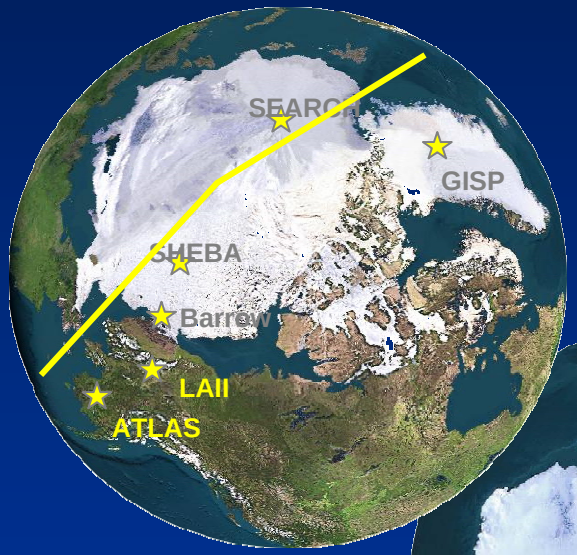
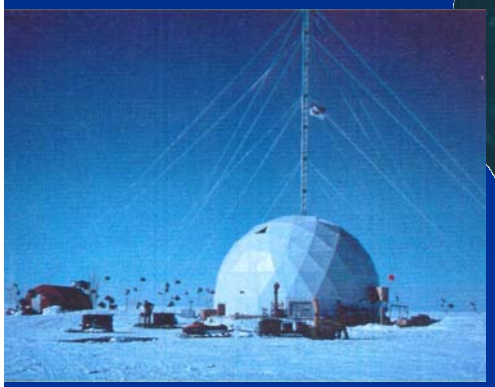
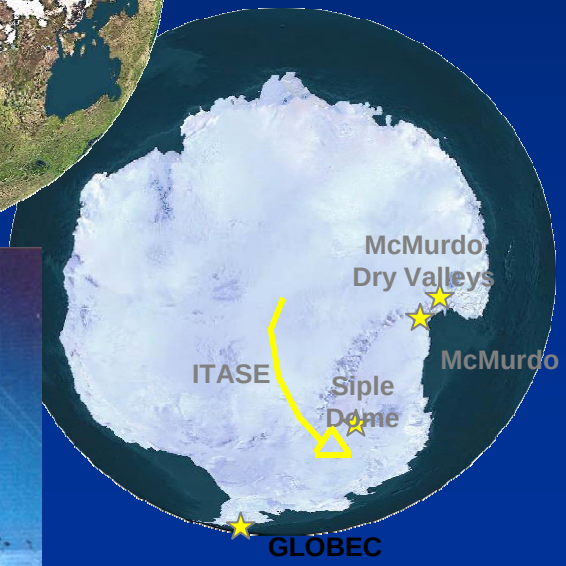
Polar Research: Climate change viewed through a prism of ice

- A window to the past – ice cores
- A canary in a coal mine – the Arctic
- A predictor for the future – feedbacks and GCM's





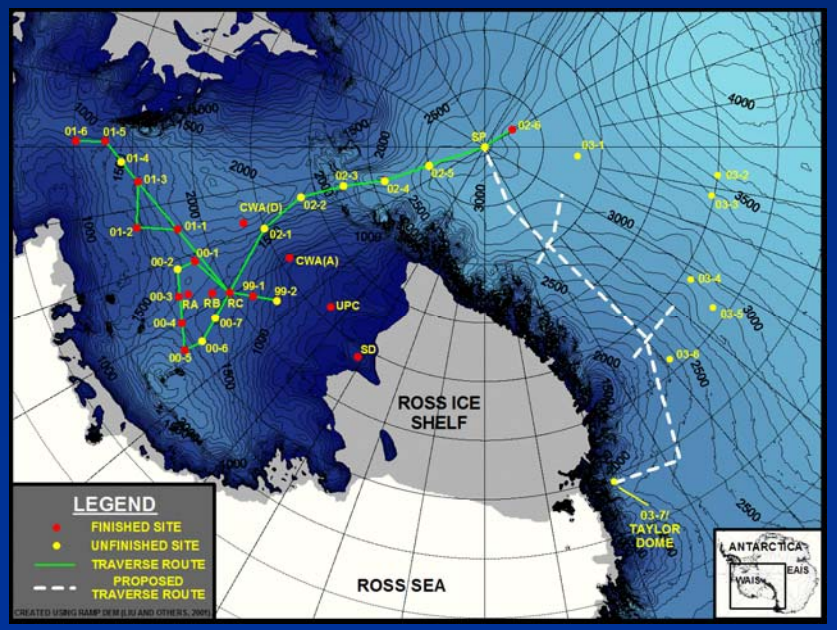


To the ends of the Earth

Ice cores: a window to the past

Ice cores can
- provide a very long history (100,000+ years)
- be very accurate
- provide more types of data

