Climate Change

Interactions with forest regeneration in Regions II&II

Dr. Nancy Fresco
Scenarios Network for Alaska & Arctic Planning
University of Alaska Fairbanks

SNAP

Climate science and SNAP data

Changes in fire cycles

Changes in permafrost and hydrology

Changes in climate

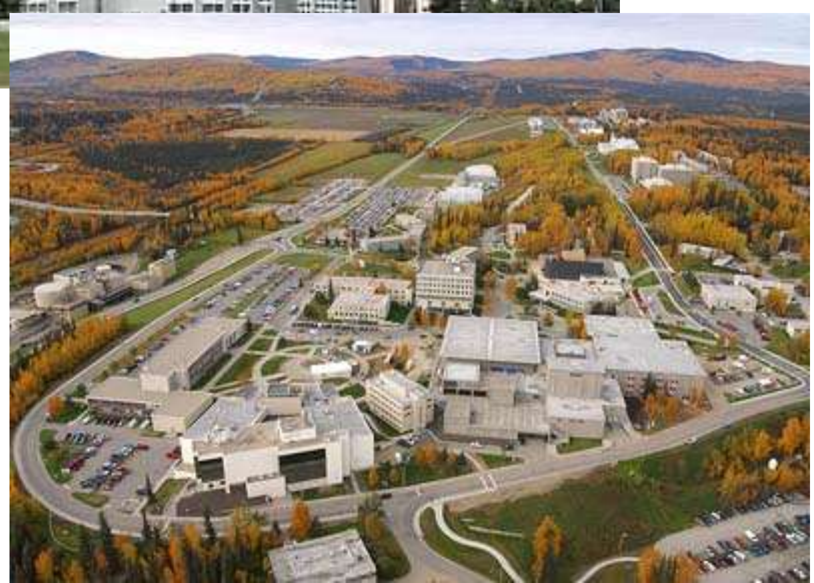
Linking models

Climate science and SNAP data

Scenarios Network

FOR ALASKA & ARCTIC PLANNING

University Resources

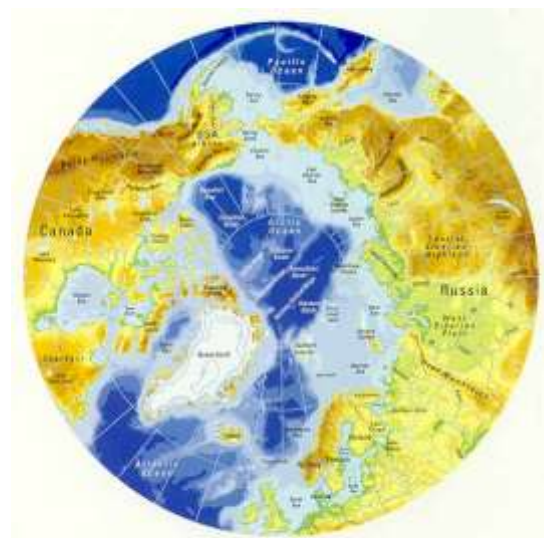


Scenarios Network
FOR ALASKA & ARCTIC PLANNING

International Arctic Research Center
IARC
University of Alaska Fairbanks

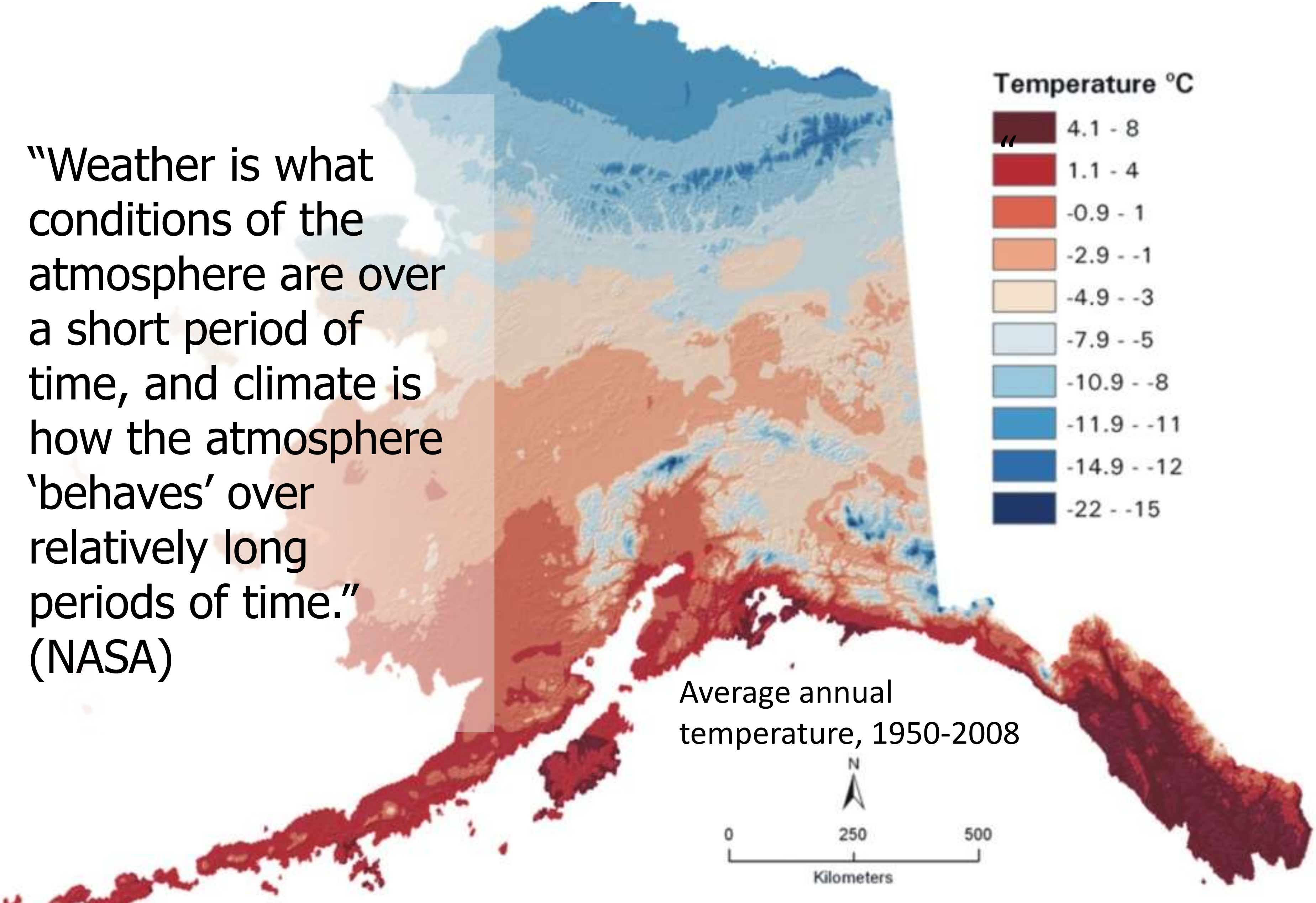
UNIVERSITY of ALASKA
Many Traditions One Alaska

Collaboration

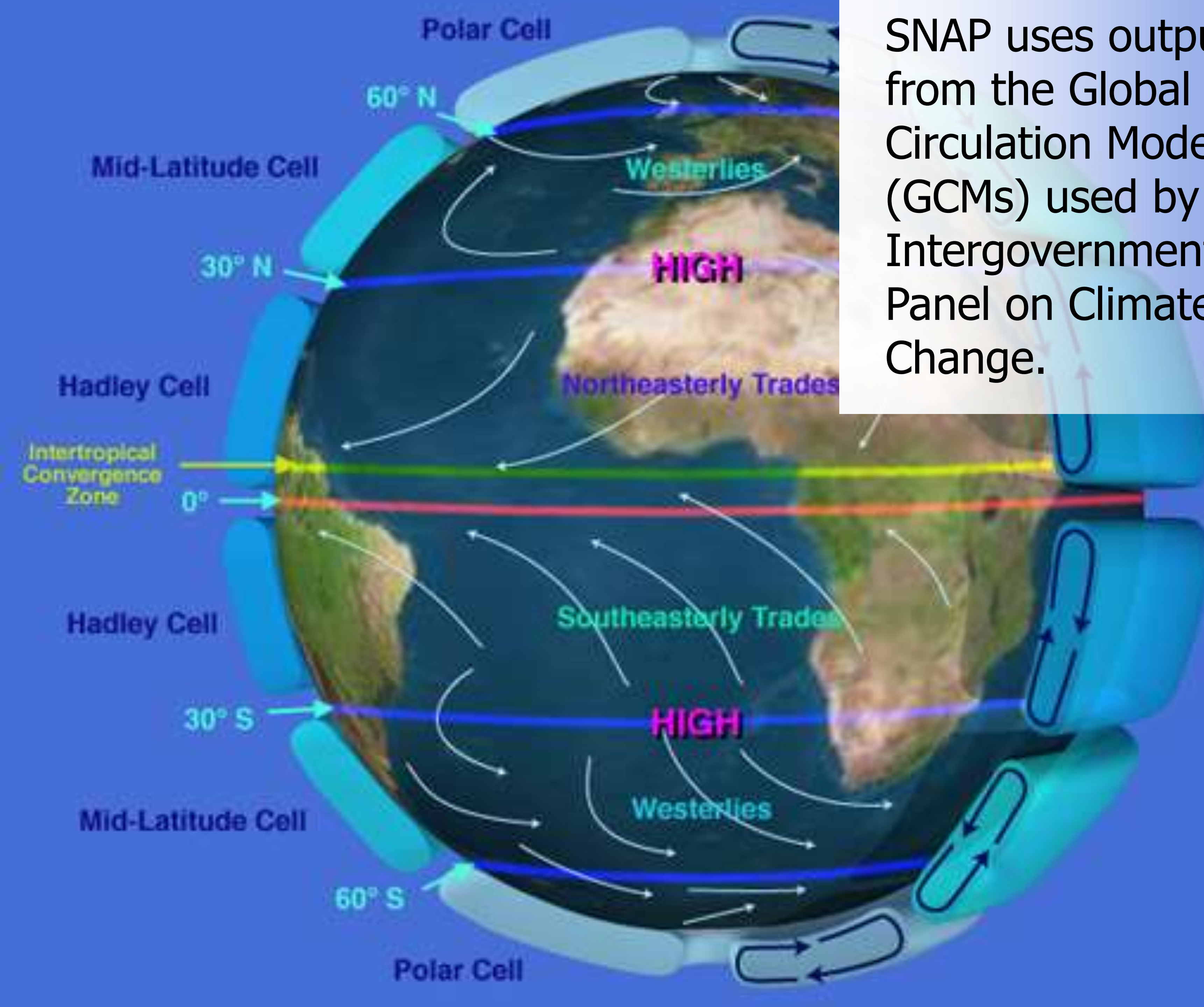


Climate Science

"Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere 'behaves' over relatively long periods of time." (NASA)



Average annual temperature, 1950-2008



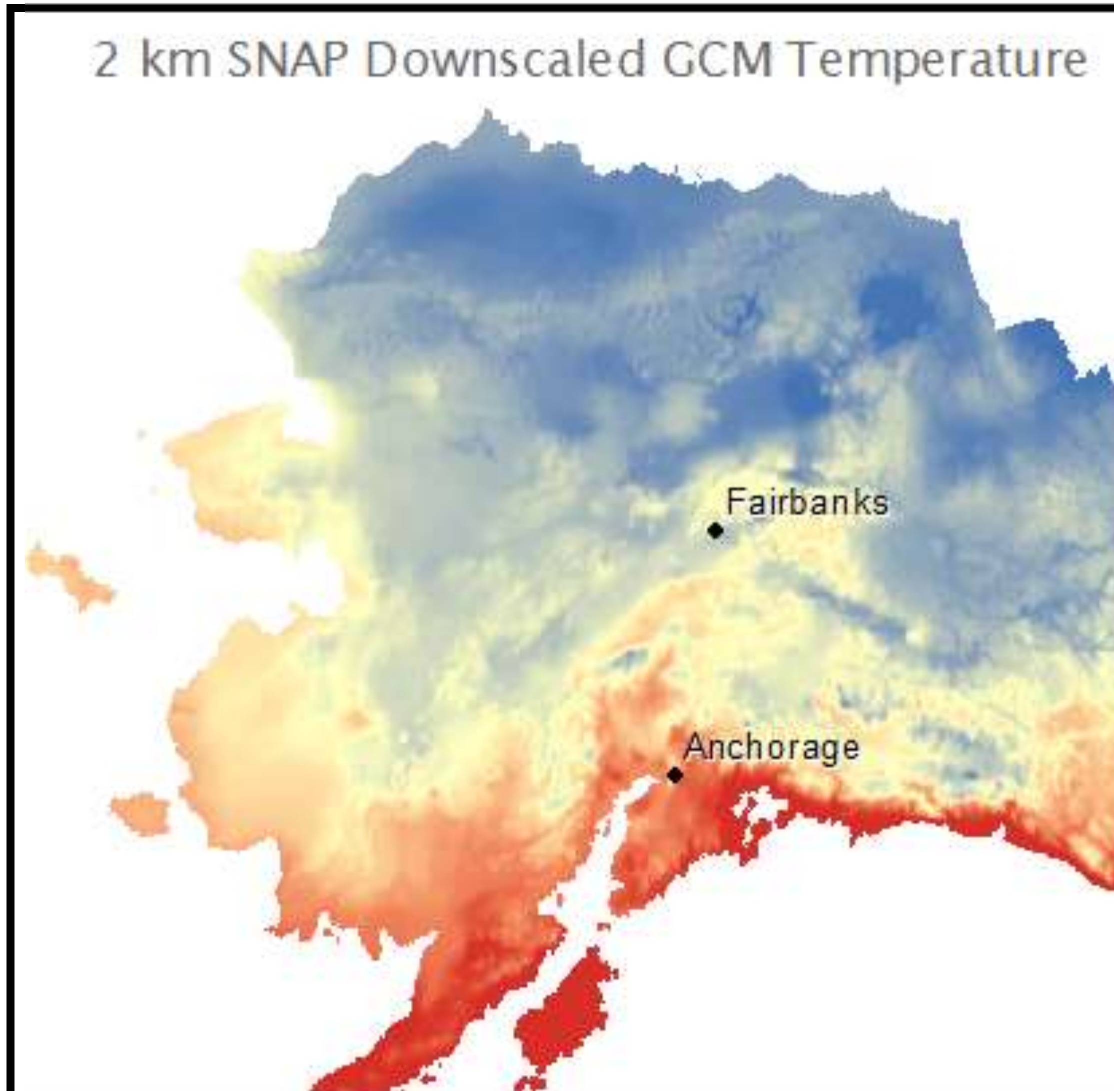
SNAP uses outputs from the Global Circulation Models (GCMs) used by the Intergovernmental Panel on Climate Change.

Downscaling

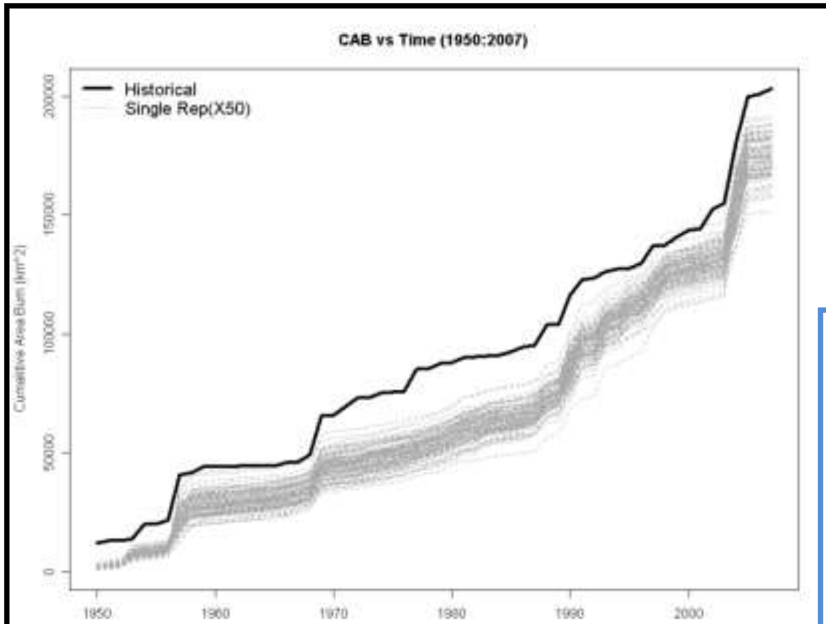
ipcc
WMO UNEP
INTERGOVERNMENTAL PANEL ON climate change

