Sea ice

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Safety Course

January 2008

Content

- UNIS & Sea ice
- Ice location & Dynamics
- Sea ice physics
- Scale and Ice feature
- Sea ice extent around Svalbard
- Decay
- Useful links

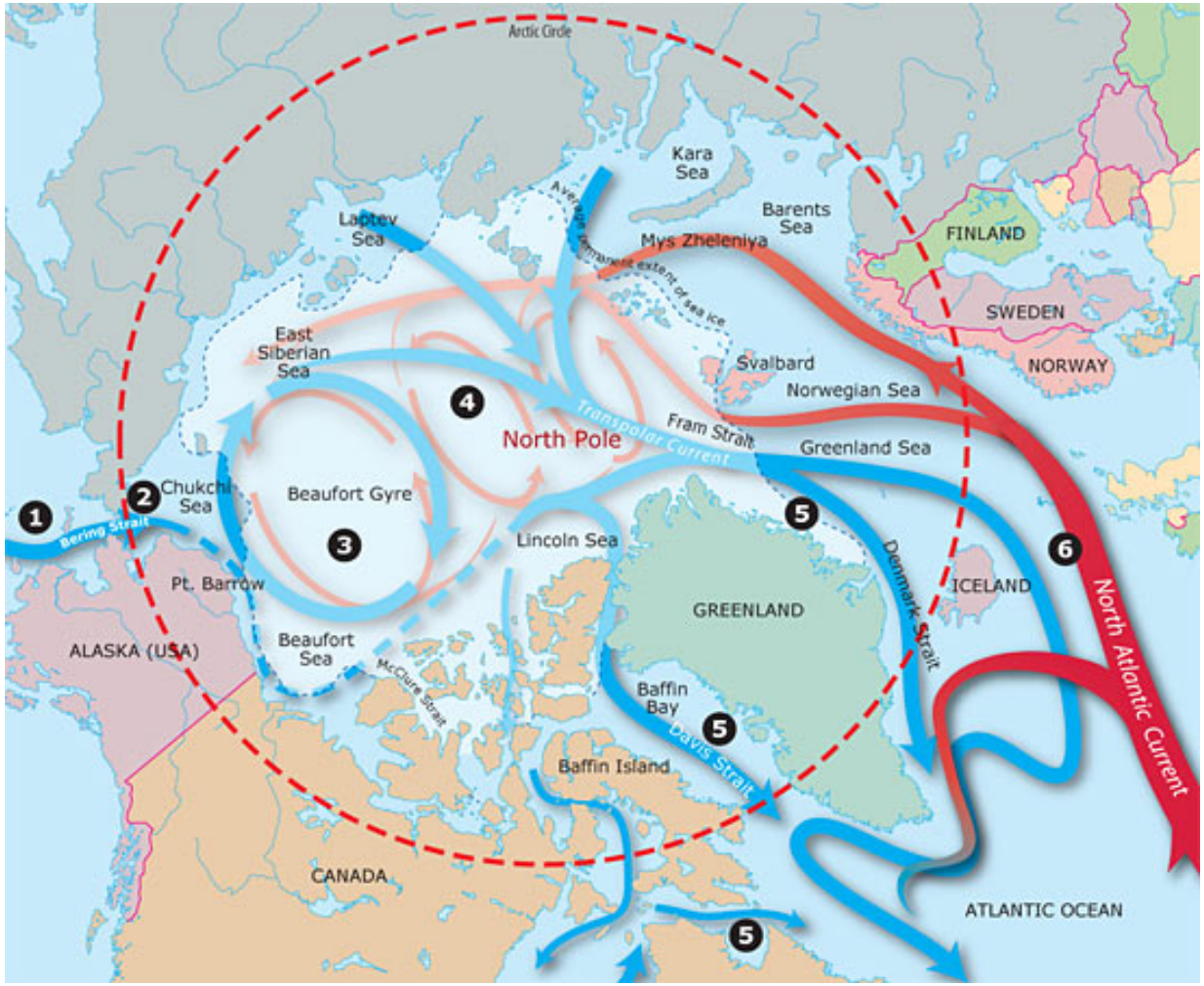
Sea ice & UNIS

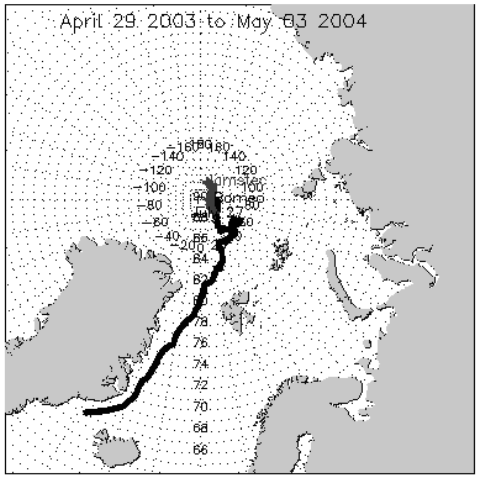
- Snow scooter driving on ice

- Cruises on research vessels

Sea ice in the northern hemisphere

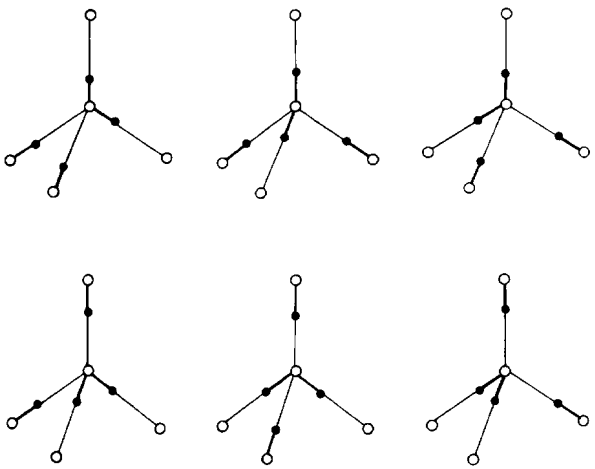
Ice dynamics

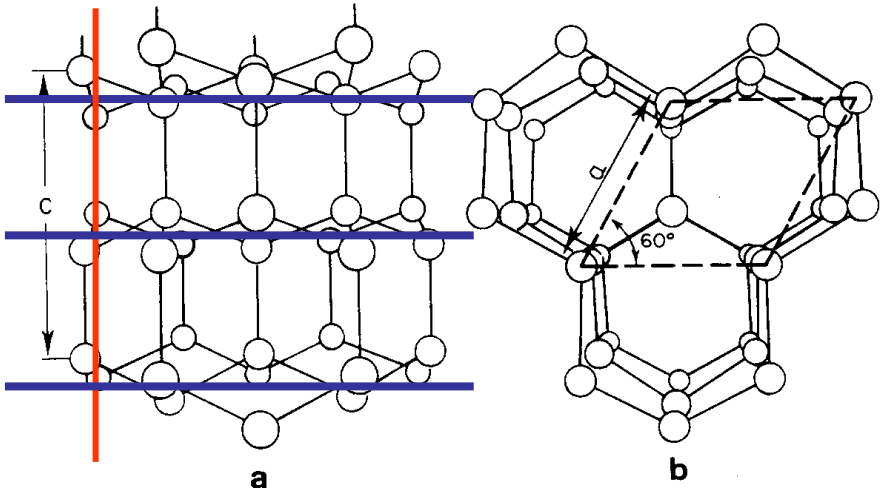




Continuous molecular structure

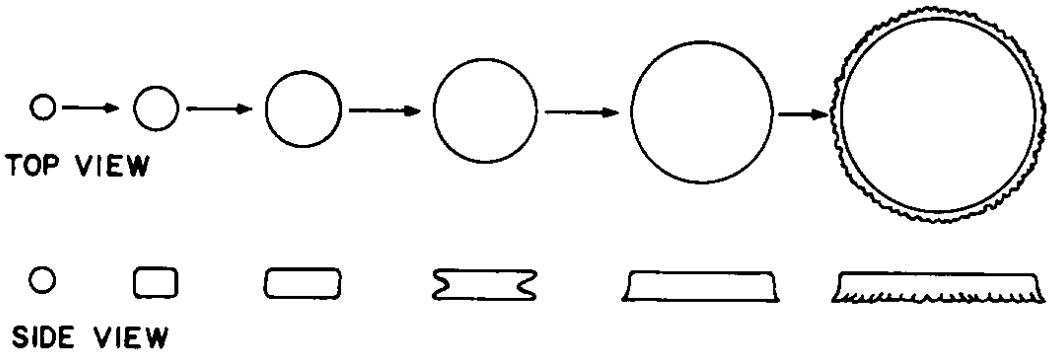
- Triple point – 3 phases are in equilibrium: T = 273.16 K, p = 611.7 kPa
