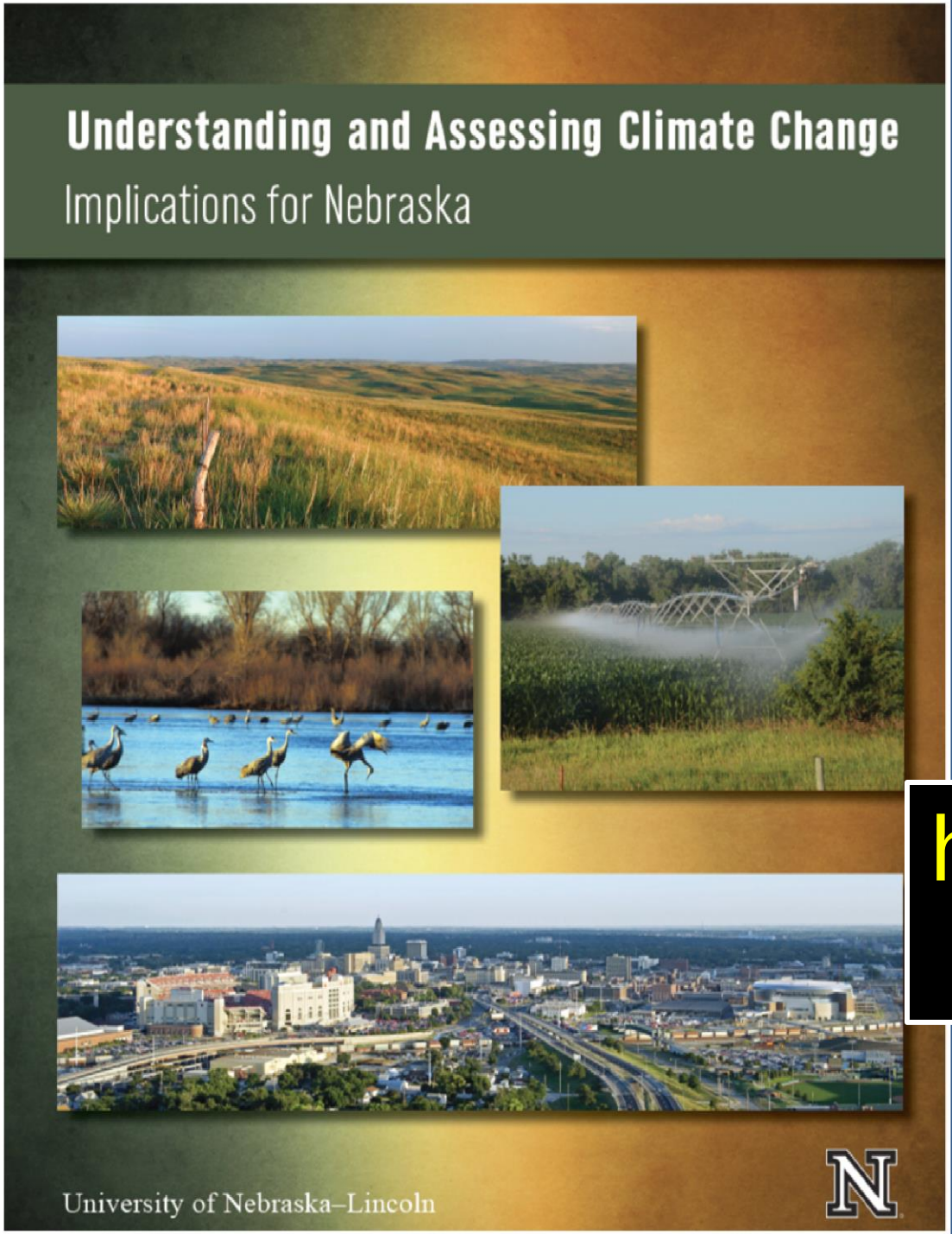
Understanding and Assessing Climate Change:

Implications for Nebraska

Donald A. Wilhite
School of Natural Resources
University of Nebraska-Lincoln

Team Members:
Deborah Bathke
Robert Oglesby
Clint Rowe



Copies of the report will be available as you exit and on line at

http://go.unl.edu/climatechange

Audience diversity . . Not a perfect analogy but . . .

Feeling like the Geico gecko!

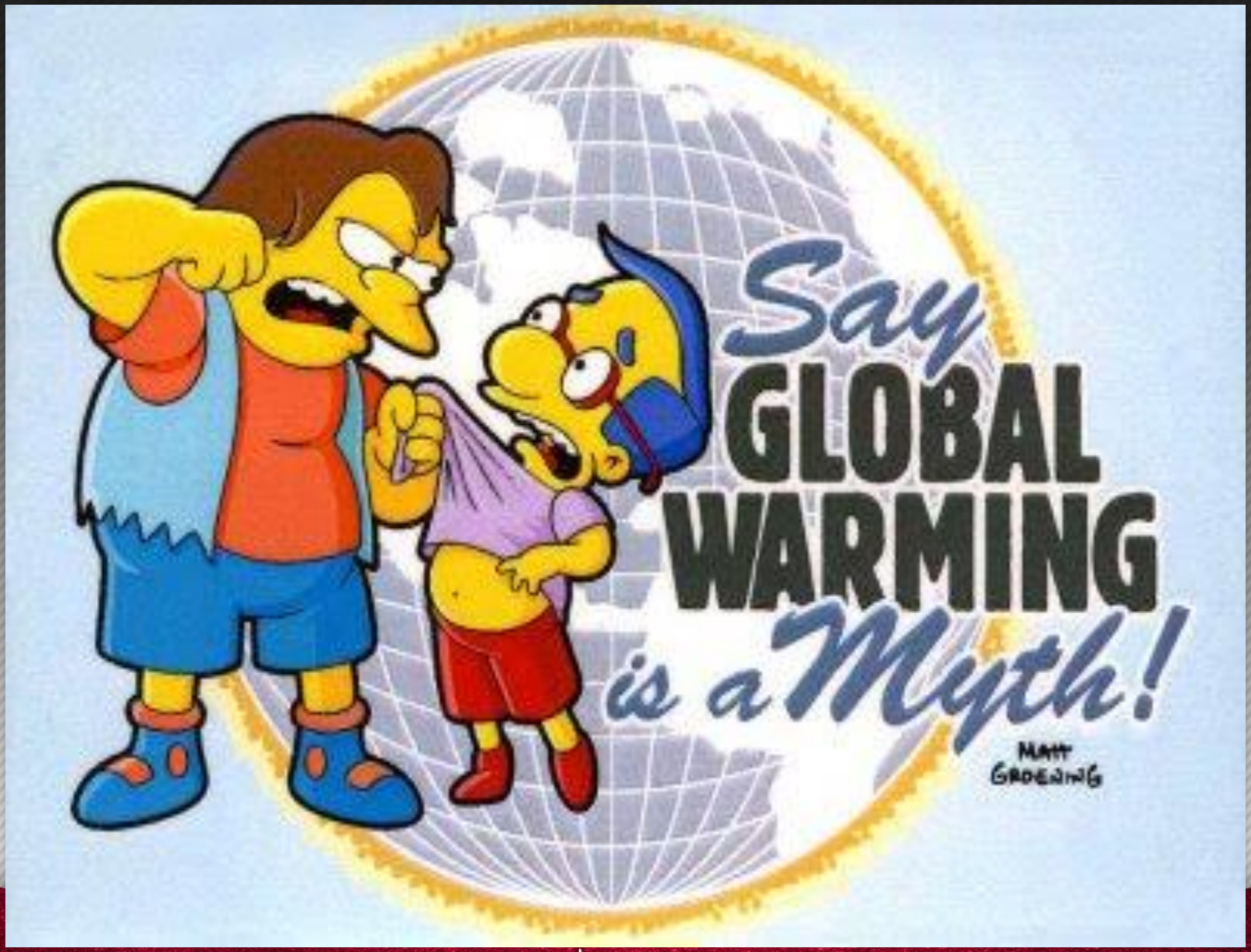
Everybody knows that!

Where do you place yourself?

Novice, but eager to learn!

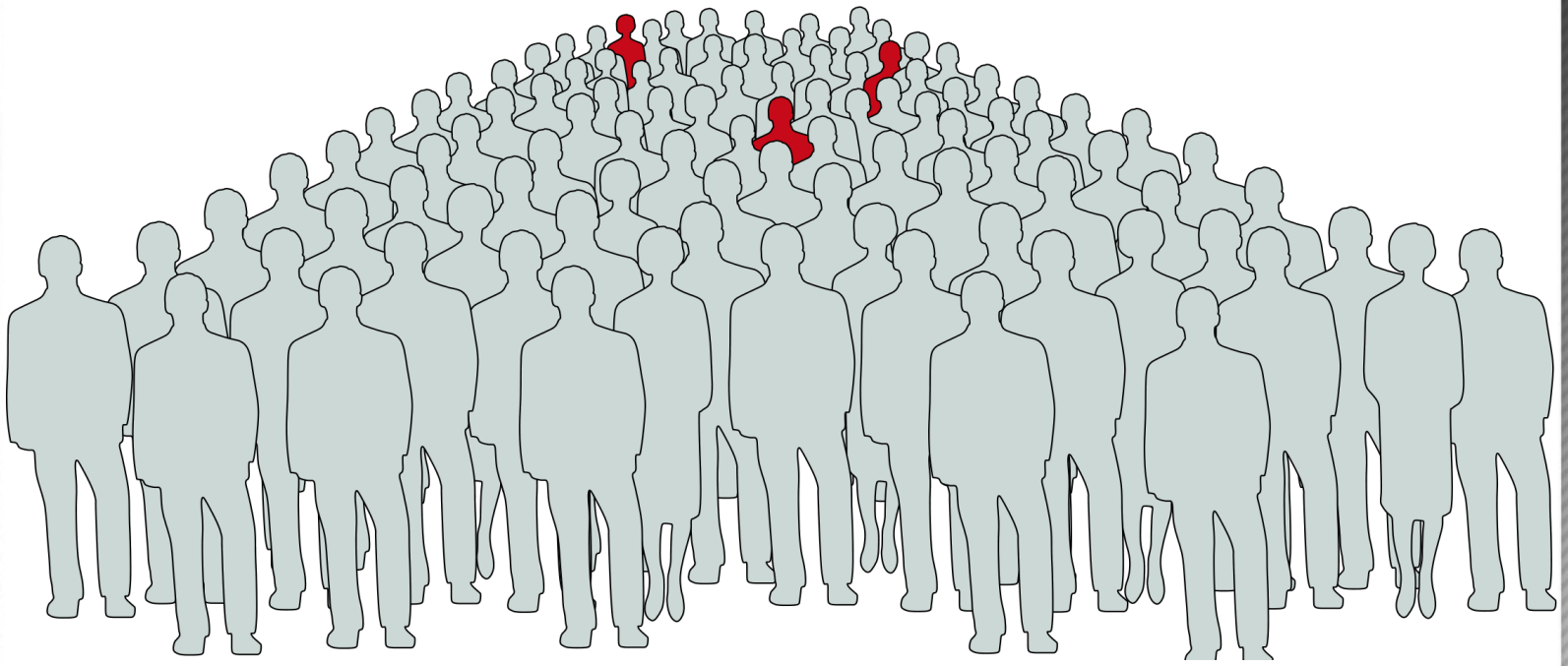
Expert

Knowledge continuum


Say
GLOBAL
WARMING
is a Myth!
MATT GROENING

Did you know that . . .

97 out of 100 climate scientists conclude that
humans are changing global climate

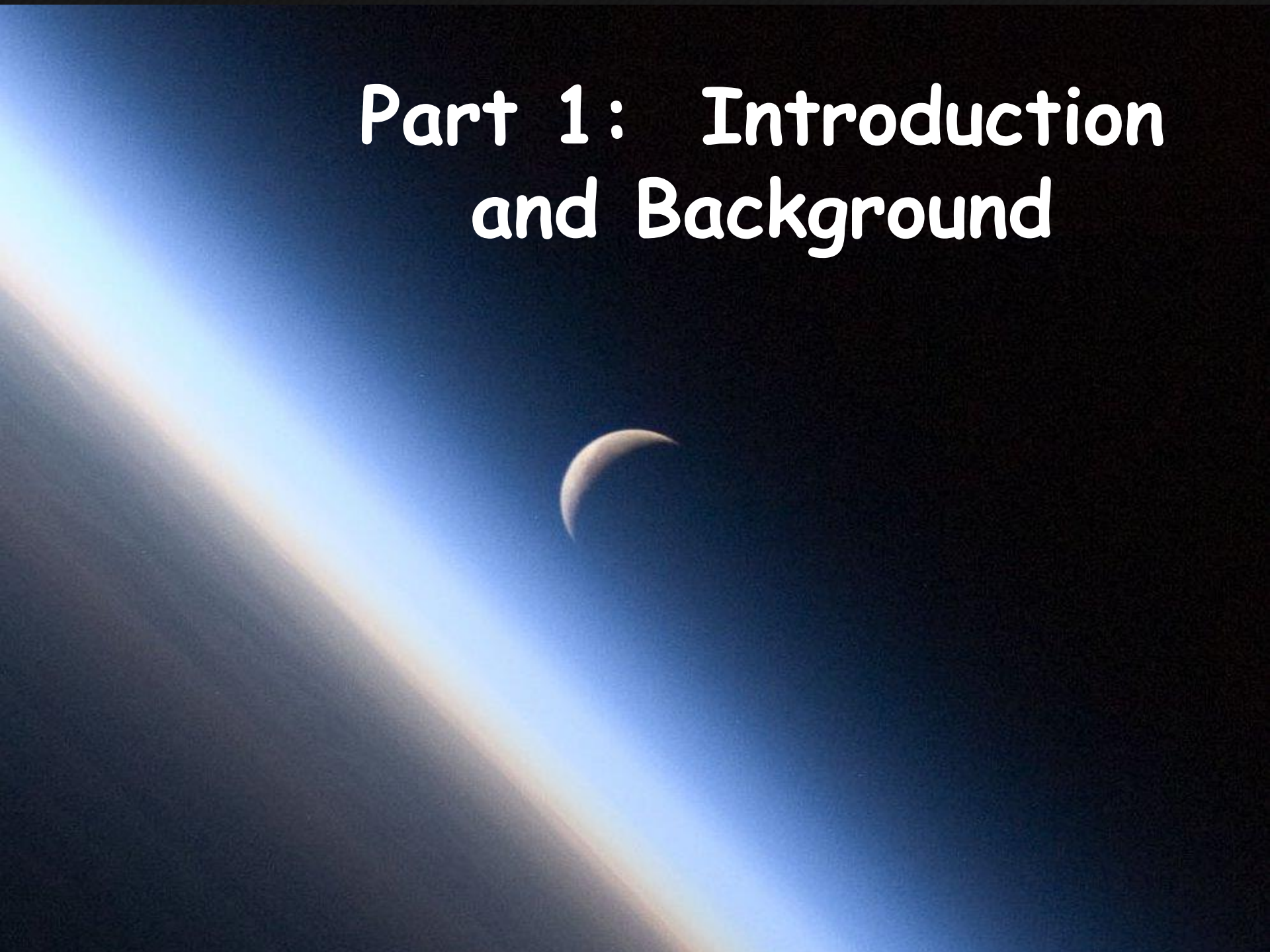


There is a significant misperception by the public about the scientific consensus that exists on this issue.

