



**Improving our Understanding
of Arctic Environmental Change
and its Impacts**

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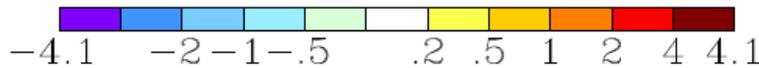
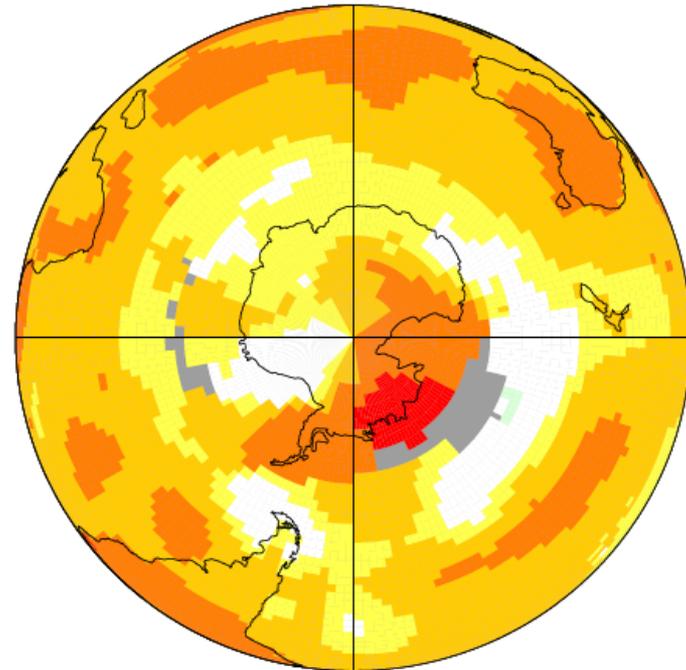
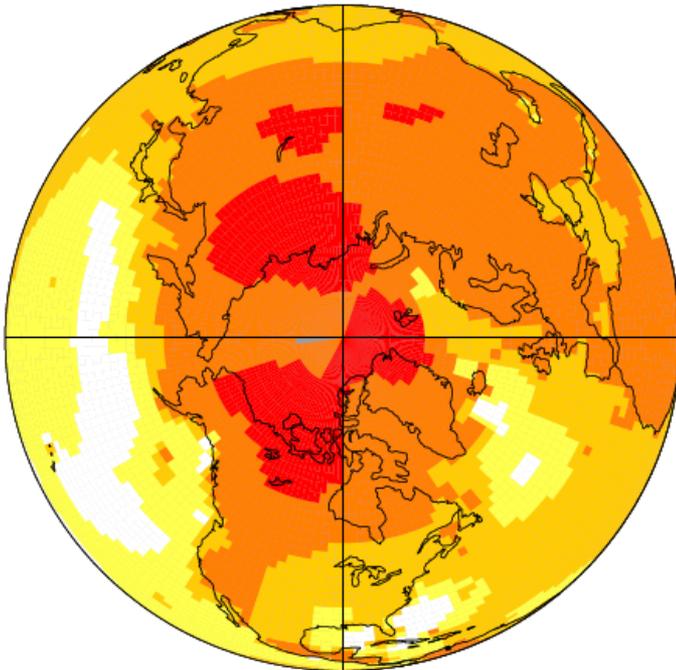
Trends in annual temperature, 1951-2014

[from NASA GISS]

