The IPCC Fourth Assessment Report: Findings for Alaska

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University of Alaska, Fairbanks

Governor's Climate Change Sub-Cabinet Meeting, 22 May 2007

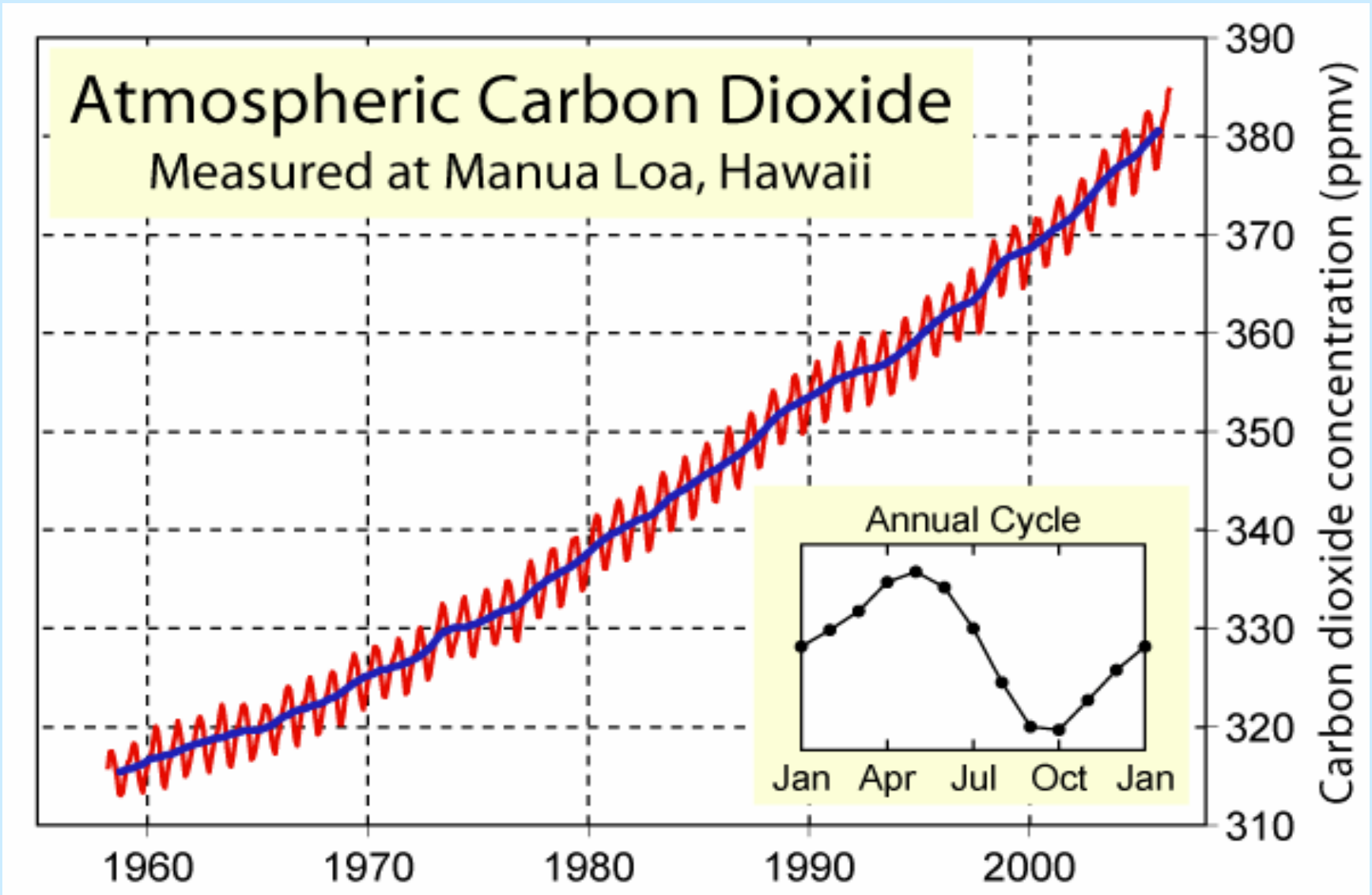
The IPCC Fourth Assessment Report (2007)

Volume I: The Physical Science Basis

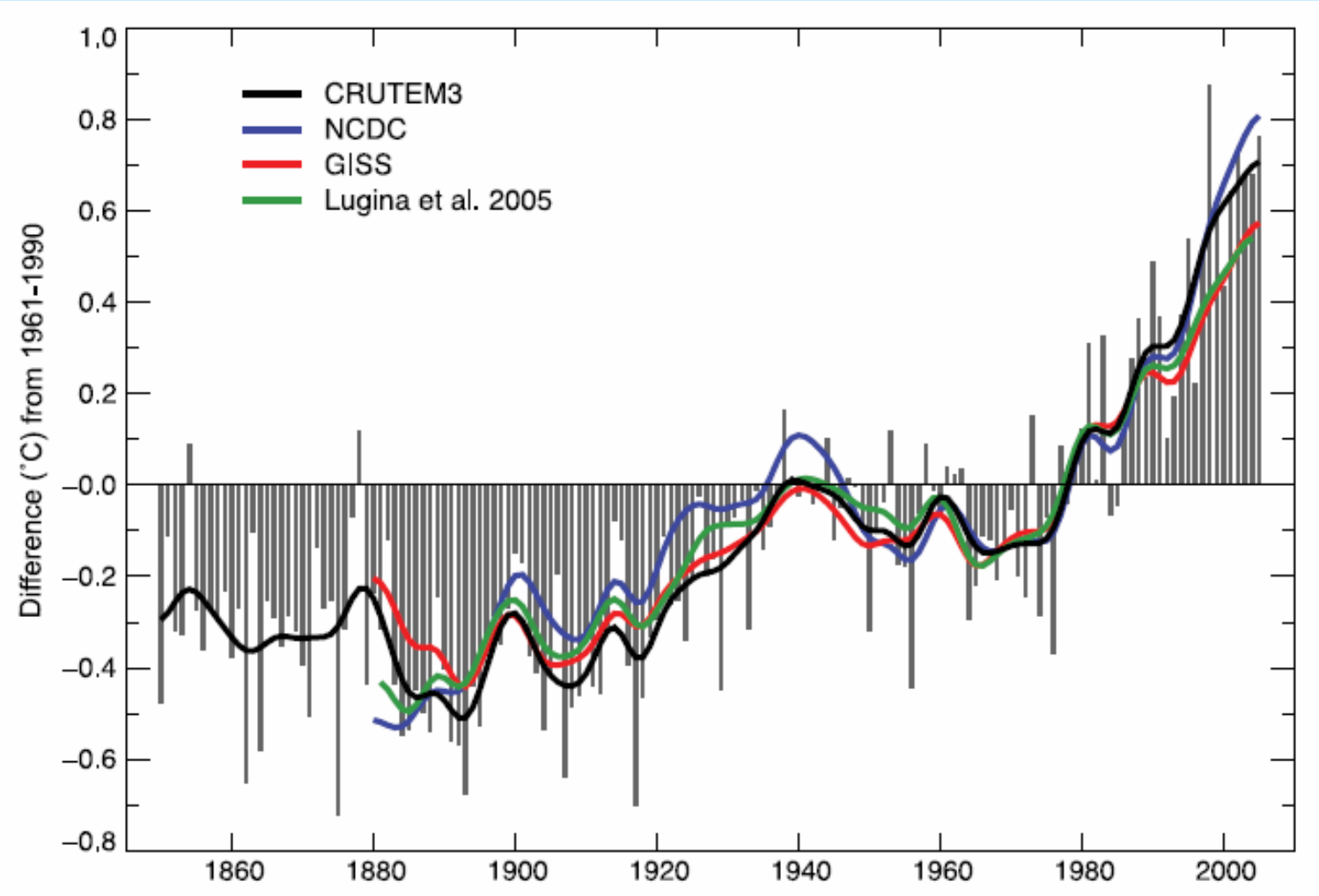
Volume II: Impacts, Adaptation and Vulnerability

Volume III: Mitigation of Climate Change

Greenhouse gas concentrations are increasing [>99% certainty]



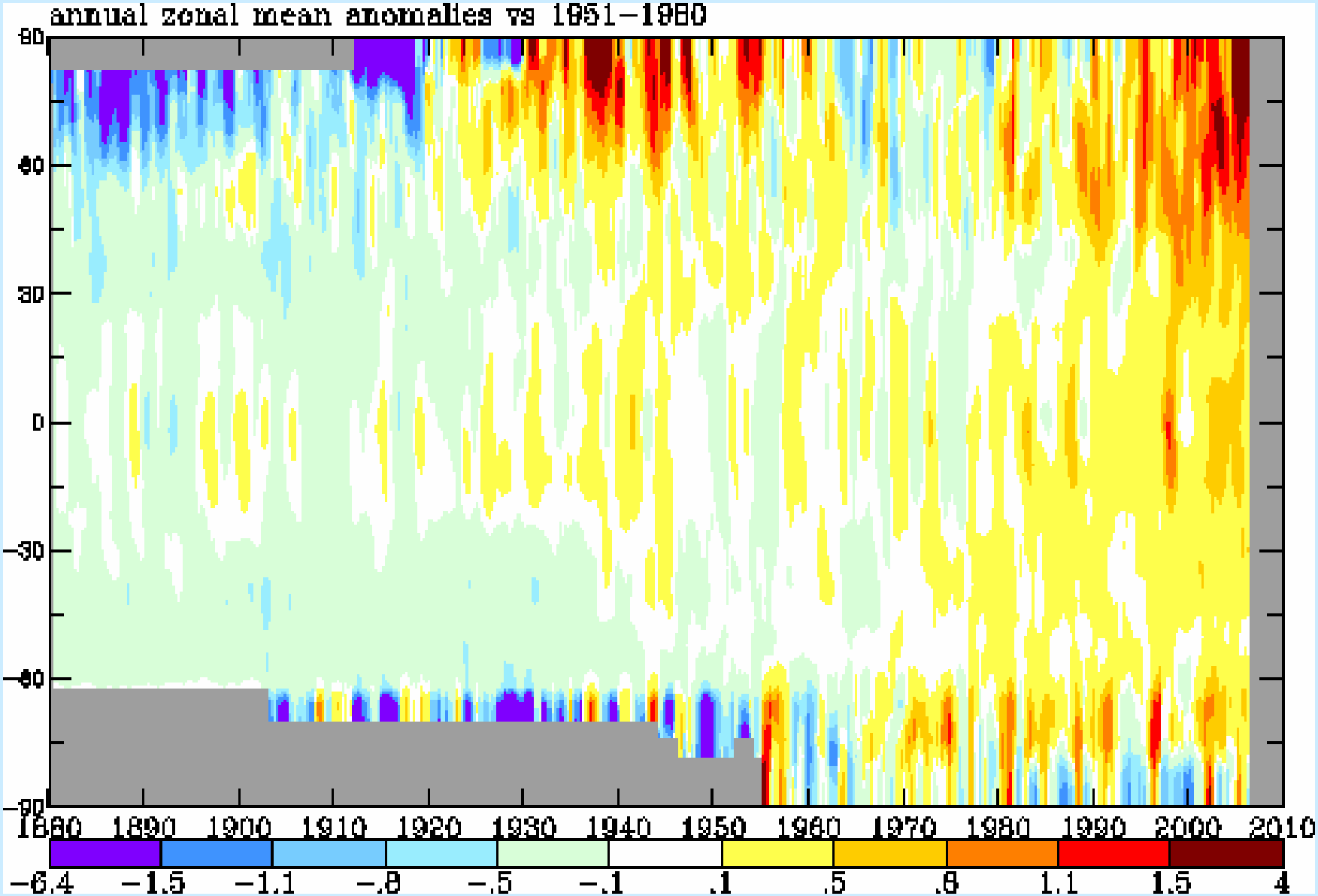
Globally: **"Most of the observed increase in globally averaged air temperature since the mid-20th century is *very likely* [>90%] due to the observed increase in anthropogenic greenhouse gas concentrations."**



- **Average Arctic and Alaskan temperatures have increased at almost twice the global rate for the past 100 years.**

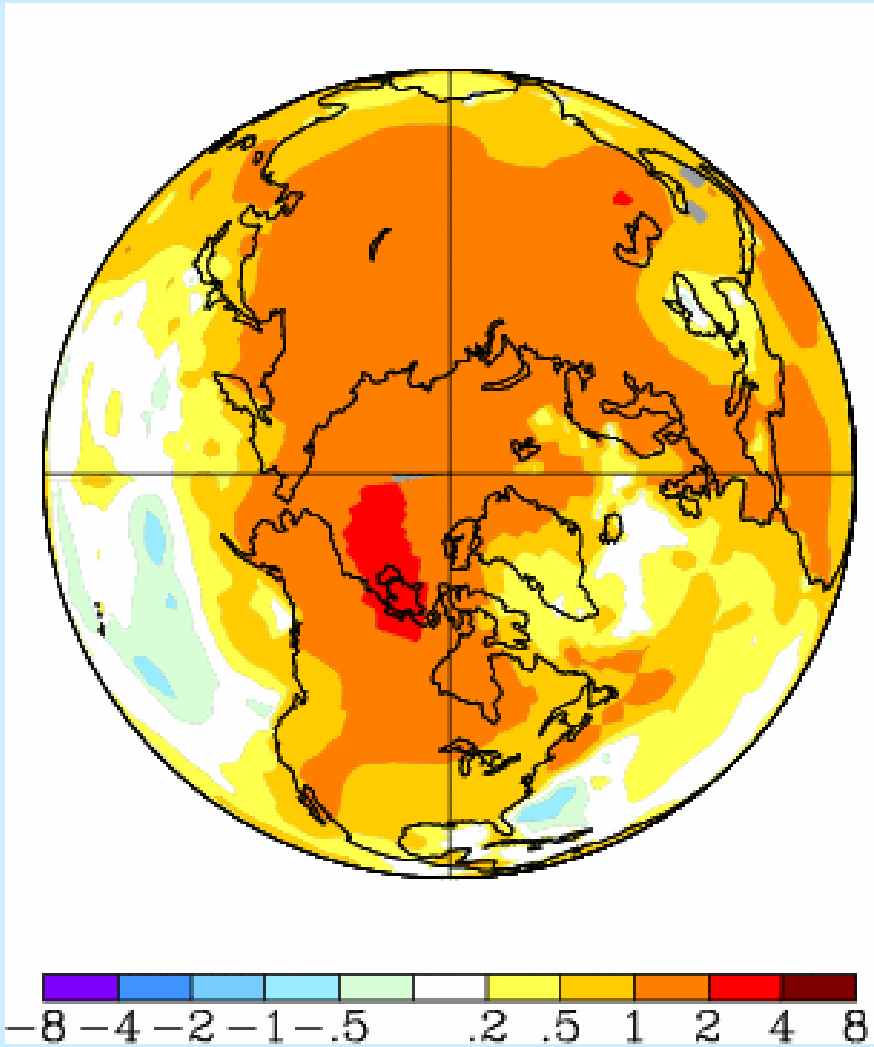
- **Arctic and Alaskan temperatures have a higher decadal variability than global temperatures.**

Annual temperature anomalies (°C) vs. latitude: 1880-2006

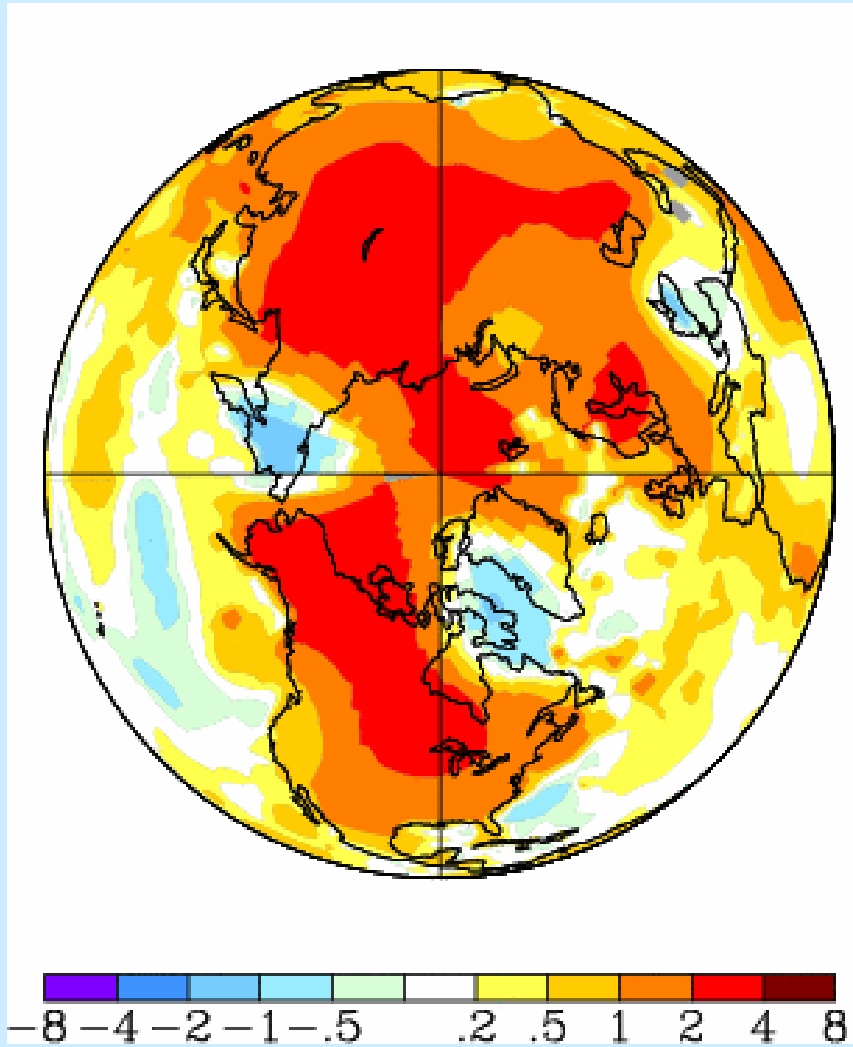


Change surface air temperature (°C) , 1957-2006

Annual



Winter



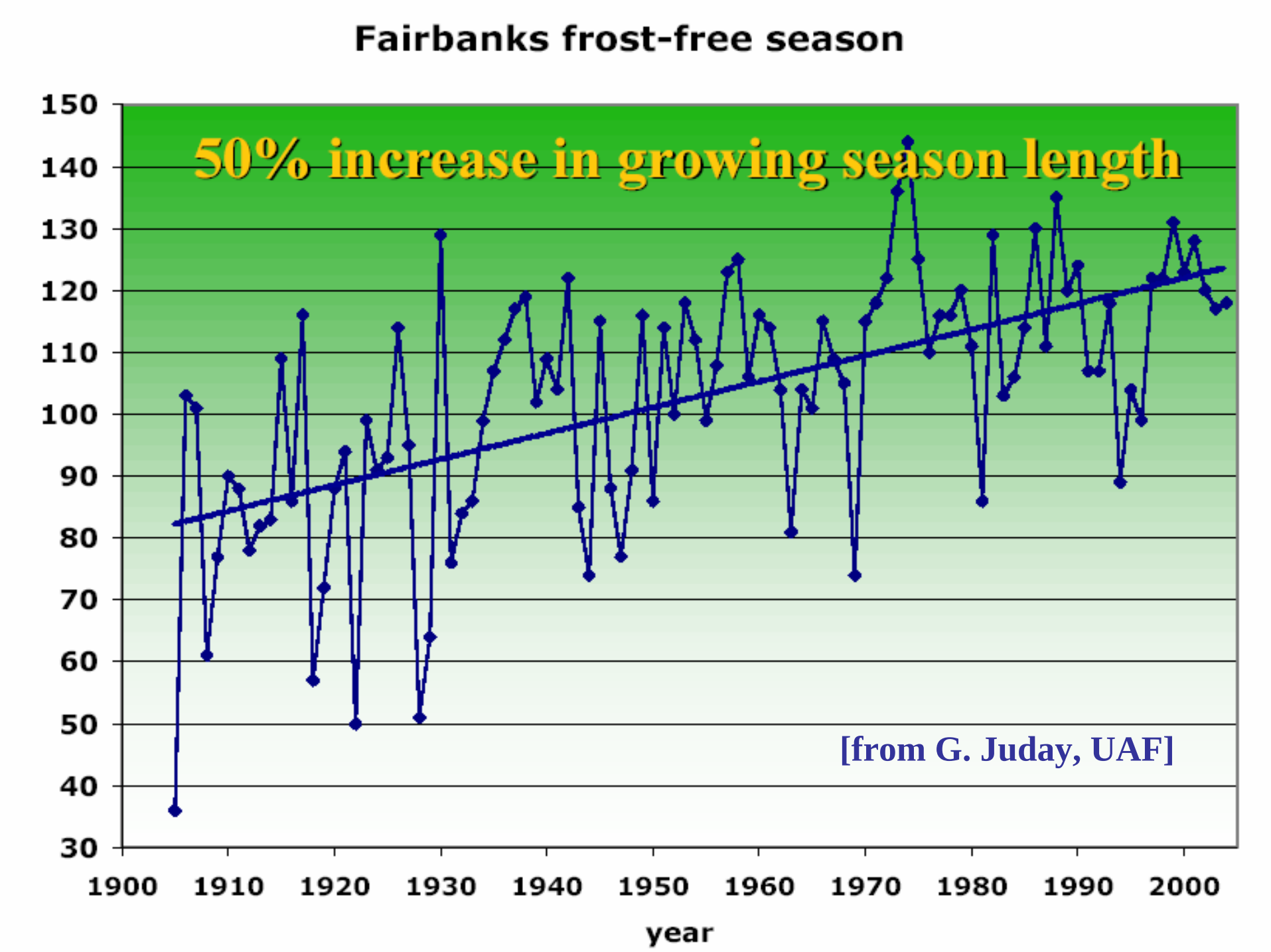
Changes of Alaskan station temperatures (°F), 1949-2006

