Global & Regional Climate Change Science

a presentation from the

CIMSS Climate Literacy Ambassadors community

A low-carbon climate education project

THE UNIVERSITY of WISCONSIN MADISON

Differences between Weather & Climate

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

Weather is the condition of the atmosphere at a particular location and moment.

Each day current weather conditions are given in local weather reports.

Climate is the collective state of the atmosphere for a given place over a specified interval of time.

There are **three parts** to this definition …

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Climate is the collective state of the atmosphere for a given place over a specified interval of time. There are three parts to this definition:

1. *Location*
   because climate can be defined for a globe, a continent, a region, or a city.

2. *Time*
   because climate must be defined over a specified interval. NOAA typically uses 30-year averages, whereas studying Earth's history often involves averages of a century or longer.

3. *Averages and extremes of variables*
   such as temperature, precipitation, pressure & winds.

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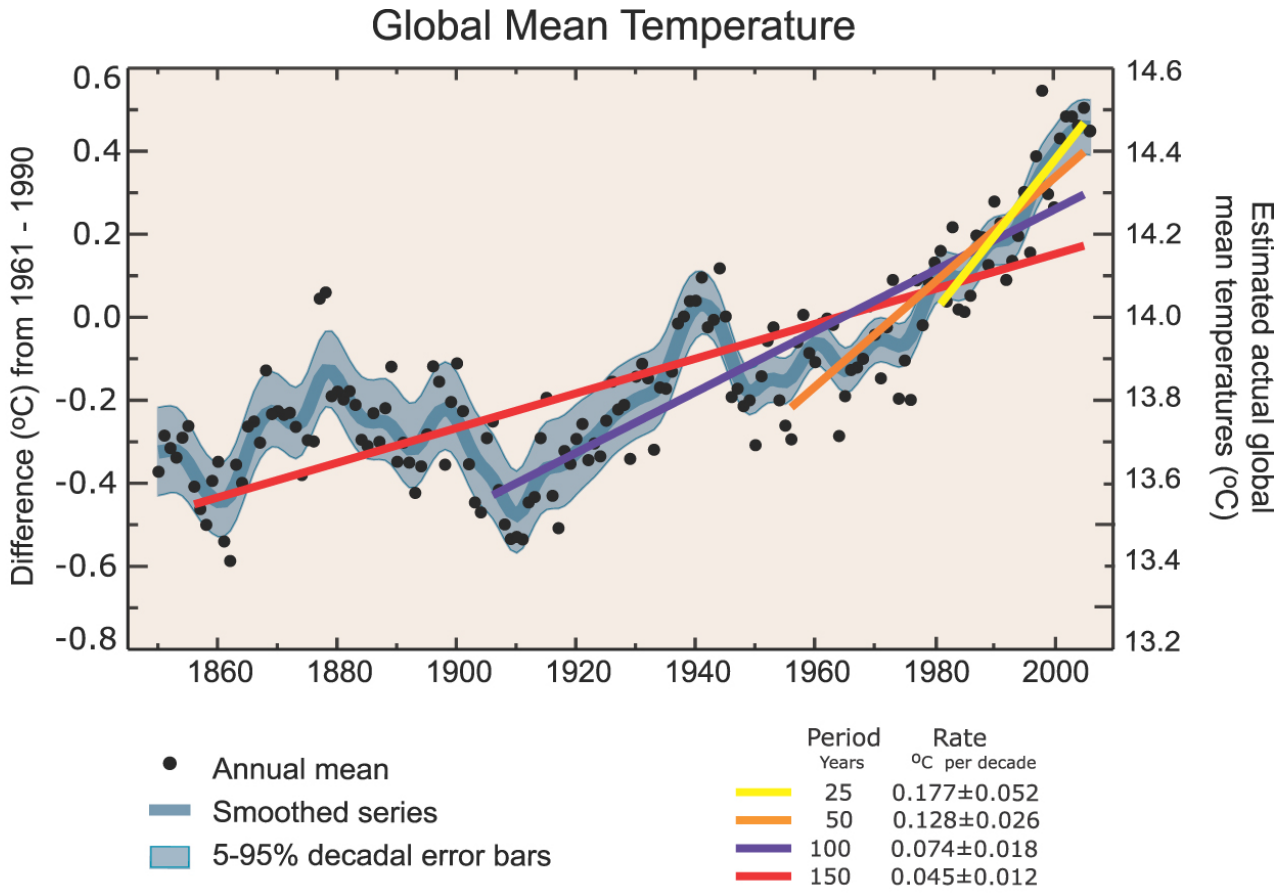
Global Climate Change

Global Temperature: Has increased by ~0.7˚ C over the last 100yr. The rate of increase is “accelerating”.



Global data & graphs in this presentation are from 2007 IPCC report

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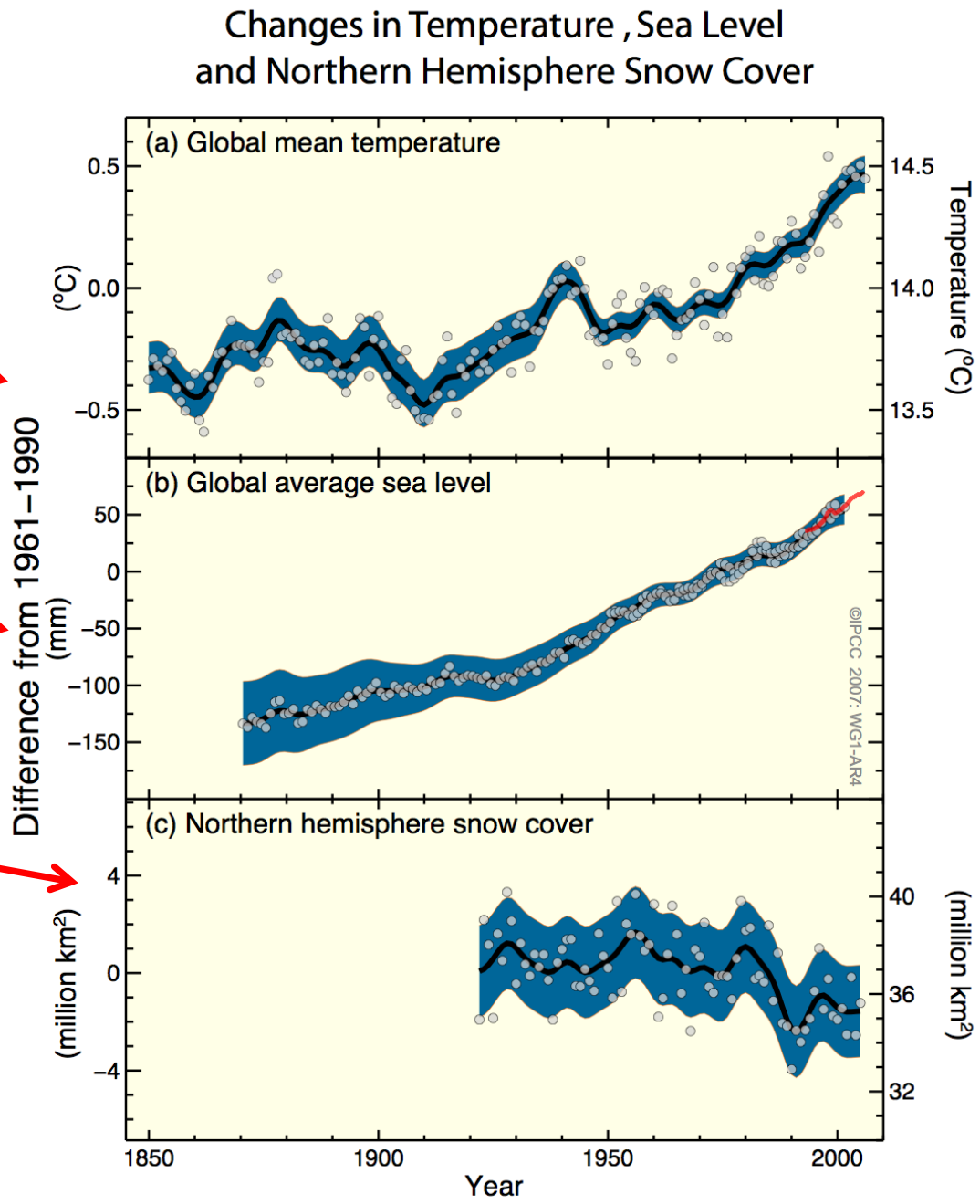
Warming is Unequivocal

