

A satellite-style map of the Arctic region, showing the North Pole and surrounding landmasses. The Arctic Ocean is a large white area in the center, surrounded by green and brown landmasses. A pink line outlines the Arctic Circle. The text is overlaid on the map.

# **The Changing State of the Arctic**

**Jackie Richter-Menge**

**US Army Corps of Engineers**

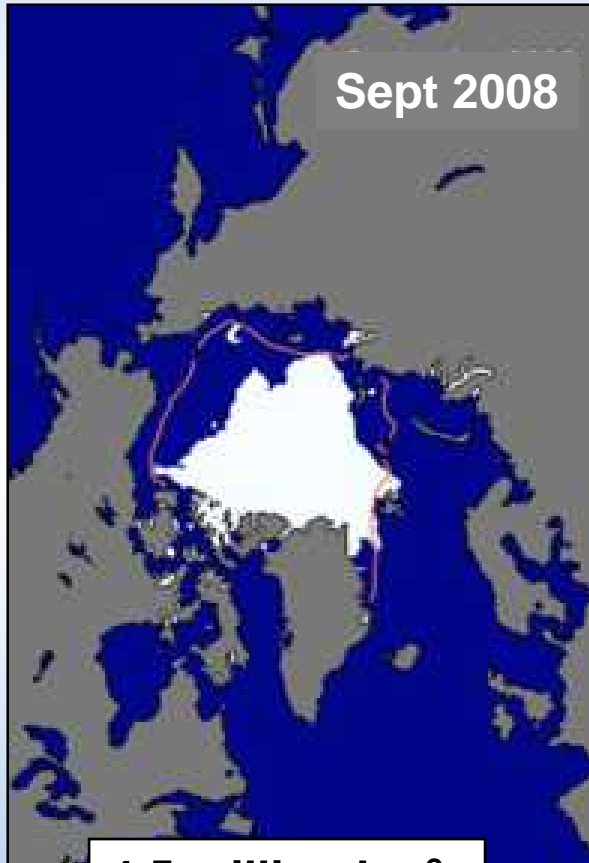
**Cold Regions Research and Engineering Laboratory**

# KEY POINTS

- Plenty of observation-based evidence demonstrating that the Arctic is under stress due to climate warming
- Expect continued trend of ice loss in summer in the face of projections of continued warming

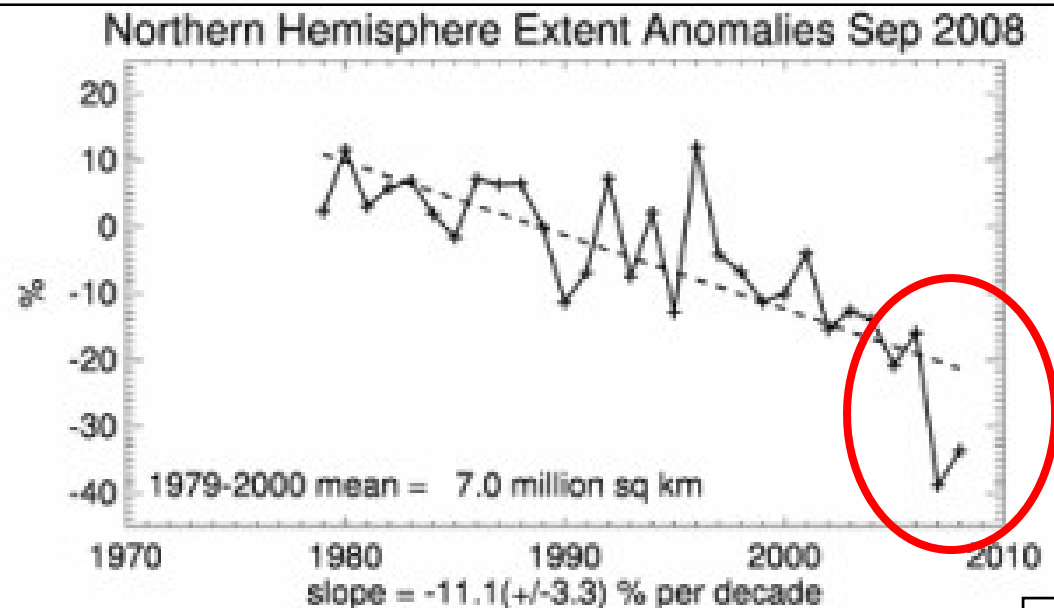
# MINIMUM EXTENT

## *September*



4.5 million km<sup>2</sup>

- Downward trend
- Dramatic decrease in extent 2007
- 39% below 1979-2000 average
- Slight recovery in 2008