- H_2O expands on freezing
- Other examples: Silicone, germanium
- The crystals reveal the hexagonal symmetry of the crystal lattice of ice (0°C< Ih <- 80°C)
- Basal plane with hexagonal symmetry and c-axis

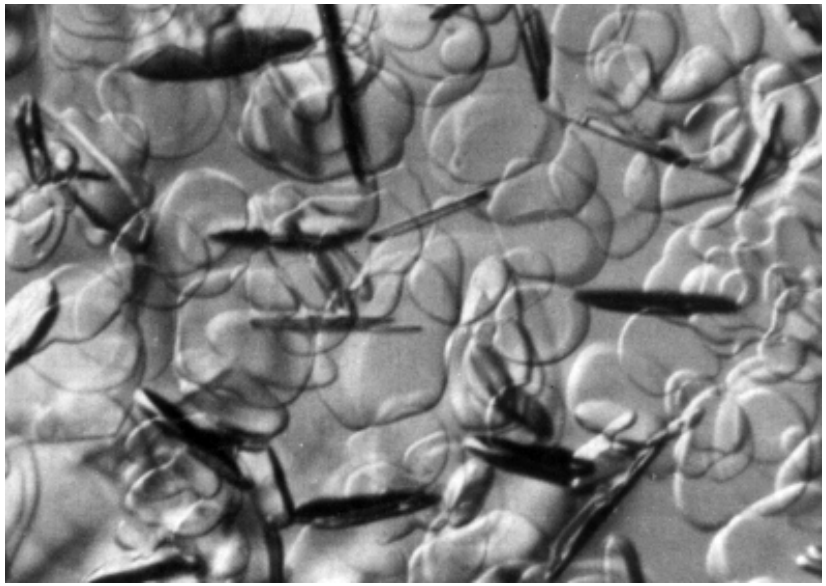




(Løset et al., 2006)

Growing of isolated crystals





Initial discs, size ≈1 mm

Stellar ice crystals

(Løset et al., 2006)

Ice growth: definition

New ice Recently formed ice:
- Frazil ice
- Grease ice
- Slush
- Shuga

Nilas
- Dark nilas < 5 cm thick.
- Light nilas > 5 cm thick.

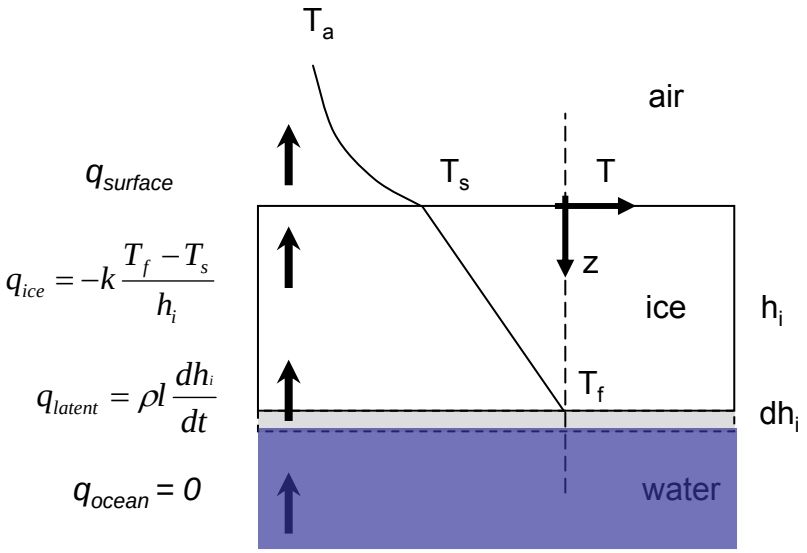
Pancake ice Circular pieces of ice 0.3-3 m in diameter, up to about 10 cm in thickness.

