Global Climate Change and the Implications for Oklahoma

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Our previous stance on global warming
Why the anxiety? Extreme Viewpoints!

• **Senator Jim Inhofe:**
  “The greatest hoax ever perpetrated on the American people.”

• **Ellen Goodman, Boston Globe:**
  “...global warming deniers are now on a par with Holocaust deniers”
OCS LEGISLATIVE MANDATE

• Conduct and report on studies of climate and weather phenomena of significant socio-economic importance to the state

• Evaluate the significance of natural and man-made ... changes ... and to report this information to those agencies and organizations in the state who are likely to be affected by such changes or modifications
A Quick Background on Climate Change
The Greenhouse effect

Solar radiation passes through the clear atmosphere.
Incoming solar radiation: 343 Watt per m²

Some solar radiation is reflected by the atmosphere and earth’s surface
Outgoing solar radiation: 103 Watt per m²

Some of the infrared radiation passes through the atmosphere and is lost in space
Net outgoing infrared radiation: 240 Watt per m²

Solar energy is absorbed by the earth’s surface and warms it...
168 Watt per m²
... and is converted into heat causing the emission of longwave (infrared) radiation back to the atmosphere

Surface gains more heat and infrared radiation is emitted again
Global Warming Is Not A New Theory
It’s the confirmation of a prediction

- **1890s** – Nobel Prize winner Svante Arrhenius theorized about a warming climate due to the burning of coal.

- **1938** – Guy Stewart Callendar asserted that warming of the 19th century forward was due to a rise in CO$_2$.

- **1965** – Roger Revelle: “By the year 2000, the increase in atmospheric CO$_2$ …may be sufficient to produce measurable and perhaps marked change in climate”
• Established in 1988 by United Nations

• Not to do research, but to synthesize and assess it

• Today:. Most recent report scientific experts from > 130 countries, > 800 authors, > 2500 peer reviewers

• Historically unprecedented: scale, scope, ambition.

• Summary approved by consensus (including representatives of the Bush Administration) at meetings of the IPCC.
Letter to U.S. Senators, Oct. 11, 2009:

• “Observations throughout the world make it clear that climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver.”

• “These conclusions are based on multiple independent lines of evidence, and contrary assertions are inconsistent with an objective assessment of the vast body of peer-reviewed science.”
• American Association for the Advancement of Science
• American Chemical Society
• American Geophysical Union
• American Institute of Biological Sciences
• American Meteorological Society
• American Society of Agronomy
• American Society of Plant Biologists
• American Statistical Association
• Association of Ecosystem Research Centers
• Botanical Society of America
• Crop Science Society of America
• Ecological Society of America
• Natural Science Collections
• Alliance Organization of Biological Field Stations
• Society for Industrial and Applied Mathematics
• Society of Systematic Biologists
• Soil Science Society of America
• University Corporation for Atmospheric Research
The following represents the VAST MAJORITY of scientific expertise on global climate change

Important to remember:

• Think GLOBALLY and DECADALLY

• Climate is in flux

• Temperature projections represent a RANGE of possible warming, dependent upon societal responses

• Regional projections are still somewhat uncertain, especially for precipitation

• Natural variability will still occur (i.e. cold years, wet and dry years)
Oklahoma is NOT the canary in the coal mine!
Observational Evidence: the Globe has warmed
Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.
The Industrial Revolution has caused a dramatic rise in \( \text{CO}_2 \).

Ice Age Cycles

Thousands of Years Ago

Years (AD)

\( \text{CO}_2 \) Concentration (ppmv)
For 650,000 years, atmospheric CO₂ has never been above this line ... until now.
The warmth of the last half century is unusual in at least the previous 1300 years

2000 Year Northern Hemisphere Reconstruction of Surface Air Temperatures

Source: Moberg et al Nature 2005
Global Warming Has Stopped??

Surface and Satellite Temperatures

Direct Surface Measurements
Satellite Measurements
UAH / RSS
Global Warming Has Stopped, Part 2??

Temperature Anomalies October 2009
(with respect to a 1971-2000 base period)
National Climatic Data Center/NESDIS/NOAA

Northern Hemisphere Sea Ice Extent

Arctic could be free of ice as early as 2030 (previously thought by 2070)

1979-2000 mean = 7.0 million sq km
Temperature and Solar Comparison

- Instrumental Temperature Record
- Solar Variability (arbitrarily scaled to fit)
- Temperature Reconstructions

**Little Ice Age**
Oklahoma’s Changes?

- Oklahoma’s climate signal still dominated by natural variability
- Warmer, wetter winters
- Extreme precipitation frequency has increased
Our winters have gotten warmer

Droughts

Wet!

