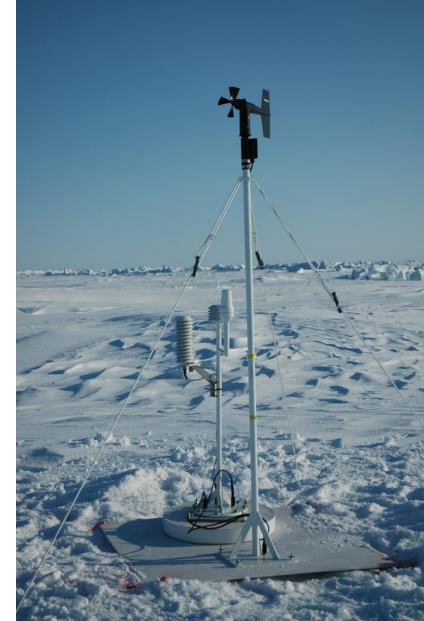
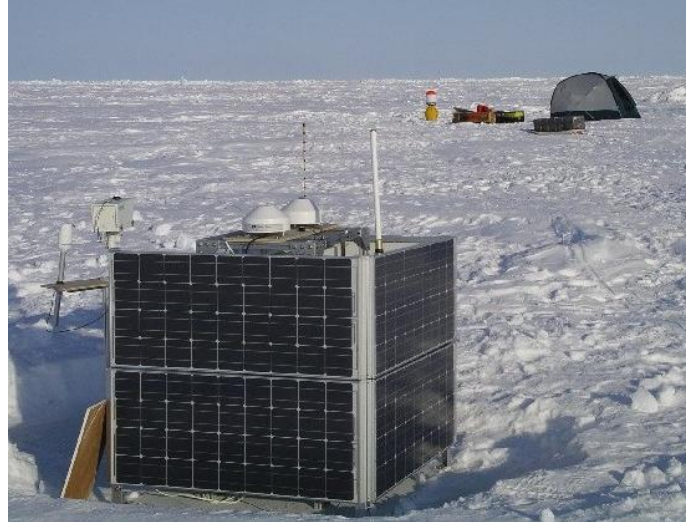
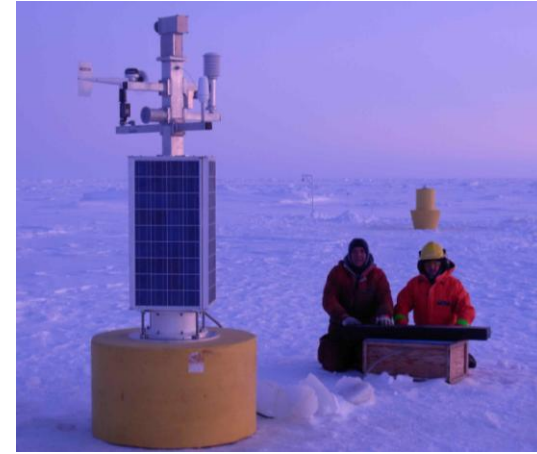
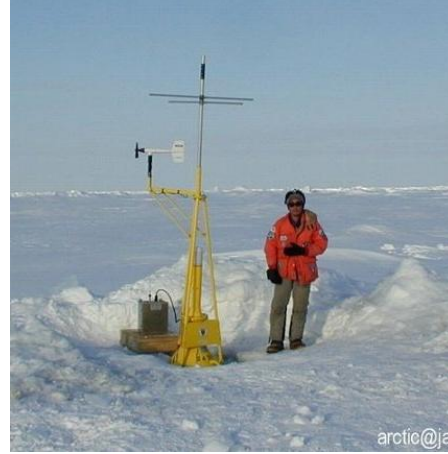


Sea ice based autonomous systems



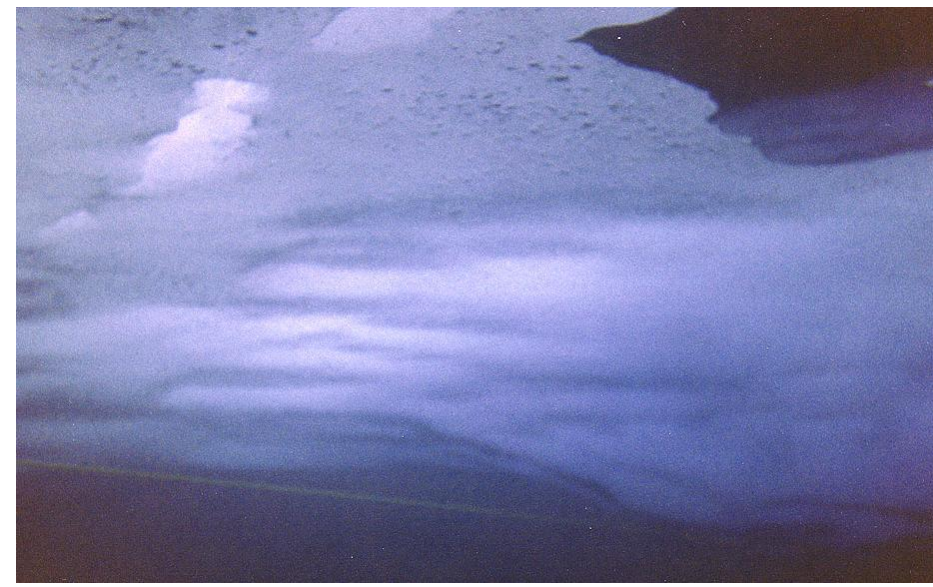
The next best thing to being there

Challenges – polar regions



Blowing snow, months of darkness, icing, and animals

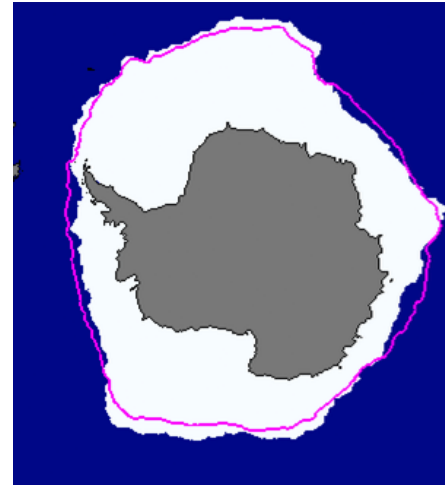
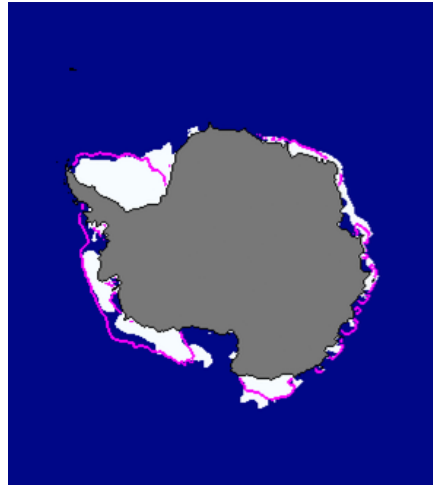
Challenges: sea ice



It breaks, it crunches, it melts, and the ocean is below

Challenges: Antarctic sea ice

- High winds
- Broken up ice cover
- Deep snow
- Thin ice
- Surface flooding
- Large ocean heat flux
- Large seasonal changes



