Insights on the Biological Carbon Pump from high-resolution glider measurements

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European Commission

erc European Research Council

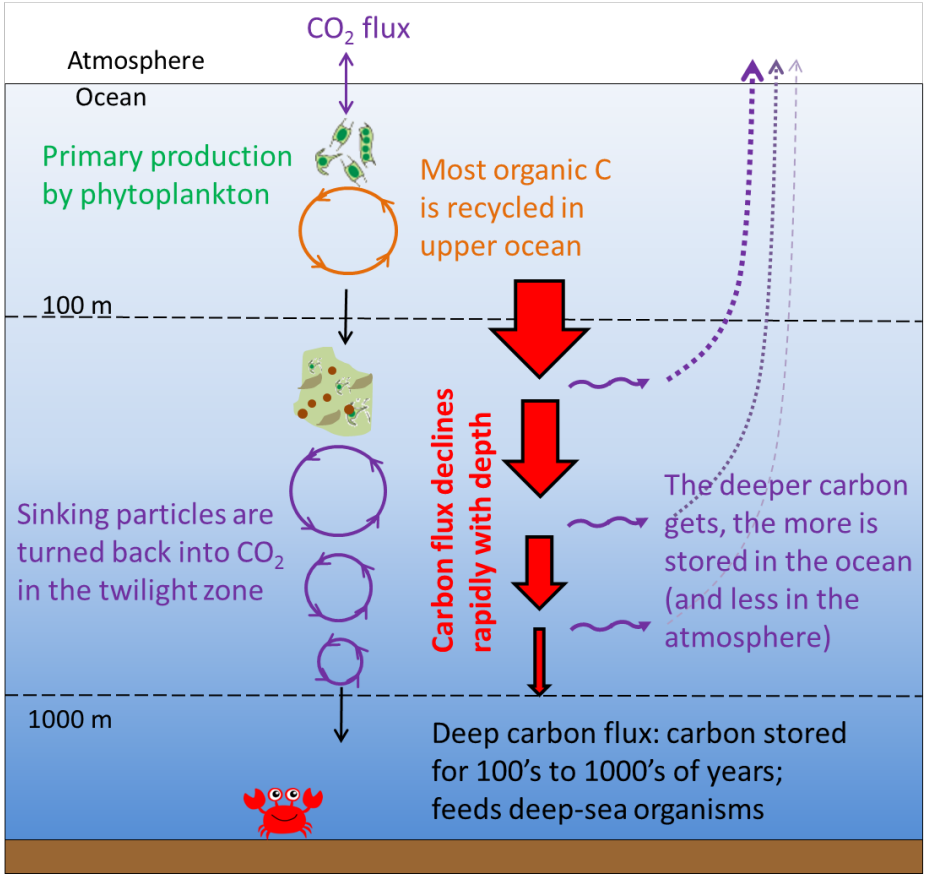
GOCART

COMICS INVESTIGATING THE TWILIGHT ZONE

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

The Biological Carbon Pump (BCP)

- Important component to the carbon cycle
- Poor understanding given logistic sampling constrains
- Remineralisation depth is key to the ocean's carbon uptake



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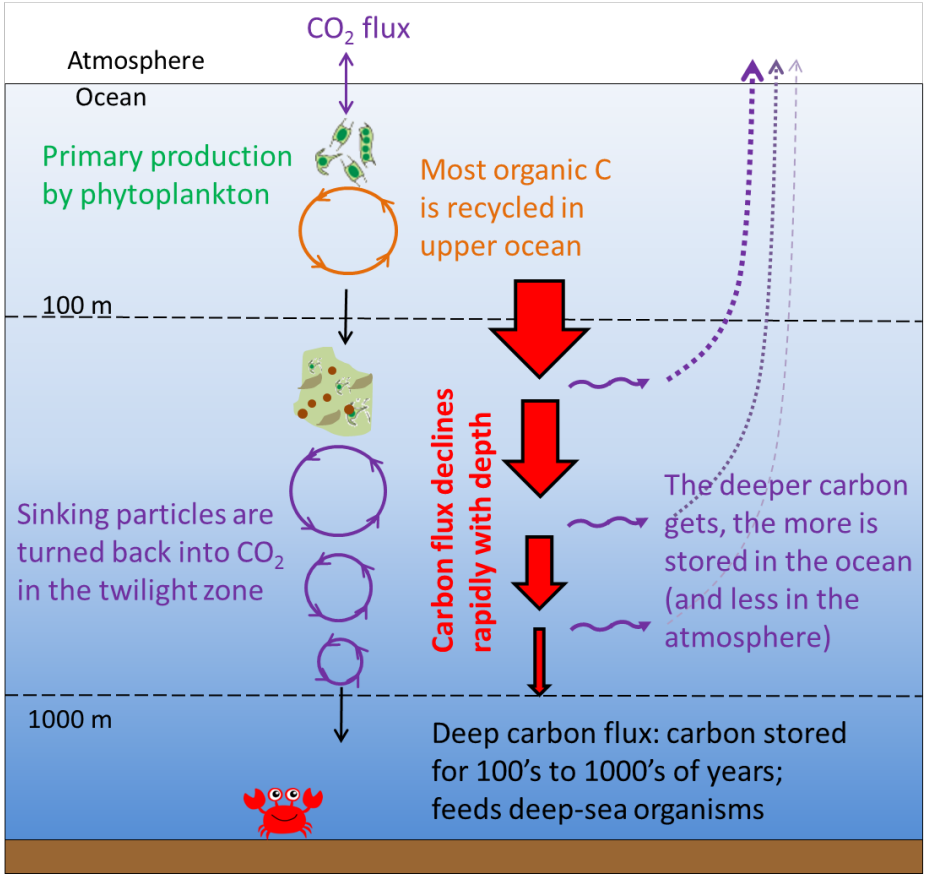
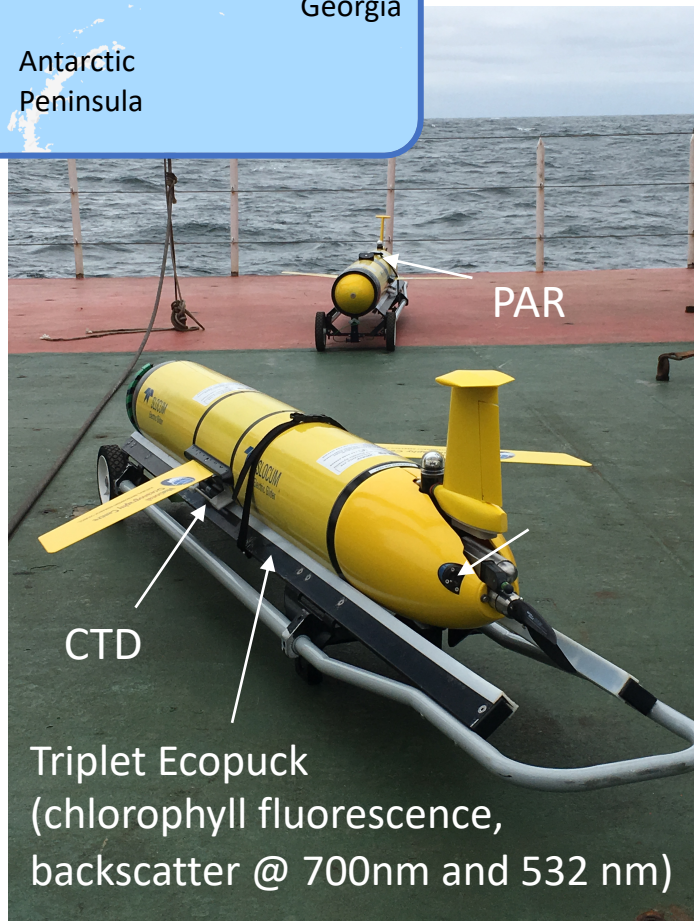


- The different 'inputs' change during the year
- The BCP is unlikely to be in steady state
- Very hard to observe variability
- Gliders can help fill that gap!

GOCART aims to quantify variability in carbon flux and remineralisation depth on daily to seasonal timescales

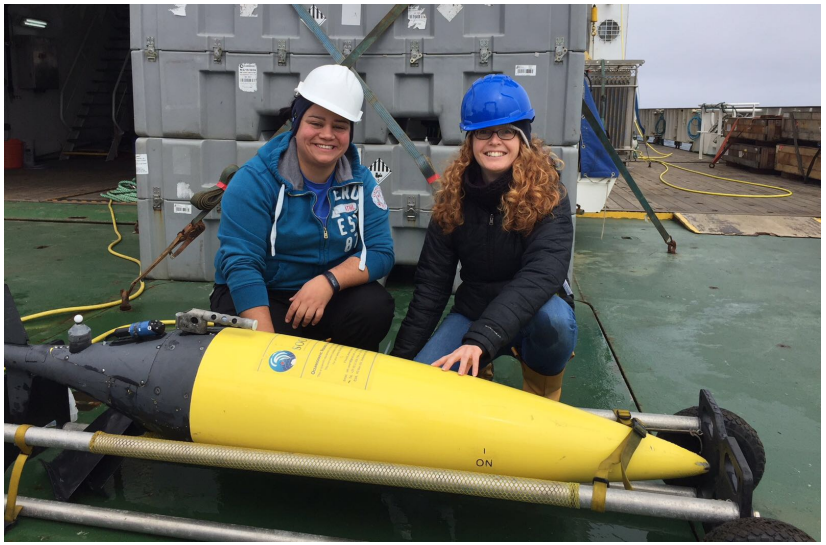
Gauging oceanic **O**rganic **C**arbon fluxes using **A**utonomous **R**obotic **T**echnologies

GOCART GLIDERS in SOUTH GEORGIA



2 Teledyne Webb Research Slocum gliders from MARS, Southampton, UK

1 Kongsberg Seaglider from the Southern Ocean Carbon and Climate Observatory, Cape Town, SA



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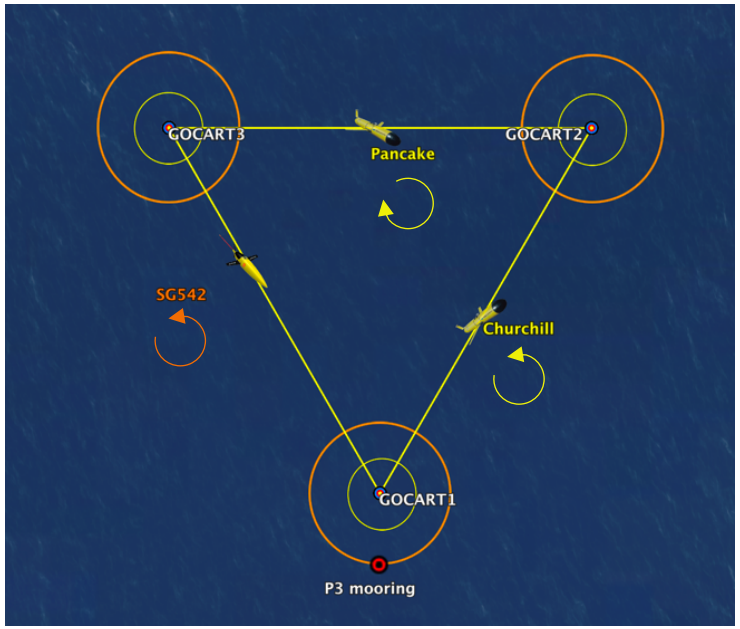
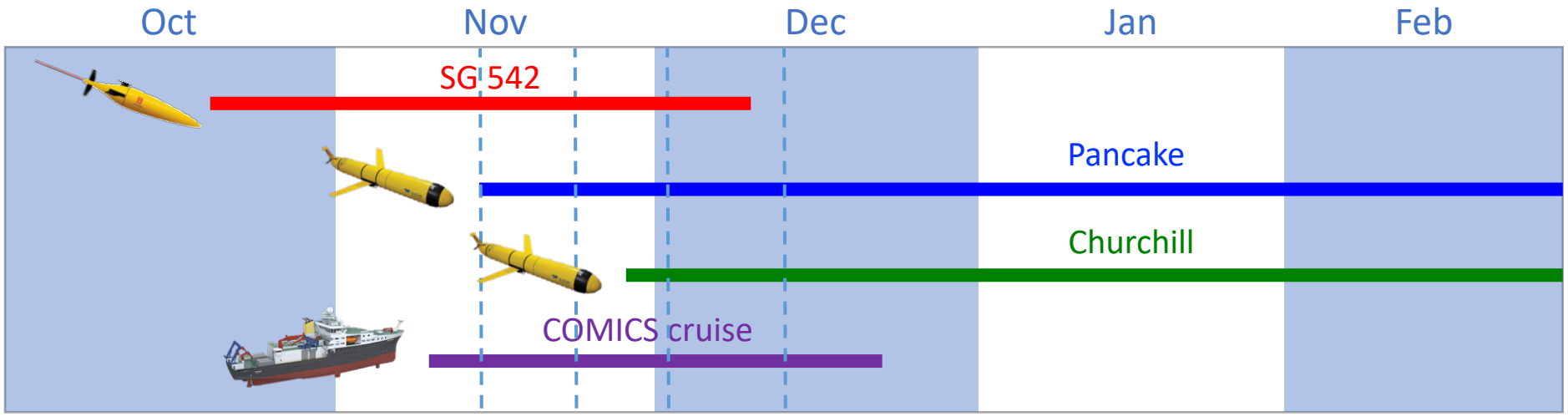


- Triangle facilitates calibration between gliders (gliders flying in opposite directions)
- At least 2 gliders sampling since the beginning of the cruise
- Targeted/non-targeted calibrations during the cruise



