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Climate Change And Oklahoma

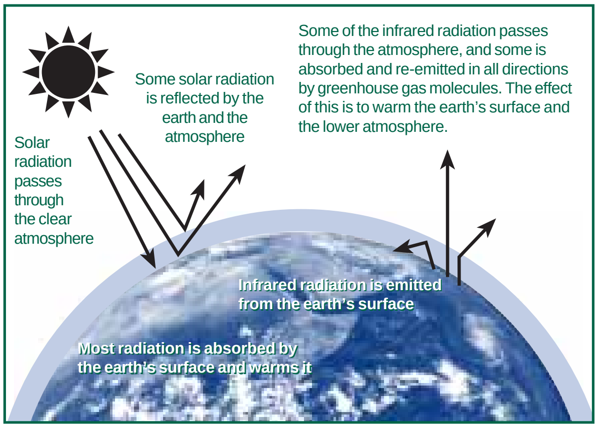
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed. Although there is uncertainty about exactly how and when the earth's climate will respond to enhanced concentrations of greenhouse gases, observations indicate that detectable changes are under way. There most likely will be increases in temperature and changes in precipitation, soil moisture, and sea level, which could have adverse effects on many ecological systems, as well as on human health and the economy.

The Climate System

Energy from the sun drives the earth's weather and climate. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the energy from the sun, creating a natural "greenhouse effect." Without this effect, temperatures would be much lower than they are now, and life as known today would not be possible. Instead, thanks to greenhouse gases, the earth's average temperature is a more hospitable 60°F. However, problems arise when the greenhouse effect is ***enhanced*** by human-generated emissions of greenhouse gases.

Global warming would do more than add a few degrees to today's average temperatures. Cold spells still would occur in winter, but heat waves would be more common. Some places would be drier, others wetter. Perhaps more important, more precipitation may come in short, intense bursts (e.g., more than 2 inches of rain in a day), which could lead to more flooding. Sea levels would be higher than they would have been without global warming, although the actual changes may vary from place to place because coastal lands are themselves sinking or rising.

The Greenhouse Effect



Source: U.S. Department of State (1992)

Emissions Of Greenhouse Gases

Since the beginning of the industrial revolution, human activities have been adding measurably to natural background levels of greenhouse gases. The burning of fossil fuels — coal, oil, and natural gas — for energy is the primary source of emissions. Energy burned to run cars and trucks, heat homes and businesses, and power factories is responsible for about 80% of global carbon dioxide emissions, about 25% of U.S. methane emissions, and about 20% of global nitrous oxide emissions. Increased agriculture and deforestation, landfills, and industrial production and mining also contribute a significant share of emissions. In 1994, the United States emitted about one-fifth of total global greenhouse gases.

Concentrations Of Greenhouse Gases

Since the pre-industrial era, atmospheric concentrations of carbon dioxide have increased nearly 30%, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about 15%. These increases have enhanced the heat-trapping capability of the earth's atmosphere. Sulfate aerosols, a common air pollutant, cool the atmosphere by reflecting incoming solar radiation. However, sulfates are short-lived and vary regionally, so they do not offset greenhouse gas warming.

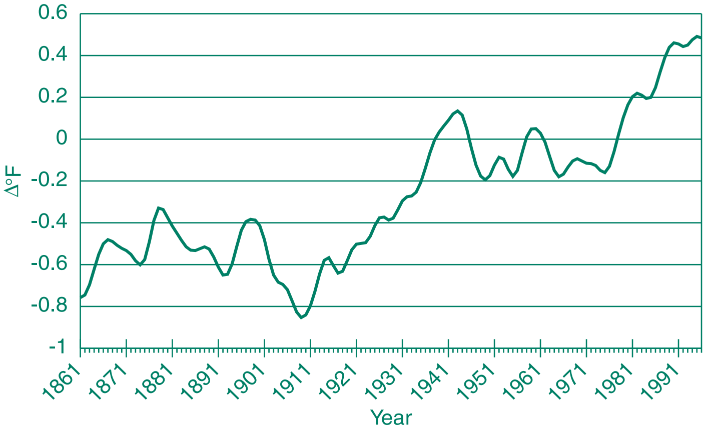
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and institutional developments. Several emissions scenarios have been developed based on differing projections of these underlying factors. For example, by 2100, in the absence of emissions control policies, carbon dioxide concentrations are projected to be 30-150% higher than today's levels.

Current Climatic Changes

Global mean surface temperatures have increased 0.6-1.2°F between 1890 and 1996. The 9 warmest years in this century all have occurred in the last 14 years. Of these, 1995 was the warmest year on record, suggesting the atmosphere has rebounded from the temporary cooling caused by the eruption of Mt. Pinatubo in the Philippines.

