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Climate Change And Alaska

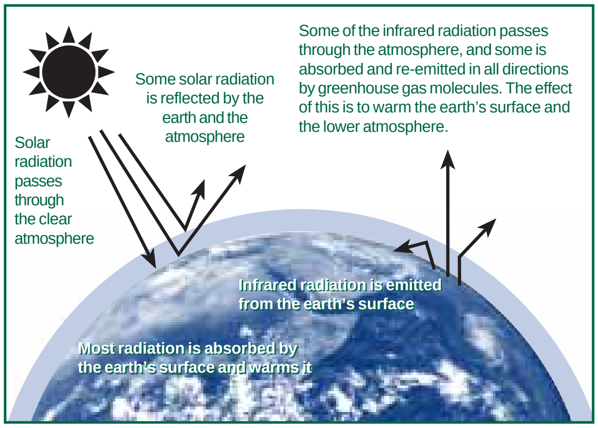
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

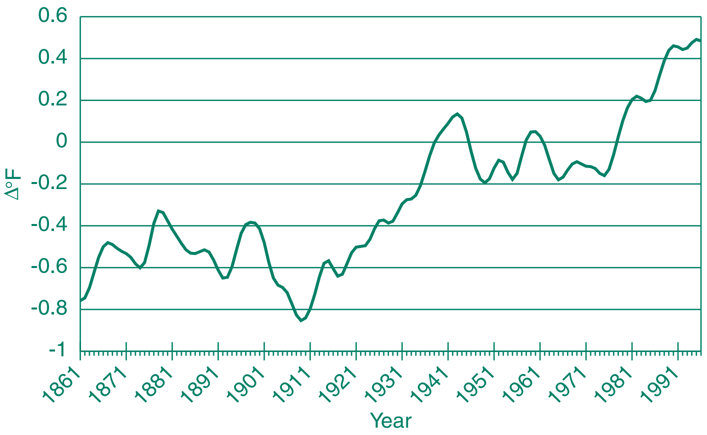
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

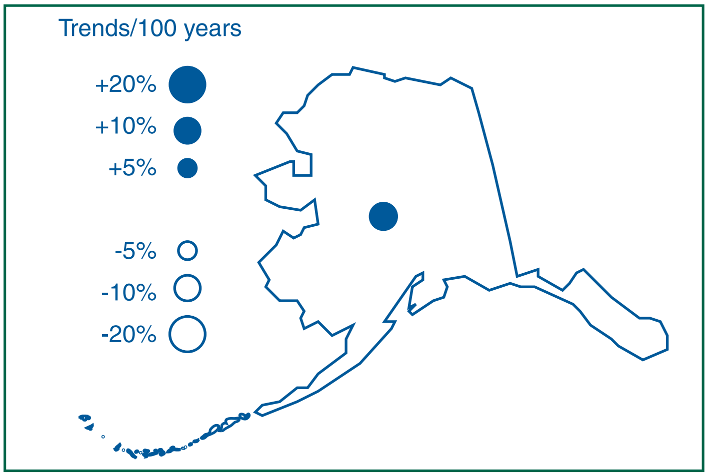
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency 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 Anchorage, Alaska, has increased 3.9°F, and over the last 41 years of available data, precipitation has increased by approximately 10% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in Alaska 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 Alaska could increase by 5°F in spring, summer, and fall (with a range of 2-9°F), and by 10°F in winter (with a range of 4-16°F). Precipitation is estimated to increase slightly in fall and winter (with a range of 0-10%) and by 10% in spring and summer (with a range of 5-15%). 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 might be affected.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

Human Health

Higher temperatures in Alaska will probably not produce conditions hot enough to cause heat-related deaths. It is also not likely that winter-related deaths will be greatly affected if warming occurs. In urban areas, 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. Although Alaska is in compliance with current ozone air quality standards, increased temperatures could make remaining in compliance more difficult. Ground-level ozone is associated with respiratory illnesses such as asthma, reduced lung function, and respiratory inflammation.

