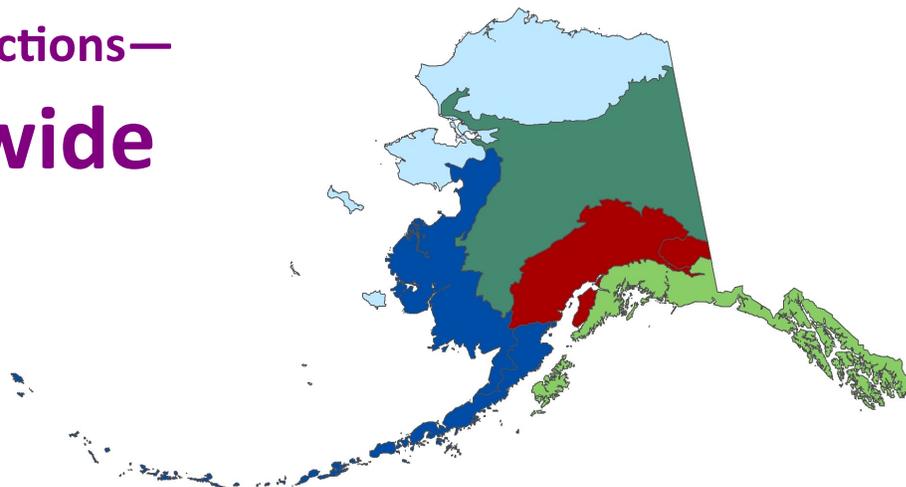


# Regional Climate Projections— Alaska Statewide Projections

## Alaska Climate Change Adaptation Series



Many areas in Alaska are already showing signs of a warming climate. Observed changes include species shifts, permafrost thaw, coastal erosion, wetland drying, glacial and sea ice recession, and an increase in fire frequency and intensity. A better understanding of where and when changes could occur is needed to help decision makers identify how Alaska's ecosystems may respond in the future. The state has been divided into five regions for planning coordination: North Slope & Northwest Coast, Interior Alaska, Southcentral, Southeast, and Southwest & Aleutians. A fact sheet for each region describes regional projections and potential impacts in greater detail.

### Who We Are

**SNAP** – The Scenarios Network for Alaska & Arctic Planning links university researchers with communities and resource managers. Through partnerships involving data sharing, research, modeling, and interpretation of model results, SNAP addresses some of the complex challenges of adapting to future conditions.

**CES** – The Cooperative Extension Service is the educational outreach component of the national land grant university system – in Alaska, the University of Alaska Fairbanks. CES conducts research and provides educational outreach statewide.

**ACCAP** – The aim of the Alaska Center for Climate Assessment and Policy is to assess the socio-economic and biophysical impacts of climate variability in Alaska, make this information available to decision-makers, and improve the ability of Alaskans to adapt to a changing climate.

Together, SNAP, ACCAP and CES provide a variety of services that may assist you in meeting your community planning needs.

### Planning for Change

Alaskans face many challenges in the next century. Rising energy costs have impacted the costs of food, fuel and other services. Changes in temperature and moisture can trigger profound landscape-level changes such as sea level rise; modified patterns of storms, flooding or fire;

and altered migration routes, breeding patterns, or survivorship of fish and wildlife.

Everyone – from engineers to farmers to wildlife managers – will need to take economic change, social change and climate change into account when planning for the future, in order to avoid costly mistakes and take advantage of new opportunities. Planning requires objective analysis of future projections, including clear explanations of the uncertainty inherent in all forms of forecasting.

### Uncertainty

While values are based on the best available climate models, they are estimates only. There is variation among climate models, and annual variation within each model. Interpretation of impacts adds additional uncertainty.

