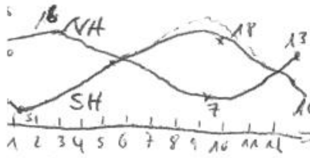
1.Oct | Sea Ice Sheet

) Sea Ice extent: Arctic: Min: September Antarctic Min: Feb–March
Max: March–April Max: September



- Antarctic has bigger amplitude
- not symmetric!

Marginal Ice zone: 0.5m thick ice in contact with open water (150-200km) interaction with ocean

Fast ice: near coastline, not moving, its fasten to the coast, stays at the same position, Barrier for ships

Shear ice: Zone between drifting and fasten / coast ice

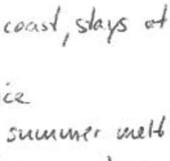
Perennial ice: multi-year (another word), survives summer melt

Polynya: wind opens edges, creates polynyas. Warm water from below also opens ice

Lead: linear fracture in the ice. Really big ~~Ex~~, ships fits through.

Calculate ice thickness:

$\left(1-\frac{\rho(fy)}{\rho(w)}\right)\cdot h = f$ ρfy: first year, replace with other densities
ρw: water density



Sea ice thermodynamics

Latent heat of fusion: (energy needed to melt 1kg at T°0C

$Q = m \cdot L = 1kg \cdot 330 \frac{J}{g} = 330000\,J$

$Q = m \cdot c_p \cdot \Delta T \Rightarrow \Delta T = 82{,}5\,K$

Sea Ice growth: $E = m \cdot L = \rho V L = \rho A h L$

$Q = \frac{E}{t \cdot A} \overset{plug\ in}{=} \frac{L \rho h}{t} \Rightarrow h = \frac{Q \cdot t}{L \cdot \rho} \approx 9cm$

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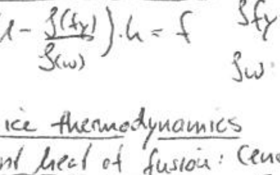
7. Nov | Rheology: Study of flow behaviours of a material → e.g. the respond of material on stresses σ

Strain ε: measure of deformation $\varepsilon = \frac{\delta L}{L}$

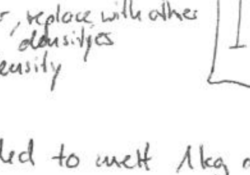
Strain rate $\dot{\varepsilon} = \frac{d\varepsilon}{dt}$ Stress $\sigma = \frac{F}{A}\ [\frac{N}{m^2}]$

ELASTIC:

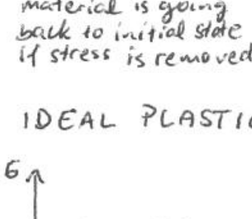


→ reversible
material is going back to initial state if stress is removed

LINEAR VISCOUS

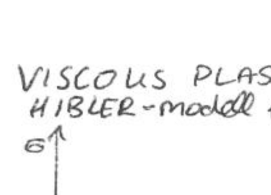


IDEAL PLASTIC



- material will fracture at certain yield stress

VISCOUS PLASTIC
HIBLER-modell for ice



- Sea ice is weak in tension, strong in shear and strongest in compression
- strength depends on

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16 Nov | Radiation

Seperation of two spectral bands possible, because
- temperature of earth and sun is very different
  - maximum wavelength depends on temperature
  - overlap is very small

$\lambda_{max,sun} = 0{,}5\mu m$ $\lambda_{max,earth} = 12\mu m$

averaged solar irradiance in January: $351{,}2\,\frac{W}{m^2}$
June: $329{,}6\,\frac{W}{m^2}$

Zonal averaged maximum in June: at north pole

radiative energy balance in steady state for snowball earth (without sensible heat, latent heat and greenhouse effect)

$(1-\alpha)\,F_R - \varepsilon\sigma T^4$ σ: Stefan-Boltzmann constant $\sigma = 5{,}67 \cdot 10^{-8}\frac{W}{m^2K^4}$
α: albedo
ε: emissivity
F_R: solar radiation
T: Surface temperature

albedo: dry snow: 0,8–0,9
open water: 0,1
meltpond ice: 0,4–0,5

Thermal emission: $F_\ell = \varepsilon\sigma T^4$ F_ℓ: longwave emission of surface

longwave emission of atmosphere: $F_{\ell\downarrow} = \varepsilon_{eff}\,\sigma T^4$

$\varepsilon_{eff} = 0{,}7855(1+0{,}2232C^2)$

C: cloud cover

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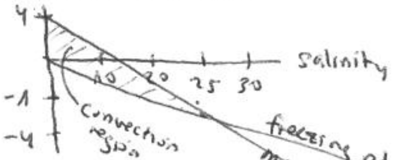
21 NOV. Sea water density



As salinity inc, you replace water molec with salt molec, and so rate freezing dec, so at higher salinities freezing depression drops

At low salinity, max density is reached before freezing point and so cold water sinks. At higher salinities, freezing pt reached first so ice forms at top

Sea ice growth find ice thickness for 1 day −10°C

$\Theta = \int (T_f - T_a)\,dt$ = cumulative freezing ~~temp~~ temp

$d = 1.38\,\Theta^{0,58}$ cumulative depth ice frozen. (cm)

We need T_f where T_f is a function of salinity.