Presentation Outline

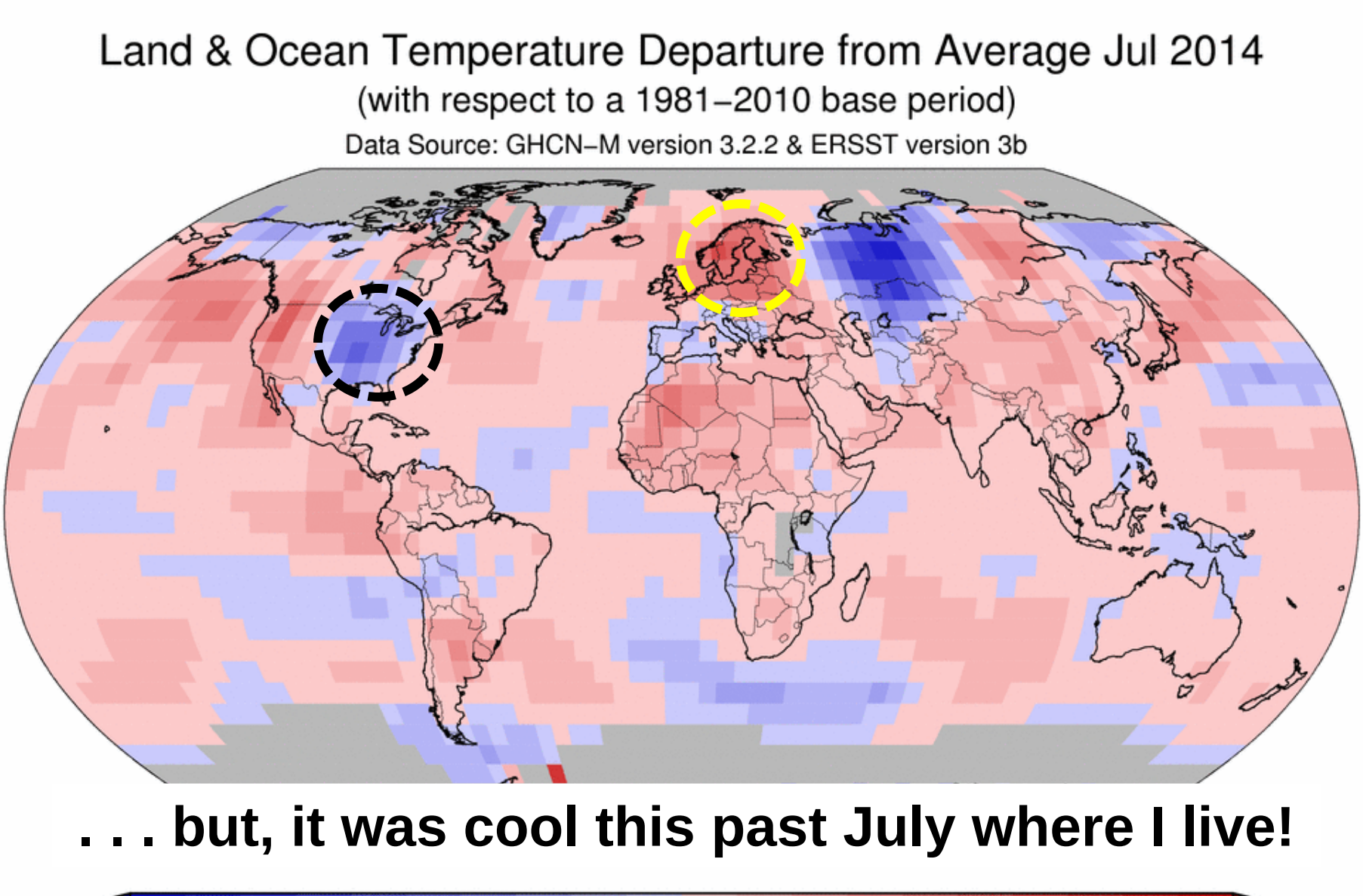
- **Part 1**: Introduction and Background
- **Part 2**: Climate Change Science
- **Part 3**: Observed Changes in Climate
- **Part 4**: Separating Natural from Human Factors
- **Part 5**: Projections of Future Climate and Implications for Nebraska
- **Part 6**: Takeaway Points, Challenges and Opportunities

Part 1: Introduction and Background



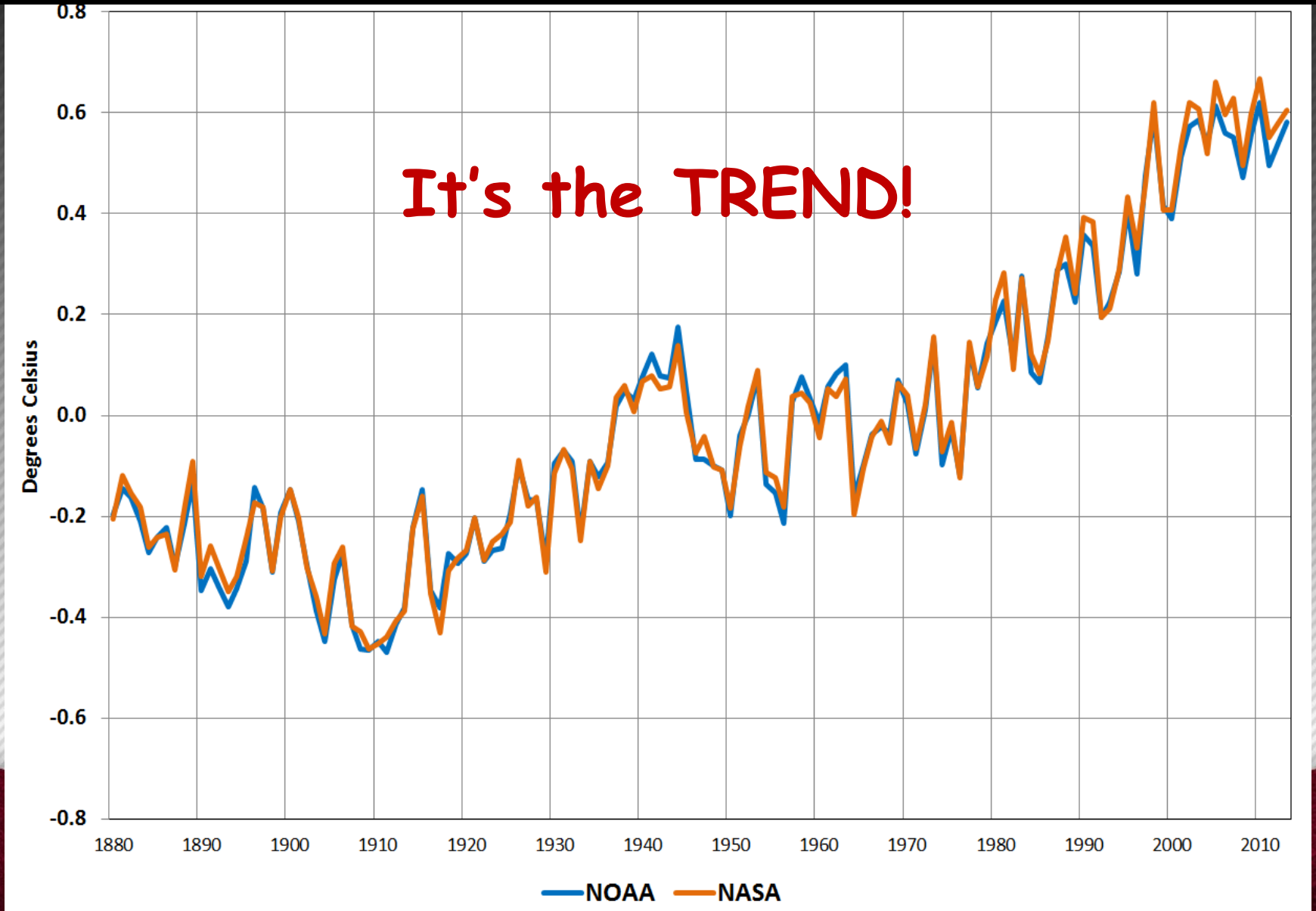
Definitions

- **WEATHER**
  - The condition of the atmosphere at a particular place and time.
    - Sunny vs. cloudy, winds, temperature, precipitation, humidity, etc.
- **CLIMATE**
  - The composite or average of weather over a long period of time (30 years or longer)—**What are the trends?**
- ***"climate is what you expect, weather is what you get." (Mark Twain)***



. . . but, it was cool this past July where I live!

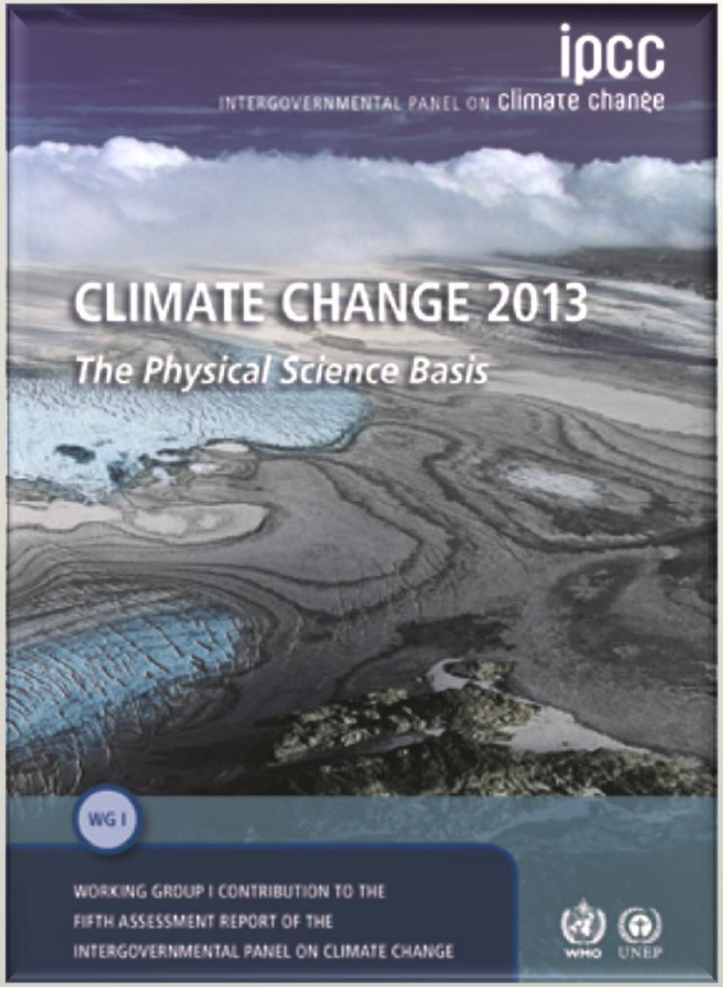
Globally Averaged Temperature: 1880-2012 (Departure from 1951-1980 average)



The IPCC and the NCA

- **IPCC, Intergovernmental Panel on Climate Change (WMO and UNEP)**
  - The IPCC is a scientific body under the auspices of the United Nations (UN). It reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters.
- **NCA, National Climate Assessment**
  - The National Climate Assessment summarizes the impacts of climate change on the United States, now and in the future. It is Congressionally mandated under the U.S. Global Change Research Program.

IPCC Fifth Assessment Report (AR5)



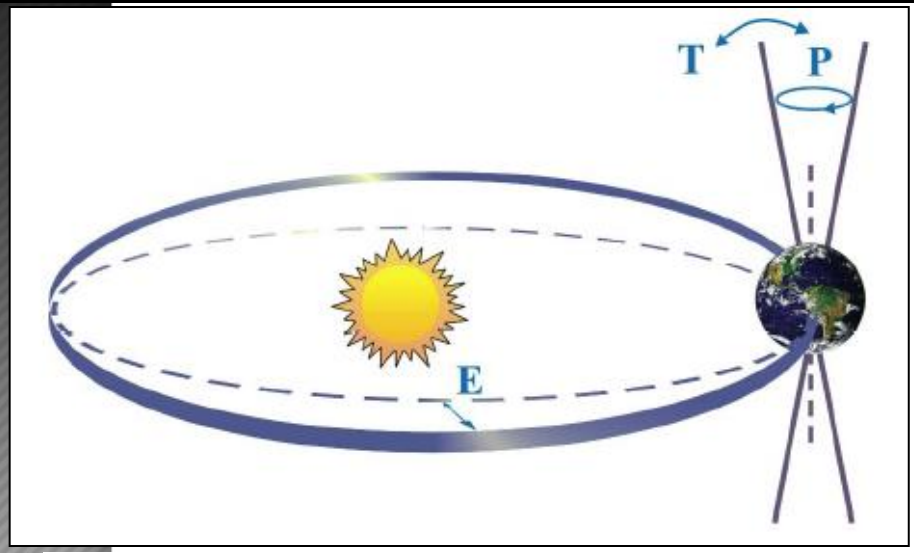
Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes.

This evidence for human influence has grown since AR4. It is *extremely likely (>95%)* that human influence has been the dominant cause of the observed warming since the mid-20th century.

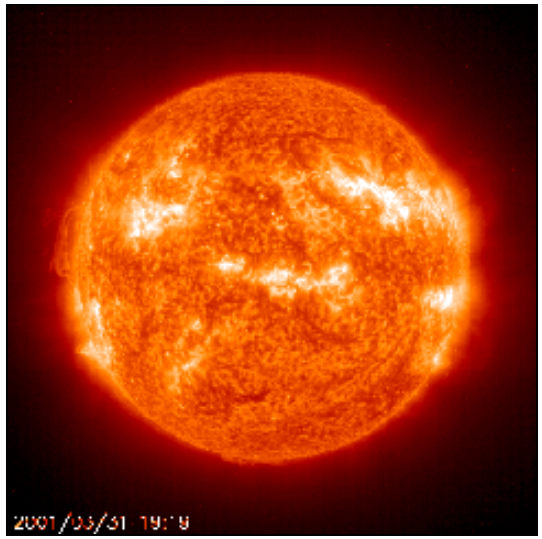
Source: IPCC Summary for Policy Makers, 2014.


Part 2: Climate
Change Science

Natural forcings affecting climate

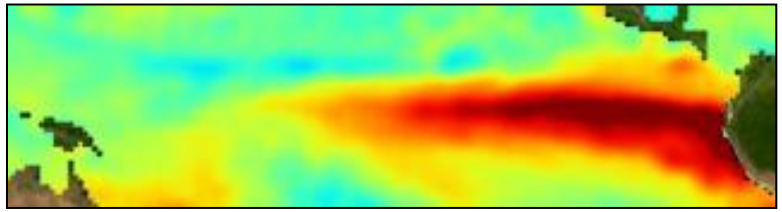


Variations in the Earth's orbit
(Milankovic effect)



Variations in the energy
received from the sun

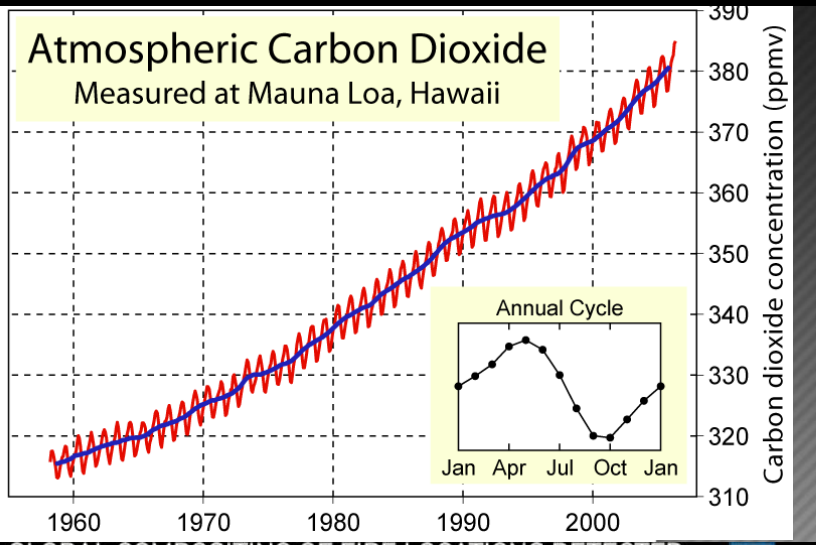
Stratospheric
aerosols from
energetic
volcanic eruptions



Chaotic interactions in
the Earth's climate
(e.g., El Nino, NAO)

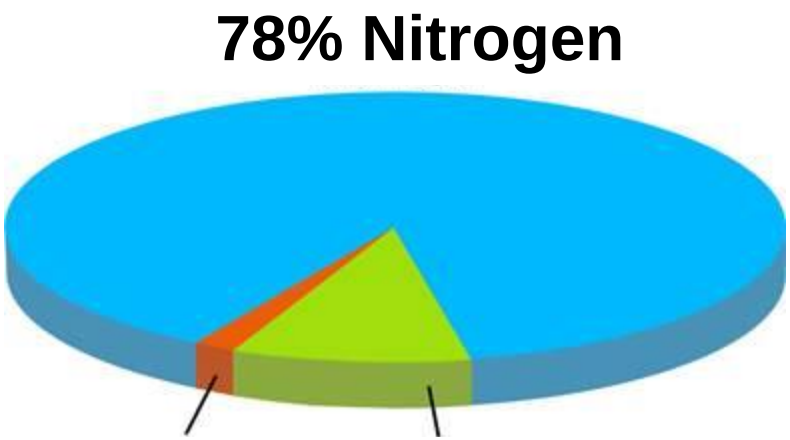
Anthropogenic forcings affecting climate

- **Changes in atmospheric concentrations of radiatively important gases, CO_2 and others**
- **Changes in aerosol particles from burning fossil fuels and biomass**
- **Changes in the reflectivity (albedo) of the Earth's surface due to land use changes**



Composition of the Earth's Atmosphere

- Nitrogen (78%)
- Oxygen (21%)
- ***Carbon Dioxide (CO_2) and other trace gases (1%)***
  - ***Methane***
  - ***Nitrous Oxide***
  - ***Water Vapor***



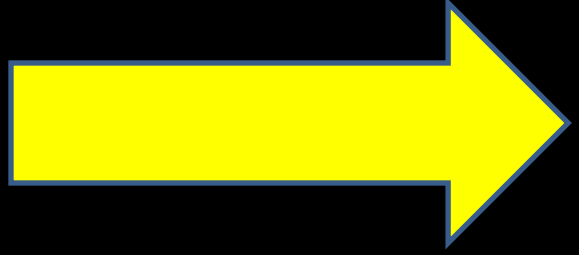
Without these GHGs, the earth's surface temperature would be about 57°F cooler.

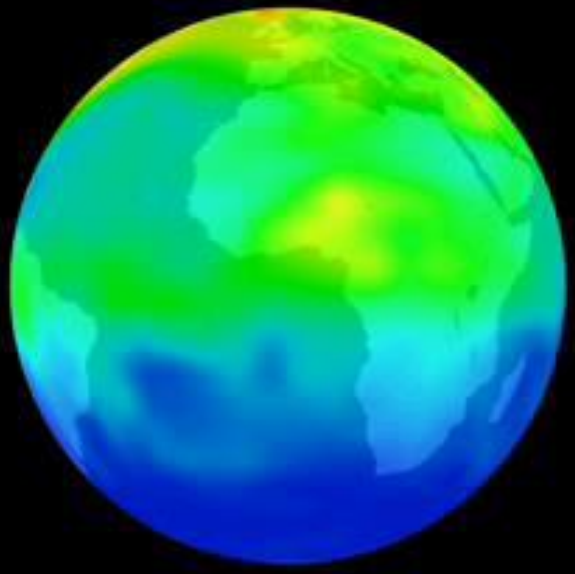
GHGs are the heat regulators for the Earth.

