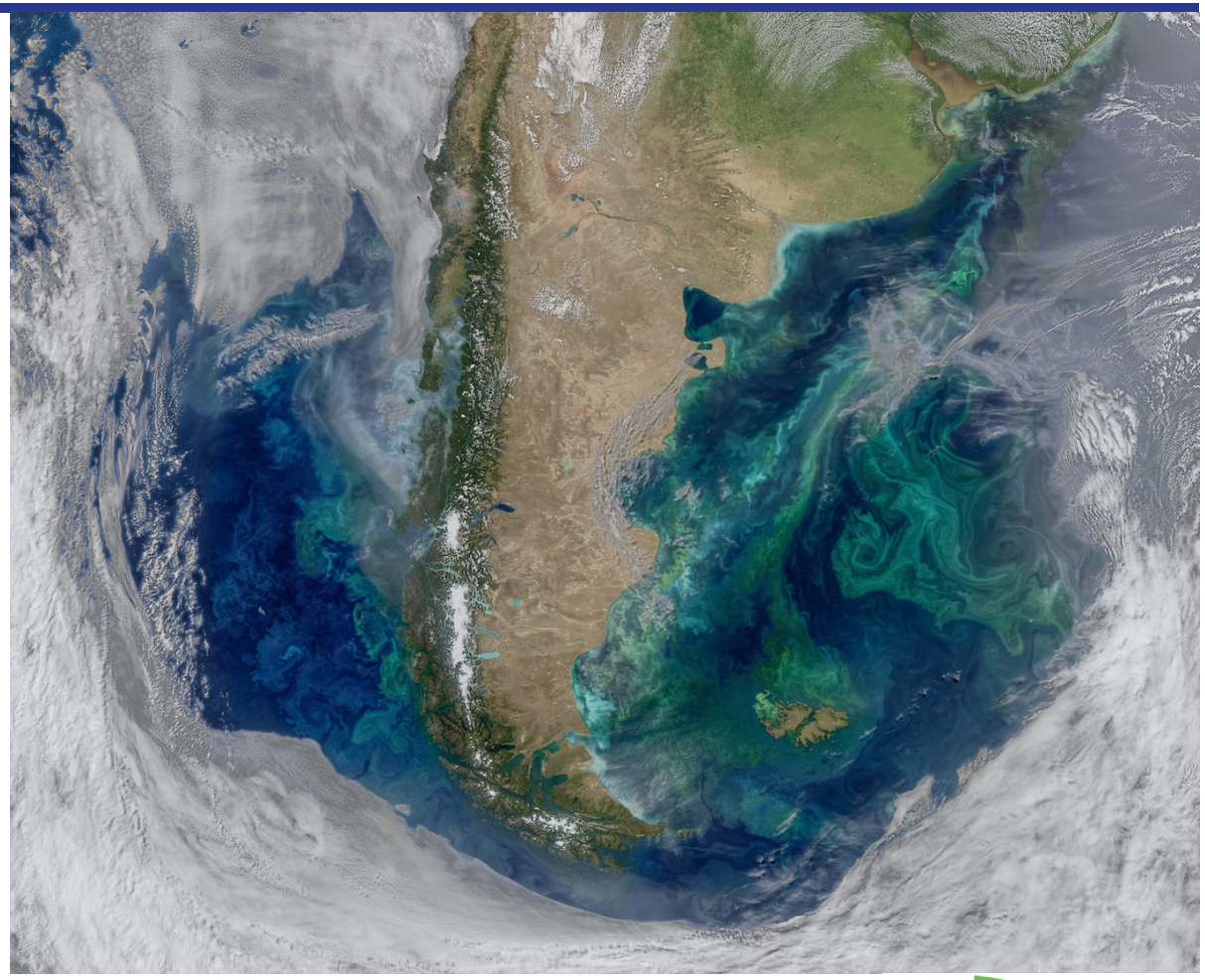
Ocean carbon pools and fluxes
From observations to process understanding



Giorgio Dall'Olmo, Marie-Fanny Racault,
Francesco Nencioli, Shubha Sathyendranath
Stefano Ciavatta, Jozef Skakala, Lee de Mora

PML | Plymouth Marine Laboratory

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Biological Carbon Pump

What is it?

- Transfers organic C from the surface to the abyss
- Surface + Sub-surface components

