Earth Observation for Management of Marine Ecosystems, Resources and Natural Capital

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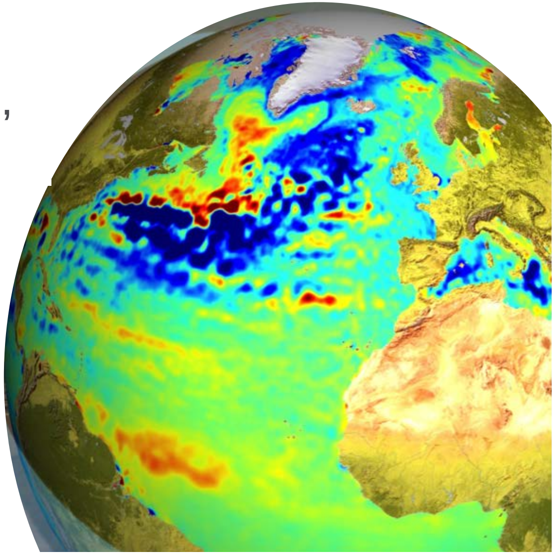


Remotely-Sensed Ecosystem Indicators

- Remote sensing meets requirements of speed, resolution, repeat frequency & cost-effectiveness for construction of ecological indicators
- Autotrophic biomass important ecosystem property
- **Primary production** fields can also be generated
- **SST** and **chlorophyll** obtainable at same resolution
- Can construct time series: seasonal dynamics can be quantified objectively
- Allows interannual comparisons

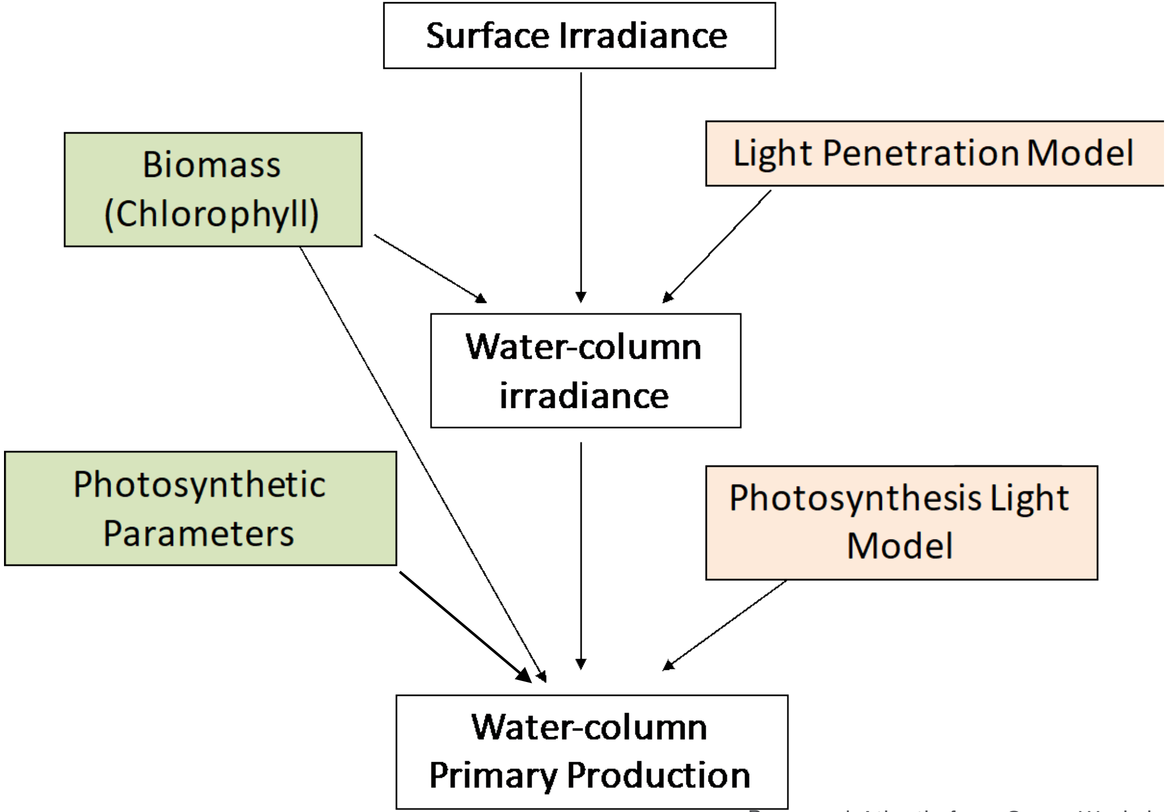
Platt & Sathyendranath (2008)