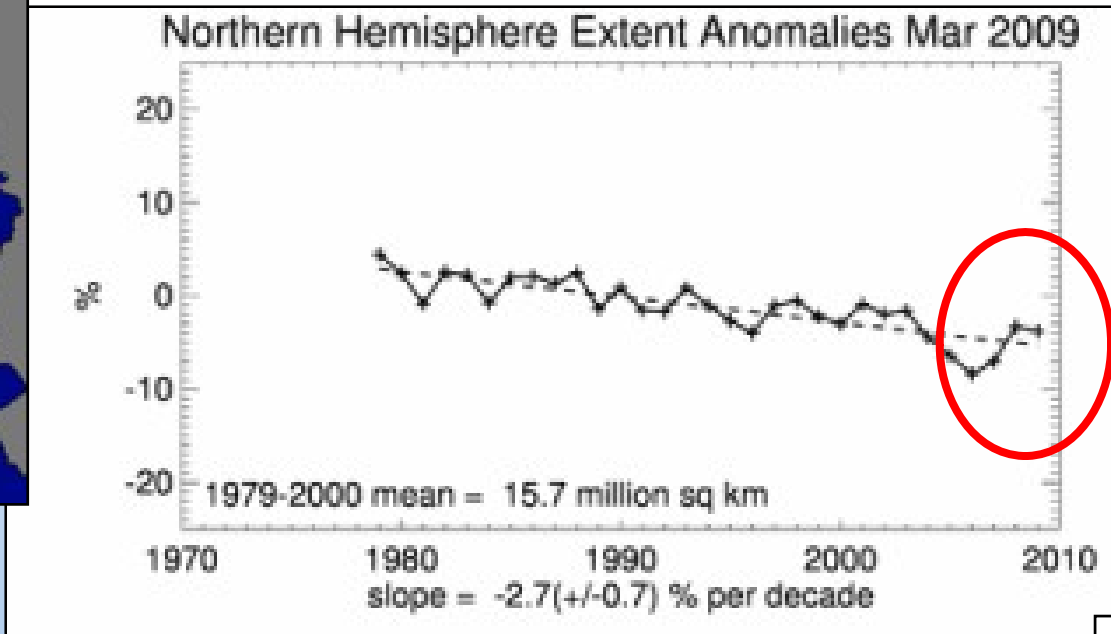
# MAXIMUM EXTENT

## *March*



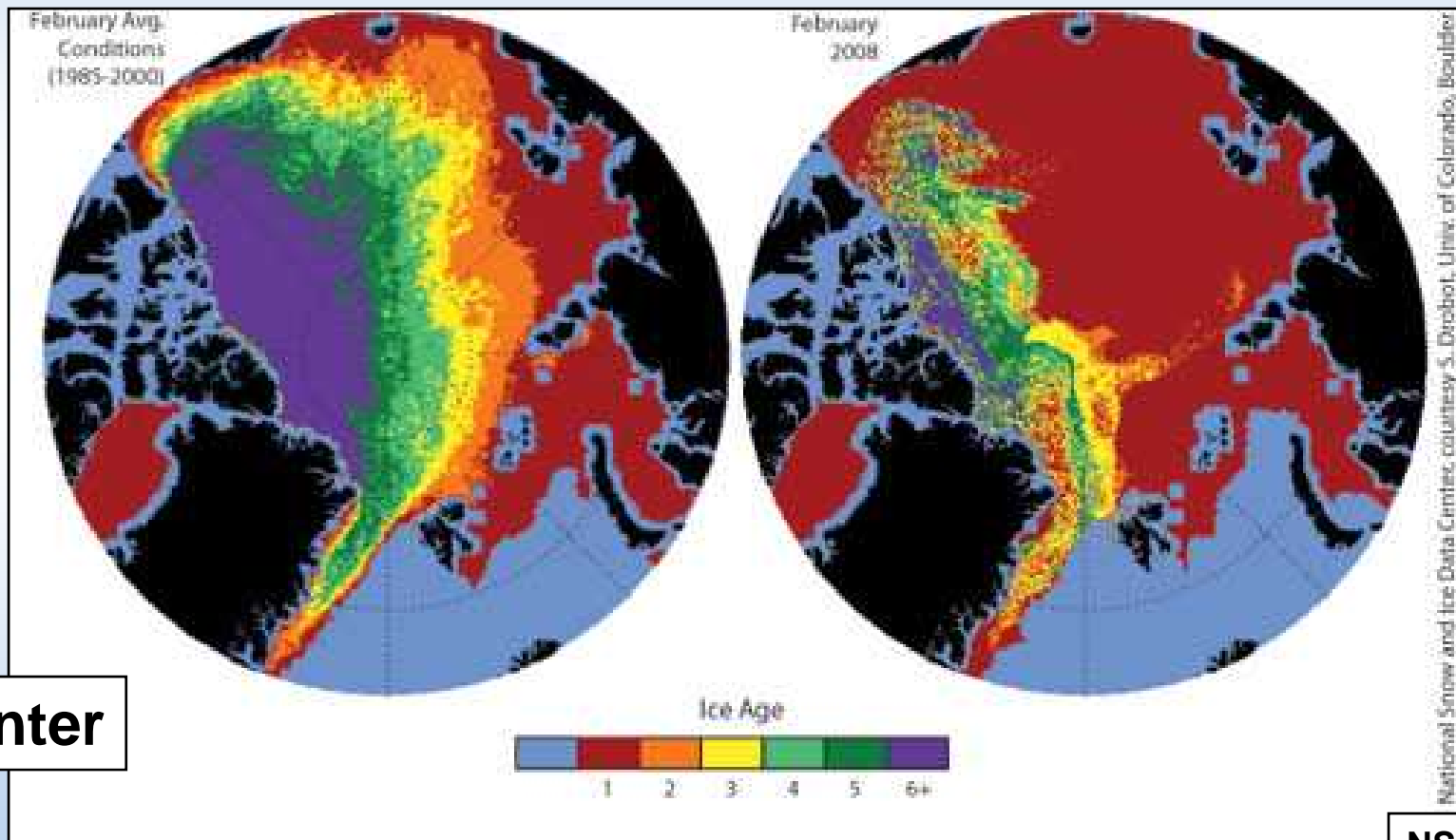
15.2 million km<sup>2</sup>

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



# SEA ICE THICKNESS

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



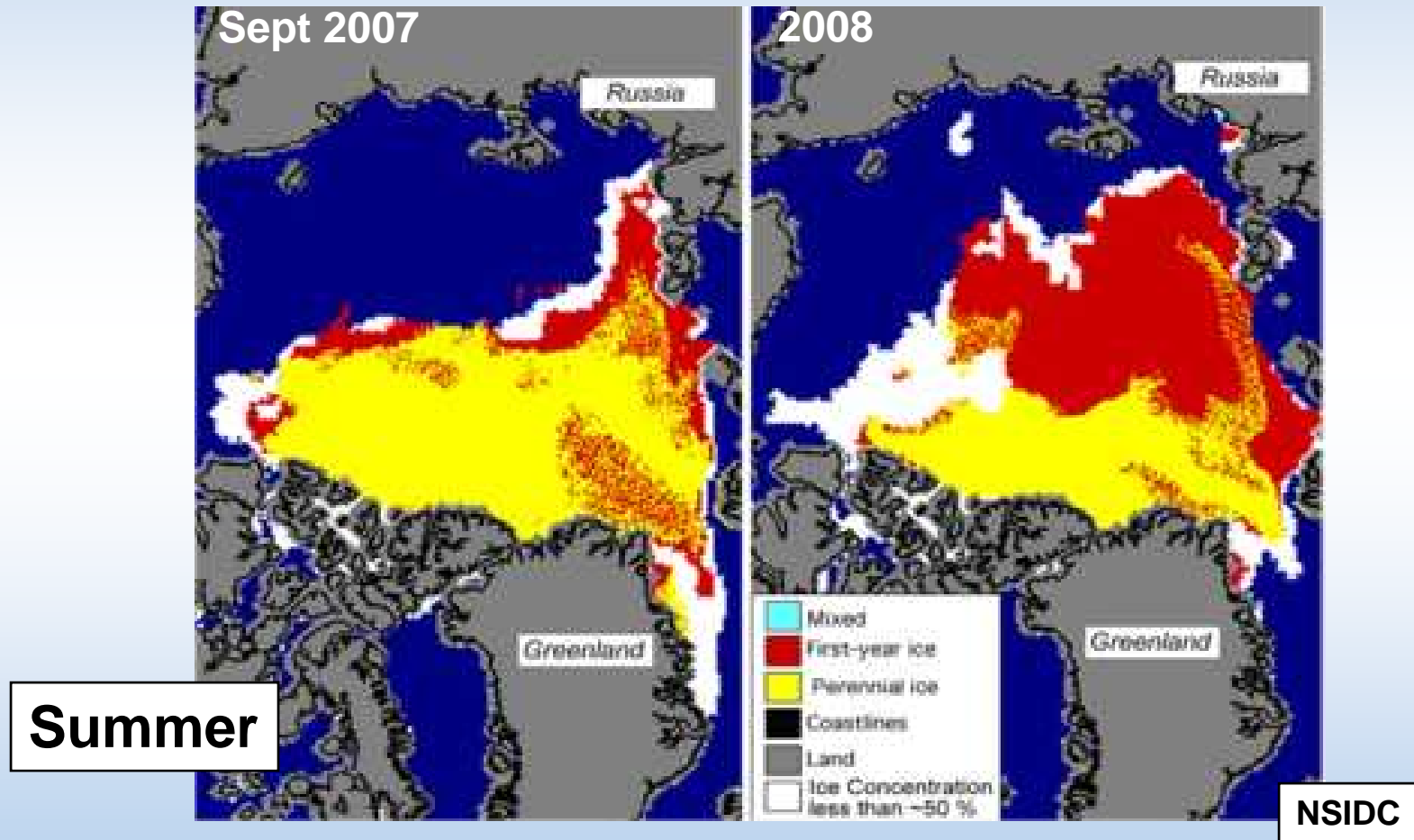
Winter

NSIDC

*Dramatic loss of older, thicker ice*

# SEA ICE THICKNESS

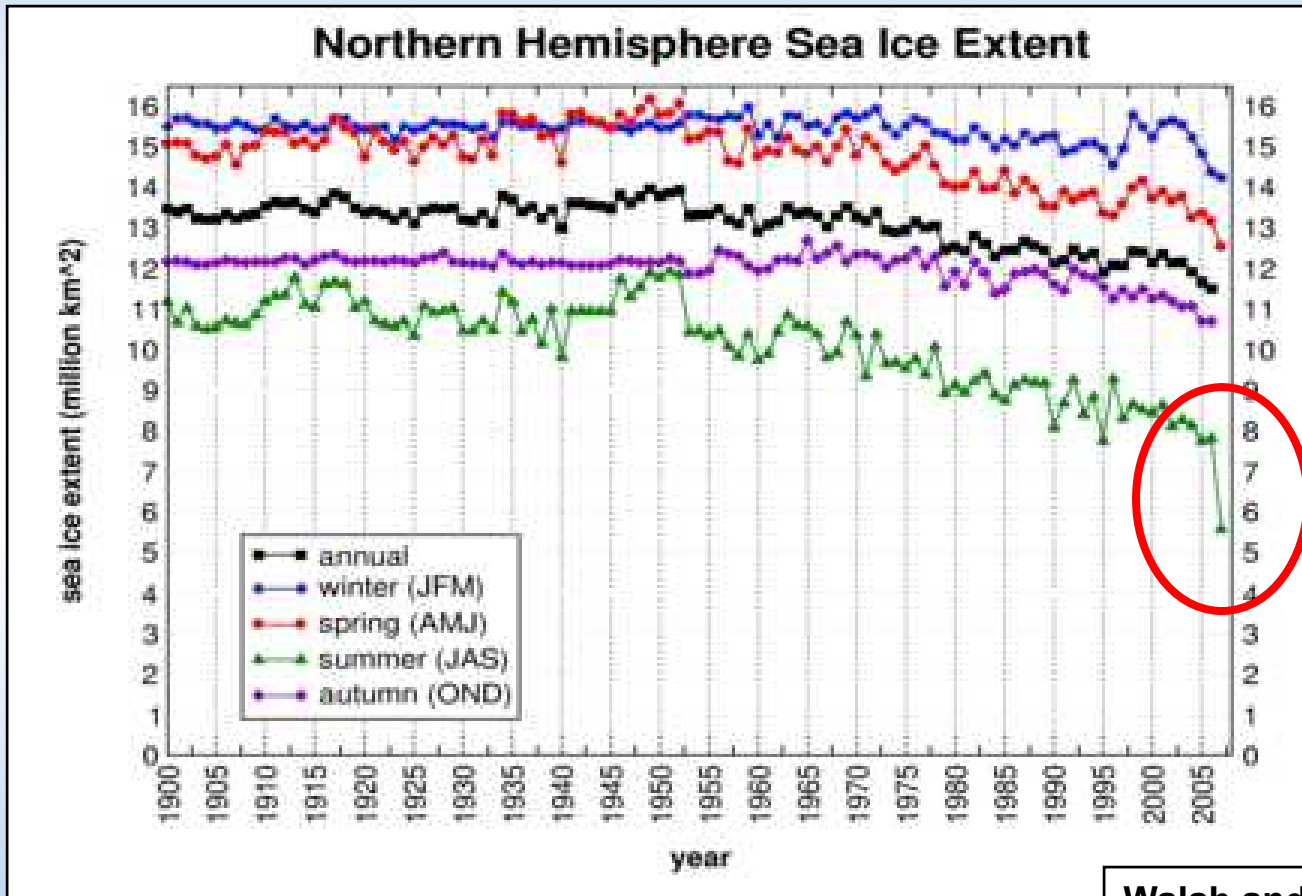