Major planetary flux of C

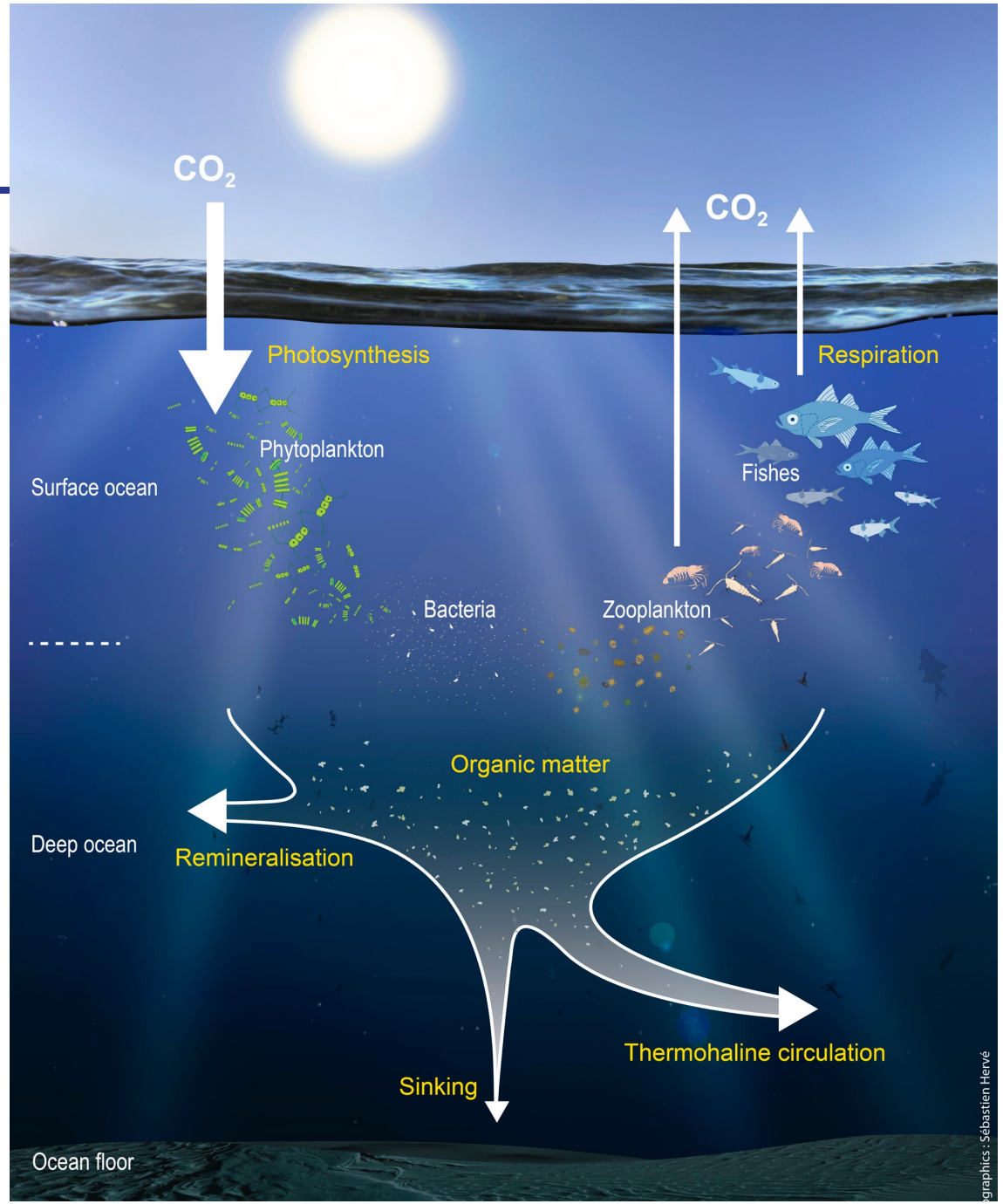
- 5 – 12 PgC/yr
- Keeps atm CO_2 ~200 ppm lower
- Sustains deep-water ecosystems (fisheries)

Uncertainties

- Current magnitude vs. net oceanic C uptake?
- Driving processes?
- Steady state?
- How will it change in the future?

Sources of uncertainties

- Severe undersampling



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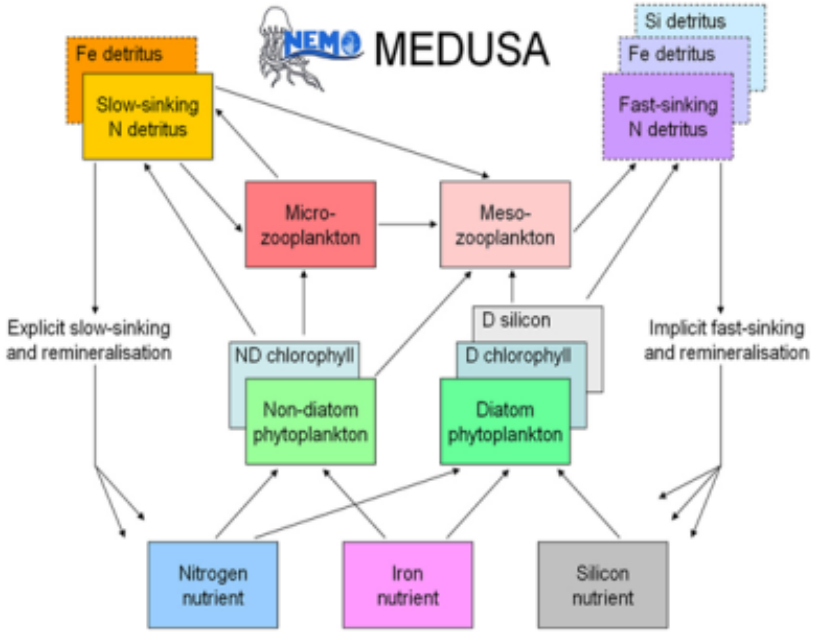
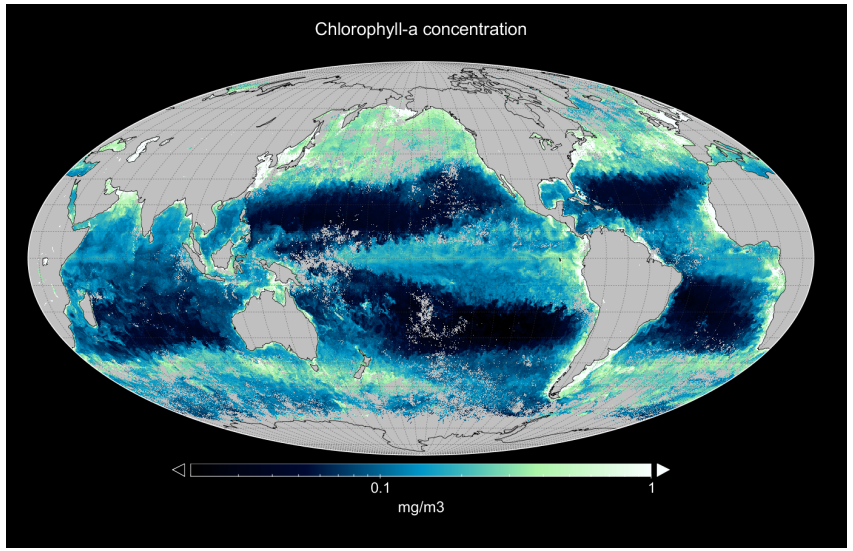
Objective and Tools

