

# Global Climate Change

- What Is It?
- How Will It Affect Us?
- Can We Reduce the Impact By Our Actions?



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Associate Professor & Director of General Chemistry, University of Toledo  
Senior Fellow, National Council for Science and the Environment

### Principles and Varieties of Solar Energy

February 21, 2013



# Which statement best represents your opinion?

0% A. Climate change is not a significant issue

8% B. Climate change is a modest-level issue

69% C. Climate change is a major issue

23% D. Climate change is major, but not practical to address

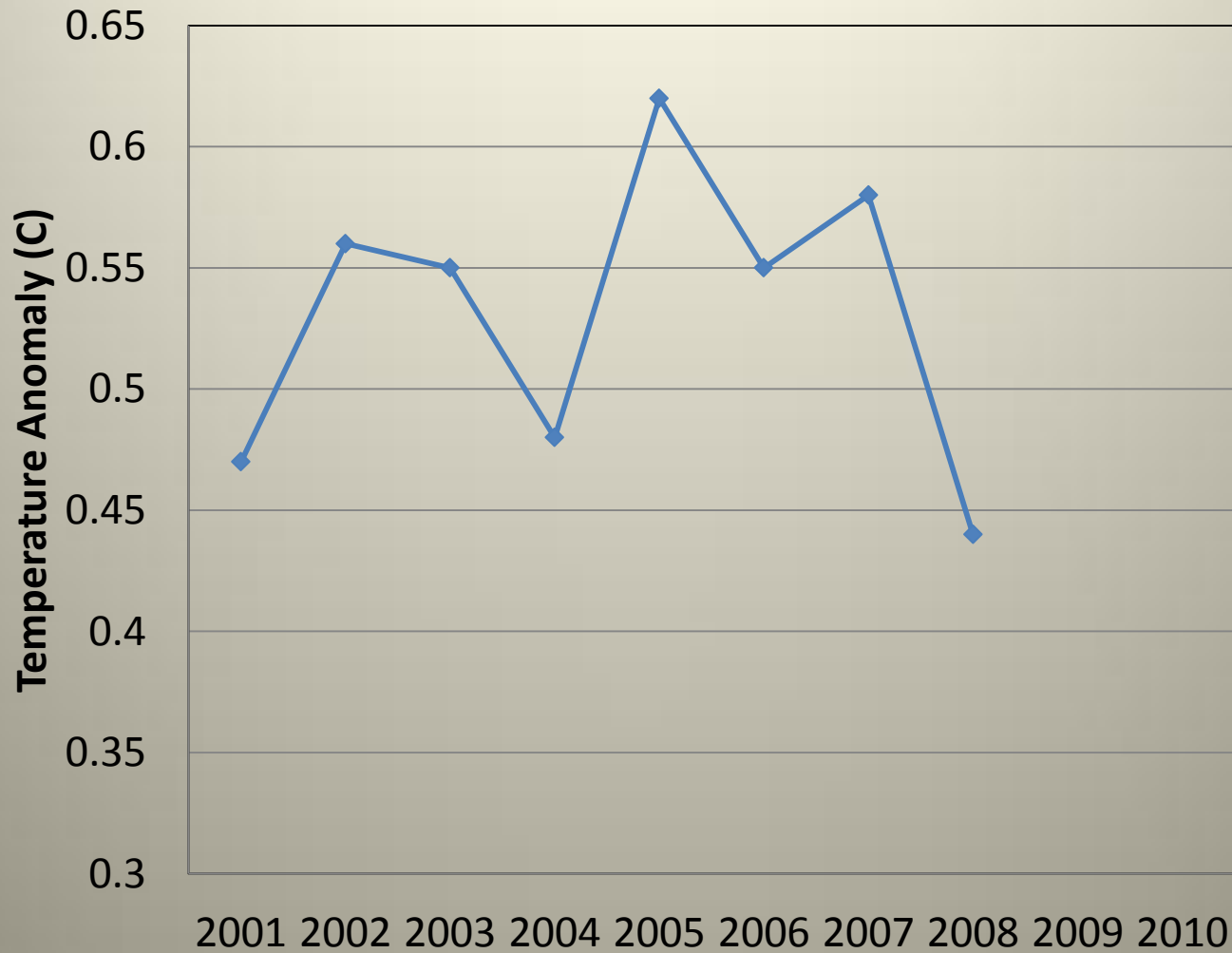
# Over the last century, global average temperatures have...

- 0% A. Cooled about 0.1° C (0.2°F)
- 7% B. Not changed significantly
- 7% C. Warmed about 0.1° C (0.2°F)
- 79% D. Warmed about 0.6° C (1.1°F)
- 7% E. Warmed about 6.0° C (11°F)

The correct answer will be given later.

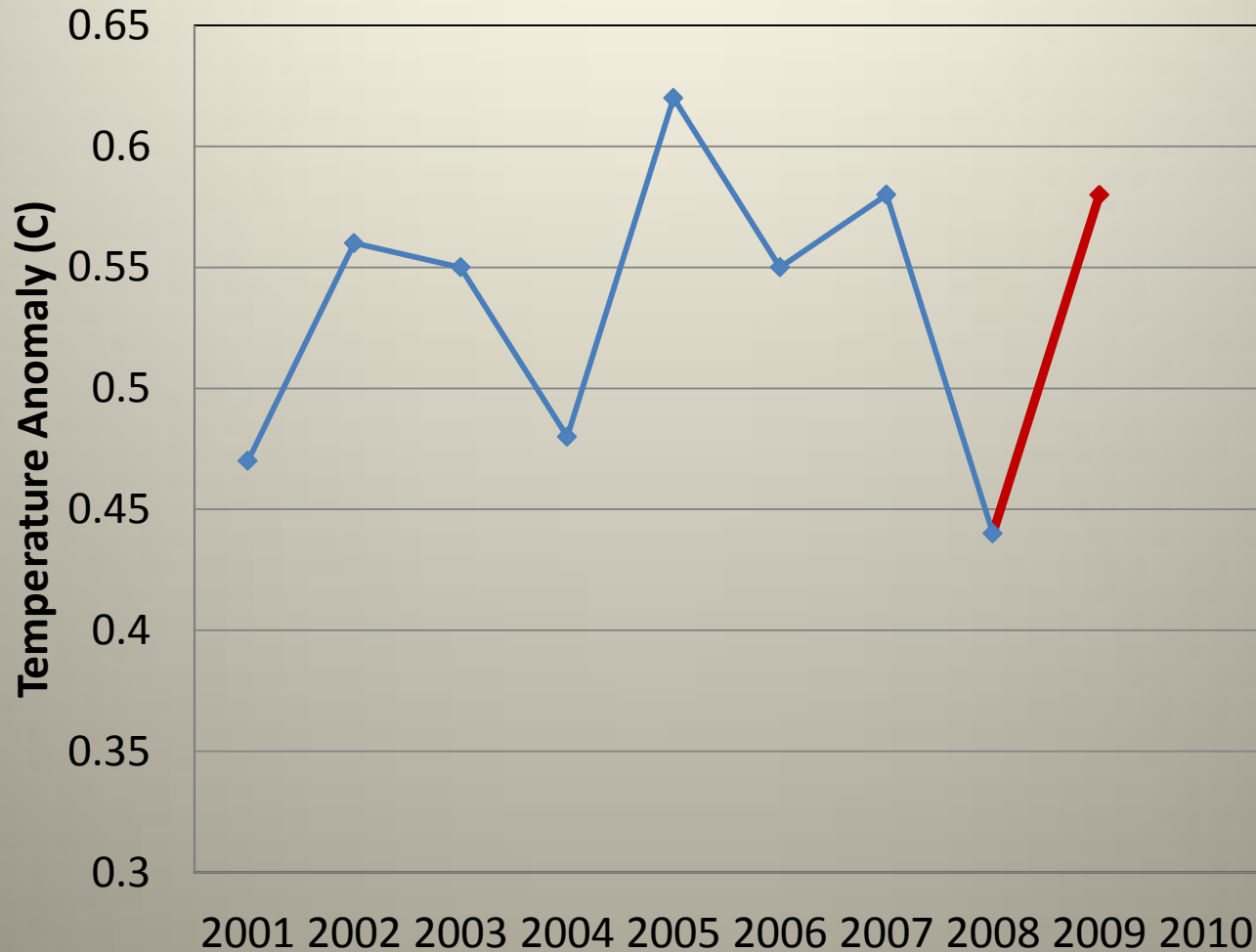
**Now let's look at some data that characterizes climate change, starting with temperature...**

## Global Land + Ocean Surface Temperature



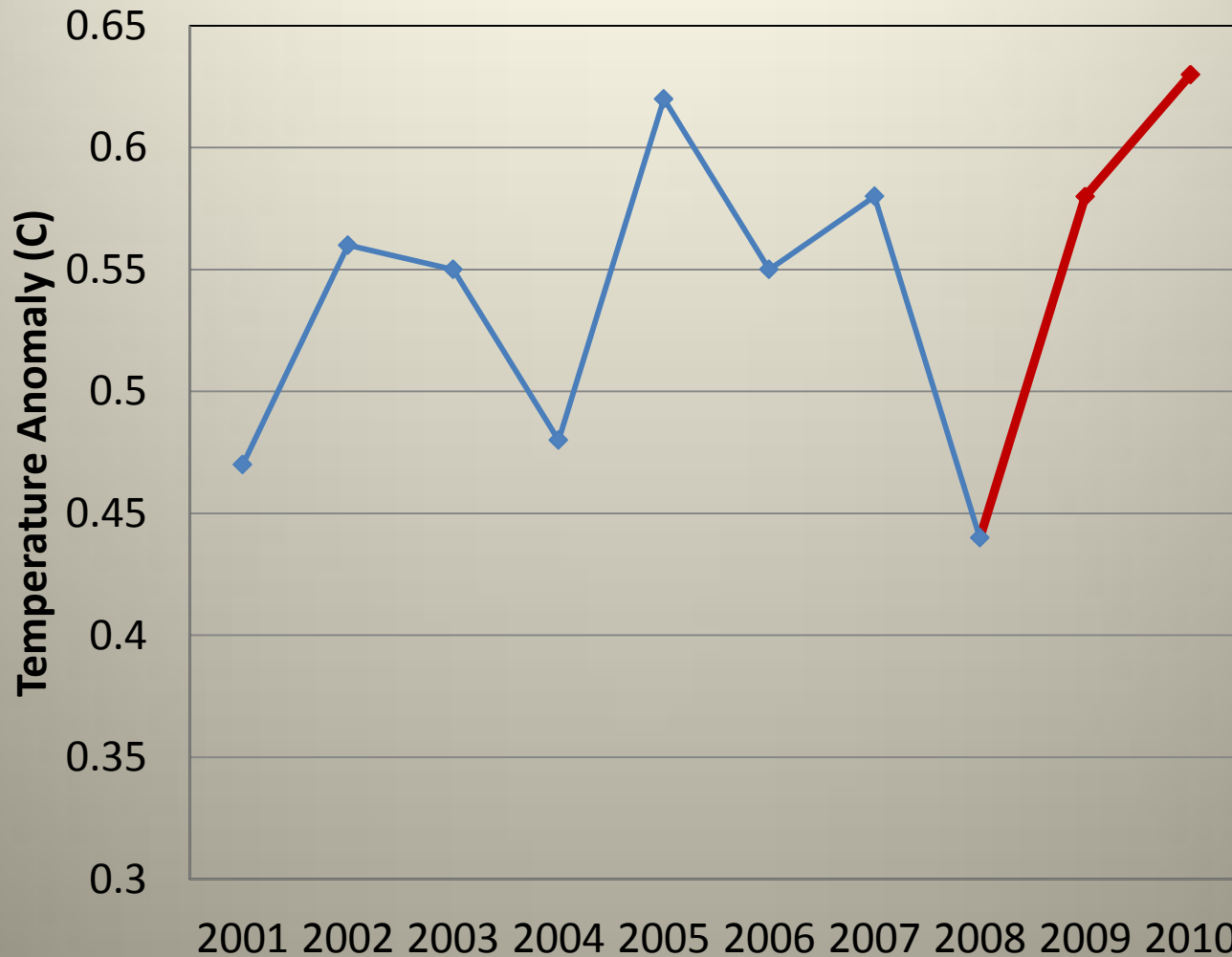
Source: NASA GISS Surface Temperature Analysis: <http://data.giss.nasa.gov/gistemp/graphs>

## Global Land + Ocean Surface Temperature



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# 2010: Tied for Warmest Year On Record



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## Research News

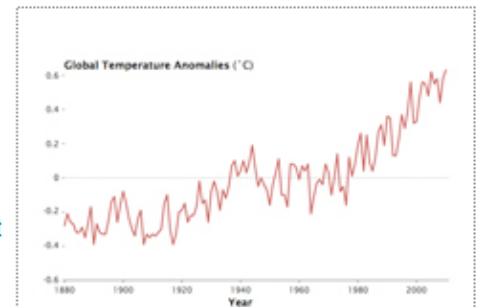
### NASA Research Finds 2010 Tied for Warmest Year on Record

January 12, 2011

Global surface temperatures in 2010 tied 2005 as the warmest on record, according to an analysis released Wednesday by researchers at NASA's Goddard Institute for Space Studies (GISS) in New York.

