Climate Change Planning in Alaska's National Parks

NORTHWEST ALASKA PARKS

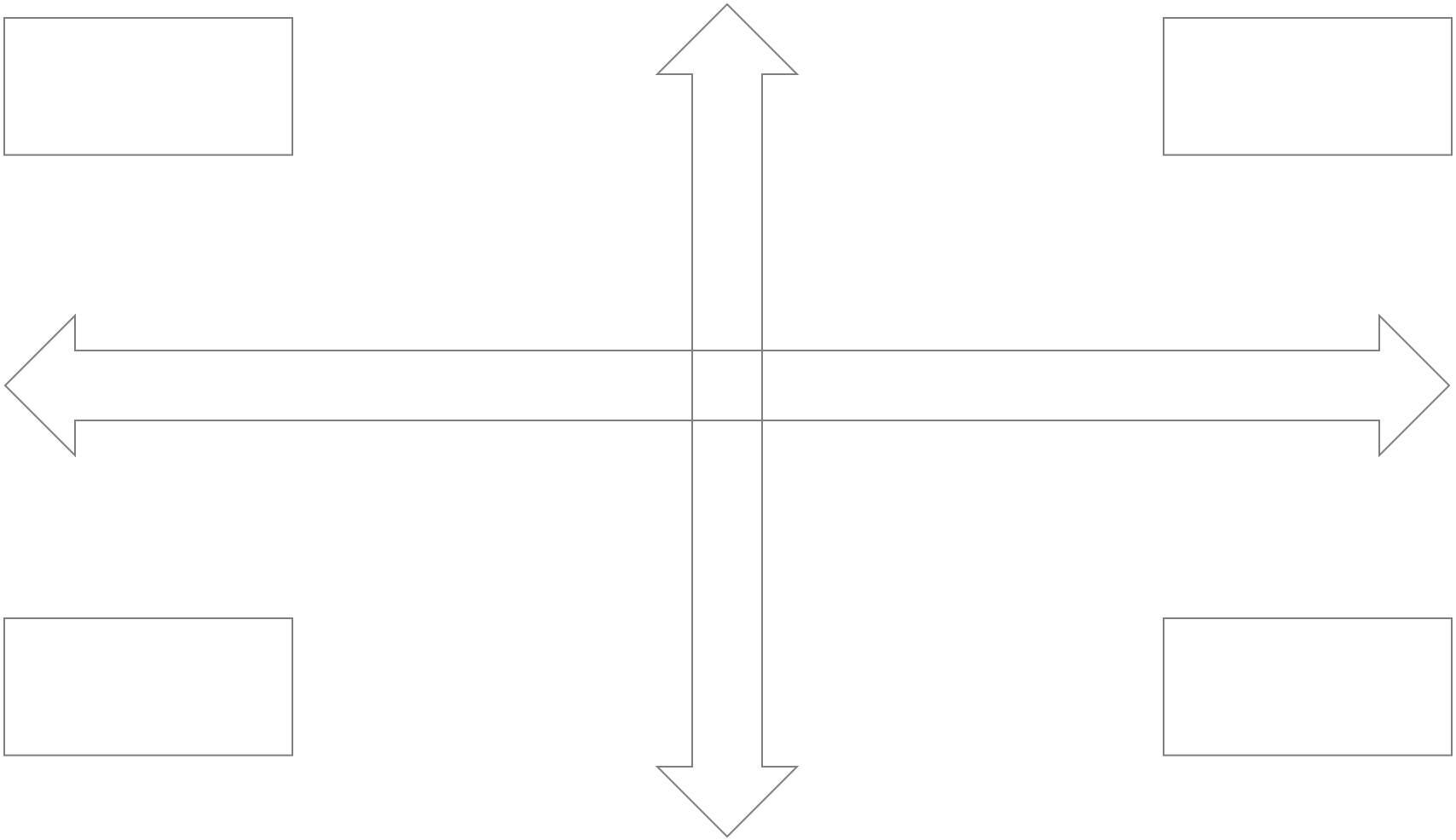
PLENARY #2: SCIENTIFIC BACKGROUND, DRIVERS, AND EFFECTS

Selecting Drivers – Key points

- Drivers are the **Critical forces** in our scenarios planning process.
- Critical forces generally have unusually **high impact** and unusually **high uncertainty**
- We are aiming to create scenarios that are:
  - **Challenging**
  - **Divergent**
  - **Plausible**
  - **Relevant**

CLIMATE SCENARIOS

BIOREGION: _____



CLIMATE SCENARIOS

BIOREGION: _____

Pick drivers with a wide range of possible outcomes

Choose drivers that impact several sectors, e.g tourism, subsistence, and wildlife, not just one

Select drivers with a high enough likelihood to be convincing to stakeholders

Select drivers with effects in most of the parks in the network

Avoid pairs of drivers that are too similar – think of the effects of crossing them with one another

Choose drivers that lead to the effects that are most critical

Northwest AK Drivers (pt. 1)