## *Thick vs. Thin Ice*



*Young ice more prevalent in summer*

# SEA ICE EXTENT

*1900 -2007*



Walsh and Chapman

*Recent decline unprecedented for at least a century*

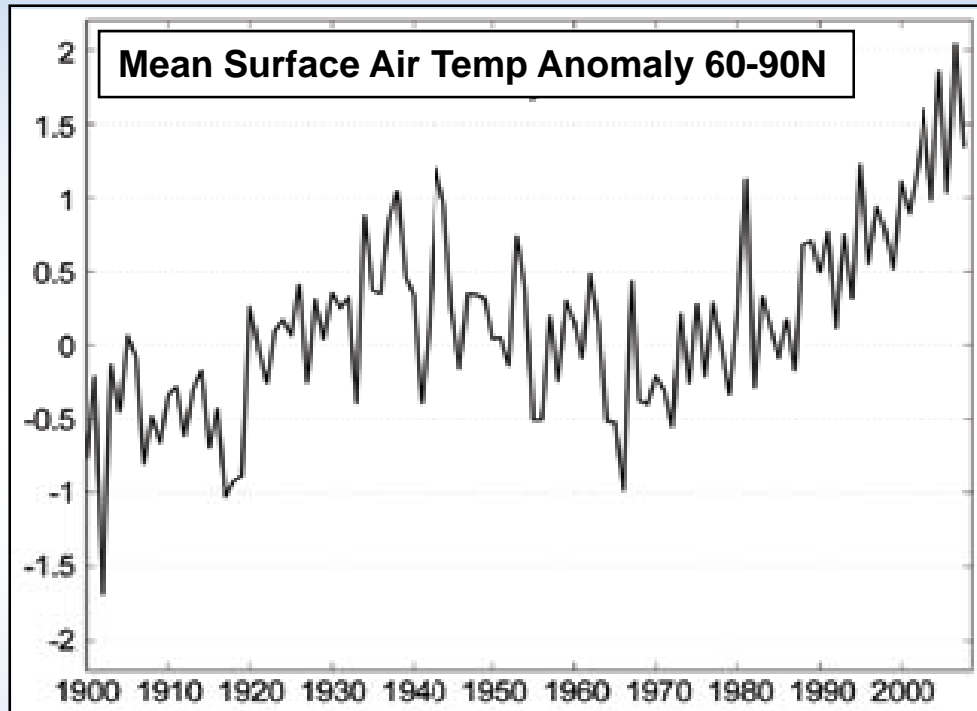
# **2007: The Perfect Storm**

- **Warming air temps**
- **Winds moving ice out of Arctic**
- **Ice albedo feedback**

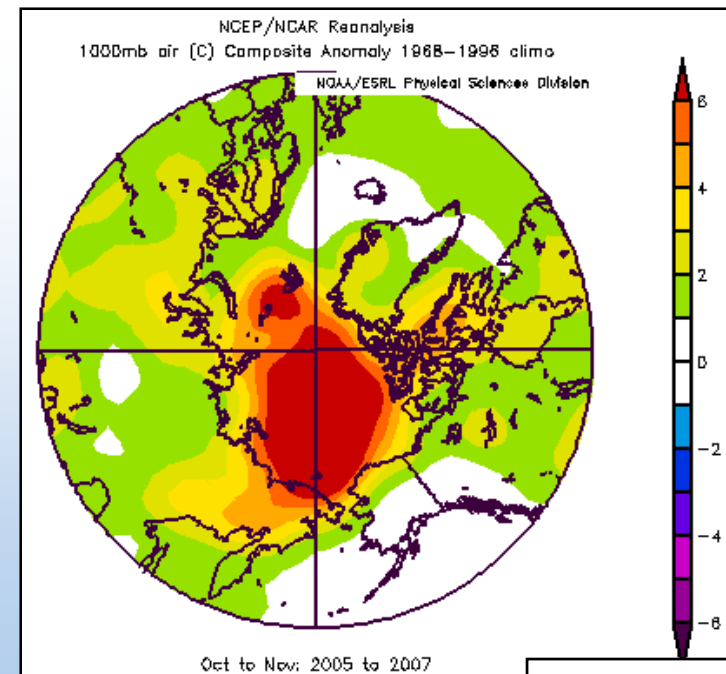


# WARMING AIR TEMPS

*Bad news for ice covers*



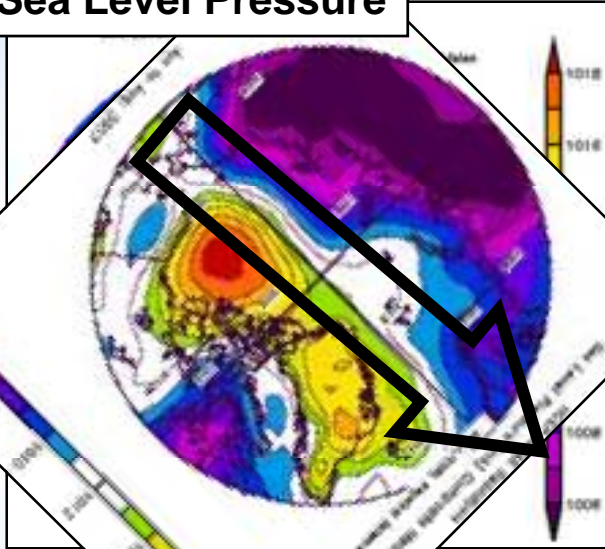
Generally warming temperatures since late 1960's



- Relatively warm temps over the entire Arctic region
- Maximum of +5°C (!)

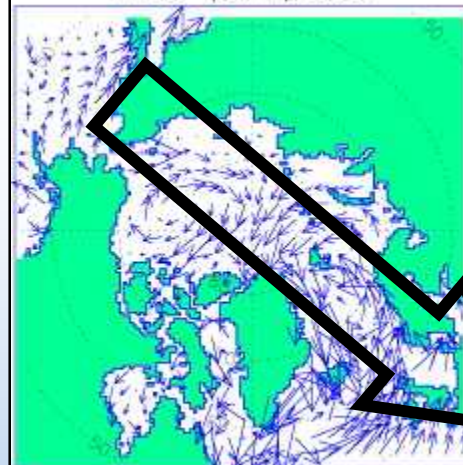
# PERSISTENT CROSS-BASIN WIND

*Summer 2007*  
Sea Level Pressure



- Persistent (months!) SLP pattern
- Sustained cross-basin winds
  - Movement of ice out Fram Strait
- Advection of warm air into Central Arctic
  - More melting

Winter (DJFM) 2007



Summer (JJAS) 2007



Upper Ocean Circulation Pattern

Proshutinsky et al.

