Phytoplankton carbon and chlorophyll-to-carbon ratios from Southern Ocean gliders

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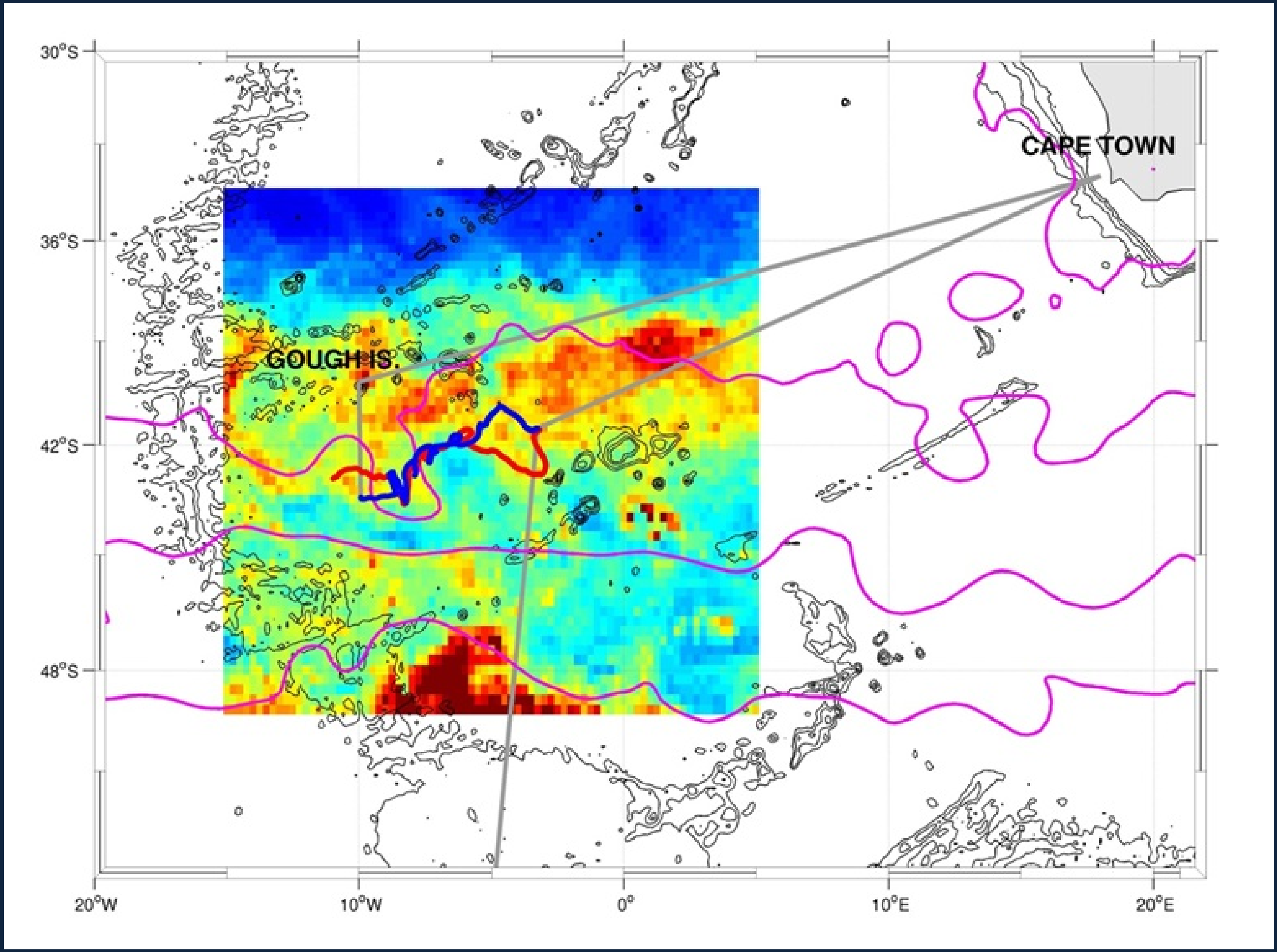
Thomalla et al. 2017. Using optical sensors on gliders to estimate phytoplankton carbon concentrations and chlorophyll-to-carbon ratios in the Southern Ocean, Front. Mar. Sci. 13.

