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

EPA Climate Change And North Carolina

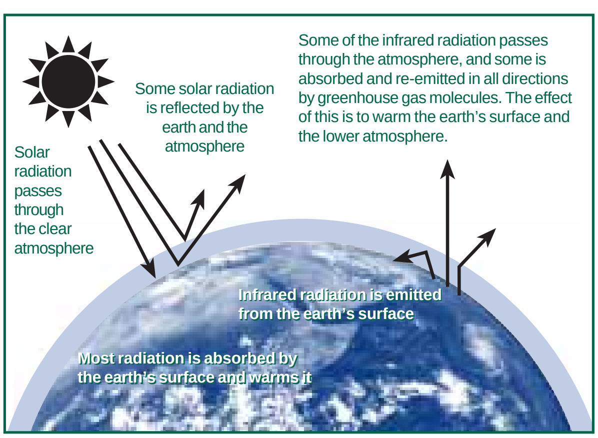
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

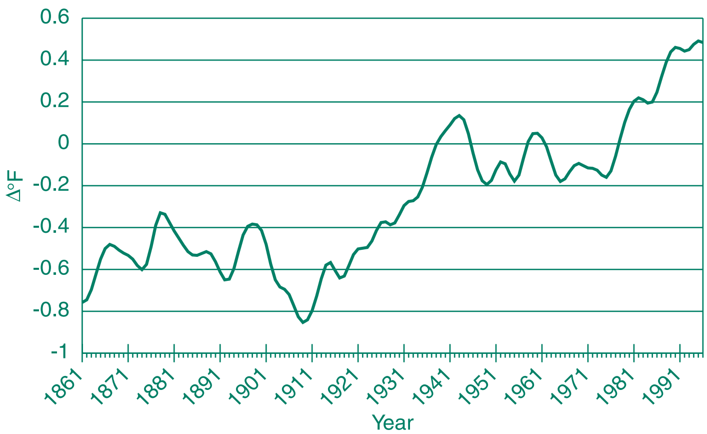
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

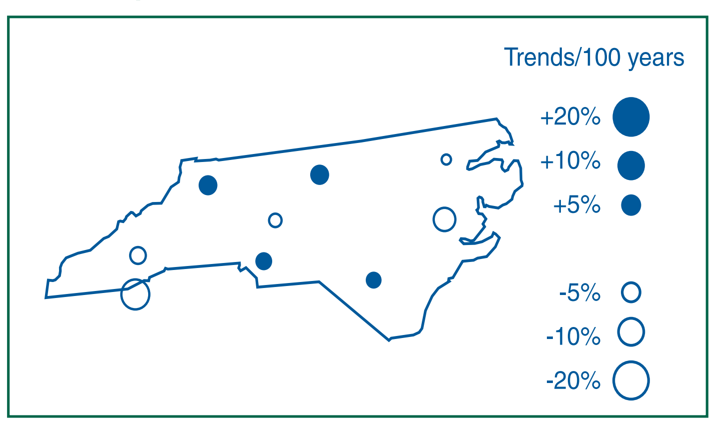
Over the last century, the average temperature in Chapel Hill, North Carolina, has increased 1.2°F, and precipitation has increased by up to 5% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in North 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 North 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 winter and spring, slightly more in summer and fall. 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. Although North Carolina is exposed to

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

regular, intense heat during a typical summer, one study suggests that the population could still be sensitive to heat waves.

In Greensboro, a warming of 3°F during a typical summer is estimated to increase heat-related deaths by nearly 70%, from about 20 to about 35 (although increased air conditioning use may not have been fully accounted for).

Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in North Carolina can carry malaria, and others can carry California and eastern equine encephalitis, which can be lethal or cause neurological damage. If conditions become warmer and wetter, mosquito populations could increase, thus increasing the potential for transmission if these diseases are introduced into the area. 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.

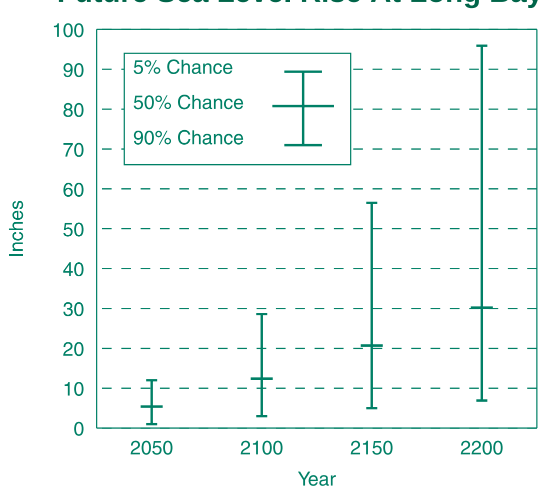
Coastal Areas

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.

North Carolina has a 3,375-mile tidally influenced shoreline, consisting of a long chain of barrier islands, including the Outer Banks, and extensive salt marshes and tidal freshwater marshes that have formed behind these barrier islands.

As sea level rises, coastal marshes may initially expand by spreading onto low-lying terraces, particularly in and around Albemarle Sound. Further changes in the extent of coastal wetlands will vary with location, with significant loss of wetlands

Future Sea Level Rise At Long Bay



Source: EPA (1995)

possible in some areas. North Carolina has experienced more direct hurricane strikes than any other Atlantic coast state except Florida, and the coast could be susceptible to additional damages from hurricanes as higher sea levels increase the vulnerability of some areas to storm surge.

