



State of the Arctic: *2009 Science Review*

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KEY POINTS

- **State of the Arctic: 2009**
- **Future outlook**
- **Impact of communicating change**

NOAA Arctic Report Card

- **A web-based tool describing the effects of climate change on the Arctic**
- **Provide clear, reliable and concise information on recent environmental conditions in the Arctic, relative to historical time series records**

NOAA Arctic Report Card

- Ø Consensus review by team of international scientists
- Ø Peer- reviewed
- Ø Initiated in 2006 with State of the Arctic Report
- Ø Focus on physical components
 - Atmosphere
 - Ocean
 - Sea Ice
 - Land
- Ø Biology section added in 2007
- Ø Web- based format
- Ø Updated annually



Arctic Report Card: *Update for 2009*

Arctic Report Card - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.arctic.noaa.gov/reportcard/

Arctic Report Card

Arctic Report Card: Update for 2009

Tracking recent environmental changes

Home Atmosphere Sea Ice Ocean Land Greenland Biology

Warming of the Arctic continues to be widespread, and in some cases, dramatic. Linkages between air, land, sea, and biology are evident.



01 02 03 04 05 06 07 08 09

Greenland: Glaciers are losing floating ice

Ocean break-off point on Helheim Glacier in SE Greenland.
Credit: NASA/Wallops

Atmosphere	Ocean
Sea Ice	Greenland
Biology	Land

Red boxes: Consistent evidence of warming.
Yellow boxes: Many indications of warming.

Atmosphere
Large scale wind patterns impacted by loss of summer sea ice

Sea Ice
Multi-year sea ice is being replaced by first year sea ice

Ocean
Upper ocean remains warm and less salty

Land
Increased runoff in Siberia, less snow in North America

Greenland
Ice sheet loss continues

Biology
High Arctic species impacted by loss of sea ice

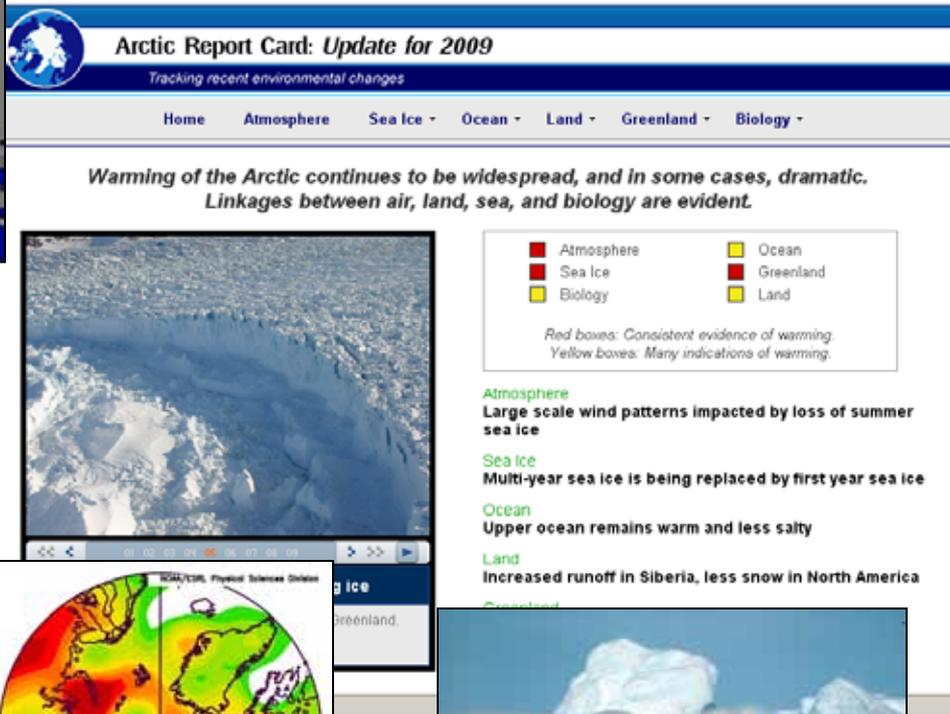
Done

Arctic Report Card

Update for 2009



Sea ice cover



Arctic Report Card: Update for 2009
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■ Atmosphere	■ Ocean
■ Sea Ice	■ Greenland
■ Biology	■ Land

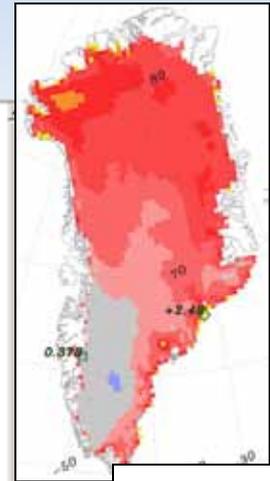
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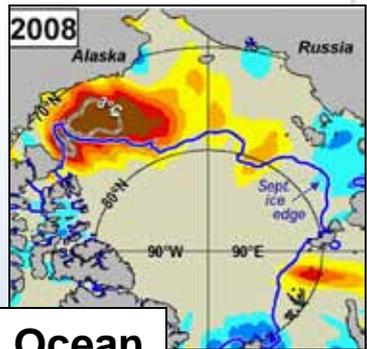
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Ocean
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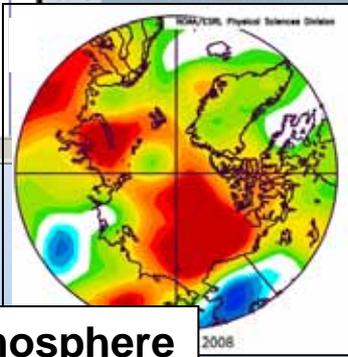
Land
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Greenland