Earth's Energy Balance

Sunlight

Visible Radiation





Heat

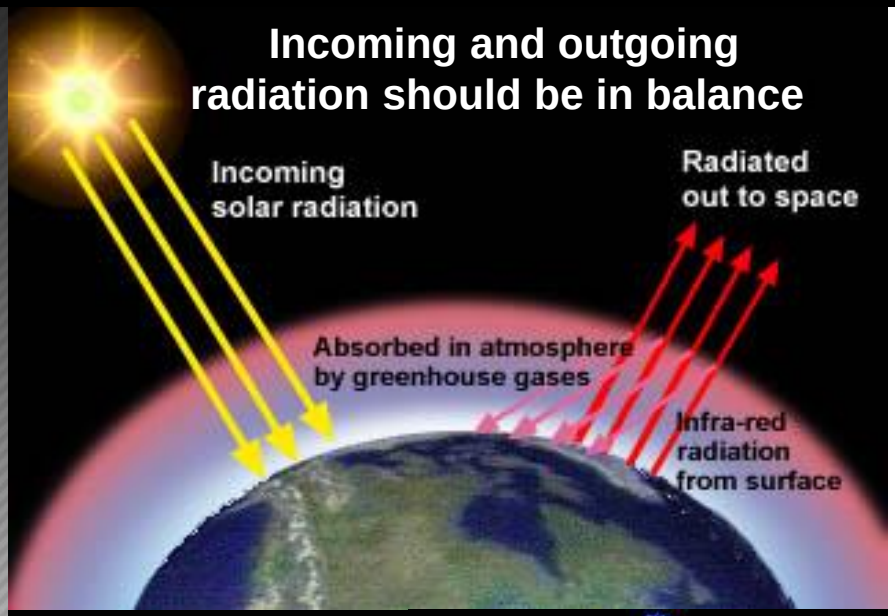
Infrared Radiation

235 Watts per square meter (Wm-2)

235 Watts per square meter (Wm-2)

When energy IN = energy OUT, climate is in balance i.e., steady state

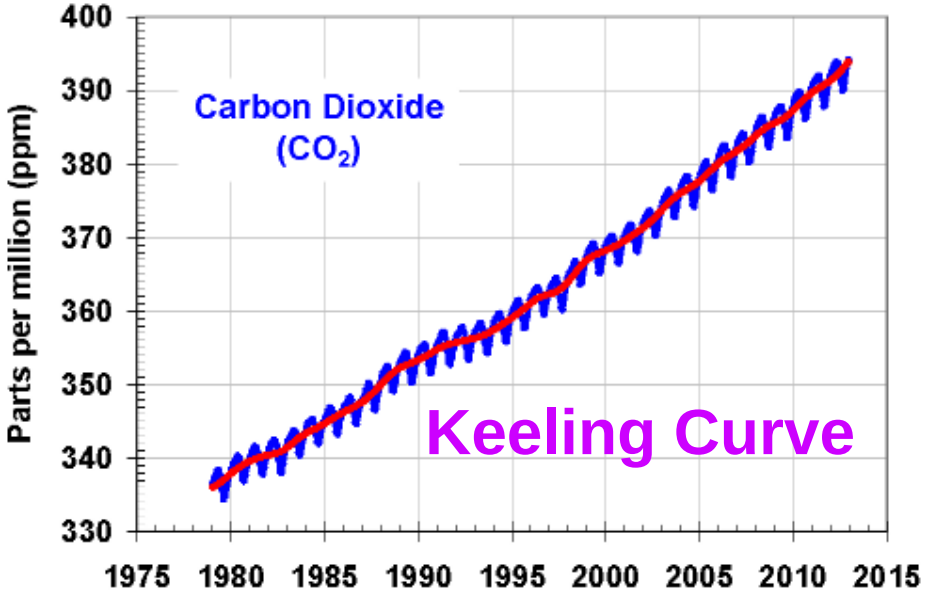
What is the 'greenhouse effect'?

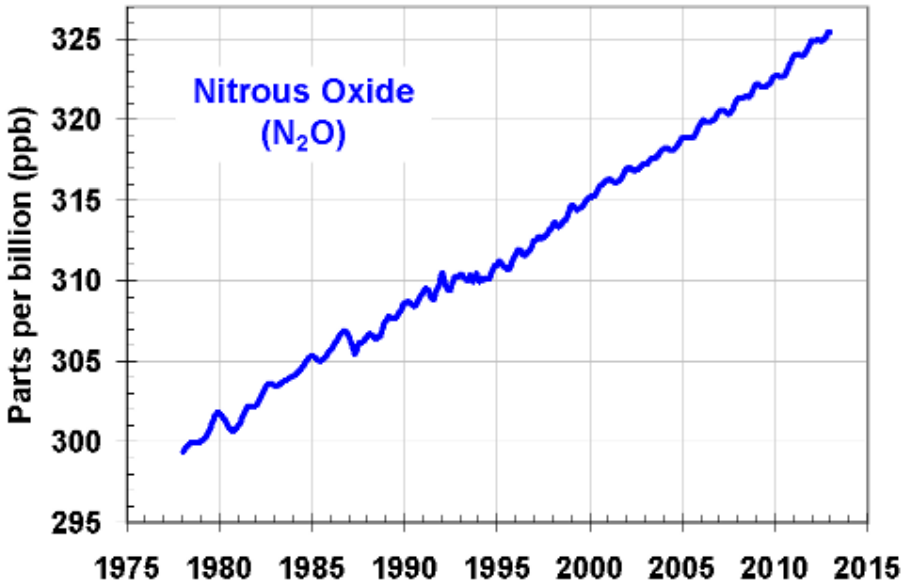


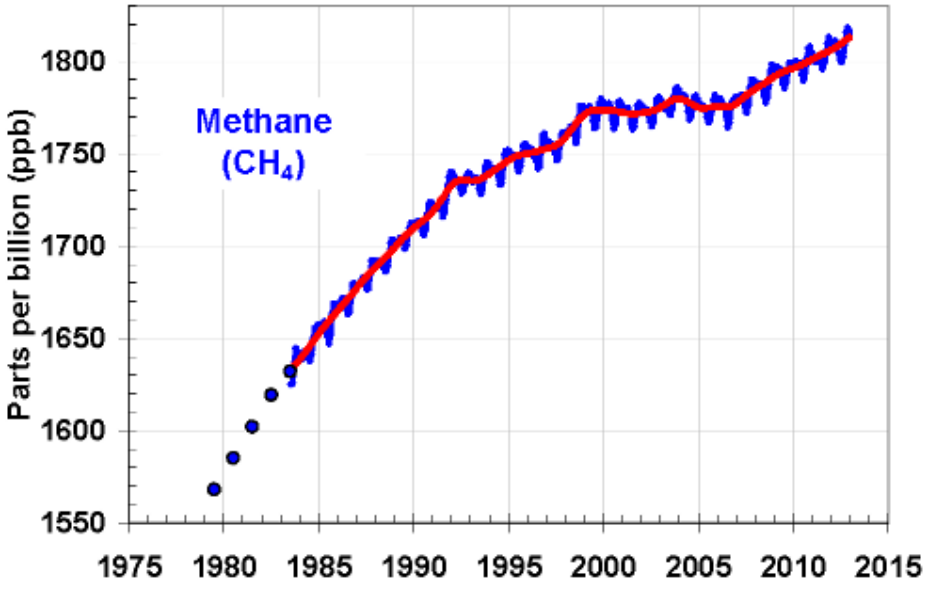
Like the sun, the Earth emits radiation. It is much cooler than the sun, so it emits in the infrared, just like a person, a cat, or any other body. Some of that infrared energy is absorbed by GHGs in the atmosphere, retaining heat and raising surface temperatures by ~57°F.

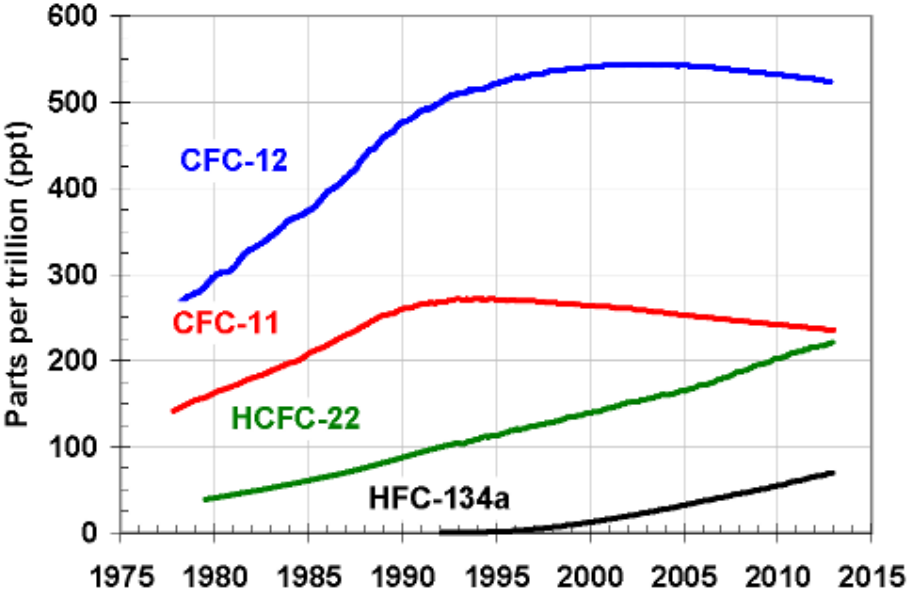
Extra CO_2 and other GHGs lead to a positive "forcing" of the climate system, an "*enhanced* greenhouse effect."

Trends of Principal GHGs









Atmospheric CO_2 is now higher than it's been for 650,000 years & increasing rapidly.

Why are we concerned about continued increases in CO_2 and other GHGs?

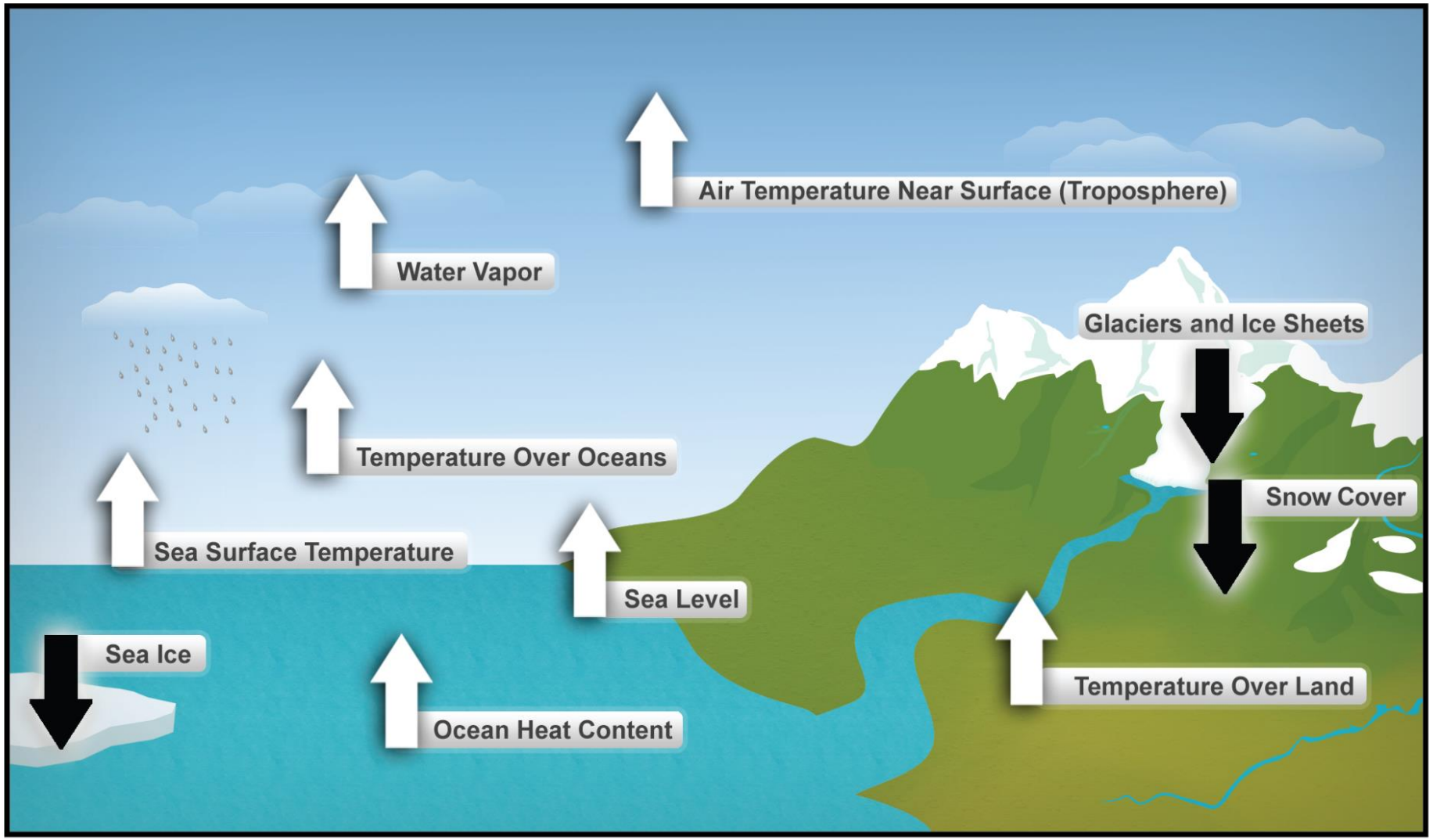
- Earth's inhabitants total more than 7 billion— expected to be 9+ billion by 2050.
- Population is increasing at a rate of 80 million/year.
- Future changes in climate are projected to be much more rapid— how can we adapt to such a rapidly changing climate?

f atmospheric samples contained in ice cores provides evidence that atmospheric CO_2 has n. (Source: NOAA)

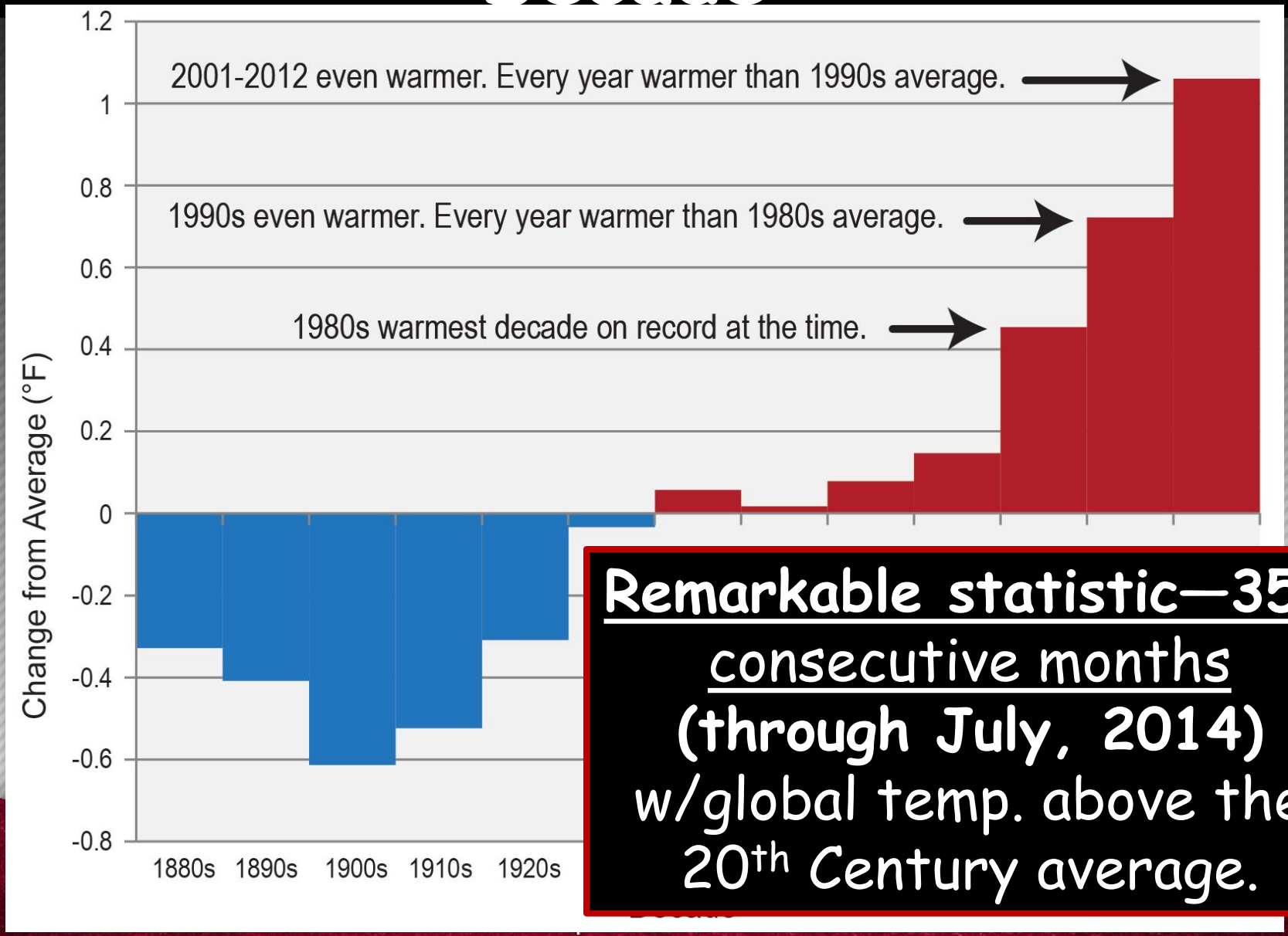
Part 3: Observed Changes in Climate

If global climate is changing . .