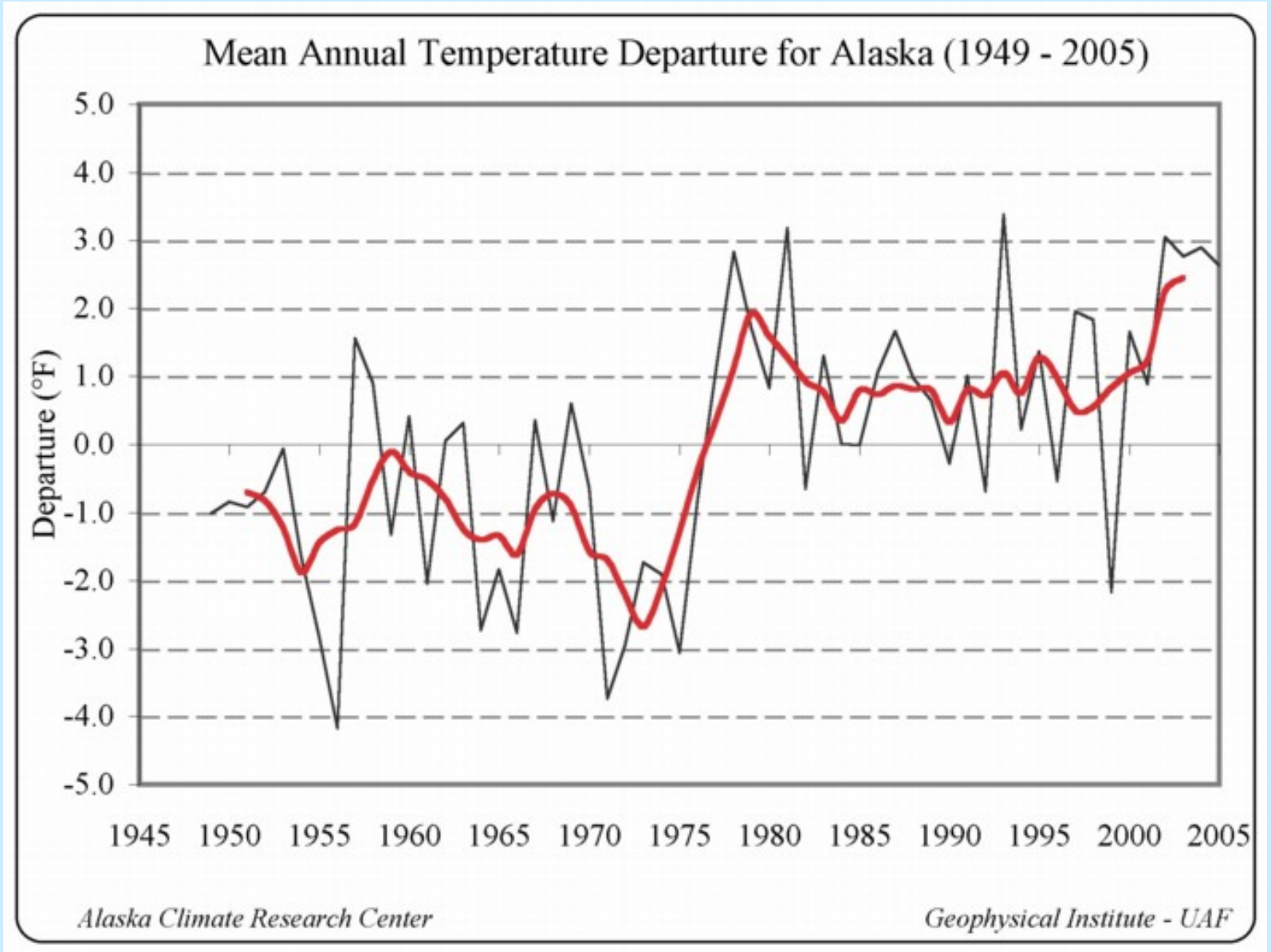
[from Alaska Climate Research Center]

Total change, °F (1949 - 2006)

Location	Annual	Spring	Summer	Autumn	Winter
Arctic					
Barrow	3.8	4.2	2.5	2.1	6.1
Interior					
Bettles	4.0	4.8	1.8	0.9	8.5
Big Delta	3.7	3.9	1.3	0	9.7
Fairbanks	3.6	4.2	2.2	-0.2	8.1
Gulkana	3.0	2.7	1.0	-0.3	8.3
McGrath	4.0	5.0	2.8	0.6	7.6
West Coast					
Bethel	3.7	5.3	2.4	0.3	6.9
Cold Bay	1.9	2.6	2.1	1.1	2.0
King Salmon	4.3	5.5	2.0	0.7	9.2
Kotzebue	3.2	2.1	2.4	1.4	6.8
Nome	3.0	4.0	2.5	0.7	4.9
St. Paul	2.3	3.3	3.2	1.5	1.5
Southcentral and Southeast					
Anchorage	3.4	4.1	2.0	1.0	7.2
Annette	2.4	2.9	1.9	0.3	4.1
Homer	4.3	4.6	3.7	1.8	7.0
Kodiak	1.5	3.1	2	-0.1	1.5
Juneau	3.6	3.5	2.4	1.4	6.8
Talkeetna	5.3	5.7	3.3	2.2	9.3
Yakutat	2.8	3.5	2.0	0.2	5.1
Average	*3.4*	*3.9*	*2.3*	*0.8*	*6.3*

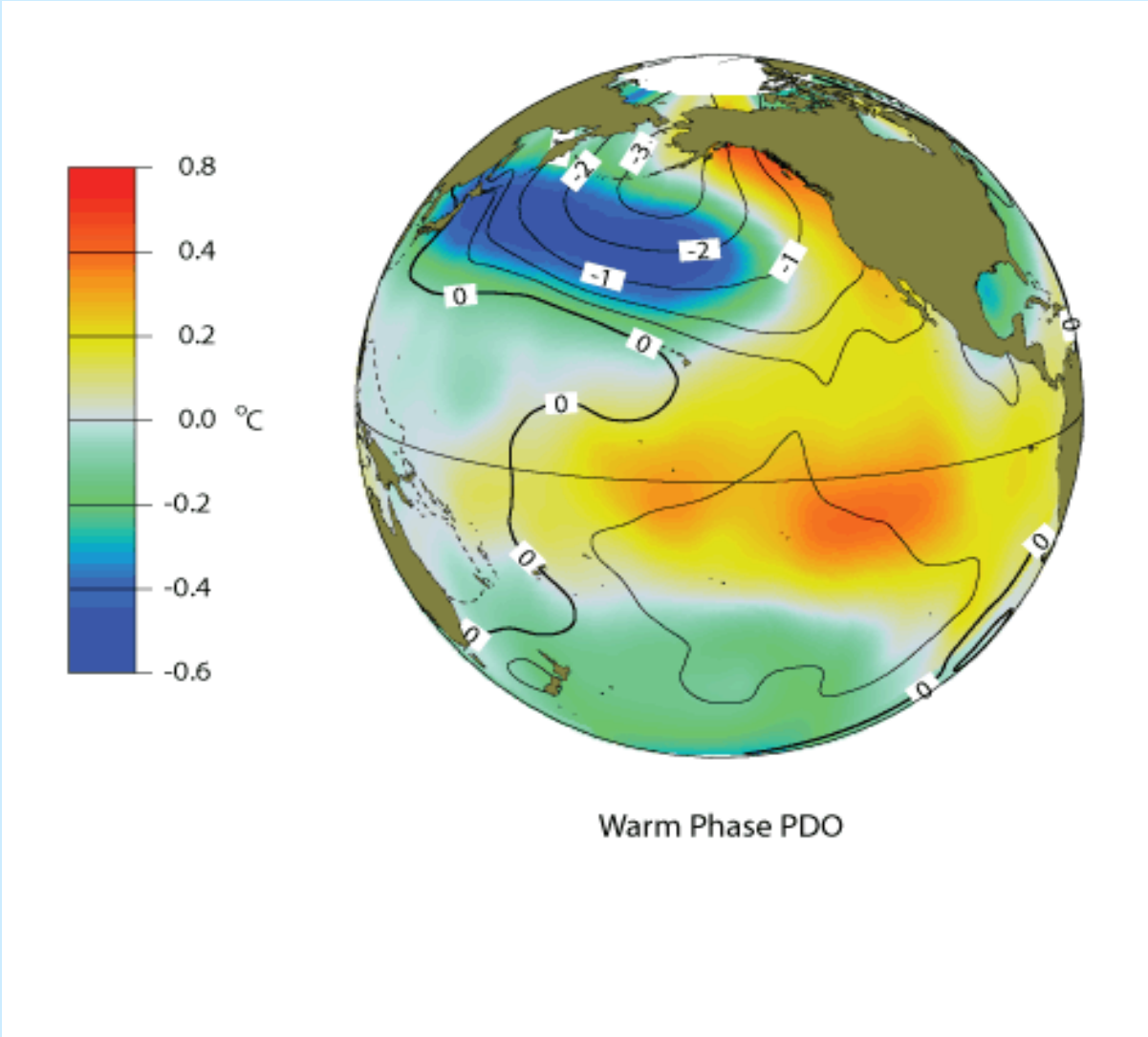
Color code: -1 - 0 | 0 - 1 | 1 - 3 | 3 - 5 | 5 - 7 | 7 - 9 | > 9


Fairbanks frost-free season
50% increase in growing season length
[from G. Juday, UAF]
150
140
130
120
110
100
90
80
70
60
50
40
30
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
year

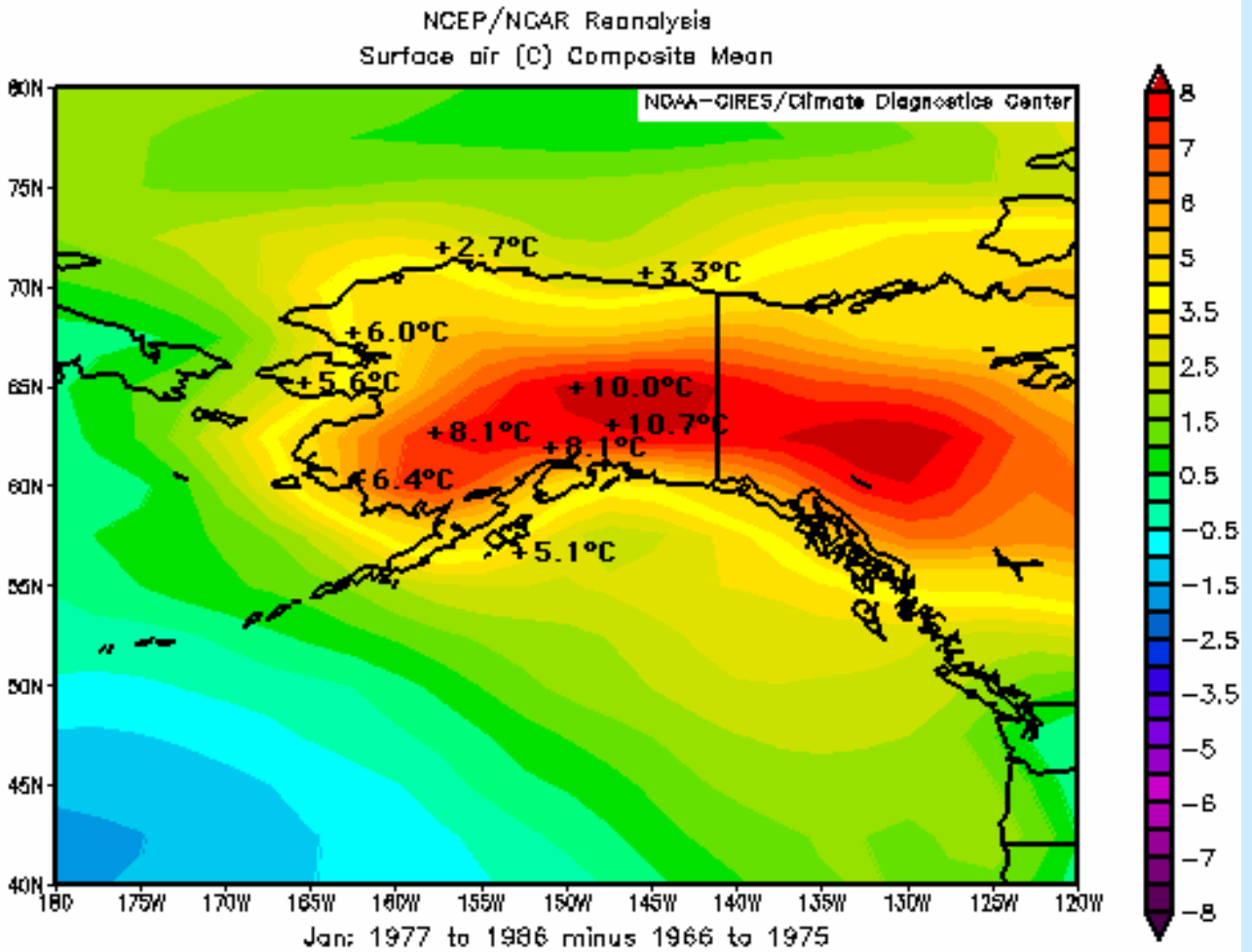


(from Alaska Climate Research Center)

Pacific Decadal Oscillation warm phase (post-1977)

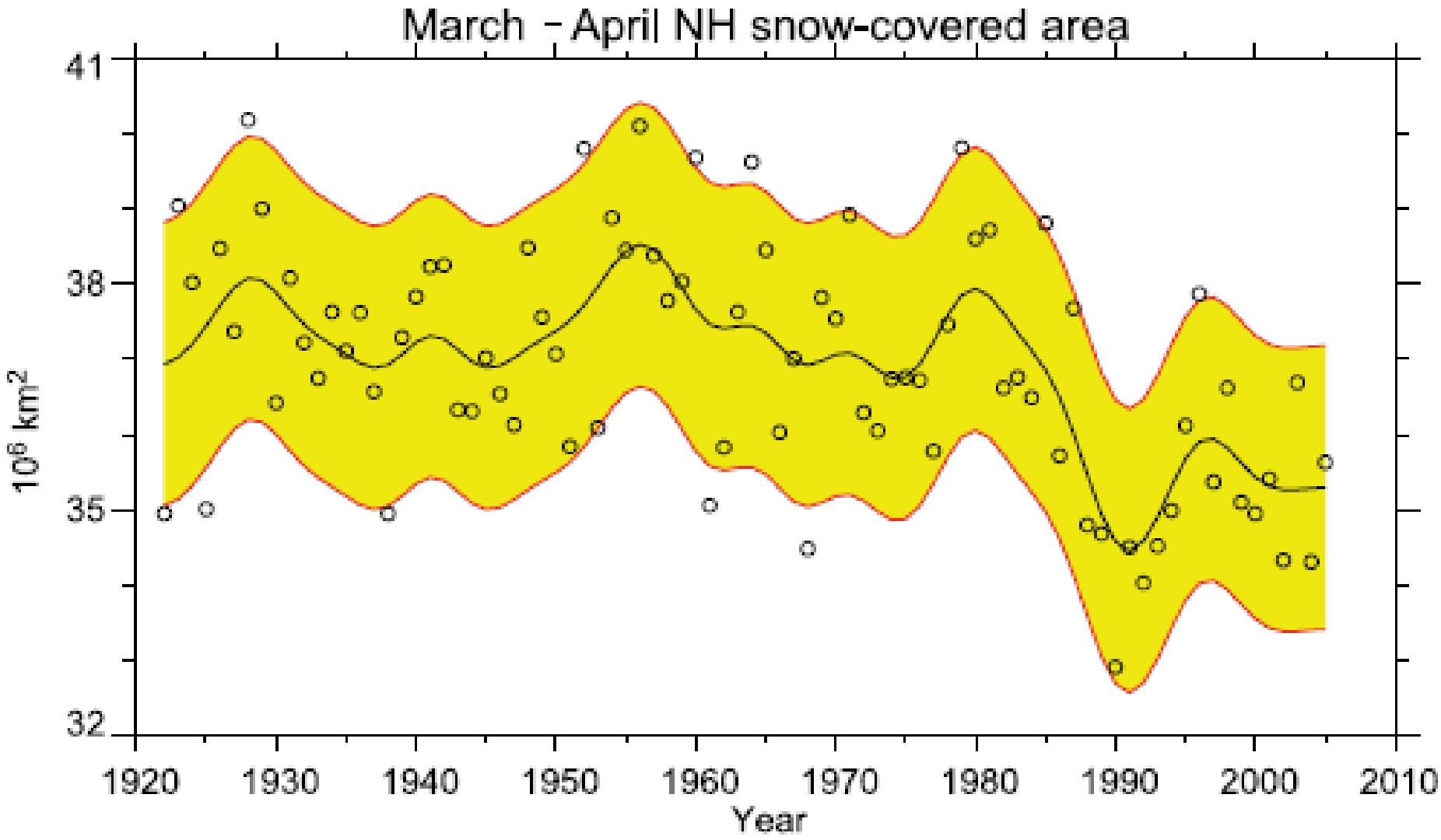


Effect of Pacific Decadal Oscillation shift (1976) on Alaskan temperatures in January: change from 1966-75 to 1977-86

