Chl-a in Antarctic sea ice from historical ice core data

K. M. Meiners[1,] **M. Vancoppenolle[2]**, , S. Thanassekos[3]

[1] ACE-CRC, Hobart, Tasmania
[2] CNRS, LOCEAN
[3] CCAMLR, Hobart, Tasmania

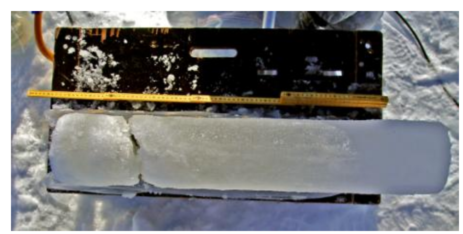
G. S. Dieckmann, D. N. Thomas, J.-L. Tison, K. R. Arrigo, D. Garrison, A. McMinn, D. Lannuzel, P. van der Merwe, K. Swadling, W.O. Smith Jr., I. Melnikov, B. Raymond

Chl-a from sea ice cores

- Chl-a is a widely measured proxy for biomass

- Methods
  - Ice core extraction
  - Cutting core into sections
  - Melting in at < 5°C in the dark
  - Filtration
  - Fluorometric analysis
  - Get Data!

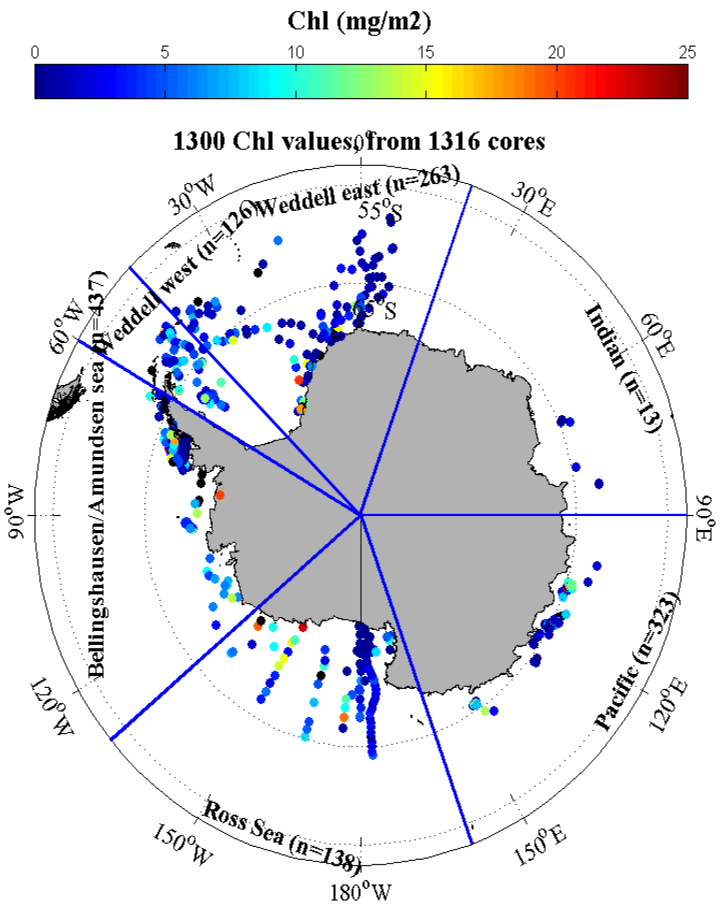
coring party



preparing an ice core

base of an ice core

The ASPeCt-BIO dataset



Distribution of cores around Antarctica

39 campaigns (1983-2008) in pack ice

Data origin: publications, cruise reports, data repositories, private contributions

Teams from: Australia, Belgium, Germany, Russia, UK, USA

1300 integrated chlorophyll [mg/m2]