Annual J-D

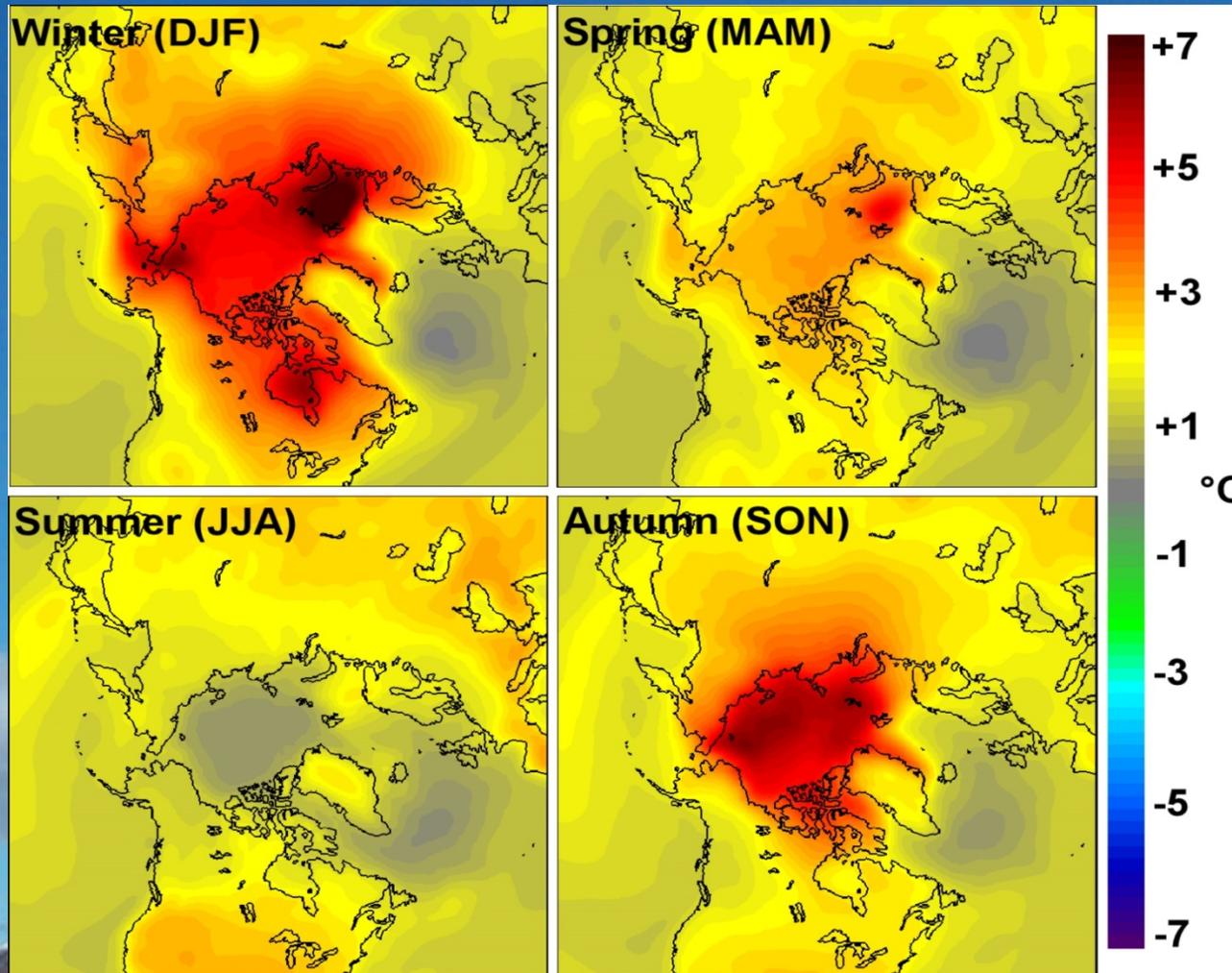
L-OTI(°C) Change 1951-2014

0.87



Walsh and Chapman, 1993-updated

Projected changes of temperature: 2070-2090



Walsh et al., 2002. J. Climate, revised

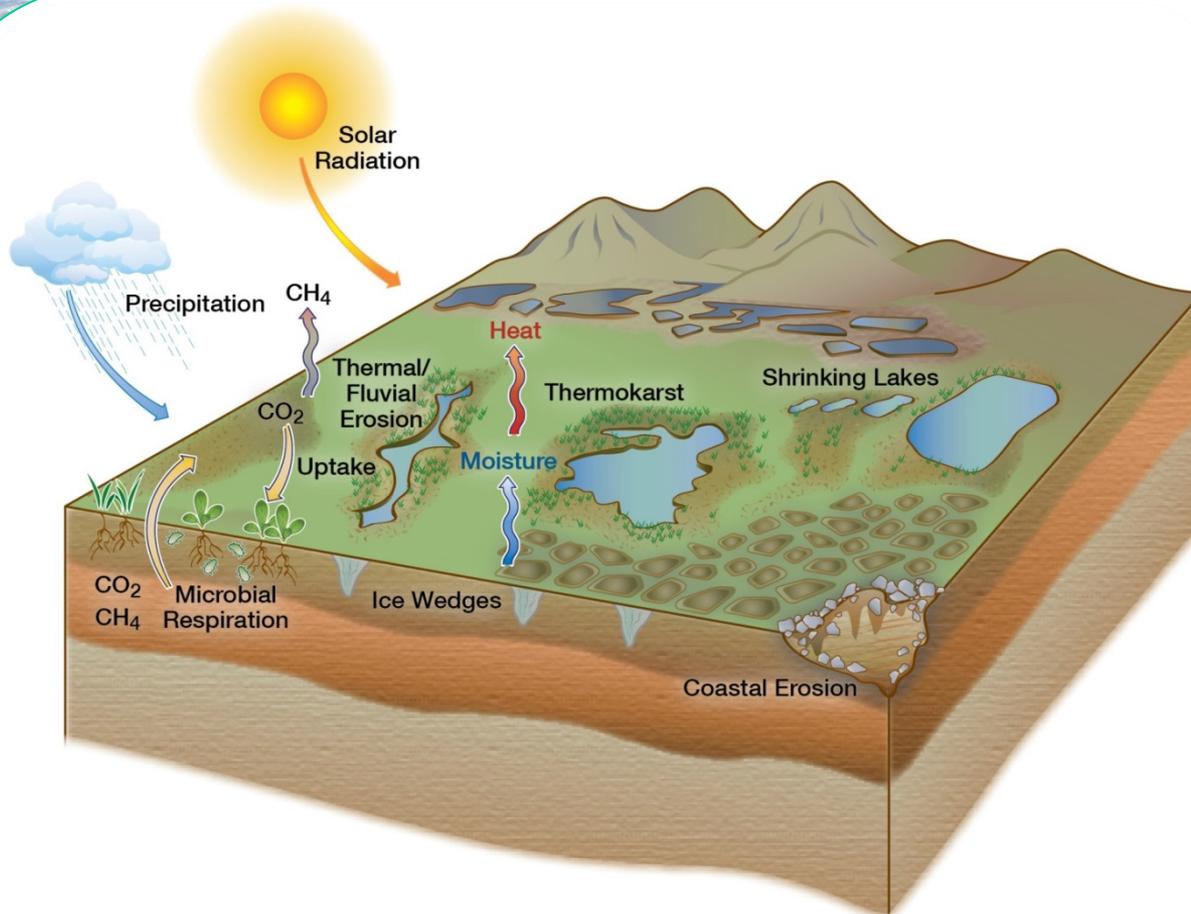


- Permafrost**
- Isolated
 - Sporadic
 - Discontinuous
 - Continuous

Source: International Permafrost Association, 1998. Circumpolar Active-Layer Permafrost System (CAPS), version 1.0.