Primary Production

- A rate measurement (has time in the denominator)

- By integrating over time further useful ecological metrics can be obtained:
  - Annual Production
  - Production throughout the bloom (lower bound of new production)
  - New production roughly equivalent to the production required to support higher trophic levels, thus useful for fisheries management

Platt & Sathyendranath (2008)


Surface Irradiance
Biomass (Chlorophyll)
Light Penetration Model
Water-column irradiance
Photosynthetic Parameters
Photosynthesis Light Model
Water-column Primary Production

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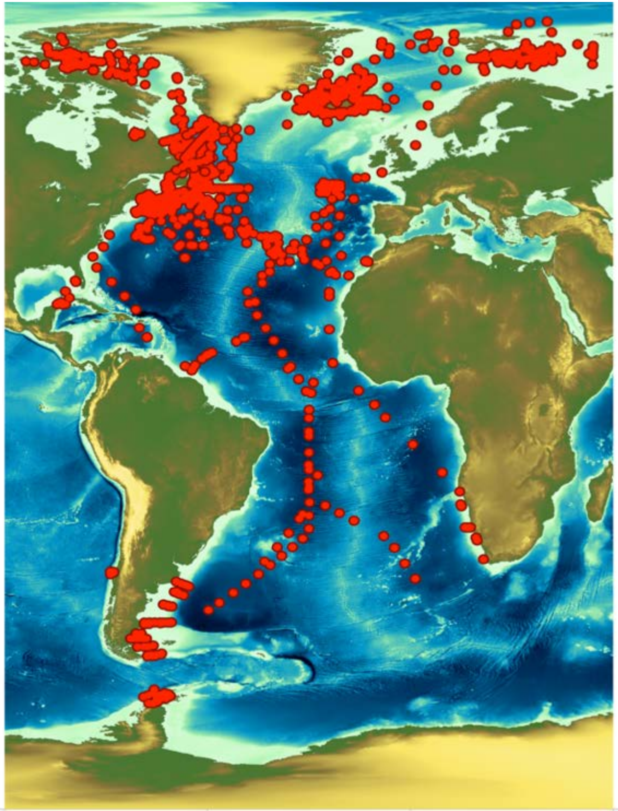

ESA-funded Marine Primary Production: Model Parameters from Space (MAPPS) project