Rising atmospheric temperature

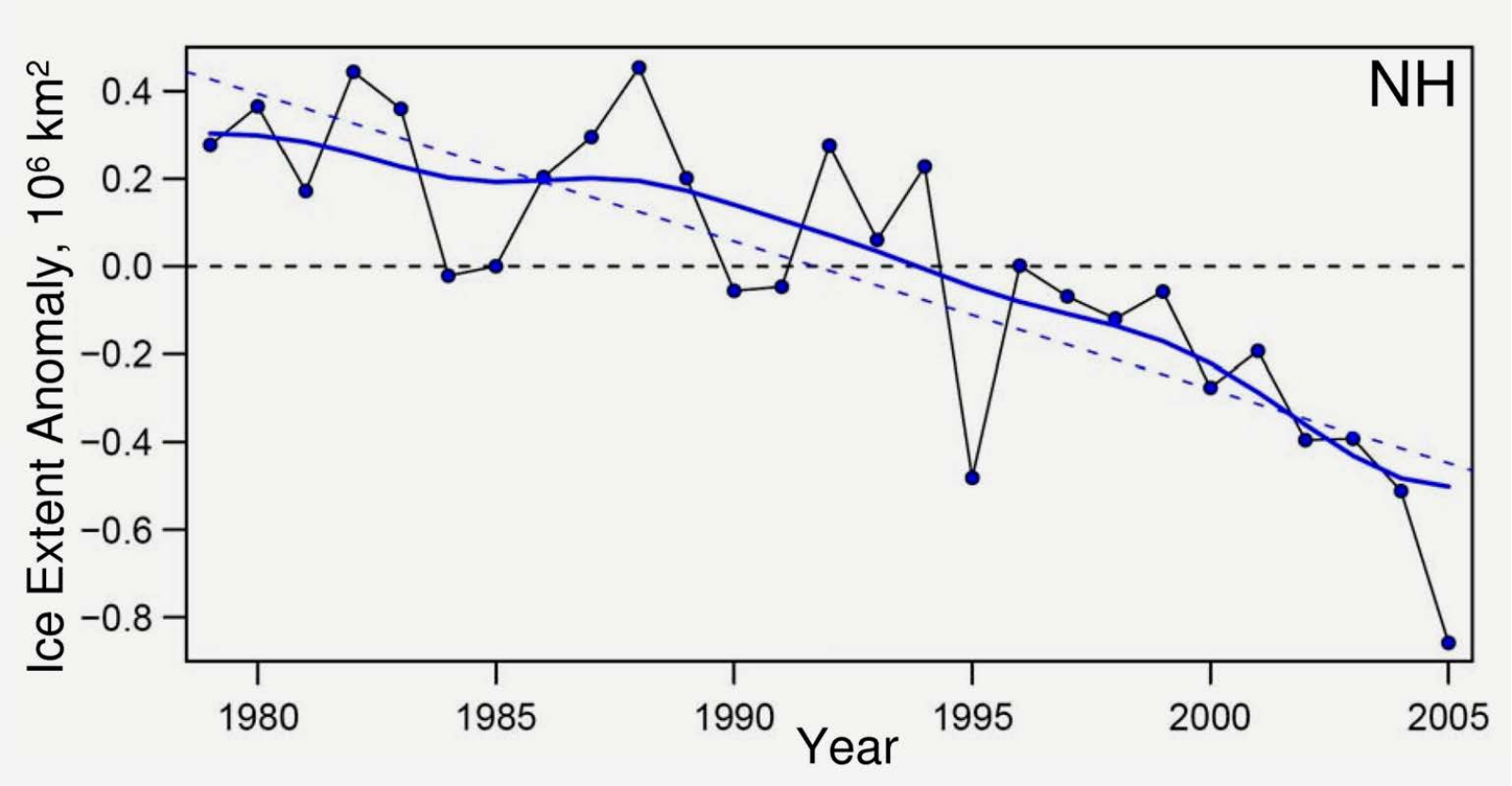
Rising sea level

Reductions in NH snow cover

Also, the Oceans are warming & becoming more acidic



A different world in the Arctic: present and future



Significant decreases in Arctic sea ice extent.

Changes in sea ice don't significantly affect sea level because this ice is already floating. Melting land ice (glaciers, ice caps, and ice sheets) increases sea level.

Large future changes in Arctic sea ice are very likely.

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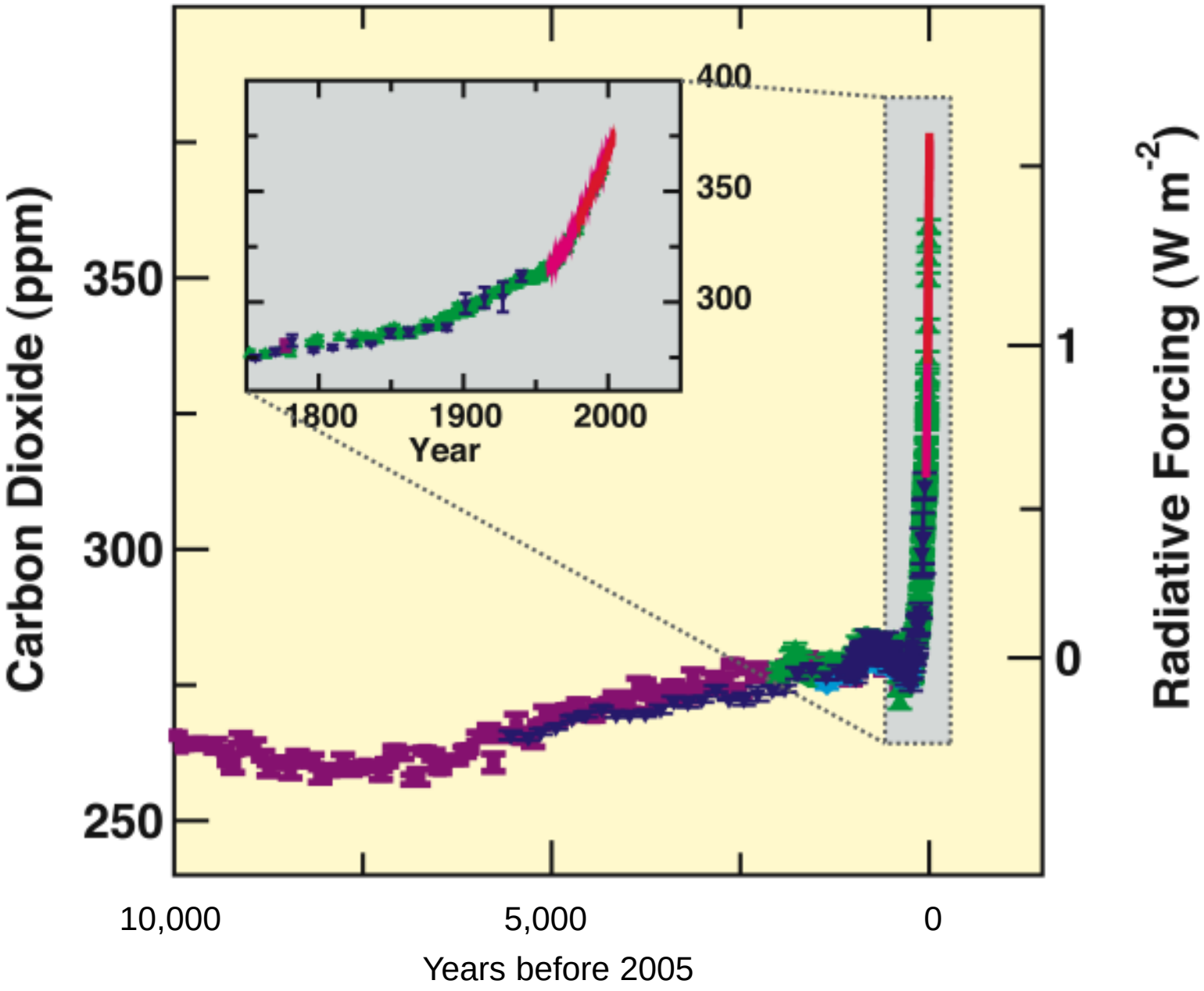
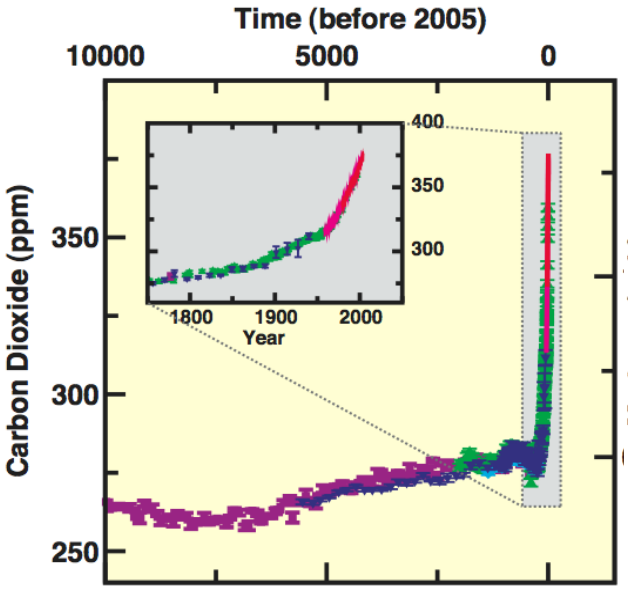
What drives the observed warming?