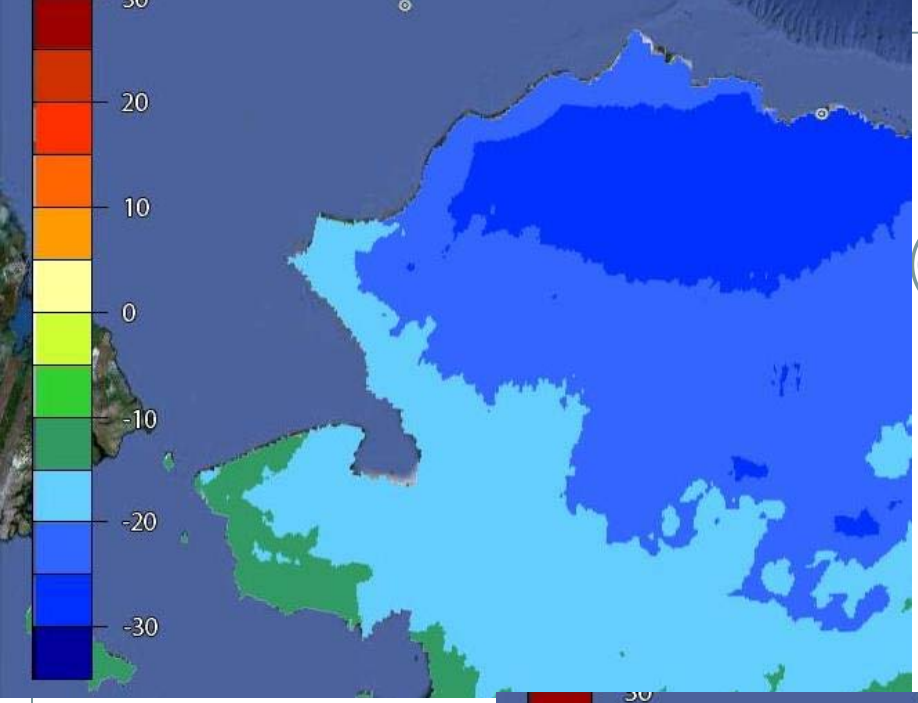
Climate Variable	General Change Expected	Specific Change Expected & Reference Period	Size of Expected Change Compared to Recent Changes	Patterns of Change	Confidence	Source & Context
Temperature	Increase	2050: +3°C ±2° ; 2100: +5°C ±3°	Large	More pronounced in autumn-winter, with winter increases of +8°C likely by 2100	>95% *Very likely* (for sign)	IPCC (2007) and SNAP/UAF
Precipitation	Increase	2050: 15-25% ± 15%; 2100:25-50% ±20%	Large	Fairly high % change, but high uncertainty and low baseline precip; drying effects of increased temperature and evapotranspiration may dominate	>90% *very likely* (for sign)	IPCC(2007) and SNAP/UAF
Relative Humidity	Little change	2050: 0% ±10%; 2100: 0% ±15%	Small	Absolute humidity increases	50% *About as likely as not*	SNAP/UAF
Wind Speed	Increase	2050: +2% ±4%; 2100: +4% ±8%	Small	More pronounced in winter and spring	>90% (sign) *Likely*	Abatzoglou and Brown*
Pacific Decadal Oscillation (atmospheric circulation)	Decadal to multidecadal circulation anomalies affecting Alaska	Unknown	Large (comparable to climatic jump in 1970s)	Major effect on Alaskan temperatures in cold season; acts as a wildcard within ongoing climate trends	Natural variation, essentially unpredictable	Hartmann and Wendler (2005, J. Climate)
Extreme Events: Temperature	Warm Events Increase / Cold Events Decrease	2050: increase 3-6 times present for warm events; decrease to 1/5-1/3 of present in cold events; 2100: increase 5-8.5 times present in warm events; decrease 1/12 to 1/8 of present in cold events	Large	Increase in frequency and length of extreme hot events and decrease in extreme cold events (winter) due to warming trend, but no clear changes in overall variability	Modeled and observed >95% *Very likely (for sign)*	Abatzoglou and Brown*; Timlin and Walsh, 2007, *Arctic*)
Extreme Events: Precipitation	Decrease/Increase	2050: -20% to +50%; 2100: -20% to +50%	Large	Increase in frequency and contribution especially in winter. Largest increase in autumn (large intermodel differences). Decreases in spring. Percent of annual precipitation falling as extreme events increases.	Modeled and observed *Uncertain*	Abatzoglou and Brown*

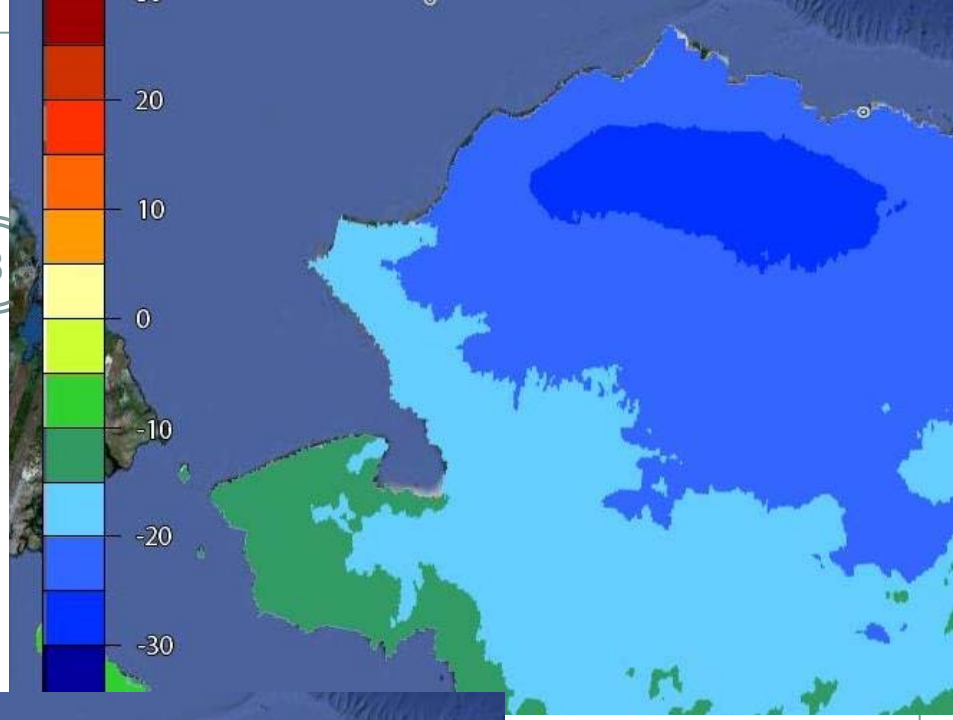
Northwest AK Drivers (pt. 2)

Climate Variable	General Change Expected	Specific Change Expected & Reference Period	Size of Expected Change Compared to Recent Changes	Patterns of Change	Confidence	Source & Context
Extreme Events: Storms	Increase	Increase in frequency and intensity	Any increases exacerbated by sea ice reduction and sea level increase	Increases at southern periphery of Arctic; little information for central Arctic	>66% *Likely*	Rachel Loehman
Sea ice	Decrease	2050: 40-60% loss in Bering Sea (winter/spring); 20-70% loss in Chukchi/Beaufort (summer)	Comparable to recent changes	Longer ice-free season; less loss of sea ice in winter than in summer	>90% Very likely	Overland and Wang (2009)
Snow	Increased snowfall during winter, shorter snow season	2050: 10-25%; 2100: 20-50%	Recent changes not well established	Cold-season snow amounts will increase in Interior, Arctic; increased percentage of precipitation will fall as rain (especially in spring, autumn)	Large uncertainty in timing of snowmelt (warmer springs, more snow to melt)	AMAP/SWIPA (Snow, Water, Ice and Permafrost in the Arctic, 2011)
Freeze-up date	Later in autumn	2050: 5-20 days 2100: 10-40 days	Large	highest near the north coast, but pronounced throughout the Arctic	>90% *Very likely* (sign)	SNAP/UAF
Length of ice-free season for rivers, lakes	Increase	2050: 10-20 days 2100: 20-40 days	Large	Largest near coasts where sea ice retreats, open water season lengthens	>90% *Very likely*	IPCC (2007); SNAP/UAF