Ten indicators of a warming world

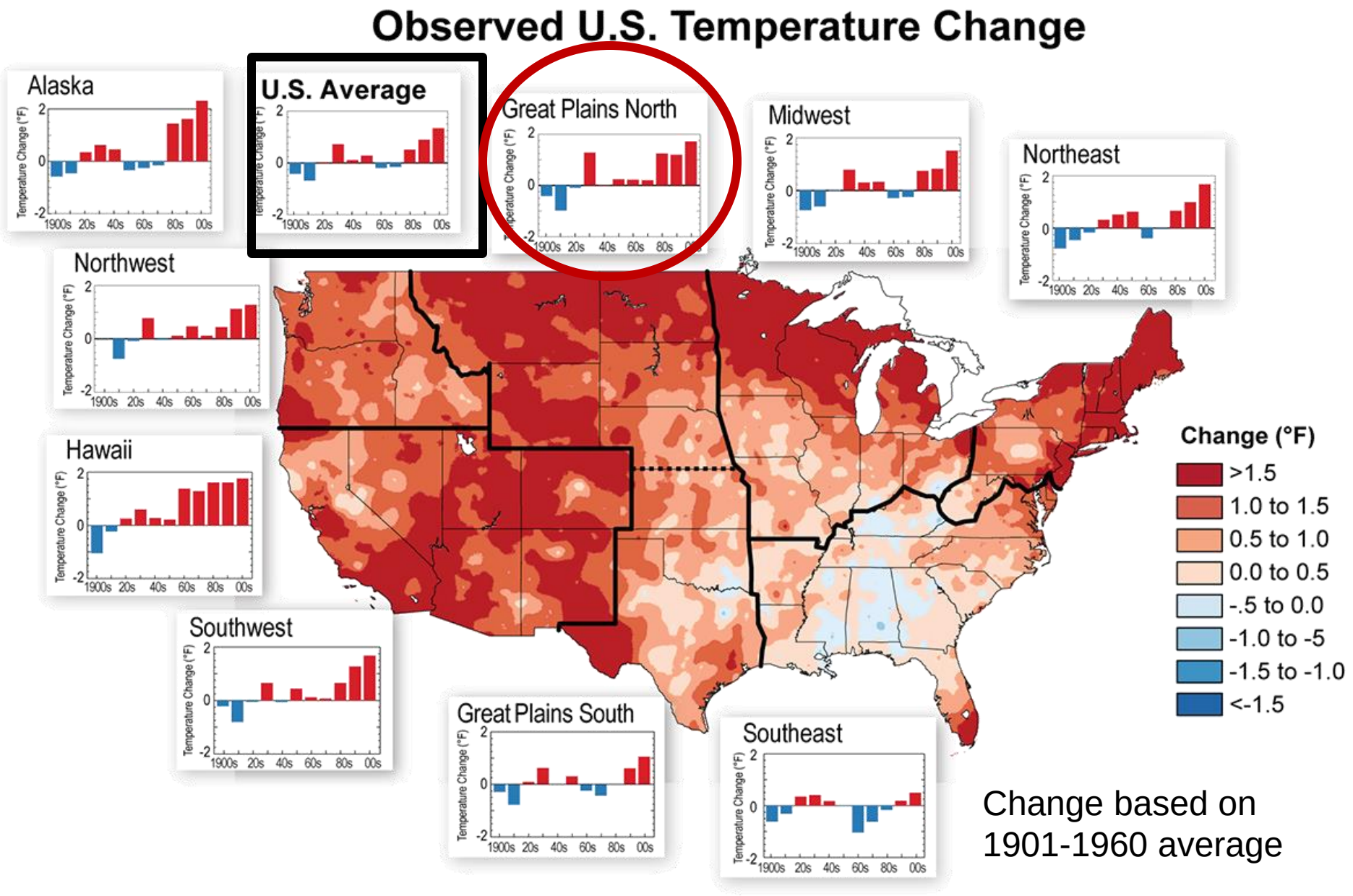


Global Temperature Change, by Decade

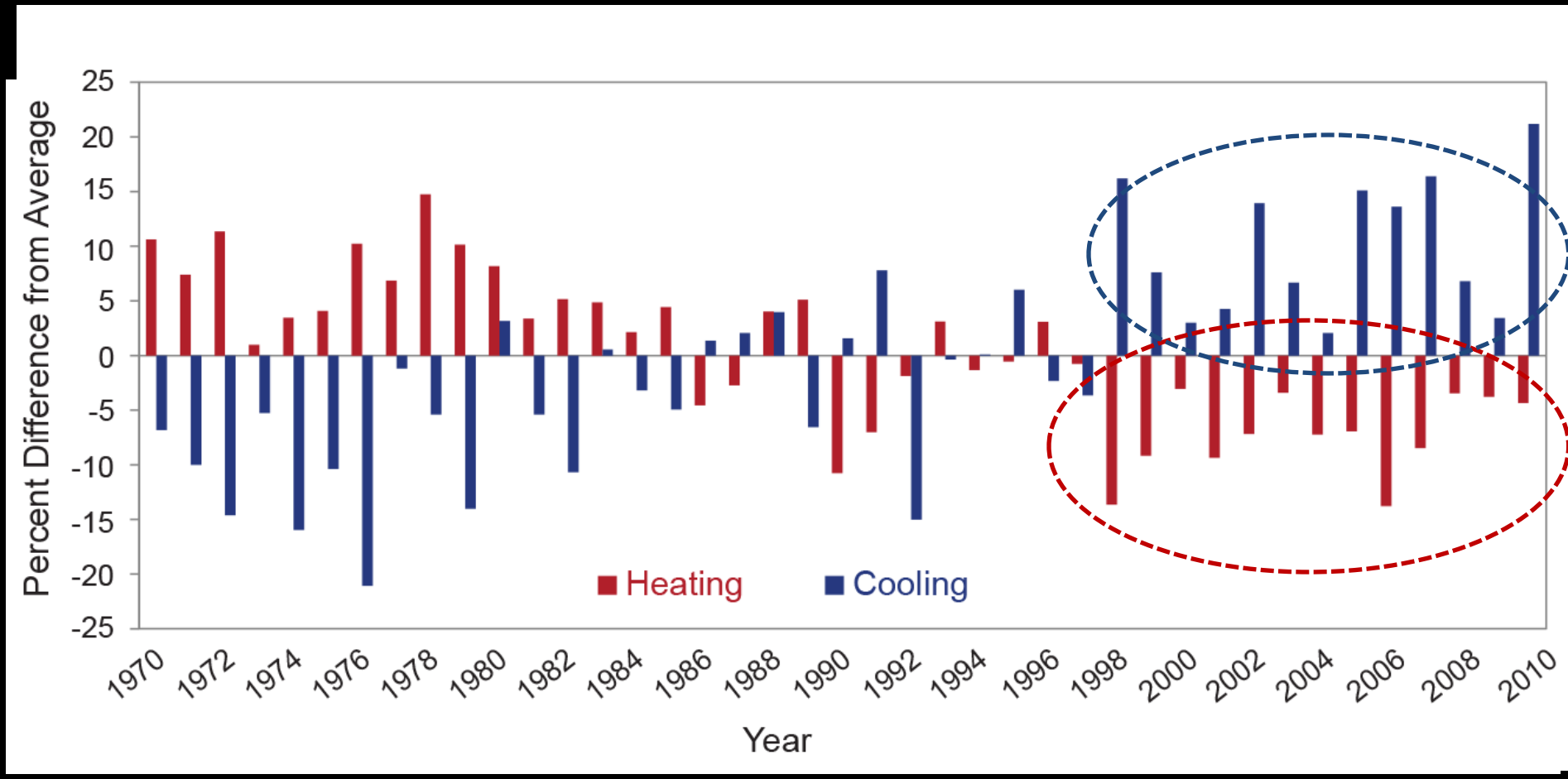


Remarkable statistic—353 consecutive months (through July, 2014) w/global temp. above the 20th Century average.

Change is apparent across the U.S.



Decrease in Heating Demand and Increase in Cooling Demand



Plant hardiness zones are shifting toward the poles as the climate changes

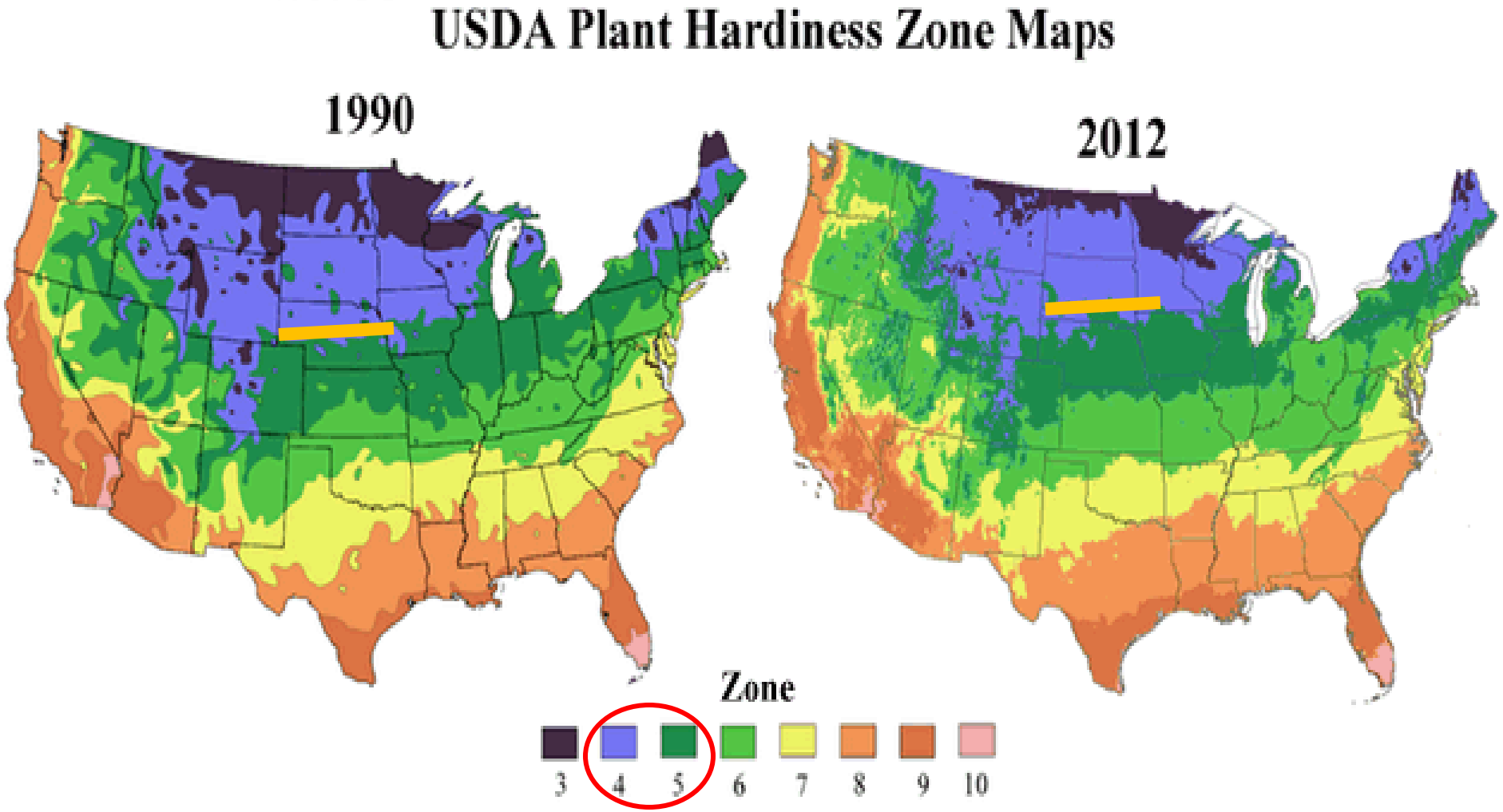
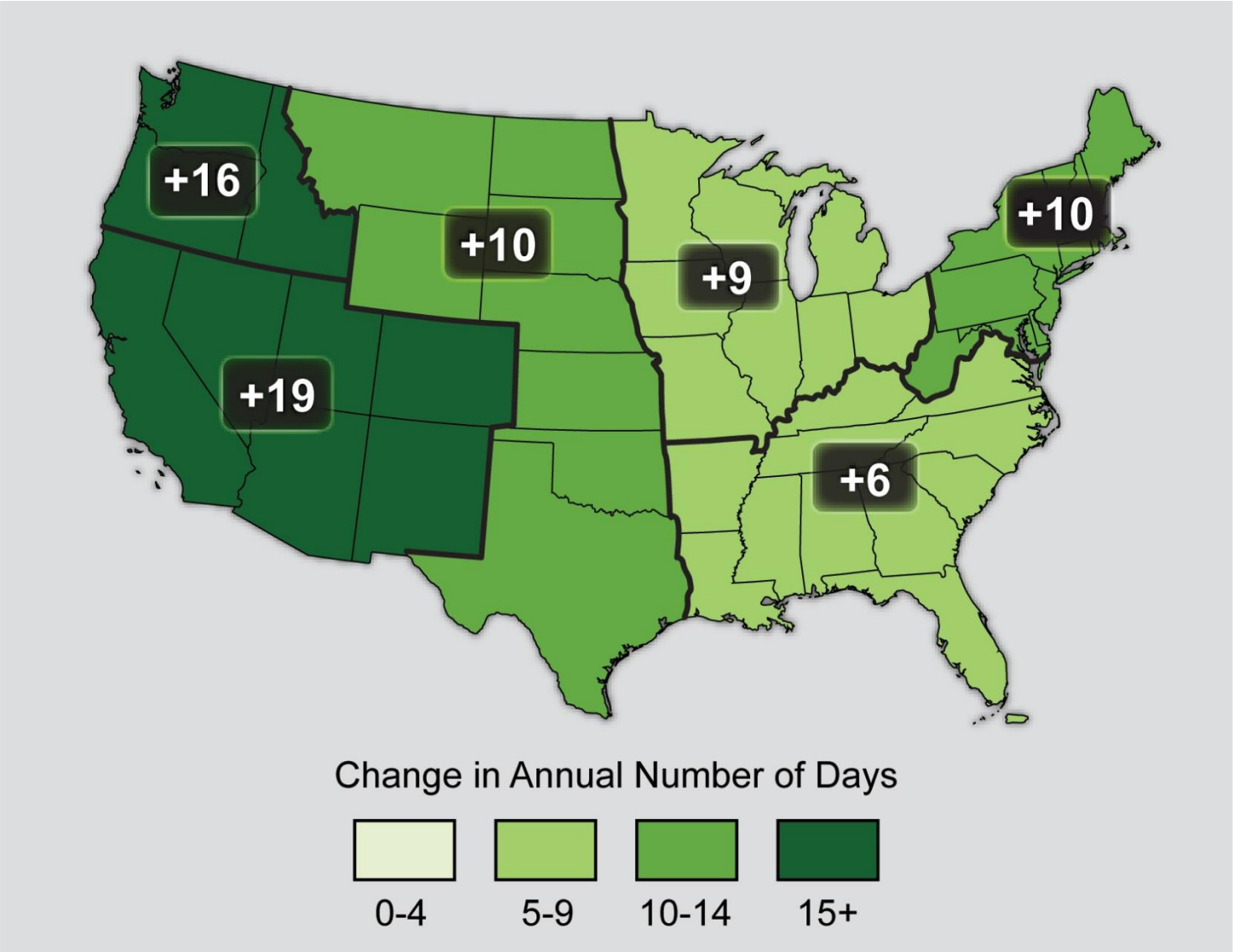
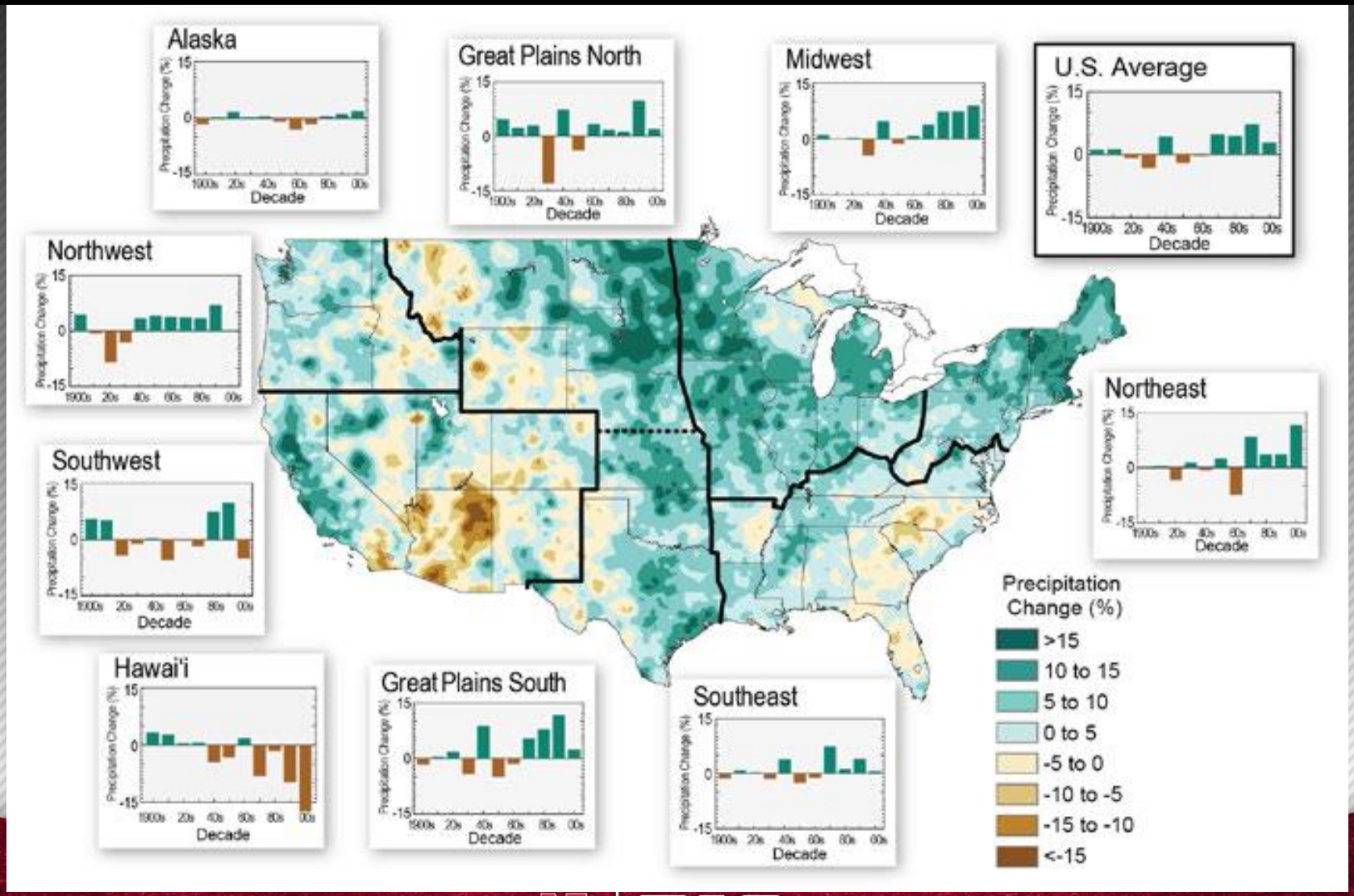


