

# State of the Arctic Report

- Consensus review by team of 26 international scientists
- Focus on physical components
  - Atmosphere
  - Ocean
  - Sea Ice
  - Land
- Highlights Arctic data from 2000 to 2005
- Updates some of the records from the Arctic Climate Impact Assessment



# **State of Arctic Report**

## ***Rules of Engagement***

- **Report of observations**
- **Relatively short: 20-25 pages**
  - **Few selected observations for each component**
    - **Relatively high confidence**
    - **Reasonably accessible: Frequent updates**
- **Limited interpretation and editorializing**

# **State of the Arctic Report**

## ***Summary***

- **Taken collectively, observations show convincing evidence of sustained period of warming temperature in Arctic**
  - Continued reduction in sea ice extent, observed at both the winter maximum and summer minimum
  - Widespread changes in Arctic vegetation
- **Warming trend tempered somewhat by shifts in the spatial patterns of land temperatures and ocean salinity and temperature**
  - Moving towards climatological norms
- **Spatial extent of recent changes in air temperature, sea ice and vegetation is greater than observed in the 20th century**
- **Still large region to region and multiyear shifts in the Arctic climate**

# **State of Arctic Report**

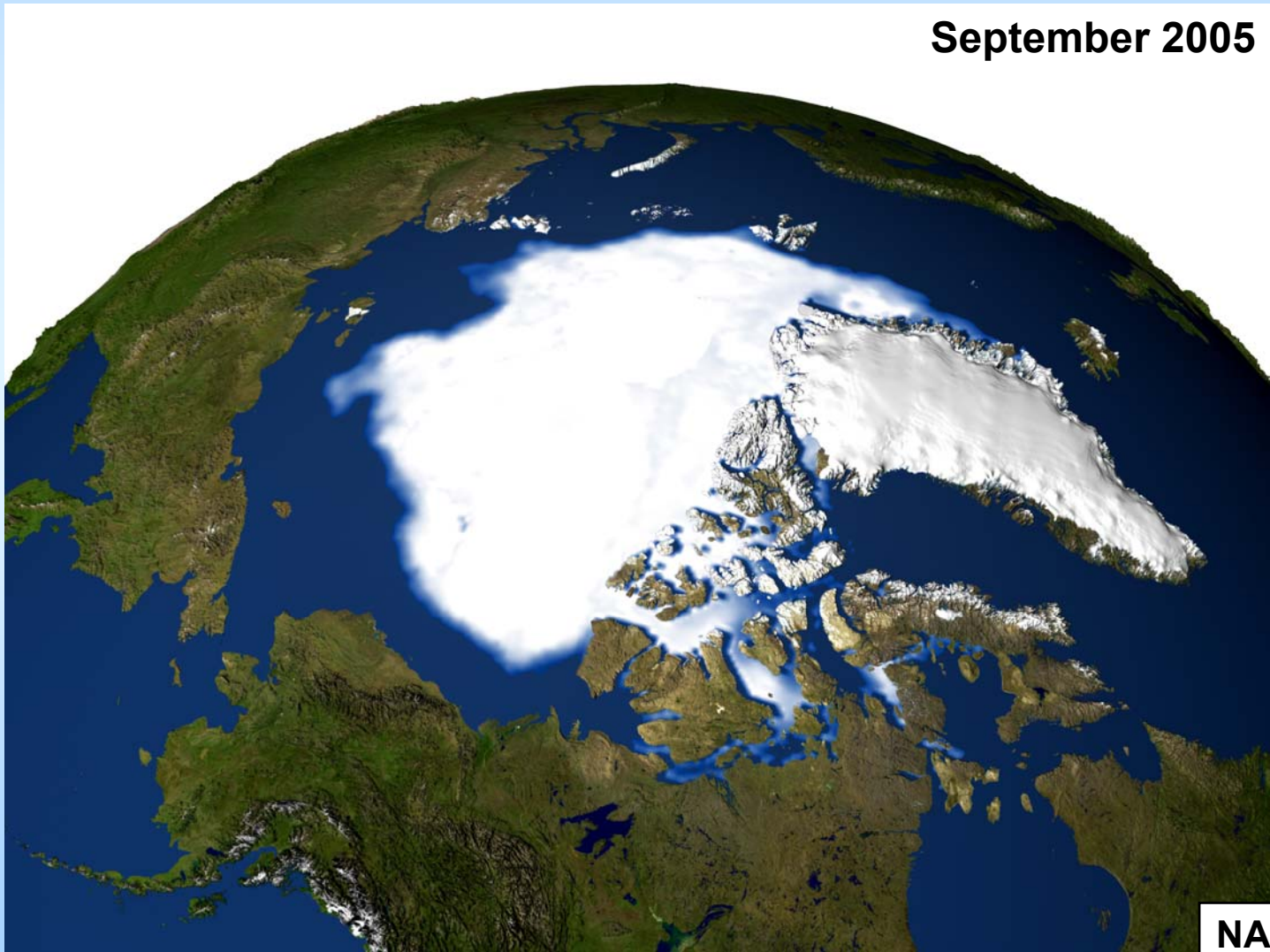
## ***Update***

### **Arctic Report Card**

- **Annual update**
- **Expansion of content**
- **Continue to present clear, reliable and concise information on recent environmental conditions in the Arctic, relative to historical time series records**
- **Material prepared by an international team of scientists and peer-reviewed**
- **Web-based format to facilitate future timely updates of the content**
- **Arctic Report Card 2007 scheduled for posting in Fall 2007: NOAA Arctic Theme Page**