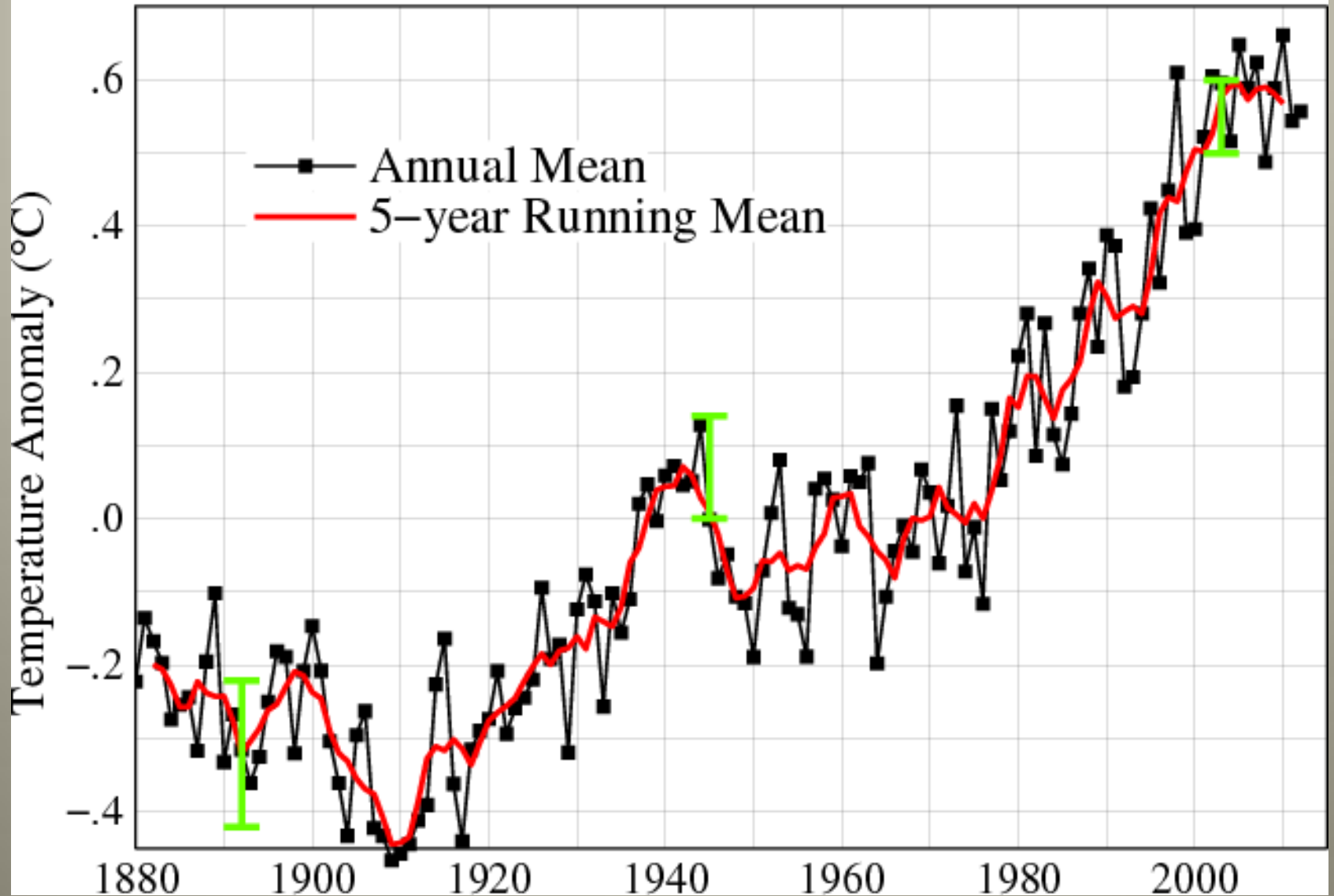
The two years differed by less than 0.018 degrees Fahrenheit. The difference is smaller than the uncertainty in comparing the temperatures of recent years, putting them into a statistical tie. In the new analysis, the next warmest years are 1998, 2002, 2003, 2006, 2007 and 2009, which are statistically tied for third warmest year. The GISS records begin in 1880.

The analysis found 2010 approximately 1.34°F warmer than the average global surface temperature from 1951 to 1980. To measure climate change, scientists look at long-term trends. The temperature trend, including data from 2010, shows the climate has warmed by approximately 0.36°F per decade since the late 1970s.





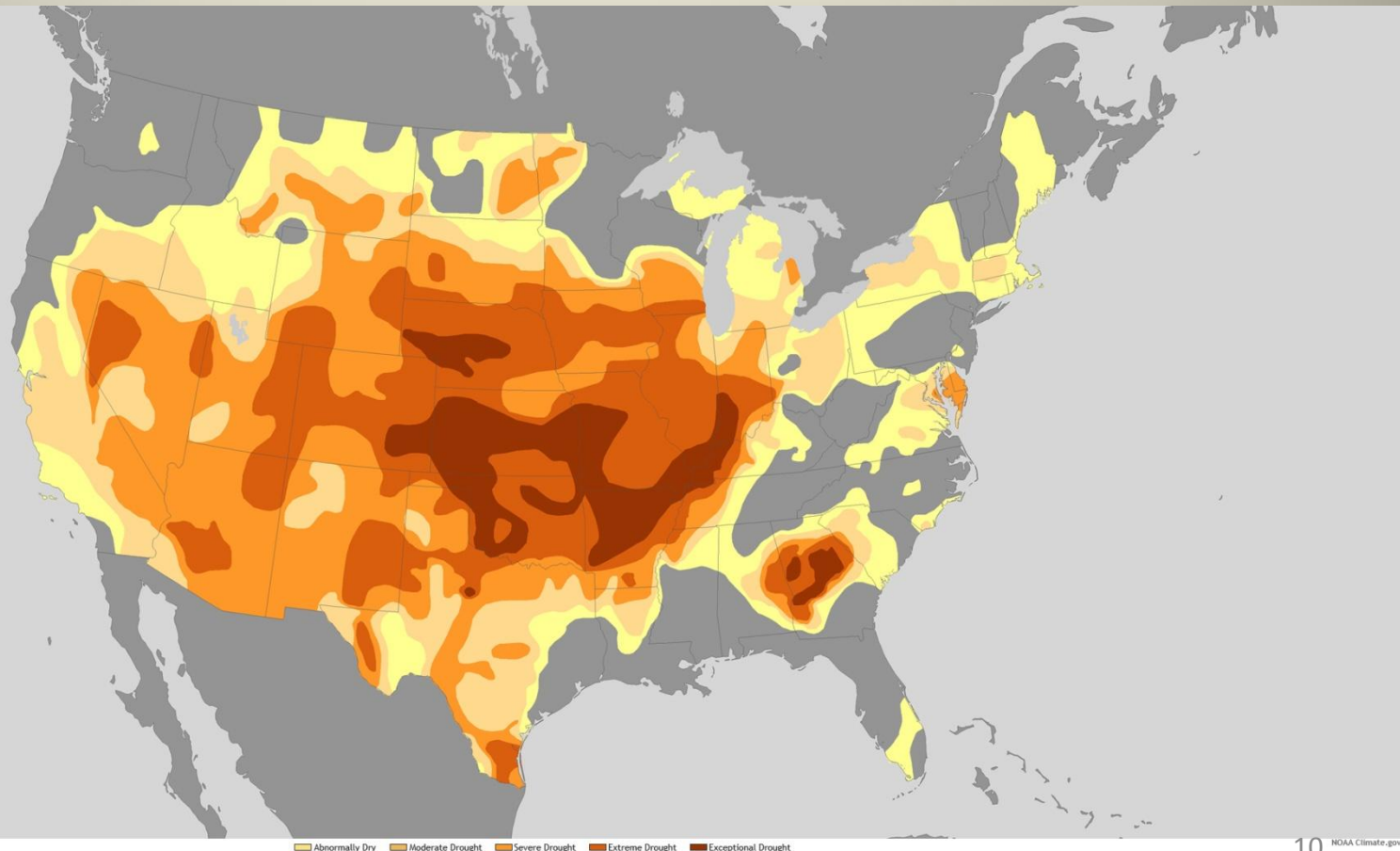
# Global Land–Ocean Temperature Index



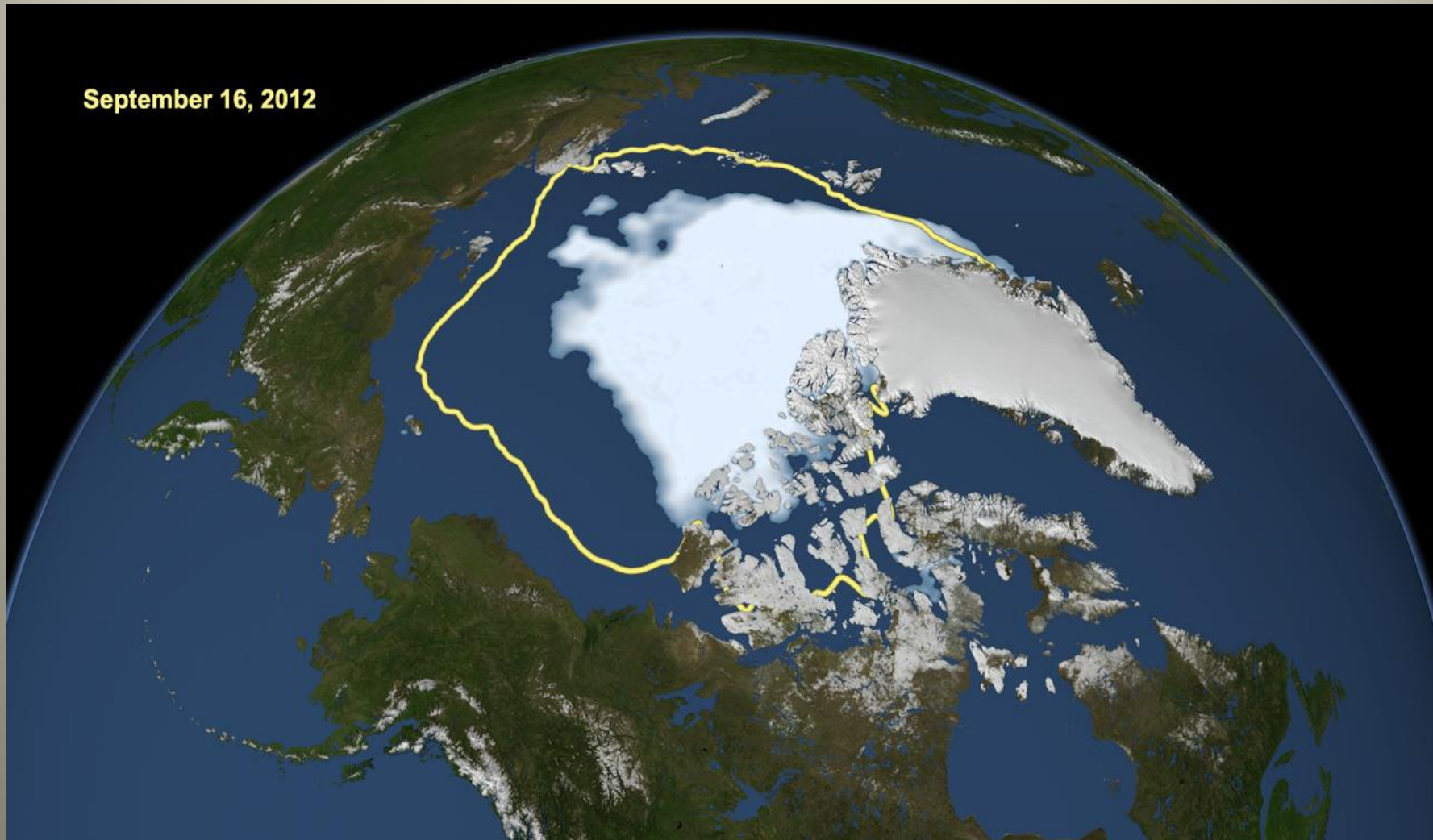
Source: NASA GISS Surface Temperature Analysis: <http://data.giss.nasa.gov/gistemp/graphs>

# NOAA – August, 2012

For the contiguous United States as a whole, about 62 percent of the country was in some state of drought, with another 16 percent ranking as “abnormally dry.”