Figure 1. Comparison of the 1990 and 2012 USDA Plant Hardiness Zone Maps. Image credit: USDA and Arbor Day Foundation.

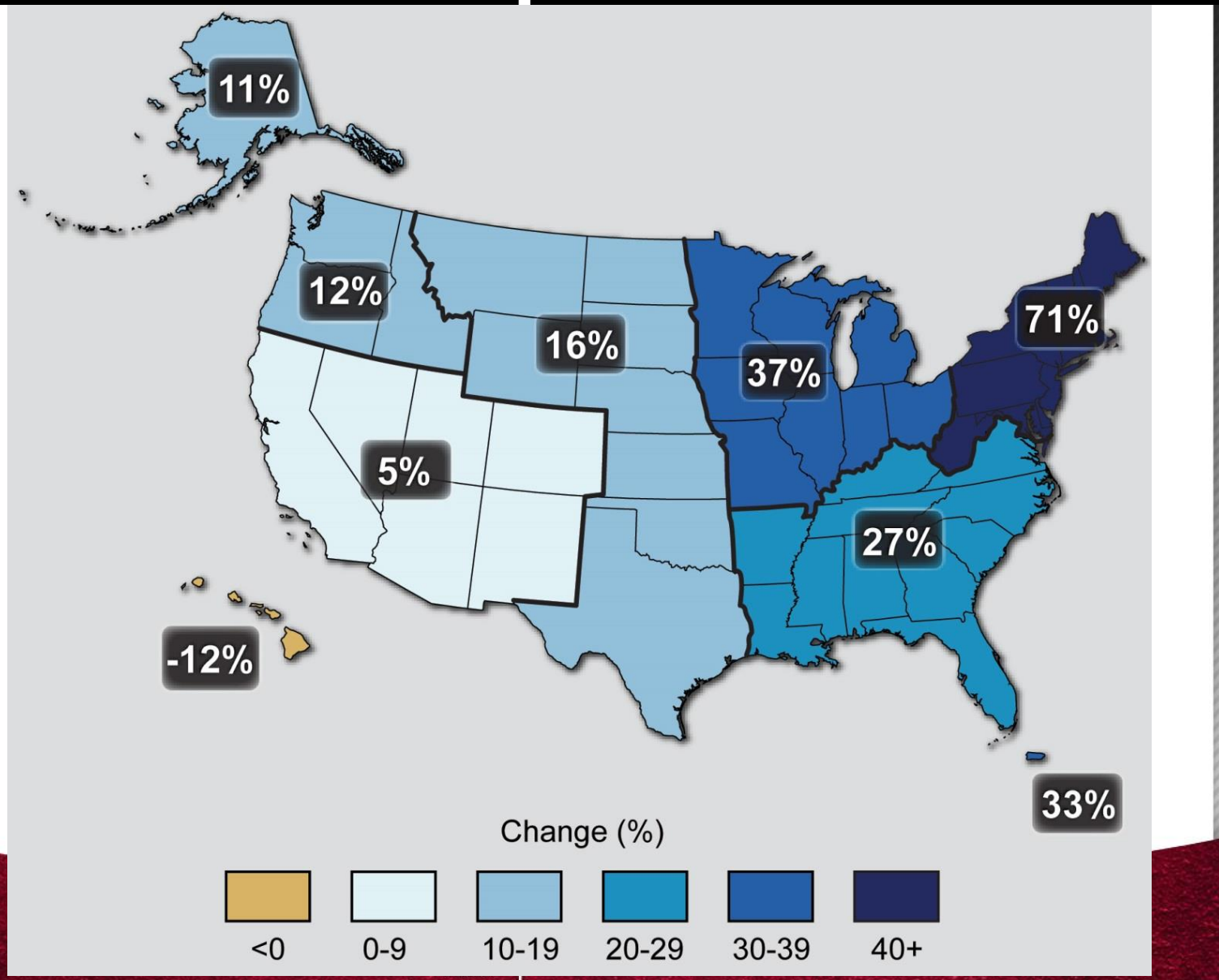
Observed Increases in Frost-Free Season



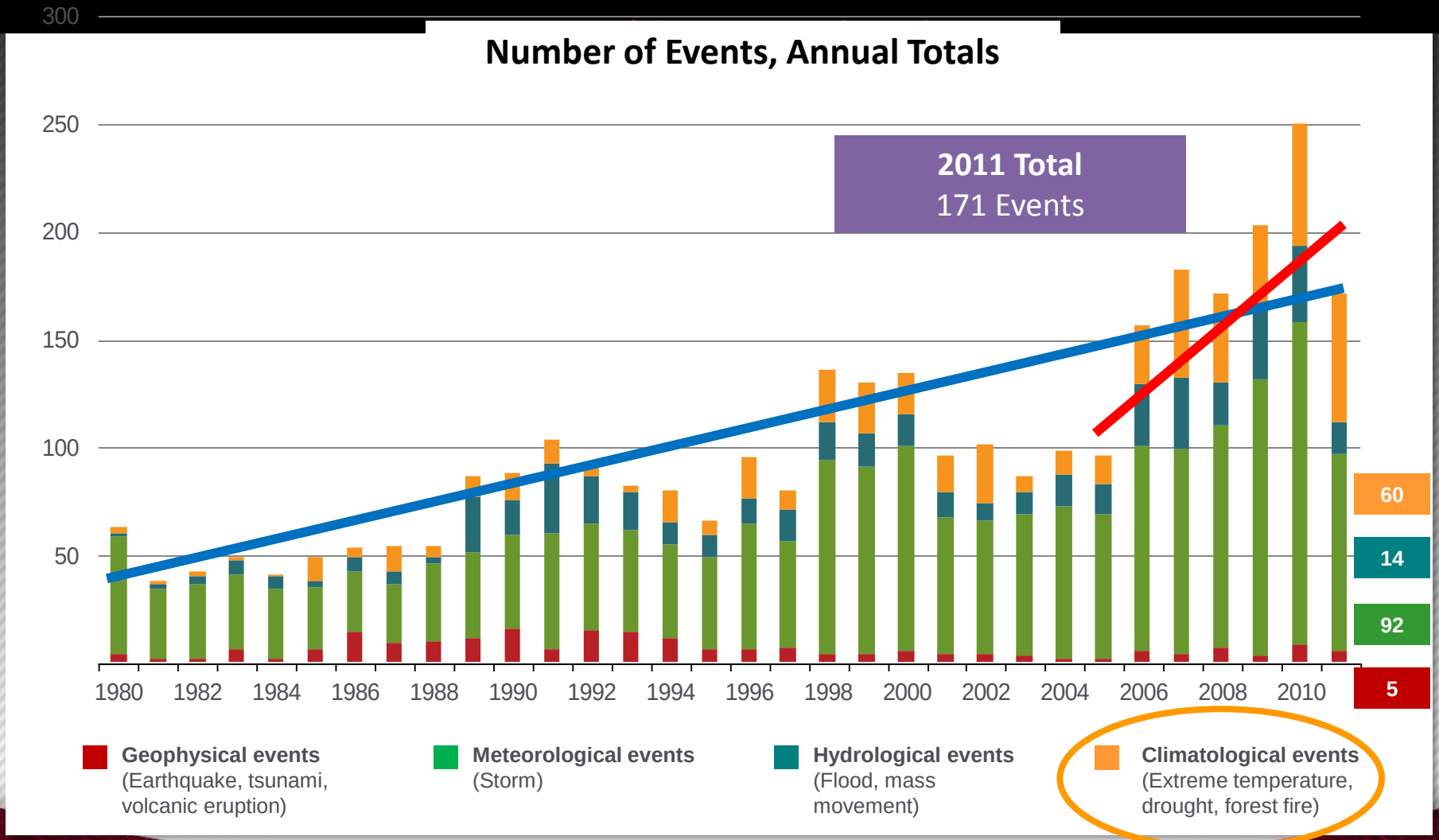
Observed US precipitation change



Observed Change in Very Heavy Precipitation



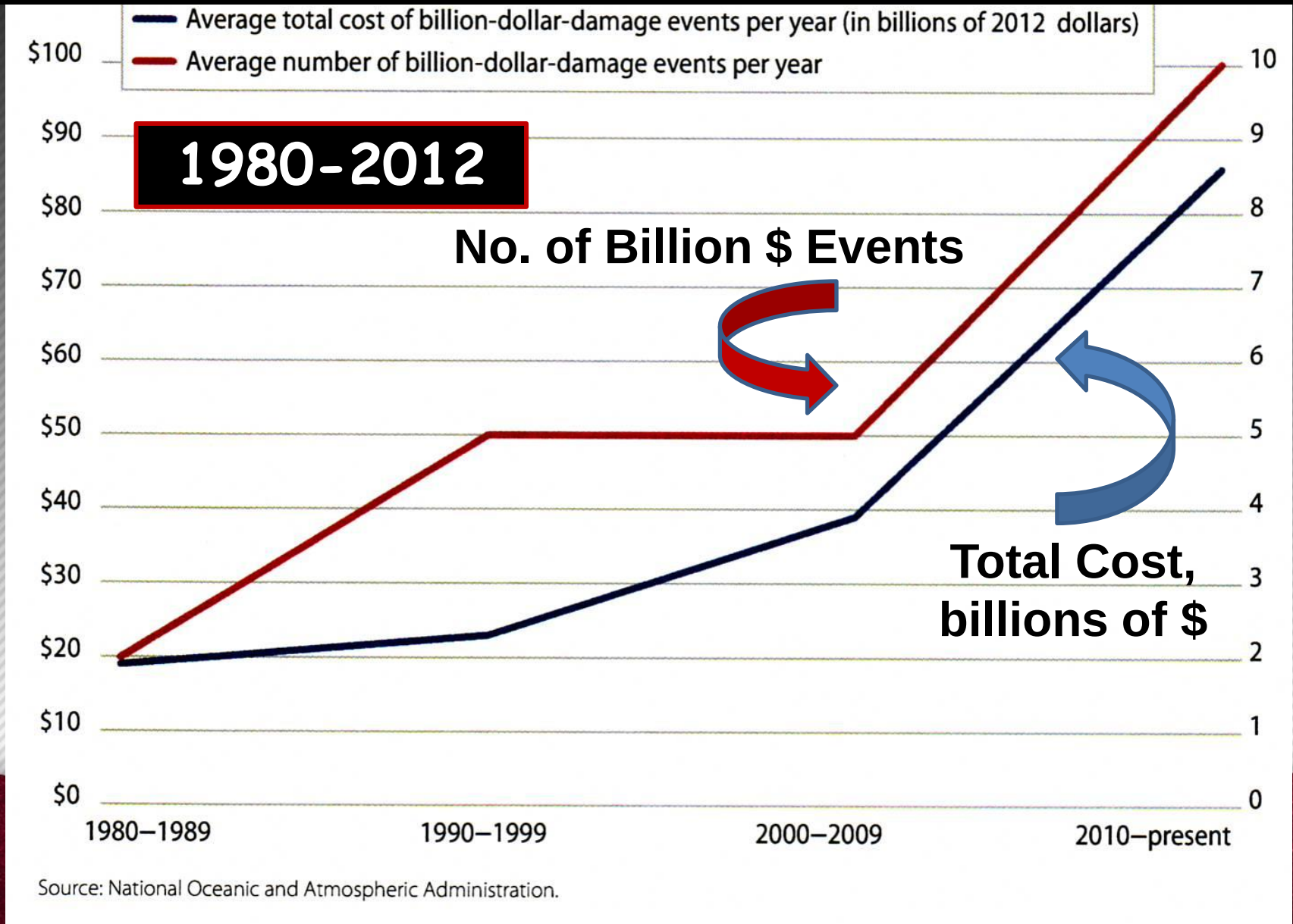
Natural Disasters in the U.S., 1980-2011



Source: MR NatCat*SERVICE*

© 2011 Munich Re

Billions of $$ in damages from extreme weather events—increasing frequency & cost

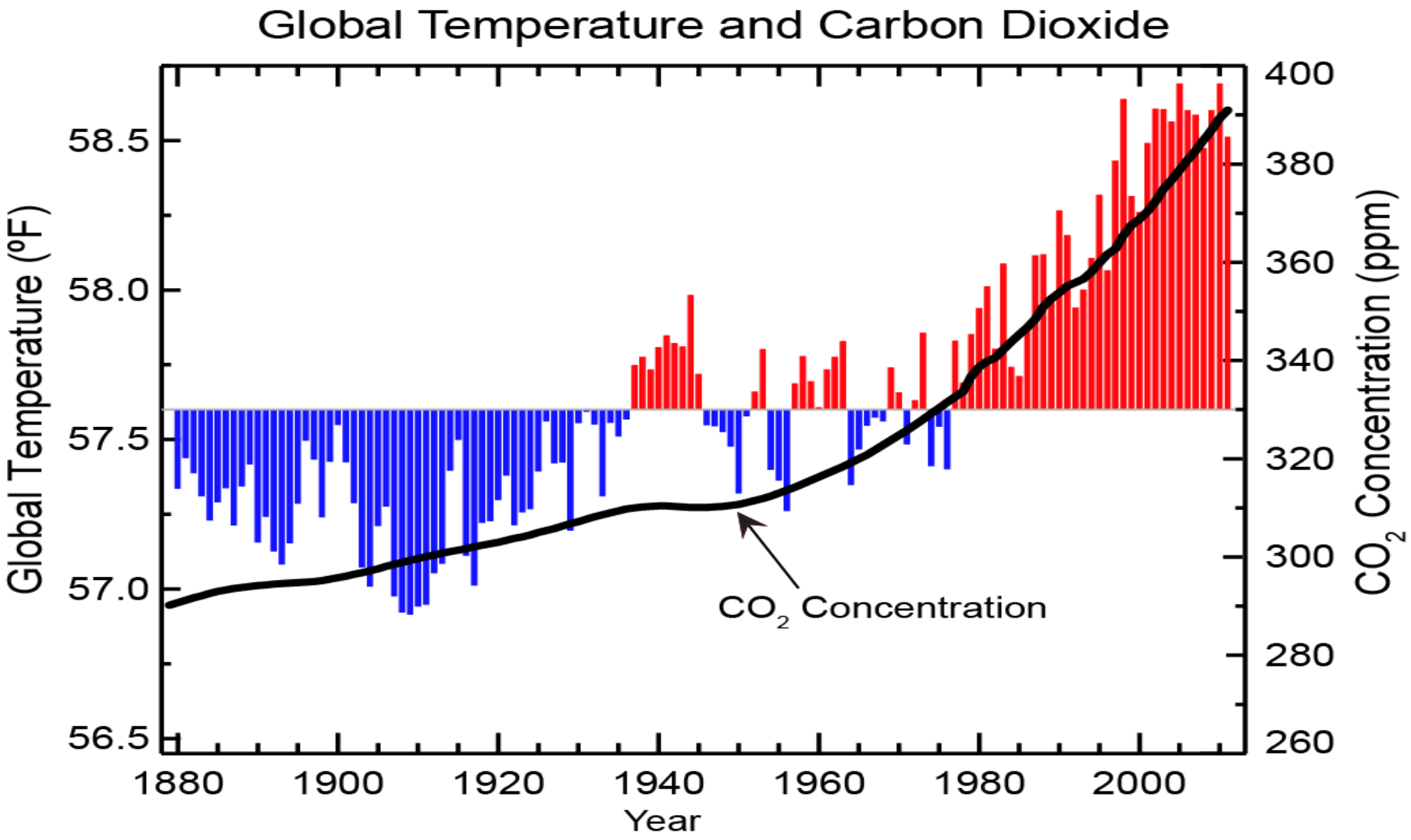


More Evidence of a Changing Climate

If you don't believe the SCIENCE, at least believe the TRENDS.

