“The Arctic in a Changing World”

Good Afternoon

The Scientific Results of the Arctic Climate Impact Assessment

The ACIA is a comprehensively researched, fully referenced, and independently reviewed evaluation of Arctic climate change including changes in ultraviolet radiation and their impacts for the region and for the world.

The Goals of ACIA:

- **Conduct a scientific assessment** within the expanded context of other developments and pressures on the Arctic environment, its economy, regional resources and peoples.by evaluating and synthesizing knowledge on climate variability, climate change, and increased UV radiation and their consequences/potential impacts.The Assessment engaged over 30-0 scientists from 15 countries.
- **Provide useful and reliable information to the governments**, organizations and peoples of the Arctic region in order to support policy-making processes, by examining the environmental, human health, social and economic impacts.

Changes across many sectors of Arctic

The Ten Key Findings of the Arctic Climate Impact Assessment

1. Arctic climate is now warming rapidly and much larger changes are projected.
2. Arctic warming and its consequences have worldwide implications.
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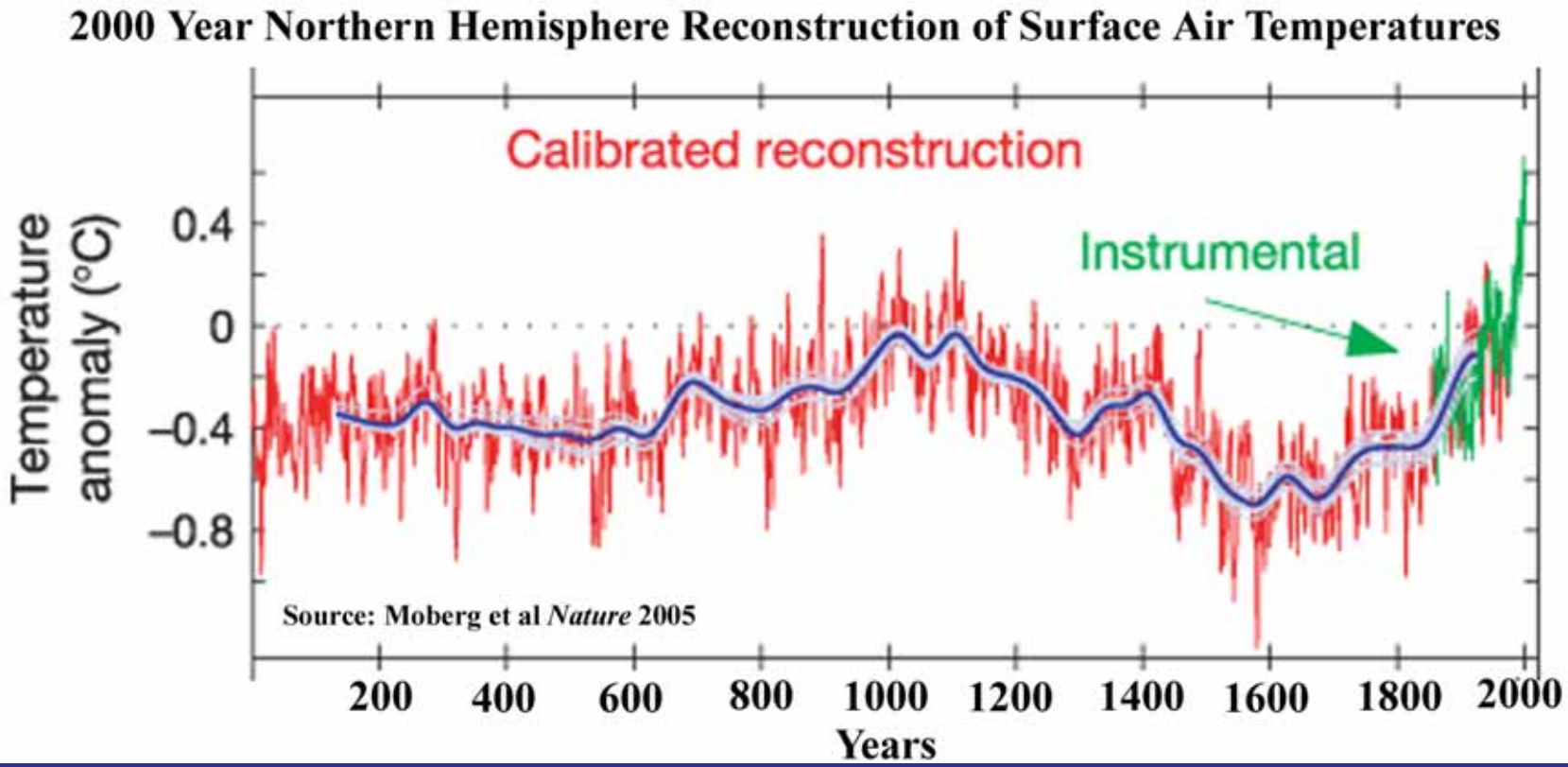
Temperature Reconstruction for the Past 2000 Years



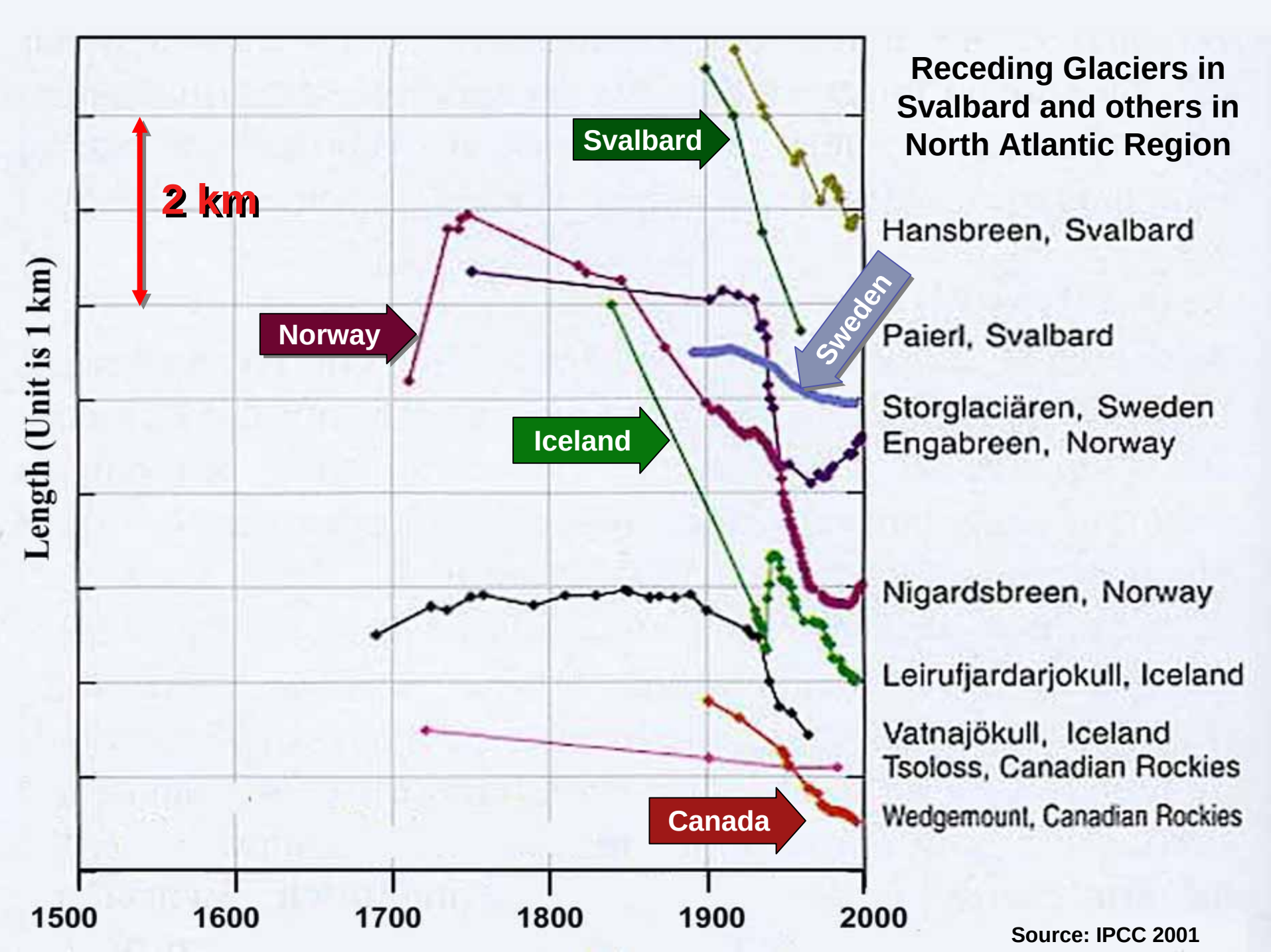
Alaska and western Canada, the average winter temperatures have increased by as much as 3 to 4˚C over the past 60 years, which is a significant increase given that the global average increase over the past 100 years has been only about 0.6±0.2°C.

IMPACTS OF A WARMING ARCTIC

Many coastal communities and facilities face increasing exposure to storms.

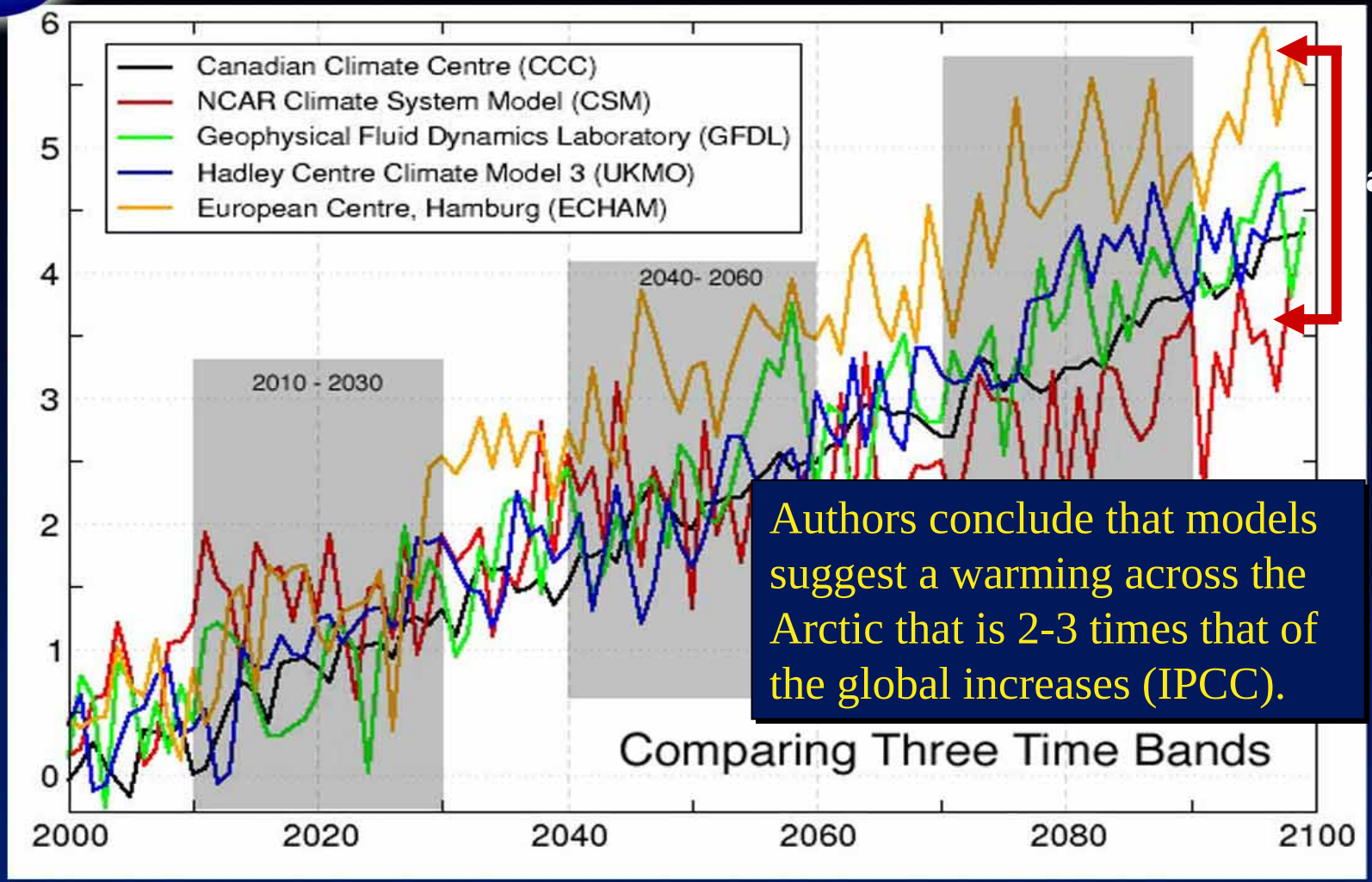
The village of Shishmaref, located on an island just off the coast of northern Alaska and inhabited for 4000 years, is now facing the prospect of evacuation.

