NORTHERN CLIMATE REPORTS

ECOLOGICAL FUTURES in STORIES, CHARTS, and DATA

Presenters

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Thanks to project leaders and programmers

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- **Tool development by the SNAP team**
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Alaska Climate Adaptation Science Center

SNAP

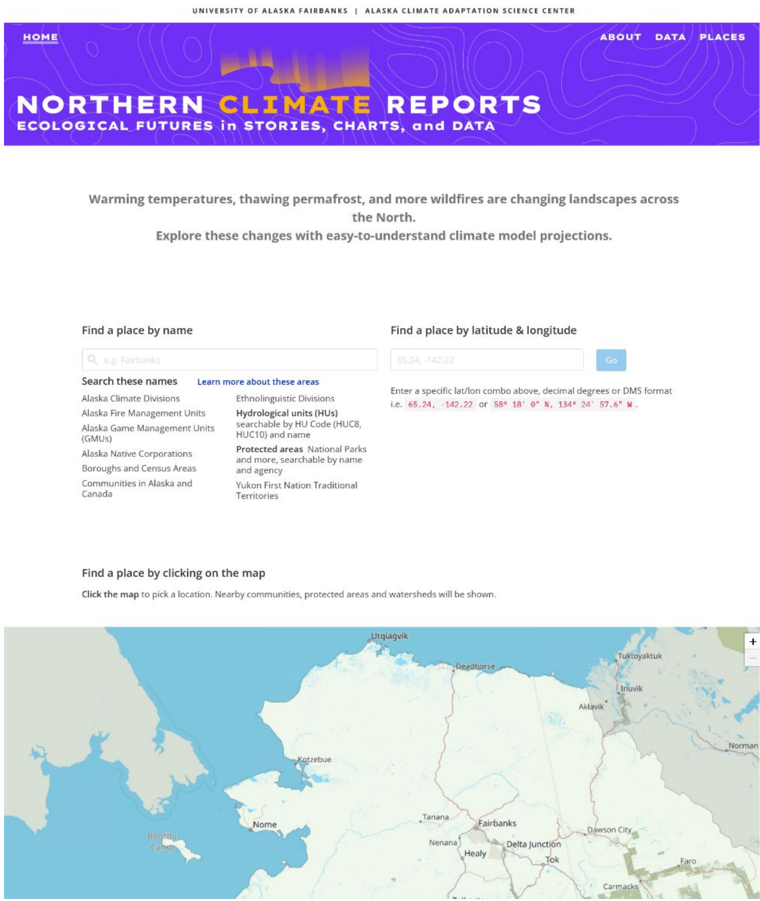
International Arctic Research Center

UAF University of Alaska Fairbanks

USGS science for a changing world

Welcome to a sneak preview of Northern Climate Reports!

- Project background, funding, leadership and rationale
- What makes this web tool different – including some of the technical framework
- Tool demo and uses
- Plenty of time for questions



To be updated and fully launched in late October 2023

https://northernclimatereports.org/

A long collaborative history

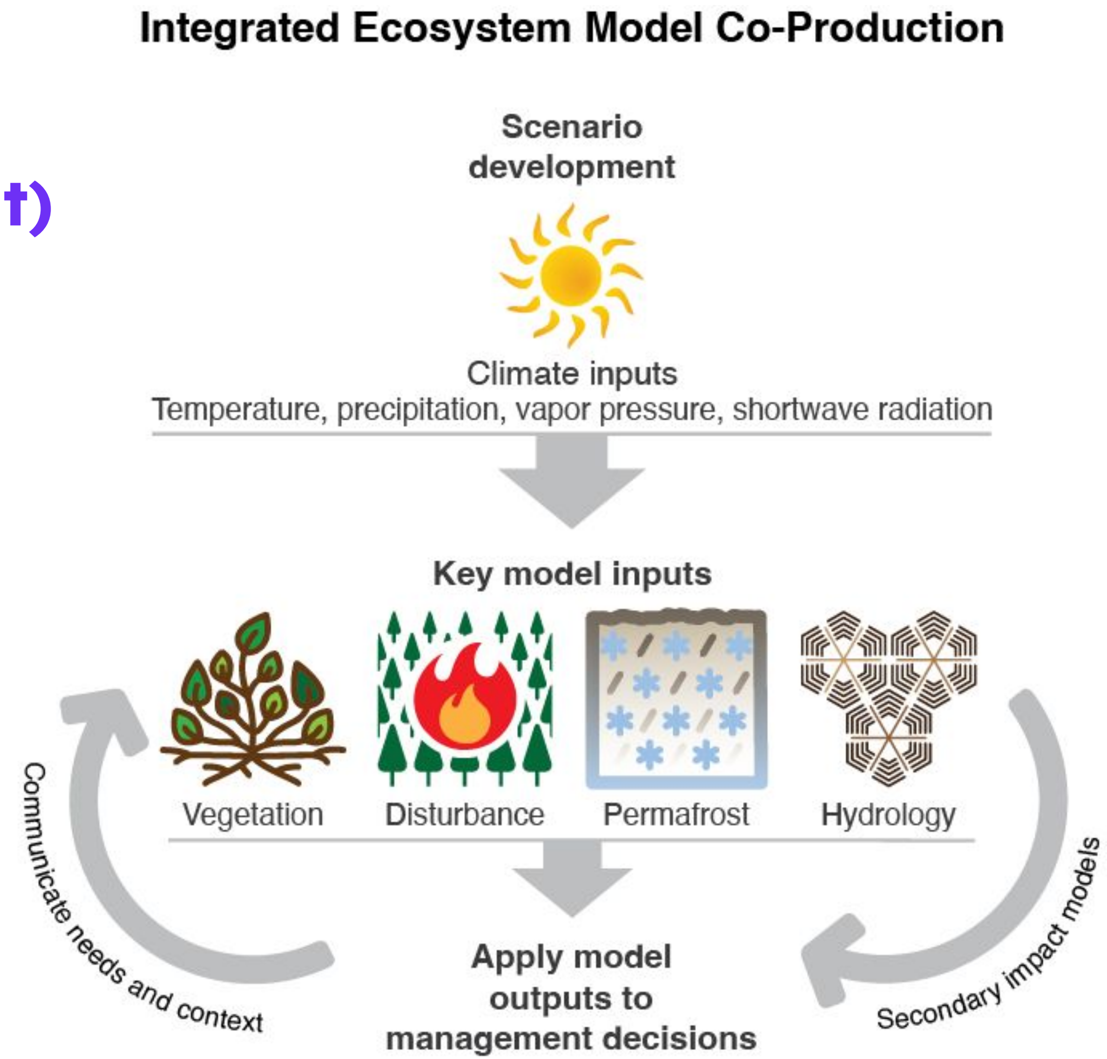
2010–2020: Funded projects through UAF, UAS, USGS ASC & AK CASC, three USFWS LCCs, USFWS, and other partners to develop regional and statewide datasets of projected changes in:

- Temperature & precipitation projections
- Snow
- Vegetation
- Permafrost
- Fire
- Habitat/wildlife
- Glaciers
- Carbon flux & cycle
- Thermokarst

Data were served online as myriad raster, tabular, and graphical datasets. Many of these were further translated for synthesis products, vulnerability/impacts assessments, and adaptation plans as partner needs emerged (and are still emerging)

The IEM (Integrated Ecosystem Management) Project

- USGS & the Alaska Climate Adaptation Science Center
- Arctic Landscape Conservation Cooperative
- Northwest Boreal Landscape Conservation Cooperative
- University of Alaska Fairbanks
- Western Alaska Landscape Conservation Cooperative



IEM goals

The IEM project explored the impact of climate variability and change on ecosystem components, while also addressing the interactions and feedbacks among components.