Part 4: Separating Natural from Human Factors

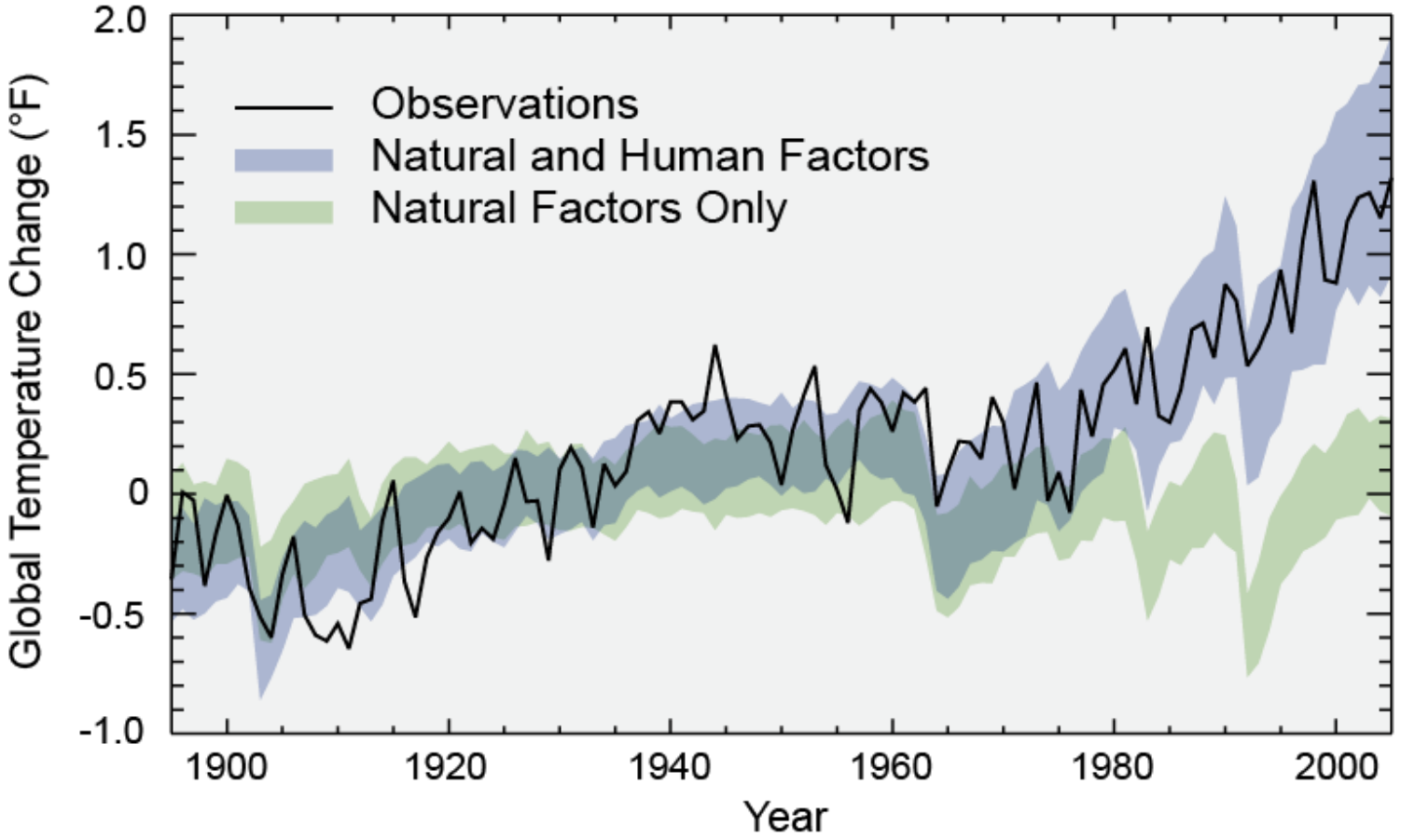
Carbon Dioxide and Human Activity



There is a close correlation between CO_2 and temperature that has been verified through many lines of research . This graph shows the relationship of temperature and CO_2 over the last 130 years.

Separating Human and Natural Influences on Climate

Climate models can capture the observed 20th century temperature change



Estimated contributions to global mean temperature change (°C)

1890-2010

Observations

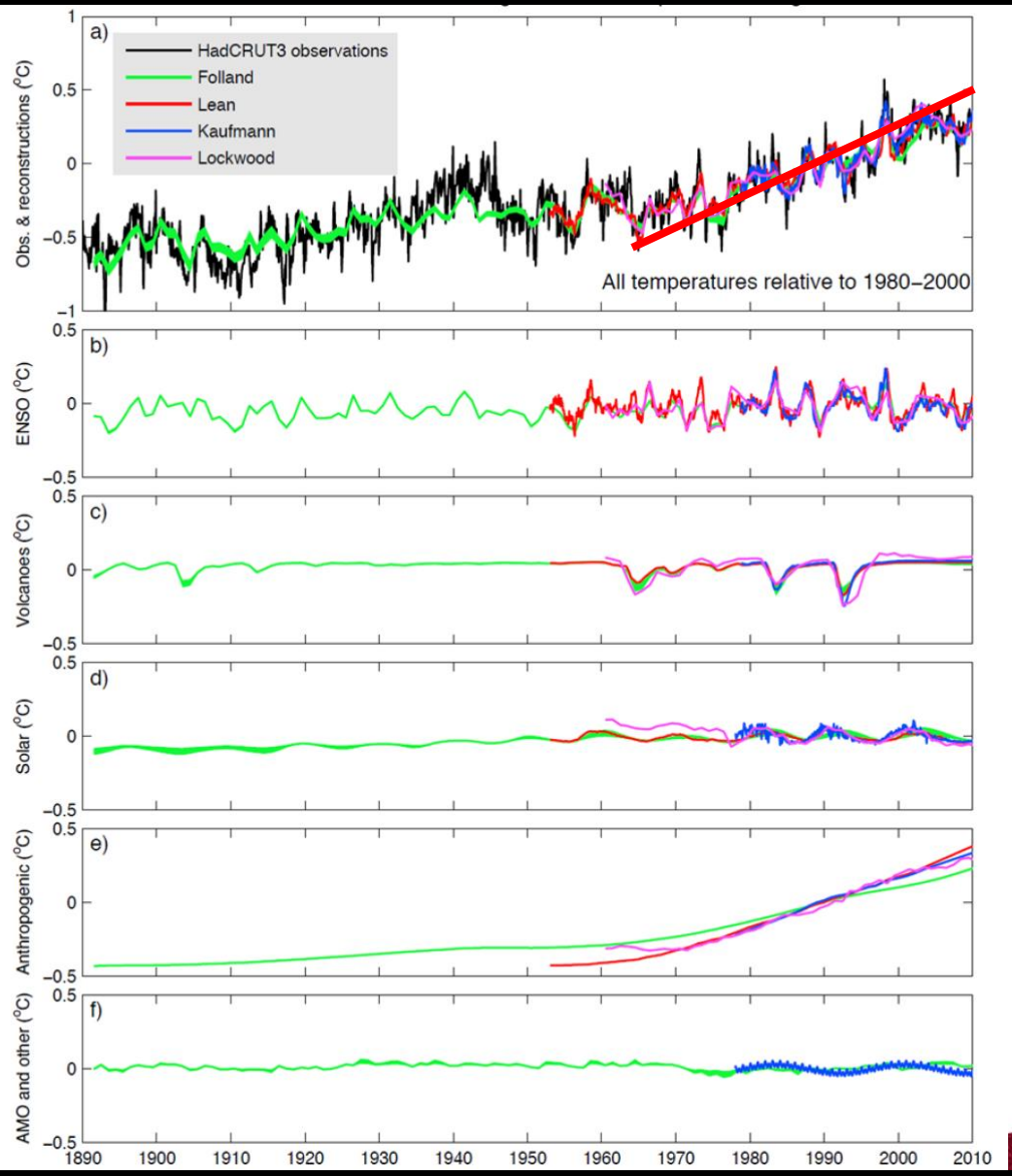
El Niño Southern Oscillation

Volcanoes

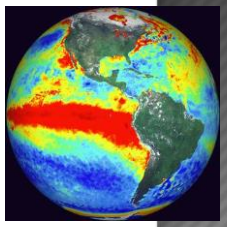
Solar

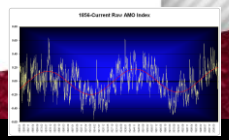
Anthropogenic

Other factors (AMO, SAM, AO)



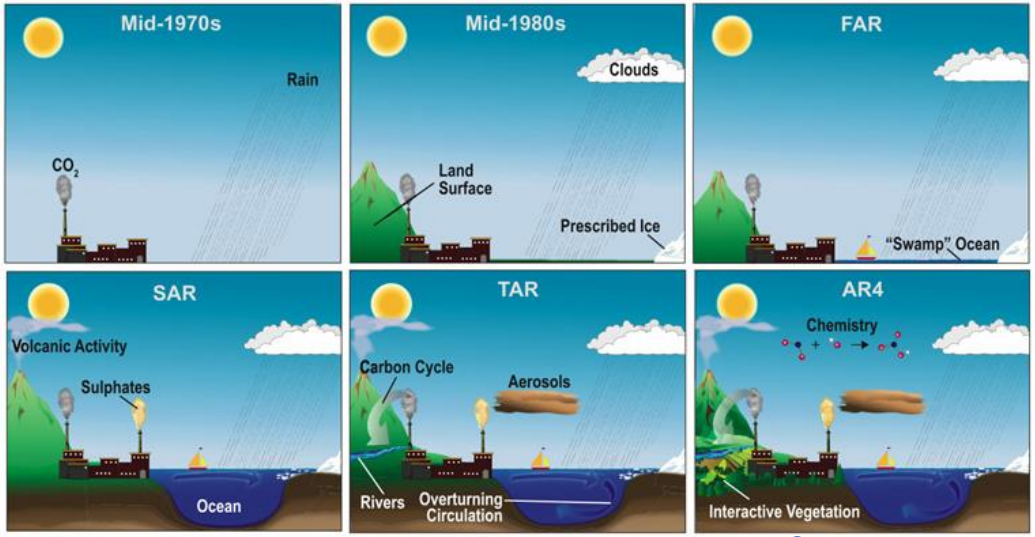
IPCC 2013; WG-I, Fig. 10.6





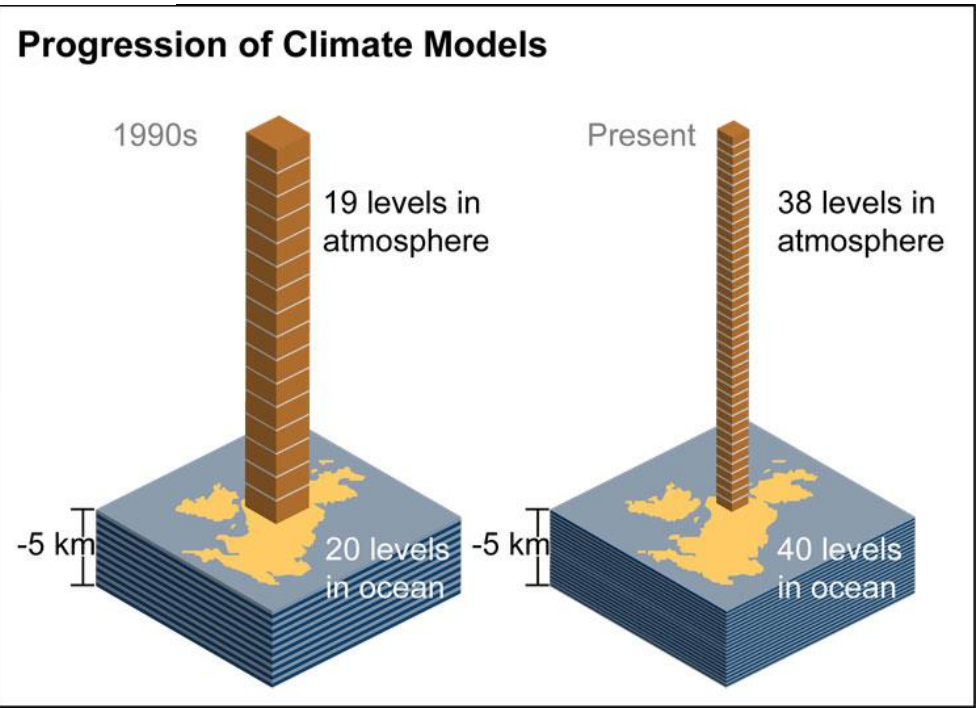
Atlantic Multi-decadal Oscillation (AMO); Southern Annular Mode (SAM); Arctic Oscillation (AO)

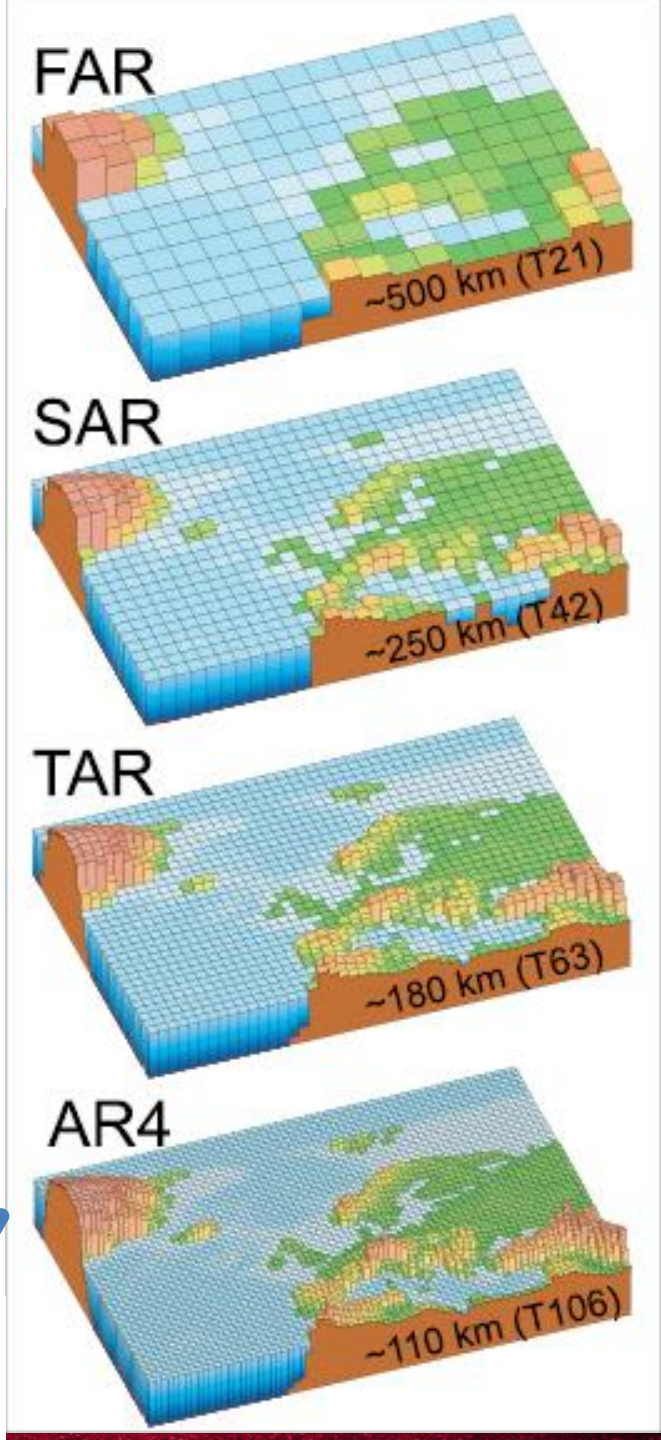
Part 5: Projections of Future Climate: Implications for Nebraska