At Long Bay, sea level already is rising by approximately 2 inches per century, and it is likely to rise another 12 inches by 2100. The cumulative cost of sand replenishment to protect the coast of North Carolina from a 20-inch sea level rise by 2100 is estimated at $660 million to $3.6 billion. However, sand replenishment may not be cost-effective for all coastal areas of the state, and therefore some savings could be possible.

Water Resources

Concerns about water demand exceeding supply could increase for growing cities such as Cary, Chapel Hill, Greensboro, and Asheville. Lower flows and higher water temperatures also could degrade water quality by concentrating pollutant levels and reducing the assimilation of wastes. This could affect rivers such as the Catawba River, which not only supplies water for Charlotte and other large cities but also receives the waste discharges from many municipalities and industries. Aquifers in the Coastal Plains, which currently suffer from declining levels and saltwater intrusion, could be diminished further. Irrigation from groundwater, which serves as an important source of water during drought periods in the Coastal Plains, also could be adversely affected.

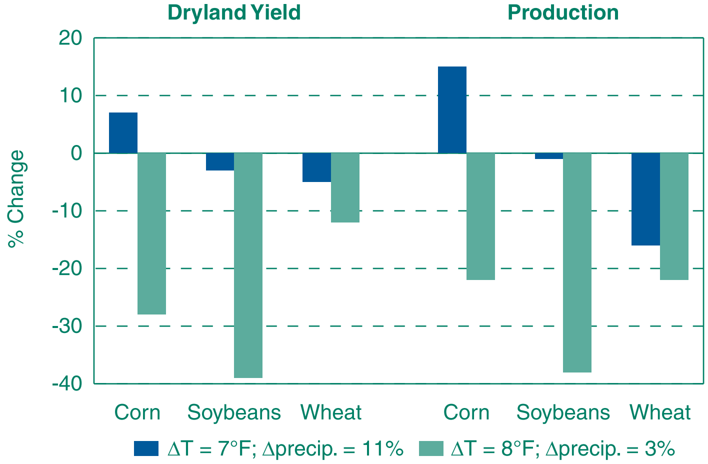
Increased precipitation could alleviate water supply problems and provide more water for dilution of pollutants, but it also could increase flooding. In the mountainous areas of western North Carolina, where stream slopes are steep and flash flooding is common, recent development in floodplain areas would be especially vulnerable to floods. Pollution of streams, lakes, and estuaries by toxins, nutrients, and sediment is a primary water quality concern in the state. Higher rainfall could increase erosion and exacerbate levels of pesticides and fertilizers in runoff from agricultural areas. It also could increase pollution in runoff from mining and urban areas. Additionally, higher streamflows could exacerbate problems in low-lying coastal areas being developed for agriculture and peat mining.

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.

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

Changes In Agricultural Yield And Production



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

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 North Carolina, production agriculture is a $5.4 billion annual industry, 60% of which comes from livestock. Very few of the farmed acres are irrigated. The major crops in the state are corn, wheat, hay, and tobacco. Soybean and wheat yields could decrease as a result of climate change, with soybeans falling by 3-39% and wheat by 5-11% as temperatures rise beyond the tolerance level of the crop. Corn yields could fall by 28% or rise by 7%, depending on how climate changes. Estimated changes in yield vary, depending on whether land is irrigated. Farmed acres are projected to remain fairly constant based on estimated changes in 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 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 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.

With changes in climate, the extent and density of forested areas in North Carolina could change little or decline by 5-10%. However, the types of trees dominating those forests are likely to change. The warmer mixed forests, dominated by southern pines and oaks, could spread northward, replacing the predominantly hardwood forests of the north and west. The forests of western North Carolina in and around the Great Smoky Mountains National Park support a rich variety of plants and animals, and they are important recreation areas. Composition changes in these forests could adversely affect diversity and recreation. 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 (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

Valuable ecosystems in North Carolina include spruce-fir forests, bogs, and unvegetated hilltops in the mountainous regions; bottomland hardwood forests and fire-maintained prairies in the piedmont; and longleaf pine forests, Carolina bays, swamps, and maritime forests in the coastal plain. These provide critical habitat for numerous native plants and animals, including 53 endangered species. The coast contains estuarine wetlands, where freshwater, saltwater, and terrestrial ecosystems are home to endangered species such as bald eagles, piping plovers, and several species of sea turtles. The Smoky Mountains have long been recognized as a global center of biodiversity. The highest peaks are home to 95 species of plants, including Fraser fir trees, and they provide habitat for animals that are typically found farther north, such as Carolina northern flying squirrels, Canada and Blackburnian warblers, and bog turtles. The southern Appalachians also contain a diverse array of salamanders, which are very sensitive to climatic factors.

Warmer temperatures could lead to reduced stream flow and warmer water temperatures, which could significantly impair reproduction of fish such as the brook trout. With an increase in average temperatures, the distribution of this species and others could be reduced and their range could become more limited. In coastal habitats, one consequence of rising sea levels will be inundation, salinization, and sedimentation of vital wildlife habitats. Rising sea levels will result in further inland penetration of saltwater, and many of the 150 streams and rivers that flow into the ocean could be adversely affected. The Appalachian spruce-fir forests are already threatened by air pollution (acid rain and ground-level ozone) and exotic pests (hemlock wooly adelgid). Warmer and drier conditions could result in significant loss of red spruce forests as conditions suitable for the growth of red spruce and Fraser fir decline.

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.