Not the best long term platform

Arctic challenge: multiyear to first year

Multiyear ice



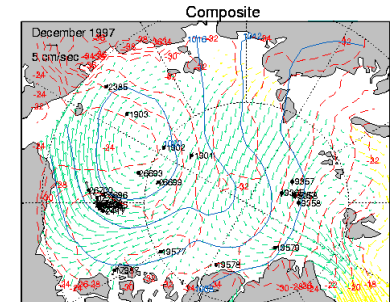
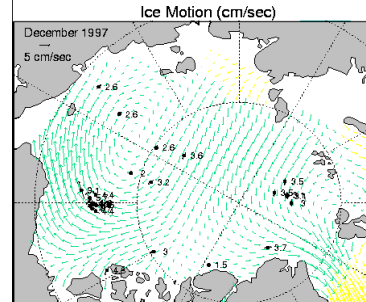
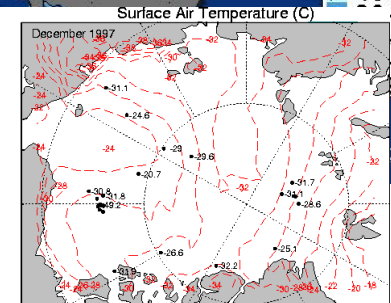
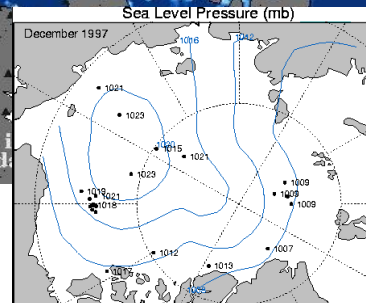
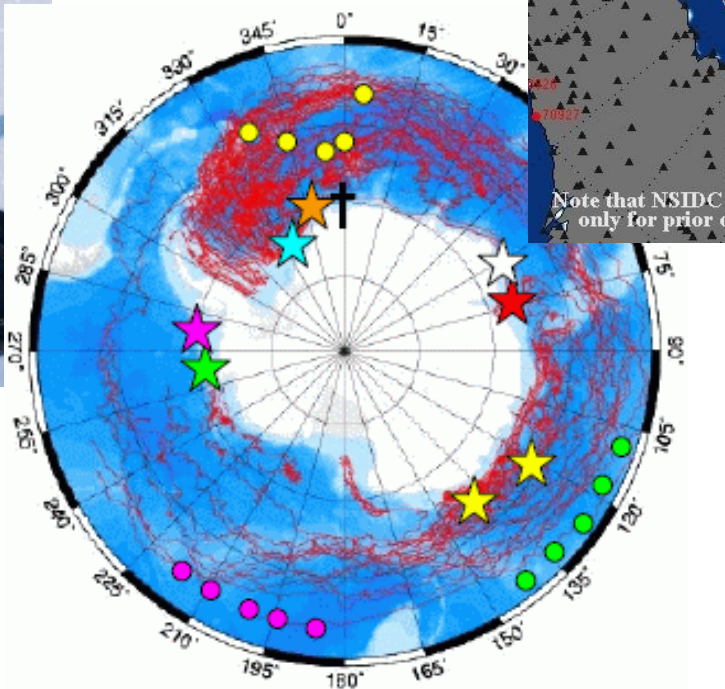
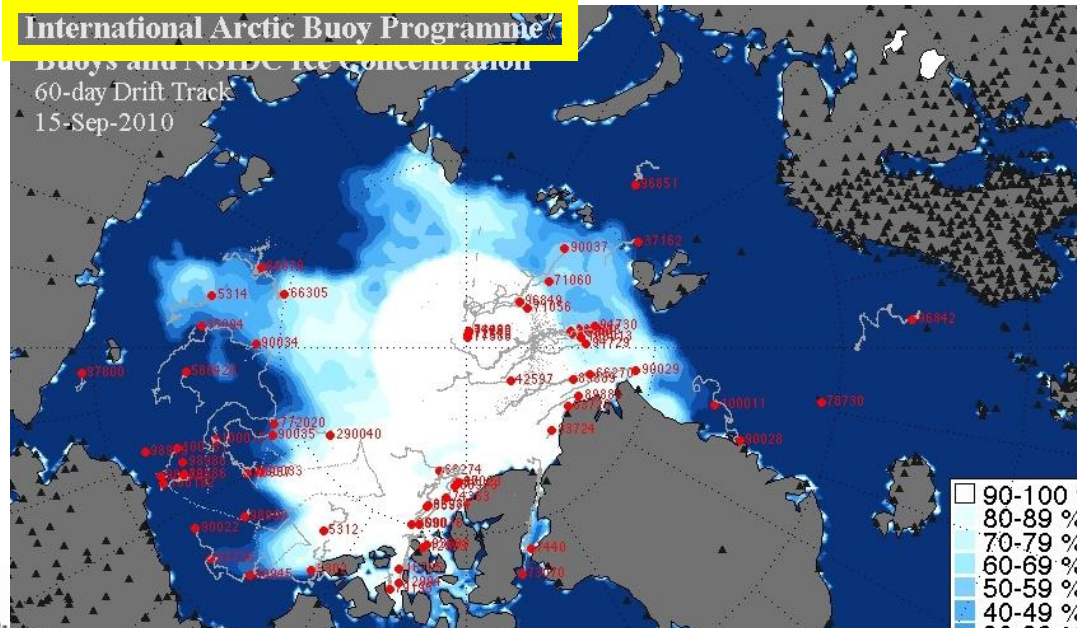
First year ice



Thinner ice and less of it

In the beginning...