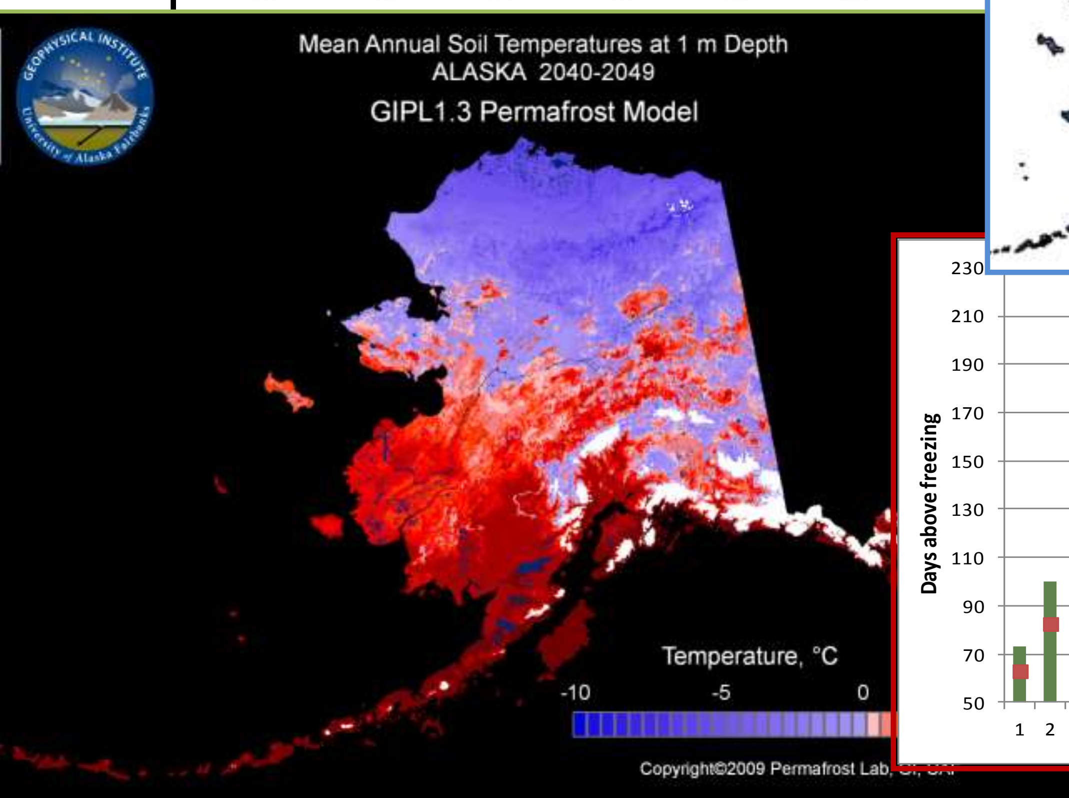
PRISM
CLIMATE GROUP

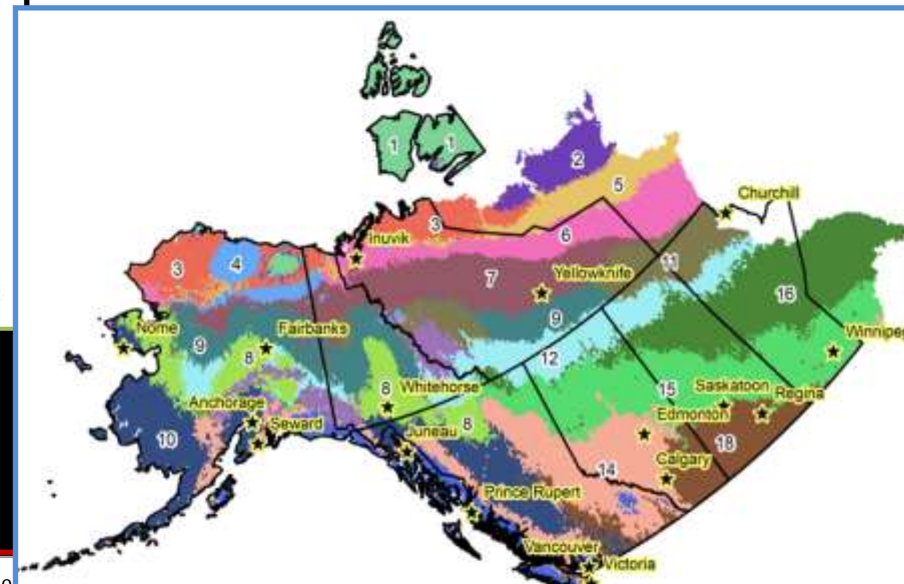
SNAP

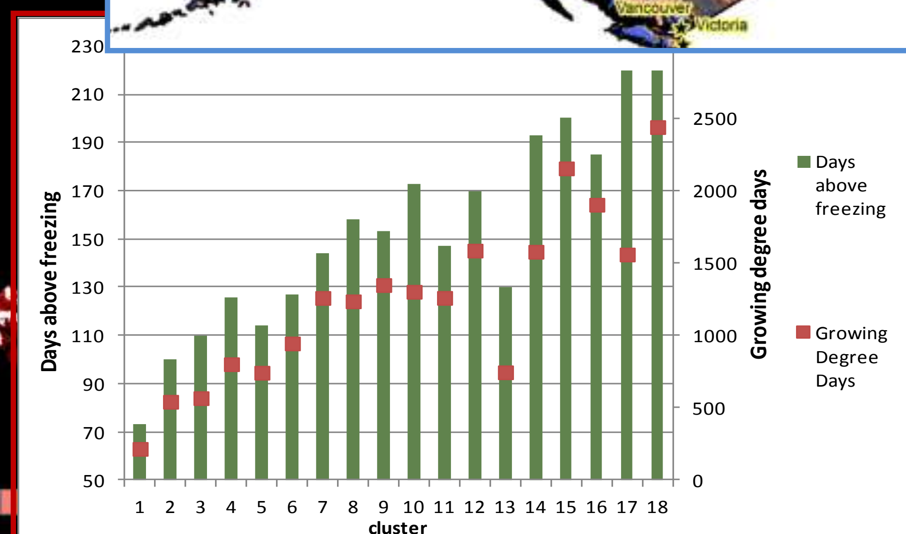


SNAP models are created using downscaled GCMs and other data



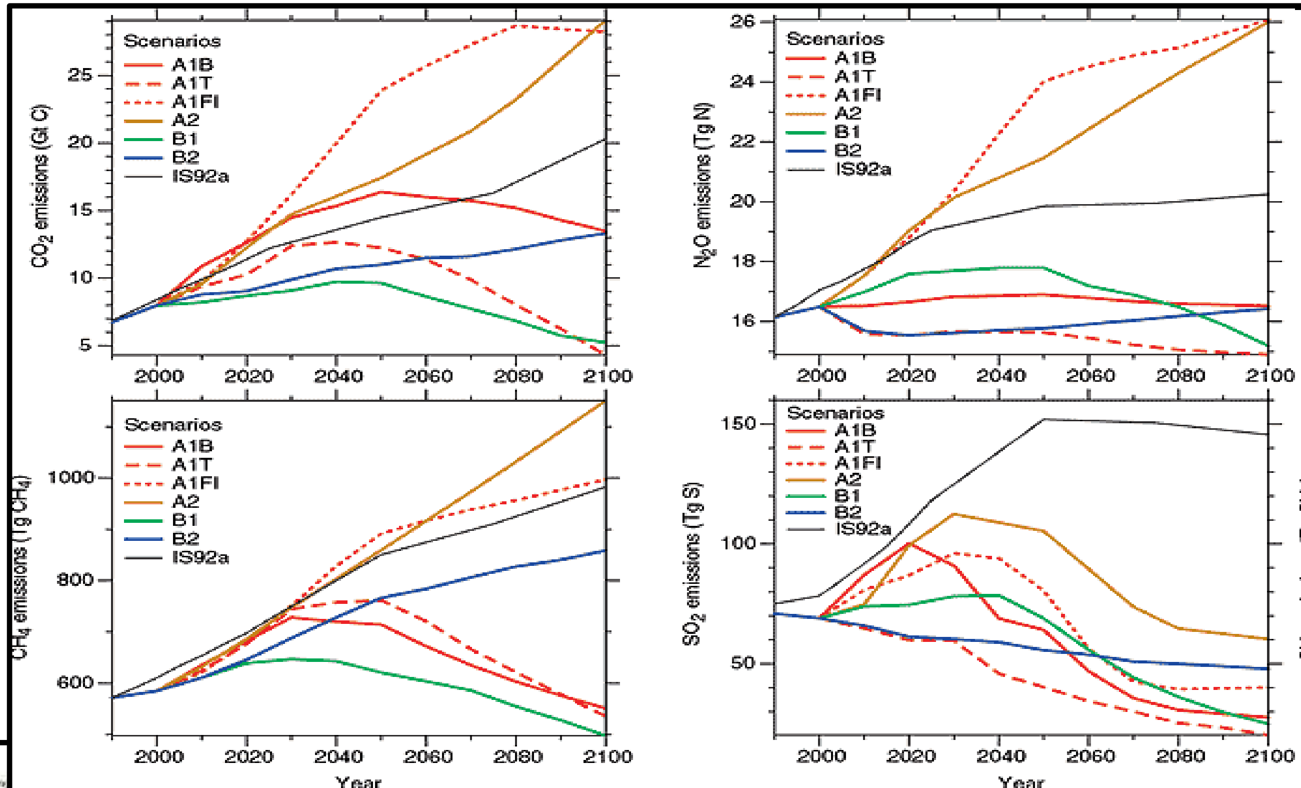


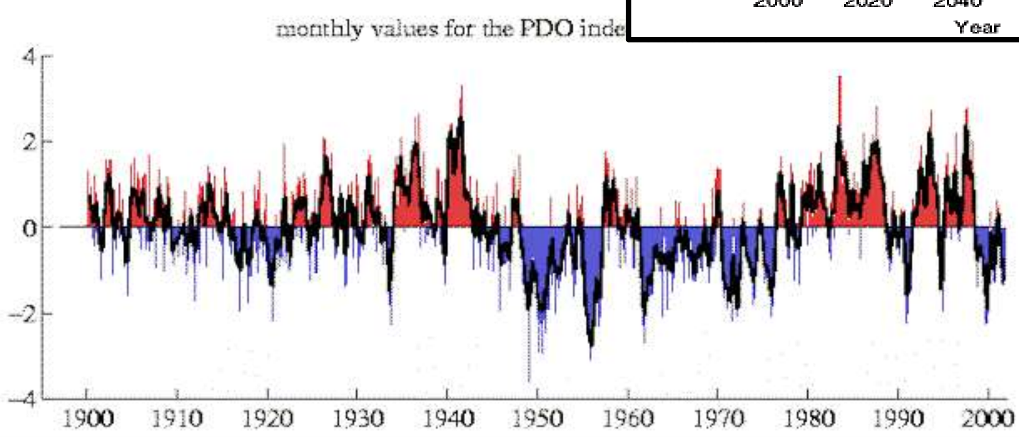




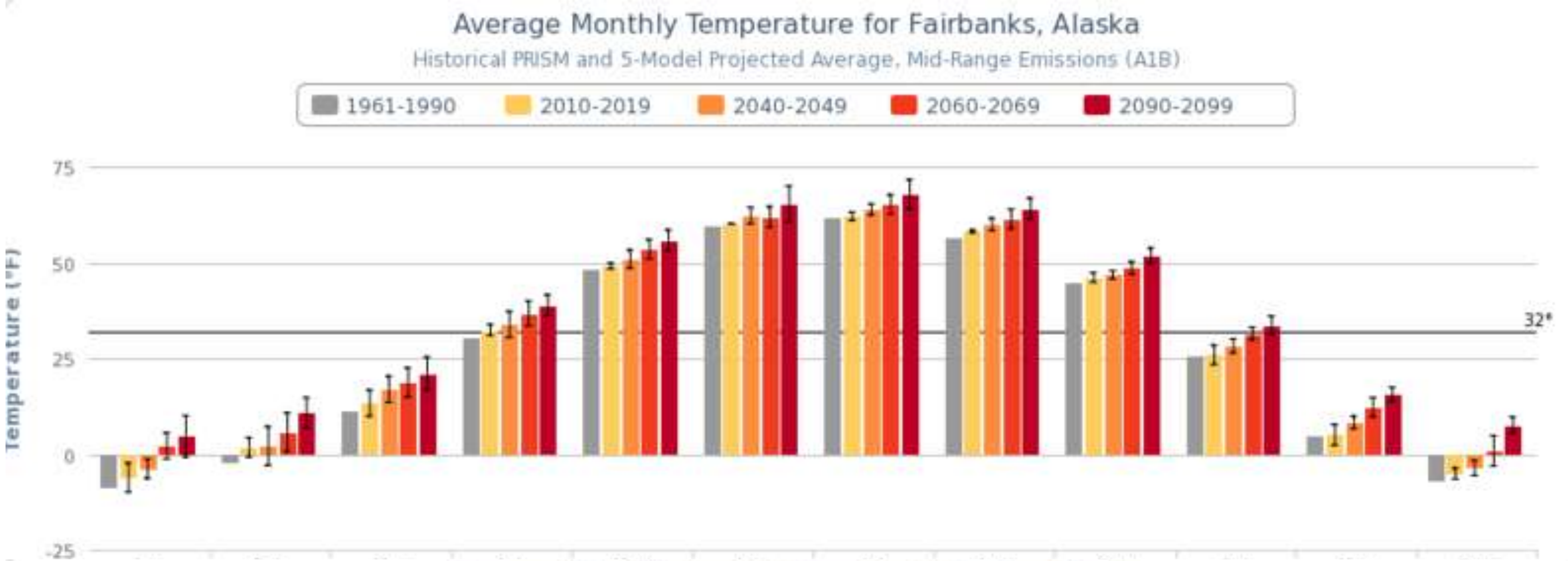
Uncertainty

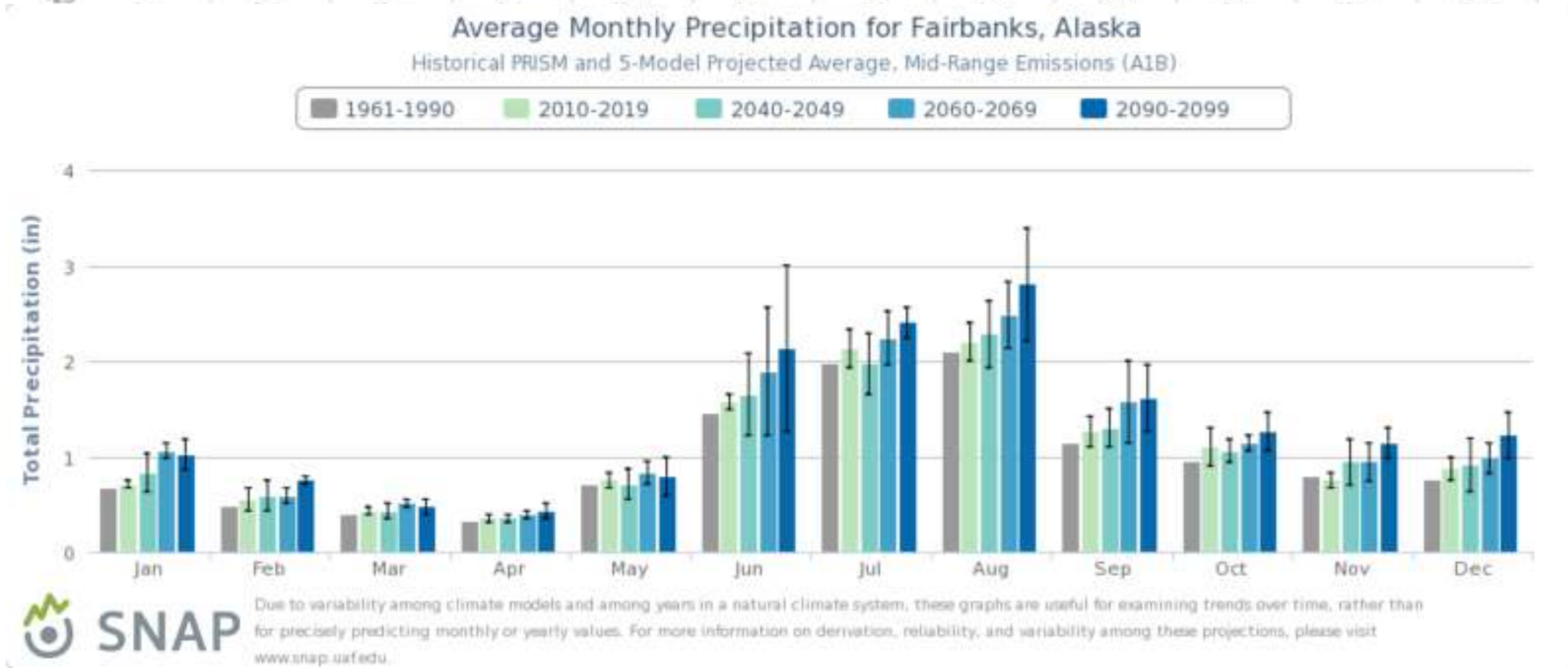
- Few climate stations
- Variable precipitation
- Complex modeling
- Thresholds (tipping points)





- Pacific Decadal Oscillation
- Unknown human behavior

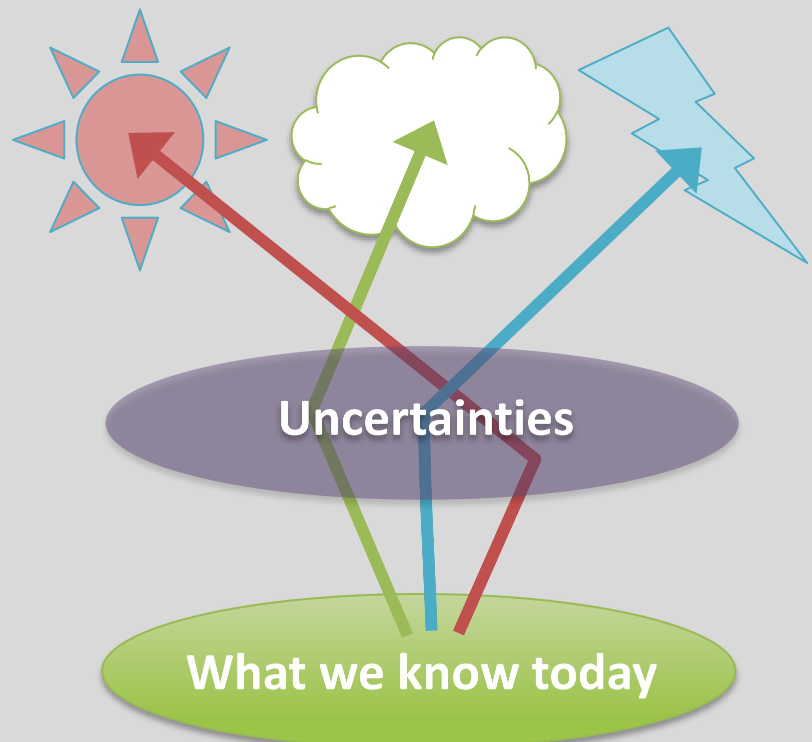

Average Monthly Temperature for Fairbanks, Alaska
Historical PRISM and 5-Model Projected Average, Mid-Range Emissions (A1B)
1961-1990
2010-2019
2040-2049
2060-2069
2090-2099
Temperature (°F)
75
50
25
0
-25
32°


Average Monthly Precipitation for Fairbanks, Alaska
Historical PRISM and 5-Model Projected Average, Mid-Range Emissions (A1B)
1961-1990
2010-2019
2040-2049
2060-2069
2090-2099
Total Precipitation (in)
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
SNAP
Due to variability among climate models and among years in a natural climate system, these graphs are useful for examining trends over time, rather than for precisely predicting monthly or yearly values. For more information on derivation, reliability, and variability among these projections, please visit www.snap.uaf.edu.

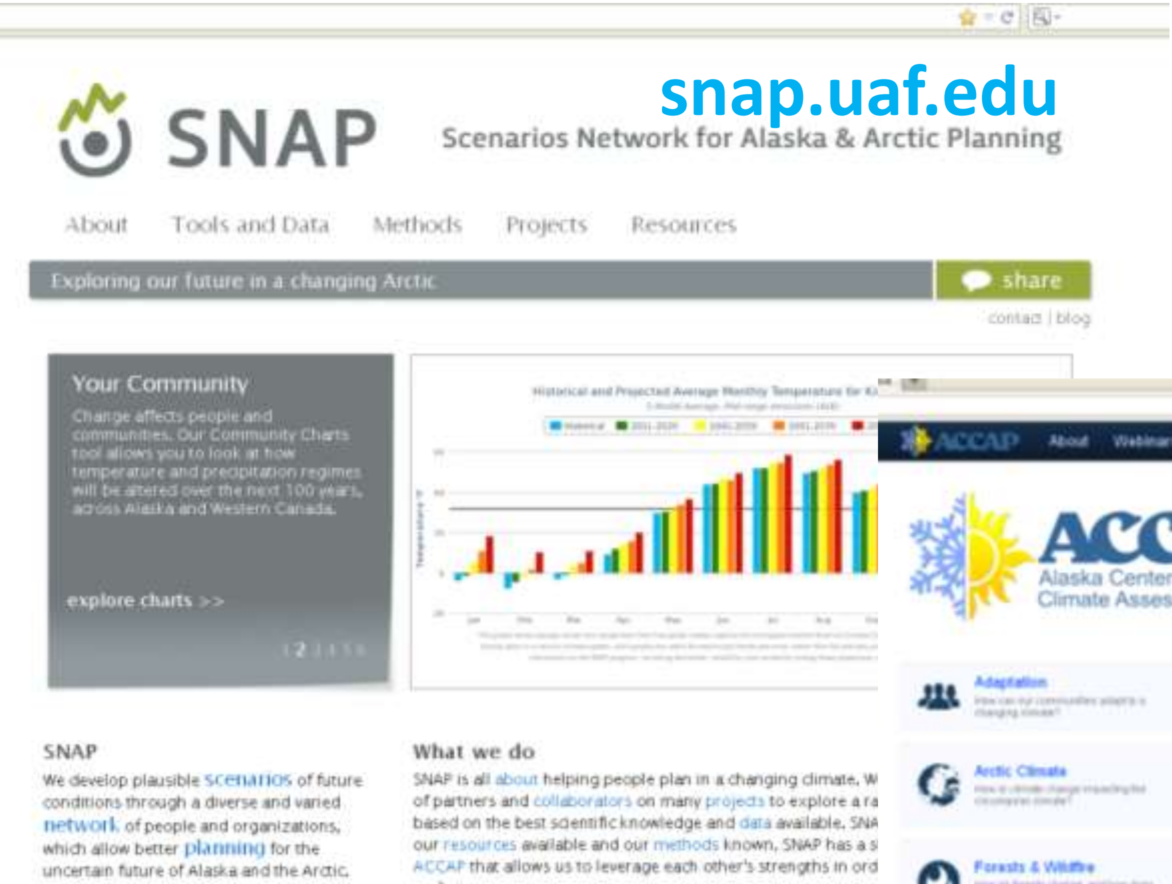
Scenarios Planning

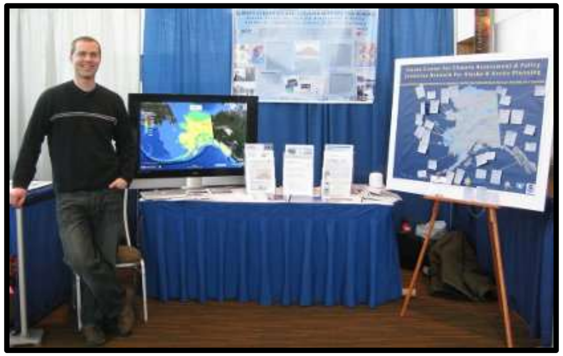
- Forecast Planning
- One Future

- Scenario Planning
- Multiple Futures



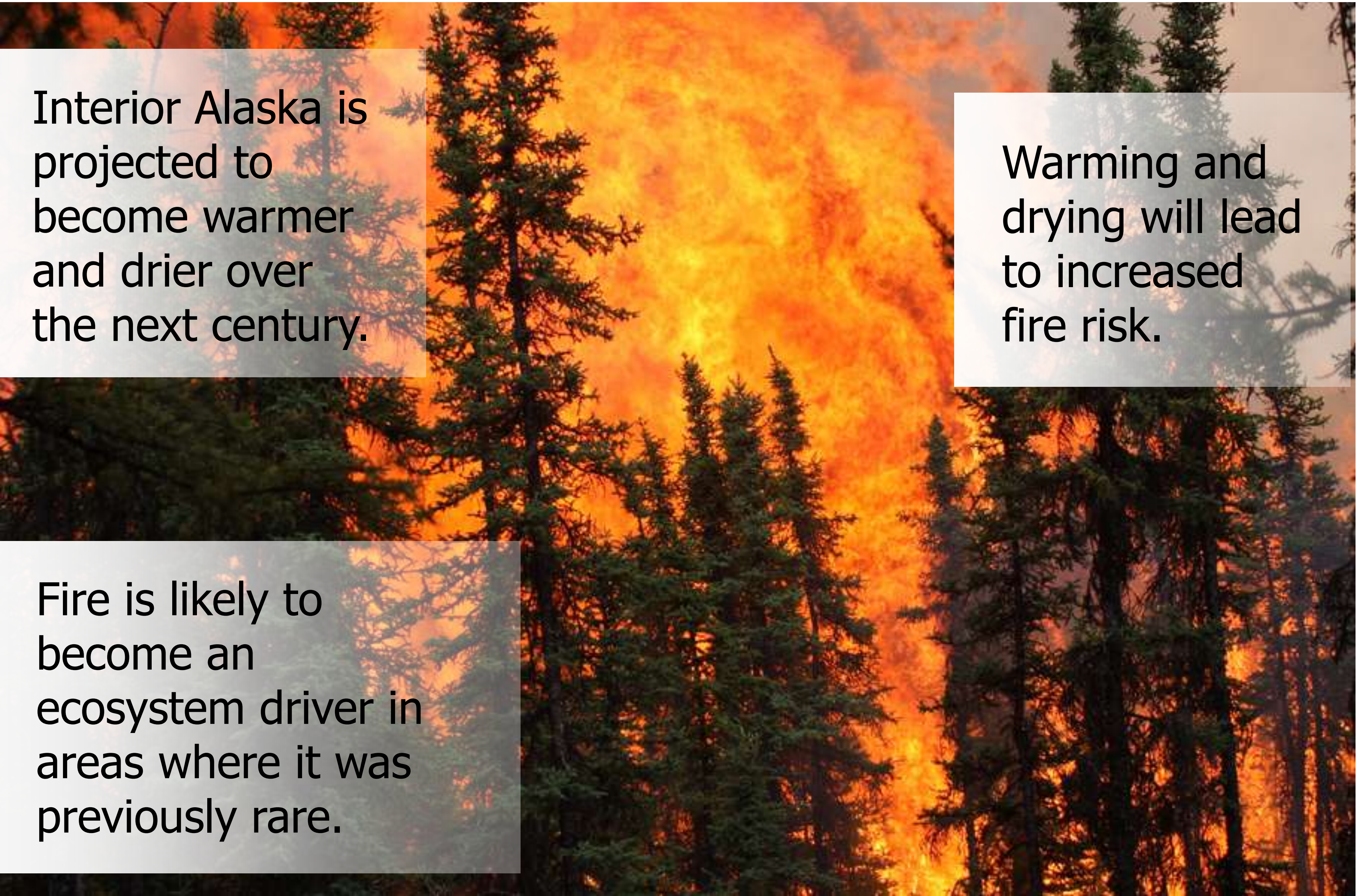
Outreach


snap.uaf.edu
SNAP
Scenarios Network for Alaska & Arctic Planning
About
Tools and Data
Methods
Projects
Resources
Exploring our future in a changing Arctic
share
contact | blog
Your Community
Change affects people and communities. Our Community Charts tool allows you to look at how temperature and precipitation regimes will be altered over the next 100 years, across Alaska and Western Canada.
explore charts >>
SNAP
We develop plausible scenarios of future conditions through a diverse and varied network of people and organizations, which allow better planning for the uncertain future of Alaska and the Arctic.
What we do