# ARCTIC SEA ICE COVER

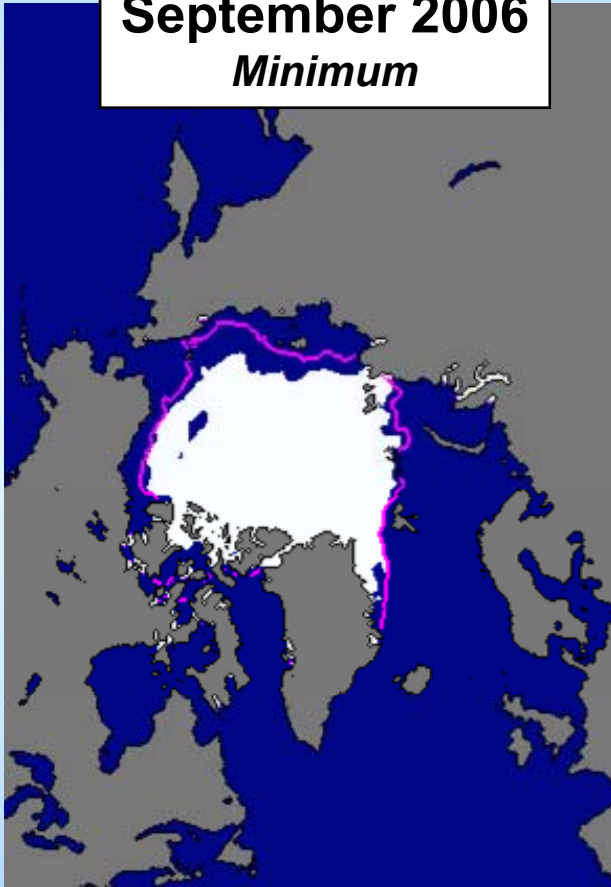
September 2005



NASA

# SEA ICE EXTENT

**September 2006**  
*Minimum*

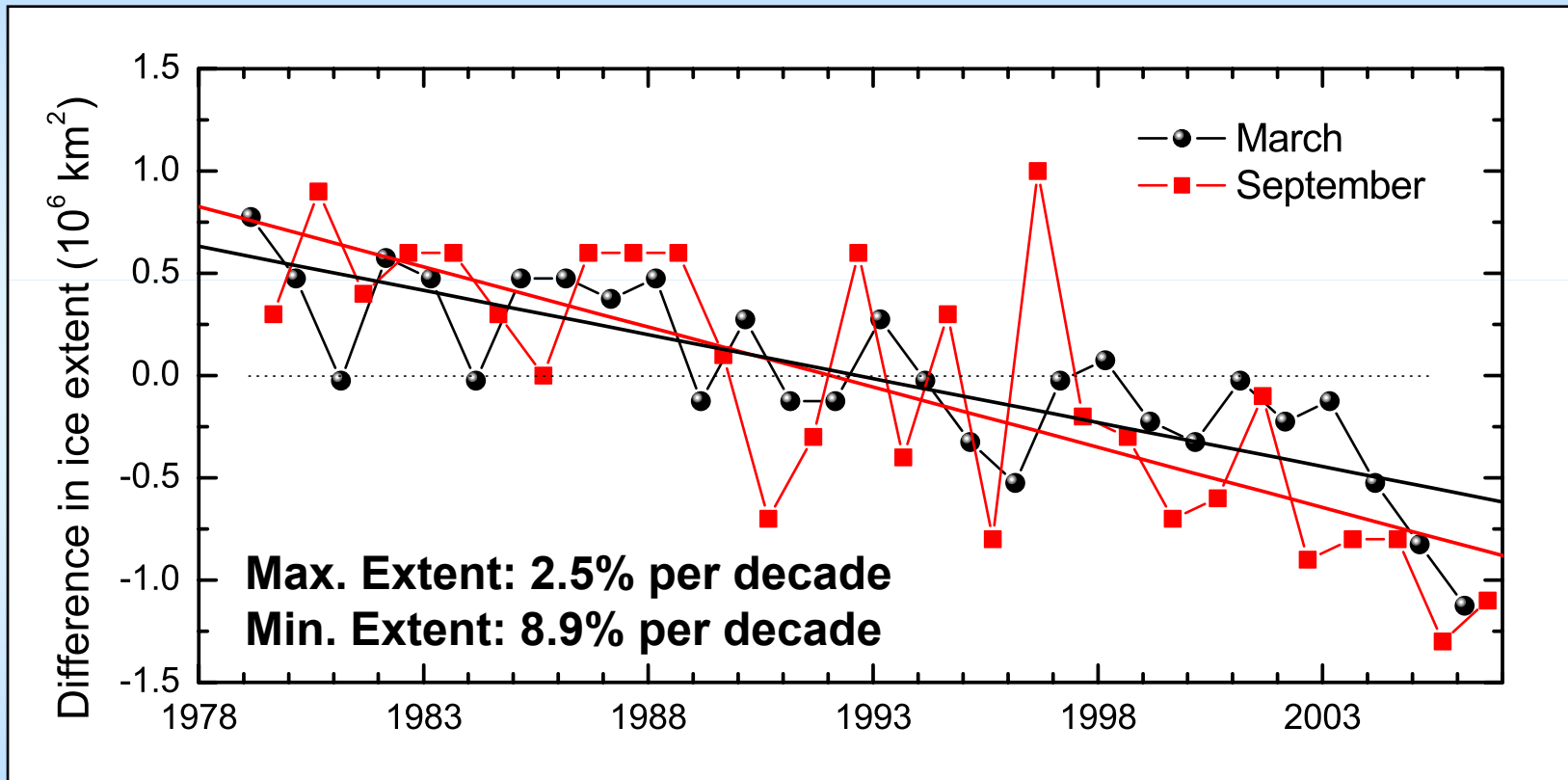


**March 2006**  
*Maximum*



***2006: At or near record minimum in summer and winter***

# SEA ICE EXTENT



***1979-2006: Decreasing trend***

# The Road (Route) Ahead?



*Ice-free summers in foreseeable future*

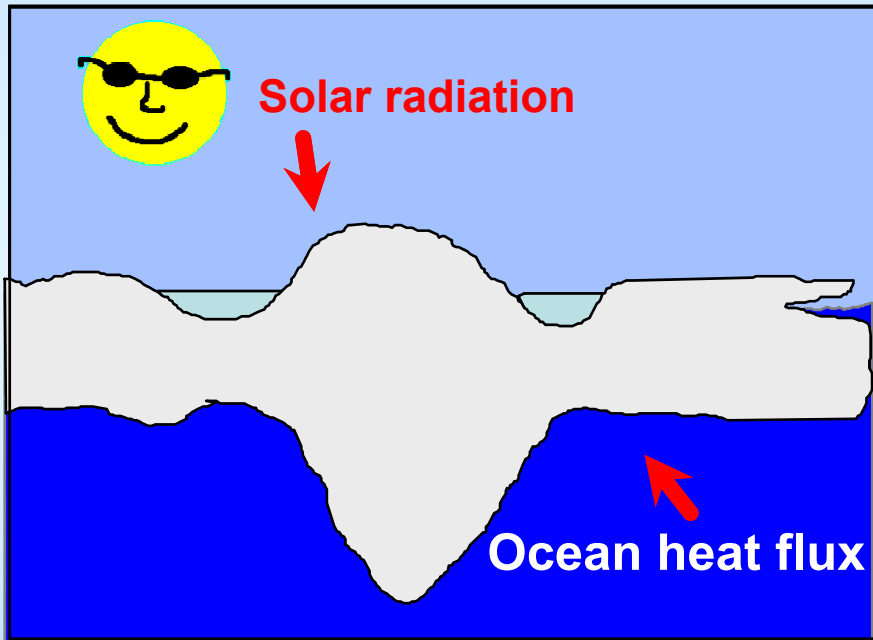


# SEA ICE COVER

*aka 'The Great Integrator'*

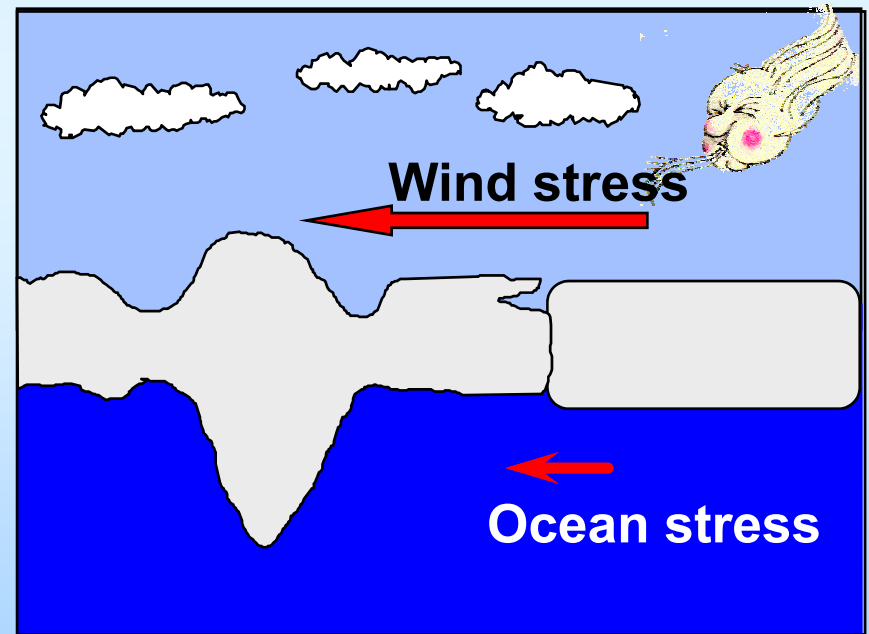
## THERMODYNAMICS

*Ice grow, melt and decay*



## DYNAMICS

*Ice motion*

