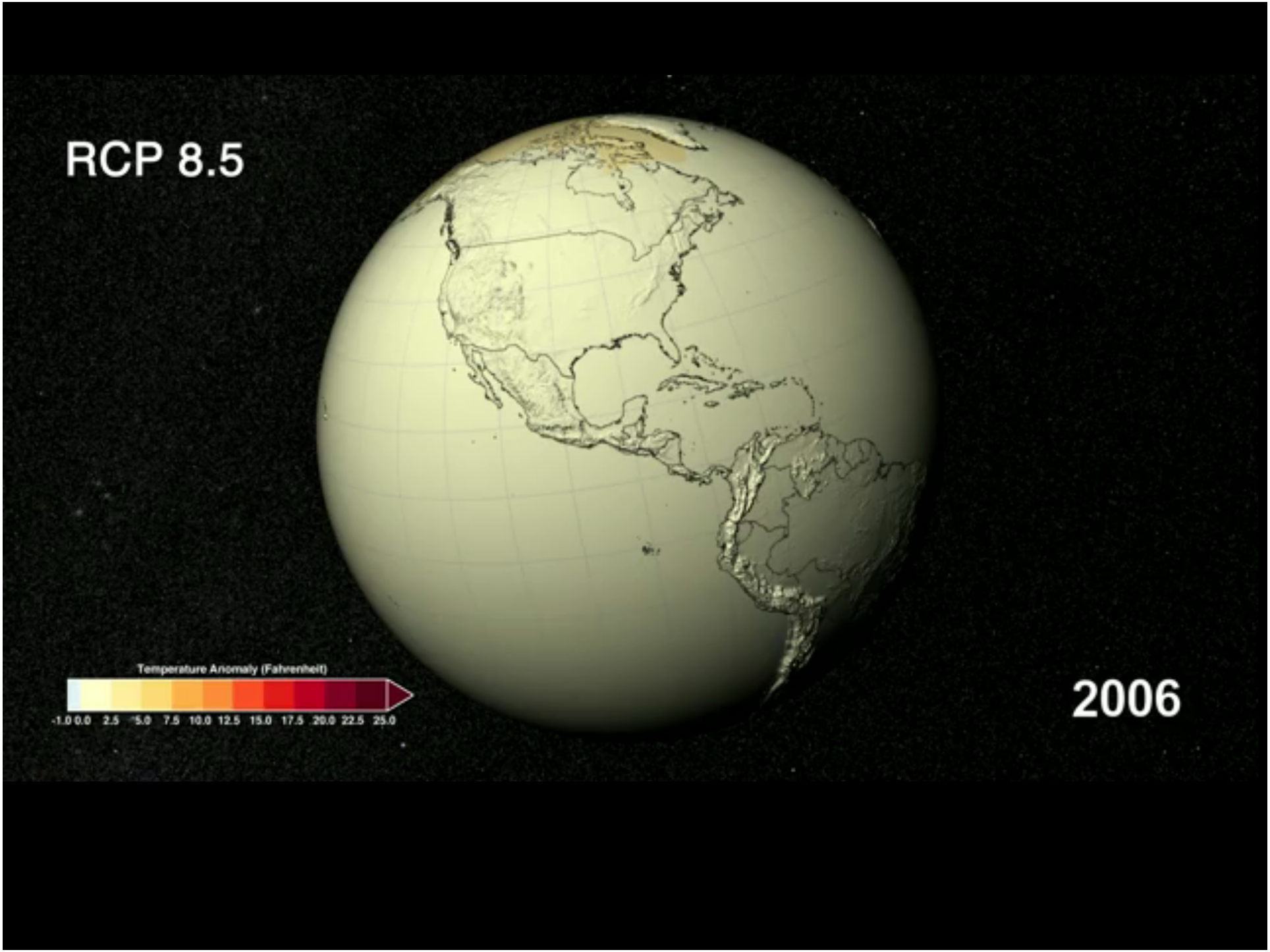
Emissions are on track for 3.2–5.4ºC "likely" increase in temperature above pre-industrial
Large and sustained mitigation is required to keep below 2ºC

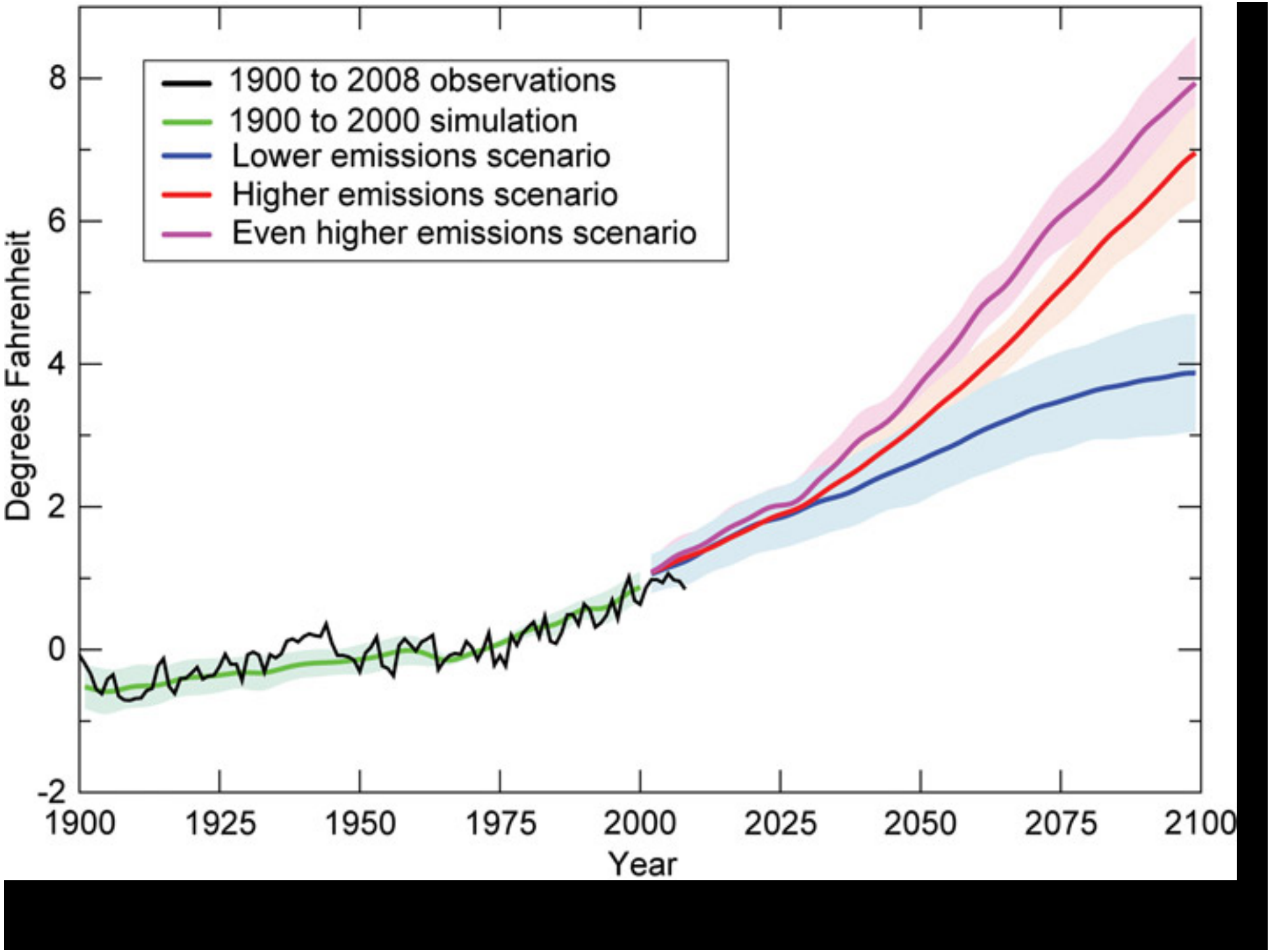
Data: CDIAC/GCP/IPCC/Fuss et al 2014



Over 1000 scenarios from the IPCC Fifth Assessment Report are shown

Source: Fuss et al 2014; CDIAC; Global Carbon Budget 2014


RCP 8.5
Temperature Anomaly (Fahrenheit)
-1.0 0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0
2006