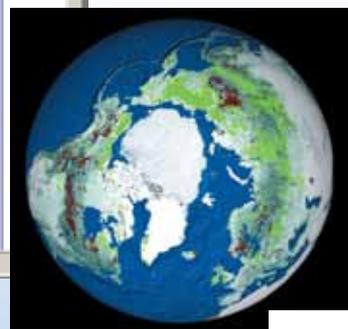
Ocean



Atmosphere



Biology



Land

Arctic Report Card

Arctic Report Card: Update for 2009
Tracking recent environmental changes

Home Atmosphere Sea Ice Ocean Land Greenland Biology

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Legend:
Red boxes: Consistent evidence of warming.
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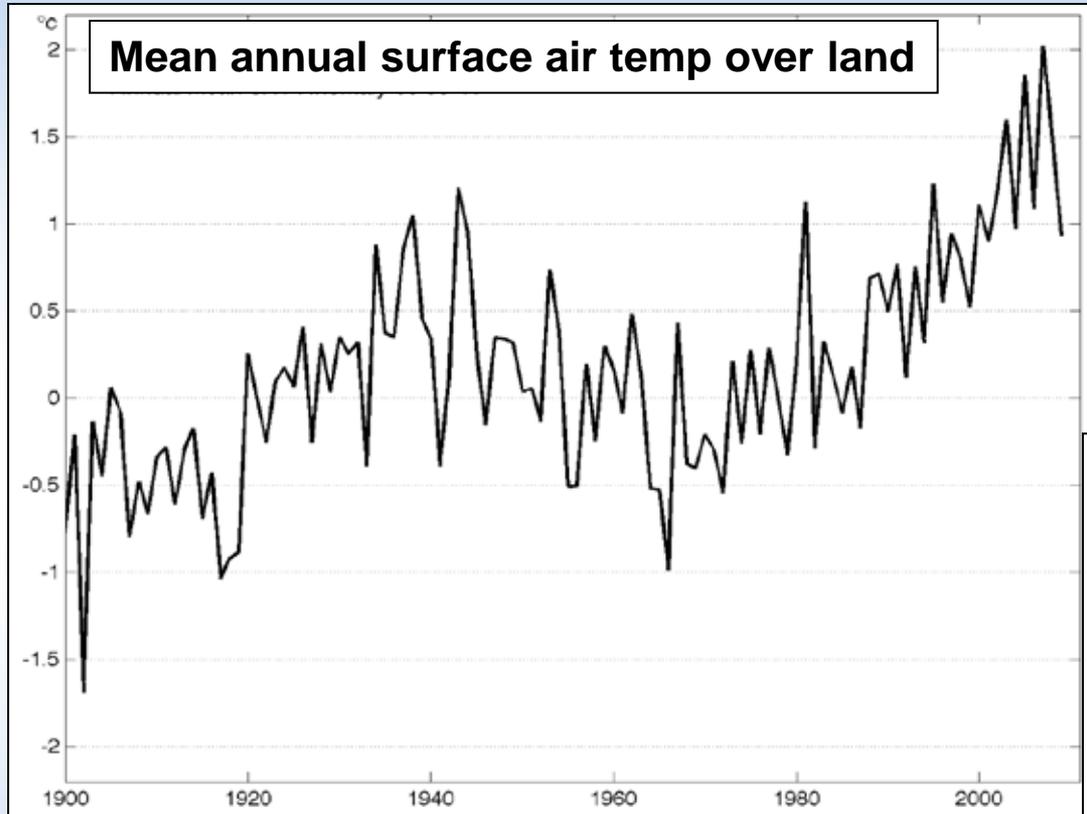
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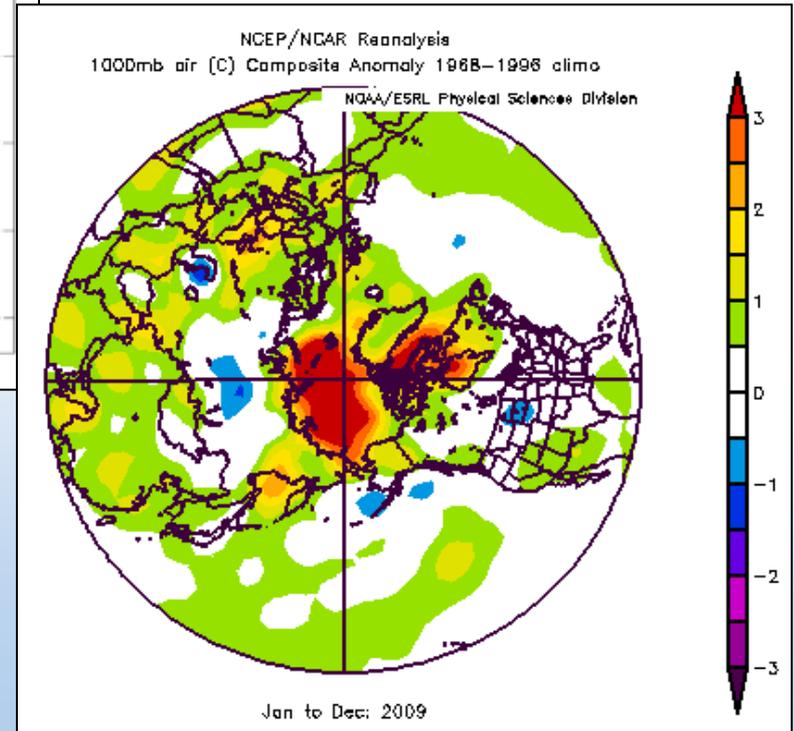
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Credit: NASA/Wallops

Done

ATMOSPHERE



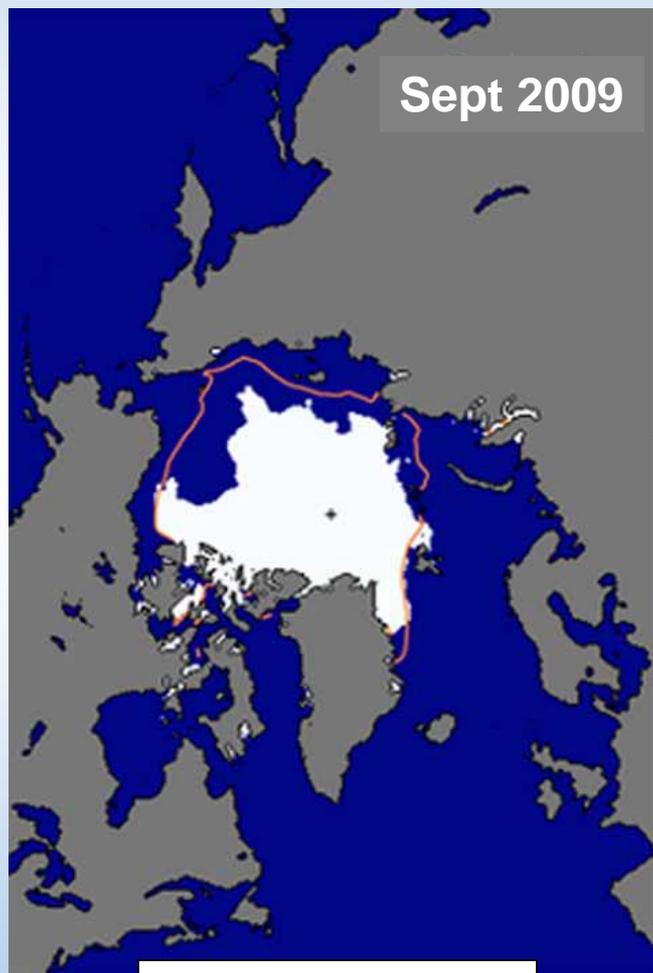
- 2009: Cooler
- Generally warming surface air temp since late 1960's



- Relatively warm temps over the entire Arctic region
- Maximum of +4°C (!) in fall

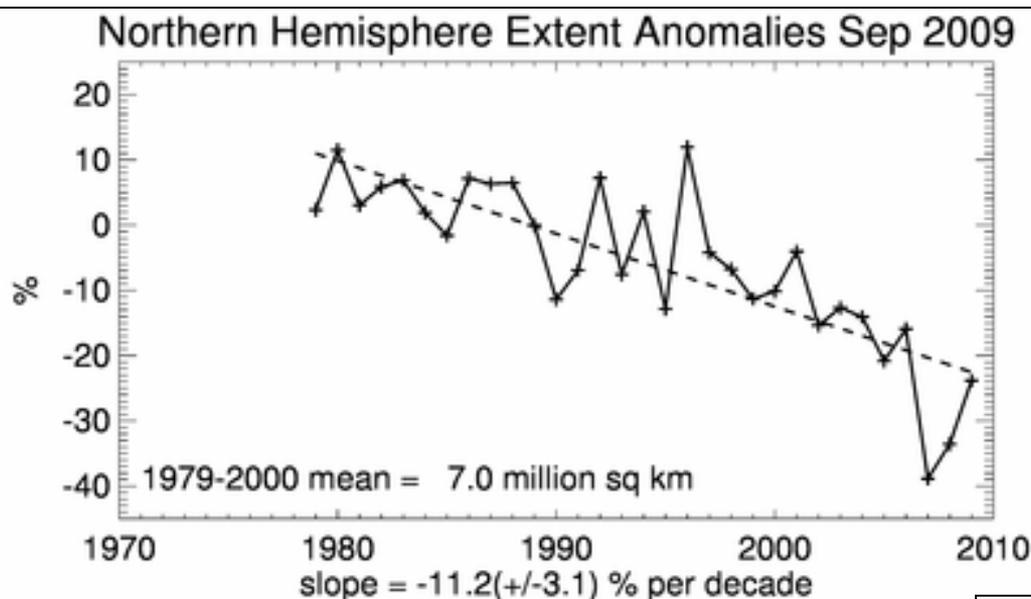
SEA ICE COVER

Minimum Extent: September



5.1 million km²

- Downward trend
- Dramatic decrease in extent 2007
 - 39% below 1979-2000 average
- Rebound in 2008 and 2009
- Still relatively small