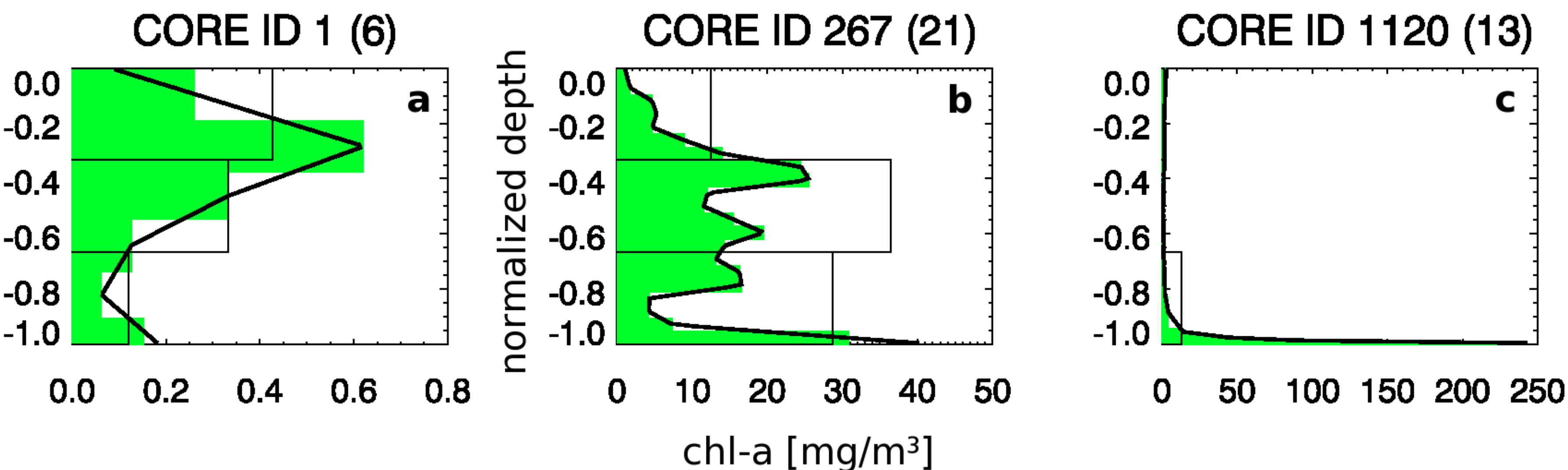
990 chlorophyll profiles with more than two sections [µg/l]

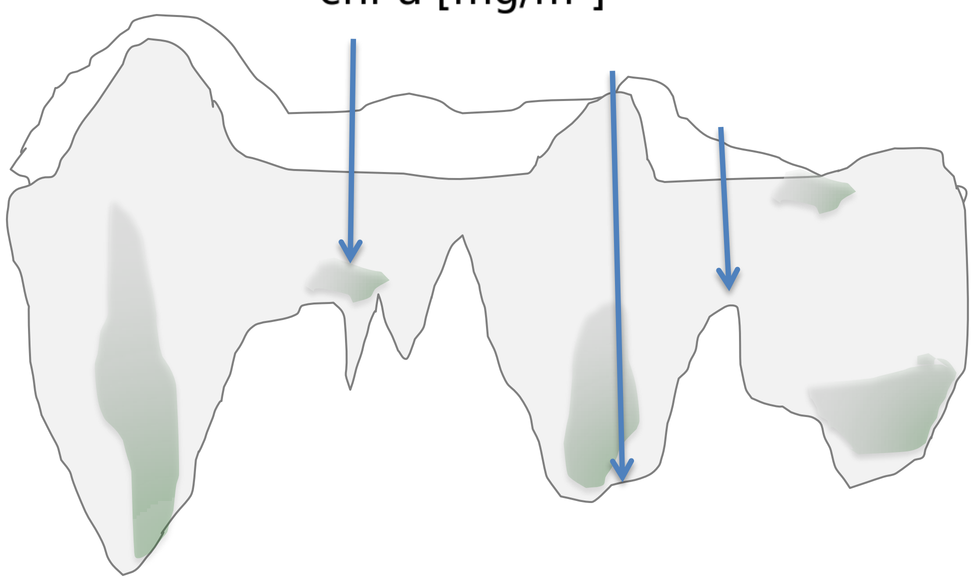
8245 chlorophyll samples [µg/l]

Integrated chlorophyll

$$I_{chl} = \rho_i / \rho_w \int_0^{h_i} C_{chl}(z) dz \quad [\text{mg chla/m}^2]$$

