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Climate Change And New York

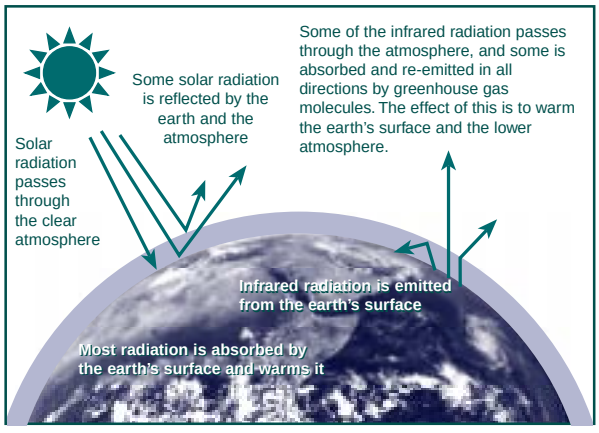
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

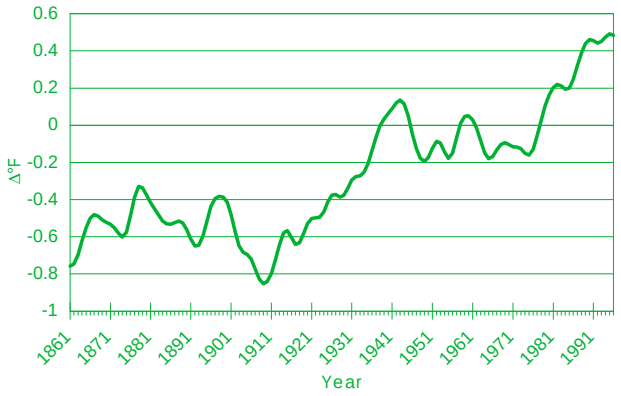
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and 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, temperatures in Albany, New York, have warmed by more than 1°F, and precipitation throughout the state has increased by up to 20%.

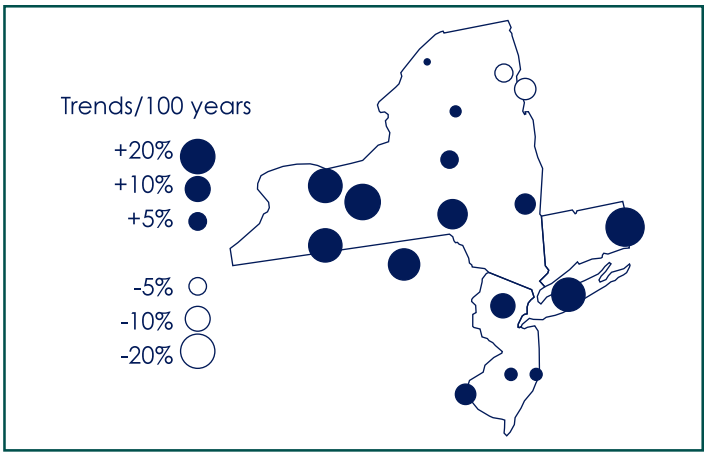
Over the next century, New York's climate may change even more. Based on projections given by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that has accounted for both greenhouse gases and aerosols, by 2100 temperatures in New York could increase about 4°F in winter and spring, and slightly more in summer and fall (with a range of 2-8°F). Precipitation is projected to increase by 10-20% (with a range of 0-40%), with slightly less change in spring and slightly more in winter.

The amount of precipitation on extreme wet (or snowy) days is likely to increase, but changes in the lengths of wet or dry spells are not clear. 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.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

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.

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. New York, with its irregular, intense heat waves, could be especially susceptible.

In New York City, one study projects that a 1°F warming could more than double heat-related deaths during a typical summer, from about 300 today to over 700 (although increased air conditioning use may not have been fully accounted for). Decreases in winter mortality probably would be less than the summer mortality increases if the climate warms. The elderly, particularly those living alone, are at greatest risk.

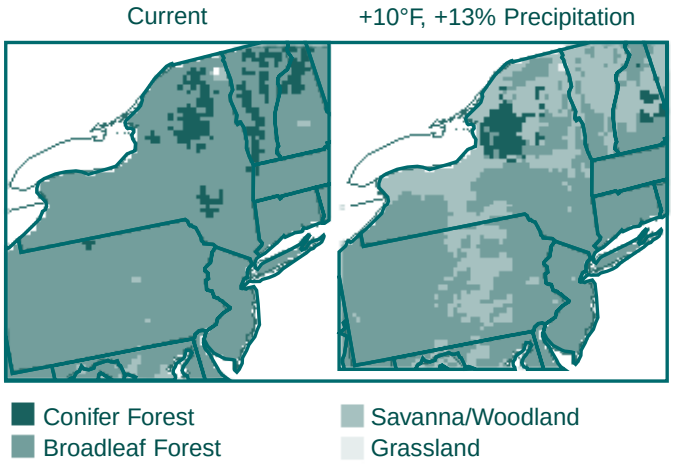
There is concern that climate change could increase concentrations of ground-level ozone. For example, high temperatures, strong sunlight, and stable air masses tend to increase urban ozone levels. Air pollution also is made worse by increases in natural hydrocarbons emissions during hot weather. If a warmed climate causes increased use of air conditioners, air pollutant emissions from power plants also will increase.