Similar Issues at Banks Island


Receding Glaciers in Svalbard and others in North Atlantic Region
Length (Unit is 1 km)
2 km
Svalbard
Norway
Sweden
Iceland
Canada
Hansbreen, Svalbard
Paierl, Svalbard
Storglaciären, Sweden
Engabreen, Norway
Nigardsbreen, Norway
Leirufjardarjokull, Iceland
Vatnajökull, Iceland
Tsoloss, Canadian Rockies
Wedgemount, Canadian Rockies
1500
1600
1700
1800
1900
2000
Source: IPCC 2001

Arctic Surface Air Temperature

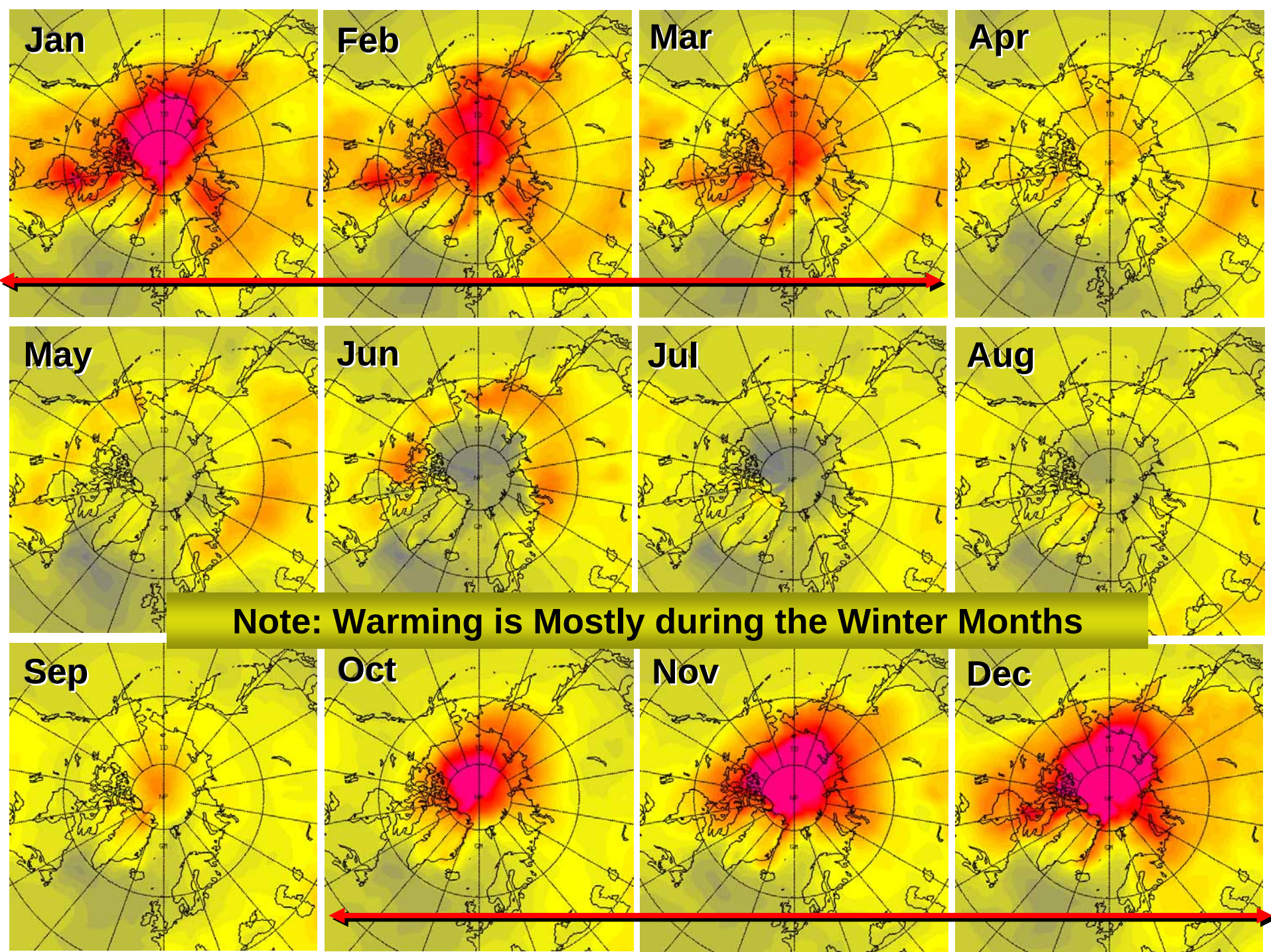
60N - Pole: Change from 1990-1999 Average (deg.C)



3.5° C to almost 6° C By 2100

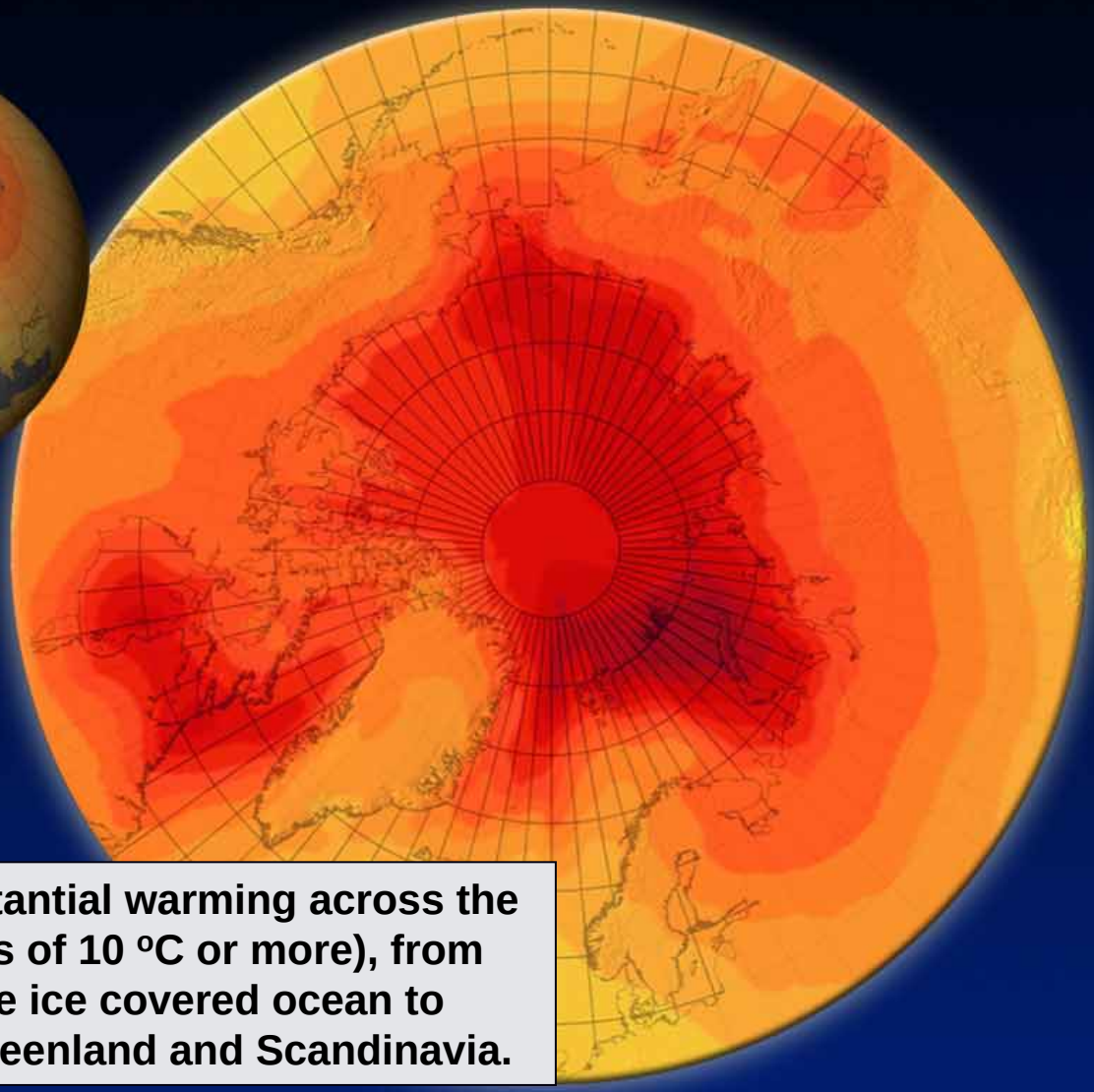
Authors conclude that models suggest a warming across the Arctic that is 2-3 times that of the global increases (IPCC).

All of the models, regardless of the emissions scenario or computer model selected, project very significant warming for the Arctic over the next 100 years.


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Note: Warming is Mostly during the Winter Months
Sep
Oct
Nov
Dec

IMPACTS OF A WARMING ARCTIC

Projected Surface Air Temperature Change: 1990s–2090s (winter Dec–Feb)



°F	°C
+21.6	+12
+18	+10
+14.4	+8
+10.8	+6
+7.2	+4
+3.6	+2
0°F	0°C

Note: The substantial warming across the Arctic, (upwards of 10 °C or more), from very warm in the ice covered ocean to less warm in Greenland and Scandinavia.

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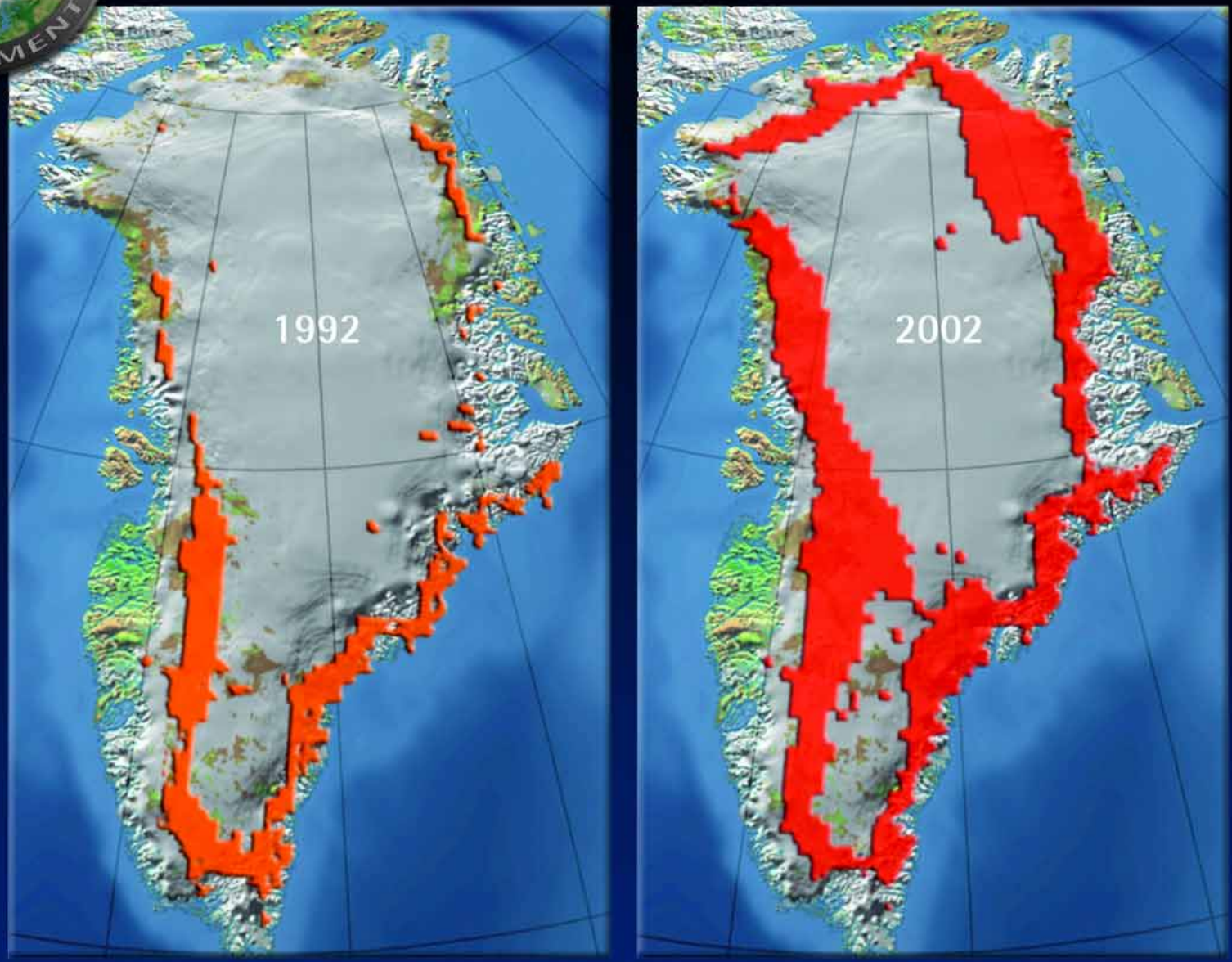
The Greenland Ice Sheet Dominates Land Ice in the Arctic

Over the past two decades, the melt area on the Greenland ice sheet has increased on average by about 0.7%/year (or about 20% from 1979 to 2005).