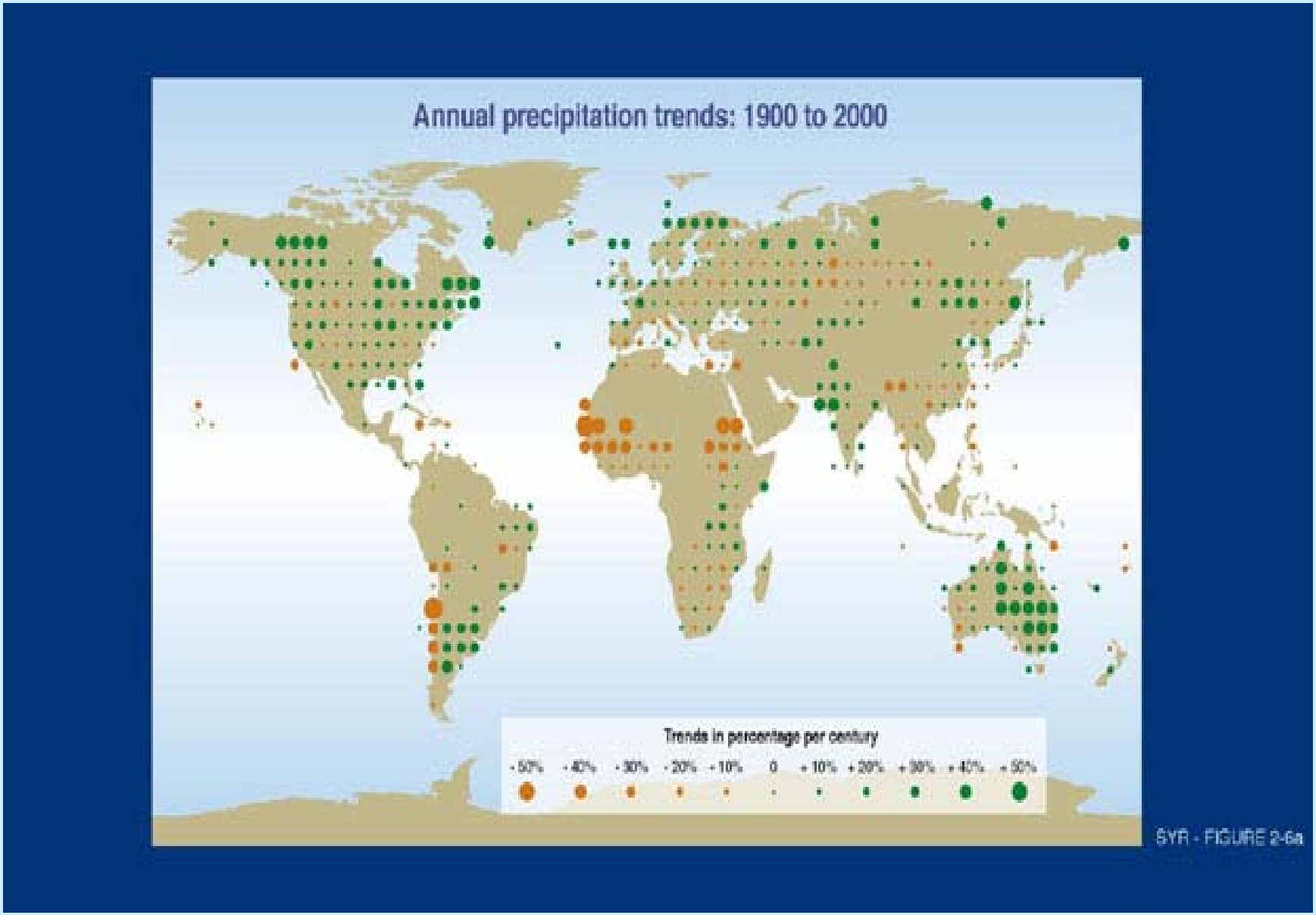


From B. Hartmann and G. Wendler, 2003
Alaska Climate Research Center

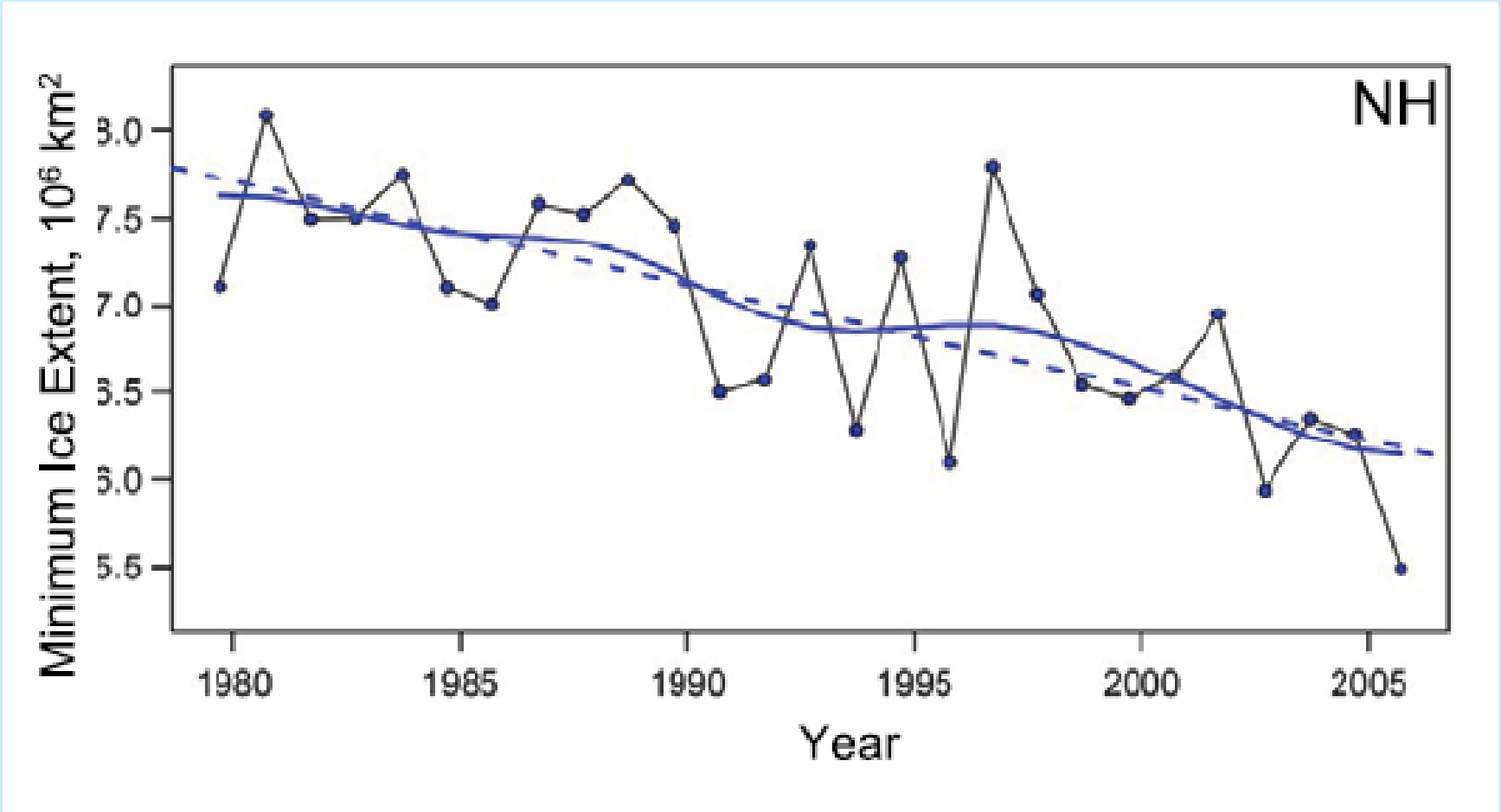
Late-winter and spring snow coverage has decreased



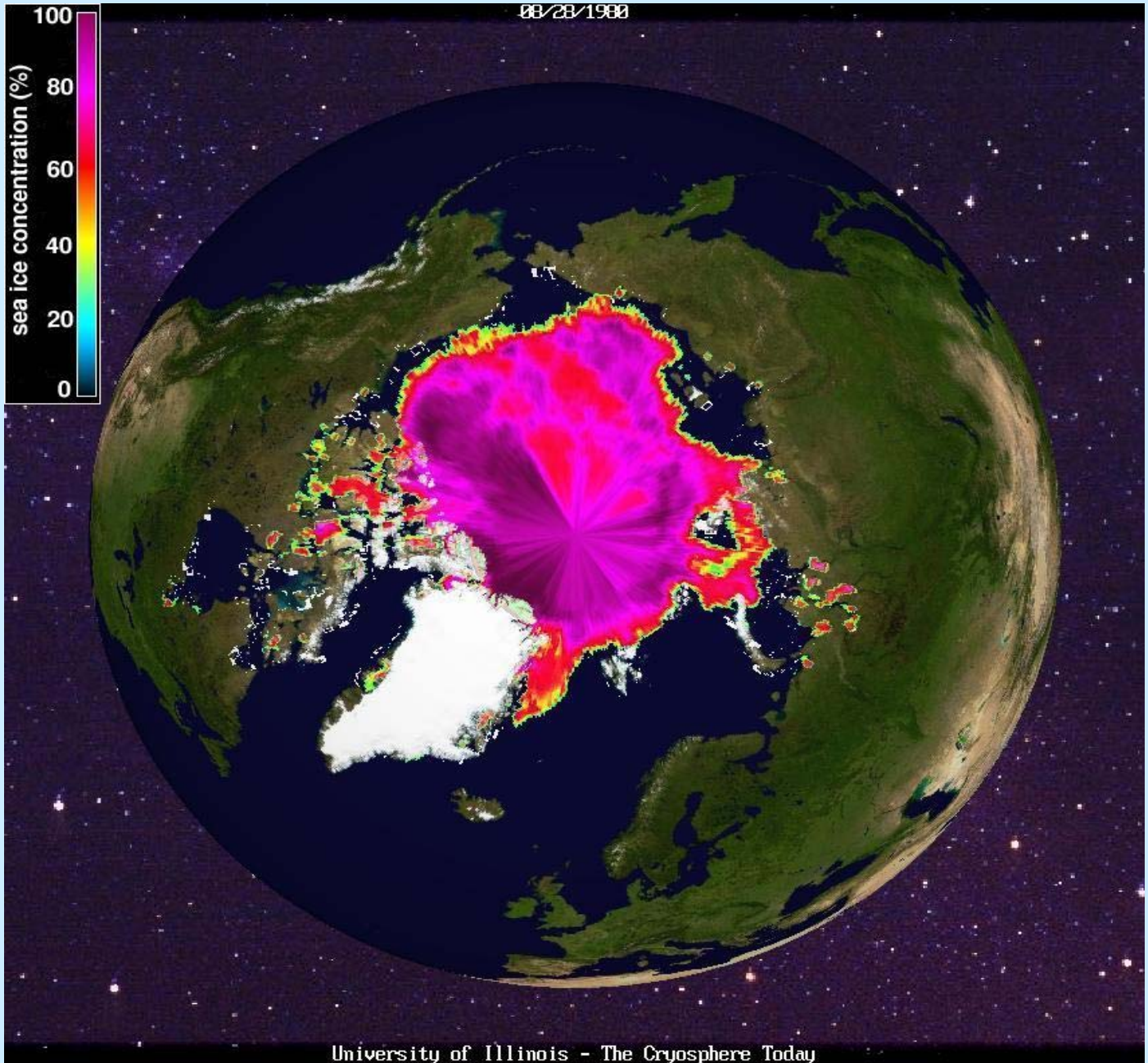
Precipitation over northern land areas has increased since 1900



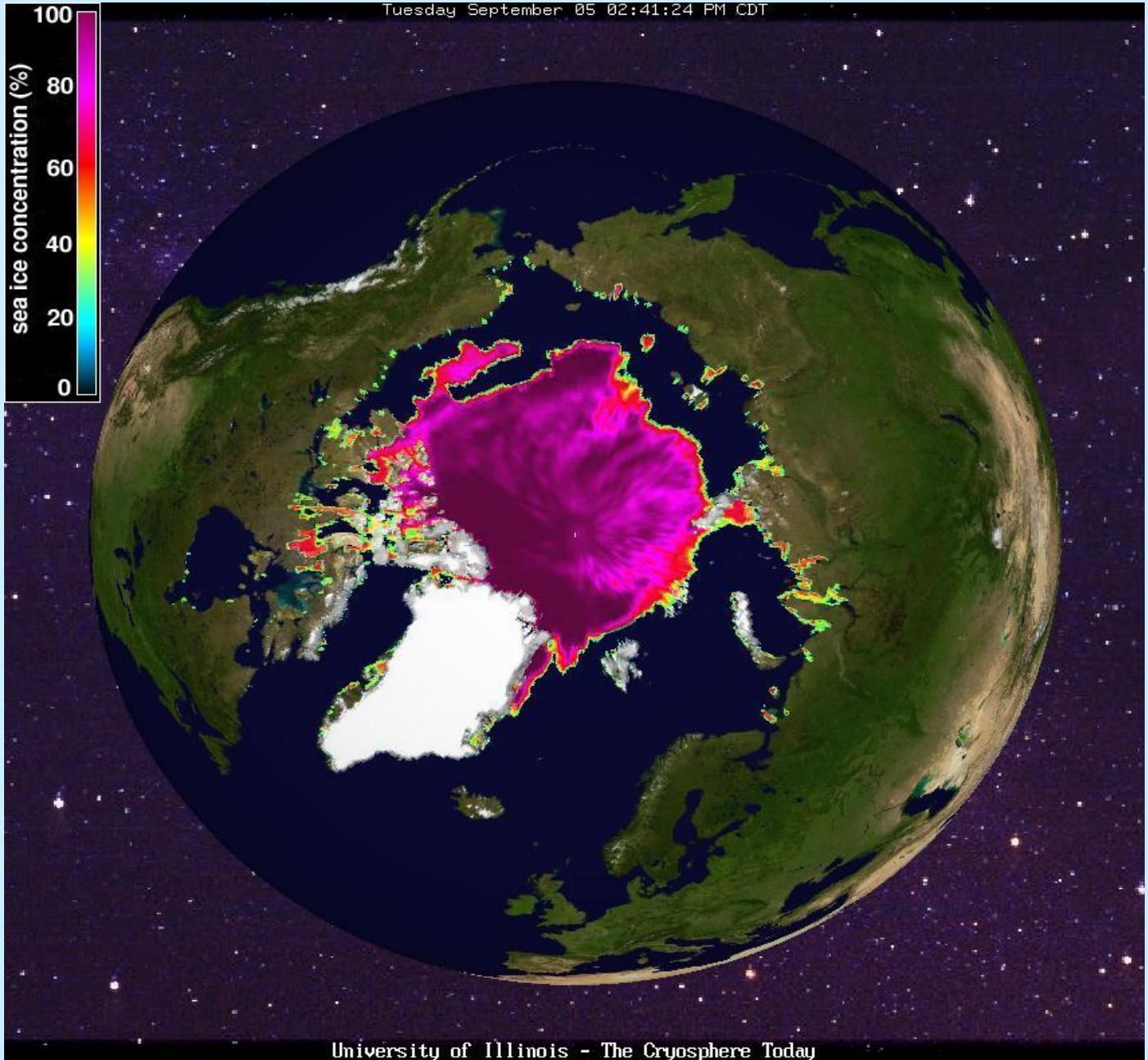
Minimum sea ice extent has decreased by 7.4% per decade since 1979; minimum ice area has decreased by 9.2% per decade.



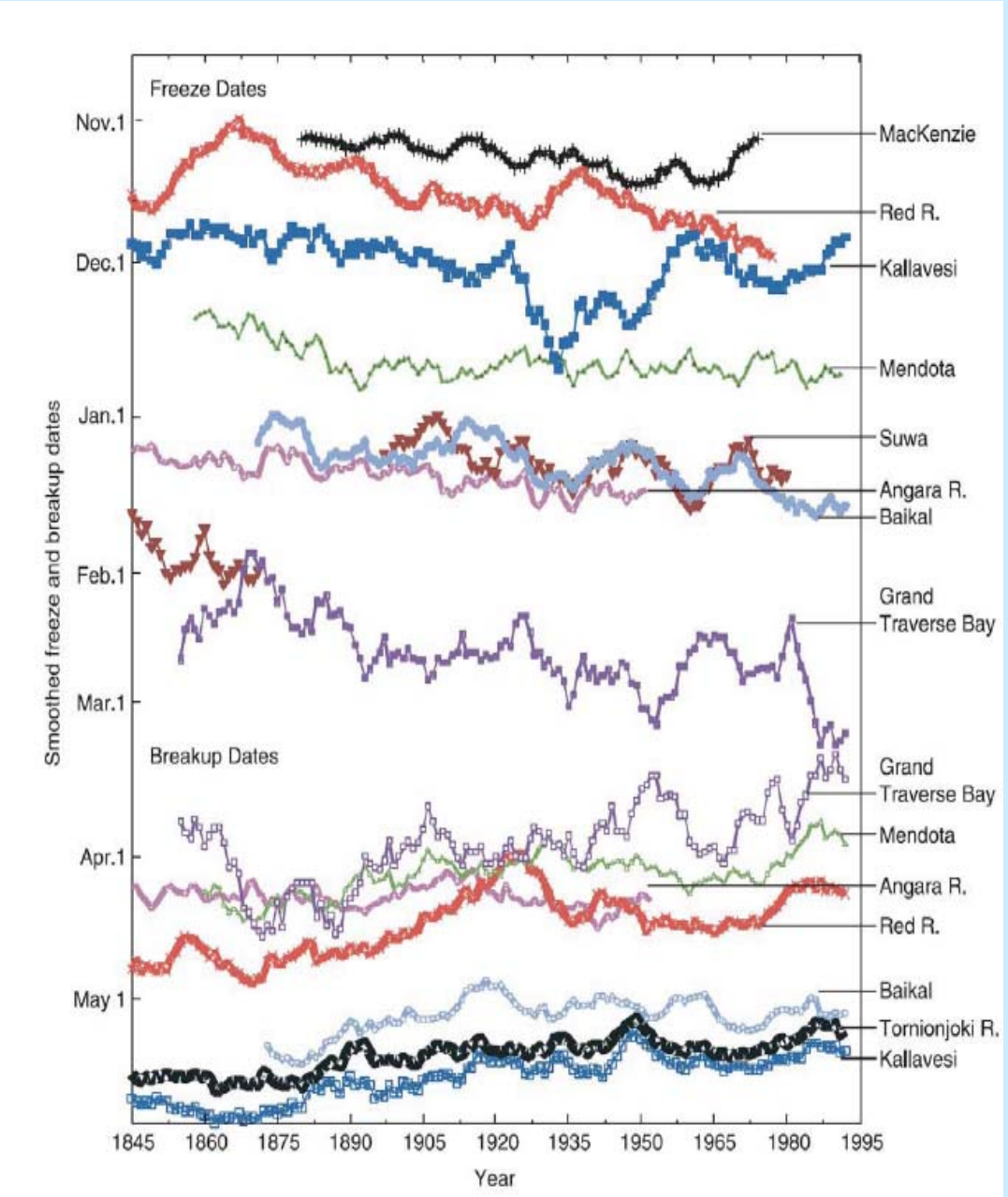
29 Aug 1980


08/28/1980
sea ice concentration (%)
100
80
60
40
20
0
University of Illinois - The Cryosphere Today

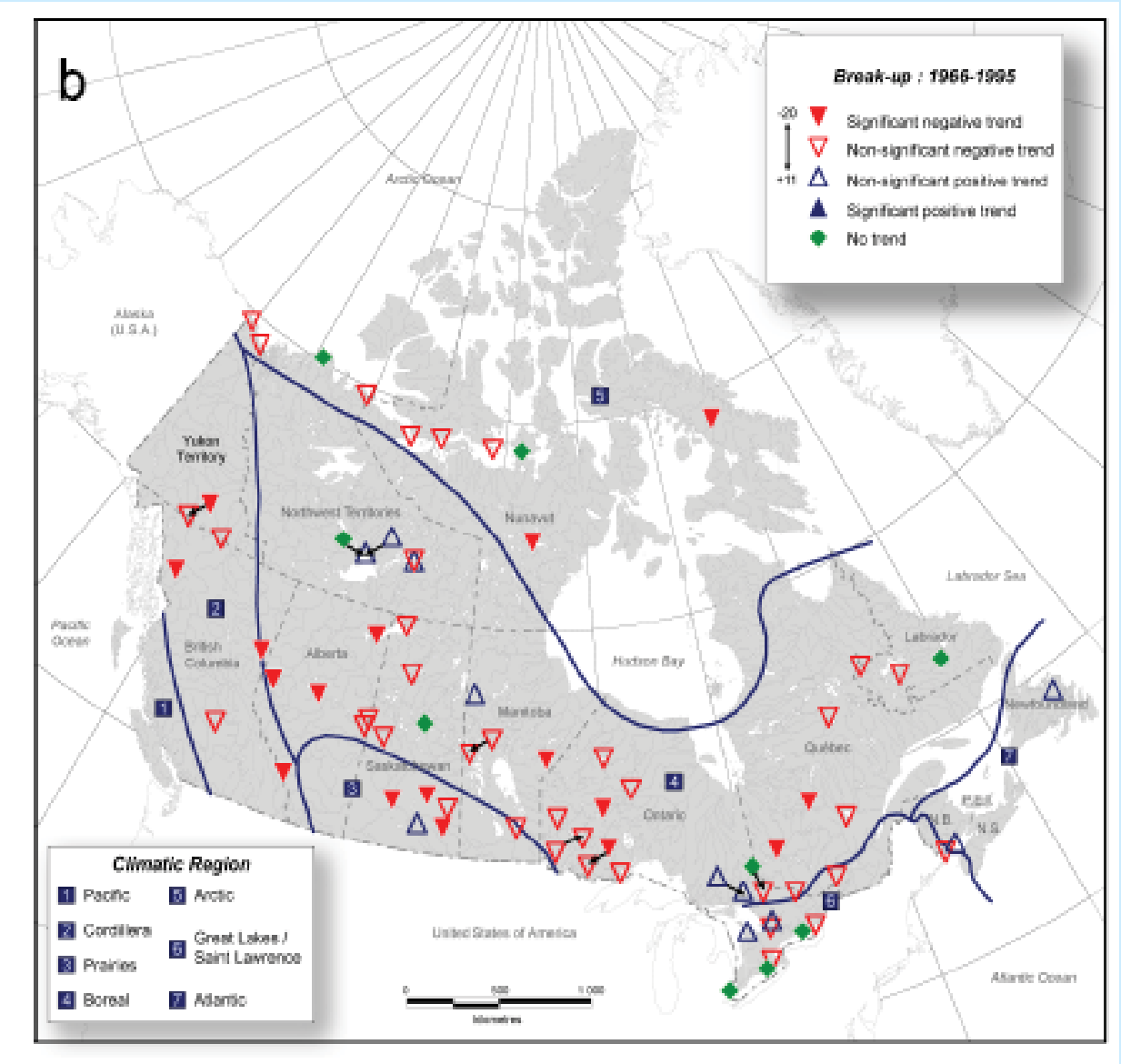
6 Sep 2006


Tuesday September 05 02:41:24 PM CDT
sea ice concentration (%)
100
80
60
40
20
0
University of Illinois - The Cryosphere Today