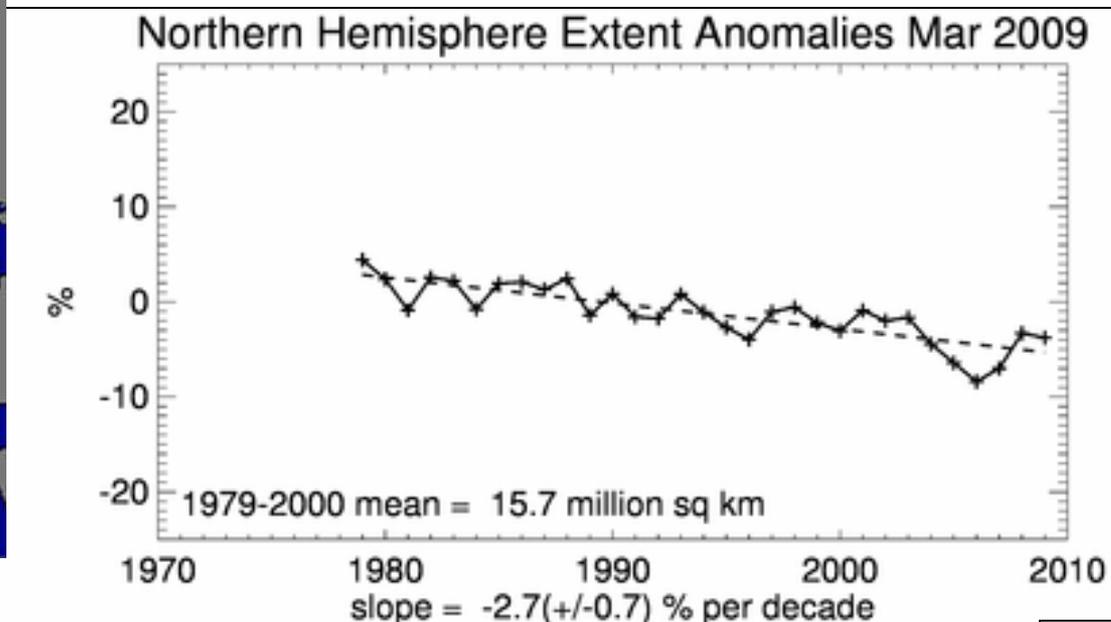
SEA ICE COVER

Maximum Extent: March



15.2 million km²

- Downward trend
- Much less pronounced than summer
- Recently above trend line



SEA ICE THICKNESS

*Thick vs. Thin Ice
(Old vs. Young Ice)*

Winter

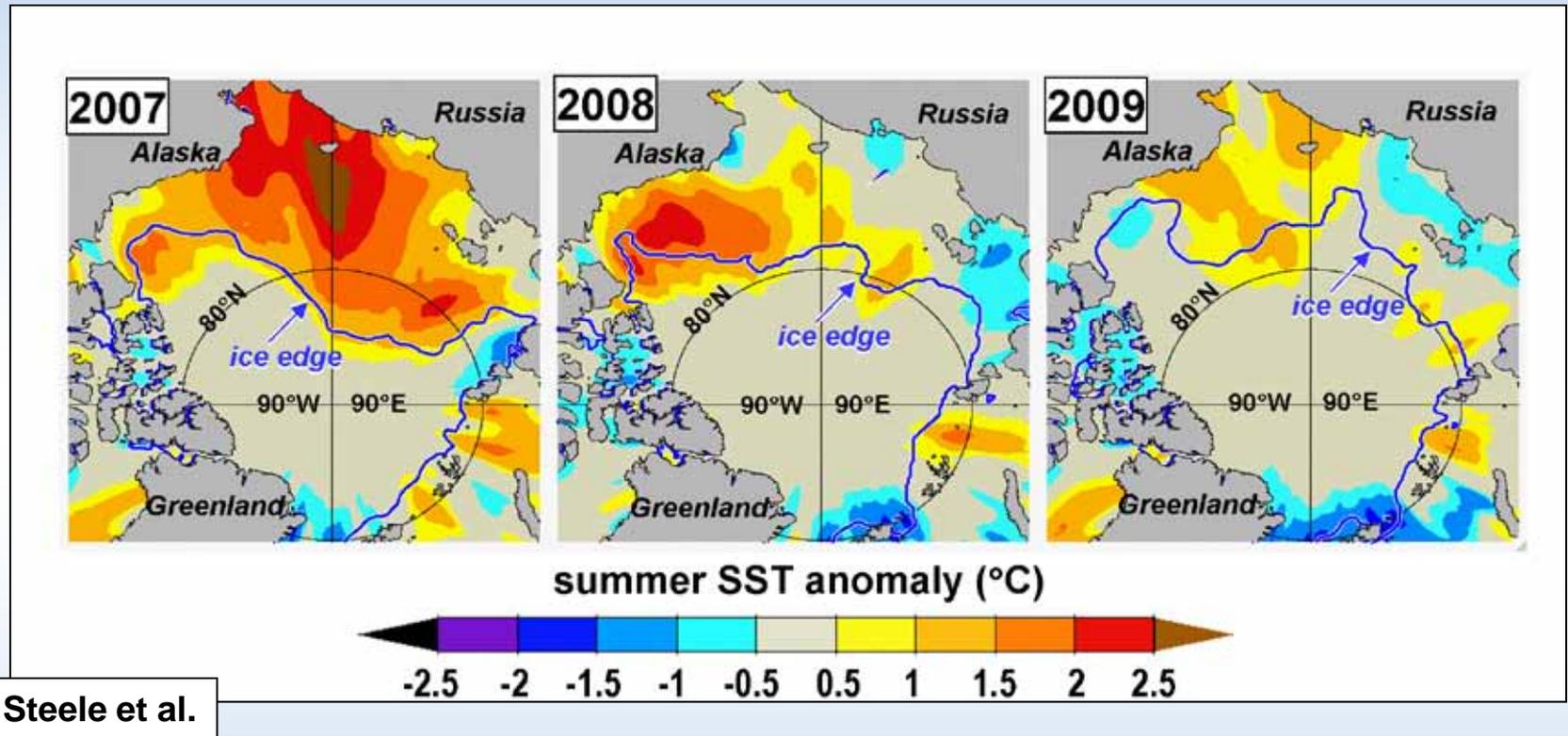


NSIDC

- *Dramatic loss of older, thicker ice*
- *Impact persists into summer*

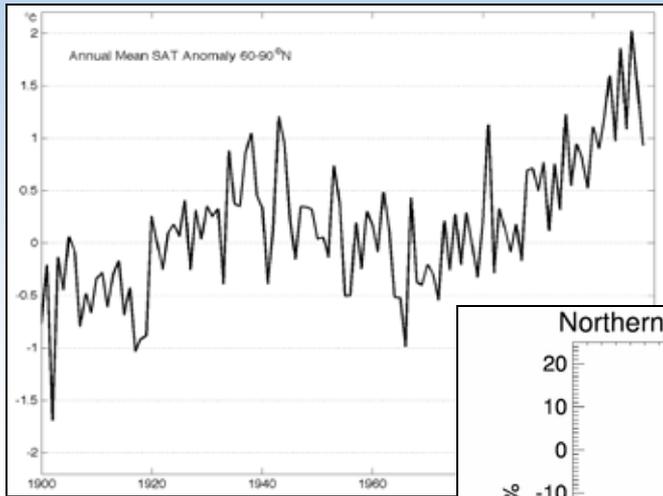
OCEAN

Sea Surface Temperature: Summer

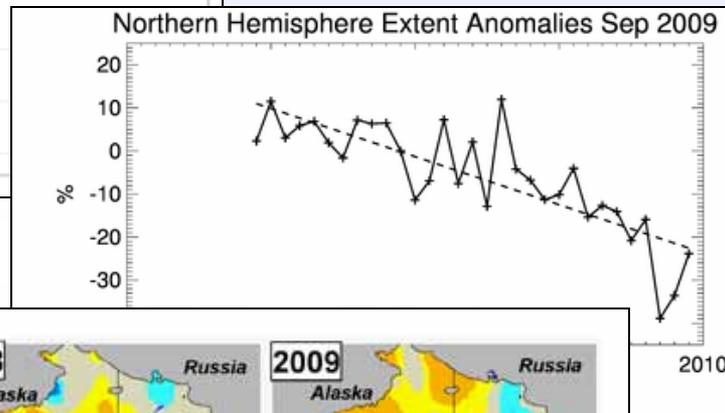


- Pronounced warming since 1995
- Maximum change in marginal seas
- Corresponds to ice-free regions
- Cooling since 2007 maximum

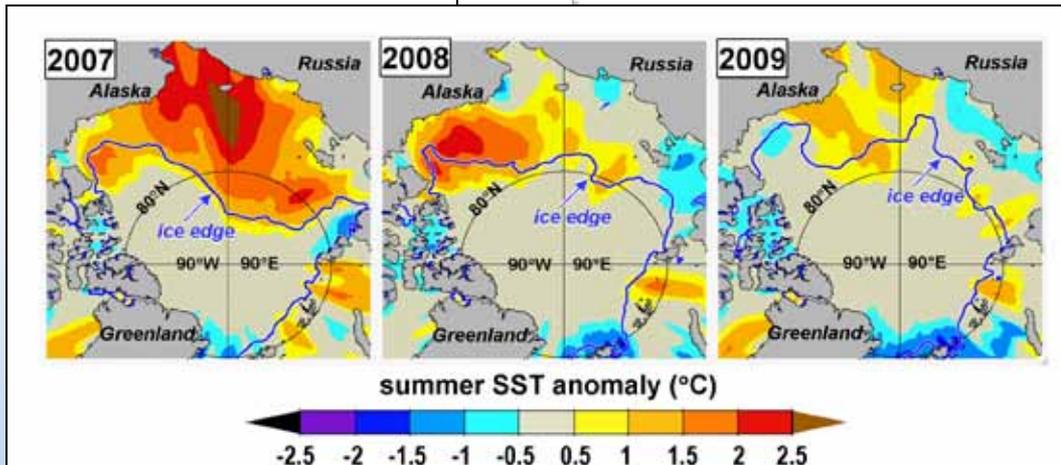
Summary: 2009



- Cooling surface temps
- Relatively warm



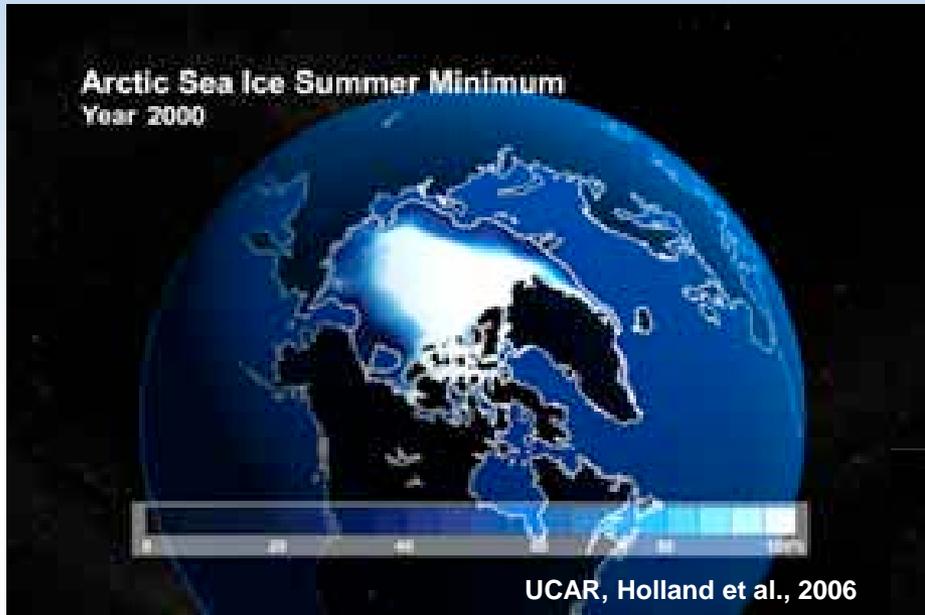
- Larger summer ice cover
- Relatively small