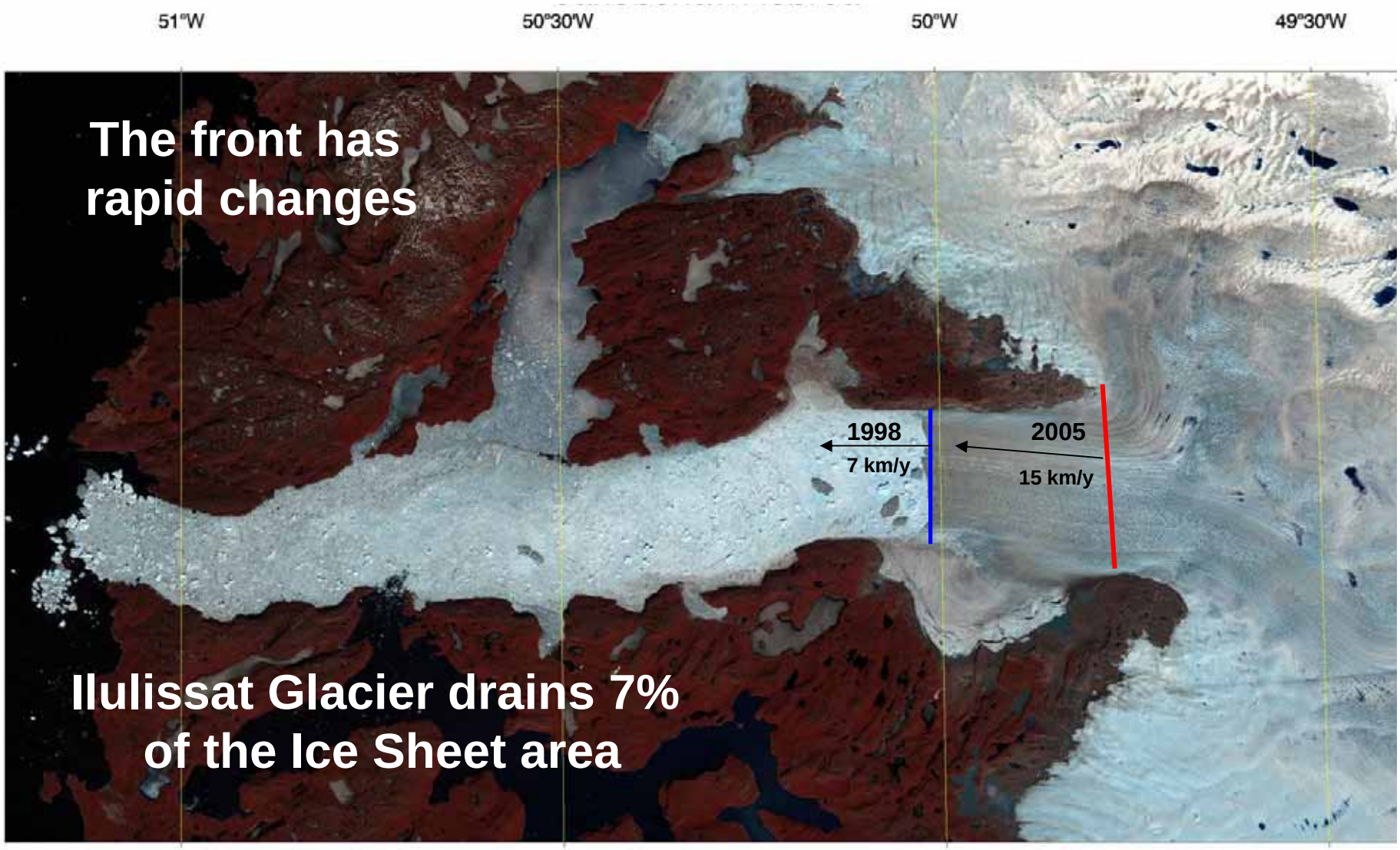
Source: Business Week Aug. 2004

IMPACTS OF A WARMING ARCTIC

Greenland Ice Sheet Melt Extent



The glacier front retreated 8 km from 2001 to 2003, the Ice Velocity increased from 10 km/yr to 15 km/yr (1.7m/hr), and the ice is thinning 10 m per year



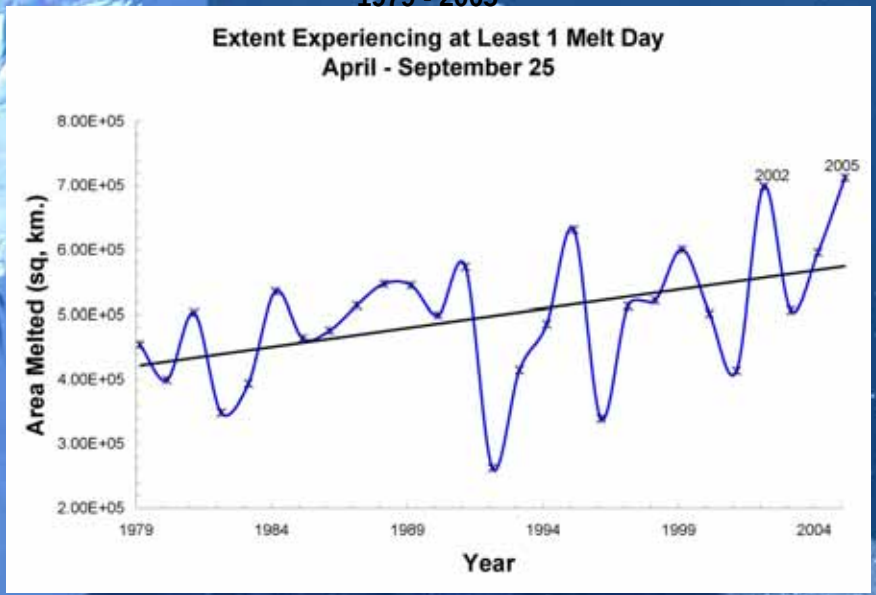
Ilulissat Glacier Retreat 1998-2005

We expect a record total melt area for 2005 given the fact that the southern and western part of Greenland are still melting in late September, whereas 2002 and 1991 experienced almost no melt in late September and during October.

Source: Konrad Steffen and Russell Huff, Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, Colorado

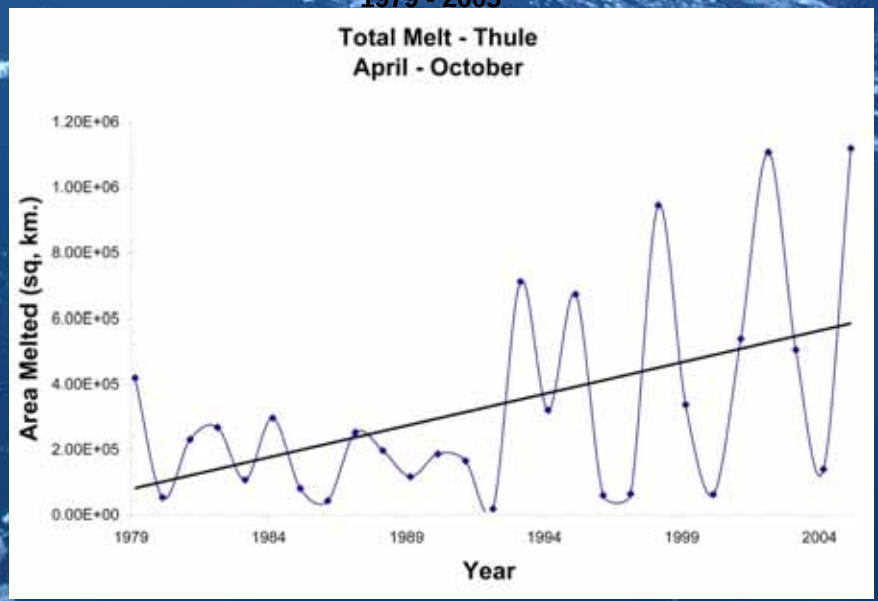
Melt Area for all of Greenland Melt

1979 - 2005



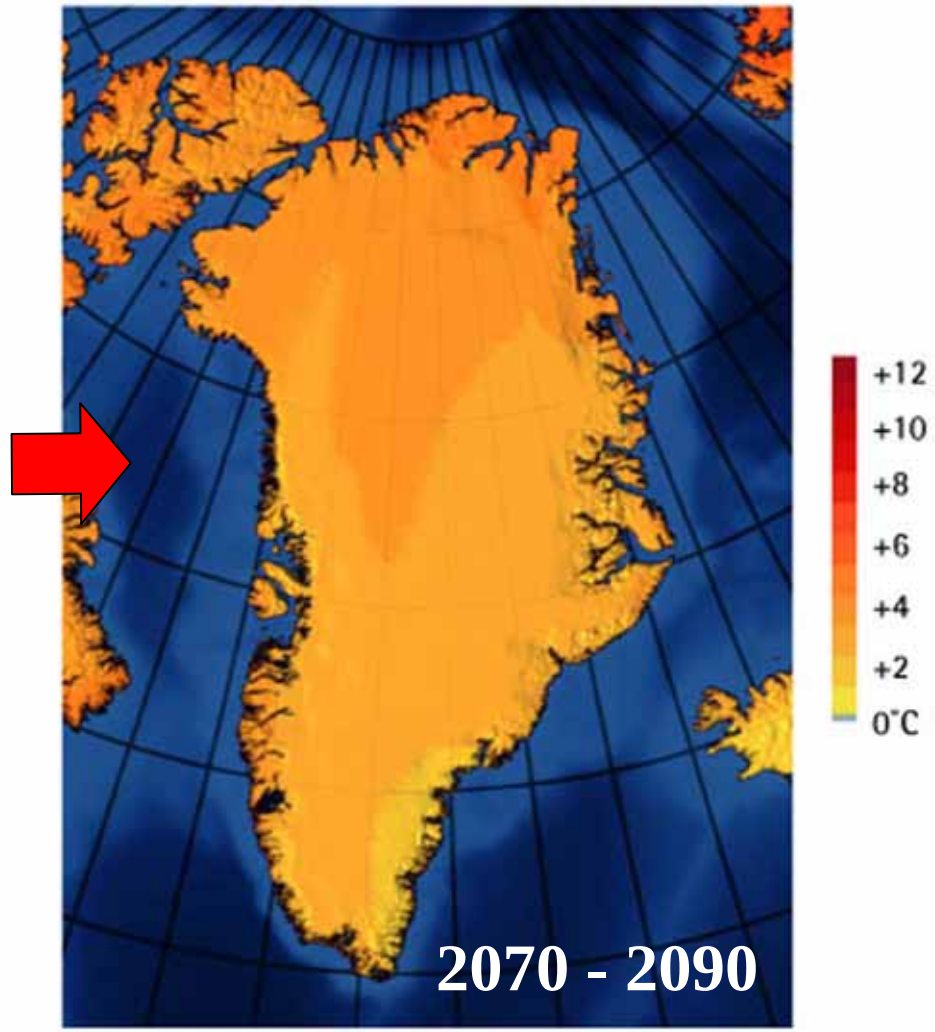
Area for NW Thule Area of Greenland

1979 - 2005



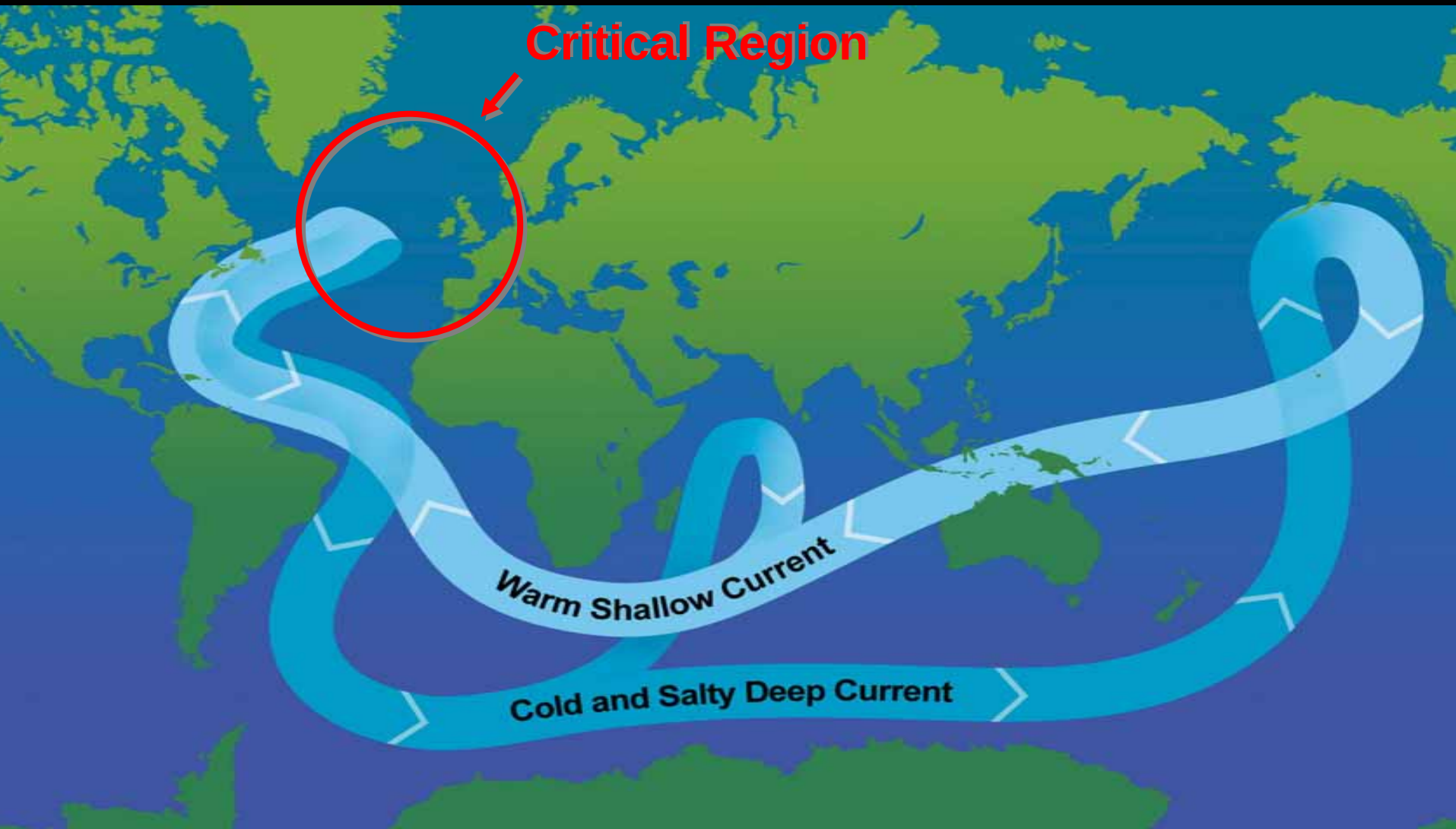
Greenland's Annual Temperatures are Projected to Increase

