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EPA Climate Change And Missouri

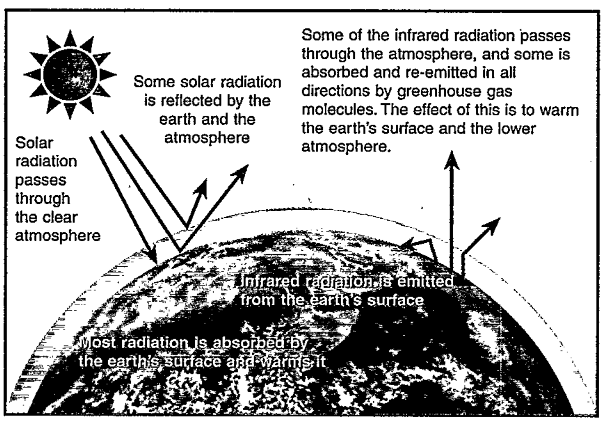
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed. 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, common air pollutants, cool the atmosphere by reflecting incoming solar radiation. However, sulfates are short-lived and vary regionally.

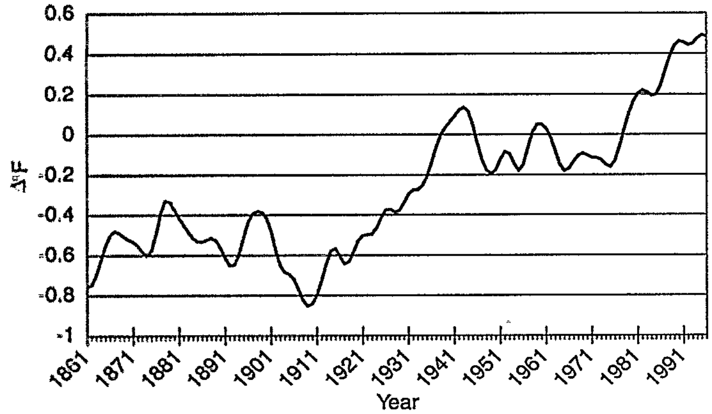
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and 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.

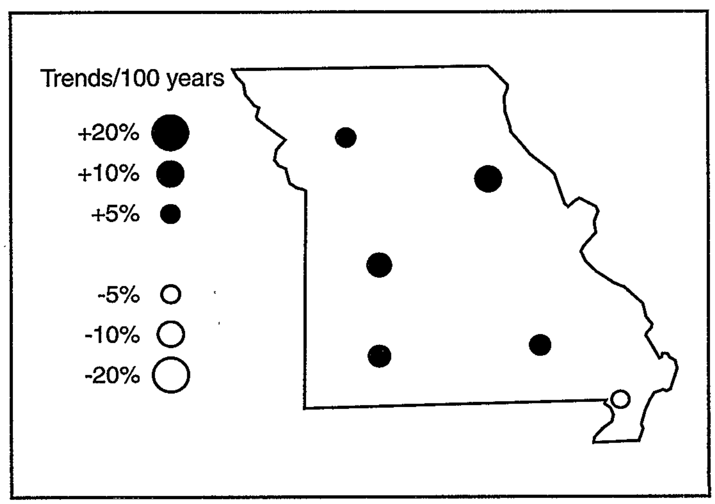
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency 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 Jefferson City, Missouri, has decreased 0.5°F, and precipitation has increased by up to 10% in many parts of the state.

Over the next century, climate in Missouri could experience additional changes. 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 Missouri could increase by about 2°F in summer (with a range of 1-4°F) and about 3°F in the other seasons (with a range of 1-7°F). Little change is estimated for winter precipitation. Increases of about 15% are estimated for spring and fall, and the summer increase is estimated to range between 20 and 60%. Other climate models may show different results, with winter precipitation increasing more than summer precipitation. 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. Although it is not clear how severe storms would change, an increase in the frequency and intensity of summer thunderstorms is possible.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

Climate Change Impacts

Global climate change poses risks to human health and to terrestrial and aquatic ecosystems. Important economic resources such as agriculture, forestry, fisheries, and water resources also may be affected. Warmer temperatures, more severe droughts and floods, and sea level rise could have a wide range of impacts. All these stresses can add to existing stresses on resources caused by other influences such as population growth, land-use changes, and pollution.

