The State of the Arctic Environmental System

Martin O. Jeffries, Ph.D.

Assistant Director for Polar Sciences
& Executive Director, Inter-agency Arctic Research Policy Committee
Office of Science and Technology Policy

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Summary

- Change is occurring on land, in the atmosphere, and in the ocean
- The changes are physical and biological
- Arctic environmental change has global consequences
- International cooperation and collaboration is required to comprehensively observe, understand, and predict the Arctic and its role in the global system

Sources

- Arctic Report Card: http://www.arctic.noaa.gov/reportcard
- State of the Climate: http://www.ncdc.noaa.gov/bams-state-of-the-climate/

Examples of Arctic Change

Changes on the Land

- Spring snow cover is disappearing earlier**
- Glaciers and the Greenland Ice Sheet are losing mass
- Permafrost is warming and thawing
- The tundra is becoming greener (biomass is increasing)

Changes in the Ocean

- Sea ice thickness, extent and volume are decreasing**
- Sea surface temperatures are increasing
- Primary productivity is increasing

Changes in the Atmosphere

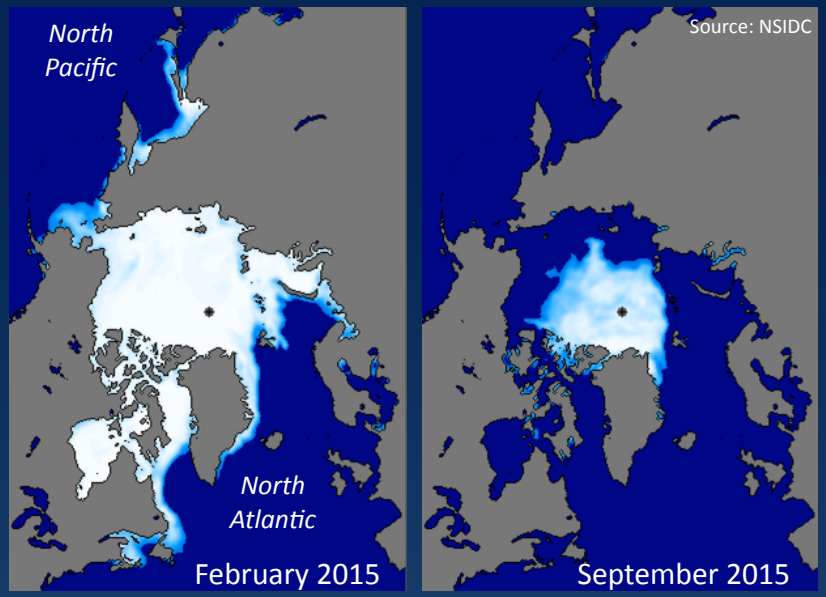
- Air temperatures are increasing in all seasons**

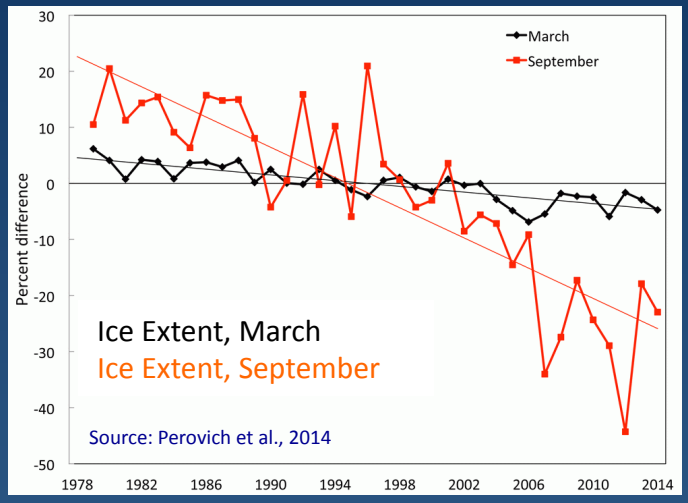
**I'll say more about these changes.

Sea Ice Extent

Maximum ice extent in 2015 occurred on 25 February, 15 days earlier than average, and was the lowest in the satellite record.

Minimum ice extent in September 2015 was the 4th lowest in the satellite record.