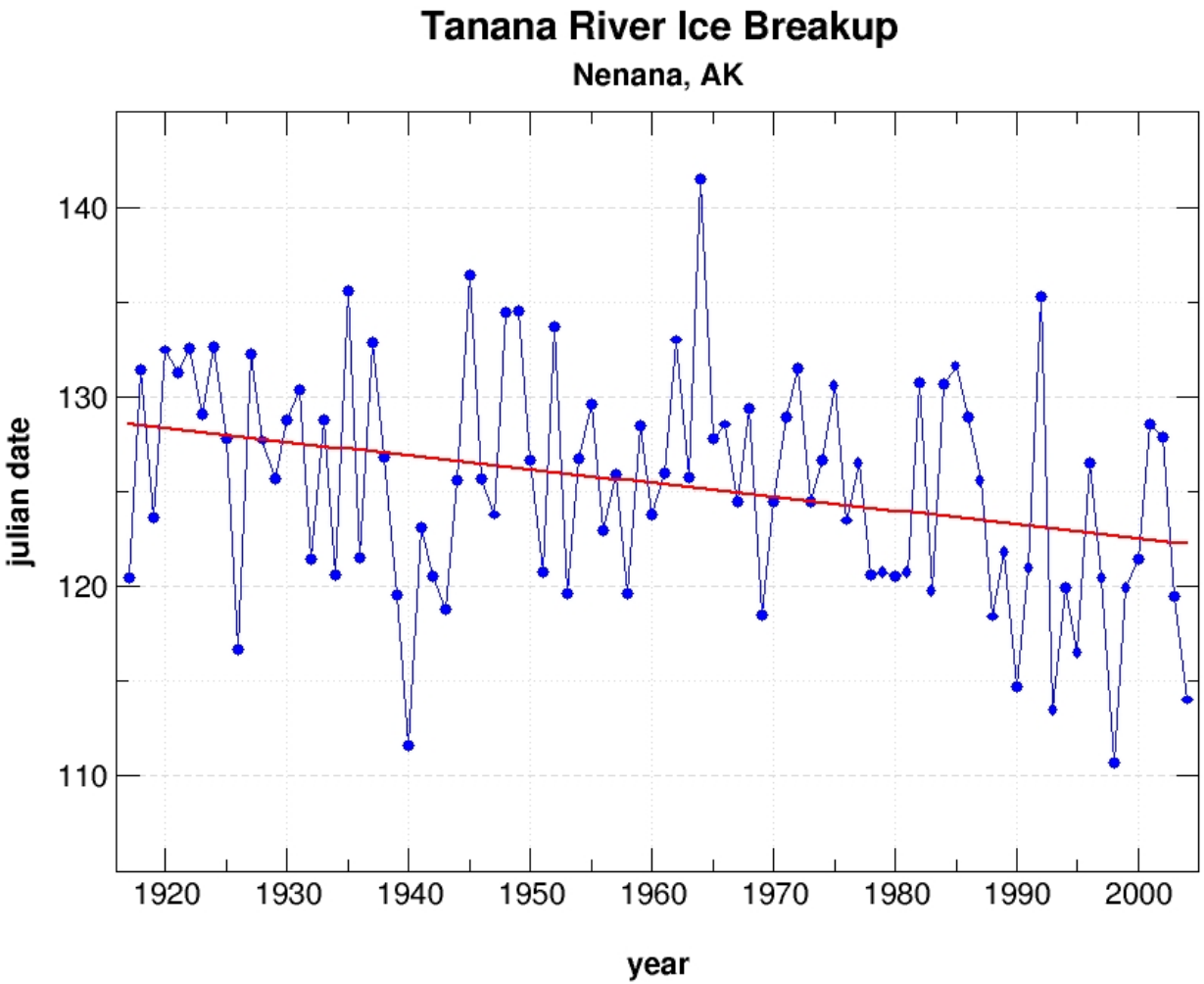
Duration of river and lake ice has decreased



“Over the past 150 years, the break-up date of river and lake ice has advanced by 9.7 days, while freeze-up date has become later by 8.7 days” -- IPCC



Break-up date of Tanana River at Nenana



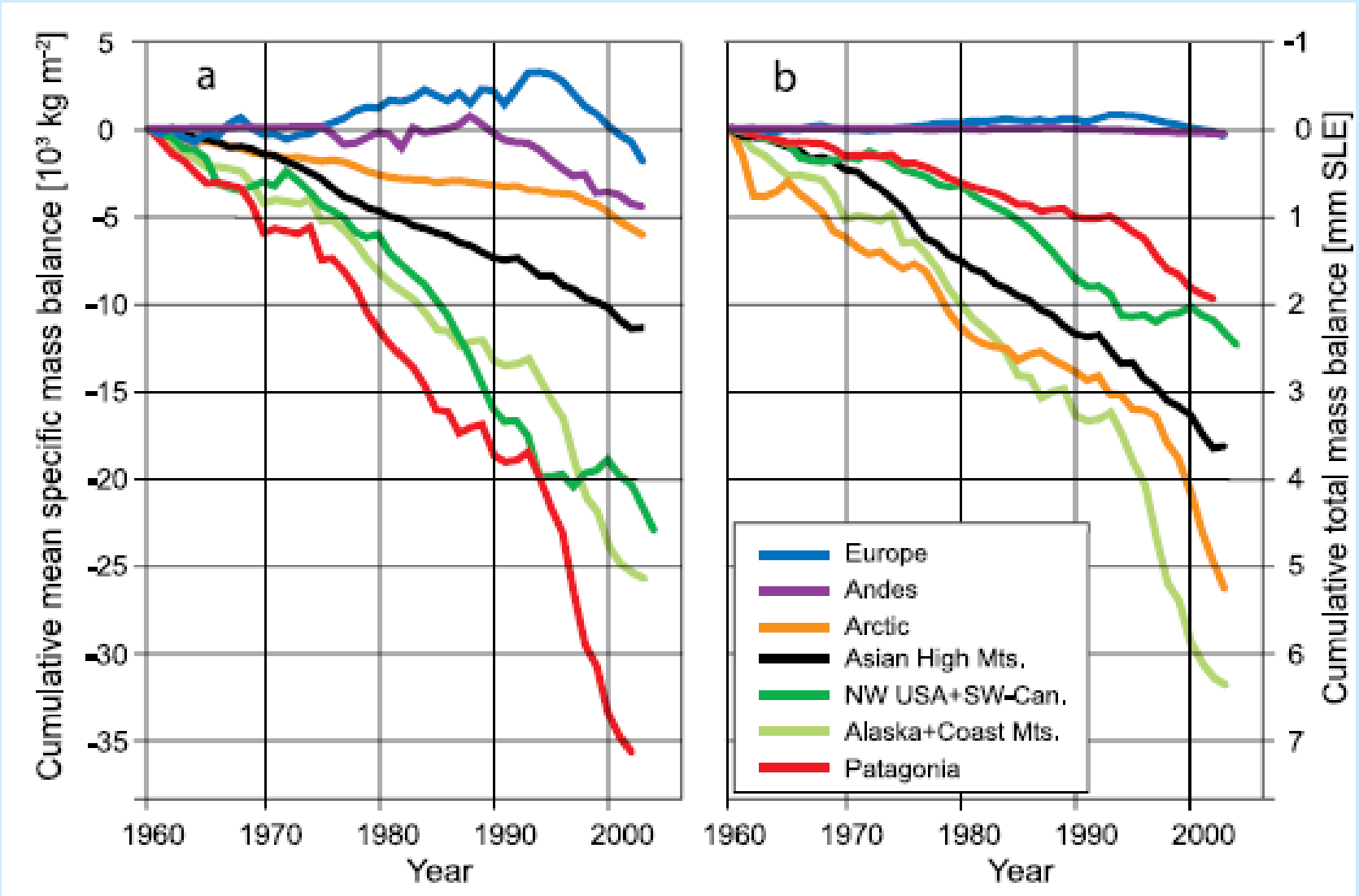
IMPACTS OF A WARMING ARCTIC

McCall Glacier Retreat
Brooks Range, Alaska

Mass balance of glaciers and ice caps

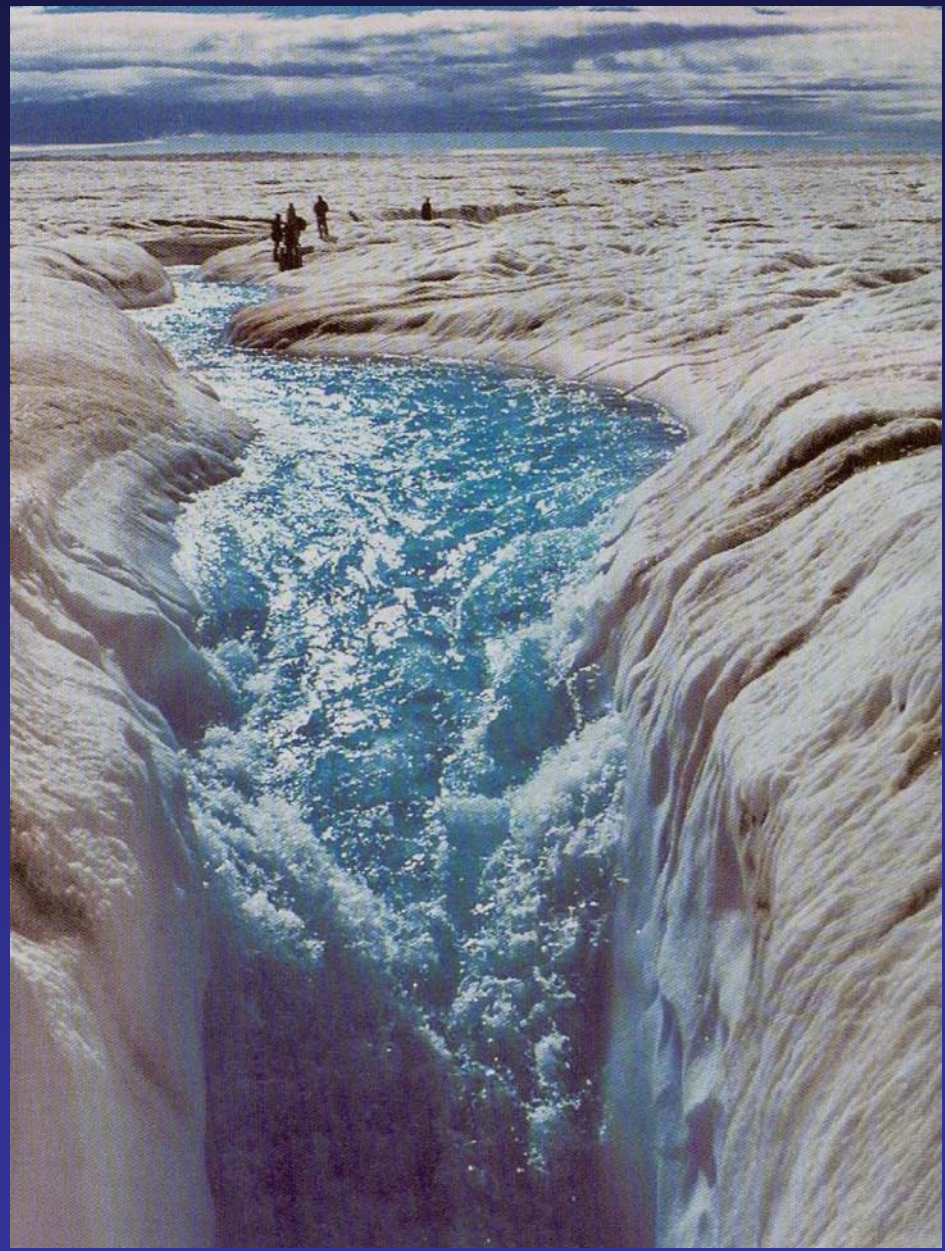
[Dyurgerov and Meier]

Cumulative mean specific mass balance **Sea level equivalent**



The Greenland Ice Sheet Dominates Land Ice in the Arctic

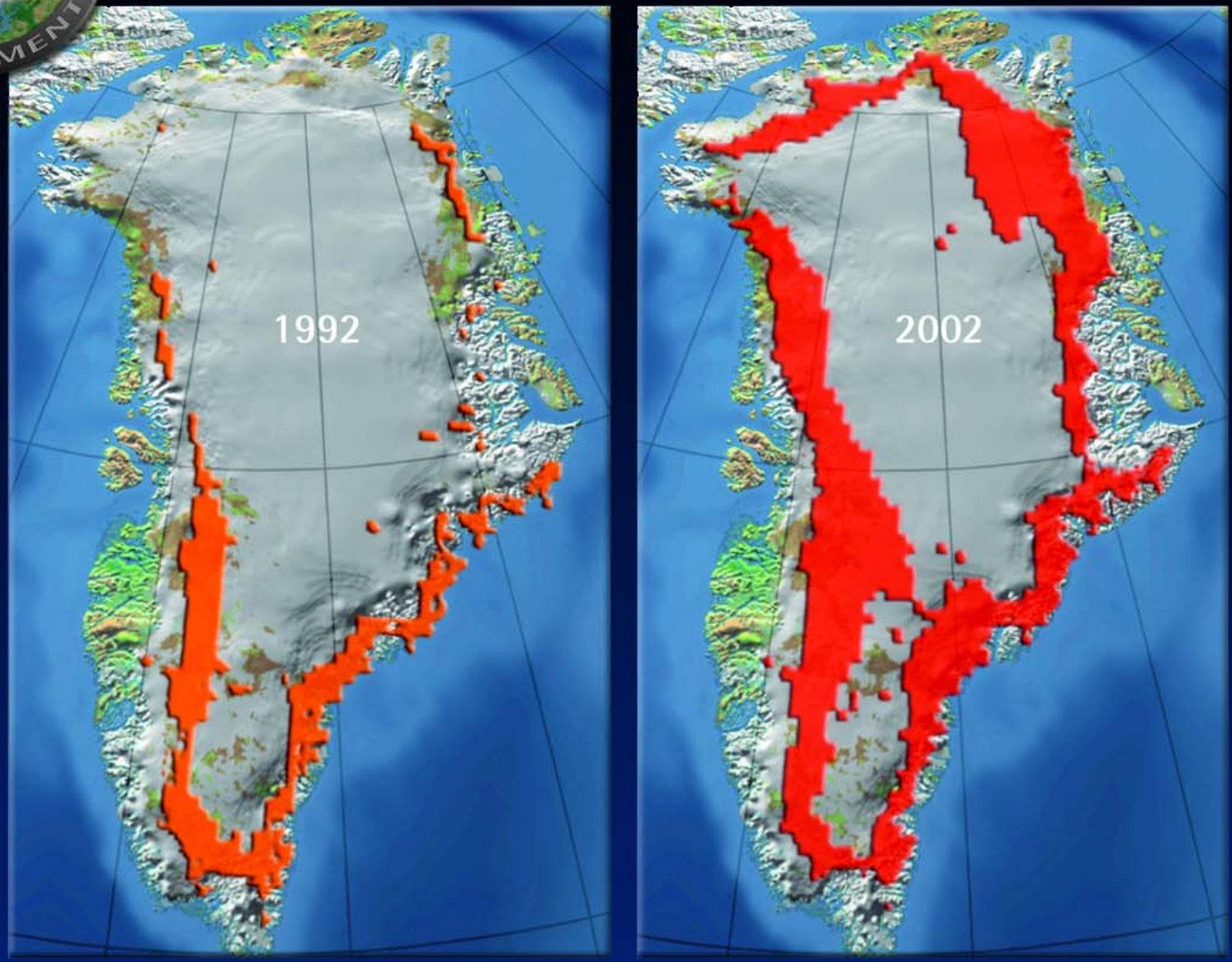
Over the past two decades, the melt area on the Greenland ice sheet has increased on average by about 0.7%/year (or about16% from 1979 to 2002).