4 targeted calibration casts during the cruise

Integrated multiplatform physical-biogeochemical studies

Water column dynamics

↓

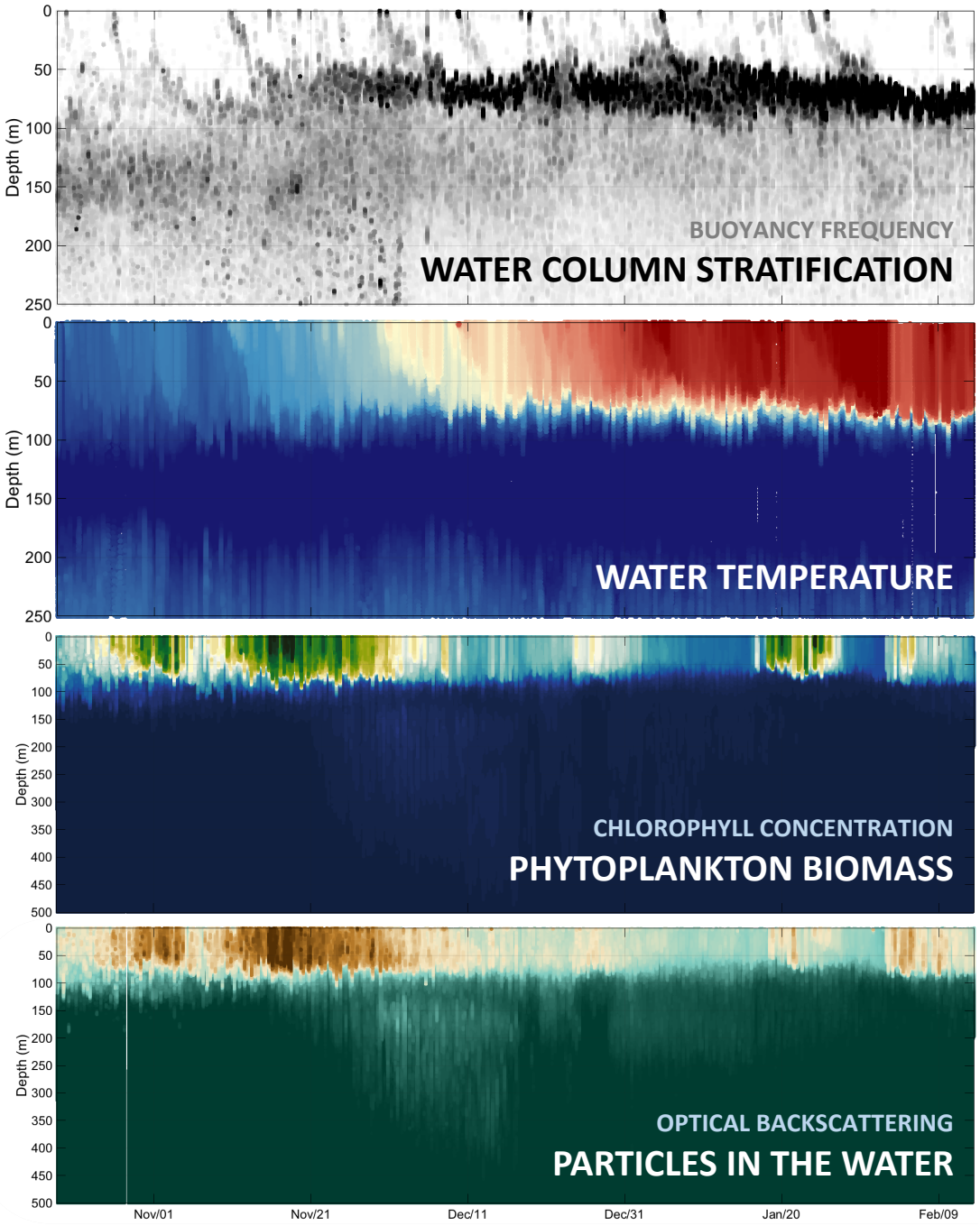
phytoplankton dynamics

↓

particle dynamics

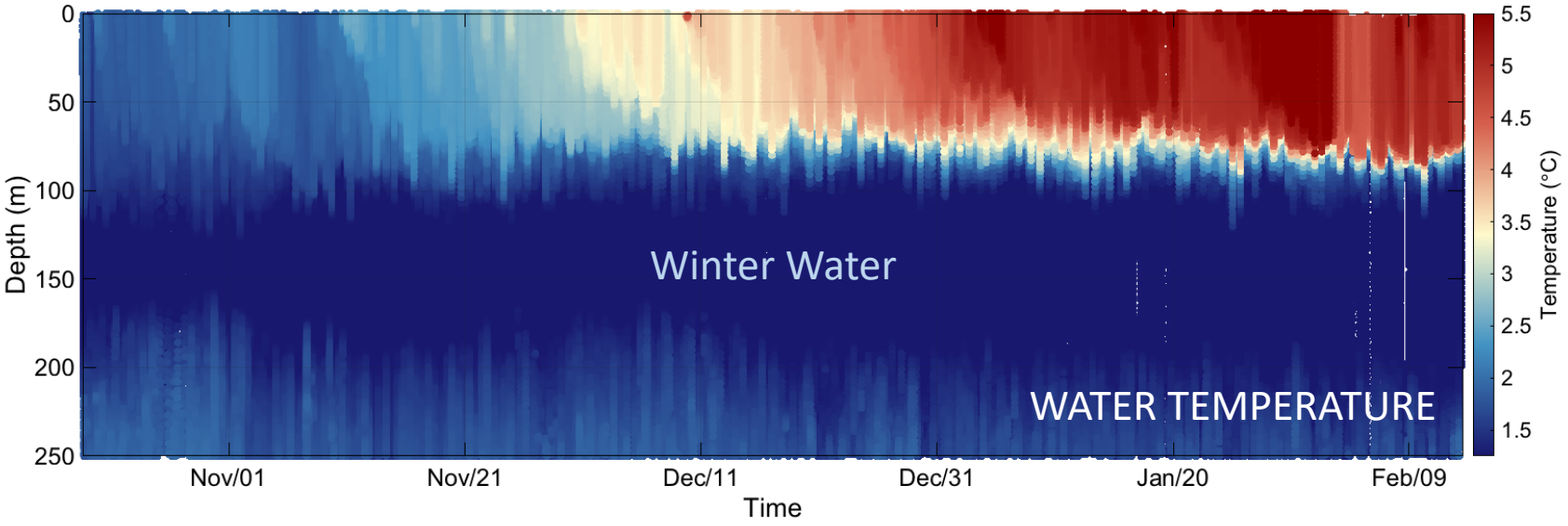
↓

carbon flux



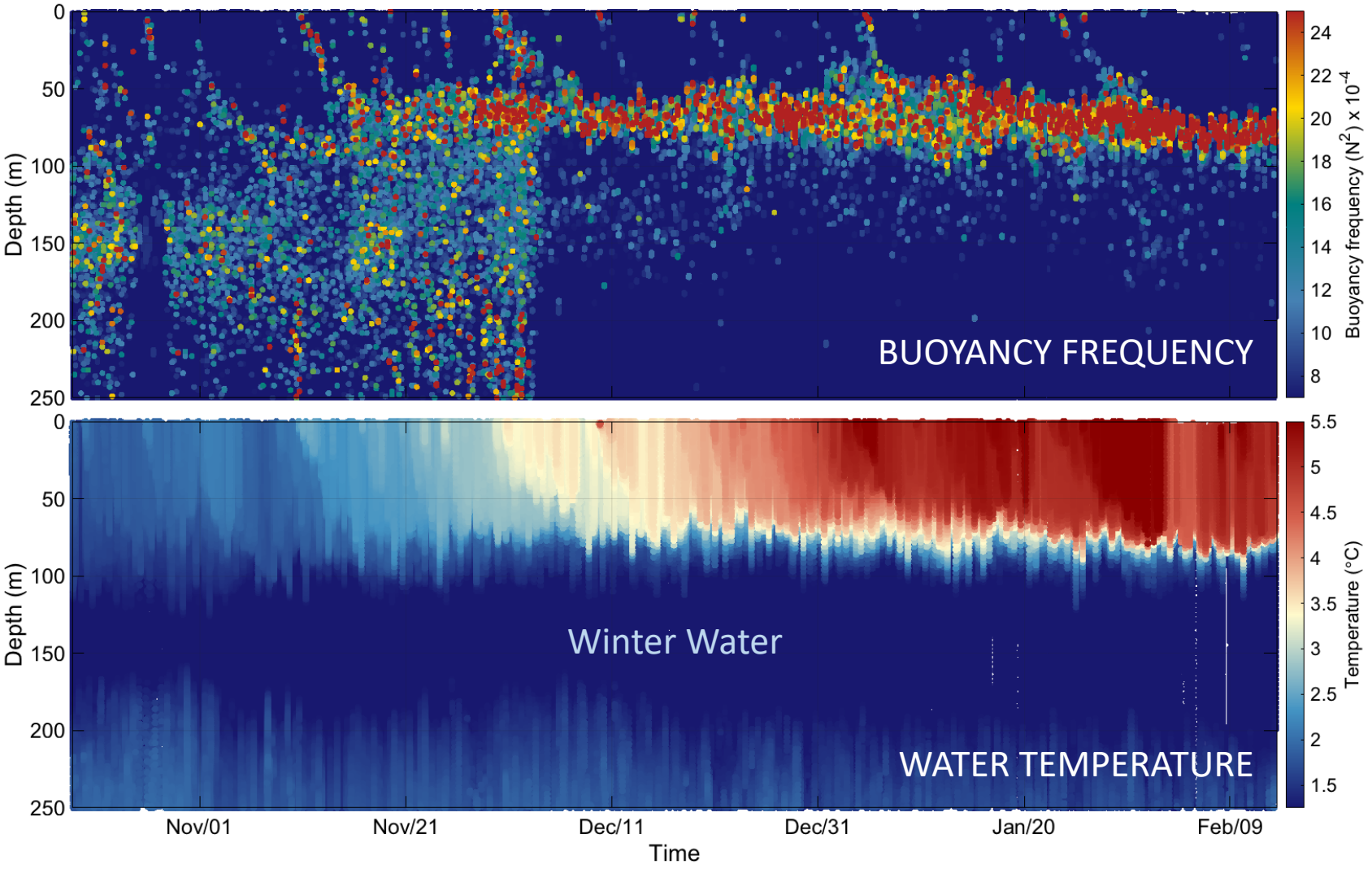
Water column stratification

Warming of the upper ocean throughout the season



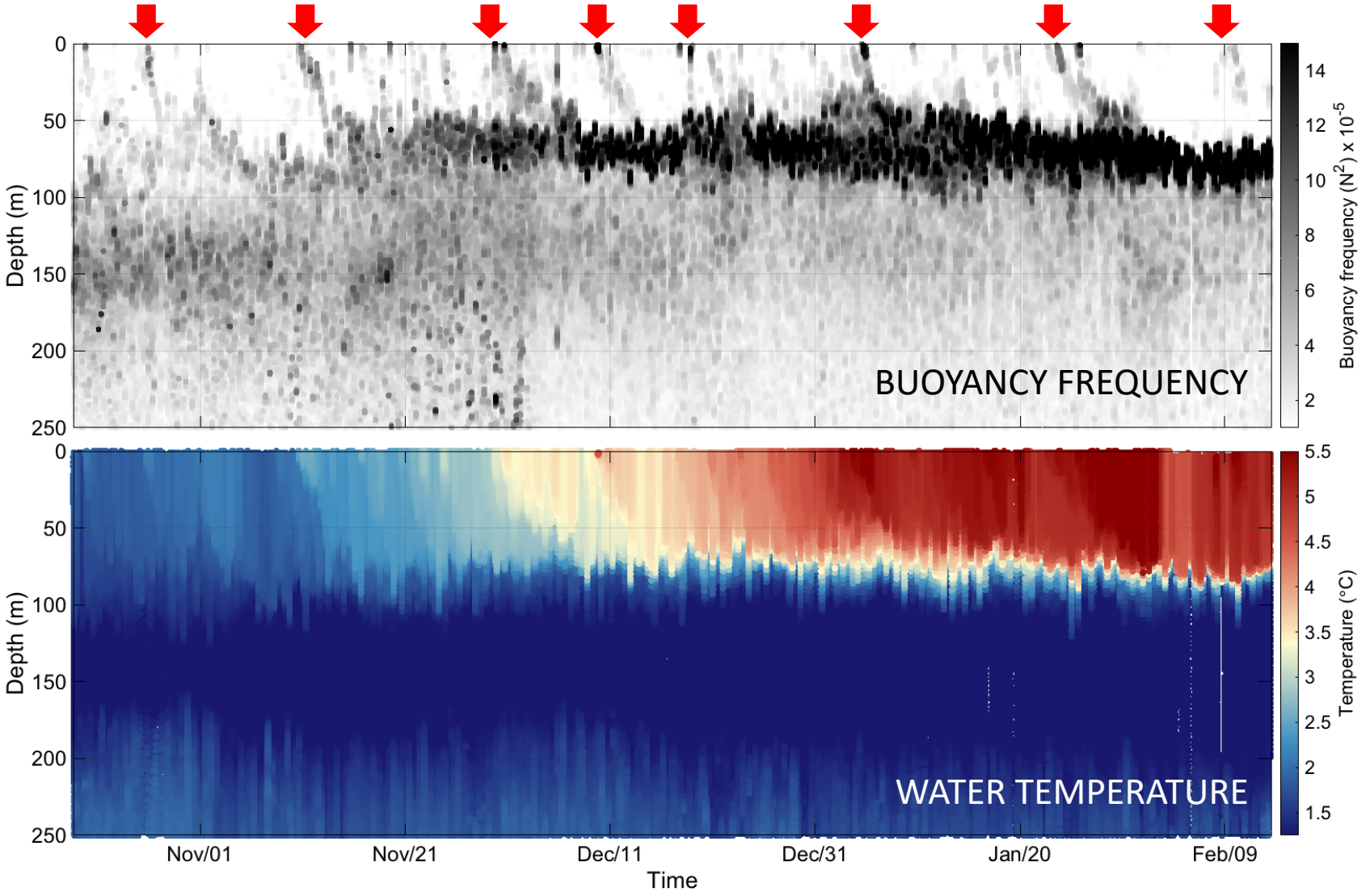
Water column stratification

Buoyancy frequency (N^2) – insight on water column stratification



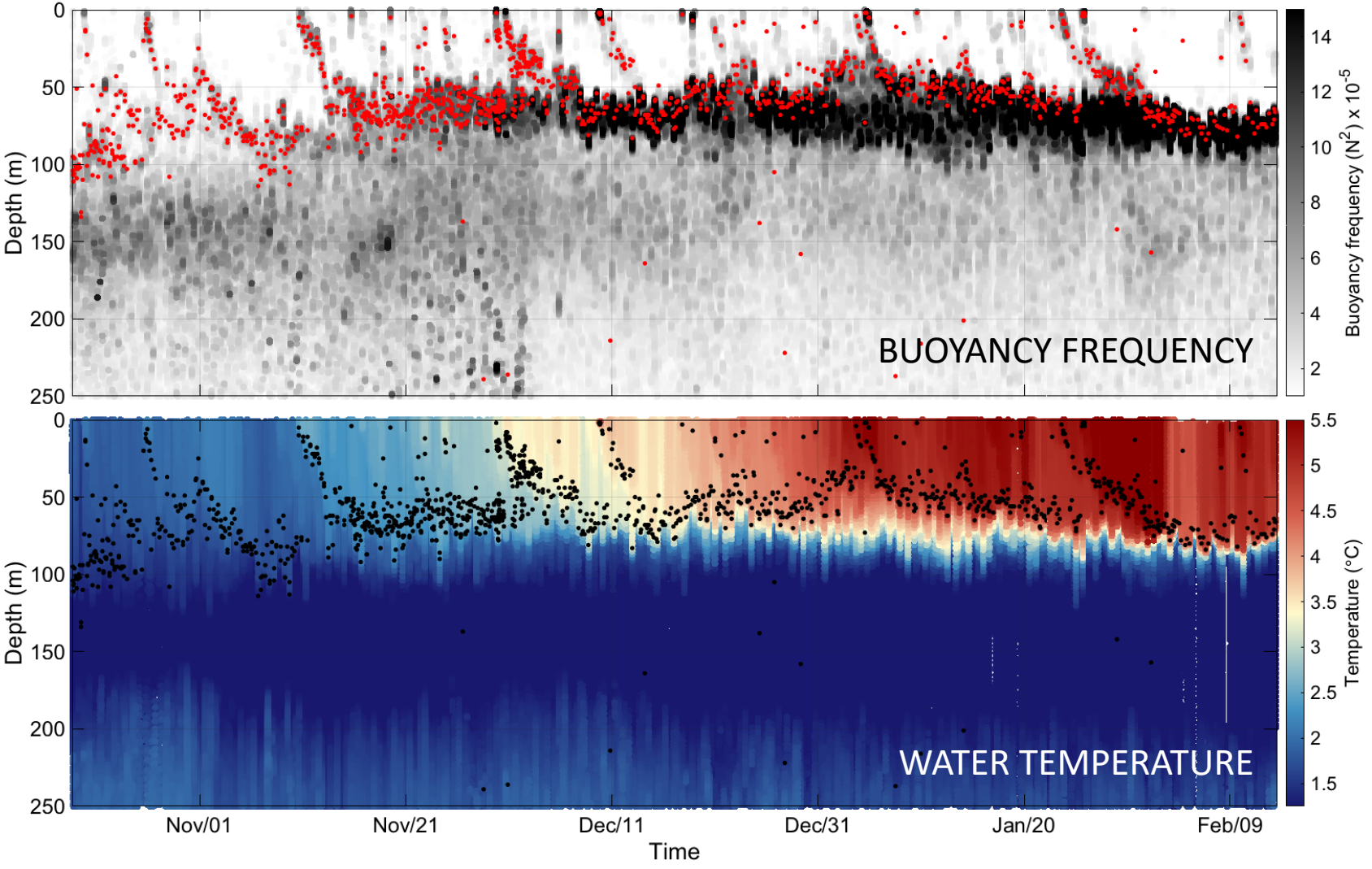
Water column stratification

Warming at the surface: re-stratification events of the water column



Thermal stratification drives MLD

MLD defined as the max(N^2) above depth where $\Delta\sigma_\theta$ = 0.05 kg m^{-3}