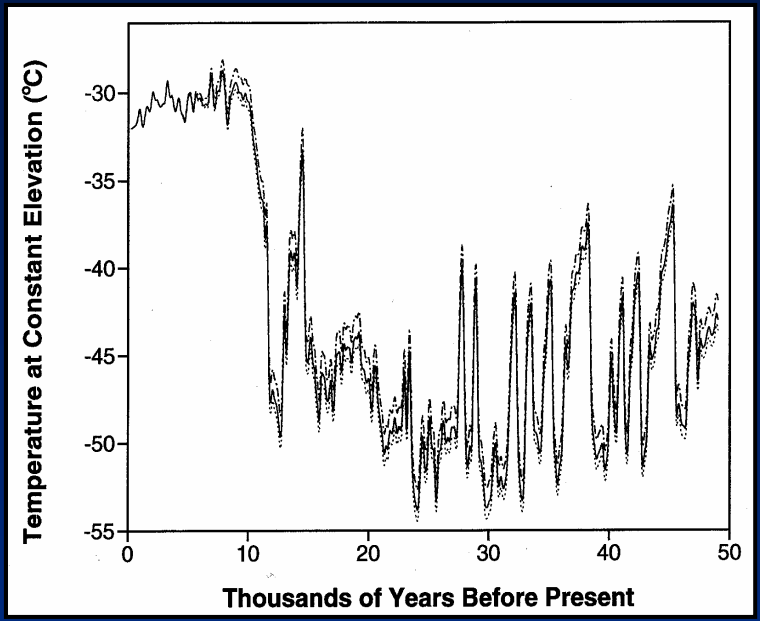
CRREL has long record
- 1950's – GISP
- 1990's – GISP II
- 2000's – Siple Dome, ITASE



100,000+ year records

Ice cores: a window to the past

Major findings:
- Site selection is critical
- Large, rapid climate changes in past 140,000 years
- Ice age transitions can occur as fast as decades
- Rapid changes of 10 ^{o}C in less than 10 years
- Changed state can persist a long time
- Change in Antarctic climate about 1940
- Anthropogenic signal in Greenland, not in Antarctic

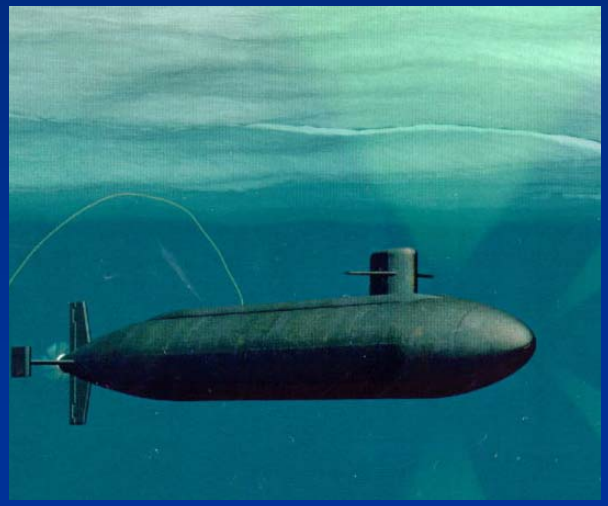


Large rapid changes

Sea ice extent and thickness

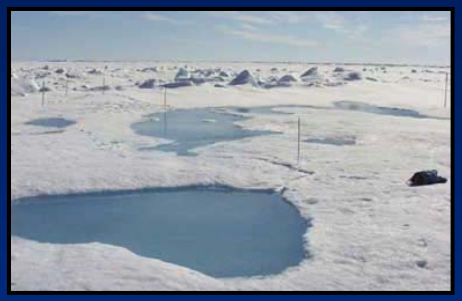
Major findings:
- Since 1970's ice area decreasing
- 3% per decade
- Ice thinning in 1990's and 2000's.