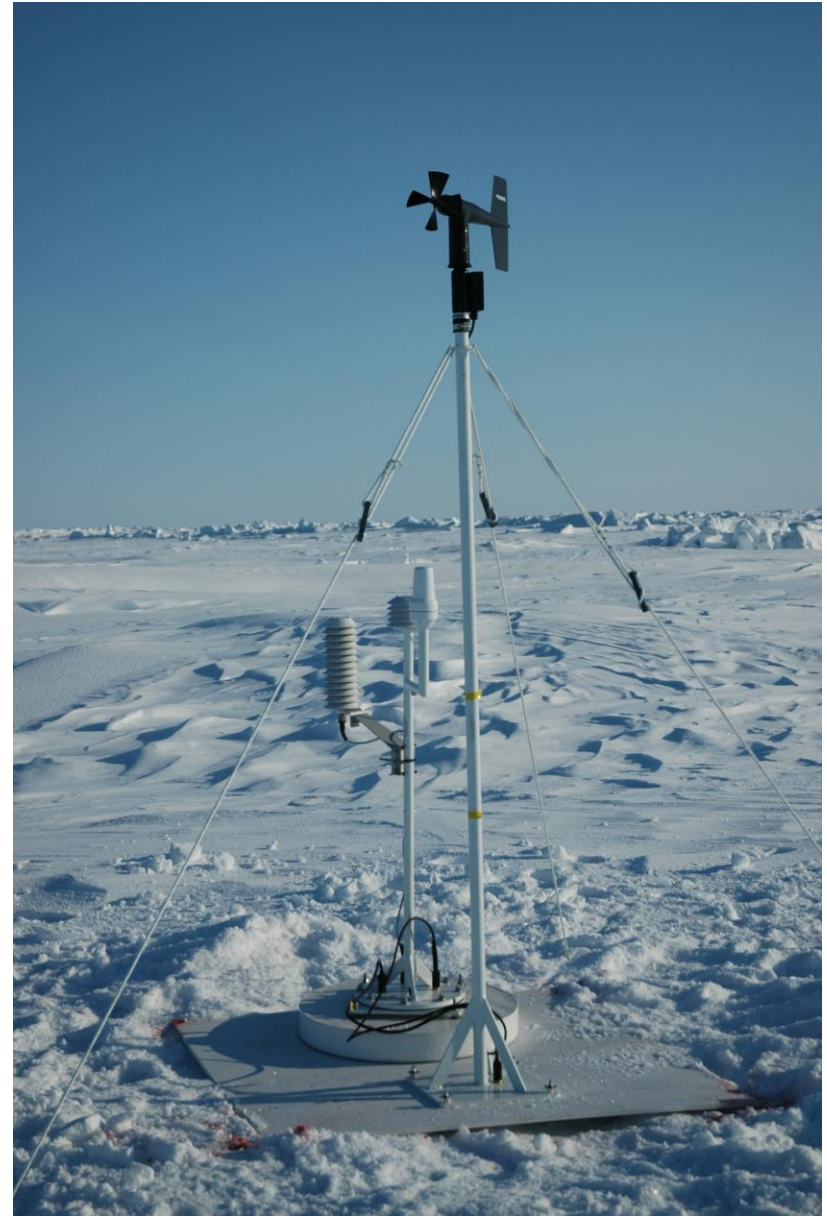
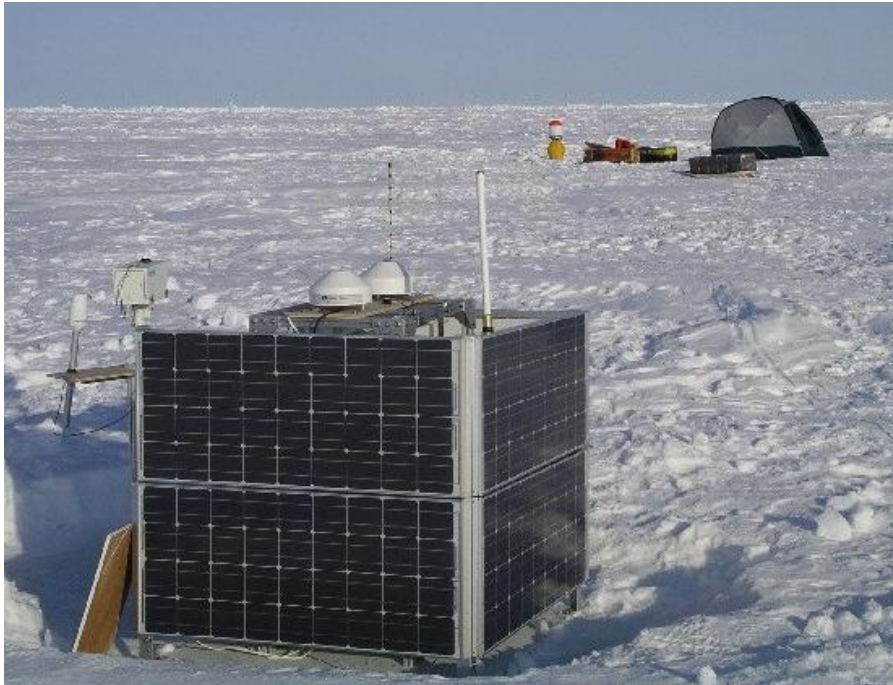
- International Arctic Buooy Program
- International Antarctic Buooy Program
- Operating since 1970's
- Position, temperature, pressure
- Many deployed every year
- Surface or air deployed



Position, temperature, and pressure

Atmosphere

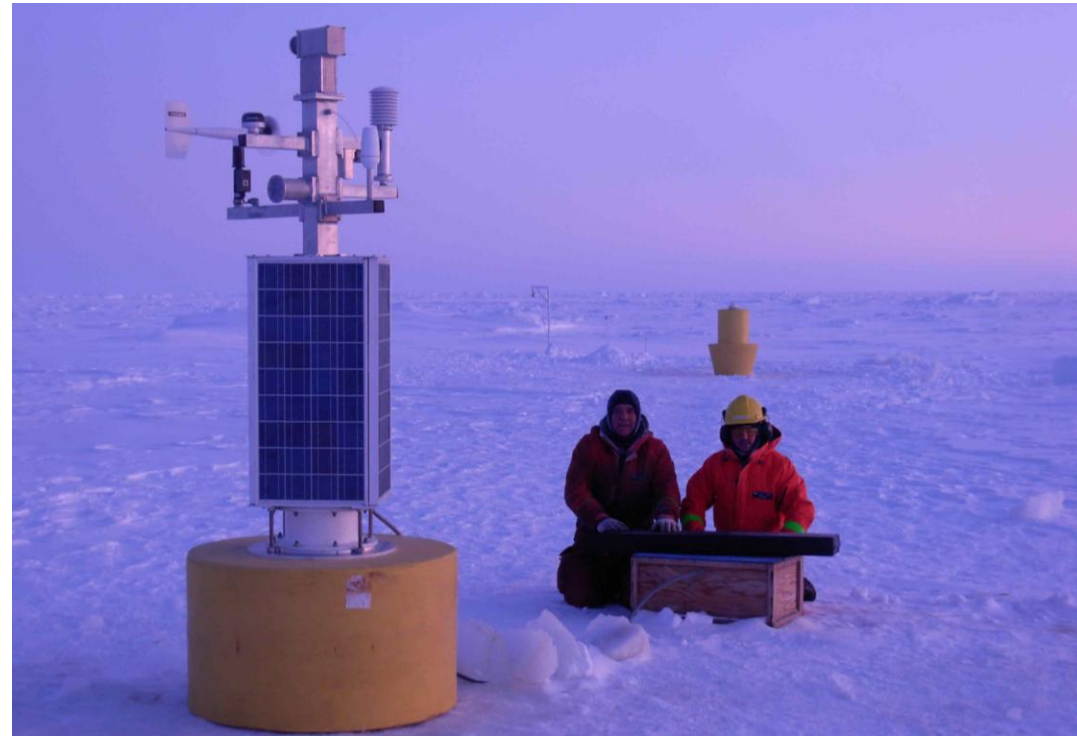
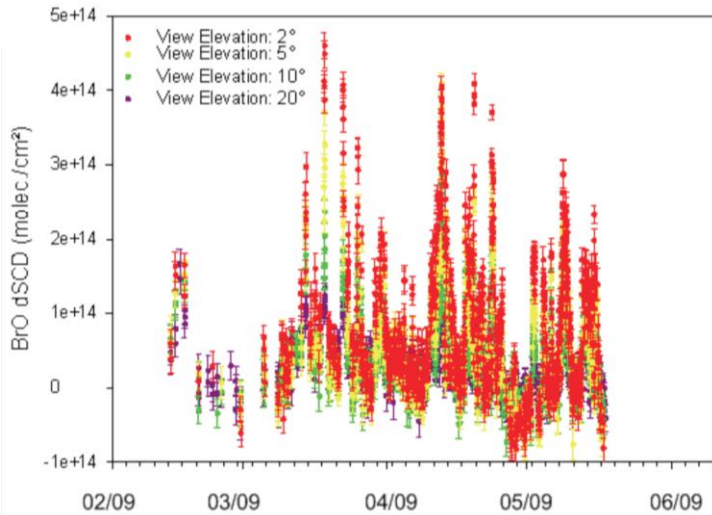
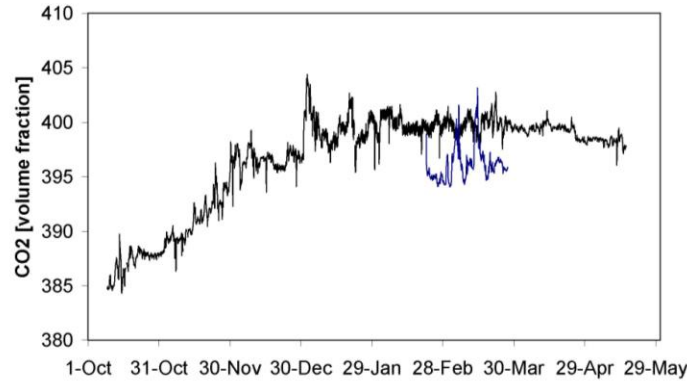
- Air temperature
- Wind speed
- Humidity
- Barometric pressure
- Can do multiple levels
- Incoming radiative fluxes
- Batteries and solar cells



