COLORADO WATER CENTER

Climate Smart Agriculture Online Courses

Brad Udall

NPCH AgroClimate Outreach Exchange March 25 - 26, 2019
CSU Lory Student Center

COLORADO STATE UNIVERSITY

Extension Listening Sessions

- 3 Listening Sessions
  - Pueblo, Akron, Adams County
  - Total of ~ 30 Agents
- Findings
  - Producers and Agents aware of climatic changes
  - Great reluctance to tie these changes to human actions
  - Support for CSU Climate-Smart Ag Initiative
  - Agents want more information
  - Agents do not want to have to lead

Climate Smart Ag Online Courses

- Target: Extension Agents and Producers
- Format: Short Mini-courses
- Topics
  - Colorado's Climate – Doesken, et al.
  - Climate Change Basics - Denning
  - Climate Change and the Water Cycle – Udall
  - Agriculture Impacts and Adaptation - Udall
  - Climate Change Myths – Udall
  - Agricultural GHG Mitigation – Paustian
- Late Spring 2019 Rollout

Ag Best Management Practices Compilation

- CSU Professor Jim Ippolito lead
- Compiling list of BMPs for Ag
  - Ranching – Casey Shawver
  - Field Crops – Dustin Diaz
- Rollout
  - Summer 2019

Climate Smart Ag Course Format

- Course composed of 5-12 ‘modules’ or ‘weeks’
- Each Module
  - Video Lecture (5-10 minutes)
  - Reading(s) (30-45 minutes)
  - Possible Quiz
  - Total Time each Module under 1 hour
- End of Course Exam
  - ~20 Questions

Climate Change Basics - Denning

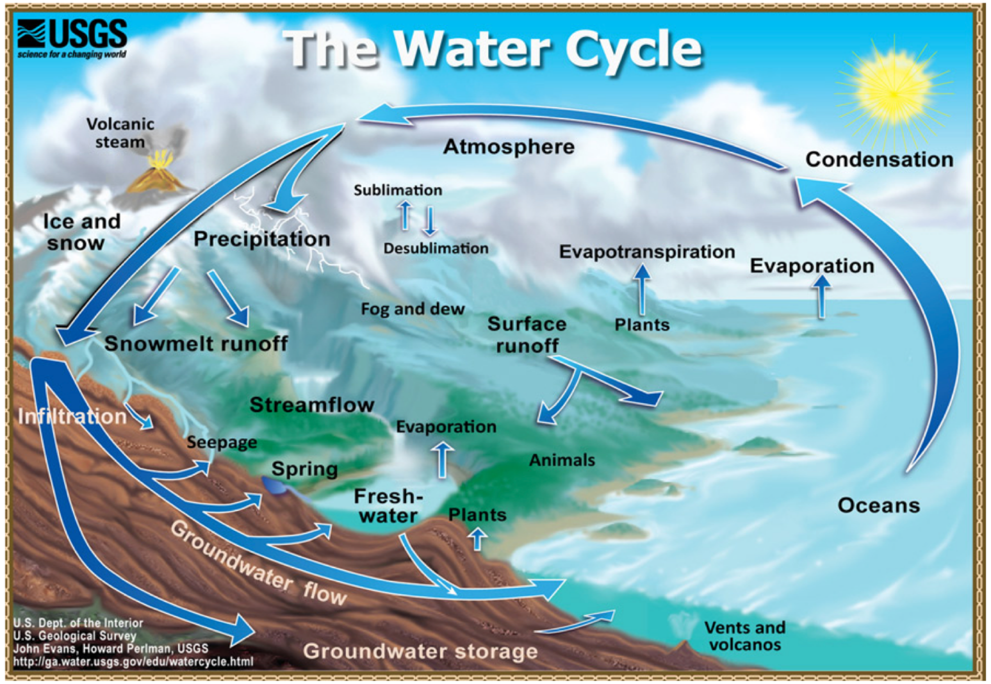
- **Heat In, Heat Out**
- **Heating and Cooling the Earth**
- **The Greenhouse Effect**
- **Climates Past and Future**
- **How Much Warmer?**
- **Water Supply and Demand**
- **Wildfire**
- **The Big Challenge**
- **Solutions**
- **Costs**

Colorado’s Climate – Doesken, Bollinger, Goble

- Intro to the Colorado Climate Center
- Climate Data
- The Role of Mountains in Weather and Climate
- Seasons and Other Cycles
- Climate Variability
- Extreme Events
- Observed Trends

Climate Change and the Water Cycle Modules

1. Course Intro (and Introduction to Climate Smart Agriculture)
2. Introduction to the Water Cycle
3. Changes in Historical Air Temperature
4. Changes in Historical Precipitation
5. Projected Temperature and Precipitation Trends
6. Changes in Water Demands
7. Changes in Snowpack Amounts and Runoff Timing
8. River Basin Flow Projections
9. Changes in Water Quality
10. Changes in Floods and Droughts
11. Changes in Water Management
12. Wrap Up



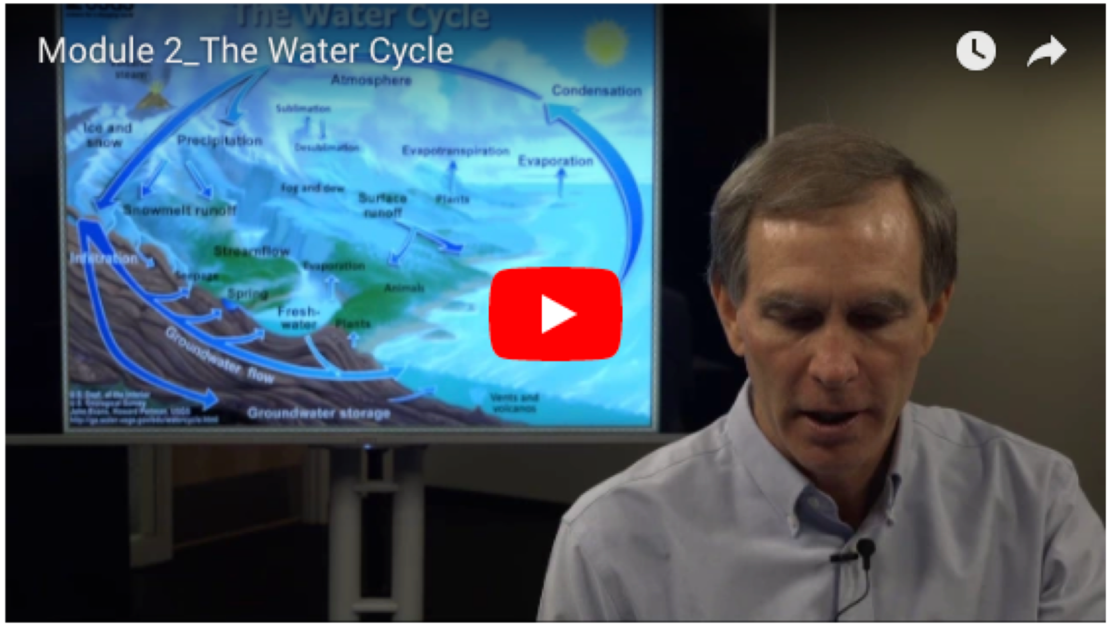
M2 Water Cycle and Climate Change

The Water Cycle

Overview

The Earth's water, or hydrologic, cycle is critical for all life. It is driven by heat, and thus as the Earth warms, it will change in significant ways. On a global scale, as the atmosphere warms, we will get more rain and less snow, more evaporation and precipitation but with regional winners and losers, earlier snowmelt and runoff, and fewer days with precipitation.

Lecture: The Water Cycle [01:33]



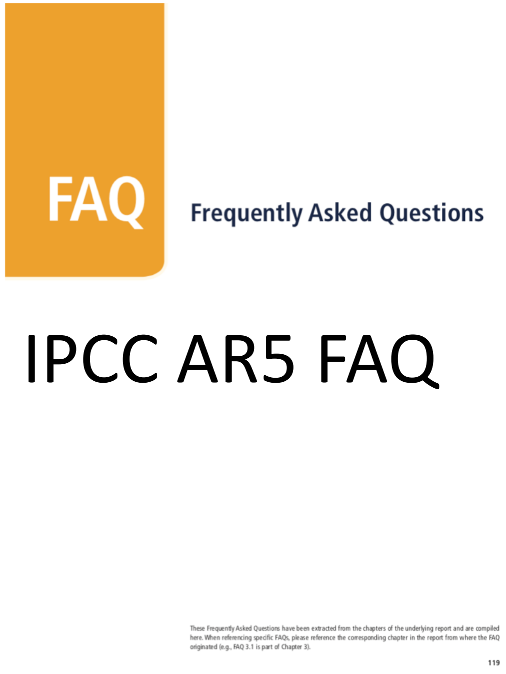
Watch the video on YouTube: https://youtu.be/D83onC5SLxo

Myths Course

- Learning Objectives
  - **Expose some of the common myths about human-caused climate change**
  - **Provide guidance on where to find trusted information**
  - **Understand the overwhelming scientific consensus on climate change**
  - **Explain often misunderstood climate system basics**
  - **Understand how climate models have performed over time**