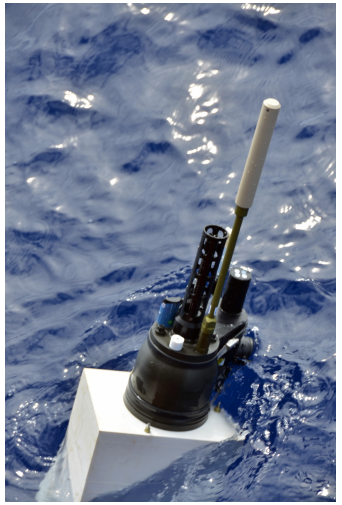
Objective: Mechanistic understanding and quantification of BCP

Tools:

- **Satellite data:** Ocean-Colour Radiometry
- **In-situ data:** Biogeochemical-Argo floats
- **Models:** NEMO-MEDUSA
- **Data assimilation:** EnKF







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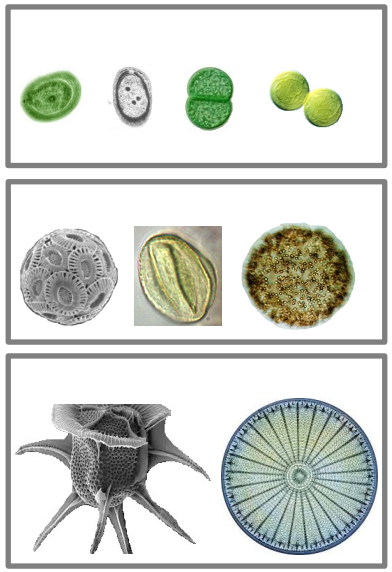
Satellite Ocean-Colour Data: Carbon pools

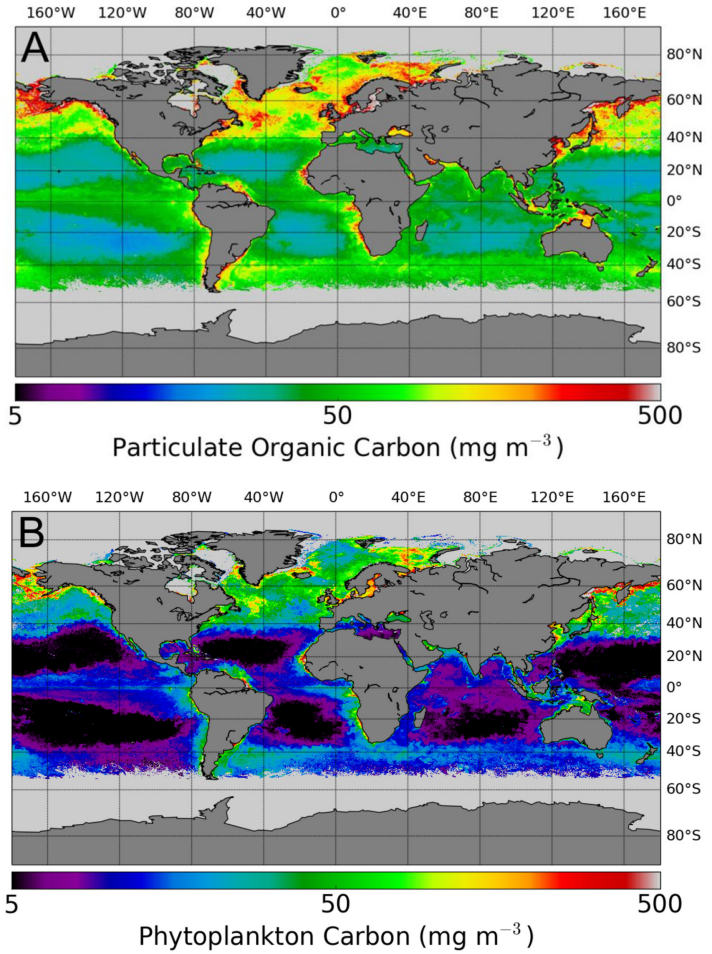
Ocean-Colour Climate Change Initiative:

- ESA-funded merged product [Sathyendranath et al., 2017]
- Decadal scale: 1998-2018
- Error characterised (needed by DA) [Brewin et al., 2013]

Carbon pools:

- Particulate Organic Carbon [Evers-King et al., 2017]
- Phytoplankton carbon [Martinez-Vicente et al., 2017]
- Carbon from Phytoplankton Functional Types