Northwest AK Drivers (pt. 3)

Climate Variable	General Change Expected	Specific Change Expected & Reference Period	Size of Expected Change Compared to Recent Changes	Patterns of Change	Confidence	Source & Context
River and stream temperatures	Increase	2050: 1-3°C 2100: 2-4°C	Large	Consistent with earlier breakup and higher temperatures	>90% *Very Likely*	Kyle and Brabets (2001)
Length of growing season	Increase	2050: 10 to 20 days 2100: 20 to 40 days	Continuation of recent changes	Largest near coasts	>90% Very likely	IPCC (2007); SNAP/UAF
Permafrost	Increased area of permafrost degradation (annual mean temperature > 0°C)	2050: ~100-200 km northward displacement 2100: ~150-300 km northward displacement	Large	Permafrost degradation primarily in area of warm permafrost; less pertinent in the Arctic, although some degradation likely in southern Arctic and coastal areas.	>90% *Very likely* (sign)	SNAP and Geophysical Institute (UAF)
Sea level	Increase	2050: 3 inches to 2 feet 2100: 7 inches to 6 feet	Large	Large uncertainties, esp. at upper end of range. Isostatic rebound is less likely in the north	>90% on sign, except in areas of strong isostatic uplift	IPCC (2007)
Water availablility (summer soil H2O = P-PET)	Decrease	2050: decrease of 0-20+% 2100: decrease of 10-40+%	Recent changes not well established	Most profound changes in areas where sub-freezing temperatures have historically limited PET, therefor highly pertinent in the Arctic. Much uncertainty regarding role of winter water storage and spring runoff	>90% *Very likely*, but likelihood varies by region	SNAP and The Wilderness Society