Myths – Sources

- IPCC 5th Assessment FAQ
- NCA3 + NCA4 FAQ
- NCA4 CSSR
- Skeptical Science Website + Videos
- Hayhoe Global Weirding Videos
- Other Videos
  - NCAR
  - Jennifer Francis
  - Seasons explained
- Realclimate.org
- Peer-reviewed Articles
  - 1970s Ice Age BAMS
  - Cook et al on the Consensus of the Consensus
- Popular Press Articles

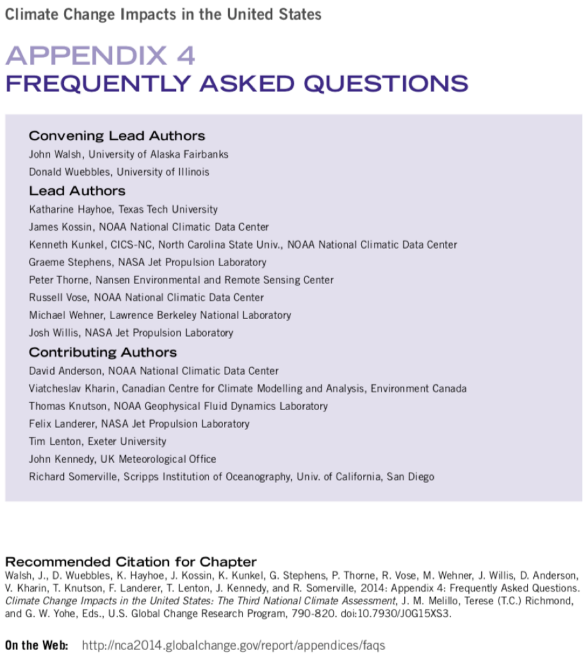

FAQ Frequently Asked Questions

These Frequently Asked Questions have been extracted from the chapters of the underlying report and are compiled here. When referencing specific FAQs, please reference the corresponding chapter in the report from where the FAQ originated (e.g., FAQ 3.1 is part of Chapter 3).

119

IPCC AR5 FAQ

NCA4 2018 – FAQ + CSSR


Climate Change Impacts in the United States

APPENDIX 4
FREQUENTLY ASKED QUESTIONS

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On the Web: http://nca2014.globalchange.gov/report/appendices/faqs

NCA3 2014 - FAQ

Modules – 3 Kinds of Myths

Fundamental Myths

- **Climate always changes**
- **Climate is changing, but how are humans influencing the climate?**
- **Climate extremes are nothing new**
- **There's no consensus**

But…Myths

- **But it is cold**
- **But what about the sun?**
- **But no warming since 1998**
- **But they said in the 1970s that we were about to enter an ice age**
- **But it was warmer in the 1930s**
- **But isn't Antarctica gaining ice?**
- **But we can't model the weather**
- **But GHG's are so tiny**
- **But the satellites say something else**
- **But urban areas corrupt the data**
- **But it is only CO2**

Non-Science Myths

- **What about positive benefits?**
- **It will cost too much to fix**
- **They changed the name**
- **I dislike Al Gore**
- **What about China and India?**

The climate has always changed. What do you conclude?

Filed under: Climate Science Communicating Climate Paleoclimate skeptics — stefan @ 20 July 2017

Probably everyone has heard this argument, presented as objection against the findings of climate scientists on global warming: *"The climate has always changed!"* And it is true: climate has changed even before humans began to burn fossil fuels. So what can we conclude from that?

A quick quiz

Do you conclude…

(1) that humans cannot change the climate?

(2) that we do not know whether humans are to blame for global warming?

(3) that global warming will not have any severe consequences?

(4) that we cannot stop global warming?

The answer

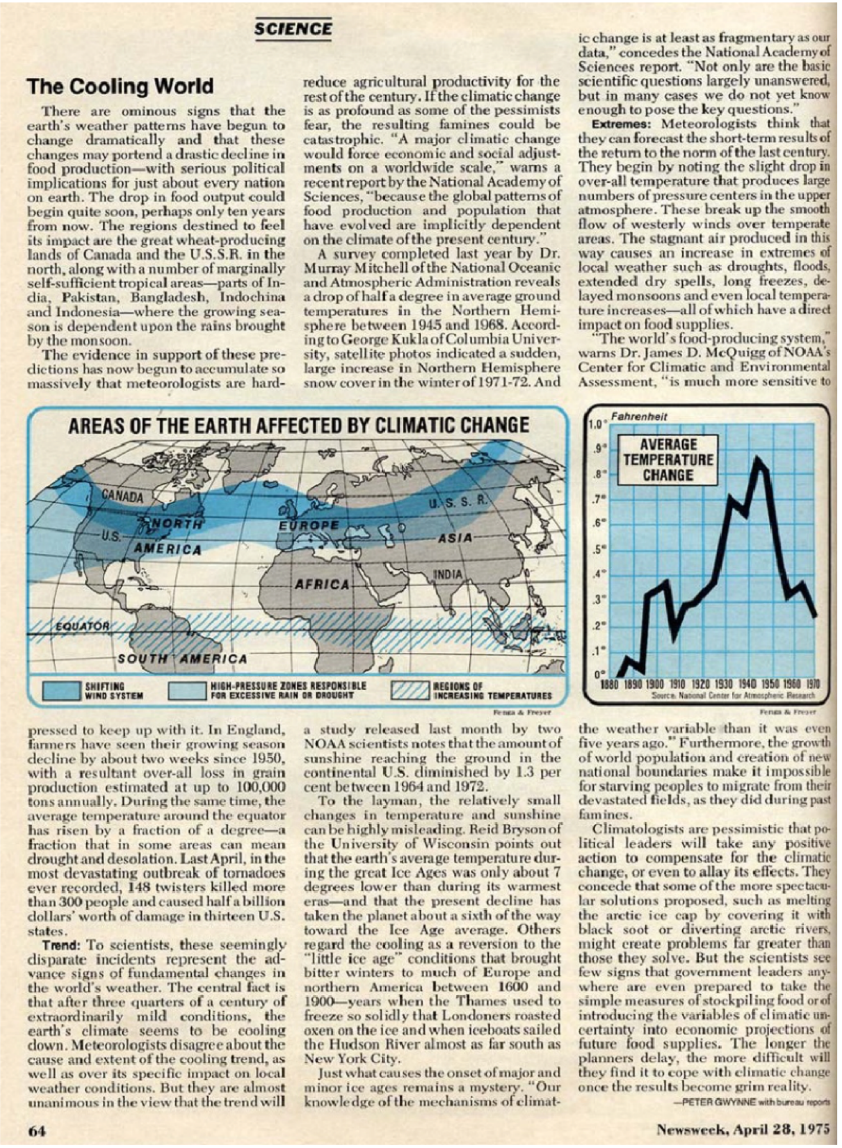
Not one of these answers is correct. None of these conclusions would be logical. Why not?

(2) Imagine there has been a forest fire. The police have extensive evidence that it was arson. They know the place where the fire began. They found traces of fire accelerants. Witnesses observed a man whose car was parked nearby. In his trunk the police finds bottles with fire accelerants, and in his house they find even more of it. He has been convicted for arson several times before. Plus some further evidence. In court, he defends himself: forest fires have always occurred lit by lightning, even before there was any man on Earth. Therefore he must be innocent. Does the argument convince you?

The evidence for the human cause of global warming is overwhelming. This is why there has been a consensus among climate researchers for a long time, and almost every scientific academy on the planet has come to the same conclusion. The most important evidence: when it gets warmer, the energy has to come from somewhere (1st law of thermodynamics). It can only come through the radiation budget of our planet. (No, Rick Perry, the energy does not come out of the ocean. To the contrary, measurements show heat is going into the oceans). The changes in this energy balance are quite well known and are shown near the front of any IPCC report – see Fig. 1. The biggest factor is the increase in CO2 concentration as well as a few other greenhouse gases, also added by human activities. The incoming solar radiation has changed just a tiny bit in comparison – since 1950, by the way, it has even decreased and thus offset a small part of the human-caused warming – hence humans have probably caused more warming than is observed (best estimate is 110% of observed warming).

But they said in the 1970s that we were about to enter an ice age

- Reading
  - Original 1975 Newsweek Article
  - 2014 Article by the Original Author
  - BAMS 2008 Literature Search Article
- Optional Reading
  - Recent Scientific American article on the original article
  - Real Climate Post by Connolley and Fleck
  - Mercer Nature paper on ‘Threat of a Disaster’
  - Broecker 1975 Article on Global Warming
  - 1979 NAS Charney Report



SCIENCE

The Cooling World

There are ominous signs that the earth's weather patterns have begun to change dramatically and that these changes may portend a drastic decline in food production—with serious political implications for just about every nation on earth. The drop in food output could begin quite soon, perhaps only ten years from now. The regions destined to feel its impact are the great wheat-producing lands of Canada and the U.S.S.R. in the north, along with a number of marginally self-sufficient tropical areas—parts of India, Pakistan, Bangladesh, Indochina and Indonesia—where the growing season is dependent upon the rains brought by the monsoon.