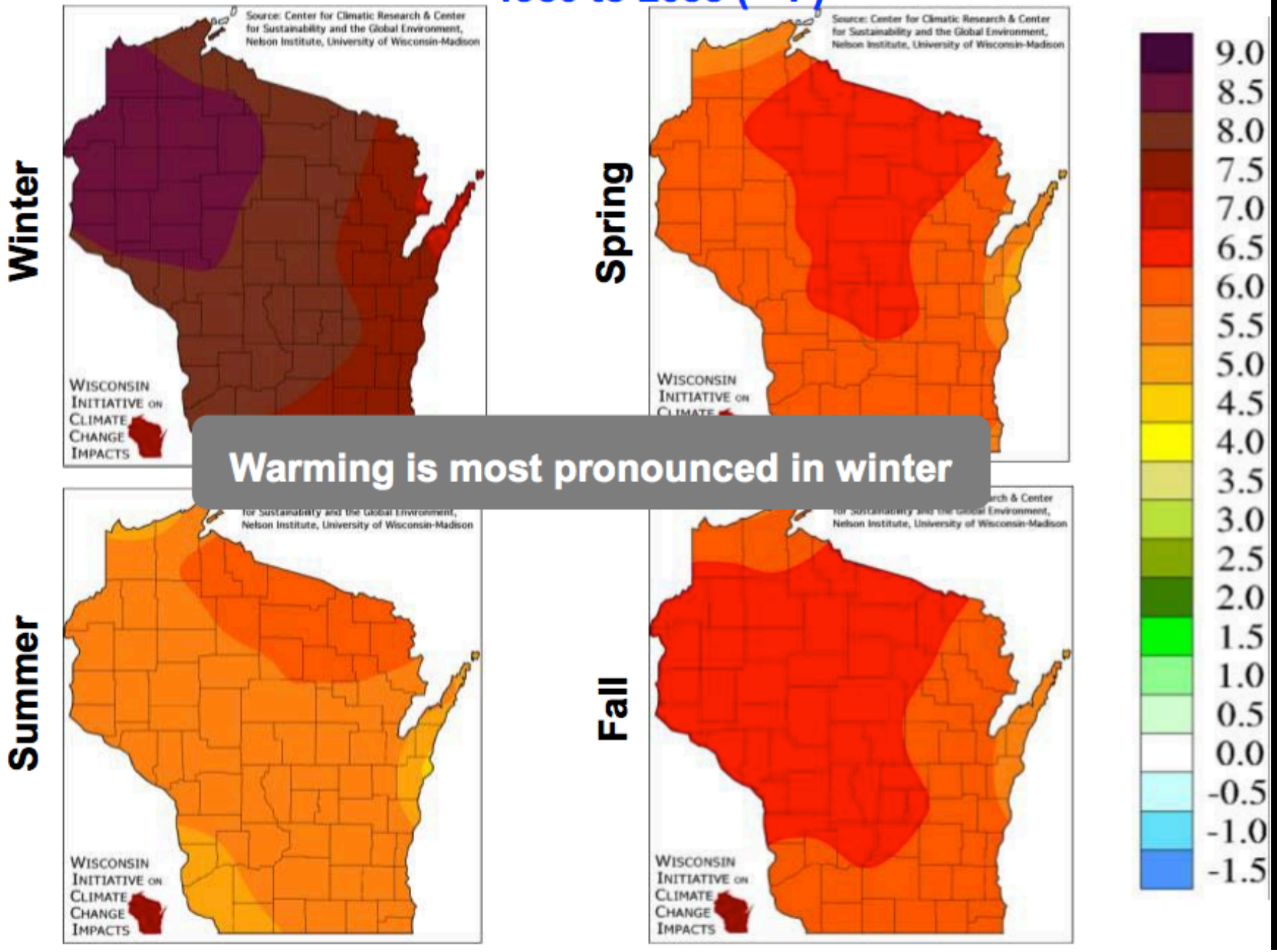

1900 to 2008 observations
1900 to 2000 simulation
Lower emissions scenario
Higher emissions scenario
Even higher emissions scenario
Degrees Fahrenheit
8
6
4
2
0
-2
1900
1925
1950
1975
2000
2025
2050
2075
2100
Year

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

Current & Developing Working Groups

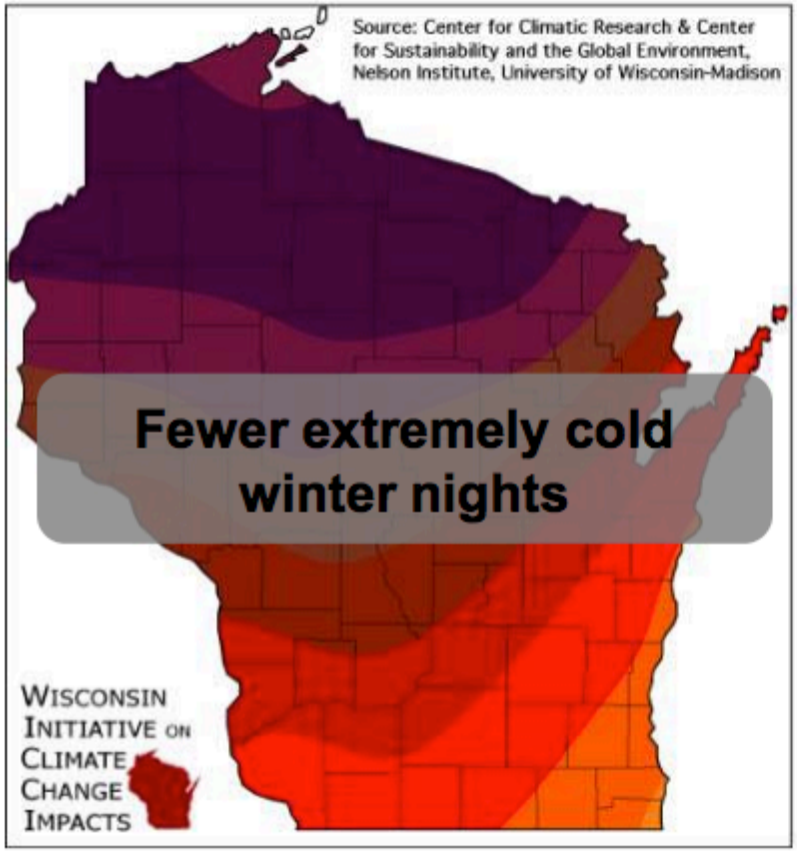
Projected Change in Seasonal Temperatures

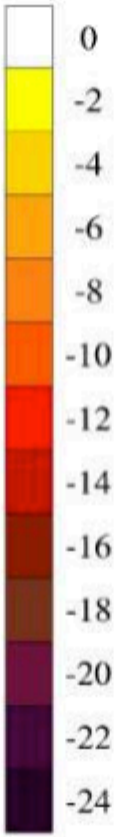
1980 to 2055 (° F)



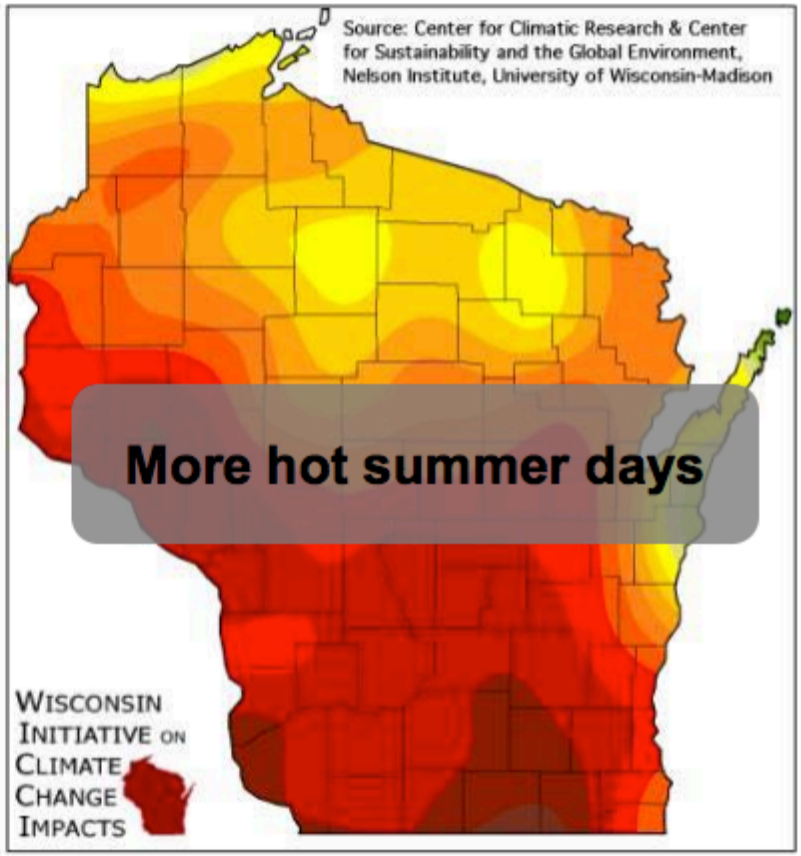
Warming is most pronounced in winter

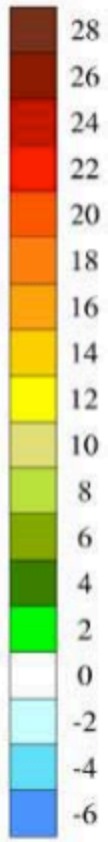
Projected change in the frequency of <0° F nights per year from 1980 to 2055