Young ice Ice in the transition stage between nilas and first-year ice, 10-30 cm thick.
- Grey ice 10-15 cm thick.
- Grey-white ice 15-30 cm thick.

First-year ice Developing from young ice, thickness 0.3 m – 2 m.
- Thin FY ice: 0.3-0.7 m thick
- Medium FY ice: 0.7-1.2 m thick.
- Thick FY ice: over 1.2 m thick.

Old ice
- Second year ice: < 2.5 m thick.
- Multi-year ice: up to 3 m or more thick

Ice growth: Stefan's law



l – latent heat of fusion (333.4 kJ/kg)

ρ – density of ice (917 kg/m^3)

k – thermal conductivity (2.2 W/m°C)

- No snow
- No radiation
- No heat transfer from the ocean, $q_{ocean} = 0$
- A linear temperature profile through the ice sheet
- $q_{ice} = -k\Delta T/\Delta z$
- $q_{latent} = q_{ice} = q_{surface}$

$$-k\frac{\Delta T}{h} = \rho l \frac{dh}{dt}$$

$$h^2(t) - h_0^2 = \frac{2k}{\rho l}\int_0^t (T_s - T_f)dt$$

Freezing Degree Days [°Cdays]

$$FDD = \int_0^t (T_a - T_f)dt$$

Ice growth: Stefan's law

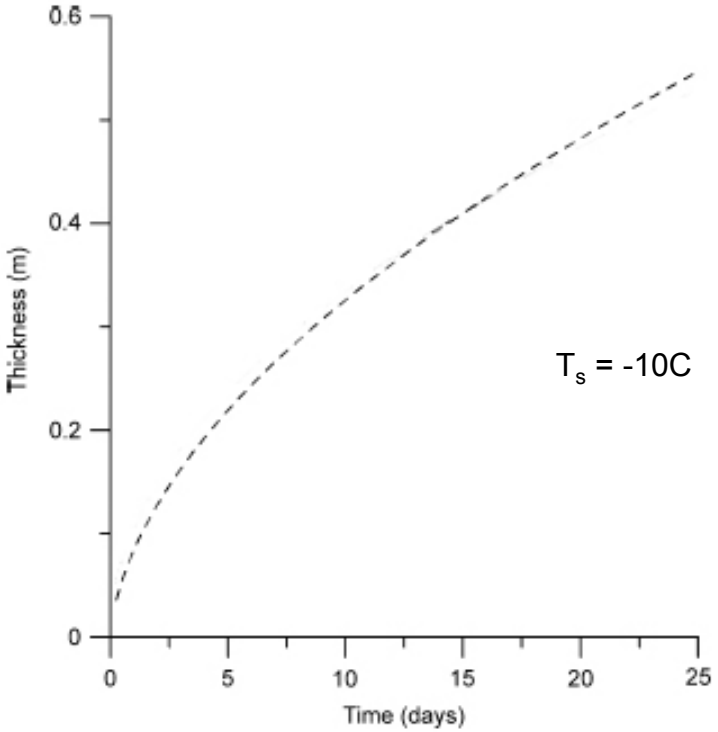
$$h^2(t) - h_0^2 = \frac{2k}{\rho l}\int_0^t (T_s - T_f)dt$$

l – latent heat of fusion (333.4 kJ/kg)

ρ – density of ice (917 kg/m^3)

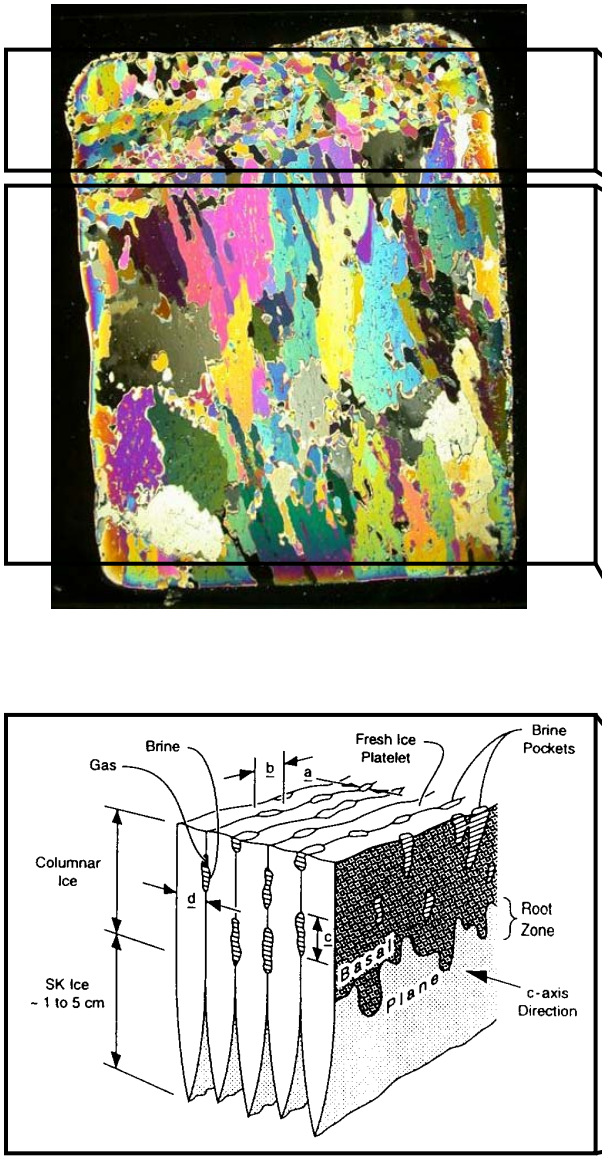
k – thermal conductivity (2.2 W/m°C)

$$H \sim \sqrt{t}$$



C. E. Bøggild (2007)

Structure of sea year sea ice



(Løset et al., 2006)