The evidence in support of these predictions has now begun to accumulate so massively that meteorologists are hard-pressed to keep up with it. In England, farmers have seen their growing season decline by about two weeks since 1950, with a resultant over-all loss in grain production estimated at up to 100,000 tons annually. During the same time, the average temperature around the equator has risen by a fraction of a degree—a fraction that in some areas can mean drought and desolation. Last April, in the most devastating outbreak of tornadoes ever recorded, 148 twisters killed more than 300 people and caused half a billion dollars' worth of damage in thirteen U.S. states.

Trend: To scientists, these seemingly disparate incidents represent the advance signs of fundamental changes in the world's weather. The central fact is that after three quarters of a century of extraordinarily mild conditions, the earth's climate seems to be cooling down. Meteorologists disagree about the cause and extent of the cooling trend, as well as over its specific impact on local weather conditions. But they are almost unanimous in the view that the trend will reduce agricultural productivity for the rest of the century. If the climatic change is as profound as some of the pessimists fear, the resulting famines could be catastrophic. "A major climatic change would force economic and social adjustments on a worldwide scale," warns a recent report by the National Academy of Sciences, "because the global patterns of food production and population that have evolved are implicitly dependent on the climate of the present century."

A survey completed last year by Dr. Murray Mitchell of the National Oceanic and Atmospheric Administration reveals a drop of half a degree in average ground temperatures in the Northern Hemisphere between 1945 and 1968. According to George Kukla of Columbia University, satellite photos indicated a sudden, large increase in Northern Hemisphere snow cover in the winter of 1971-72. And a study released last month by two NOAA scientists notes that the amount of sunshine reaching the ground in the continental U.S. diminished by 1.3 per cent between 1964 and 1972.

To the layman, the relatively small changes in temperature and sunshine can be highly misleading. Reid Bryson of the University of Wisconsin points out that the earth's average temperature during the great Ice Ages was only about 7 degrees lower than during its warmest eras—and that the present decline has taken the planet about a sixth of the way toward the Ice Age average. Others regard the cooling as a reversion to the "little ice age" conditions that brought bitter winters to much of Europe and northern America between 1600 and 1900—years when the Thames used to freeze so solidly that Londoners roasted oxen on the ice and when iceboats sailed the Hudson River almost as far south as New York City.

Just what causes the onset of major and minor ice ages remains a mystery. "Our knowledge of the mechanisms of climatic change is at least as fragmentary as our data," concedes the National Academy of Sciences report. "Not only are the basic scientific questions largely unanswered, but in many cases we do not yet know enough to pose the key questions."

Extremes: Meteorologists think that they can forecast the short-term results of the return to the norm of the last century. They begin by noting the slight drop in over-all temperature that produces large numbers of pressure centers in the upper atmosphere. These break up the smooth flow of westerly winds over temperate areas. The stagnant air produced in this way causes an increase in extremes of local weather such as droughts, floods, extended dry spells, long freezes, delayed monsoons and even local temperature increases—all of which have a direct impact on food supplies.

"The world's food-producing system," warns Dr. James D. McQuigg of NOAA's Center for Climatic and Environmental Assessment, "is much more sensitive to the weather variable than it was even five years ago." Furthermore, the growth of world population and creation of new national boundaries make it impossible for starving peoples to migrate from their devastated fields, as they did during past famines.

Climatologists are pessimistic that political leaders will take any positive action to compensate for the climatic change, or even to allay its effects. They concede that some of the more spectacular solutions proposed, such as melting the arctic ice cap by covering it with black soot or diverting arctic rivers, might create problems far greater than those they solve. But the scientists see few signs that government leaders anywhere are even prepared to take the simple measures of stockpiling food or of introducing the variables of climatic uncertainty into economic projections of future food supplies. The longer the planners delay, the more difficult will they find it to cope with climatic change once the results become grim reality.

—PETER GWYNNE with bureau reports

Newsweek, April 28, 1975

THE MYTH OF THE 1970s GLOBAL COOLING SCIENTIFIC CONSENSUS

BY THOMAS C. PETERSON, WILLIAM M. CONNOLLEY, AND JOHN FLECK

There was no scientific consensus in the 1970s that the Earth was headed into an imminent ice age. Indeed, the possibility of anthropogenic warming dominated the peer-reviewed literature even then.

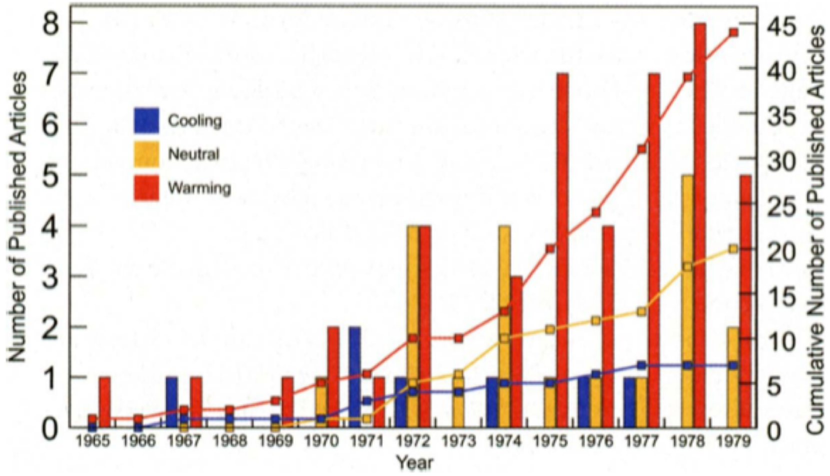


FIG. 1. The number of papers classified as predicting, implying, or providing supporting evidence for future global cooling, warming, and neutral categories as defined in the text and listed in Table 1. During the period from 1965 through 1979, our literature survey found 7 cooling, 20 neutral, and 44 warming papers.

8 AUGUST 1975

Climatic Change: Are We on the Brink of a Pronounced Global Warming?

Abstract. *If man-made dust is unimportant as a major cause of climatic change, then a strong case can be made that the present cooling trend will, within a decade or so, give way to a pronounced warming induced by carbon dioxide. By analogy with similar events in the past, the natural climatic cooling which, since 1940, has more than compensated for the carbon dioxide effect, will soon bottom out. Once this happens, the exponential rise in the atmospheric carbon dioxide content will tend to become a significant factor and by early in the next century will have driven the mean planetary temperature beyond the limits experienced during the last 1000 years.*

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West Antarctic ice sheet and CO_2 greenhouse effect: a threat of disaster

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If the global consumption of fossil fuels continues to grow at its present rate, atmospheric CO_2 content will double in about 50 years. Climatic models suggest that the resultant greenhouse-warming effect will be greatly magnified in high latitudes. The computed temperature rise at lat 80° S could start rapid deglaciation of West Antarctica, leading to a 5 m rise in sea level.

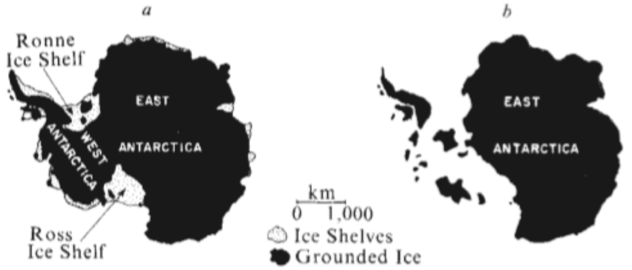


Fig. 3 *a*, Antarctic ice cover today, and *b*, after a 5–10 °C warming.

But it is cold or snowing so climate change can't exist.

- Videos
    - Animations of Earth's movement around the sun
    - NASA Video of Solstices, Equinoxes
    - Jerry Meehl on Hot/Cold Records
- Reading
    - Meehl et al., 2009. Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S.
    - Climate Signals Webpage on Records
- Optional
    - Jennifer Francis on Arctic Amplification and the Jet Stream
- My Video
    - Describes how the Earth's tilt leads to the seasons, how sunlight is critical for local climate, how it can snow more when it is warmer in some places (e.g., Lake Effect, or previously too cold)