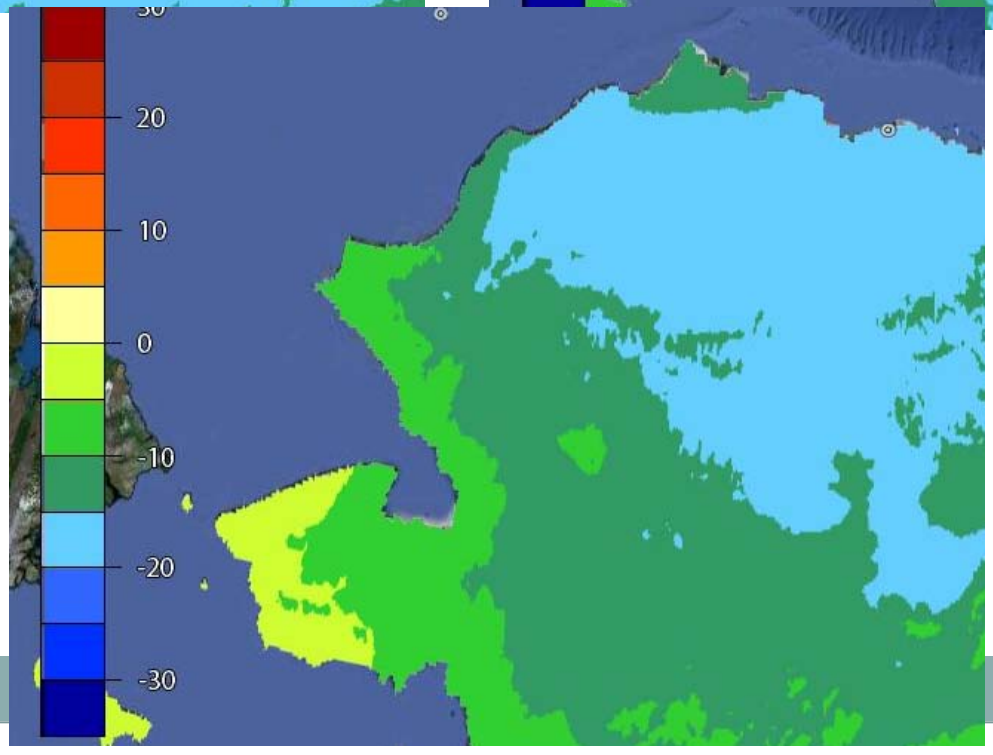


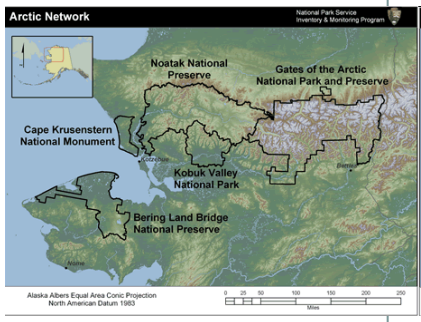


Winter 2000's

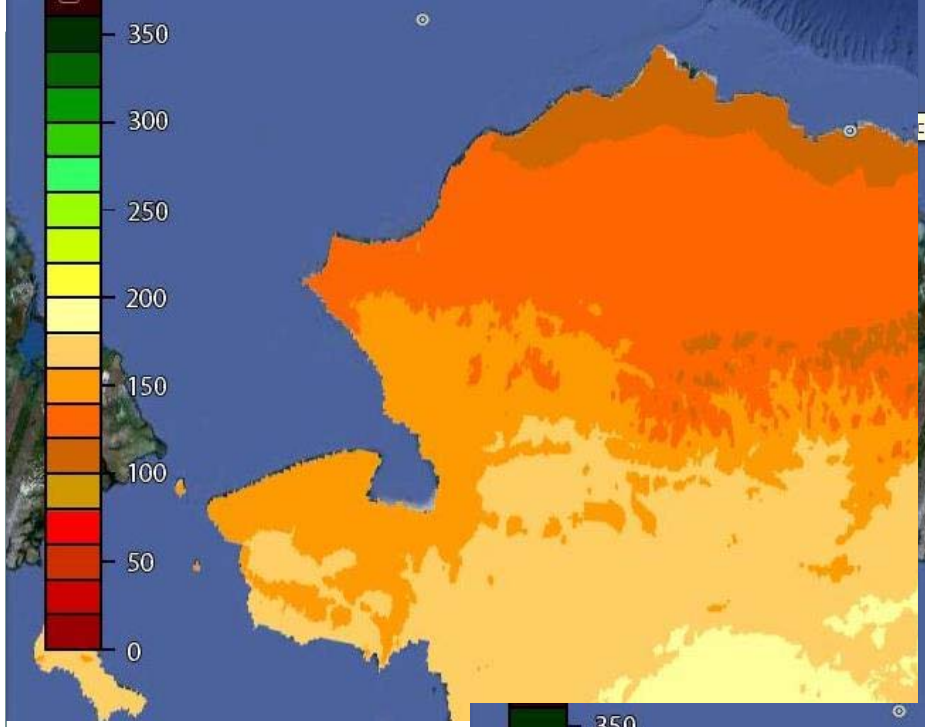
Winter 2030's

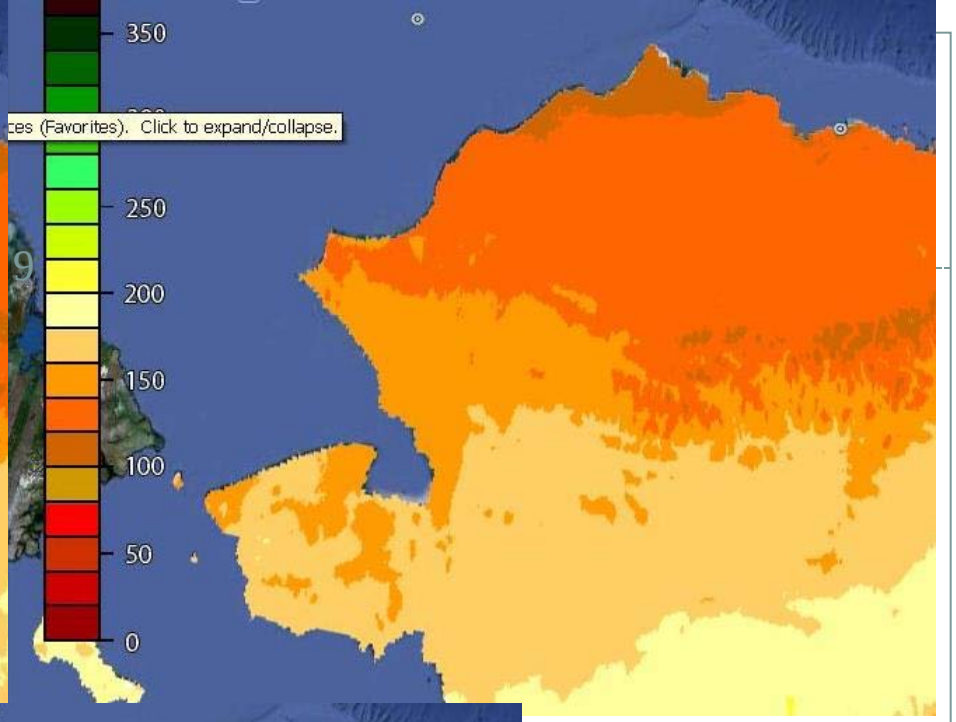
Temperature projections for Dec-Jan for selected decades (composite A1B model)





Winter 2090's



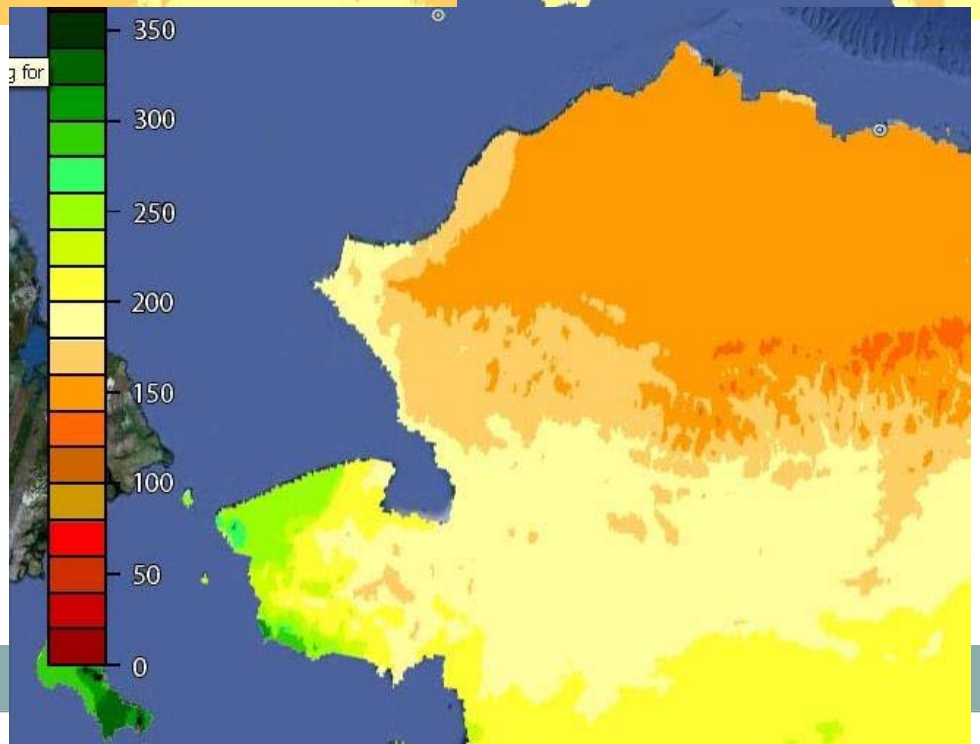


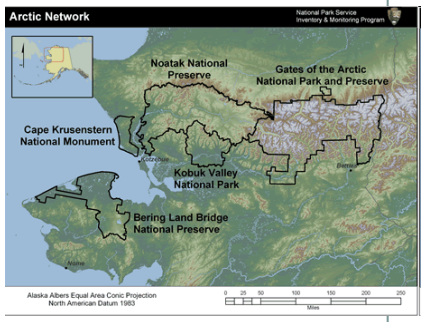
2000's

2030's

Unfrozen* season length predictions for selected decades (composite A1B model)