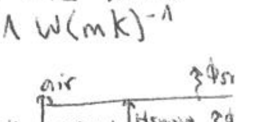
Conductive heat flux w/o snow layer

calculate heatflux for $T_{sfc} = -32C$ $d_{ice} = 10\,cm$

sea ice thermal conductivity $= 2.1\,W(mK)^{-1}$

$F_c = \frac{k}{H}(T_o - T_f)$

conductive heat flux & snow layer

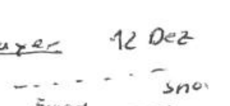


$H = H_{snow} + H_{ice}$

$\frac{H}{k} = \frac{H_{snow}}{k_{snow}} + \frac{H_{ice}}{k_{ice}}$ (1)

Equilibrium ice thickness with a snow layer 12 Dez

$F_{snow} + F_{ice} + F_{ocean} = 0$ for equilibrium



i) conductive heat flux: $F = \frac{k}{H}(T_o - T_f)$

ii) calculate $\frac{k}{H}$ for snow and ice together

$\Rightarrow -F_{ocean} = \left(\frac{H}{k}\right)^{-1}(T_o - T_f) = F_{snow+ice}$ with (1)

with $F_{snow+ice} = \frac{H}{k}F_{snow} + F_{ice}$

iii) solve for H_{ice}

- Coastal polynyas form when ice is pushed away by the wind and freezing water is exposed to a large negative heat flux. (Latent Heat). Ocean polynyas are driven by upwelling of warmer water - they are also called "sensible heat polynyas."
- Polynyas occur near topography. Most coastal polynyas occur in marginal seas, where the adjacent ice edge leaves room for ice divergence. - Means that most coastal polynyas occur in the Bering, Okhotsk, and Barents Seas. Most coastal polynyas form in the lee of headlands, islands, ice shelves, and grounded icebergs - downwind of ice tounges.

<u>Arctic</u> - St. Lawrence Island Polynya
Kashevarov Bank Polynya

<u>Antarctic</u> - Weddell Polynya
Maud Rise Polynya
Cosmonaut Sea Polynya

- Thickness produced in winter:
  <u>Arctic</u> = 5m <u>Antarctic</u> = 10m

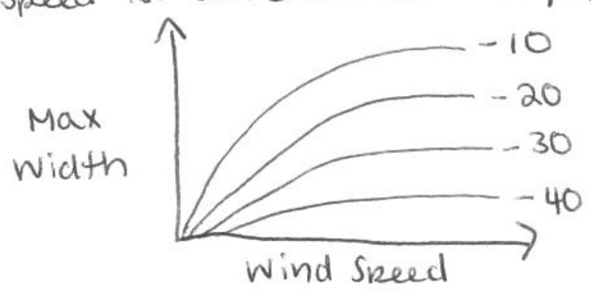
Polynyas influence on transport of sediment:
Turbulence brings up sediment from the bottom, which could form ice crystals in the water column. A ice cover forms. Within the water column, sediments are found and transported to ice. Booyancy increases.

- Biological Importance:
  Marine mammels live near polynyas and use them as breathing holes. Polynyas are vital for the overwinter survival of Arctic species. Also, polynyas are an important feeding area for whales.
- Influence on the Arctic Ocean:
  Polynyas produce a large amount of ice and brine, which effects water masses (denser water.)
- Balance leading to max width of polynya:

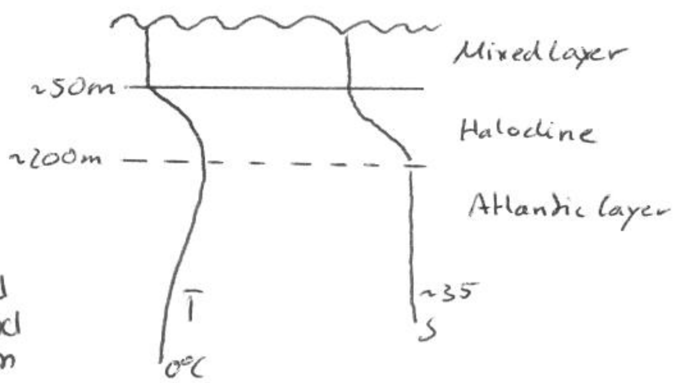
$$\frac{dX_p}{dt} = \underset{\substack{\uparrow \\ \text{Ice Advection}}}{V_i} - \frac{X_p F_i}{H_i}$$

Polynya width multiplied by freezing rate divided by the depth of ice.

- Relation between Maximum Width and Wind Speed for different Air Temps:



Arctic water layers



Mixed Layer: cold, fresh water
Halocline: warm, saltier water
Atlantic Layer: warm, salty water