Projected to be in the range of + 3^0 to 6^0 C



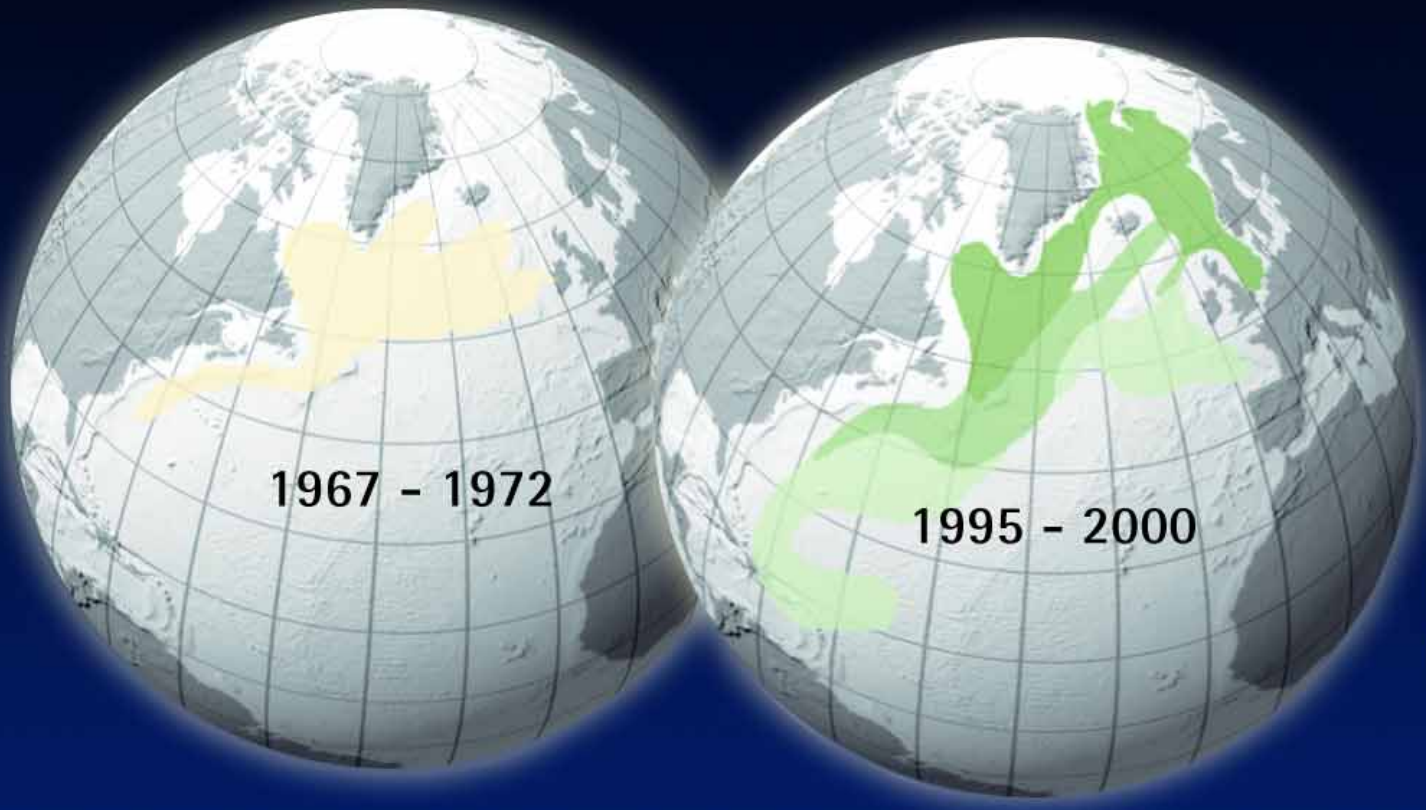
Climate models indicate that the local warming over Greenland is likely to be up to three times the global average.

Does this Melting of Sea Ice have other Effects, such as an Impacts on Oceanic Circulation?