Dataset consists of > 5000 photosynthesis-irradiance experiments

Particularly rich in the Atlantic Basin

Bouman et al. (2018) ESSD

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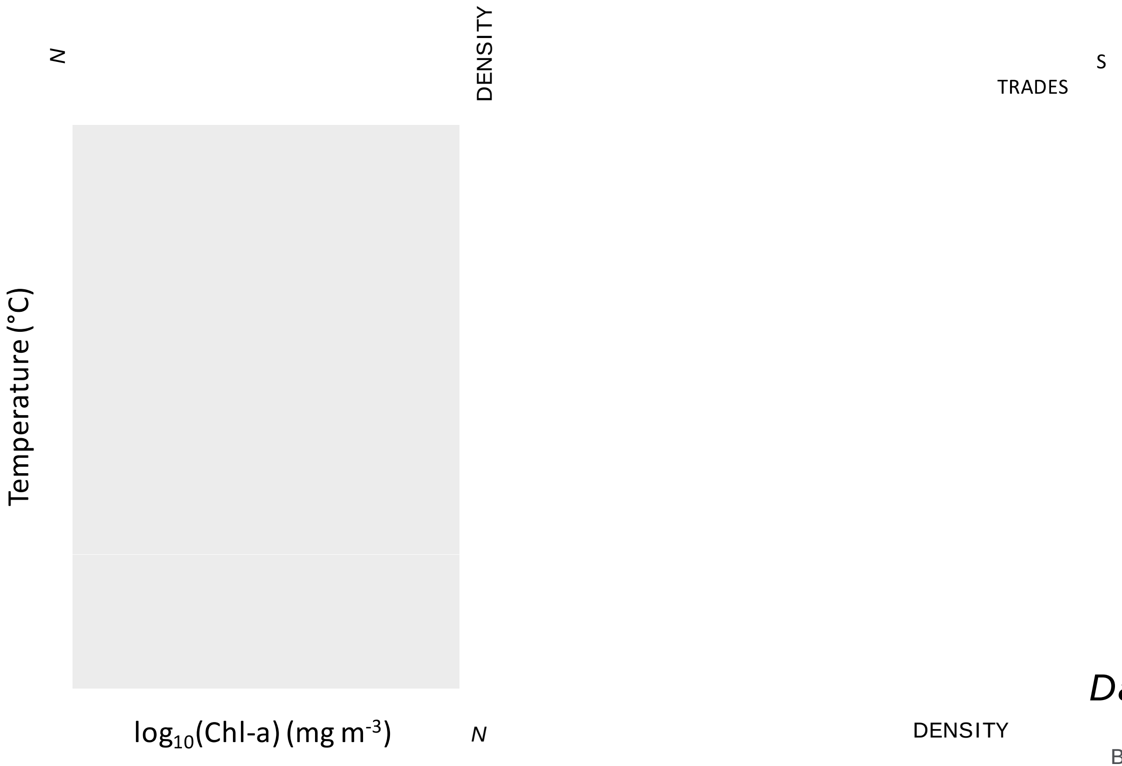

MAPPS dataset covers a range of hydrographic and trophic conditions.

Representation of the four marine biomes (Longhurst).

Ancillary measurements of pigment of markers also show significant variation in community structure across the dataset.

Data source: Bouman et al. (2018) ESSD

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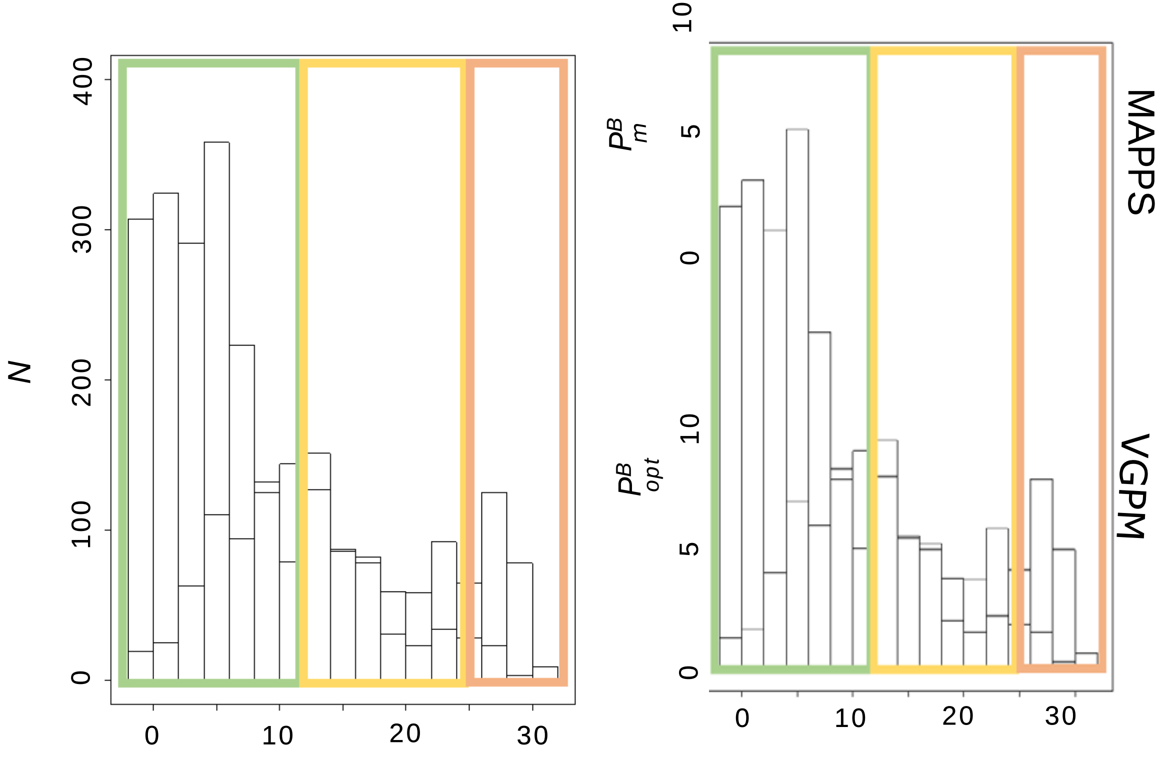