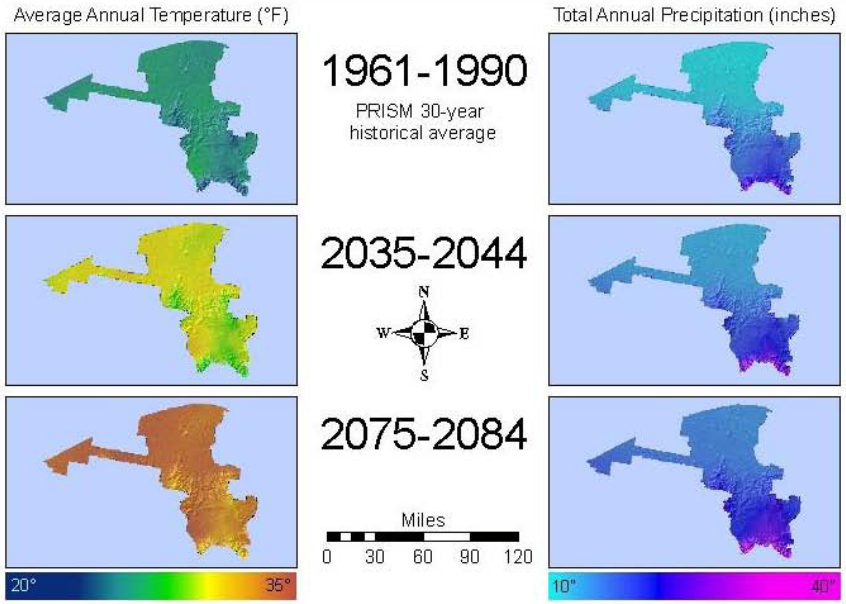
**** Time between when running mean temperature crosses the zero point in spring and in fall***





2090's

Projected climate change scenarios for Bering Land Bridge National Preserve



Magnitude of climatic change

Projected Temperature (TEMP) Change (°F)				Projected Precipitation (PRCP) Change (in.)				
Season	Time	Avg. TEMP	Δ TEMP*	Season	Time	Total PRCP	Δ PRCP*	% Δ PRCP*
Annual	Hist	21.6 ± 0.2	NA	Annual	Hist	12.4 ± 1.5	NA	NA
	2040	27.2 ± 0.2	5.6		2040	15.4 ± 1.5	3.0	24%
	2080	31.9 ± 0.3	10.3		2080	18.1 ± 1.5	5.7	46%
Summer	Hist	43.6 ± 0.4	NA	Summer	Hist	7.4 ± 0.9	NA	NA
	2040	46.0 ± 0.4	2.4		2040	8.8 ± 0.9	1.5	20%
	2080	48.5 ± 0.4	4.8		2080	9.8 ± 0.9	2.4	33%
Winter	Hist	5.9 ± 0.4	NA	Winter	Hist	5.1 ± 0.6	NA	NA
	2040	13.8 ± 0.5	7.9		2040	6.6 ± 0.6	1.5	31%
	2080	20.1 ± 0.6	14.3		2080	8.3 ± 0.6	3.3	65%

* Δ PRCP/TEMP: change in decadal precipitation/temperature average from historic value

For more information:
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Climate Change Implications for Bering Land Bridge National Preserve

Climate Change in Alaska

Many areas in Alaska are already showing signs of climate change. Scientists have reported observations of wetland drying, glacial and polar sea ice recession, spruce-bark beetle infestations, and an increase in fire frequency and intensity throughout the state. A better understanding of where and when such changes could continue to occur is needed to help decision makers identify how Alaska's ecosystems may respond in the future.

In order to understand what these changes may be like, data from a composite of five down-scaled global circulation models was used to estimate decadal averages of future temperature and precipitation values within the preserve. These models assume a steady increase in carbon dioxide (CO_2) emissions from fossil fuel combustion over the first several decades of the 21st century, followed by a gradual decline in emissions as several kinds of low-emission energy alternatives become more prevalent. This emissions regime is considered a "moderate" estimate[1]. Several other scenarios have predicted higher emission rates, and scientists have since determined current levels[2] are significantly greater than even the most extreme concentrations analyzed by the Intergovernmental Panel on Climate Change. Higher emissions rates will likely accelerate changes in climate and lead to more severe ecosystem impacts.

Temperature changes in Bering Land Bridge National Preserve

Temperatures are projected to increase over the coming decades at an average rate of about 1°F per decade. Average annual temperature is expected to rise by about 6°F by 2040 and as much as 10°F by 2080.

Considering the natural variation in temperatures across the study area, this is likely to result in a transition from average annual temperatures below the freezing point (~22°F), to temperatures near or above the freezing point (~32°F).

A likely outcome of these changes is a lengthening of the growing season, a change that could have profound affects on wildlife mating cycles, plant growth and flowering, water availability in soil and rivers, and hunting and fishing.

Winter temperatures are projected to change the most dramatically. Mean winter temperatures could reach a high of 20°F by 2080, a figure that represents an impressive 14°F rise from the historical 6°F average. Average summer temperatures are projected to rise by almost 5°F by 2080 (from ~44°F to ~49°F). Some species may benefit from these changes, while others may not be able to adapt or find suitable habitat conditions to sustain their populations.

Precipitation changes in Bering Land Bridge National Preserve

Precipitation is predicted to increase across the study area. Despite this area-wide increase, conditions are expected to become substantially drier in the summer and fall and potentially icier in winter. Although summer rainfall is expected to rise by 33%, this increase is unlikely to be enough to offset an increase in evapotranspiration caused by warmer temperatures and a longer growing season. Winter precipitation may increase by as much as 65% and could fall in the form of snow, ice, or rain, depending on the temperature. Ultimately, the timing and intensity of precipitation will determine how these changes affect the landscape and hydrology of the Preserve.

Summary of findings

Bering Land Bridge National Preserve is projected to become warmer and drier over the next century. Warmer temperatures and a longer growing season are expected to increase evapotranspiration enough to outweigh a regional increase in precipitation. Seasonal changes in climate will have profound impacts on the condition and health of wildlife habitat, lead to increased fire risk, and contribute to the likelihood of wetlands, steams, and lakes drying.

It is important to note that predicting changes in environmental variables is difficult, especially in Alaska where historical climate monitoring data is sparse. Increasing the scope of precipitation, temperature, and ecological monitoring throughout Alaska is one of the best strategies for improving our understanding of changes in climate and the response of ecosystems.