accap.uaf.edu
ACCAP
About
Webinars
Library
Projects
Explore
ACCAP
Alaska Center for Climate Assessment & Policy
Improving the ability of Alaskans to respond to a changing climate
Adaptation
Arctic Climate
Forests & Wildfire
Coastal & Marine
Native & Tribal
Sea Ice
ACCAP Statewide Climate Webinars
Upcoming Webinars

Fire in Regions II and III

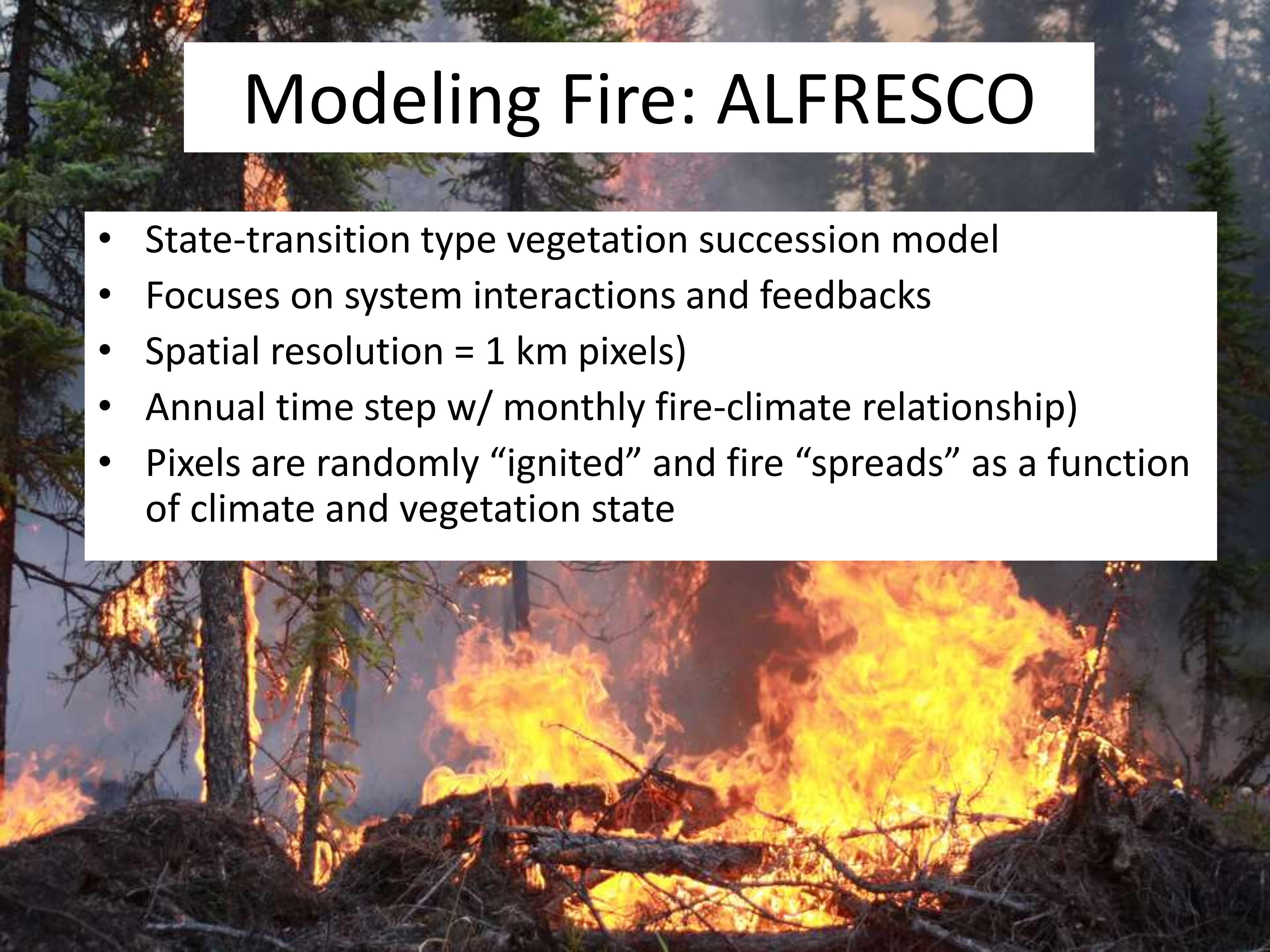


Interior Alaska is projected to become warmer and drier over the next century.

Warming and drying will lead to increased fire risk.

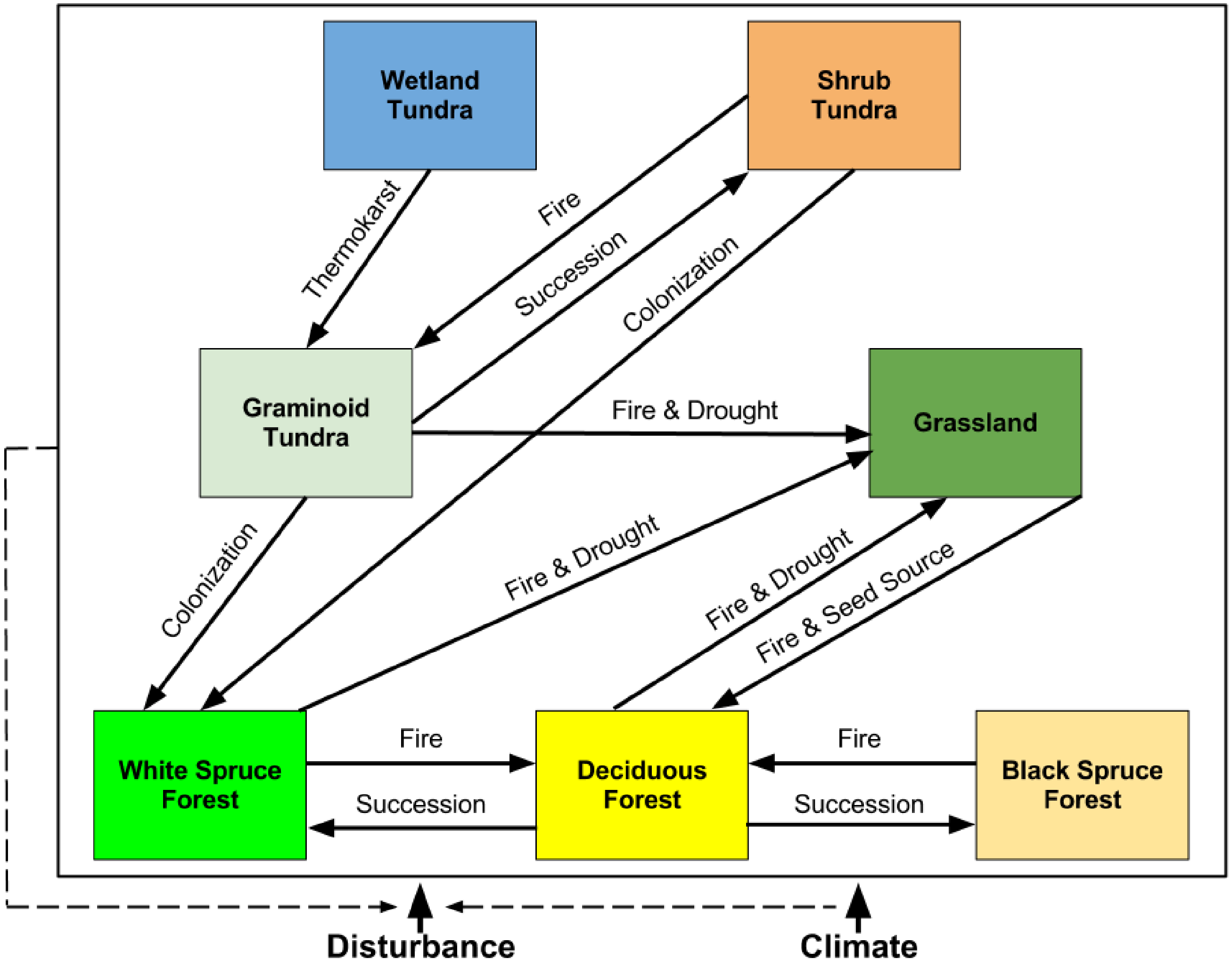
Fire is likely to become an ecosystem driver in areas where it was previously rare.

Modeling Fire: ALFRESCO



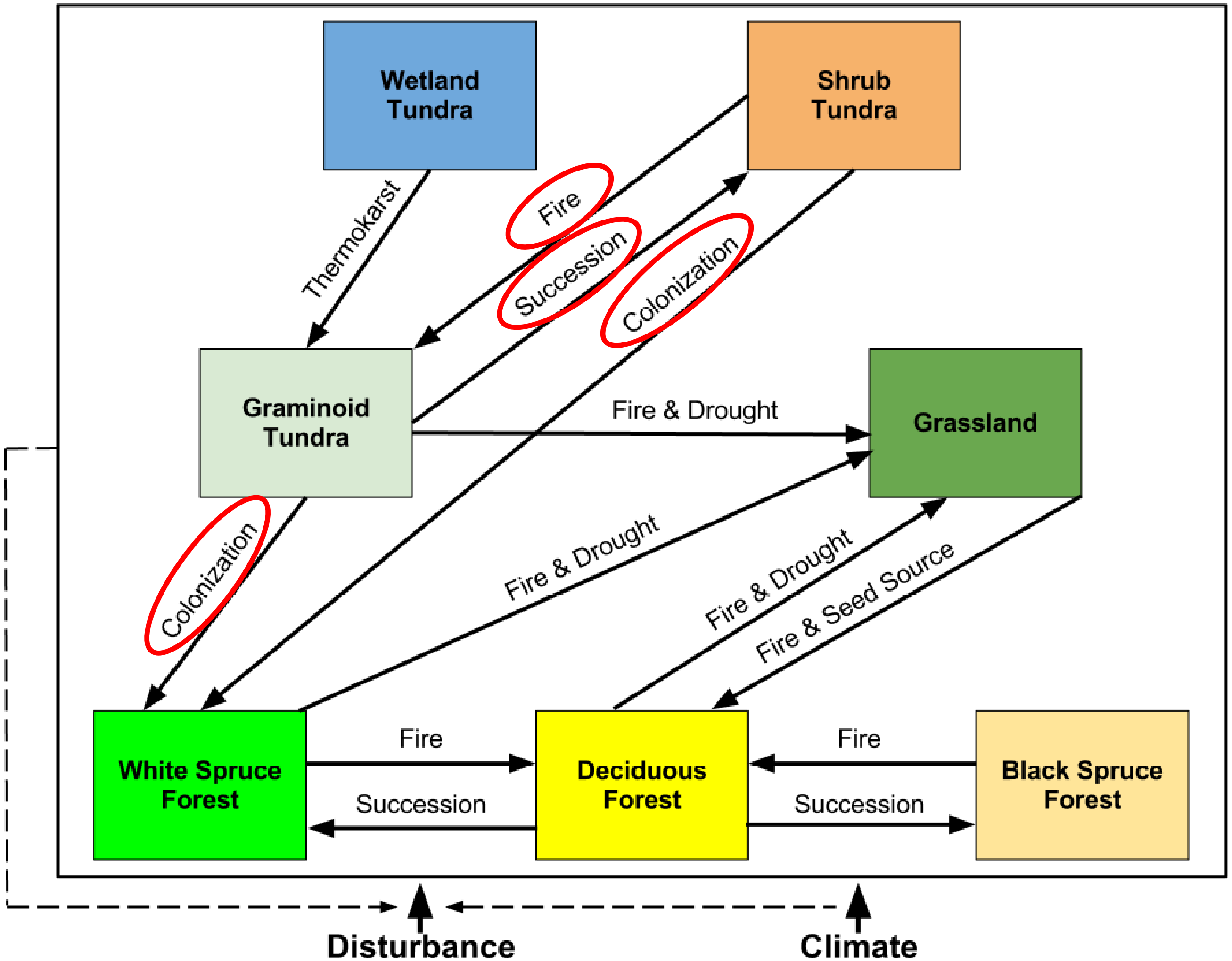
- State-transition type vegetation succession model
- Focuses on system interactions and feedbacks
- Spatial resolution = 1 km pixels)
- Annual time step w/ monthly fire-climate relationship)
- Pixels are randomly “ignited” and fire “spreads” as a function of climate and vegetation state

ALFRESCO 2.0



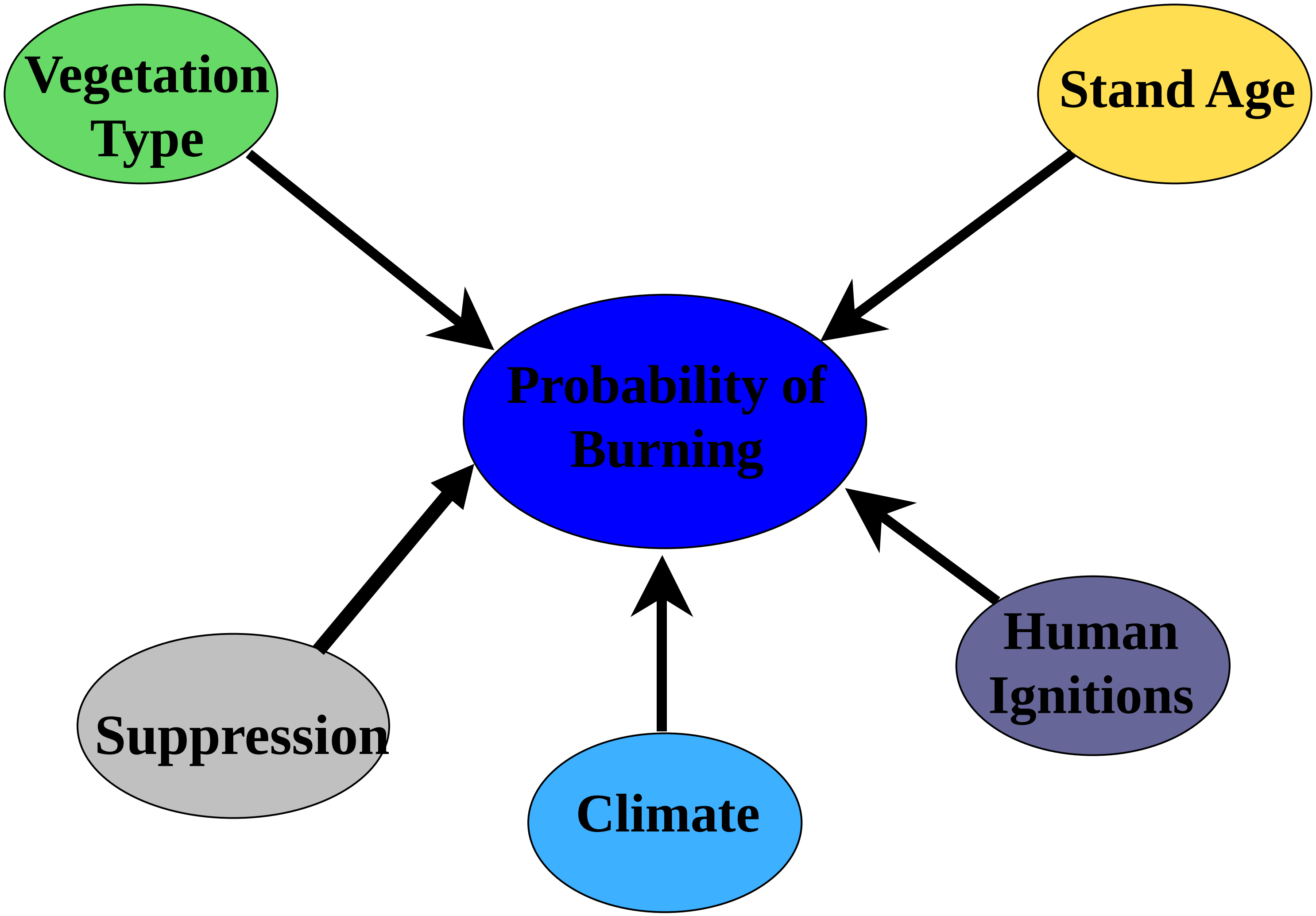
Wetland Tundra
Shrub Tundra
Thermokarst
Fire
Succession
Colonization
Graminoid Tundra
Grassland
Fire & Drought
Colonization
Fire & Drought
Fire & Drought
Fire & Seed Source
White Spruce Forest
Fire
Succession
Deciduous Forest
Fire
Succession
Black Spruce Forest
Disturbance
Climate

ALFRESCO 2.0

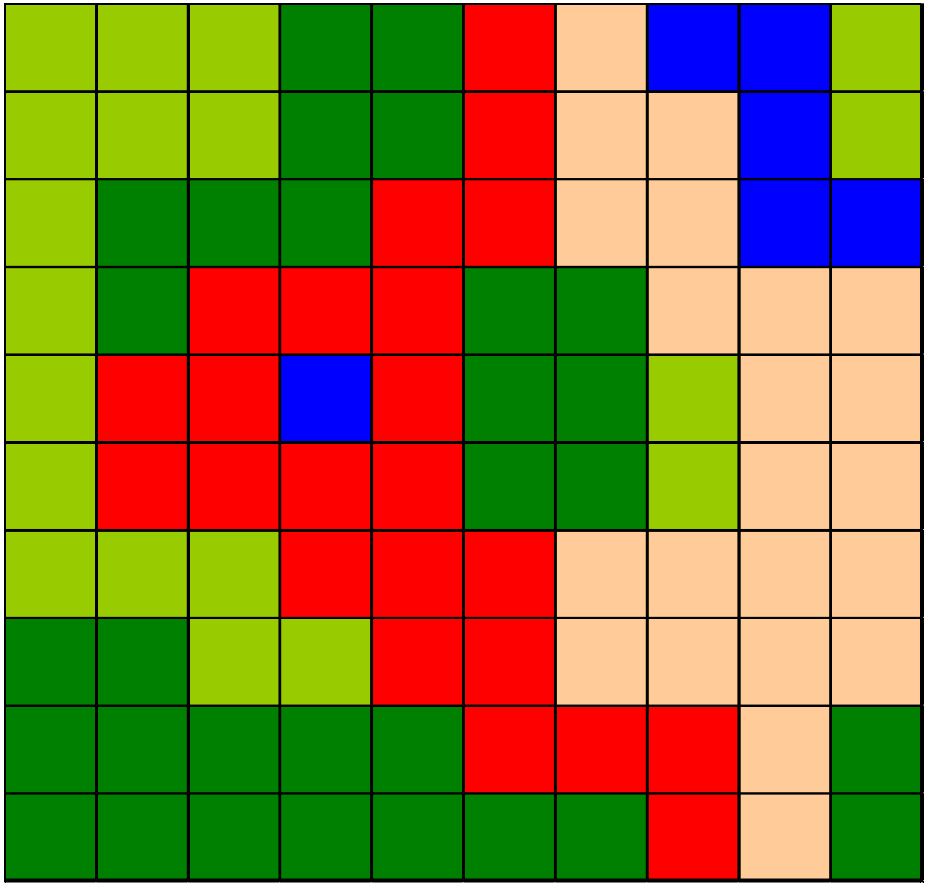


Wetland Tundra
Shrub Tundra
Thermokarst
Fire
Succession
Colonization
Graminoid Tundra
Fire & Drought
Grassland
Colonization
Fire & Drought
Fire & Drought
Fire & Seed Source
White Spruce Forest
Fire
Succession
Deciduous Forest
Fire
Succession
Black Spruce Forest
Disturbance
Climate