Ice Storms

Winter Temperature History with 5-year Tendencies
Oklahoma Statewide: 1896-2007

USDA

OKLAHOMA CLIMATOLOGICAL SURVEY
Rainfall events have become more intense

- Oklahoma’s value: 22%
- One-year recurrence-level storms (i.e. 59 largest storms)
Climate Projections
Higher confidence now exists in projected patterns of warming than exists for other elements such as rainfall

Hot extremes and heat waves will increase

Heavy precipitation event frequency will continue to increase

Snow cover and sea ice continues to shrink

Sea levels will rise

Storm tracks are projected to move poleward

Increasing acidification of the ocean

Further 21st century emissions will contribute to warming & sea level rise for more than a millennium
Societal response is key

Multi-model Averages and Assessed Ranges for Surface Warming

©IPCC 2007: WG1-AR4

Global surface warming (°C)

Year

1900 2000 2100

B1 A1T B2 A1B A2 A1F1
Temperature Projections: A Range of Possibilities

Societal Response

Green Response

Middle Road

Maximum Growth
A Closer Look From A Single Model

Lower Emissions Scenario$^{91}$

Degrees F
- 7
- 6
- 5

Higher Emissions Scenario$^{91}$

Degrees F
- 10+
- 10
- 9
- 8

CMIP3-B$^{117}$
Annual U.S. precip will increase in the northeast and decrease in the southwest.

High Confidence
Days with frost

Heat waves

Growing Season
Projections for Oklahoma as we scale down
Temperature

• Annual warming by the 2020s
  • “Middle Road” scenario: 2-4°F
  • “Maximum Growth scenario: 2-4°F
• Annual warming by the 2090s
  • “Middle Road” scenario: 4-7°F
  • “Maximum Growth scenario: 10-12°F
• Summer becomes longer and spring weather arrives earlier
• Winters warm - longer frost-free periods and a longer growing season
• Earlier maturation of winter wheat and orchard crops leave them more vulnerable to late freeze events (think 2007 and 2009)
August 12, 1936 – Will our record hot weather become our “really hot” weather?

120 degrees!
100-degree days (1971-2000)

Average based on 1971-2000 data

Days per Year with High Temp >= 100°F
(c) 2002 Oklahoma Climatological Survey
100-degree days – Projections
Precipitation

- Rain-free periods will increase, but individual rainfall events will be more intense
- Increased year-round evaporation from the ground and transpiration from green vegetation
- Drought frequency and severity increases
- The risk of wildfires increases, especially during summer
Oklahoma’s Water Future?

Fewer (but more intense) precipitation events:

• More runoff, more flooding
• Crop damage
• More pollution from runoff
• Increased erosion
• Possibly less water available, even if yearly totals increase
“There will be winners and losers from the impacts of climate change, even within a single region, but globally the losses are expected to far outweigh the benefits.” – from the National Academies’ report “Understanding and Responding to Climate Change”.
• The earth's climate has warmed during the last 100 years;
• The earth's climate will continue to warm for the foreseeable future;
• Much of the global average temperature increases over the last 50 years can be attributed to human activities, particularly increasing greenhouse gases in the atmosphere;
• Oklahoma will be impacted.

Across the globe, a warming climate will be beneficial to some and detrimental to others. Anticipating how this climatic shift will impact Oklahoma is of vital importance to state decision-makers. One of the greatest impacts will be the exposure of Oklahoma's growing population and economy to water stress. Oklahoma's future requires access to fresh water. Thus, due diligence in protecting our water resources and adapting to future climate variability is paramount if we are to maintain and improve the quality of life and the economy of Oklahoma.

The Science of Global Climate Change
The earth's climate is always changing. Evidence such as tree ring and ice core studies indicates large and sometimes abrupt climate changes have occurred in the earth's distant past, lasting centuries to millennia. These climate swings are attributed to natural variations, such as changes in the output of the sun or shifts in the earth's orbit. Oklahoma has experienced distinct climate periods attributable to natural variability in the last 100 years, from the decadal-scale droughts of the 1950s, 1970s and 1990s to an extended period of abundant precipitation during the 1980s and 1990s. Mounting evidence continues to indicate, however, that human activities have begun to impact the earth's climate through the release of greenhouse gases. Ice core studies show carbon dioxide and methane are at their greatest levels within the last 650,000 years. Due to the extended periods required for these gases to be removed from the atmosphere, further emissions during the 21st century will cause additional warming for more than a millennium. In fact, even if greenhouse gas concentrations were held steady since the year 2000, the earth is committed to decades of warming from heat already absorbed by the oceans.

Global Climate Change Impacts for Oklahoma
The continued warming of the climate averaged across the globe will create a cascade of climatic shifts which could impact Oklahoma's climate. These shifts will not mean an end of year-to-year natural variability - hot years and cold years will continue, as will wet years and dry years. The projected changes will be seen at time scales averaged over a decade or more. Little is known of the effects climate change will have on severe weather. The ingredients required for severe weather involve complex combinations that do not exhibit clear changes in a warming climate. Further, global climate models are unable to accurately simulate small-scale weather events like thunderstorms or tornadoes.
Find out about climate change for yourself at

http://www.ipcc.ch/

http://www.globalchange.gov/

Thank you!