Chemical composition of sea ice & Freezing point

1000 g of sea water contains:

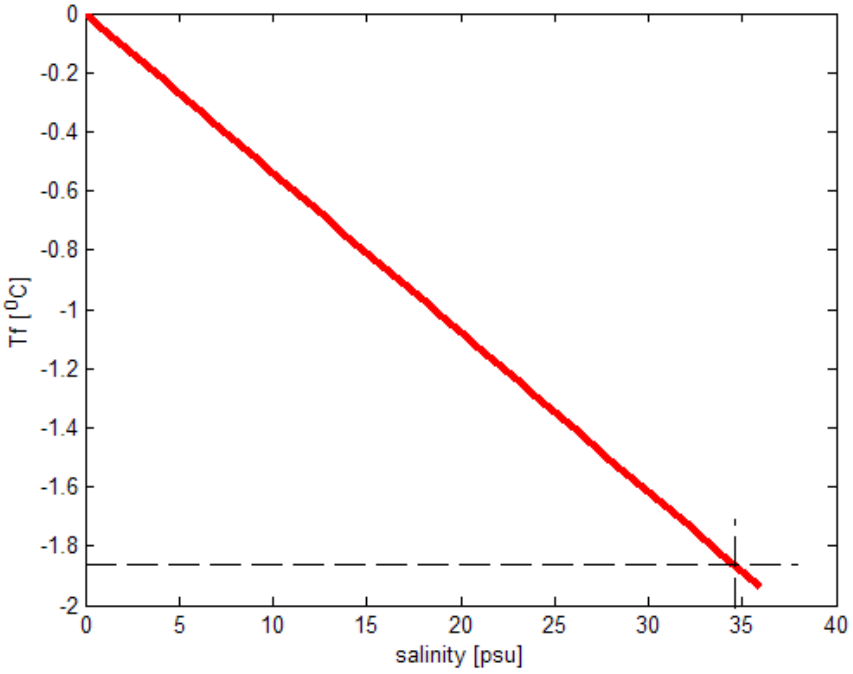
23.5 g	NaCl
4.5 g	$MgCl_2$
3.9 g	Na_2SO_4
1.1 g	$CaCl_2$