Individual Cell Flammability

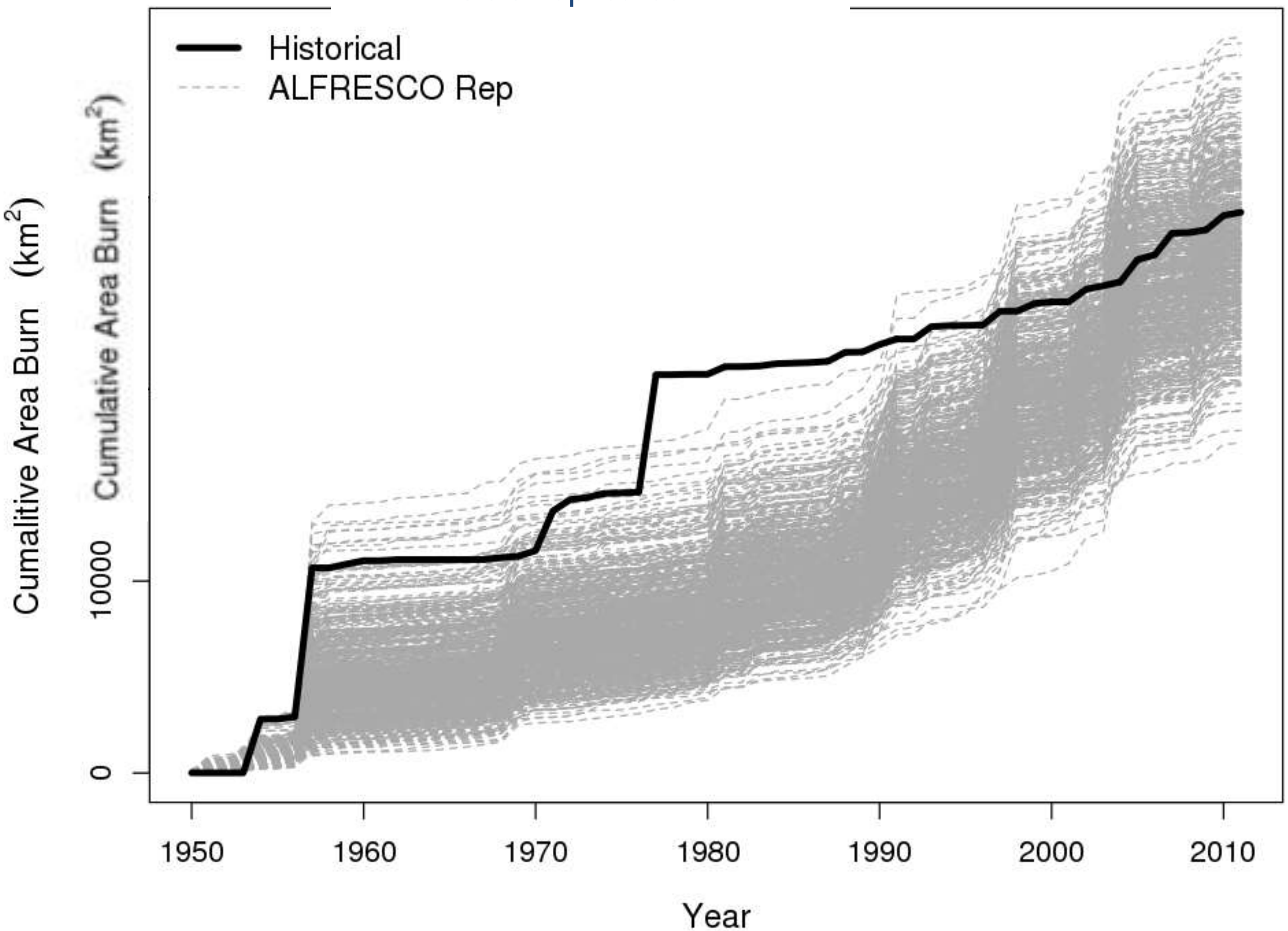


Recursive Fire Spread Algorithm

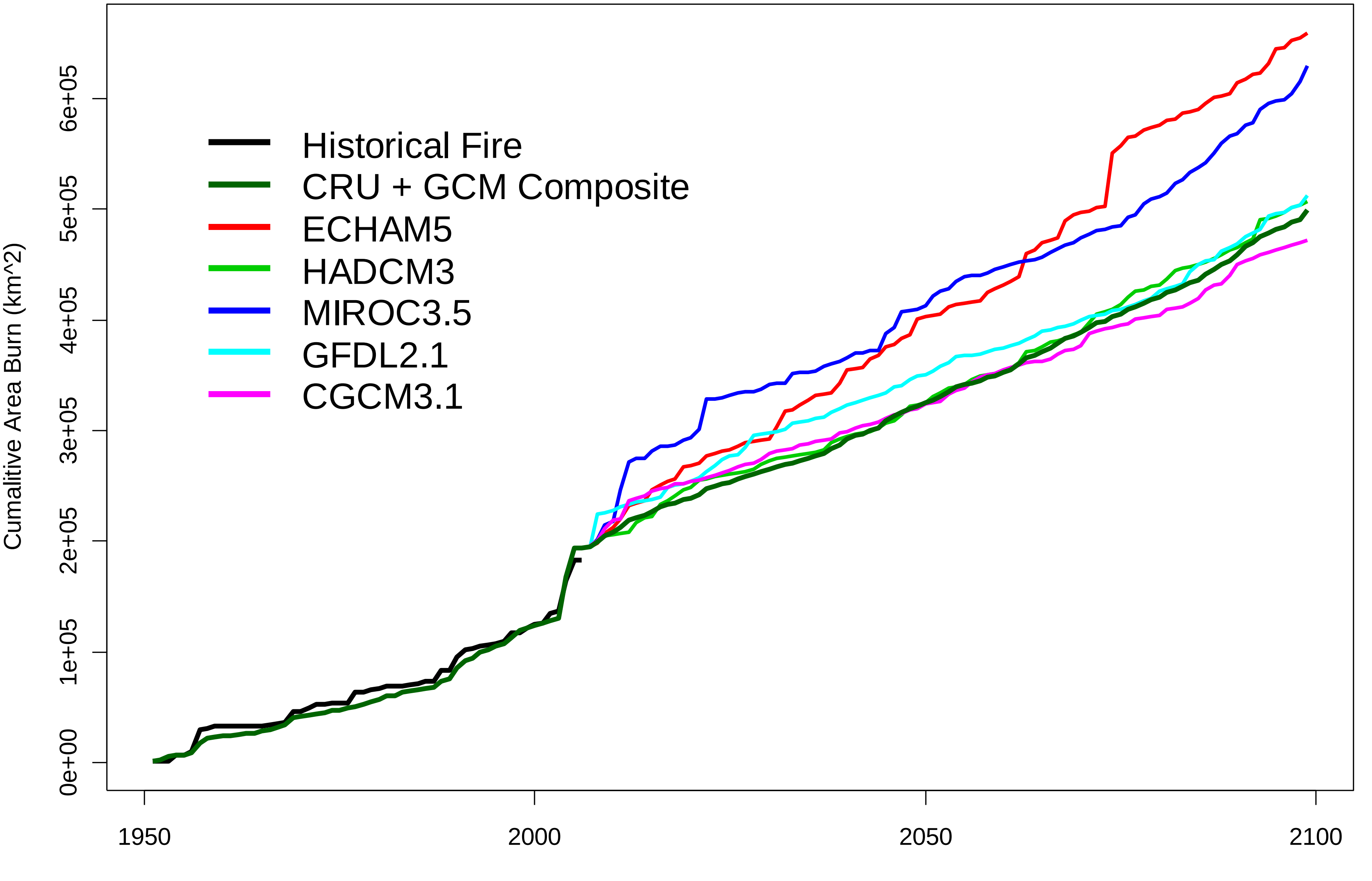


Cumulative Area Burned

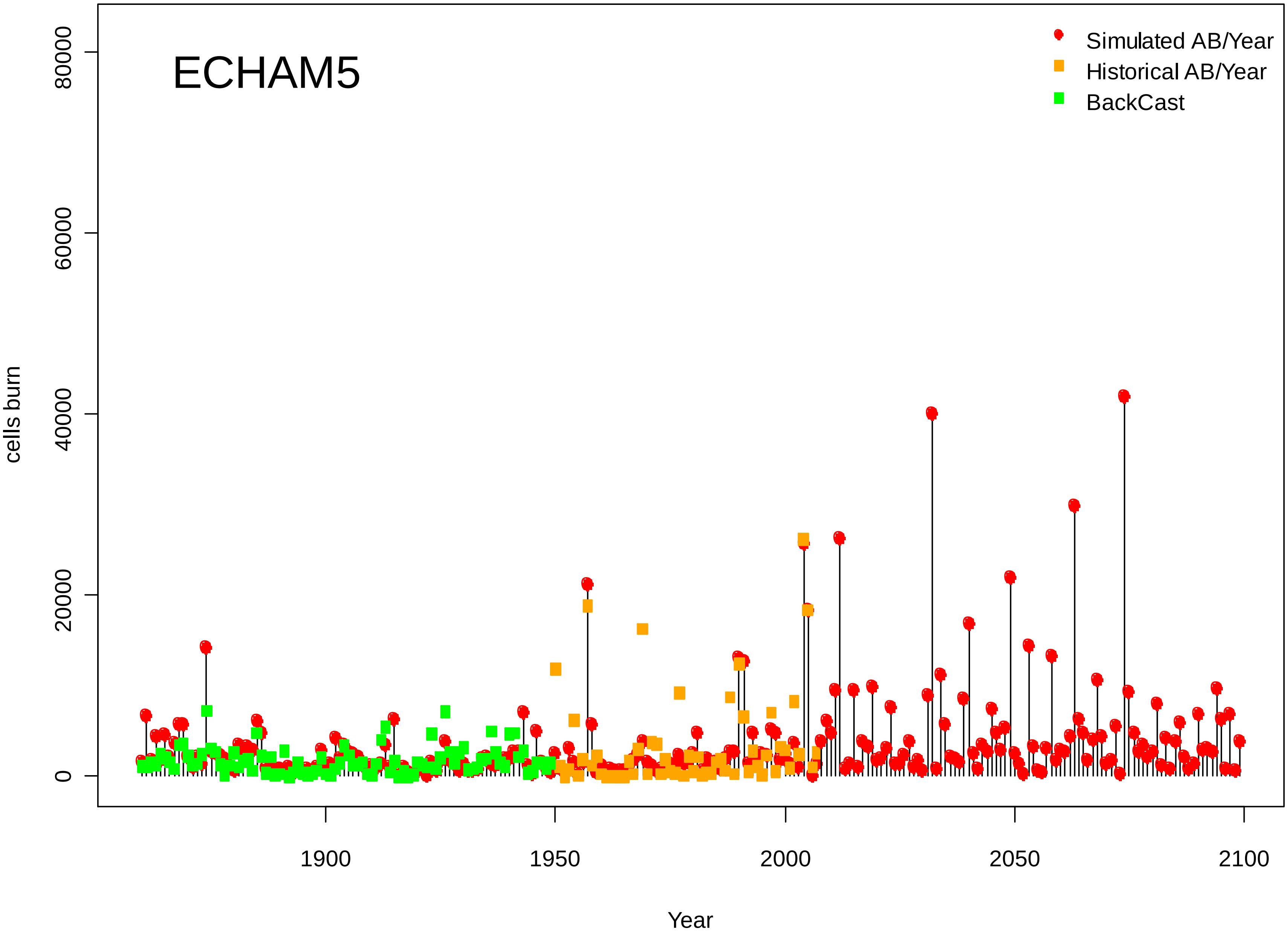
Historical (1950-2011)
ALFRESCO replicates



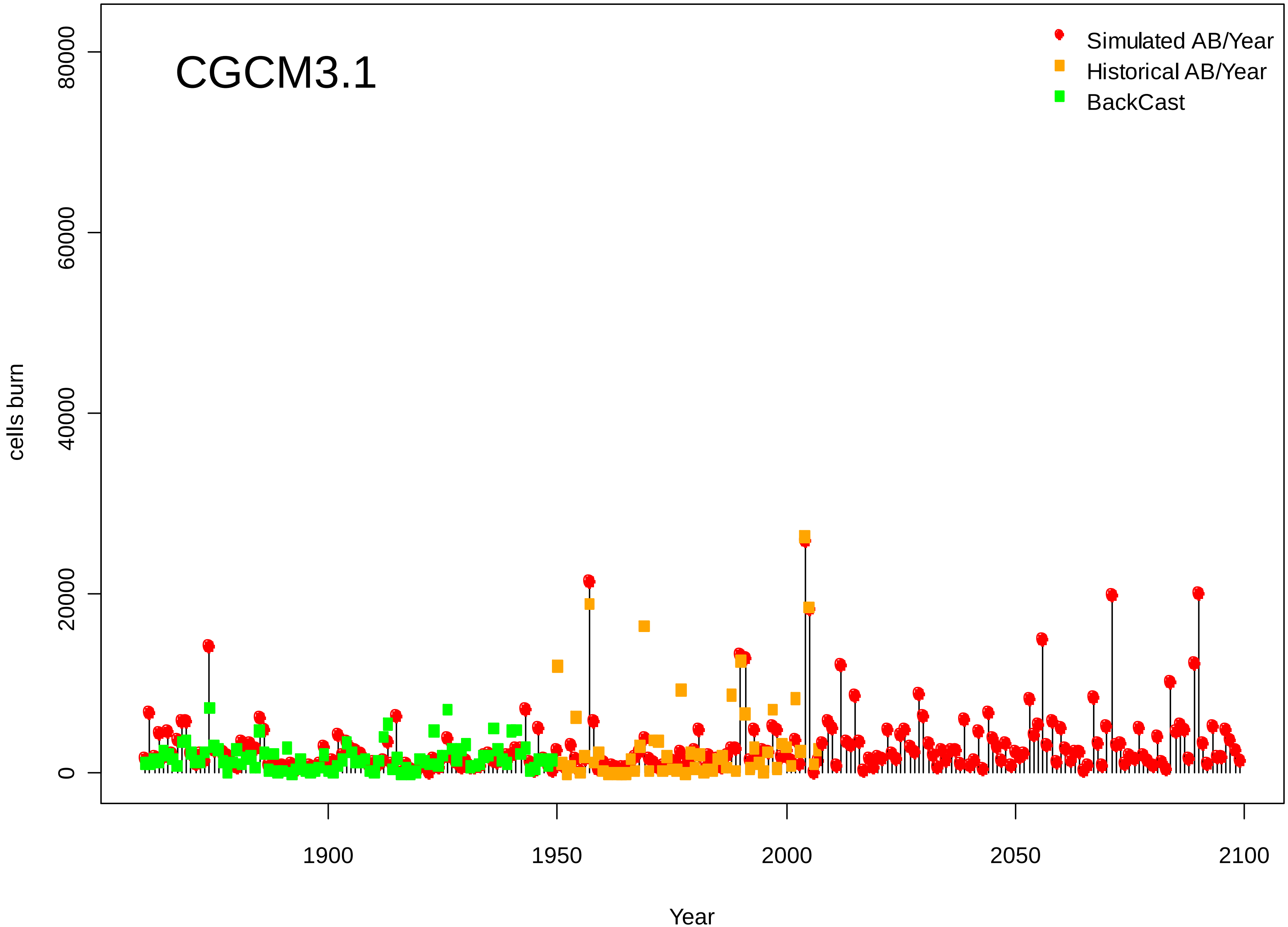
Simulated Cumulative Area Burned



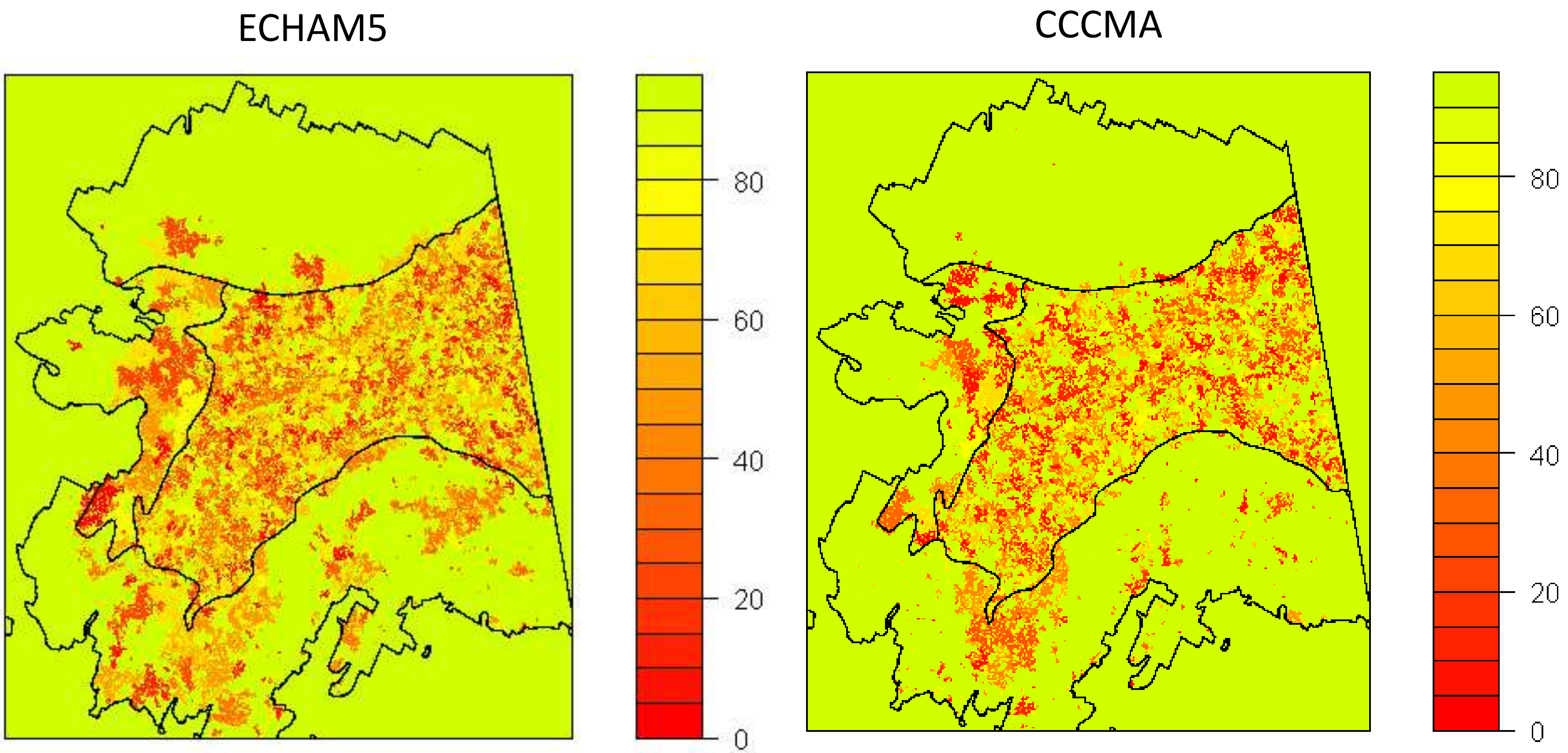
Simulated Annual Area Burned – Best Replicate