Source: Business Week Aug. 2004

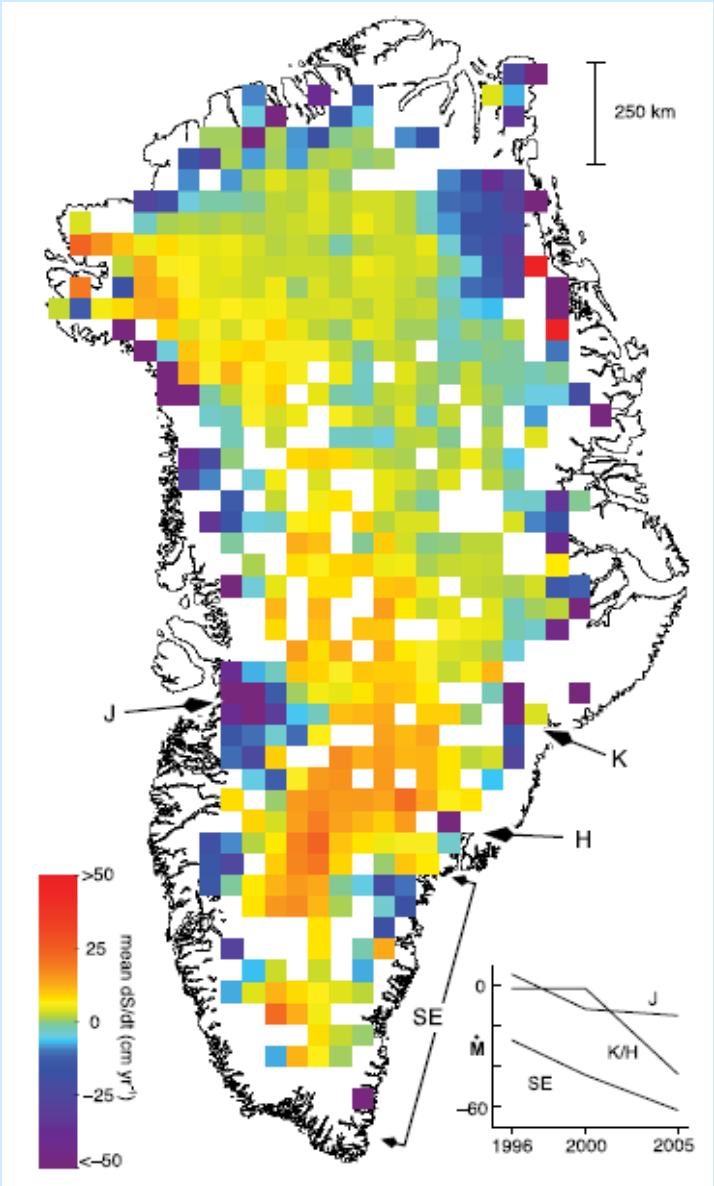
IMPACTS OF A WARMING ARCTIC

Greenland Ice Sheet Melt Extent



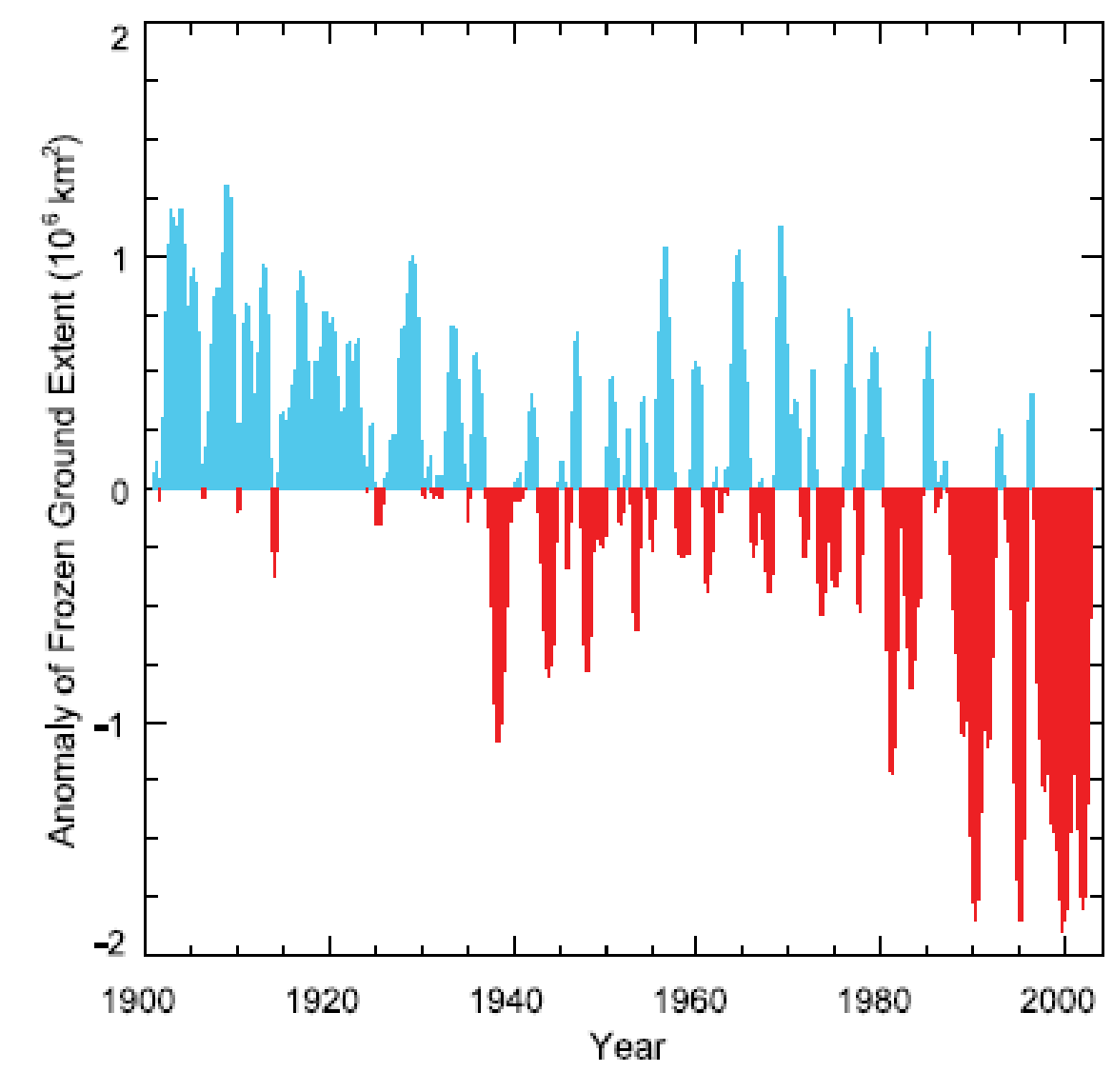
Rates of Greenland surface elevation change, 1998/99 to 2005

[Rignot and Kanagaratnam]



Extent of seasonally frozen ground

[T. Zhang]

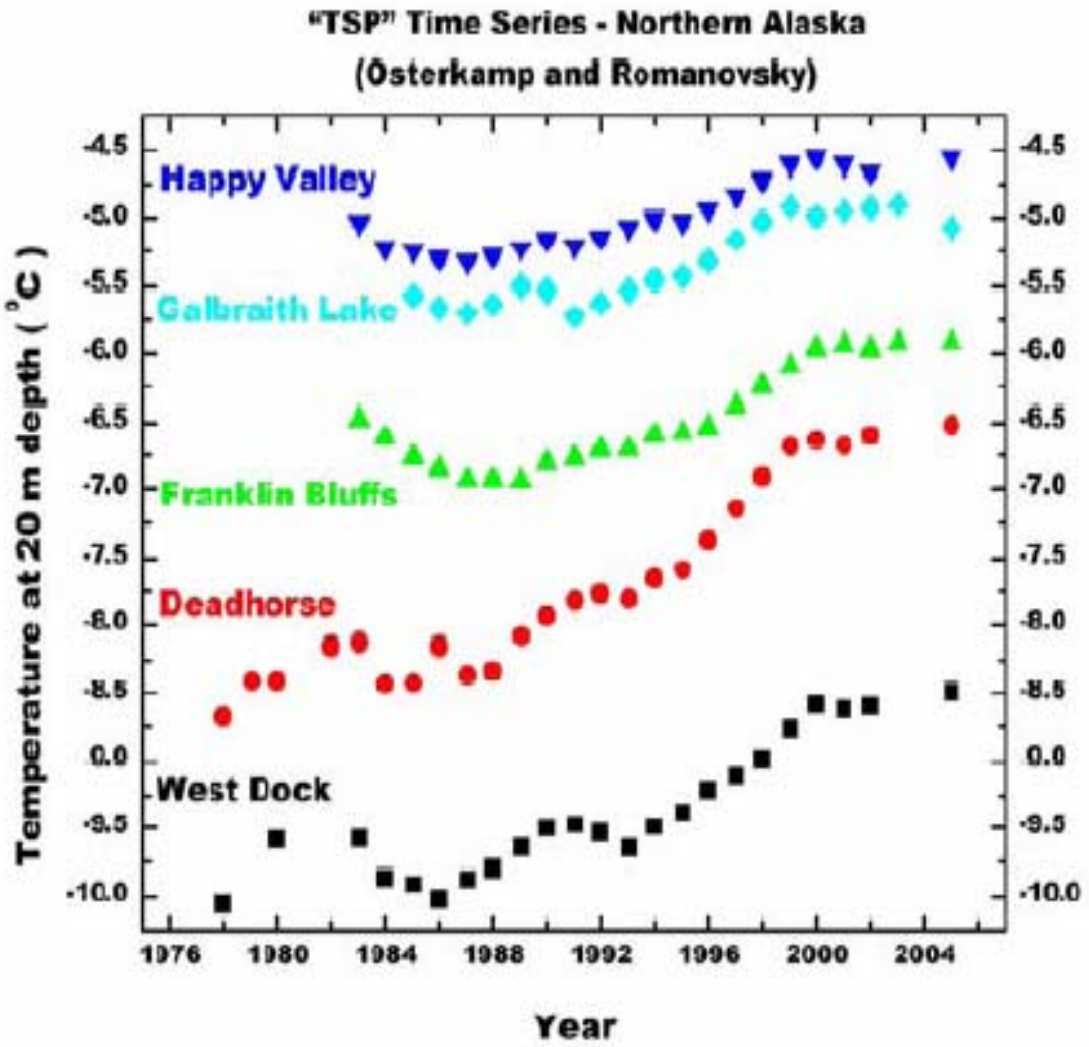


Recent trends in permafrost temperatures

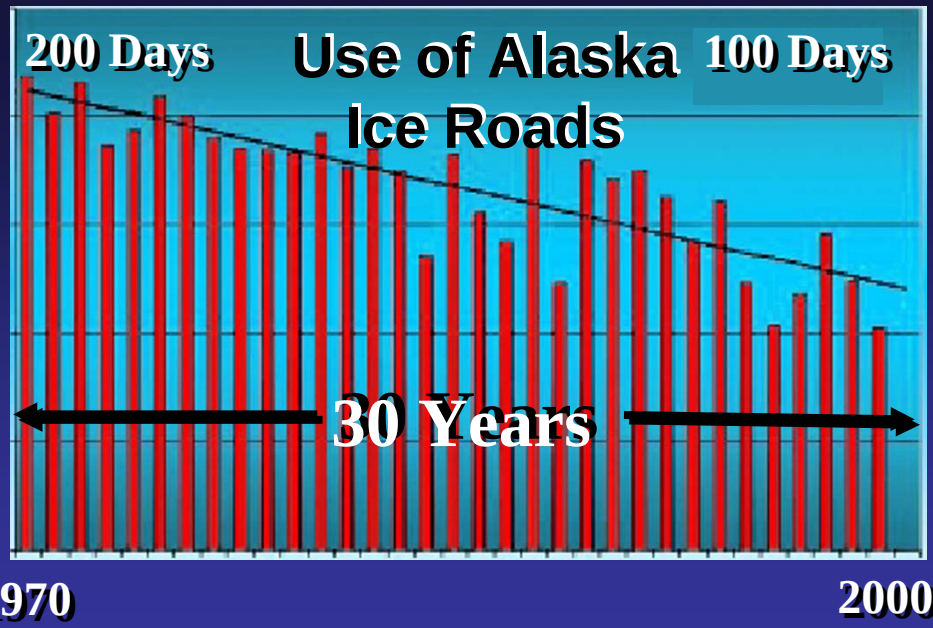
Table 4.5. *Recent trends in permafrost temperature (updated from Romanovsky et al., 2002 and Walsh et al., 2005).*

Region	Depth (m)	Period of Record	Permafrost Temperature Change (°C)	Reference
United States				
Northern Alaska	~1	1910s–1980s	2–4	Lachenbruch and Marshall, 1986
Northern Alaska	20	1983–2003	2–3	Osterkamp, 2005
Interior of Alaska	20	1983–2003	0.5–1.5	Osterkamp, 2005
Canada				
Alert, Nunavut	15	1995–2000	0.8	S.L. Smith et al., 2003
Northern Mackenzie Valley	20–30	1990–2002	0.3–0.8	S.L. Smith et al., 2005
Central Mackenzie Valley	10–20	Mid-1980s–2003	0.5	S.L. Smith et al., 2005
Southern Mackenzie Valley & Southern Yukon Territory	~20	Mid-1980s–2003	0	Haeberli and Burn, 2002
Northern Quebec	10	Late 1980s–mid-1990s	<–1	Allard et al., 1995
Northern Quebec	10	1996–2001	1.0	DesJarlais, 2004
Lake Hazen	2.5	1994–2000	1.0	Broll et al., 2003
Iqaluit, Eastern Canadian Arctic	5	1993–2000	2.0	S.L. Smith et al., 2005

Increase in Alaskan permafrost temperatures at 20 m depth



Thawing ground will disrupt transportation, buildings, and other infrastructure.

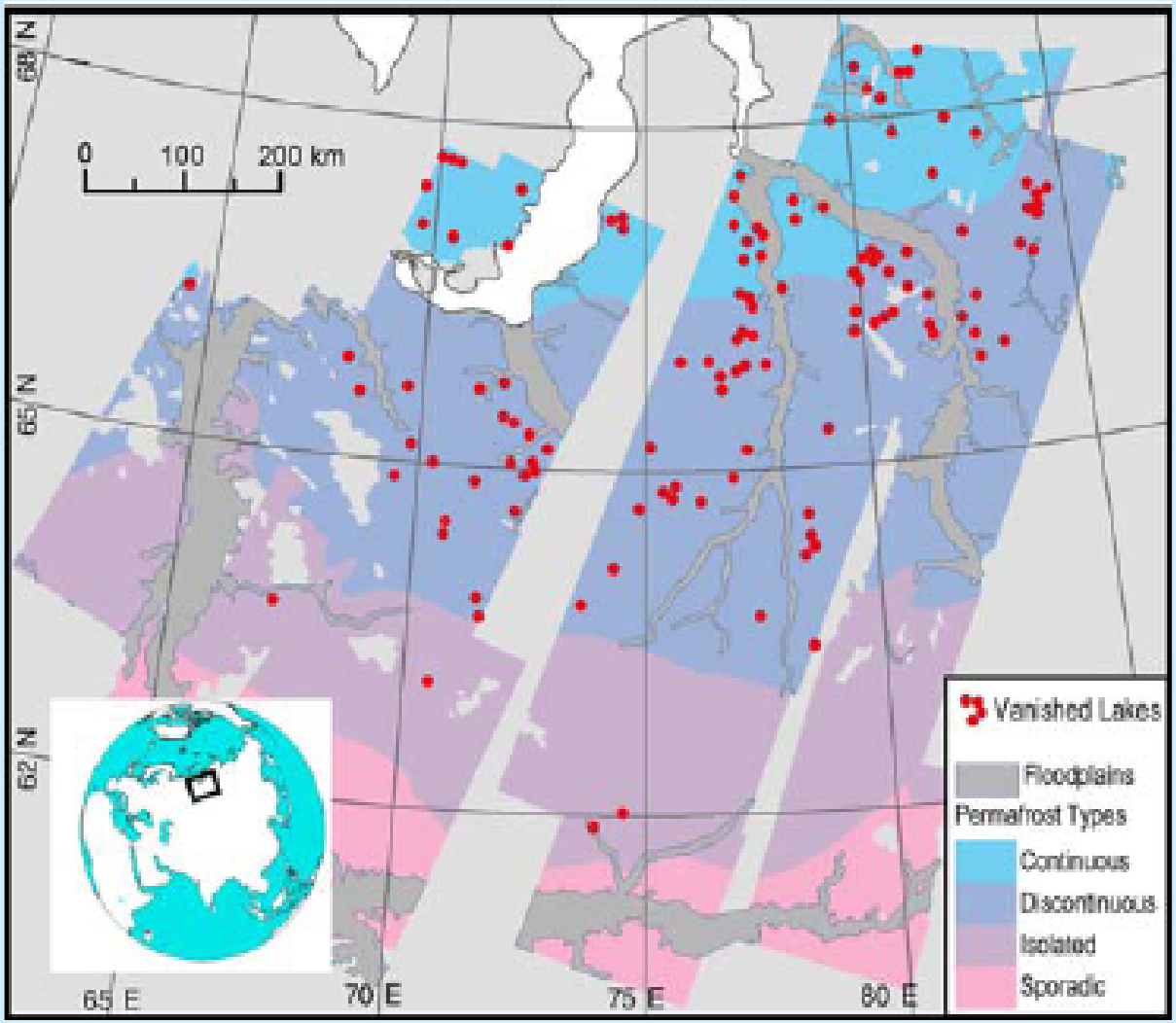


- Transportation and industry on land, including oil and gas extraction and forestry, will increasingly be disrupted by the shortening of the periods during which ice roads and tundra are frozen sufficiently to permit travel.
- As frozen ground thaws, many existing buildings, roads, pipelines, airports, and industrial facilities are likely to be destabilized, requiring substantial rebuilding, maintenance, and investment.
- Future development will require new design elements to account for ongoing warming that will add to construction and maintenance costs.
- Permafrost degradation will also impact natural ecosystems through collapsing of the ground surface, draining of lakes, wetland development, and toppling of trees in susceptible areas.

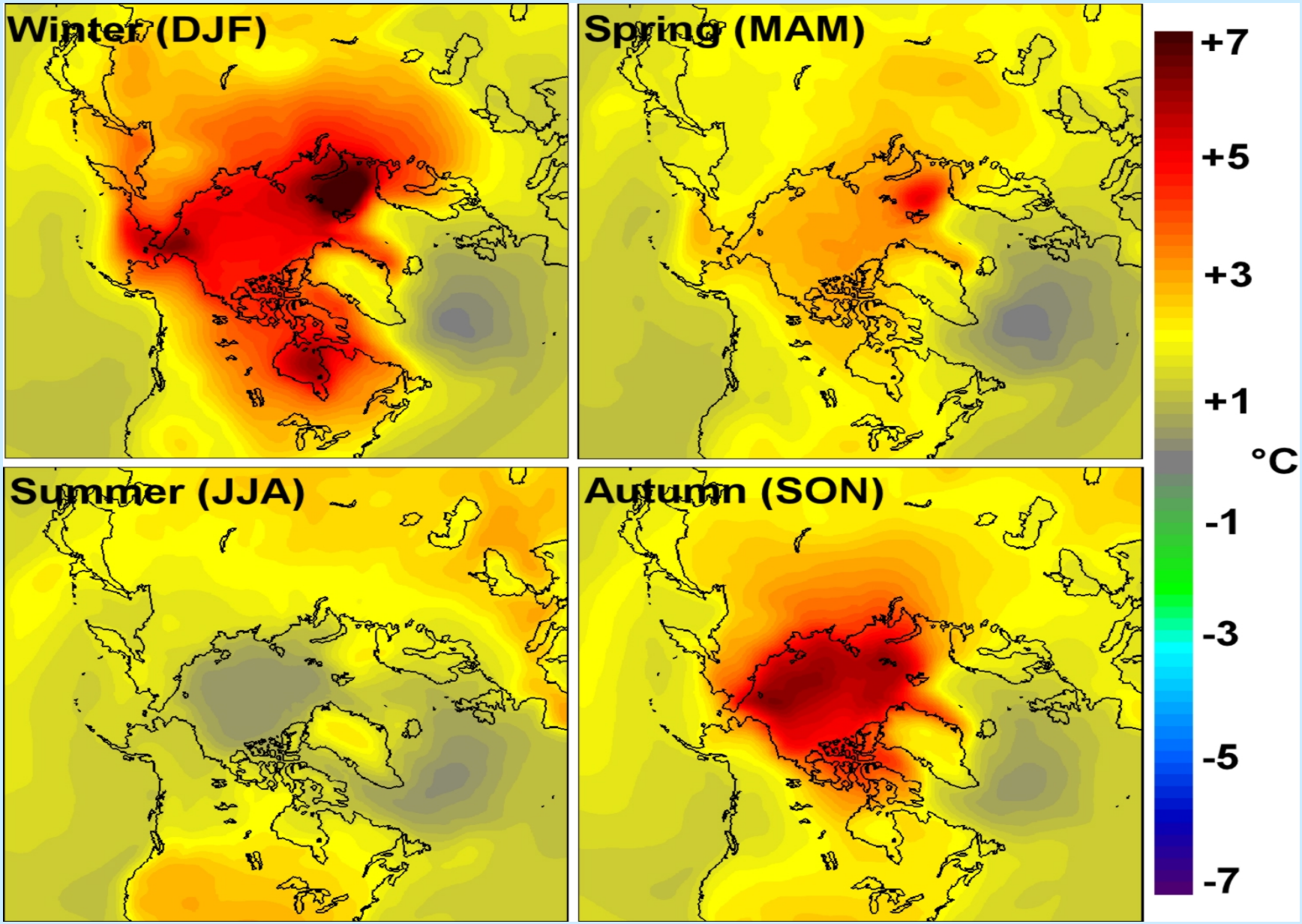
Spatial pattern of Siberian lake disappearance, 1970s to 1997-2004

[Smith et al.]