# Arctic Sea Ice Sets a New Low

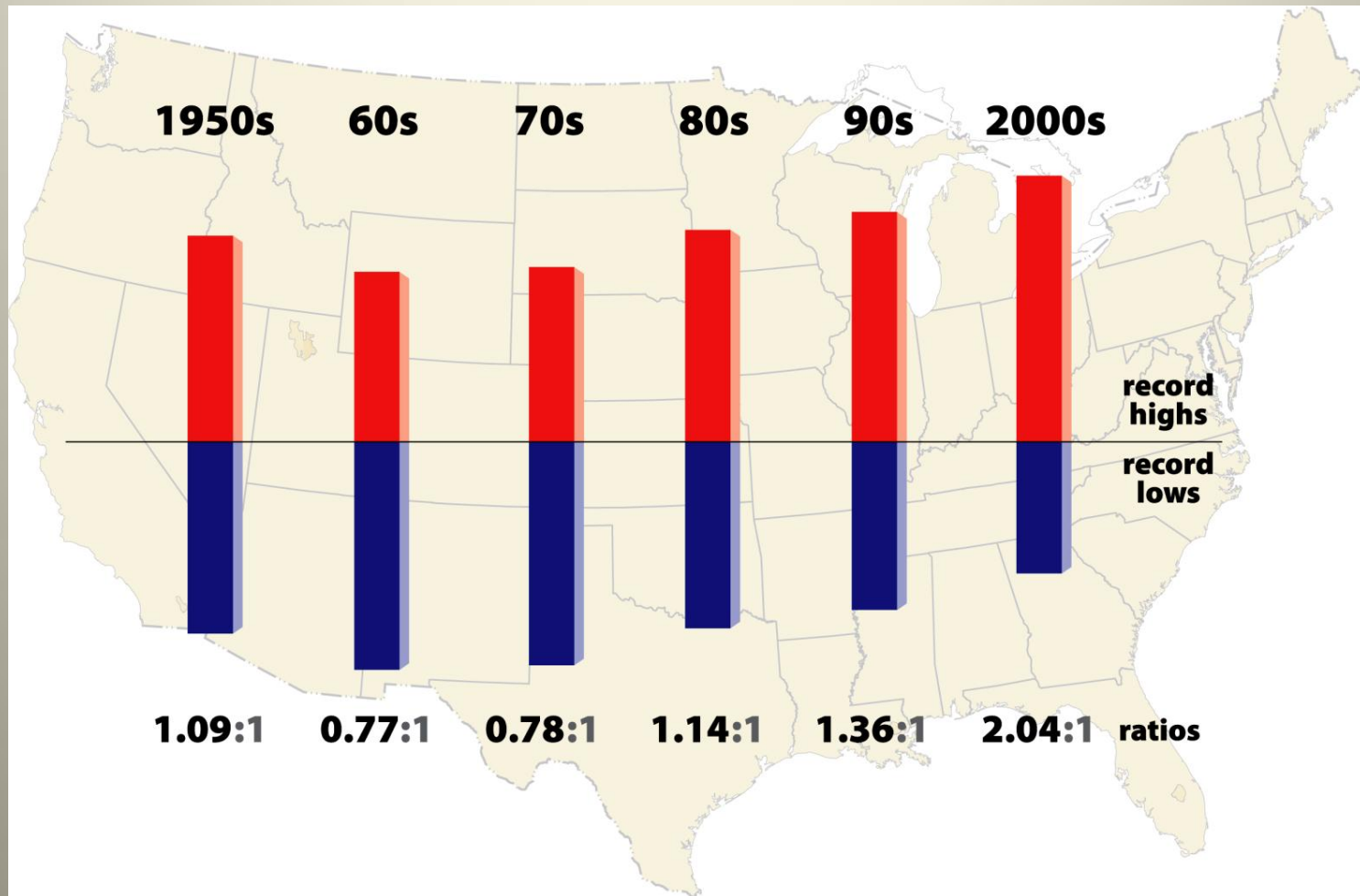


Source: NASA/Goddard

# NOAA Summary for 2012

- 2012 was warmest and 2<sup>nd</sup> most extreme year on record for the contiguous US.
- The average temperature for 2012 was 55.3°F, 3.2°F above the 20<sup>th</sup> century average and 1.0°F above 1998, the previous warmest year.
- Record warm spring, second warmest summer, fourth warmest winter and warmer-than-average autumn.
- 2012 was a historic year for extreme weather that included drought, wildfires, hurricanes and storms; however, tornado activity was below average.

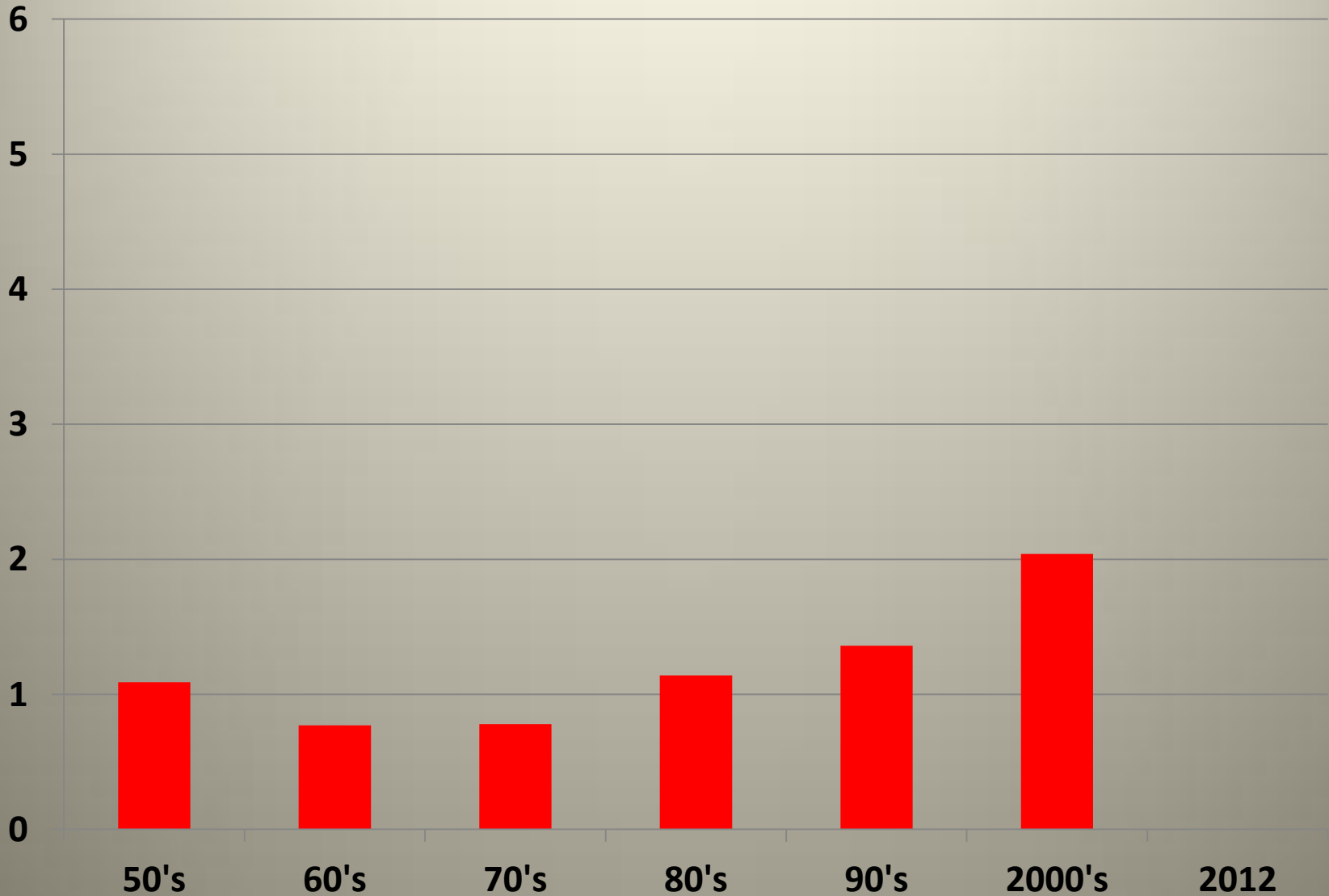
# Record Highs Outpacing Lows



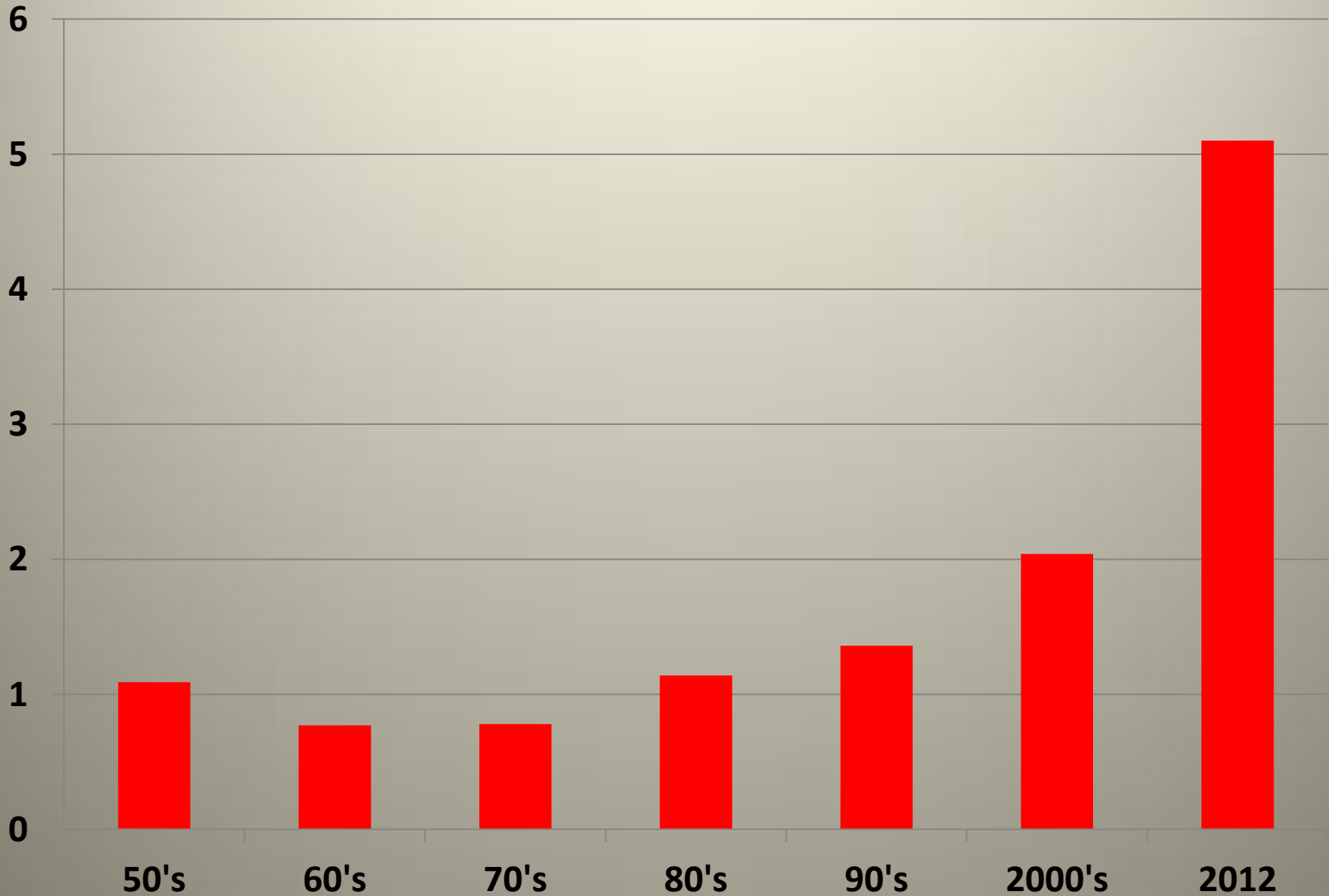
Ratio of record daily highs to record daily lows observed at about 1,800 weather stations in the 48 contiguous United States from Jan 1950 through Sept 2009

<http://www.ucar.edu/news/releases/2009/maxmin.jsp#>

# Record Highs Outpacing Lows



# Record Highs Outpacing Lows



**Why is Earth's temperature changing?**



# The Greenhouse Effect

Some sunlight that hits the earth is reflected. Some becomes heat.