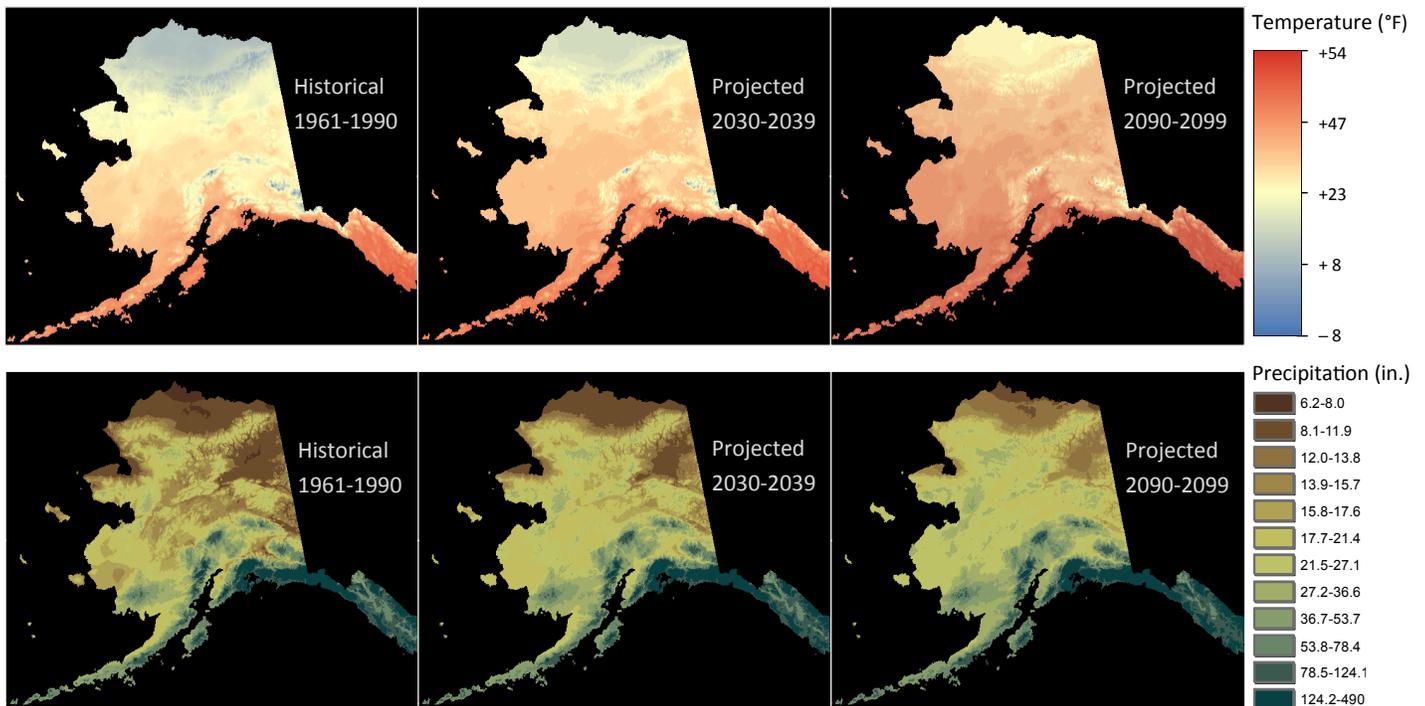
### Climate Models

SNAP provides average values of projections from five global models used by the Intergovernmental Panel on Climate Change (IPCC). Climate projections are based on three scenarios for carbon dioxide emissions, which cover a wide range of possible future conditions.

### Statewide Trends

Temperatures and precipitation are expected to increase across the state throughout the next century. The growing season will lengthen, and glaciers, sea ice, and permafrost will be reduced. Significant ecosystem shifts are likely statewide.

## Temperature & precipitation projections based on SNAP models (5-model average, mid-range A1B emissions scenario)



### Climate Change

Climate change is a complex issue because of the interactions and feedbacks of the ocean, land and atmospheric systems. Though there is debate about the magnitude and speed of expected changes, there is no doubt that change is underway. The far north is now experiencing some of the most rapid and severe climate change on earth. In the last century, average annual temperatures in the Arctic have increased at almost twice the rate as the rest of the planet.

Climate change is magnified in Alaska because polar regions are more sensitive to change. This is partly because of the snow-albedo feedback. Albedo is a measure of the amount of solar energy reflected from a surface. Snow and ice have a high albedo and reflect more energy than uncovered ground or water. Higher temperatures lead to less snow and ice and more solar energy absorbed, which leads to further surface warming and snow and ice retreat.

### Climate Projections for Alaska

In general, temperatures and precipitation are expected to increase across the entire state of Alaska throughout the next century. Higher temperatures are predicted for every month, particularly in the winter. The growing season is likely to increase statewide. Precipitation alone does not predict moisture availability, and even with increased precipitation, drier conditions are possible due to increases in evapotranspiration.