*Dramatic export of ice via Fram Strait*

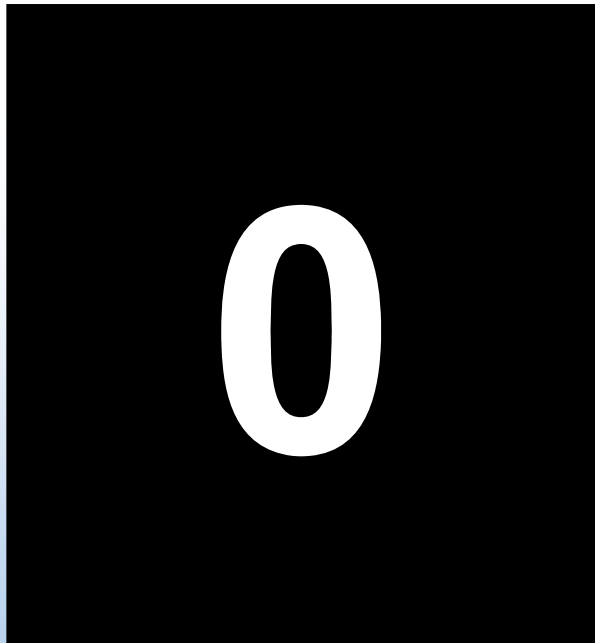


$$\text{Albedo} = \frac{\text{reflected sunlight}}{\text{incoming sunlight}}$$

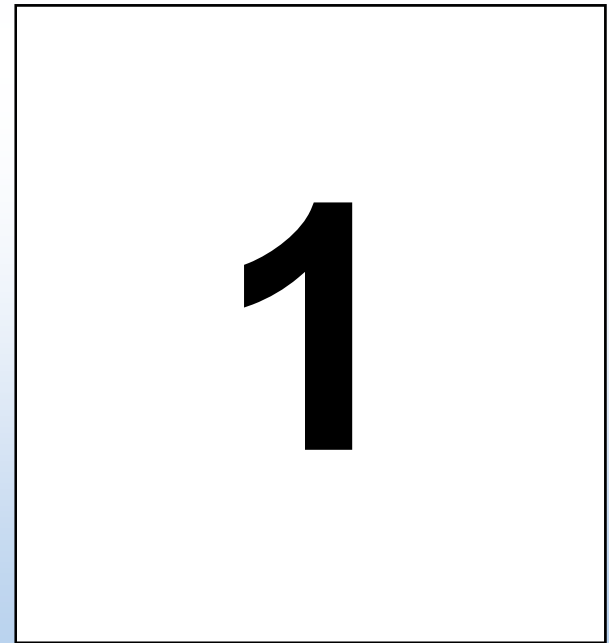


# ALBEDO

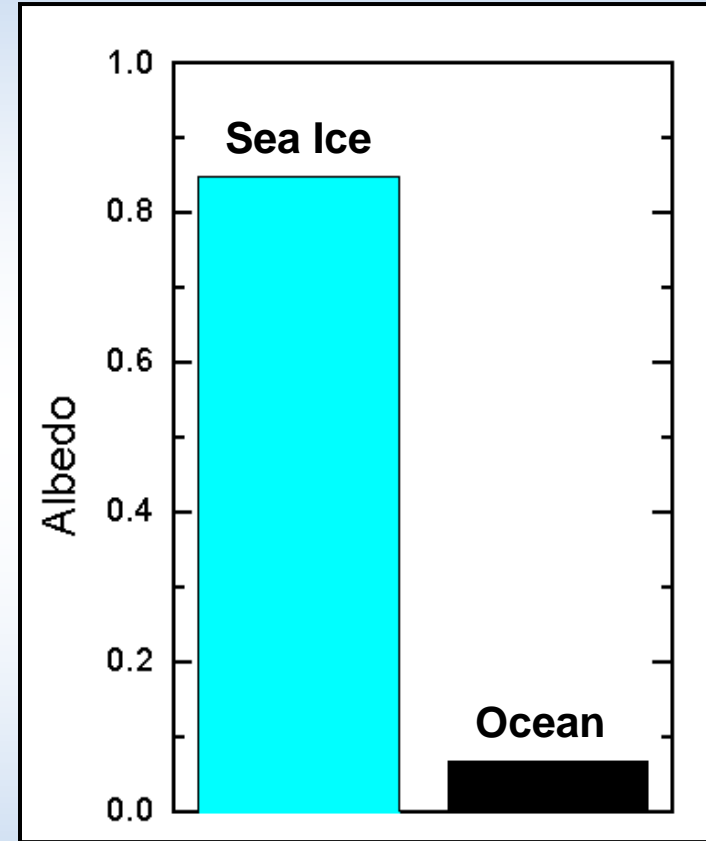
Varies between...