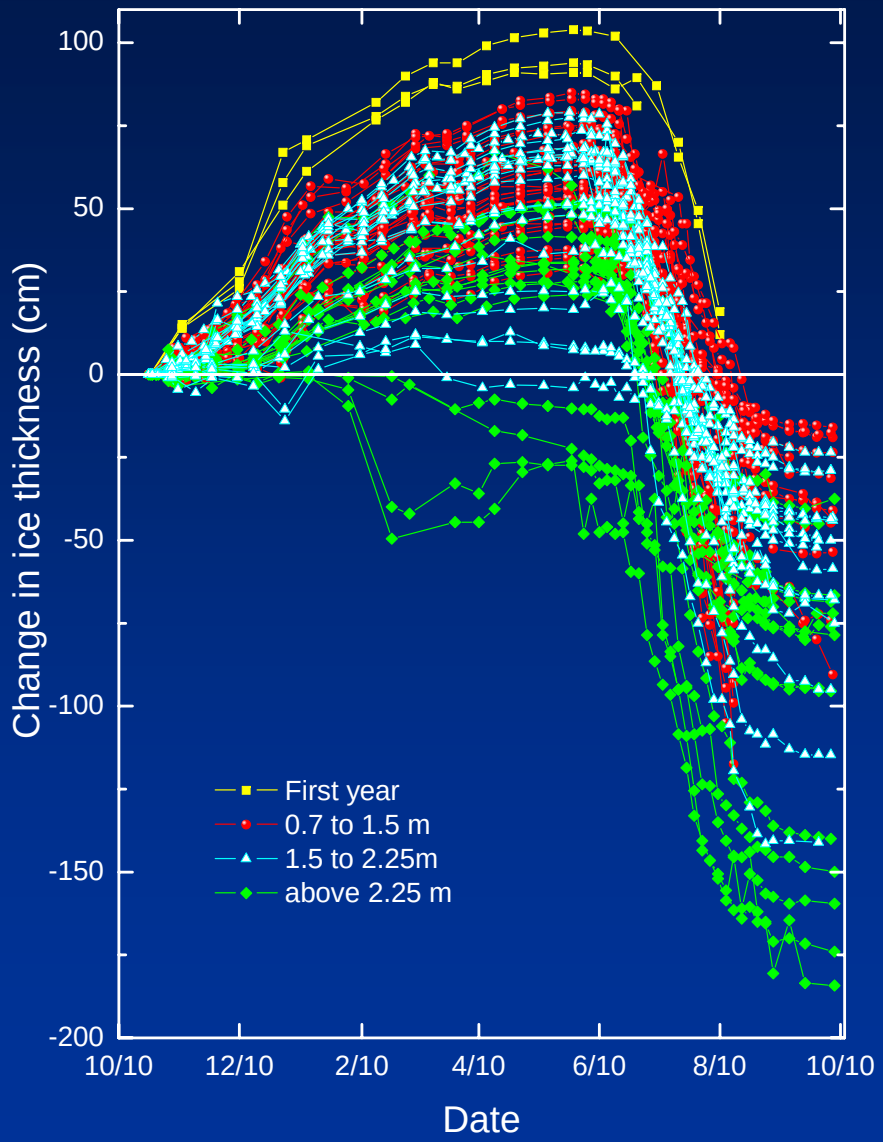
CRREL contributions
- Release and analysis of submarine data
- Surface characterization for remote sensing
- Algorithm improvement



Sea ice decreasing…but why?