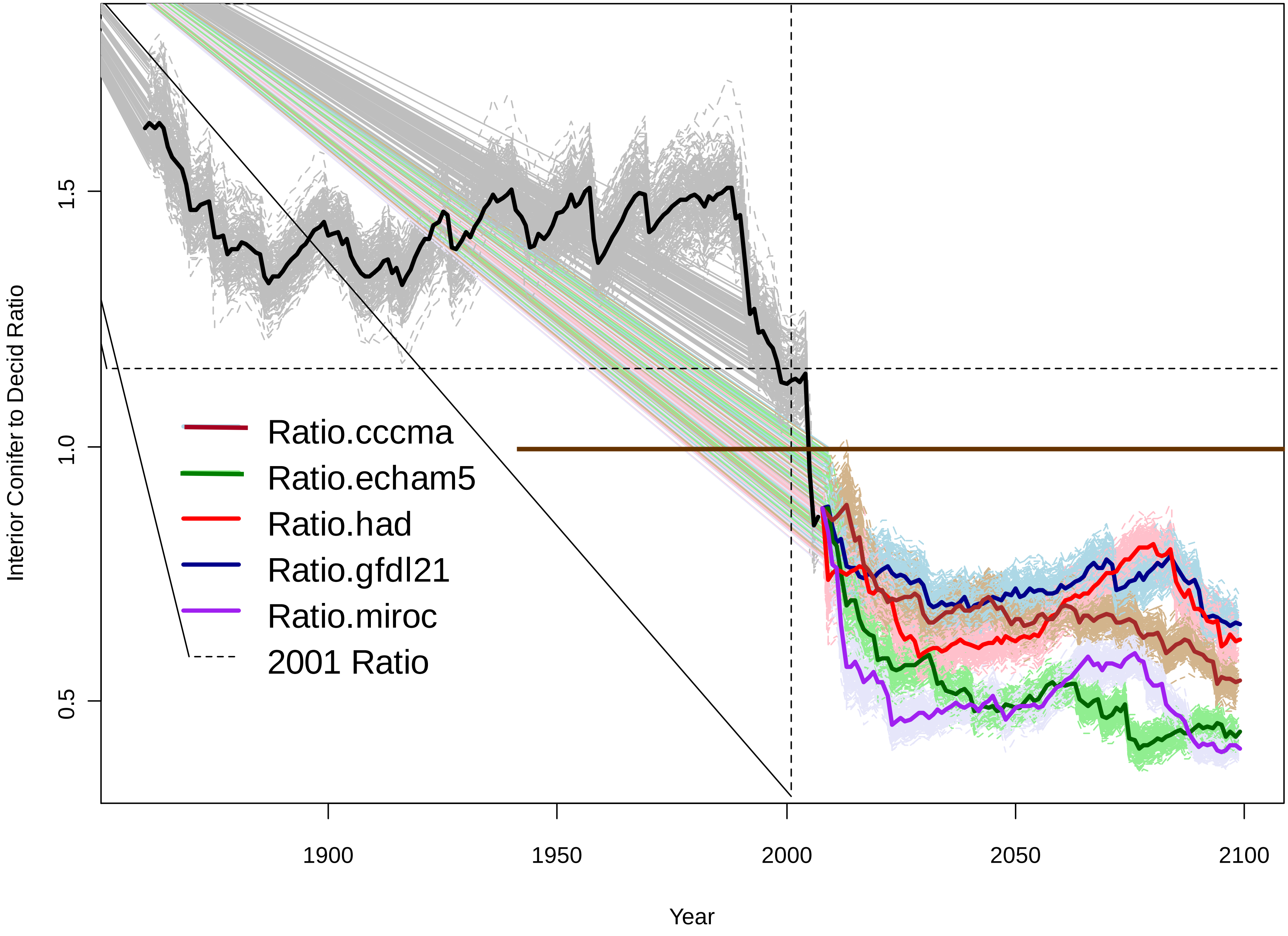
Simulated Annual Area Burned – Best Replicate



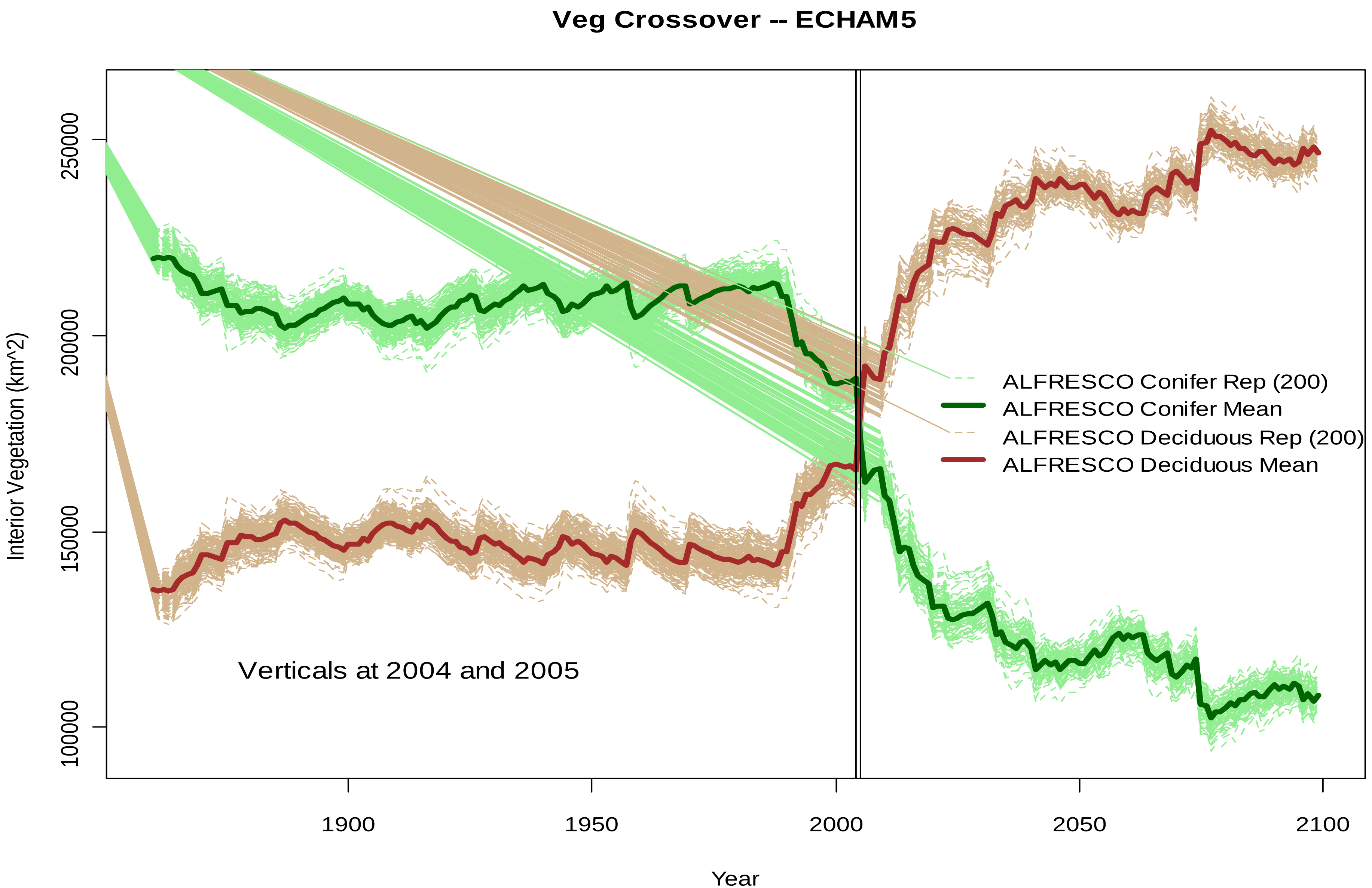
Time Since Last Fire at 2099



Simulated Conifer to Deciduous Ratio



Simulated Conifer to Deciduous Ratio



Projections for Spatial Transitions

		Global Circulation Model			
		CCCMA		ECHAM5	
Vegetation Class	Year	Area (km^2)	Area change (Percent change)	Area (km^2)	Area change (Percent change)
All Forest	2014	52,154	-	52,509	-
	2050	56,234	4,080 (7.82)	54,353	1,844 (3.51)
	2100	63,418	7,184 (12.78)	59,094	4,741 (8.72)
total			11,264 (20.60)		6,585 (12.23)
All Tundra	2014	393,495	-	393,140	-
	2050	389,415	-4,080 (-1.04)	391,296	-1,844 (-0.47)
	2100	382,231	-7,184 (-1.84)	386,555	-4,741 (-1.21)
total			-11,264 (-2.88)		-6,585 (-1.68)
Graminoid Tundra	2014	124,589	-	126,863	-
	2050	122,629	-1,960 (-1.57)	119,162	-7,701 (-6.07)
	2100	114,684	-7,945 (-6.48)	98,181	-20,981 (-17.61)
total			-9,905 (-8.05)		-28,682 (-23.68)
Shrub Tundra	2014	194,802	-	192,173	-
	2050	192,682	-2,120 (-1.09)	198,030	5,857 (3.05)
	2100	193,443	761 (0.39)	214,270	16,240 (8.20)
total			-1359 (-0.69)		22,097 (11.25)

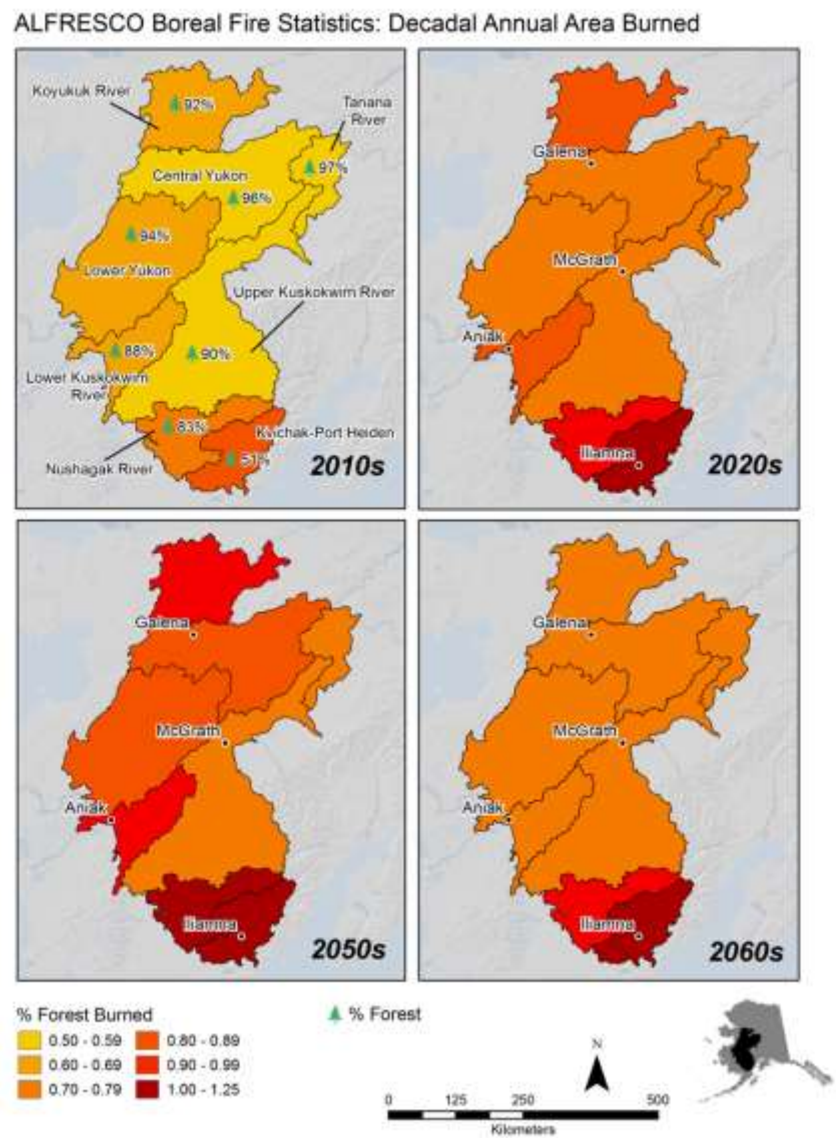
Case study: Lime Hills region

Maps show projected area of forest burned by region.

Forested area ranges from 51% to 97%.

Increased burning is expected in all sub-regions.

Some leveling off is projected by the 2060s, perhaps due to decreased fuel availability.



Case study: Lime Hills region

Watershed (3rd level HUC)	Fire return interval, forested land			
	2010s	2020s	2050s	2060s
Tanana River	182	139	133	134
Kvichak-Port Heiden	112	94	81	99
Upper Kuskokwim River	174	137	131	138
Nushagak River	130	101	92	105
Lower Kuskokwim River	146	122	111	127
Central Yukon	175	143	125	137
Lower Yukon	161	129	122	137
Koyukuk River	164	122	108	137

Fire return intervals currently range from 112 to 182 years, based on ALFRESCO modeling.

These intervals may shorten markedly and then level off.

Management Implications

- Regions II and II will likely experience substantial burning over the next 3 decades in response to projected warming and drying.
- Shorter fire cycles are likely to alter the relative proportions of early- vs. late-succession vegetation.
- Fire frequency is likely to stabilize over time.

Management Implications

- As a result the forest will likely transition to a new landscape equilibrium dominated by deciduous vegetation.
- The age structure of this new landscape will likely be considerably younger.

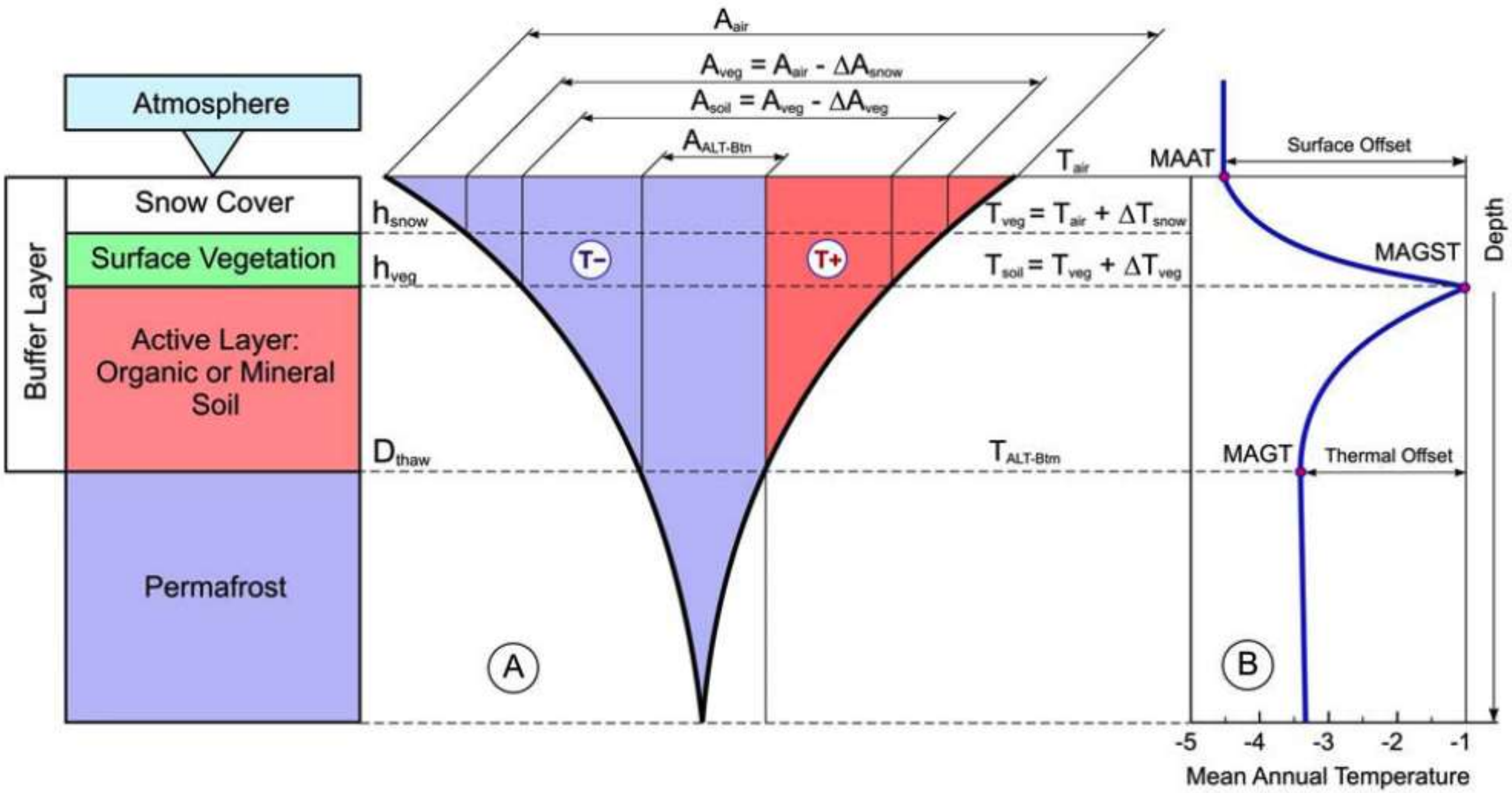
Habitat may increase for some species and decrease for others.

Fire risk prevention?

Funding for new technologies can save money in the long run.