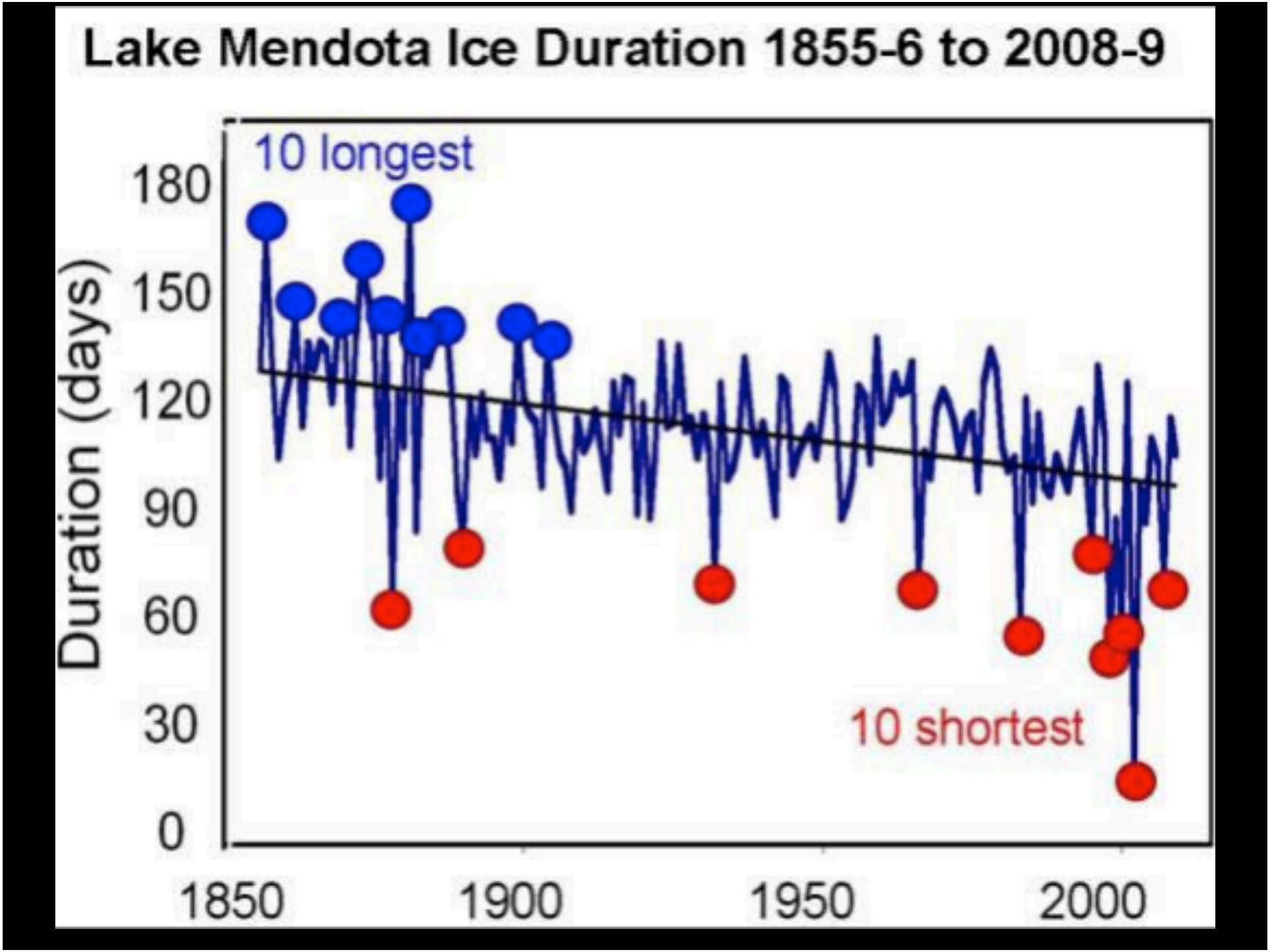




Projected change in the frequency of ≥90° F days per year from 1980 to 2055

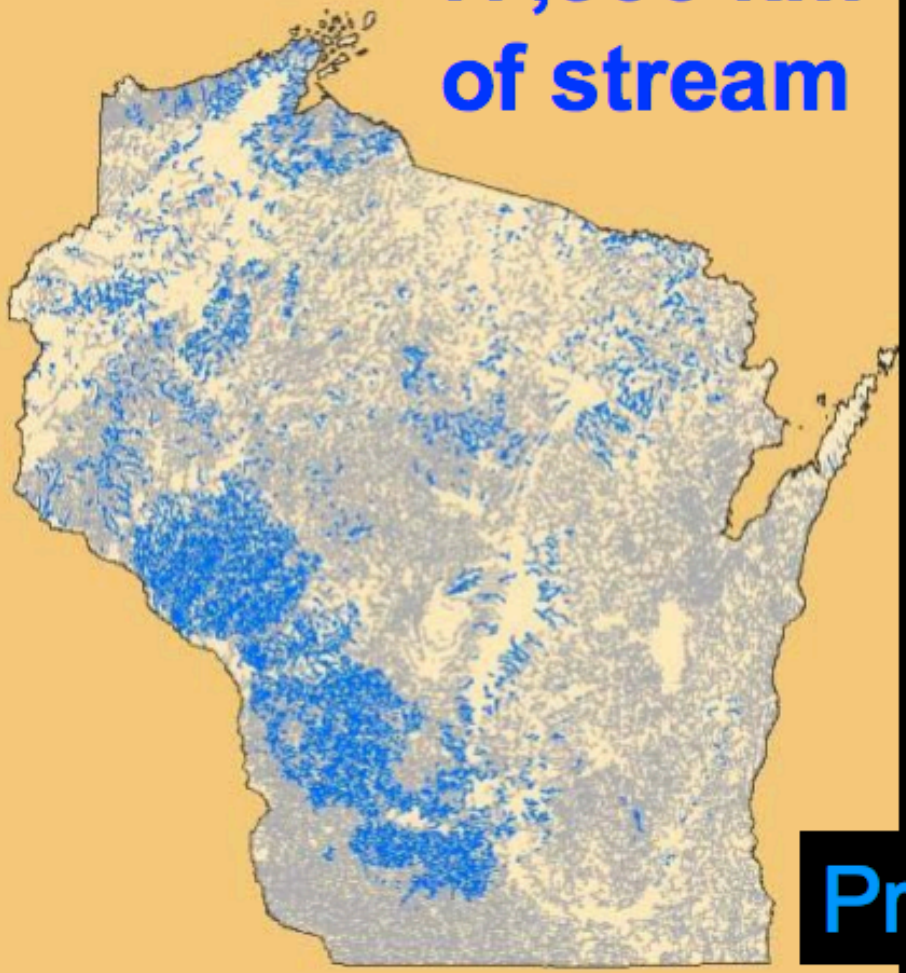




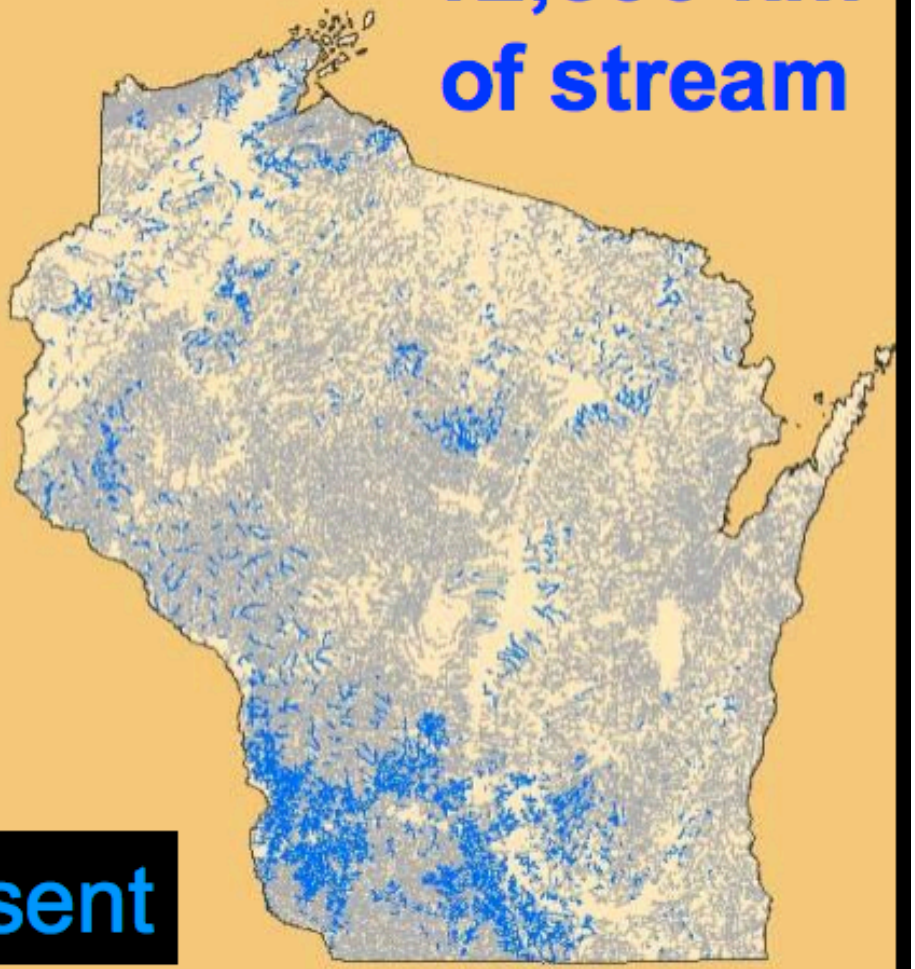

Lake Mendota Ice Duration 1855-6 to 2008-9
10 longest
10 shortest
Duration (days)
180
150
120
90
60
30
0
1850
1900
1950
2000

