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Climate Change And Mississippi

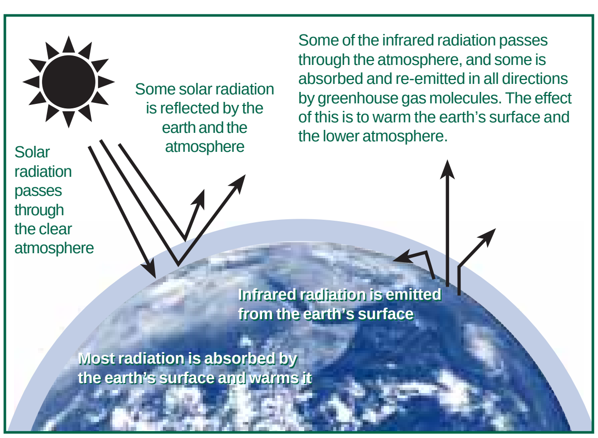
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed. 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.

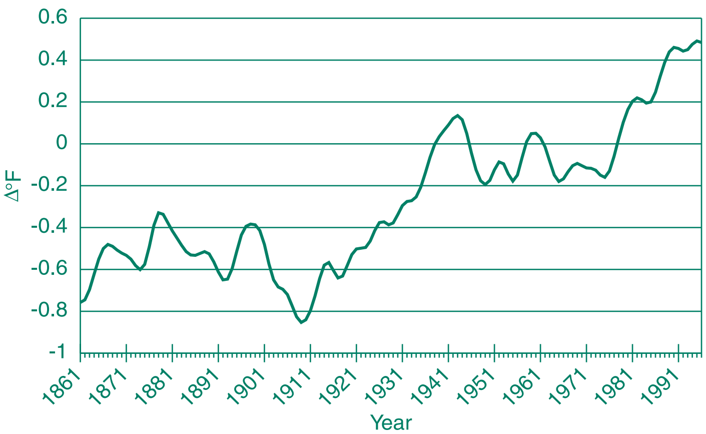
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

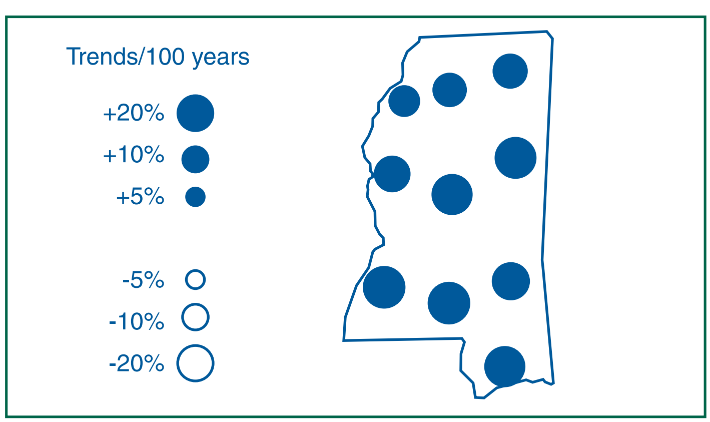
Over the last century, the average temperature near Jackson, Mississippi, has decreased 2.1°F, and precipitation has increased by up to 20% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in Mississippi 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 Mississippi could increase by 2°F in winter and summer (with a range of 1-4°F), 3°F in spring (with a range of 1-5°F), and 4°F in fall (with a range of 2-6°F). Precipitation is estimated to change little in winter, increase by 10% in spring (with a range of 5-20%), and 15% in summer and fall (with a range of 5-25%). 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 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 hurricanes might be affected, although an increase in the frequency and intensity of summer thunderstorms is possible.

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, particularly those living alone,

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

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.

Upper and lower respiratory allergies are influenced by humidity. A 2°F warming and wetter conditions could increase respiratory allergies.

Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in Mississippi can carry malaria, and others can carry eastern 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. Increased runoff from heavy rainfall could increase water-borne diseases such as giardia, cryptosporidia, and viral and bacterial gastroenteritides. Rodent populations that carry hantavirus and leptospirosis (a bacterium) are sensitive to climatic factors. Drought can reduce rodent predators (owls, snakes, coyotes), and sudden rains can bring new food supplies to rodents. These conditions could be associated with upsurges in rodent populations. Developed countries such as the United States should be able to minimize the impacts of these diseases through existing disease prevention and control methods.

In addition, warmer seas could contribute to the increased intensity, duration, and extent of harmful algal blooms, that is, red tides. These blooms damage habitat and shellfish nurseries, can be toxic to humans, and can carry bacteria like those causing cholera.

Coastal Areas

Sea level rise could lead to flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater contamination of drinking water, and decreased longevity of low-lying roads, causeways, and bridges. In addition, sea level rise could increase the vulnerability of coastal areas to storms and associated flooding.

Mississippi has a 360-mile tidally influenced shoreline along the Gulf of Mexico. The shoreline consists of a low-lying coastal plain, narrow barrier islands, and low terraces. At Pass Christian, sea level already is rising by 5 inches per century, and it is likely to rise another 15 inches by 2100. Possible responses to sea level rise include building walls to hold back the sea, allowing the sea to advance and adapting to it, and raising the land (e.g., by replenishing beach sand, elevating houses and infrastructure). Each of these responses will be costly, either in out-of-pocket costs or in lost land and structures. For example, the cumulative cost of sand replenishment to protect the coast of Mississippi from the estimated sea level rise by 2100 is $70-$140 million. However, sand replenishment may not be cost-effective for all coastal areas in the state, and therefore some savings could be possible.

Water Resources

In a warmer climate, runoff in Mississippi would primarily be influenced by higher temperatures, increased evaporation, and changes in precipitation. Lower streamflows, lake levels, and groundwater levels in the summer could affect water availability and increase competition among domestic, industrial, and agricultural uses of water.

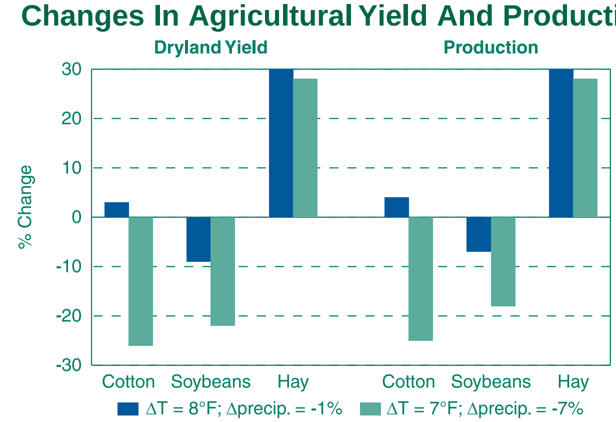
Declining groundwater levels are a matter of concern throughout the state. Increased rice irrigation and fish farming in the northwestern Delta region have reduced groundwater levels in the Mississippi alluvial aquifer. Increased municipal and industrial withdrawals in the metropolitan Jackson area, along the Gulf Coast, and in northeastern Mississippi also have lowered groundwater levels. Additionally, in the southern half of the state, saline water has begun to intrude into freshwater aquifers because of declining groundwater levels along the coast as well as from saline waste water injection into oil-field production zones. Warmer and drier conditions, particularly if accompanied by sea level rise, could compound these types of problems due to higher demand and lower flows.

Higher rainfall and streamflow would alleviate water supply problems, but could increase flooding. Floodplains along the Pearl River, including areas near Jackson, Columbia, Picayune, and along the lower reaches to the Gulf of Mexico, are vulnerable to flooding. Reaches of the Yazoo, Big Black, Tombigbee, and Leaf rivers near Hattisburg, as well as low-lying agricultural lands, also are subject to periodic inundation. Higher rainfall could increase erosion and levels of pesticides and fertilizers in runoff from agricultural lands, a major cause of degraded water quality.