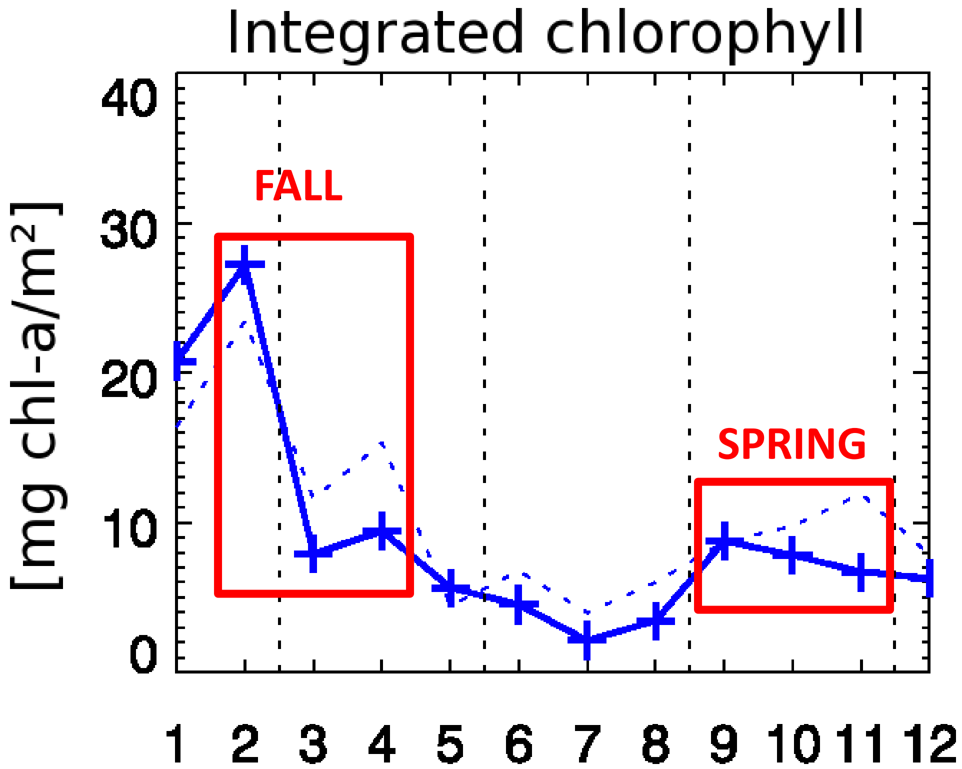
Chl-a from sea ice cores





30% of cores have
less than 1mg chl-a/m2

Seasonality



solid = mean
dots = std

1 Light

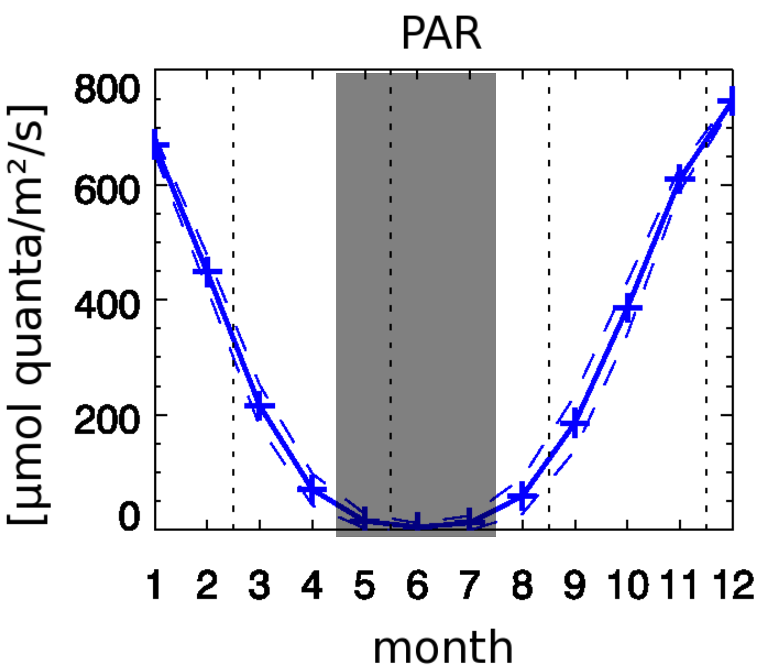
2 Nutrient supply mechanisms, e.g., brine dynamics, vary in time