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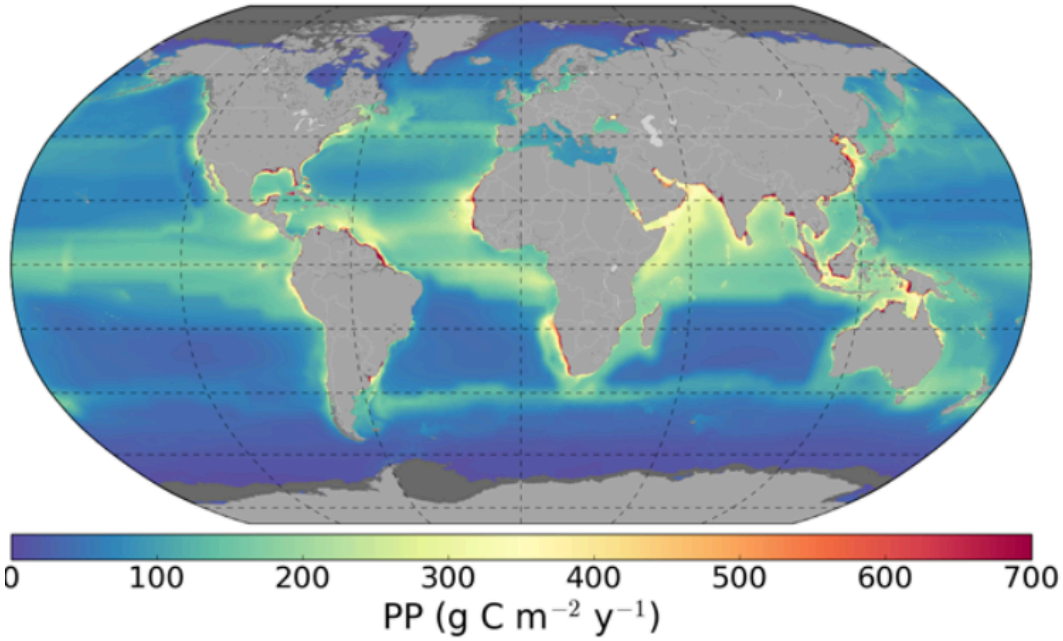
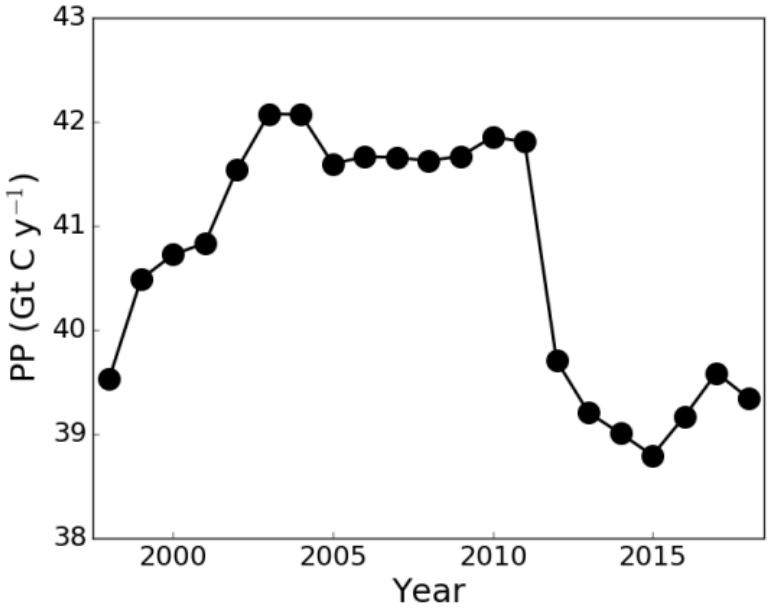
Satellite Ocean-Colour Data: Carbon fluxes

Net primary production: 1998-2018 (Kulk et al., 2020)





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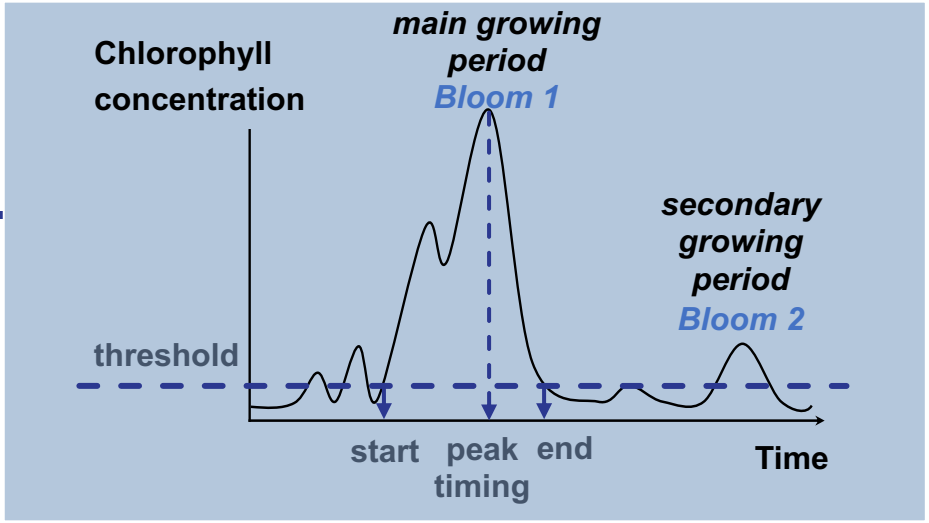
Phytoplankton phenology from space

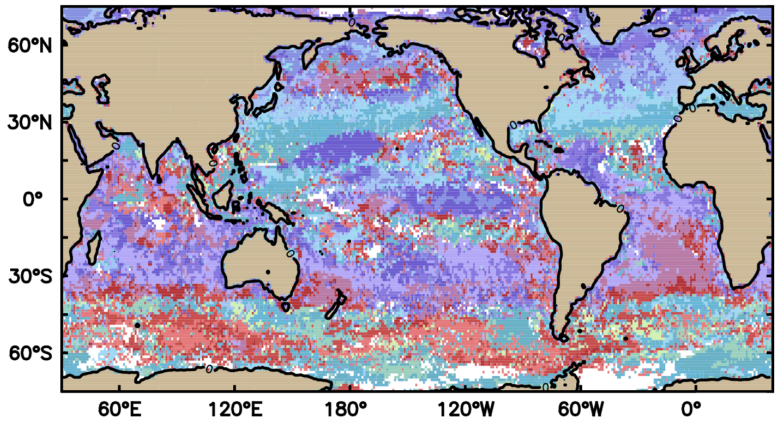


Production and analyses of datasets of phytoplankton phenology metrics using new algorithm and new version of ESA OC-CCI Chl-a

Climate indicators to assess biological changes:

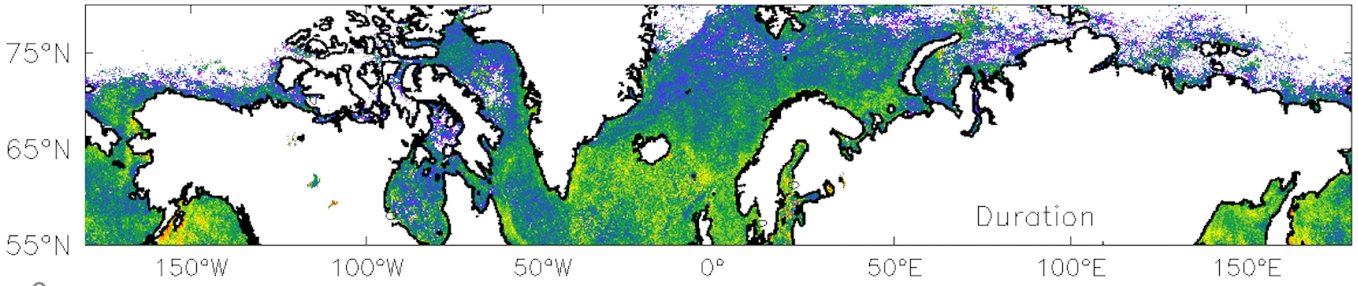
Global phytoplankton phenology:

Global oceans, 1997-2018, 5-Day and 1x1 deg resolution
Input data: OC-CCI v4.0 Chlor-a L3, 4km res., 5-day
SST-CCI v2.0 L4, 5km res., daily



Arctic phytoplankton phenology:

Arctic region, 1997-2018, 8-Day and 1km resolution
Input data: OC-CCI v3.1 Chlor-a L3, 1km res., 8-day
SST ECMWF ERA-Interim, 12.5km res., monthly



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Satellite Ocean-Colour limitation

Only surface (~40 m)

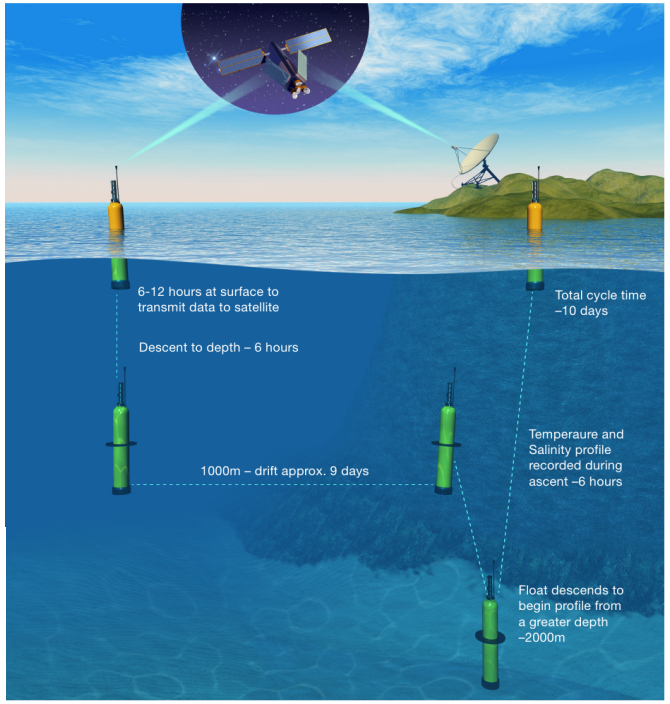
In-situ Biogeochemical-Argo floats

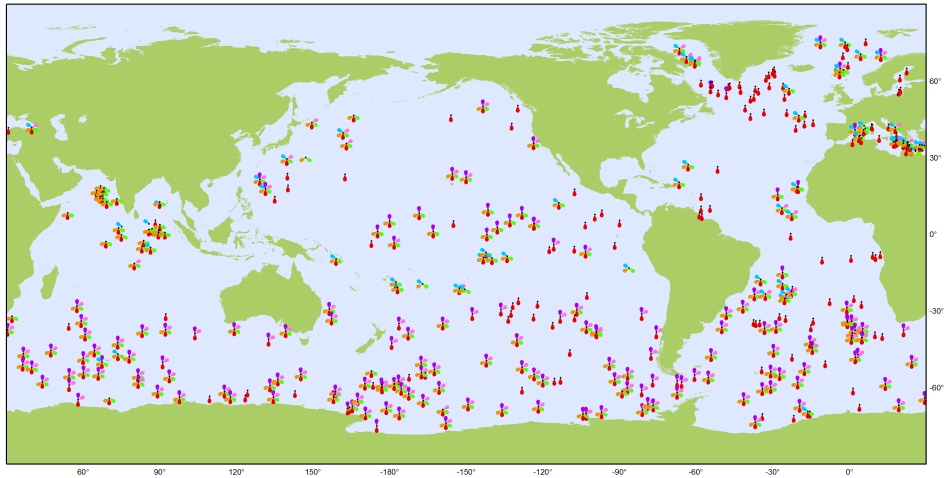
Biogeochemical Argo:

- Argo variables: T, S, depth
- New variables: oxygen, chl-a, suspended particles, NO_3, pH, light
- 0-2000 m, 2-10 day cycle
- Target: ~1000 floats

Carbon pools and fluxes:

- Sub-surface C stocks and export fluxes
- Can see under-sampled processes





Biogeochemical Argo Sensor Types May 2020

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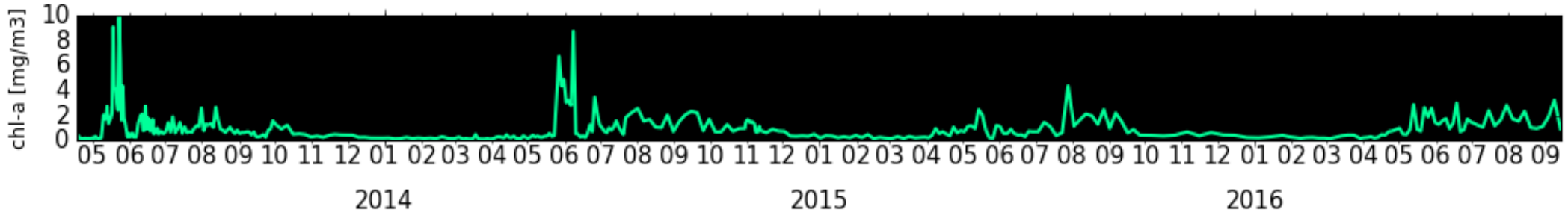