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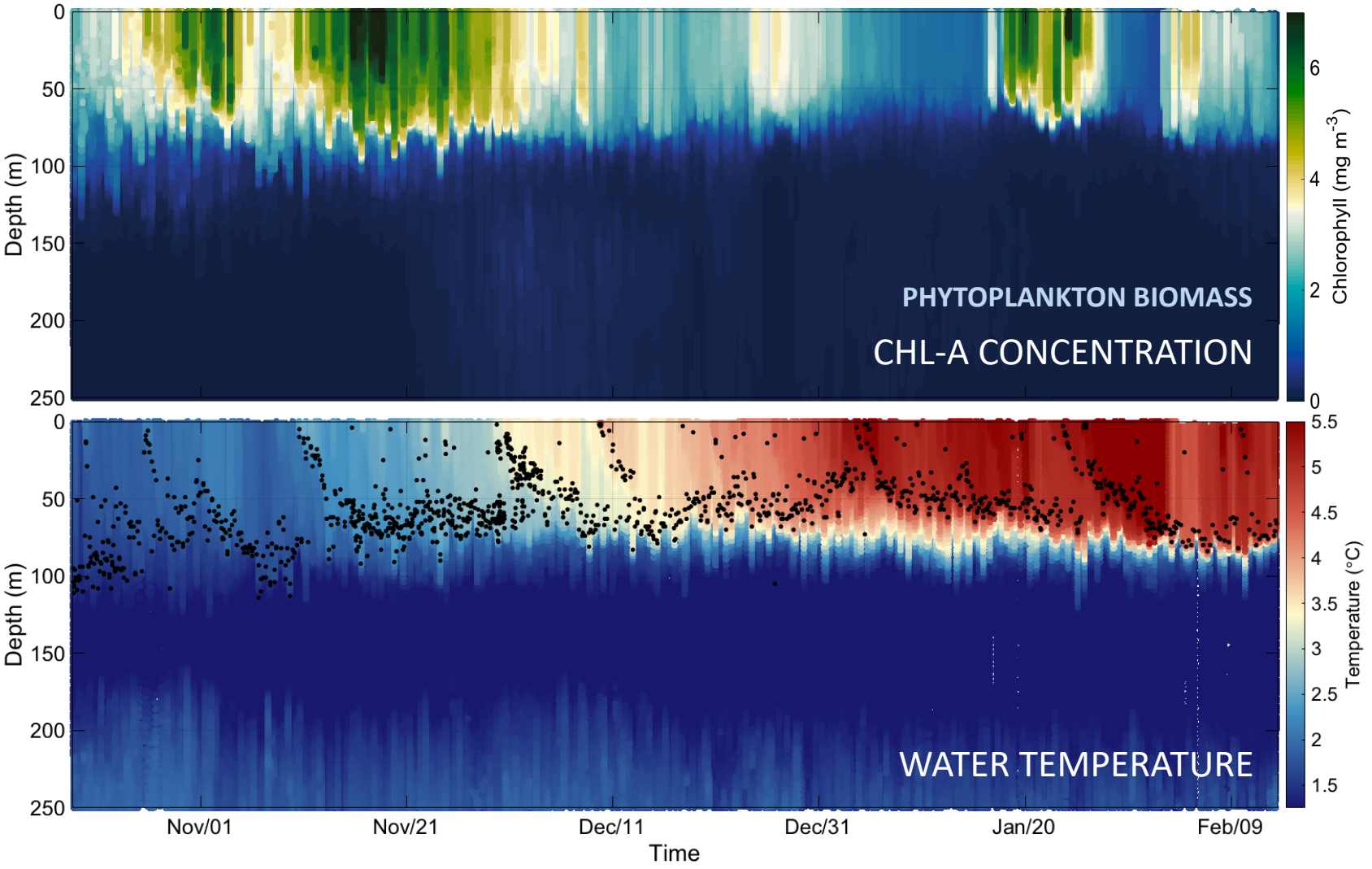
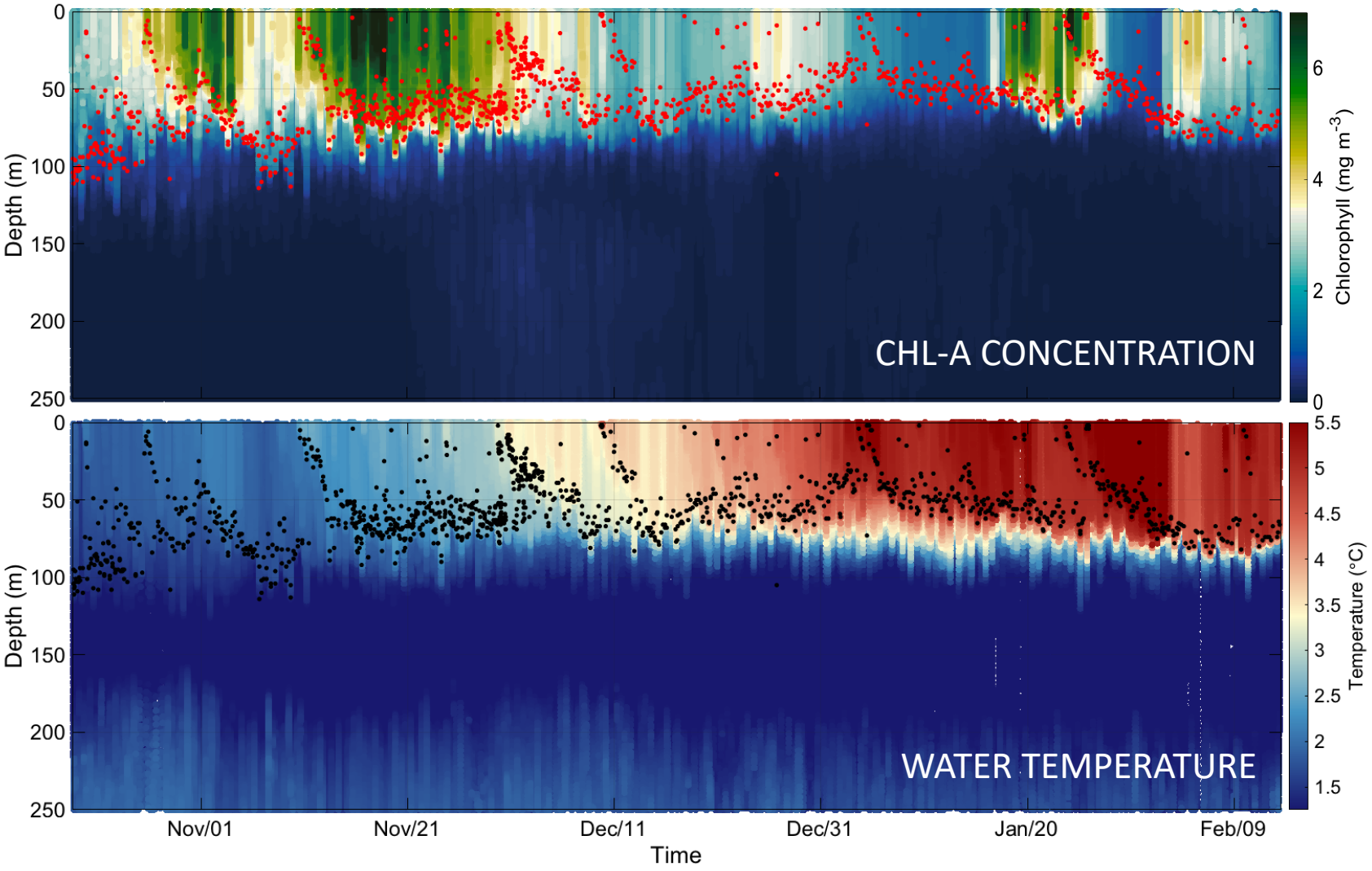
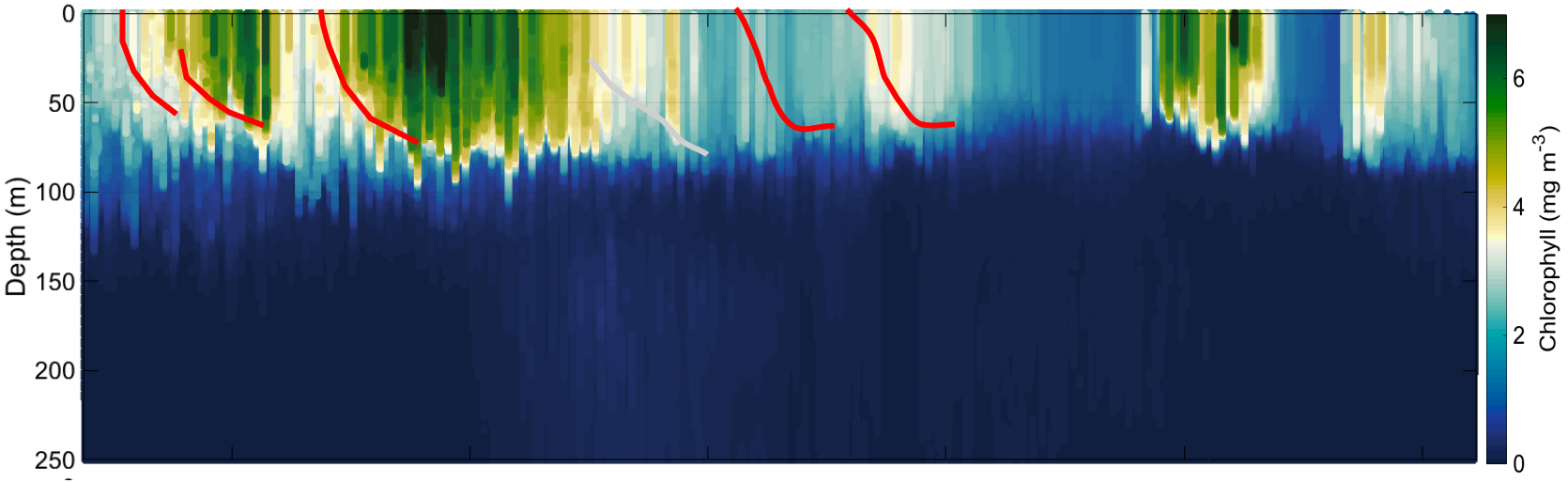


Thermal stratification drives MLD

Increased phytoplankton with thermal stratification events



Phytoplankton net growth



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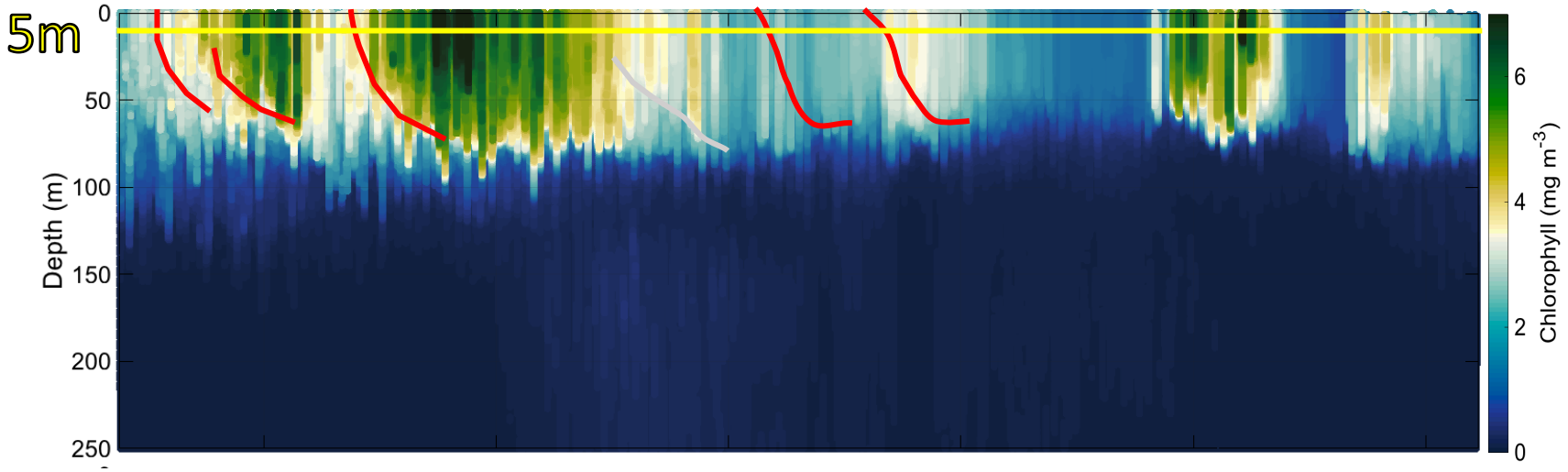
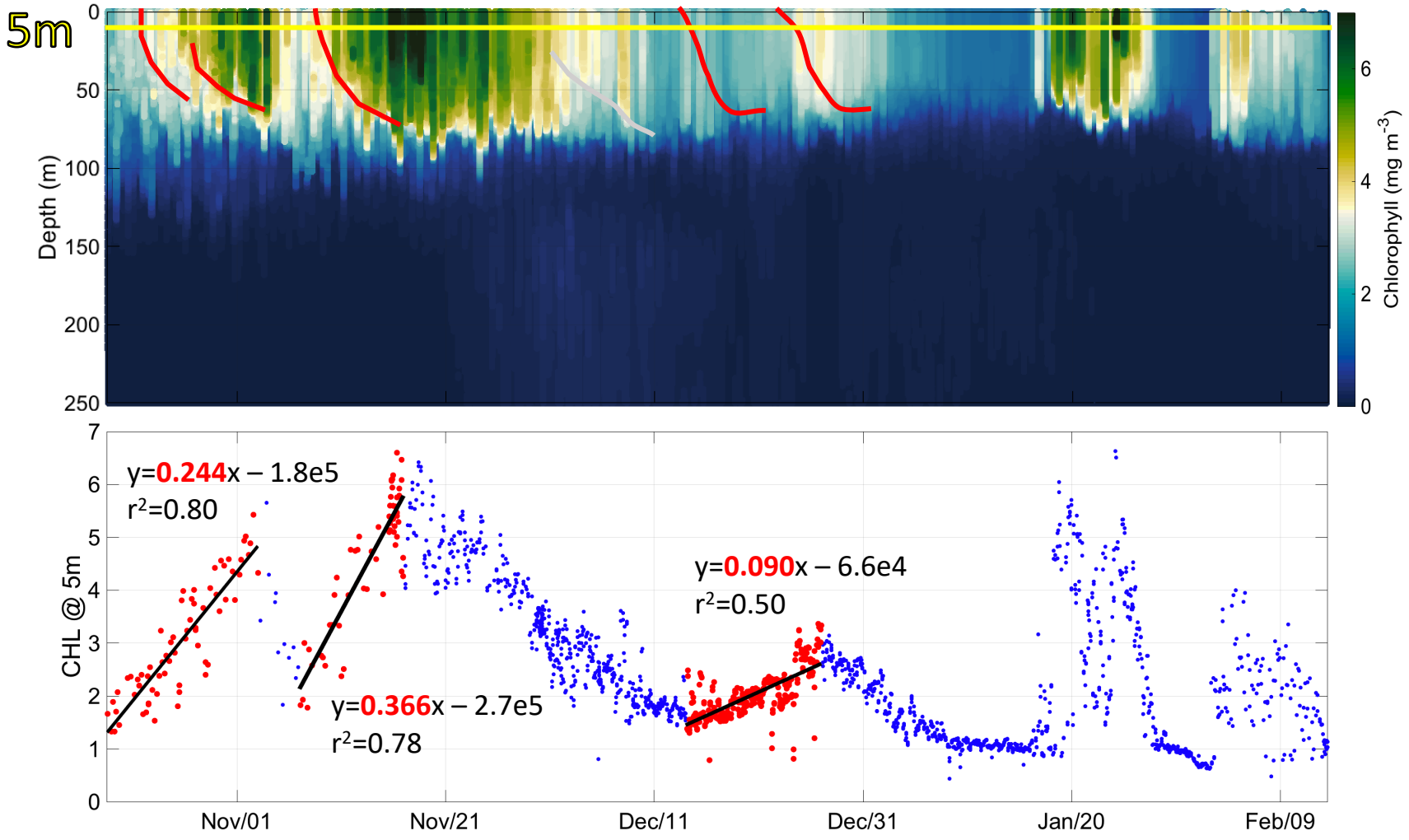
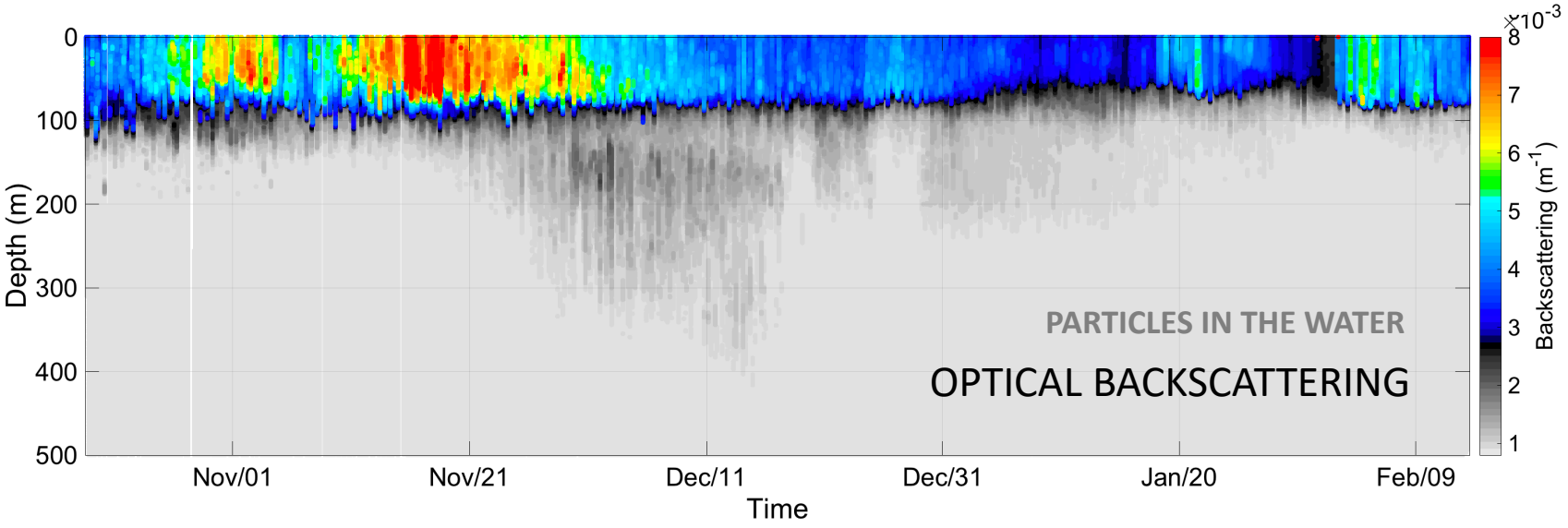