Several pieces of additional evidence consistent with warming, such as a decrease in Northern Hemisphere snow cover, a decrease in Arctic Sea ice, and continued melting of alpine glaciers, have been corroborated. Globally, sea levels have risen

Global Temperature Changes (1861–1996)



Source: IPCC (1995), updated

4-10 inches over the past century, and precipitation over land has increased slightly. The frequency of extreme rainfall events also has increased throughout much of the United States.

A new international scientific assessment by the Intergovernmental Panel on Climate Change recently concluded that ***"the balance of evidence suggests a discernible human influence on global climate."***

Future Climatic Changes

For a given concentration of greenhouse gases, the resulting increase in the atmosphere's heat-trapping ability can be predicted with precision, but the resulting impact on climate is more uncertain. The climate system is complex and dynamic, with constant interaction between the atmosphere, land, ice, and oceans. Further, humans have never experienced such a rapid rise in greenhouse gases. In effect, a large and uncontrolled planet-wide experiment is being conducted.

General circulation models are complex computer simulations that describe the circulation of air and ocean currents and how energy is transported within the climate system. While uncertainties remain, these models are a powerful tool for studying climate. As a result of continuous model improvements over the last few decades, scientists are reasonably confident about the link between global greenhouse gas concentrations and temperature and about the ability of models to characterize future climate at continental scales.

Recent model calculations suggest that the global surface temperature could increase an average of 1.6-6.3°F by 2100, with significant regional variation. These temperature changes would be far greater than recent natural fluctuations, and they would occur significantly faster than any known changes in the last 10,000 years. The United States is projected to warm more than the global average, especially as fewer sulfate aerosols are produced.

The models suggest that the rate of evaporation will increase as the climate warms, which will increase average global precipitation. They also suggest increased frequency of intense rainfall as well as a marked decrease in soil moisture over some mid-continental regions during the summer. Sea level is projected to increase by 6-38 inches by 2100.

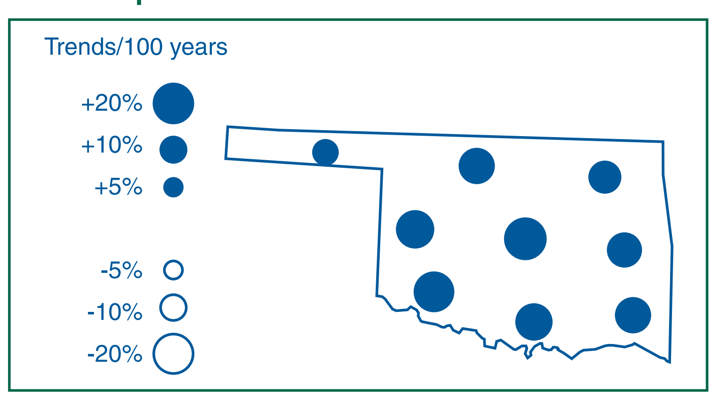
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency of hot or cold spells, and the intensity of associated fire and pest outbreaks) could increase.

Local Climate Changes

Over the last century, the average temperature in Stillwater, Oklahoma, has increased 0.6°F, and precipitation has increased by up to 20% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in Oklahoma may change even more. For example, based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that accounts for both greenhouse gases and aerosols, by 2100 temperatures in Oklahoma could increase by 2°F (with a range of 1-4°F) in spring, 3°F in summer and fall (with a range of 1-5°F), and 4°F in winter (with a range of 2-6°F). Precipitation is estimated to change little in winter, to increase slightly in fall (with a range of 0-10%), and to increase by 20% in spring and summer (with a range of 10-30%). Other climate models may show different results, especially regarding estimated changes in precipitation. The impacts described in the sections that follow take into account estimates from different models. The amount of precipitation on extreme wet days in summer is likely to increase. The frequency of extreme hot days in summer would increase because of the general warming trend. It is not clear how the severity of storms such as tornados might be affected, although an increase in the frequency and intensity of summer thunderstorms is possible.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

Human Health

Higher temperatures and increased frequency of heat waves may increase the number of heat-related deaths and the incidence of heat-related illnesses. The elderly, especially those living alone, are at greatest risk. These effects have been studied only for populations living in urban areas; however, even those in rural areas may be susceptible. This study projects little change in winter-related deaths.

Climate change could increase concentrations of ground-level ozone. For example, high temperatures, strong sunlight, and stable air masses tend to increase urban ozone levels. Although Oklahoma is in compliance with current air quality standards, increased temperatures could make remaining in compliance more difficult. Ground-level ozone is associated with respiratory illnesses such as asthma, reduced lung function, and respiratory inflammation. Air pollution also is made worse by increases in natural hydrocarbon emissions such as emissions of terpenes by trees and shrubs during hot weather. If a warmed climate causes increased use of air conditioners, air pollutant emissions from power plants also will increase. Upper and lower respiratory allergies also are influenced by humidity. A 2°F warming and wetter conditions could increase respiratory allergies.