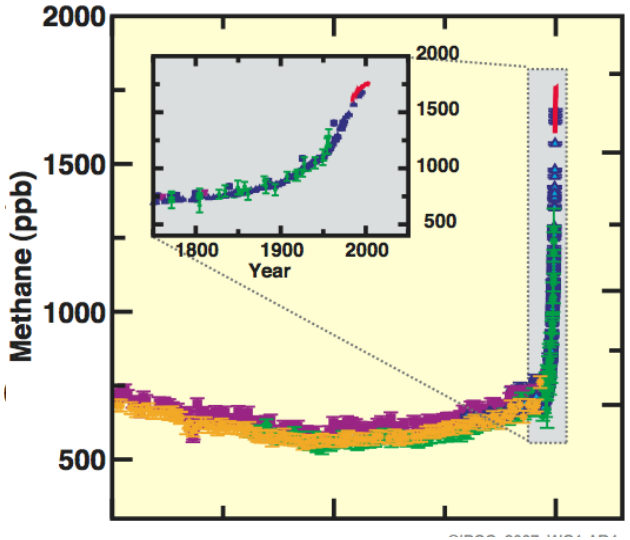

Carbon Dioxide (ppm)
350
300
250
400
350
300
1800
1900
2000
Year
1
0
Radiative Forcing (W m-2)
10,000
5,000
0
Years before 2005

Industrial revolution and the atmosphere

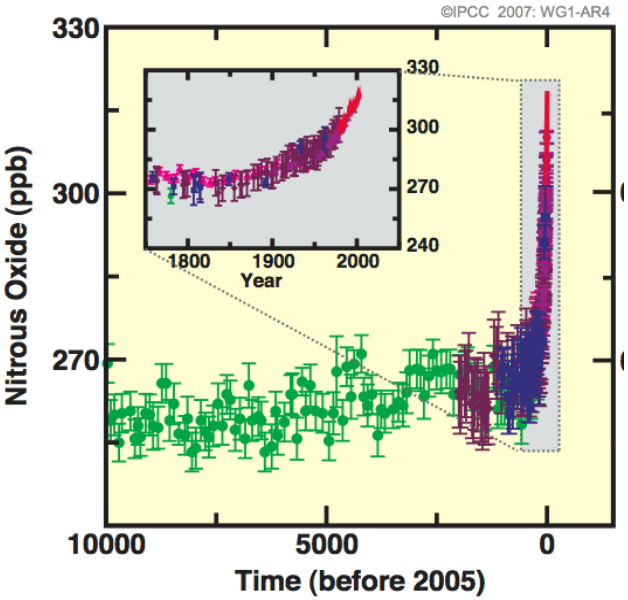
The current concentrations of key greenhouse gases, and their rates of change, are unprecedented.



Carbon dioxide



Methane

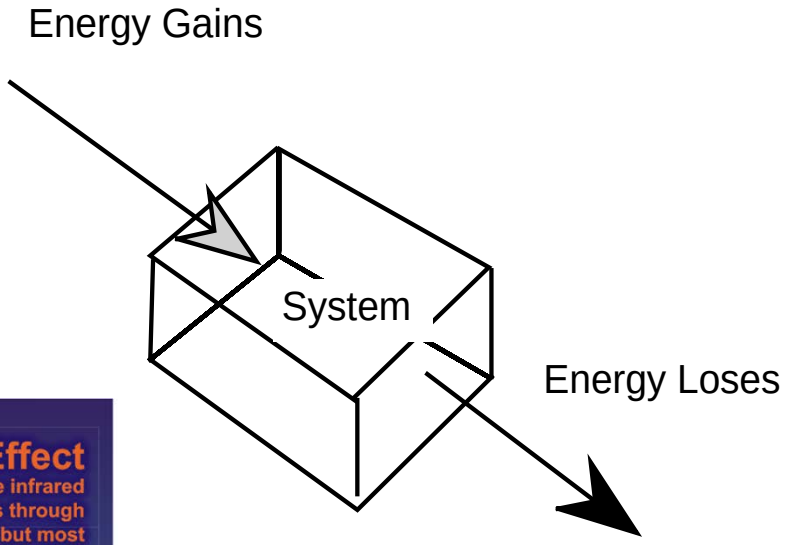


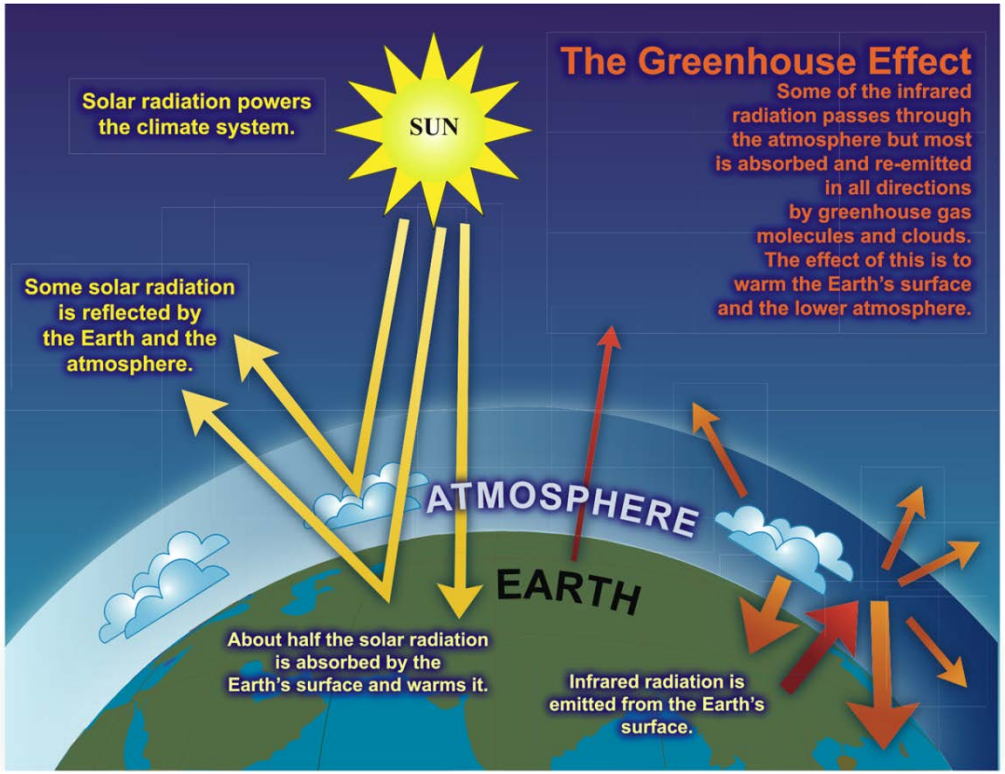
Nitrous Oxide

Intergovernmental Panel on Climate Change 2007

How do CO_2 (and other gases) cause global warming?

Global Climate Change





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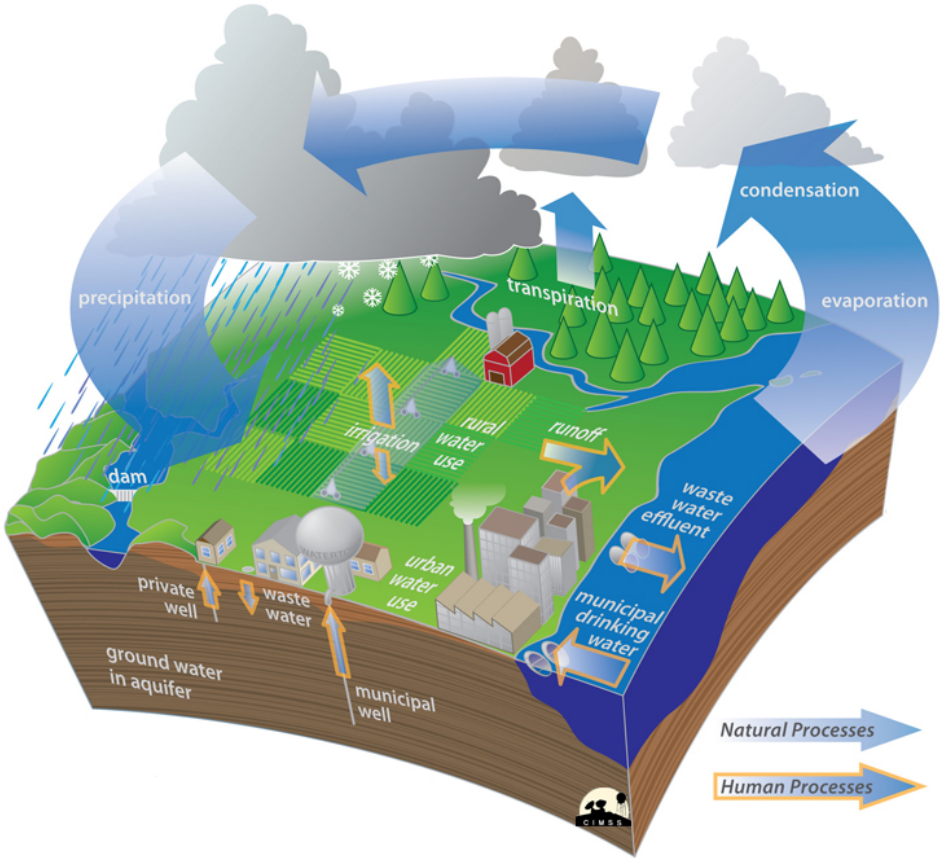
The climate system is more complex than just CO_2 and radiation

What about the feedbacks?

One way to think about Climate Change is an intensification of the water cycle



As the temperature of the atmosphere rises, more water is evaporated from ground storage (rivers, oceans, reservoirs, soil). Because the air is warmer, the relative humidity can be higher, and the atmosphere can 'hold' more water vapor. As a greenhouse gas, the higher concentration of water vapor is then able to absorb more thermal IR energy radiated from the Earth, thus further warming the atmosphere. The warmer atmosphere can then hold more water vapor and so on and so on. This is referred to as a 'positive feedback loop'.