SST is widely used as a predictor of the parameter describing maximum photosynthetic rate.

Although MAPPS dataset has dramatically increased the number of observations at low temperatures, more data is required at intermediate and high temperatures.

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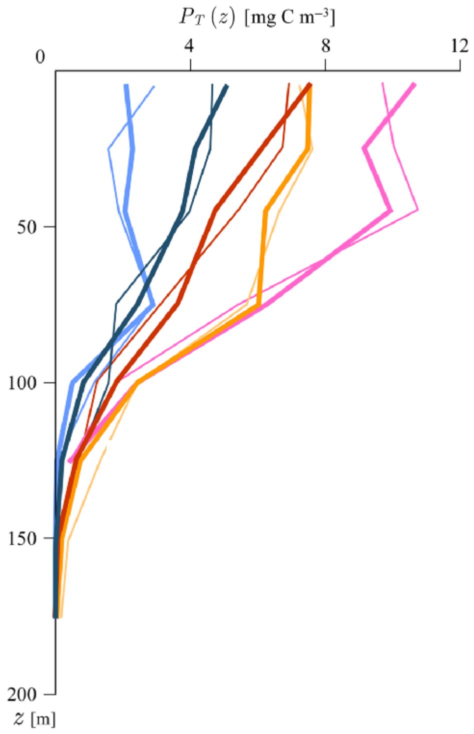
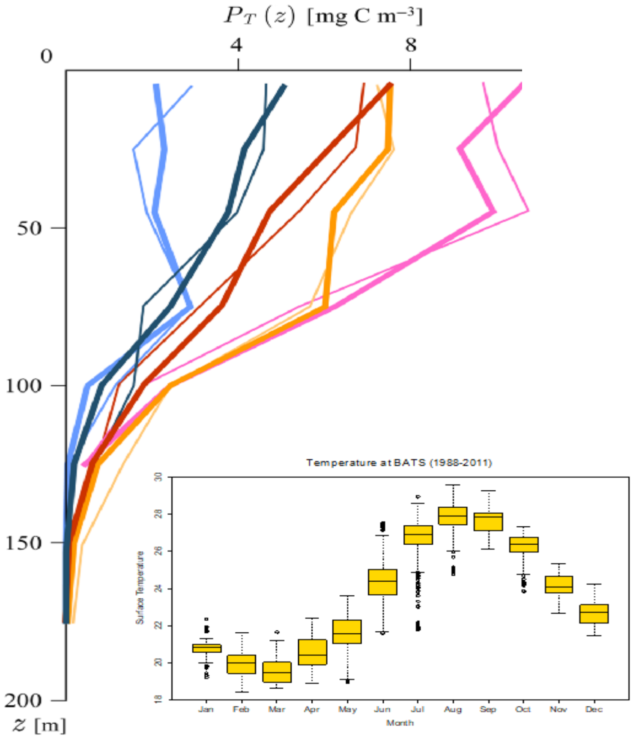
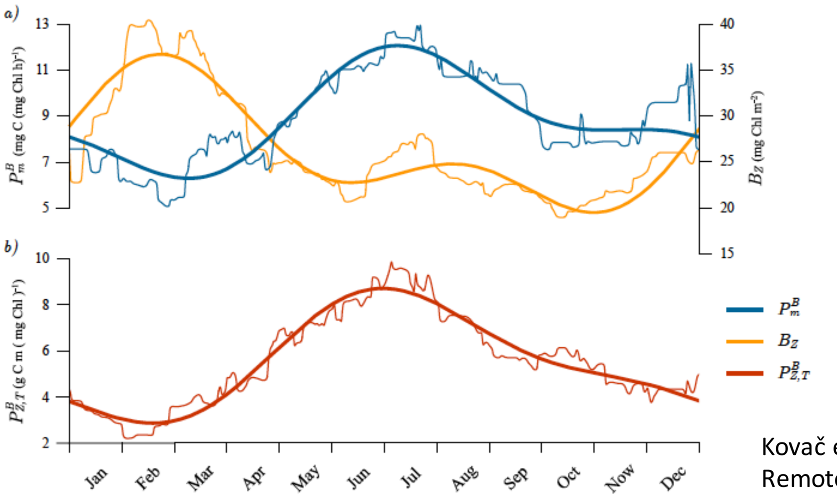