&

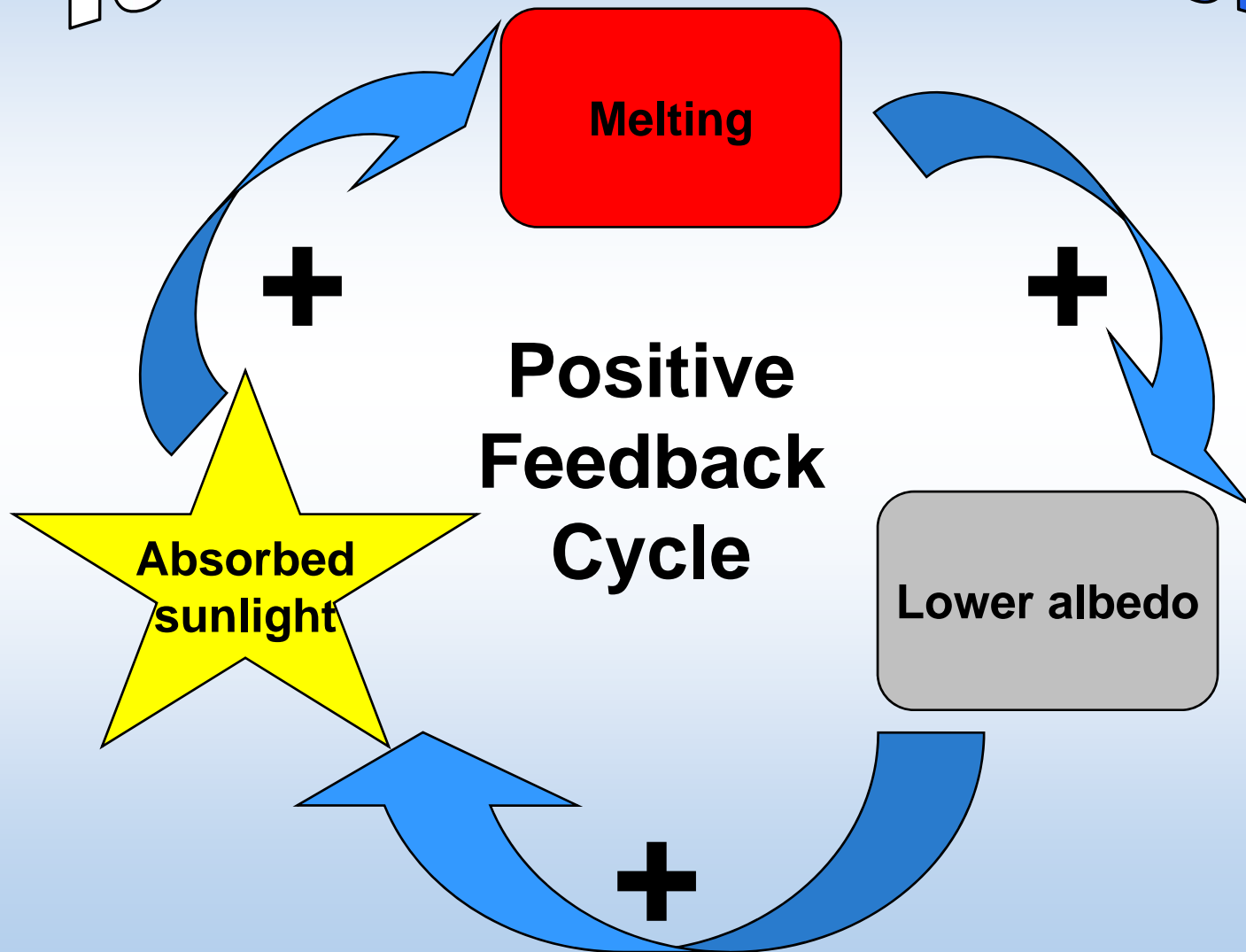


# Arctic Ocean



***Largest and smallest albedos on earth***

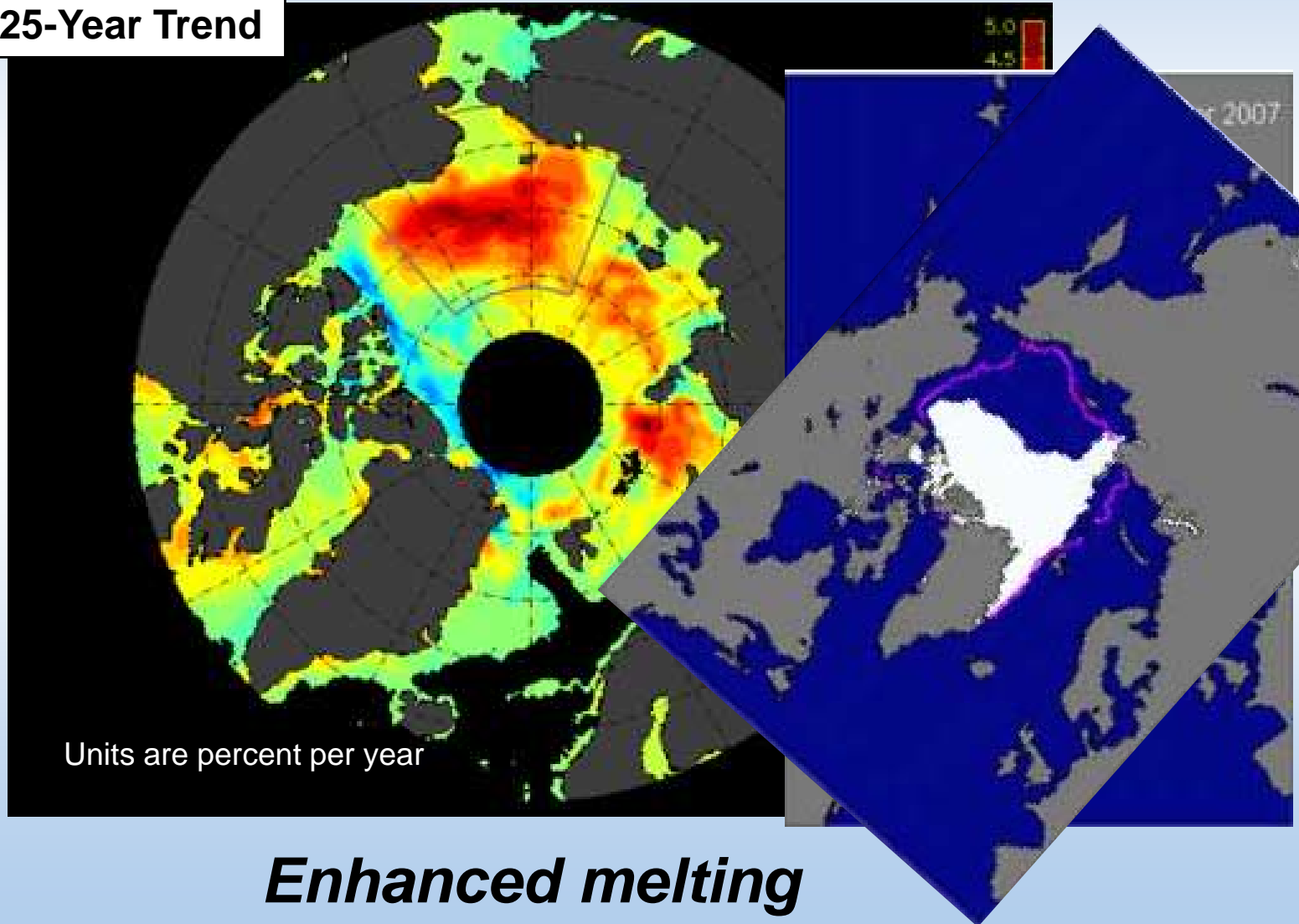