+ rest

34.5 g of salt

Sea ice language : 34.5 *psu* or *ppt*

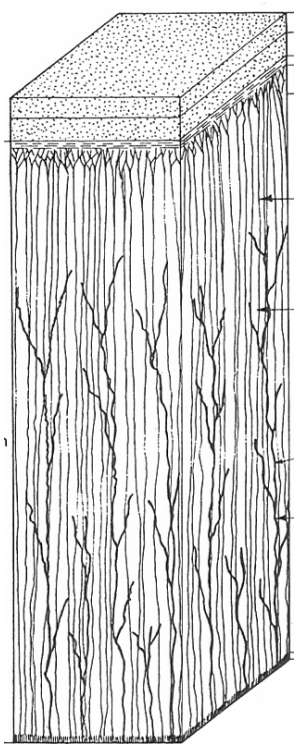
Freezing point vs salinity*:*

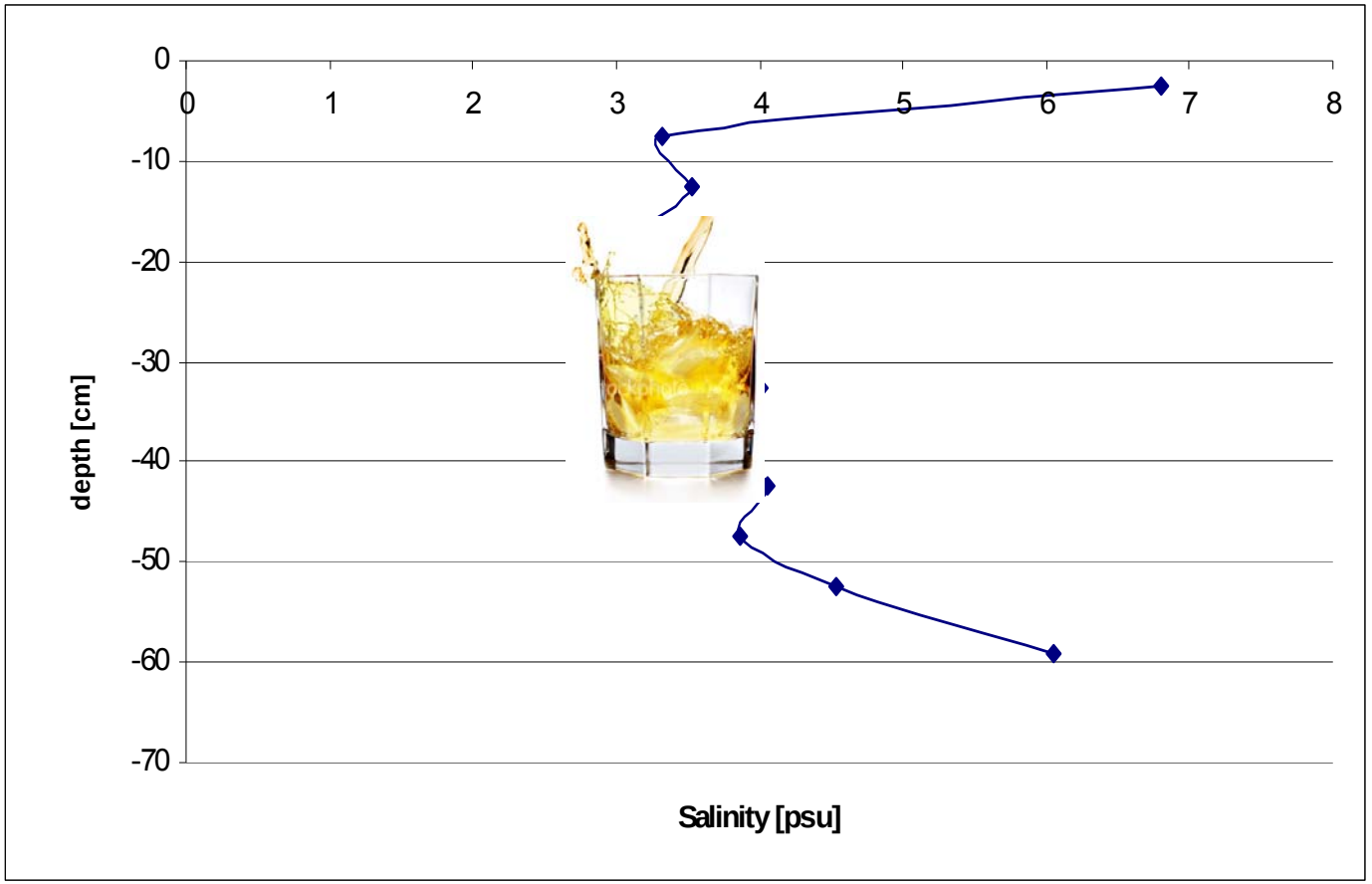


$$T_f(℃) = -0.0539 \cdot S(psu)$$

$\Rightarrow$ $T_f = -1.86°C$

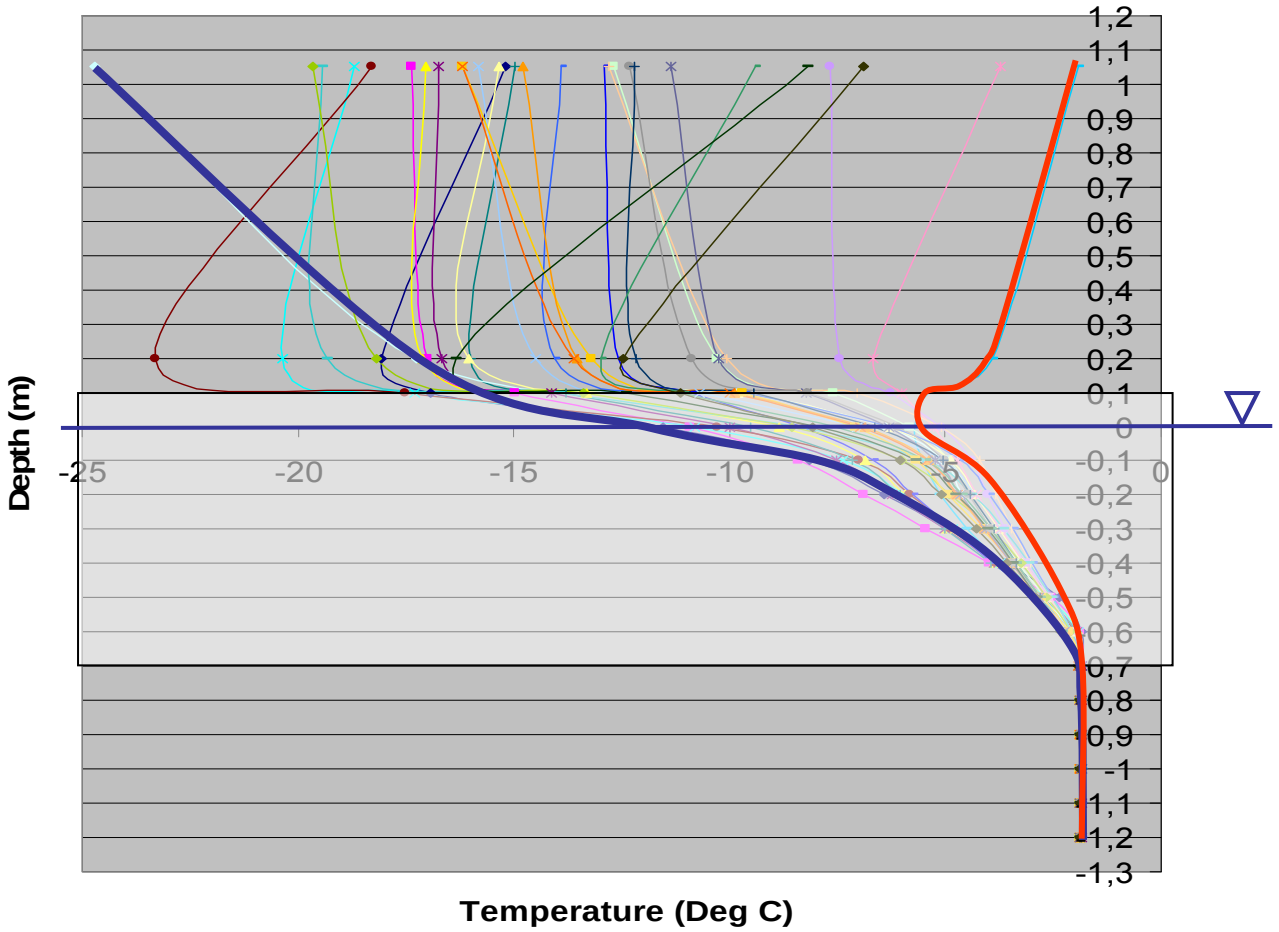
Salinity profile





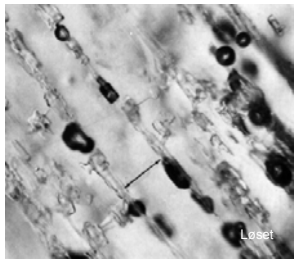
C - shape

Temperature profile



Scales in sea ice research

- microscale 10^{-4} - 10^{-1} m *physics*

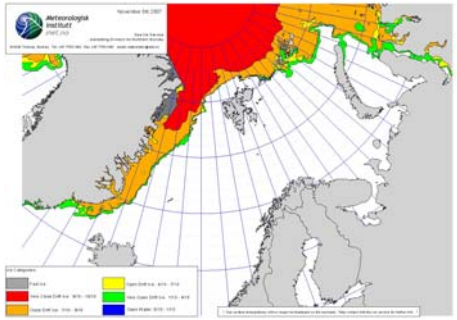


- local scale 10^{-1} - 10^{1} m *engineering*

- floe scale 10^{2} - 10^{3} m

- mesoscale 10^{4} - 10^{5} m *geophysics*

- large scale 10^{6} m *geophysics*



Ice features