3 Physical conditions **(T and S)** are not always optimal for ice algal growth

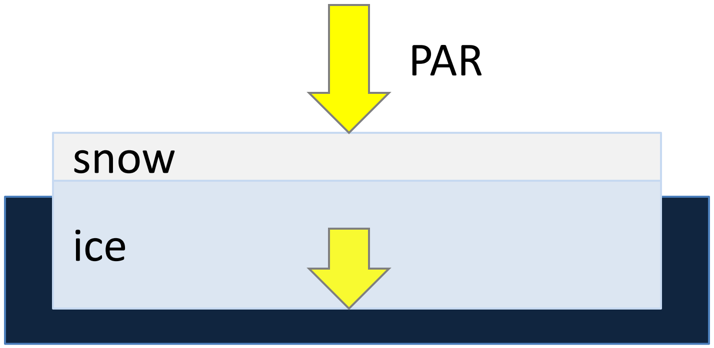
4 Snow

5 Water column

1 – Light



Mean seasonal cycle of incoming PAR in the Southern Ocean sea ice zone



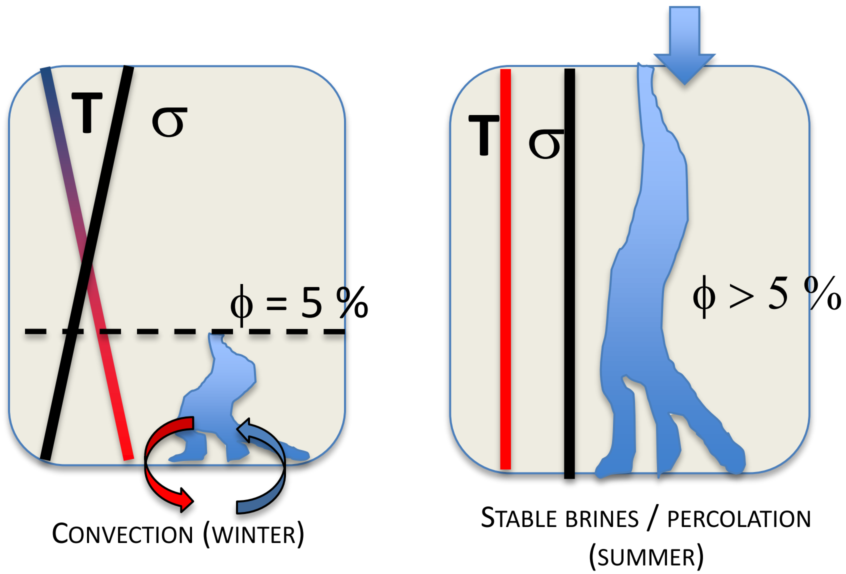
Incoming PAR computed as a function of latitude, day of year, cloud fraction, humidity [*Shine*, 1984; *Vancoppenolle et al.*, 2011]

Averaged over the entire sea ice zone (using SSMI data)

Incoming light takes off in September and shuts off in May

Small latitude variations

2 – Brine dynamics and nutrient supply



If unstable brine gradient in sea ice, nutrient fluxes are possible.

Convection starts below -2.7°C
[Jardon et al., in revision]

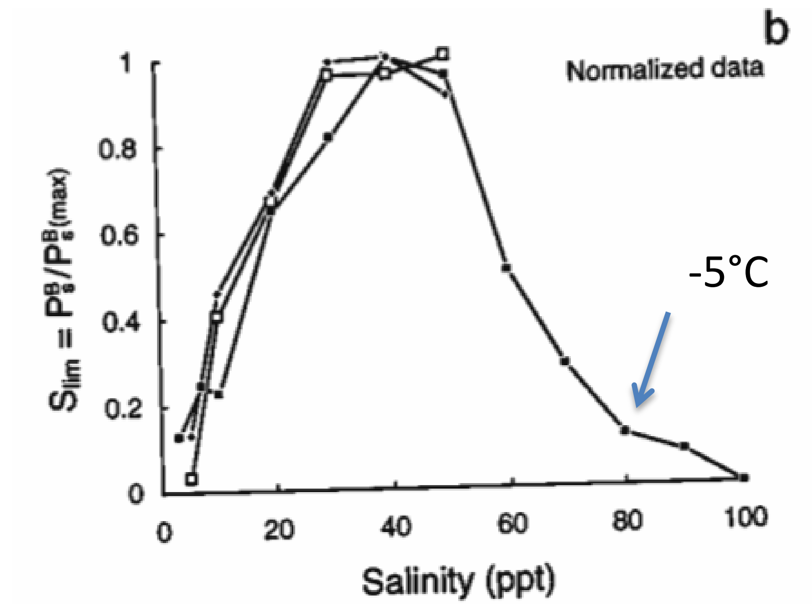
If no unstable gradient in sea ice, no nutrient fluxes are possible, probable limitation by one of the nutrients

3 – Temperature and brine salinity

Photosynthetic efficiency decreases at low temperatures and high salinities.