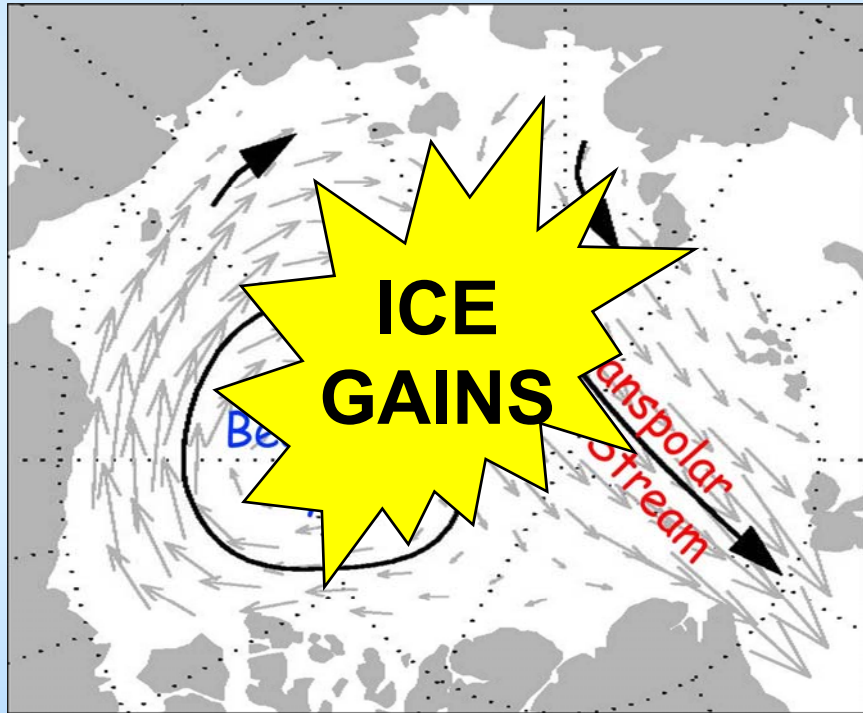


*Reflects impact of atmospheric and oceanic forcing*

# Arctic Oscillation (AO)

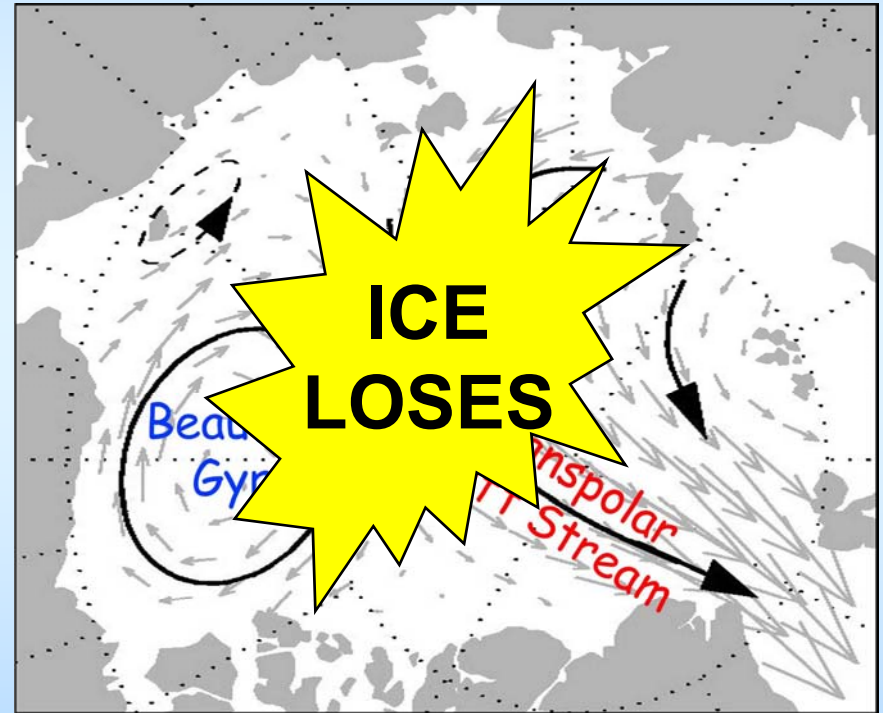
## *Two Dominant Regimes*

### Negative AO



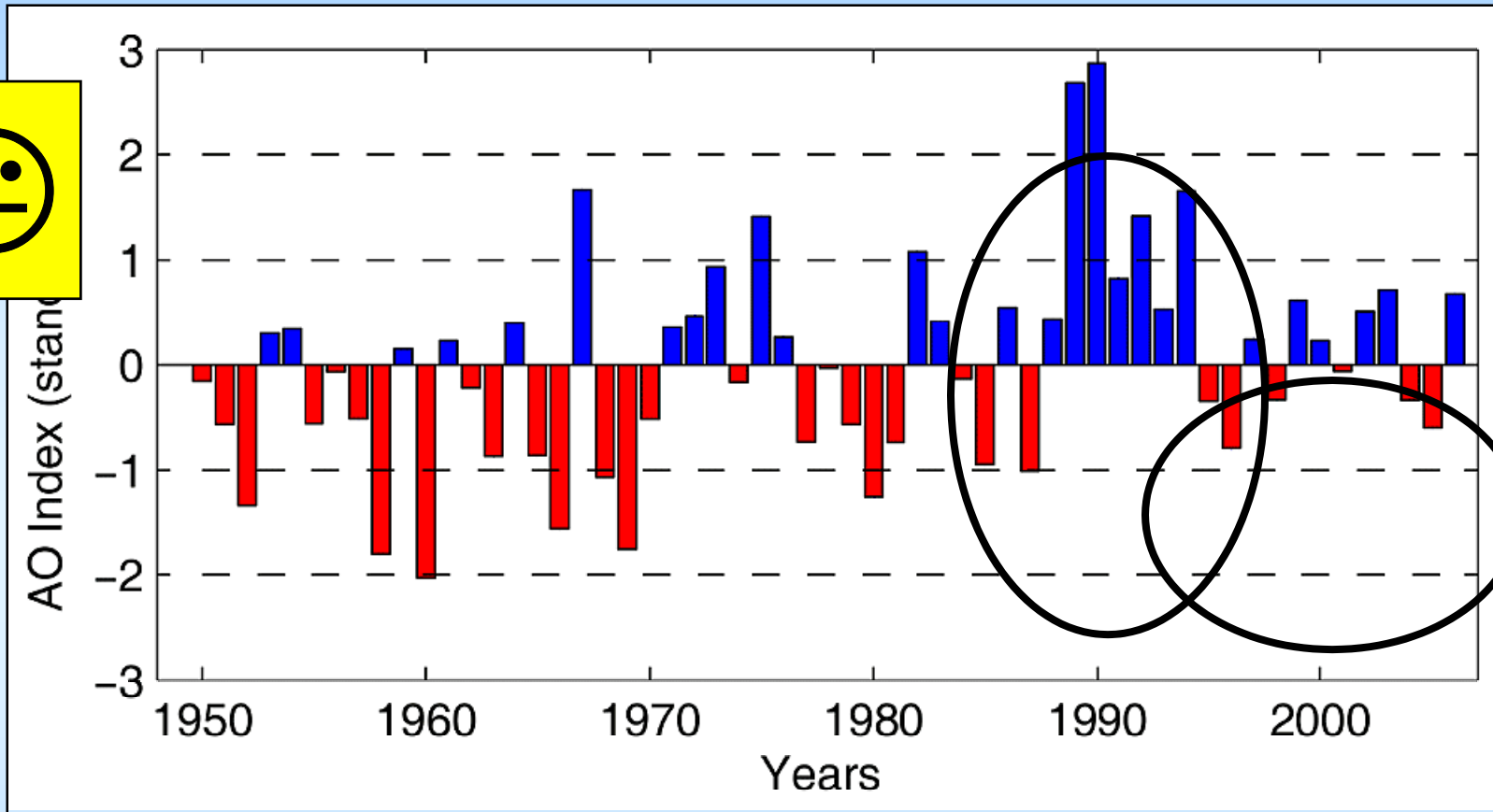
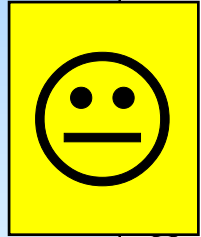
- Colder winter temperatures
- Strong Beaufort Gyre increases residence time for ice

### Positive AO



- Warmer winter temperatures
- Transpolar Drift Stream sweeps ice out of Arctic Ocean

# Atmospheric Oscillation (AO)



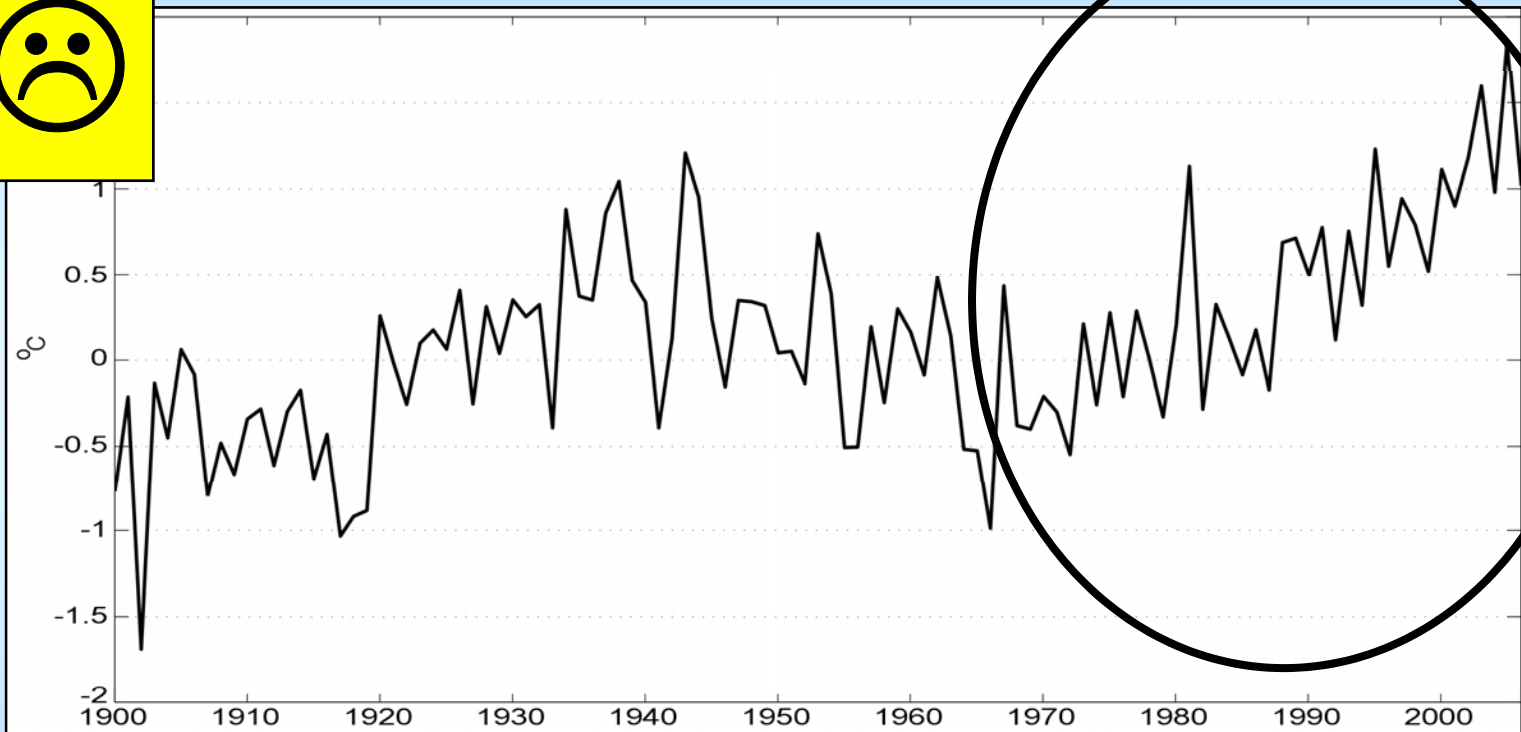
**Strong positive pattern dominated from 1989 – 1996**