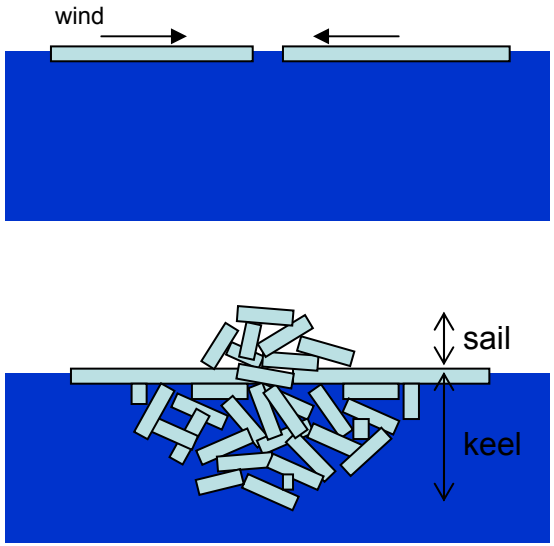
Landfast ice, Franz Josef Land

Ice Ridge, NW Barents Sea – drift ice

Ice floes – drift ice

Iceberg, Franz Josef Land – drift ice

FY ice ridge



Ice blocks, Ridge Sail

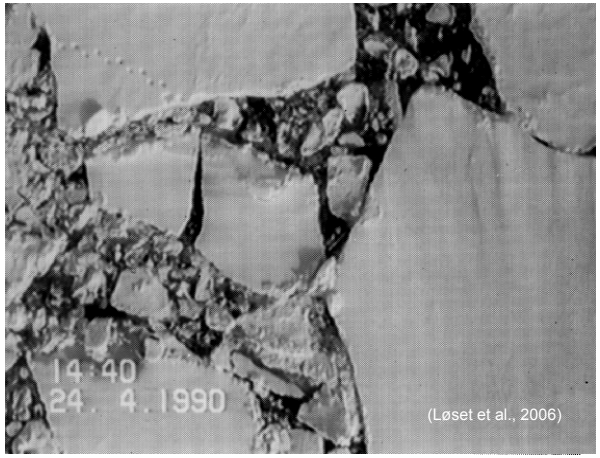
Ice rubble-blocks, Ridge Keel

Ice ridge

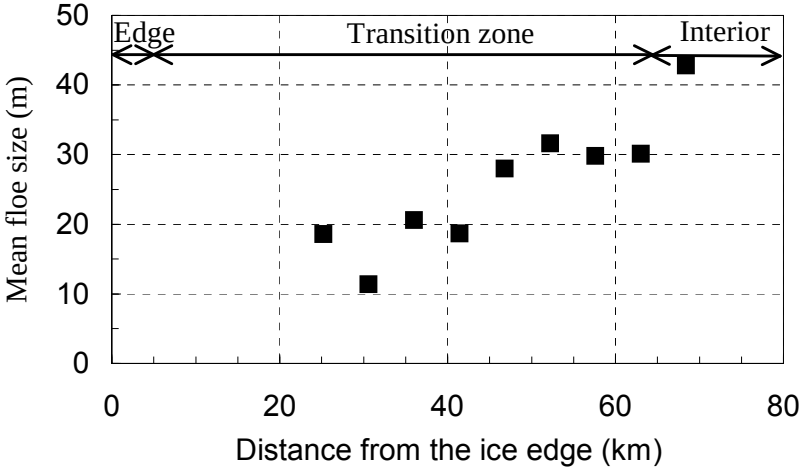
Description of drift ice

Ice cover zones of different dynamic character:

- Landfast ice
- Shear zone
- Marginal ice zone (MIZ)
- Central pack



Ice floes in MIZ zone



(Løset et al., 1989)

Drift ice divided as:

5 tenths "open drift"

6 tenths "open drift"

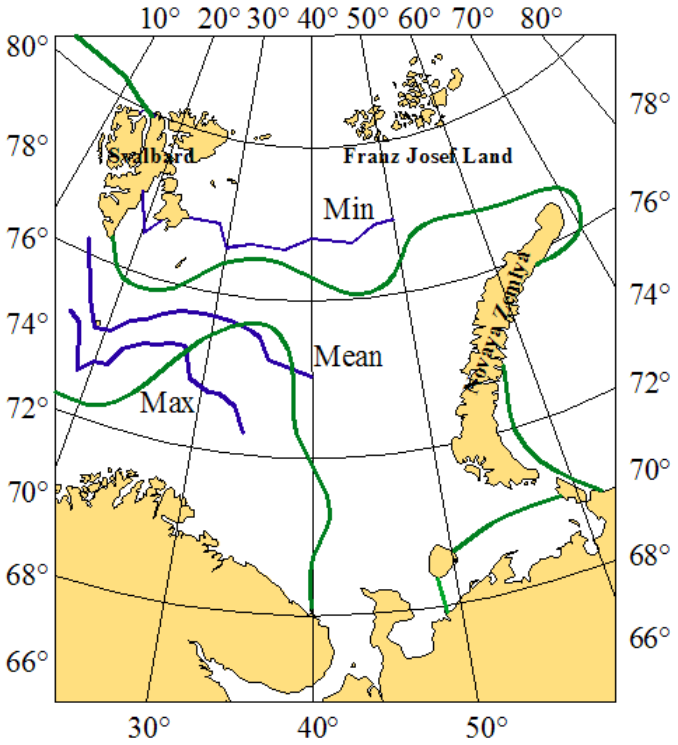
7 - 8 tenths "close pack"