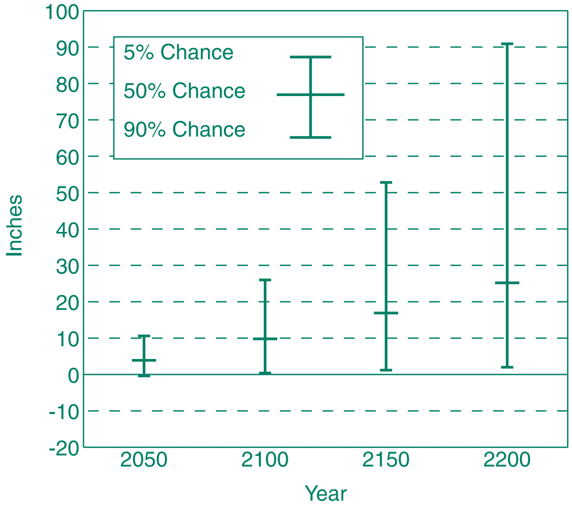
Mosquito-borne diseases of humans have not been reported in Alaska in the 1990s. However, if conditions become warmer and wetter, mosquito populations could increase, thus increasing the risk of transmission of malaria and encephalitis if these diseases are introduced into the area. Increased runoff from heavy rainfall could increase water-borne diseases such as giardia, cryptosporidia, and viral and bacterial gastroenteritides. 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.

Alaska has 31,400 miles of tidally influenced shoreline. The shoreline consists largely of fiords, bluffs, beaches, and islands, including the extensive Aleutian chain. The Alaskan coast also supports a wide range of wetland systems. For example, a proposed National Estuarine Research Reserve in Kachemak Bay spans nearly 400,000 acres. Much of Alaska's coast remains undeveloped; however, more than 40 percent of the population currently resides in the coastal city of Anchorage.

Future Sea Level Rise At Adak



Sources: Lyles et al. (1988); EPA (1995)

Current rates of erosion of Alaska's coastline vary widely because of local terrain and differences in the rates of uplift, as well as the abundance of sea ice and permafrost. In some areas, uplift as a result of tectonic activity is rapid. On average, however, Alaska's coastline is eroding at a rate of 8 feet per year, and this rate could increase with sea level rise.

Along much of Alaska's coast, the rate of sea level rise is nearly equal to or less than the rate of uplift. Accounting for the effects of climate change, sea level may rise a total of 10 inches by 2100, although at some locations a net uplift is most likely. 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.

Water Resources

Alaska has abundant water resources, but water is not always available where and when it is needed. Major Alaskan rivers, the Yukon, Kusdodwin, and Cooper, are among the 10 largest in the United States. There are more than 3 million lakes in the state; two principal aquifers hold large amounts of water. However, environmental, legal, and technological constraints limit the use of these supplies. Glacial-fed streams are often laden with silt, many streams freeze and run dry during the winter, and permafrost limits the availability of groundwater. Rapid population growth in Anchorage, Fairbanks, and Juneau, continued development of mineral and energy resources, and expansion of other industries have increased water demand. In many areas, water distribution systems are strained and there is concern that projected demands could exceed available supplies, especially in the winter.

Runoff in the state varies widely, depending on location and elevation, but largely results from late spring and summer melting of snow and glacial ice. At lower elevations, late summer rains also contribute to runoff. In a warmer climate, winter precipitation could increase in the northern latitude and Arctic regions. At higher latitudes and elevations, increases in precipitation could lead to greater snowfall and snow accumulation. In other regions, warmer winters could lead to less winter precipitation as snow and more as rainfall. Warmer temperatures could mean earlier, more rapid snowmelts and earlier ice breakups. This could increase water availability in the winter, when supplies are traditionally limited. However, river and reservoir systems that rely on glacier or snowmelt for summer flow could find supplies insufficient during critical periods of high demand and little rainfall. Additionally, more rain-on-snow events or sudden winter thaws could cause severe flooding. Higher flows and more rapid snowmelt also could increase stream bank erosion and sediments suspended in glacial-fed streams. Warmer temperatures and shifts in seasonal flows could alter the productivity of fish well adapted to current conditions.

Warmer temperatures would lead to thawing of permafrost, melting of glaciers, and a reduction of ice on lakes and rivers. Thawing of the permafrost can reduce slope stability and increase erosion and landslides, which can threaten roads and bridges and cause local floods. Changes in permafrost also could alter the lake and wetland ecosystems maintained above the impermeable frost layer. Reduced ice cover could improve opportunities for water transport, tourism, and trade. In some areas, reduced ice thickness could result in less severe breakups and ice-jam flooding. However, reduced sea ice in the Bering Sea could render coastal areas more susceptible to erosion and inundation during severe weather events such as storm surges.

