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Climate Change And South Carolina

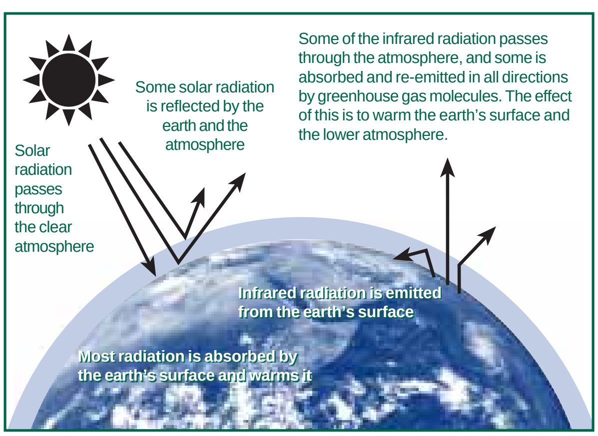
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

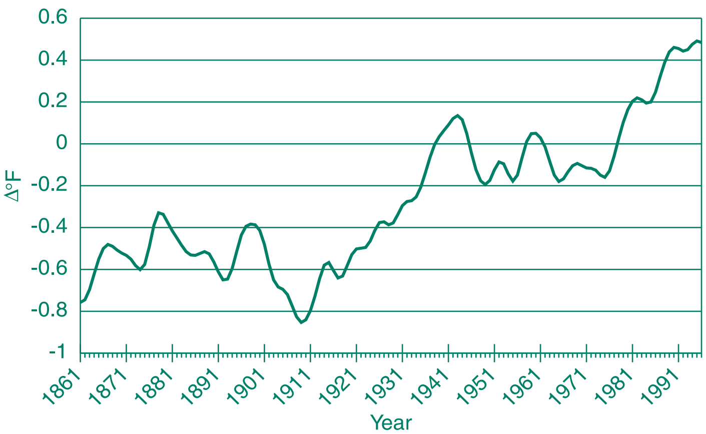
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

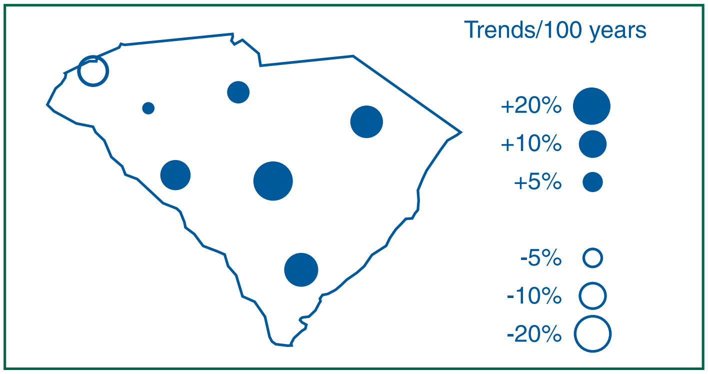
Over the last century, the average temperature in Columbia, South Carolina, has increased 1.3°F, and precipitation has increased by up to 20% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in South Carolina 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 South Carolina could increase by 3°F (with a range of 1-5°F) in all seasons (slightly less in winter and summer, slightly more in spring and fall). Precipitation is estimated to increase by 15% (with a range of 5-30%) in spring, slightly more in summer and fall, and slightly less in winter. 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.

Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in South Carolina 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. 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 the rodents. These conditions could be associated with upsurges of rodent populations. Warmer temperatures could also increase the incidence of Lyme disease and other tick-borne diseases in South Carolina, because populations of ticks, and their rodent hosts, could increase under warmer temperatures and increased vegetation.

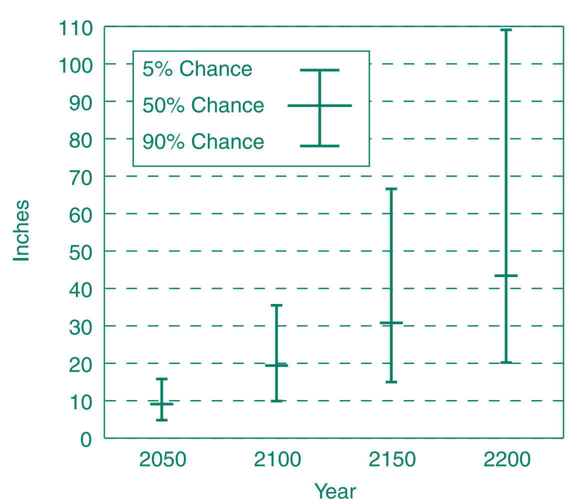
In addition, warmer seas could contribute to the increased intensity, duration, and extent of harmful algal blooms, that is, red tides. These blooms damage habitat and shellfish nurseries, can be toxic to humans, and can carry bacteria like those causing cholera. Brown algal tides and toxic algal blooms already are prevalent in the Atlantic. Warmer ocean waters could increase their occurrence and persistence.

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.

Future Sea Level Rise At Charleston



Source: EPA (1995)

There are 2,876 miles of tidally influenced shoreline in South Carolina. Historical rates of accretion and erosion vary considerably across the state's coastline — erosion has been most severe on a 20-mile section of the Grand Strand and parts of the Santee delta, while Kiawah Island is accreting at a rate of 9 feet per year. Erosion is likely to increase under a 1-3 foot rise in sea level. The potential for increased storm damage as a result of sea level rise is particularly high along the densely developed Grand Strand.