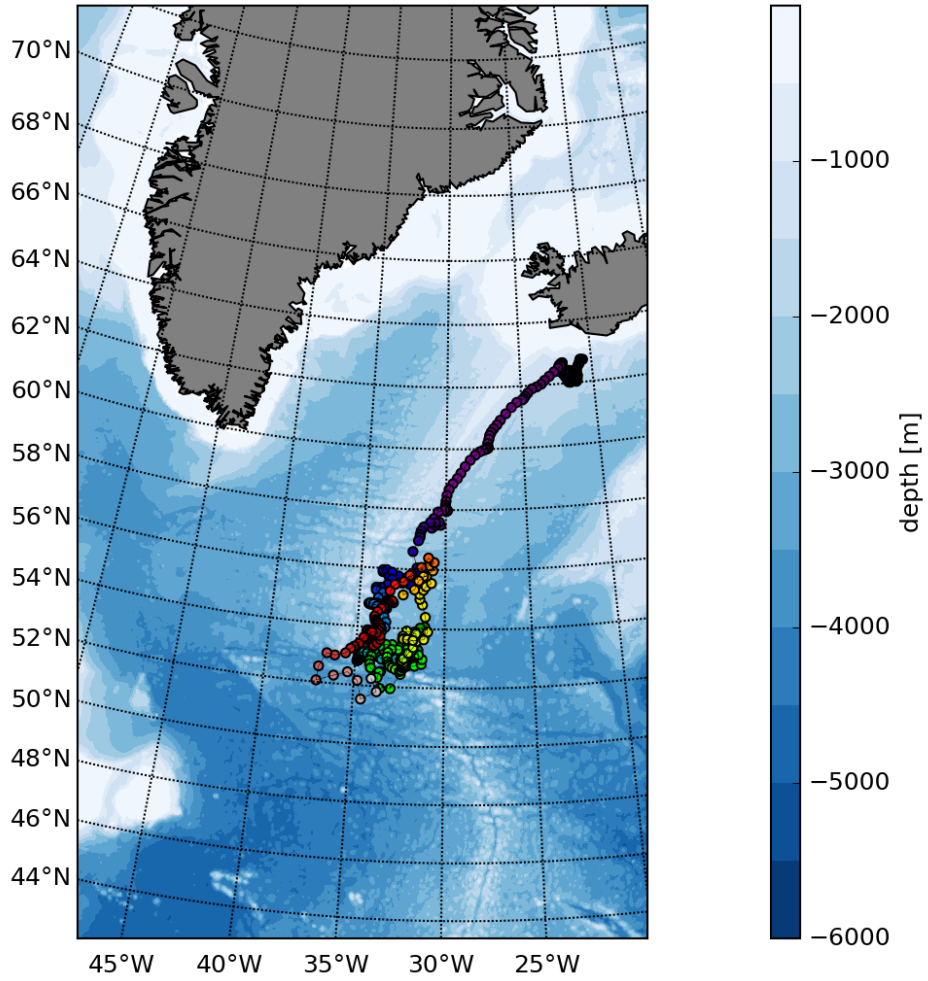

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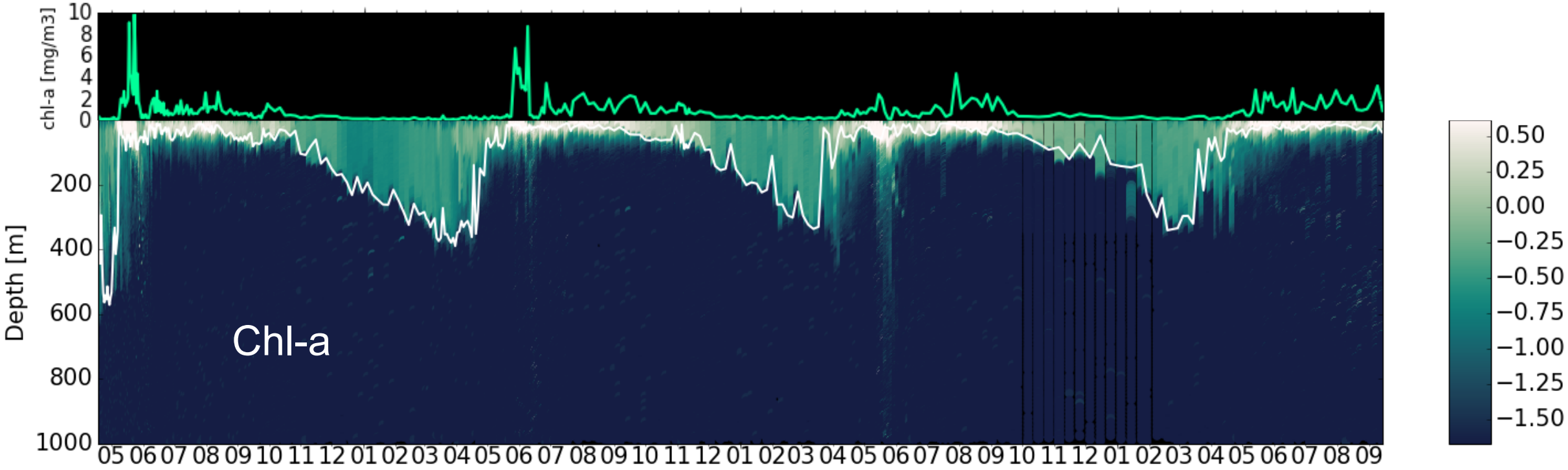