Phytoplankton net growth

Increased phytoplankton growth during thermal stratification events



Biogeochemical data from GOCART gliders



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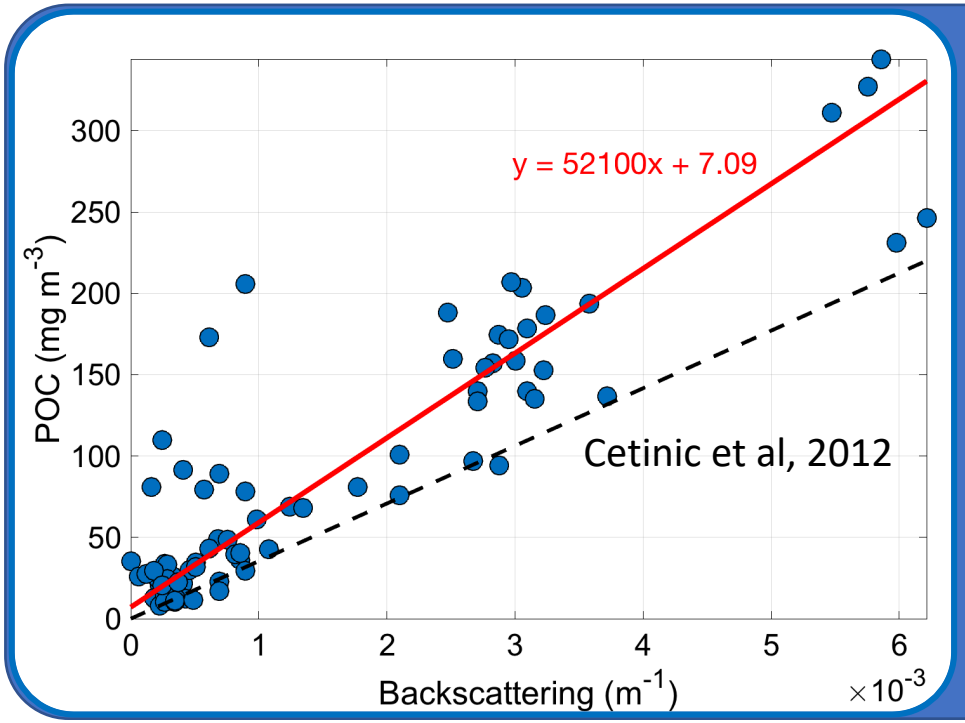
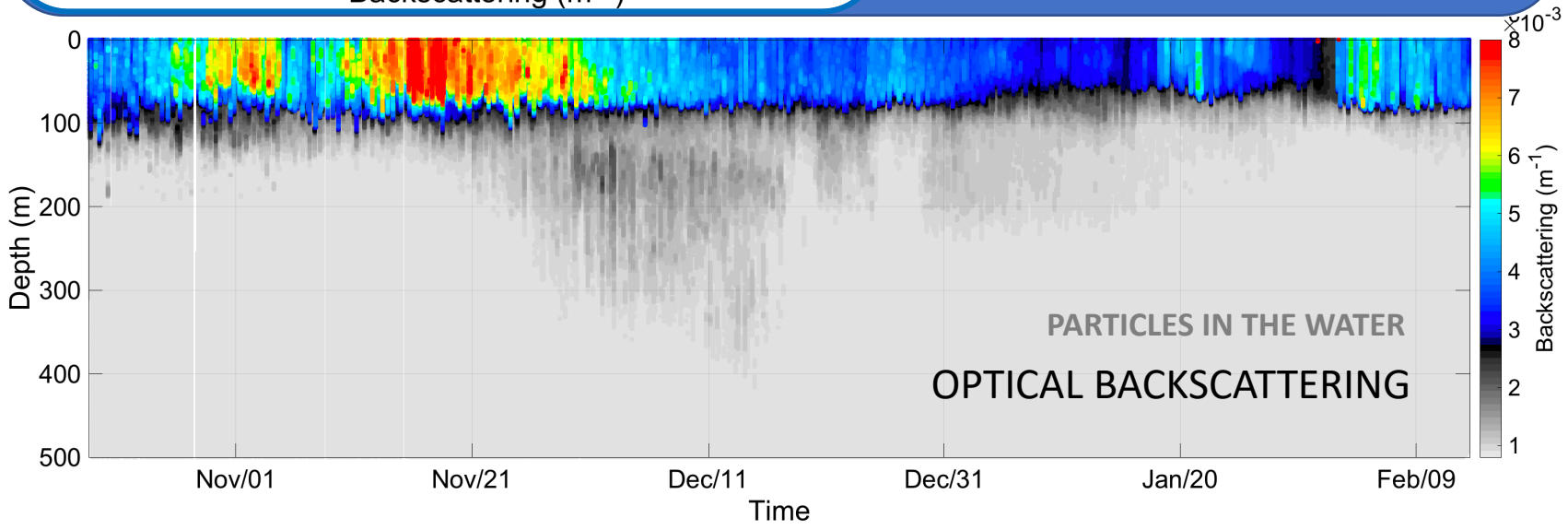


Converting Optical Backscattering to Particulate Organic Carbon, POC

in situ POC samples vs the ECO Triplet bbp 700 nm on the rosette

Cetinić *et al.*, 2012
(North Atlantic)
Ratio: 37,671 ± 1,858

GOCART South Georgia
(South Atlantic)
Ratio: 52,100



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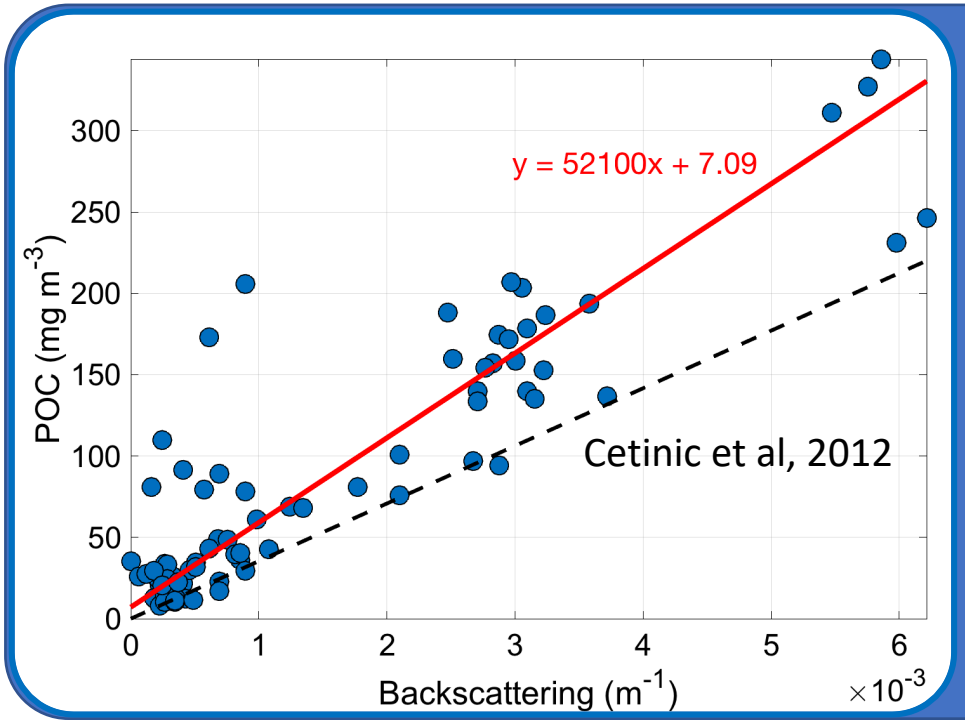

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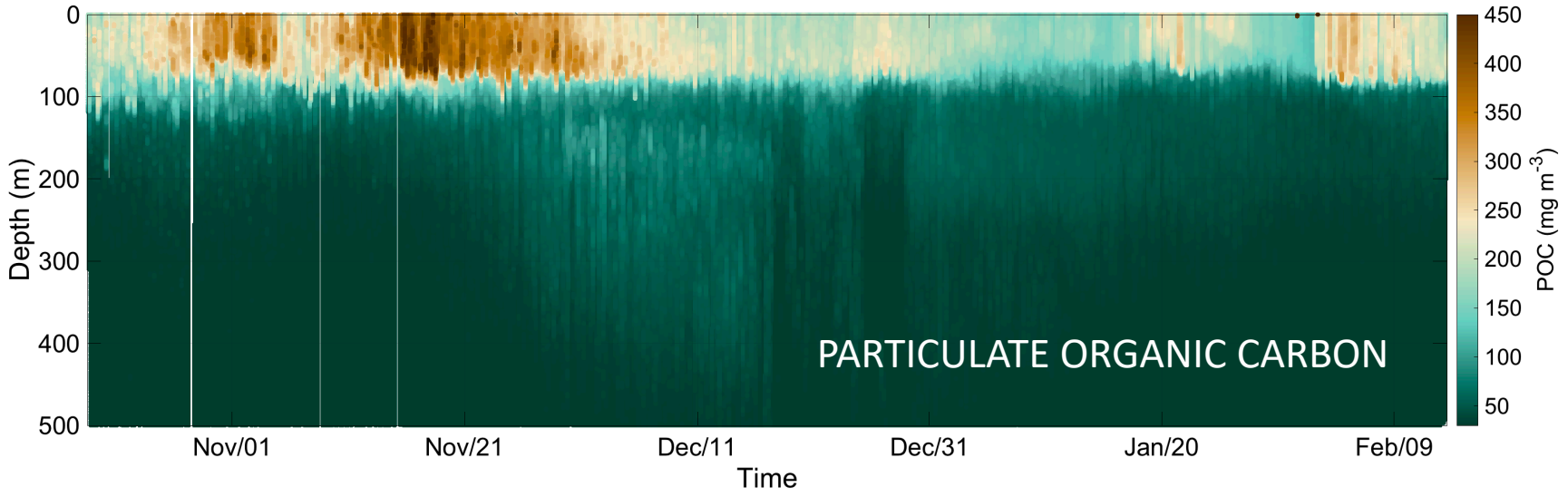

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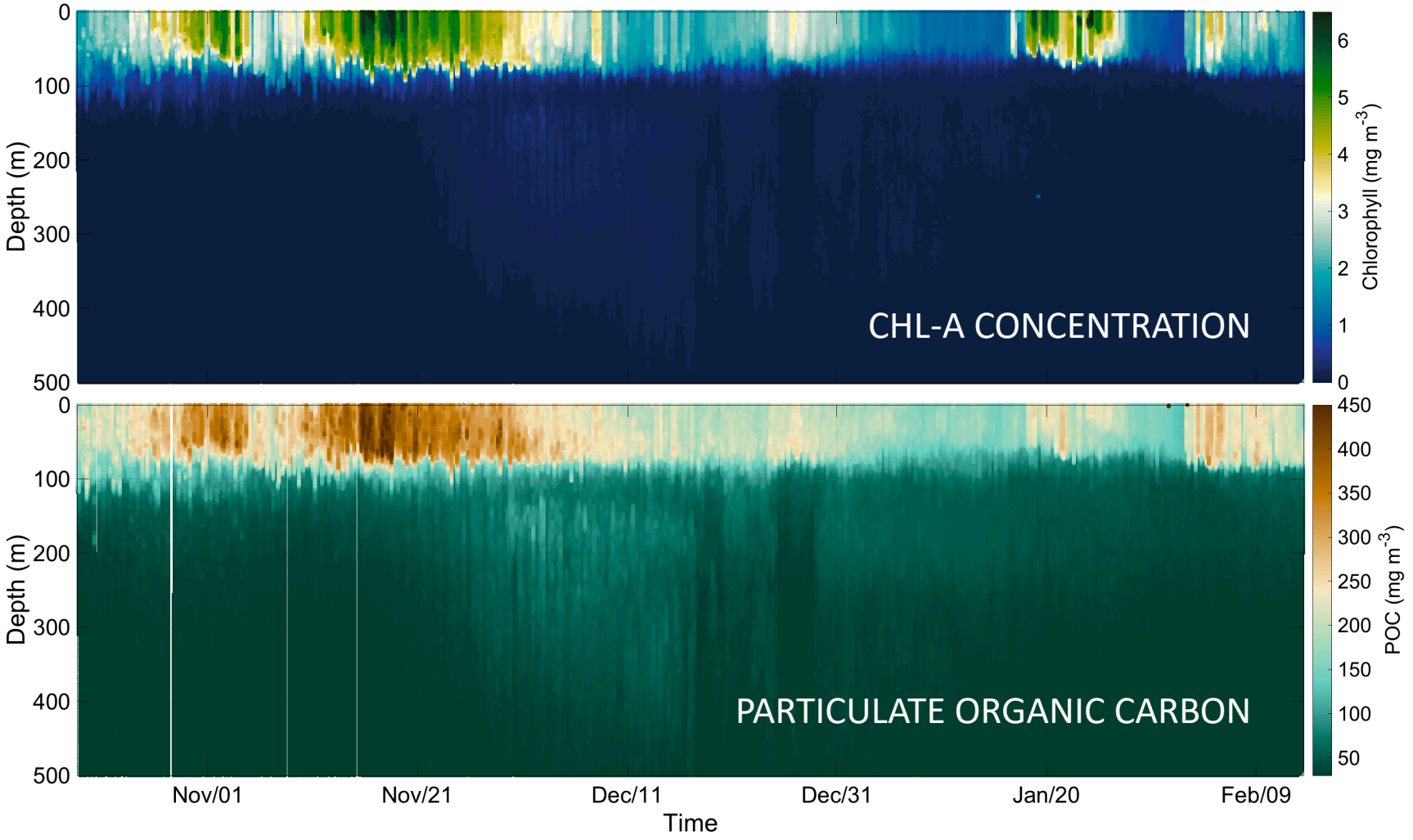