In a warming climate, water vapor plays a major role in a positive feedback loop that amplifies global climate change.

(*H_20 responds to changes in climate, but it doesn't drive climate chang*

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Observed warming is consistent with observed changes:

There is a widespread retreat of nonpolar glaciers.

Arctic sea-ice has thinned by 40% in recent decades (summer & autumn)
And decreased in extent by 15% since the 1950s in spring and summer.

Northern Hemisphere snow cover has decreased by 10% since the 1960s.

The growing season has lengthened by about 1 to 4 days per decade during the last 40 years in the Northern Hemisphere, especially at higher latitudes.

The duration of ice cover on lakes decreased by about 2 weeks over the 20th century in mid- and high latitudes of the Northern Hemisphere.

The global mean sea level has increased at an average annual rate of 1 to 2 mm during the 20th century.

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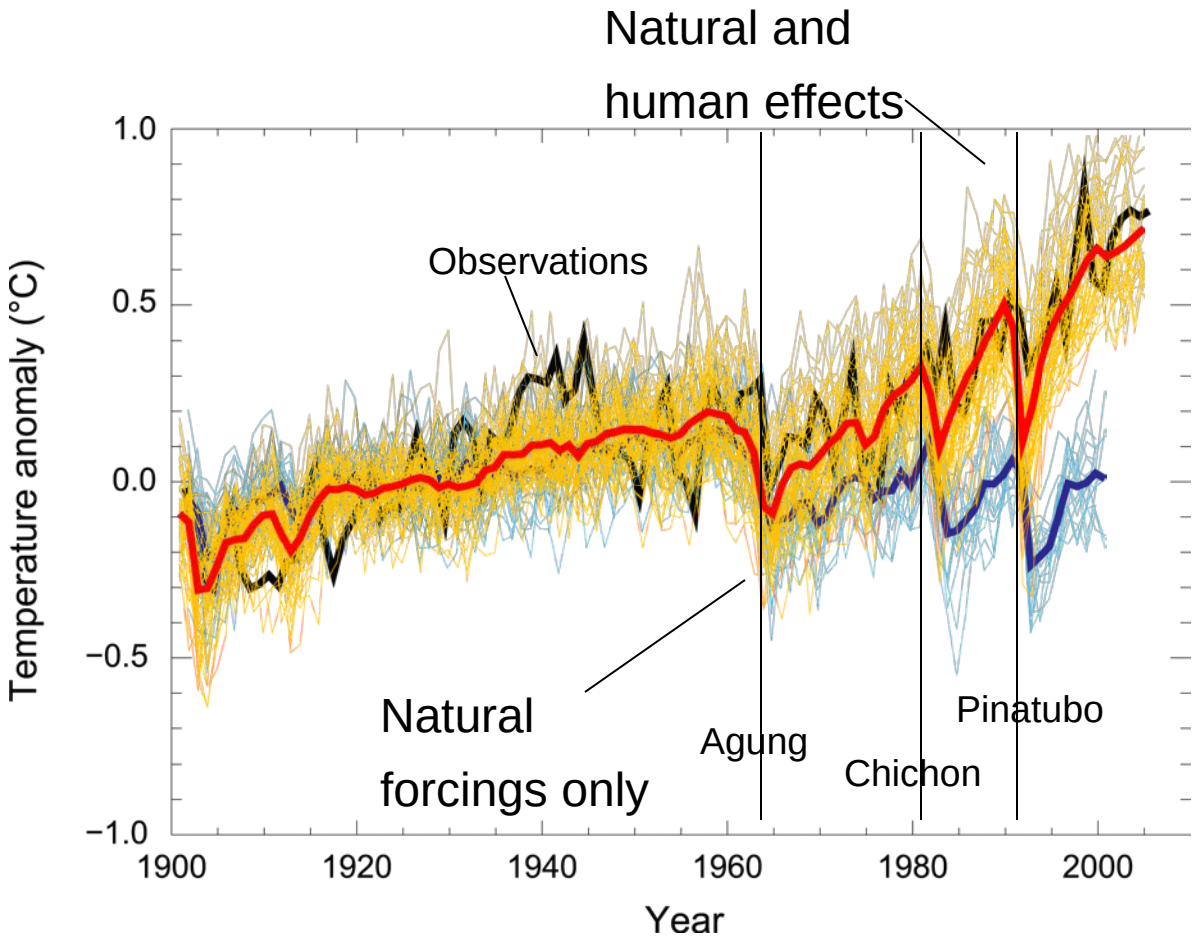
Are Humans Responsible?

IPCC (1995):
"Balance of evidence suggests discernible human influence"

IPCC (2001):
"Most of global warming of past 50 years *likely* (odds 2 out of 3) due to human activities"

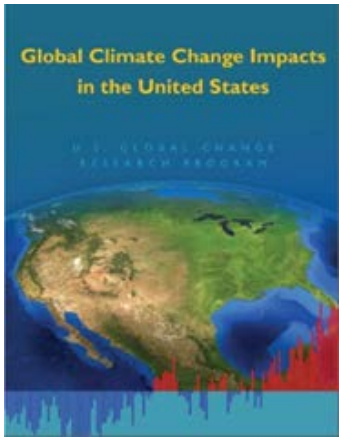
IPCC (2007):
"Most of global warming of past 50 years *very likely* (odds 9 out of 10) due to greenhouse gases"



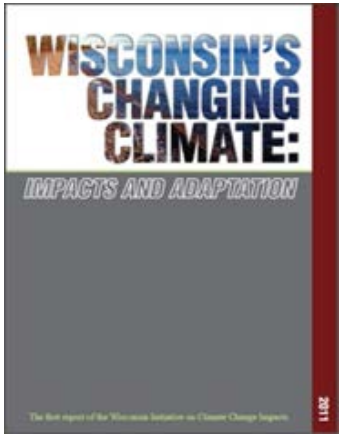
IPCC WG1 - 2007
(Intergovernmental Panel on Climate Change)

Regional Climate Change

Featuring information from two recent reports:



Global Climate Change Impacts in the United States
- 2009 –
U.S. Global Change Research Program
Midwest Region



Wisconsin's Changing Climate: *Impacts and Adaptation*
- 2011 -
Wisconsin Initiative on Climate Change Impacts (WICCI)

http://www.wicci.wisc.edu/

Great Lakes Key Issues

During the summer, public health & quality of life, especially in cities, will be negatively affected by increasing heat waves, reduced air quality, and increasing insect and waterborne diseases.

The likely increase in precipitation in winter and spring, more heavy downpours, and greater evaporation in summer would lead to more periods of both floods and water deficits.

Reductions in Great Lakes water levels will have impacts on shipping, infrastructure, beaches, & ecosystems.

Native species are very likely to face increasing threats from rapidly changing climate conditions, pests, diseases, and invasive species.

While the longer growing season provides the potential for increased crop yields, increases in heat waves, floods, droughts, insects, and weeds will present increasing challenges to managing crops, livestock, and forests.

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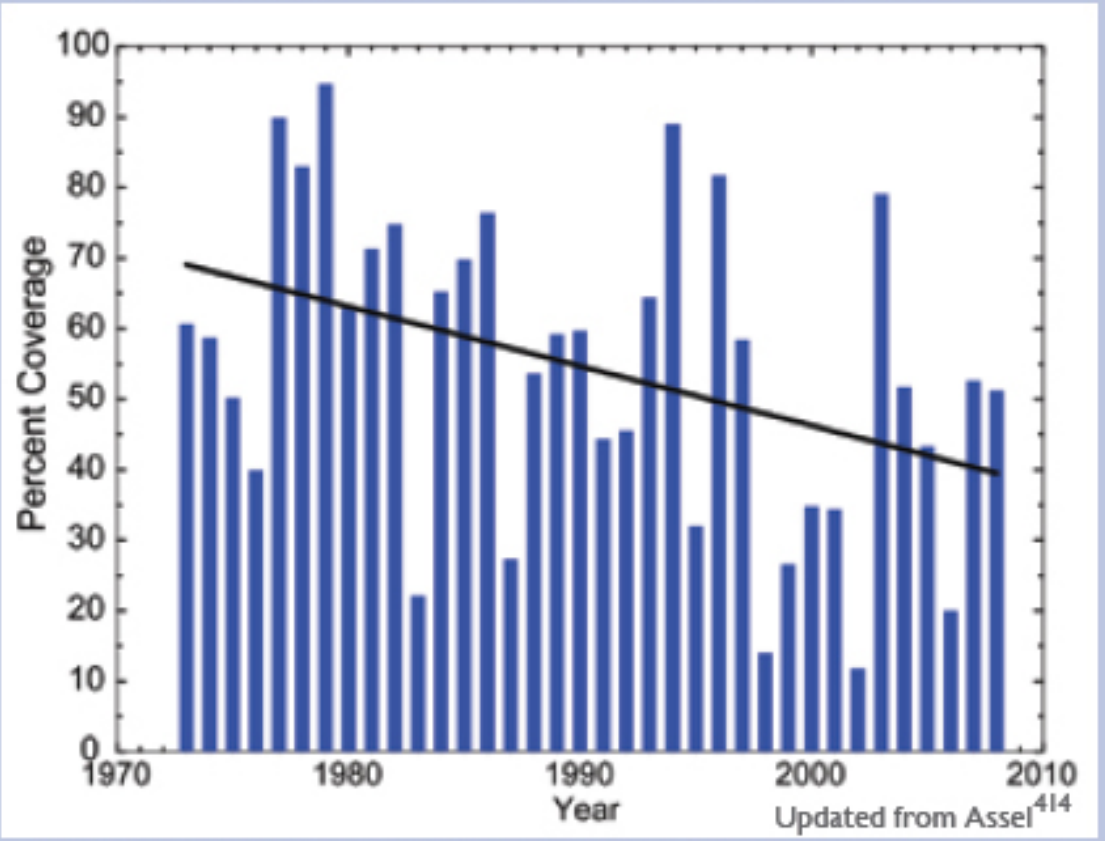
Observed Changes

Observed Changes in Great Lakes Ice Cover

Seasonal Maximum Coverage, 1973 to 2008



Reductions in winter ice cover lead to more evaporation, causing lake levels to drop even farther. While the graph indicates large year-to-year variations, there is a clear decrease in the extent of Great Lakes ice coverage, as shown by the black trend line.

