The 4th National Climate Assessment: An Overview of Volume I

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USGCRP Climate Science Special Report

Volume 1 of the 4th National Climate Assessment

– CSSR is an authoritative assessment of the science of climate change, with a focus on the United States
  • 477 pages
  • 32 Lead Authors and 19 Contributing Authors (federal, national lab, academic, and industry scientists)
– Overseen by a federal Science Steering Committee
– Extensively reviewed (including public, National Academy of Sciences, and U.S. agencies)
  • 3 Review editors that were not authors
Climate Science Special Report

Fourth National Climate Assessment (NCA4), Volume I

This report is an authoritative assessment of the science of climate change, with a focus on the United States. It represents the first of two volumes of the Fourth National Climate Assessment, mandated by the Global Change Research Act of 1990.

science2017.globalchange.gov
NCA Volume II on impacts expected to be published in Dec. 2018
The Science: The Bottom Line

- Our climate is changing,
  - It is happening now;
  - It is happening extremely rapidly;
- Severe weather is becoming more intense;
- Sea levels are rising;
- It is largely happening because of human activities and associated pollution;
- The climate will continue to change over the coming decades.
Many Different Observations Show a Changing Climate
Global Annually-Averaged Temperature Record (NOAA, through 2016)

Globally, annually-averaged temperature has increased by 1.8 °F from 1901-2016

Graphs are relative to 1901-1960
Conditions today appear to be unusual in the context of the last 2,000 years...

Updated from Mann et al., 2008  PNAS
Our Climate Continues to Change Rapidly

The global long-term warming trend continues.

2016 was the warmest year on record, 2015 is 2\textsuperscript{nd} and far surpassed 2014, which is 3\textsuperscript{rd}. 2017 is 2\textsuperscript{nd} or 3\textsuperscript{rd} warmest year on record.

Seventeen of the last 18 years are the warmest years on record.

Temperature trends (change in deg. F) for the period 1986-2015 relative to 1901-1960
Over contiguous United States, annually-averaged temperature has increased by 1.8 °F from 1895-2016
Observed U.S. Precipitation Change

Annual precipitation has increased overall by 4% in the United States. It has decreased in much of the West, Southwest, and Southeast.
The Arctic is on the Front Lines of Climate Change

Stark examples of rapid changes:
- temperature warming at 2x rate of rest of world.
- accelerated melting of multi-year sea ice cover
- mass loss from the Greenland Ice Sheet
- reduced snow cover
- permafrost thawing
We are seeing changing trends in extreme weather and climate events.
NOAA analyses show increasing effects of Severe Weather on U.S. economy: Total of $1.1 trillion since 1980

Every U.S. region has been affected by this growing trend.

Billion-dollar weather and climate disasters frequency: 1980-2016 (accounts for inflation)
Billion Dollar Events in 2018 through June

Heat advisory in southern Minnesota; flood warnings to the north

Ron Trenda  July 12, 2018, 8:36 AM

Record heat put thousands of Californians in the dark Friday. Scientists predicted this from climate change.

Capital Weather Gang

California's Mendocino complex of fires now largest in state's history

Major flooding is occurring in parts of Pennsylvania, and rivers continue to rise in the Mid-Atlantic

And globally: Canada, Japan, India, Europe, Siberia, ...
Extreme Events Show Important Trends Globally and in United States

- Heat waves are increasing.
- Cold waves are decreasing.
- More precipitation coming as larger events.
- Increasing risk of floods (esp. in NE, MW).
- Increasing intensity of droughts (esp. in SW, SE).
- Incidence of large wildfires has increased (West, Alaska).
- Increasing intensity of Atlantic hurricanes.
- Tornado activity more variable – increase in outbreaks.
- Hail may be coming more intense.