Basic data for surface energy budget

Atmospheric chemistry: O – buoy

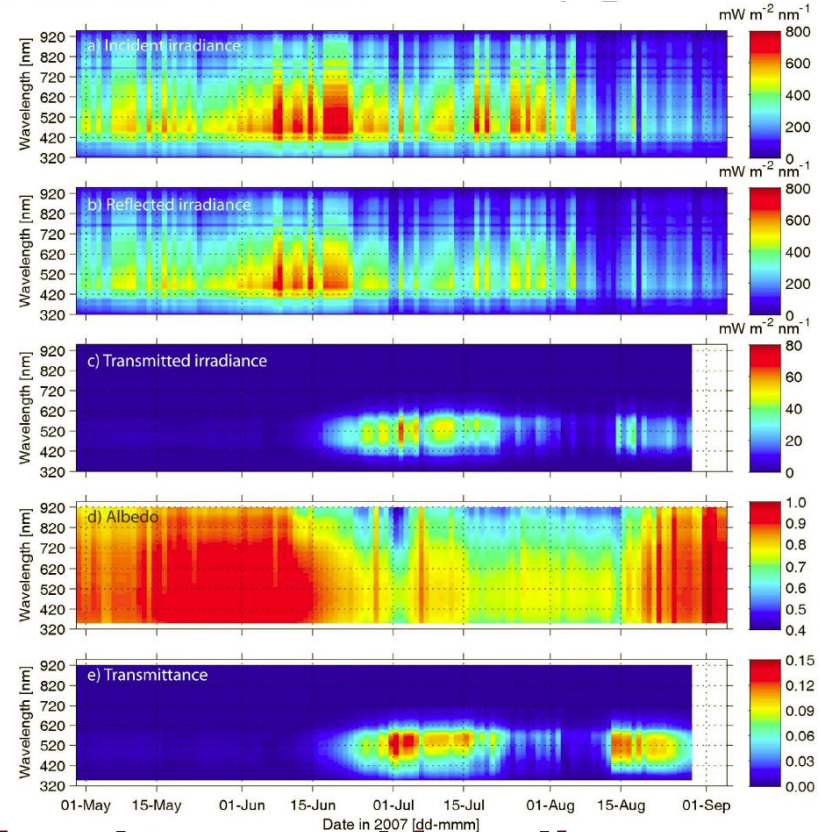
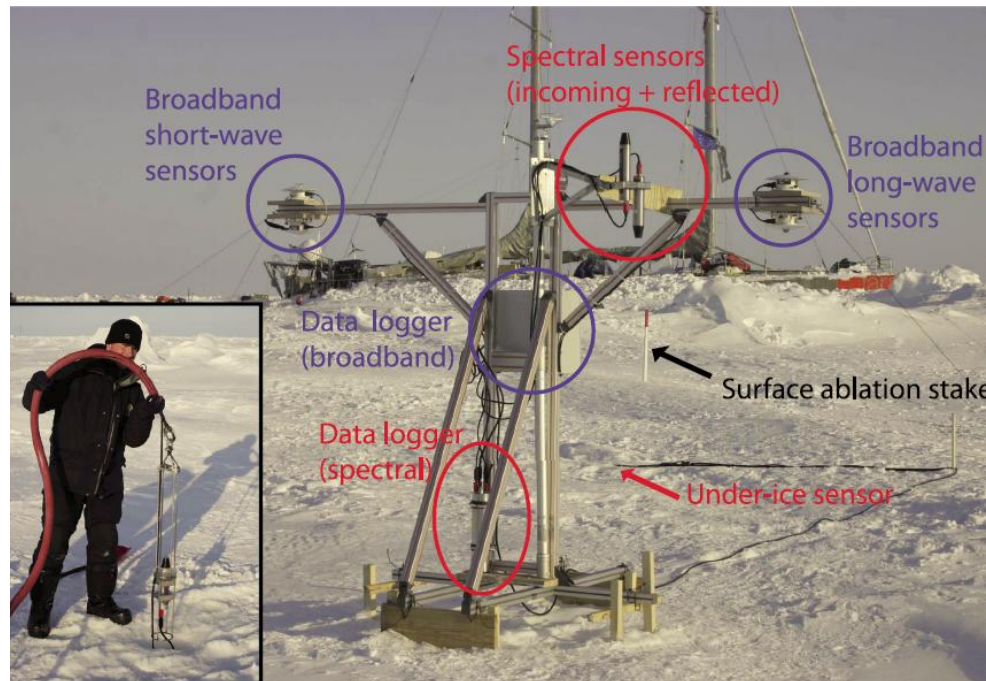
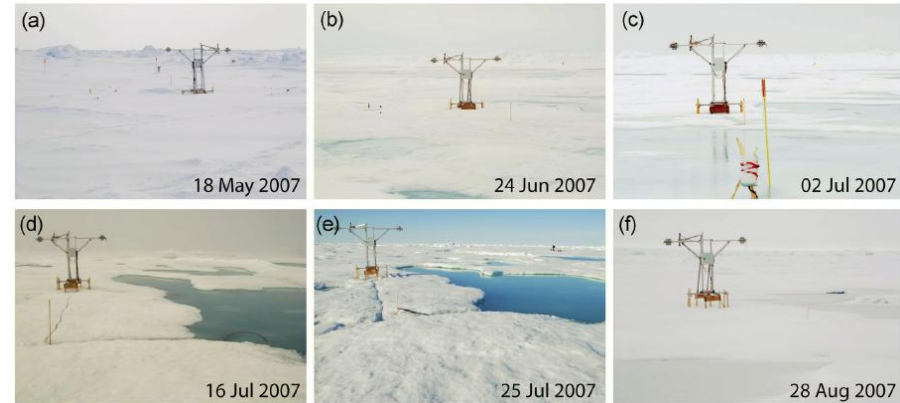
- Ozone
- Carbon dioxide
- Bromine monoxide
- Position
- Air temperature
- Wind speed
- Humidity
- Orientation
- Web cam
- Lithium, lead acid, solar