- Cooling ocean temps
- Relatively warm

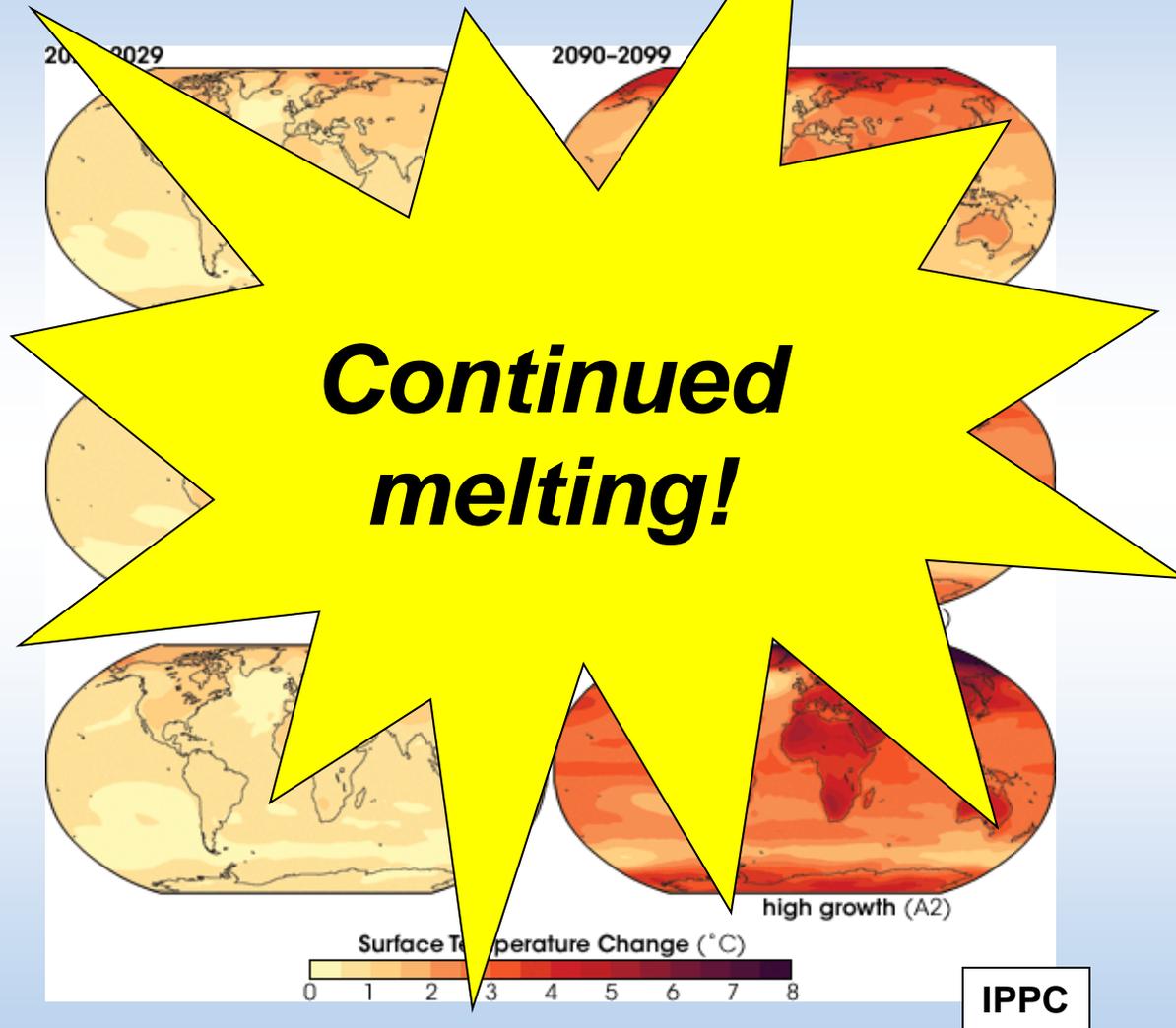
- Recovery from dramatic 2007 record season
- Continued evidence of warming

The Road Ahead



Ice-free summers in foreseeable future

CONTINUED WARMING !