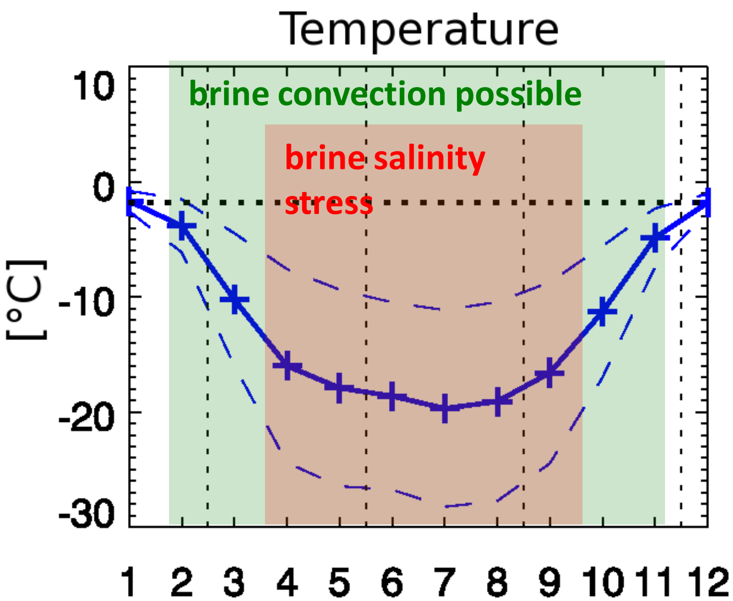
Brine salinity increases fast with temperature and this effect outcompetes temperature.

At -5°C, growth is 10 x smaller than at -2°C.



Normalized ice algal growth in mesocosm experiments as a function of solution salinity (Arrigo and Sullivan, 1992)

Temperature constraints



Mean seasonal cycle of 2m air temperature based on NCEP-NCAR data (1983-2008)

Air temperature provides two constraints on algal growth

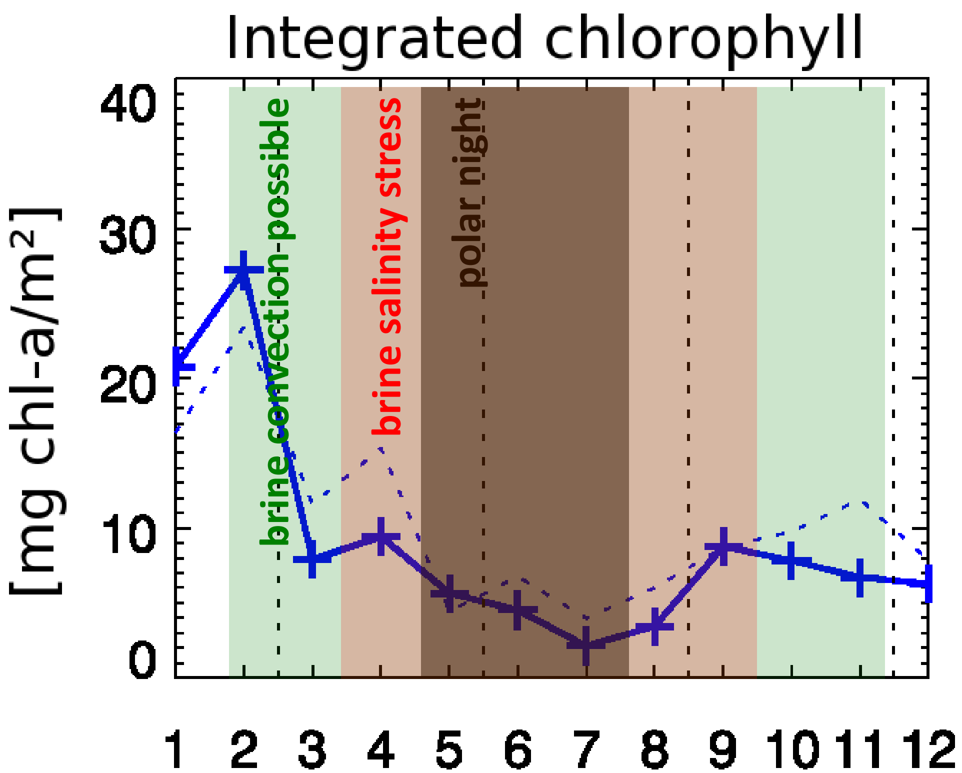
Air temperature frequently drops below -3 °C from February to November