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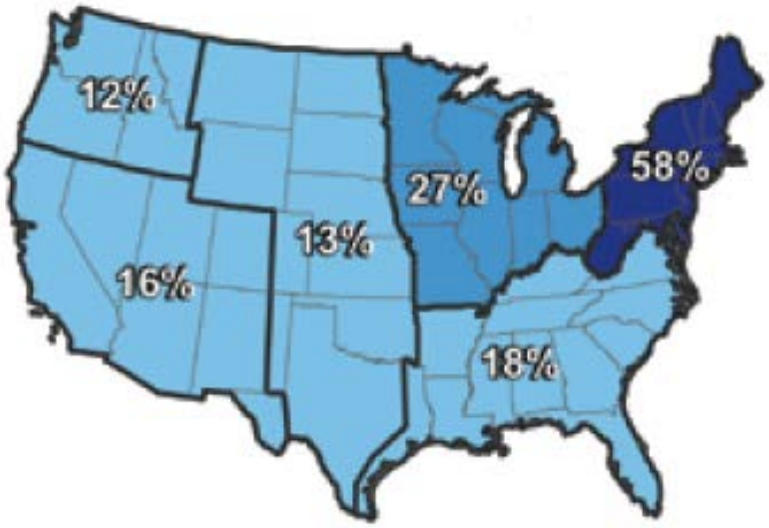
FLOODING
Observed



Increases in the average number
of days with very heavy precipitation
1958 to 2007

2008 Lake Delton Dam failure
due to heavy rains

From 1950 to 2006, Wisconsin as a whole became wetter, with a 10 percent increase in annual precipitation (3.1 inches)

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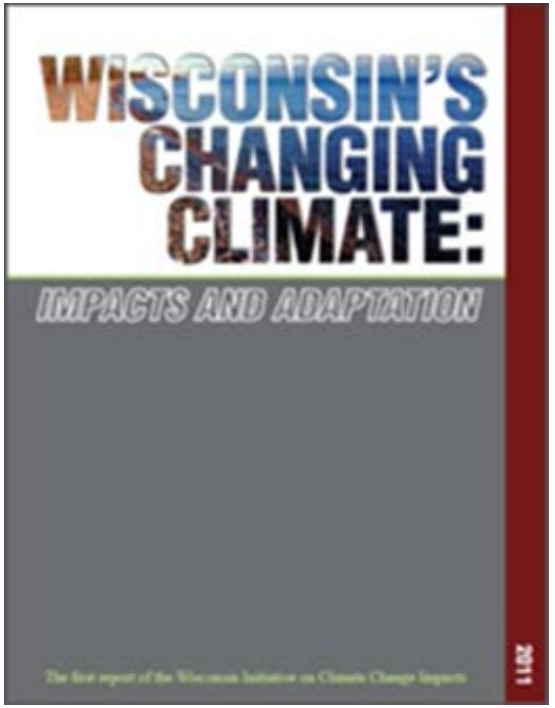
Climate Change in Wisconsin

What does the historical record tell us?

Climate change in Wisconsin: 1950-2006

Wisconsin isn't necessarily getting hotter, but rather less cold.

http://www.wicci.wisc.edu/

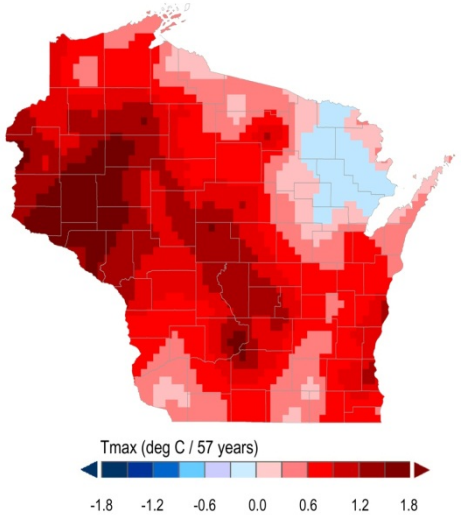


Climate Change in Wisconsin

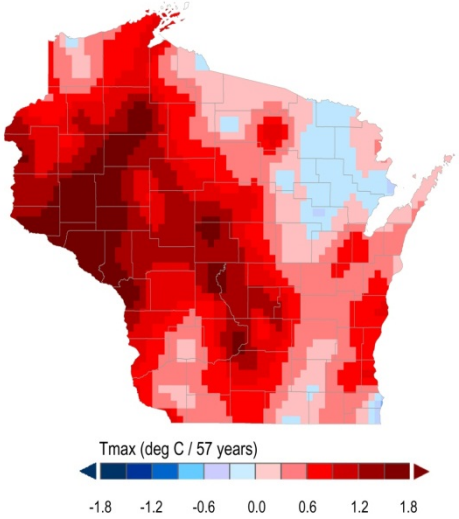
What does the historical record tell us?

Changes in Daily Maximum Temperature:

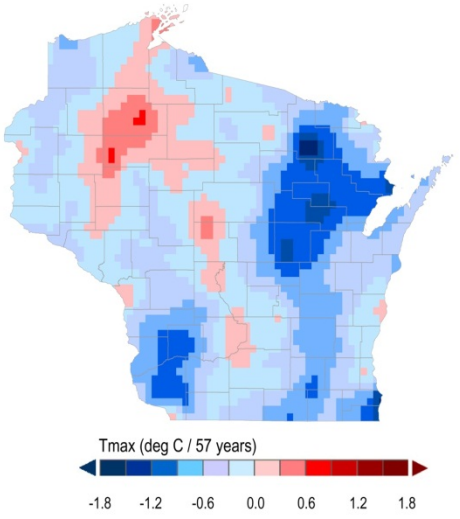
Winter T_{max}



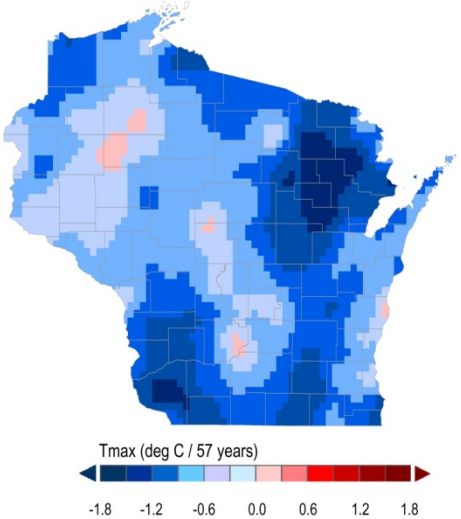
Spring T_{max}



Summer T_{max}



Fall T_{max}



The Greatest Amount of Warming is Occurring in Winter and Spring

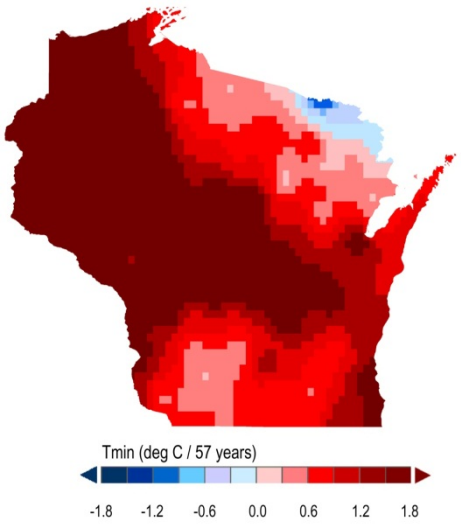
Kucharik and Serbin, *in prep*

Climate Change in Wisconsin

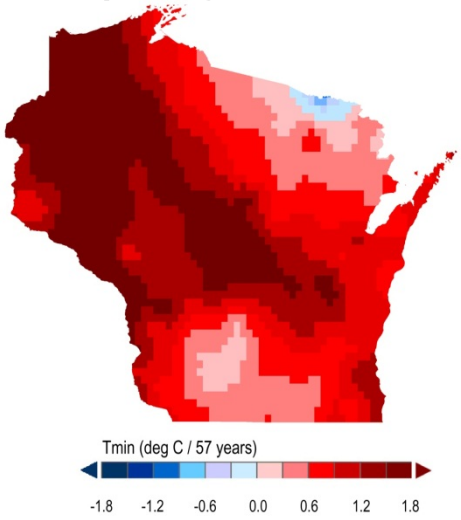
What does the historical record tell us?