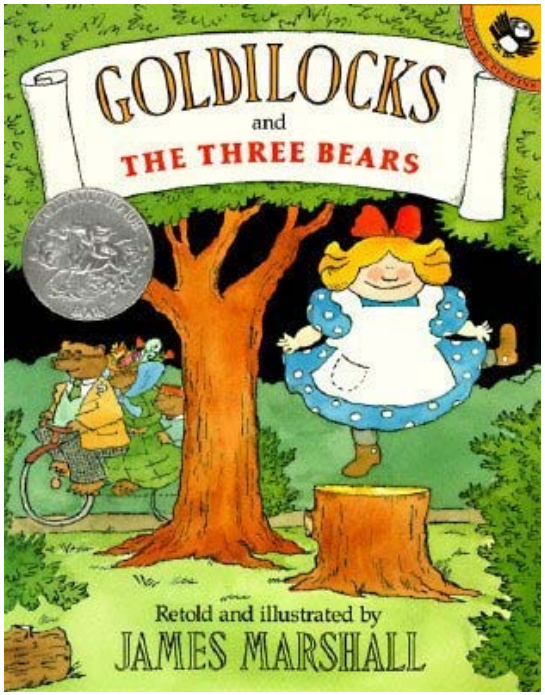
[1] *This emissions outlook is the "A1B" scenario from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, published in 2007. The models used in this analysis included Echam5, Gfdl2.1, Miroc3.2MR, HadCM3, and CGCM3.1.*

[2] *Recent rates of global CO_2 emissions can be found on the Carbon Dioxide Information Analysis Center website (www.cdiac.esd.ornl.gov).*

Keep in mind....

We will be synthesizing our results to create a small number of alternative stories

- Sixteen (or more) choices available (4x4)
- Need to select only 3-4 to turn into narratives and planning tools
- Focus on scenarios that are:
  - Relevant
  - Divergent
  - Plausible
  - Challenging
- Create a narrative (story) about each scenario



Keep in mind…

Name	Species	Hair/Fur	Age	Appetite Level	Size	Preliminary Porridge Assessment	Preliminary Mattress Assessment
Goldilocks	Human	Blonde	8	Moderate	Petite	N/A	N/A
Papa	Bear	Brown	12	High	Big	Too Hot	Too Hard
Mama	Bear	Tawny	11	Moderate	Medium	Too Cold	Too Soft
Baby	Bear	Red-Brown	3	Low	Small	Just Right	Just Right

Effective storytelling matters!

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Drivers are linked to effects

Sector	Subsector	Potential Effects to Resources, Operations, and People	Level of impact (H/M/L)	Comments
Atmosphere	Greenhouse gases	**Deliberate biological and geological sequestration** may be implemented on federal-owned and other lands	LLLLL	
	Air temperature	**Air temperature increases** at an average rate of 1°F (0.56°C) per decade. For Bering Land Bridge, mean annual temps 10°F higher by 2080, with largest change in winter -- 8°F by 2040. 14°F by 2080.	HHHHH	
		Average annual temperatures shift from below freezing to above freezing in coastal areas by the end of the century.	HHHHHH	Nancy Fresco- remember that all of these can be viewed as cascading effects.
	Precipitation	**Average annual precipitation increases** through the mid- to late-21st Century. Relative proportions of moisture deposited as snow, ice or rain change as temperature increases.	MMHHH	Don C.-this will have a particularly pernicious effect re: access and subsistence activities.
		Arctic likely to experience drying conditions despite increased precipitation, due to higher temperature and increased rates of evapotranspiration.	MMHHH	Peter Neitlich- BELA has had huge fire episodes in past.

Climate Effects

Climate effects are the outcomes of the critical forces or drivers, as expressed by significant changes in particular parks. Points to consider include:

- Time frame (20 years? 100 years?)
- Uncertainty (of both driver and effect)
- Severity of effect (and reversibility)
- Scope: what parks, who is impacted?
- Repercussions: what is the story?
- Feedback to policy

Drivers are also linked to other drivers

		Arctic snow cover declines, with higher average air temperatures, earlier spring thaw, and cryoconite deposition (atmospheric soot and dust)**.**	MHH	Nancy Fresco- lots of uncertainty here.
Cryosphere		**Lack of snow cover leads to deeper freezing of water in the ground or river beds resulting in more aufeis (overflow ice) on rivers and lakes and formations of pingos and yedomas on land.**	M	Nancy Fresco-uncertainty here as well.
		Undiscovered cultural resources are exposed as perennial snow and ice patches melt and recede.	LL	
	Sea Ice	**Shorter sea ice season, with less and thinner ice** complicates travel over ice, while easing boat travel through ice. Lack of sea ice in Spring-Fall impacts ecosystems (negatively for marine mammals/positively for some fish species), impacts subsistence access, increases risk and costs for marine mammal hunters. Adds energy to storm surges which increases erosion with high economic costs for community relocation.	HH	
		Seasonal reductions in Arctic sea ice enable more marine transportation and shipping accidents. As passenger and cargo traffic increases, the potential for accidents and the risk of spills contaminating NPS coastal resources increases.	MMHHH H	Wendy Loya-A spill would be significant. Peter Neitlich-O&G development/shipping major concern.
	Ice Roads	**Reduced winter transportation opportunities on frozen tundra** affect opportunities for natural resource development, access to subsistence sites, and travel between villages, spurring discussion of alternative transportation routes and easements.	MHHH	
	Permafrost	**Mercury and other pollutants are released into the aquatic environment** as the permafrost thaws, increasing contaminant exposure for wildlife and humans that rely on the marine ecosystem for food.	MH	
	Sea level	**Some coastal villages rapidly lose ground relative to sea level**, such as Shishmaref and Kivalina in Northwest Alaska. Erosion and subsidence are complicating factors.	HHHH	Peter-relocations will have effect on parks.

Climate Change Scenario Drivers

TEMPERATURE AND LINKED VARIABLES

thaw, freeze, season length, extreme days, permafrost, ice, freshwater temperature

PRECIPITATION AND LINKED VARIABLES:

rain, snow, water availability, storms and flooding, humidity

PACIFIC DECADAL OSCILLATION (PDO)