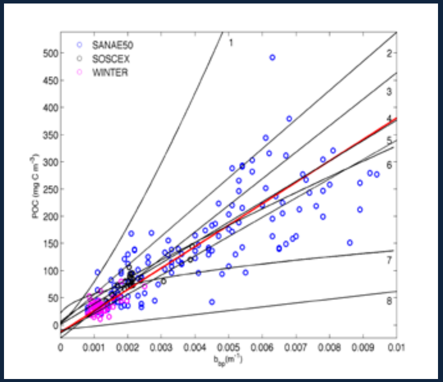
Rationale

- In the Southern Ocean sub-seasonal temporal scales, and meso- to submeso- spatial scales are important.
- We need to develop ecosystem-appropriate, well characterised products for platforms that can sample the ocean at the time scales necessary to address climate response questions (e.g. autonomous gliders / floats, satellite ocean colour).
- Carbon from optical sensors is one of the first candidates, given the importance of phytoplankton production in driving the carbon sink.

5.5 Month glider transect in the Subantarctic Southern Ocean



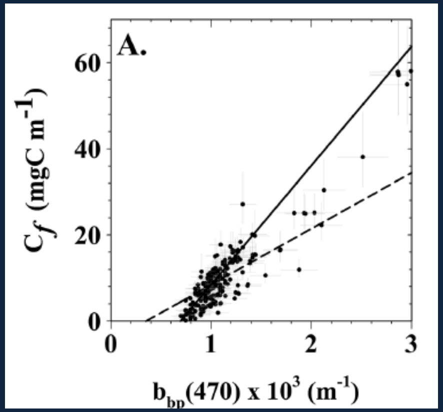
4 methods of deriving phytoplankton carbon (C_{phyto}) from optical data



1. 30% POC:

POC *bbp* data fit + constant 30% fraction (SAZ)

$$C_{phyto} = 0.3[(39418 \pm 3000)b_{bp470} - (13 \pm 6)]$$



2. Behrenfeld et al., 2005

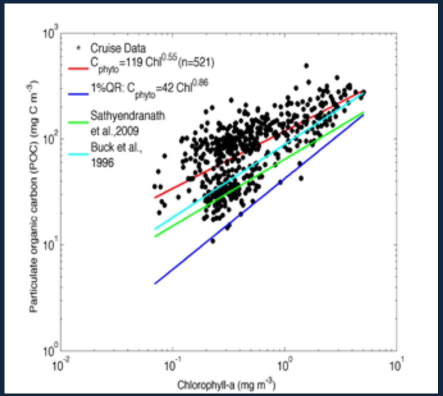
Satellite data (global)

$$C_{phyto} = 13000\left(b_{bp470} - 3.5\ 10^{-4}\right)$$

3. Martinez-Vicente et al., 2013

Flowcytometry (Atlantic)