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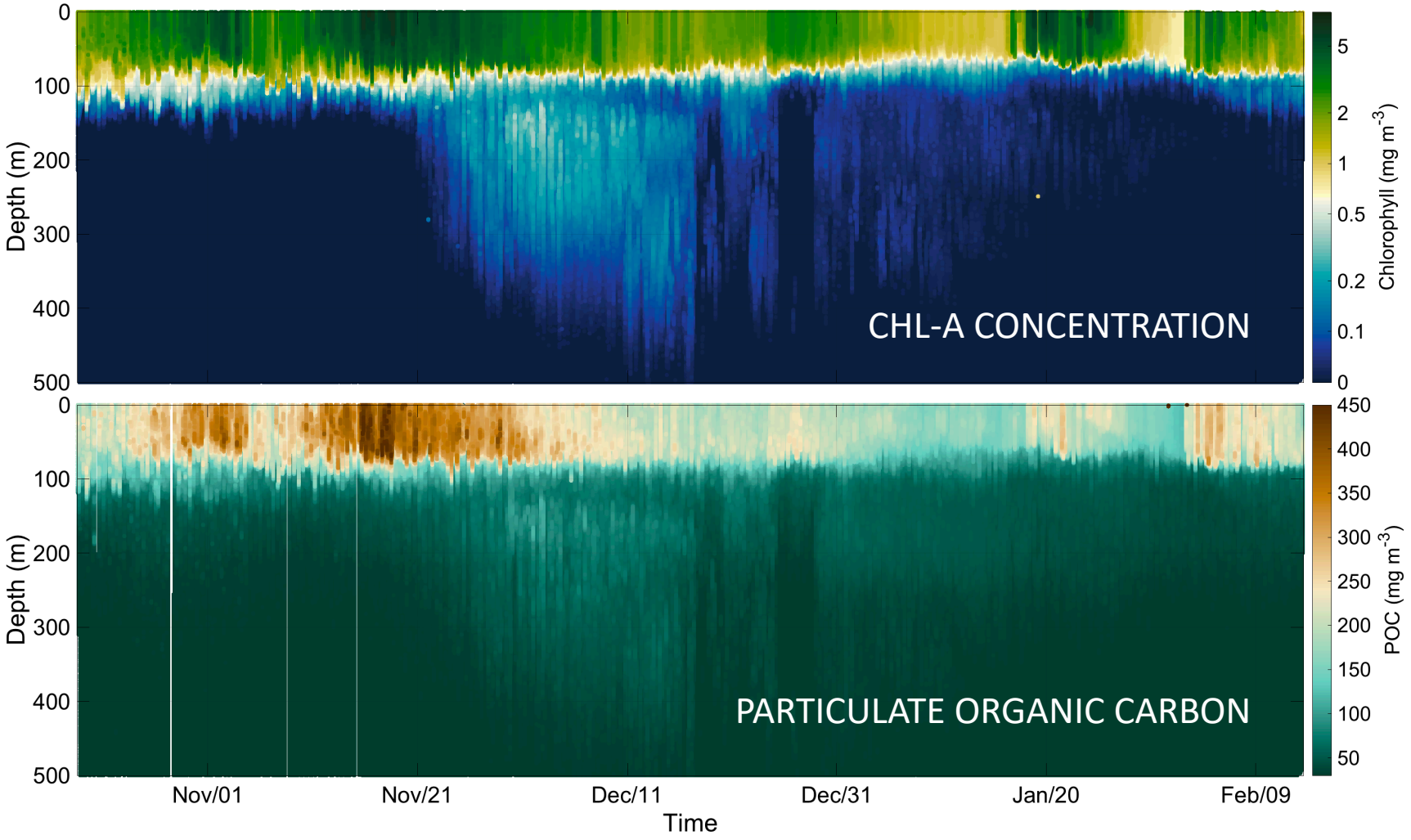
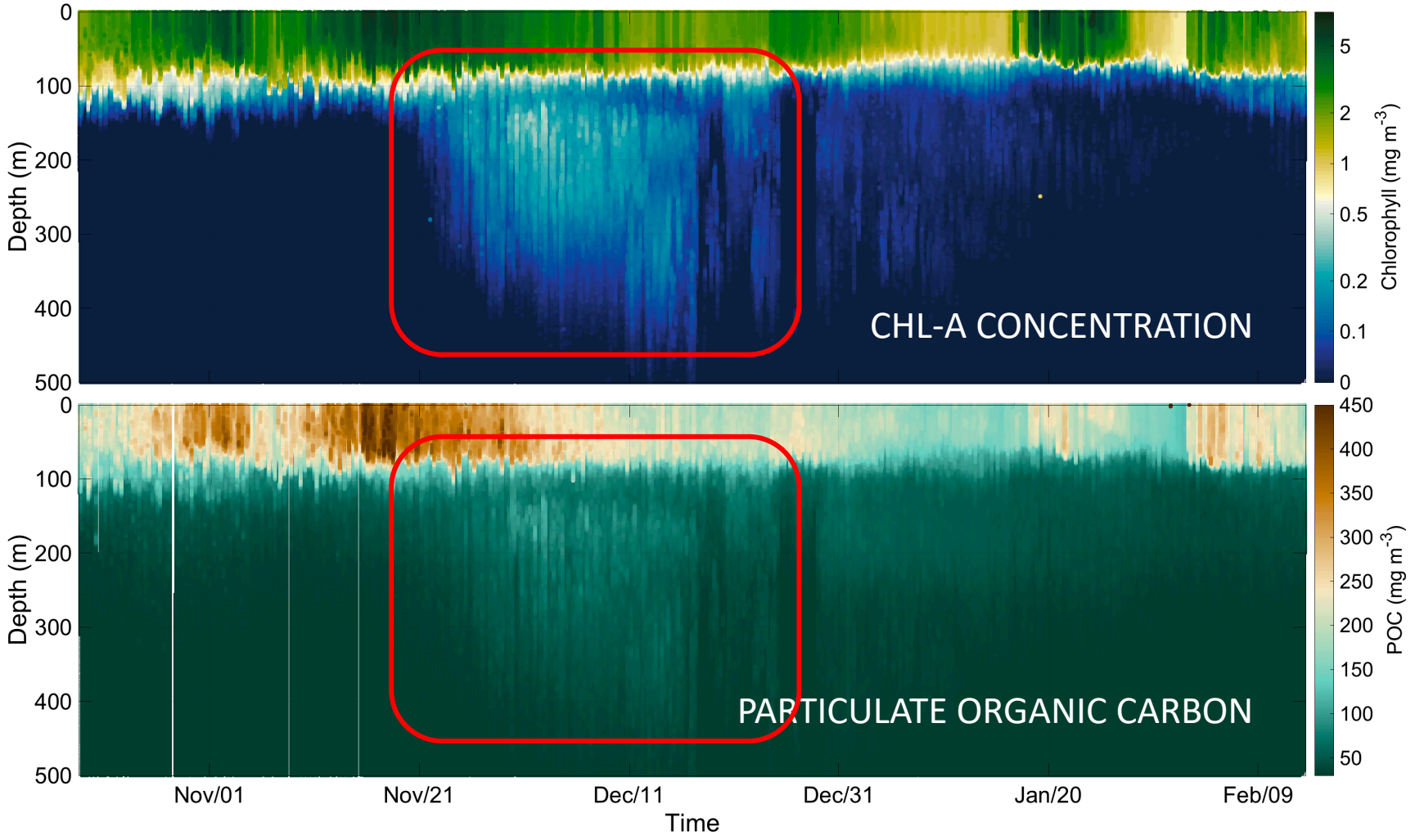
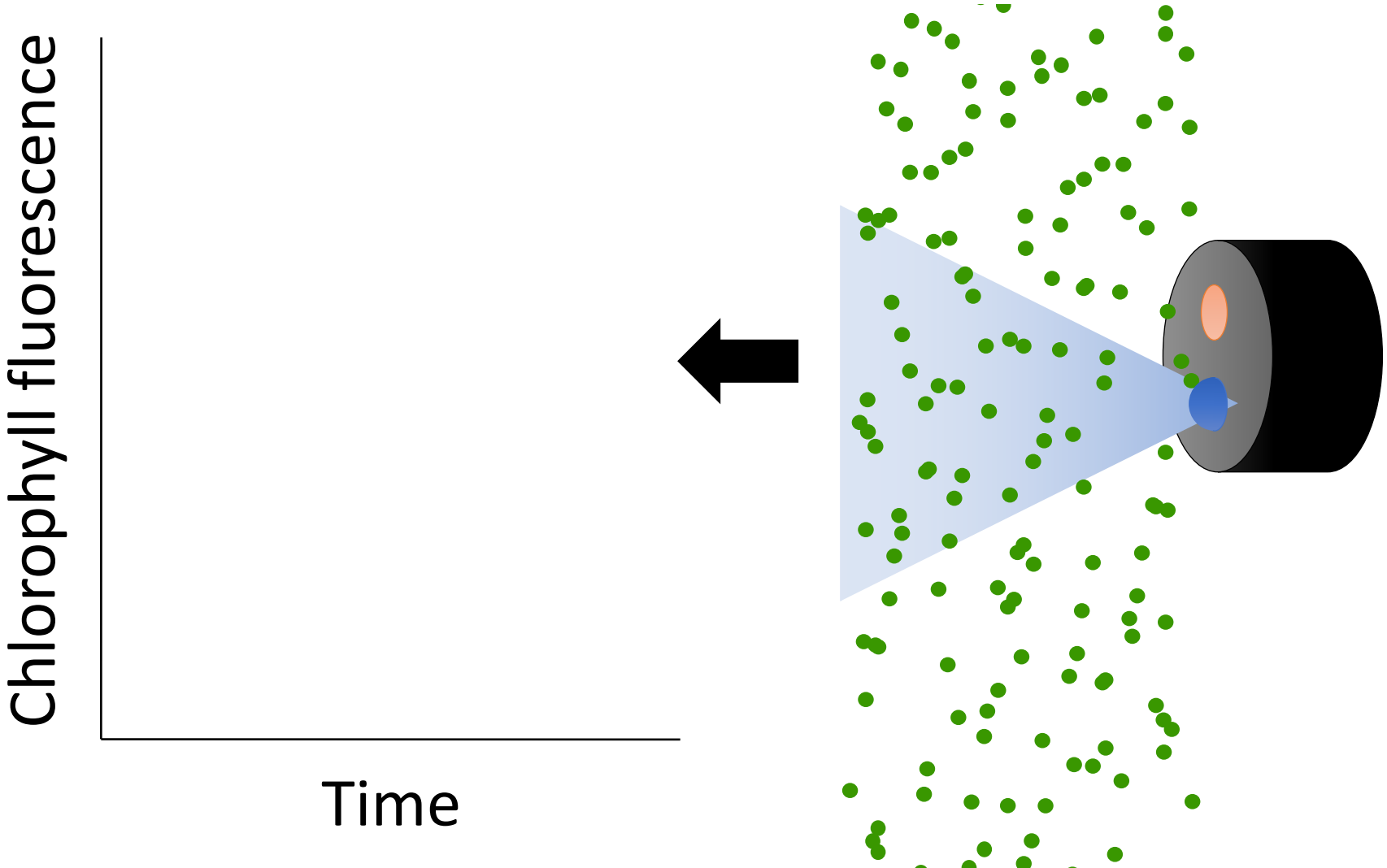


Biogeochemical data from GOCART gliders

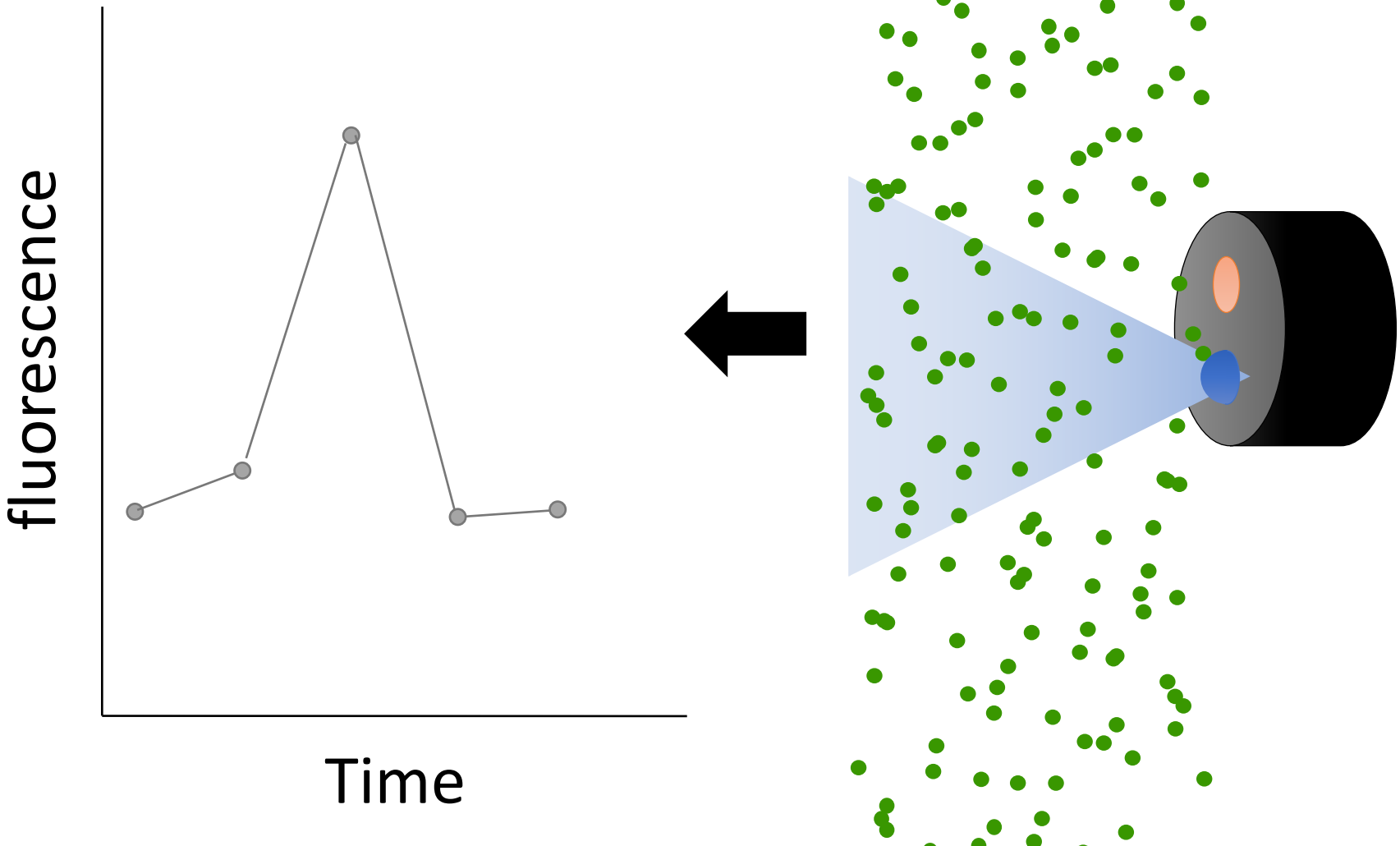
Phytoplankton/carbon sinking below the MLD



Using high resolution optical proxies to evaluate Particulate Organic Carbon concentration and flux