***Favors loss of sea ice***

**More neutral pattern from 2000 - 2006**

***Opportunity for recovery***

# Arctic Surface Air Temperature 1900- 2006

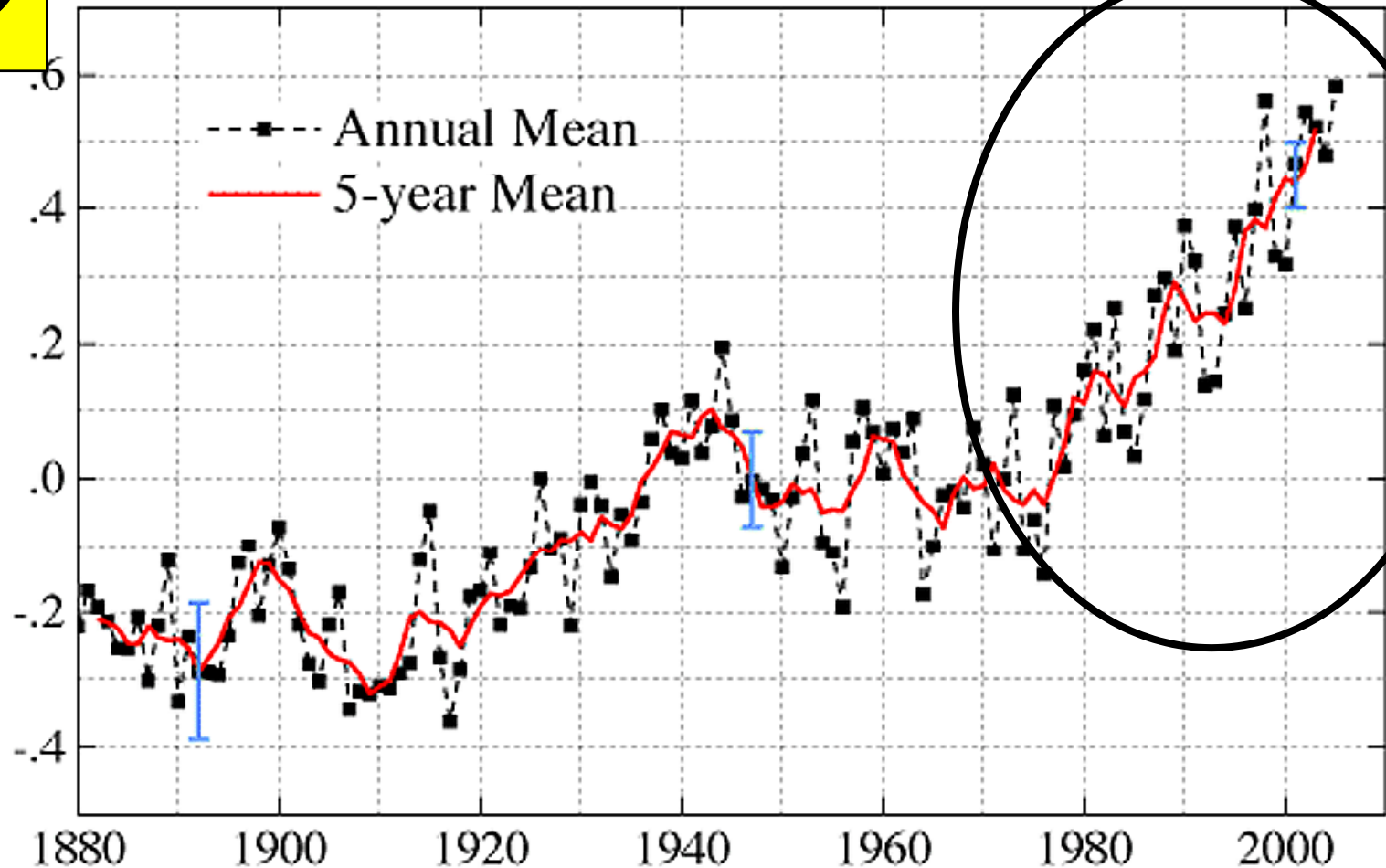


*Arctic-wide, annual averaged SAT anomalies (60 – 90 °N) over land*

***1980-present: Warming trend***



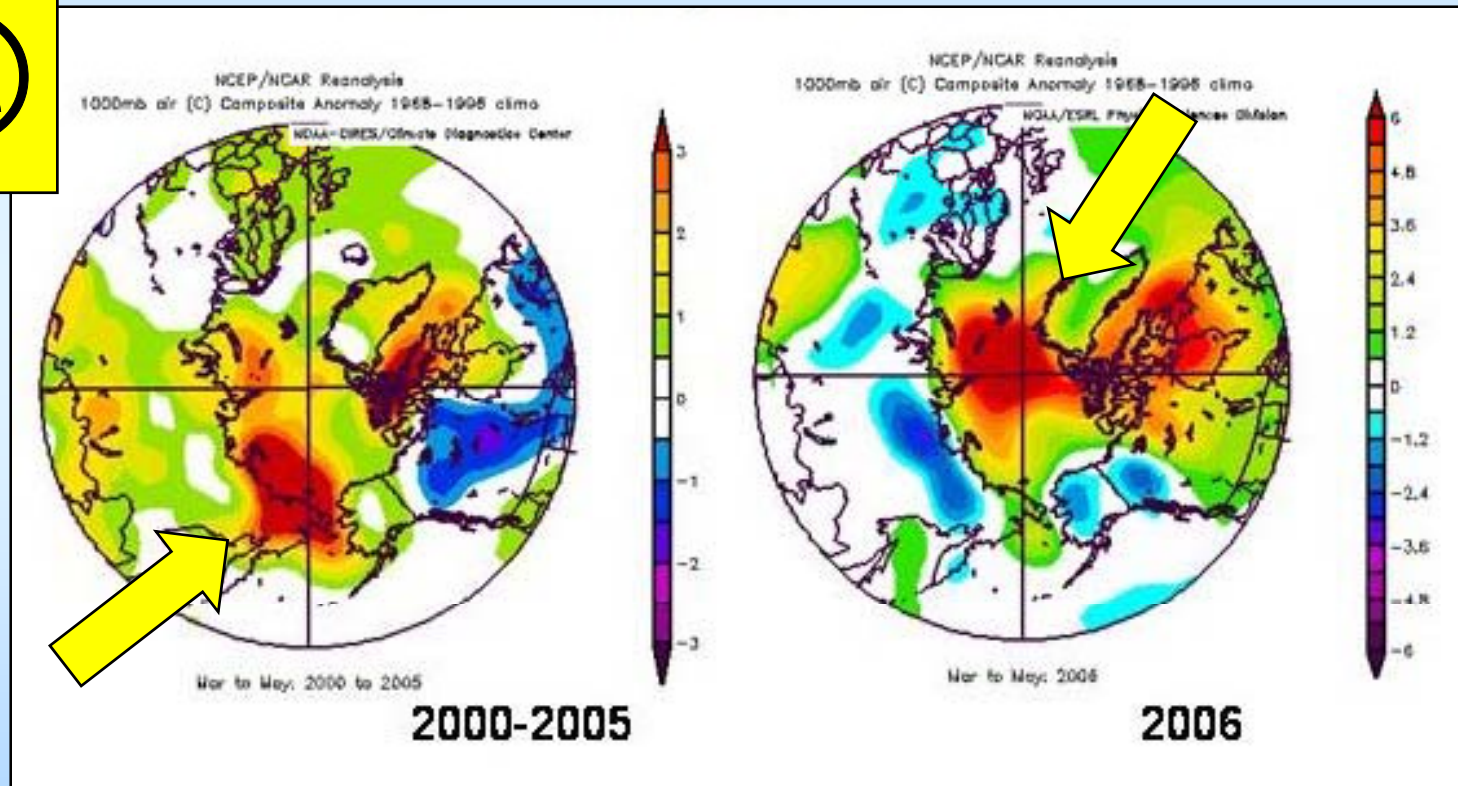
(a) Global-Mean Surface Temperature Anomaly ( $^{\circ}\text{C}$ )