Landscapes in transition

...integrates hydrology, vegetation dynamics, soil processes, and energy transfer in the Arctic.



ESD11-019

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Must understand mechanisms that underlie the processes that control carbon and energy transfer in the biosphere.

Must also understand how those processes play out in a changing landscape.



Photo by Larry Hinzman

Global Carbon Pools

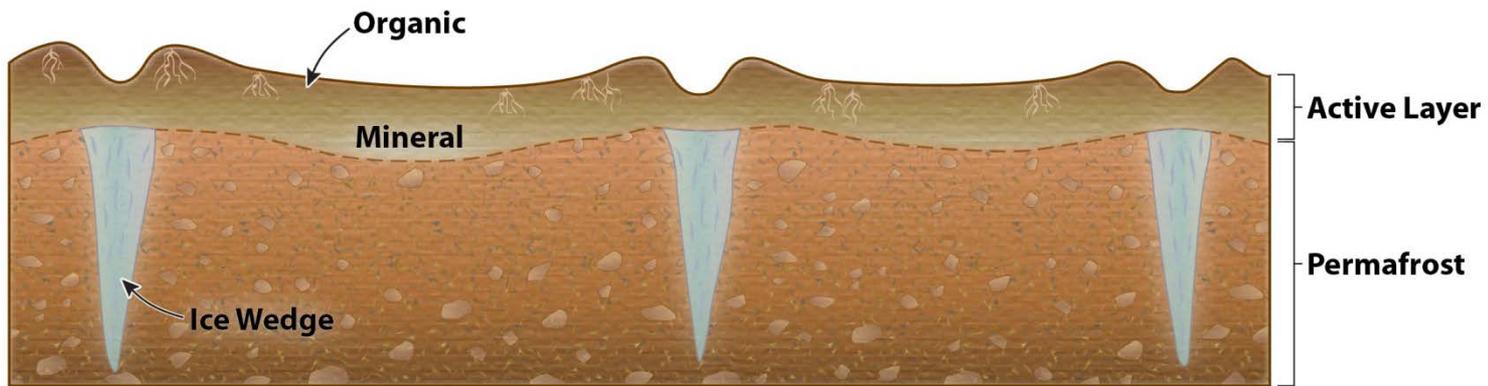
Global Vegetation C	650 Pg
Global Soil C (1m)	1500 Pg
Atmosphere	777+ Pg

Permafrost Zone Soil C

Peatlands (several m)	277 Pg
Mineral Soil (3m)	747 Pg
Siberian Deep C (~25m)	407 Pg
Alluvial Deep C (~25m)	241 Pg
	<u>1672 Pg</u>



Photo by Larry Hinzman

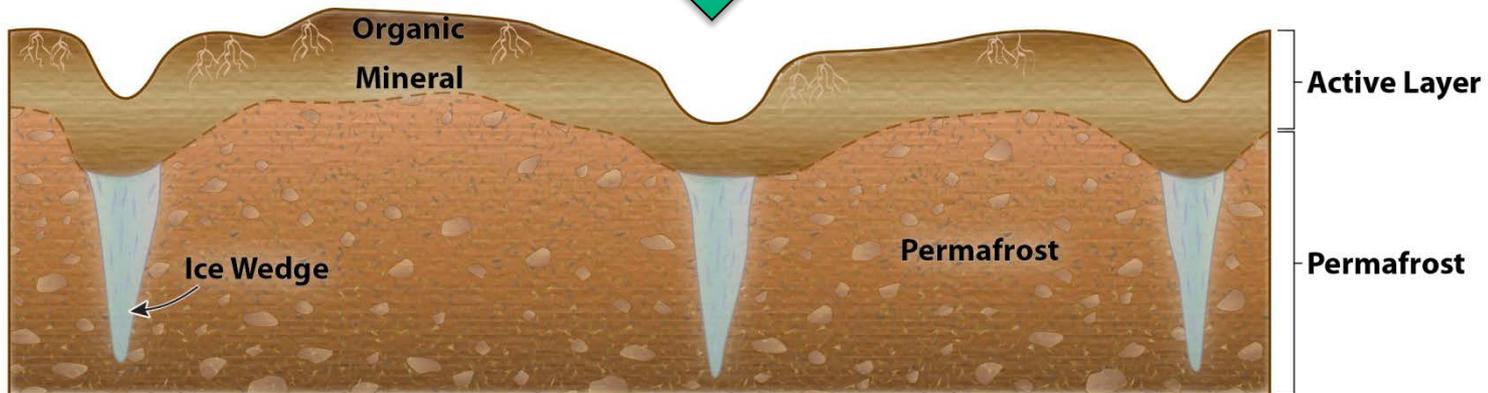


Low Centered Polygons

Warming



Disturbance



High Centered Polygons

Surface-subsurface interactions and the consequences for landscape evolution.