$$C_{phyto} = (30100 \pm 1100)\left[b_{bp470} - (7.6 \pm 0.4)\ 10^{-4}\right]$$

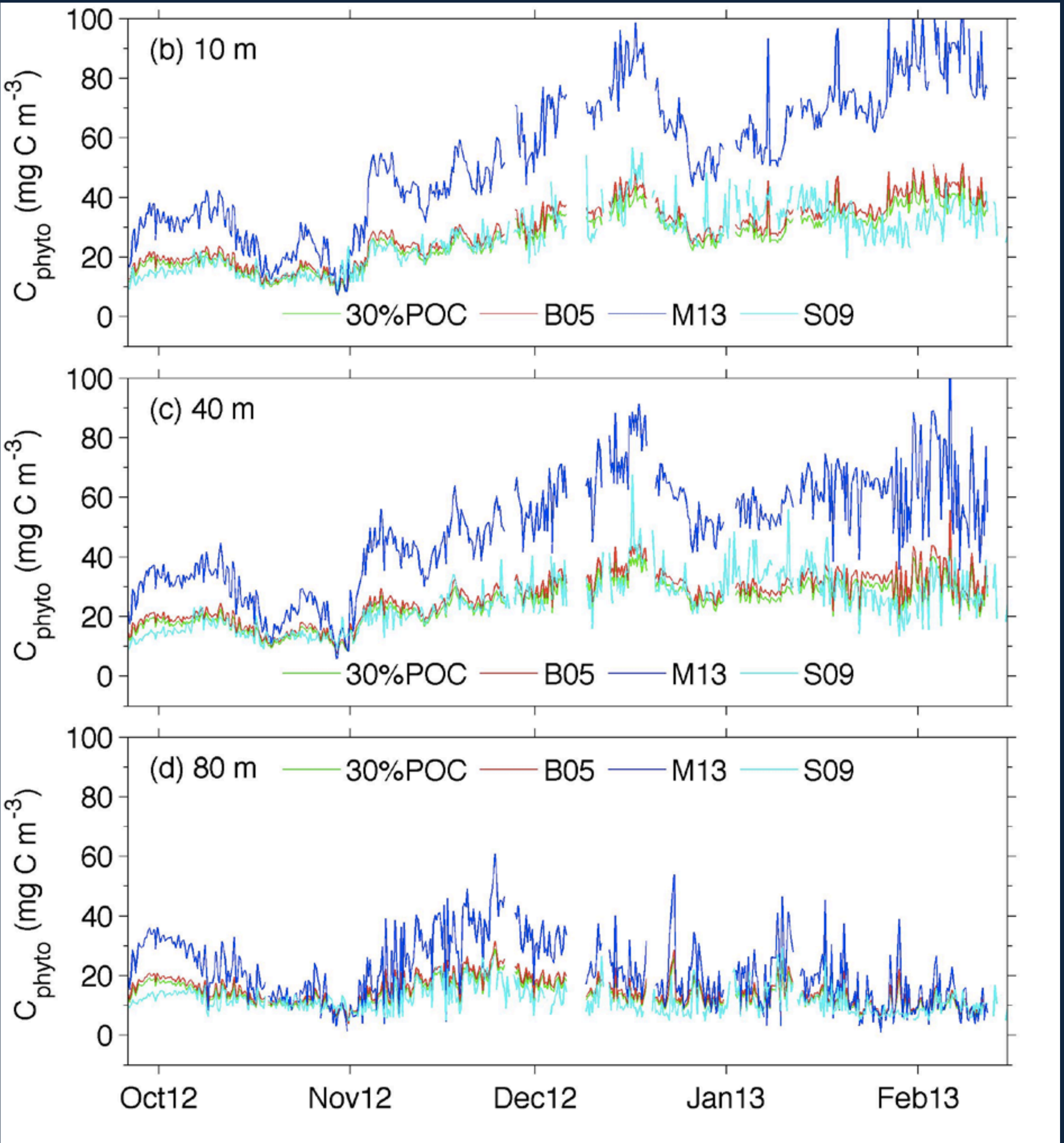