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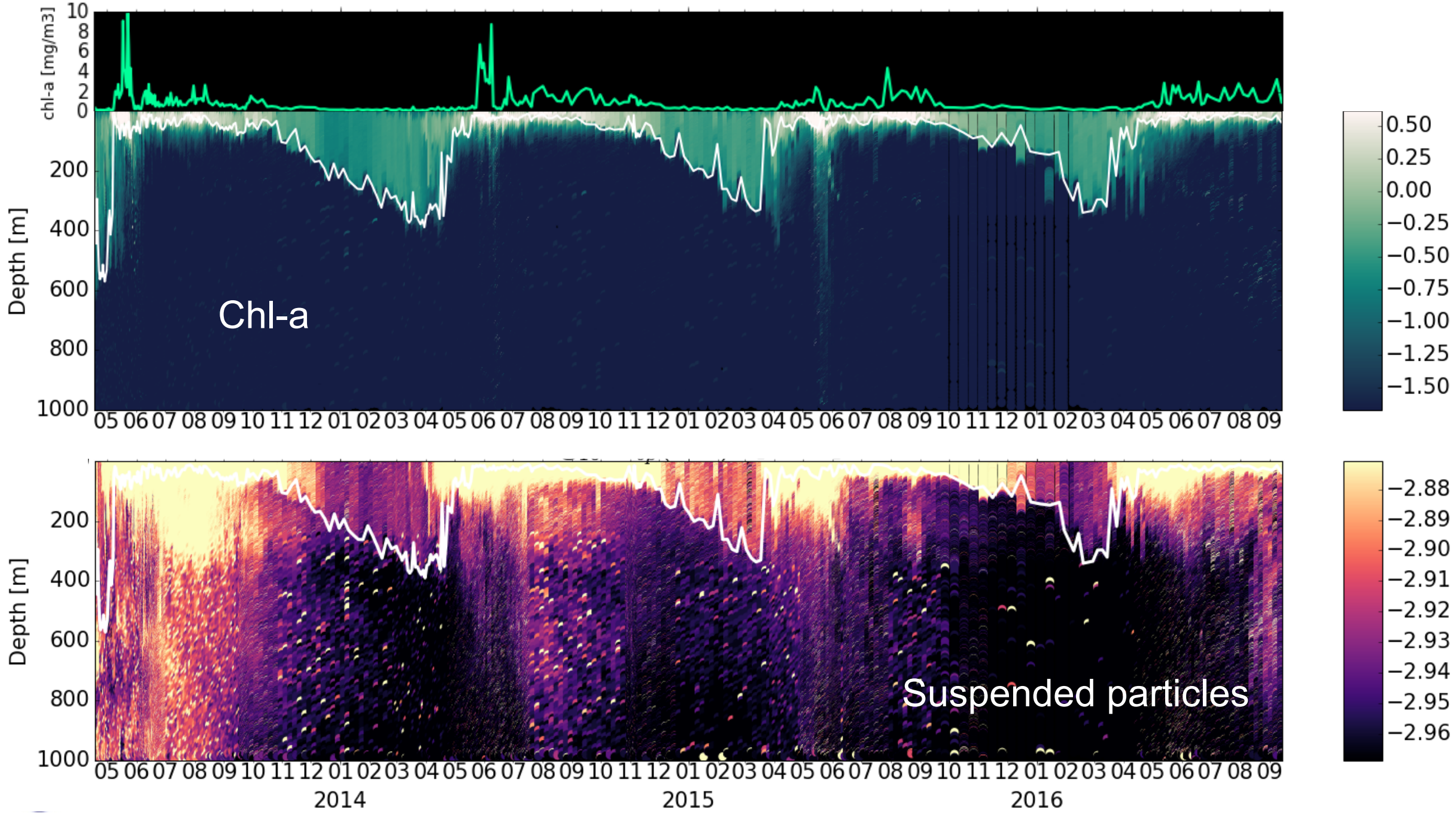
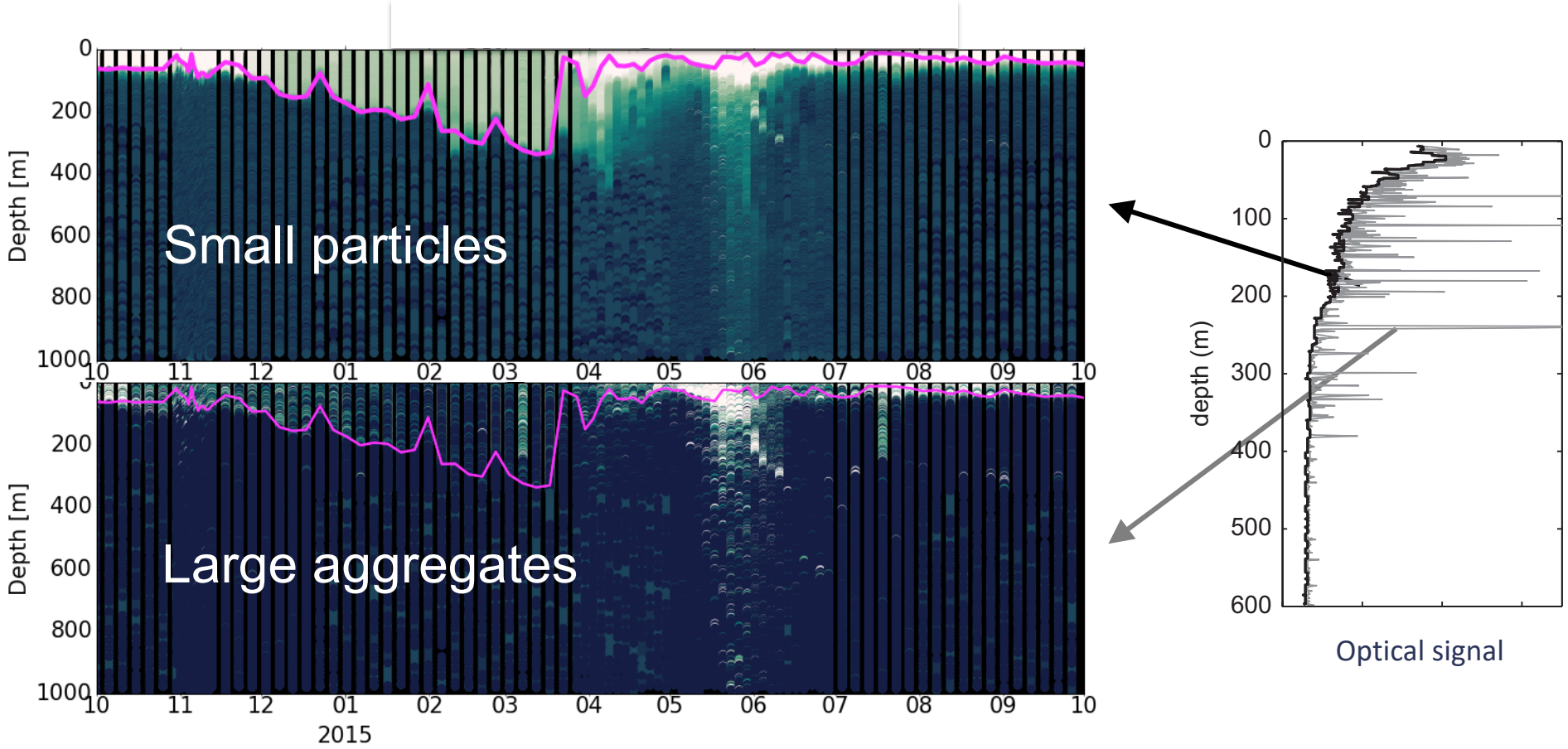