***Warming: Arctic trend consistent with global trend***

# SURFACE TEMPERATURE

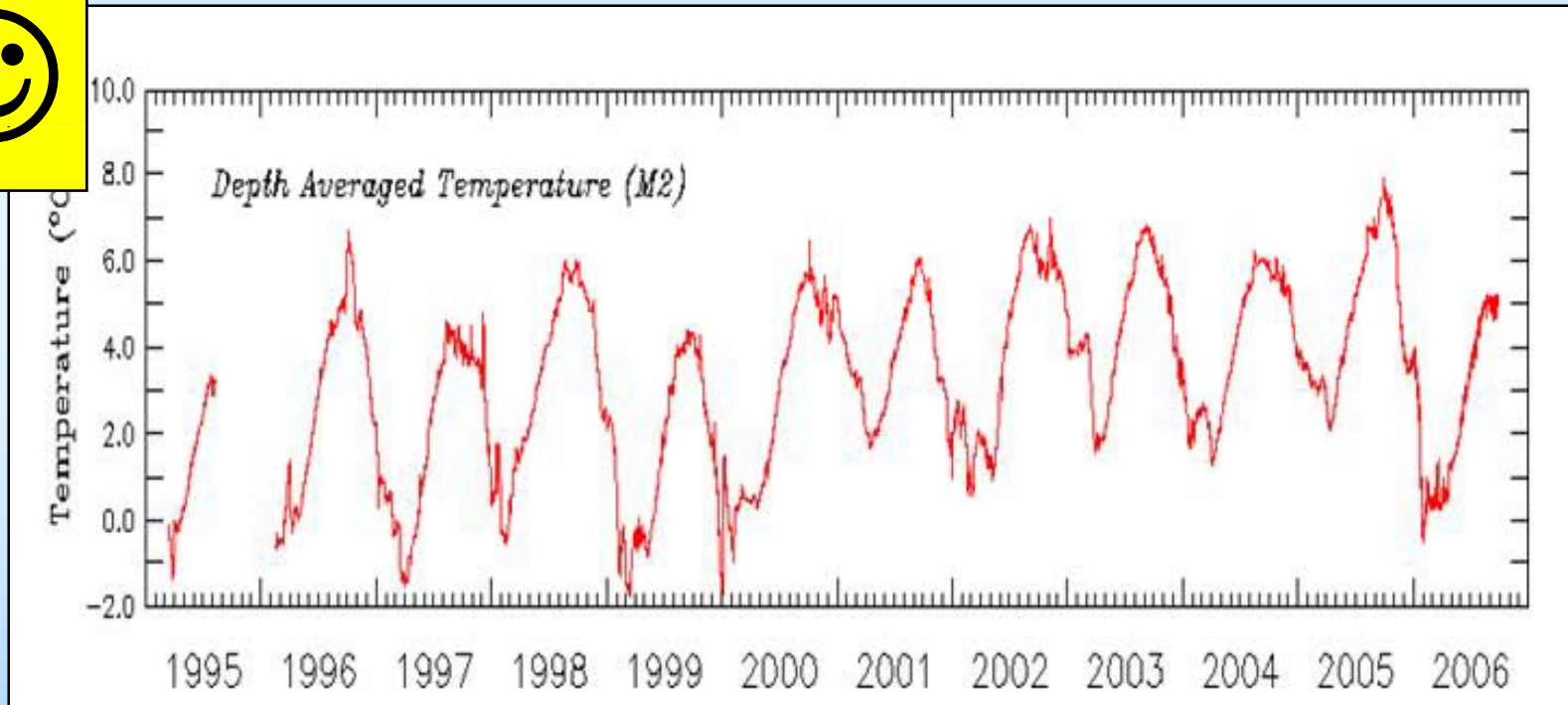
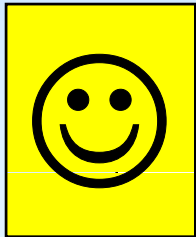
- *March-May temperature anomaly composites*
- *Relative to a 1968-1996 base period*



***Despite shift, positive (warm) anomalies remain over the entire Arctic***

# OCEAN *Temperature*

*Southeastern Bering Sea continental shelf mooring*



***2006: Significant cooling compared to previous 6-years***

# North Pole Region



# OCEAN

## Temperature & Salinity

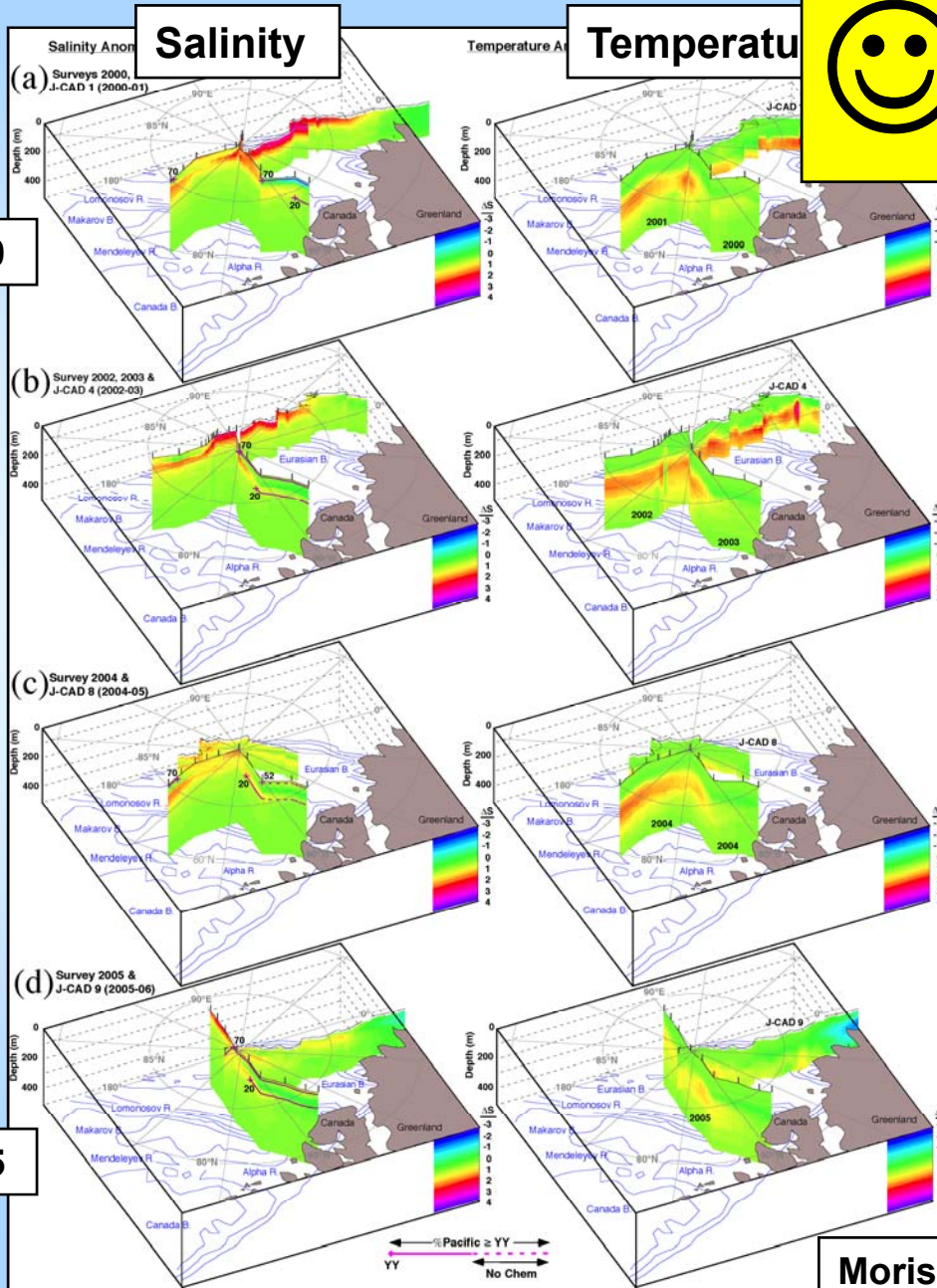
Anomalies relative to EWG climatology (1950-1980s)