9 tenths "very close pack"

10 tenths "compact"

Sea ice extent around Svalbard

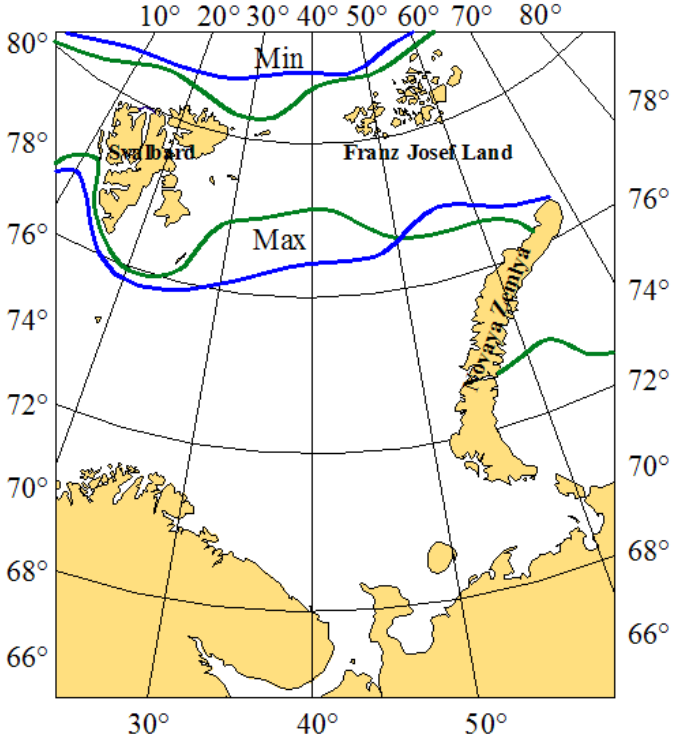
April



DNMI data (IDAP report, 1994)

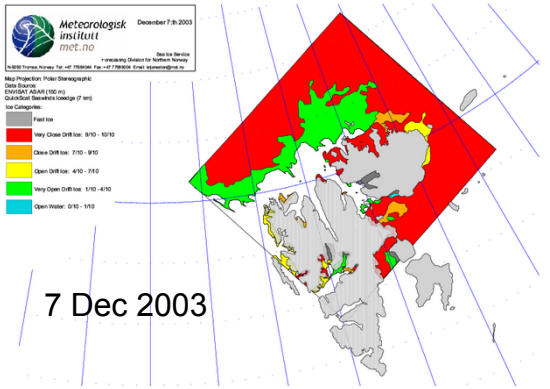
USSR Atlas of the Oceans, 1980

September

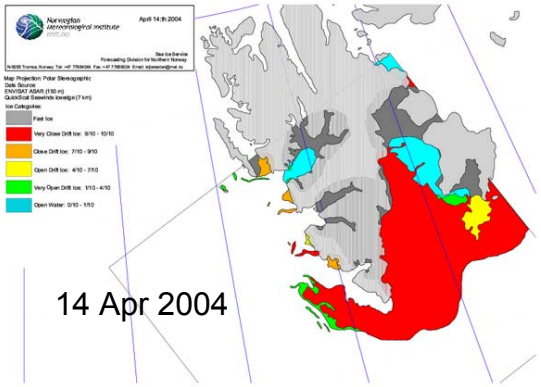


August,
September
(USSR Atlas of the Oceans, 1980)