The ultimate aim of the IEM was to provide resource managers and decision makers with scenarios for potential changes in landscape structure and/or ecosystem structure and function.

Data produced by the IEM encompasses most of Alaska and parts of northwest Canada. The domain coincides with the five Landscape Conservation Cooperatives. (LCCs).

These scenarios are intended for use as inputs to resource- or sector-specific impact models and decision support tools.

IEM model components

The Alaska Frame-Based Ecosystem Code (ALFRESCO) simulates wildland fire, vegetation establishment, and succession.

The Terrestrial Ecosystem Model (TEM) simulates characteristics of organic and mineral soils, hydrology, vegetation succession, plant community composition, biomass, and carbon balance in soil.

The Geophysical Institute Permafrost Lab model (GIPL) simulates permafrost dynamics—such as active layer thickness, changes in soil temperature and changes in permafrost extent.

Development of an “IEM Web Tool”

A multi-agency (USFWS, NPS, NASA) “collaboration team” of experts provided input on tool priorities.

They wanted:

- Climate projection summaries, fire, and permafrost information tailored to regions they chose, worked in, or managed
- The ability to extract summaries as tables, graphics, and data for analysis in spreadsheets

How is the Northern Climate Reports (NCR) tool different from other web tools?

SNAP offers a range of online tools geared to answer different types of climate-related questions for various audiences.

NCR is our most flexible tool yet!

Airport Winds

Alaska airport winds across the decades

Alaska Garden Helper

Explore changing growing conditions in Alaska

Alaska Wildfire Explorer

Alaska wildfires within the larger forest ecosystem

Arctic-EDS

Climate data in the context of key environmental variables for Northern engineers

Changing Subsistence Lifeways

How climate change is affecting subsistence in interior Alaska

Climate Scenarios for the NWT

Climate projections for communities in Canada's Northwest Territories

Community Climate Charts

Climate projections for over 3,800 communities in Alaska and Canada

Community Permafrost Data

Community vulnerability to permafrost change

Community Wind

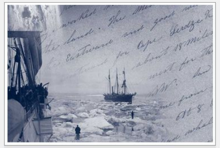
Community wind changes across Alaska

Fire Tally

See how much of Alaska has burned since 2004

Fish and Fire in Interior Alaska

Possible futures for interior Alaska aquatic ecosystems



Historical Sea Ice Atlas

Sea ice data across the decades (1850-present)

Northern Climate Reports

How temperature, permafrost, and wildfire are driving landscape change

Precipitation Projections for Alaska Infrastructure

Precipitation change and its effects on Alaska infrastructure

Statewide Temperature Index

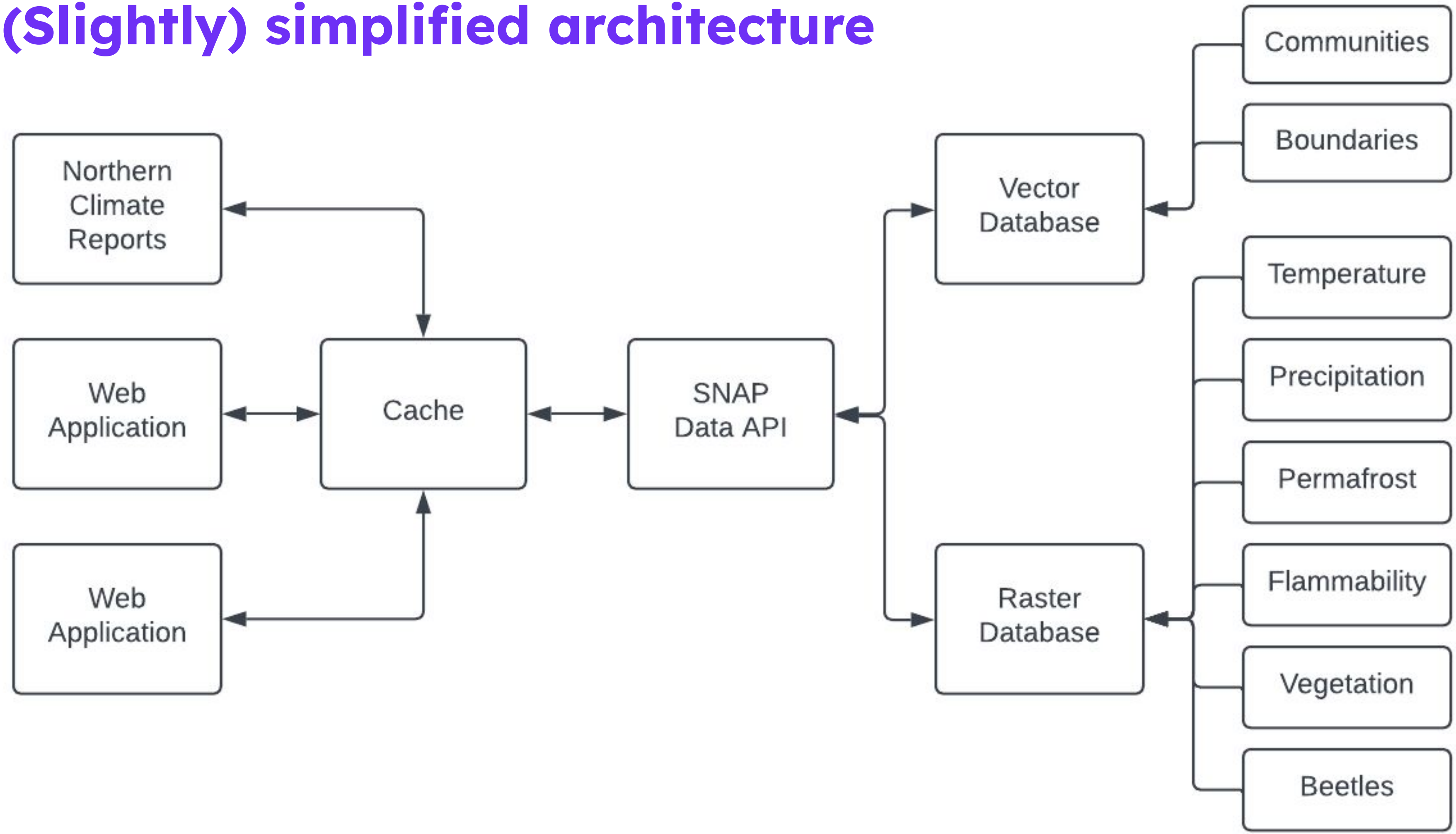
Daily average Alaska temperatures compared with historical averages

The infrastructure that powers Northern Climate Reports

- The Northern Climate Reports web application was built on top of a system of interconnected data, software, and server components
- Each component of the system is tailored towards flexibility and reuse
- SNAP's Data API (application programming interface) is the glue that binds all of these components together