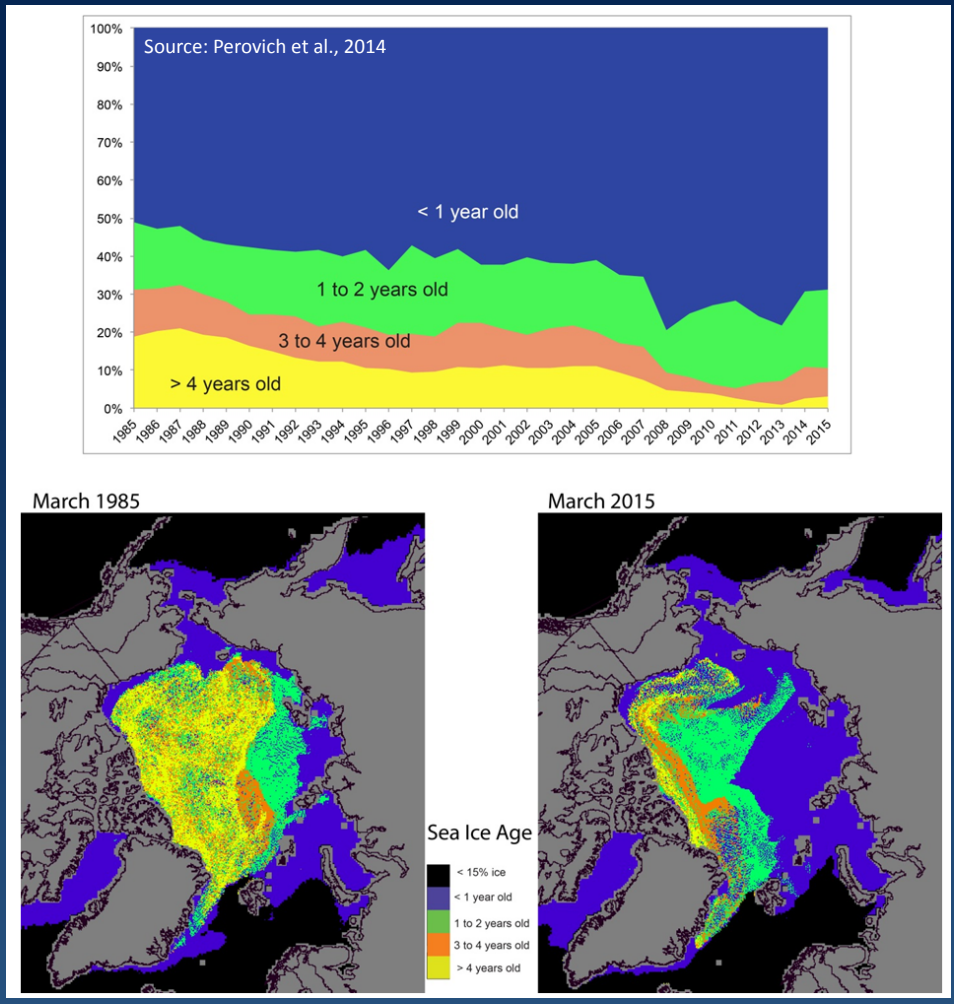




Maximum ice extent is declining at a rate of -2.6% per decade relative to the 1981-2010 average.

Minimum ice extent is declining at a rate of -13.4% per decade relative to the 1981-2010 average.

