NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

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Humans, Oceans Shaped North American Climate over Past 50 Years

Sea-Surface Temperatures Vital to Predicting U.S. Regional Climate Changes

Greenhouse gases play an important role in North American climate, but differences in regional ocean temperatures may hold a key to predicting future U.S. regional climate changes, according to a new NOAA-led scientific assessment. The assessment is one in a series of synthesis and assessment reports coordinated by the U.S. Climate Change Science Program.

This latest assessment, *Reanalysis of Historical Climate Data for Key Atmospheric Features: Implications for Attribution of Causes of Observed Change,* describes what has changed—and why—in North America's climate over the past half century. The assessment addresses the likelihood and extent to which human activity or natural variations have driven surface warming, precipitation, droughts, and floods.

"A major implication of this assessment is that improving predictions of regional sea-surface temperatures will be crucial to predicting climate variability across the U.S. from years to decades, as well as projecting long-term regional climate changes," said Randall Dole, lead author and a scientist at NOAA's Earth System Research Laboratory in Boulder, Colo.

Some regional temperatures rose sharply, while others held steady; drought impacts worsened; and precipitation swung widely—all within the continent's gradually warming climate.

Changes in sea-surface temperature patterns likely played an important role in determining differences in U.S. regional temperature trends. They also contributed to large precipitation swings from year to year or decade to decade during the past 50 years.

While a general trend toward warmer ocean conditions is expected with increasing greenhouse gases, regional differences in sea surface temperature trends can be either natural or human-caused, according to Dole.

The assessment found that an increase in greenhouse gases is likely responsible for more than half of the average continental warming of 1.6° Fahrenheit observed during the past 50 years. Greenhouse gases, emitted by fossil fuel burning and natural sources, trap heat in Earth's atmosphere and warm the surface.

Drought impacts have likely become more severe as surface temperatures warmed, increasing evaporation, reducing soil moisture, and causing other water stresses. The scientists found no long-term trends in where or how often droughts occur or in how much rain or snow has fallen on average each year.

The assessment also describes in detail how climate scientists use enormous amounts of data in a powerful method for examining past climate, called "reanalysis." Another section

illustrates how they systematically probe cause-and-effect relationships to find the most likely cause of a climate trend, a prolonged drought, or an unusually hot year – a process termed 'attribution'.

In a reanalysis—or retrospective analysis—a high-quality climate record is constructed from past observations collected over a period of time from many different observing systems and combined within a climate model. Reanalysis data, which currently extend as far back as the mid-twentieth century, are important in helping researchers understand how climate evolved.

"Using reanalysis and attribution methods we can now say with more confidence what's driving some of the extreme climate conditions of the past few years: whether it's global warming, El Niño, La Niña, or some other pattern," said NOAA scientist Martin Hoerling, also of the Earth System Research Laboratory and a lead author on the report. "That's the information policymakers and the public ask for." Hoerling also heads NOAA's climate attribution team.

NOAA understands and predicts changes in the Earth's environment, from the depths of the ocean to the surface of the sun, and conserves and manages our coastal and marine resources. www.noaa.gov.

On the Web:
U.S. Climate Change Science Program: http://www.climatescience.gov

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Climate Changes in North America Since 1951: Key Findings

Temperature -- What happened?

• From 1951 to 2006 the yearly average temperature for North America increased by 1.6° Fahrenheit. Virtually all of this warming has occurred since 1970.

• Six of the ten warmest summers in the continental United States since 1951 occurred between 1997 and 2006.

• The largest yearly average regional temperature increases have occurred over northern and western North America, with up to 3.6°F warming in 56 years over Alaska, the Yukon Territories, Alberta, and Saskatchewan.

• No significant yearly average temperature changes have occurred in the southern United States and eastern Canada.

Why?

• More than half of the warming averaged over all of North America is *likely* (more than 66 percent chance) the result of human activity.

• Regional differences in summertime surface temperature trends across North America are *unlikely* (less than 33 percent chance) to be the result of human activity alone. The temperature trends *likely* have been influenced by regional variations in sea surface temperature.

Precipitation -- What Happened?

• There has not been a significant trend, either up or down, in North American precipitation since 1951, although there have been substantial changes from year to year and even decade to decade.

Why?

• The regional and seasonal differences in precipitation changes are *unlikely* to be the result of human activity alone. Some of the variations that have occurred are *likely* the result of regional variations in sea surface temperatures.

• Part of this variability is *likely* the result of regional variations in sea surface temperatures, which influence precipitation patterns.

Drought -- What Happened?

• It is *unlikely* that a fundamental change has occurred in either how often or where severe droughts have occurred over the continental United States during the past half-century.

• Drought impacts over North America have likely become more severe in recent decades.

Why?

- It is *likely* that changes in sea surface temperatures have contributed to multi-year droughts that have affected North America during the past half-century.

- It is *likely* that warming due to human activity has increased drought impacts over North America in recent decades through increased water stresses associated with warming land surface temperatures.