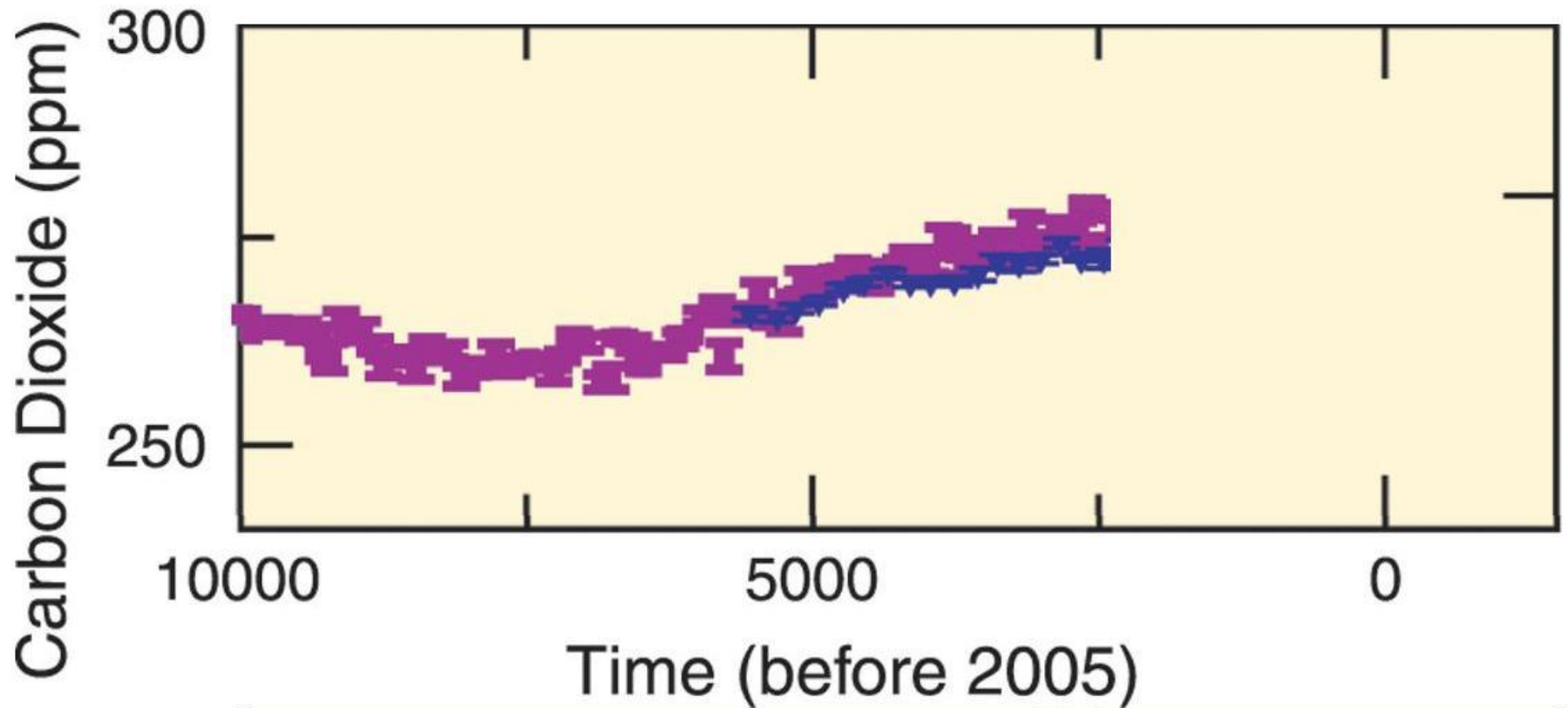
CO<sub>2</sub> and other gases in the atmosphere trap heat, keeping the earth warm.

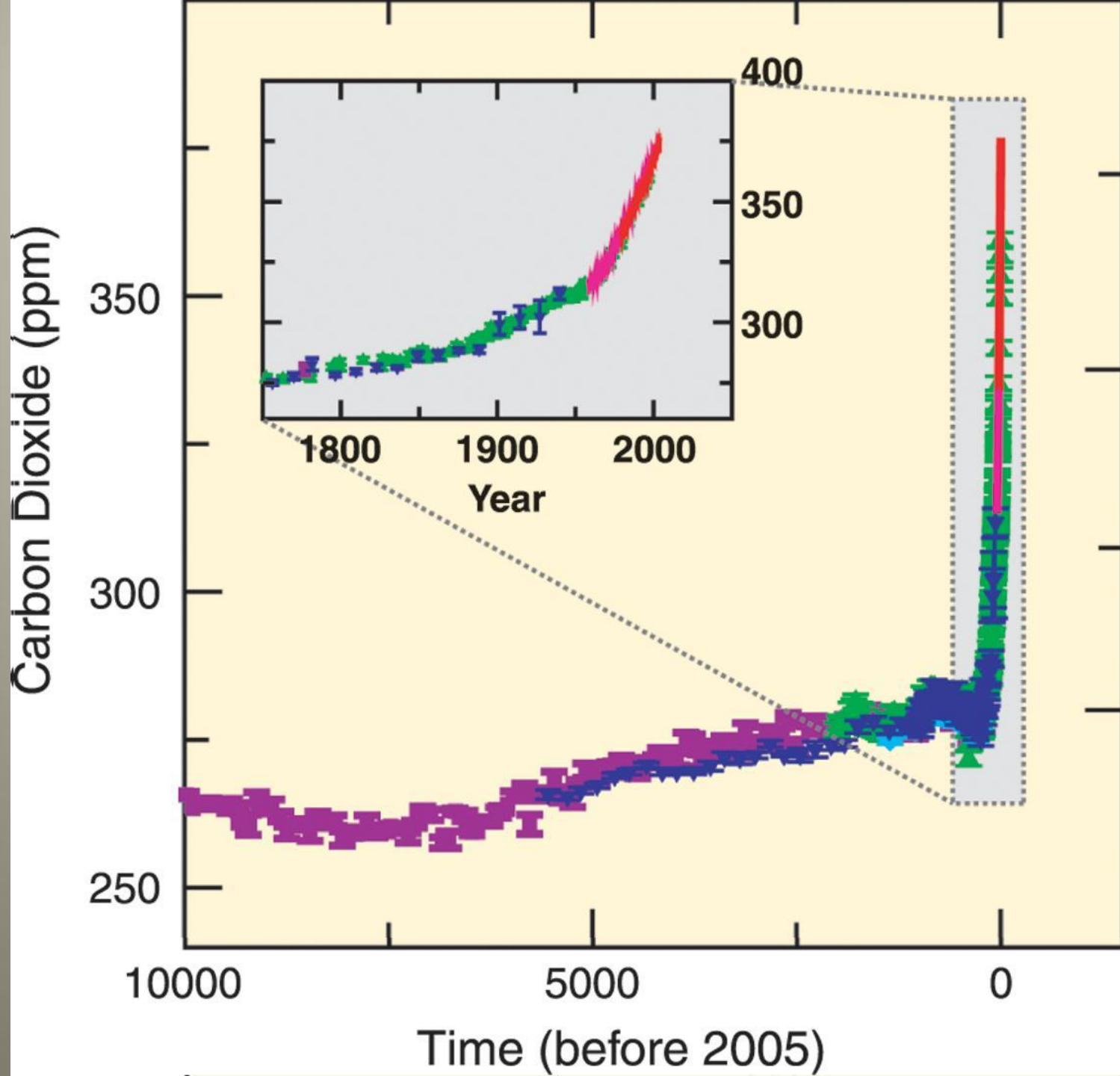
ATMOSPHERE

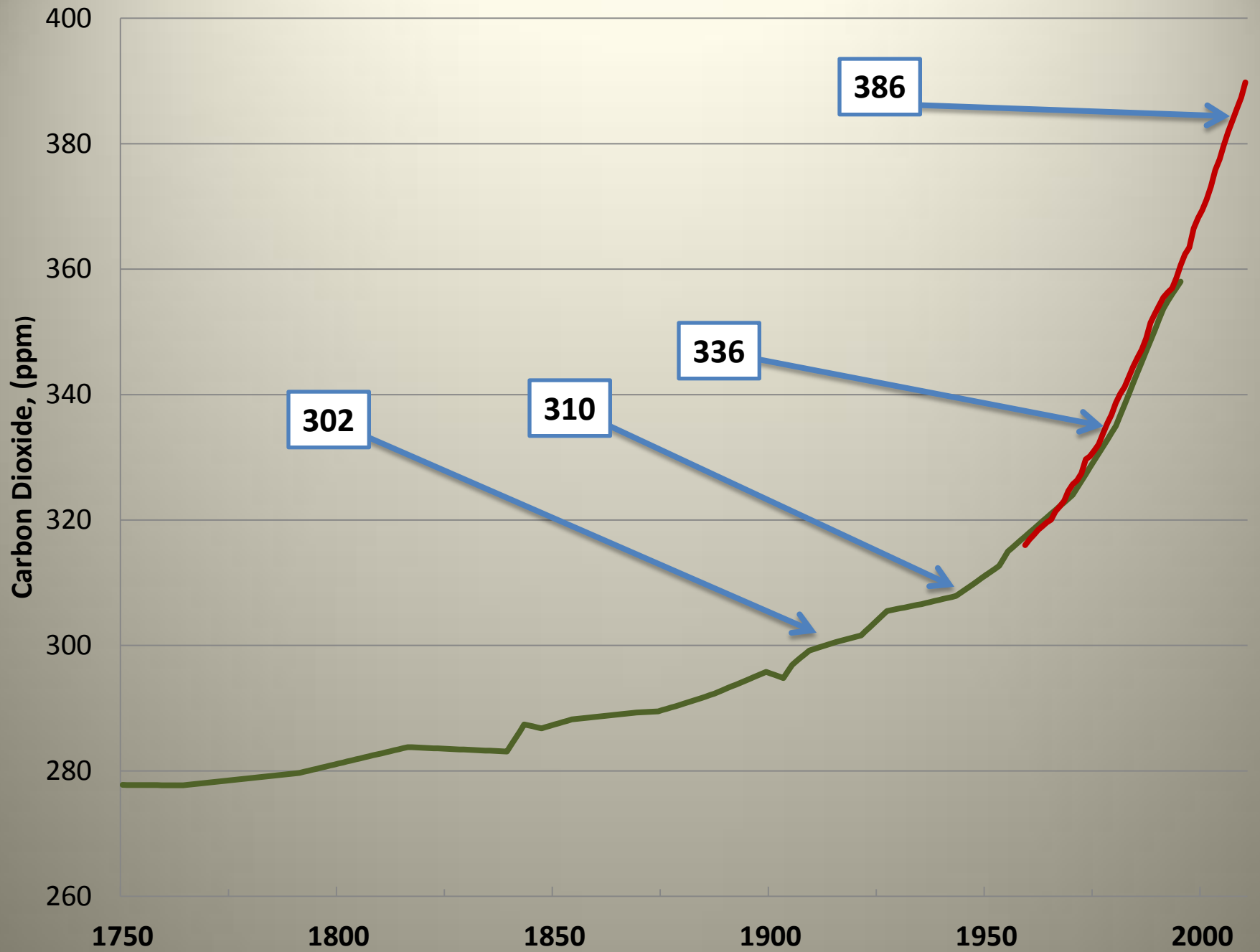
**Let's look at the primary chemical behind the Greenhouse Effect, CO<sub>2</sub>**