Thermokarst



Thermal erosion

Thawing



photo Cameron Wobus, CIRES

Trends of decreasing sea ice and increased open-water fetch, combined with warming air and ground temperatures, are expected to result in higher wave energy, increased seasonal thaw, and accelerated coastal retreat along large parts of circum-Arctic coast.

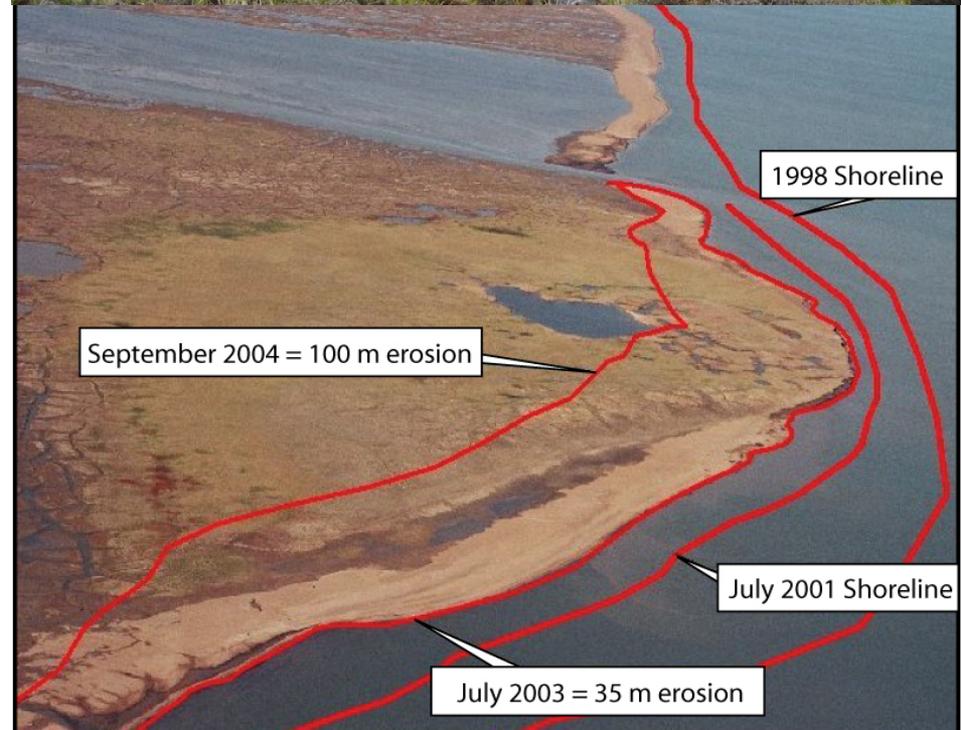
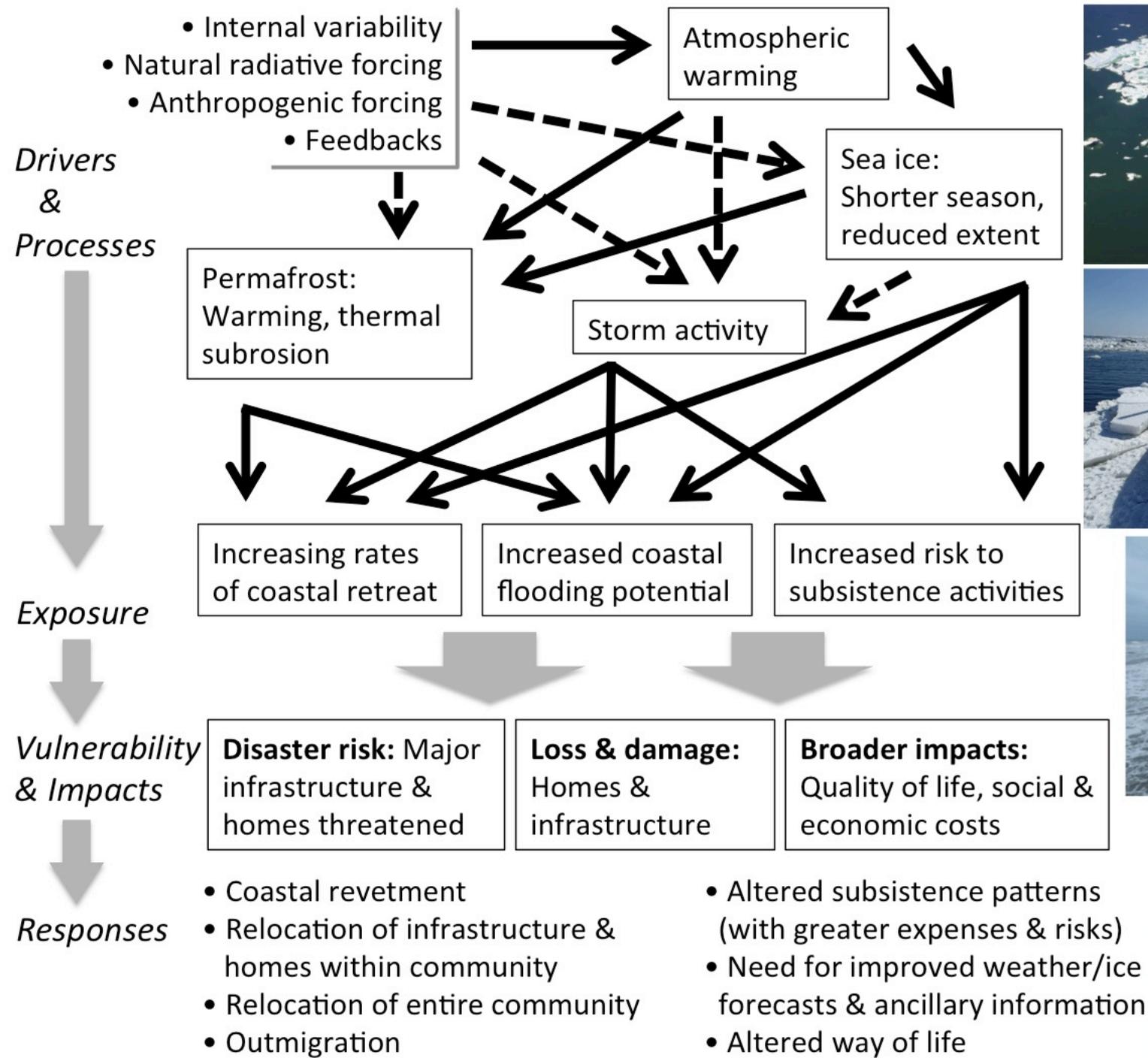
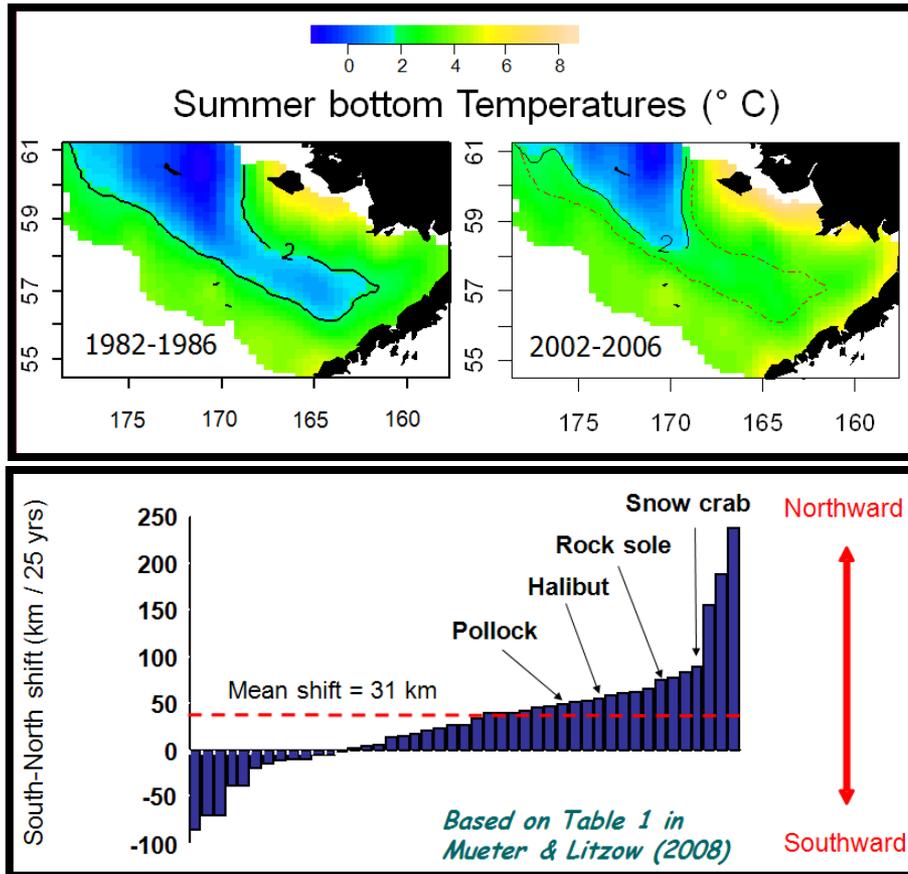