-> nutrient supply by brine convection possible

Air temperature does not go above -5° from April to October

-> brine salinity stress on ice algae

Summary



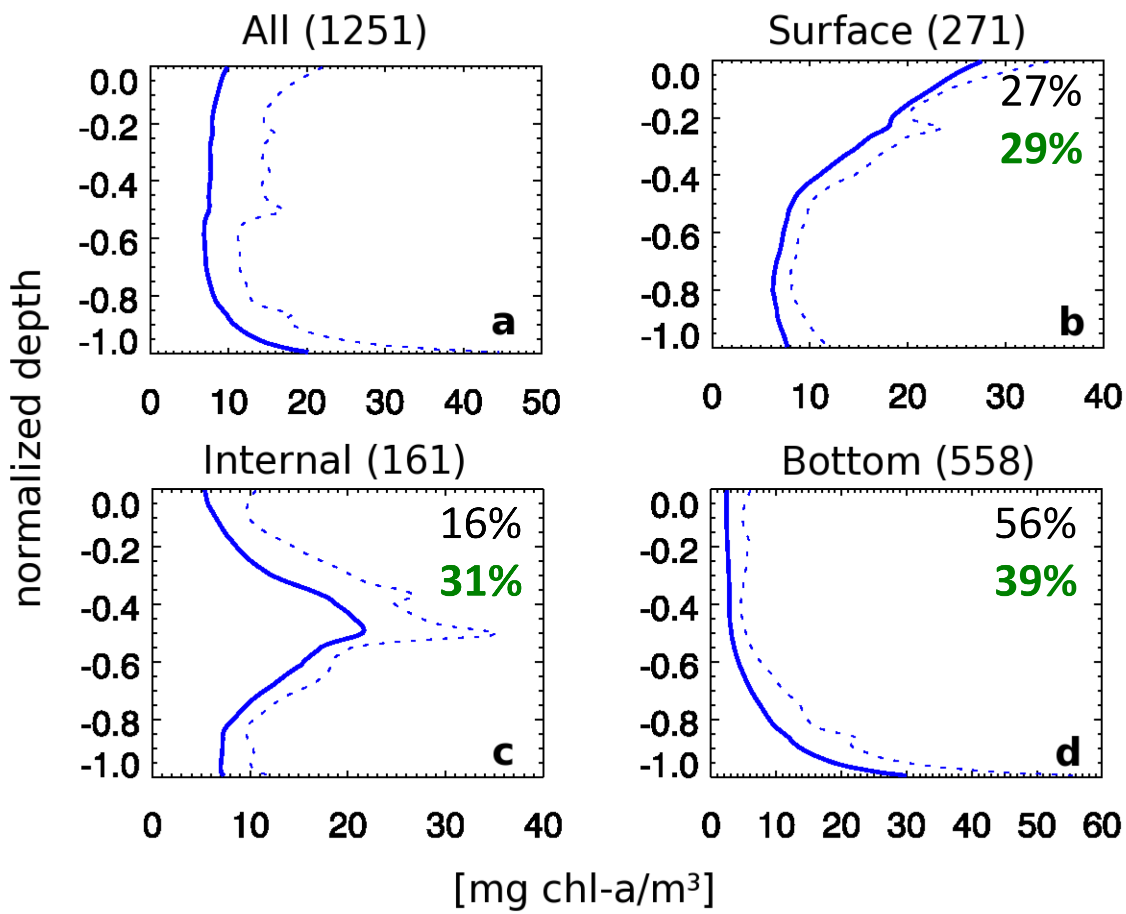
light and air temperature provide two key controls on ice algae

remaining questions:

why high chl-a in January?
snow?
water column?
forced convection due to ice motion?
nut supply from storms ?

why remaining chl-a in winter?