Brand new, complex buoy

Spectral radiation

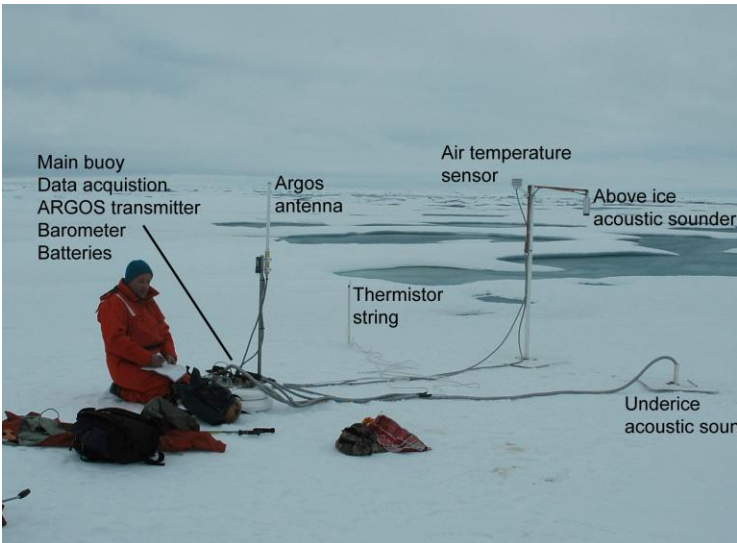
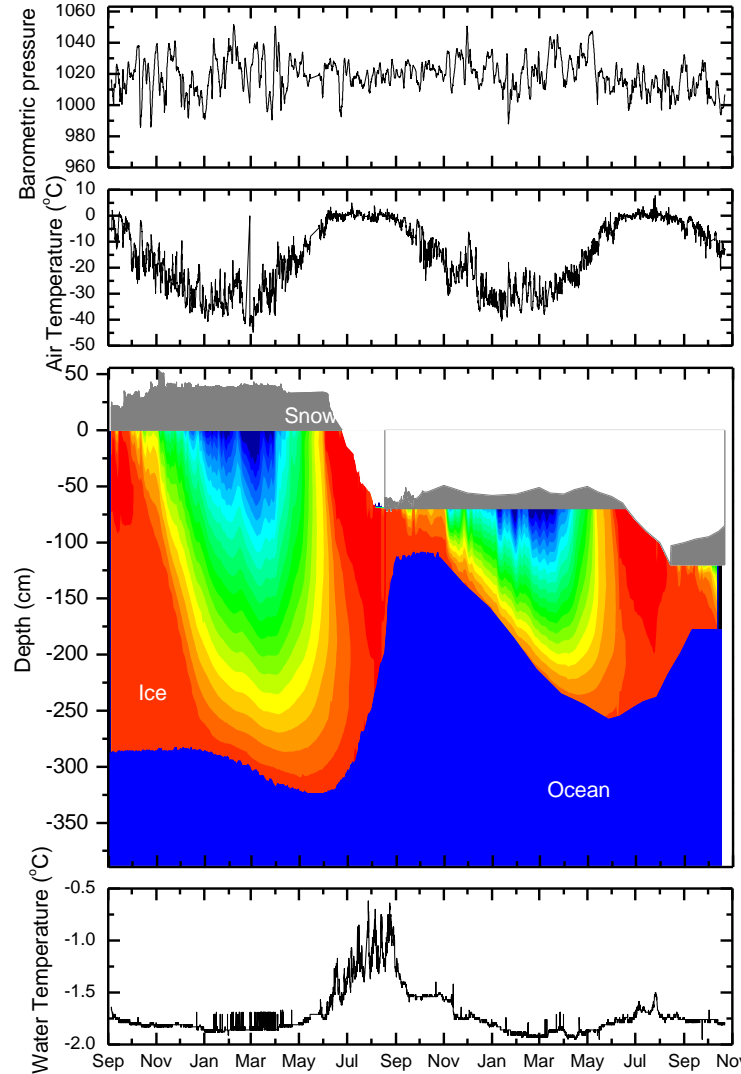
- Measurements of
 - Spectral incident
 - Spectral reflected
 - Spectral transmitted
 - All-wave incident, reflected
- Deployed at ice camp
- Ready for autonomous



Incident, reflected and transmitted spectral irradiance

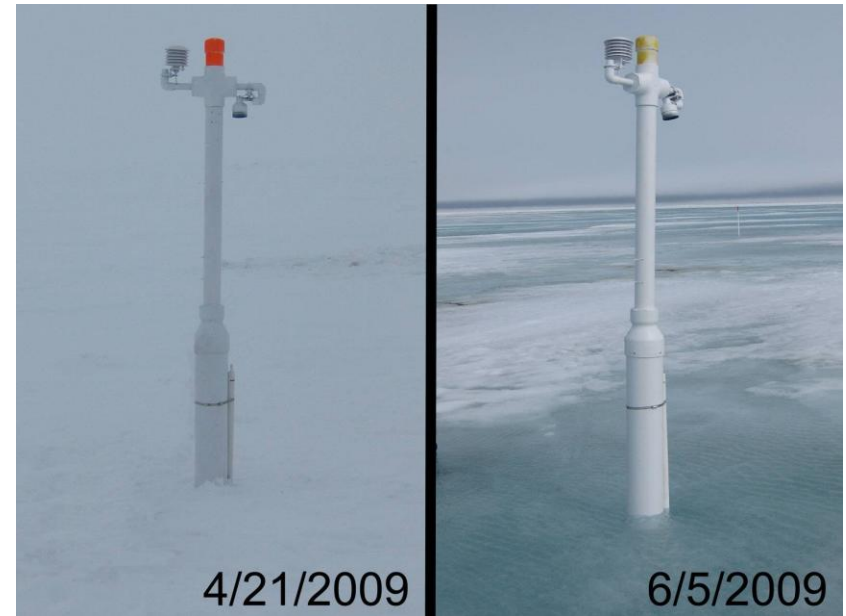
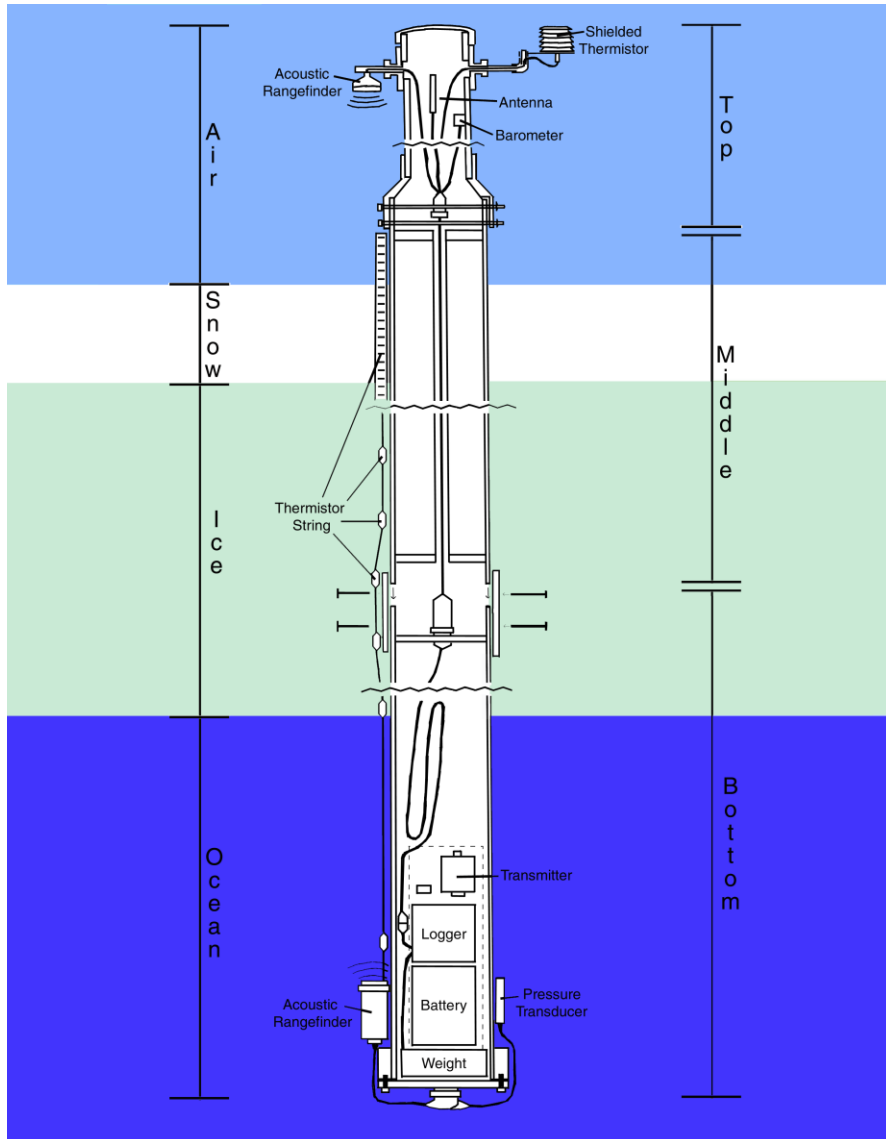
Sea ice mass balance