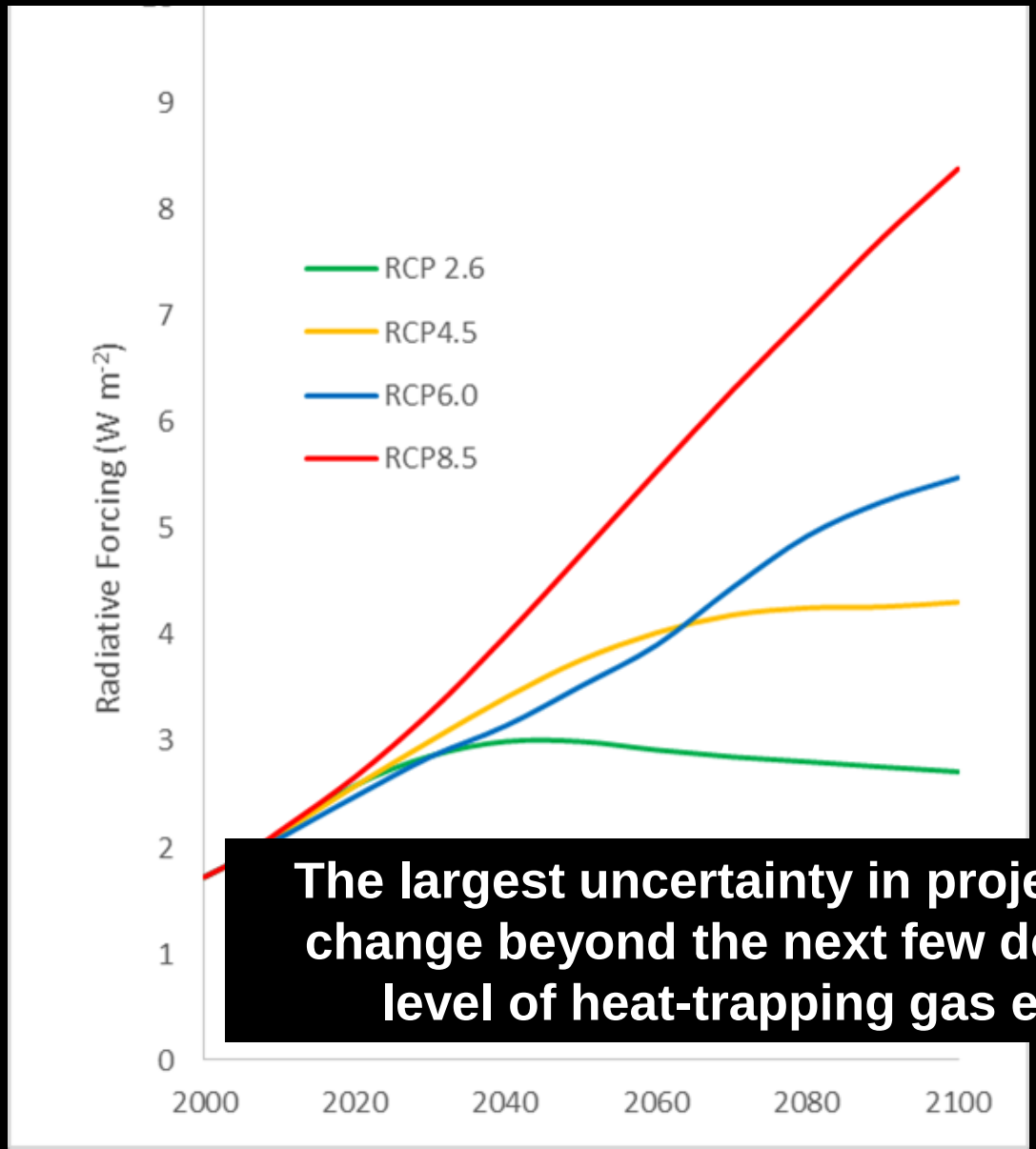
Increasing model complexity

Decreasing grid cell size





Projecting Future GHG Emissions



The largest uncertainty in projecting climate change beyond the next few decades is the level of heat-trapping gas emissions.

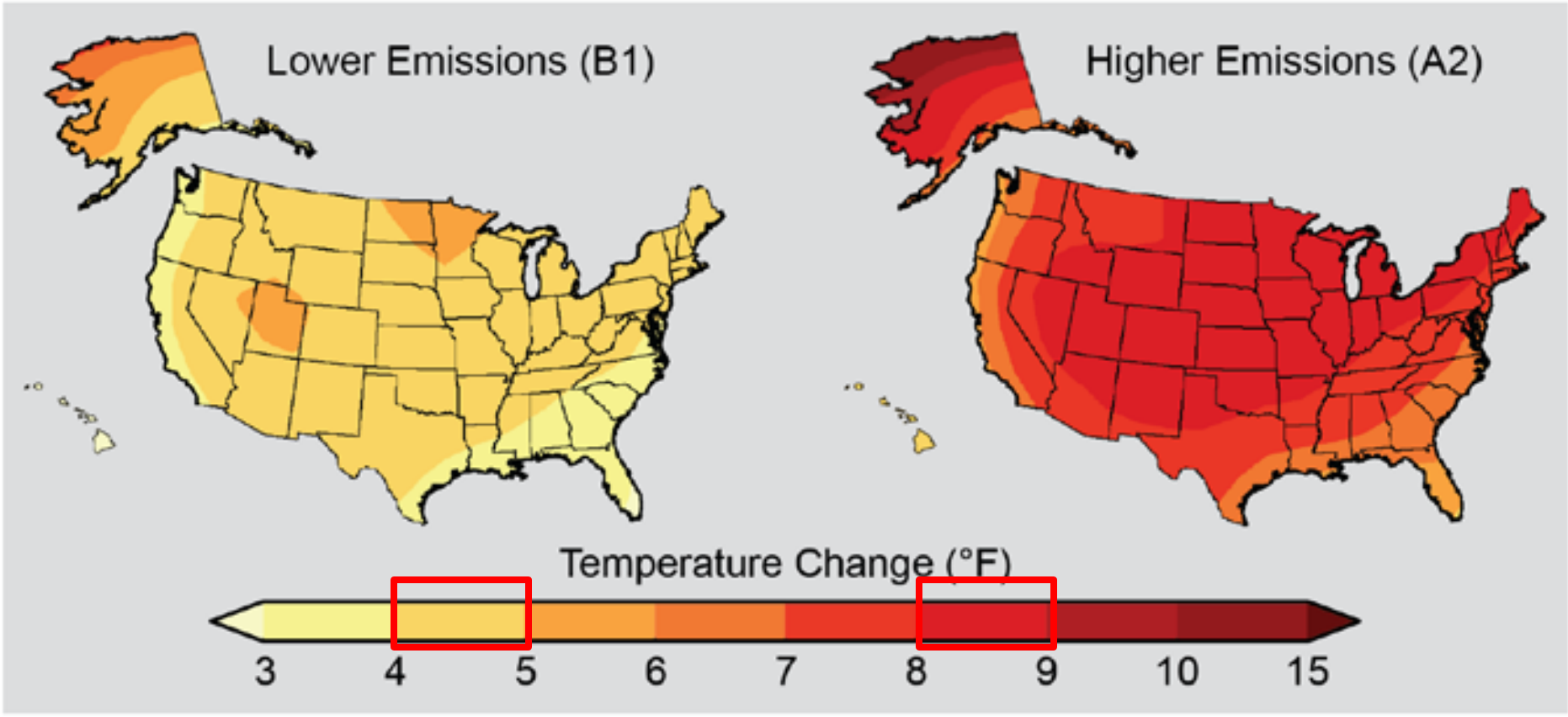
Assessing Changes in Climate and Implications for Nebraska

1. Assessed observed changes in climate
2. Interpreted the projections of the National Climate Assessment Report (May, 2014) for Nebraska
3. Invited Commentaries by Key Sector Experts to interpret the implications of projected changes on their sector
   - Water
   - Agriculture
   - Energy supply and use
   - Forestry
   - Human health
   - Urban systems, infrastructure and vulnerability
   - Rural communities
   - Insurance industry

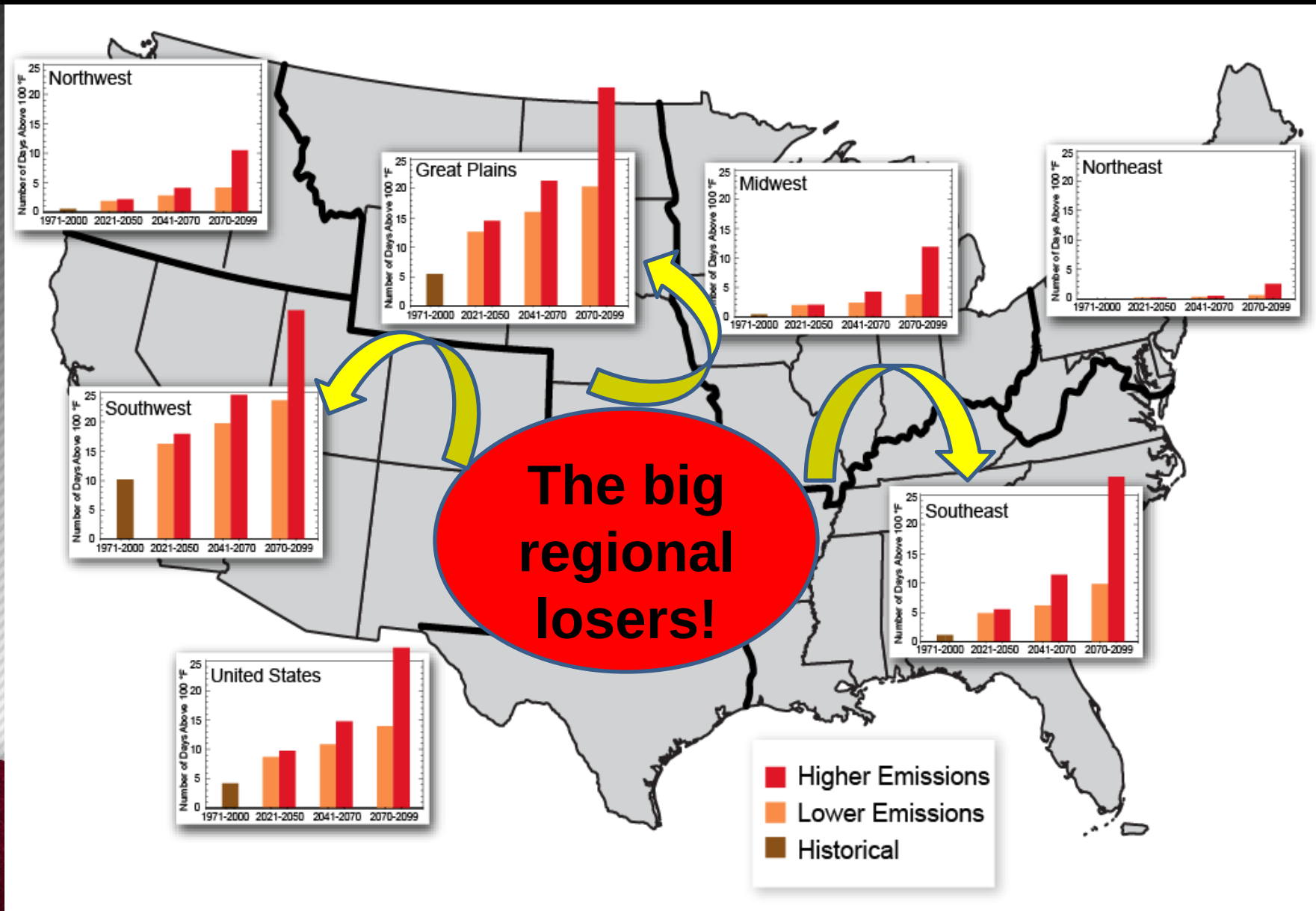
Nebraska Climate Projections

- **Temperature**
  - Increases range from **4-5˚ to 8-9˚F by 2071-2099.** The range is largely due to **uncertainties in future emissions**.
  - Projected high temperature stress days (>100°F), increasing to **13-16 additional days** (lower emissions) to **22-25 additional days** (higher emissions).
  - Number of warm nights increases.
  - Frost-free season continues to increase by an **additional 2 weeks** by the end of the century.

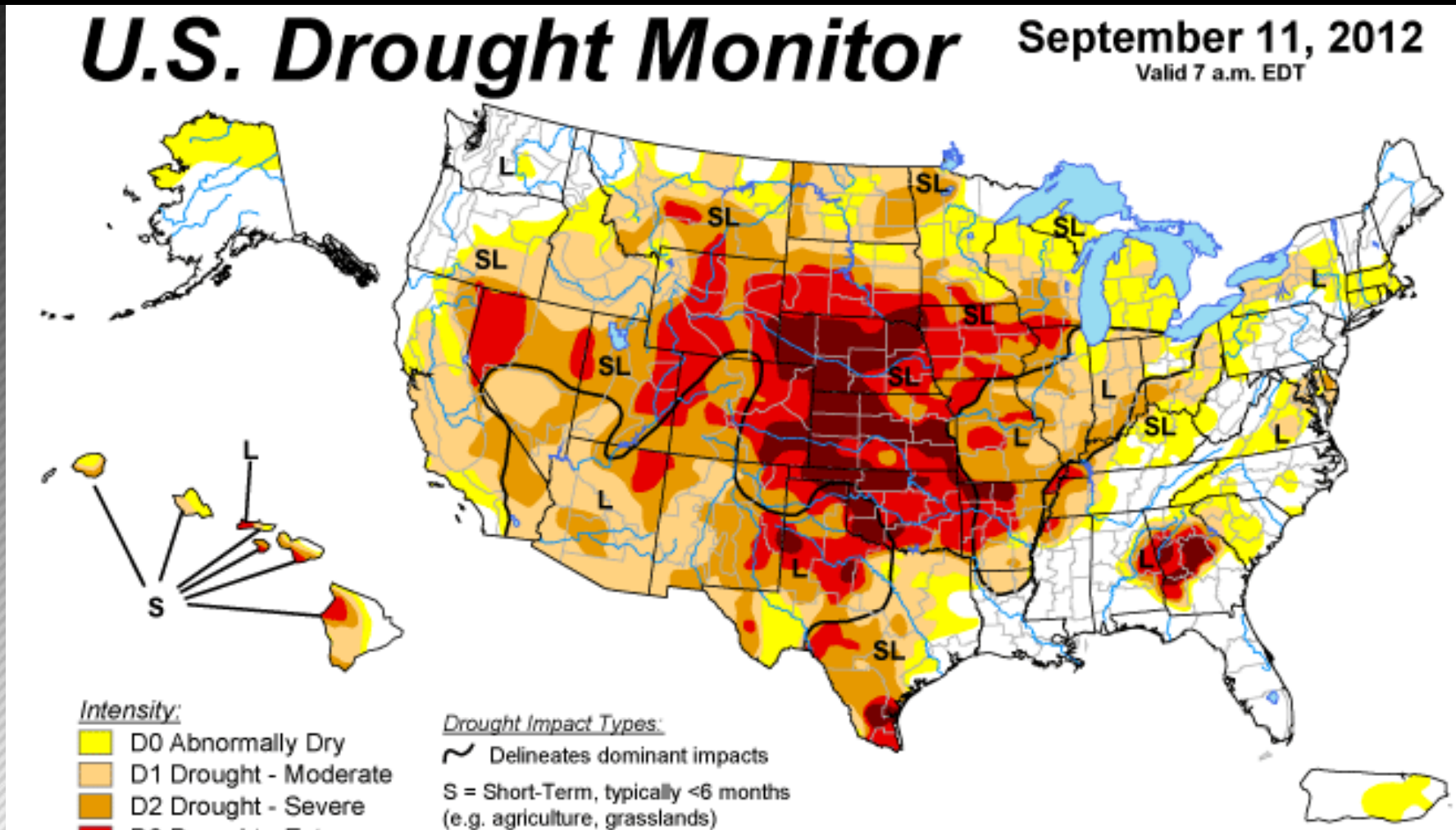
Projected temperature change, 2071-2099



Projected Increase, Number of Days Over 100˚F, 2021-2099, Low and High Emission Scenarios

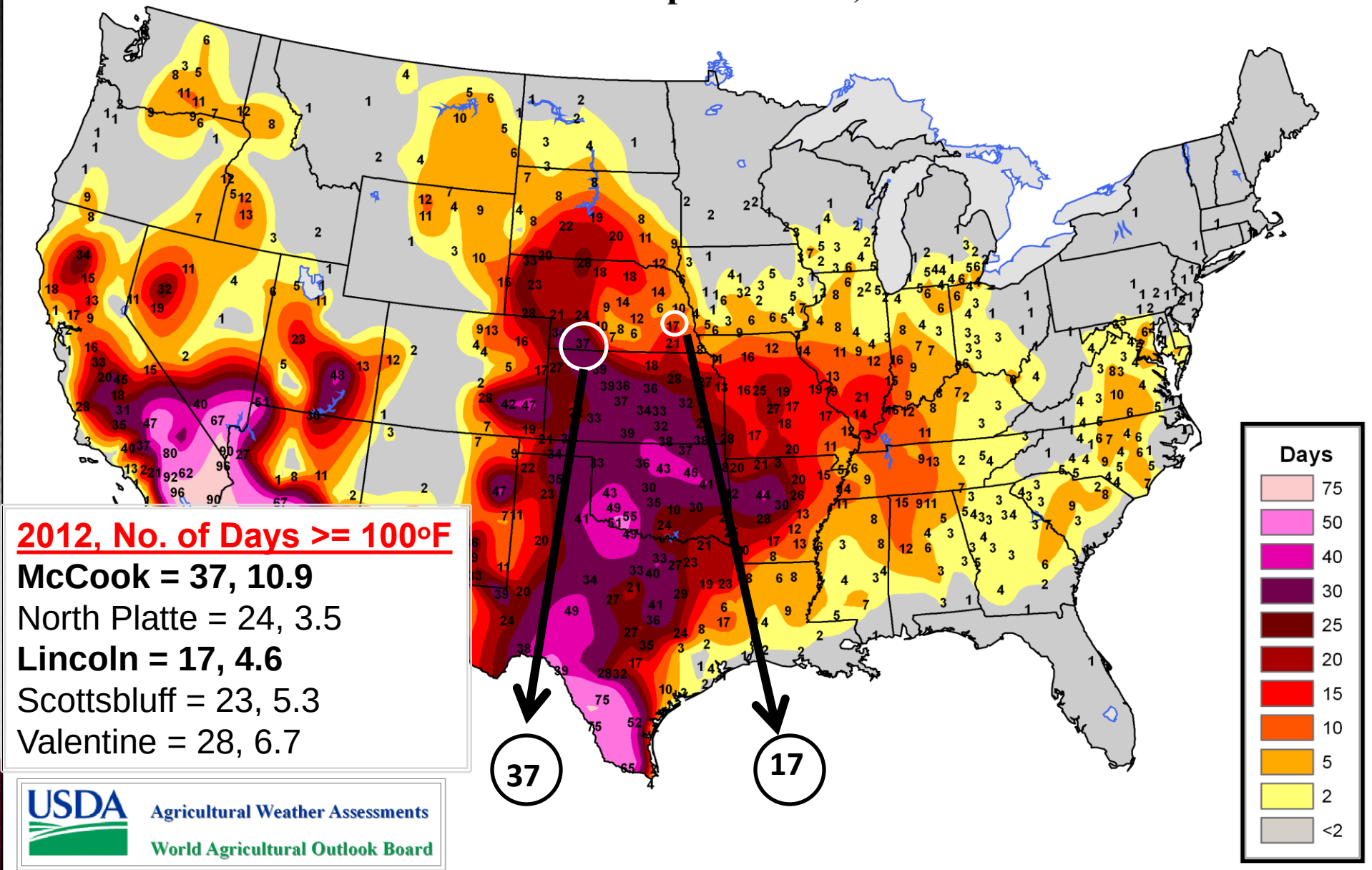


Remember when?



