United States Environmental Protection Agency
Office of Policy (2111)
EPA 236-F-98-007a
September 1998

Climate Change And Alabama

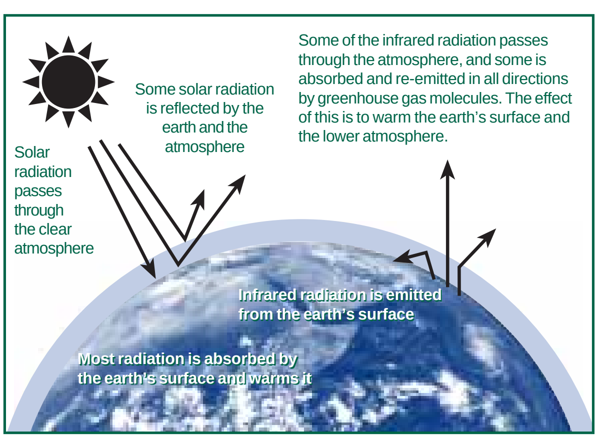
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

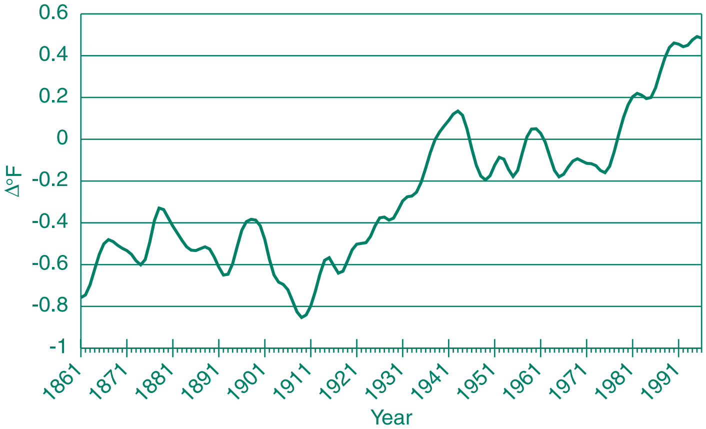
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

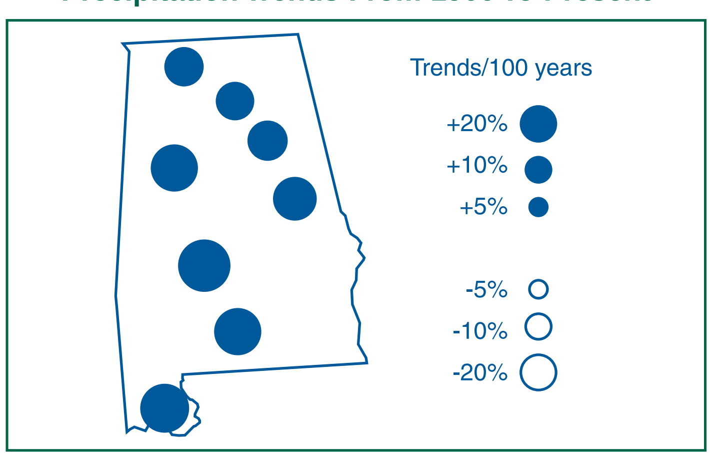
Over the last century, the average temperature in Tuscaloosa, Alabama, has decreased 0.1°F, and precipitation has increased by up to 20% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in Alabama 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 Alabama 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 2-7°F). Precipitation is estimated to change little in winter, increase by 10% in spring (with a range of 5-20%), and increase by 15% in summer and fall (with a range of 5-30%). 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 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. One study, which included Birmingham, found that populations in some southern states are used to regular, intense heat; therefore, little change in the number of heat-related deaths (currently about 40 in Birmingham) is expected.

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. Currently, Birmingham is classified as a moderate “nonattainment” area for ozone (but only marginally). Increased temperatures could increase ozone concentrations further. Ground-level ozone is associated with respiratory illnesses such as asthma, reduced lung function, and respiratory inflammation.

Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in Alabama 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 of rodent populations. 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.

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

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.

Alabama has a 600-mile tidally influenced shoreline along the Gulf of Mexico. The shoreline consists of a low-lying coastal plain, narrow barrier islands, forested swamps, and low terraces. Along much of the Florida Panhandle and Alabama Gulf coast, sea level already is rising by approximately 9 inches per century, and it is likely to rise another 20 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 Alabama from the estimated sea level rise by 2100 is $60-$220 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

