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Climate Change And Florida

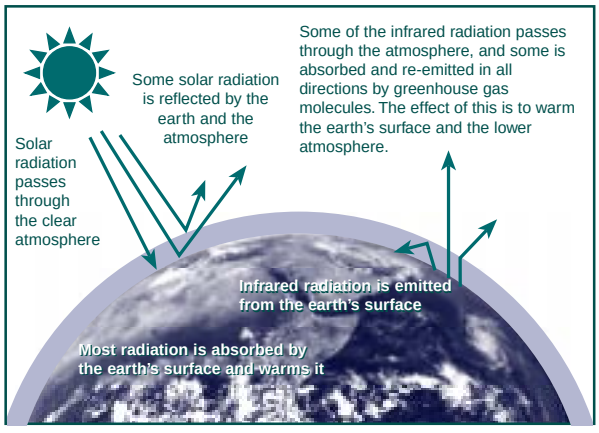
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

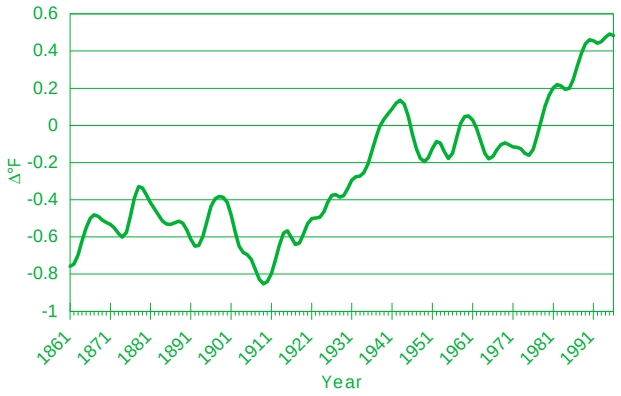
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and 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 since the late 19th century. 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, average temperatures have increased in Florida. At Ocala, the 1892-1921 average temperature was almost 67°F; the 1966-1995 average temperature was over 69°F. Precipitation over the last hundred years has decreased in the Keys and parts of south Florida, and increased in central Florida and the panhandle.

Over the next century, Florida's climate may change even more. Based on projections given by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that has accounted for both greenhouse gases and aerosols, by 2100 temperatures in Florida could increase by 3-4°F (with a range of 1-6°F) in spring, summer, and fall, and by somewhat less in winter. Little change is projected for precipitation.

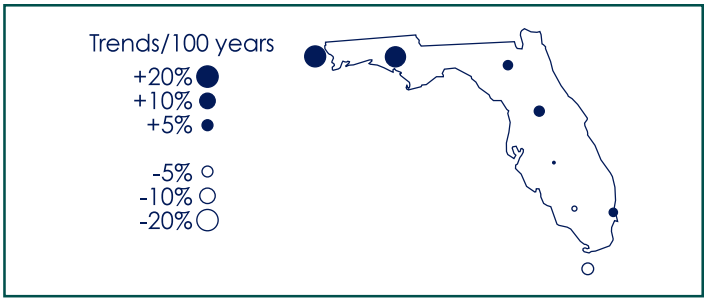
The frequency of extreme hot days in summer is expected to increase along with the general warming trend. It is not clear how severe storms such as hurricanes would change.

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.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

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. Recent scientific work suggests that 28 people die every year in Tampa from heat-related causes during the summer. Even if people adjust to climate change, a 3°F warming could more than double this figure; as many as 68 additional heat-related deaths could occur every year in Tampa during the summer. The elderly, particularly those living alone, are at greatest risk.

There is concern that climate change could increase concentrations of ground-level ozone. For example, specific weather conditions — strong sunlight, stable air masses — tend to increase urban ozone levels. While Florida is in compliance with current air quality standards, increased temperatures could make remaining in compliance more difficult. Ground-level ozone has been shown to aggravate existing respiratory illnesses such as asthma, reduce lung function, and induce respiratory inflammation. In addition, ambient ozone reduces agricultural crop yields and impairs ecosystem health.