definition, effects, and predictability

SEA LEVEL

erosion also linked to sea ice and storms

OCEAN ACIDIFICATION

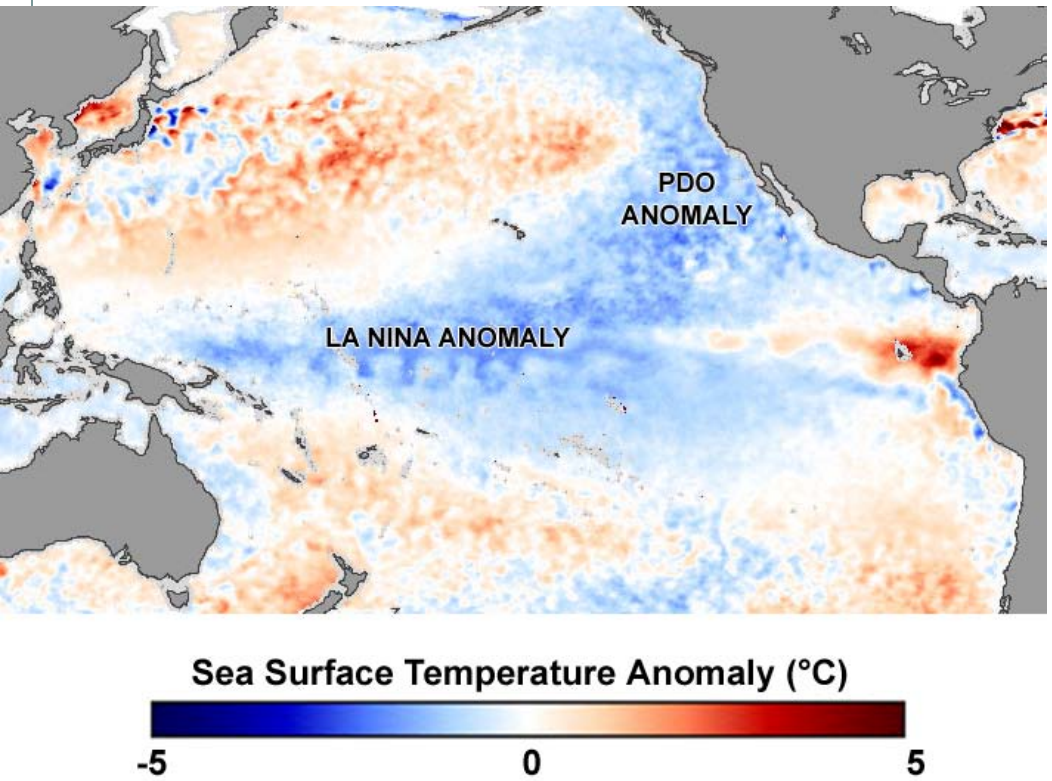
Temperature and linked variables

- Temperature based on downscaled monthly averages from SNAP
  - Uncertainty due to GCM uncertainty, emissions scenarios, downscaling uncertainty, PDO
- Season length, freeze, and thaw dates interpolated from mean monthly temperatures
- Permafrost thaw derived from ground cover, soil type, air temperature projections
- Extreme days an extension of temperature trend
- Sea ice and freshwater temperature also linked to air temperature

Precipitation and linked variables

- Temperature based on downscaled monthly averages from SNAP
  - Uncertainty due to GCM uncertainty, emissions scenarios, downscaling uncertainty, PDO
  - Uncertainty greater than for temperature
- Models do not separate rain/snow
- Storms include wind and precipitation
  - Flooding and erosion more dependent on timing than quantity
- Water availability linked to precipitation and temperature
- Humidity and cloud cover

Pacific Decadal Oscillation (PDO)



http://en.wikipedia.org/wiki/File:La_Nina_and_Pacific_Decadal_Anomalies_-_April_2008.png

Pattern of Pacific climate variability that shifts phases about every 20 to 30 years (compared to 6-18 months for ENSO)

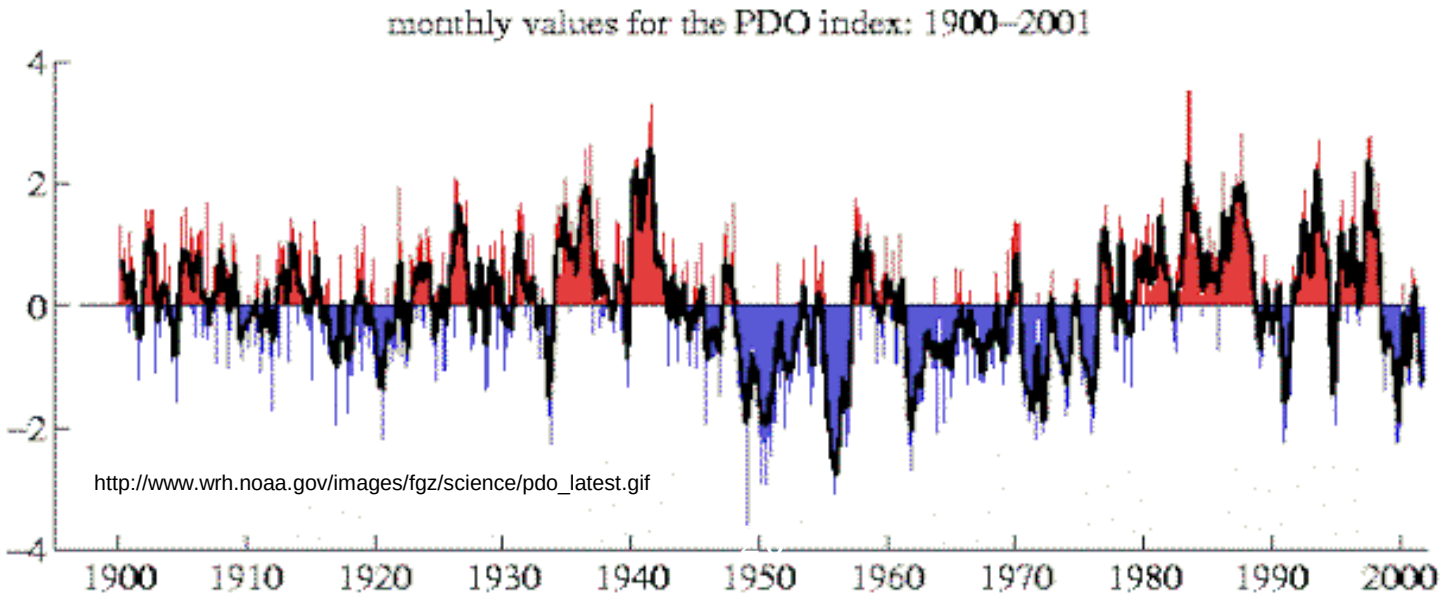
First identified by Steven R. Hare in 1997.

Warm or cool surface waters in the Pacific Ocean, north of 20° N.

In a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms; during a "cool" or "negative" phase, the opposite occurs.