First, a brief technical overview…

(Slightly) simplified architecture

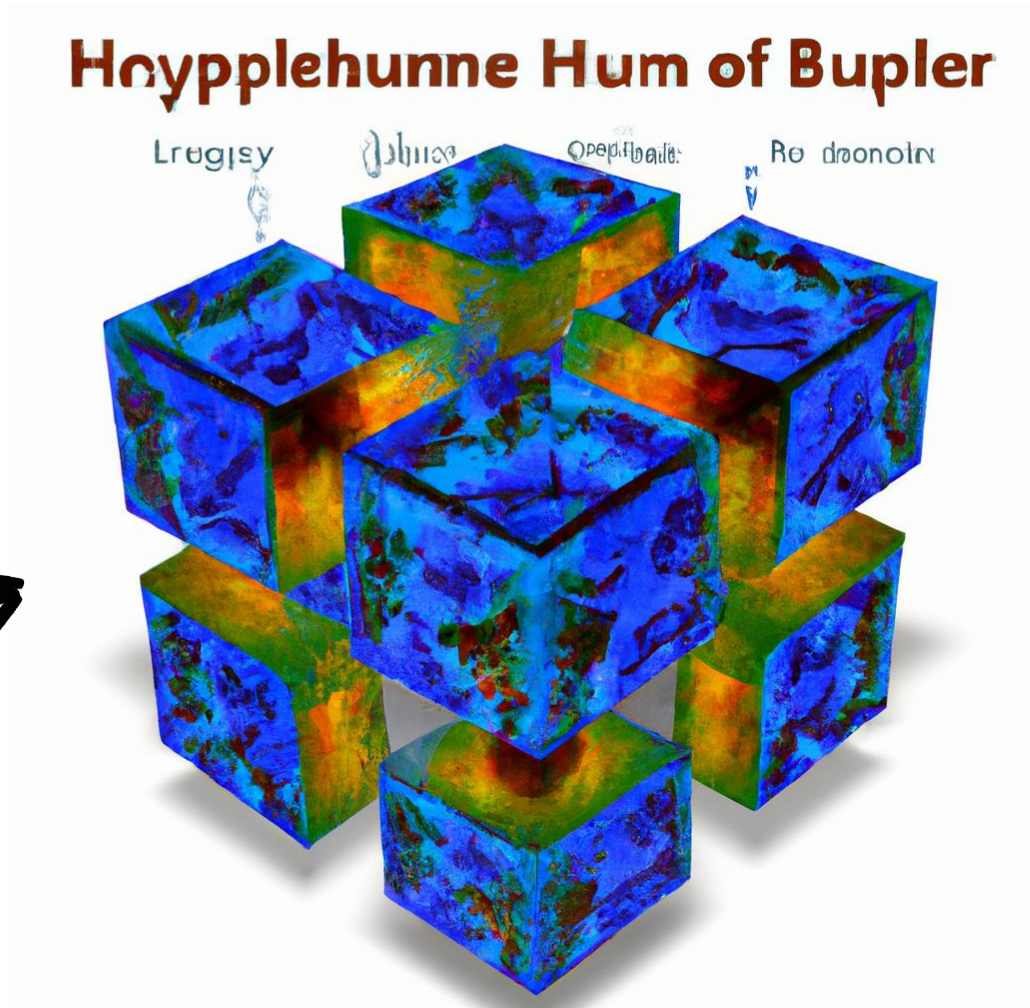


It all starts with hypercubes.

- Each dataset displayed in the tool (temperature, precipitation, permafrost, etc.) is stored as an n-dimensional data cube
- Data cube dimensions vary for each dataset, but generally include:
  - Latitude
  - Longitude
  - Time
  - Global climate model
  - Emissions scenario
- This flexible approach allows us to extract and average point data or 2-dimensional slices along a set of axes (e.g., “Give me a map of the mean flammability from 2070-2099 for the NCAR CCSM4 model under RCP 8.5”)

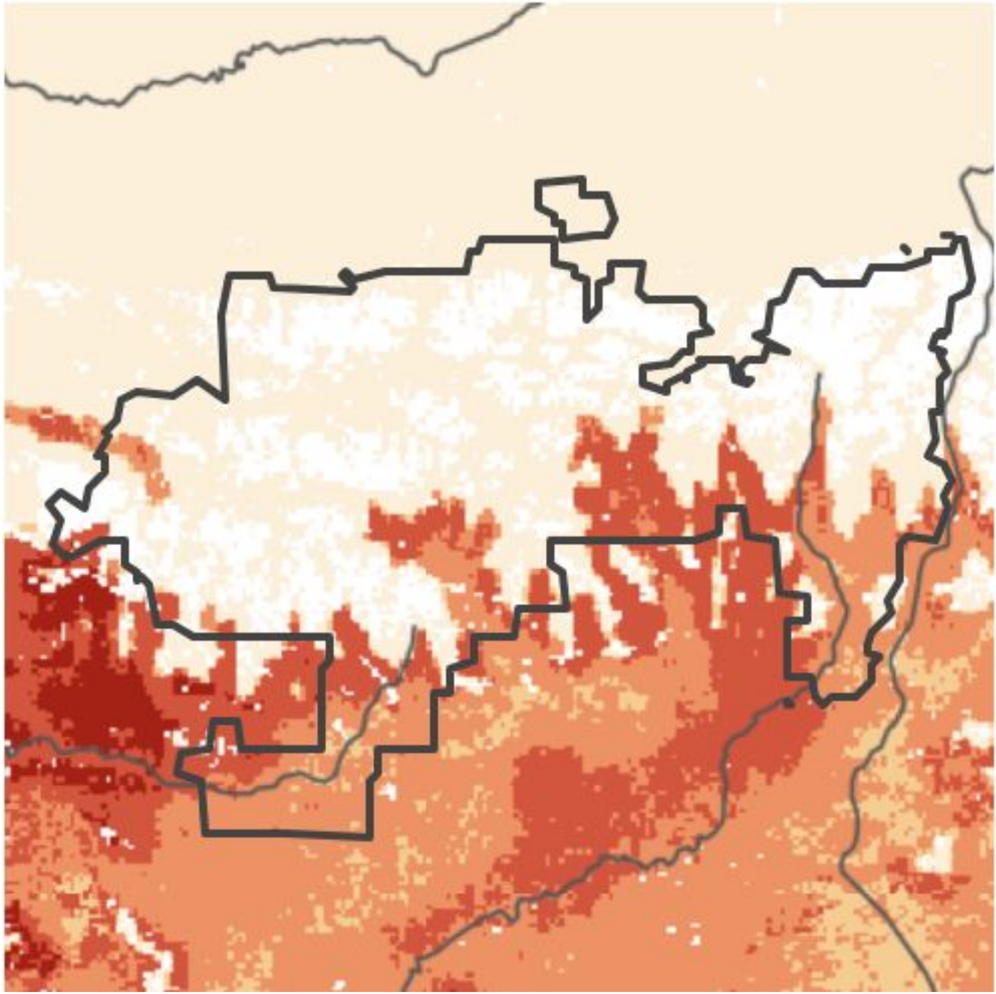
Hypercubes can hard to visualize, however ...

A visualization of a climate hypercube according to artificial intelligence



Averages over boundaries

- Getting a 2D slice of data is half the battle
- Many charts and tables in NCR show averages of raster data over irregularly shaped physical and administrative boundaries
- SNAP's Data API averages across large irregular boundaries and across time, but this is computationally demanding and slow
- To remedy this, all queries for known boundaries are pre-cached to speed up even the largest boundary queries



Northern Climate Reports talks to SNAP's Data API

- Northern Climate Reports is one of many possible applications that can be built on top of SNAP's Data API
- All of this functionality is accessible via a public, user-friendly web service
- Web applications and scripts can retrieve the data they need by simply passing lat/lon coordinates or a boundary identifier into the endpoint for the corresponding dataset
- You can use SNAP's Data API, too!

https://earthmaps.io/

Example queries

- Get historical and projected temperature data for Lat: 65, Lon: -146
  https://earthmaps.io/temperature/point/**65/-146**

- Get historical and projected climate protection from spruce beetle outbreaks for Denali National Park and Preserve (area code NPS5)*
  https://earthmaps.io/beetles/area/**NPS5**

- Download a CSV of all available area codes*
  https://earthmaps.io/places/all?format=csv

**Query not available until late October launch*

Getting started with Northern Climate Reports

What questions do you have?

- What are the many ongoing effects of climate change?
- What are the specific projections for certain variables such as fire, extreme heat, permafrost thaw, or spruce beetle outbreaks?

