Ocean Carbon From Space 2022 Workshop

Phytoplankton Carbon from Space

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cbiomes
Simons Collaboration on Computational Biogeochemical Modeling of Marine Ecosystems

BICEP
Biological Pump and Carbon Exchange Processes

Summary

- Uses the Geider et al. (1997) photo-acclimation model, with its exact solution from Jackson et al. (2017), extended to incorporate spectral effects in light penetration in water and in photosynthesis (Sathyendranath et al. 2020)

- Phytoplankton carbon concentration in the mixed layer is computed using chlorophyll-a from European Space Agency's Ocean Colour Climate Change Initiative product (version 4.2), surface irradiance from NASA, climatological mixed-layer depth, and a global dataset of photosynthesis-irradiance parameters (Bouman, 2018, Kulk et al. 2020, 2021).

- The computations are coupled to the primary production products (Kulk et al. 2020, 2021) through the photosynthesis-irradiance parameters, ensuring consistency between the two products.

- The phytoplankton carbon concentration was then subdivided into three size classes, based on the Brewin et al. (2015) model (adapted to carbon units, see Sathyendranath et al. 2020).

- The outputs have been generated for 23 years (from 1998 to 2020) at 9 km resolution, and are being made available to the public.

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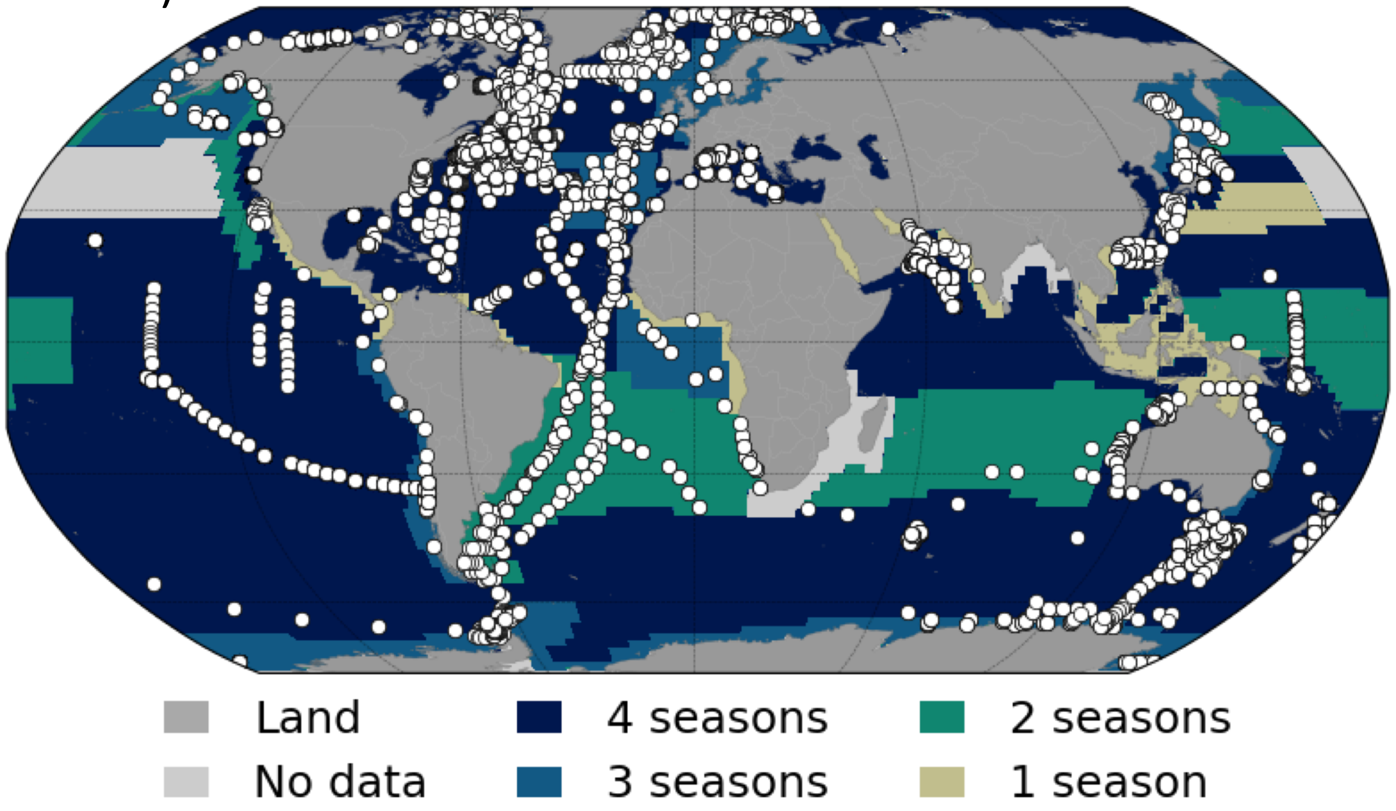
Implementation