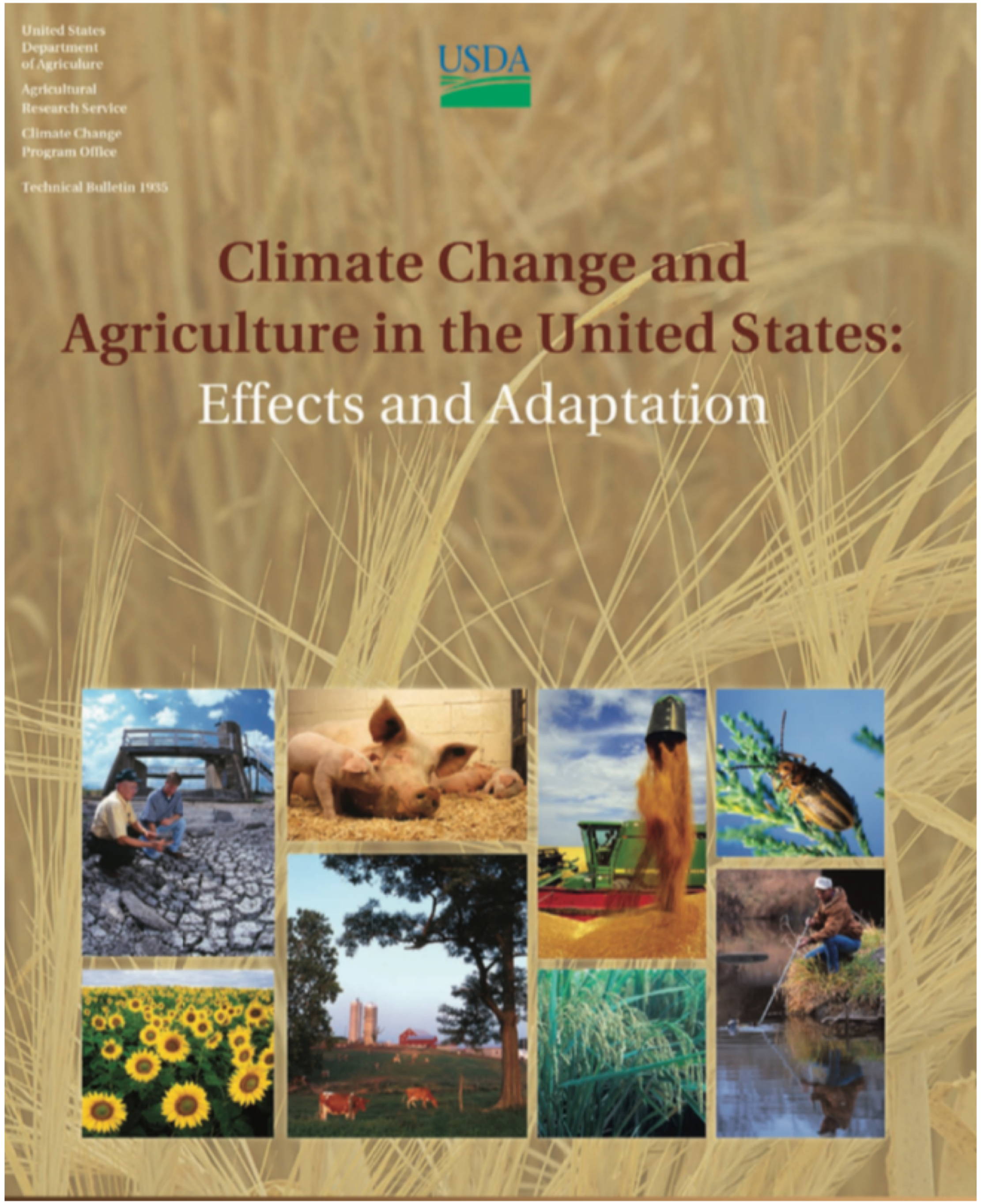
Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S.

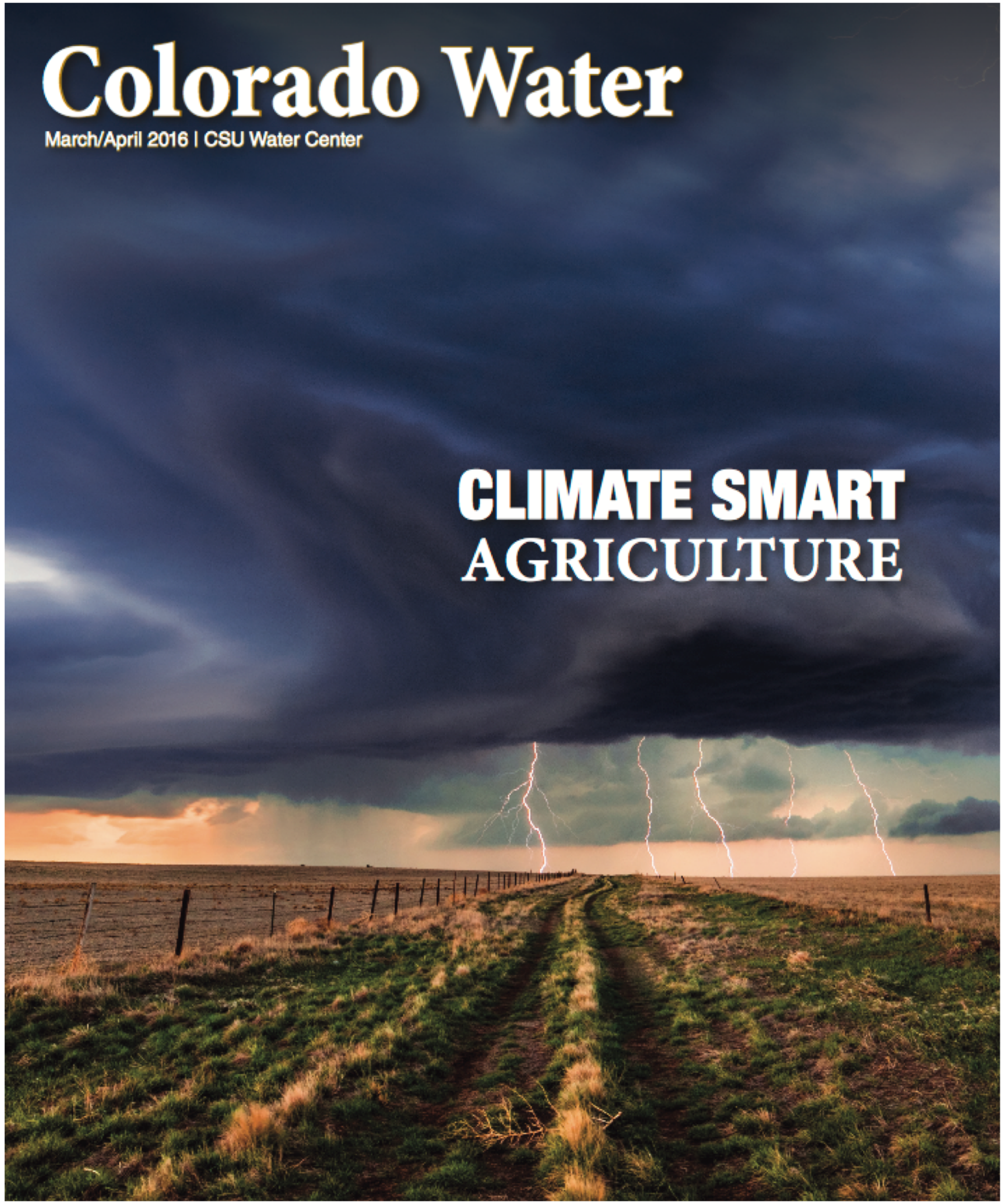
Gerald A. Meehl,[1] Claudia Tebaldi,[2] Guy Walton,[3] David Easterling,[4] and Larry McDaniel[1]

Received 28 August 2009; revised 13 October 2009; accepted 20 October 2009; published 1 December 2009.

Climate Change Agriculture Impacts and Adaptations

- Learning Objectives
  - Why and how are climate change and agriculture so connected?
  - How climate change will impact agriculture internationally, nationally, and regionally?
  - What risks and vulnerabilities do producers face from climate change?
  - What are the 4 general ways in which adaptations are possible?
  - How might producers adapt to the coming climate changes?
  - Why is soil carbon / soil health so important to both adaptation and greenhouse gas mitigation?


United States
Department
of Agriculture
Agricultural
Research Service
Climate Change
Program Office
Technical Bulletin 1935
USDA
Climate Change and
Agriculture in the United States:
Effects and Adaptation


Colorado Water
March/April 2016 | CSU Water Center
CLIMATE SMART
AGRICULTURE

USDA Northern Plains Regional Climate Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies

Photo Credit: David Augustine, ARS

Authors: Justin Derner (ARS), Northern Plains Hub Lead; Linda Joyce (Forest Service) Northern Plains Hub; Rafael Guerrero (NRCS), Northern Plains Hub; Rachel Steele, National Climate Hubs Coordinator

Northern Plains Climate Hub
USDA ARS, Natural Resources Research Center
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May 2015

Contributors: Our thanks to Juliet Bochicchio, RD; Wendy Hall and Marlene Cole, APHIS; Sharon Hestvik, RMA; Aaron Krauter, FSA; Dana Coelho and Trey Schillie, Forest Service; Michele Schoeneberger and Gary Bentrup, National Agro-forestry Center (Forest Service); Sharon Papiernik, Ann Heckart, and Lee Panella, ARS; and David Buland, Elise Boeke, Joyce Swartzendruber, Neil Dominy, Ted Alme, Jeffrey Zimprich, and Dennis Kimberlin, NRCS. We acknowledge ICF International for their contributions to the Greenhouse Gas Profile.

Edited By: Terry Anderson, ARS.

Southern Plains Assessment of Vulnerability and Preliminary Adaptation and Mitigation Strategies for Farmers, Ranchers and Forest Land Owners

Photo Credit: Michael Brown, USDA, ARS.