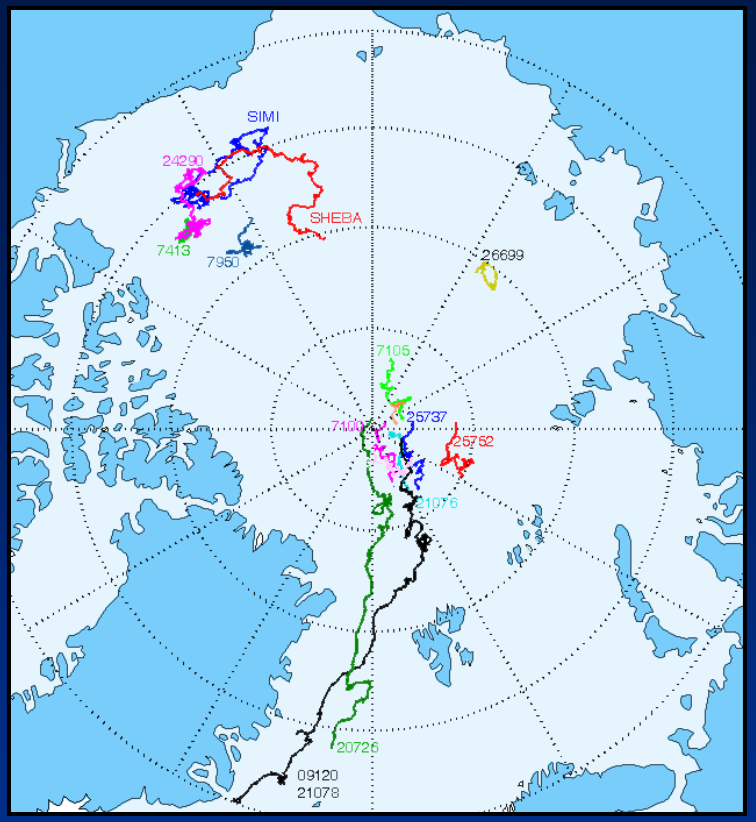
Sea ice mass balance

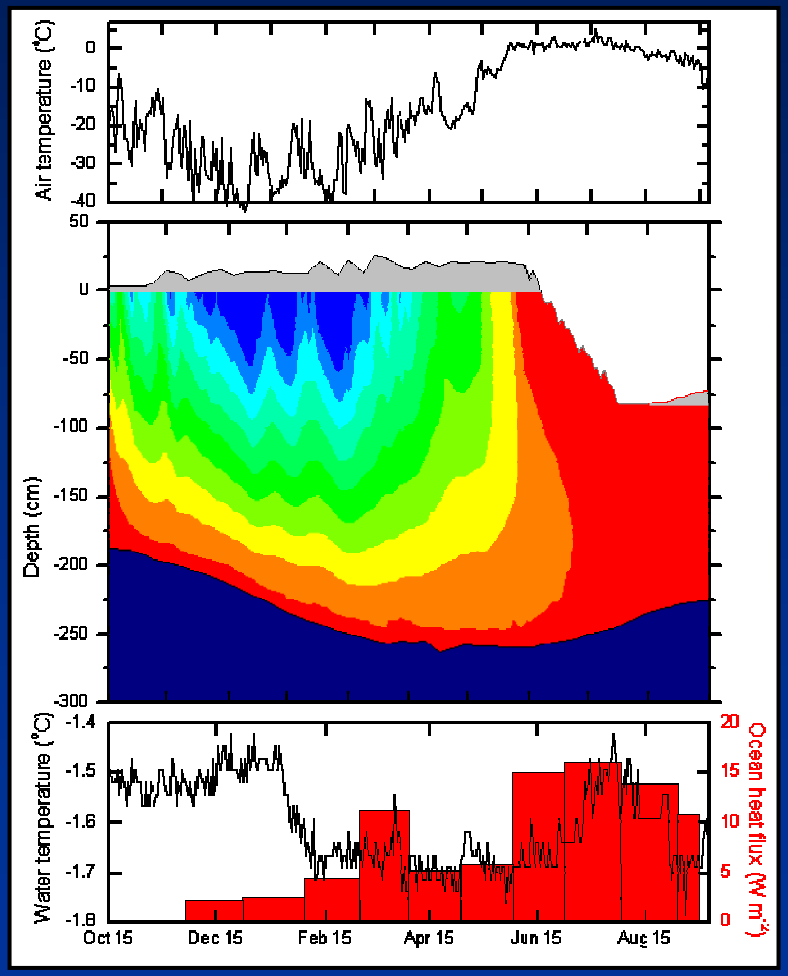


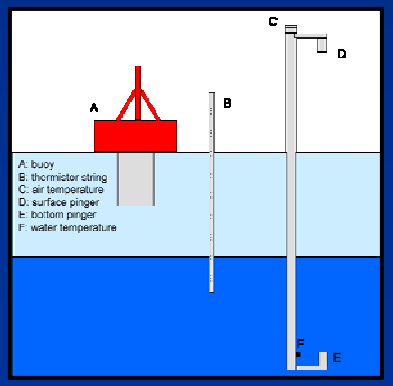


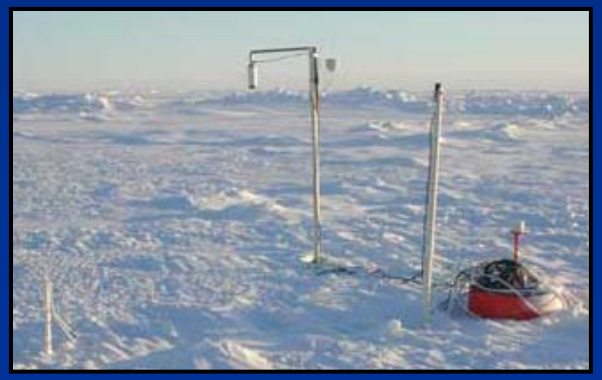
Enhanced melting – particularly at the ice bottom

Mass balance observations









Autonomous buoys: developing a mass balance climatology

Polar Science: Summary

Key Science Issues

- Investigate past, present, and future polar climate.
- Understand the workings of the system – ocean, ice, atmosphere, land, people.
- Determine the properties and processes of polar terrestrial and marine environments.
- Explore mass, energy, and chemical exchanges from microscale to synoptic scale.

Unique Aspects of CRREL Polar Research

- Polar measurements on local and regional scales.
- Autonomous observing systems.
- Extensive cold rooms, ice testing facilities, and apparatus.
- Theory and modeling of fundamental processes from the microscale to the planetary scale.
- Leadership role in large, interdisciplinary research efforts

Advances in Polar Sciences

Analysis of 100,000 year ice core climate record

- Models of ice mechanics from microscale to synoptic scale
- Turbulent transfer theory for air-ice and air-snow interactions.
- Observations and parameterizations of the ice-albedo feedback.
- Mass and energy model of snow and sea ice.
- Observation, theory and model of snow-wind pumping and chemical exchange.
- Ice sheet dynamics from GPR and ice cores.
- Validation of satellite observations and models.