Large (>150µm) particles cause “spikes” in optical backscatter



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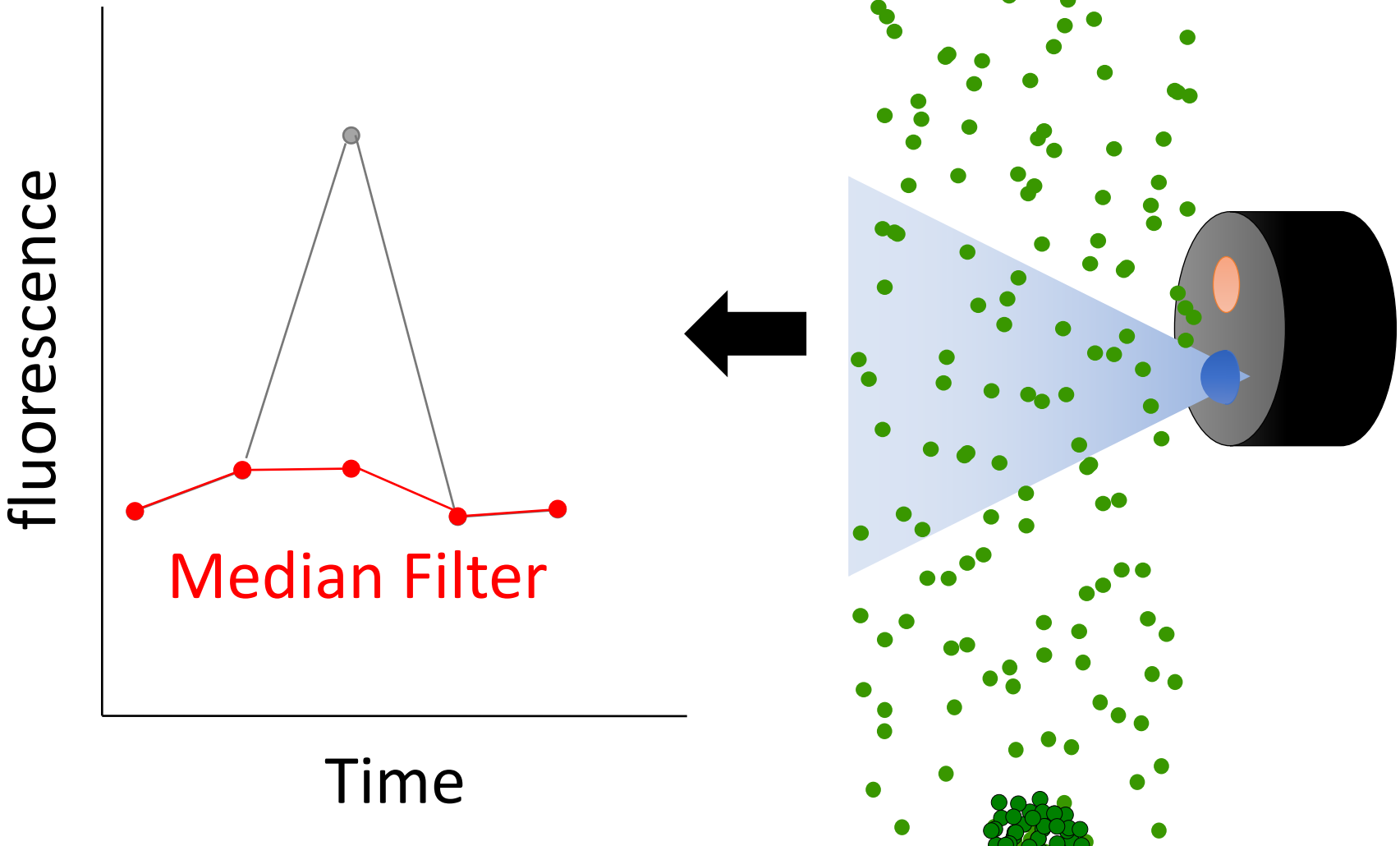

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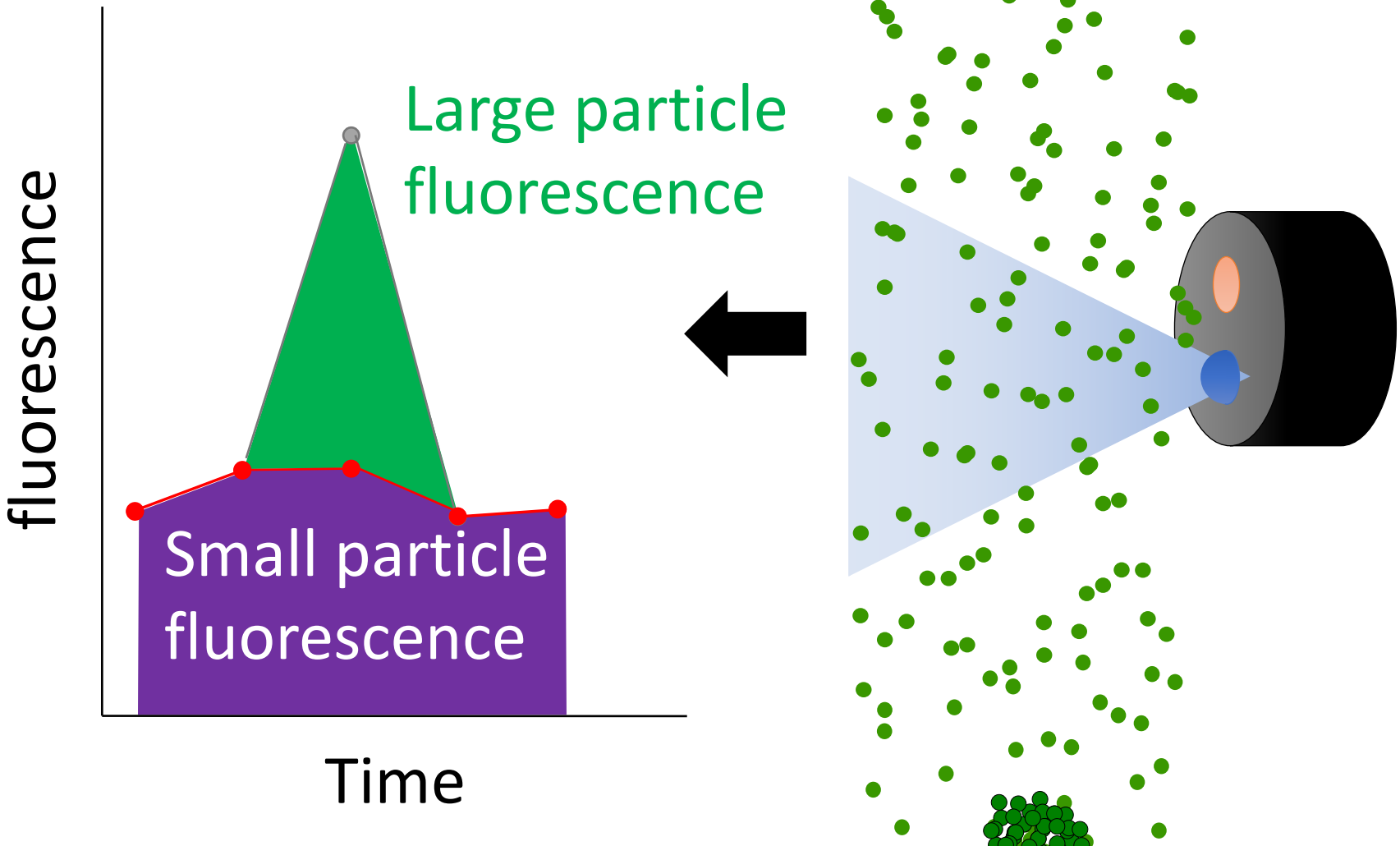

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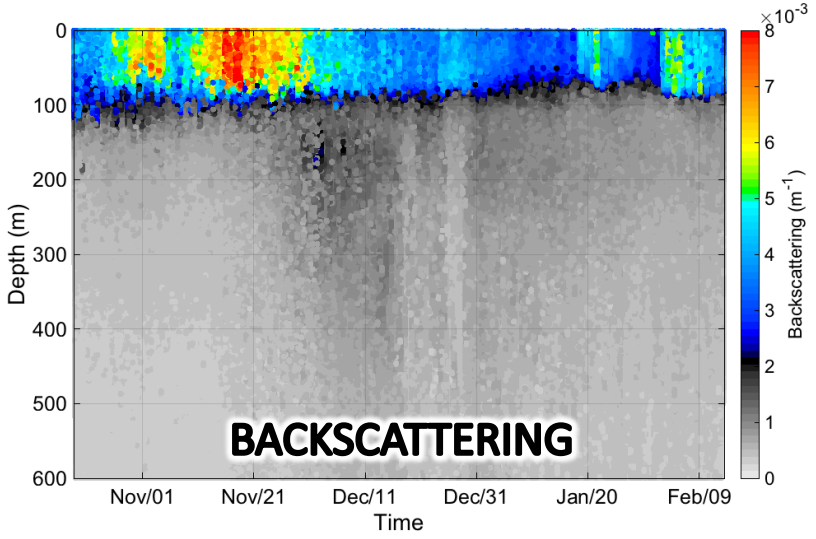

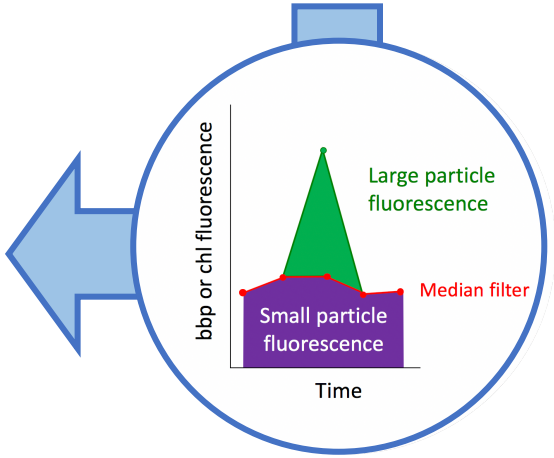

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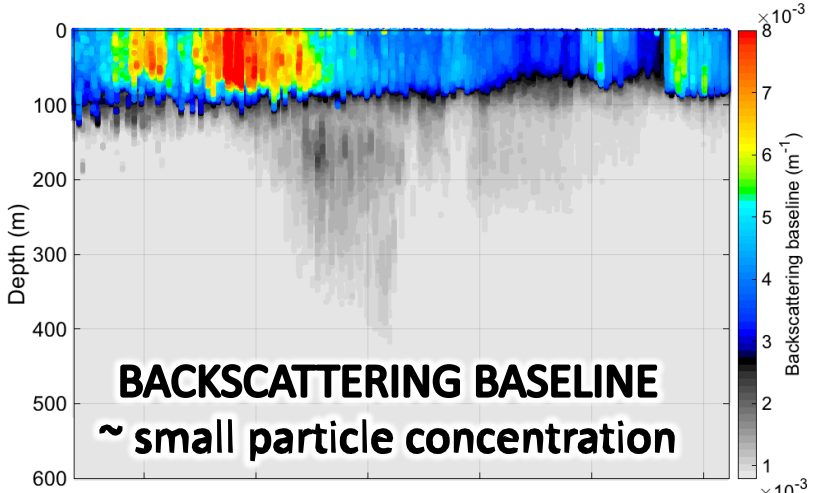

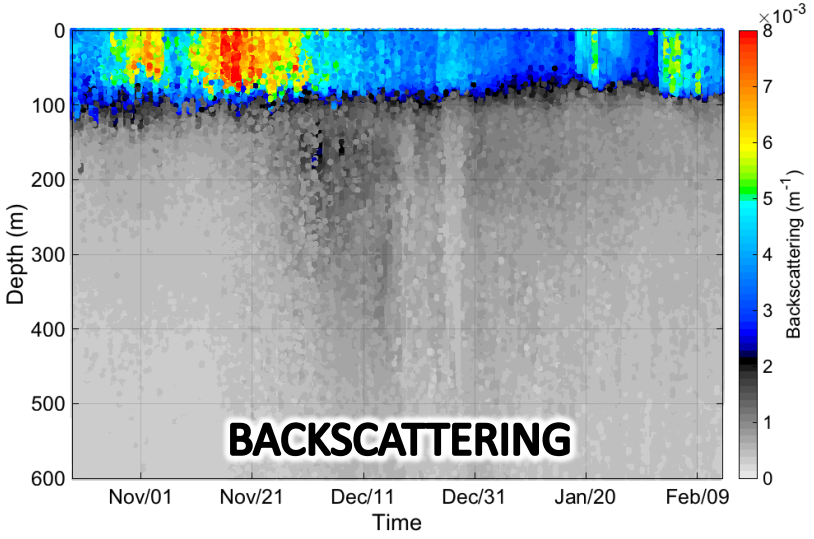

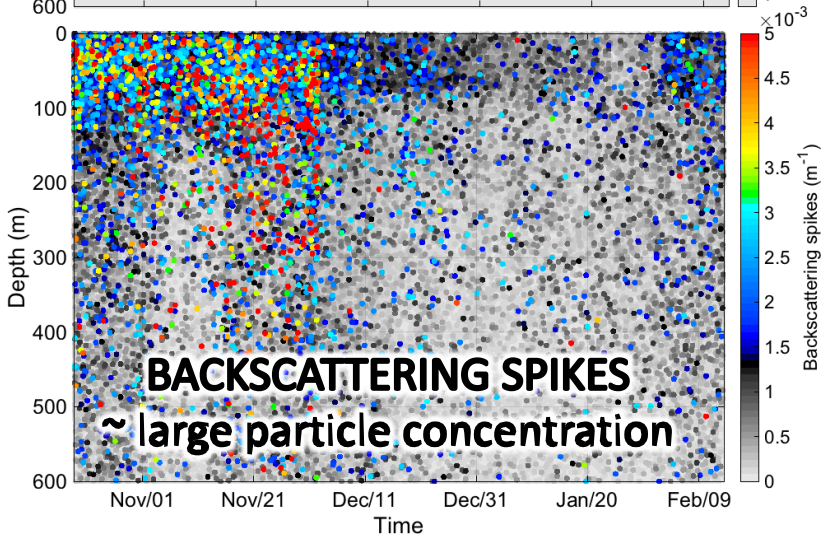

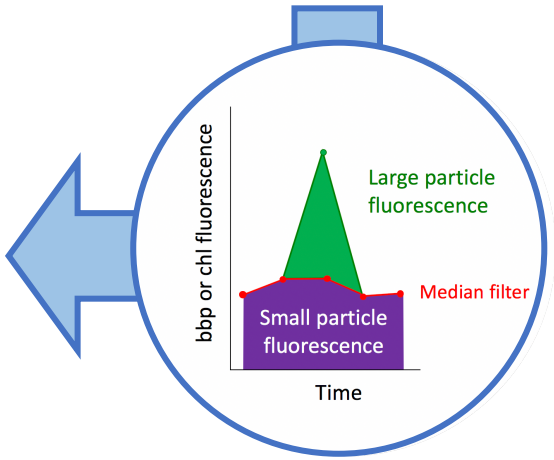

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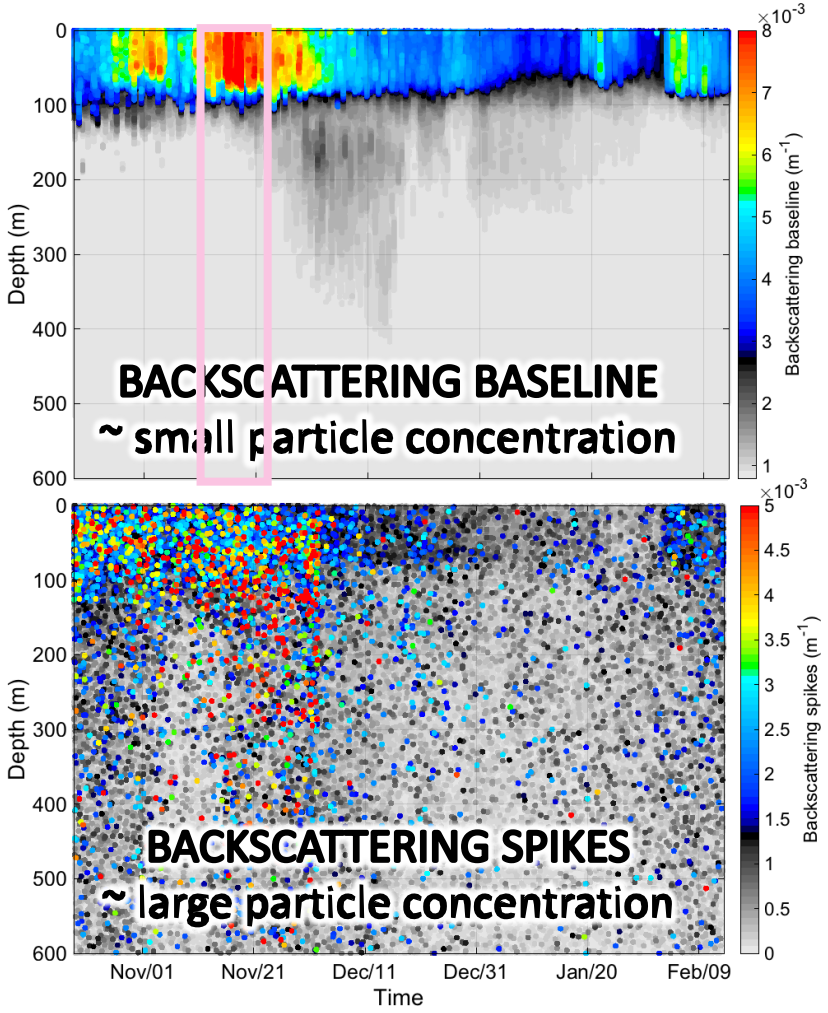