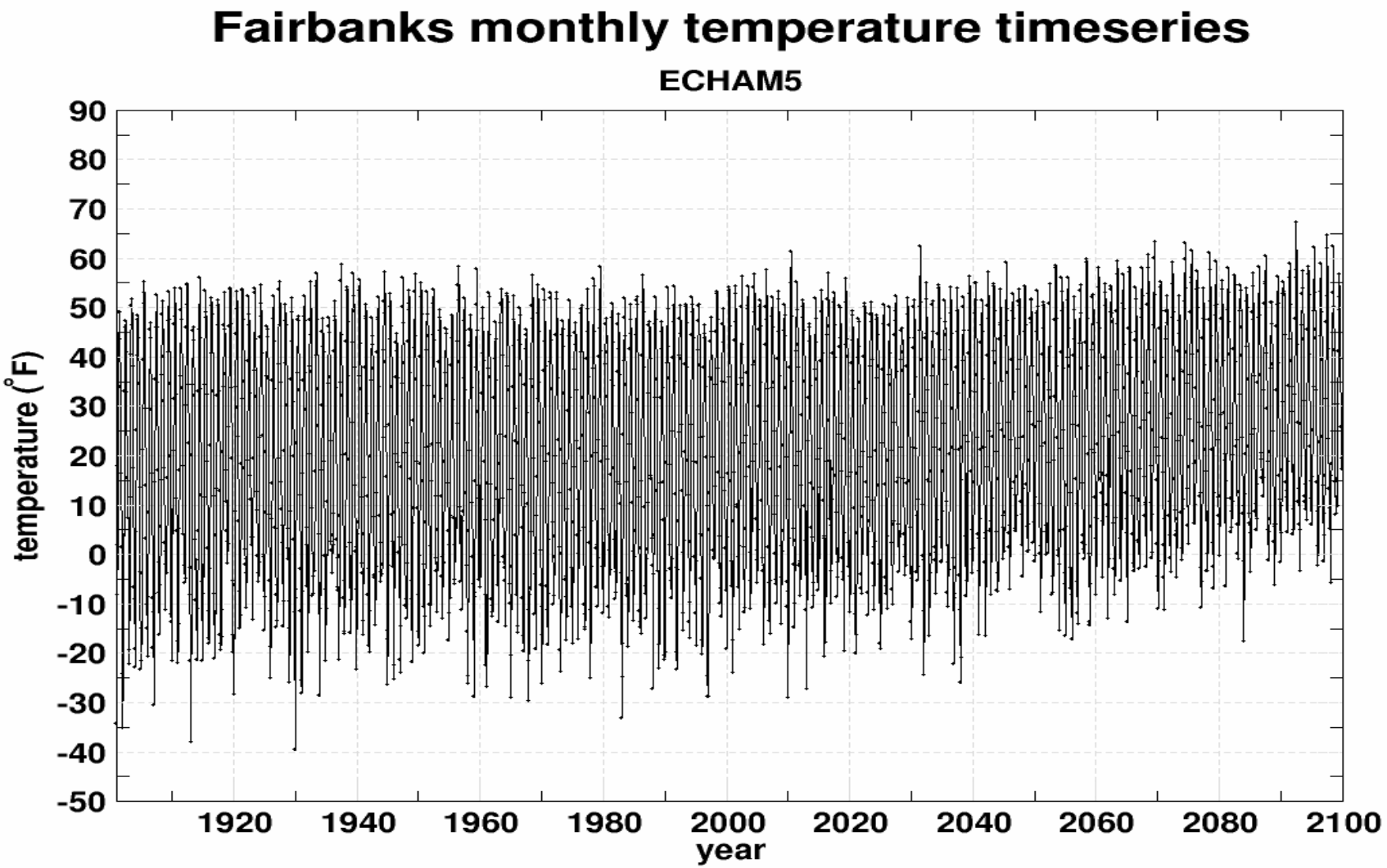
"The spatial pattern of lake disappearance strongly suggests that permafrost thawing is driving the changes." -- IPCC



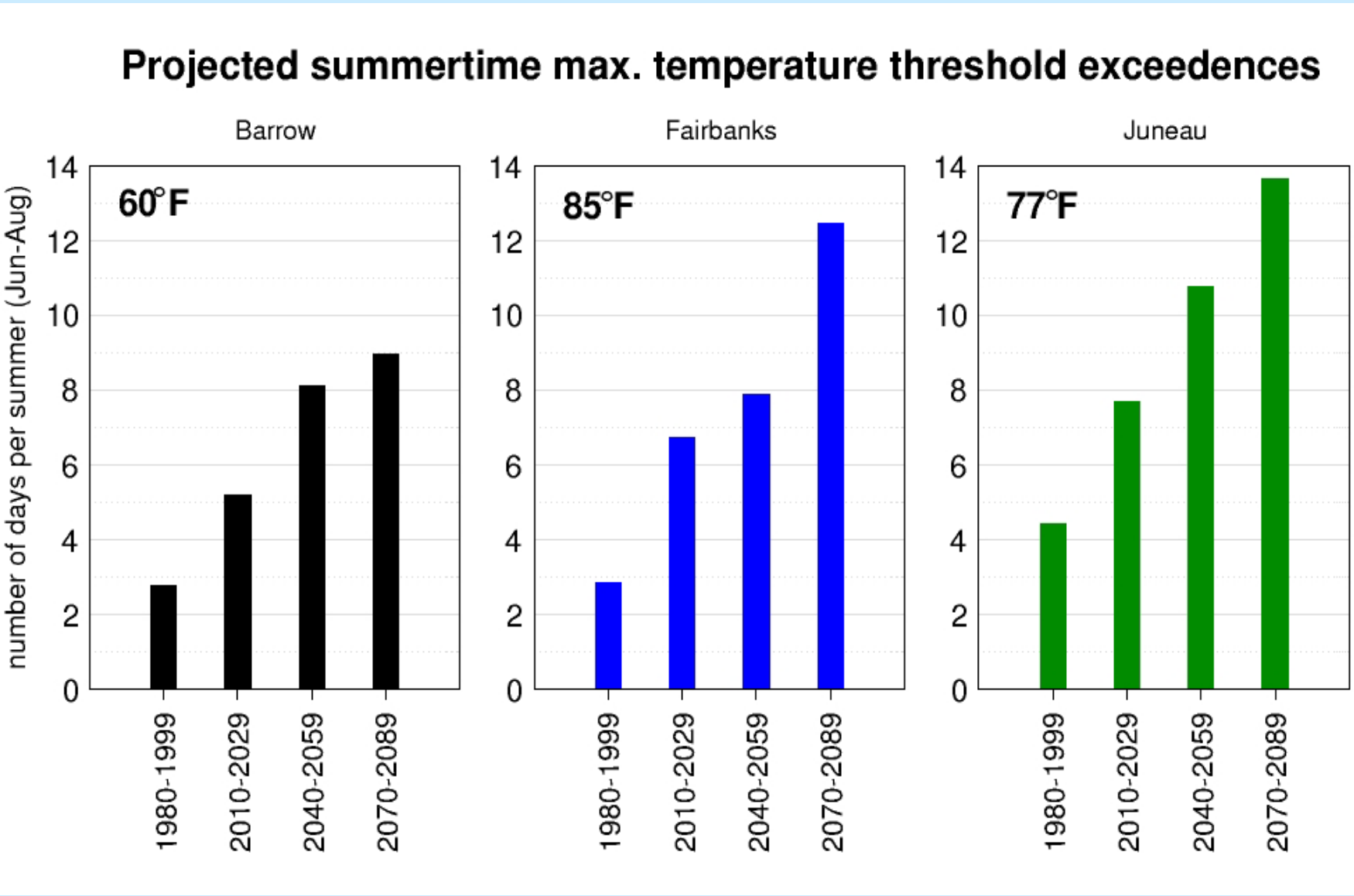
Projected changes of temperature: 2070-2090



Sample of model-projected monthly temperatures: Fairbanks (A1B scenario)

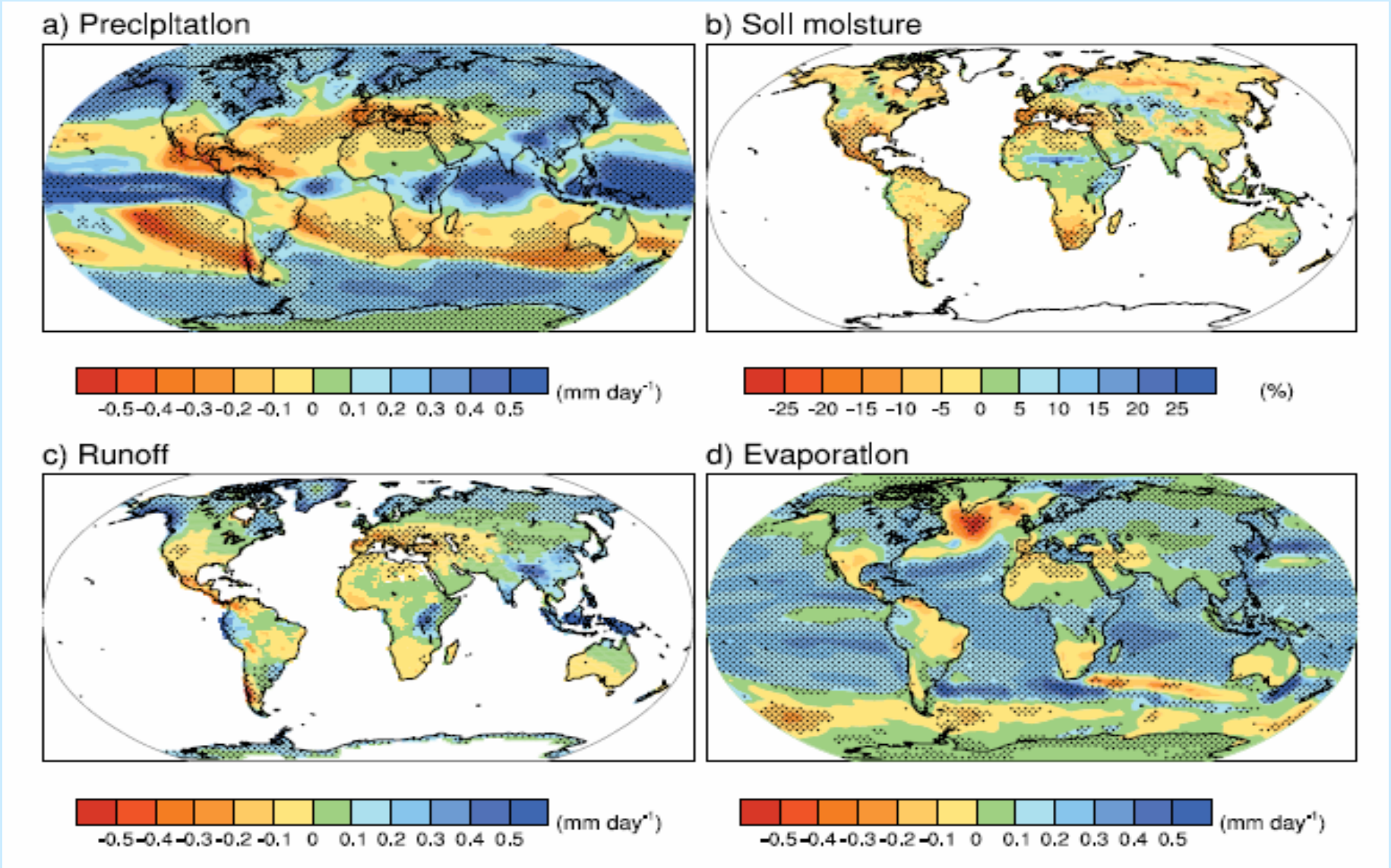


Projected numbers of "hot days" (global models)

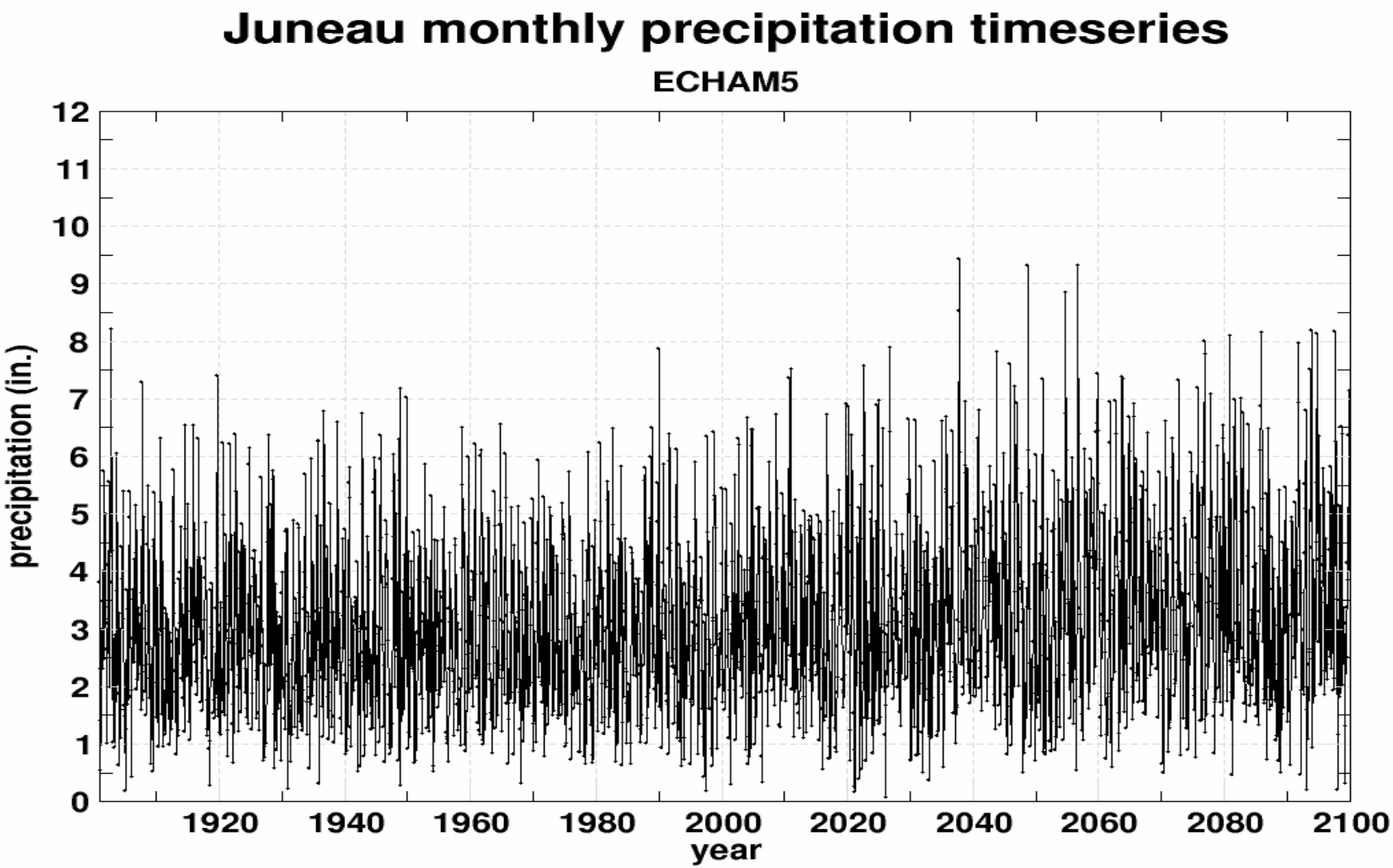


Projected hydrologic changes, 2080-2099:

For Alaska: Precip. ↑, Evap. ↑, Runoff ↑(10-30%), Soil moisture ↓

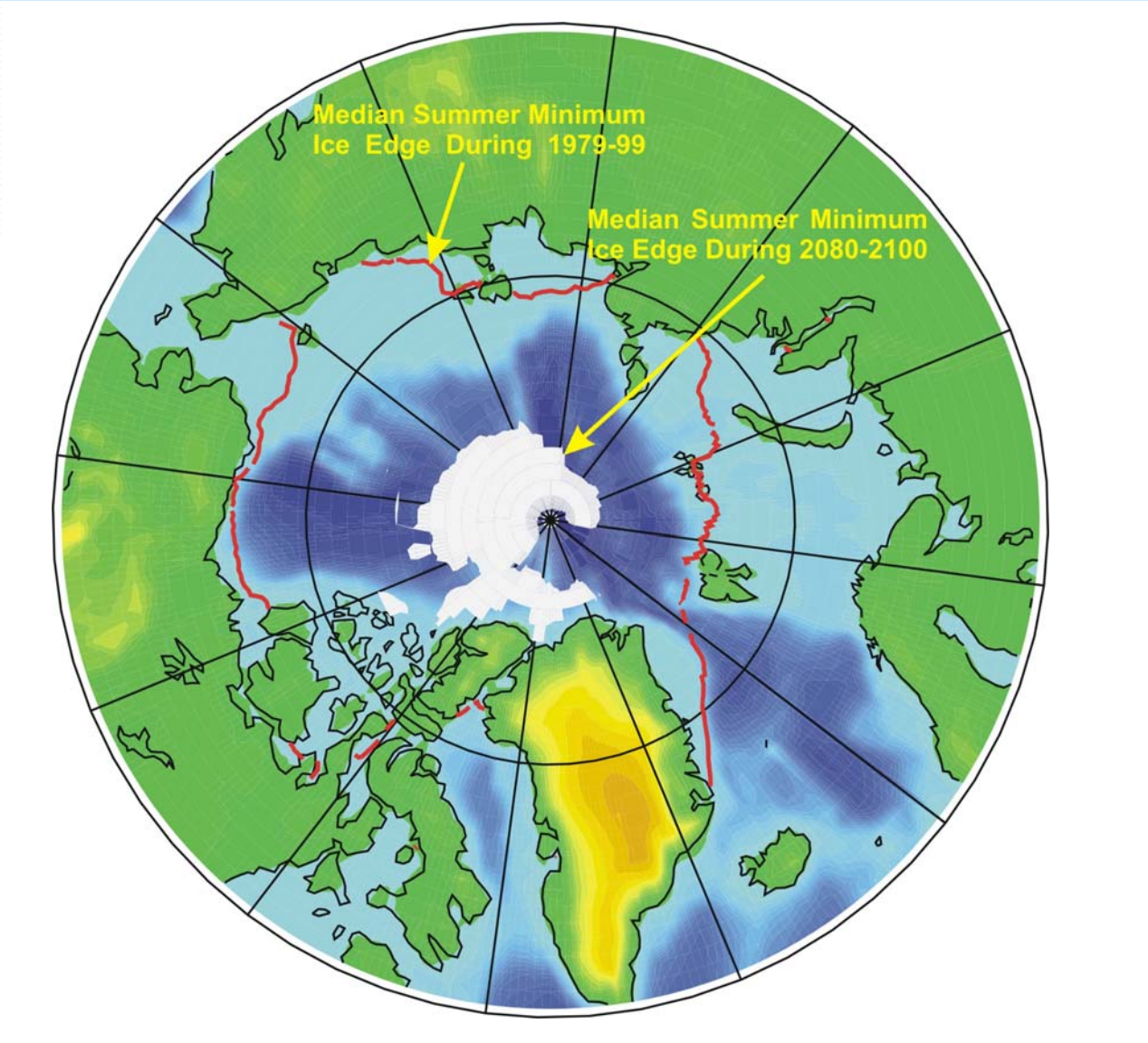


Sample of model-projected monthly precipitation: Juneau (A1B scenario)

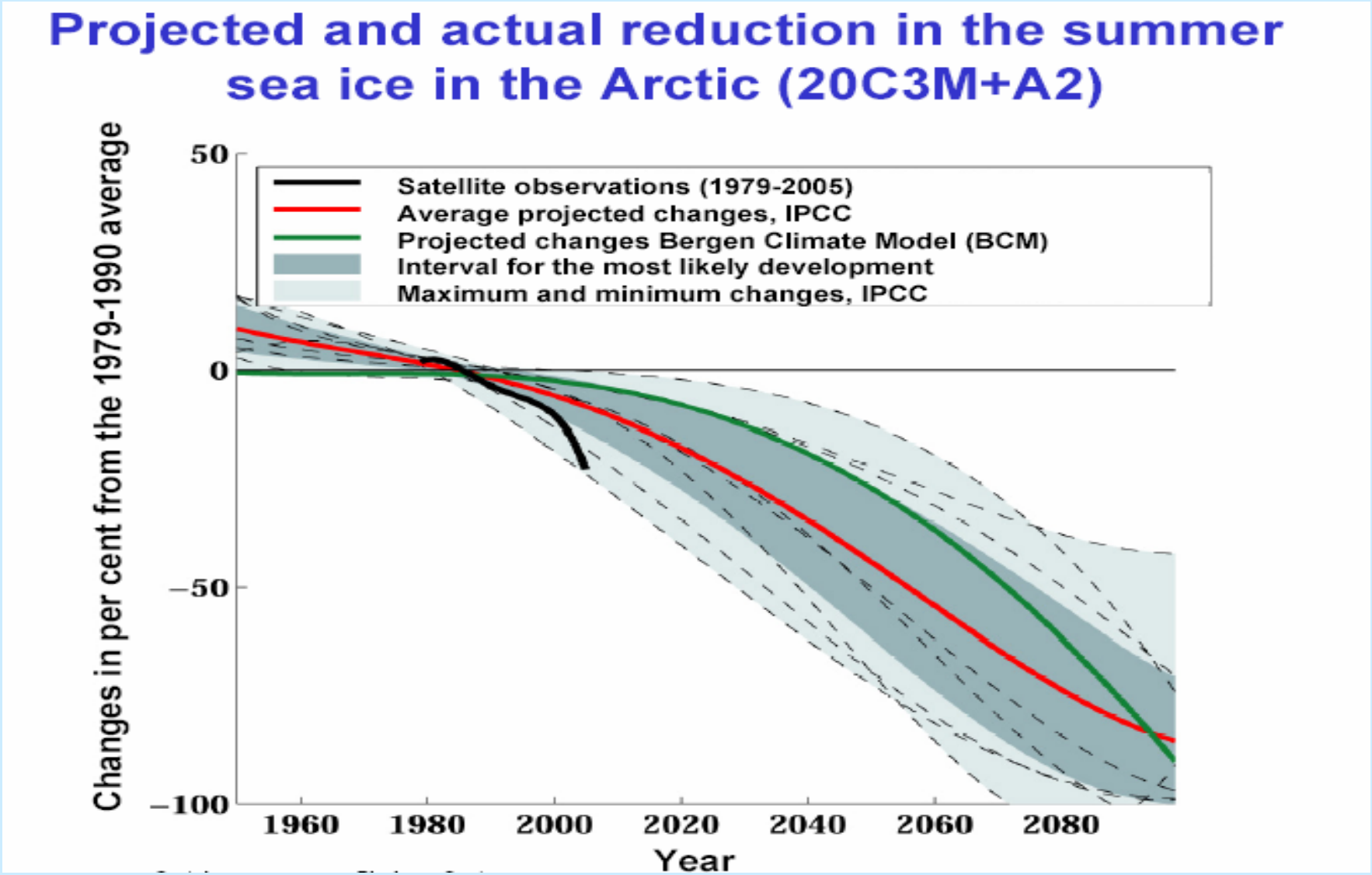


Projected summer ice retreat, 2080-2100 (IPCC AR4 models)