What is your region of interest?

- A political unit such as a town or borough
- A point such as the location of my home or berry patch
- An ecological/physiological unit such as a watershed

With whom do you need to share your results?

- Others in my community need to know
- I'm writing a grant proposal
- I'm contacting lawmakers or land managers

Step 1: Choose a location (two ways)

Find a place by name

e.g. Fairbanks

Search these names Learn more about these areas

- Alaska Climate Divisions
- Alaska Fire Management Units
- Alaska Game Management Units (GMUs)
- Alaska Native Corporations
- Boroughs and Census Areas
- Communities in Alaska and Canada
- Ethnolinguistic Divisions
- **Hydrological units (HUs)** searchable by HU Code (HUC8, HUC10) and name
- **Protected areas** National Parks and more, searchable by name and agency
- Yukon First Nation Traditional Territories

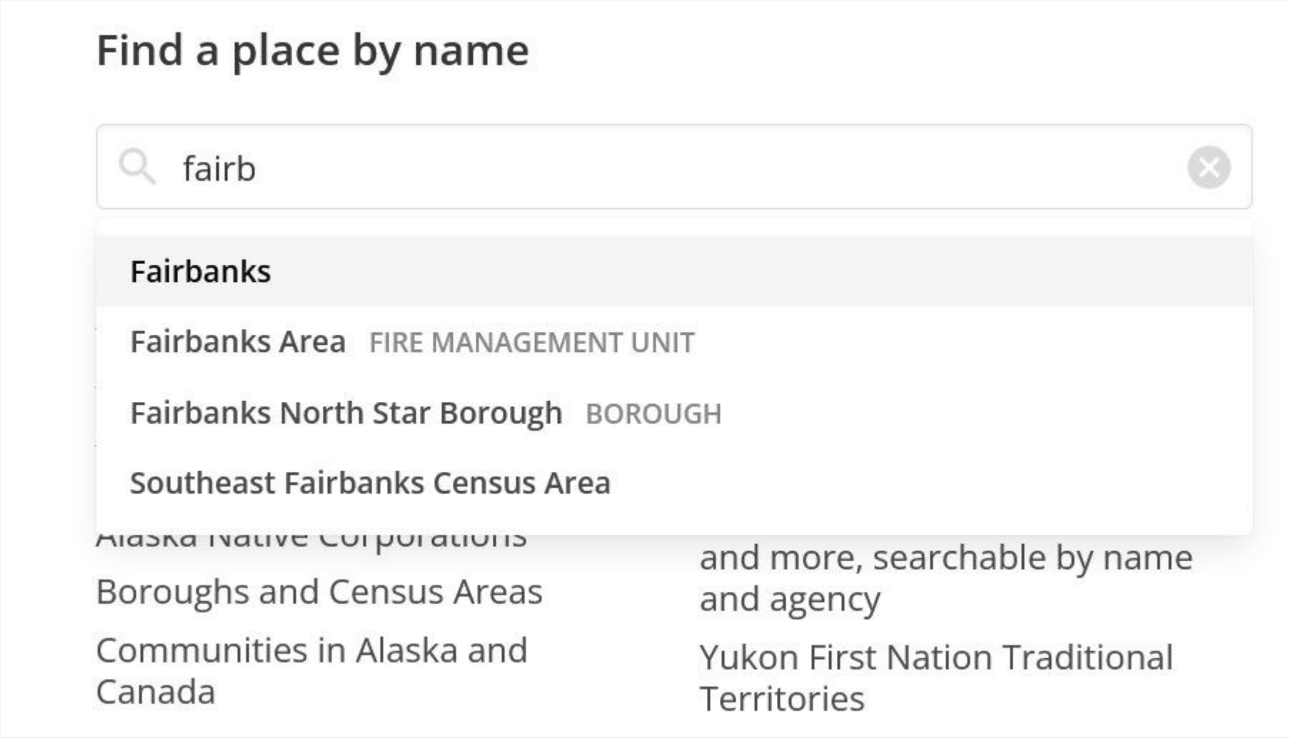
Find a place by latitude & longitude

65.24, -142.22

Go

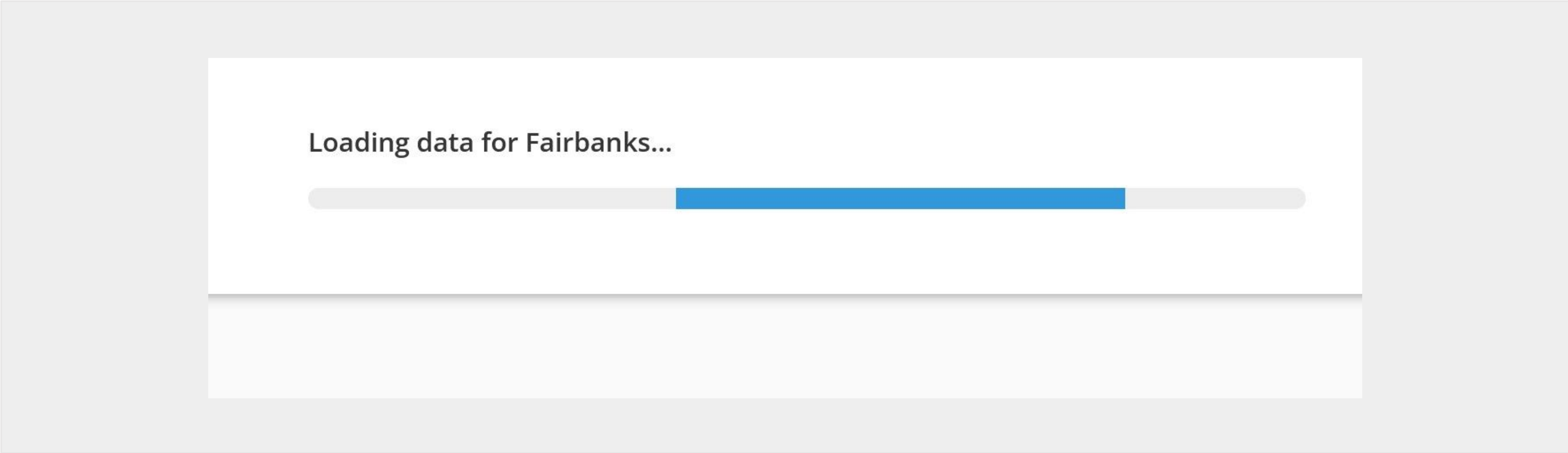
Enter a specific lat/lon combo above, decimal degrees or DMS format i.e. `65.24, -142.22` or `58° 18' 0" N, 134° 24' 57.6" W` .

Step 2: Start typing and see place names appear.



I chose "Fairbanks"

Data may take a few minutes to load, especially with slower connections (please be patient!). Data is being pulled and compiled as described in the previous slides.



Summary of results

The tool generates a summary for the selected area for all the key variables, including temperature, precipitation, fire, and bark beetles.

In **Fairbanks**,
average annual temperatures
may increase by about **13°F** by the end of the century.

Winter temperatures are increasing the most (**+18°F**).

Spring and **fall** may transition from below freezing
to **above freezing** in the future.

Models have higher uncertainty with regard to precipitation,
but **spring** is likely to have more precipitation (**+88%**).

In the past, this area had **moderate** flammability. Future
flammability may be **about the same** (+30% by late century).

Based on climate and fire-driven shifts, vegetation in this area
may be **notably different** by the end of the century.

Historically, climate conditions were **highly protective** against
spruce beetle outbreaks. Under normal snow conditions,
climate conditions in the future may provide **about the same
protection** by mid-century and **less protection** by late this
century.

Summary across all models and scenarios. See tables and sections below for more detailed information and definitions.