4. Sathyendranath et al., 2009

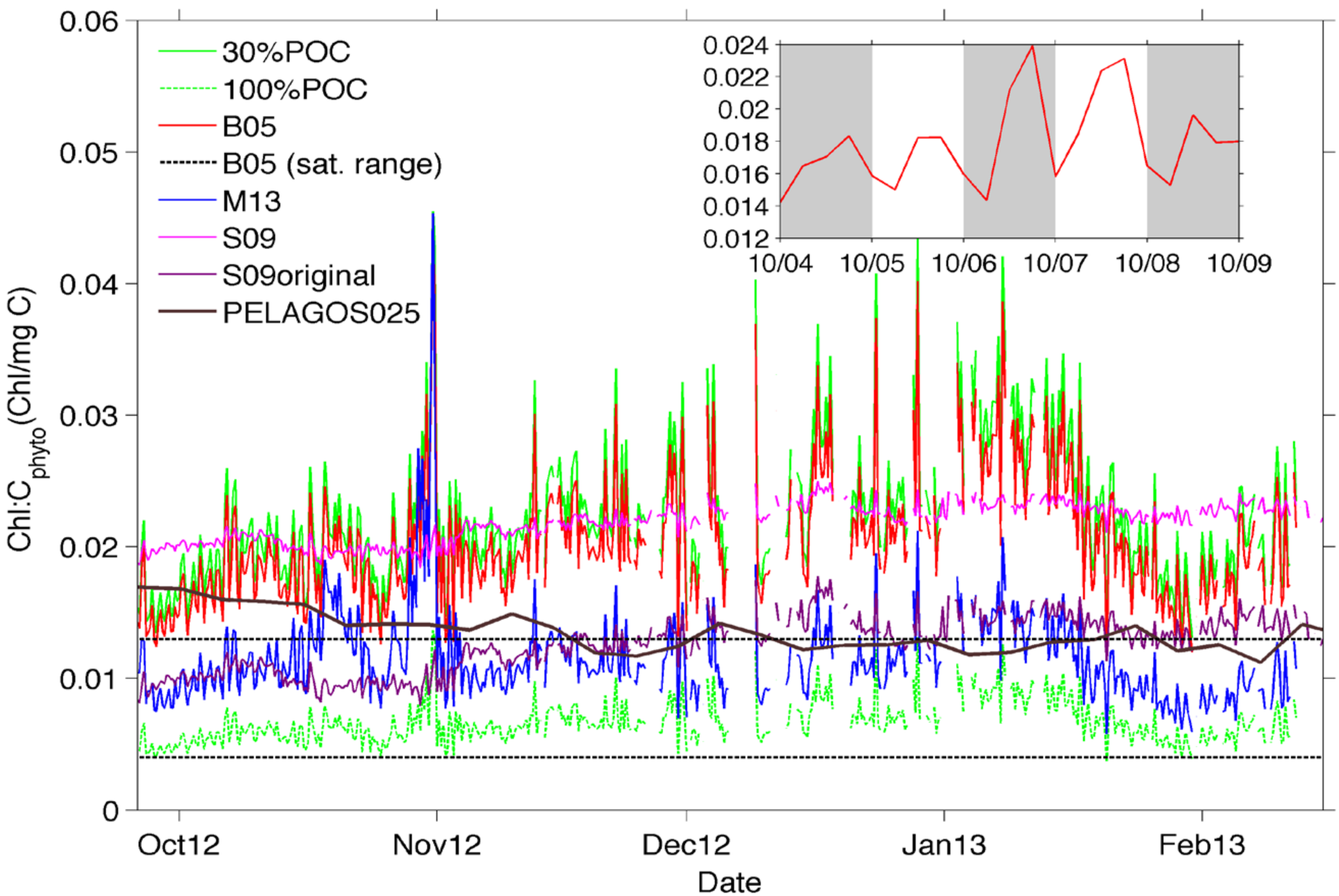
Chl and carbon data 1% quantile regression fit (SAZ)