In situ database of photosynthesis-irradiance parameters P_m^B and α^B combined with the unified model of photo-acclimation and primary production (Sathyendranath et al. 2020)…



Bouman et al. 2018; Kulk at al. 2021

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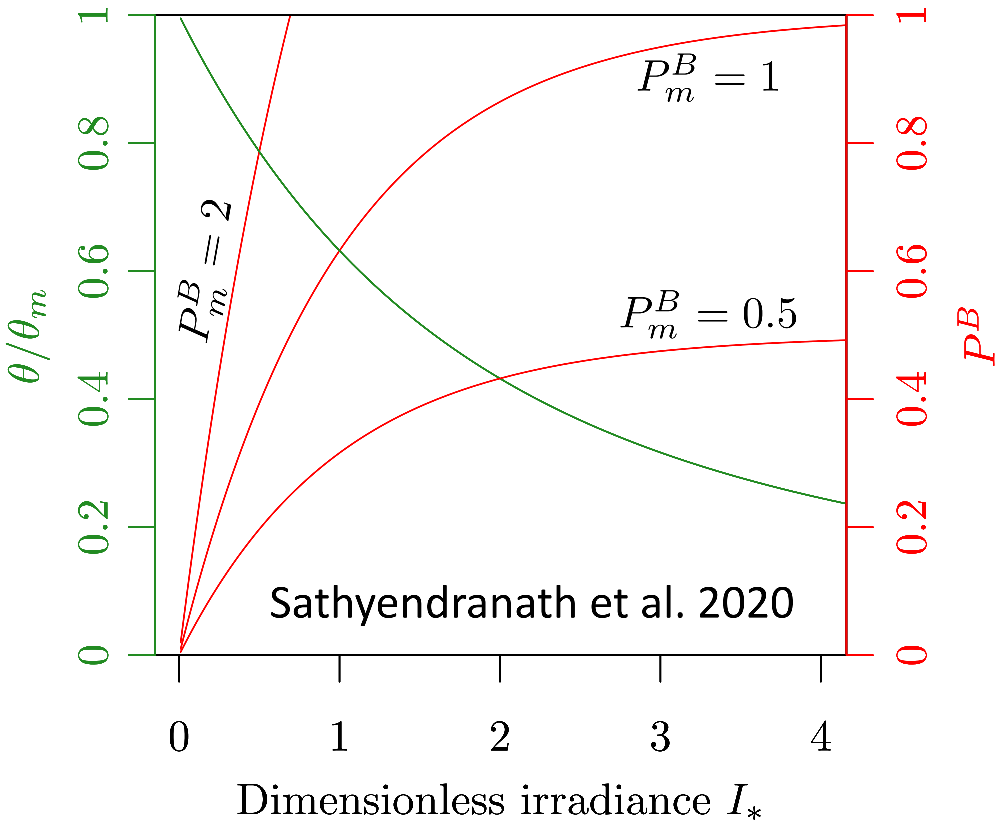
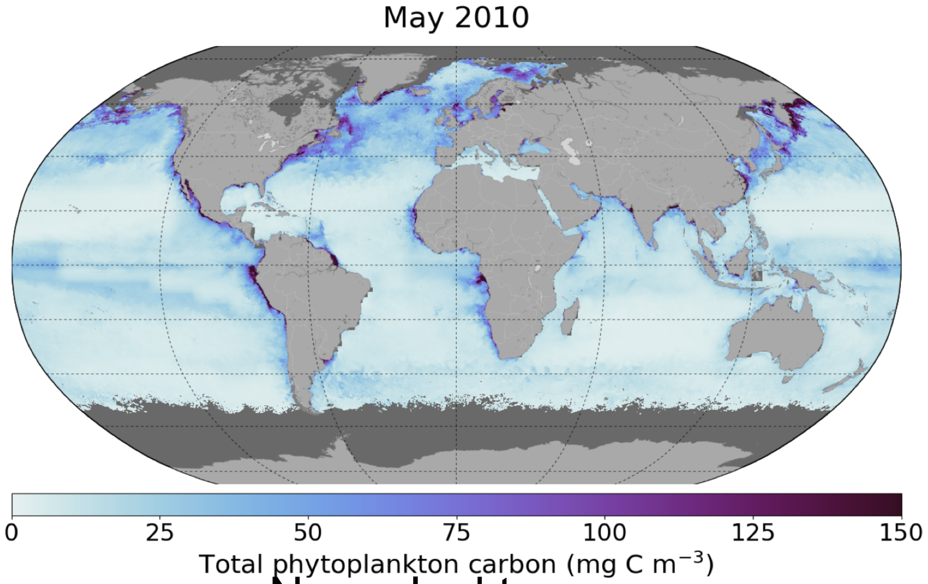
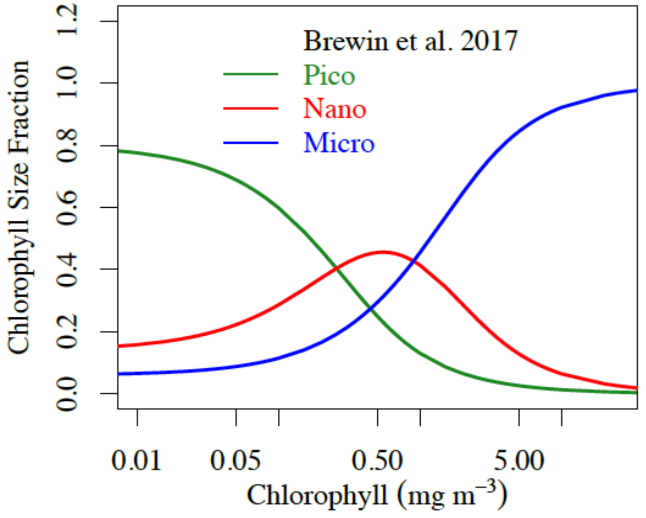