Authors: Jean L. Steiner, Laboratory Director and Acting Lead, Southern Plains Climate Hub; Jeanne M. Schneider, Consultant, Weather Sense LLC, formerly Lead, Southern Plains Climate Hub; Clay Pope, Consultant, CSP LLC; Sarah Pope, Consultant, CSP LLC; Paulette Ford, US Forest Service; and Rachel F. Steele, National Climate Hubs Coordinator, Washington D.C.

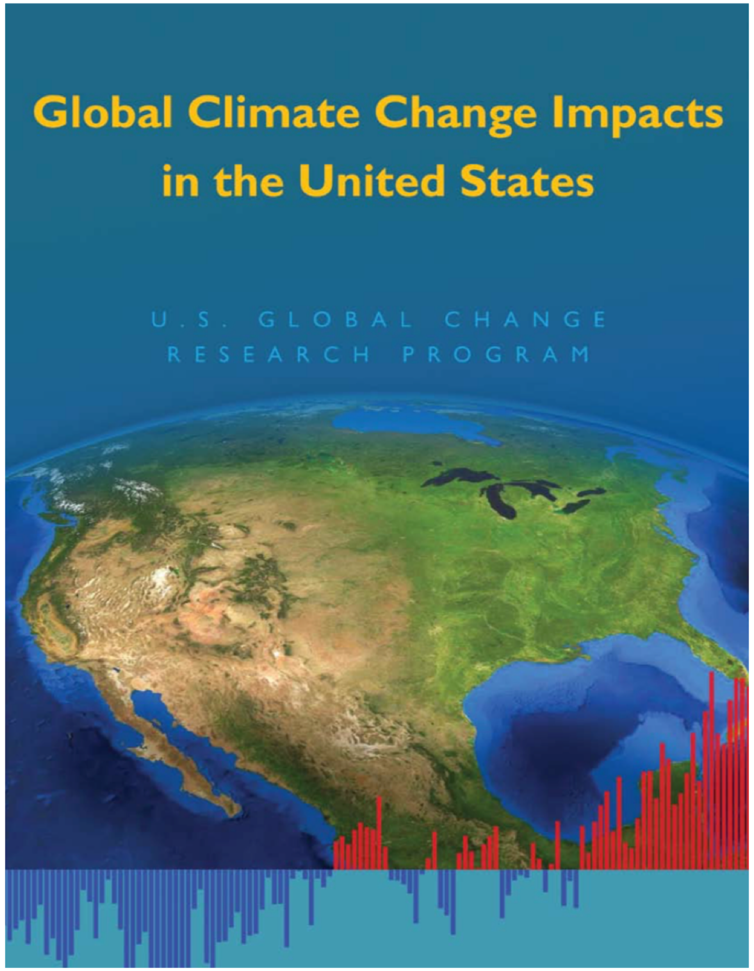
USDA Southern Plains Climate Hub
USDA-ARS Grazinglands Research Laboratory
7207 West Cheyenne Street, El Reno, OK 73036

October 2015

Contributors: Our thanks to Rafael Guerrero, NRCS; Juliet Bochicchio, RD; Wendy Hall and Marlene Cole, APHIS; Sharon Hestvik, RMA; Adrian Polansky, FSA; Michele Schoeneberger and Gary Bentrup, National Agroforestry Center (Forest Service); David Meriwether, Steve McNulty, and Priya Shahani, Forest Service. We acknowledge ICF International for their contributions to the Greenhouse Gas Profile.

Edited By: Terry Anderson, ARS

Suggested Citation: Steiner, J.L., J.M. Schneider, C. Pope, S. Pope, P. Ford, R.F. Steele 2015. *Southern Plains Assessment of Vulnerability and Preliminary Adaptation and Mitigation Strategies for Farmers, Ranchers, and Forest Land Owners,* T. Anderson, Ed., United States Department of Agriculture, 61 pp.