Changing climate conditions also may affect human health through impacts on terrestrial and marine ecosystems. In particular, warming and other climate changes may expand the habitat and infectivity of disease-carrying insects, increasing the potential for transmission of diseases such as malaria and dengue ("break bone") fever. Although dengue fever is currently uncommon in the United States, conditions already exist in Florida that make it vulnerable to the disease. Warmer temperatures resulting from climate change could increase this risk.

Finally, sea surface warming and sea level rise could increase health threats from marine-borne illnesses and shellfish poisoning in Florida. Warmer seas could contribute to the increased intensity, duration, and extent of harmful algal blooms. These blooms damage habitat and shellfish nurseries, can be toxic to humans, and can carry bacteria like those causing cholera. In turn, algal blooms potentially can lead to higher incidence of water-borne cholera and shellfish poisoning. Acute poisoning related to the consumption of contaminated fish and shellfish has been reported in Florida.

Coastal Areas

Global sea level rise is one of the most likely effects of global warming. Along much of the Florida coast, the sea level already is rising 7-9 inches per century. Because of local factors such as land subsidence and groundwater depletion, sea level rise will vary by location. For Florida, the sea level is likely to rise 18-20 inches by 2100. As sea level rises, coastal areas in Florida, particularly wetlands and lowlands along the Gulf and Atlantic coasts, could be inundated. Adverse impacts in these areas could include loss of land and structures, loss of wildlife habitat, accelerated coastal erosion, exacerbated flooding and increased vulnerability to storm damage, and increased salinity of rivers, bays, and aquifers, which would threaten supplies of fresh water.

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 and/or elevating houses and infrastructure). Each of these responses would be costly, either in out-of-pocket costs or in lost land and structures. For example, the cumulative cost of sand replenishment to protect Florida's coast from a 20-inch rise in sea level by 2100 is estimated at $1.7-$8.8 billion.

Forests

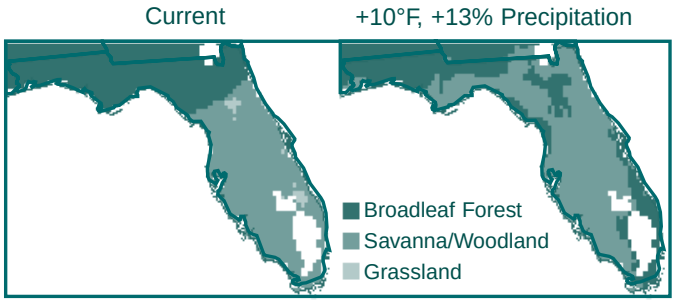
Trees and forests are adapted to specific climate conditions, and as climate warms, forests will change. Changes in tree species, geographic extent, and the health and productivity of forests could be expected with a warmer climate. If conditions also become drier, the current range of forests could be reduced and replaced by grasslands and pasture. Even a warmer and wetter climate would lead to changes; trees that are better adapted to warmer conditions, such as tropical 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 they are accelerated by other stresses such as fire, pests, and diseases. Some of these stresses would themselves be worsened by a warmer and drier climate.

The mixed conifer/hardwood forests found in the northern and panhandle sections of Florida are likely to retreat northward. These forests eventually could give way to wet tropical forests such as tropical evergreen broadleaf forests and dry tropical savanna. These changes would be accompanied by a reduction in forest density. The dry tropical savanna of the Florida peninsula could become more of a seasonal tropical forest with a corresponding increase in forest density. The potential dieback of forests along the Gulf coast could adversely affect forest-based recreation and commercial timber.

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,

Changes In Forest Cover



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

particularly in the summer. In addition, more intense precipitation could increase flooding. If streamflow and lake levels drop, groundwater also could be reduced.