- Position
- Air temperature
- Barometric pressure
- Ice temperatures
- Upper ocean temperatures
- Snow accumulation and ablation
- Ice growth
- Surface and bottom ice melt



A way to attribute change

Seasonal ice Mass Balance Buoys



Ice mass balance – the next generation

Web cams: North Pole

North Pole NetCam #1 Thu Jun 03 23:21:01 2004 UTC

Image © NOAA/PMEL

June 03



North Pole NetCam #1 Mon Jul 05 00:21:39 2004 UTC

Image © NOAA/PMEL

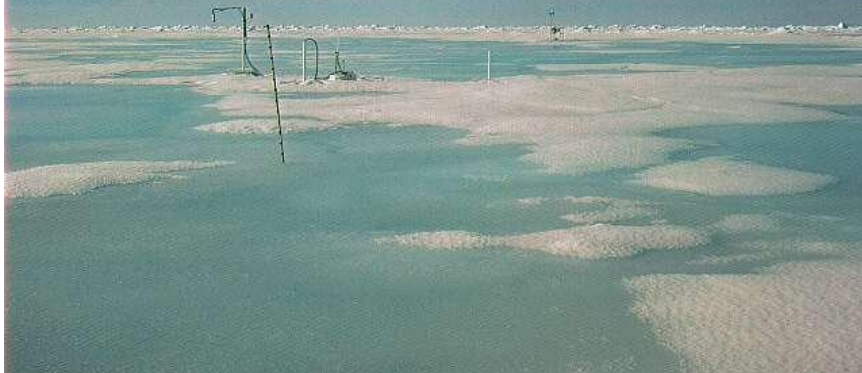
July 05



North Pole NetCam #1 Sat Jul 10 16:10:28 2004 UTC

Image © NOAA/PMEL

July 10



North Pole NetCam #1 Thu Sep 02 06:14:08 2004 UTC