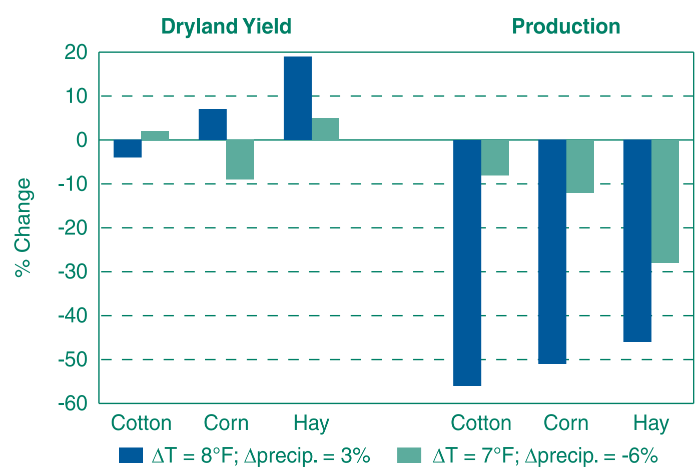
In a warmer climate runoff would be influenced primarily by higher temperatures, increased evaporation, and changes in precipitation. Reduced runoff and lower groundwater levels in the summer could affect the availability of water to satisfy Alabama’s growing and competing needs for municipal, industrial, irrigation, and recreational uses of water. Large groundwater withdrawals in the coastal zones of Baldwin and Mobile counties, which include the Mobile Bay and Gulf Shores regions, have increased salinity in wells due to saltwater intrusion into the aquifers. An increase in sinkhole formation has also been associated with growing groundwater withdrawals. Warmer and drier conditions, particularly if accompanied by rising sea levels, could compound these types of problems due to higher demand and lower flows.

Lower flows and higher temperatures could also degrade water quality by concentrating pollutants and reducing the assimilation of wastes. One of the largest offstream uses of water in Alabama is thermoelectric power generation. Higher water temperatures could reduce the efficiency of industrial and power plant cooling systems and might make it increasingly difficult to meet regulatory standards for acceptable downstream water temperatures, particularly during extremely warm periods. Increases in precipitation would alleviate these impacts. However, higher rainfall, particularly during the traditional winter-spring flood season, could contribute to localized flooding and increased levels of pesticides and fertilizers in runoff from agricultural areas.

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

Changes In Agricultural Yield And Production



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

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.

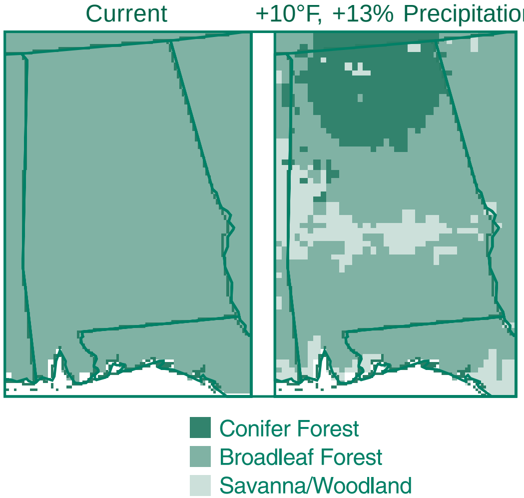
In Alabama, production agriculture is a $3 billion annual industry, two thirds of which comes from livestock, mainly poultry. Very few of the farmed acres are irrigated. The major crops in the state are cotton, corn, and hay. Climate change could leave cotton yields essentially unchanged, and corn yields could rise by 7% or fall by 9%, depending on how climate changes. Hay yields are projected to rise 5-19%. Farmed acres are projected to fall 29-54% as a result of changes in farm production and prices. 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. Commercial timber production could also be affected by resulting changes in growth rates, plantation acreage and management, and market conditions.

In Alabama, longleaf and slash pine forests could expand northward and replace some of the 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, 40-70% 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. Even warmer and wetter conditions could stress forests by increasing the winter survival of insect pests.

Changes In Forest Cover



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

Ecosystems

Alabama is located at the intersection of several geographic areas, and its ancient and complex geological terrain is home to a variety of ecosystems, ranging from the Appalachians in the north to the coastal plain in the south. Although it ranks 29th of all the states in area, it is the nation's fourth in terms of plant and animal species richness. With 235,000 miles of waterways spanning three major river basins (the Mobile, Tennessee, and Apalachicola), its aquatic biodiversity is particularly notable. Freshwater fauna in the rivers and streams include 52% of North America's known freshwater turtles (of these, 22% are endemic to the state), 38% (41% endemic) of freshwater fishes, 60% (34% endemic) of mussels, and 43% (77% endemic) of all gill-breathing snails. The Cahaba River, Alabama's longest free-flowing river, is home to 131 species of fish, the greatest diversity for any river of its size on the continent. Habitat for warmwater fish could be reduced by hotter temperatures. Alabama's coastline may be small in comparison to other Gulf Coast states, but over 500 species of marine mollusks have been found in the coastal sands and waters of Alabama.

Climate change could exacerbate threats to coastal and freshwater ecosystems. For example, warmer air 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. 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, and increases in erosion rates and storm damage resulting from increased storm frequency. If rainfall increases, runoff along the Gulf Coast and the rate of estuarine flushing are expected to increase, leading to reduced yields in shrimp and other species favoring high salinities. Higher runoff rates and outflow into the Gulf of Mexico could increase nutrient loads and alter water temperatures, exacerbating the already serious eutrophication and hypoxia.

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.