Alaska is a unique region because of its location, sensitive ecosystems, and wide range of landscapes. It is also extremely vulnerable to the observed and projected impacts from a warming climate. Changes in permafrost,

glaciers, sea ice, snow cover, fire, vegetation, and storm events have already been observed and are expected to accelerate in the next century.

### Potential Impacts

Future increases in precipitation, shorter and warmer winters, substantial decreases in snow cover and ice cover would all have profound biophysical, ecological, social and economic impacts in Alaska. Some plant and animal species may benefit from warmer temperatures, while others may not be able to adapt or find suitable habitat conditions to sustain their populations.

Vegetation zones are likely to shift, resulting in wide-ranging impacts to biomes, wildlife habitat, fire regimes, and agriculture. Many animal species will have to adapt to changes related to a warming climate. These include polar bears, seals and birds that rely on sea ice for habitat; caribou stressed by changes to food sources, breeding grounds and migration routes; and fisheries affected by ocean acidification and other changes in the marine environment.

Changes in climate affect people as well. Indigenous communities face major impacts as their subsistence way of life is threatened. As sea level rises and sea ice shrinks, higher waves and storm surges reach the shore and erode the coastline. Thawing permafrost disrupts transportation, buildings and other infrastructure. Some communities are being forced to relocate. Not only do these changes threaten food security and infrastructure, they also threaten the basis of Native Alaskans' culture and identity.

The table on the following two pages provides a summary of changes that may affect humans and ecosystems across Alaska.

## Projected Effects of Climate Change in Alaska

Sector	Subsector	Potential Impacts
<b>ATMOSPHERE</b>	Greenhouse Gases	Increased carbon storage where forests spread; decreased where drought causes loss of forest or where fire and permafrost release methane and CO <sub>2</sub>
	Air Temperature	Air temperature increases ~1°F per decade; greatest change in the north and in winter.
	Precipitation	Average annual precipitation increases. Relative amounts of snow, ice or rain change. Many areas experience drying conditions despite increased precipitation. More freezing rain events affect foraging success for wildlife, travel safety, etc.
	Storms	Lightning and lightning-ignited fires continue to increase. Storm and wave impacts increase in northern Alaska where land-fast sea ice forms later.
	Air Quality	More smoke from longer and more intense fire seasons.
	Contaminants	Increased contaminants and shifting contaminant distribution.
<b>CRYOSPHERE</b>	Ice/Snow	Later onset of freeze-up and snowfall + earlier spring snowmelt and break-up. Arctic snow cover declines with higher air temperatures and earlier spring thaw. Lack of snow cover leads to deeper freezing of water in the ground or rivers. Cultural resources are exposed as snow and ice patches melt and recede.
	Glaciers	Most glaciers diminish as warming continues, though a few are still advancing. Glacial outwash affects aquatic productivity and forms deposits in shallow water. Glacial lakes fail more frequently, creating risk of flash floods and debris flows. Surging glaciers could block rivers and fjords, resulting in severe flooding.
	Sea Ice	Less sea ice complicates travel, impacts ecosystems, and adds energy to storm surges. Seasonal reductions in sea ice increase the risk of spills contaminating coastal resources.
	Ice Roads	Reduced winter transportation affects opportunities for travel and subsistence.
	Permafrost	Mercury & other pollutants are released into aquatic environments as permafrost thaws.
<b>HYDROSPHERE</b>	Sea level	Global average sea level is predicted to rise 1-6 feet by the end of the 21 <sup>st</sup> Century. Increased storm surges and permafrost erosion compound effects of change in sea level. Some coastal villages rapidly lose ground from storms, erosion and subsidence.
	Marine	Increasing sea surface temperature affects fish, seabird, and wildlife populations. Falling global phytoplankton could reduce ocean productivity and CO <sub>2</sub> sequestration. Freshwater influx from thawing glaciers dilutes marine waters, stressing animals. Toxic marine algae & shellfish poisoning attributed to changes in water conditions. Ocean acidification affects food sources of fish, marine mammals and birds in the Arctic.
	Estuarine	Coastal erosion and sea level rise increase the frequency of saltwater flooding. Some shallow water areas convert to terrestrial ecosystems with post-glacial rebound.
	Freshwater	Stream flows from melting glaciers increase and then decrease over time. Ponds shrink as ground ice thaws or thermokarst drainage occurs in permafrost areas. Drainage from thawing waste and sewage dumps contaminates rural water supplies.
	Groundwater	Groundwater supplies dependent on seasonal glacial recharge become less predictable.
<b>LITHOSPHERE</b>	Ground Level	Ground level rises in recently de-glaciated areas because of isostatic rebound.
	Ground Stability	More roads and infrastructure fail or require repairs due to permafrost thaw. Glacial retreat and permafrost thaw leave steep and unstable slopes. Earthquake activity increases in recently deglaciated areas due to isostatic rebound. Large and small tsunamis could result from collapse of unstable slopes in fjords. Coastal erosion claims both natural and cultural resources and constructed assets. Burials and other remains are exposed as cultural sites thaw and erode.
	Soil	Soil moisture declines due to rising soil temperature, thawing permafrost, and drainage.