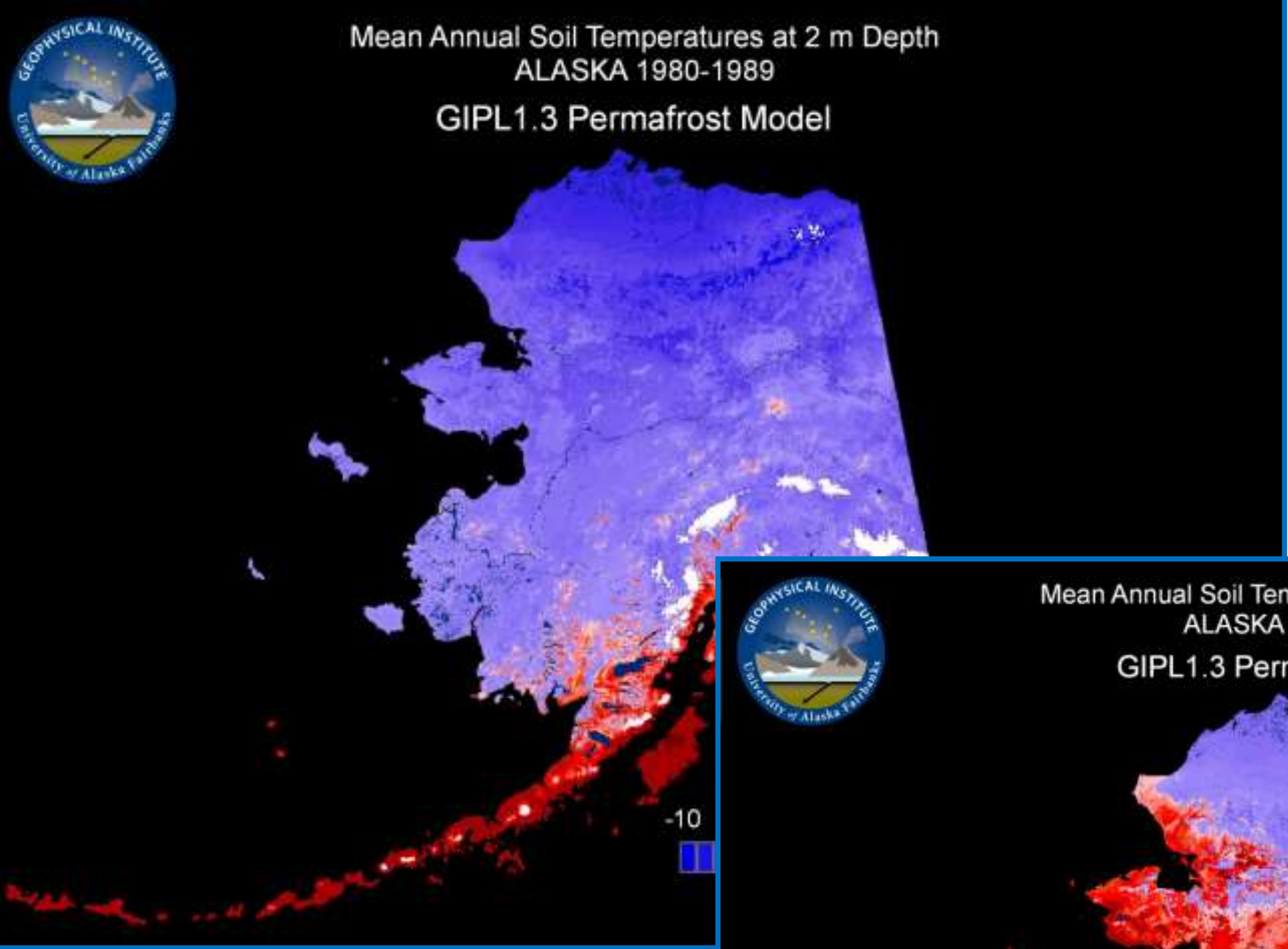
Changes in permafrost and hydrology

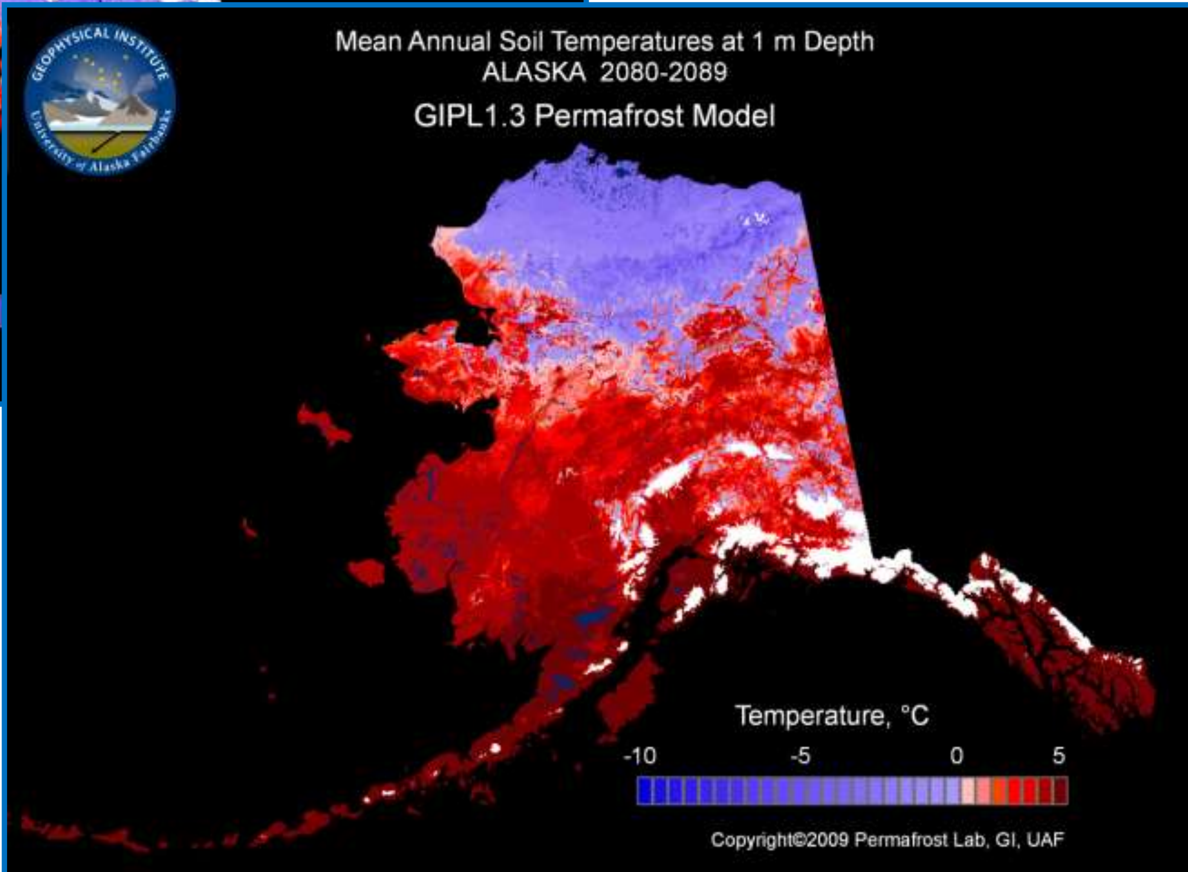
Schematic of GIPL model



Permafrost thaw leads to multiple effects, including frost heaves, pits, gullies, differential tussock growth, localized drying, and changes in shrub and moss species abundance, productivity, and mortality

Permafrost is rapidly thawing.





Mean soil temperature at 1 meter depth, 1980s and 2080s

Climate change will cause widespread loss of permafrost, and contribute to the drying of wetlands, streams, and lakes.

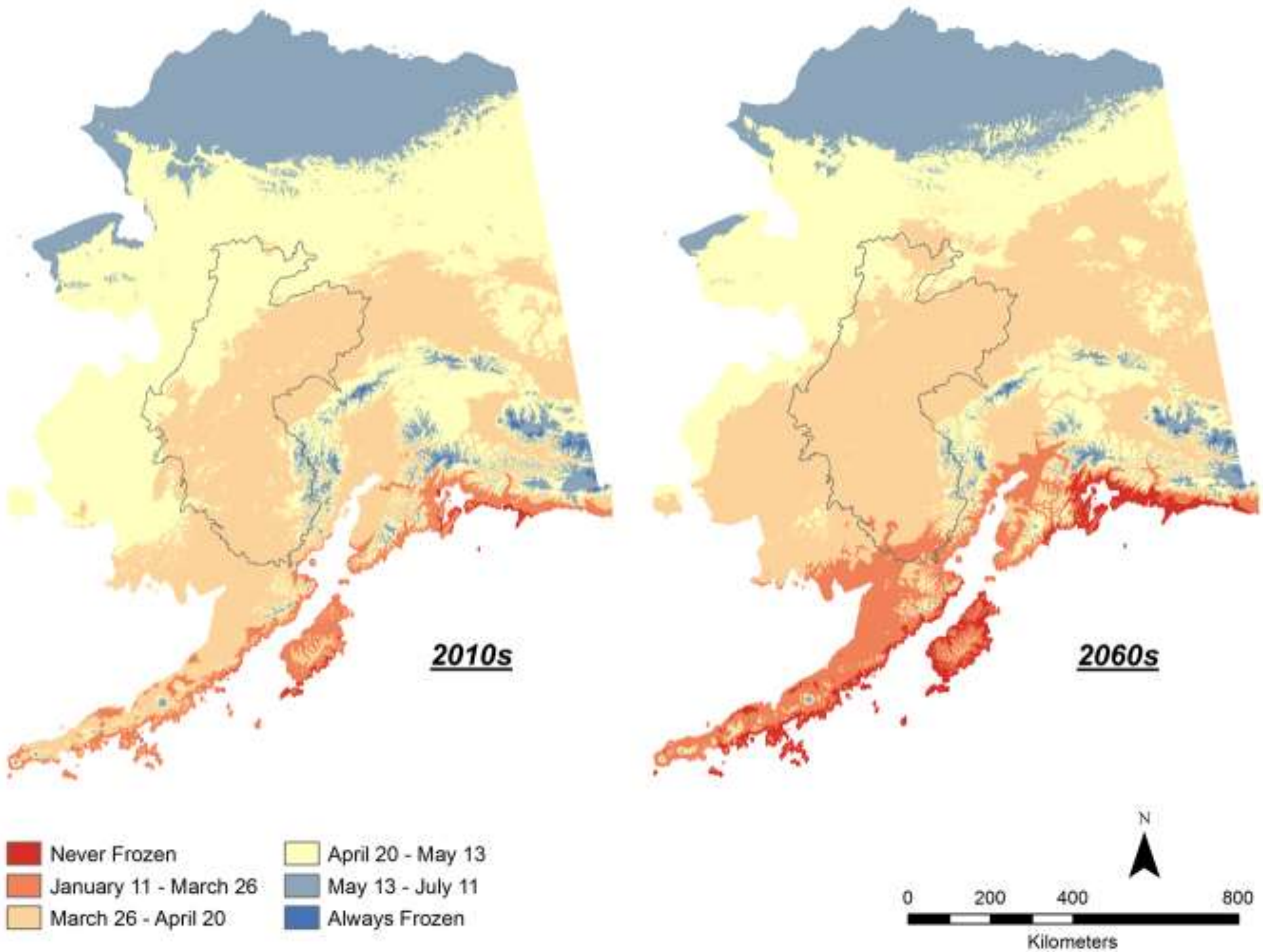
Drying and draining of soils

Climate change in Regions II and III

Shifting Vegetation

Warming temperatures and changing hydrology will likely lead to a northward and upward moving treeline, habitat loss, and encroachment by invasive species.

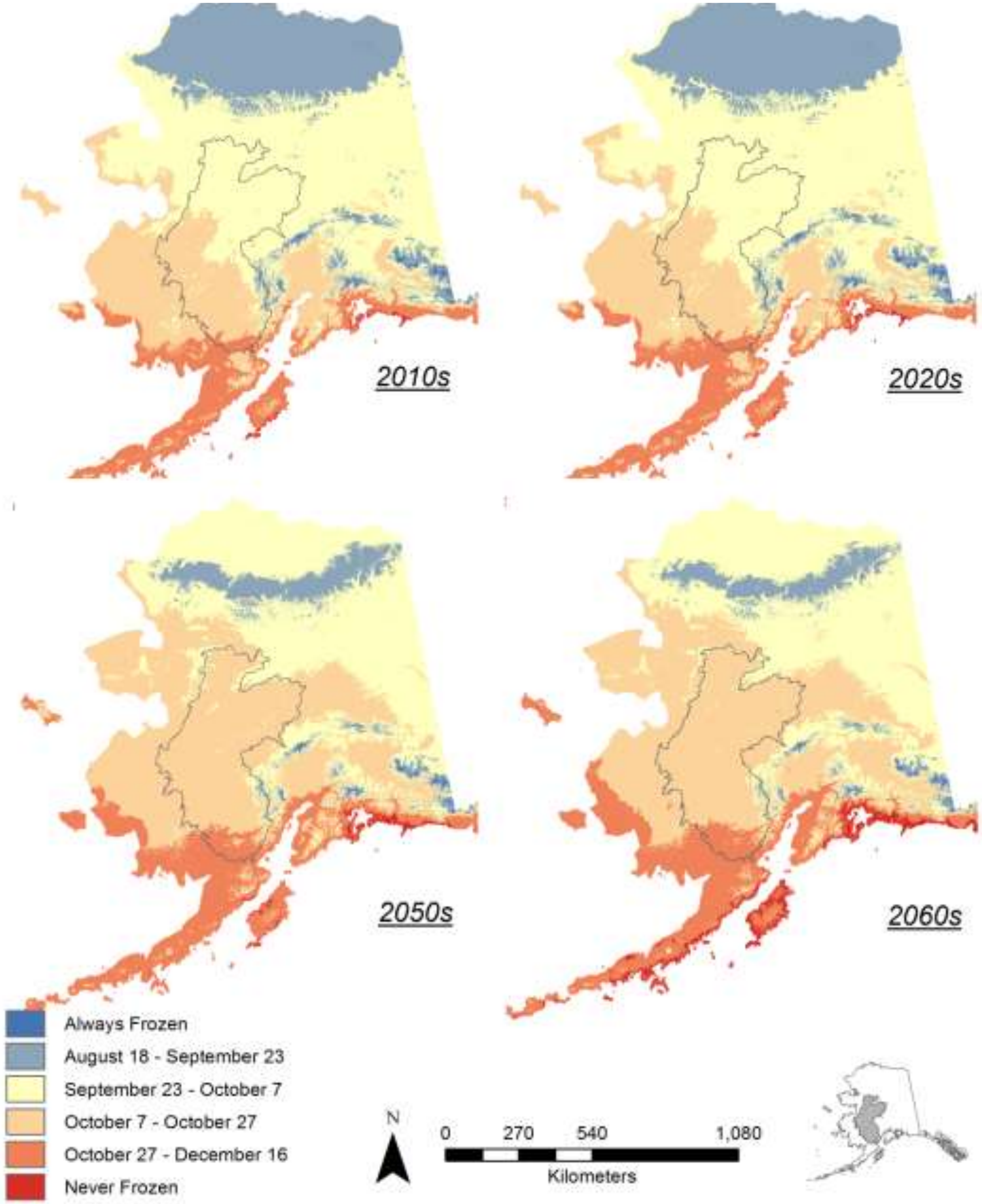
Projected date of thaw (DOT)

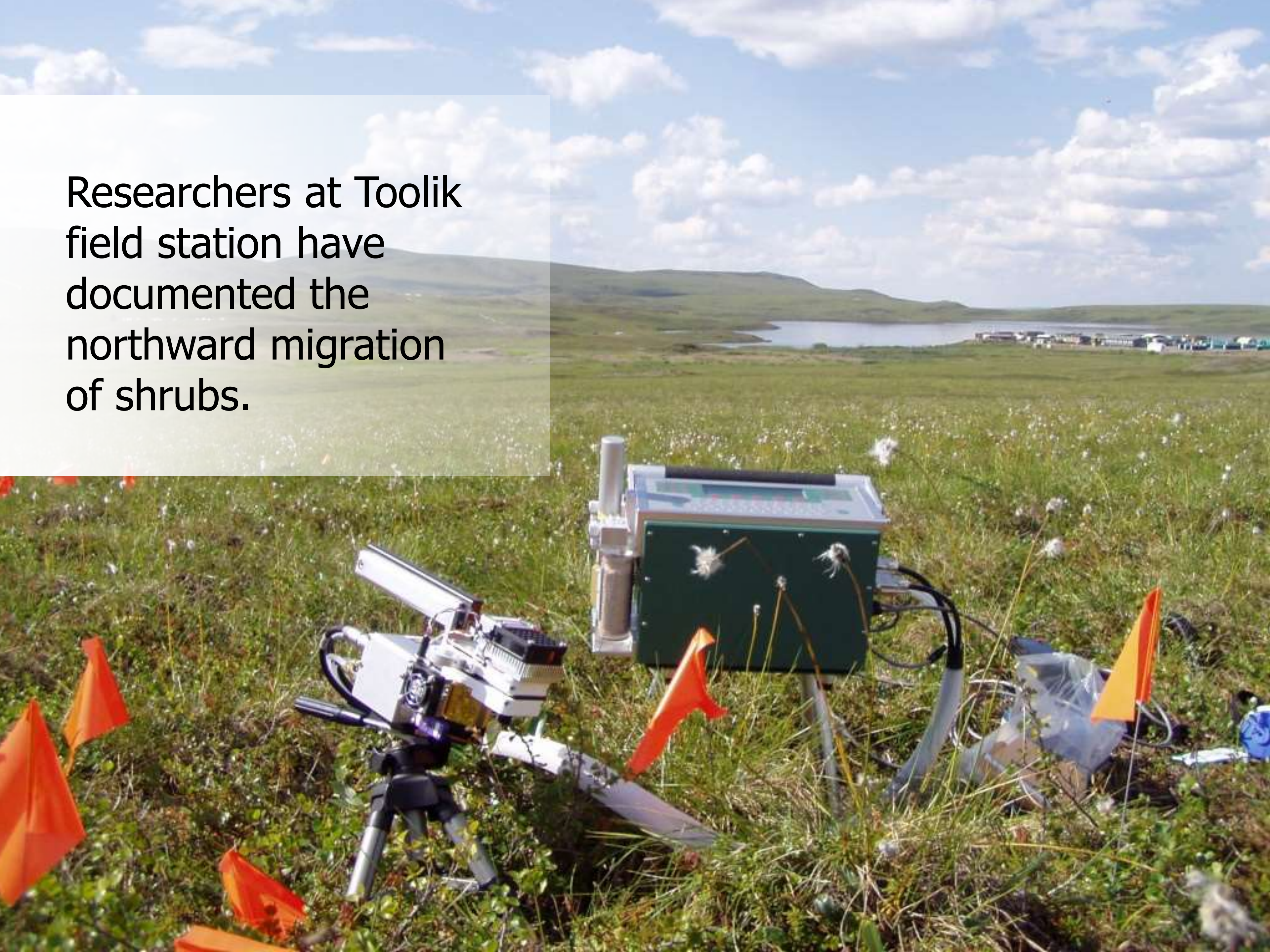


Data at which the running mean temperature crosses the freezing point in the spring.

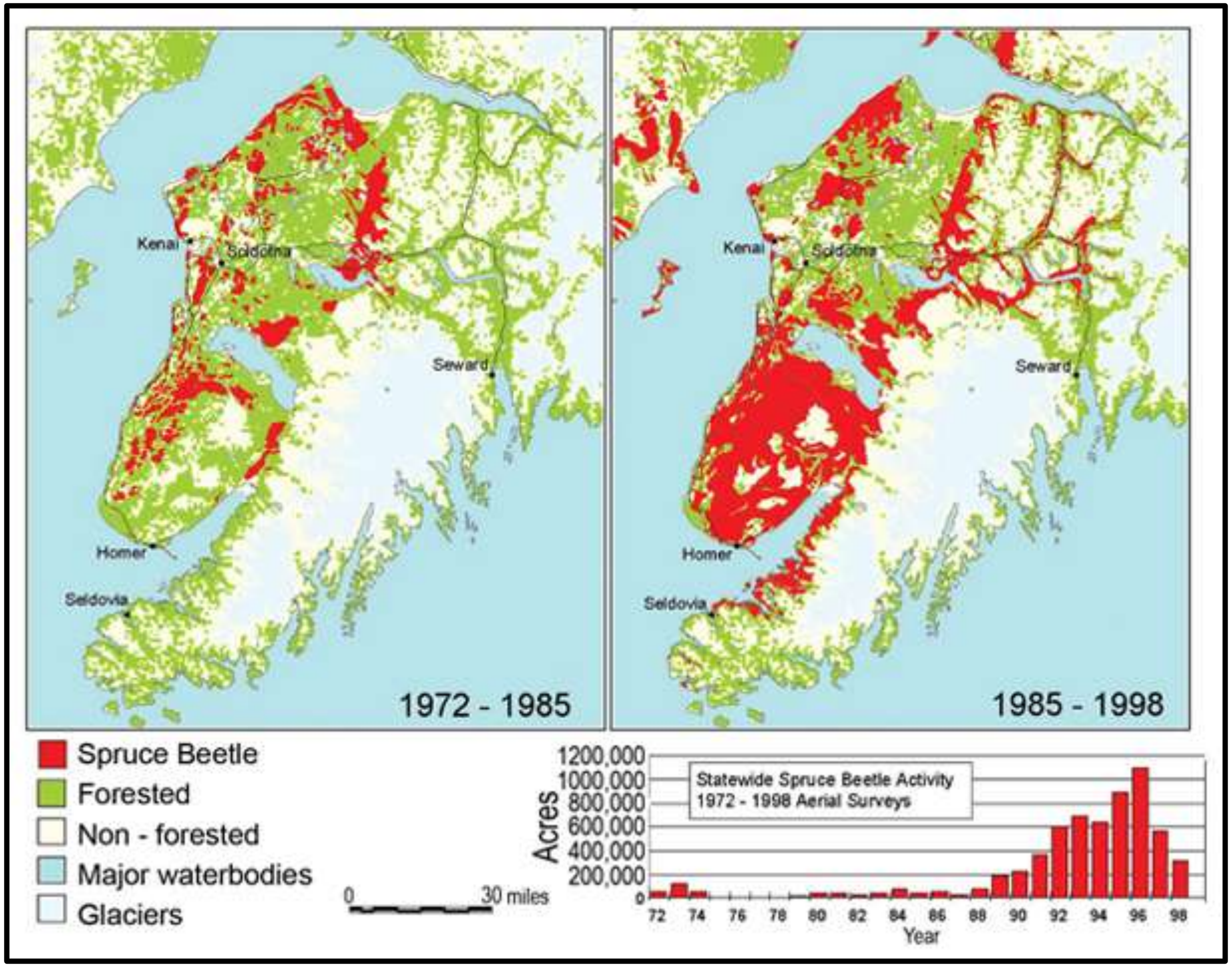
(Statewide context provides a range of reference).

Projected date of freeze (DOF)





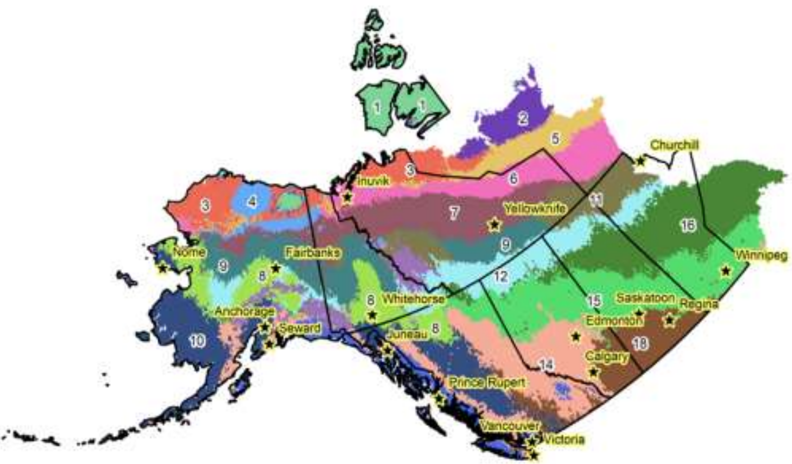
Researchers at Toolik field station have documented the northward migration of shrubs.