Using information on surface irradiance, light attenuation, and profiles of chlorophyll concentration and primary production rates, the photosynthetic parameters can be recovered.

Kovač et al. (2016) *ICES*



Kovač et al. (2018)
Remote Sens.

Using information on surface Irradiance, light attenuation, and profiles of chlorophyll concentration and primary production rates, the photosynthetic parameters can be recovered.

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Now Dec

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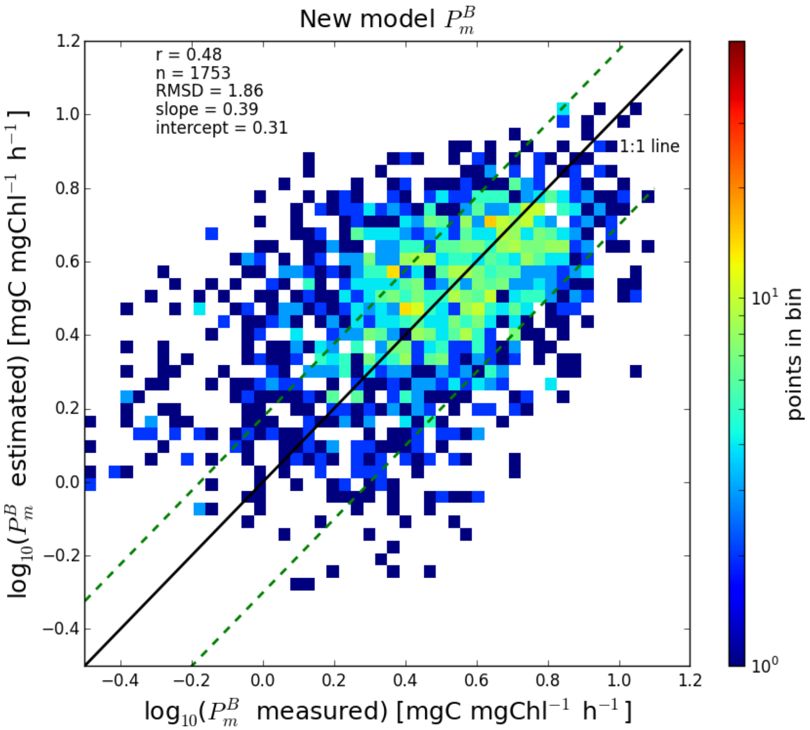

To estimate and assign the assimilation Number on a pixel-by-pixel basis, rather than using only temperature-dependent relationships, we are now able to use remote sensing data to account for the combined influence of temperature, nutrients and light on photosynthetic parameters.

Phytoplankton biomass and production, as estimated by earth observations, may be considered indices that address the question “How much?”. But we would also like to know “What kind?”.

Different phytoplankton classes or types are known to play different roles in both ecosystems and biogeochemical cycles.

Large datasets assembled from the Atlantic basin can be exploited to map the distribution and productivity of key species.