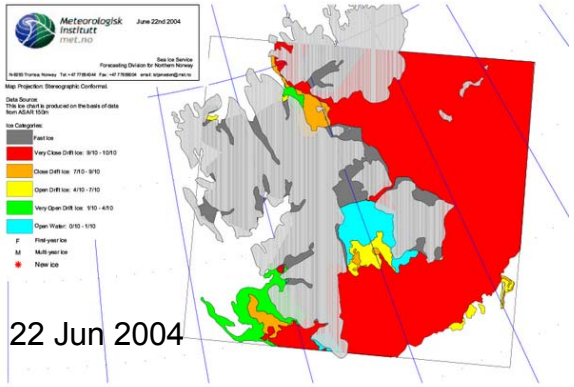
Sea ice extent around Svalbard in 2004



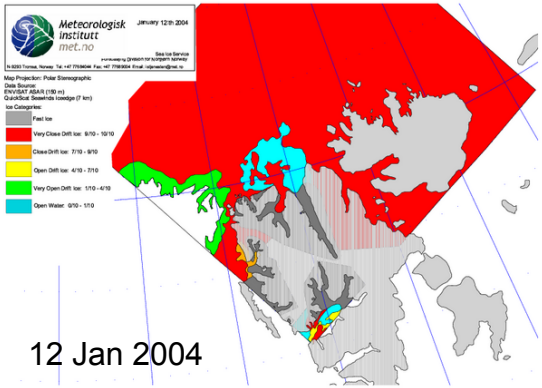
7 Dec 2003



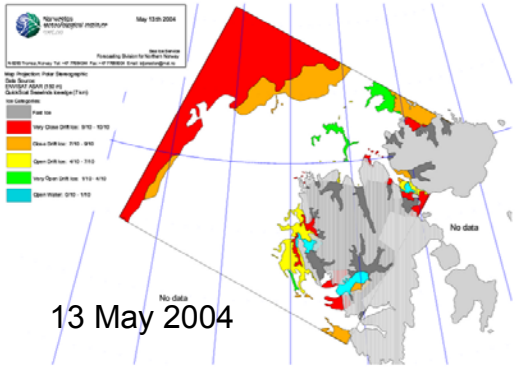
14 Apr 2004



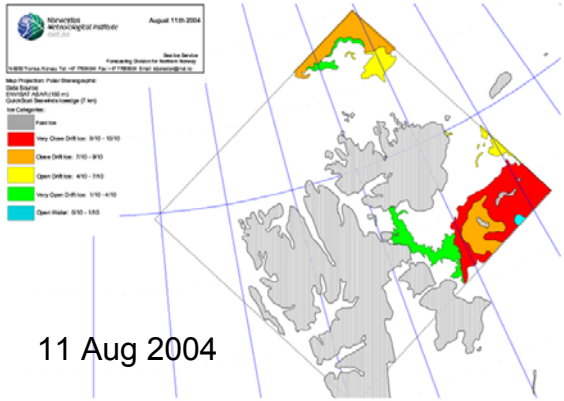
22 Jun 2004



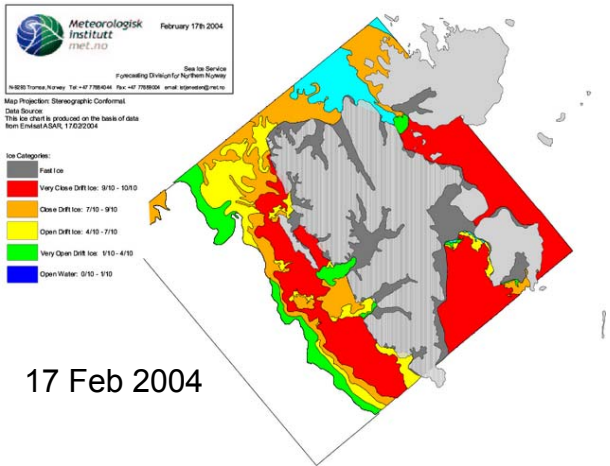
12 Jan 2004



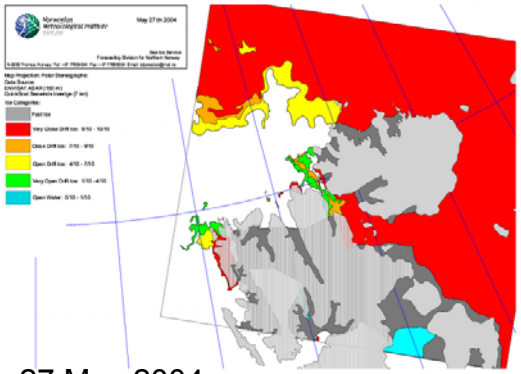
13 May 2004



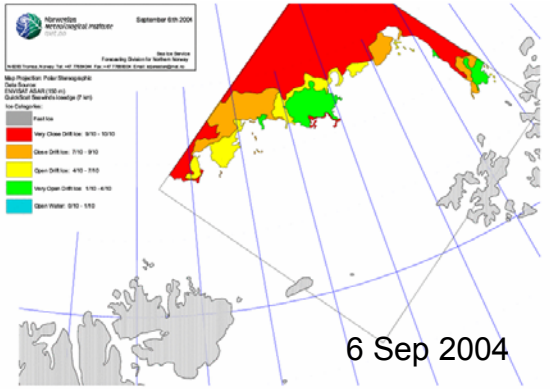
11 Aug 2004



17 Feb 2004

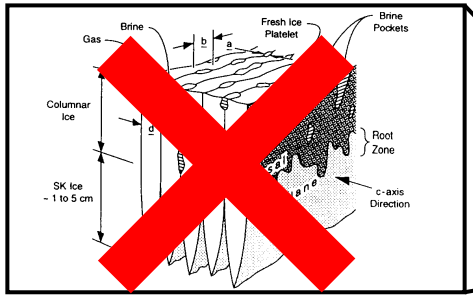


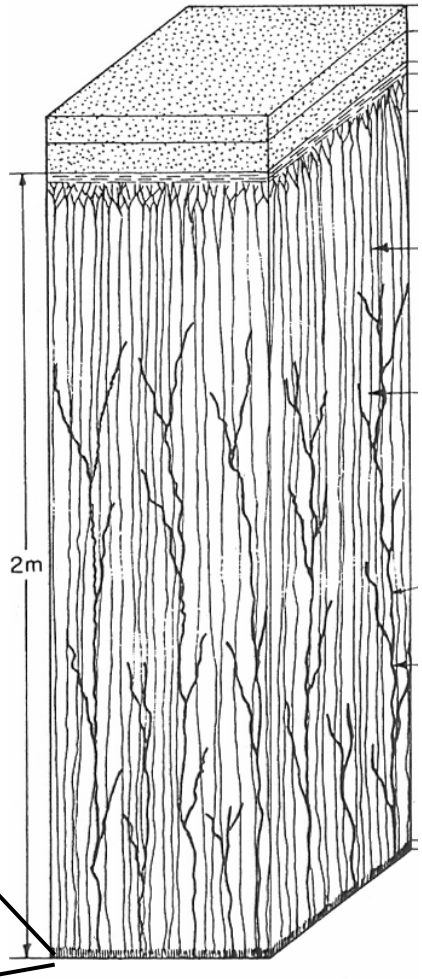
27 May 2004



6 Sep 2004

Sea ice decay





Sea ice maps for Svalbard and Fram Strait

Norwegian Meteorology Institute

- http://met.no/kyst_og_hav/iskart.html (ice maps)
  Also on:
  - → W:\COURSE MTR & DATA StudentsReadOnly\Common Data
  - → Library
  - → UNIS entrance
- http://polarview.met.no/cgi-bin/highres_arkiv.pl (ice maps archive)
- http://conman.met.no/sathav-is/svalbard_forecast.html (ice forecast)

University of Bremen

- http://www.seaice.de
- http://iup.physik.uni-bremen.de:8084/amsr/amsre.html

ESA financed program

- http://www.polarview.org
- http://www.seaice.dk/test.N