Warming and other climate changes could expand the habitat and infectivity of disease-carrying insects, thus increasing the potential for transmission of diseases such as malaria and dengue ("break bone") fever. Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in Oklahoma can carry western equine encephalitis, which can be lethal or cause neurological damage. If conditions become warmer and wetter, mosquito populations could increase, thus increasing the risk of transmission if these diseases are introduced into the area.

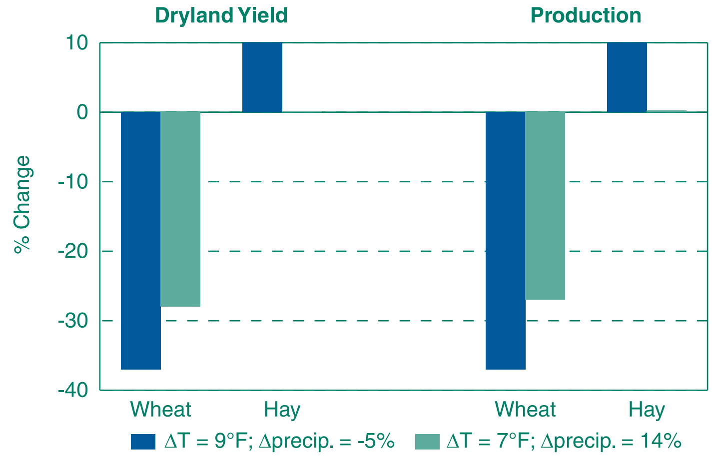
Warmer temperatures could increase the incidence of Lyme disease and other tick-borne diseases in Oklahoma, because populations of ticks, and their rodent hosts, could increase under warmer temperatures and increased vegetation. Increased runoff from heavy rainfall could increase water-borne diseases such as giardia, cryptosporidia, and viral and bacterial gastroenteritides.

Developed countries such as the United States should be able to minimize the impacts of these diseases through existing disease prevention and control methods.

Agriculture

The mix of crop and livestock production in a state is influenced by climatic conditions and water availability. As climate warms, production patterns could shift northward. Increases in climate variability could make adaptation by farmers more difficult. Warmer climates and less soil moisture due to increased evaporation may increase the need for irrigation. However, these same conditions could decrease water supplies, which also may be needed by natural ecosystems, urban populations, industry, and other users.

Changes In Agricultural Yield And Production



Sources: Mendelsohn and Neumann (in press); McCarl (personal communication)

Understandably, most studies have not fully accounted for changes in climate variability, water availability, crop pests, changes in air pollution such as ozone, and adaptation by farmers to changing climate. Including these factors could change modeling results substantially. Analyses that assume changes in average climate and effective adaptation by farmers suggest that aggregate U.S. food production would not be harmed, although there may be significant regional changes.

In Oklahoma, production agriculture is a $3.9 billion annual industry, 70% of which comes from livestock, mainly cattle. Very few of the farmed acres are irrigated. The major crops in the state are wheat and hay. Climate change could reduce wheat yields by 27-37% as temperatures rise beyond the tolerance levels of the crop. Hay and pasture yields could remain constant or could rise by 10%, depending on how climate changes. Farmed acres could remain fairly constant. Livestock and dairy production may not be affected, unless summer temperatures rise significantly and conditions become significantly drier. Under these conditions, livestock tend to gain less weight and pasture yields decline, limiting forage.

Water Resources

Oklahoma lies entirely within the Arkansas, White, and Red river basins. The water resources of the state, however, are unevenly distributed. The eastern part of Oklahoma has plentiful surface water, which is used primarily for the municipal supplies of Oklahoma City and Tulsa, for thermoelectric power generation, and for pulp and paper manufacturing. The western part of the state relies primarily on groundwater, which is used principally for irrigation. The largest groundwater withdrawals are in the panhandle, which overlies the High Plains, or Ogallala, aquifer. Oklahoma's water resources are characterized by long droughts and frequent floods. This situation could be exacerbated by a warmer climate. Runoff in the state is determined largely by rainfall and to a small degree by spring snowmelt. A warmer climate would lead earlier to snowmelt, resulting in higher streamflows in winter and spring. In the summer, without large increases in precipitation, higher temperatures and increased evaporation could lower streamflows and lake levels. Less recharge also would reduce groundwater levels. Less water would be available to support important uses of the numerous reservoirs in eastern Oklahoma, such as navigation, hydropower generation, water supply, recreation, and fish and wildlife habitat. In the central area of the state, the higher water demands resulting from population growth, increasing urbanization, and industrialization would become increasingly difficult to meet. In western Oklahoma, water withdrawals exceed recharge in some areas and groundwater levels are declining. Surface waters are also undependable and often unusable because of high concentrations of chloride and dissolved minerals. Many urban areas in western Oklahoma have water demands that exceed their supply, and they continually acquire additional surface-water rights as they become available or explore the possibility of water transfer from surplus areas to the east. Lower flows would compound water shortages in the west. Increased temperatures and lower streamflows also could impair water quality by concentrating pollutant levels and reducing the ability of streams to assimilate wastes. Increased pollution is a concern in streams downstream of large urban areas such as Oklahoma City and in scenic rivers such as the Illinois River where development has expanded.