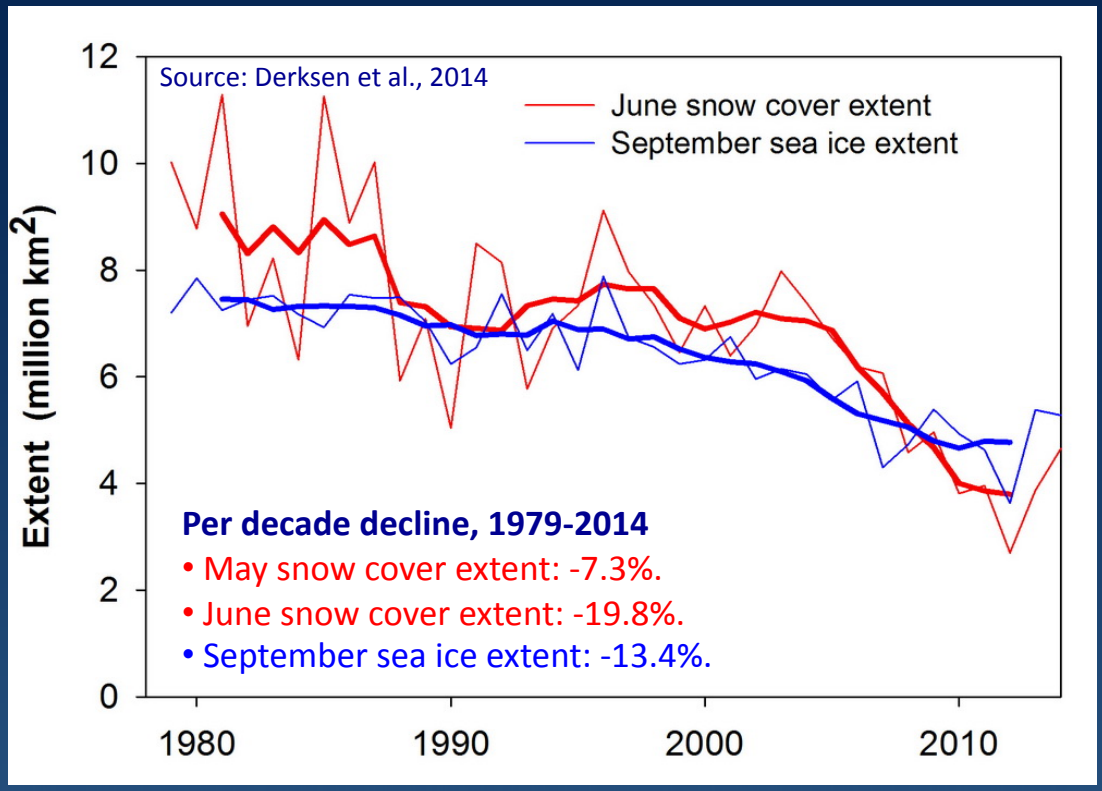
Sea Ice Age



The age of sea ice, a proxy for thickness, is decreasing.

Snow Cover & Sea Ice

Emerging evidence that Arctic warming is driving synchronous pan-Arctic responses in the terrestrial and marine cryosphere.



The rates of decline in terrestrial snow cover extent in May and June bracket the rate of decline in September sea ice extent.

Why Loss of Sea Ice & Snow Cover Matters

Snow/Ice Albedo Feedback

Snow:	0.9
Bare Ice:	0.6
Vegetation:	0.2
Ocean:	0.06

Albedo: 1

Albedo: 0

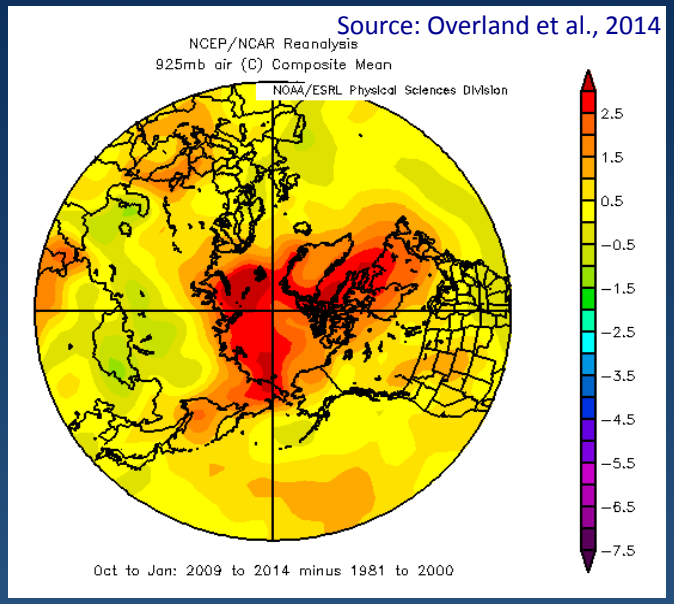
Source: PolarTREC

Source: Don Perovich, CRREL

Air Temperature

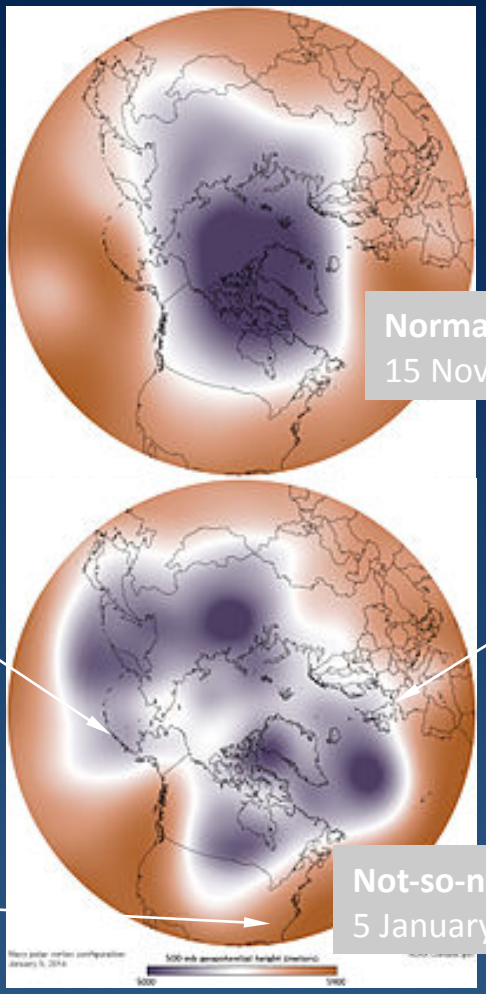
In 2015, the mean annual surface air temperature anomaly for Arctic lands was +1.1°C (relative to the 1981-2010 mean).