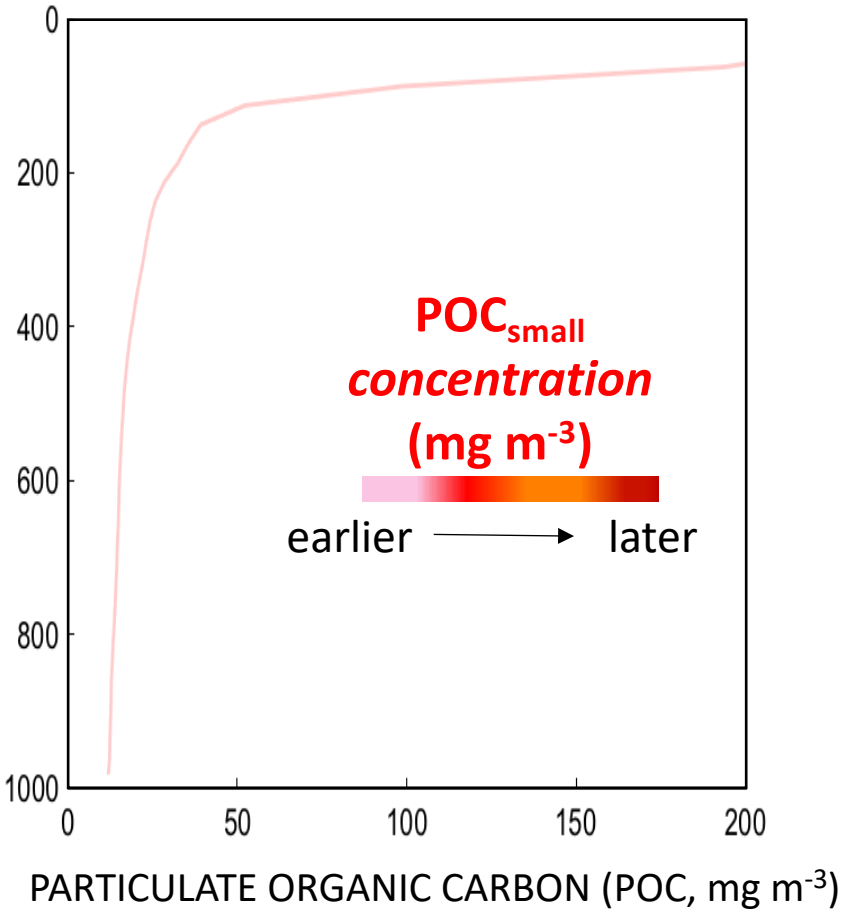

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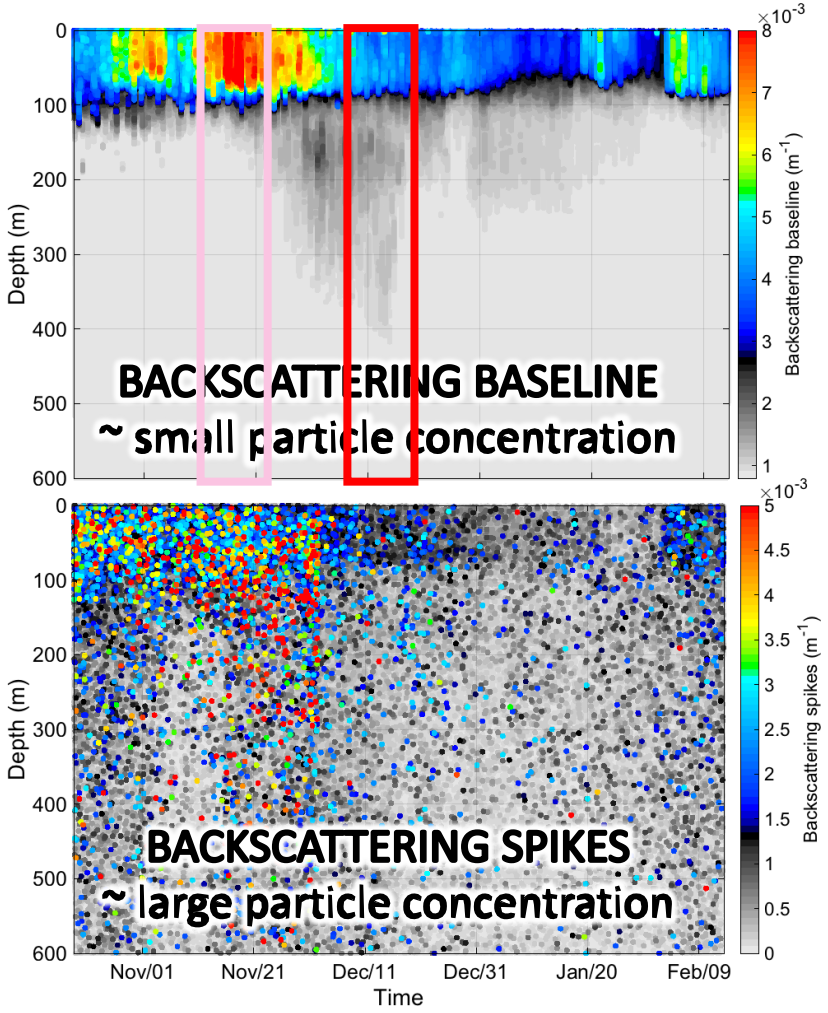

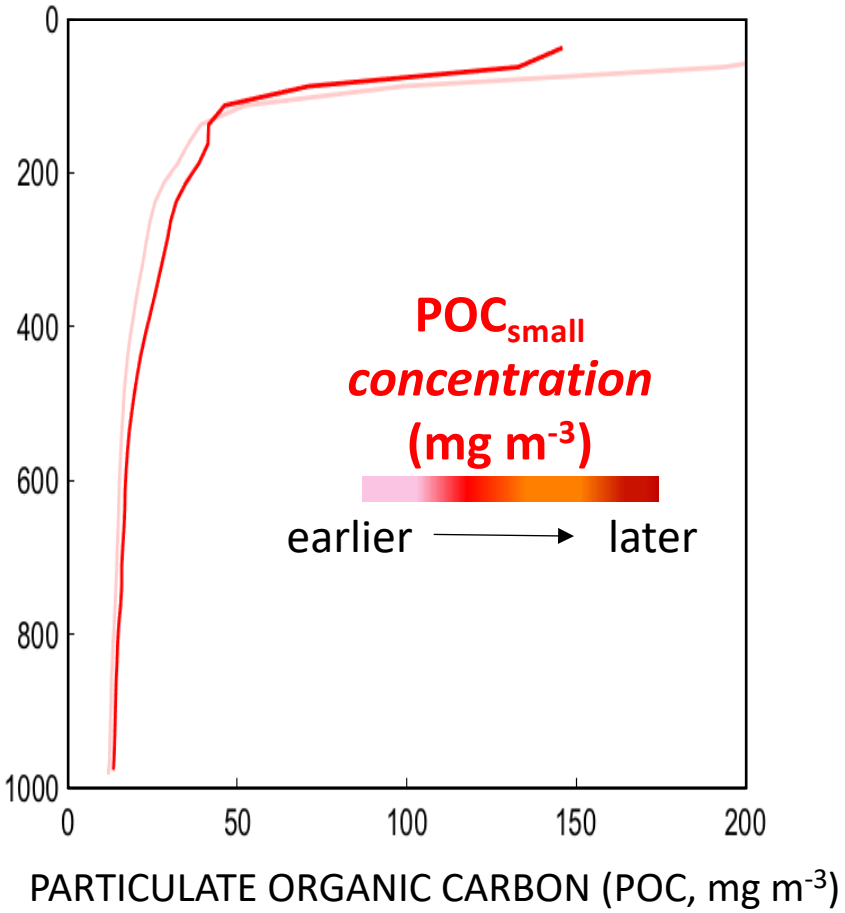

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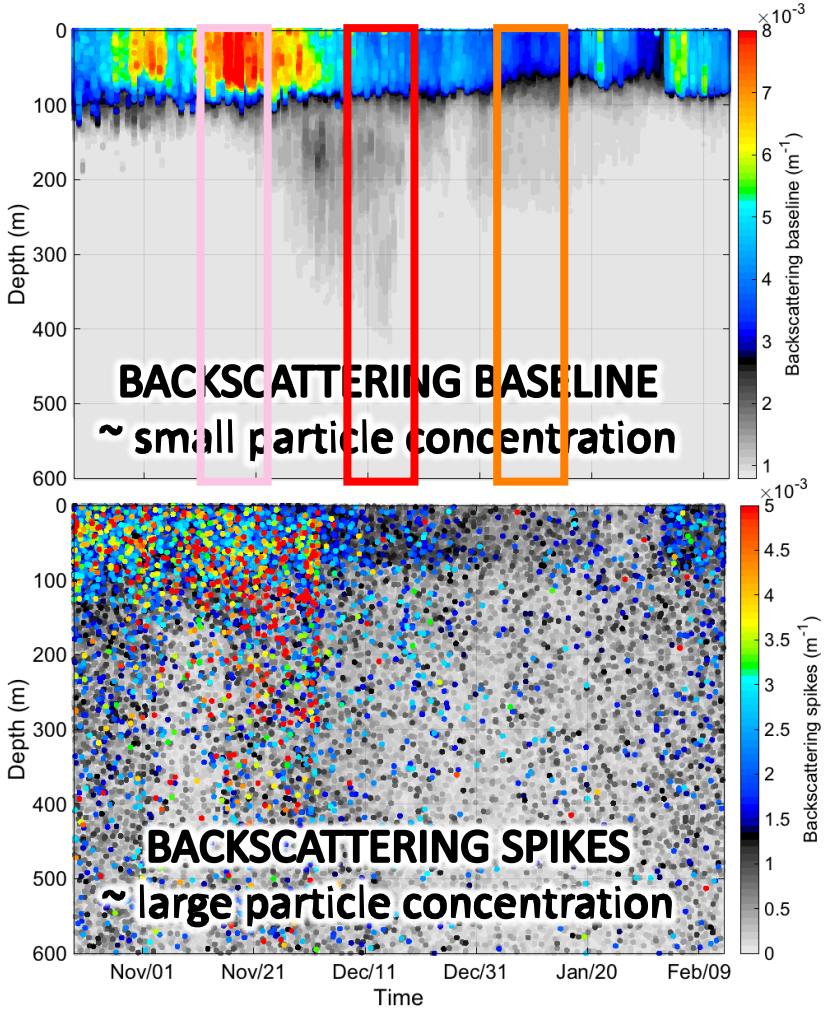