NOW

17,900 km of stream



12,500 km of stream

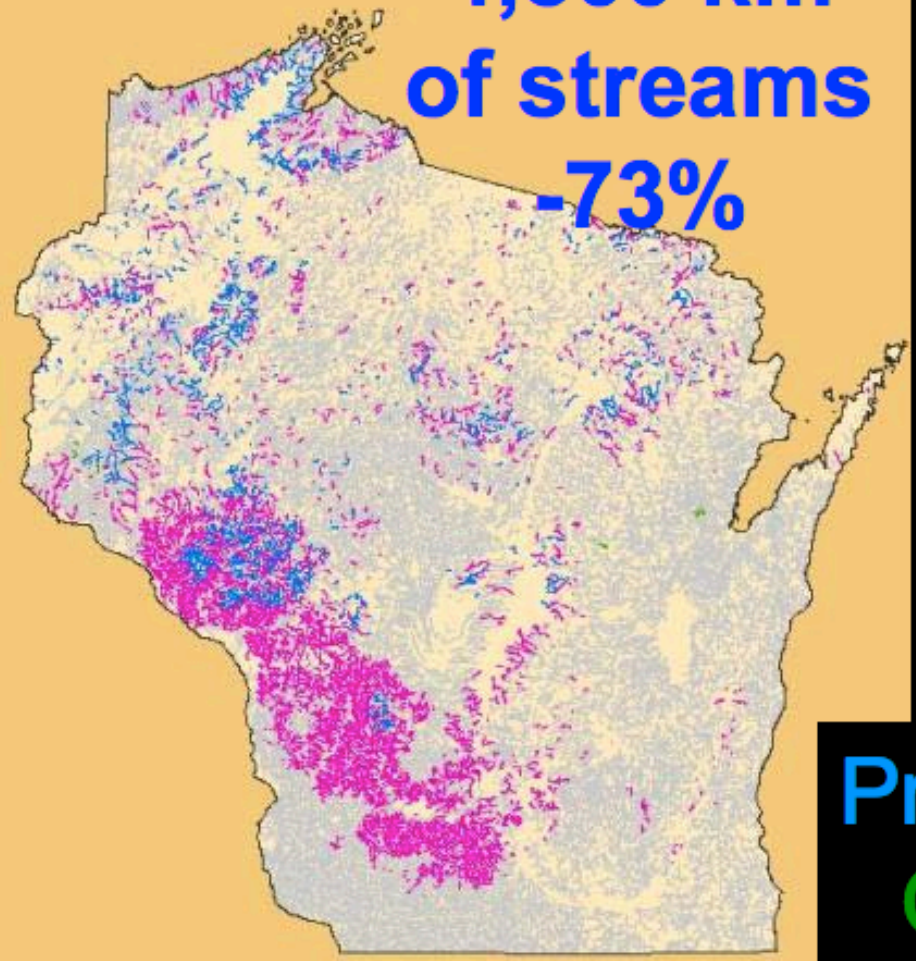


Present

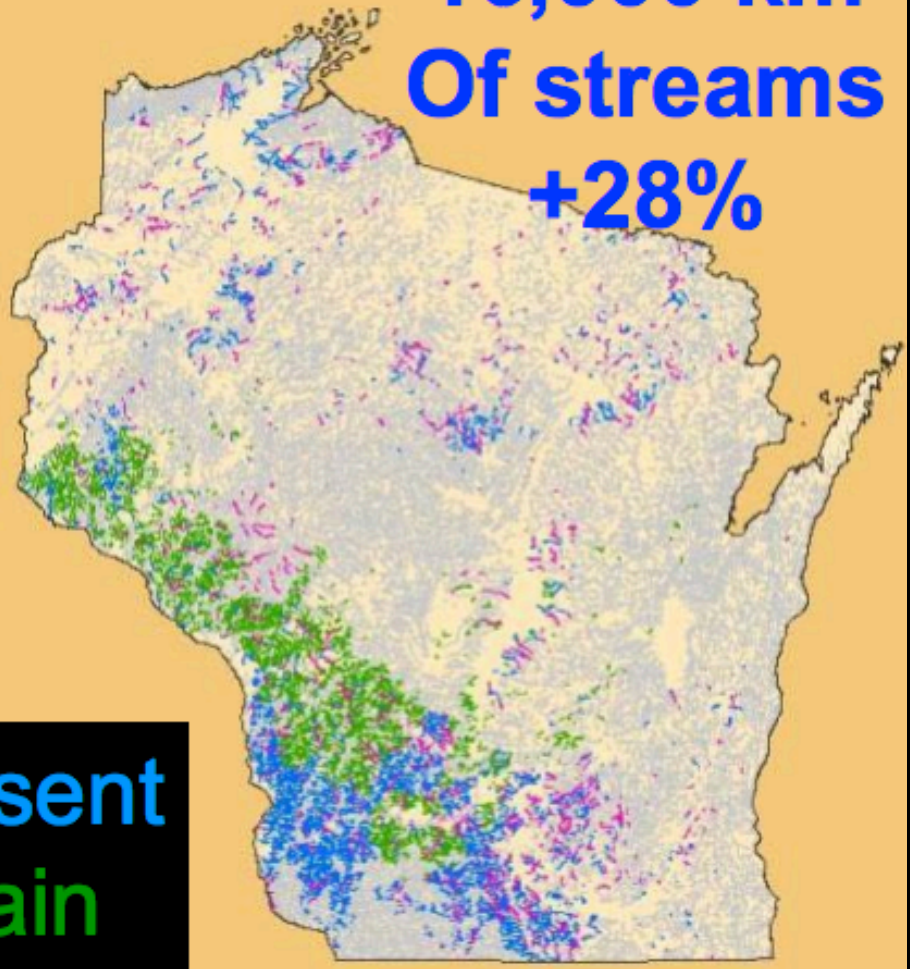
Matt Mitro & John Lyons WDNR

+1° C

4,800 km
of streams
-73%



16,000 km
Of streams
+28%

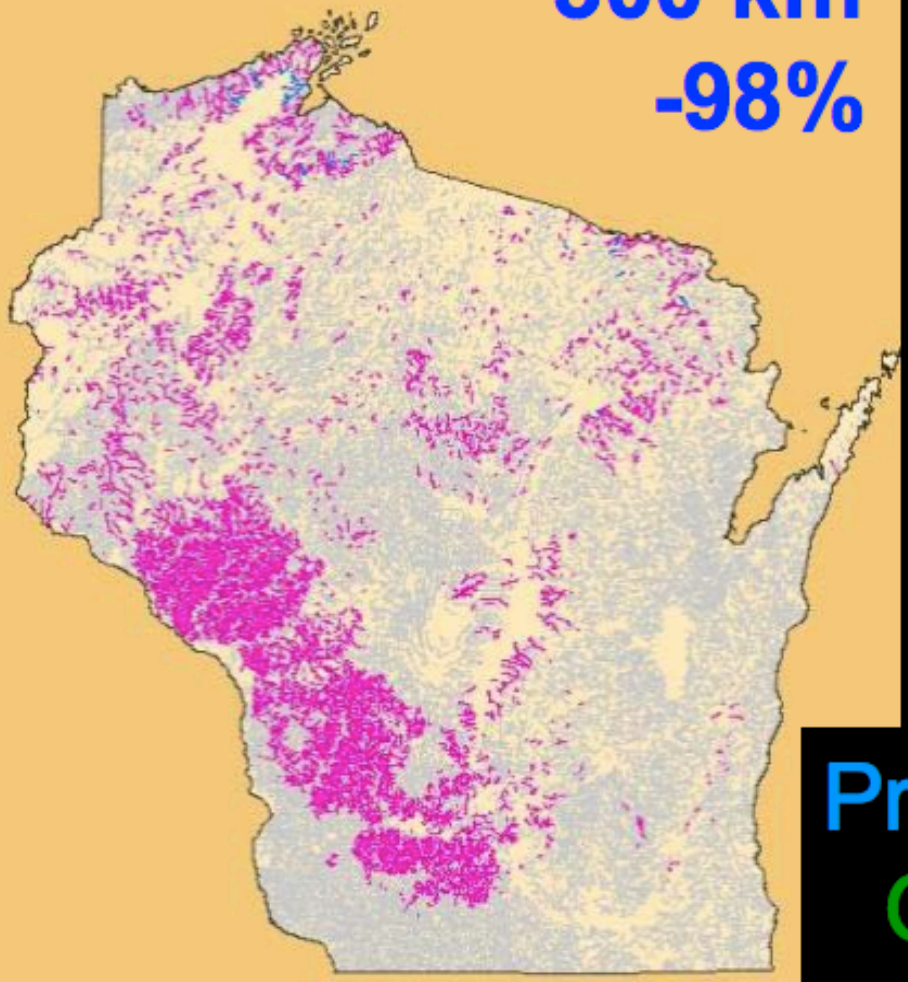


Present
Gain
Loss

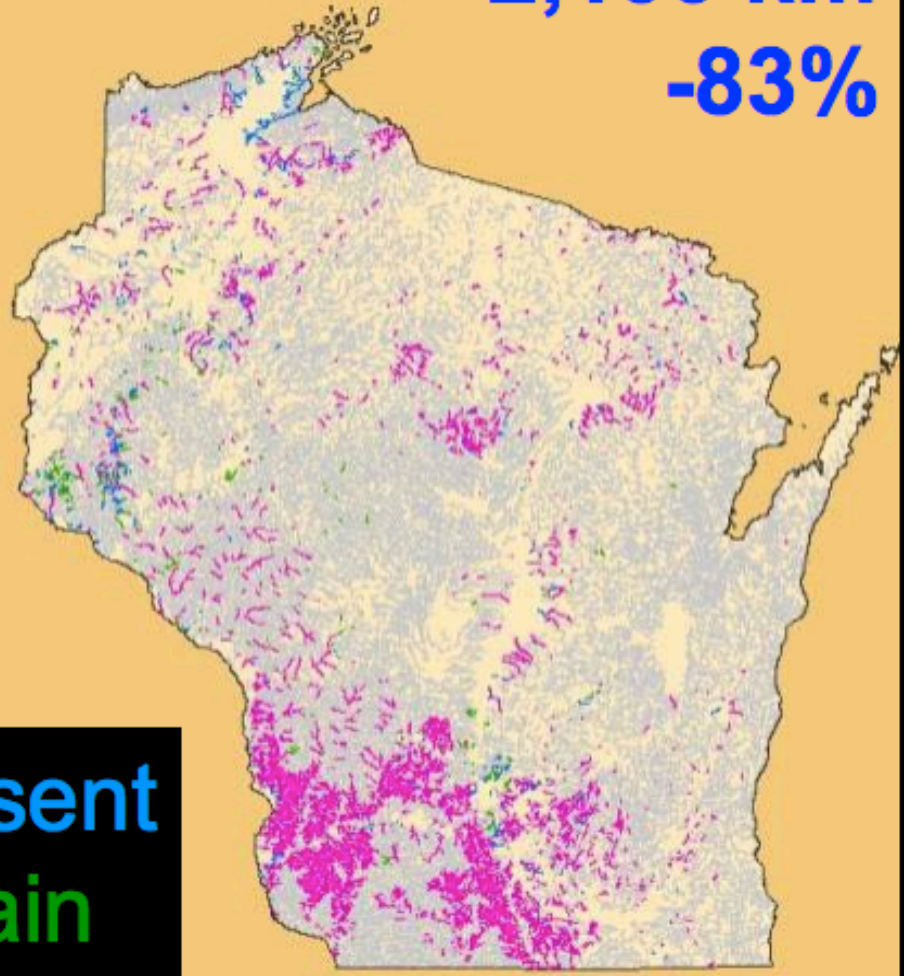