Global Climate Change Impacts
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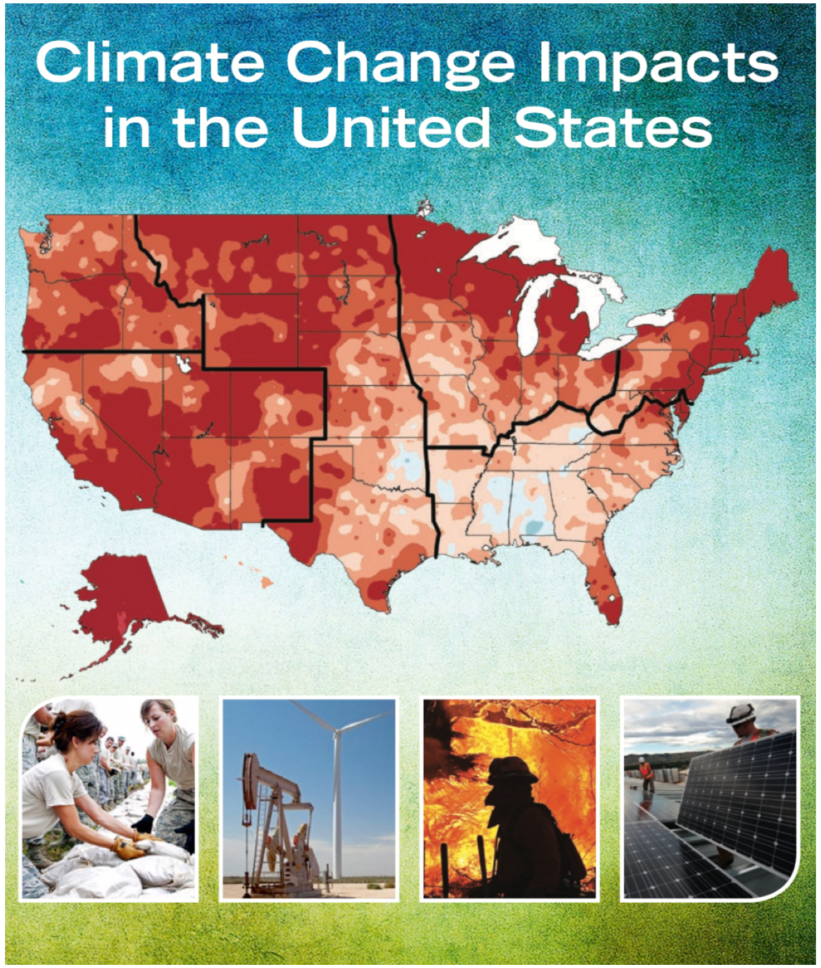
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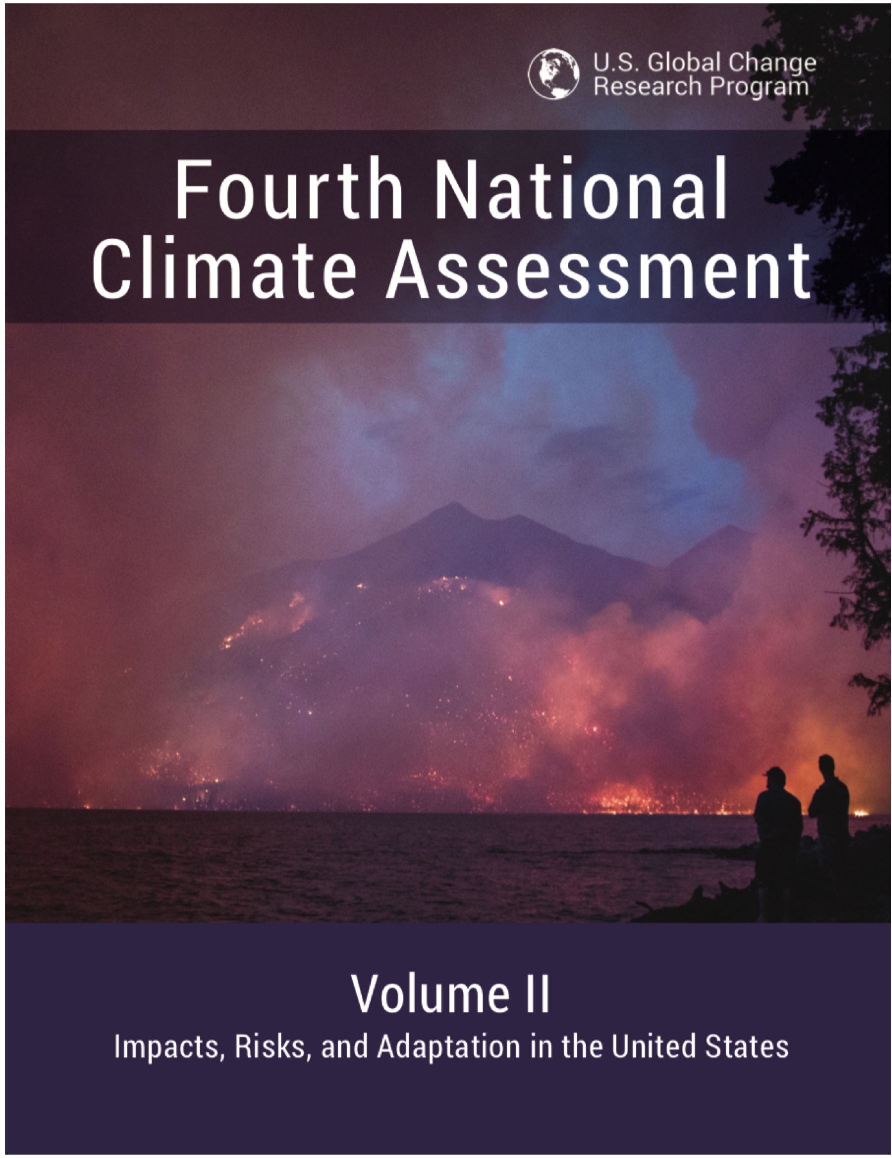
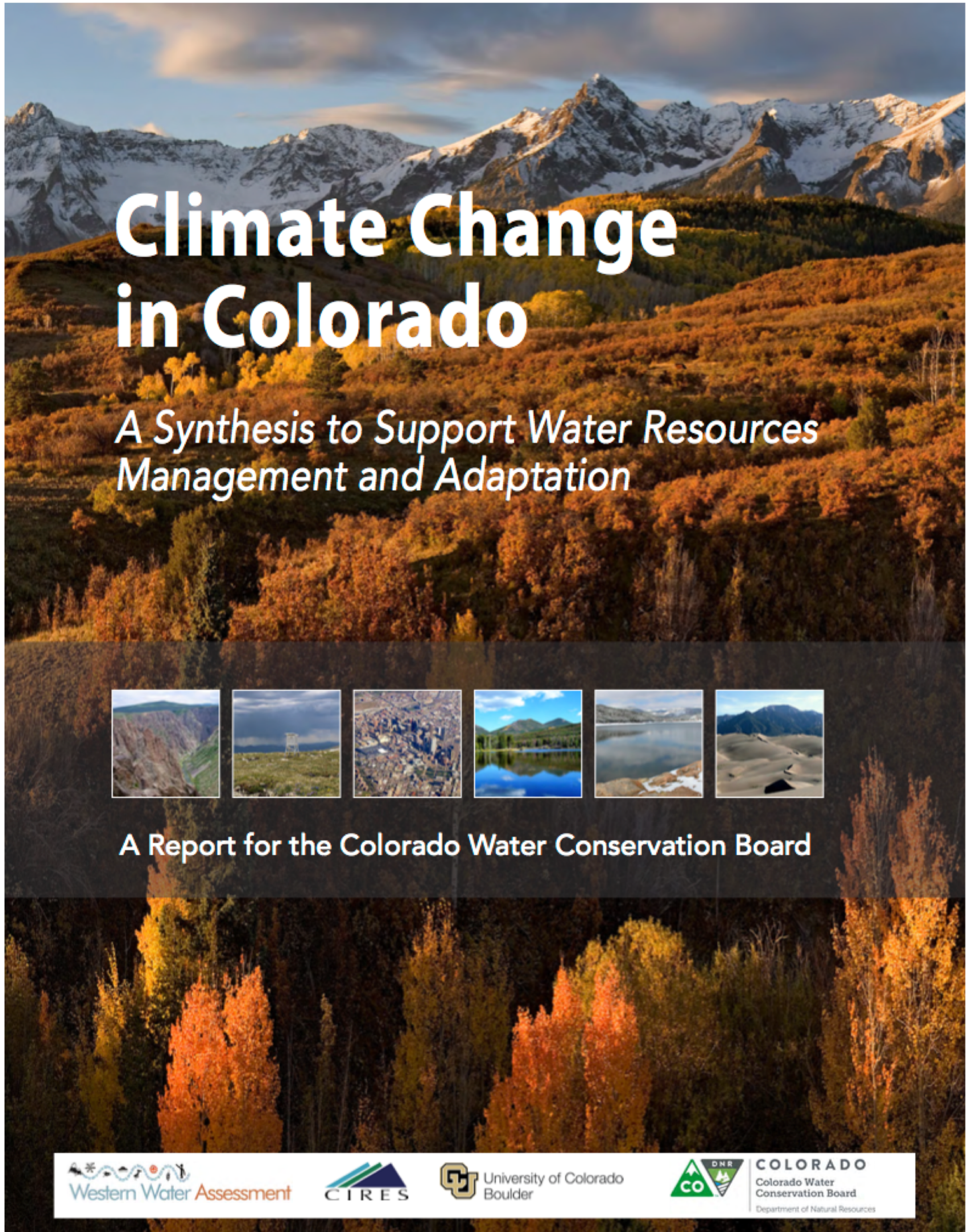
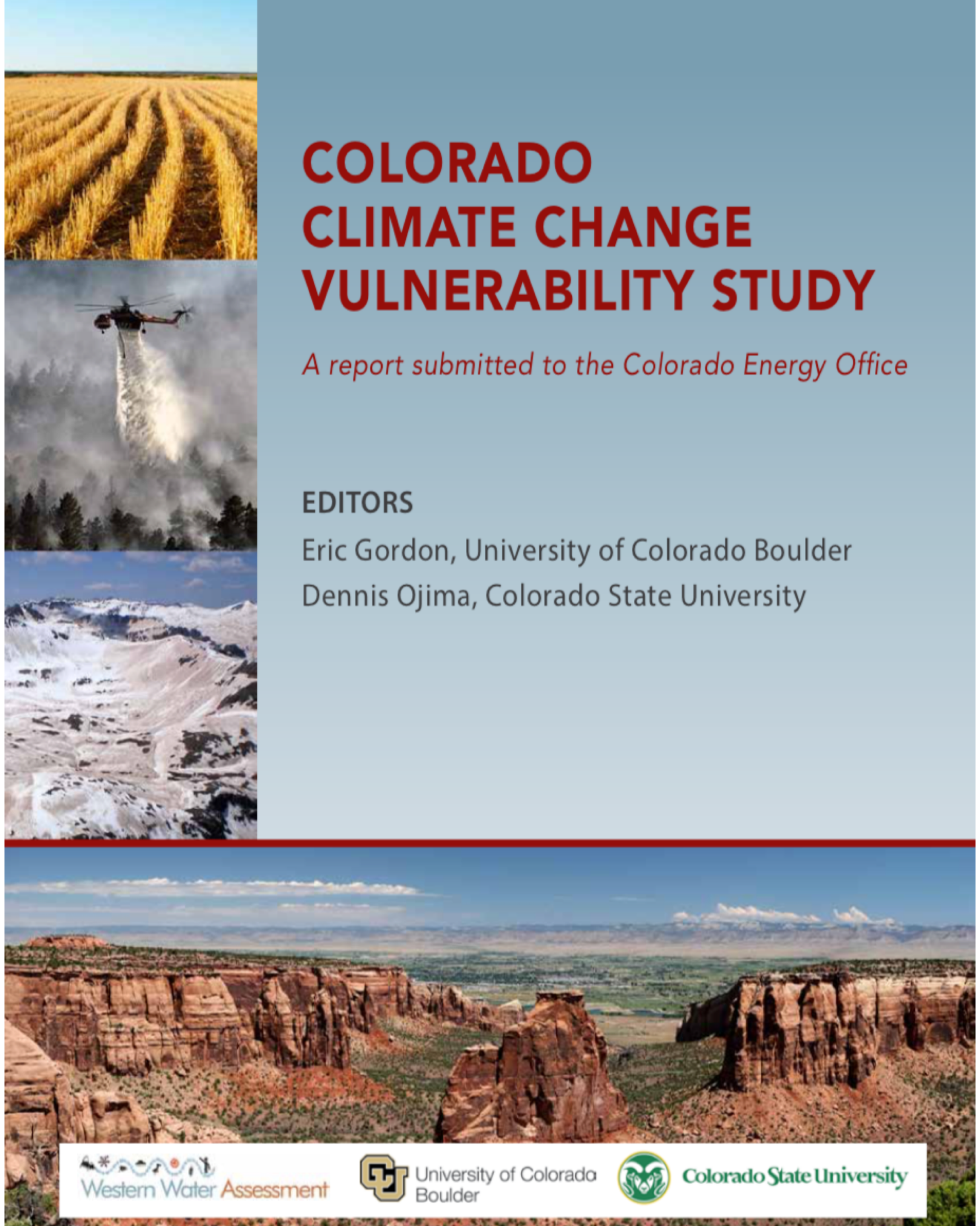

U.S. Global Change
Research Program
Fourth National
Climate Assessment
Volume II
Impacts, Risks, and Adaptation in the United States


Climate Change in Colorado
A Synthesis to Support Water Resources Management and Adaptation
A Report for the Colorado Water Conservation Board
Western Water Assessment
CIRES
University of Colorado Boulder
COLORADO
Colorado Water Conservation Board


COLORADO CLIMATE CHANGE VULNERABILITY STUDY
A report submitted to the Colorado Energy Office
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Dennis Ojima, Colorado State University
Western Water Assessment
University of Colorado Boulder
Colorado State University

Ag Impacts - Modules

- Introduction
- Climate Change Connection to Agriculture
- Global Climate Change Impacts to Agriculture
- National Climate Change Impacts to Agriculture
- Climate Hub Overview, General Adaptation Options
- Risks, Vulnerabilities, Adaptation Options – Field Crops
- Risks, Vulnerabilities, Adaptation Options – Grazing, Livestock, Forestry
- Adaptation Options – Soil Health
- Conclusion