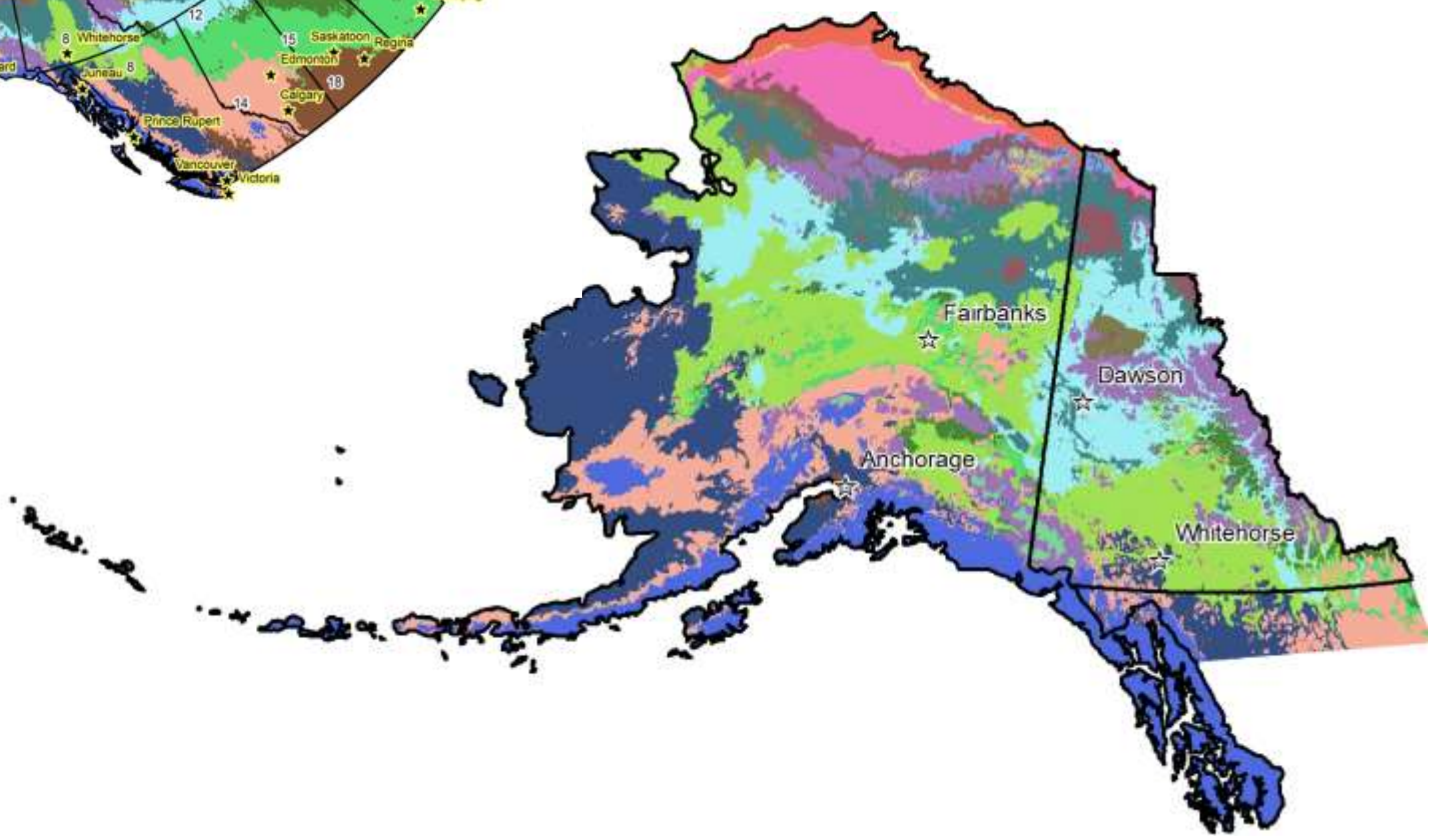


Berman, M., G. P. Juday, and R. Burnside 1999

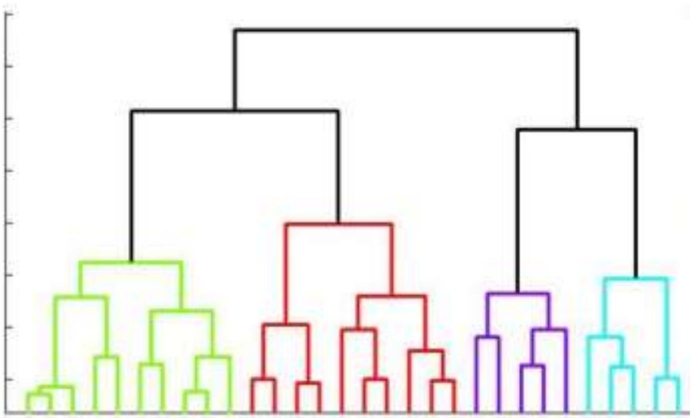
Increases in temperature are expected to result in more insect outbreaks.

Climate-Biome Shift





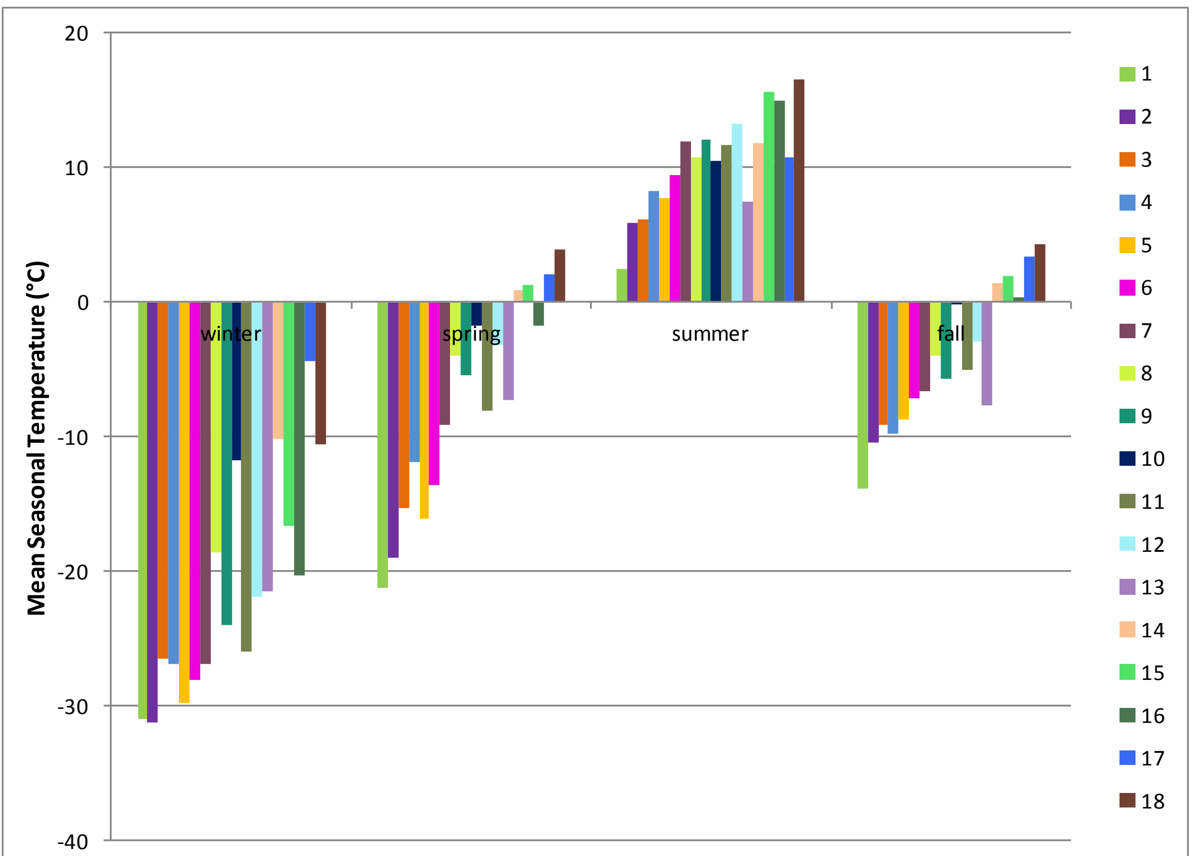
Methods: cluster analysis



Example of a dendrogram. Clusters can be created by cutting off this tree at any vertical level, creating (in this case) from one to 29 clusters.

- Cluster analysis is the statistical assignment of a set of observations into subsets so that observations in the same cluster are similar in some sense.
- It is a method of "unsupervised learning" – where all data are compared in a multidimensional space and classifying patterns are found in the data.
- Clustering is common for statistical data analysis and is used in many fields.

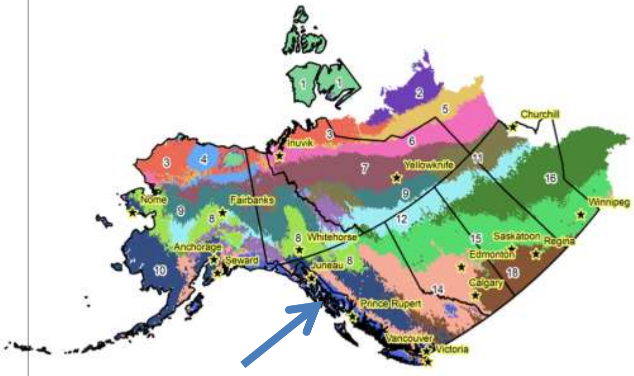
Describing the clusters:
temperature



Mean seasonal temperature by cluster. For the purposes of this graph, seasons are defined as the means of 3-months periods, where winter is December, January, and February, spring is March, April, May, etc.

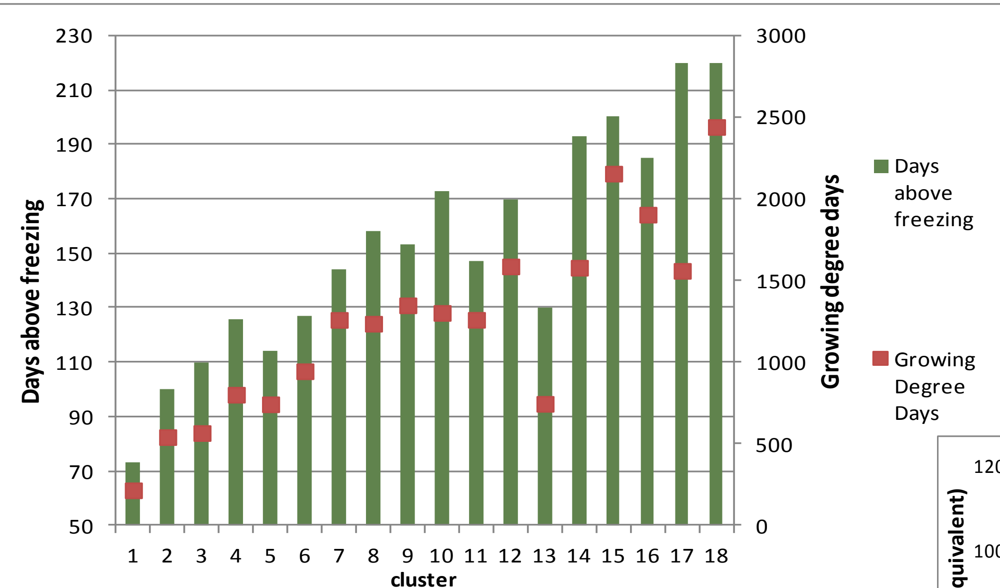
Describing the clusters:
precipitation

Precipitation by cluster. Mean annual precipitation varies widely across the clustering area, with Cluster 17 standing out as the wettest.

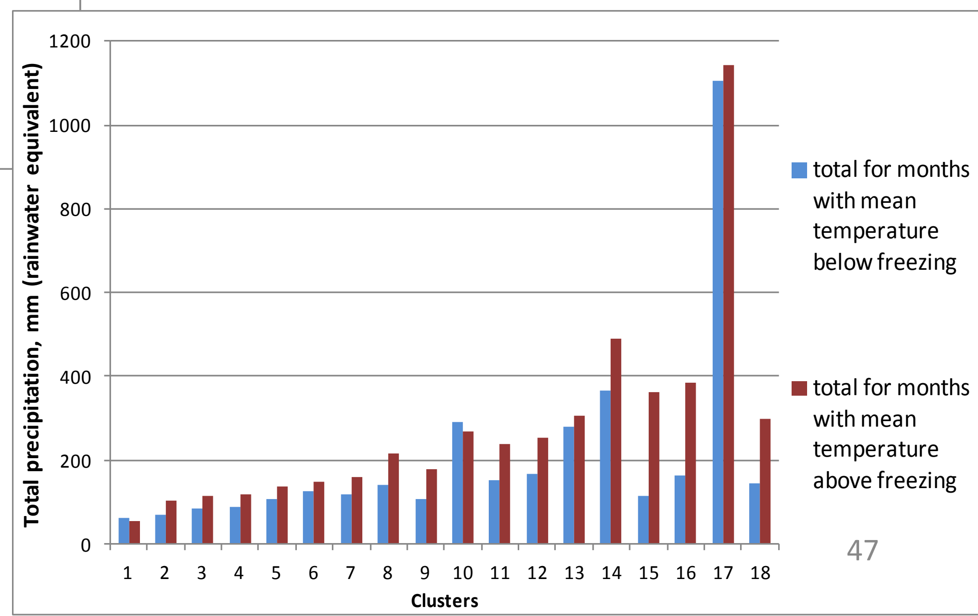


Cluster 17

Describing the clusters:
growing degree days, season length, and snowfall



Length of above-freezing season and GDD by cluster. Days above freezing were estimated via linear interpolation between monthly mean temperatures. Growing degree days (GDD) were calculated using 0°C as a baseline.



Warm-season and cold-season precipitation by cluster. The majority of precipitation in months with mean temperatures below freezing is assumed to be snow (measured as rainwater equivalent).

Describing the clusters:
existing land classification

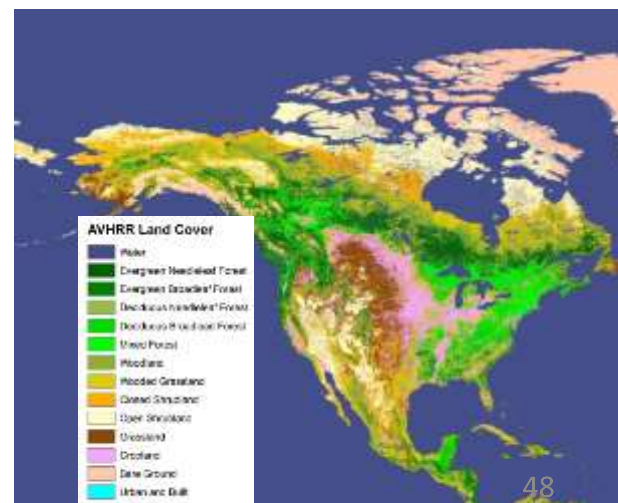
http://land cover.usgs.gov/nalcms.php

North American Land Change Monitoring System (NALCMS 2005)

GlobCover 2009

Alaska Biomes and Canadian Ecoregions.

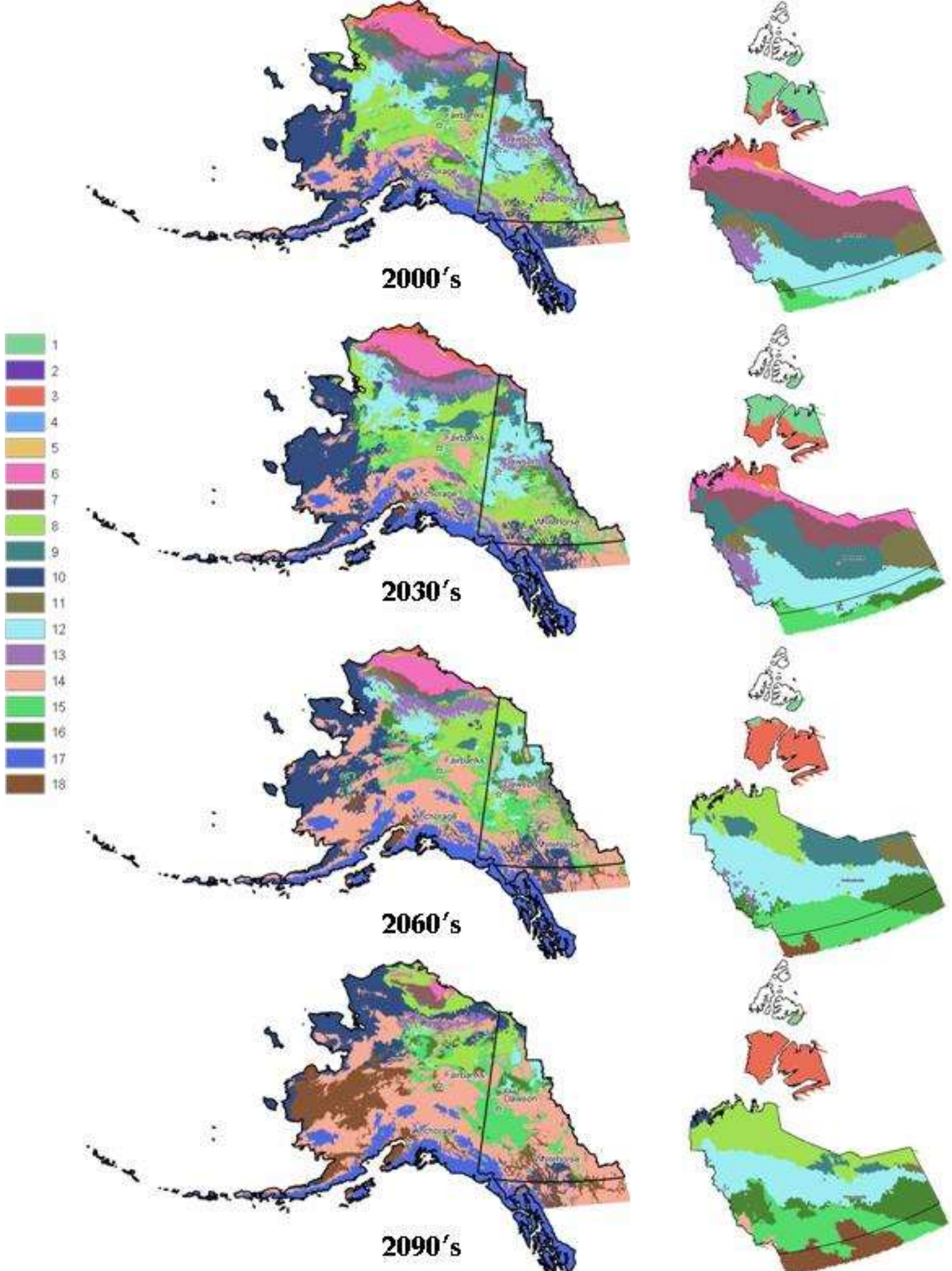
AVHRR Land cover, 1995

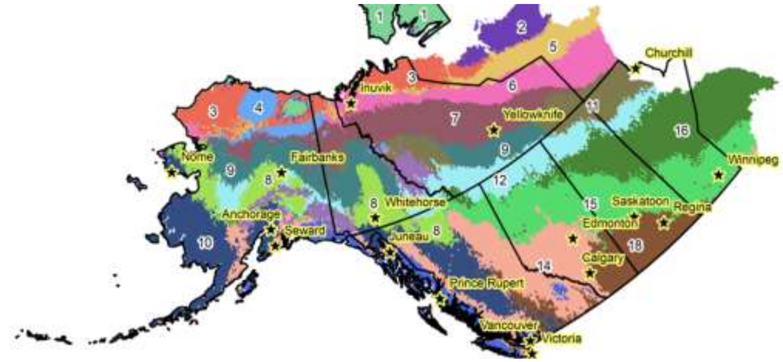


Cluster Number	AVHRR	Canadian and Alaskan Ecoregions	GlobCover	NALCMS
1	Open shrub	Northern Arctic	Sparse (<15%) vegetation	barren lands
2	Open shrub	Southern Arctic	Sparse (<15%) vegetation	polar or subpolar grassland lichen moss
3	Open shrub	Alaska Arctic	Sparse (<15%) vegetation	polar or subpolar grassland lichen moss
4	Closed Shrubland	Alaska Arctic	Sparse (<15%) vegetation	polar or subpolar grassland lichen moss
5	Open shrub	Southern Arctic	Sparse (<15%) vegetation	polar or subpolar grassland lichen moss
6	Closed Shrubland	Taiga Shield	Sparse (<15%) vegetation	polar or subpolar grassland lichen moss
7	Woodland	Taiga Plain	Sparse (<15%) vegetation	subpolar taiga needleleaf forest
8	Wooded Grassland	Boreal Cordillera	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	temperate or subpolar needleleaf forest
9	Woodland	Alaska Boreal	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	temperate or subpolar shrubland
10	Grassland	Western Tundra	Sparse (<15%) vegetation	temperate or subpolar shrubland
11	Woodland	Taiga Shield	Sparse (<15%) vegetation	subpolar taiga needleleaf forest
12	Woodland	Taiga Plain	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	temperate or subpolar needleleaf forest
13	Open shrub	Taiga Cordillera	Sparse (<15%) vegetation	barren lands
14	Evergreen Needleleaf Forest	Montane Cordillera	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	temperate or subpolar needleleaf forest
15	Evergreen Needleleaf Forest	Boreal Plain	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	cropland
16	Evergreen Needleleaf Forest	Boreal Shield	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	temperate or subpolar needleleaf forest
17	Bare Ground	North Pacific Maritime	Sparse (<15%) vegetation	temperate or subpolar needleleaf forest
18	Grassland	Prairie	Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	cropland

Comparison of cluster-derived cliomes with existing land cover designations. This table shows only the highest-percentage designation for each land cover scheme. Color-coding helps to distinguish categories.