Scroll down below results for background information and context

The Introduction has basic information on what you're seeing:

- Physiography of your chosen location
- definitions for GCMs and RCPs
- Seasonal definitions
- Unit choices (imperial or metric)

Introduction

The tables and charts below are specific to the gridded data extracted from the location of Fairbanks, indicated by a marker on the map above. The shaded region on the map is the nearest watershed (hydrological unit, level 12) and is only used to summarize wildfire data around this place.

The average (mean) elevation near this point is 433ft above sea level. The minimum elevation is 381ft and the maximum elevation is 486ft, which should be kept in mind when interpreting these results.

The sections below show output from different scientific simulations of possible future conditions for temperature, precipitation, permafrost, flammability, vegetation change, and climate protection from spruce beetle outbreaks. These simulations use different **Global Climate Models (GCMs)**—climate models—such as the National Center for Atmospheric Research Community Climate System Model 4.0 (NCAR CCSM4).

These climate models use **Representative Concentration Pathways (RCPs)** to compare different future greenhouse gas emissions scenarios. Compared to current emissions RCP 4.5 is a scenario representing a reduction in global emissions, while RCP 8.5 represents a scenario similar to, or possibly higher than, current global emissions trajectories. RCP 6.0 is between these two trajectories. Read more about climate models and RCPs.

Some of the data has been averaged by season.

- **Winter** is December, January and February,
- **Spring** is March, April and May,
- **Summer** is June, July and August,
- **Fall** is September, October and November.

Click the icon in the upper–right of charts to get a hi-res download.

You can display these visualizations in Imperial or metric units.

Units

◉ Imperial ○ Metric

Contents

Jump directly to the section you want, or scroll through all outputs.

Contents

- Temperature charts and tables with multiple models and scenarios, grouped decadally and into mid/late century
- Precipitation charts and tables with multiple models and scenarios, grouped decadally and into mid/late century
- Wildfire charts of flammability and vegetation change with with multiple models and scenarios
- Climate Protection from Spruce Beetles visualizes the climate-related protection from spruce beetles in forested areas of Alaska

Graphs

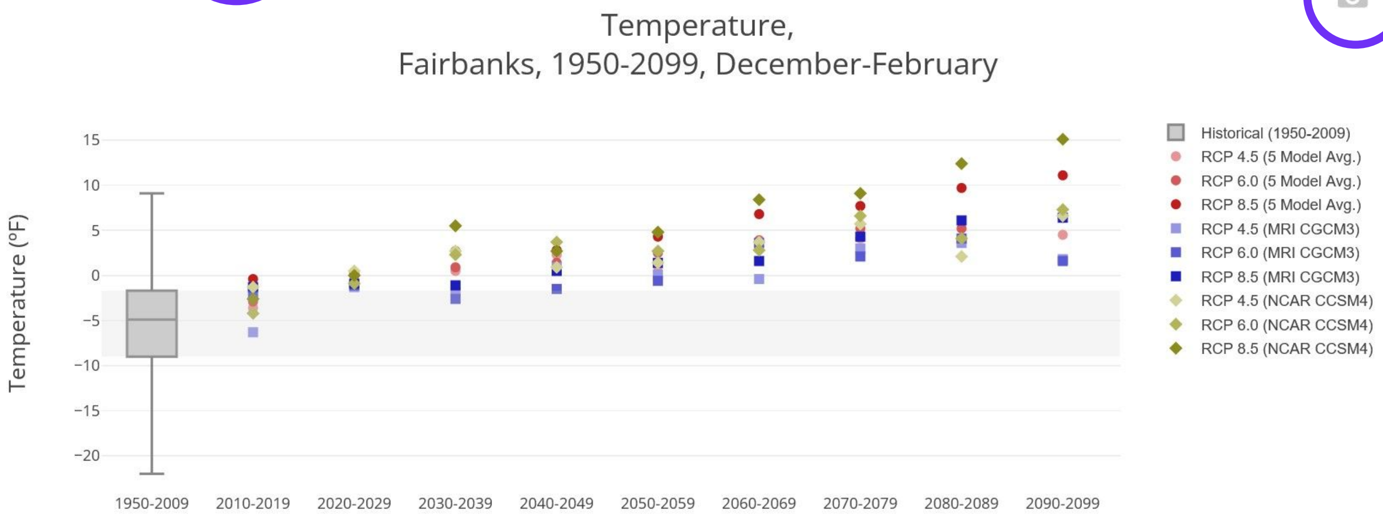
- View a range of time periods, models, and plausible futures.
- Select by season.
- Download images by clicking the camera icon.

Temperature

This section shows projections for average (mean) temperature, compared with a historical range (1950–2009, CRU TS 4.0). Results are averaged by season (three month averages) for two specific climate models (MRI CGCM3 and NCAR CCSM4) as well as average of five models which perform well in Alaska and the Arctic. See information about the dataset shown here.

Season

◉ Winter ○ Spring ○ Summer ○ Fall



The boxplot represents the interquartile range (IQR) of historical means for the season, from 1950–2009 (CRU TS 4.0).
The shaded gray region shows the extent of common variation for the historical period.
The line inside the boxplot represents the median historical temperature.

Tables

View the same information in tabular form.
Download it as a CSV for use in your own spreadsheets.

Temperature, Fairbanks, 1950–2099

		Mid-Century (2040–2069)				Long-Term (2070–2099)			
		Low Emissions (RCP 4.5)		High Emissions (RCP 8.5)		Low Emissions (RCP 4.5)		High Emissions (RCP 8.5)	
Season	Historical (1950–2009)	MRI CGCM3	NCAR CCSM4	MRI CGCM3	NCAR CCSM4	MRI CGCM3	NCAR CCSM4	MRI CGCM3	NCAR CCSM4
Winter	-5.4°F	0.1°F +5.5	1.9°F +7.3	1.2°F +6.6	5.4°F +10.8	2.8°F +8.2	4.8°F +10.2	5.5°F +10.9	12.2°F +17.6
Spring	29.8°F	33.4°F +3.6	36.5°F +6.7	34.3°F +4.5	37.6°F +7.8	34.2°F +4.4	37.9°F +8.1	36.7°F +6.9	42.4°F +12.6
Summer	58.8°F	61°F +2.2	63.7°F +4.9	61.7°F +2.9	65.1°F +6.3	61°F +2.2	65.1°F +6.3	63°F +4.2	68.4°F +9.6
Fall	25.5°F	29.7°F +4.2	31.1°F +5.6	31.6°F +6.1	33.6°F +8.1	32.2°F +6.7	33.1°F +7.6	35.1°F +9.6	37.8°F +12.3

Values show averages for the indicated date ranges. Red text means warmer temperatures. Read more about models and emissions scenarios.

Indicators

- Geared toward real-world questions
- Input from users (you!) can help us select the most useful indicators

Temperature Indicators, Fairbanks, 1950–2099

		Mid-Century (2040–2069)				Long-Term (2070–2099)			
		Low Emissions (RCP 4.5)		High Emissions (RCP 8.5)		Low Emissions (RCP 4.5)		High Emissions (RCP 8.5)	
Indicator	Historical (1988–2017)	MRI CGCM3	NCAR CCSM4	MRI CGCM3	NCAR CCSM4	MRI CGCM3	NCAR CCSM4	MRI CGCM3	NCAR CCSM4
Very Cold Day Threshold Only 5 days in a year are colder than this	-50.8°F	-47.7°F +3.1	-52.4°F -1.6	-46.3°F +4.5	-45.8°F +5.0	-44°F +6.8	-44.3°F +6.5	-41.4°F +9.4	-22.9°F +12.8
Very Hot Day Threshold Only 5 days in a year are warmer than this	86°F	90.7°F +4.7	90.5°F +4.5	90.1°F +4.1	91.9°F +5.9	87.4°F +1.4	96.1°F +10.1	90.9°F +4.9	99.3°F +13.3
Summer Days Temperature above 77°F	18	23 +5	33 +15	24 +6	43 +25	22 +4	41 +23	26 +8	68 +50
Deep Winter Days temperature below -22°F	23	15 -8	15 -8	13 -10	11 -12	14 -9	12 -11	11 -12	7 -16
Warm Spell Duration Index how often are there 6 or more hot days in a row?	🥦🥦 TBD	36	45	39	61	43	54	66	114
Cold Spell Duration Index how often are there 6 or more cold days in a row?	🥕🥕 TBD	4	4	4	4	3	2	0	0

This table lists some climate indicators derived from a wide range of models. Read more about the dataset and processing used to generate these data.