Image © NOAA/PMEL

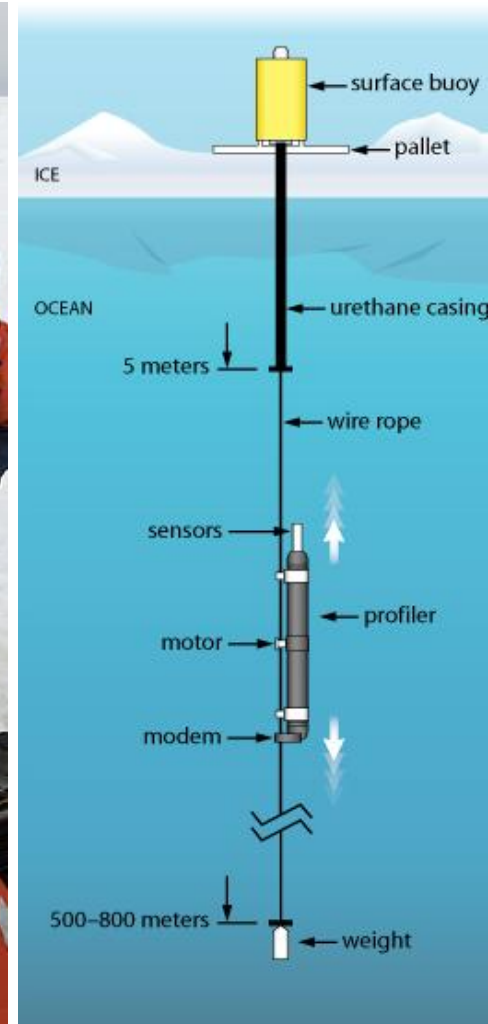
Sept 02



A picture is worth 1000 words

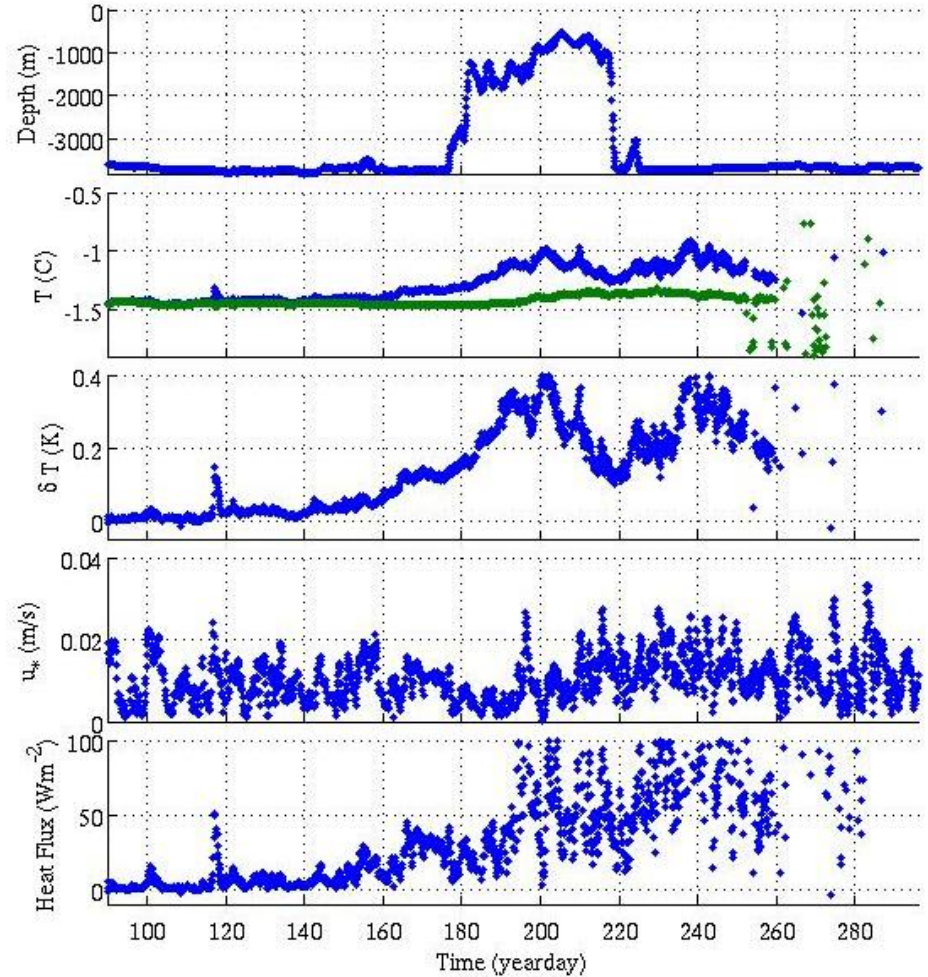
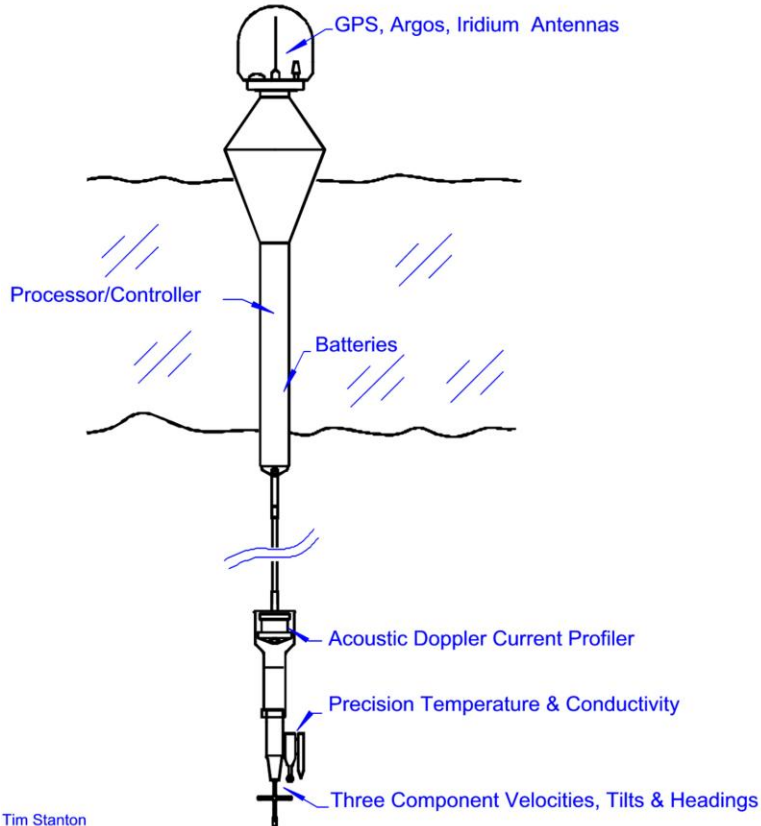
Ocean profiles

- Different methods
 - Fixed locations
 - Up and down
- Profiles of ocean properties
 - Temperature
 - Salinity
 - Currents
 - Biochemical
 - Optical



Vertical profiles of ocean properties

Ocean fluxes

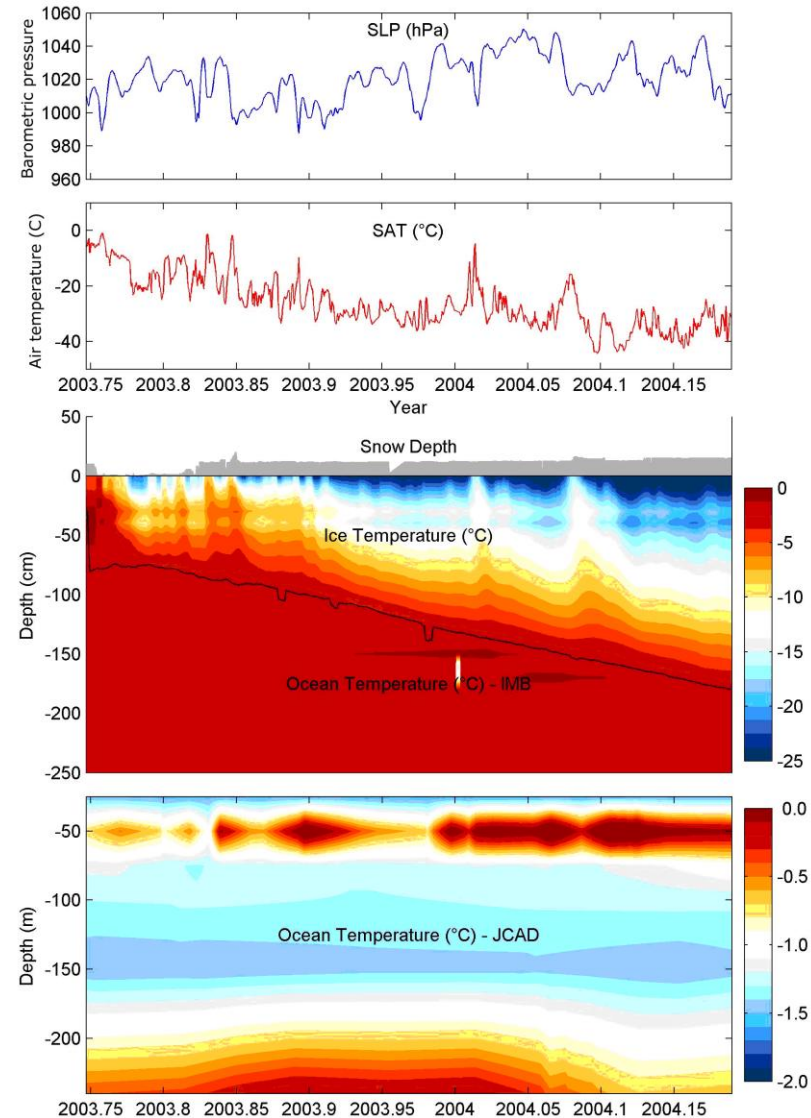


Tim Stanton
Naval Postgraduate School

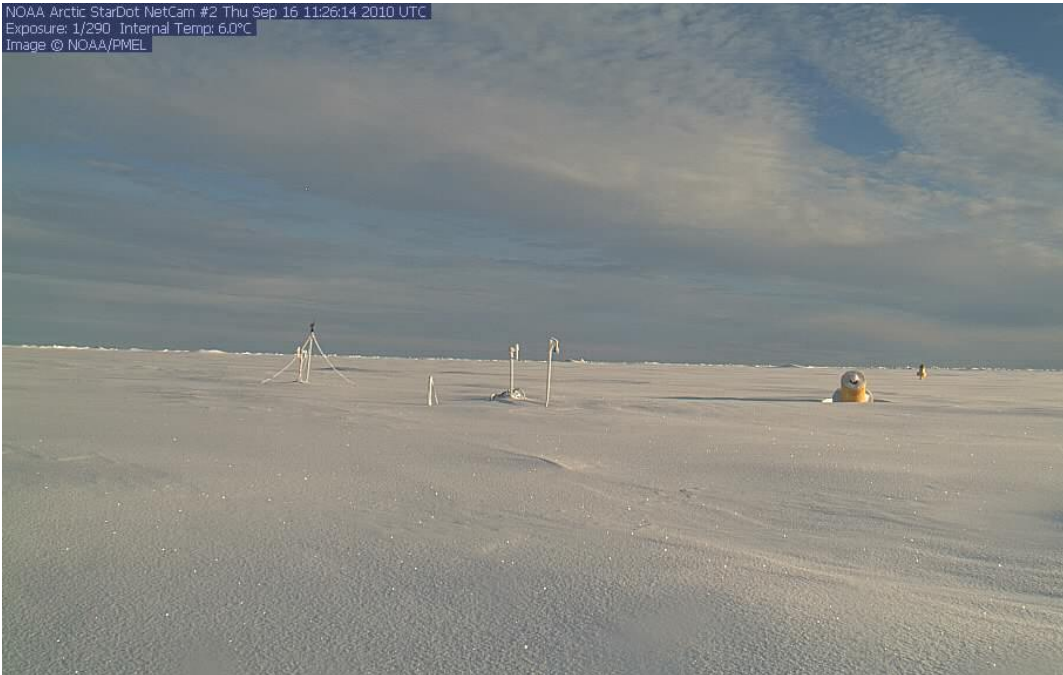
High temporal resolution of heat, salt, momentum fluxes