… allows the computation of primary production and phytoplankton carbon in the mixed layer, in a mutually consistent manner. Here, θ is the chlorophyll-to-carbon ratio, θ_m is its maximum value.

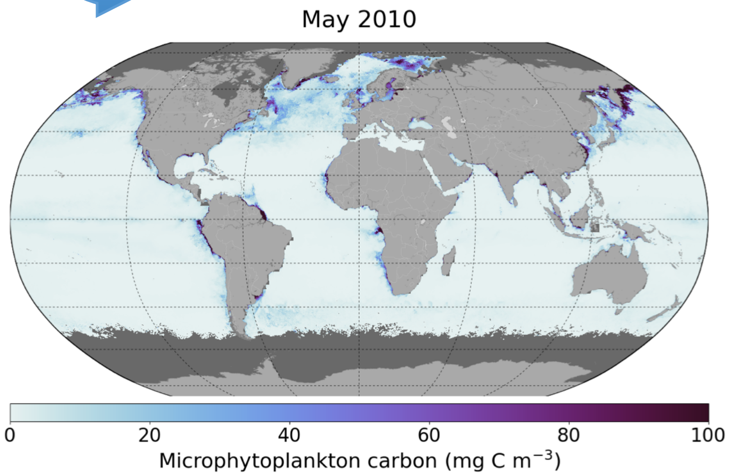
Fields of phytoplankton carbon (an example)

Total phytoplankton carbon combined with a size class model (Brewin et al. 2015) in carbon units (Sathyendranath et al. 2020) allows partition of total phytoplankton carbon into three size classes.