$$C_{phyto} = 42\ (chl)^{0.86}$$

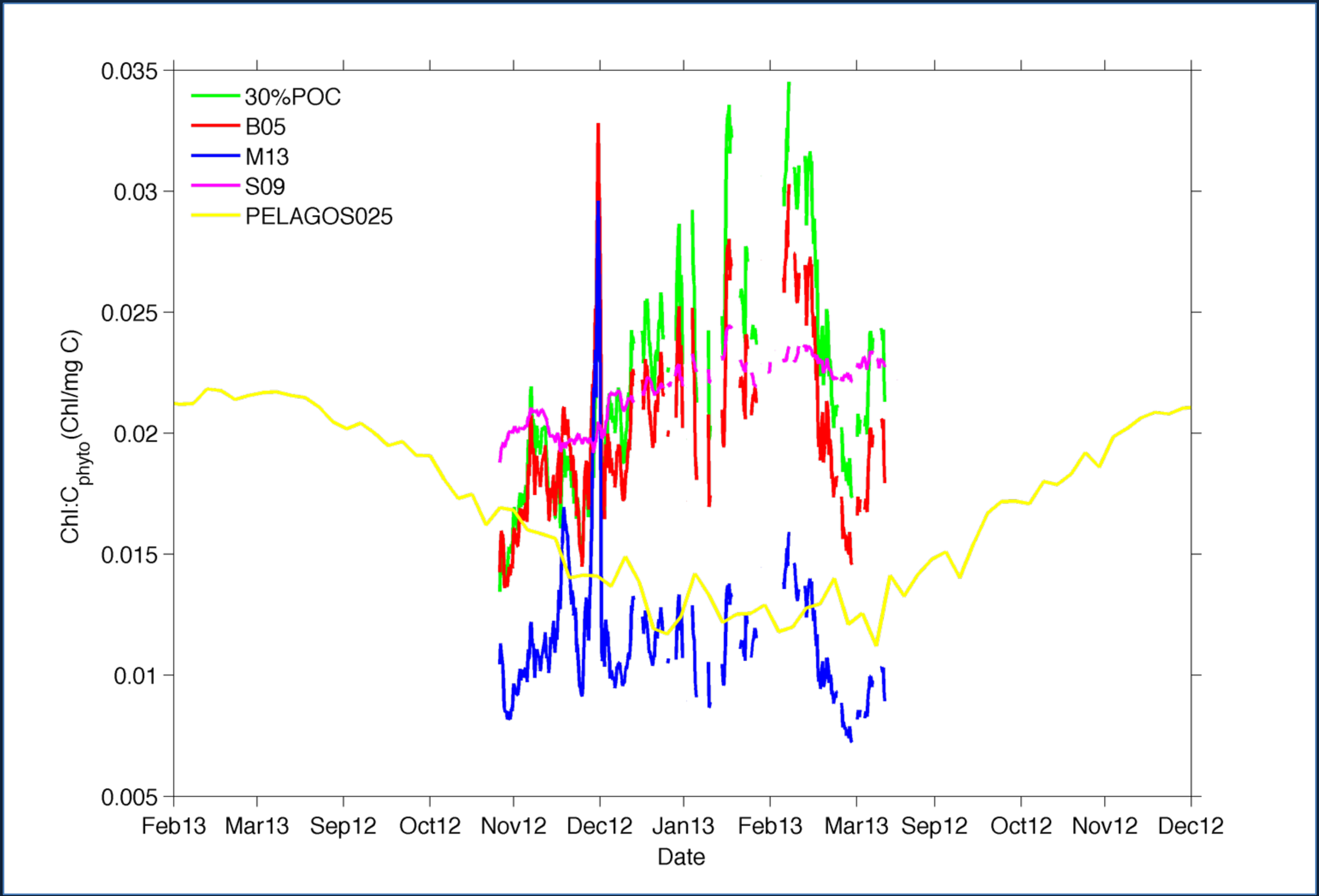
Time series of C_{phyto} with depth



Seasonal time series of chl:C_{phyto} ratios

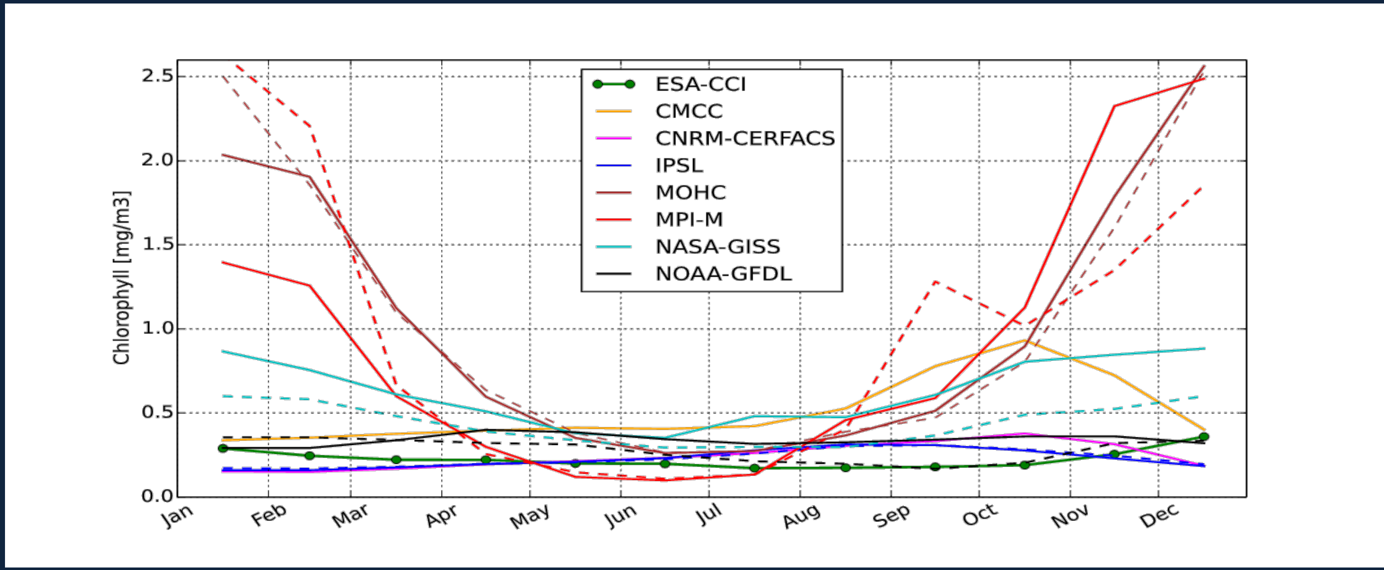


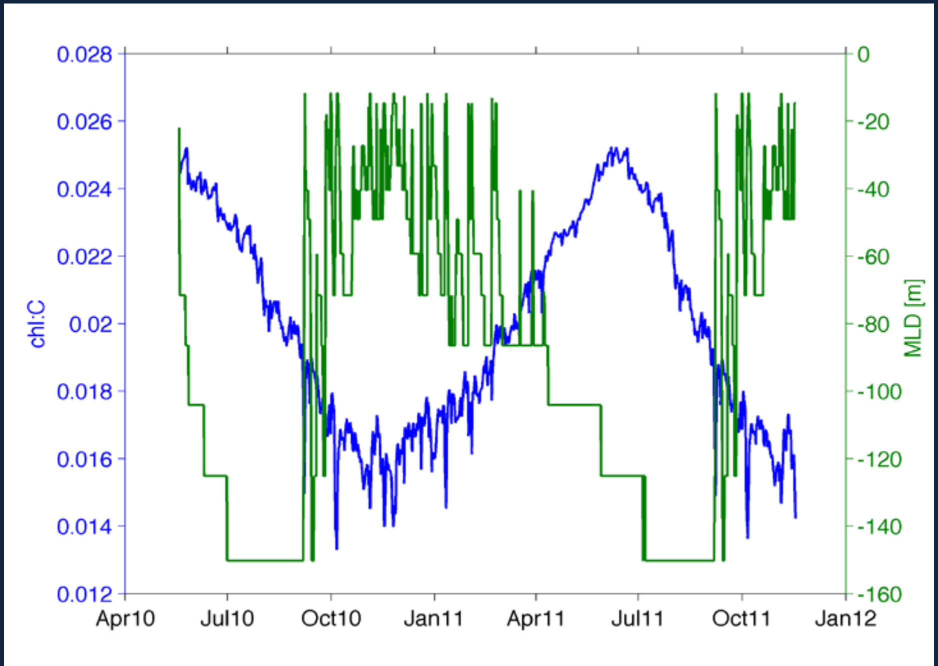
A broader perspective



Implications for models

The seasonal mismatch may result from the models assumption that all seasonal variability is simply due to acclimation by McKiver et al. (2015)





Models need to accommodate for variable chl-a:C_{phyto} ratio that reflect phytoplankton adaptation to low light conditions in spring (low optimal chl-a:C_{phyto} ratio) and higher optimal chl-a:C_{phyto} ratios with species-specific increasing growth rates in summer.