Changes in Daily Minimum Temperature:

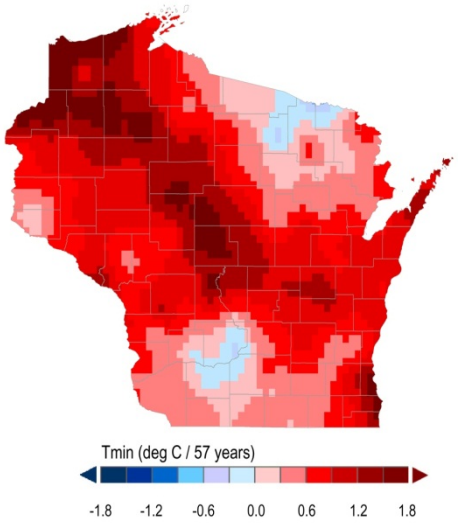
Winter T_{min}



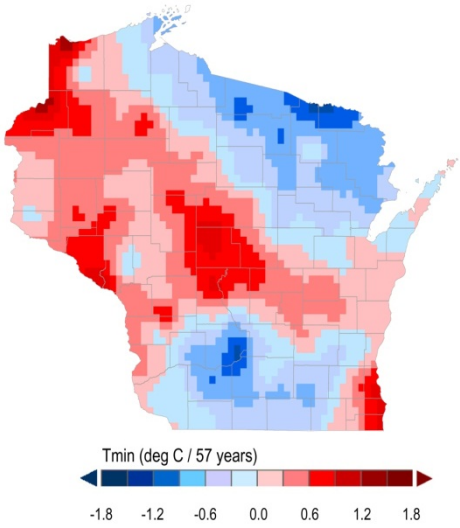
Spring T_{min}



Summer T_{min}



Fall T_{min}



Nighttime low temperatures are warming faster than daytime highs

Kucharik and Serbin, *in prep*

Climate Change in Wisconsin

BIRD MIGRATION	VEGETATION
Geese arrival: 29 days earlier	Baptista first bloom: 18 days earlier
Cardinal first song: 22 days earlier	Butterfly weed first bloom: 18 days earlier
Robin arrival: 9 days earlier	Marsh milkweed first bloom: 13 days earlier

Table 1. Evidence of earlier arrival of spring in Wisconsin from 1936-1998.

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

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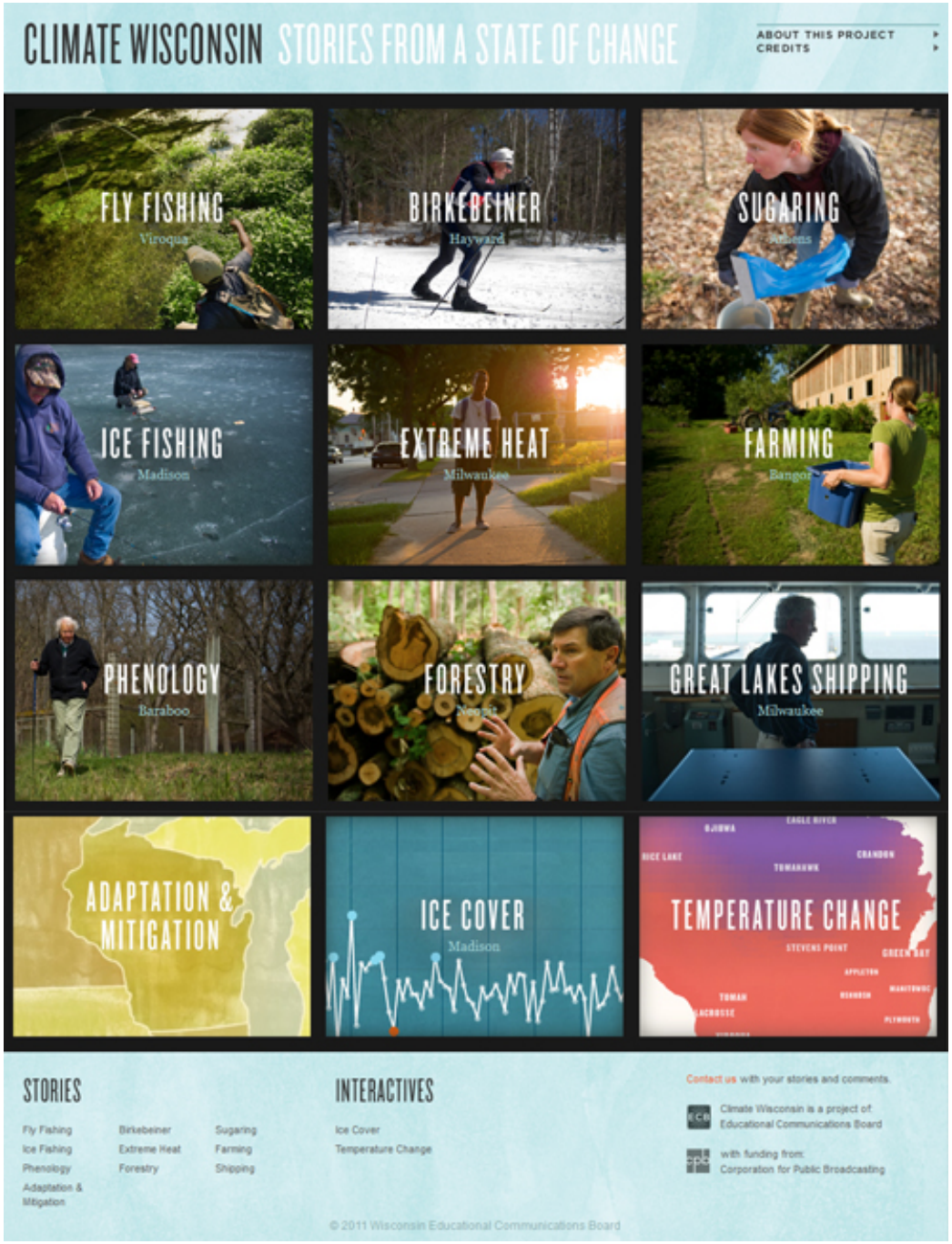

Learn more from
CLIMATE WISCONSIN

www.climatewisconsin.org

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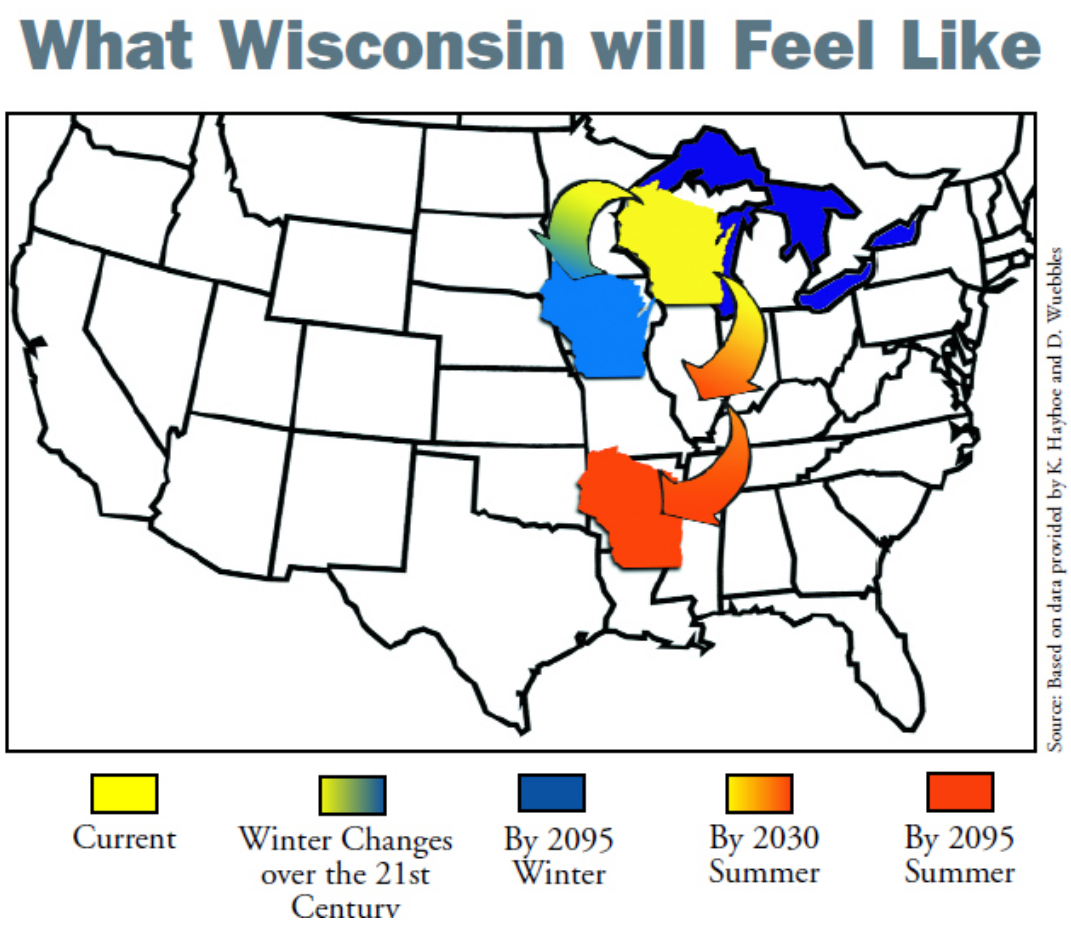
Models Project Continued Warming



UW-Madison researchers used “down-scaled” climate models to project that ***Wisconsin’s warming trend will continue and increase considerably in the decades ahead.***

By the middle of the century, statewide annual average temperatures are likely to warm by 6-7 degrees Fahrenheit.