# Ice albedo feedback



# ICE ALBEDO FEEDBACK

*Solar heating of the ocean*

25-Year Trend



*Enhanced melting*

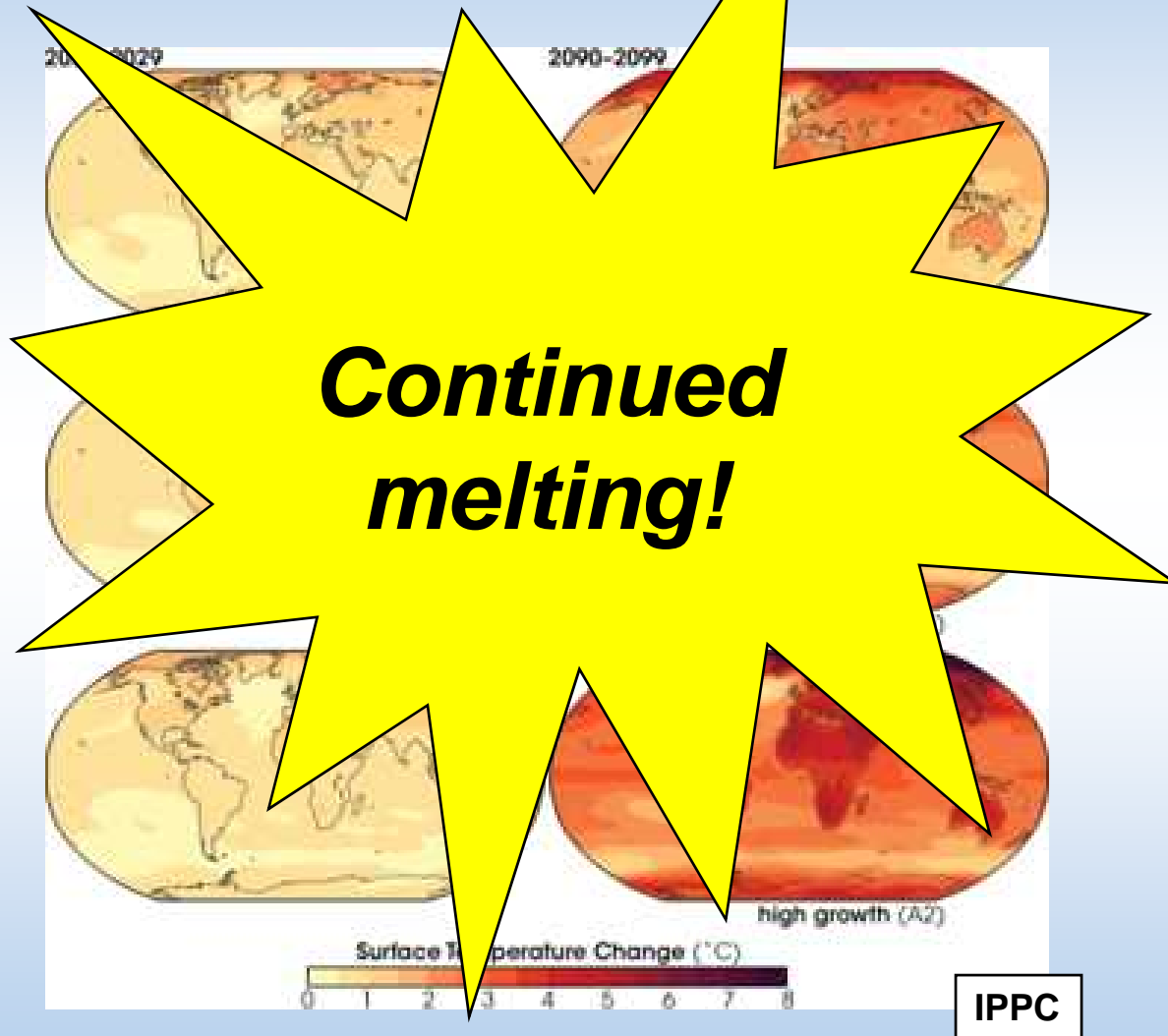
# The Road Ahead?