Climate-biome Projections





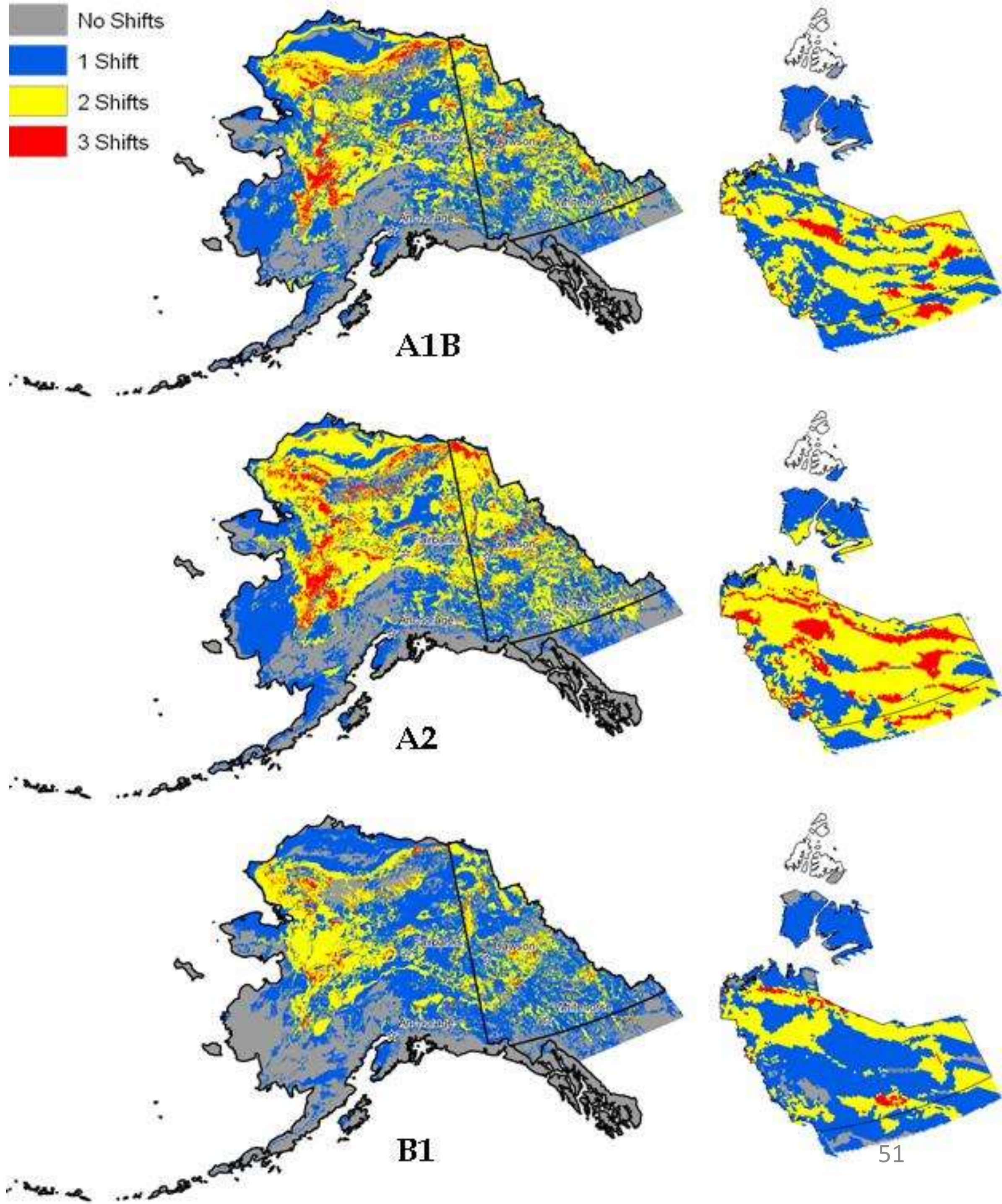
Original 18 clusters

Projected cliomes for the five-model composite, A1B (mid-range) climate scenario.

Alaska and the Yukon are shown at 2km resolution and NWT at 10 minute lat/long resolution .

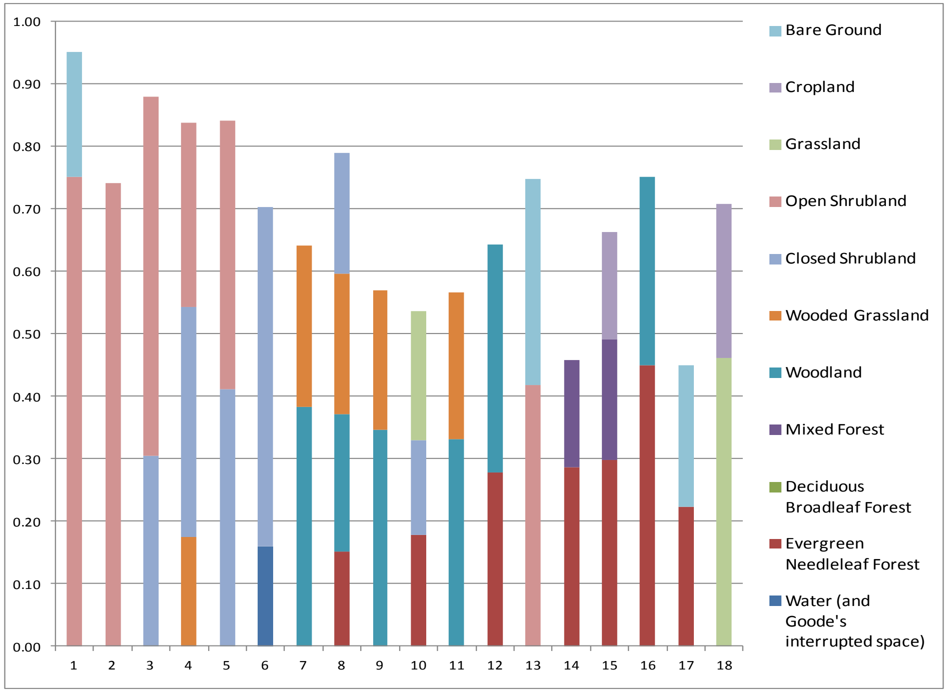
Future Projections

Projected change and resilience under three emission scenarios. These maps depict the total number of times models predict a shift in cliome between the 2000's and the 2030's, the 2030's and the 2060's, and the 2060's and the 2090's. Note that number of shifts does not necessarily predict the overall magnitude of the projected change.



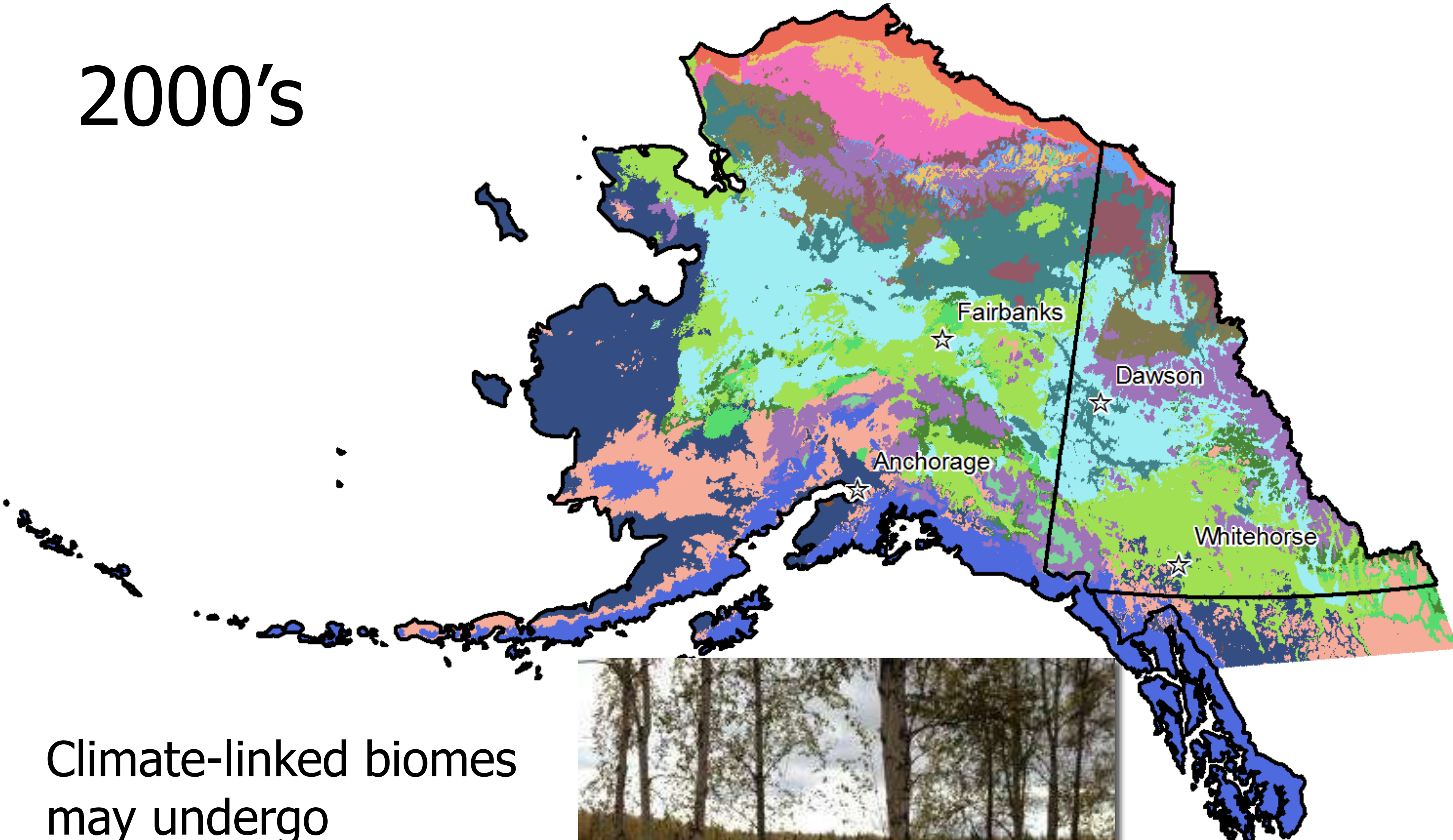
Discussion:
Interpreting results

- Comparison with existing land cover designations
- Assessment of which shifts are most significant in terms of vegetation communities
- Linkages with species-specific research
  - Habitat characteristics/requirements
  - Dispersal ability
  - Historical shifts



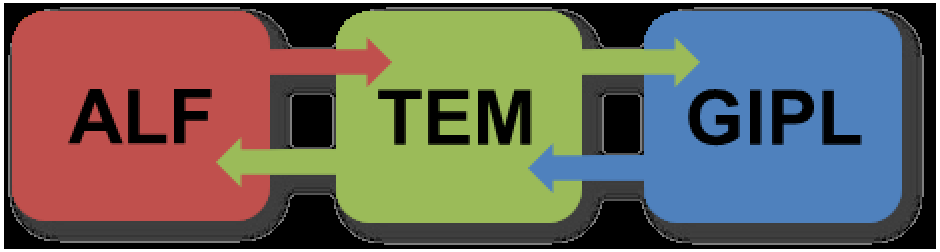
Dominant AVHRR land cover types by cluster number. All land cover categories that occur in 15% or more of a given cluster are included.

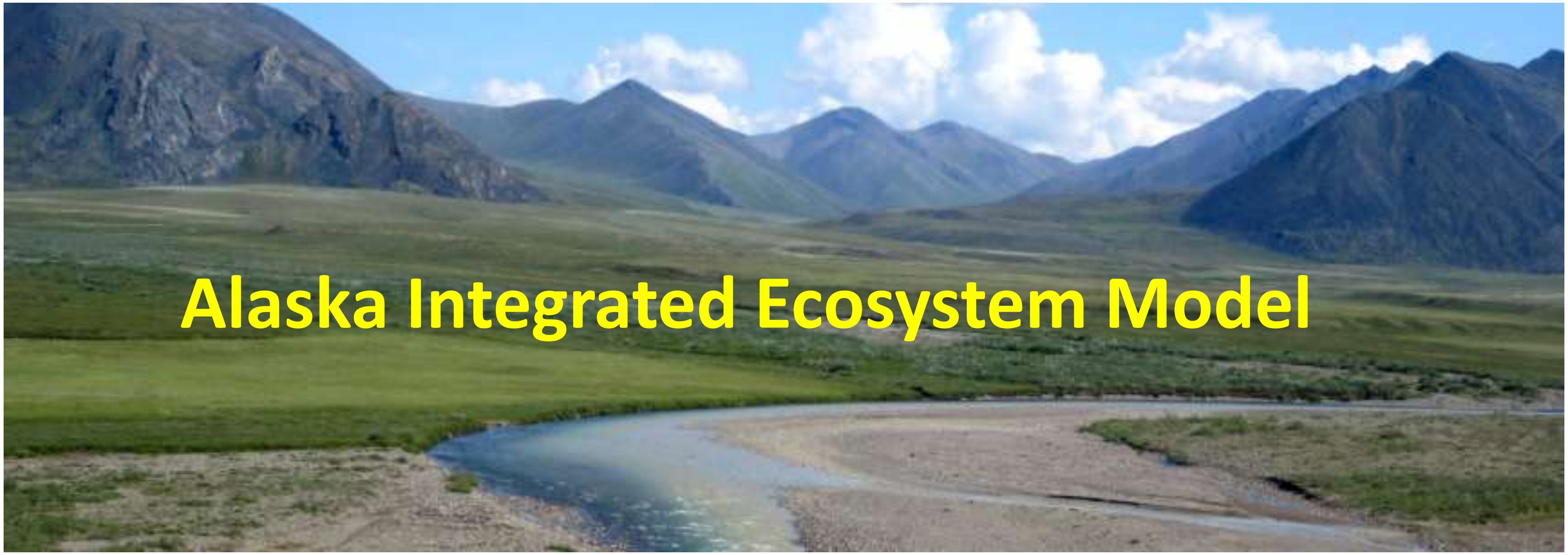
2000's



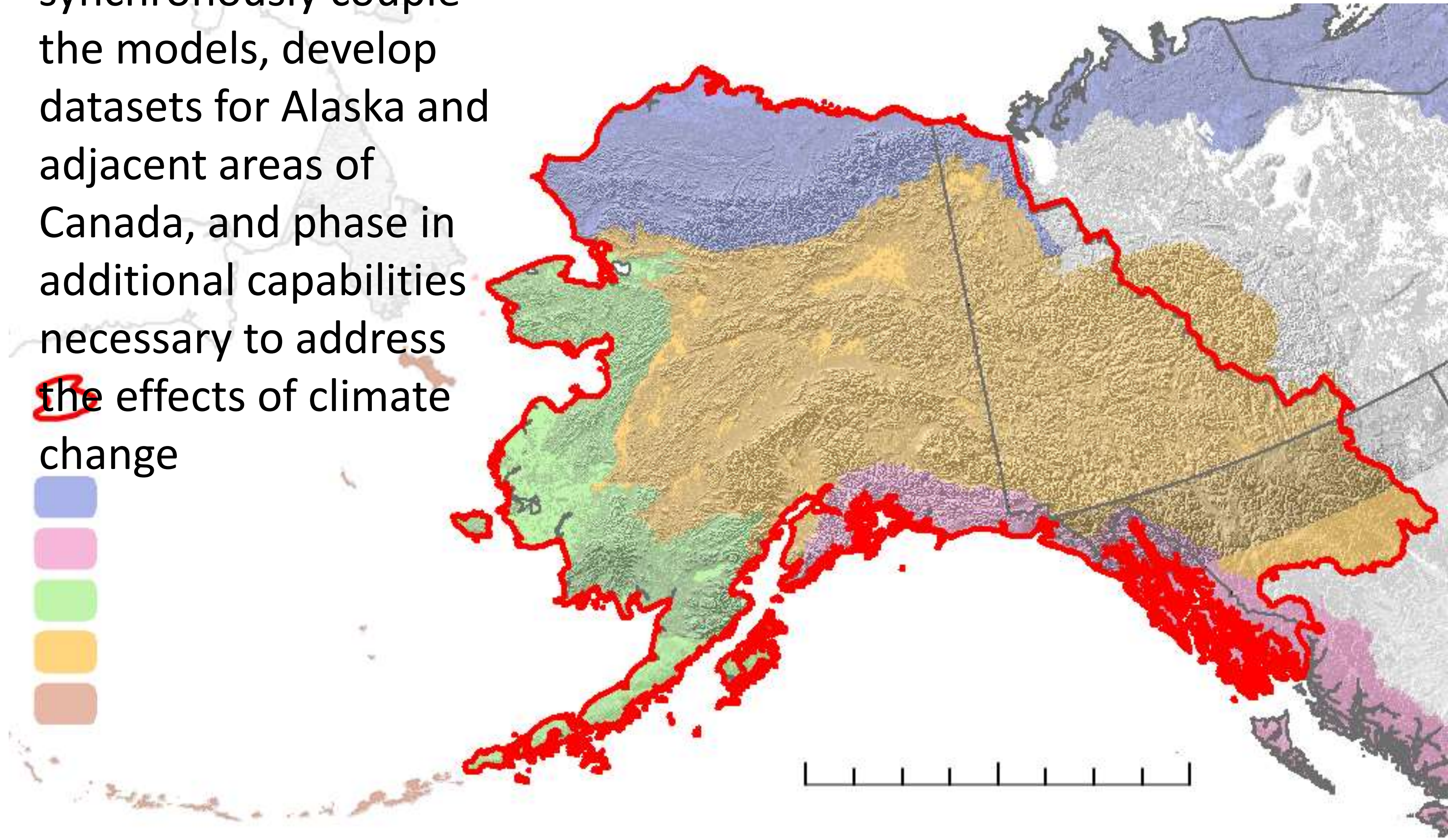
Climate-linked biomes may undergo profound changes during this century.

Linking models

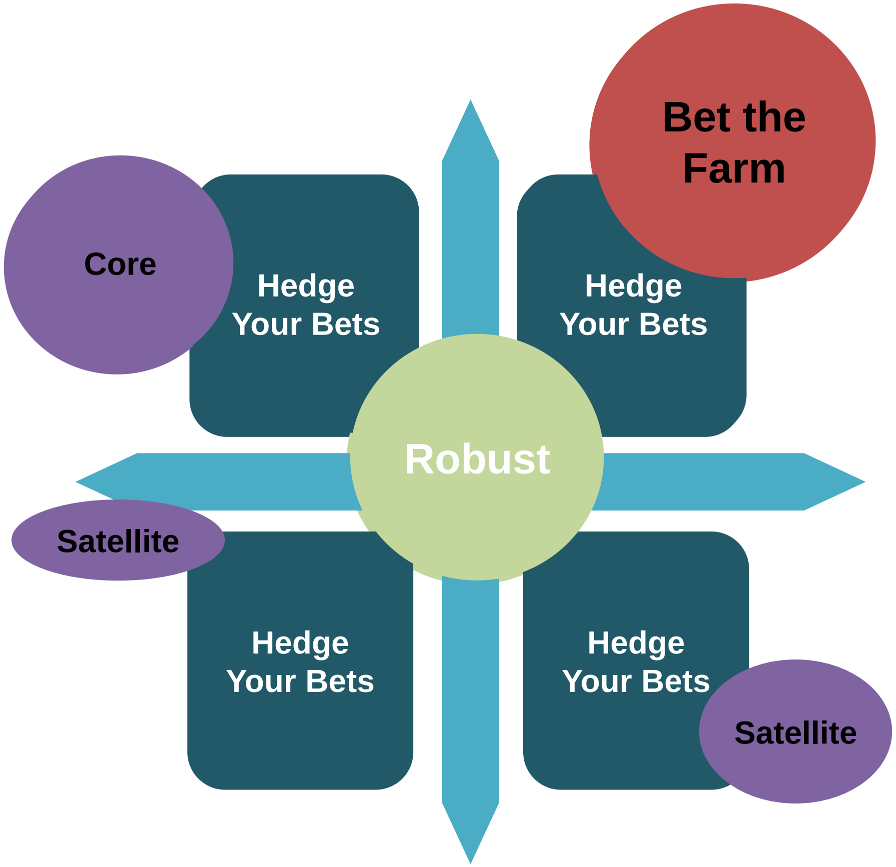




Objectives are to synchronously couple the models, develop datasets for Alaska and adjacent areas of Canada, and phase in additional capabilities necessary to address the effects of climate change



Scenarios Planning



Adapted from Global Business Network (GBN)

Robust: Pursue options that would work out well in any scenario

Bet the Farm: Make one bet that a certain future will happen

Hedge Your Bets: Make several bets of equal size

Core / Satellite: Place one major bet, with small bets as a hedge against uncertainty

Questions?