Similar temperature changes have occurred in the past, but the previous changes took place over centuries or millennia instead of decades. The ability of some plants and animals to migrate and adapt appears to be much slower than the predicted rate of climate change.

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. Missouri, with its irregular, intense heat waves, could be especially susceptible.

In St. Louis, one study projects that by 2050 heat-related deaths during a typical summer could increase 170%, from about 80 heat-related deaths per summer to over 200 (although increased air conditioning use may not have been fully accounted for). Winter-related deaths are expected to change very little. The elderly, particularly those living alone, are at greatest risk.

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. Air pollution also is made worse by increases in natural hydrocarbon emissions during hot weather. If a warmed climate causes increased use of air conditioners, air pollutant emissions from power plants also will increase.

A 4°F warming in the Midwest, with no other change in weather or emissions, could increase concentrations of ozone, a major component of smog, by as much as 8%. Currently, the St. Louis area is classified as a "moderate" nonattainment area for ozone. Ground-level ozone has been shown to aggravate respiratory illnesses such as asthma, reduce existing lung function, and induce respiratory inflammation. In addition, ambient ozone reduces crop yields and impairs ecosystem health.

Warming and other climate changes may 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. Mosquitos flourish in Missouri, and some carry St. Louis encephalitis. Also, the mosquitoes that carry dengue fever, Eastern equine encephalitis, and LaCrosse encephalitis recently have spread as far north as Chicago. Global warming could shift farther north the region where these mosquitoes breed and overwinter. If conditions become warmer and wetter, mosquito populations could increase, thereby increasing the risk of transmission of these diseases.

Water Resources

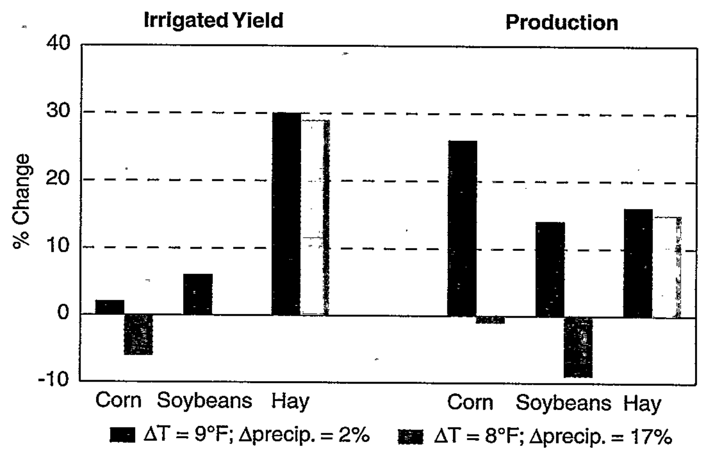
Water resources are affected by changes in precipitation as well as by temperature, humidity, wind, and sunshine. Changes in streamflow tend to magnify changes in precipitation. Water resources in drier climates tend to be more sensitive to climate changes. Because evaporation is likely to increase with warmer climate, it could result in lower river flow and lower lake levels, particularly in the summer. If streamflow and lake levels drop, groundwater also could be reduced. In addition, more intense precipitation could increase flooding.

The Missouri River drains about two-thirds of the state. The remainder of the rivers in the state drain directly to the Mississippi River, except a few in the southern portion of the state that drain into the Arkansas River. The Missouri, Mississippi, and Arkansas are all large rivers, whose flows are mostly generated outside and well upstream of the state (for example, in Montana and Wyoming). Increased rainfall could lead to localized flooding. However, summer flows could be reduced considerably if summer rainfall decreases. These conditions could present a range of problems for municipal and industrial water supply, as well as for instream water uses such as navigation and recreation.