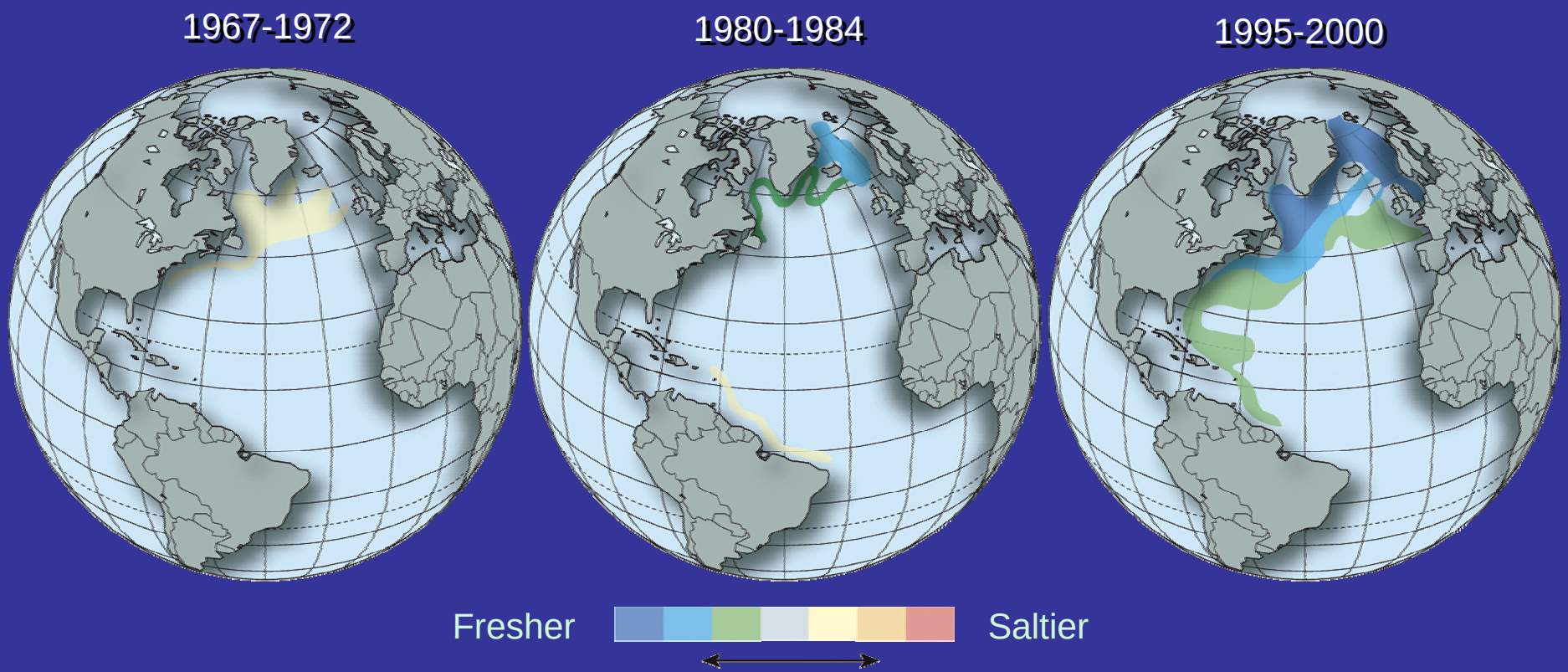


IMPACTS OF A WARMING ARCTIC

Reduced Salinity of North Atlantic Waters

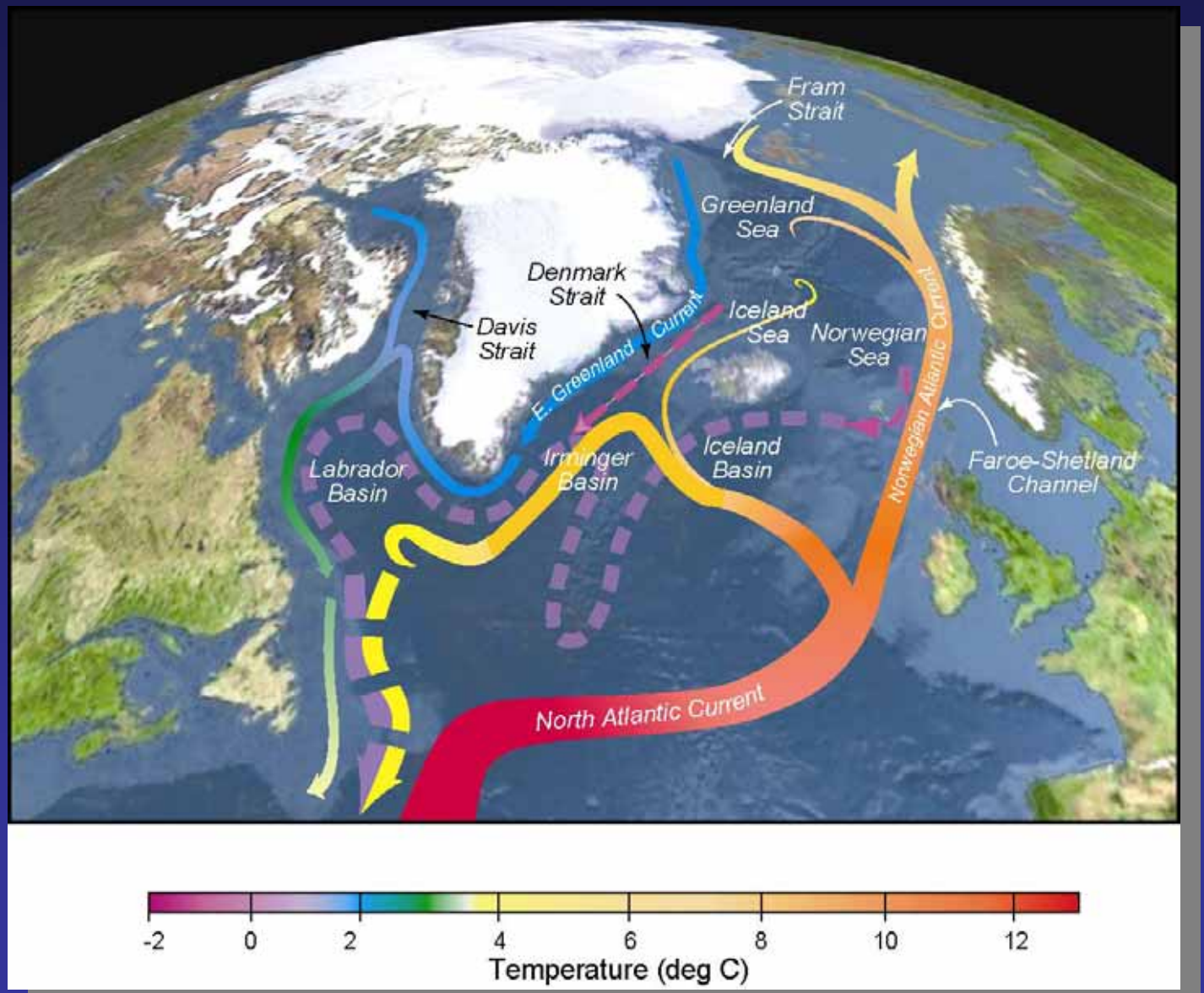


Fresher Deep Water Flowing South at 3000 m

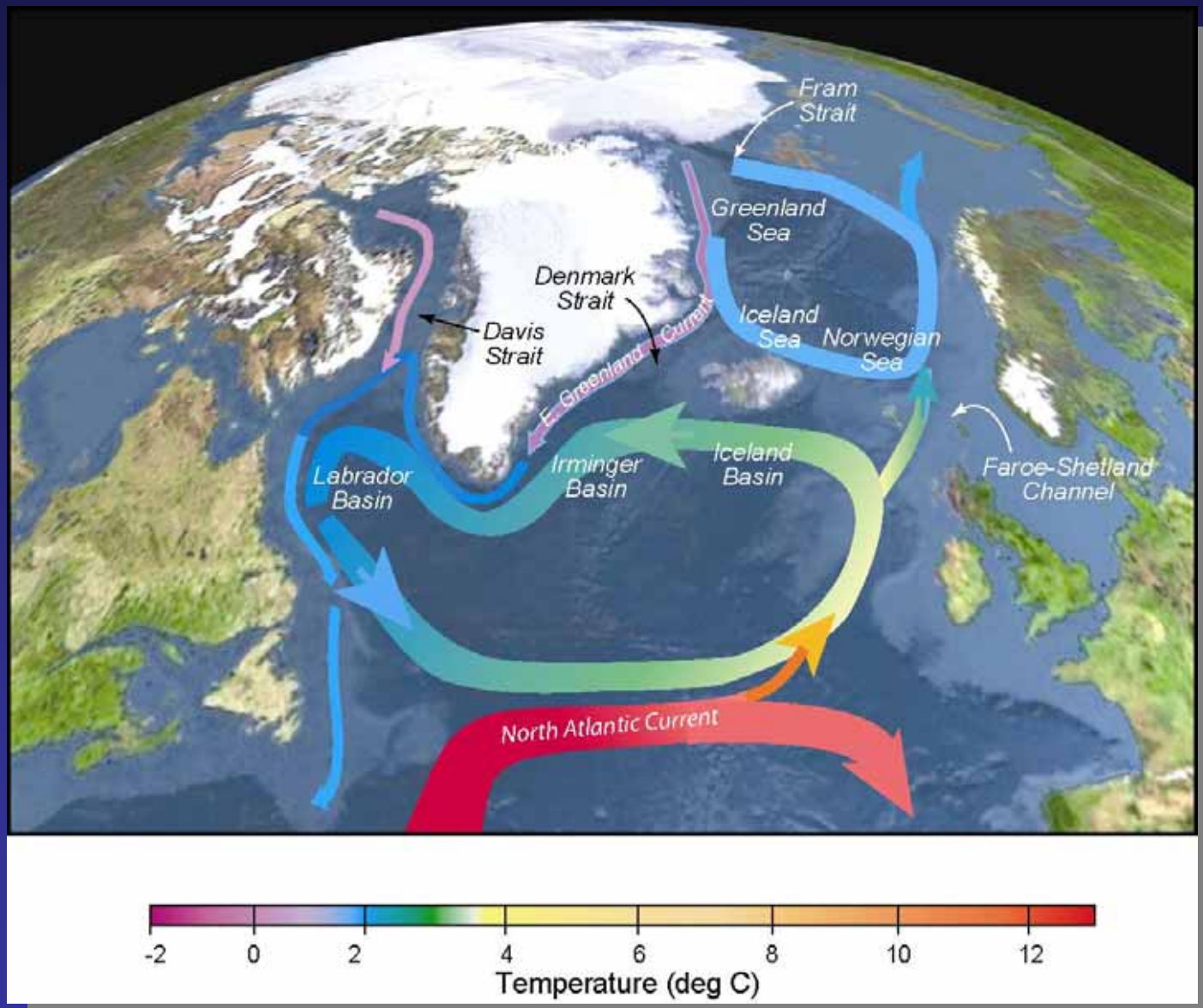


Ruth Curry (pers. comm.)

Changes in Oceanic Temperatures of Importance.



Conveyor OFF



- Strong cooling in North Atlantic
- Warming everywhere else
- No net global change

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"The Arctic in a Changing World"

Animal species' diversity, ranges, and distribution will change.

IMPACTS OF A WARMING ARCTIC

Seals are the main food of the Polar bear, without ice, the Polar bear can not effectively hunt the seal and hence maintain their body weight and long term survival.

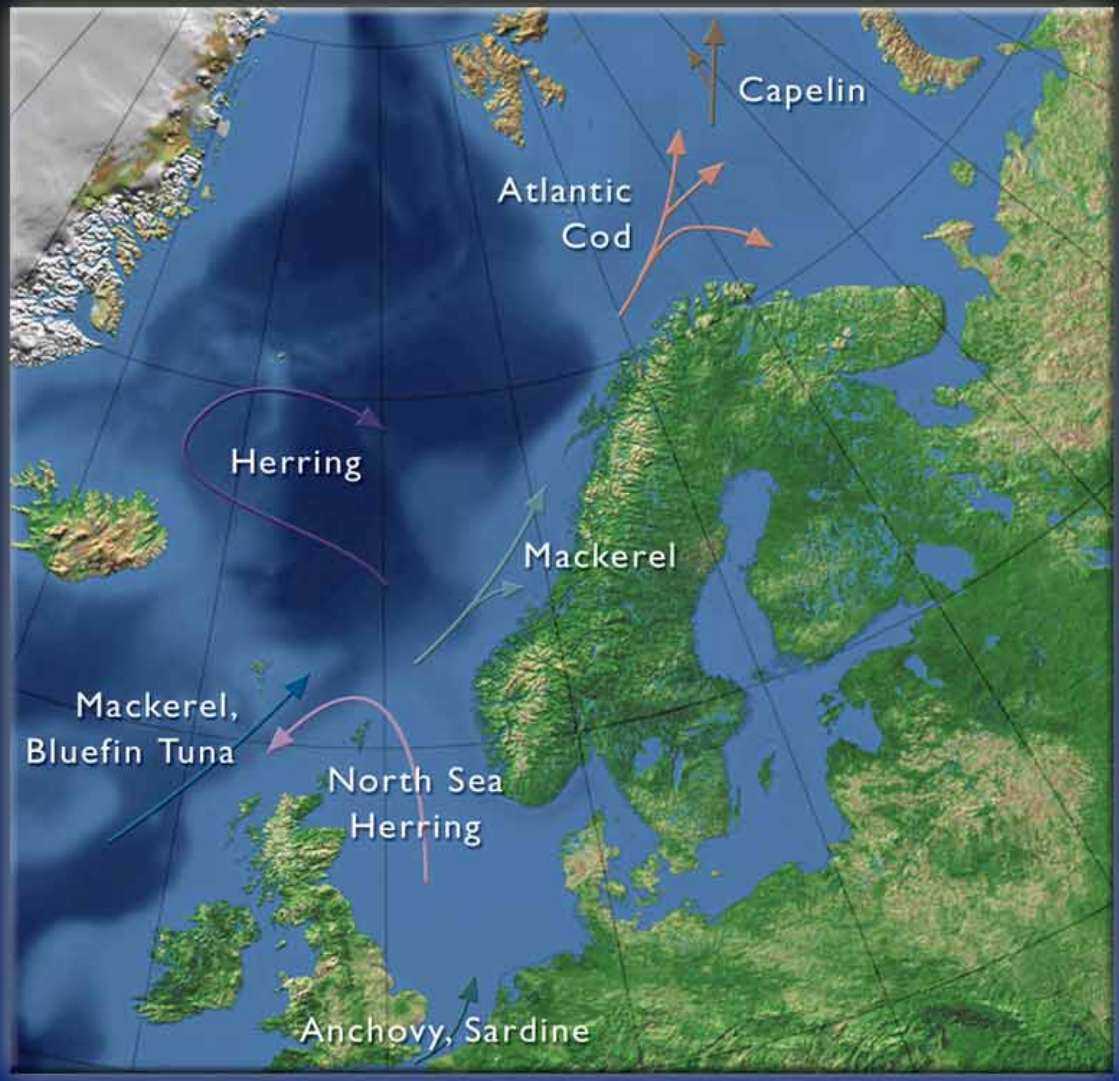
Hudson Bay

An early indicator of the changing climate

IMPACTS OF A WARMING ARCTIC

Possible Changes in Fish Distribution

Climate driven changes in marine ecosystems.



These shifts are governed by (1) changes in oceanic temperatures, (2) salinity, (3) nutrients, (4) changing patterns in North Atlantic Deep Water formation, and (5) interspecies interactions.

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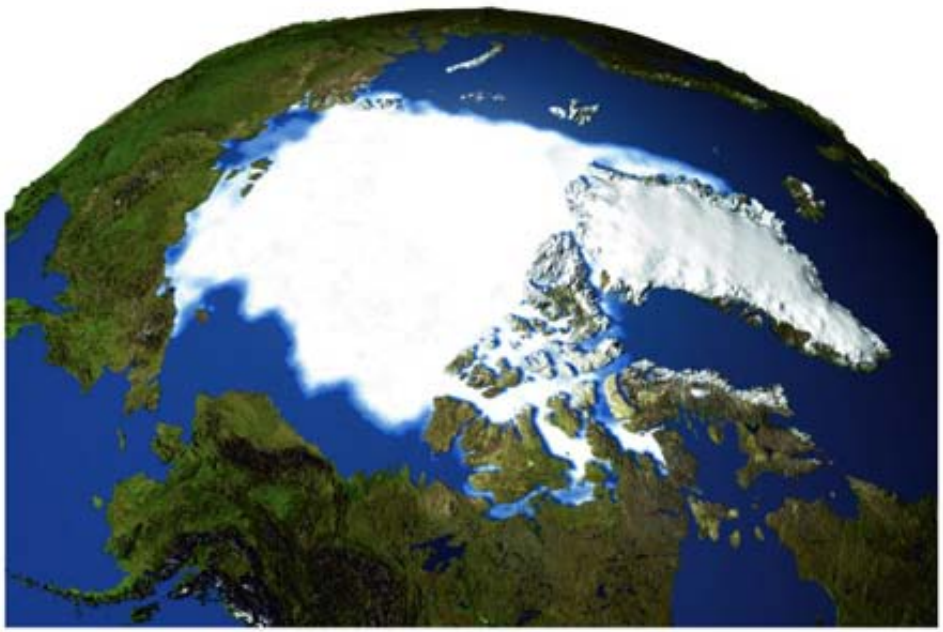
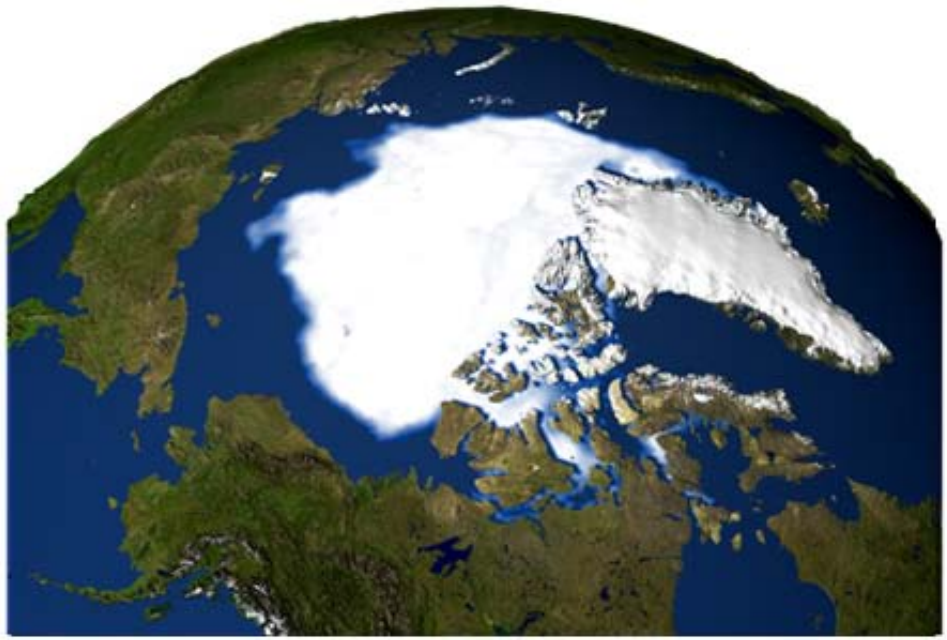
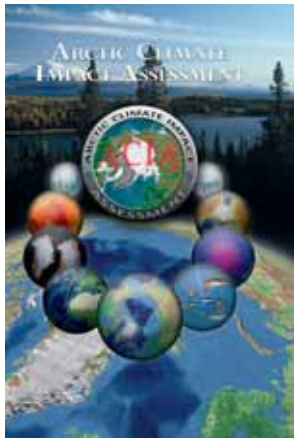
Status of the Arctic Sea Ice
What happened in 2005?