***Ice-free summers in foreseeable future***

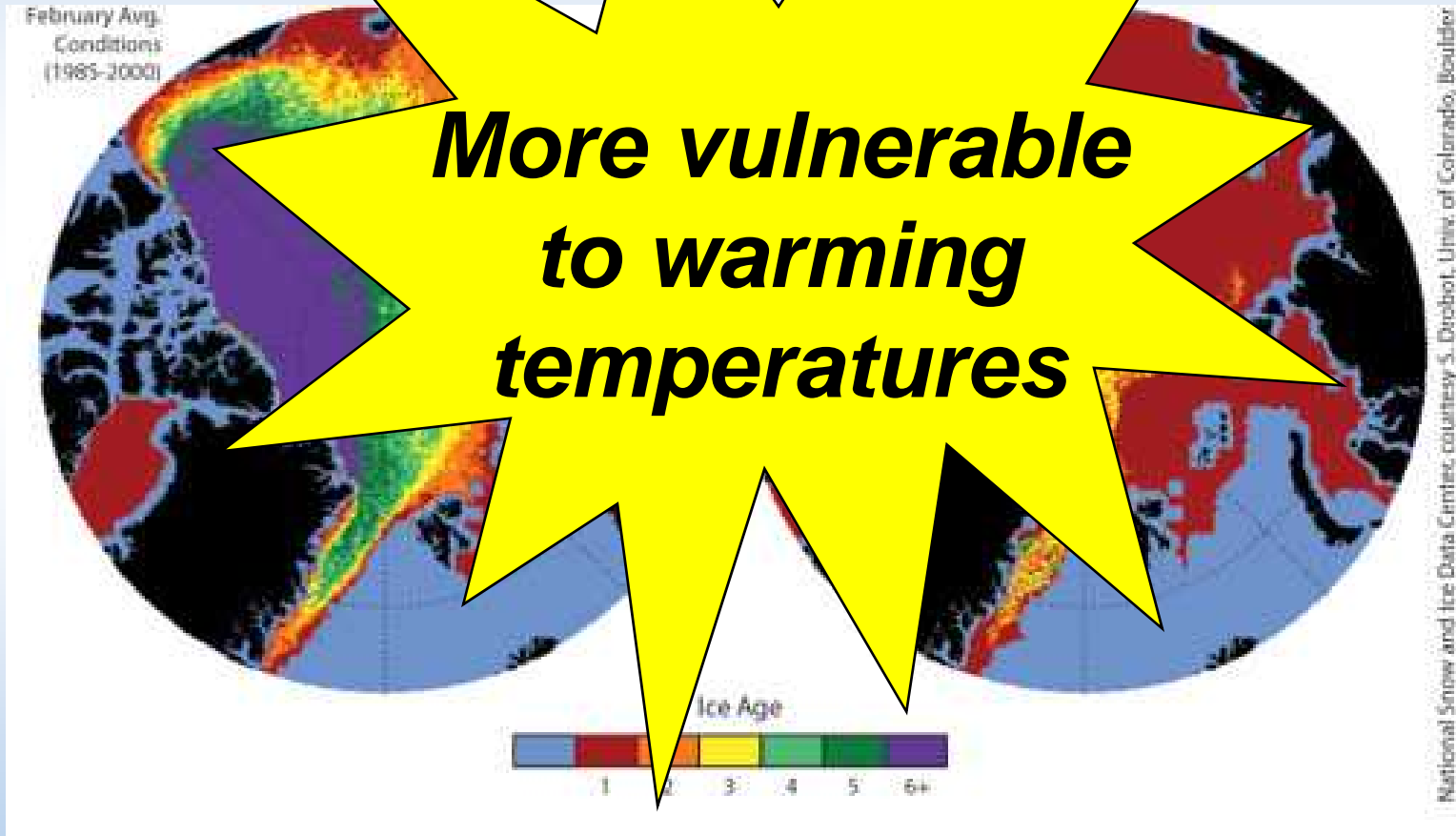


# CONTINUED WARMING !



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

# RELATIVELY THIN ICE



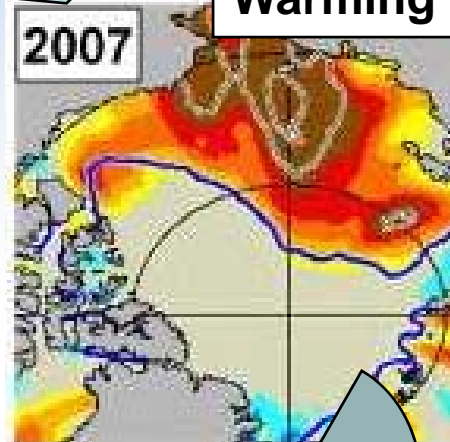
*Loss of older, thicker ice*

# Sum of the parts...

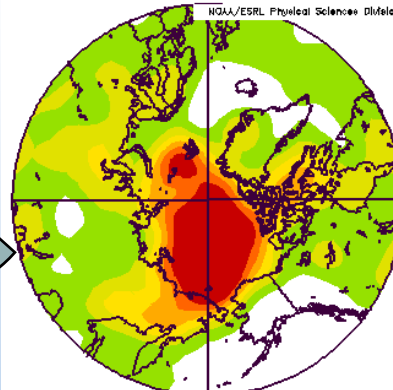
Melting ice



Warming ocean surface



NCEP/NCAR Reanalysis  
1000mb air (C) Composite Anomaly 1968-1998 clima  
NOAA/ESRL Physical Sciences Division



Warming air temperatures

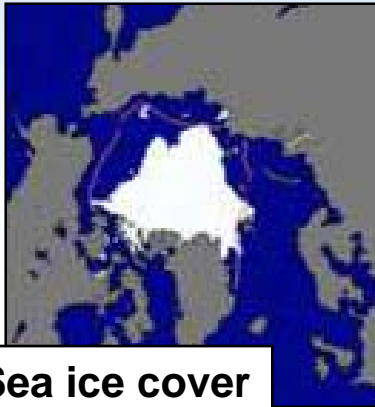
*... provides compelling argument for continued reduction*

# **KEY POINTS**

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# Arctic Report Card

*A web-based tool describing the effects of climate change on the Arctic*

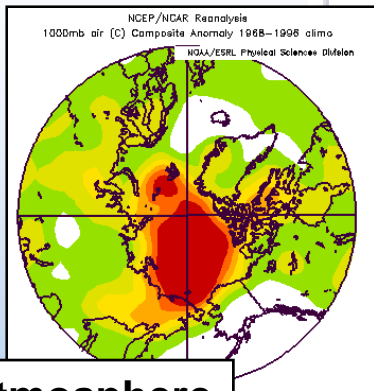


Sea ice cover

A screenshot of the Arctic Report Card 2008 website. The page features a navigation menu with categories: Home, Atmosphere, Sea Ice, Ocean, Land, Greenland, and Biology. A legend identifies color-coded sections: Atmosphere (red), Sea Ice (orange), Biology (yellow), Ocean (green), Greenland (light green), and Land (dark green). A central text box states: "These conditions in the arctic region and, in some cases, dramatic evidence of an overall warming of the Arctic system." Below this, there are six summary boxes for each category: Atmosphere (8° C temperature increases in autumn), Sea Ice (Near-record minimum summer sea ice extent), Biology (Fisheries and marine mammals impacted by loss of sea ice), Ocean (Observed increase in temperature of surface and deep ocean layers), Greenland (Records set in both the duration and extent of summer surface melt), and Land (Permafrost temperatures tend to increase, while snow extent tends to decrease). At the bottom, there are links for "About the Report Card" and "Printable Report Card (PDF)".



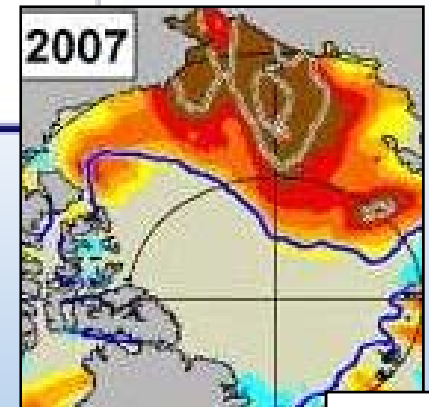
Land



Atmosphere



Biology



Ocean

<http://www.arctic.noaa.gov/reportcard/index.html>