photo Susan Flora, BLM



Shifting Species: Winners and Losers



- “Cold pool” is <math>< 2\text{ C}</math> bottom water, formed with winter sea ice, lasts through summer
- Cold pool shifted 230 km north from 1980s to 2000s
- Arctic species (e.g., snow crab) will retreat north, fishery will decline in Bering Sea with ongoing shrinking cold pool
- Subarctic groundfish species will expand north; some fisheries likely to expand
- Pollock (largest US fishery) projected to decline as juveniles can no longer hide in cold pool from being eaten by expanding arrowtooth flounder (low value, mushy flesh)

Predicted increase:



Predicted decrease:



Subsistence in Alaska – More than a Lifestyle

Big Picture Question: How are subsistence species impacted by changing environmental conditions?



Walrus Adaptability and Long-term Responses

The Problem:

-  Low walrus harvest on St. Lawrence Island and economic disaster declaration in 2013
-  Walrus habitat is changing
-  Altered food chains
-  Ice as haul-out platform is disappearing
-  Thousands of walrus haul out on Alaska's coasts, 2007-2014
-  Walrus status (Endangered Species Act) under review in 2016



What We Do:

- Learn from the past to predict the future!
- Climate change is **NOT** new to walrus populations (e.g., Roman warm, Little Ice Age)

 Has walrus diet changed over the past 2,500 years?