The rate of warming in the Arctic is >2x the rate of the rest of the World.



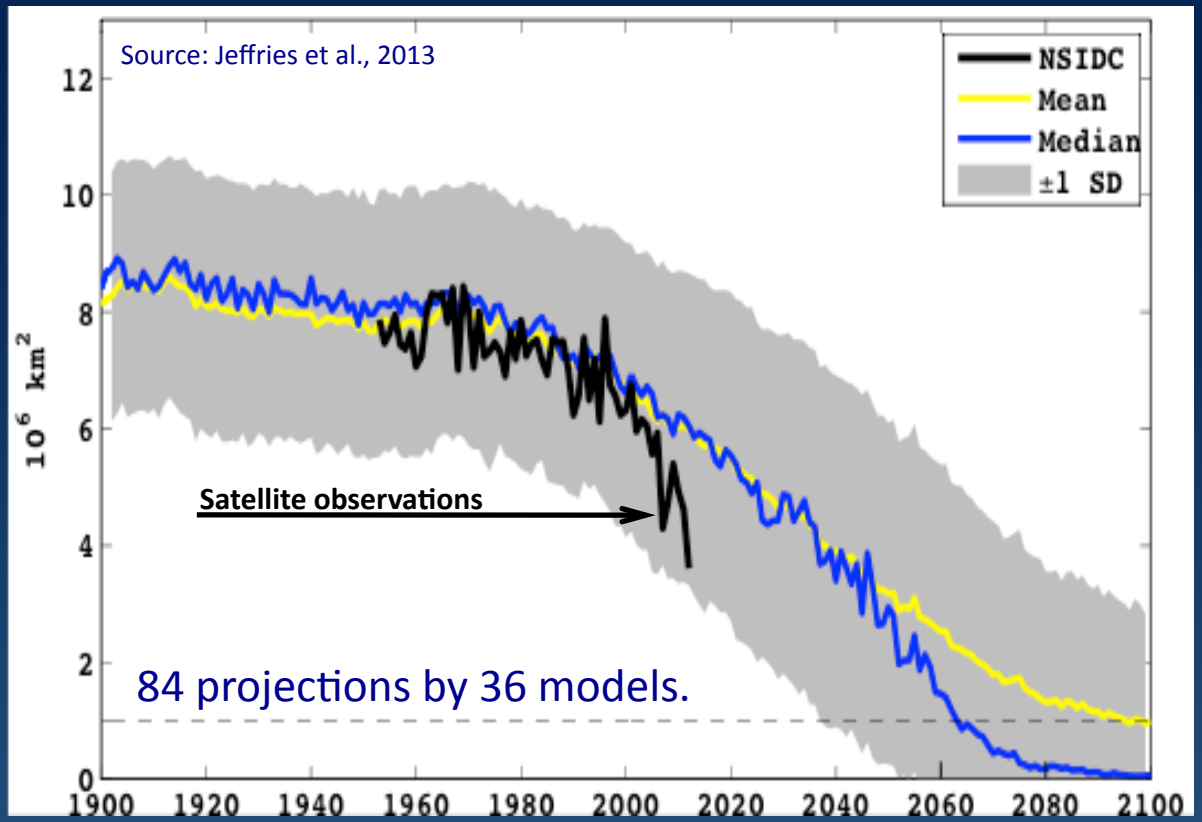
Autumn air temperature anomaly: early 21st Century vs. late 20th Century.

In early 2014, Arctic and mid-latitude weather patterns were strongly connected: The so-called ***Polar Vortex.***



Source: NOAA PMEL

Whither Sea Ice?



Continued decrease in sea ice extent.
Continued increase in the area of open water.

The Need for Arctic Observations

- To initialize models
  - start model runs with specified variables, e.g., sea ice thickness
- To assimilate into models
  - impose reality on models to improve performance
- To improve model physics, and thus performance,
  - understanding processes, interactions and feedbacks
- To evaluate model performance
  - how well does the model match reality? (see previous slide)
- To detect and monitor change
  - long-term observing
- To create value-added products and services
  - sea ice charts, weather maps and forecasts, snow water equivalent .....
  - data need to be freely and openly available in a timely fashion

Observing, Understanding and Predicting the Arctic

- No single country can
  - develop the necessary integrated Arctic Observing System
  - perform the research to understand processes, interactions and feedbacks in the Arctic environmental system, and its role in the global system
  - develop and improve Arctic System modeling and numerical prediction capability
- It will require international cooperation and collaboration to achieve this ambitious goal
- For this reason, the White House is planning the first ever **Arctic Science Ministerial** that will occur later this year in Washington, DC.

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