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 sectors.

Changes In Agricultural Yield And Production

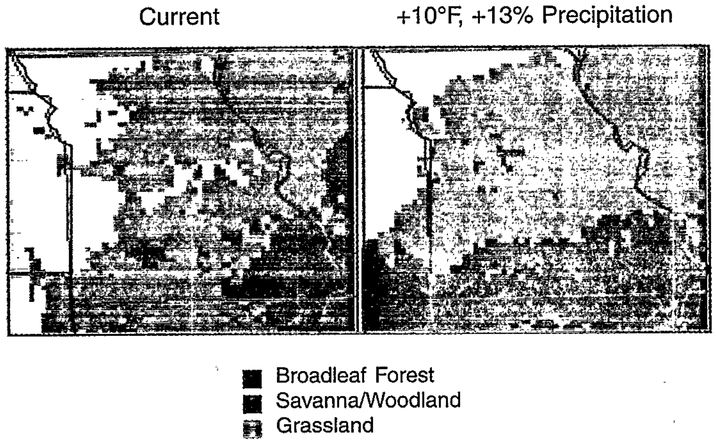


Source: Mendelsohn and Neumann (in press); McCarl (personal communication).

Understandably, most studies have not fully accounted for changes in climate variability, water availability, and imperfect responses 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 Missouri, agriculture is a $4 billion annual industry, one-half of which comes from livestock, especially cattle. Less than 10% of the crop acreage is irrigated. The major crops in the state are corn, soybeans, and hay. Corn and soybean yields could fall by as much as 22% or rise by as much as 6%, depending on whether irrigation is used. Hay yields could increase by about 30%. These yield changes could lead to changes in acres farmed and production. For example, corn yields could increase only slightly while production rises substantially because of an increase in corn acres farmed.

Changes In Forest Cover



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

Forests

Trees and forests are adapted to specific climate conditions, and as climate warms, forests will change. These changes could include changes in species, geographic range, and health and productivity. If conditions also become drier, the current range and density 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 oaks and southern pines, would prevail. Under these conditions, forests could become more dense. These changes could occur during the lifetimes of today's children, particularly if 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 of forested areas in Missouri could change little or decline by as much as 10-20%. The uncertainties depend on many factors, including whether soils become drier and, if so, how much drier. Hotter, drier weather could increase the frequency and intensity of wildfires, whereas increased rainfall could reduce their severity. In areas with richer soils, the range and density of southern pines could increase and become more dominant within the oak and hickory forests that predominate in southern Missouri and in the Ozarks. In areas with poorer soils, which are more common in Missouri's forestlands, scrub oaks of little commercial value (e.g., post oak and blackjack oak) could increase. Grasslands and savanna eventually could replace forests and woodlands in northern Missouri. These changes would significantly affect the character of Missouri forests and the activities that depend on them.

Ecosystems

Ecosystems in Missouri include extensive forests, rivers, streams, and prairies. The Ozark Mountains contain several rivers designated as "Wild and Scenic" by Congress; these rivers also provide winter habitat for many bald eagles. Riparian and stream ecosystems are especially sensitive to changes in rainfall. Water temperature changes caused by climate change could reduce habitat for smallmouth bass, northern pike, and other species such as walleye and yellow perch.

Changes in temperature and rainfall could shift the types and locations of habitats and ecosystems, in particular, the tallgrass prairies. Climate change could increase pressure on Missouri prairie lands from non-native plants. Prairie State Park, which is Missouri's largest remaining tallgrass prairie, provides habitat for approximately 150 bird species and 25 rare or endangered species. The park also contains Missouri's most pristine prairie headwater stream, East Drywood Creek, and wildlife such as the American bison, elk, greater prairie chicken, northern harrier, upland sandpiper, scissor-tailed flycatcher, and coyote. The fragmented prairie could impede migration of some plants and animals vulnerable to climate change.

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.