Download temperature data as CSV

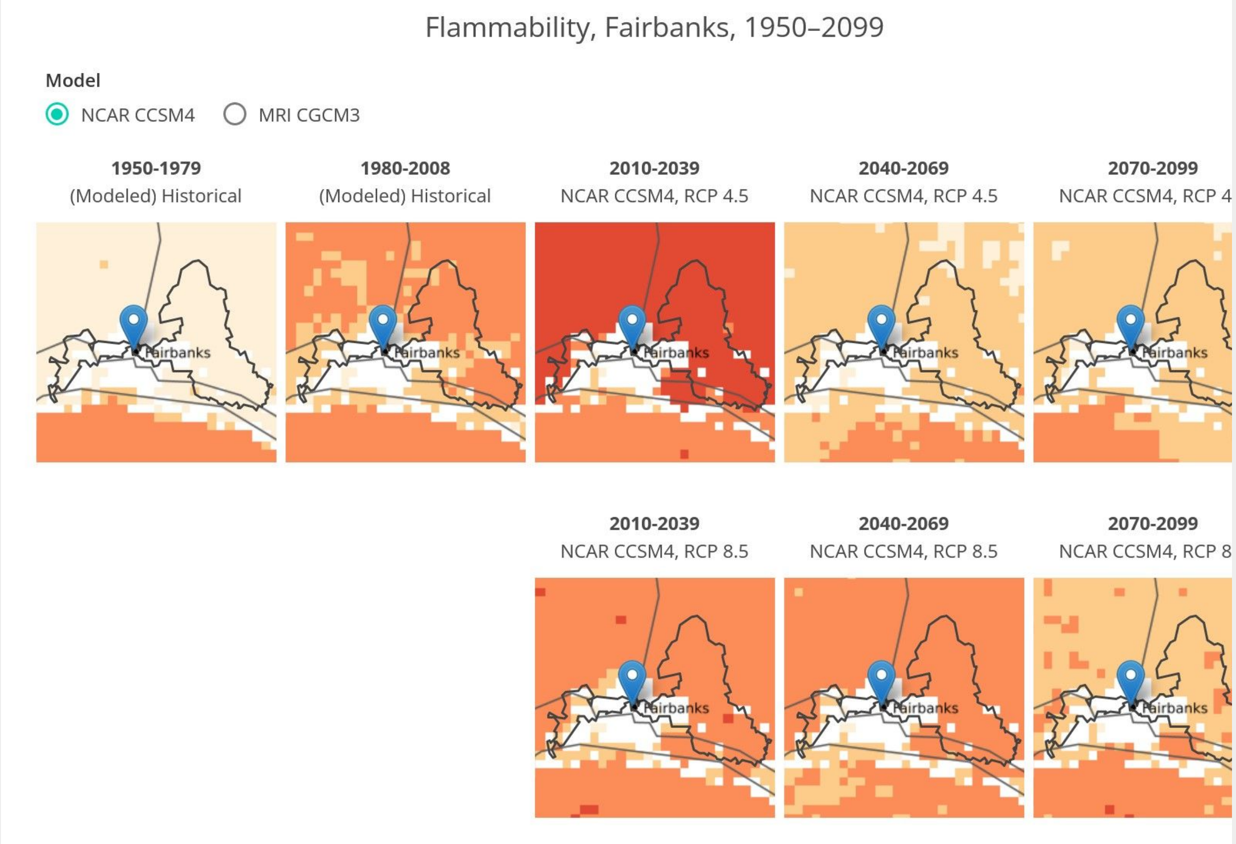
Precipitation

- The same data choices and visualizations are available for precipitation.
- Extreme events and rain vs. snow are also important.

Fire and vegetation

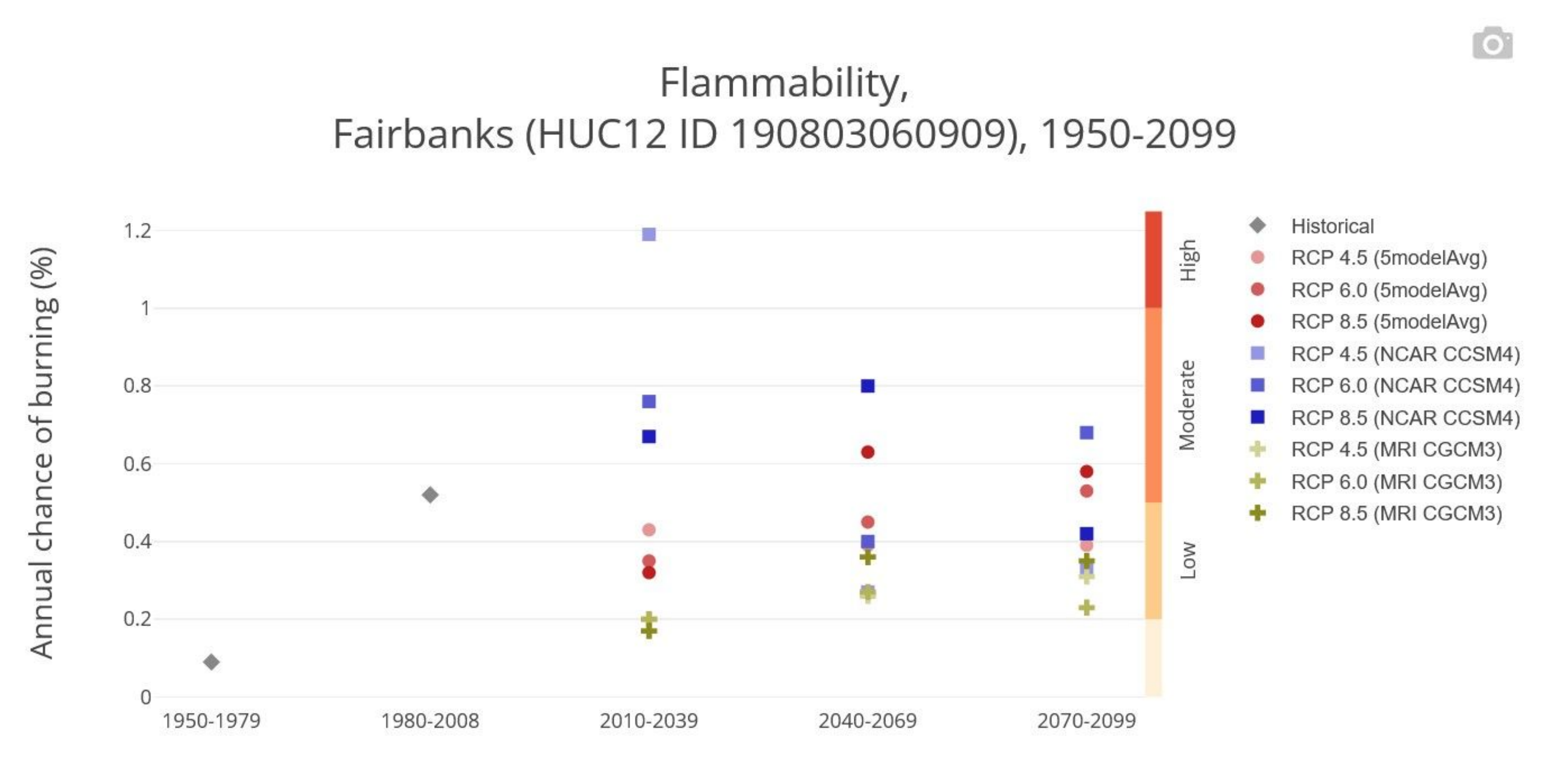
These model outputs are based on the ALFRESCO fire and vegetation model.