**2000-2005:**

*Relaxation to near pre-1990 climatology*

2000

2005



Morison et al., 2006a



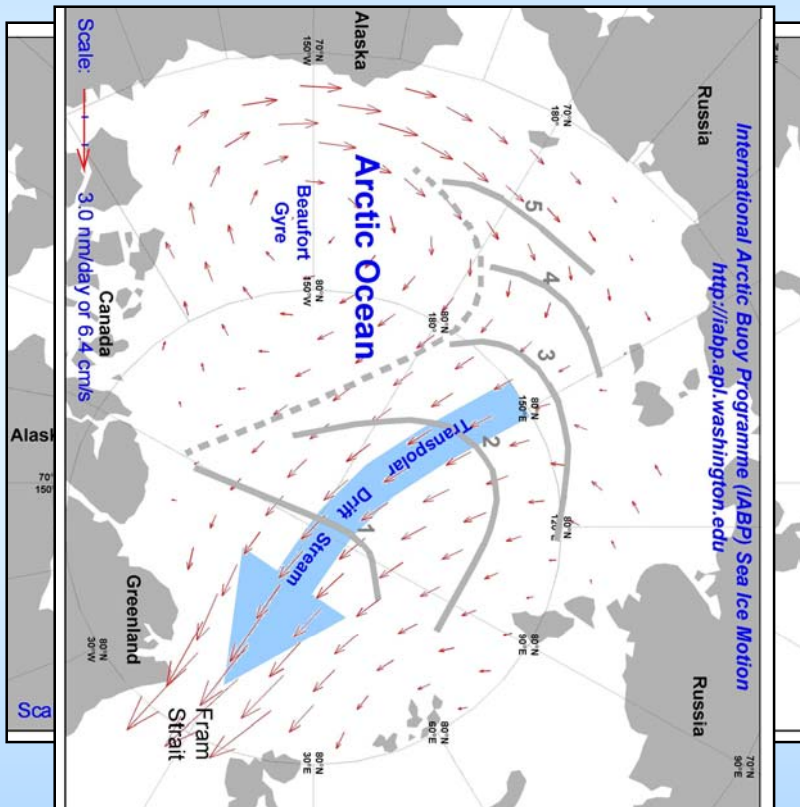
# **2007 Arctic Report Card**

## ***Sea Ice Cover***

***Why continued decrease in extent?***

# SEA ICE AGE

Circulation pattern



Thickness contours



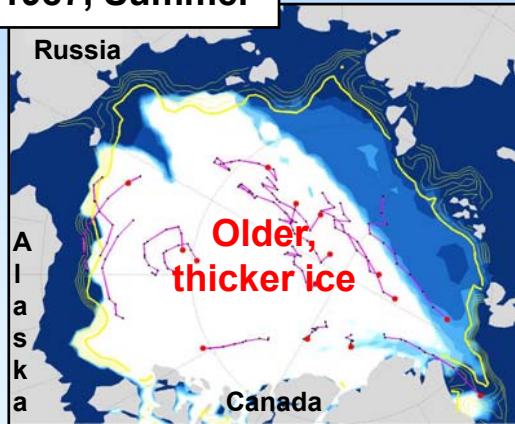
From Bourke and Garrett, 1987

***Older ice tends to be thicker, more robust***

# SEA ICE AGE

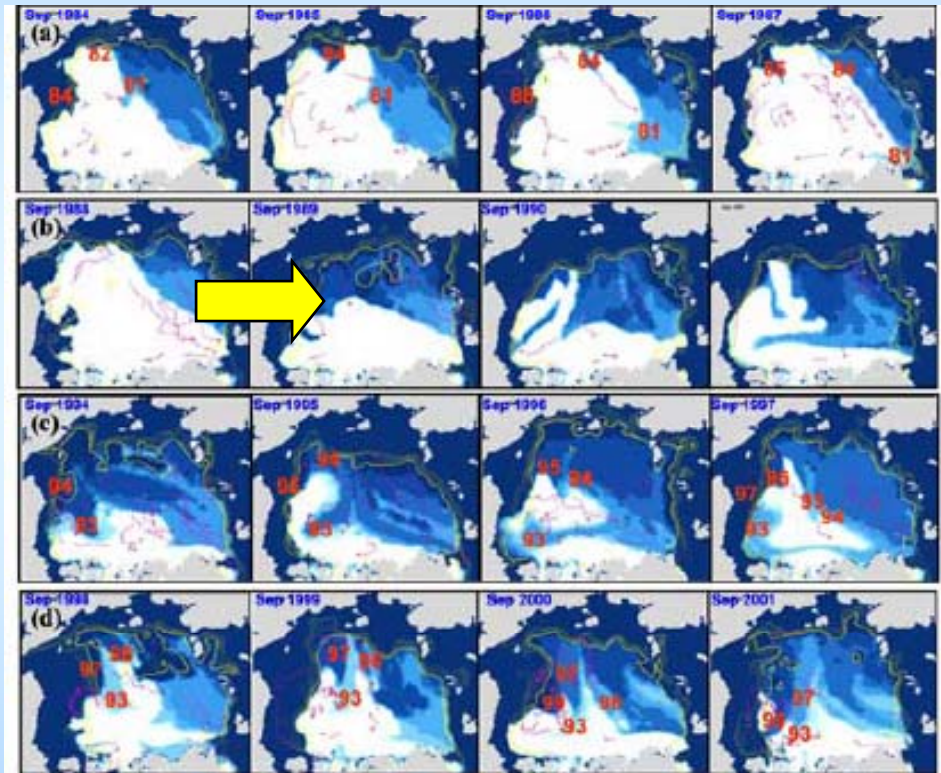
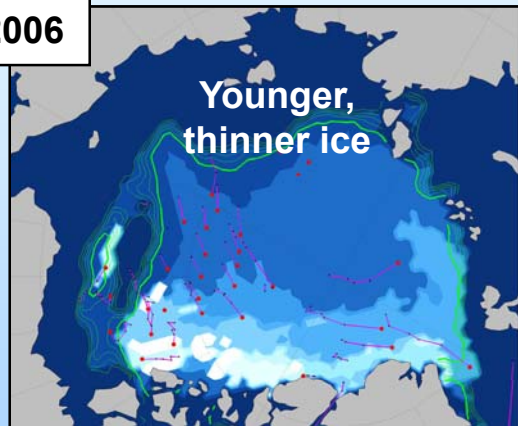
(After Rigor and Wallace, 2004)