However ………

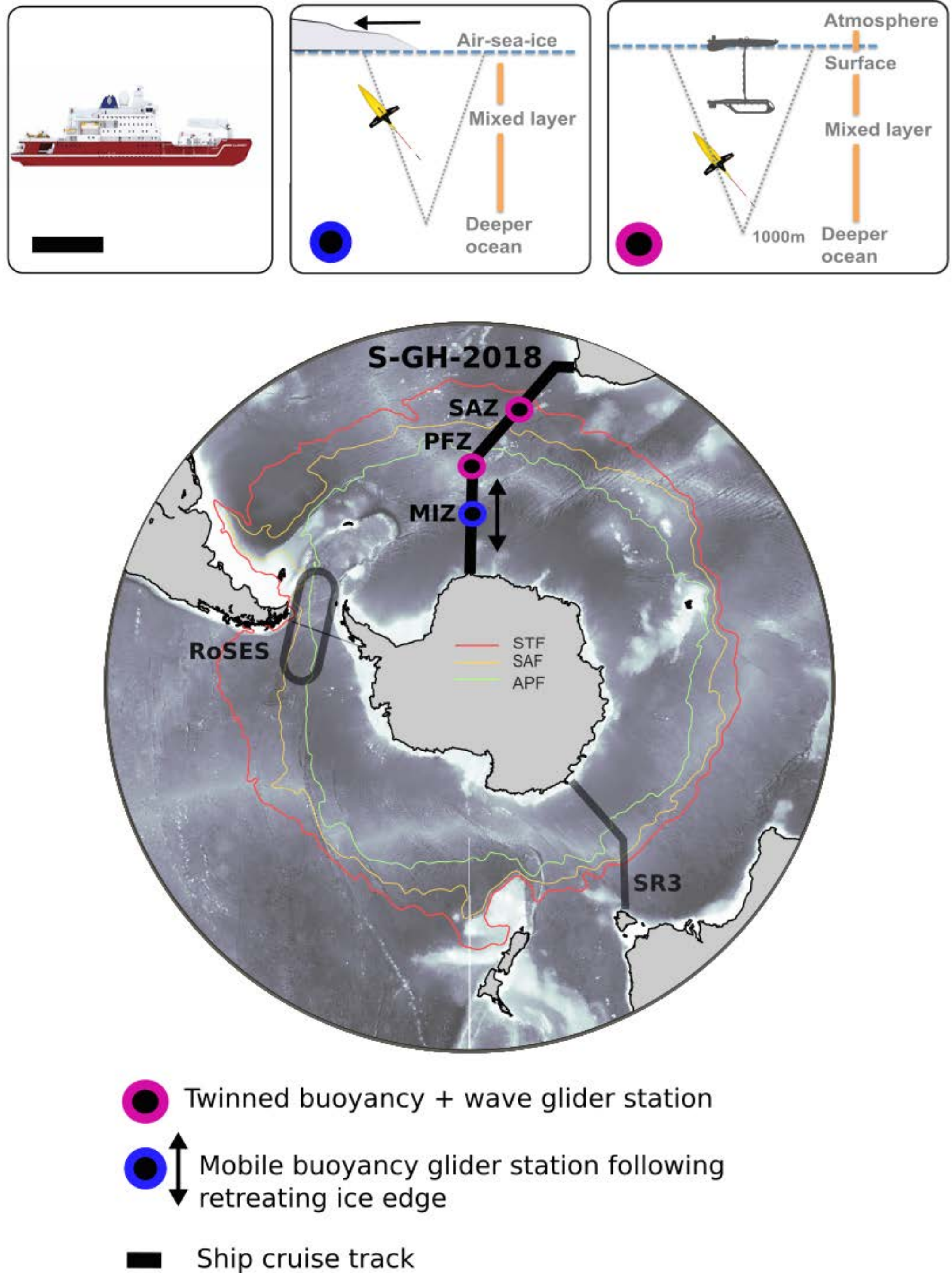
An alternative explanation for the seasonal increase in chl-a:C_{phyto} ratios is a decrease in the ratio of C_{phyto} to total POC as the bloom develops i.e. a greater percentage of the particulate backscattering signal is due to non-phytoplankton specific carbon (heterotrophic bacteria, detritus, viruses, ciliates etc.)

Conclusions

Methods converting backscattering to C_{phyto} need to take into account the space-time variability of non-algal contributions to particulate backscattering, which can vary by more than one order of magnitude.

We need quantitative assessments of C_{phyto} (e.g. Graff et al., 2015, DSR1) for evaluating and validating optical methods of determining.

GoodHope 2018 Cruise and Seasonal Cycle Experiment



Optically characterising the phytoplankton community: IOP's

FiRe: Fv/Fm

MFL: Multiple wavelength fluorescence

OSCAR: Hyperspectral absorption

BB9: Backscatter 9 wavelengths

ACS: Hyperspectral absorption and attenuation

Debubbler

Automated valves

Filter series

Acidification, PH sensor

Important for being able to link phytoplankton biomass, community structure, physiology and production to carbon export

Improved POC, chla, size, FQY and PP algorithms