Observed Sea Ice September 1979



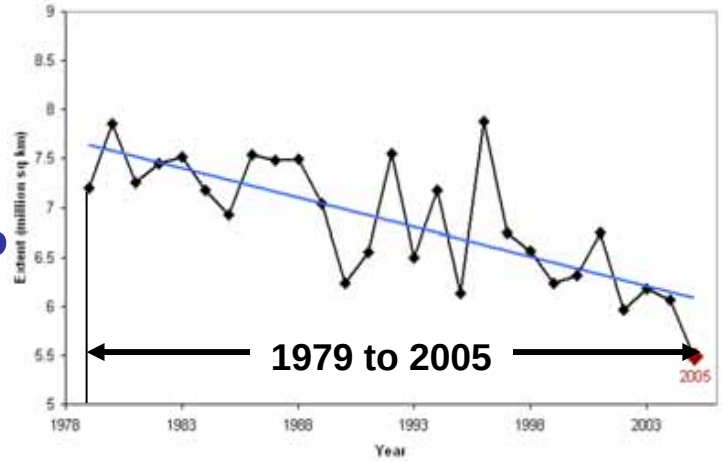
Observed Sea Ice September 2005

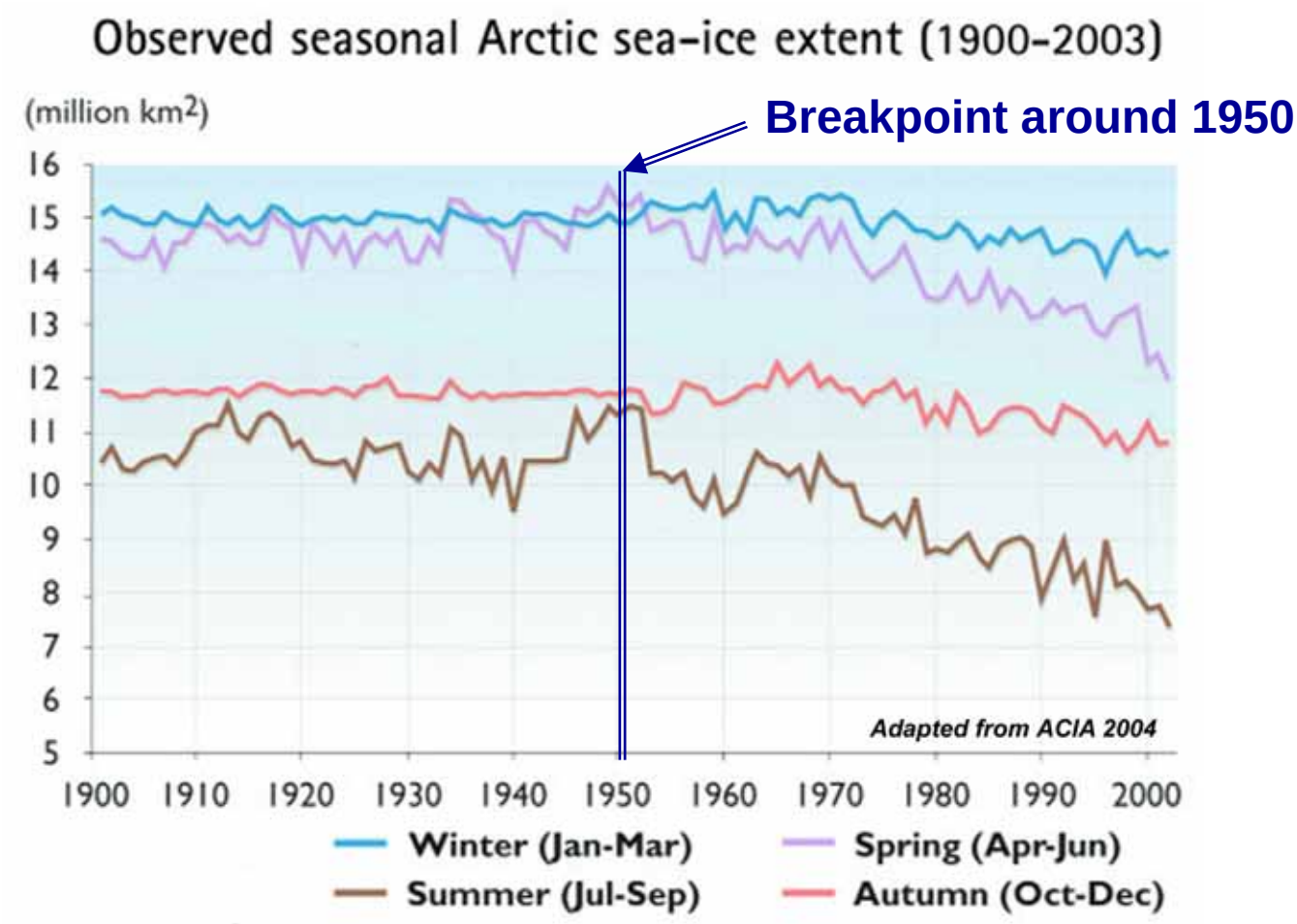




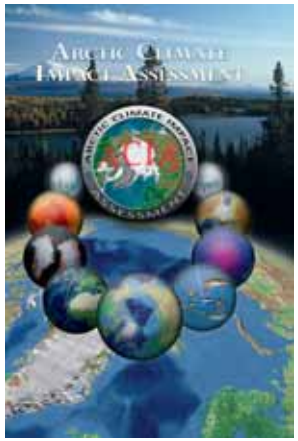
The Scientific Report

Arctic Sea Ice.
Is it a Short Term Process?

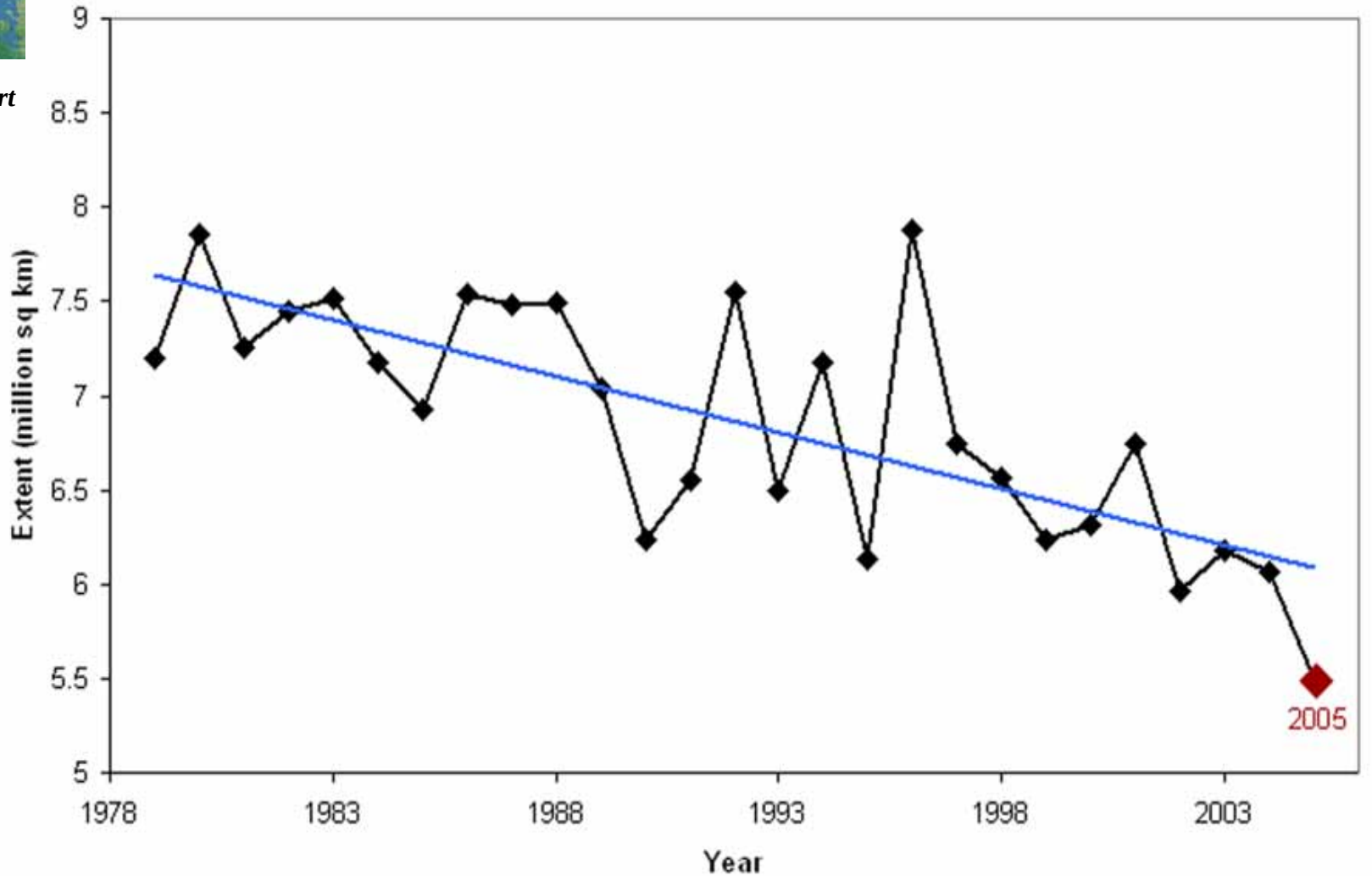




Status of the Arctic Sea Ice. What happened in 2005?



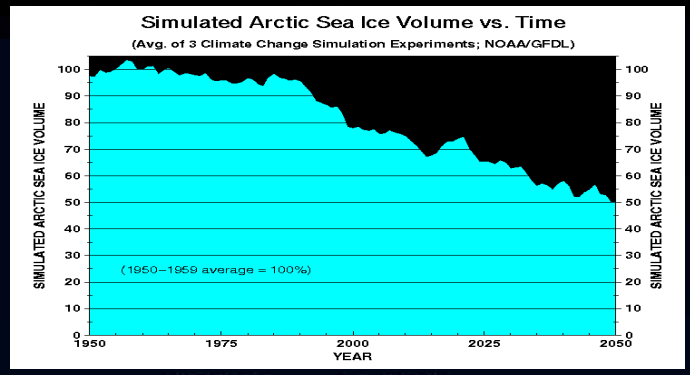
The Scientific Report



Sea Ice Movements during the Winter (Dec thru Feb)

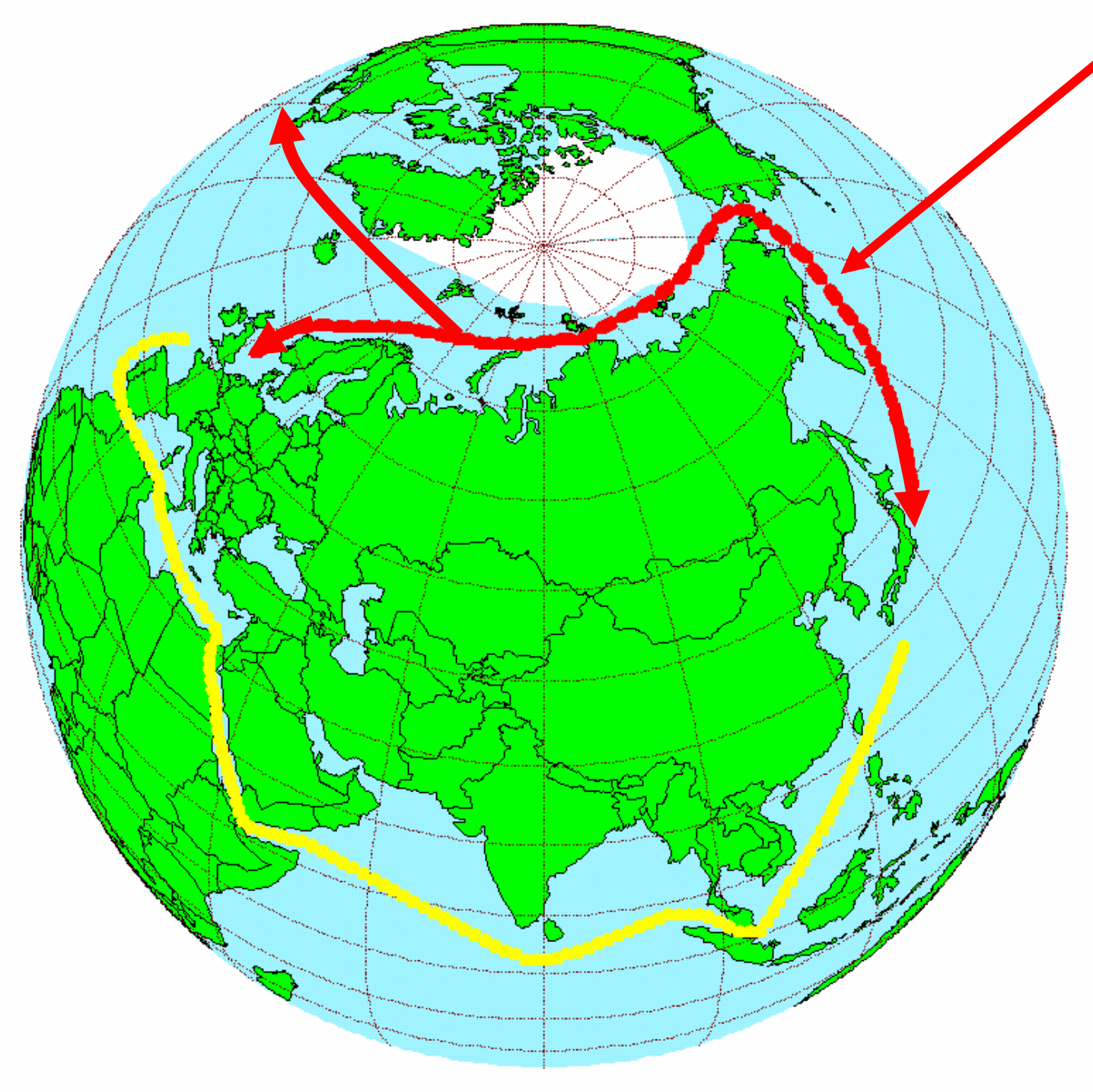
QuickTime™ and a
Cinepak decompressor
are needed to see this picture.