At Charleston, sea level already is rising by 9 inches per century, and it is likely to rise another 19 inches by 2100. The cumulative cost of sand replenishment to protect the coast of South Carolina from a 20-inch sea level rise by 2100 is estimated at $1.2-$9.4 billion. 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 northwestern South Carolina, where most of the state's population lives, lower streamflows, lake levels, and groundwater levels could affect the availability of water supplies for industrial, municipal, and recreational activities. Levels could be lowered in the shallow wells which serve the rural population in this region. Along the Coastal Plain, increased groundwater pumping in areas such as Hilton Head-Beaufort and Myrtle Beach has resulted in saltwater intrusion into freshwater aquifers. Increased use of groundwater for irrigated agriculture in the Coastal Plain also has resulted in declining groundwater levels and may have accelerated the formation of sinkholes in the region's limestone terrain. These conditions, particularly if accompanied by sea level rise, could be exacerbated by warmer, drier conditions.

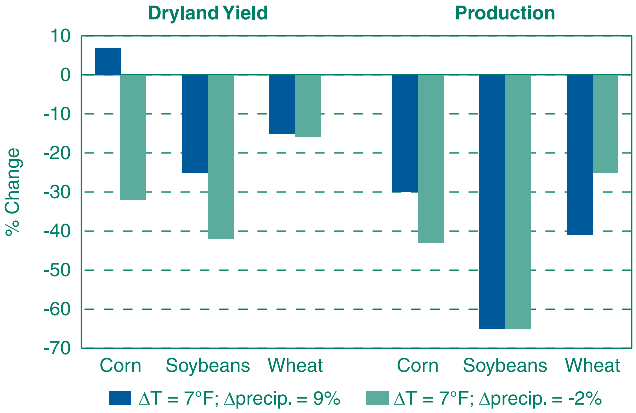
Lower flows and higher temperatures could worsen current water quality concerns such as the excessive growth of aquatic weeds in lakes and the impacts of wastewater discharges on shellfish harvests and recreation.

Higher rainfall could mitigate these effects, but would contribute to localized flooding. Higher rainfall also could increase erosion and exacerbate levels of pesticides and fertilizers in runoff from agricultural areas. It also could increase pollution in runoff from urban areas. The effect of buried hazardous wastes on groundwater quality, particularly in Barnwell County and near the Savannah River Plant, is a concern in South Carolina. Although the effects of climate change on the movement of pollutants are not well understood, changes in infiltration rates could affect the rate at which pollutants migrate throughout an aquifer. Increased precipitation could contribute to groundwater contamination by increasing the inflow of contaminants into nearby aquifers.

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

Changes In Agricultural Yield And Production



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

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 South Carolina, production agriculture is a $1.2 billion annual industry, almost split evenly between crops and livestock. Very few of the farmed acres are irrigated. The major crops in the state are corn, soybeans, and wheat. Soybean and wheat yields could decrease as a result of climate change by 15-42% as temperatures rise beyond the tolerance level of the crop and are combined with increased stress from decreased soil moisture. Corn yields could fall by 32% or rise by 7%, depending on how climate changes. Farmed acres could decrease by as much as 30-40%. 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 South Carolina, longleaf and slash pine forests are likely to expand northward, and could replace some of the forests currently dominated by loblolly and shortleaf pines. Wetter conditions would favor expansion of oak and hickory deciduous forests as well as the gum and cypress forests found along the southeastern seaboard. In contrast, under drier conditions, 10-15% of the forested areas in the northwestern part of the state could be replaced by grasslands and pasture. Maritime forests, important for their recreational and aesthetic value and for their role in coastal hydrology, could be affected adversely by changes in the frequencies of large storms associated with climate change (hurricanes in the late summer and fall, nor'easters in the winter and spring). Warmer and drier conditions could increase the frequency and intensity of fires, and 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.

Ecosystems

South Carolina is dominated by coastal ecosystems that provide critically important habitat for endangered and threatened species such as the American alligator, Bachman's warbler, bald eagle, brown pelican, loggerhead sea turtle, piping plover, red-cockaded woodpecker, shortnose sturgeon, and woodstork. Important wetland habitats include Carolina bays and pocosins, both of which contain a number of endangered plants, many with restricted ranges. Terrestrial habitats include large areas of oak-hickory-pine forest and the extreme southern part of the Appalachian highlands.

Sea level rise under a changed climate could threaten many low-lying coastal ecosystems. A study in the Cape Romaine National Wildlife Refuge revealed that at the current rate of sea level rise (9 inches per century), the refuge's marshlands and barrier islands could be reduced in size by as much as 58% by 2100. Changes in climate could increase this rate. Endangered birds such as the Bachman's warbler and red-cockaded woodpecker will lose more than 50% of their habitat. The intrusion of seawater from rising seas also will threaten the viability of freshwater systems. Extensive human coastal development is an impenetrable barrier to the landward migration of coastal wetland habitats.

A 4°F increase in average temperature could substantially reduce brook trout populations in South Carolina, where they are currently at the southern limit of their distribution. Habitat for warm water fish could also be reduced by hotter temperatures. In the forests of the western part of the state, pine seeds and seedlings, able to tolerate extreme environmental conditions, may come to dominate hardwood stands at the expense of oak and hickory.

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.