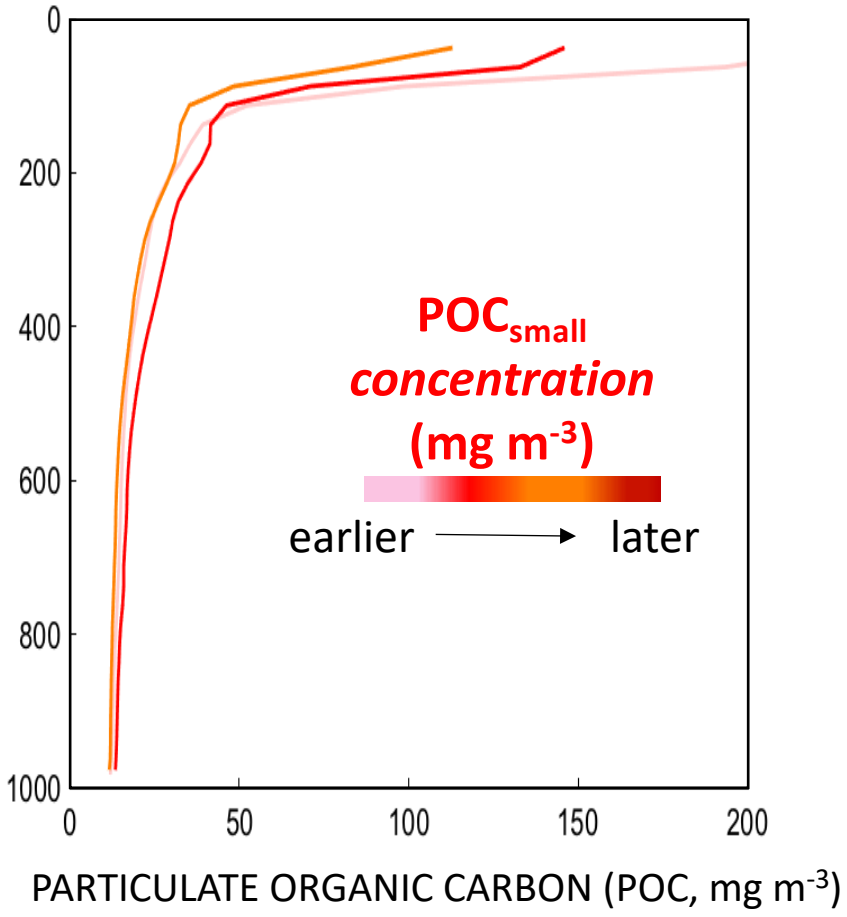

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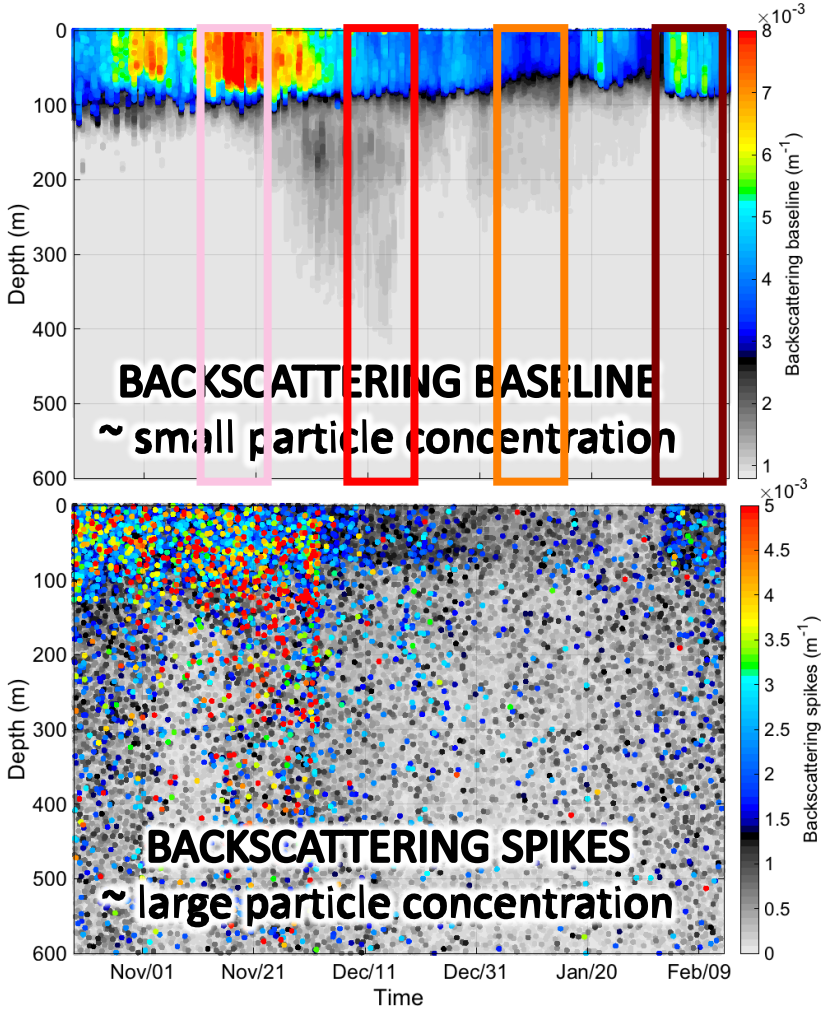
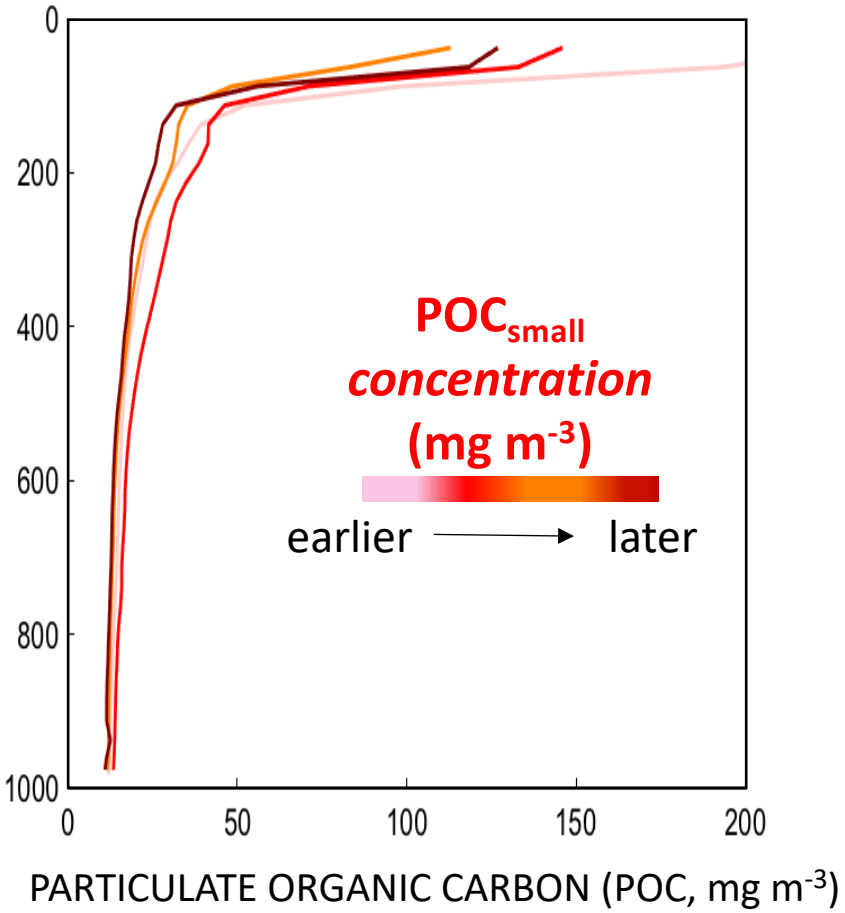
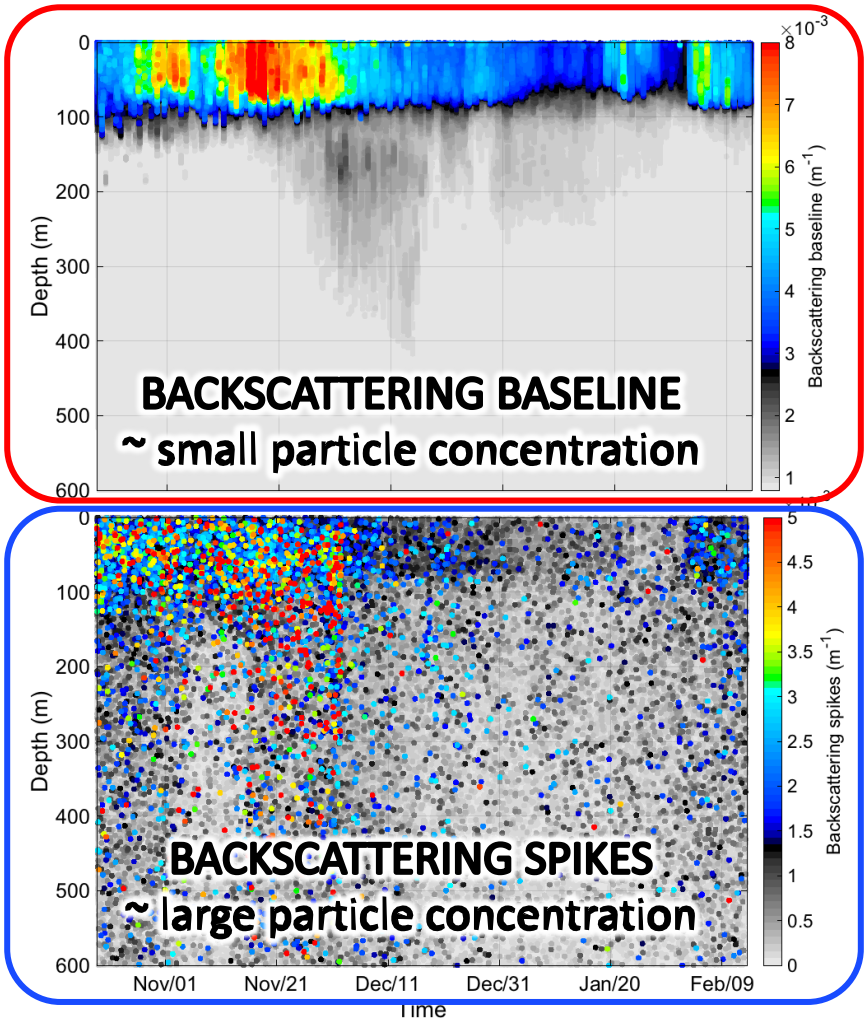
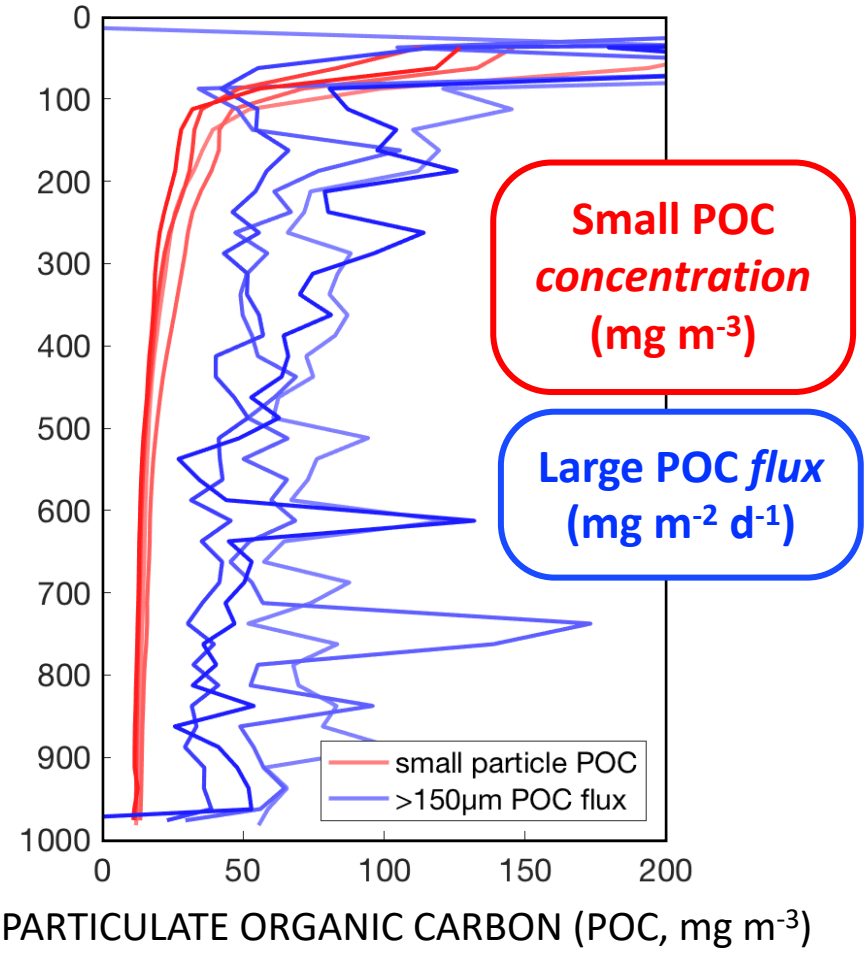




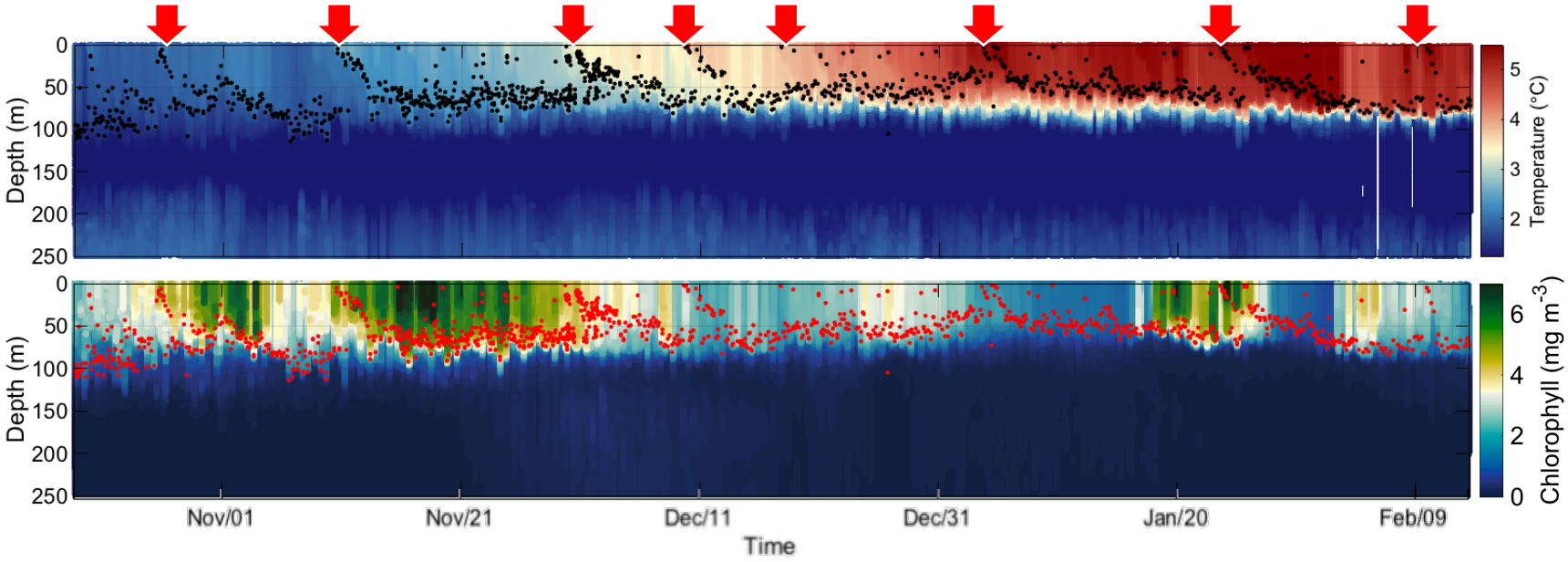
Using high resolution optical proxies: reduce the uncertainties regarding the temporal variability in carbon flux





Take home message

- Thermal stratification events fuel blooms by shoaling of the MLD – possible drivers: solar irradiance, winds



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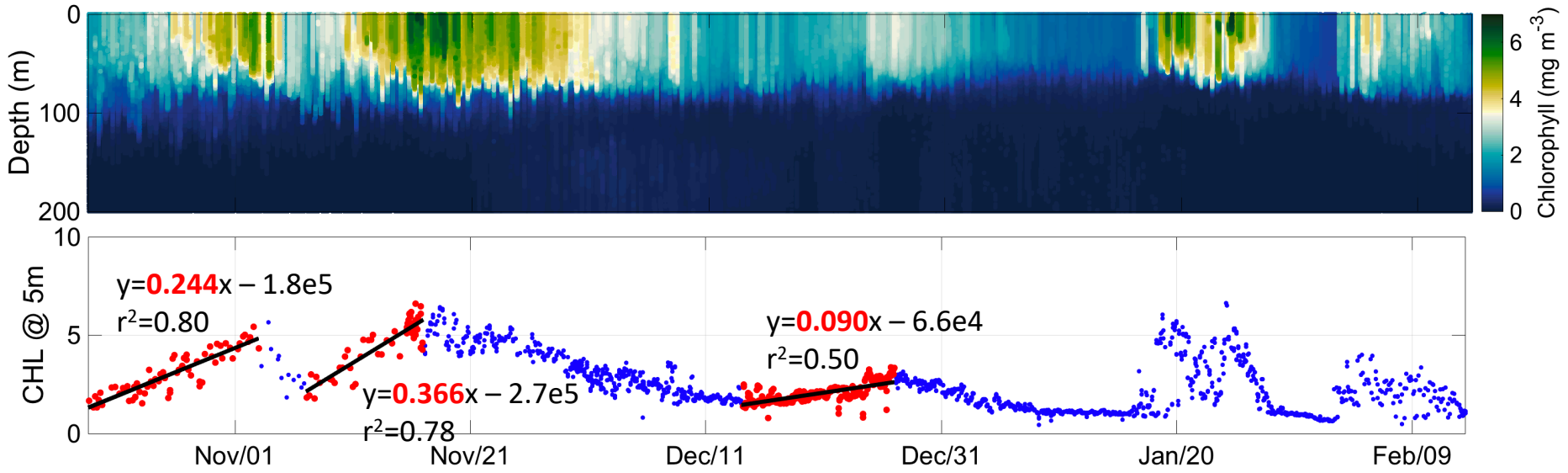
- Thermal stratification events fuel blooms by shoaling of the MLD – possible drivers: solar irradiance, winds
- Low net growth rates observed for each event
- Likely nutrient limitation (?) during some events



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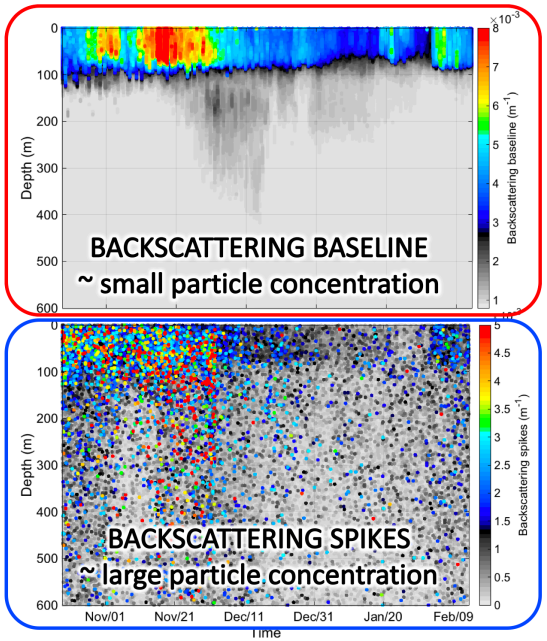

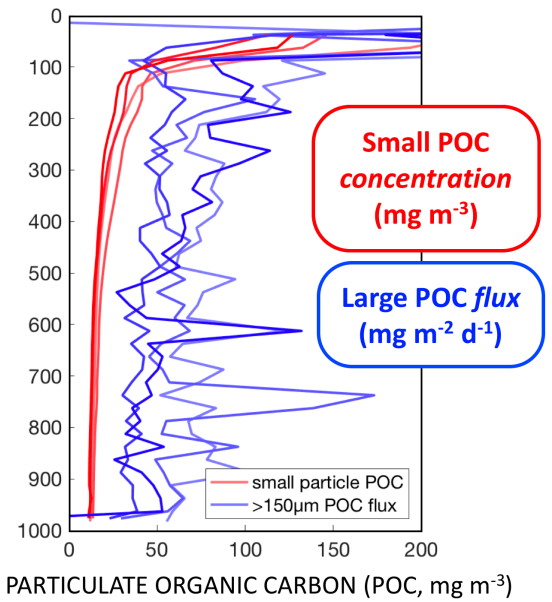

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Future work

- Drivers/controls of stratification events → phytoplankton
- Validate estimates with cruise data
- Quantify links between upper ocean dynamics and carbon export
- **Lots of unused biogeochemical data collection in this room … collaborate!**

Bring together multiple sensors characterise particles in the water

CUSTARD

BIARRITZ
Bridging International Activity and Related Research Into the Twilight Zone

- Go beyond particle abundance
- Need to understand what's in the water
- The LISST glider (first open ocean deployment – using LISST to look at non-sediment particles – link to carbon flux)

Red Camera Frame profiler (ship):

- ECO Triplet (chl, bbp)
- LISST Holo
- P-Cam

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GOCART goals

Understand the magnitude and significance of temporal variability in organic C flux and remineralisation in the ocean, and its implications for understanding ocean C storage

- Quantify the variability in flux of particulate organic carbon through the TZ and its RLS on daily to subseasonal timescales
- Determine the characteristics and significance of episodic pulses of flux
- Investigate potential drivers of episodic flux pulses
- Quantify the effect of temporal variability on uncertainty in RLS estimates
- Establish and test a new empirical parameterisation of RLS that incorporates temporal variability

KEY CONCEPT: TEMPORAL VARIABILITY