Sep 1987, Summer



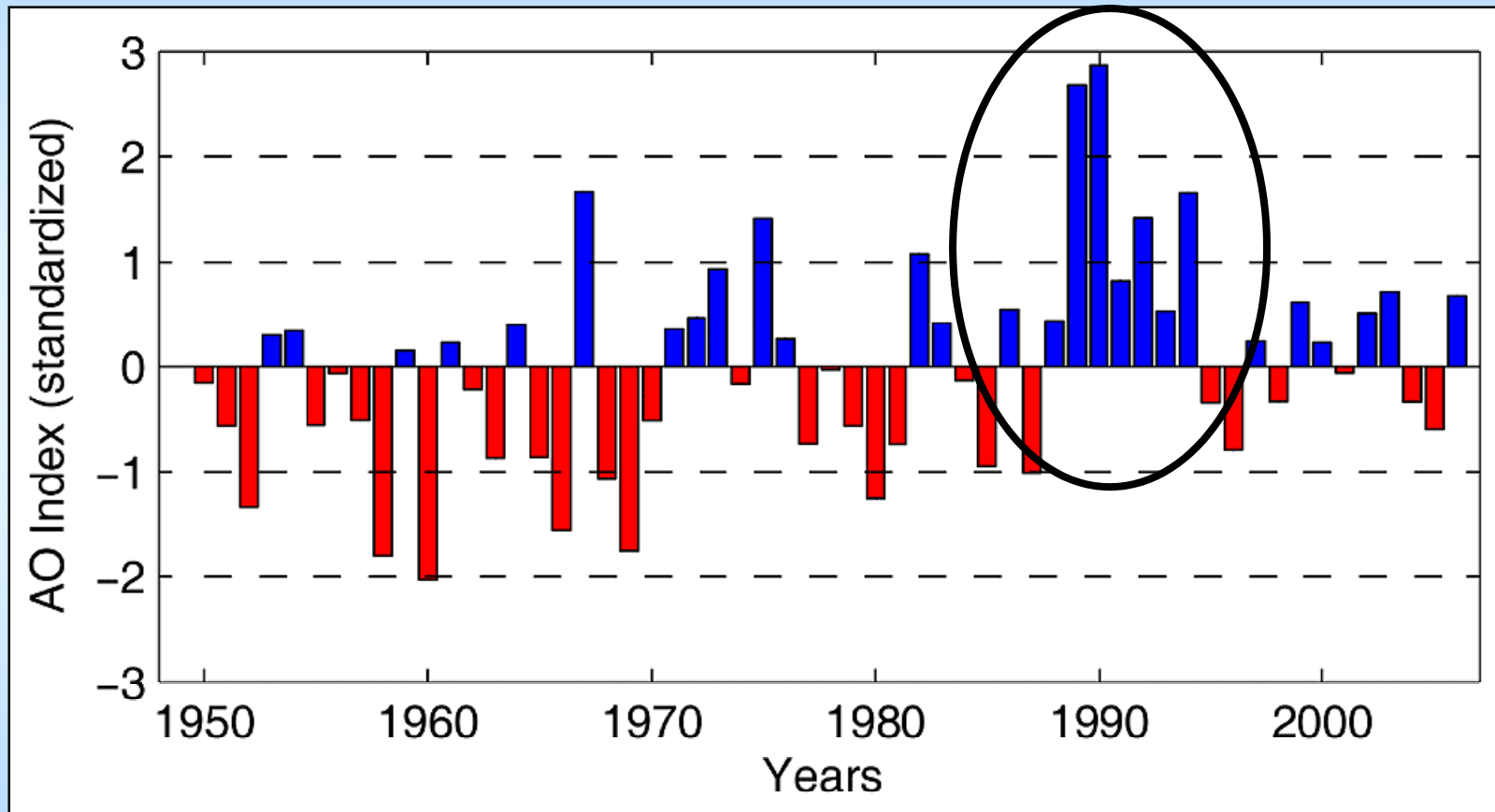
Age: OW 0 1 2 3 4 5 6 8 10+ Years

Sep 2006



**1988-1990: Precipitous decrease in older ice**

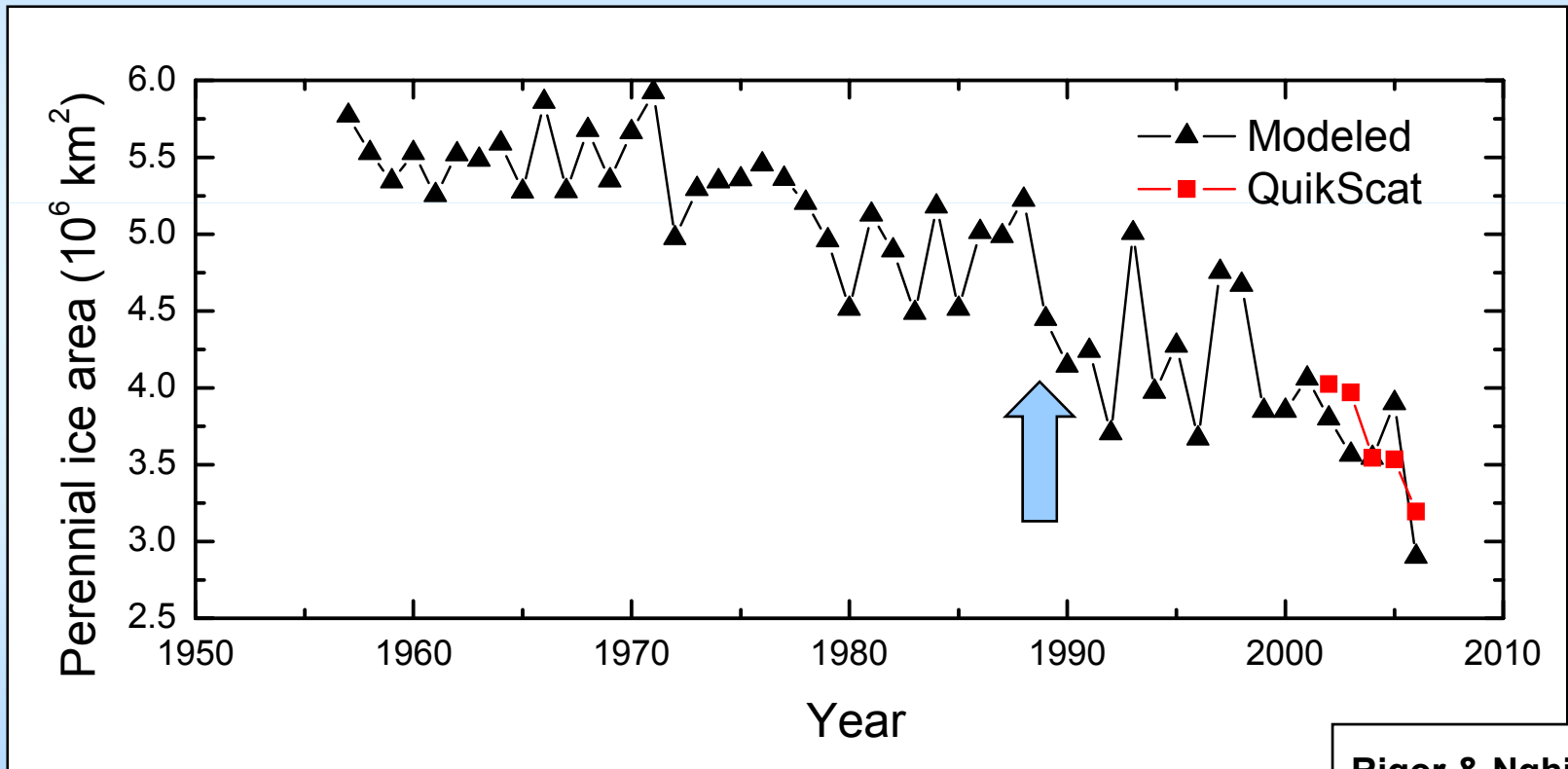
# Atmospheric Oscillation (AO)



**Strong positive pattern dominated from 1989 – 1996**  
***Favors loss of sea ice***

# SEA ICE AGE

## *Older, thicker ice*



Rigor & Nghiem

***Continued decrease in volume of older ice***

# The Arctic Sea Ice Cover

An aerial photograph of a coastal region, likely in the Arctic, showing a mix of green vegetation, brownish tundra, and dark blue water. A large white rectangular box with a black border is superimposed over the center of the image, containing the word 'ALBEDO' in bold, black, uppercase letters. The sky above the horizon is a pale, overcast grey.

**ALBEDO**

*From the Living Earth*

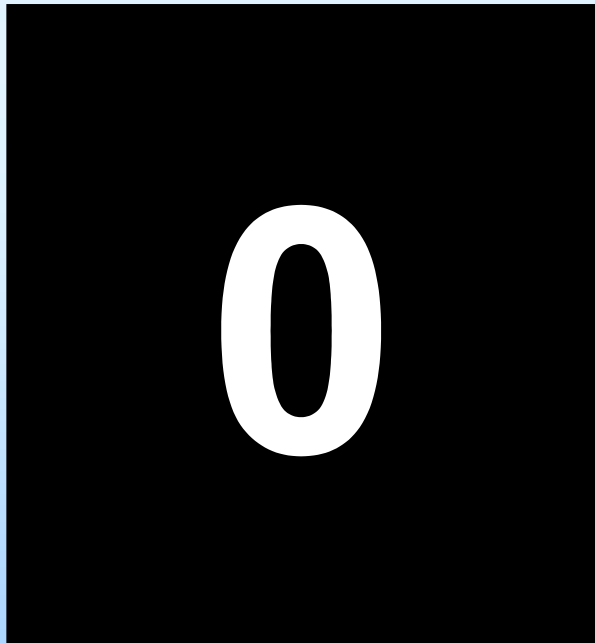


$$\text{Albedo} = \frac{\text{reflected sunlight}}{\text{incoming sunlight}}$$

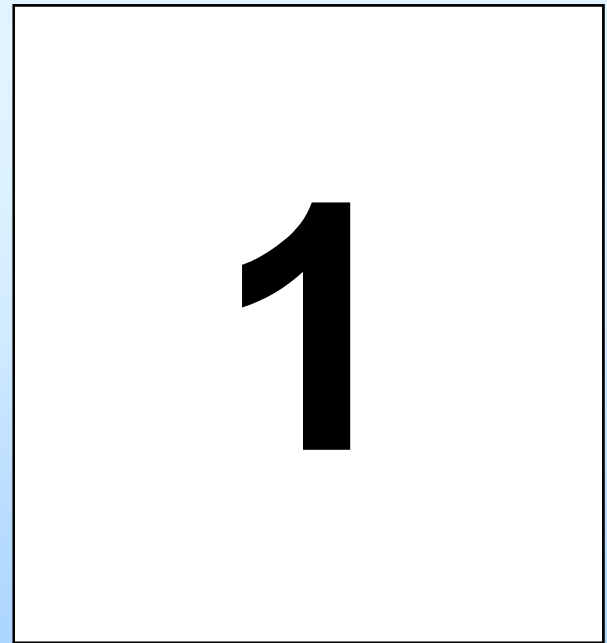


# ALBEDO

Varies between...