Projected increase of surface temperatures in Arctic: +4 to 8 °C

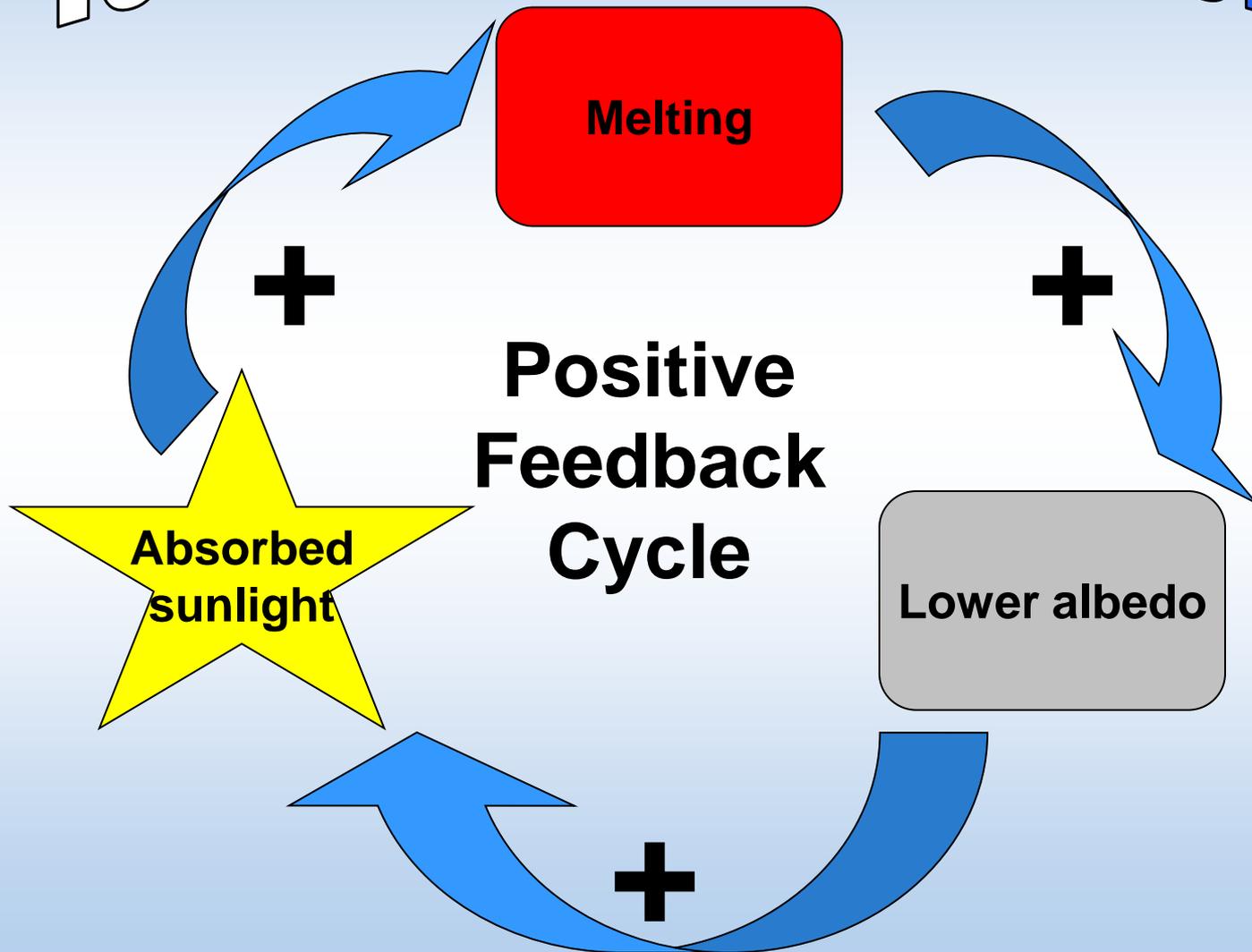
RELATIVELY THIN ICE



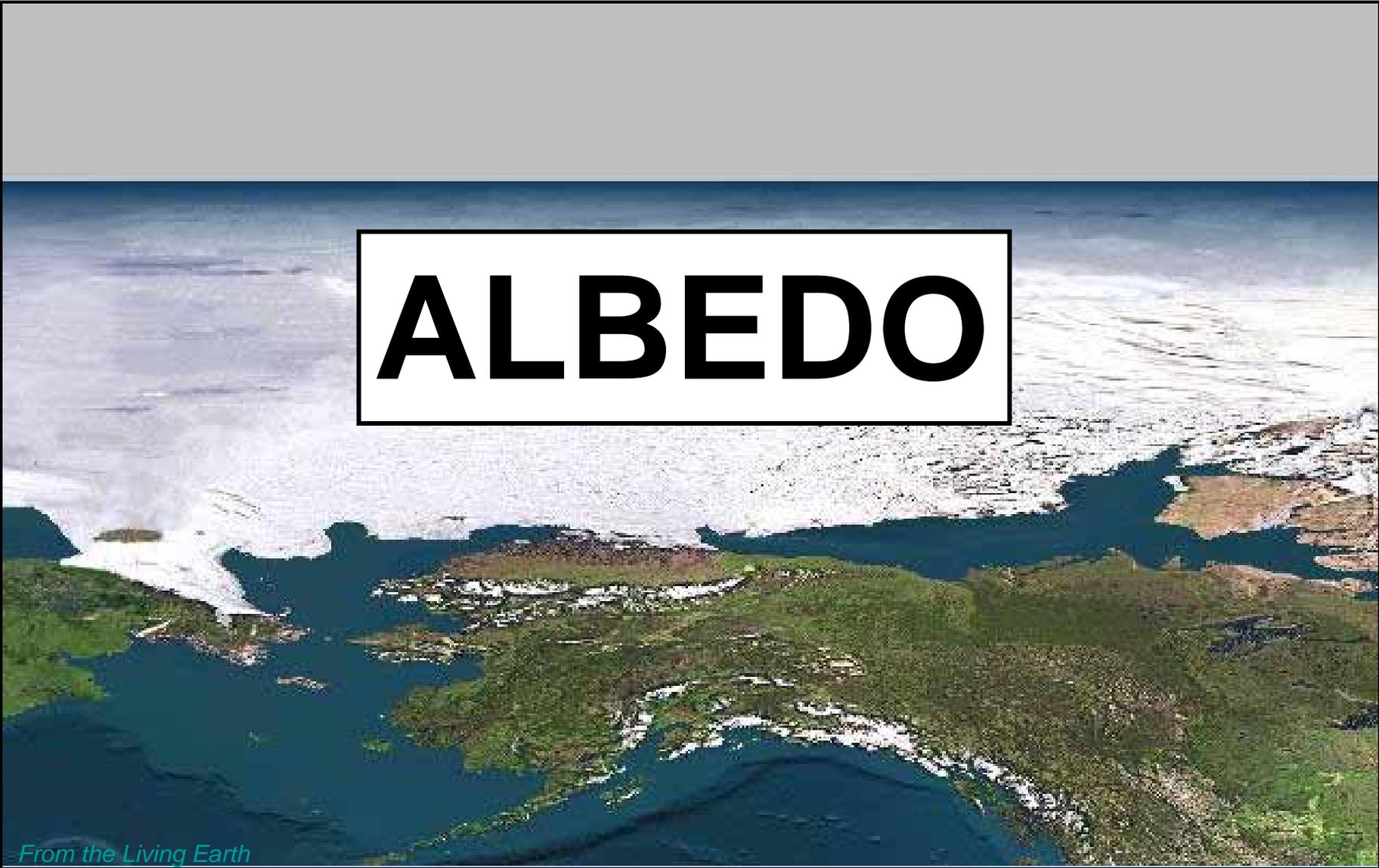
*More vulnerable
to warming
temperatures*

Loss of older, thicker ice

Ice albedo feedback



The Arctic Sea Ice Cover

An aerial photograph of a coastal landscape. The foreground shows a dark blue body of water, possibly a fjord or bay, with green, vegetated land on the surrounding hills. In the middle ground, there is a large, flat, white area that