Matt Mitro & John Lyons WDNR

+3° C

300 km
-98%

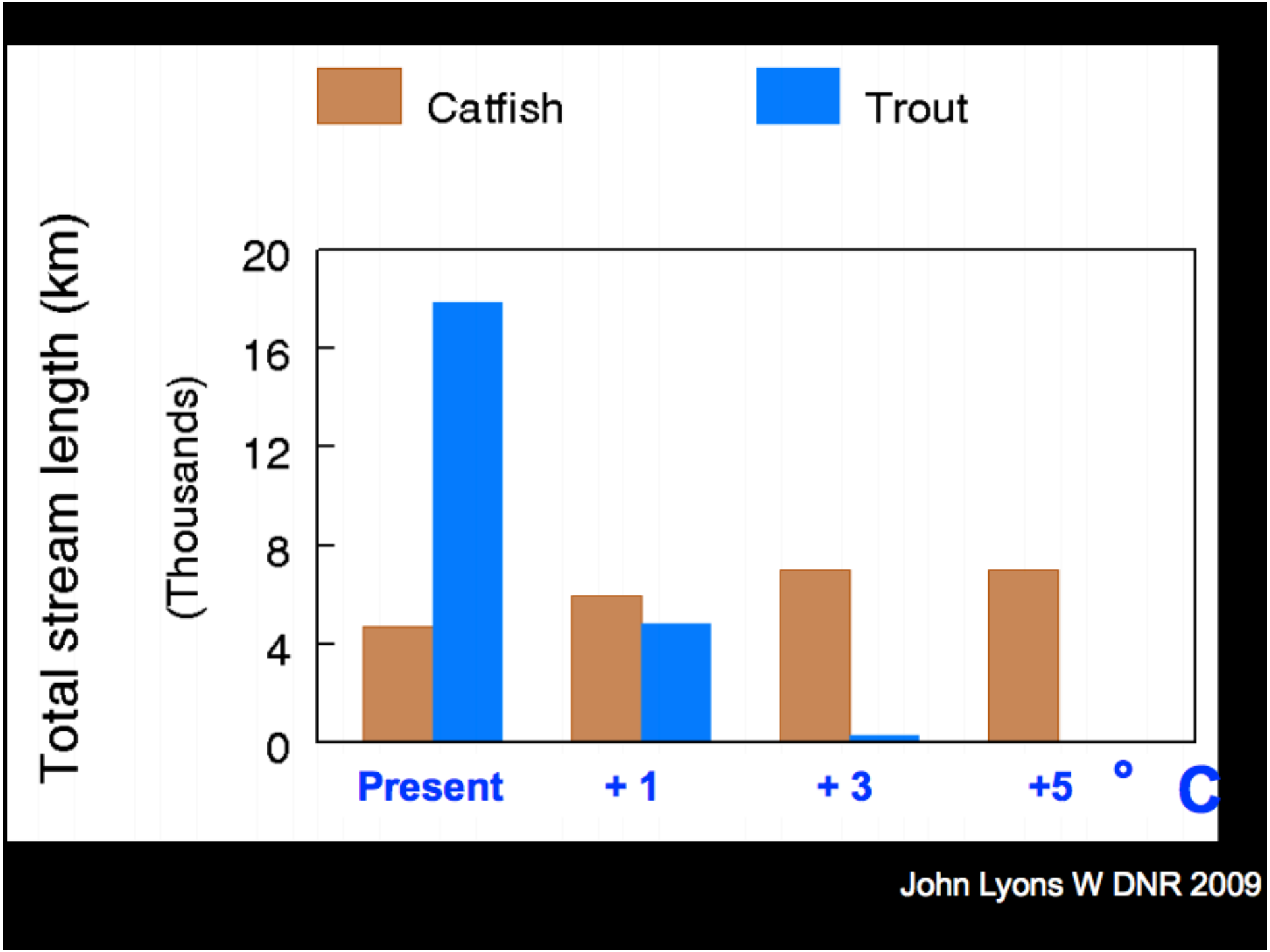


2,100 km
-83%

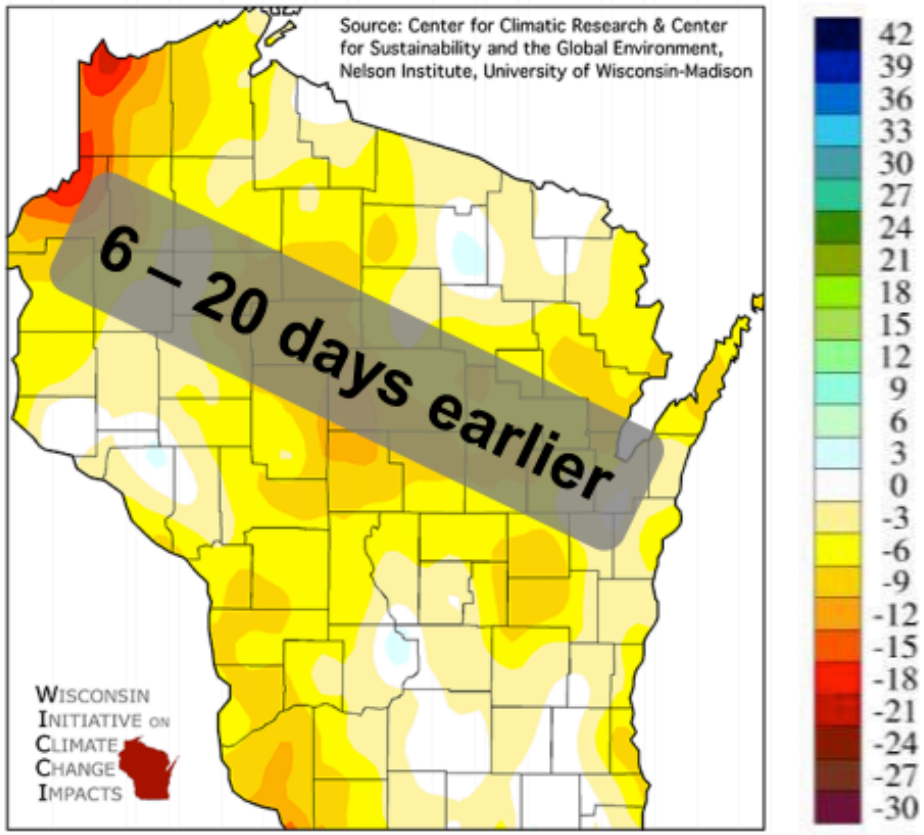


Present
Gain
Loss

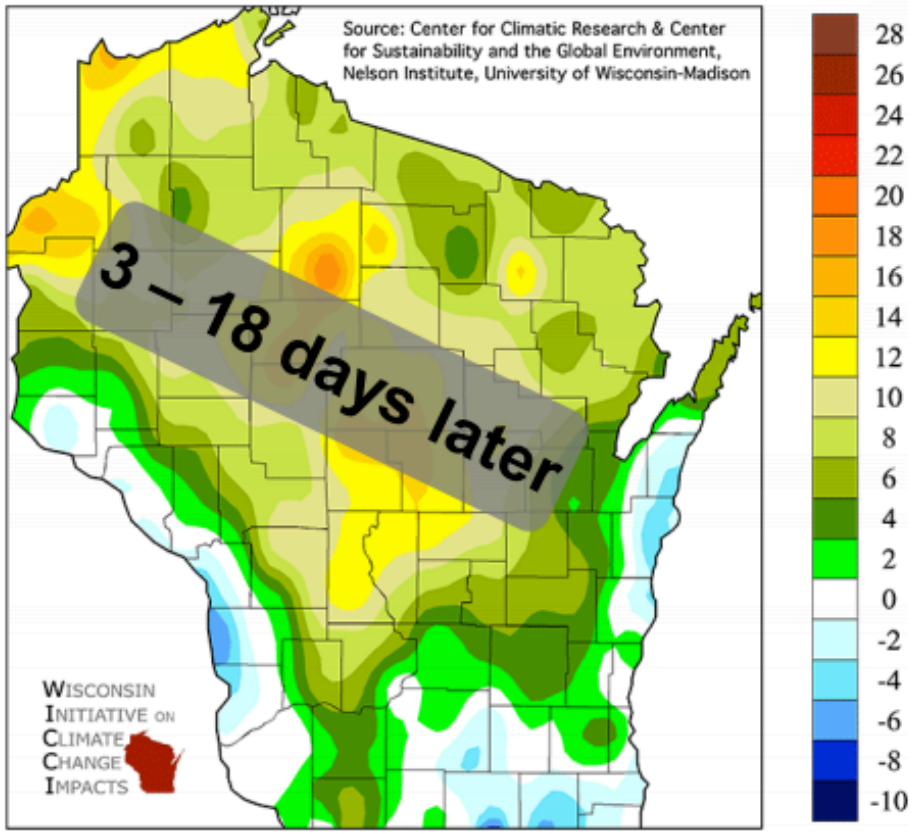
Matt Mitro & John Lyons WDNR


Catfish
Trout
Total stream length (km)
(Thousands)
20
16
12
8
4
0