These trends are expected to continue.
The frequency and intensity of extreme heat events are increasing in most continental regions of the world, including the United States.
Extreme Precipitation Events are Increasing in Frequency and Intensity

2-Day Precipitation Events Exceeding 5-Year Recurrence Interval

99th Percentile Precipitation (1958–2016)

Change (%)

-<0 0-9 10-19 20-29 30-39 40+

Date

Name of Meeting
More Precipitation Comes as Extreme Events

- Historical simulations show a significant increase in accuracy at projecting extreme precipitation events compared to GCMs.
- Extreme events increase and median precipitation days decrease in all 3 regions in the RCM simulations, which was not the case in GCM simulations.
- RCMs also project a much different outcome in terms of dry days (~2 mm). This is especially true in the Southwest where a large increase in dry days could lead to hydrological stress.
Increasing Trends in Wildfires

- The U.S. fire season is about 3 months longer than 40 years ago.
- The average fire is much bigger & hotter than before.
- In Alaska, even the tundra is experiencing wildfires.
Increasing Trends for Intense Hurricanes

Tropical cyclones get their energy from the warm surface layer of the ocean (which is getting warmer and deeper). More ocean energy → stronger cyclone

Projected increase in precipitation rates, tropical cyclone intensity, and the number of very intense tropical cyclones – but in not the overall number of storms.

Sea level rise will increase the frequency and extent of extreme flooding associated with coastal storms.
Many Studies Examining Detection and Attribution

Climate change likely affected Hurricane Harvey:
- Occurrence 3 to 3.5 times more likely
- Rainfall 15 to 38% greater

Now, it’s a 1% chance per year. Before end of century, 18% chance each year.

Emanuel 2017; Risser & Wehner 2017; van Oldenberg et al. 2017
What is Causing Observed Changes in Climate

- Many lines of evidence demonstrate that human activities are primarily responsible for the observed climate changes.
- There are no credible alternative explanations supported by the extent of the observational evidence.
  - Solar output changes and natural variability can only contribute marginally to observed climate changes.
  - There are no natural cycles in the observational record that can explain the observed changes in climate.
The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years.
It is extremely likely (> 95% certainty) that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century.

Contributions to radiative forcing on climate since 1750
Observed Temperature Trends Only Explained by Human Emissions

Global Mean Temperature Change

(a) CMIP5 All-Forcing
- GISTEMP Observed
- HadCRUT4.5 Observed
- NOAA Observed

(b) CMIP5 Natural-Forcing Only
- GISTEMP Observed
- HadCRUT4.5 Observed
- NOAA Observed
Climate will Continue to Change

- Globally climate is expected to continue to change over this century and beyond.
- The magnitude of climate change depends primarily on the additional amount of greenhouse gases emitted globally, and on the sensitivity of Earth’s climate to those emissions.
Global Temperature and Other Changes in Climate Depend on Future Emissions
Projected U.S. Temperature Change

Projected changes in average annual temperatures (°F)
Projected U.S. Precipitation Change

2070-2099 relative to 1975-2005
For RCP8.5 (High scenario)
Projected Changes: Number of Days with $T>90^\circ F$ and $T<32^\circ F$ for 2036-2065 (relative to 1976-2005) for a High Emissions Scenario
Extreme Precipitation Event Frequency for events of 2-day duration and 5-year return (for high and intermediate scenarios)
WIDESPREAD OBSERVED IMPACTS
The CHANGING OCEAN

- Sea levels have risen 7-8 inches since 1900
- Sea Level Rise Now Highest Rate in at least 2800 years
- Acidification of the Oceans
- Changing ocean circulation
“Nuisance Flooding” is Increasing Across the United States

Based on 2014 U.S. National Climate Assessment

But latest analyses suggest the high end may not be high enough
Past and Projected Changes in Global Sea Level

Best SLR estimate is another 1-4 feet by 2100. But could be as large as 8 feet.
Regional SLR in 2100 projected for the Intermediate Scenario (3.3 feet) GMSL

Projected Relative Sea Level Change for 2100 under the Intermediate Scenario

Change in Sea Level (feet)
Potential Surprises: There is a Significant Possibility for Unanticipated Changes

- **Tipping elements** within the Earth system exhibit critical thresholds, sometimes called “tipping points”.
- They have the potential to enter into self-amplifying cycles that commit them to shifting from their current state into a new state.
- State shifts can occur abruptly; or they may be locked in rapidly but take decades or centuries to play out.