appears to be a snowfield or a large ice deposit. The background shows a hazy, overcast sky. A large white rectangular box with a black border is superimposed over the white area, containing the word "ALBEDO" in bold, black, sans-serif capital letters.

ALBEDO

From the Living Earth

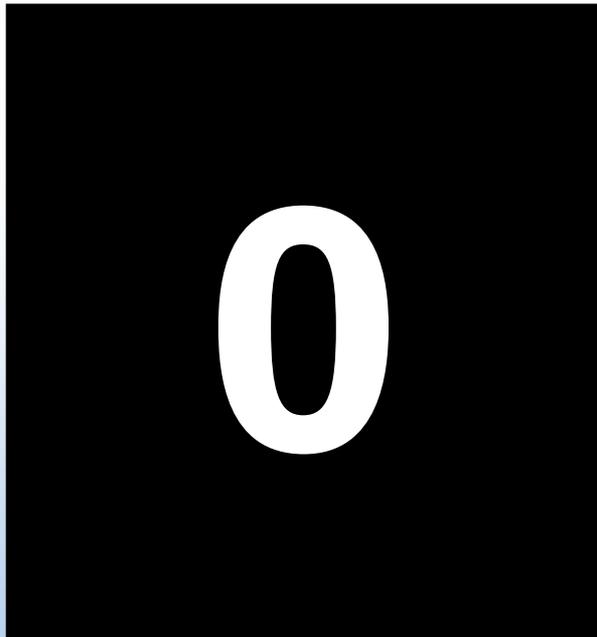


$$\text{Albedo} = \frac{\text{reflected sunlight}}{\text{incoming sunlight}}$$

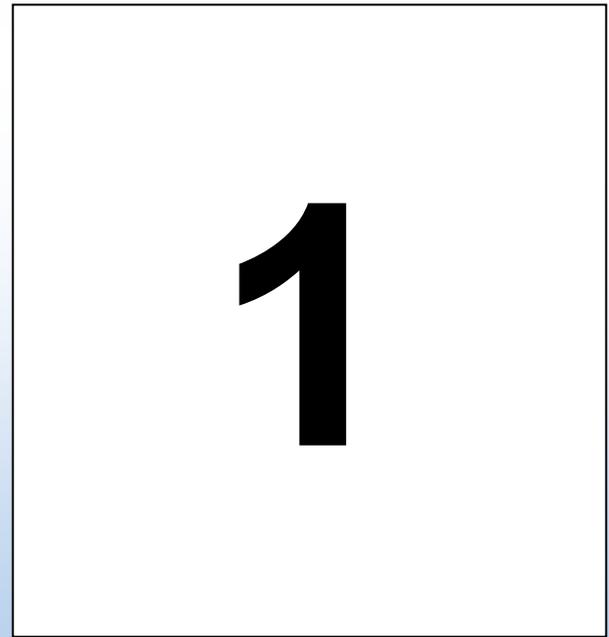


ALBEDO

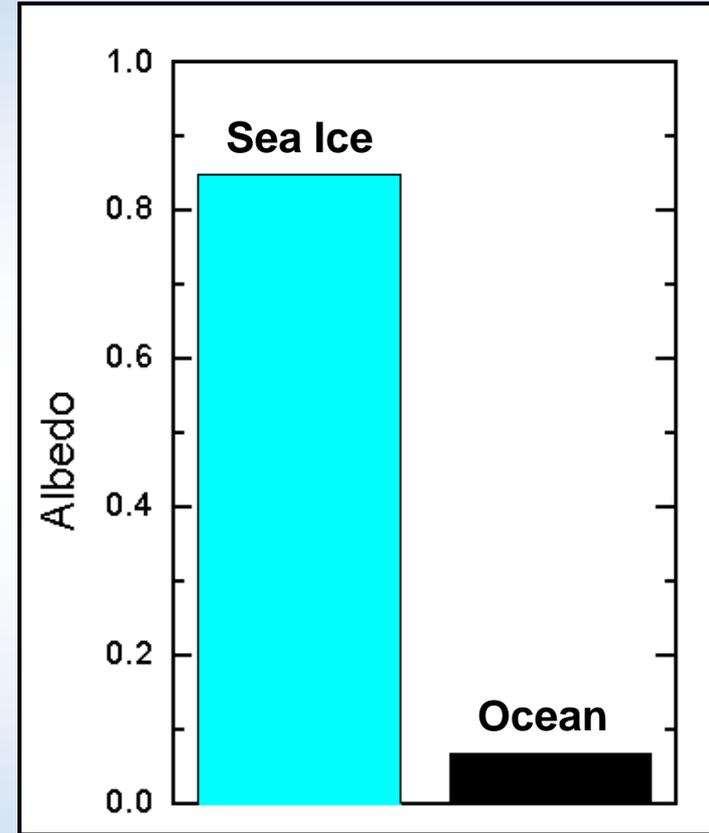
Varies between...