Agricultural Adaptation Options

Technology

- New cultivars
- Weather and Climate Information
- Water Management Innovations

Government Programs and Insurance

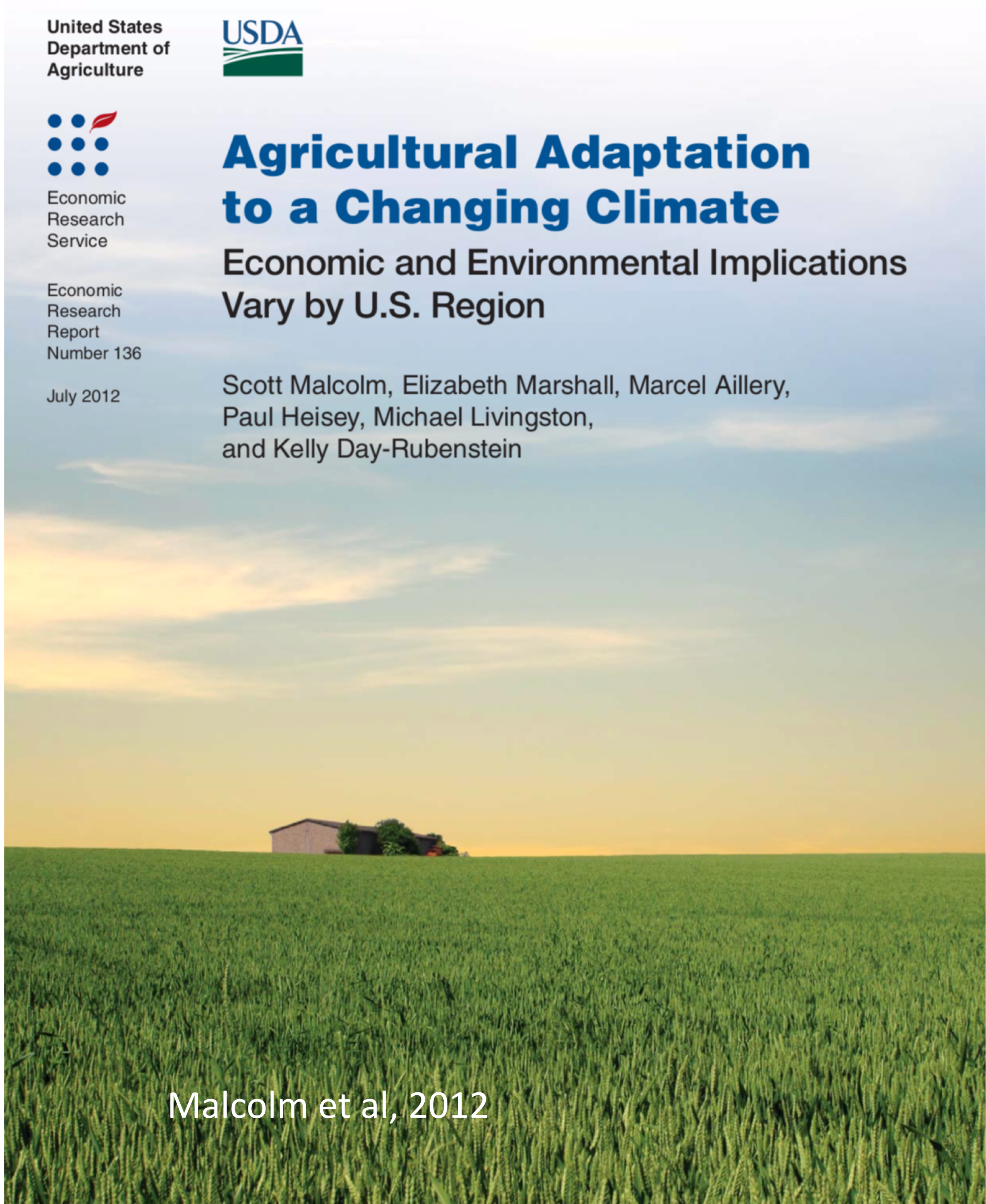
- Ag Subsidy and Price Support Programs
- Private Insurance

Farm Production Practices

- Diversify crop and livestock types
- Alternative Fallow and Tillage
- Irrigation
- Timing of Operations (plant/harvest)

Farm Financial Management

- Crop Insurance



# Risks	Irrigated Crops	Alfalfa/Hay	Corn	Dry Edible Beans/Peas	Oilseed Crops	Soybeans	Sugar Beets	Sunflowers	Wheat	Grazing Lands	Livestock Grazing	Confined Livestock	Agroforestry	Urban Forests	Wood Products and Bioenergy
Longer, hotter growing seasons with earlier arrival of spring.	x	x	x	x	x	x	x	x	x	x	x	x	x		x
More extreme weather events (e.g., downpours and droughts, snowstorms).	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Altered distribution of seasonal precipitation (more winter and spring precipitation, but less summer precipitaton	x	x	x	x	x	x	x	x	x	x	x	x			
Greater wildfire risk from warmer and expected drier summers.													x		x
More outbreaks of pests and pathogens.													x		
Urban heat island-effect coupled with longer, hotter growing seasons, and potential for more drought.														x	
Expansive impervious surfaces coupled with increased extreme events (e.g., downpours).														x	
Air pollution sources interacting with changes in climate.														x	
Low tree species diversity increases susceptibility to invasive and non-native plants and animals.														x	
More outbreaks of native insects such as mountain pine beetle and spruce beetle															x

Adaptation Strategies	Irrigated Crops	Alfalfa/Hay	Corn	Dry Edible Beans/Peas	Oilseed Crops	Soybeans	Sugar Beets	Sunflowers	Wheat
Genetic development of cultivars through breeding programs can help offset negative effects of rising temperatures, drought, and soil salinity.		X	X	X	X	X	X	X	X
Increase soil health through enhanced soil management and residue management.		X	X	X	X	X		X	X
Increase soil health through enhanced soil management, residue management, cover crops, and rotations.							X		
Increase irrigation efficiency (i.e., more crop per drop) and utilize new technology for subsurface irrigation to reduce water use.		X	X						
Use tile drainage practices to reduce excess seasonal soil water conditions.			X			X			
Dry edible beans and peas can be used for double cropping or pulse crops to provide nearly year- round ground cover to reduce soil exposure to water and wind erosion.				X					
Oilseed crops being used for double cropping or pulse crops to provide nearly year-round ground cover to reduce soil exposure to water and wind erosion.					X				
Alter the dryland wheat-fallow system by adding summer crops (e.g., forages) which provides nearly year-round ground cover to reduce soil exposure to water and wind erosion. Both winter and spring wheat can add diversity to corn-soybean rotation with cover crops.									X
Use new technology for subsurface irrigation, and irrigation with gray or reclaimed water to reduce water use	X								
Increase irrigation efficiency (i.e., more crop per drop).	X					X	X		
Shift to more water-efficient crops	X								
“Water-bank” by using less irrigation in non-drought years, saving water for use in drought years,and creating markets to lease conserved water to municipalities to balance agricultural and municipal water needs.	X								

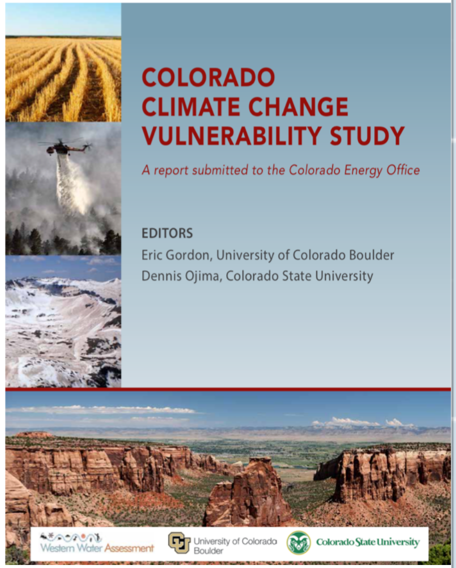
Colorado Climate Change Vulnerability Study

2014 CSU + CU Study
+ Colorado Energy Office

Type of Crop
Climate Impact
Key Vulnerability

Climate Overview

Sectors
- Ecosystems
- Public Health
- Energy
- Water
- Transportation
- Agriculture
- Recreation



	Climate Impact	Key Vulnerabilities
Field Crops	• Rising temperatures	• Crop yields vulnerable to reductions due to heat stress
	• Increasing frequency and severity of drought	• More frequent losses of crops, forage, and soil
	• Earlier onset of spring; longer growing seasons	• Crops vulnerable to increased weeds and pests due to longer growing season
	• Potentially reduced streamflow	• Production losses due to irrigation shortages
	• Increased CO_2 levels	• Crops potentially affected by weeds encouraged by CO_2 fertilization
	• Extreme weather events	• Continued losses of crops, facilities (structures, ditches, equipment)
Fruits and Vegatables	• Earlier spring thaws	• Fruit crops vulnerable to frost damage worsened by early budburst
	• Increasing frequency and severity of drought	• Increased potential for water shortages occurring simultaneously with higher crop water demand
	• Reduction streamflow, especially in late summer	• Reduced production due to limited irrigation supply, increased water prices
Livestock	• More favorable conditions for pathogens	• Cattle vulnerable to lower weight gain and other health problems due to higher temperatures
	• Increasing temperatures	• Loss of weight and animal health in higher temperature; increased costs of facilities
Green Industry	• Extreme weather events	• Damage to facilities and products
	• Potential reduction in streamflow	• Loss of production due to water use restrictions

C. Climate is always changing. How is recent change different than in the past?

The Earth has experienced many large climate changes in the past. However, current changes in climate are unusual for two reasons: first, many lines of evidence demonstrate that these changes are primarily the result of human activities (see Question I for more info); and second, these changes are occurring (and are projected to continue to occur) faster than many past changes in the Earth's climate.