Present
+ 1
+ 3
+5
°
C
John Lyons W DNR 2009

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	*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.

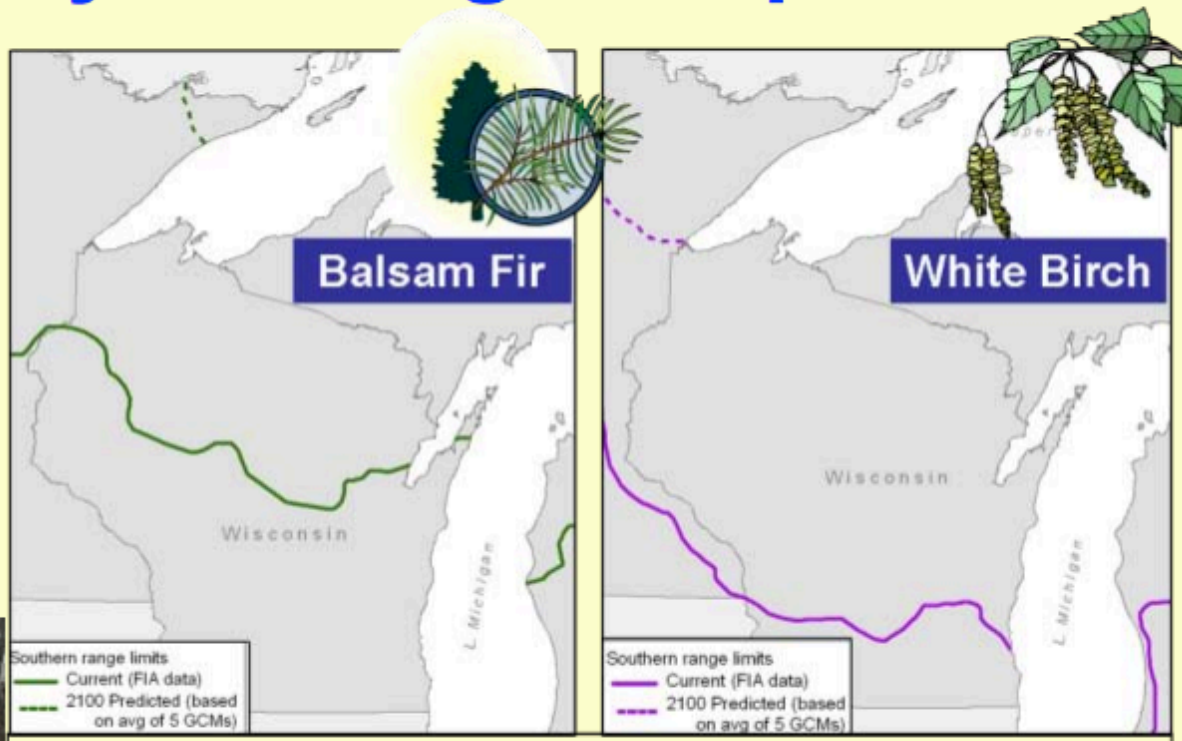
Source: Bradley et al., 1999. Phenological changes reflect climate change in Wisconsin. Proc. Natl. Acad. Sci., 96: 9701-9704.