Integrated sites

- North Pole and Beaufort Gyre Observatories
- Atmosphere, ice, and ocean
 - Air temp., pressure, humidity, wind velocity
 - Radiometers
 - Sea ice mass balance
 - Web cams
 - Ocean fluxes
 - Ocean profiles of temperature, salinity
- Getting a long time series



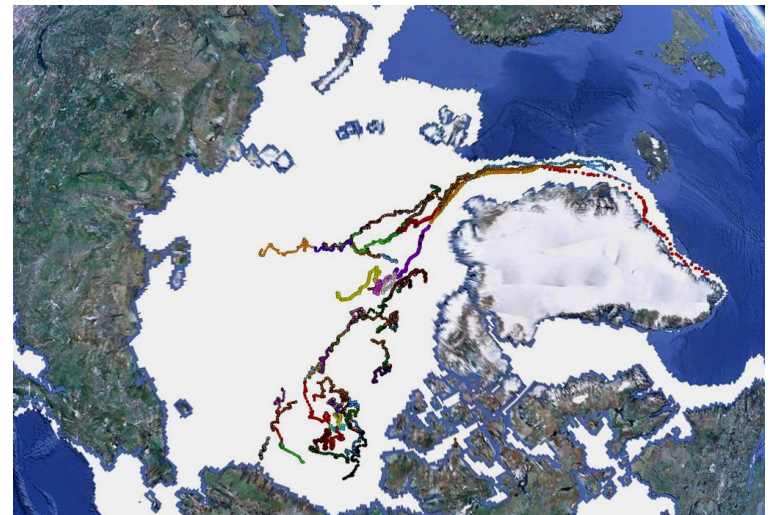
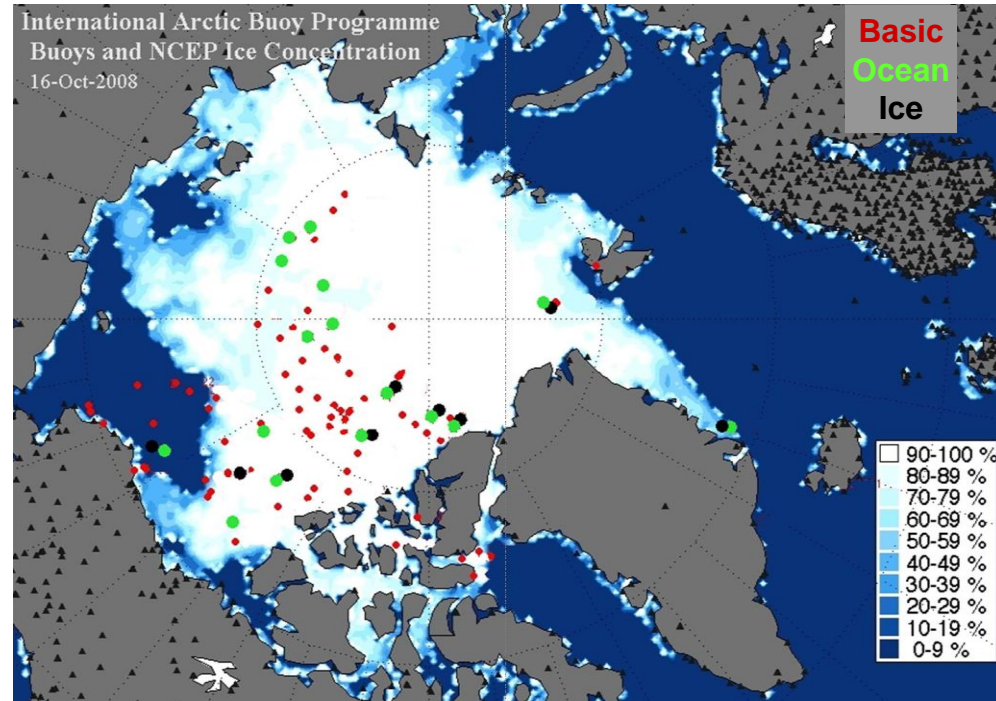
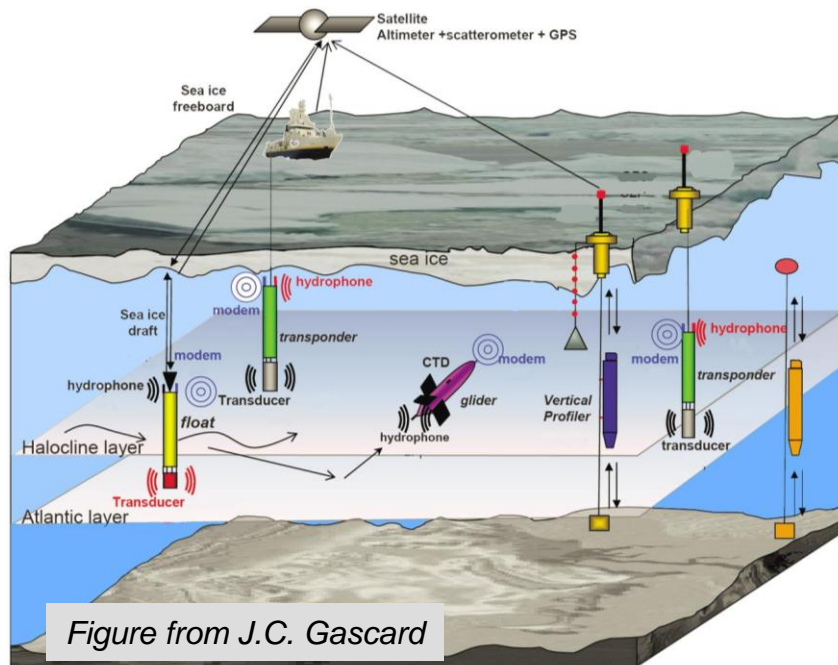
NOAA Arctic StarDot NetCam #2 Thu Sep 16 11:26:14 2010 UTC
Exposure: 1/290 Internal Temp: 6.0°C
Image © NOAA/PMEL



The most important advance is integration

Present and future networks

- Arctic Observing Network
 - Major advance
 - Great opportunities for coordination
 - Atmosphere, ice, and ocean
- Antarctic autonomous experiments
 - Similar buoys
 - Mainly first year ice, shorter lived



The technology is developing – integration is the key

Outreach – Adopt a buoy



Autonomous networks are a great outreach opportunity