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)

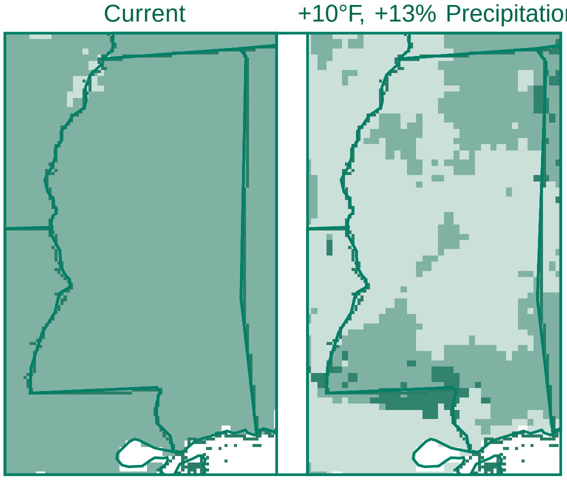
Understandably, most studies have not fully accounted for changes in climate variability, water availability, crop pests, changes in air pollution such as ozone, and adaptation by farmers to changing climate. Including these factors could change modeling results substantially. Analyses that assume changes 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 Mississippi, production agriculture is a $2.6 billion annual industry, 60% of which comes from livestock, mainly poultry. Almost 20% of the farmed acres are irrigated. The major crops in the state are cotton, soybeans and hay. Irrigated soybean yields could rise by 4-18%; without irrigation soybean yields could fall 9-22%. Cotton yields could rise by 3% or fall by 25%, depending on how climate changes. Farmed acres are projected to remain fairly constant; however, an increased share of this acreage could become irrigated. 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.

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 subtropical evergreens, would prevail over time. 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.

Changes In Forest Cover



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

In Mississippi, longleaf and slash pine forests could expand northward and replace loblolly and shortleaf pine forests. Wetter conditions would favor expansion of southern pine forests as well as oak and hickory forests and the gum and cypress forests found along the Gulf Coast. In contrast, under drier conditions, 50-75% of forests in the east-central part of the state could be replaced by grasslands and pasture. Warmer and drier conditions could increase the frequency and intensity of fires, which could result in increased losses to important commercial timber areas and speed the transition to grassland. Even warmer and wetter conditions could stress forests by increasing the winter survival of insect pests.

Ecosystems

Most of Mississippi is made up of habitats associated with either the coastal plain or the Mississippi Delta. The coastline is separated from the Gulf of Mexico by a shallow sound and is paralleled by a series of barrier islands. Farther inland are tracts of wet savanna habitat, home to the critically endangered nonmigratory Mississippi sandhill crane. Only small remnants are left of the formerly extensive Black Belt and Jackson Prairies, in which several species of endemic crayfish are found. Bald eagles, a threatened species, use the Upper Mississippi River valley as a winter migration corridor and for summer nesting habitat. The Mississippi flatlands in the alluvial plain attract hundreds of thousands of migrating snow geese, Canada geese, and ducks in the winter. About 55% of the land area of Mississippi is covered with forests, including bottomland hardwoods, pine woods, and oak-hickory forests.

Wetlands play a major role in basin hydrology and serve as wildlife habitats. Changes in water levels brought about by a changing climate can dramatically alter the extent of these ecosystems. Wet savanna habitats are already under threat from conversion into pine plantations. Coastal wetlands are among the ecosystems most vulnerable to climate change. The low-lying Mississippi Delta is particularly vulnerable to the effects of sea level rise — inundation of coastal lands, intrusion of saltwater into coastal freshwater ecosystems, increase in erosion rates and storm damage with increasing wave force and storm frequency. If runoff along the Gulf Coast increases, estuarine flushing rates would increase, leading to reduced yields in shrimp and other species favoring high salinities. Increasing runoff rates and outflow into the Gulf of Mexico could increase nutrient loads and alter water temperatures, exacerbating the already serious eutrophication and low oxygen levels. Loss of coastal wetlands and marshes with rapid sea level rise would reduce estuarine health because many estuarine species depend on wetlands as nursery areas and sources of organic matter. Warmer temperatures could lead to reduced stream flow and warmer water temperatures, which would significantly impair reproduction of fish and other animals and favor the spread of exotic species that exhibit a high tolerance for extreme environmental conditions.

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.