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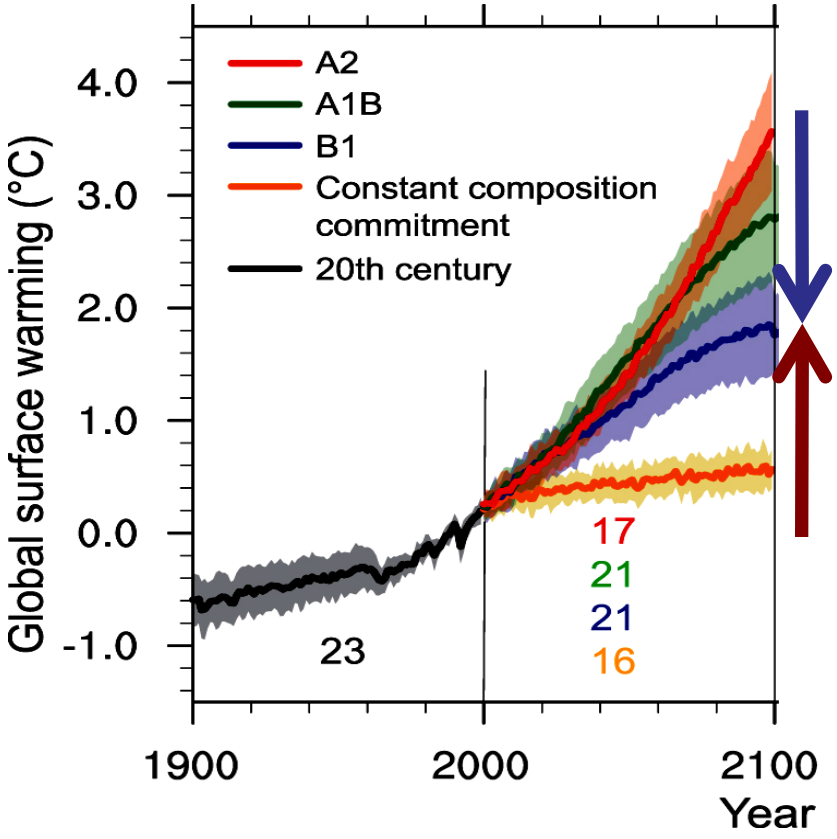
Slowing Change & Minimizing Impacts

Mitigation: reduces amount of global warming

Adaptation: reduces the impact



Mitigation:

Necessary to avoid *dangerous* climate change

Adaptation:

Climate change is happening; Adaptation needed to minimize impacts

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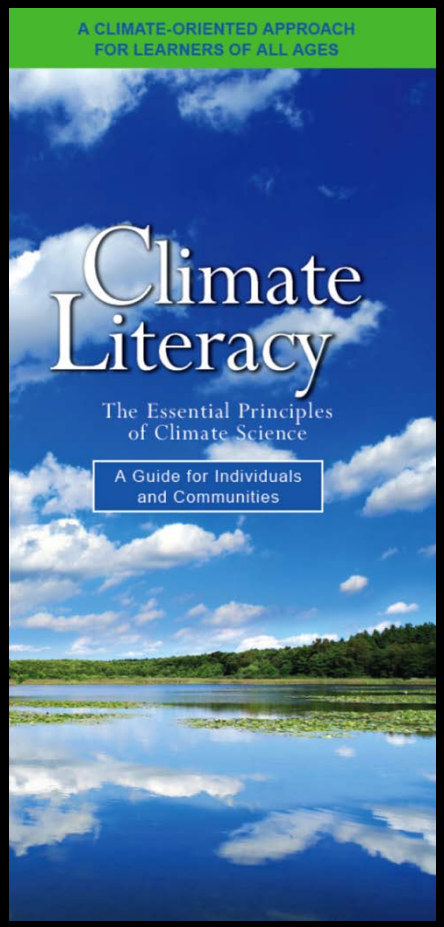
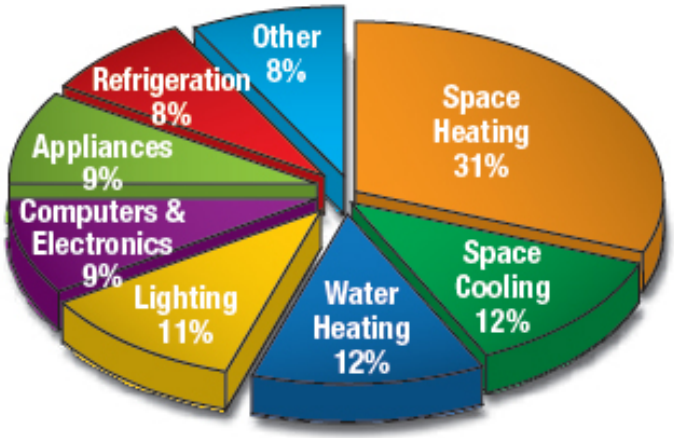


Guiding Principle:

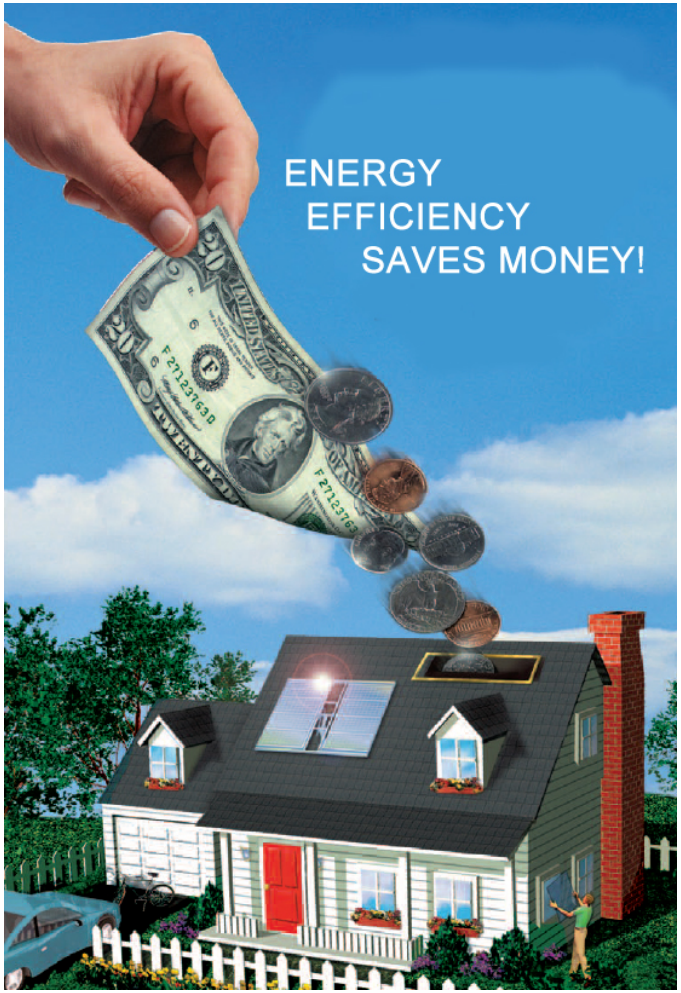
Humans can take actions to reduce climate change and its impacts

Many actions have co-benefits

Co-Benefits of Carbon Mitigation



How We Use Energy in Our Homes



1) By using less energy, you can reduce carbon emissions *and* **save money**

2) By walking or riding a bike to work a few days a week you can improve your health *and* **save money**

3) Did we mention saving money ???

Co-Benefits of Driving Less: Clean Air

Along with saving money on gas ….

Asthma and Air Pollution

- Natural experiment during 1996 Summer Olympic games in Atlanta
- Peak morning traffic decreased 23% and peak ozone levels decreased 28%

- Asthma-related emergency room visits by children decreased 42%
- Children's emergency visits for non-asthma causes did not change during same period

Friedman et al. *JAMA* 2001;285:897

Can you commit to car pooling, walking or riding to work one day a week? (or two or three?)