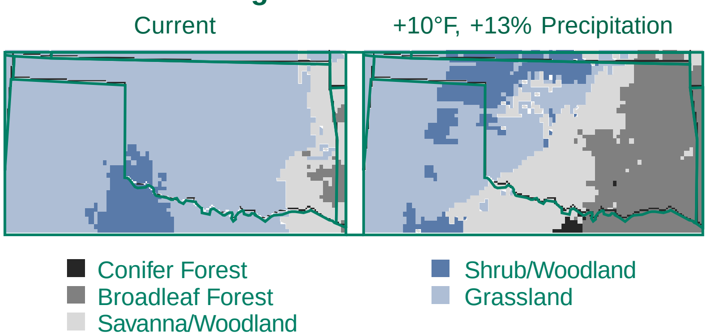
More rain could ameliorate these impacts, but it also could increase flooding. Flooding in urban areas and along tributary streams is a recurring problem in Oklahoma. More intense rains are also expected with climate change, which would increase erosion and sedimentation and exacerbate levels of pesticides and fertilizers in runoff from agricultural areas. It also would increase pollution in runoff from mining areas and oil and gas exploration areas.

Forests

Trees and forests are adapted to specific climate conditions, and as climate warms, forests will change. These changes could include changes in species composition, geographic range, and health and productivity. If conditions also become drier, the current range of forests could be reduced and replaced by grasslands and pasture. Even a warmer and wetter climate could lead to changes; trees that are better adapted to warmer conditions, such as southern pines, would spread. Under these conditions, forests could become more dense. These changes could occur during the lifetimes of today's children, particularly if the change is accelerated by other stresses such as fire, pests, and diseases. Some of these stresses would themselves be worsened by a warmer and drier climate.

With changes in climate, the extent and density of the forested areas in eastern Oklahoma could change. Hotter, drier weather could increase wildfires and the susceptibility of pine forests to pine bark beetles and other pests, leading to reduced forests and expanded grasslands and arid shrublands. However, with increased rainfall (shown in some studies), the areal extent of Oklahoma forests could rise. In some areas, the types of trees dominating eastern Oklahoma forests would change; for example, southern pines and oaks could increase in some of the hardwood forests of eastern Oklahoma.

Changes In Forest Cover



Sources: VEMAP Participants (1995); Neilson (1995)

Ecosystems

Few states encompass as much natural diversity as Oklahoma. In the southeast, the forests of the Mississippi River floodplain are home to bald cypresses. In the extreme west, piñon and ponderosa pines are found at elevations approaching 4,500 feet. Between these extremes, oak woodlands historically transitioned into tallgrass and shortgrass prairies. Today, in the face of agricultural development, many of these native ecosystems are endangered. The tallgrass prairie ranks as one of the most threatened plant communities in the Midwest and the world. Extensive agriculture, demand for irrigation, and dam construction on the Arkansas River have degraded habitats of prairie fishes. Historically, frequent, low-intensity surface fires perpetuated park-like ponderosa pine stands with grassy undergrowth. Today, after 60 years of fire suppression, many of the ponderosa pine forests have high densities of trees, are plagued by epidemics of insects and diseases, and are subject to severe stand-destroying fires. Climate change could exacerbate the stresses and threats to these sensitive ecosystems.

Warmer temperatures and precipitation increases could alter the balance of freshwater ecosystems. The physical impacts on streams in the Ozarks are likely to be significant. Because of extensive land use changes, coarse gravel (with low water retention capacity) has been accumulating along riparian shores at the expense of fine sediment. Research has demonstrated that changes in water flow, which could be exacerbated by climate change in the future, affect the ability of willows and sycamores to germinate, which in turn is expected to affect sediment transport processes and habitat availability in these riparian systems. A warming climate with less rain could increase pressure on aquifers such as the Ogallala, which in turn may affect the Arkansas river basin.

For further information about the potential impacts of climate change, contact the Climate and Policy Assessment Division (2174), U.S. EPA, 401 M Street SW, Washington, DC 20460, or visit http://www.epa.gov/globalwarming/impacts.