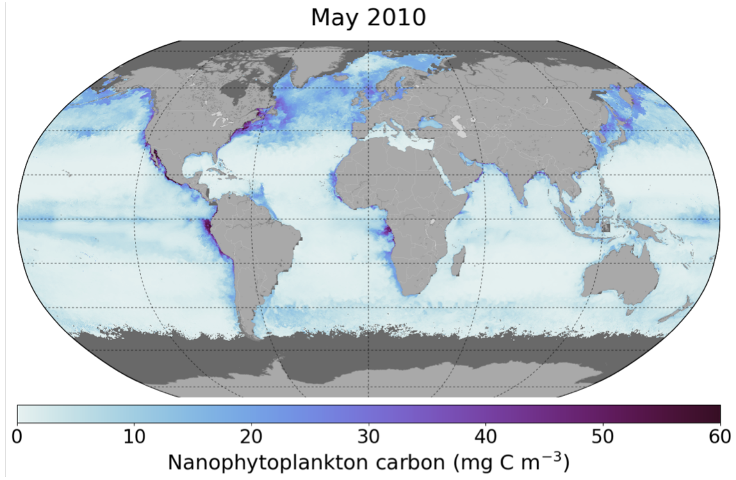




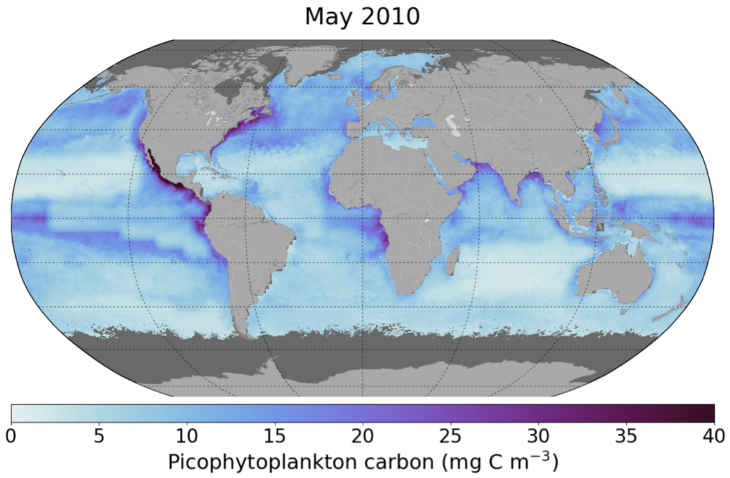
Microplankton



Nanoplankton



Picoplankton



Products are being made publicly available, from 1998 to 2020. Material presented in this poster is work in progress, as yet unpublished. Please do not reproduce or cite without prior permission from authors.

Phytoplankton Carbon Pools

Global OceanCarbon Pool	Pool Size (Pg C)	Reference	Remarks
Phytoplankton Carbon (estimates for the whole water column) - Total - Microphytoplankton - Nanophytoplankton - Picophytoplankton	1 0.78 0.11 0.39 0.28	Falkowski *et al.* (1998) LeQuéré *et al.* (2005)	The authors note that this is 0.2% of the photosynthetically-active carbon biomass on the Earth Model output. Based on chlorophyll profile of Uitz et al. (2006) C/Chl ratio = 50 C/Chl ratio = 125 C/Chl ratio = 125
Phytoplankton Carbon (estimates for the mixed layer)	0.41 0.2-0.3	Behrenfed *et al.* (2013) Kostadinov *et al.* (2015)	Based on satellite Lidar data (CALIOP) Satellite algorithms + CMIP models
Phytoplankton Carbon (estimates for the mixed layer) - Total - Microphytoplankton - Nanophytoplankton - Picophytoplankton	 0.216 0.0282 0.0568 0.134	Sathyendranath et al. (this work, ms under preparation)	BICEP/CBIOMES C/Chl ratio dynamically assigned, using a photo-acclimation model

Key Messages

- These primary production and the phytoplankton carbon products rely on the same set of photosynthesis-irradiance parameters. Method respects considerations of resource allocation embedded in the Geider et al. (1997) model.
- Availability and development of *in situ* databases have been central to the work, and have helped identify priorities for additional data, in particular for photosynthesis-irradiance parameters, to improve regional and seasonal coverage.
- Gaps: Lack of photosynthesis-irradiance parameters in some provinces and seasons. High uncertainty in the photo-assimilation parameter θ_m for the three size classes, but especially for the picoplankton size class.
- Priorities: With approaches such as the one presented here, where physiological models are combined with satellite data, priority should be assigned to improving estimates of, and uncertainties in, model parameters. This requires improved seasonal and geographic coverage. Ideally, we would move towards dynamic assignment of parameters. Many models use temperature-dependent physiological parameters. Evidence to date suggests that might not be sufficient, and might even be misleading at times. It is worthy of further investigation.

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