 Have feeding locations changed?

 Are walrus stressed when changing diet?

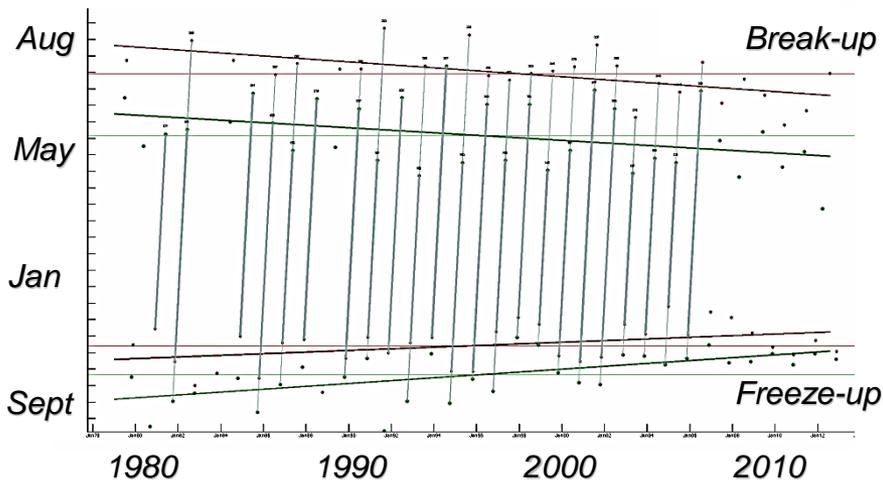
 Has population structure changed?



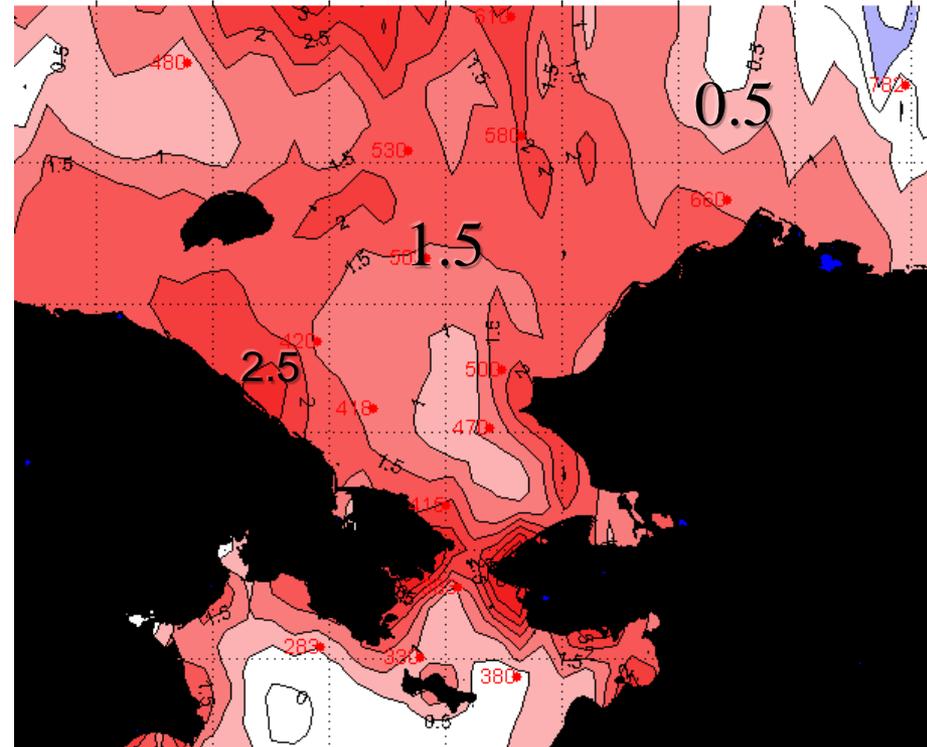
Brenda K. Stone
NOAA AFSC CAEP
Permit No. 14243

Analysis of satellite sea ice concentration to statistically define dates of sea ice freeze-up and break-up.

Long term trends showing delay of freeze-up and earlier break-up.