**The next graph is the concentration of CO<sub>2</sub> in the atmosphere over time.**

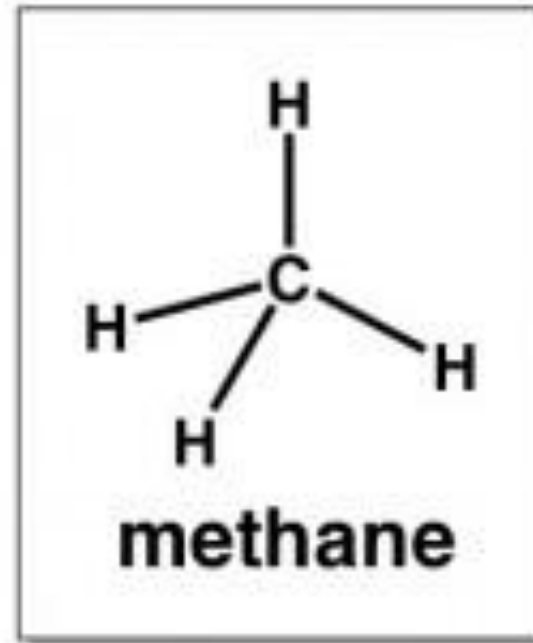
**This data is from a time when humans were not a factor.**







# There are other GHG's



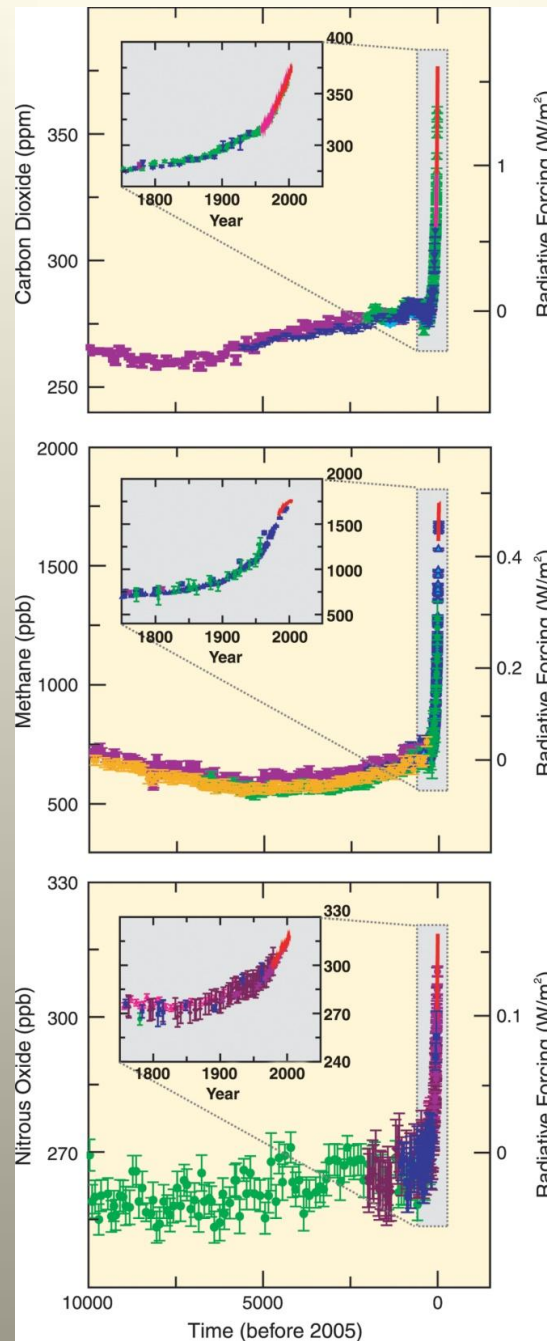
← **COW**

**Methane is 23 times more potent as a GHG compared to CO<sub>2</sub>.  
In addition to cows, it comes from decaying plants and trees.**

CO<sub>2</sub>

CH<sub>4</sub>

N<sub>2</sub>O

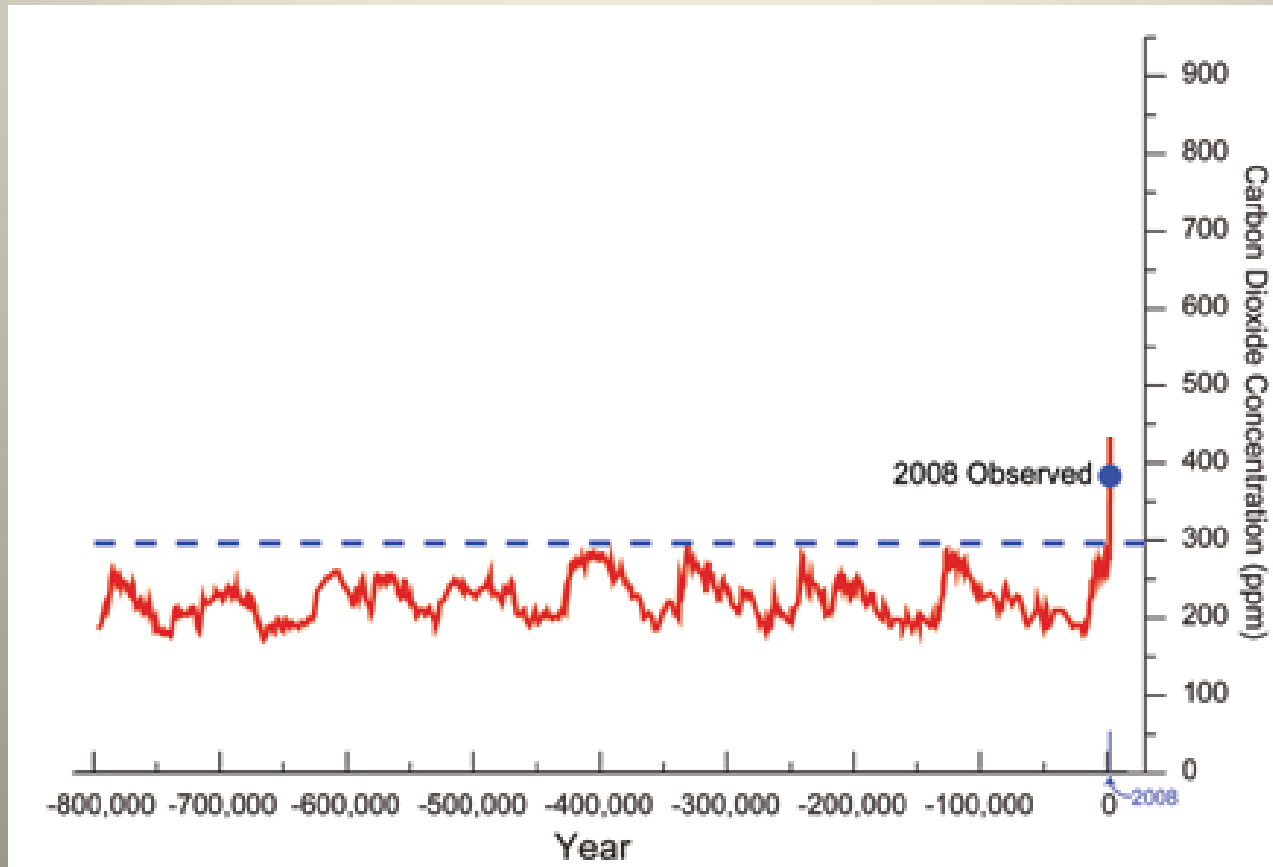


**Figure 2.3.** Atmospheric Concentrations of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O over the last 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores (symbols with different colours for different studies) and atmospheric samples (red lines). The corresponding radiative forcings relative to 1750 are shown on the right hand axes of the large panels. {WGI Figure SPM.1}

**What do we know about carbon dioxide over a longer time frame?**



# 800,000 Year Record of CO<sub>2</sub> Concentration



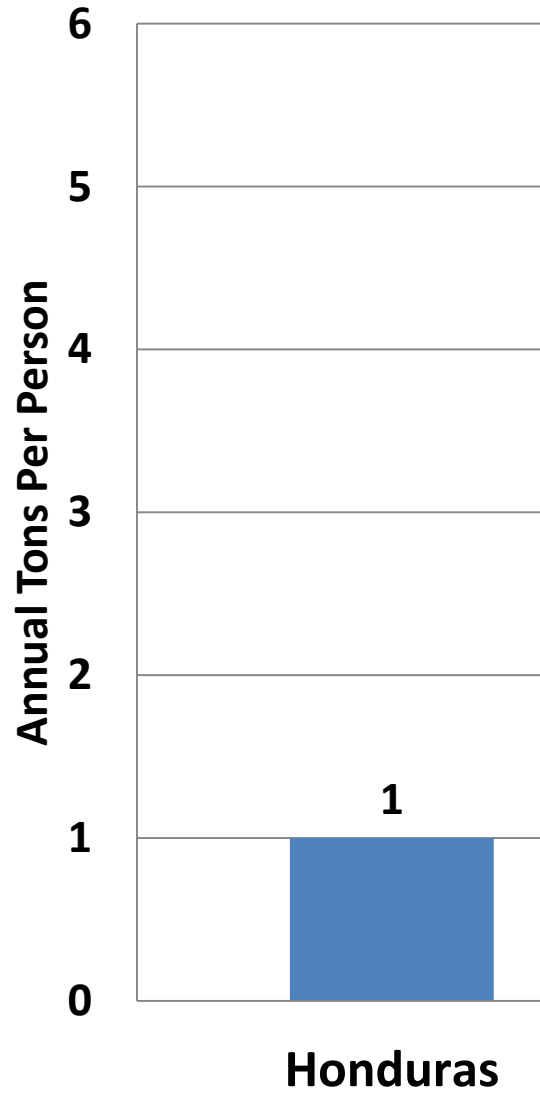
Global Climate Change Impacts in the United States, 2009

**Where does the carbon dioxide  
come from?**

**Let's relate this to individuals –  
tons of carbon dioxide per person.**

DOE [http://cdiac.ornl.gov/trends/emis/tre\\_tp20.html](http://cdiac.ornl.gov/trends/emis/tre_tp20.html)