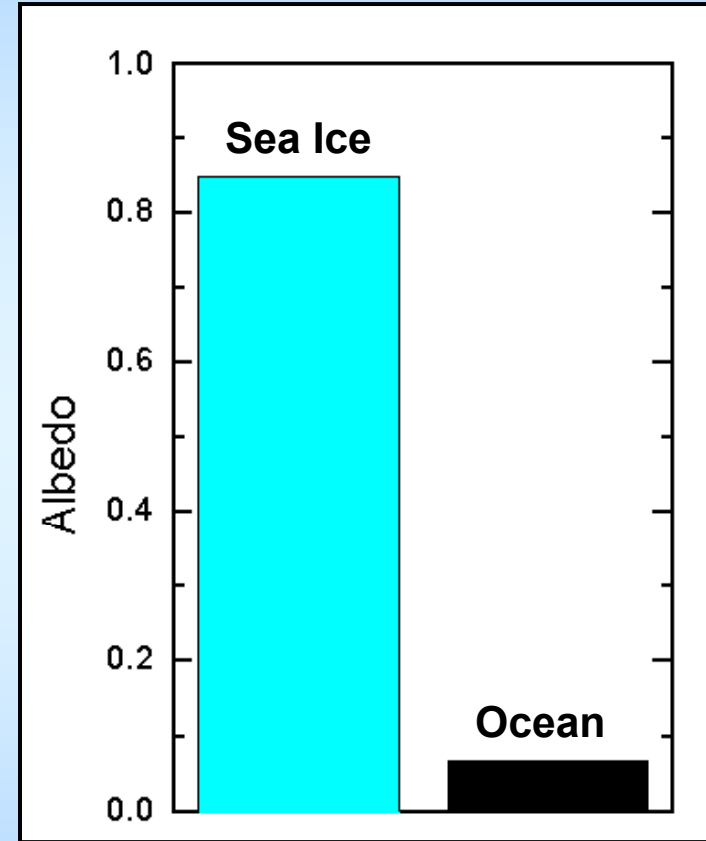


&



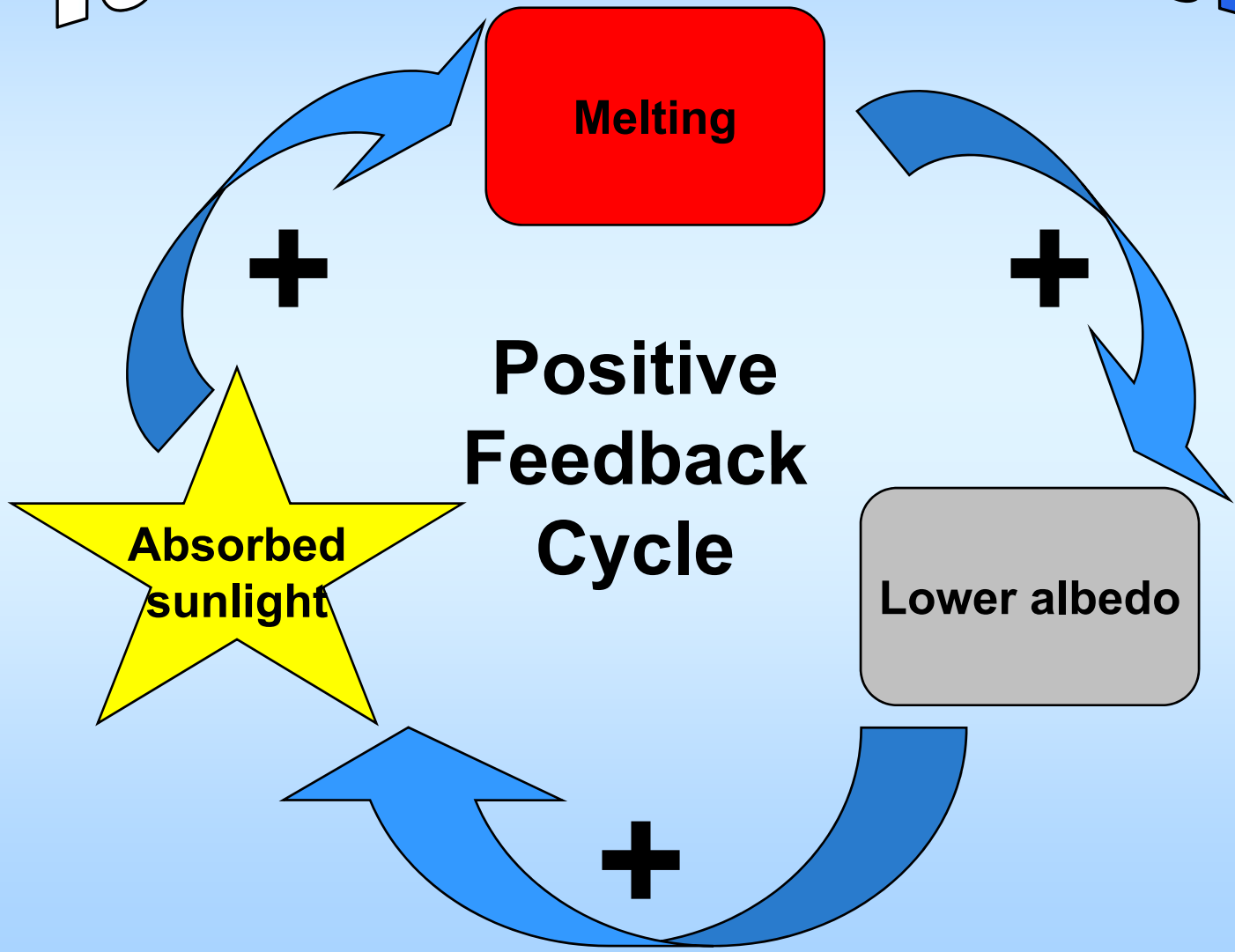


# Arctic Ocean



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

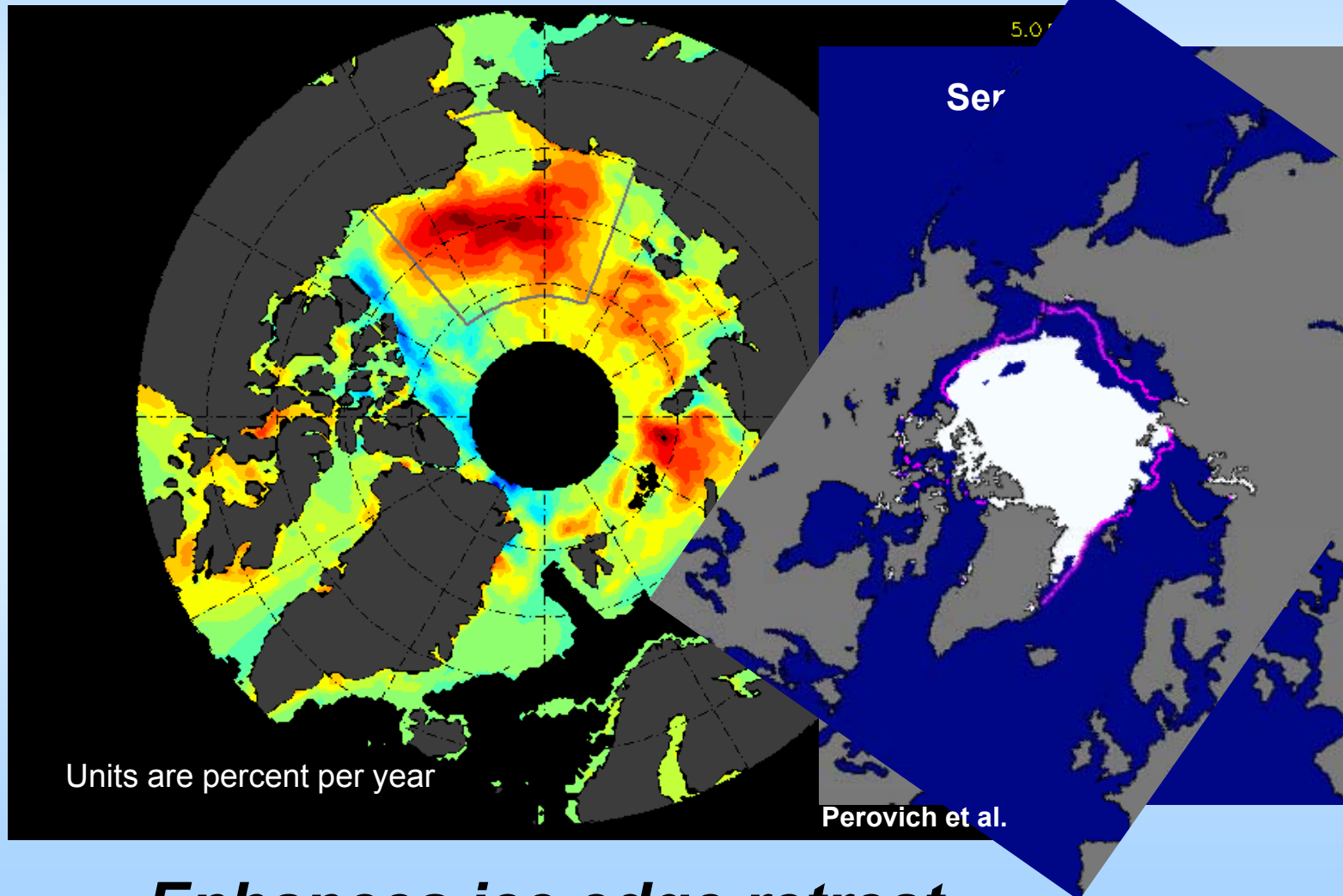
# Ice albedo feedback



# Ice-Albedo Feedback

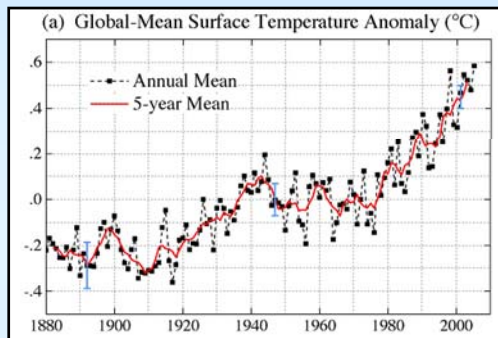
*25-year trend of annual solar heat input to ocean*

**Increasing solar heat input in 85% of area**



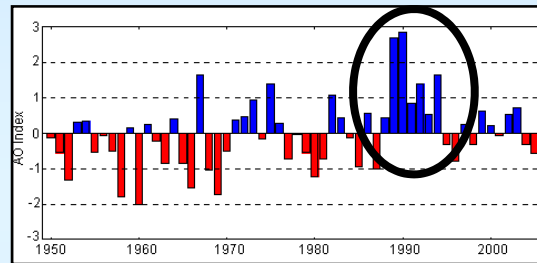
***Enhances ice edge retreat***

# Confluence of Events...



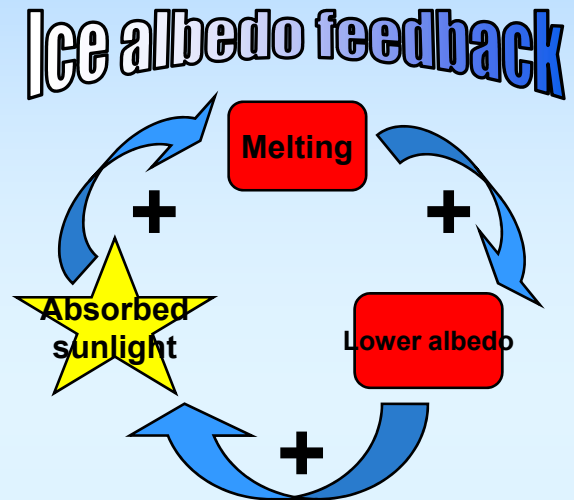
**Rising Global Temperature**

+

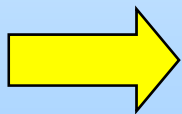


**Strong & Persistent Positive AO (Loss of old sea ice)**

+



**Strong Positive Feedback Cycle**



***Sea ice cover susceptible to loss***

# State of the Arctic Sea Ice Cover

## Summary

- **System under stress**
  - General warming global temperatures
  - Strong positive feedback cycle: Ice albedo
  - Precipitous drop in older, thicker ice
- **Destabilization?**
  - Rebound vs. State Transition

# International Polar Year



<http://www.ipy.org/>

# **SEA ICE: *Summer minimum extent***



***Reduction from 1982 to 2005***