Number of Days >= 100°F

June 1 - September 15, 2012



2012, No. of Days >= 100°F

McCook = 37, 10.9

North Platte = 24, 3.5

Lincoln = 17, 4.6

Scottsbluff = 23, 5.3

Valentine = 28, 6.7

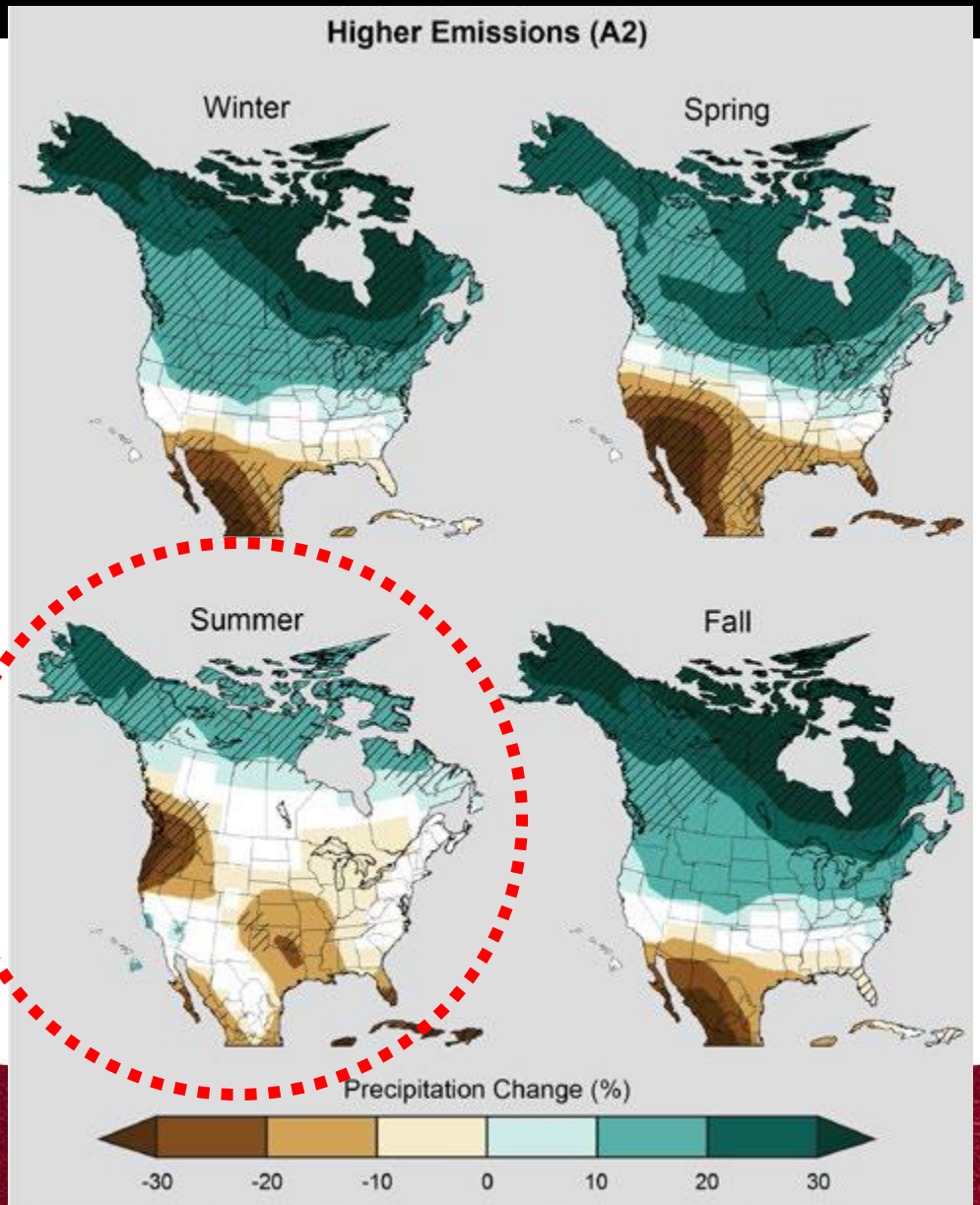
USDA Agricultural Weather Assessments

World Agricultural Outlook Board

Nebraska Climate Projections

- **Precipitation**
  - Trend for increased precipitation in the northern Plains, decrease in southern Plains, to continue.
  - Little change in winter/spring precipitation in NE.
  - Small projected changes in summer and fall with a drying trend in the central Plains in summer.
  - Increase in heavy precipitation events expected to continue for Great Plains states—a 16% increase has been observed for the region.
  - Increased precipitation, if any, will likely be ineffective when temperature increases are factored into the assessment.

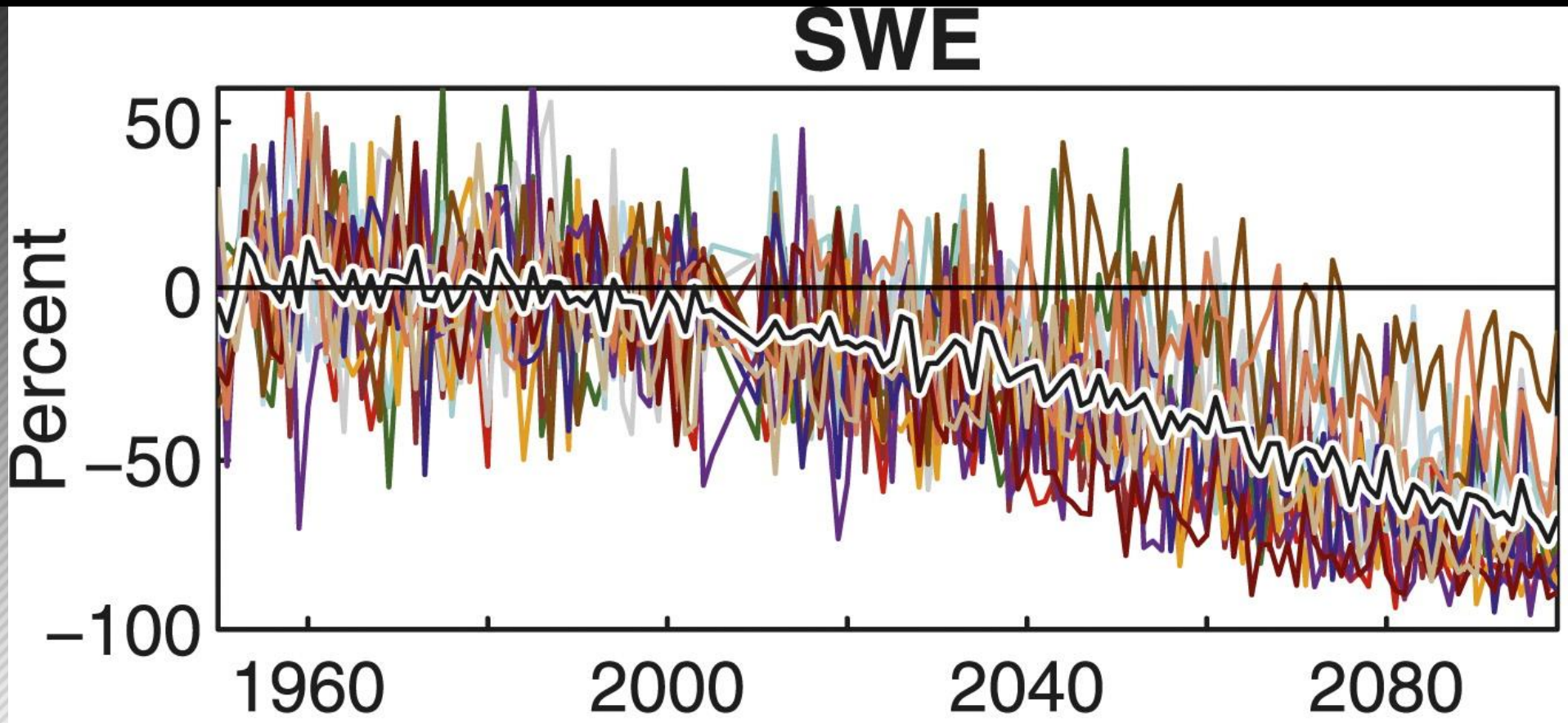
Projected precipitation by season



Nebraska Climate Projections

- **Soil Moisture**
  - Decrease in available soil moisture between 5-10% for Nebraska
- **Flood Magnitude**
  - Flood magnitudes have been increasing in the eastern portions of the Great Plains, reflecting increased heavy rainfall events
- **Snow Cover**
  - Reduced snowpack in the central/northern Rockies → reduced Platte/Missouri river flow

Western Snowpack
April 1 Snow Water Equivalent

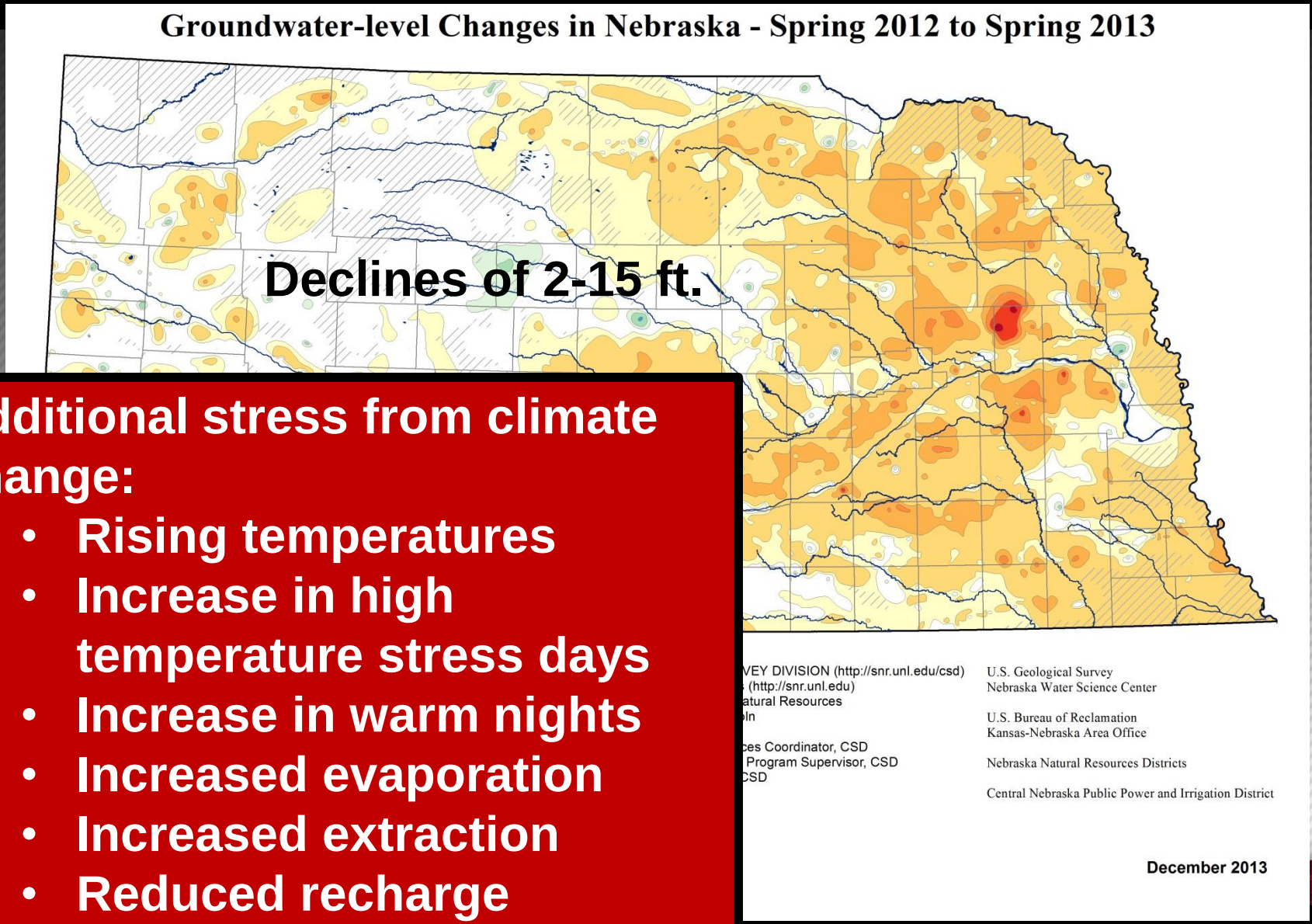


Source: Pierce and Cayan, Journal of Climate, 2013

Nebraska Climate Projections

- **Irrigation/Land Use Changes**
  - Research has demonstrated that large-scale irrigation has kept summer temperatures cooler and wetter.
  - Reduced water availability (higher temperatures, increased atmospheric demand, greater seasonal precipitation variability) and reduced ground water recharge could reduce irrigation potential.

Groundwater Resources



Additional stress from climate change:

- **Rising temperatures**
- **Increase in high temperature stress days**
- **Increase in warm nights**
- **Increased evaporation**
- **Increased extraction**
- **Reduced recharge**

Source: UNL Conservation and Survey Division

Part 6: Takeaway Points, Challenges and Opportunities

Great Plains Region: Key Findings

(NCA Report, 2014)

- **Rising temperatures** are leading to **increased demand** for water and energy. This will constrain development, stress natural resources, and increase competition for water among communities, agriculture, energy production, and ecological needs.
- Changes to **crop growth cycles** due to warming winters and alterations in the timing and magnitude of rainfall events have been observed—**these changes will require new agriculture & livestock management practices**.
- **Landscape fragmentation** is increasing—a highly fragmented landscape will **hinder adaptation of species** when climate change alters habitat composition and timing of plant development cycles.

Great Plains Region: Key Findings

- Communities that are already the most **vulnerable to weather and climate extremes** will be stressed even further by more frequent extreme events occurring within an already highly variable climate system.
- The magnitude of expected changes will exceed those experienced in the last century. **Existing adaptation and planning efforts are inadequate** to respond to these projected impacts.

Nebraska Climate Projections

- **Assessing the impact of projected changes**
  - consequences depends on the sensitivity of key sectors to these changes—can we increase resilience?
  - the ability of sectors to adapt to these changes as they occur;
  - how proactive these sectors are in adapting to change;
  - the availability of ground water to respond to the increased demand for water;
  - mitigation measures adopted to reduce GHG emissions.
- **With slight changes in precipitation amounts projected, increasing temperatures and the number of high temperature stress days will be the critical factor affecting impact and the ability of various sectors to adapt to a changing climate.**

Key Takeaway Messages

- Dramatic changes in climate are being observed from global to local scales; it cannot be stopped, only attenuated. **Rapidity of change**!
- Human activities are the drivers of this change.
- Projections of future changes represent the current state of climate science. **Surprises?**
- The uncertainties associated with future changes are largely due largely to the uncertainties in future GHG emissions—a range of scenarios.
- We must **adapt** to current and projected changes in climate and **mitigate** as much future warming as possible by reducing GHG emissions.

Key Takeaway Messages

- Current and projected changes in temperature will have positive benefits for some; negative consequences for others. **Winners and Losers!**
- Early adapters will be better able to cope with changes.
- Changes in the frequency/severity of extreme events will continue, resulting in escalating social, economic and environmental costs.
- Imbedded in all **challenges** are **opportunities** to improve the **resilience** of sectors to climate change.
- **Action** *now* is more cost-effective than **reaction** *later*.

Thanks for your attention!
Get engaged in the conversation!

Questions?

The report is available on line at
http://go.unl.edu/climatechange