ALFRESCO considers climate change *as well as* past fires and existing vegetation types.



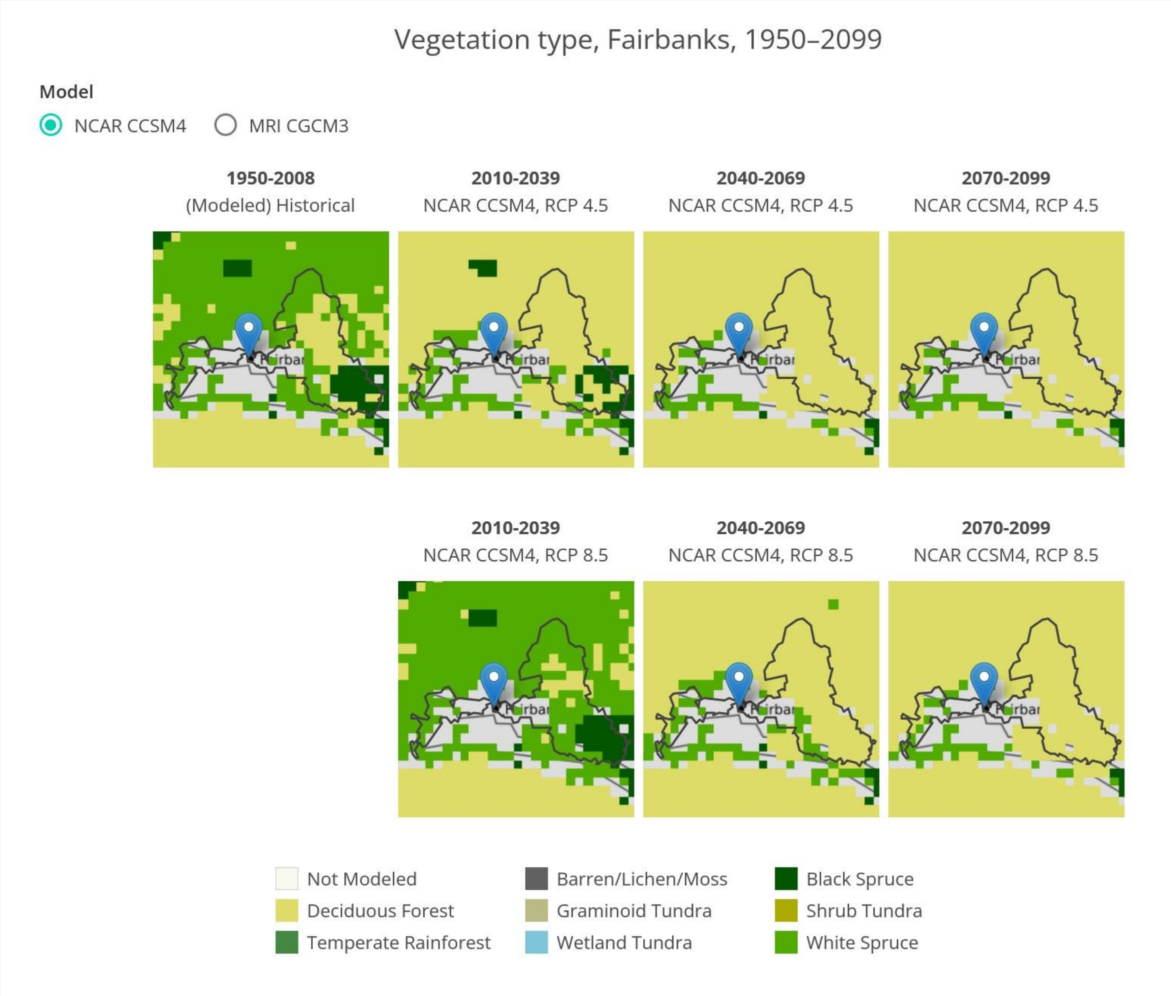
Fire is highly variable from year to year

A single prediction would be misleading.
A range shows a more realistic set of possibilities.



Fire drives vegetation change

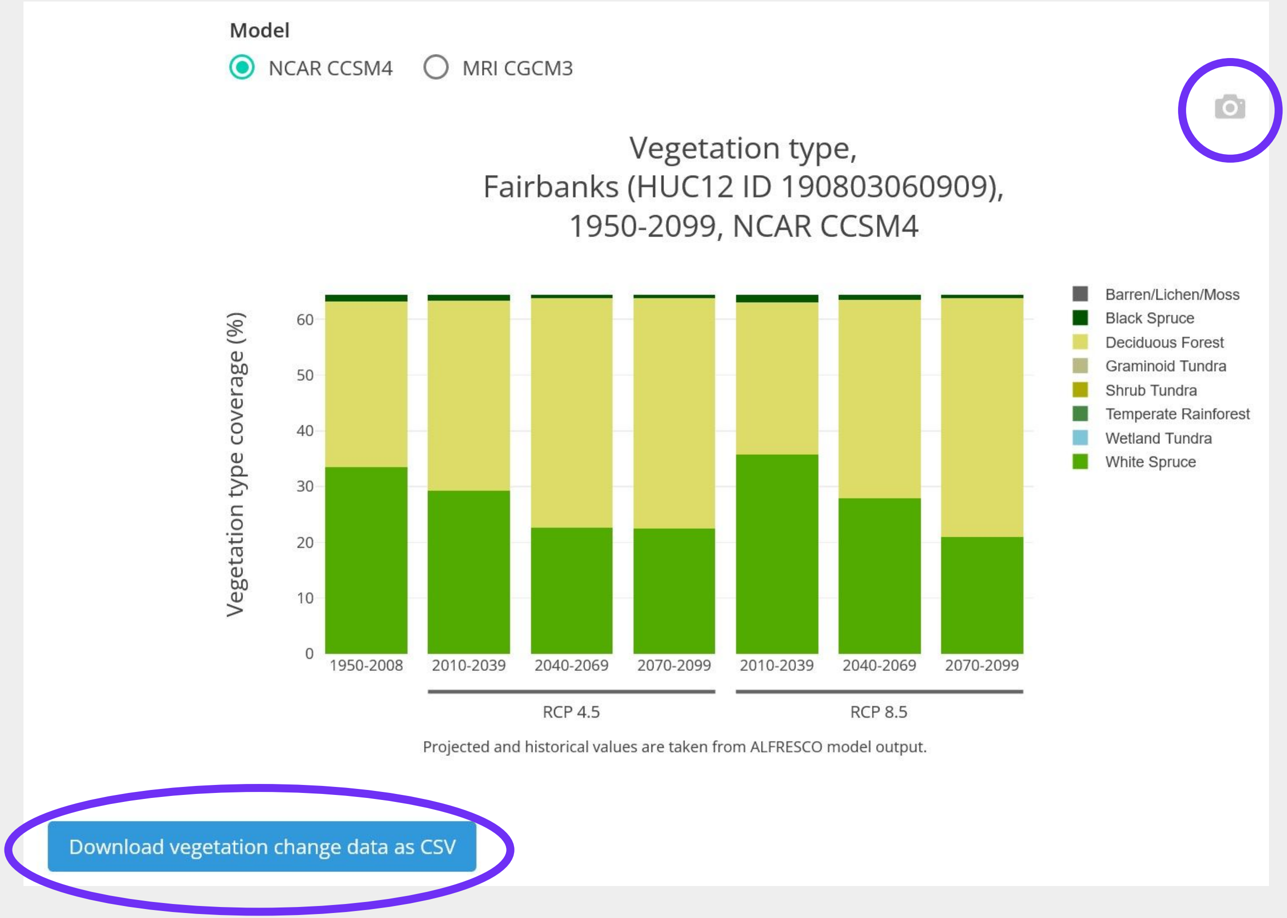
Here, increased fire early in the current century is driving a shift to more deciduous vegetation and less flammable spruce.