GFDL Simulation Projects 50% Reduction by 2050



(2010–2030) (2040 – 2060) (2070 – 2090)

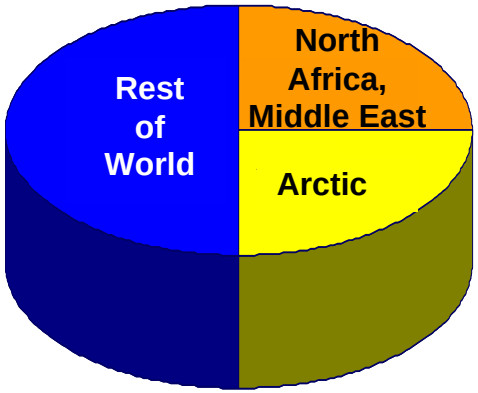
Five Models Project Sea Ice Extent for Mid-September

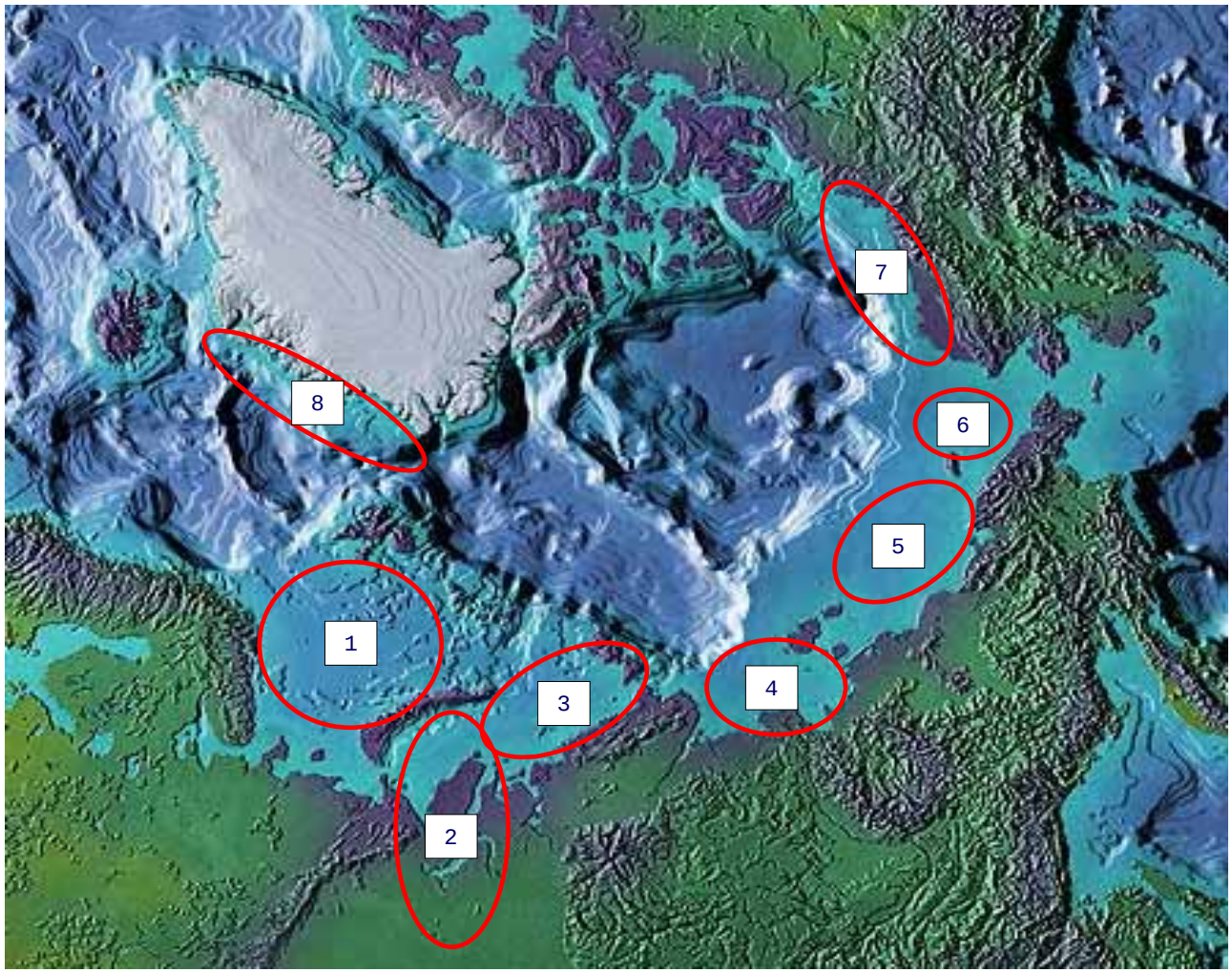


Northern Sea Route is 45% Shorter than through the Suez Canal

The ACIA models projects that the current navigation season of 20-30 days per year will increase to 3-6 months/yr by 2080, with one model indicating an ice-free summer by 2040

Worlds Petroleum Potential





1. Barents Sea
2. Southern Kara Sea and Western Siberia
3. Northern Kara Sea
4. Laptev Sea
5. East Siberian Sea
6. Chukchi Sea
7. Alaska North Slope
8. East Greenland

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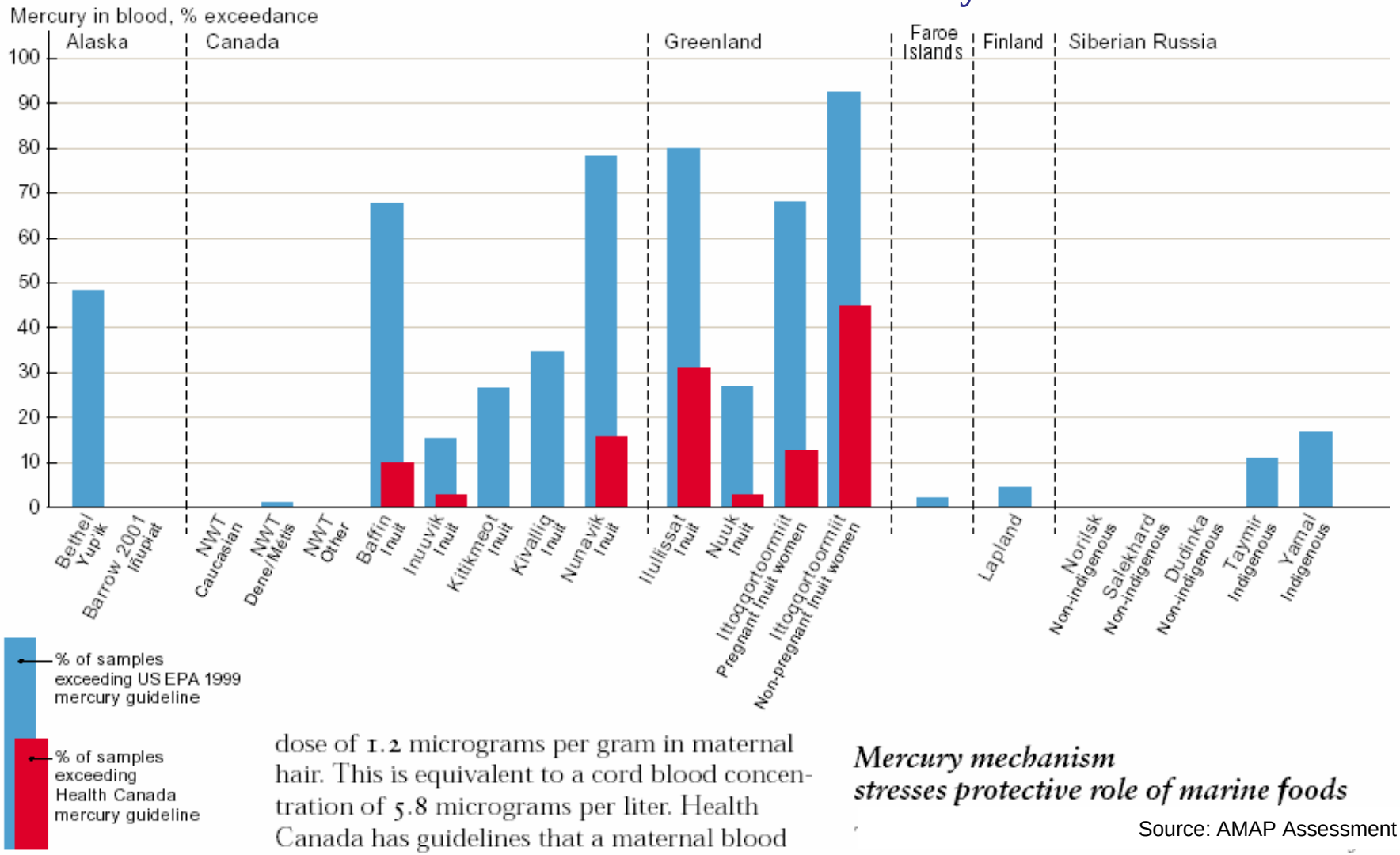
"The Arctic in a Changing World"

The Contaminants Issue:

The Human Health Issue of Mercury in Blood



dose of 1.2 micrograms per gram in maternal hair. This is equivalent to a cord blood concentration of 5.8 micrograms per liter. Health Canada has guidelines that a maternal blood

Mercury mechanism stresses protective role of marine foods

Source: AMAP Assessment

Connections between Climate Change and Zoonotic Diseases

Climate change will have significant effects on animal species including:

- **Changes in range**
- **New migratory pathways**
- **Mixing of species**
- **Stress and population reductions**

All of these effects will alter the balance, distribution and occurrence of infectious disease agents.

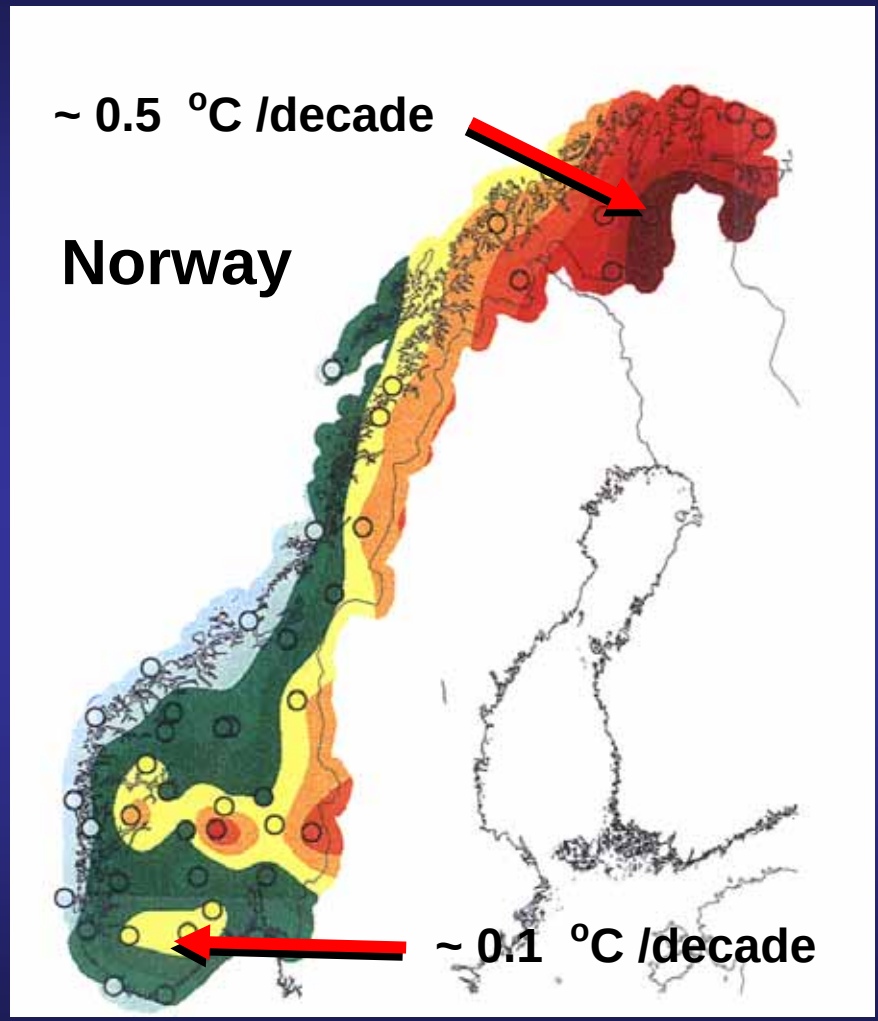
What have we learned of Essential Importance?