[from X. Zhang]



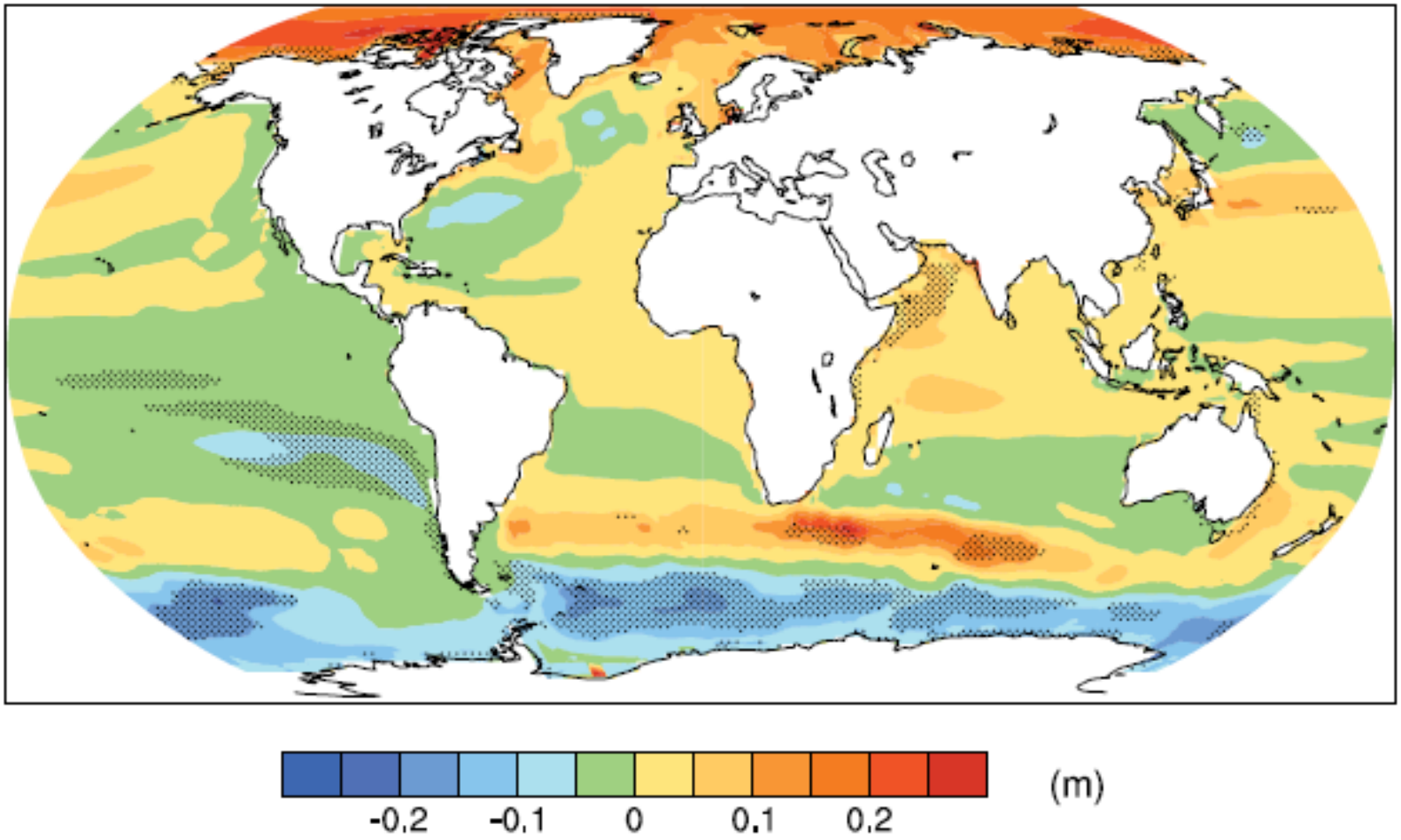
IPCC models: Arctic sea ice coverage, 1950-2100



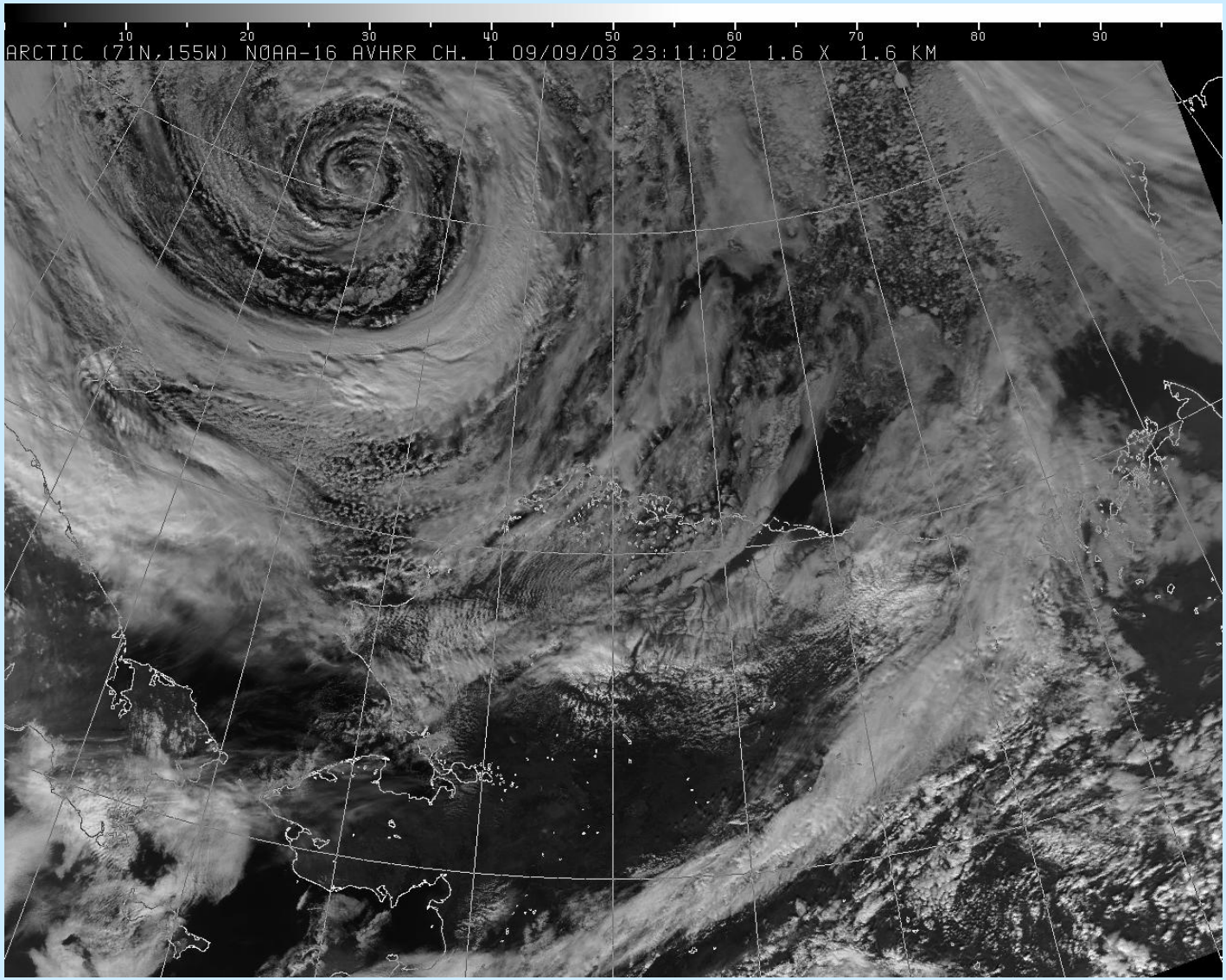
IMPACTS OF A WARMING ARCTIC

Many coastal communities and facilities face increasing exposure to storms.

Projected change of sea level (16 models), 2080-2099, due to ocean density and circulation changes

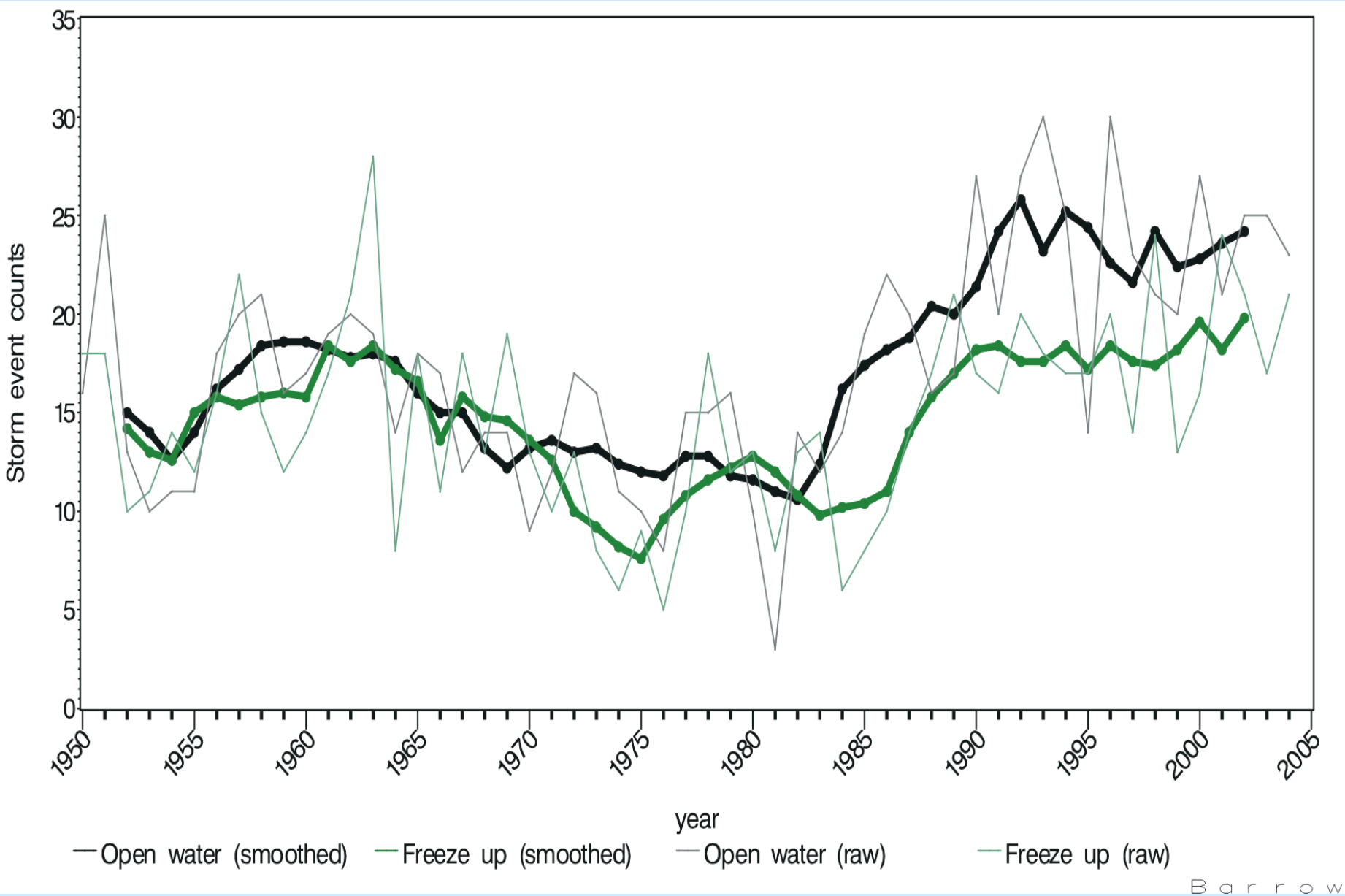


Intense Arctic cyclone affecting Alaskan coast



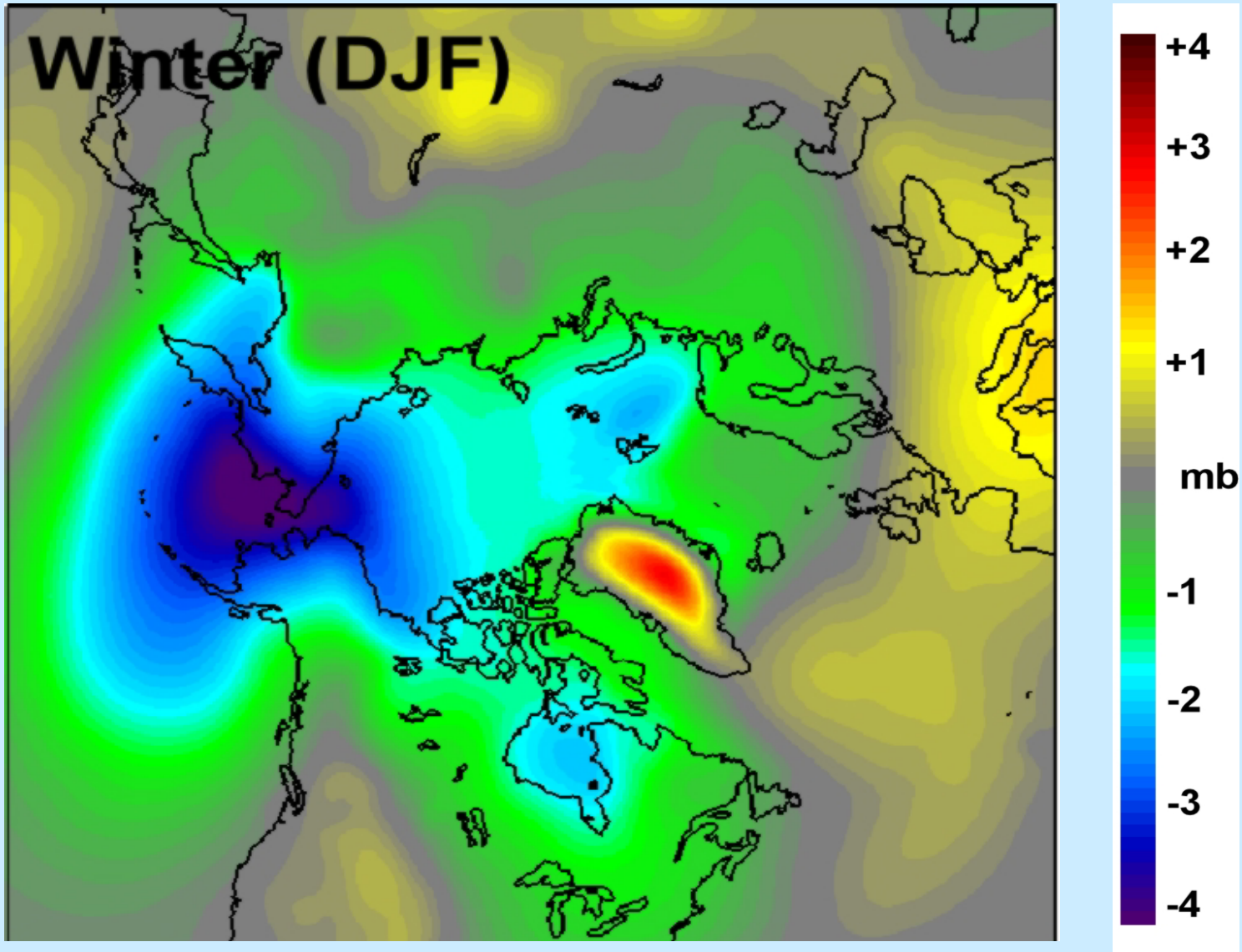
Yearly storm counts at Barrow, Alaska

[from D. Atkinson, UAF]