## Projected Effects of Climate Change in Alaska

Sector	Subsector	Potential Impacts
<b>BIOSPHERE</b>	Vegetation	Average number of frost-free days for the Arctic could increase between 20-40 days by 2100. Increased agricultural production in Alaska because of longer growing season. Potential large-scale shift of tundra to shrubs, to conifers, to deciduous forests or grass. Atypical outbreaks of pests and diseases affect native species and increase fire hazards. Invasive exotic plant species and native species from other areas expand their ranges.
	Forests	Black spruce may expand with warming—or contract as permafrost soils thaw and fires increase. Mature forests and “old growth” decline because of drought, insects, disease, and fire. Mature yellow cedars decline across southeast Alaska, possibly due to lack of insulating snow.
	Fire	Models show a warmer climate leads to larger, more frequent and intense fires. Wildland fire hazards increase, affecting communities and isolated property owners. Fire-related landcover and soil changes result in vegetation shifts, permafrost thaw, etc.
<b>BIOSPHERE</b>	Wildlife	Changes to terrestrial and aquatic species occur as ranges shift, contract, or expand. Animals and plants will expand into landscapes vacated by glacial ice. Migratory routes and destinations will change (e.g. wetlands, open tundra, snow patches).
	Birds	Arctic and alpine birds’ breeding habitats reduced as trees and shrubs encroach on tundra. Waterfowl shifts occur as coastal ponds become more salty. Productivity of nesting shorebirds may increase if schedules change to coincide with insects. Predation on ground nesting birds could increase if prey (lemming) abundance declines. Coastal seabirds (e.g. Ivory Gull and Aleutian Tern) are vulnerable to climate change. Population cycles of birds and their prey could be out of sync due to higher temperatures.
	Marine Mammals	Arctic marine mammals (e.g. seals, walrus and whales) are affected by sea ice decline. Less sound absorption (ocean acidification) affects marine mammals that rely on echolocation. Polar bears may have increasing difficulty accessing prey and finding shelter.
<b>BIOSPHERE</b>	Caribou/ Reindeer	Caribou and reindeer health are affected by changes in weather, forage, and insects and pests. Earlier green-up could improve caribou calf survival because of more available forage. Caribou may suffer heavy losses if rain events prevent successful feeding during cold weather.
	Moose	Shifts in forests could mean less habitat for caribou, but more habitat for moose. Climate change could hinder moose calf birth success and moose calf survival.
	Small Mammals	Fire may create new burrowing habitat and forage growth to help vole populations. Less snow cover reduces survival of subnivalian species, due to increased predation & cold stress.
	Fisheries	Commercial fisheries are affected by changes to ocean communities in the Bering Sea. Some marine plant and animal populations may decline with ocean acidification. New stream habitats become available for fish and wildlife as glaciers decline. Some salmon waters may become unsuitable for migration, spawning and incubation. Fish habitats in permafrost areas are degraded by slumps and sediment input into rivers.
	Invertebrates	Ice worm populations decline locally as glacier habitats melt. Exotic pests expand from warmer areas, and endemic pests expand as host species are stressed.
	Subsistence	Altered animal migration patterns make subsistence hunting more challenging. Sea ice changes make hunting for marine mammals less predictable & more dangerous. Managing new species and intensified management of native species may be needed.
<b>OTHER</b>	Tourism	Longer summer seasons and more cruise ships in the Bering Strait could increase tourism.
	Hazards	Safety hazards related to climate change, e.g. thin ice, flooding, changing fire regimes, etc.
	TEK	Uses of traditional ecological knowledge become less predictive and less reliable.
	Development	More natural resource development in Alaska with increasing global demand. More developmental pressures, e.g. opening Northwest Passage, community resettlement, etc.