A 4°F warming in New York City, with no other change in weather or emissions, would increase concentrations of ground-level ozone, a major component of smog, by 4%. Current ozone concentrations exceed the national health standards in many urban areas, especially New York City and Long Island. 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.

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. Mosquitoes flourish in some areas around New York City. Some can carry malaria, while others can carry Eastern equine encephalitis, which can be lethal or cause neurological damage. Lyme disease, which is carried by ticks, has increased in New York. If conditions become warmer and wetter, mosquito and tick populations could increase, thereby increasing the risk of transmission of these diseases.

In addition, 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. Brown algal tides already are prevalent in the Atlantic. Warmer ocean waters could increase their occurrence and persistence.

Changes In Forest Cover



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

Forests

Trees and forests are adapted to specific climate conditions, and as climate warms, forests will change. This would include changes in species, geographic extent, and health and productivity. If conditions also become drier, the current range of forests might 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 southern pines, would prevail. Forests could, under these conditions, become more dense. These changes might 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.

With changes in climate, the extent of forested areas in New York could change little or could decline by as much as 10-25%. However, the types of trees dominating New York forests are likely to change. The predominant maple, beech, and birch forests found in northern and western New York would retreat northward. The brilliant autumn foliage of the maples eventually could give way to forests dominated by oaks, ash, and pines. Across the state, as much as 50-70% of the maple forests could be lost. As a result, the character of heavily visited areas such as the Adirondacks may change.

Coastal Areas

Along much of New York's coast, sea level already is rising 10 inches per century, and it is likely to rise another 22 inches by 2100. Sea level rise can lead to flooding of low-lying areas, 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.

New York has one of the most urbanized coastlines in the United States. Over 20 million people use New York's beaches and coastal regions for recreation each year. New York has been successful at preventing major permanent losses of its beaches

and urban coastline, but sites such as Long Island continue to suffer from chronic beach erosion. Long Island's south shore, which is made up of barrier islands, barrier spits, ponds, and sand beaches, could suffer extensive damage from sea level rise and coastal storms.

Protecting New York's coast would require significant resources and planning. For example, Manhattan's 29-mile coast probably could be protected by raising existing bulkheads and sea walls at a cumulative cost of $30-$140 million for a 1-3 foot rise in sea level. The costs of raising existing bulkheads already have begun to accrue, and they could continue throughout the next century.

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

Scientists are unable to predict whether streamflow in New York would rise or fall on average. However, there could be higher streamflow in the winter and lower streamflow in spring and summer. Changes in the seasonality of streamflow (more in winter, less in summer) would make it difficult for the water supply systems in cities like New York to meet current demands reliably. In addition, higher temperatures and lower flow could reduce water quality in New York's rivers and streams.

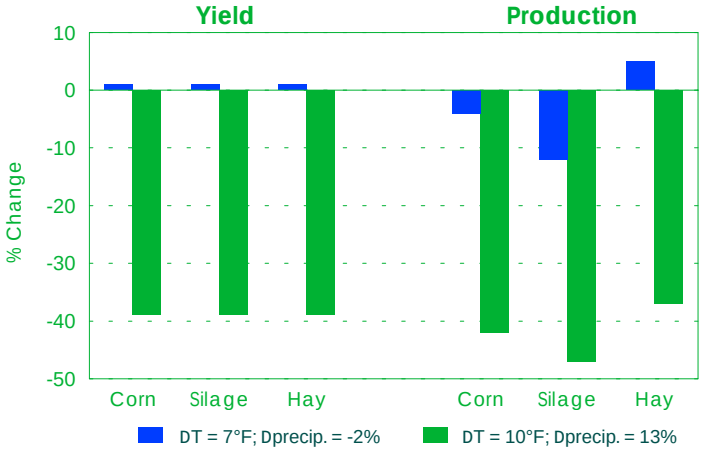
Increased evaporation probably would reduce the average levels of Lakes Erie and Ontario by up to a foot. These changes would exacerbate water quality problems in those lakes, as well as in the numerous smaller lakes in the St. Lawrence River basin. Lower water levels in Lakes Erie and Ontario would reduce flood damages, but shore erosion would increase from wind and rain. The ice-free season for the St. Lawrence Seaway would be longer, with positive benefits to navigation.

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 Agricultural Yield And Production



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

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.

In New York, agriculture is about a $3 billion a year industry, two-thirds of which comes from dairy livestock. The major crops in the state are hay, corn, and silage. Changes in New York yields could range from 0 to -40%. Climate change could lower production and farm income, but total acres farmed most likely would remain constant. Although very little land is currently irrigated, irrigated acreage probably would increase with climate change.

Ecosystems

The ecosystems of New York are quite diverse, ranging from coastal marshes to mountain forests. These ecosystems would be affected by everything from sea level rise to changes in fires and pest outbreaks. Sea level rise could alter food availability for wading birds and other animals in the coastal areas because of loss of wetlands. In higher elevation wetlands, climate warming could reduce streamflow and lake levels, which would result in losses of vegetation such as cranberries. Brook trout habitat and fisheries, which require cold temperatures, could be lost entirely throughout New York, and most of the habitat for brown trout could be lost.

Adirondack State Park is the largest single forested area east of the Mississippi, consisting of 6 million acres, 2.6 million of which are a forest preserve. The park represents one of the most significant hardwood ecosystems in the world. A warmer climate could change the types and extent of forests. The migration of species to new locations out of the park could be impeded by economic development around the park.

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.