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 and density 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 these conditions, such as hemlock and sitka spruce, would thrive. 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.

With changes in climate, the extent of forested areas in Alaska could increase as warmer temperatures extend forested areas northward and inland. White spruce stands, usually located on south-facing slopes, could be more sensitive to warming than the black spruce stands found on colder, north-facing slopes. Warmer weather could increase the likelihood of insect outbreaks and of subsequent wildfires in the dead fuel left after such an outbreak. If the permafrost melted, the productivity of forests could increase, but this would also be subject to wildfires and a shift in forest composition. The extent of these changes depends on many factors, including whether soils become drier and, if so, how much drier. Hotter, drier weather could increase the frequency and intensity of wildfires, which could change the composition and character of the Alaskan landscape. Warmer and wetter conditions could also affect the character and composition of some of Alaska's forests and the activities that depend on them.

Ecosystems

Alaska is home to many immense and mostly pristine ecosystems. In the southern panhandle and coastal regions, western hemlock-Sitka spruce forests are a valuable timber resource. Farther north, the steep mountains of the Alaska Range give rise to rocky slopes, icefields, and glaciers. Broad valleys separate peaks that often rise to above 12,000 feet. Interrelationships among permafrost, surface water, fire, slope, and soil type result in diverse and complex ecosystems, including shrub communities, bogs, floodplains, and spruce-dominated and mixed-wood forests. At the mouth of the Yukon and Kuskokwim rivers, an Indiana-sized area of wetlands and tundra of the subarctic coastal plain is one of the most important waterfowl nesting areas in North America. Tens of thousands of lakes, ponds, and streams provide a summer home to millions of migrant birds from six continents, including more than half of the continental population of black brant and most of the world's emperor geese, tundra swans, and cackling and Pacific white-fronted geese. In the far north of the state, the tundra of the northern arctic coastal plain stretches from the foothills of the Brooks Range to the Arctic Ocean. Here, many species once common farther south are still abundant, including grizzly bears, lynx, wolverines, eagles, caribou, and wolves. During the short arctic summer, female caribou congregate in the Arctic National Wildlife Refuge in the tens of thousands to give birth and raise their calves. Later in the summer, they begin a migration that will lead them over a route longer than that of any other terrestrial animal. The coastal plain is also frequented by specialized arctic species found only in the polar regions, including polar bears, arctic foxes, collared lemmings, arctic and tundra hares, and muskoxen. The oceans around Alaska are a rich marine resource and provide habitat for endangered northern right, bowhead, sei, blue, fin, humpback, and sperm whales.

Despite the remote and pristine nature of Alaska's ecosystems, they stand at the forefront of potential impacts of global climate change. Warming is projected to be greater at high latitudes than elsewhere in the world, and with sufficient warming, tundra ecosystems are projected to significantly decline. As recorded in tree rings, the western Arctic has experienced a period of steady warming since approximately the 1840s. Glacier retreat, melting permafrost, and reductions in pack ice are all projected to continue. These changes have serious implications for many arctic species. Earlier springs on the arctic coastal plain could reduce plant diversity and could disrupt food resources available to migrating caribou. These warming-induced changes in plant communities appear to be under way. Thawing of permafrost could reduce caribou habitat, cause landslides and erosion, clog salmon spawning rivers with silt, and trigger the loss of areas of boreal forest. Boreal forests could suffer increases in the annual area burned, drought-related dieoffs, and increased susceptibility to insect pests such as the white pine beetle. A predicted increase in forest fires and an eventual transition to younger stands are of particular concern for wildlife species that make extensive use of mature and old-growth forests, such as marten, fisher, and caribou. The low-lying marshes of the Yukon and Kuskokwim rivers are threatened by salinization due to sea level rise and periodic storm surges. Marine resources also could be heavily affected. Warming of lakes and rivers could decrease populations of coho, sockeye, and chinook salmon in the southern parts of their ranges. Species associated with the pack ice, including arctic cod, polar bear, ring seal, walrus, narwhal, and beluga whale, are estimated to experience population declines or changes in distribution.

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.