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
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 CO₂ ~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
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
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
Satellite Ocean-Colour Data: Carbon fluxes

Net primary production: 1998-2018 (Kulk et al., 2020)
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
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, NO₃, 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
In-situ Biogeochemical Argo floats

Chl-a

Suspended particles
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]
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