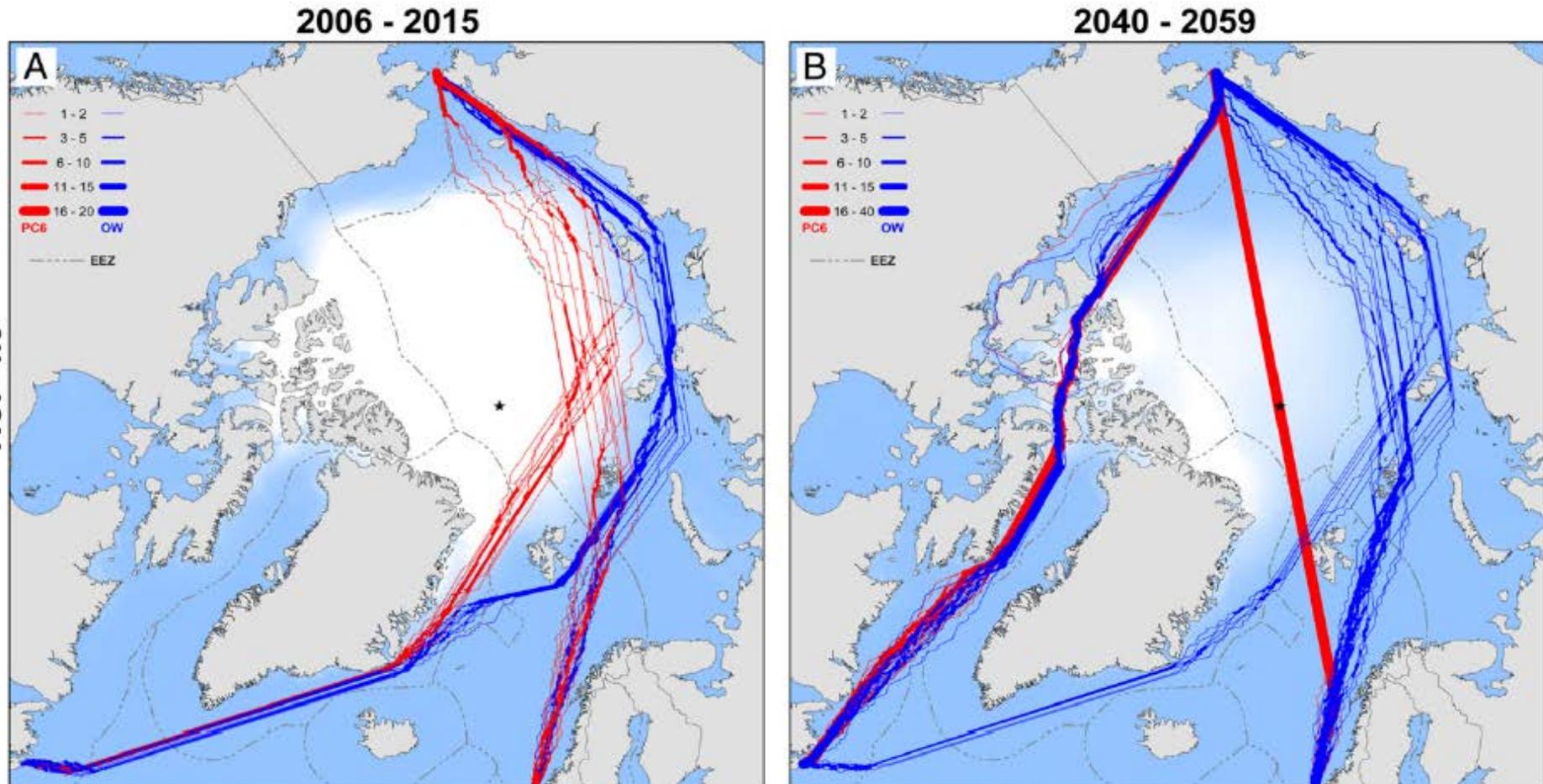


Forecasted delay (months) for freeze-up in 2015 compared with 1979.

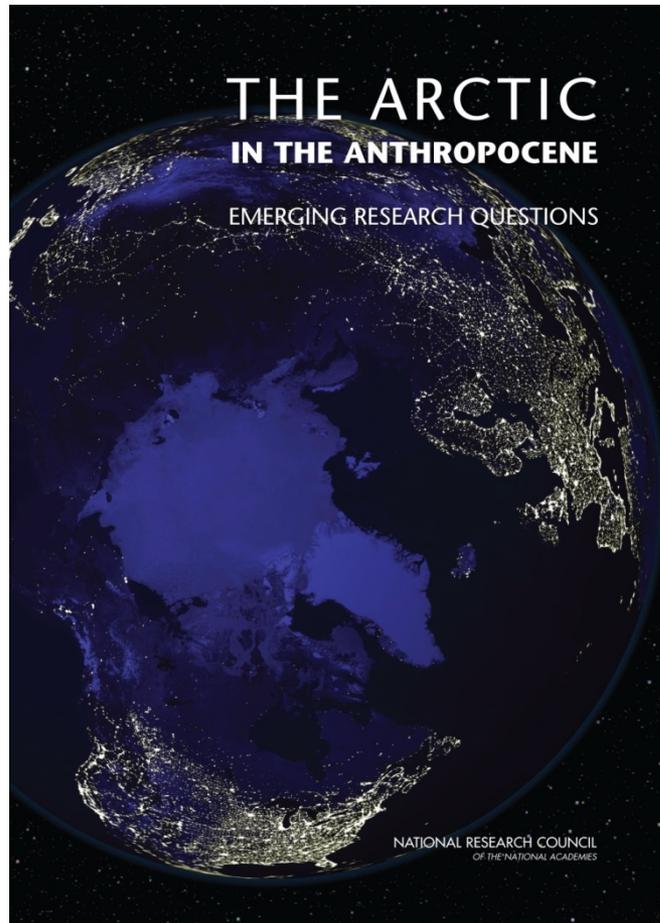


By midcentury, changing sea ice conditions enable expanded September navigability for common open-water ships crossing the Arctic along the Northern Sea Route over the Russian Federation, robust new routes for moderately ice-strengthened (Polar Class 6) ships over the North Pole, and new routes through the Northwest Passage for both vessel classes. Smith and Stephenson, 2013.