Two Critically Important Thoughts:

- **Changes and Impacts are Felt at Local Levels**
- **The Ocean Controls the Magnitude and Timing of Climate Processes and Change**

Impacts are Local:

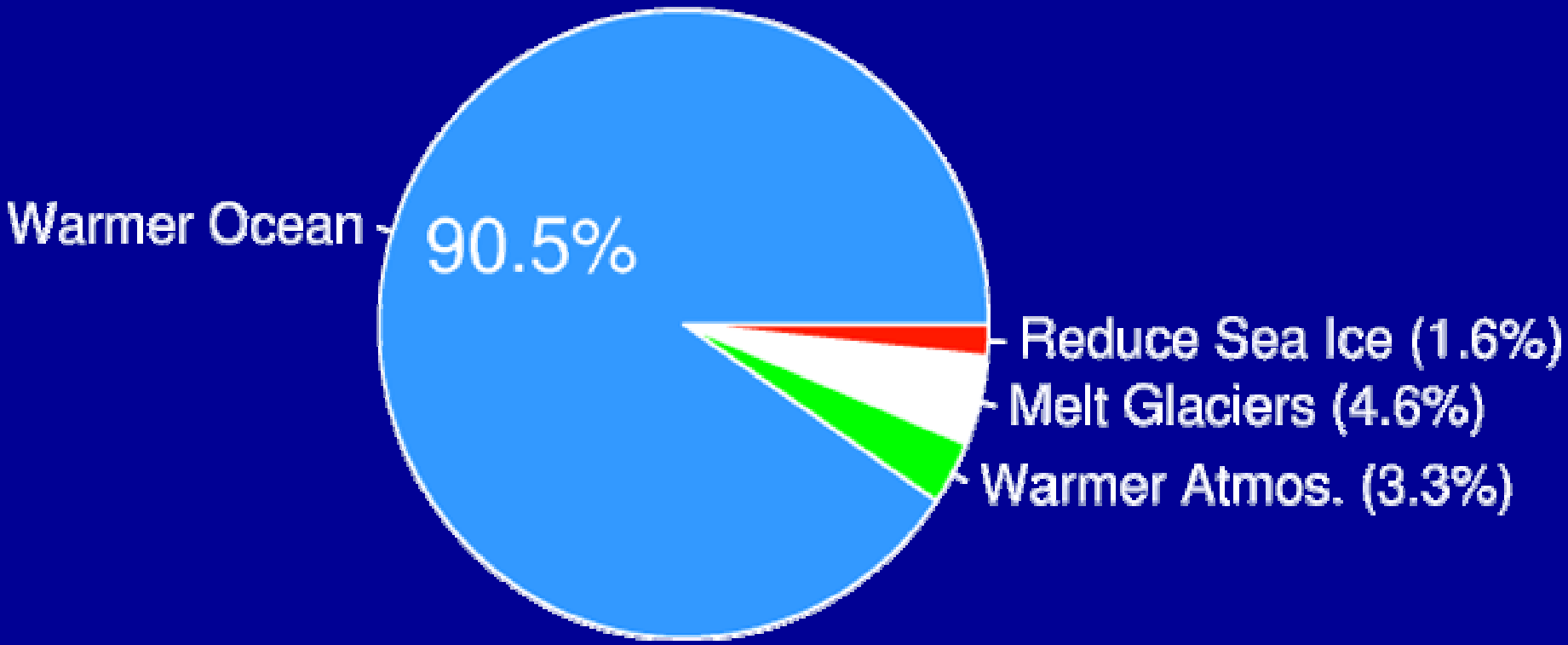
While IPCC and climate and global change research, during the past 10-20 years, have substantially enhanced and deepened our knowledge of the global means and large-scale trends of climate change and is consequences, the reality is that now **we must extend that knowledge to the regional or more local scales** where the "patchiness", extremes, and "surprises" are most likely to be expressed. This is where residents, stakeholders, and governments "see" the consequences of climate variability and change.



Regional variations are significant.

Why are the oceans Important?

Because, that is where the heat goes !



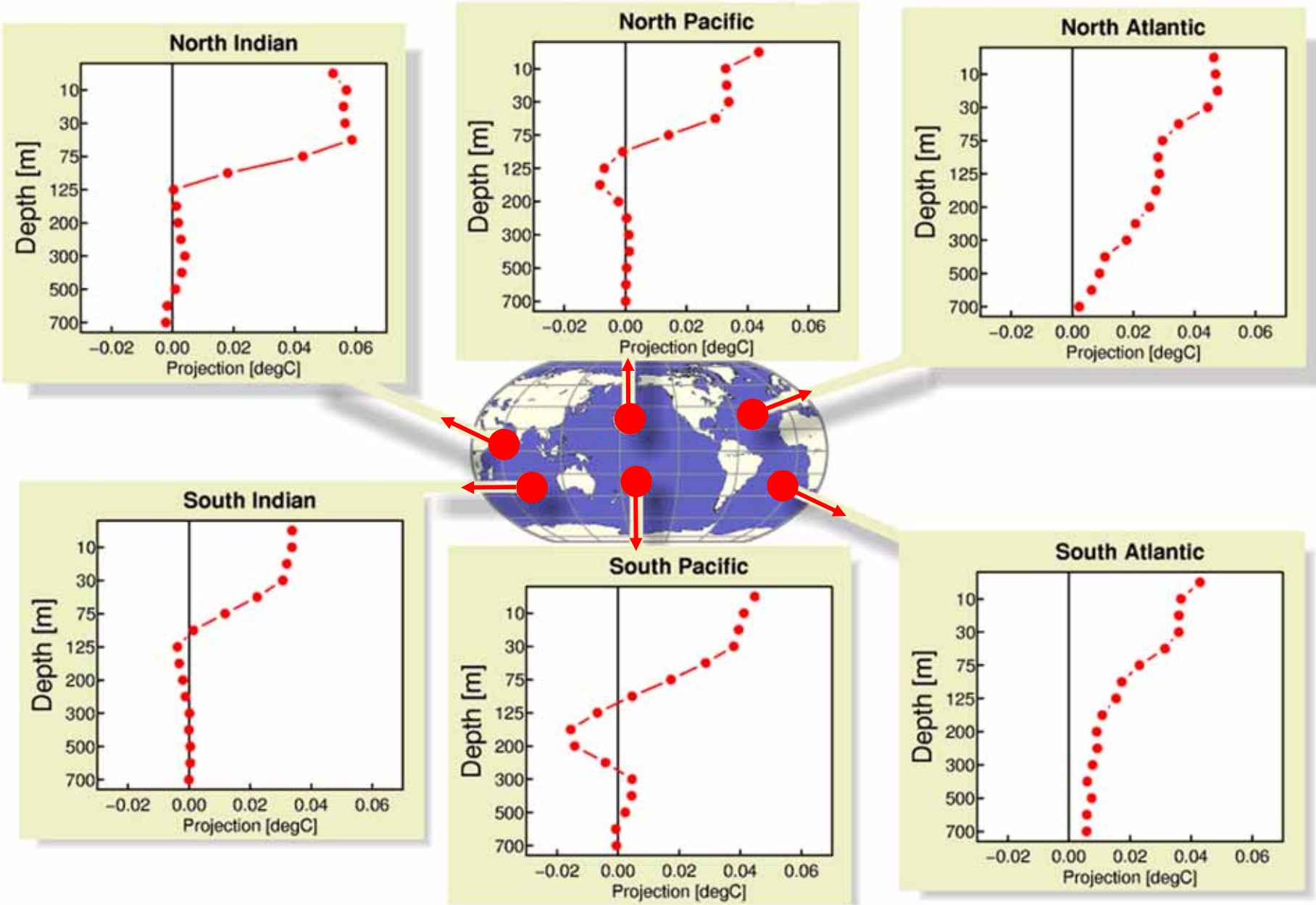
Data from Levitus et al, *Science*, 2001

How will the Oceans Change as the Earth Warms?

- The oceans will warm, sea level will rise, salinity balance will be altered, and it's ability to absorb CO_2 will change.
- It will impact atmospheric circulation, storm tracks, severe storms, and the frequency and distribution of droughts

Penetration of Ocean Warming Signal (1955–1999)

Red = Millions of observations from the World's Oceans over 40 years and down to 700 meters.



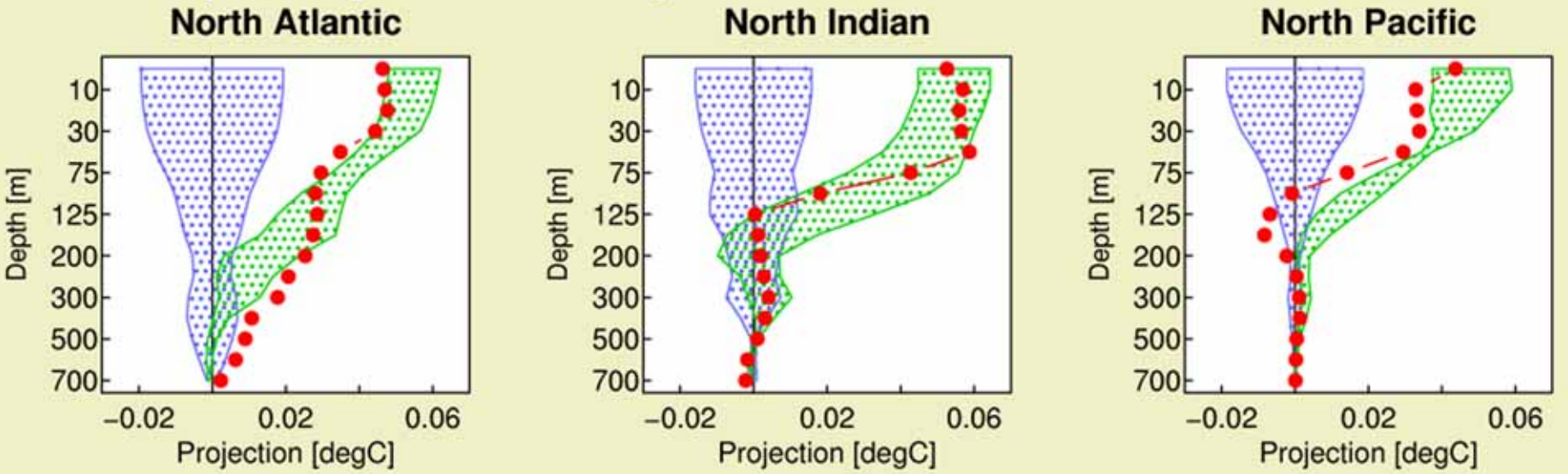
Global Warming of the World's Oceans (T.P. Barnett, et al 2005)

No Anthropogenic Forcing (Blue)

With Anthropogenic Forcing (Green)

Observational Data (Red)

HadCM3 (Hadley CM3 Model)



Key:

Blue: Temperature distribution with no anthropogenic forcing (the blue swath). Signal strength values falling within this region can be forced simply by 'natural variability'.

Green: Temperature distribution produced by five different climate-change model runs with anthropogenic forcing (greenhouse gasses and aerosols produced by human activity).

Red: The red dots show the signal strength estimated from the observations. The agreement between what is observed, and what is expected to arise from anthropogenic forcing, is excellent in all ocean basins.

Earth's Energy Imbalance: Confirmation and Implications

James Hansen, et al (*Science* 2005)

Significance of Hansen's *Science* Paper:

The Earth is now absorbing 0.85 +/- 0.15 W/m^2 more energy from the Sun than it is re-emitting back into space. This imbalance is confirmed by precise measurements of increasing ocean heat content over the past 10 years.

Major implications:

> ***"An expectation of additional global warming of about 0.6^{o}C without further change of atmospheric composition."***

Couple of Thoughts about the Knowledge - Policy Interface:

- **The Nest within which the scientific assessments are conducted, and**
- **The Interface between Science and Public Policy.**

A Critically Important Issue to the Science-Policy Interface!

The literature is clear that assessments and the development of policy-relevant science are more likely to be effective to the extent that they are credible, salient, and legitimate to users.

- **Credibility (Is it true?)** The scientific and technical objectivity and "believability" of the assessment.
- **Salience (Is it relevant?)** The ability of an assessment to address the particular concerns of a user-community.
- **Legitimacy (Is it fair?)** A legitimate assessment process is one that has been conducted in a manner that allows users to be satisfied that their interests were taken into account and that the process was a fair one.

The Challenges of Taking Knowledge to Action

Action

- UNFCC
- Action Agreements
- National Action Plans
- Regional Action Plans
- Local Action Plans
- Etc.

Taking Knowledge through Wisdom to Action

- Political Realities
- Moral Judgments
- Culture
- Ethics
- Values

Valley of Indecision and Delay

Focusing Knowledge and Insights

- IPCC
- ACIA, AMAP, MA, etc.
- Country Assessments
- Regional Assessments

The Challenges of Understanding Climate Change in The Arctic Region

The principle findings of the ACIA are contained in three documents:

- **The Scientific Report -- Over 1000 pages**
- **The Overview Report -- 140 pages**
- **The Policy Recommendations Report**

These can be purchased from Cambridge University Press (www.cambridge.org) or on the Web at the ACIA Website (www.acia.uaf.edu)


ARCTIC CLIMATE IMPACT
ACIA
ASSESSMENT
Thank You
www.acia.uaf.edu