Slide adapted from C. Kucharik, UW-Madison

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

Forestry Working Group

Loss of Northern Tree Species



Source: D. Mladenoff, UW-Madison; adapted from Prasad, A.M. and L.R. Iverson. 1999-ongoing. http://www.fs.fed.us/ne/delaware/atlas/index.html

Photo: Karin Fassnacht, WDNR

Impacts of Warmer Winters on Logging

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

Stormwater Working Group

Damage to communities and transportation systems from extreme storm events

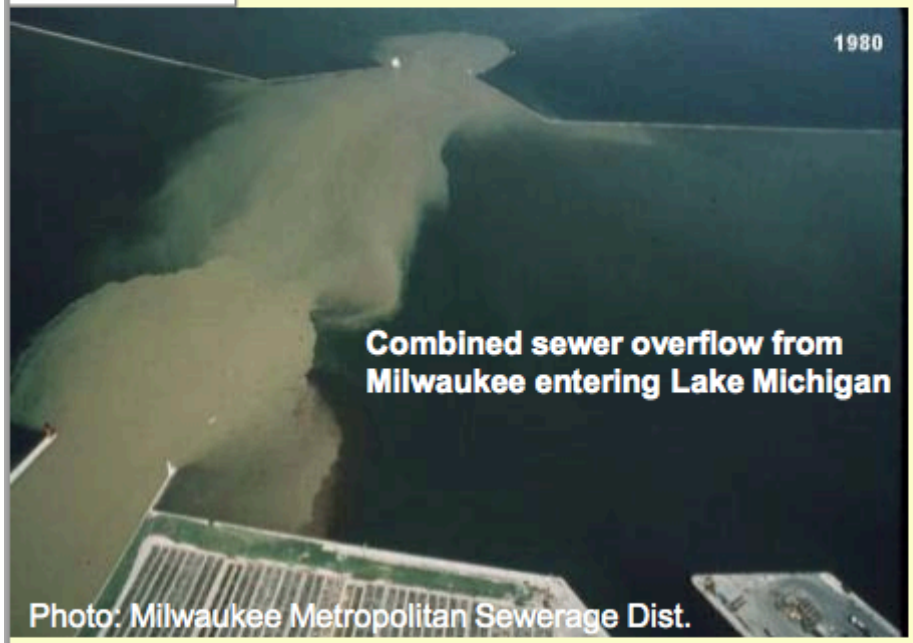
Rock Springs, WI, June 2008
Photo: Michael Kienitz


Madison, WI, July 2006
Photo: Gordy Stephenson


Jamie McCartney
HWY 60 near Excelsior, WI
August 20, 2007

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

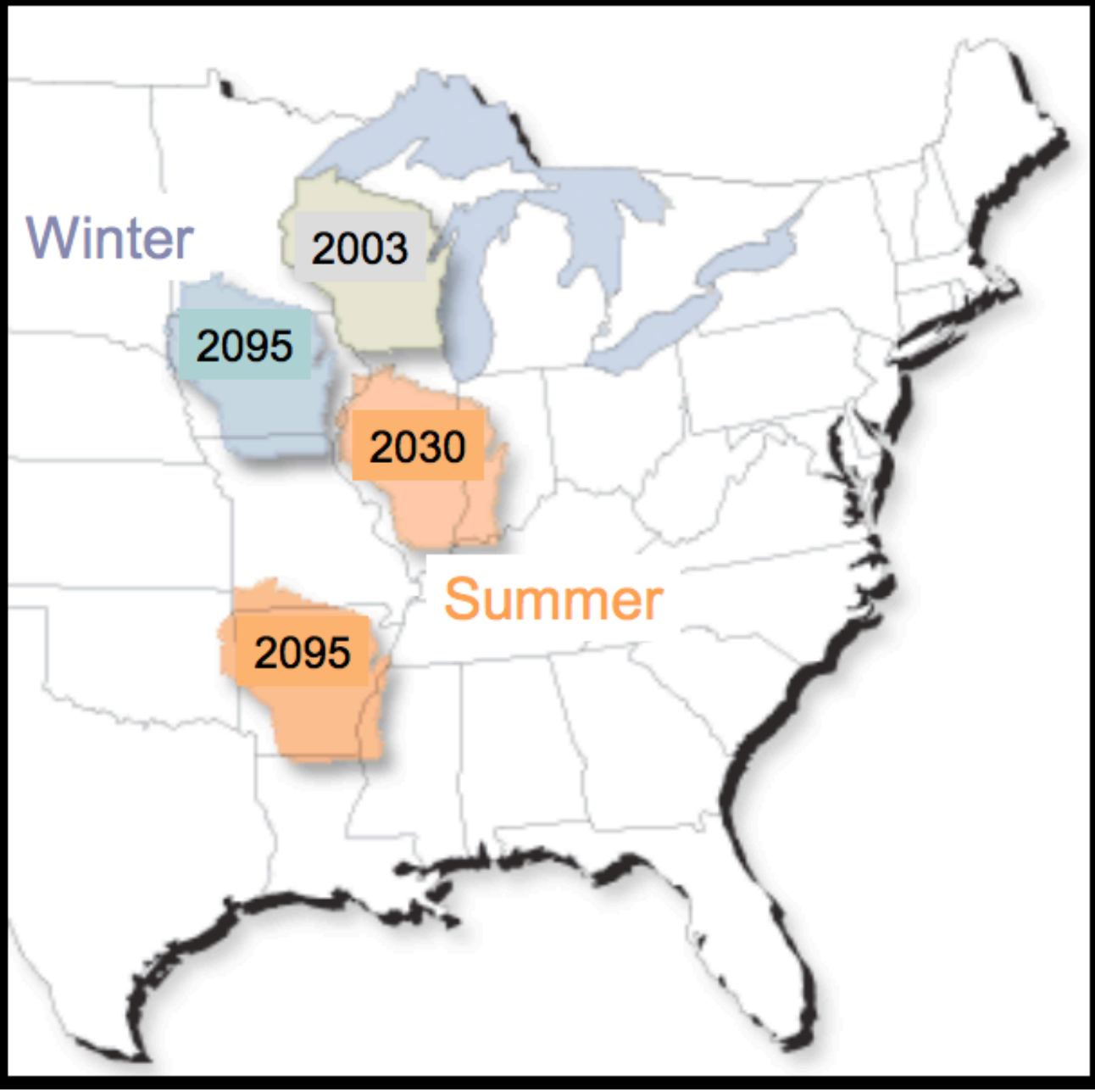
Human Health Working Group



Increase in waterborne infectious diseases from more intense storms

Increase in respiratory health problems from air pollution and climate change

Wisconsin Migrating Climate



Why is this controversial?

Obama's Effort to Slow Climate Change Heads to Court

By CORAL DAVENPORT 5:00 AM ET

President Obama's most far-reaching regulation to slow climate change will have its first day in court on Thursday, the beginning of what is expected to be a multiyear legal battle over the policy.

1990

SO, THIS CLIMATE CHANGE THING COULD BE A PROBLEM...

1995

CLIMATE CHANGE: DEFINITELY A PROBLEM.

2001

YEP, WE SHOULD REALLY BE GETTING ON WITH SORTING THIS OUT PRETTY SOON...

2007

LOOK, SORRY TO SOUND LIKE A BROKEN RECORD HERE...

2013

WE REALLY HAVE CHECKED AND WE'RE NOT MAKING THIS UP.

2019

IS THIS THING ON?