RCP 4.5



The Arctic in the Anthropocene



- **Existing Questions** Those that have been the subject of ongoing research but remain unanswered or for other reasons deserve continued attention
- **Emerging Questions** Those that we are only now able to ask because they:
 - Address newly recognized phenomena
 - Build on recent results and insights
 - Can be addressed using newly available technology or access
 - *How do we not miss the boat?*

Examples of emerging research questions

- Will Arctic communities have greater or lesser influence on their futures?
- How will rapid Arctic warming change the jet stream and affect weather patterns in lower latitudes?
- Will local, regional, and international relations in the Arctic move toward cooperation or conflict?
- How can twenty-first century development in the Arctic occur without compromising the environment or indigenous cultures while still benefitting global and Arctic inhabitants?

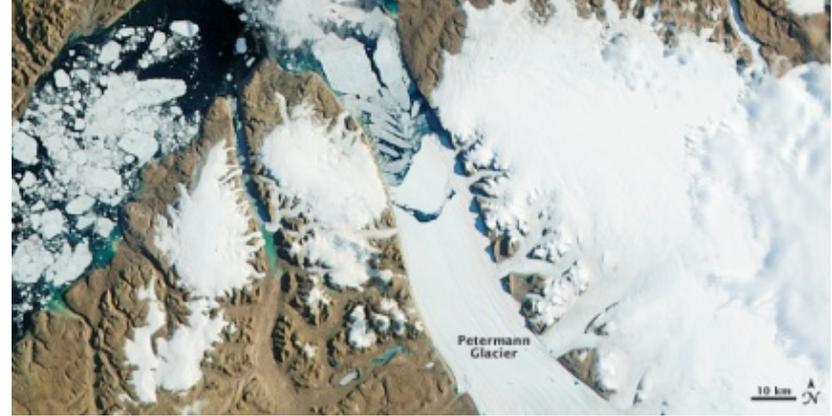


Image source: NASA



Photo source: USCG

Meeting the Challenges

- Maintaining and Building Operational Capacity
- Sustaining Long-Term Observations
- Growing Human Capacity
- Enhancing Cooperation
- Managing and Sharing Information
- Investing in Research



Photo credit: S. Roberts



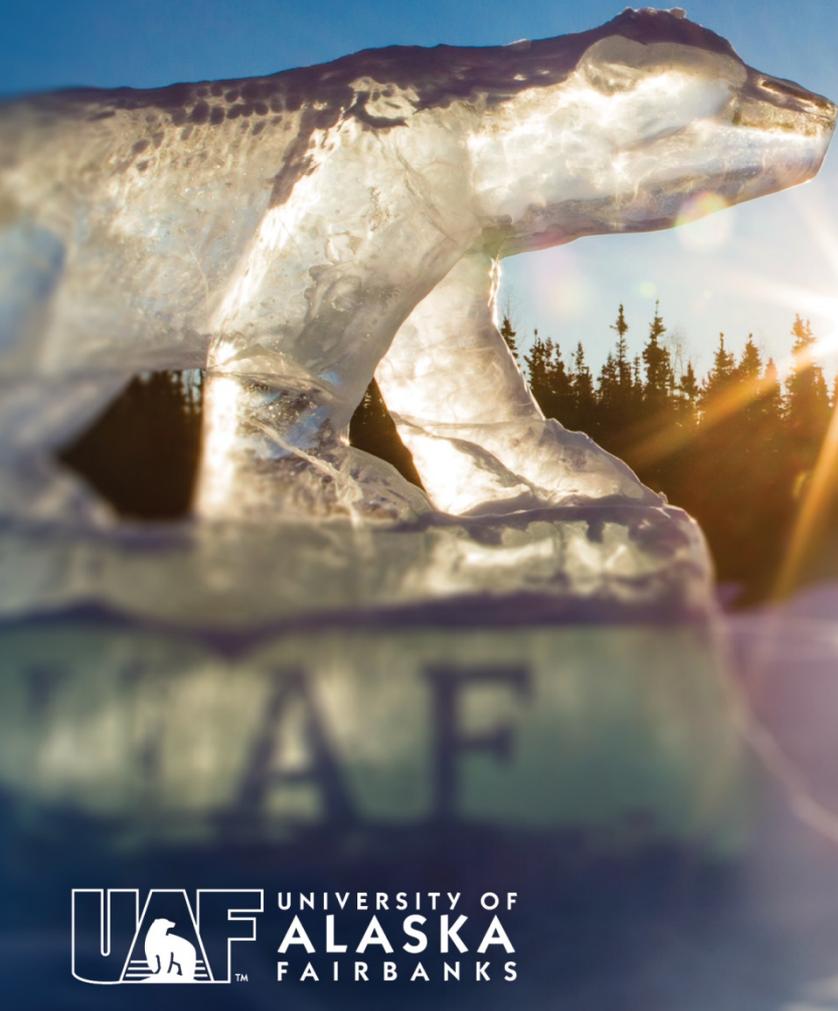
Photo credit: H. Huntington

The need for sustained observations

- Increased economic activity in the Arctic such as shipping and resource development and impacts from changing environment require effective responses
- Effective responses build on prediction & tracking of changes: Need for sustained observations of Arctic change
- Ability to respond to hazards & emergencies currently relies on patchwork of efforts by a multitude of actors
- Limited coordination in data acquisition & program design: Requires resources & support
- Great potential for collaborative, cooperative approaches to observing



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