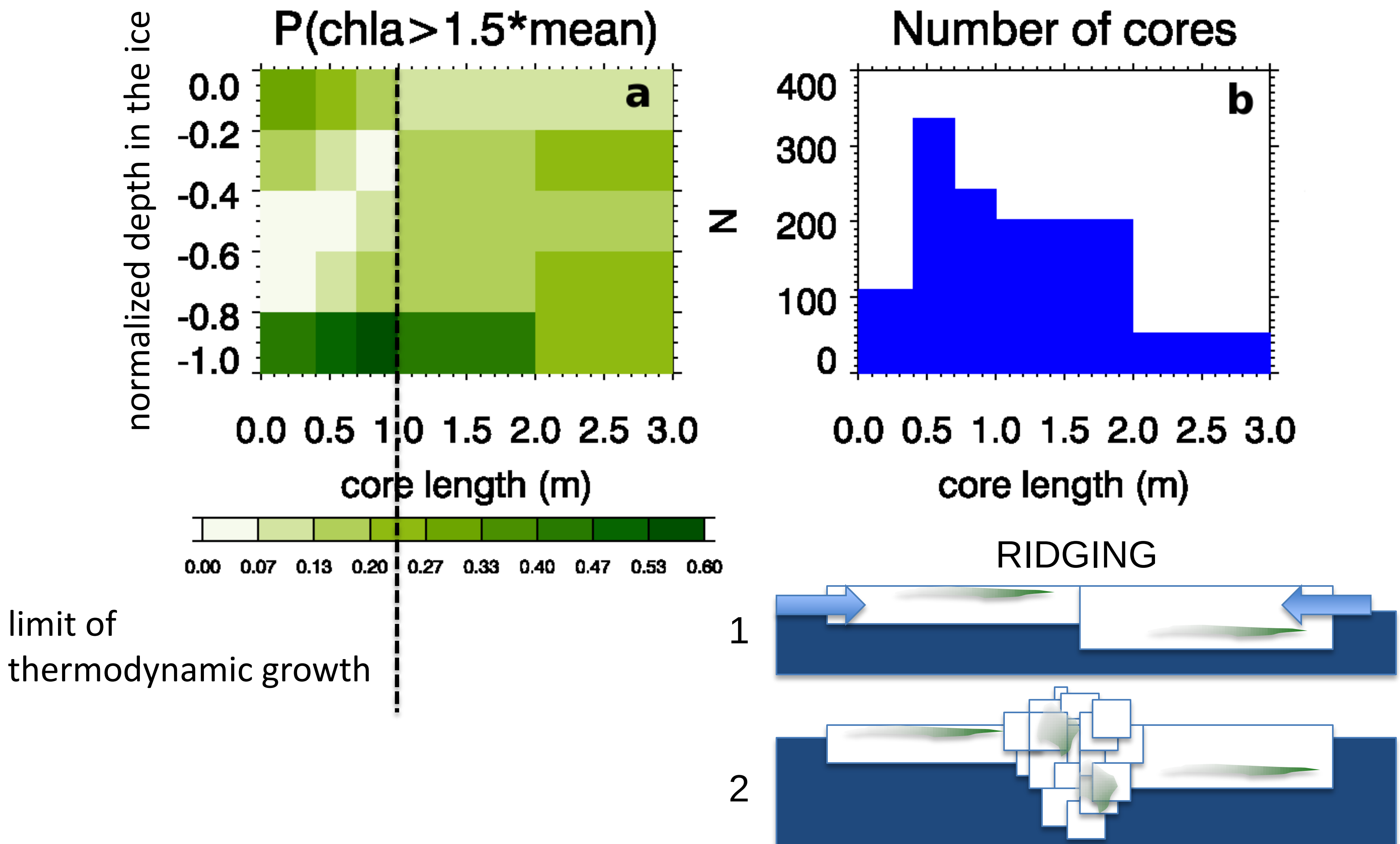
Normalized vertical chl-a profile



profile-type classification

contribution to integrated chl-a

Dependence on ice thickness



Limitations

- Space and time coverage is uneven
- Chl-a in sea ice is patchy
- Humans who core avoid thick ice
- Material is lost during ice coring
- Varying chl-a/C ratios

Conclusions & Perspectives

- The ASPeCt-BIO data set has **large-scale signals**
- **Seasonal** peaks in spring and late summer
  - role of light, temp & nutrients
  - role of snow and water column?
- The **three community types** (surface, internal, bottom) equally contribute to biomass
- **Vertical profile** of chl-a changes with ice thickness

- **ROVs** to tackle patchiness issues and measure biomass at floe scales
- **Future changes** in winter ice thickness distribution will affect food availability for krill
- What about the **Arctic** ?
- Modelling: **multi-layer** models have to be used
- DATA AVAILABLE SOON VIA THE ASPECT PORTAL (Klaus)