chl-a [mg/m3]
10
8
6
4
2
0
Depth [m]
200
400
600
800
1000
Chl-a
05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.25
−1.50
Depth [m]
200
400
600
800
1000
Suspended particles
05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09
2014
2015
2016
−2.88
−2.89
−2.90
−2.91
−2.92
−2.93
−2.94
−2.95
−2.96

BGC-Argo data: export and fragmentation fluxes



- Small particles generated from the fragmentation of large aggregates
- Major driver of flux attenuation
- Sets the depth of remineralisation: partitioning of C reservoir between atmosphere and ocean

[Briggs, Dall'Olmo & Claustre, *Science*, 2020]

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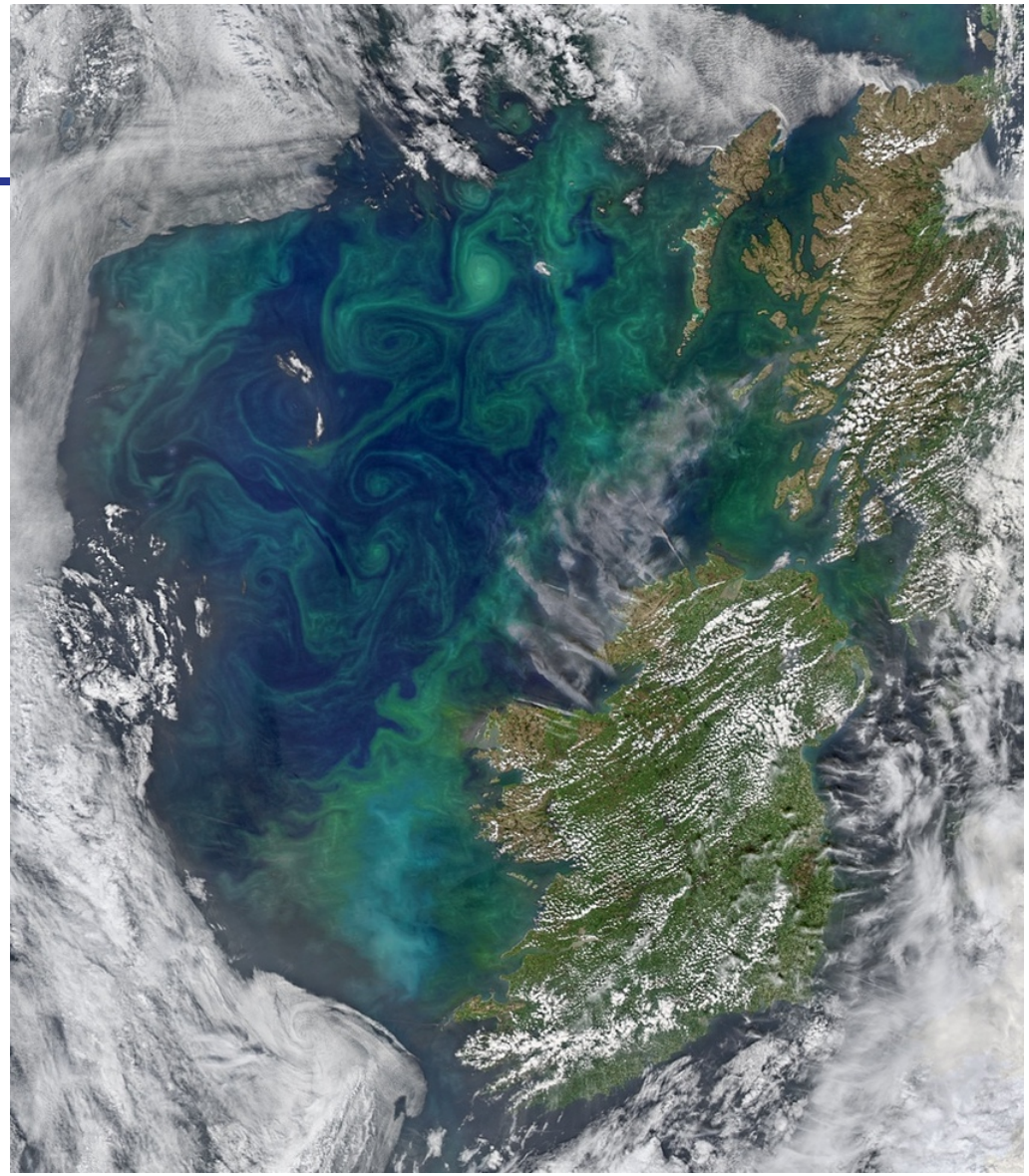
BGC-Argo data limitation

Coarse spatial resolution

Outlook

Approaches to combine satellite and BGC-Argo data:

- Investigate mechanisms linking surface to deep pools and fluxes using BGC-Argo data + extrapolate satellite data using this new knowledge
- Assimilate in global ocean biogeochemical model satellite and in-situ data to better quantify and understand the biological carbon pump



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