TAP TAP TAP

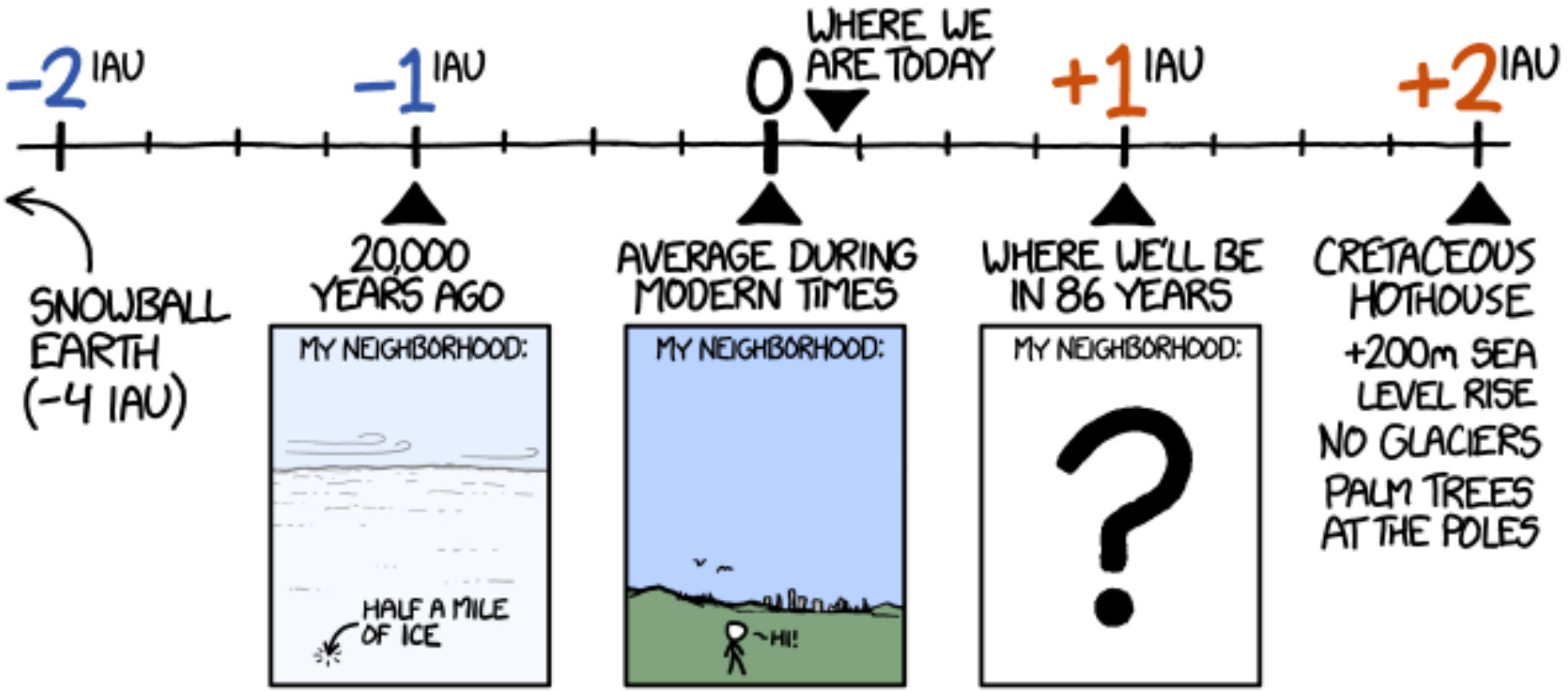
KUDELKA. 28/9/13

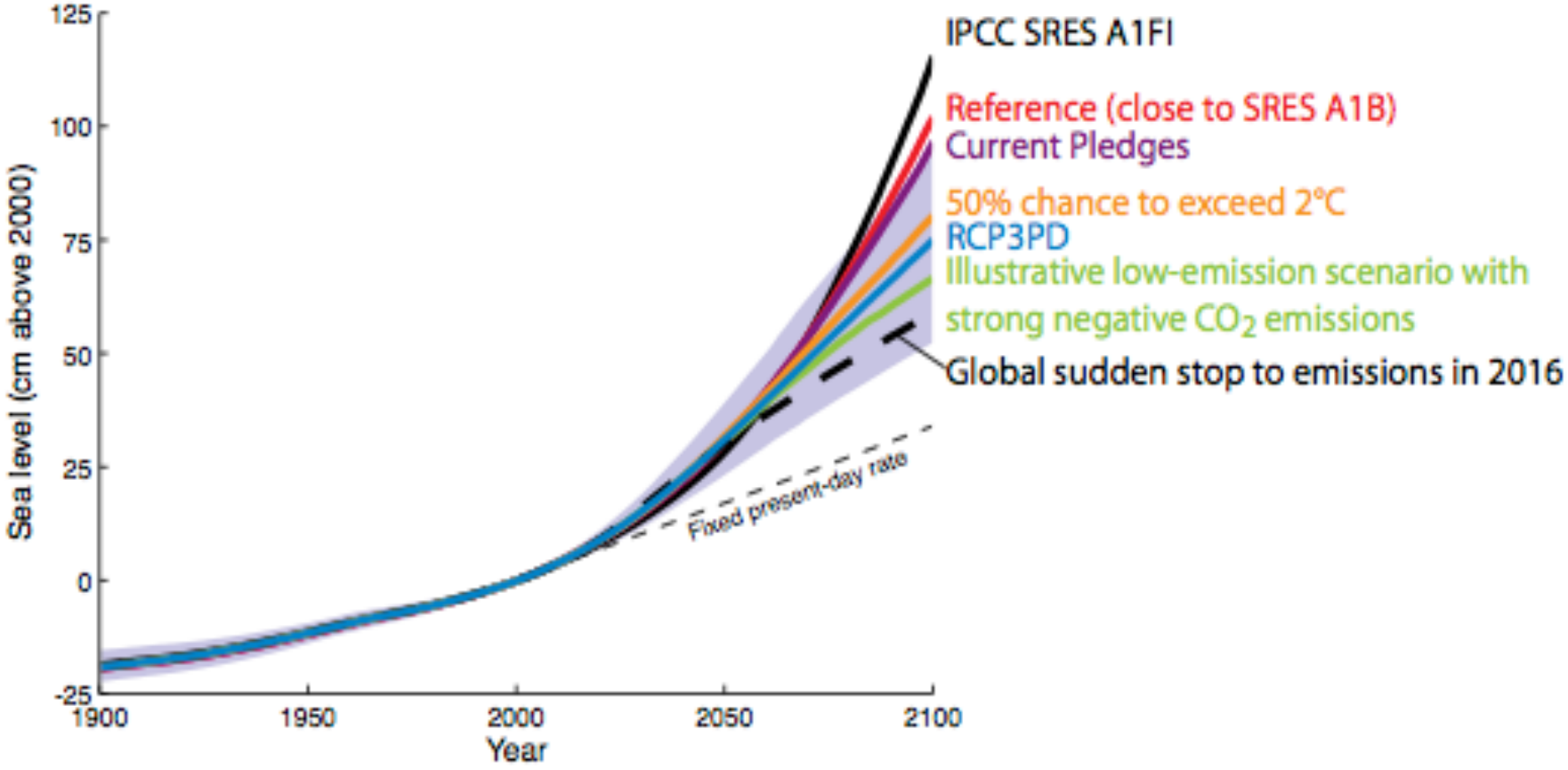
WITHOUT PROMPT, AGGRESSIVE LIMITS ON CO_2 EMISSIONS, THE EARTH WILL LIKELY WARM BY AN AVERAGE OF 4°-5°C BY THE CENTURY'S END.

HOW BIG A CHANGE IS THAT?

IN THE COLDEST PART OF THE LAST ICE AGE, EARTH'S AVERAGE TEMPERATURE WAS 4.5°C BELOW THE 20TH CENTURY NORM.

LET'S CALL A 4.5°C DIFFERENCE ONE "ICE AGE UNIT."




125
100
75
50
25
0
-25
Sea level (cm above 2000)
1900
1950
2000
2050
2100
Year
IPCC SRES A1FI
Reference (close to SRES A1B)
Current Pledges
50% chance to exceed 2°C
RCP3PD
Illustrative low-emission scenario with
strong negative CO_2 emissions
Global sudden stop to emissions in 2016
Fixed present-day rate

What Are The Options?

- Adaptation
  - Economic/political (relocation, tech transfer, payments for damages, reduce poverty, educate)
  - Technological (resilient tech, seawalls, genetic hybrids, cure malaria, colonize new planet)
- Mitigation
  - Economic (taxes, cap and trade, R&D)
  - Political (treaties, bans, compacts, fuel/energy standards, public transit, voluntary agreements)
  - Societal (sustainable development)
  - Technological (CO2 capture, geoengineering, green tech, alternative energy, energy efficiency)