&

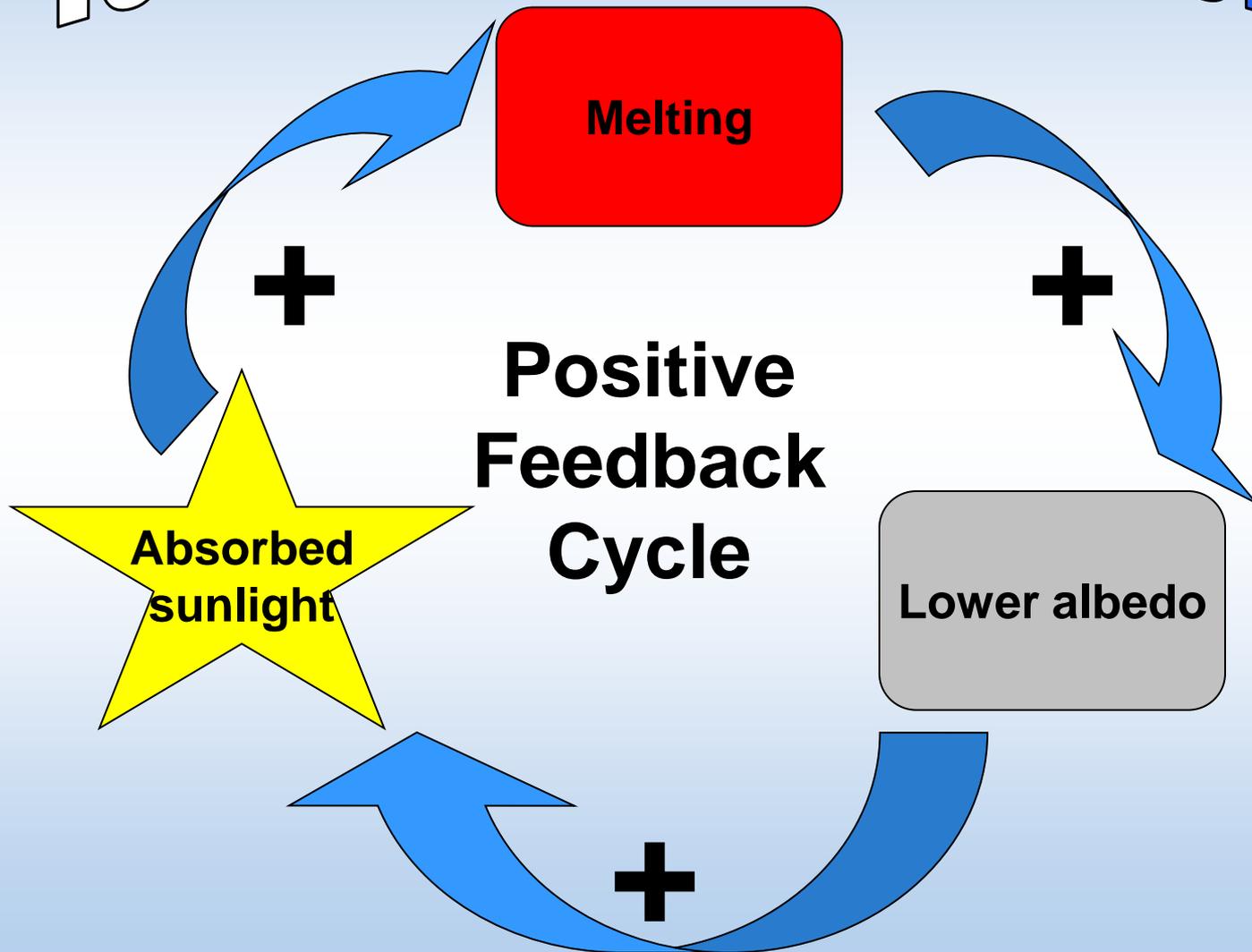


Arctic Ocean



Largest and smallest albedos on earth

Ice albedo feedback

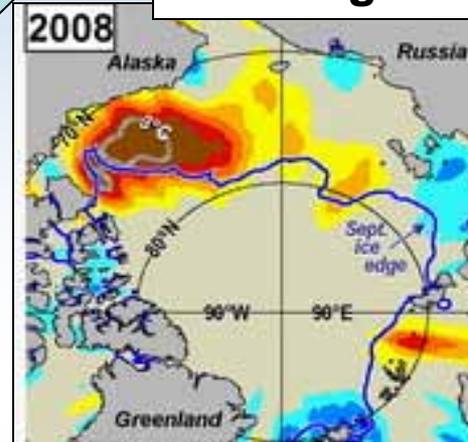


Sum of the parts...

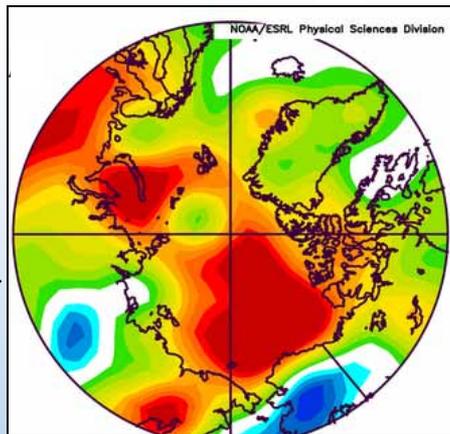
Melting ice



Warming ocean surface



Warming air temperatures



... provides compelling argument for continued reduction

KEY POINTS

- 2009: Most ... is, relative to 2007
- Still please **COMMUNICATE!** based evidence the Arctic is un ... to climate warming
- Expect continued warming

Outreach

- Community
- Empowerment
- Strategic

**THEY ARE
LISTENING!**

Information



U.S. Navy Arctic Road Map

October 2009



Task Force Climate Change
Director, RADM Dave Titley, Oceanographer of the Navy



Drivers

Arctic Region Policy

National Security / Homeland Security
Presidential Directive (NSP-1 / HSPD-25)

- Develop greater capability & capacity to respond to threats
- Increase Arctic *Maritime Domain Awareness*
- Protect *global mobility* of US vessels and aircraft
- Project a *sovereign US maritime presence*
- Encourage *peaceful resolution of disputes*
- Cooperate with other nations to *address increase in piracy*
- Establish capability to *address hazards in the Arctic*, including icebreaking and cooperative search and rescue operations
- Evaluate feasibility of using the Arctic as a *strategic transit route*

No... but implies "be prepared"

UNCLASSIFIED

Arctic Roadmap



Strategic

- Region for...
...deter major power war
- Win our Nation's wars as part of a joint campaign
- Contribute to homeland defense in depth
- Foster and sustain cooperative relationships with more international partners
- Prevent or mitigate disruption or crises

The Maritime Strategy applies equally in the Arctic as in other regions of the globe

UNCLASSIFIED

...ing Arctic Environment

Access is...
- Our best estimate is that summer 'ice free' conditions in 25...
- Confidence level is...