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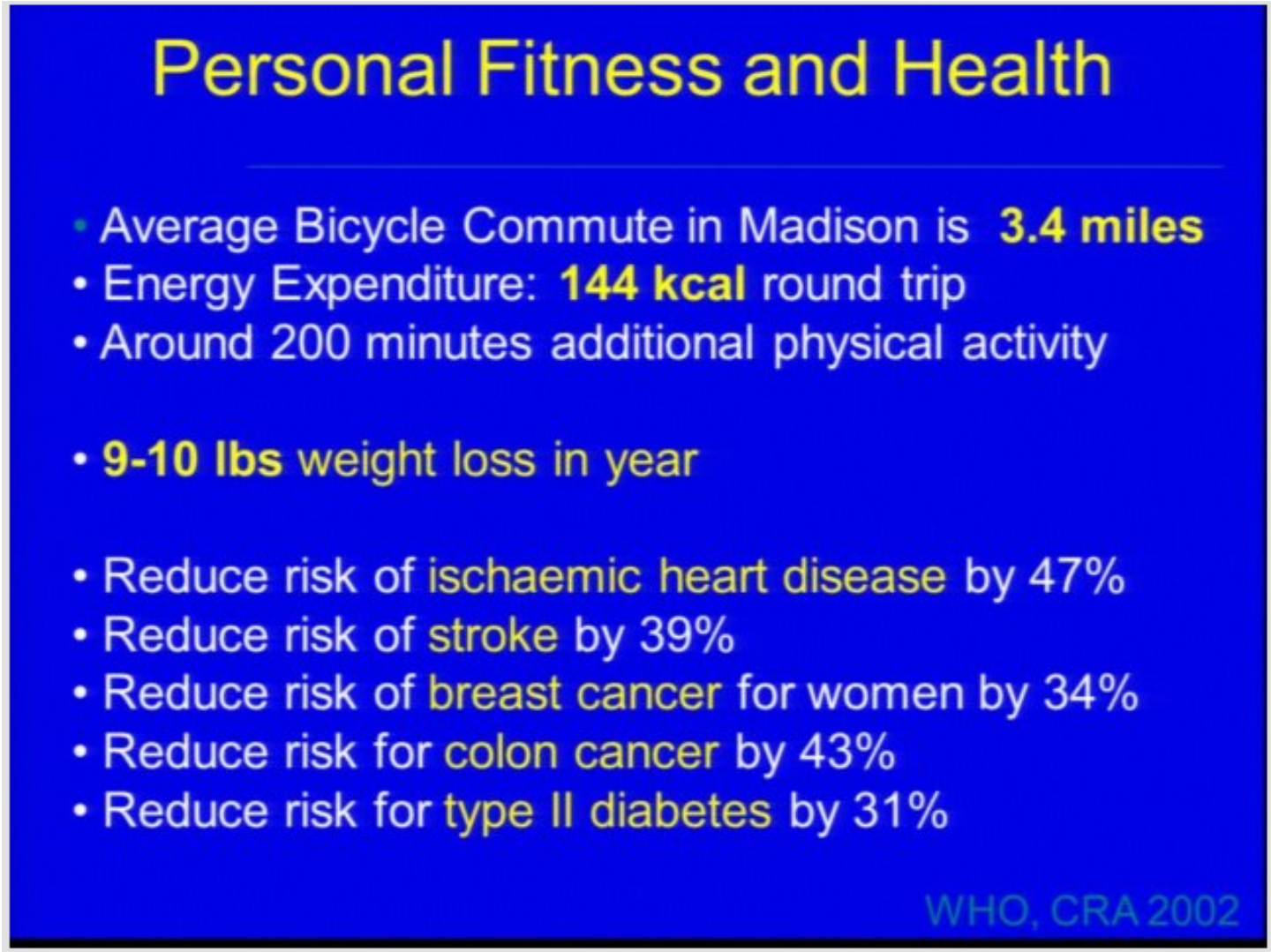
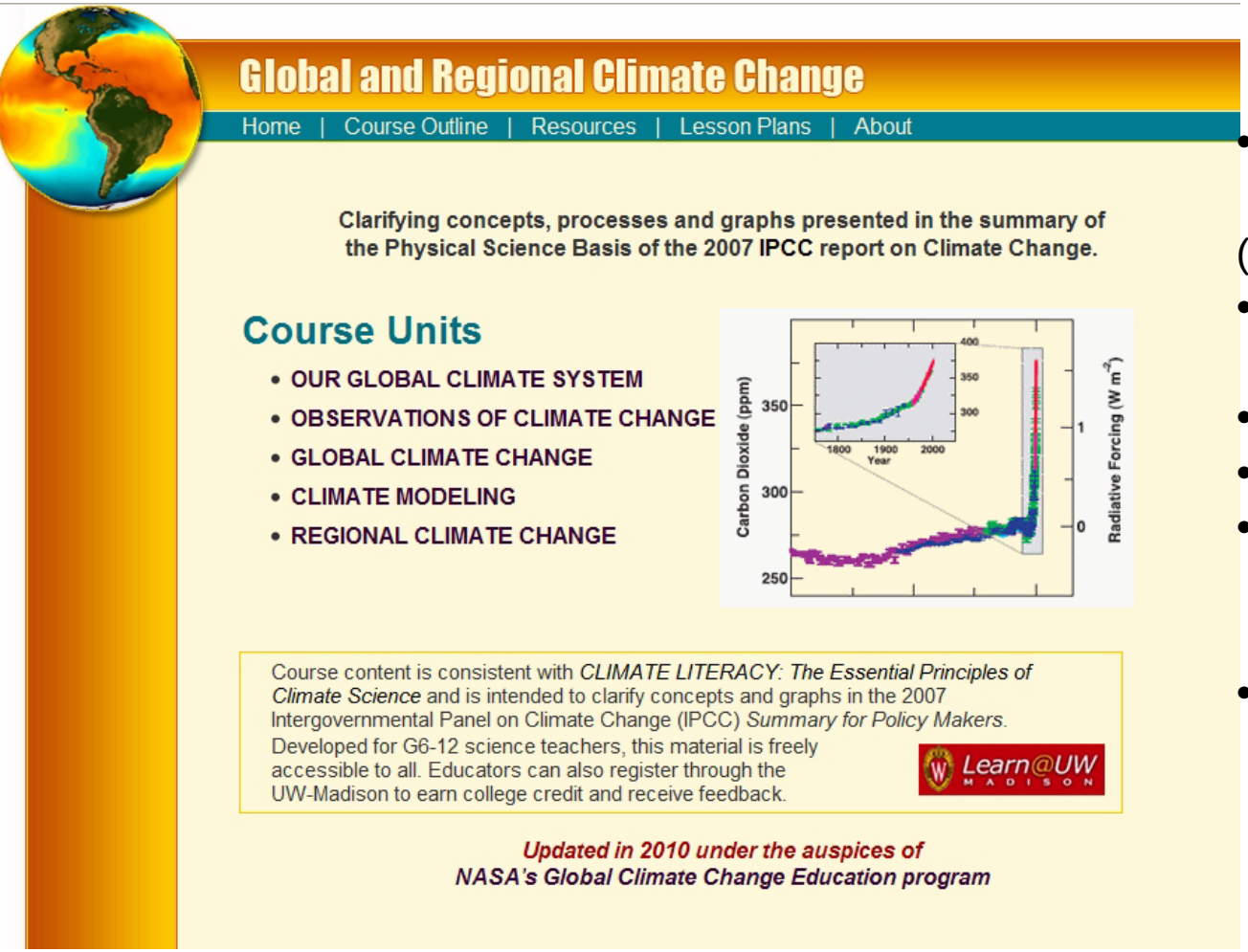
Co-Benefits of Driving Less: Health

Along with saving money on gas ….



Learn More On-Line

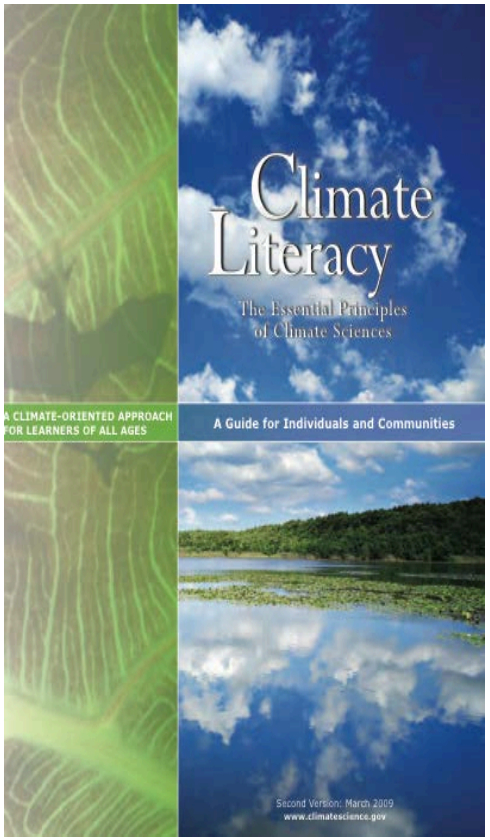
http://cimss.ssec.wisc.edu/climatechange/



- Developed collaboratively by four UW departments (CIMSS, AOS, Geology, CCR)
- Consistent with Climate Literacy Framework
- Clarifies IPCC report
- Beta version debuted 2008
- NASA 2010 GCCE support for updates, revisions & stipends for G6-12 teachers
- Credit *OR* Certificate

Steve.Ackerman@ssec.wisc.edu
Margaret.Mooney@ssec.wisc.edu

The Climate Literacy Ambassadors program was developed to raise awareness of climate science and lay the foundation for the guiding principle of the Climate Literacy:



Humans can take actions to reduce climate change and its impacts