Different data views

See the same data as a bar graph.

As with other data, images or CSVs are available for instant download.



Bark beetles

This tool launch adds the outputs from a new modeling effort that examines the protective effects of Alaska's cold climate on spruce beetles.

How may that protection decline with climate change?

Climate Protection from Spruce Beetles, Low Snowpack, Fairbanks, 1988–2099

Historical modeled climate protection (Daymet, 1988–2017) is **high**.

	Early-Century (2010–2039)		Mid-Century (2040–2069)		Long-Term (2070–2099)	
Model	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
NCAR CCSM4	high	high	high	high	high	high
GFDL ESM2M	high	high	high	high	high	high
HadGEM2 ES	high	high	high	high	high	high
MRI CGCM3	high	high	high	high	high	high

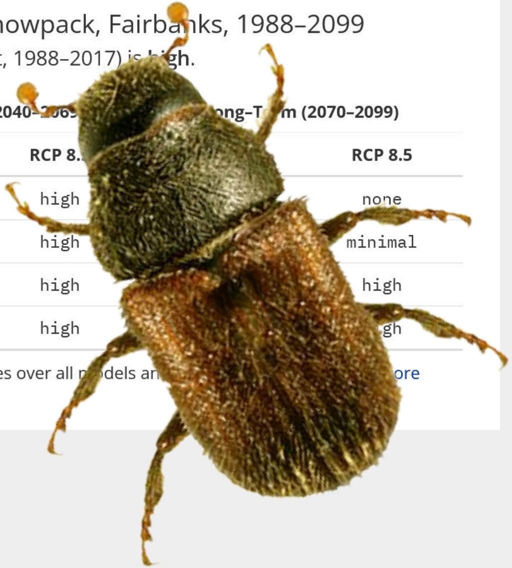
Values show climate-related protection from spruce beetles for the indicated date ranges over all models and emission scenarios. Read more about models and emissions scenarios.

Climate Protection from Spruce Beetles, Medium Snowpack, Fairbanks, 1988–2099

Historical modeled climate protection (Daymet, 1988–2017) is [illegible]gh.

	Early-Century (2010–2039)		Mid-Century (2040–[illegible]		[illegible]ong-T[illegible]m (2070–2099)	
Model	**RCP 4.5**	**RCP 8.5**	**RCP 4.5**	**RCP 8.[illegible]**	[illegible]	**RCP 8.5**
NCAR CCSM4	high	high	high	high	[illegible]	none
GFDL ESM2M	high	high	high	high	[illegible]	minimal
HadGEM2 ES	high	high	high	high	[illegible]	high
MRI CGCM3	high	high	high	high	[illegible]	[illegible]gh

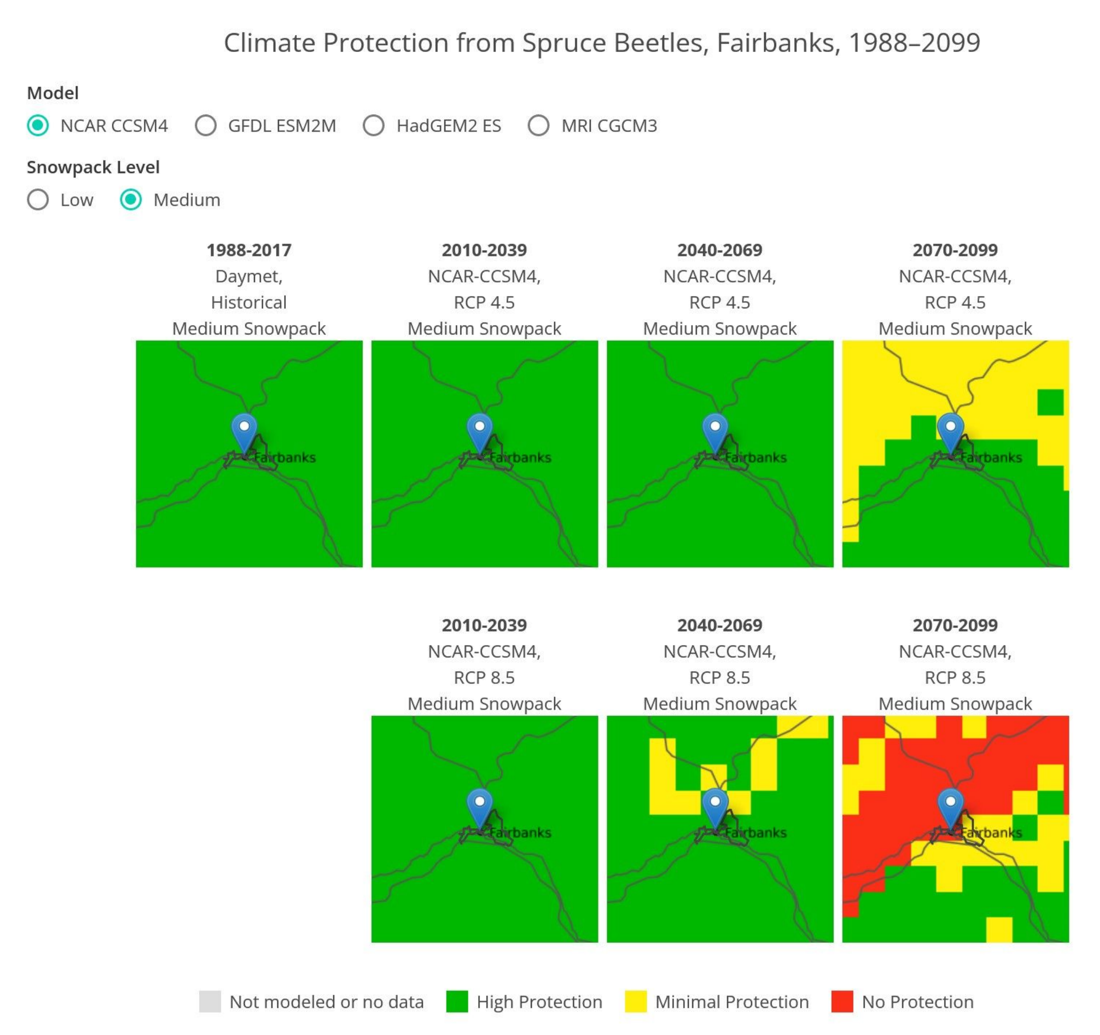
Values show climate-related protection from spruce beetles for the indicated date ranges over all [illegible]dels an[illegible]ore about models and emissions scenarios.



Less protection as the climate warms

In some parts of Alaska, warmer summers are allowing beetles to mature in 1 summer rather than in 2.

Here in the Interior, we are losing the protection of extreme winter cold.



Examples from audience

If possible, we pause the ppt and do a live demo of a place or places of interest.