A critical factor in Florida's development, especially in southern Florida, has been water. Although south Florida receives an annual average of 60 inches of rain, annual evaporation sometimes can exceed this amount. Rainfall variability from year to year is also high, resulting in periodic droughts and floods. Competing demands for water — for residences, agriculture, and the Everglades and other natural areas — are placing stresses on south Florida's water resources.

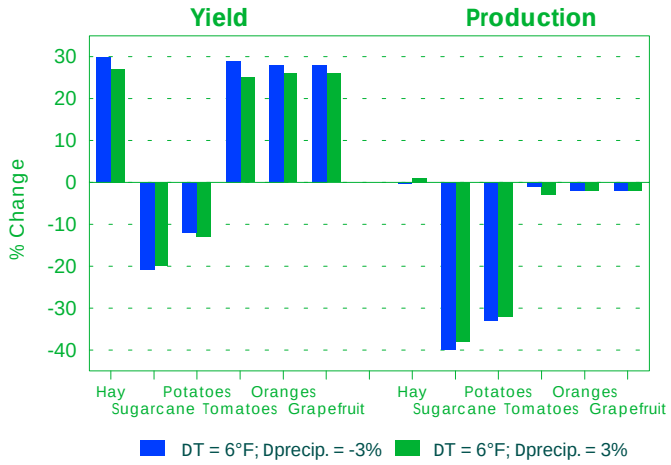
Higher temperatures increase evaporation, which could reduce water supplies, particularly in the summer. Saltwater intrusion from sea level rise also could threaten aquifers used for urban water supplies. These changes could further stress south Florida's water resources.

Agriculture

The mix of crop and livestock production in a state is influenced by climatic conditions and water availability. As climate warms, production patterns will 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, and other economic sectors.

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 substantially change modeling results. Analyses based on changes in average climate and which assume farmers effectively adapt suggest that aggregate U.S. food production will not be harmed, although there may be significant regional changes.

Changes In Agricultural Yield And Production



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

Florida is one of the leading states in terms of cash revenue from farming, with irrigated cropland accounting for the high value of farm production. Yields of citrus fruits could decrease with warmer temperatures in the southernmost part of the state because of a lack of a sufficient dormant period. Changes in cotton and sorghum production are unclear — increasing CO_2 levels and rainfall would be likely to increase yields, but the shortened growing season brought on by increasing temperatures could result in plants producing fewer or smaller seeds and fruit, which would decrease yields. Increases in temperature (about 6°F) and rainfall (10%) are projected to reduce corn yields by 14%.

Unique Ecosystems: The Big Cypress Swamp, The Everglades, And The Keys

Southern Florida has national treasures in the Big Cypress Swamp, the Everglades, and the Keys. These three ecosystems are interlinked and have a common history. The Big Cypress Swamp is part of the broad, shallow river moving fresh water south into the Everglades. The Keys mark the last outposts of the Everglades lands. Once hummocks of higher vegetation set in a prehistoric swamp, they have struggled against the rising sea. Mangroves on their perimeters collect silt and organic material, building a barricade secure against all but the most severe hurricane winds and tides. In the Everglades and Big Cypress Swamp, there is a strong contrast between the seasons. From early spring well into autumn, they have ample rainfall, averaging 50 inches per year. Winter is a time of drought and fire, and saltwater penetrates farther inland.

Already stressed by water diversions, invading species of plants and animals, and the natural phenomena of drought, flood, and storms, these ecosystems will be stressed further by climate change. A 20-inch sea level rise would cause large losses of mangroves in southwest Florida. Increased salinity, resulting from rising saltwater into the Everglades from Florida Bay, also would damage freshwater ecosystems containing sawgrass and slough. Communities of wet prairie also would decline with the rise in sea level.

Climatic conditions in central Florida may become suitable for subtropical species such as Gumbo-limbo, now confined to subtropical hummocks in the southern part of the peninsula and the Keys. Theoretically, such species could move as far north as Gainesville and Jacksonville, but agricultural and urban development could preclude such migration.

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.