# CO<sub>2</sub> Emissions



# What do you think is the emission level is for China?

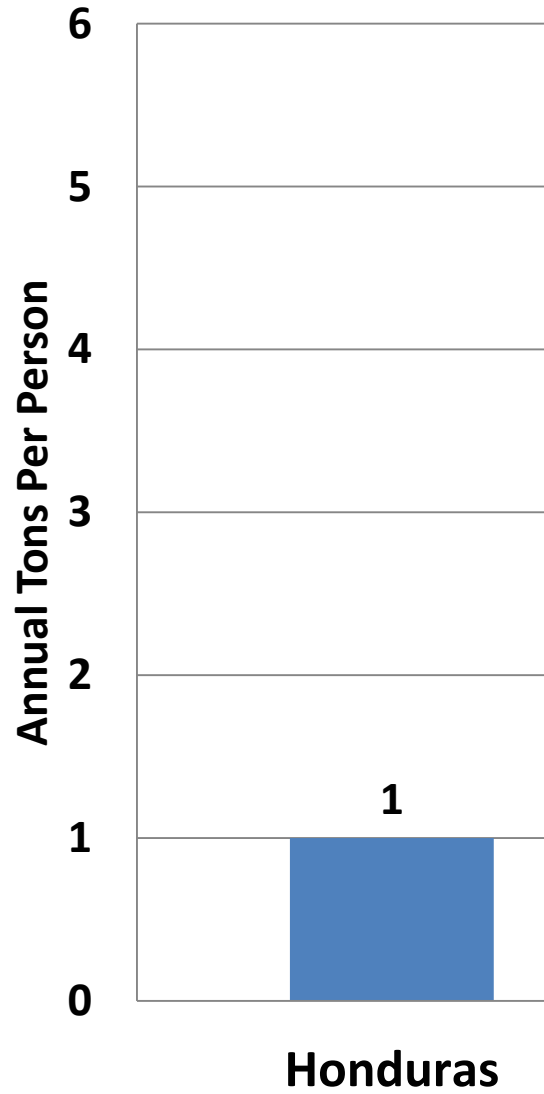
21% A. 2.5

0% 😊 B. 4.9

43% C. 6.8

36% D. 8.6

# CO<sub>2</sub> Emissions



# What do you think is the average emission level for the US?

38% A. 6.7

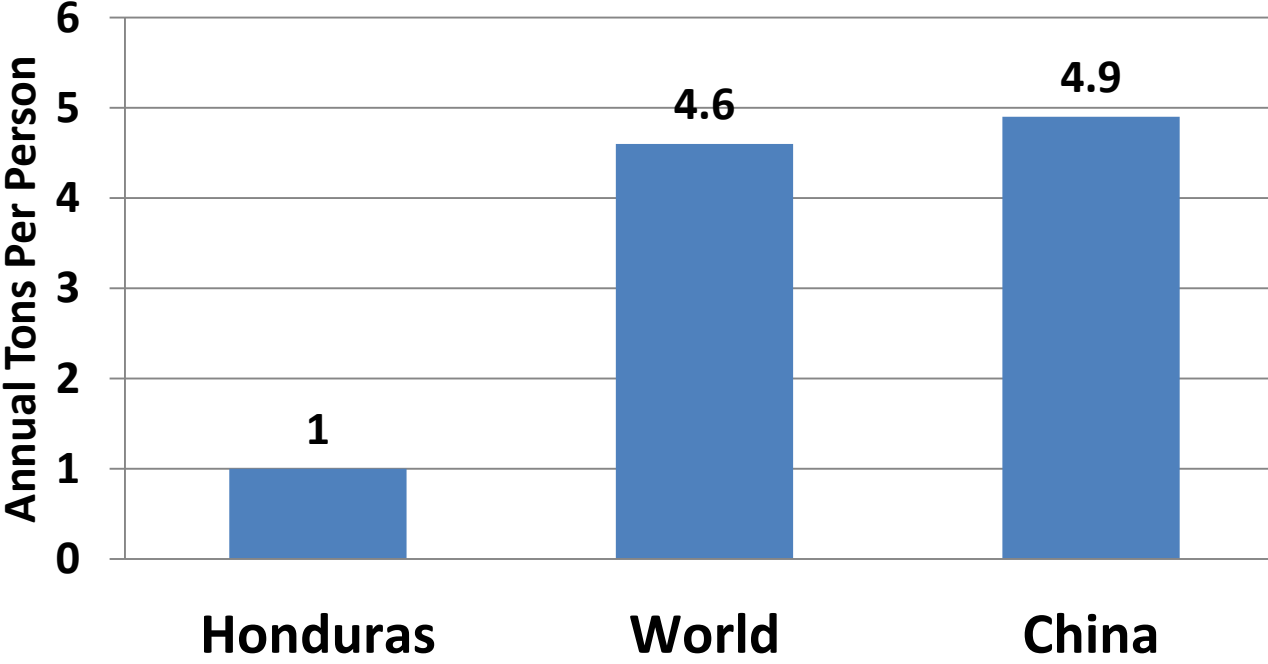
8% B. 9.5

31% C. 12.2

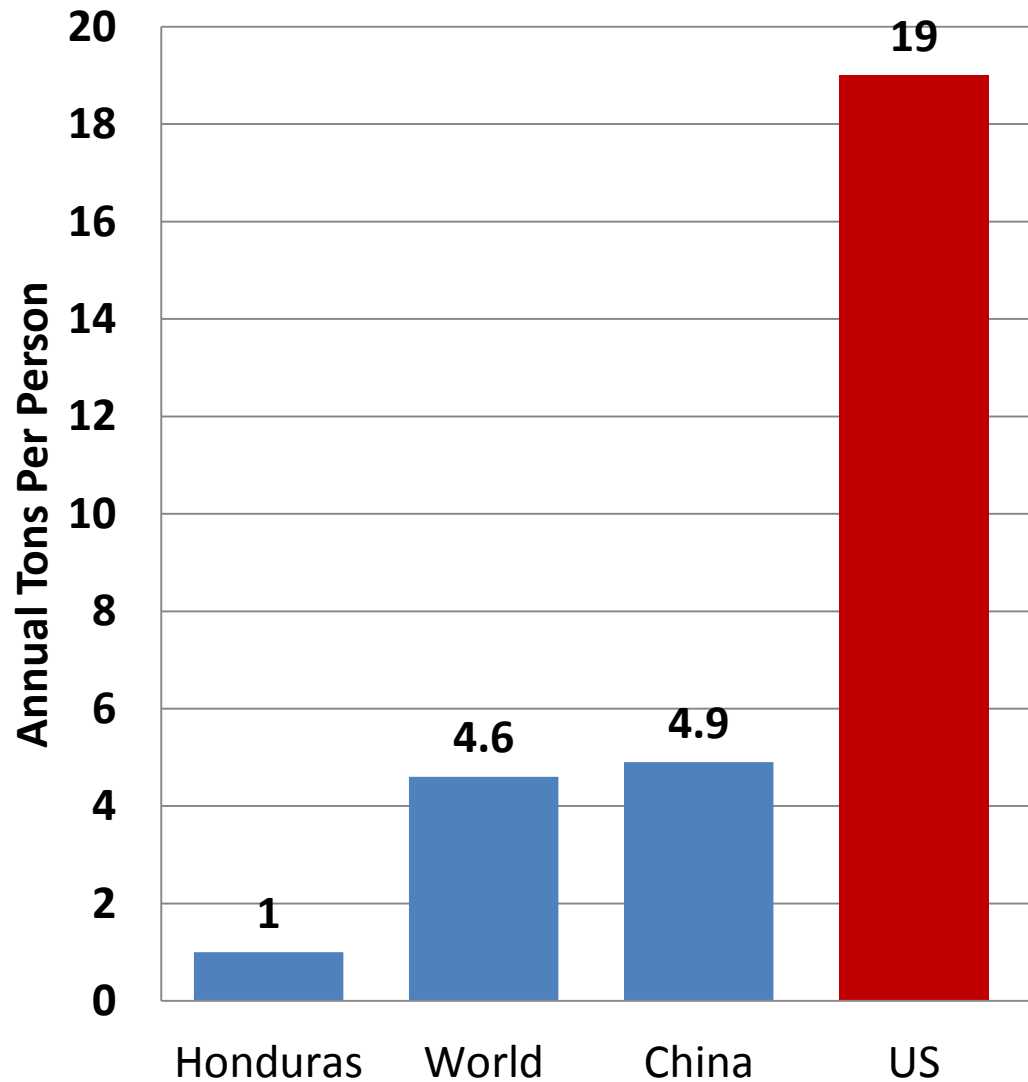
8% D. 16.7

15%  E. 19.5

# CO<sub>2</sub> Emissions



# CO<sub>2</sub> Emissions





# Recent News about Emissions



## Carbon Emissions Reach New Record

By *Daniel Politi* | Posted Sunday, Dec. 2, 2012, at 2:57 PM ET

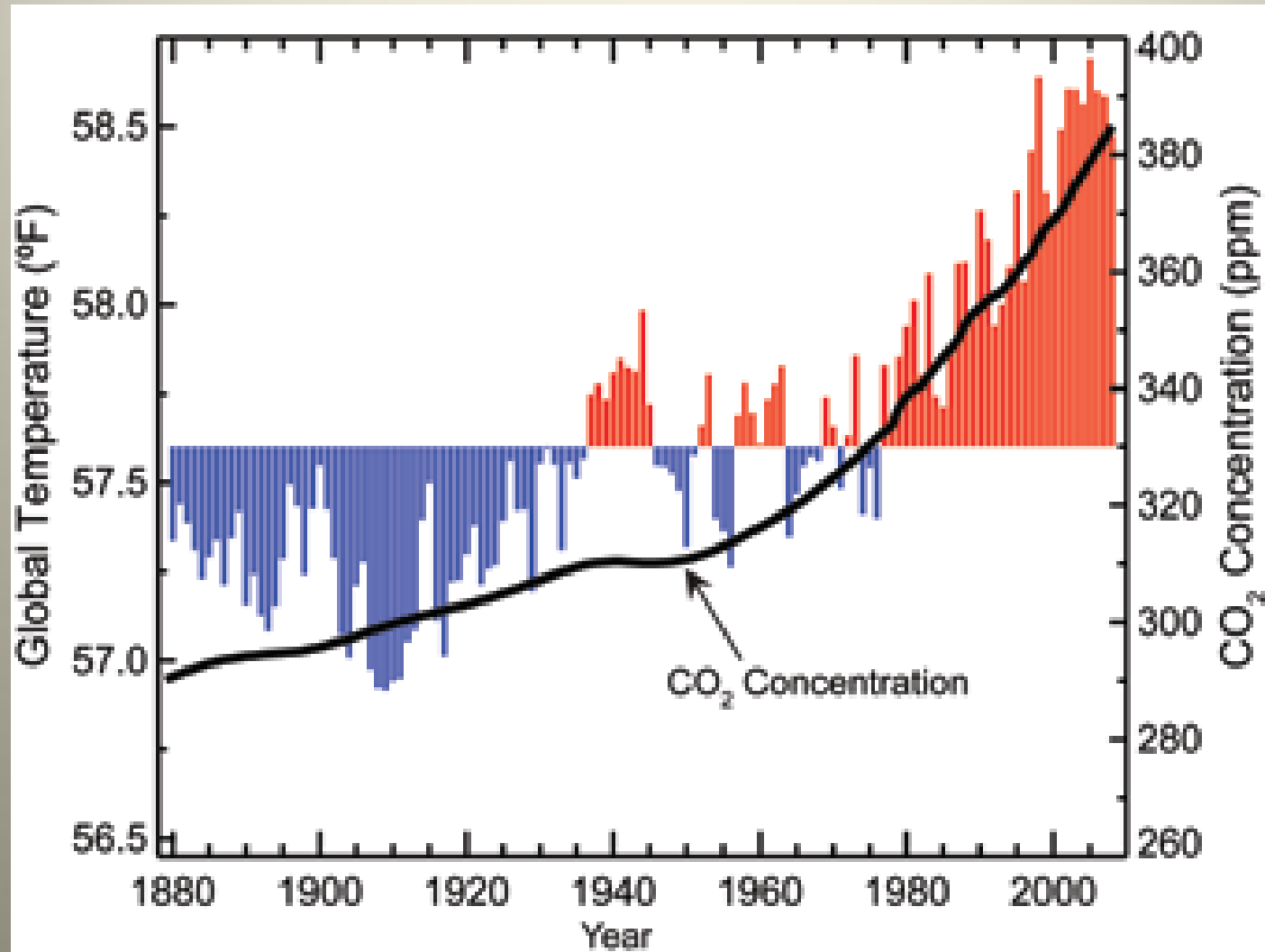
“While the United States decreased emissions by 2 percent to 5.9 billion tons and Germany by 4 percent to 0.8 billion tons, China’s emissions soared 10 percent to 10 billion tons and India’s rose 7 percent to 2.5 billion tons. Global emissions increased 3 percent in 2011 and are expected to rise another 2.6 percent this year.”