Complex Environment
- Observation & predictions are challenging
- Arctic climate entering more dynamic mode
- Highly variable
- IPCC Projections - not sufficient

- Harsh under normal conditions

Despite uncertainty in predictions, the timeline for change implies the Arctic is a challenge, not a crisis



UNCLASSIFIED

CHALLENGE, NOT CRISIS



Transportation Access

Shipping industry requirements

- Ø 8+ weeks of ice-free conditions
- Ø Not anticipated for at least 40 years



Concerns

- Ø Insurance
- Ø Charts
- Ø Search & Rescue
- Ø Governance
- Ø Reliable sea-ice forecasts
- Ø Ice-strengthened hulls
- Ø Environmental compliance





Security Concerns

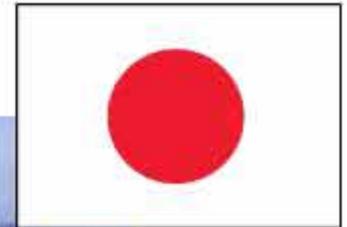
Maritime boundary Disputes

US-Canada
Russia-Norway



Challenges

Japanese Perspective



Opportunities

Russia & China





Common Operational Challenges

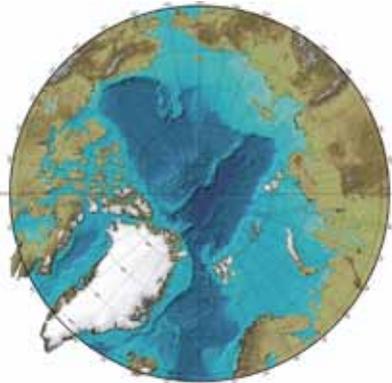
Communications

USAF Polar SATCOM program at risk



Navigation

Limited bathymetric data



Access & Logistics

Limited infrastructure



Environment

Ice acts as a moving lee shore



Phasing

Phase 1 (FY10)



Fleet readiness assessment, external studies, strategic implementation plan



Advocate for UNCLOS***



Monitor Polar SATCOM Program***



Innovative Readiness Training (IRT)***



Arctic TTX & LOE

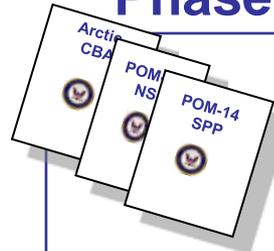


Cooperative Navy-NOAA Bering Strait Hydrographic Survey



POM-12 investment for air-ocean-ice numerical prediction

Phase 2 (FY11-12)



POM-14 CBA, NSP, & SPPs address the Arctic



Formalize expanded / new cooperative partnerships



Arctic SAREX, Arctic Edge, Northern Edge***



ICEX-11



Environmental assessments



Support National Ocean Policy / Marine Spatial Planning Implementation For Arctic***



Interagency partnership for air-ocean-ice numerical prediction

Phase 3 (FY13-14)



Execute POM-14



Implement expanded / new cooperative partnerships



Arctic UUV operations

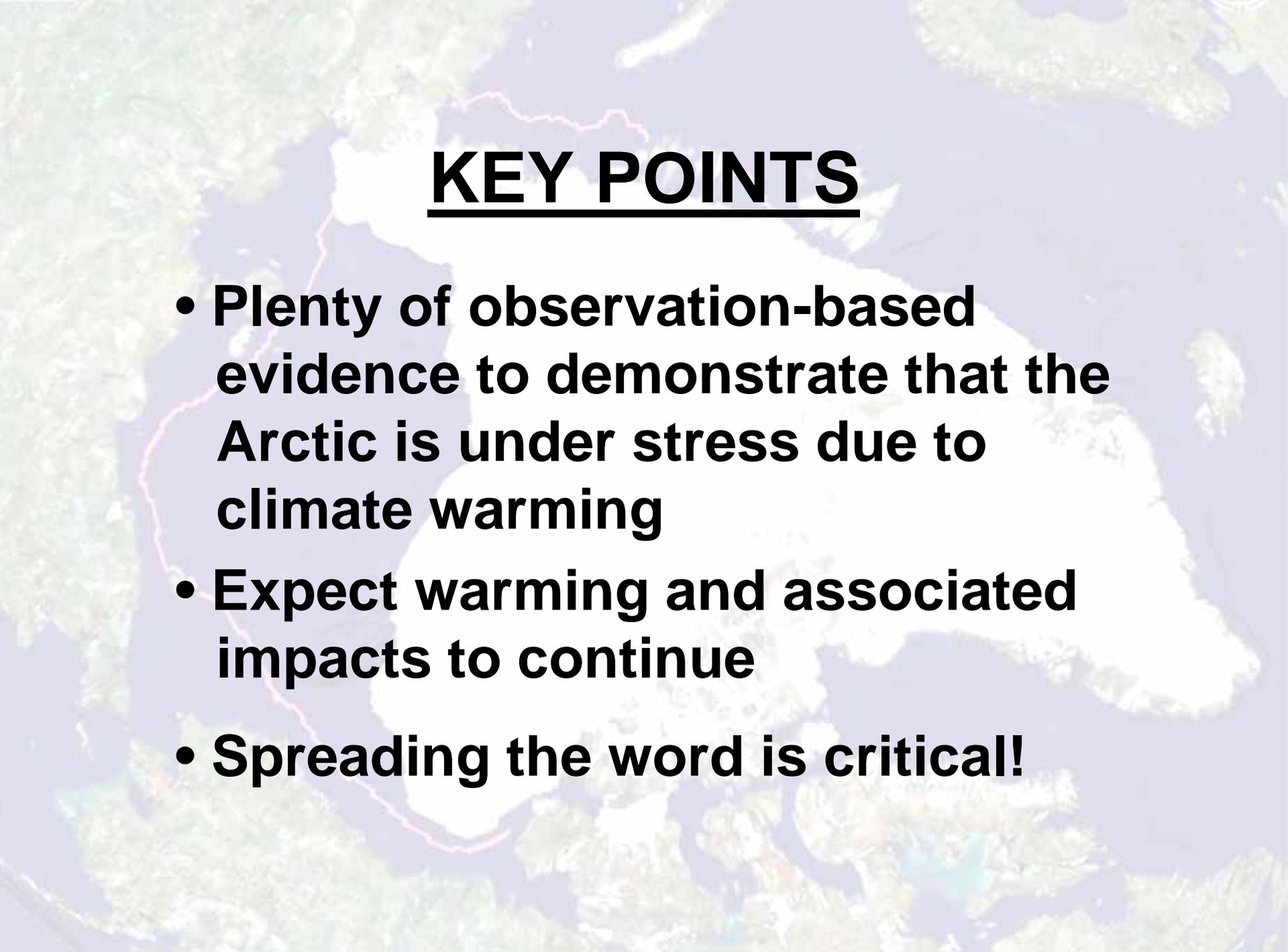


ICEX-13

Update roadmap ICW QDR



Navy recognized as a valued joint, interagency, & international partner in the Arctic



KEY POINTS

- **Plenty of observation-based evidence to demonstrate that the Arctic is under stress due to climate warming**
- **Expect warming and associated impacts to continue**
- **Spreading the word is critical!**