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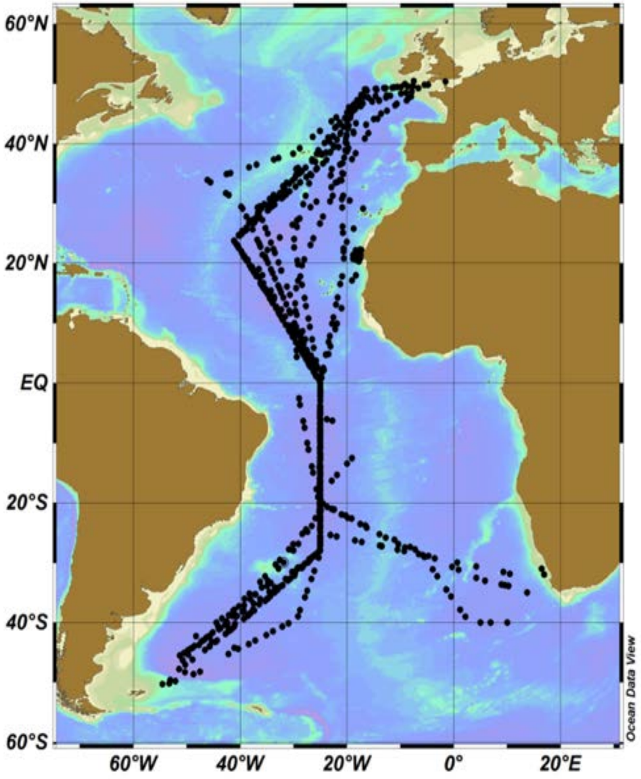

Prochlorococcus is the smallest and most abundant photosynthetic organism on the planet.

Can contribute up to half of the autotrophic biomass in the immense subtropical gyre ecosystems.

Can be readily counted using flow cytometry based on their unique optical properties and have a unique pigment marker to assess their contribution to Chl-a biomass.

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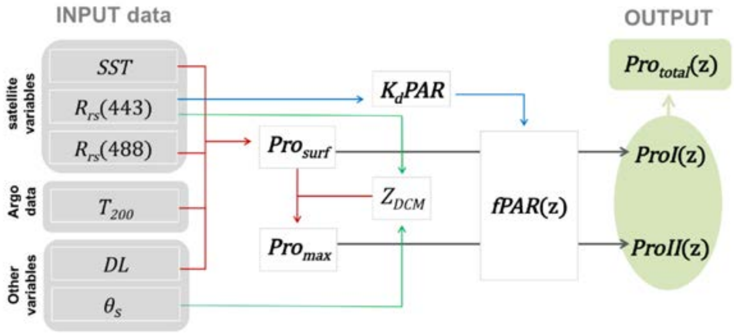
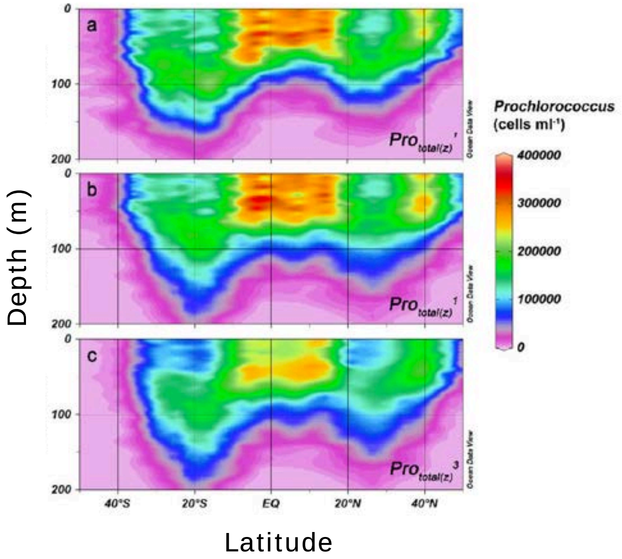
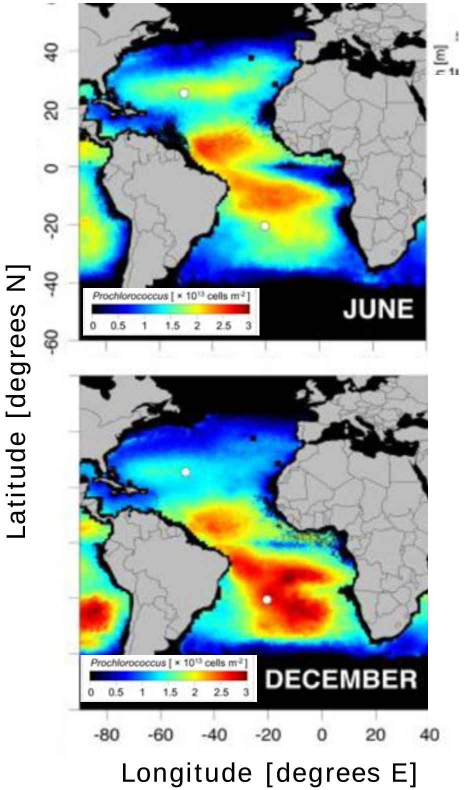