US =19.0 t/p

China=7.5 t/p

India =2.0 t/p

# Relationship Between Global Temperature and CO<sub>2</sub>



**What are the sources of these greenhouse gases?**

# What do you think is the largest source of GHG's in the world?

15% **A. Transportation (cars, planes, trains, trucks)**

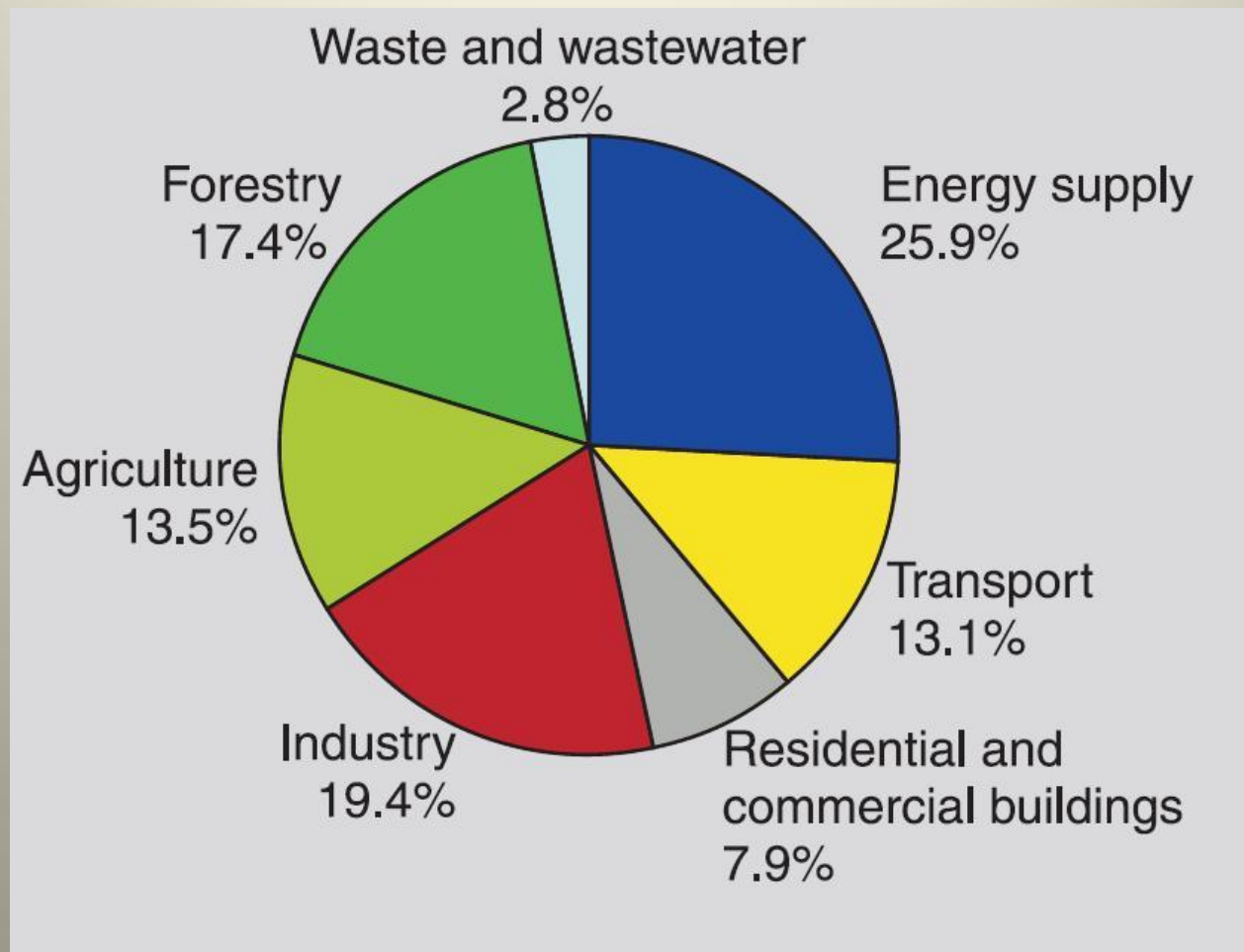
8% **B. Industry**

8% **C. Residential & commercial buildings**

46%  **D. Generating energy**

23% **E. Agriculture**

# Global Anthropogenic GHG Emissions



IPCC Climate Change 2007: Synthesis Report **Figure 2.1**. Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO<sub>2</sub>-eq. (Forestry includes deforestation.)

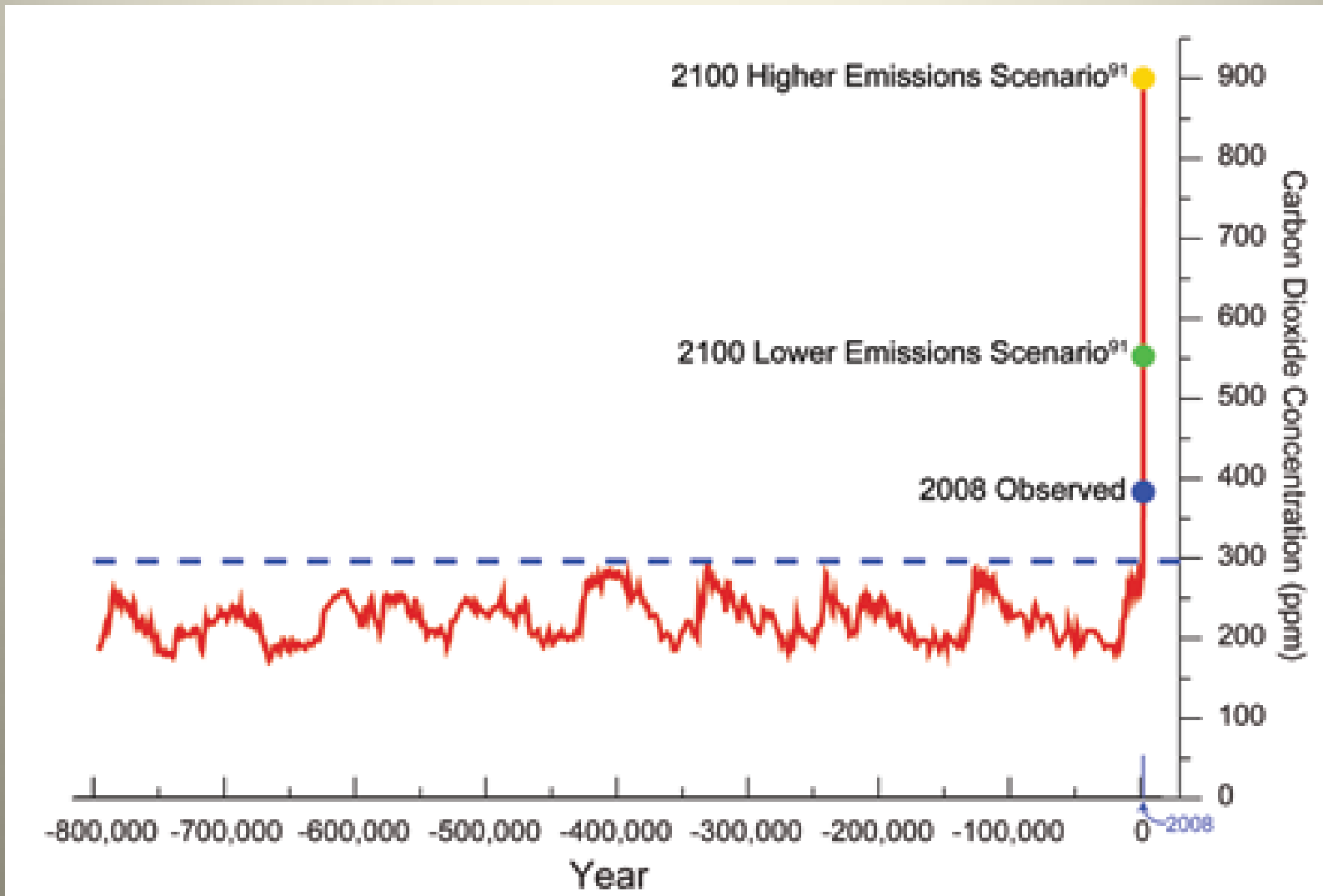
# Facts About Climate Change In Past 100+ Years

- The average temperature of the earth has increased, with **2010 tied at the highest**
- Continental US temperatures **set record in 2012**
- CO<sub>2</sub> concentrations have **increased by 30%**
- Sea level has increased, though modestly
- Glaciers have generally decreased in volume
- Greenland, Arctic and Antarctic ice have decreased

**Now we consider projections.**

**What are the projections for CO<sub>2</sub>  
concentrations in 2100?**

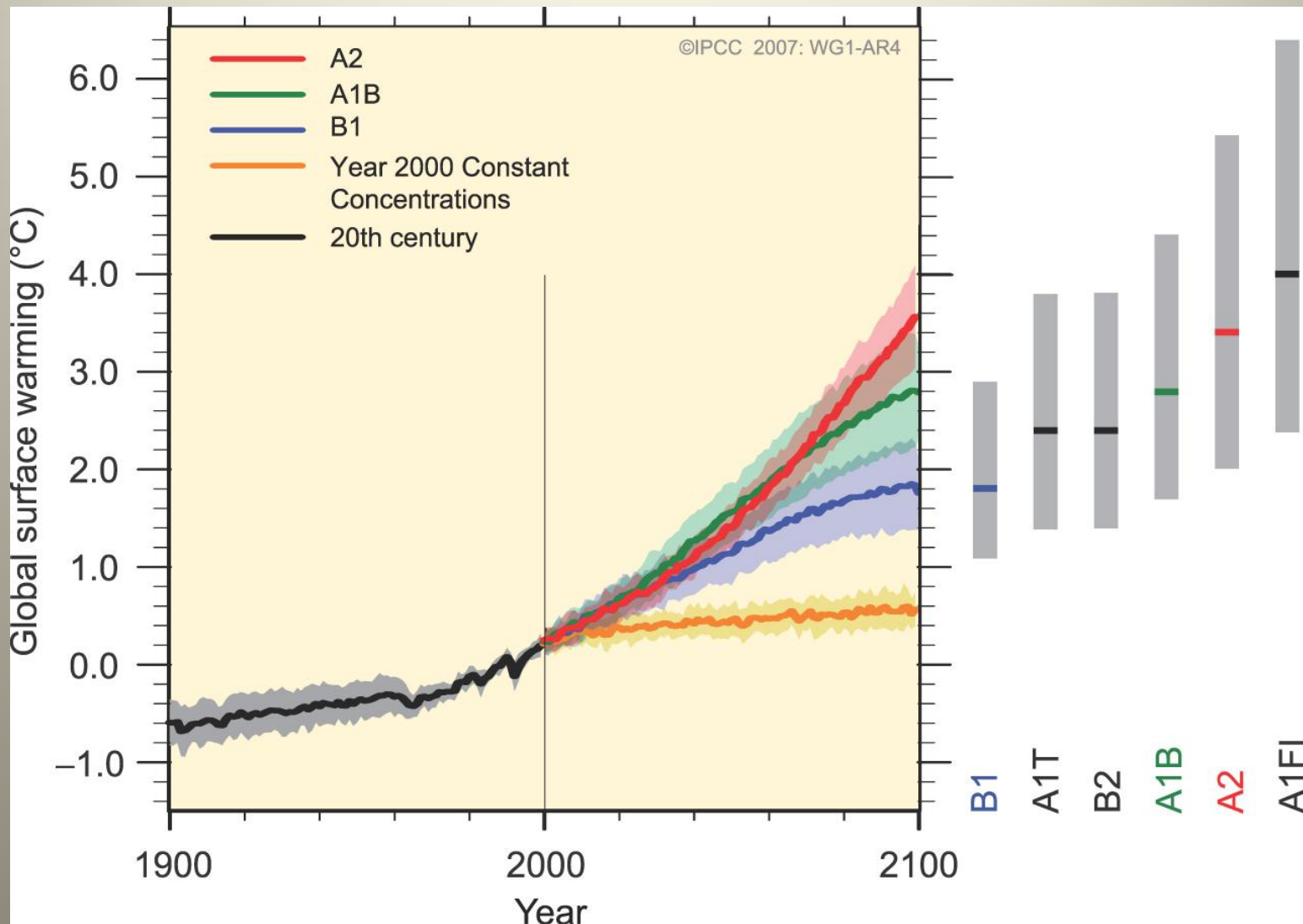
# 800,000 Year Record of CO<sub>2</sub> Concentration