In the past, climate change was driven exclusively by natural factors: explosive volcanic eruptions that injected reflective particles into the upper atmosphere, changes in energy from the sun, periodic variations in the Earth's orbit, natural cycles that transfer heat between the ocean and the atmosphere, and slowly changing natural variations in heat-trapping gases in the atmosphere. All of these natural factors, and their interactions with each other, have altered global average temperature over periods ranging from months to thousands of years. For example, past glacial periods were initiated by shifts in the Earth's orbit, and then amplified by resulting decreases in atmospheric levels of carbon dioxide and subsequently by greater reflection of solar radiation by ice and snow as the Earth's climate system responded to a cooler climate. Some periods in the distant past were even warmer than what is expected to occur from human-induced global warming. But these changes in the distant past generally occurred much more slowly than current changes.

Carbon Emissions in the Industrial Age

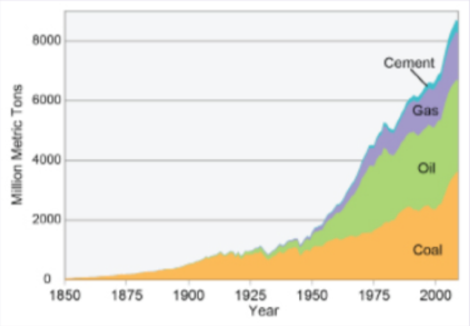


Figure 4. Global carbon emissions from burning coal, oil, and gas and from producing cement (1850-2009). These emissions account for about 80% of the total emissions of carbon from human activities, with land-use changes (like cutting down forests) accounting for the other 20% in recent decades. (Data from Boden et al. 2012[3]).

Natural factors are still affecting the planet's climate today. The difference is that, since the beginning of the Industrial Revolution, humans have been increasingly affecting global climate, to the point where we are now the primary cause of recent and projected future change.

Records from ice cores, tree rings, soil boreholes, and other forms of "natural thermometers," or "proxy" climate data, show that recent climate change is unusually rapid compared to past changes. After a glacial maximum, the Earth typically warms by about 7°F to 13°F over thousands of years (with periods of rapid warming alternating with periods of slower warming, and even cooling, during that time). The observed rate of warming over the last 50 years is about eight times faster than the average rate of warming from a glacial maximum to a warm interglacial period.

1700 Years of Temperature Change from Proxy Data

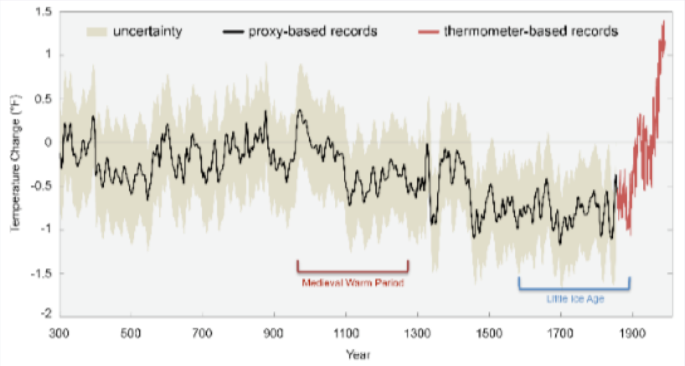


Figure 5. Changes in the temperature of the Northern Hemisphere from surface observations (in red) and from proxies (in black; uncertainty range represented by shading) relative to 1961-1990 average temperature. These analyses suggest that current temperatures are higher than seen globally in at least the last 1700 years and that the last decade (2001 to 2010) was the warmest decade on record. (Figure source: adapted from Mann et al. 2008[4]).

Global temperatures over the last 100 years are unusually high when compared to temperatures over the last several thousand years. Atmospheric carbon dioxide levels are currently higher than any time in at least the last 800,000 years. Paleoclimate studies indicate that temperature and atmospheric carbon dioxide levels have been higher in the distant past, millions of years ago, when the world was very different than it is today. But never before have such rapid, global-scale changes occurred during the history of human civilization.

Our societies have not been built to withstand the changes that are anticipated in the relatively near future, and thus are not prepared for the effects they are already experiencing: higher temperatures, sea level rise, and other climate change related impacts.

FAQ

Frequently Asked Questions

IPCC AR5 FAQ

These Frequently Asked Questions have been extracted from the chapters of the underlying report and are compiled here. When referencing specific FAQs, please reference the corresponding chapter in the report from where the FAQ originated (e.g., FAQ 3.1 is part of Chapter 3).

FAQ

Frequently Asked Questions

NCA3 2014 - FAQ

Climate Change Impacts in the United States

APPENDIX 4
FREQUENTLY ASKED QUESTIONS

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On the Web: http://nca2014.globalchange.gov/report/appendices/faqs

A. How can we predict what climate will be like in 100 years if we can't even predict the weather next week?

B. Is the climate changing? How do we know?

C. Climate is always changing. How is recent change different than in the past?

D. Is the globally averaged surface temperature still increasing? Isn't there recent evidence that it is actually cooling?

E. Is it getting warmer at the same rate everywhere? Will the warming continue?

F. How long have scientists been investigating human influences on climate?

G. How can the small proportion of carbon dioxide in the atmosphere have such a large effect on our climate?

H. Could the sun or other natural factors explain the observed warming of the past 50 years?

I. How do we know that human activities are the primary cause of recent climate change?

J. What is and is not debated among climate scientists about climate change?

K. Is the global surface temperature record good enough to determine whether climate is changing?

L. Is Antarctica gaining or losing ice? What about Greenland?

M. Weren't there predictions of global cooling in the 1970s?

N. How is climate projected to change in the future?

O. Does climate change affect severe weather?

P. How are the oceans affected by climate change?

Q. What is ocean acidification?

R. How reliable are the computer models of the Earth's climate?

S. What are the key uncertainties about climate change?

T. Are there tipping points in the climate system?

U. How is climate change affecting society?

V. Are there benefits to warming?

W. Are some people more vulnerable than others?

X. Are there ways to reduce climate change?

Y. Are there advantages to acting sooner rather than later?

Z. Can we reverse global warming?

NCA4 2018 - FAQ

Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II

A5 Appendix 5. Frequently Asked Questions

This appendix is an update to the frequently asked questions (FAQs) presented in the Third National Climate Assessment (NCA3). New questions based on areas of emerging scientific inquiry are included alongside updated responses to the FAQs from NCA3. The answers are based on the U.S. Global Change Research Program's (USGCRP) sustained assessment products, other peer-reviewed literature, and consultation with experts.

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NCA4 2018 - FAQ

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NCA4 – 2018

Volume 1

Equivalent of IPCC Working Group 1

State of the Science

(not impacts)

Vulnerabilities

Field Crops

Vulnerabilities	Irrigated Crops	Alfalfa/Hay	Corn	Dry Edible Beans/Peas	Oilseed Crops	Soybeans	Sugar Beets	Sunflowers	Wheat
Altered snowpack levels with earlier snow melt and runoff to reservoirs.	x	x					x		
Dropping levels in groundwater aquifers limits water availability and increases drilling and pumping costs.	x						x		
Reservoir management timing to accommodate the earlier snow melt and runoff.	x								
Excess seasonal soil water in eastern parts of the Northern Great Plains.	x								
Predicted higher frequency of downpours could present water runoff and quality issues for lands with erosion risk and/or drainage issues.	x	x	x	x	x	x	x	x	x
Greater frequency, duration, and intensity of drought can increase reliance on groundwater/surface irrigation water for crop production.	x	x	x	x	x	x	x	x	x
Longer and warmer growing seasons and altered distribution of seasonal precipitation can increase pest and weed pressure for crops.	x	x	x	x	x	x	x	x	x
Greater spring precipitation decreases the number of workable field days in the eastern portion of the Northern Plains and will place a constraint on producers being able to accomplish all of their spring operations in a timely manner.	x								
Increased Soil Salnity		x					x		
Warming temperatures and longer growing season has led to expansion of corn and soybeans (and displacement of wheat/small grains/pastures/dry edible beans and peas) in the eastern part of North Dakota and South Dakota.			x	x	x	x			x
Increasing use of corn for ethanol creates greater land use change.			x						
Excess seasonal soil water in eastern parts of the northern Great Plains.			x			x			
Warming in the fall through early spring can result in longer emergence periods for seedlings, thereby increasing their vulnerability to environmental conditions (e.g. frost damage)								x	