Projected change in winter sea level pressure: 2070-2090

lower pressure ⇒ more storms? Plausible

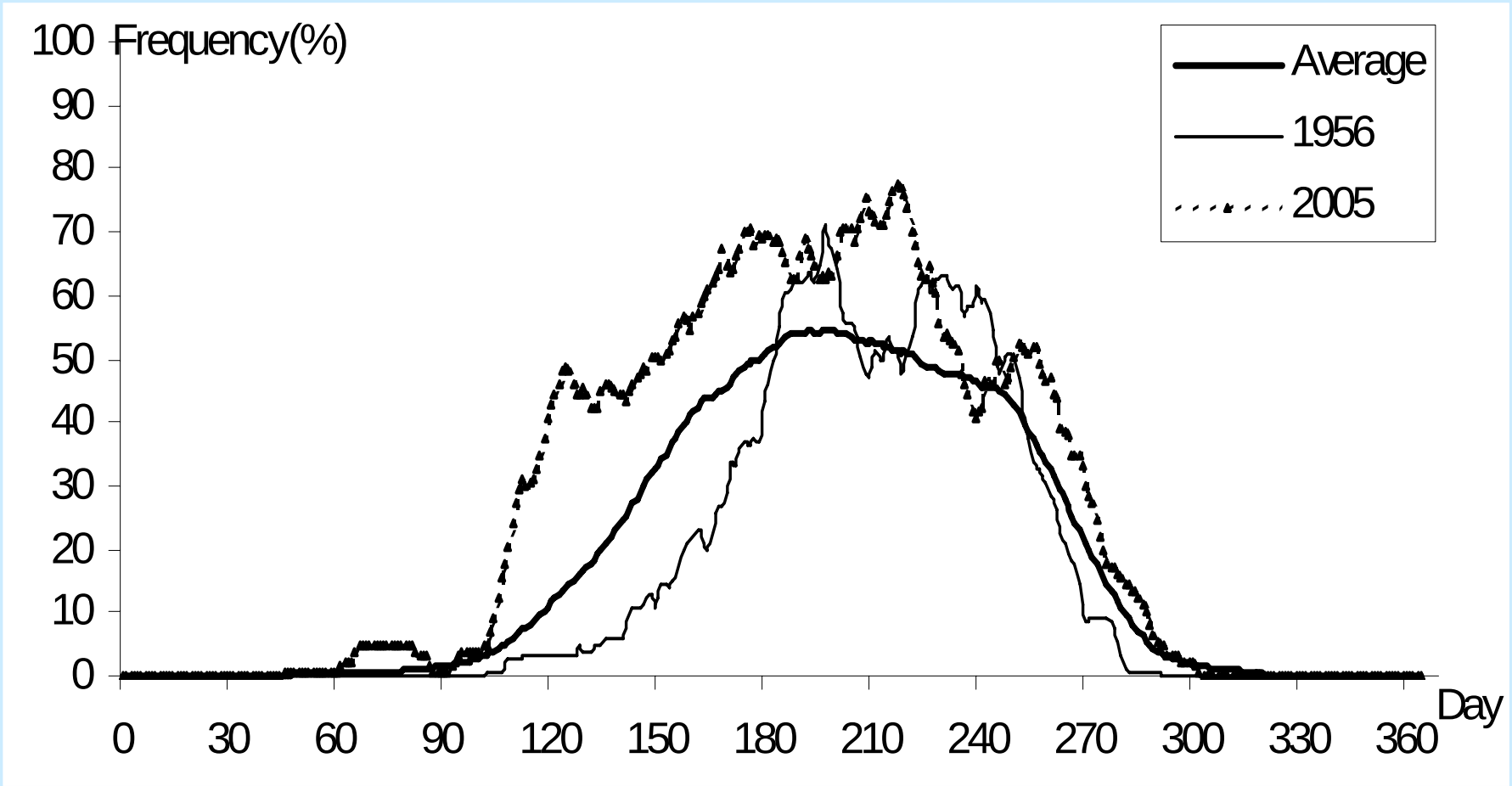


Projected impacts of climate change in the Arctic

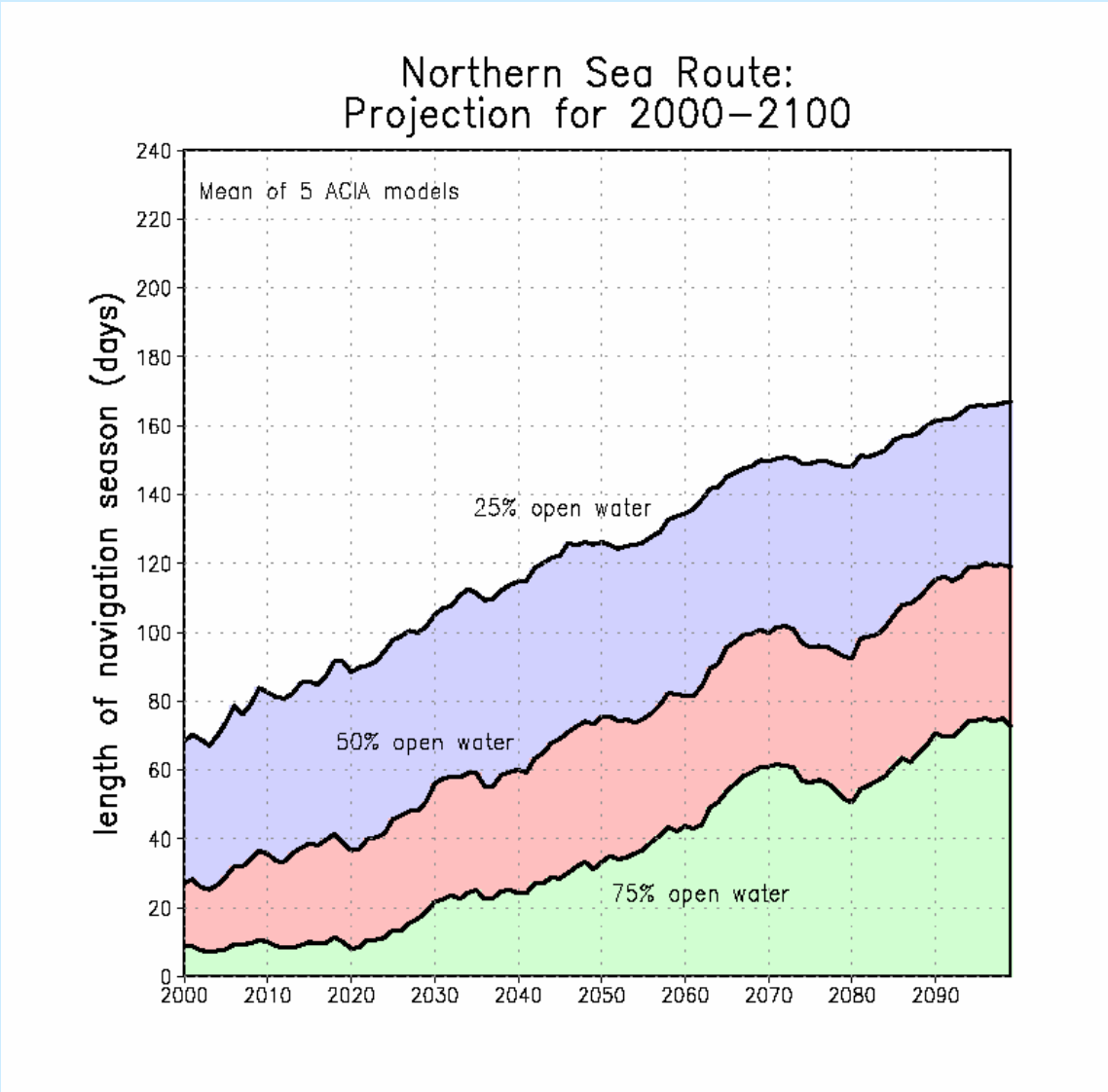
- **Longer growing season**
  ⇒ opportunities in agriculture, forestry
- **Reduced heating costs**
- **Increased marine access**
  ⇒ tourism, commercial, industrial, military/security implications

Seasonal frequency of weather conducive to sightseeing (King Salmon, AK)

Start day: January 1



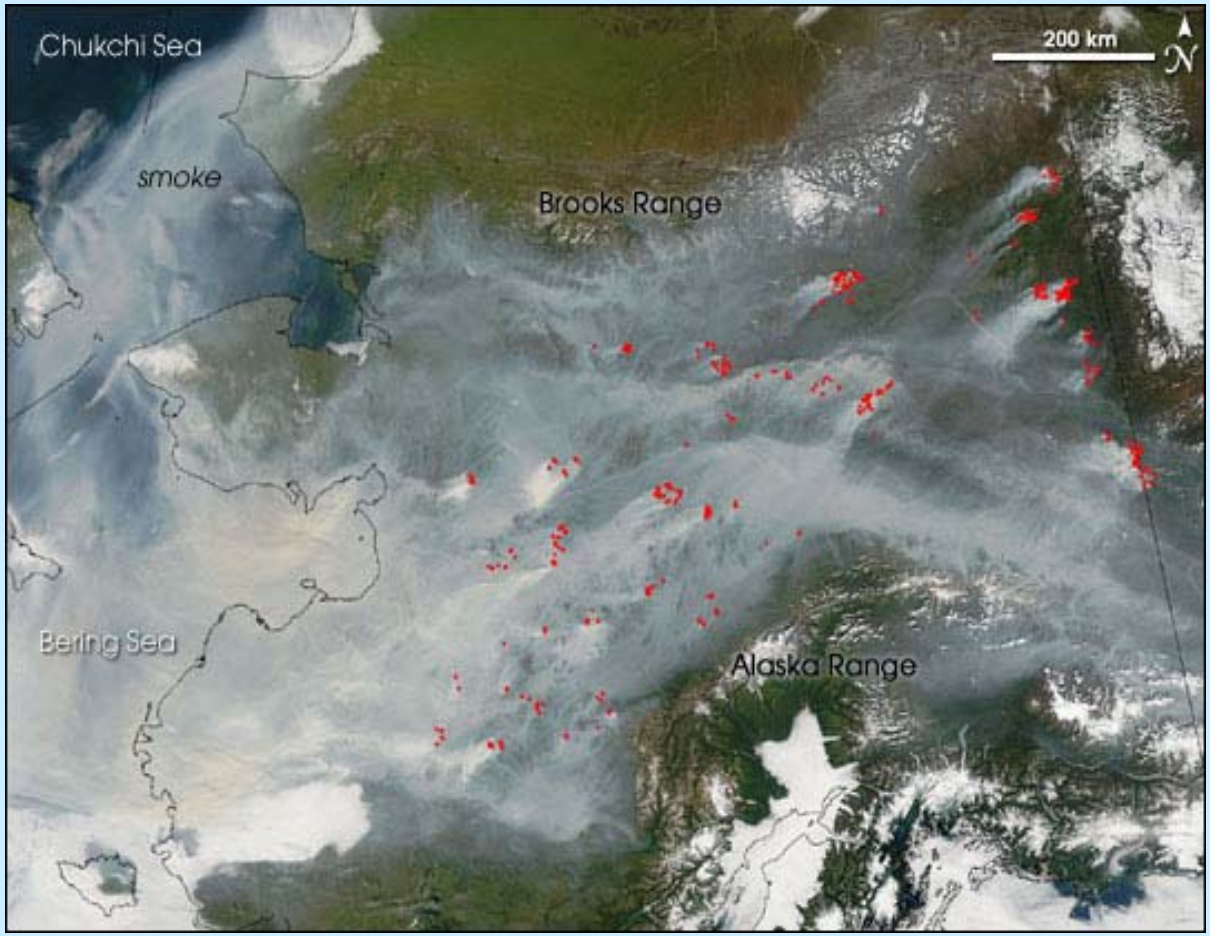
Projected changes of navigation season length, Northern Sea Route (ACIA, 2005)



Projected impacts of climate change in the Arctic

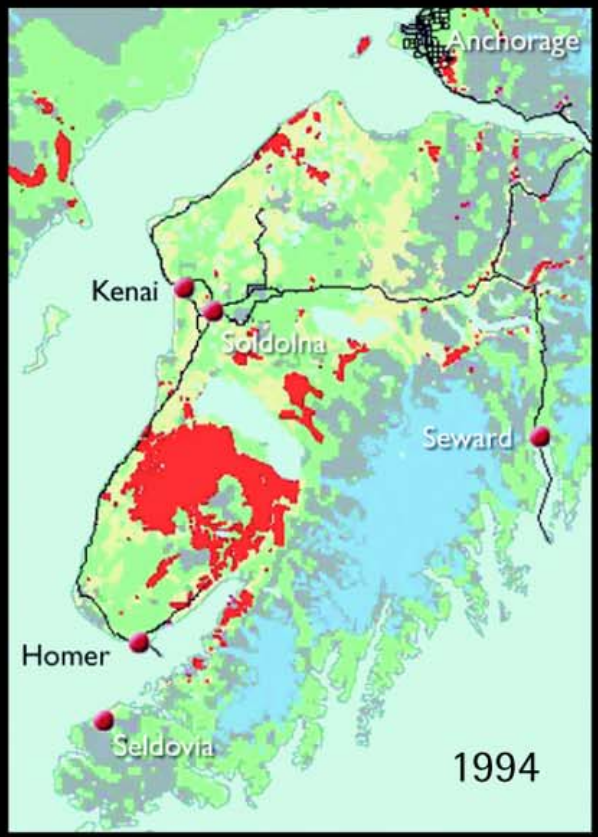
- **"Large-scale forest fires and outbreaks of tree-killing insects that are triggered by warm weather…are likely to increase."**
- **earlier timing of spring events (leaf-out, bird migrations, egg-laying,…)**
- **thawing of discontinuous permafrost;**
  increase of active layer thickness by 15-50%
- **accelerated melt of glaciers, ice caps**
- **poleward and upward shifts in ranges of plants, animal species**
- **"Changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and higher predators."**

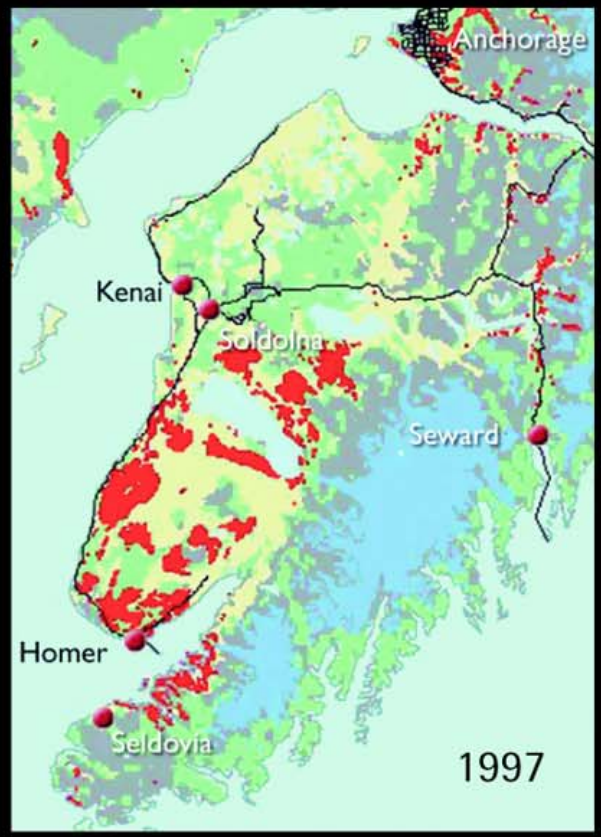
2004: record heat in Southeast Alaska and fires in the Interior

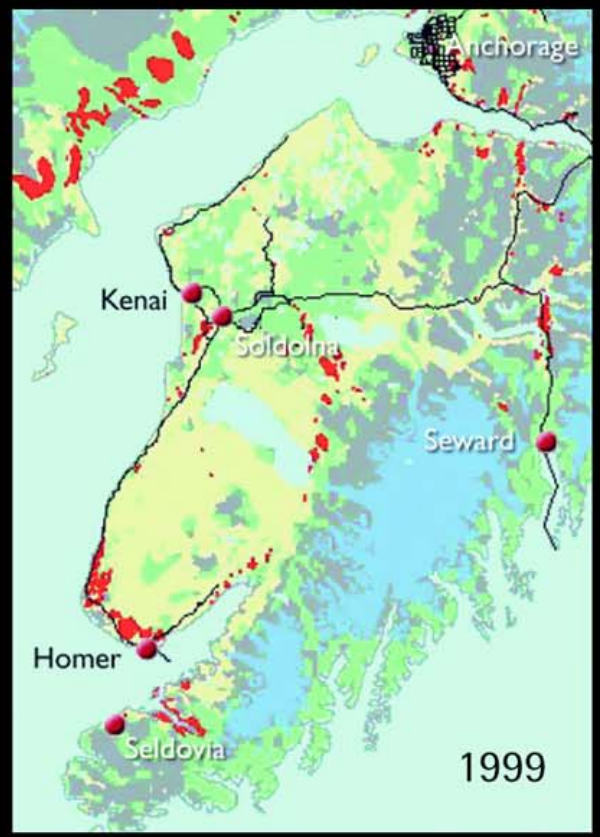


IMPACTS OF A WARMING ARCTIC

Spruce Beetle Activity Kenai Peninsula 1994–1999

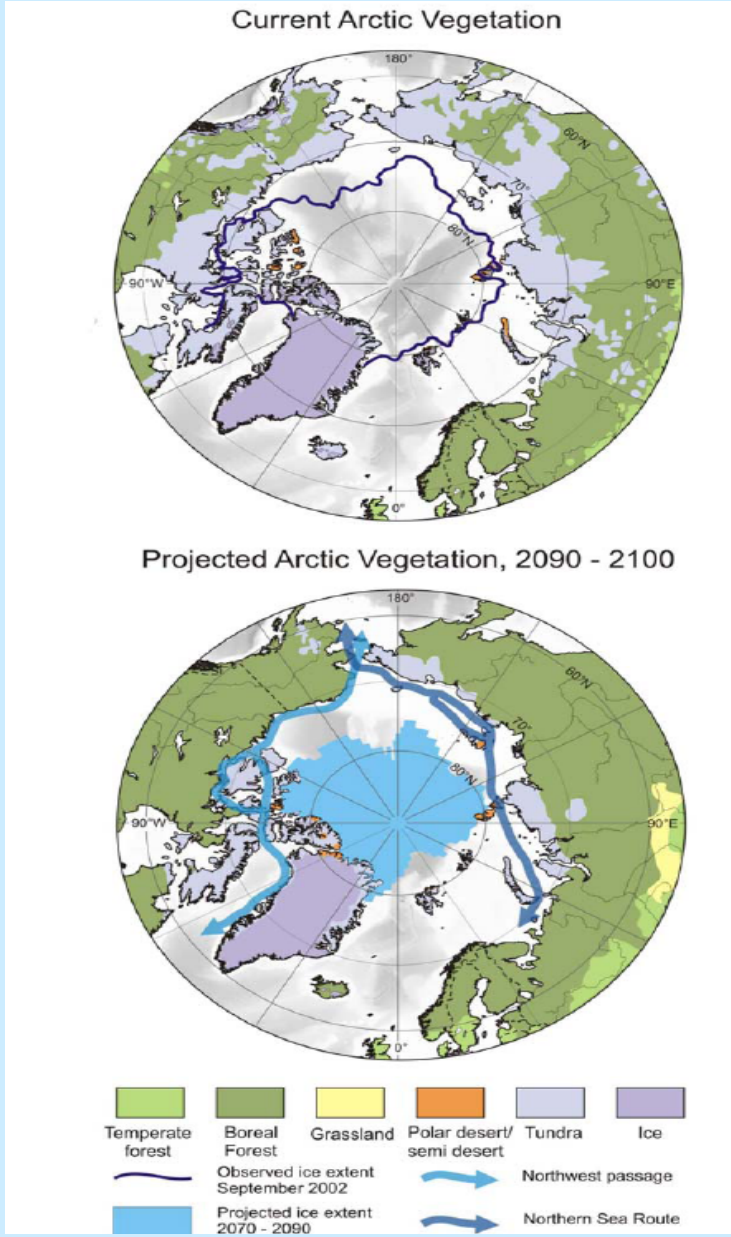






- Tree Mortality due to SBB
- Past Tree Mortality due to SBB
- Forest
- Non-Forest
- Glacier

Arctic vegetation: Current and projected (2090-2100)



Projected impacts with direct human consequences

- **Permafrost: "A discontinuous high-risk zone containing population centers, pipelines and extraction facilities will develop around the Arctic Ocean by the mid-21st century." -- IPCC**

- **"Substantial investments will be needed to adapt or relocate physical structures and communities."** ***[high confidence: >80%]***

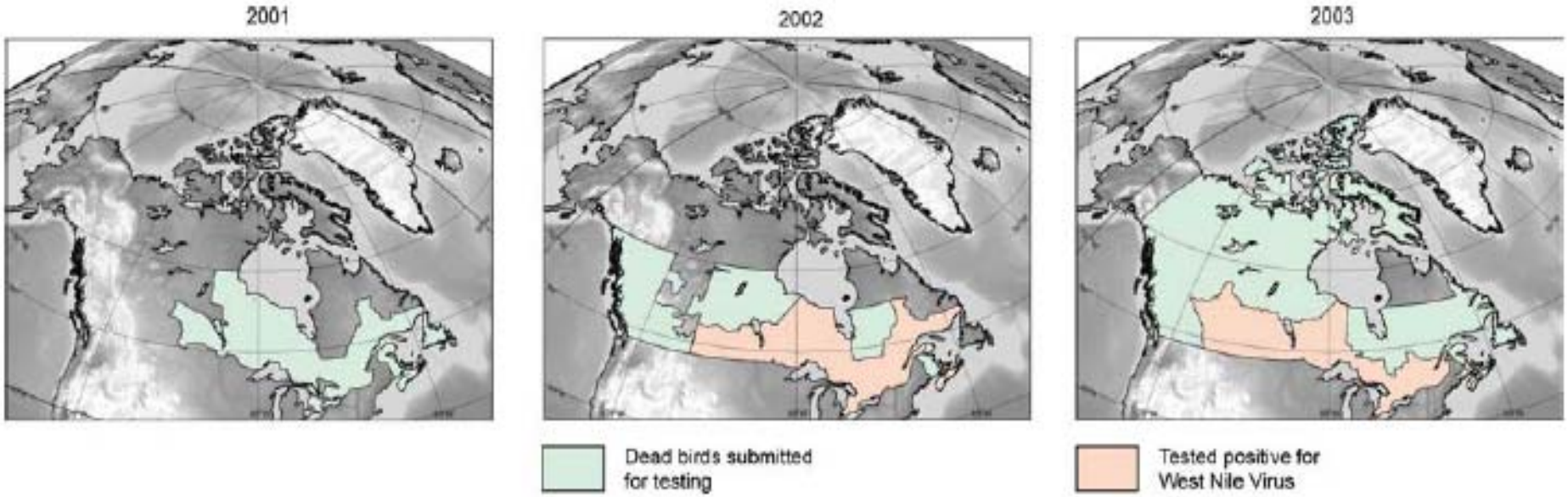
- **Migration of major fisheries (marine ecosystems are already shifting northward).**

- **"Both internal and external stressors are already challenging the adaptive capacities of Arctic human communities… Some traditional ways of life are being threatened…" -- IPCC**

- **Changes in disease vectors are likely to affect the Arctic.**

Distribution of West Nile virus in Canada

[Warren et al.]



Key uncertainties

- **Role of thresholds, extreme events**
- **Ongoing and future changes in biodiversity (terrestrial and marine)**
- **Ongoing and future changes in carbon budgets of the Arctic**
- **Role of Arctic freshwater discharge and ice melt on global ocean processes (e.g., thermohaline circulation)**
- **Impacts of multiple stressors, possibly magnifying effects of climate change**
- **Adaptive capacity of natural and human components of Arctic system**

IMPACTS OF A WARMING ARCTIC

Thank you