**And what will these  
concentrations mean for  
temperature in 2100?**

# MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING



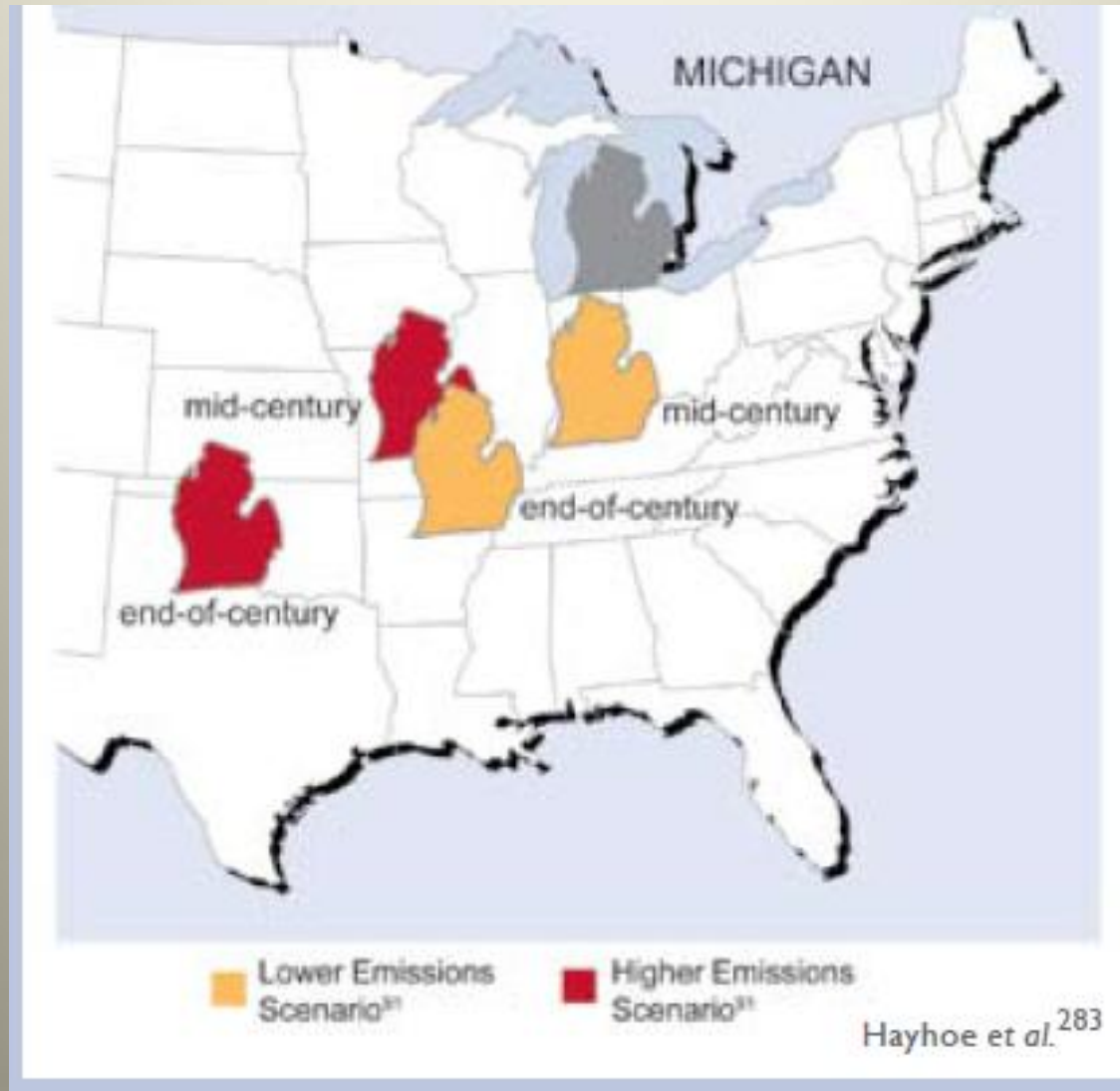
## Statement on this Analysis by John Holdren

*“In the 2007 scenario (previous figure)... a mid-range trajectory takes us by 2050 to a global average surface temperature of about 2°C above the 1900 level. The last time it was that warm on this planet was 130,000 years ago.”*

*“On the mid-range trajectories, we get to 3°C or so above 1900 by 2100. The last time the world was that warm was 30 million years ago.”*

Professor, Harvard University, President and Director, The Woods Hole Research Center, presently on leave as science advisor to President Obama

# Impacts for Michigan in the Summer



# *International Energy Agency*

*May, 2011*

- **Worldwide CO<sub>2</sub> emissions reached a record high in 2010**
- **After a dip in 2009 caused by the global financial crisis, emissions are estimated to have climbed to a record, a 5% jump from the previous record year in 2008**
- **80% of projected 2020 emissions from the power sector are already locked in**

# **So what? It has been warmer before, so why should we be concerned?**

- **The population of the world was not 7 billion**
  - Many live in areas near the ocean, some low-lying
  - Half of US population lives in a coastal county
- **Agriculture & animal cycles have developed with this climate**
- **Transportation has developed with this climate**
- **The present change is very rapid**

**Lesson from previous warming – sea level was more than 10 meters (30+ feet) higher than present.**

## Selected Key Findings from Report: Global Climate Change Impacts in the US, 2009

- *Global warming is unequivocal and primarily human-induced.*
- *Climate changes are underway in the US and are projected to grow. This includes: increases in heavy downpours, rising temperature and sea level, thawing permafrost.*
- *Risks to human health will increase: heat stress, extreme weather events, diseases transmitted by insects and rodents*
- *Thresholds will be crossed, leading to large changes in climate and ecosystem: changes in sea ice and permafrost, survival of species*
- *Future climate change and its impacts depend on choices made today.*

# Mitigation Strategies

Term refers to reducing the problem.

## Reducing CO<sub>2</sub> and other GHG Emissions by

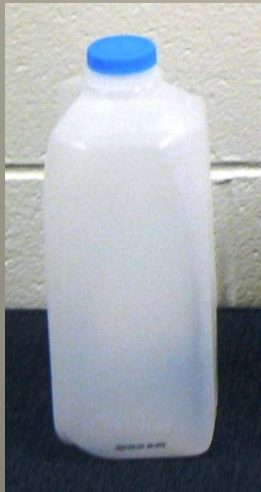
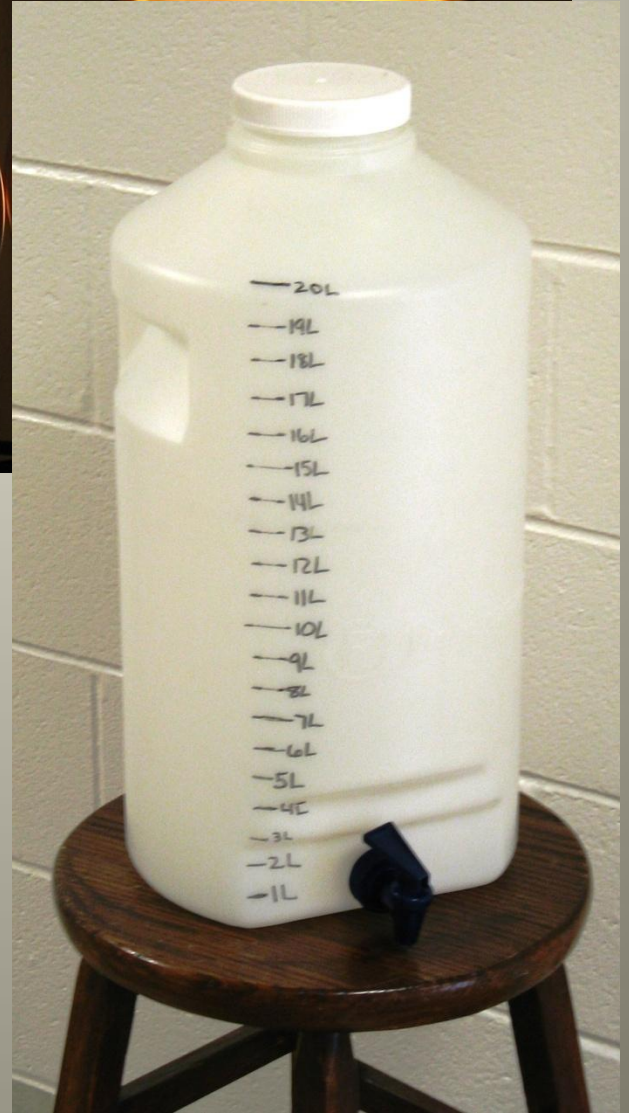
- Improved efficiency: homes, cars, manufacturing
- Changing to alternate fuels or nuclear fuel
- Reducing destruction of plants and trees
- Replacing coal with natural gas-70% more energy
- Personal actions:
  - Change light bulbs; Recycle Al cans; Change eating



# Three Types of Light Bulbs



# Amount of CO<sub>2</sub> Produced in 1 Hour





# Recycling Aluminum Cans



# Amount of CO<sub>2</sub> To Produce 1 New Aluminum Can



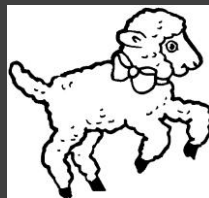
25 Gallons of CO<sub>2</sub> To Produce 1 New Aluminum Can!

Relative Carbon dioxide Production

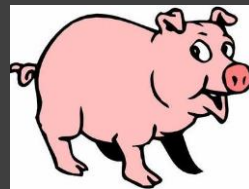
10  
9  
8  
7  
6  
5  
4  
3  
2  
1  
0



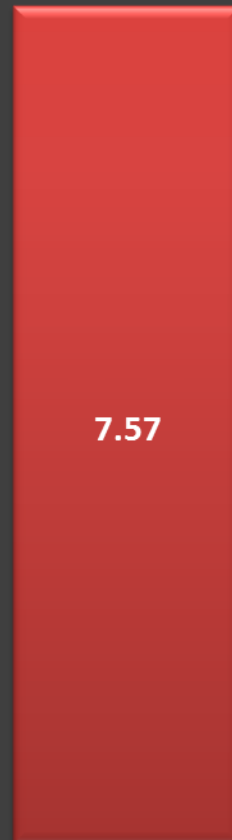
Chicken



Lamb



Pork



Beef

# Which statement best represents your opinion?

- 0% A. Climate change is not a significant issue
- 8% B. Climate change is a modest-level issue
- 75% C. Climate change is a major issue
- 17% D. Climate change is major, but it is not practical to address

**Now what is your response to  
this information?**

**What do you think WE –  
and YOU – should do?**

# Are you convinced that a reduction in GHG emissions should be achieved?

46% **A. Yes, there should be a large reduction**

54% **B. Yes, there should be a medium reduction**

0% **C. Yes, there should be a small reduction**

0% **D. No, because there is no problem**

0% **E. No, because it will not do any good**



# Are you willing to reduce your emissions by conserving, recycling, changing eating habits, etc?

62% **A. I will modestly reduce my emissions**

23% **B. I will significantly reduce my emissions**

15% **C. It would be difficult to reduce emissions**

0% **D. I see no need to reduce my emissions**

**Generating electricity using nuclear fuel produces less GHG's. Should we develop more nuclear power?**

**8% A. Significantly more nuclear power**

**33% B. Somewhat more nuclear power**

**17% C. Continue at present level of nuclear power**

**42% D. Reduce dependence on nuclear power**

# Should we engineer the atmosphere to reduce climate change?

- 7% A. Yes, at a significant level
- 14% B. Yes, at a modest level
- 36% C. Only if it is obvious to be important
- 43% D. Under no circumstances

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If you're on the Left Coast and like snow, it may be time to rejoice. If you're on the East Coast, though, don't...

### Obama Proposal Could Weaken Key Climate Agency

COMMENTARY By Andrew Freedman  
An Obama admin...

### A Graphical Tour Through the Climate of 2011

New data from the National Oceanic and Atmospheric Administration and NASA show that for the 35th year in a row, the g...

2011 Was At Least 11th Warmest

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<http://www.camelclimatechange.org/>

# President Obama – January 21, 2013

- We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations.
- The path towards sustainable energy sources will be long and sometimes difficult. But America cannot resist this transition; we must lead it.
- We cannot cede to other nations the technology that will power new jobs and new industries — we must claim its promise.
- That is how we will preserve our planet, commanded to our care by God. That's what will lend meaning to the creed our fathers once declared.

# President Obama – February 12, 2013

- But for the sake of our children and our future, we must do more to combat climate change.
- (T)he fact is, the 12 hottest years on record have all come in the last 15. Heat waves, droughts, wildfires, and floods – all are now more frequent and intense.
- We can choose to believe that Superstorm Sandy, and the most severe drought in decades, and the worst wildfires some states have ever seen were all just a freak coincidence.
- Or we can choose to believe in the overwhelming judgment of science – and act before it's too late.
- The good news is, we can make meaningful progress on this issue while driving strong economic growth.

# One Reason for the Challenges of Educating About Climate Change

theguardian

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[Environment](#) > [Climate change scepticism](#)

## Secret funding helped build vast network of climate denial thinktanks

Anonymous billionaires donated \$120m to more than 100 anti-climate groups working to discredit climate change science

- [How Donors Trust distributed millions to anti-climate groups](#)

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[Suzanne Goldenberg](#), US environment correspondent

 [Follow](#)

The Guardian, Thursday 14 February 2013 08.39 EST

# Acknowledgments

## **NASA for support under Global Climate Change Education**

Award# NNX09AL64G

*“Creation and Dissemination of an Interdisciplinary Undergraduate General Education Course on Climate Change”*



National Aeronautics  
and Space Administration

## **National Science Foundation for support under Climate Change Education**

Award #DUE-0950396

*"Creating a Learning Community for Solutions to Climate Change"*



National Science Foundation  
WHERE DISCOVERIES BEGIN

Acknowledge David Kitchen & Scott Mandia for information  
Matthew Jorgensen and Tom Kina for technical assistance.







**Final Thought:**

**We Only Have One, So Let's Take Good Care of It!**