The work flow of all calculations, from satellite input variables, through to derived input variables, and to the final product of *Prochlorococcus* cell abundance integrated in the water column

Vertically-resolved cell abundance





Lange et al. (2018) Remote Sens.

Conclusions

Although the MAPPS database has provided the remote sensing and biogeochemical modelling communities with a valuable open-access repository of photosynthesis-irradiance data, there remains a pronounced sampling bias in the Atlantic, both spatially and temporally.

Adopting the approach of Kovač et al. (2016, 2018) will allow us to revisit historical measurements of water-column primary production and retrieve the photosynthetic parameters in regions and seasons currently underrepresented in the database (e.g. Southern hemisphere, winter), leading to a more accurate method of parameter assignment.

Conclusions

Next to phytoplankton pigments, flow cytometric counts of marine phytoplankton are one of the most frequently measured biological variables in the ocean.

Combining in situ measurements of cell abundance using flow cytometry with remotely-sensed data will provide valuable new insight on the role of marine microbes in ocean biogeochemical cycles.

Recommendations of Future Investments

Historical deck, and in situ, primary production measurements from the Atlantic basin, with accompanying chlorophyll and underwater irradiance measurements, should be assembled. Priority should be given to regions where data are sparse in space and time (southern hemisphere, subtropics & tropics, winter)

Ancillary nutrient, temperate and irradiance data should be used in the development of parameterisation algorithms to account for spatio-temporal variability in the photosynthetic parameters, and allow for a dynamic assignment of parameters that captures physiological changes in the cells.

Recommendations of Future Investments

Developing novel algorithms to estimate the abundance and activity of marine microbes at the basin scale is timely, given the wealth of data available from microbial oceanographers.

The use of remote sensing to scale up microbial processes will be of tremendous interest to the rapidly growing community of environmental microbiologists as well as ocean biogeochemists and climate modellers.

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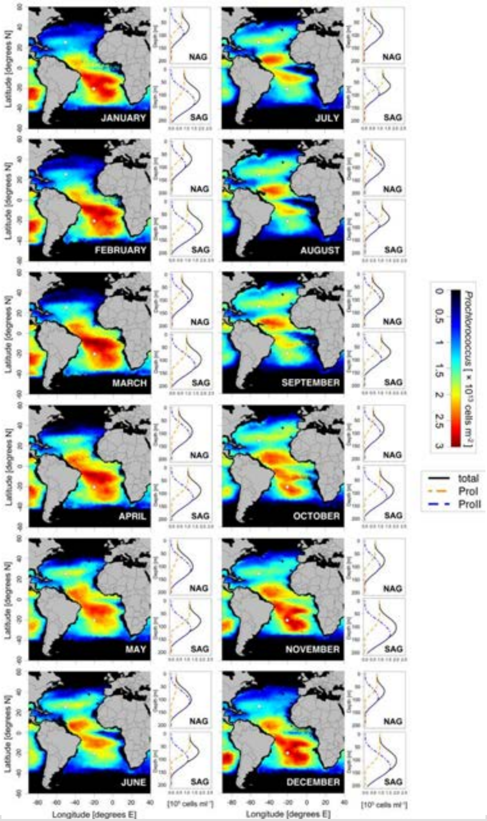

Evidence that the gyres are expanding, which has potential implications to the marine carbon cycle.

Given that *Prochlorococcus* is the dominant primary producer in these ocean deserts, developing an understanding of how their productivity may be changing is of key importance to assessing the role of the oceans in the global carbon cycle.