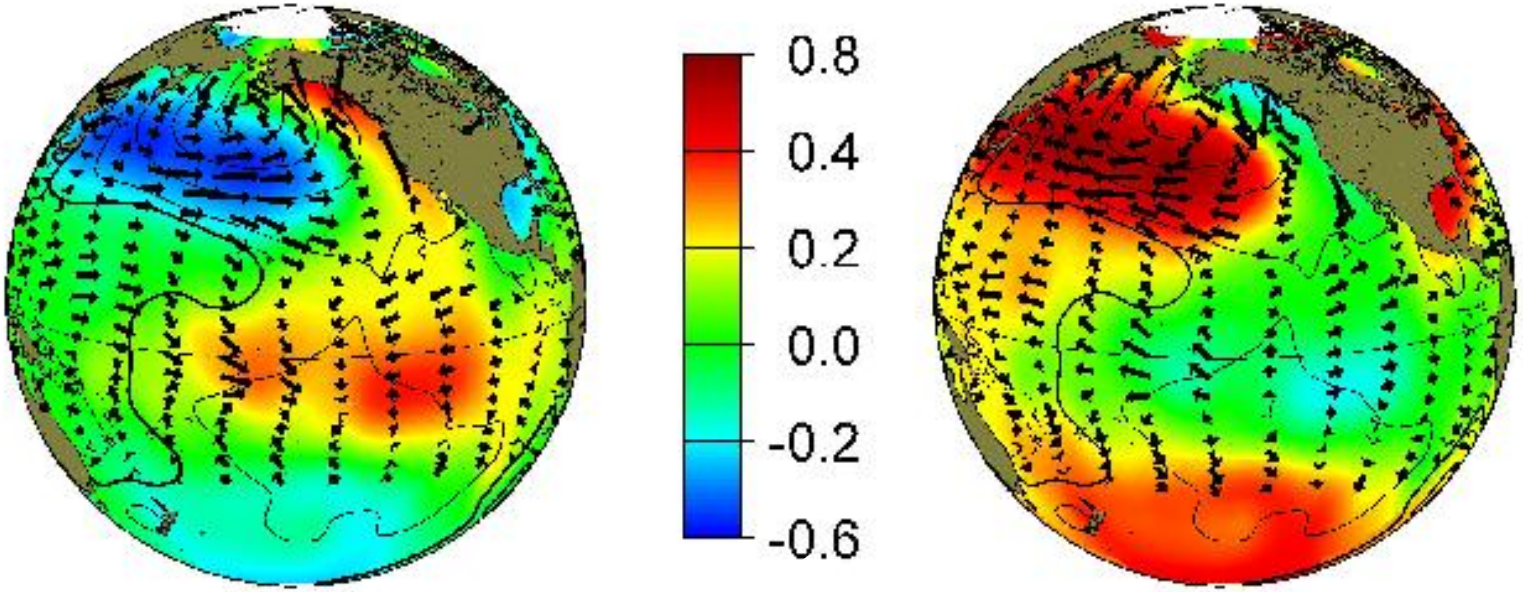
PDO -- Effects

- Major changes in marine ecosystems correlated with PDO.
- Warm eras have seen enhanced coastal ocean productivity in Alaska and inhibited productivity off the west coast of the contiguous United States.
- Cold PDO eras have seen the opposite.



PDO -- Predictability

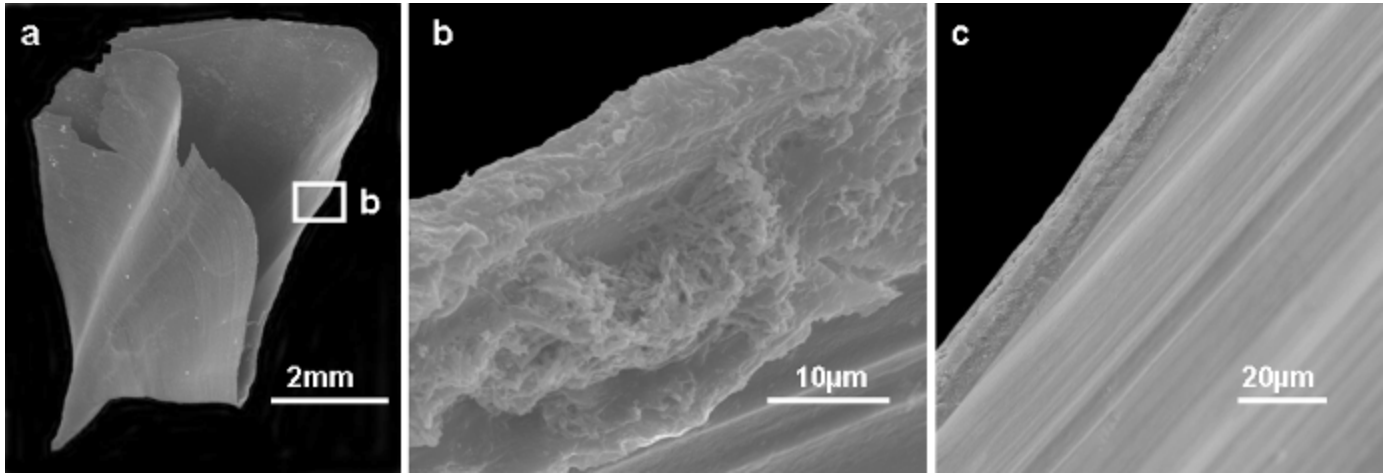
- PDO is caused by several processes with different origins, including ENSO and more stochastic influences .
- Currently NOAA has limited ability to predict PDO more than 1 year out.
- Controversy exists over how PDO works, and how it might best be monitored, modeled and predicted.
- Predictive strength may be improving.



http://jisao.washington.edu/pdo/

Ocean Acidification

Reduced survival of larval marine species
Algae and zooplankton reduced
Serious consequences for food webs
Exact thresholds unclear



Sea Level and Storm Surges

Along the southern shores of Alaska the effect so far is hardly noticeable, because most of the coastline also is slowly rising due to tectonic forces and isostatic rebound.

On the Bering Sea coast and in the Arctic, however, communities are experiencing increased damage from storm surges (extreme high water events caused by high winds and low atmospheric pressure), shoreline loss to fierce winter storms, and saltwater intrusion into freshwater sources, sanitation lagoons, and fish and wildlife habitats.

http://seagrant.uaf.edu/map/climate/docs/sea-level.pdf

Indications are that all of this is being made worse by a gradual rise in sea level.

Critical Uncertainties

Southwest Alaska Network (SWAN) group, August workshop

Less	Water availability	More
Normal	Stream/lake temps	Warmer
Less	River basin hydrology	More
Measureable	Ocean Acidification	Catastrophic
Historical	Extreme precip/storms	Significant increase
Negative (colder)	PDO	Positive (warmer)

Climate Drivers

- Climate drivers are the **critical forces** in our scenarios planning process
- Critical forces generally have unusually **high impact** and unusually **high uncertainty**
- Climate drivers table specific for SE Alaska were compiled by John Walsh and Nancy Fresco of SNAP (see handouts).
- All scenarios are created by examining the intersection of two drivers, creating four sectors
- **Selection of drivers** is crucial to the planning process