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Prediction of photo-protective carotenoids at global scale

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Introduction

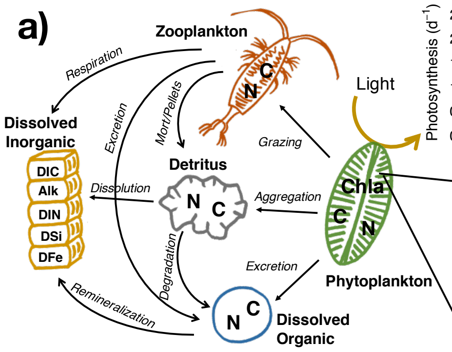
Microalgae are capable of acclimating to dynamic light environments as they have evolved mechanisms to optimize their light harvesting ability and minimize the damage to the photosynthetic machinery. Xanthophyll cycle (XC) is one of the most important protective mechanisms that prevents photodamage to photosystems (PSII). Photoprotective carotenoids (PPC) involved in the XC accumulate when cells acclimate to high light, altering their absorption properties.

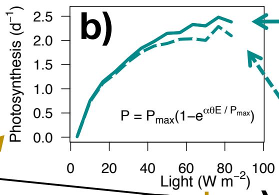
Objective

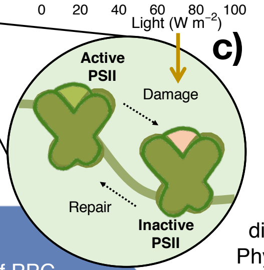
Model photodamage and repair of PSII.
↓
Predict an index for photo-protection.
↓
Compare predicted index to PPC observations.

The model

The BGC model REcoM2 resolves two groups of phytoplankton that are responsible for capturing light energy into carbon fixation (**a**). The Photosynthesis-Light (PE) curve relates this two variables and its initial slope, α, indicates the total light affinity of the light harvesting apparatus (**b**). Under high light part of the photosystems (PSII) can be inactivated leading to a decrease in α and thus to photoinhibition (**c**). We combined in REcoM2, two phytoplankton growth models that consider constant or variable α, respectively:

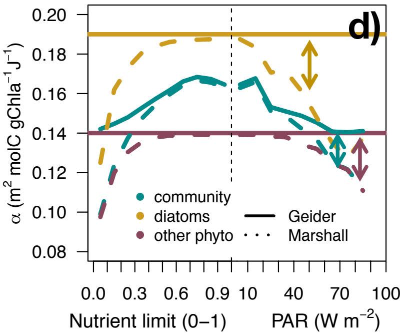






Geider *et al.* (1998) [1]
All PSII are active, α is diverse due to changes in phytoplankton communities adapted to different light regimes, but remains constant at short-term.

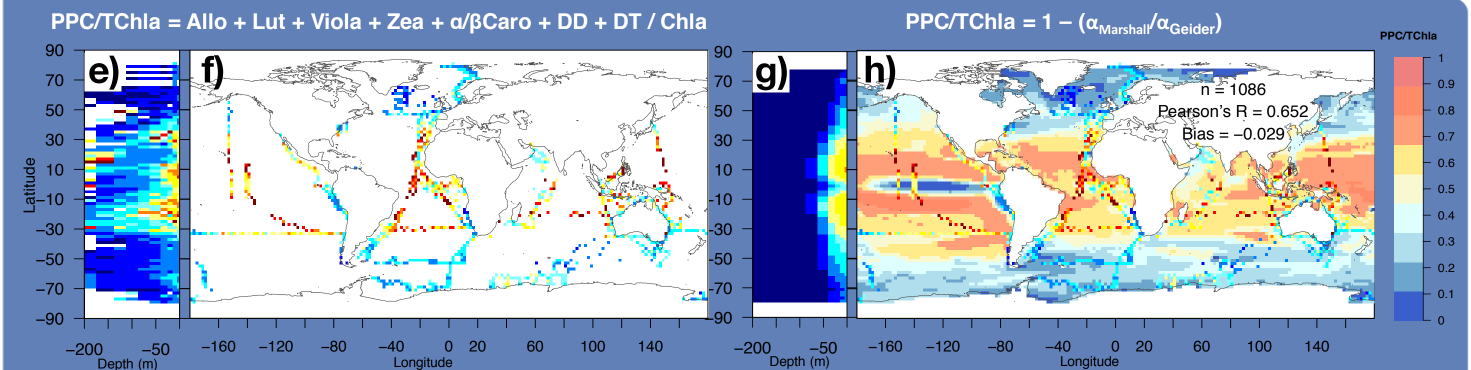
Marshall *et al.* (2000) [2]
Part of the PSII are inactive, α is variable at short term and depends on the proportion of active PSII. Non-photochemical quenching (NPQ) protects PSII from damage considering a constant pool of PPC.



If photoinhibition is small in communities adapted to ambient light [3], the difference between both estimates of α constitutes a proxy for photoprotection (**d**). Phytoplankton protect themselves by accumulating pigments involved in the XC [4]. Hence, the photoprotection index reflects the PPC accumulated under natural conditions.

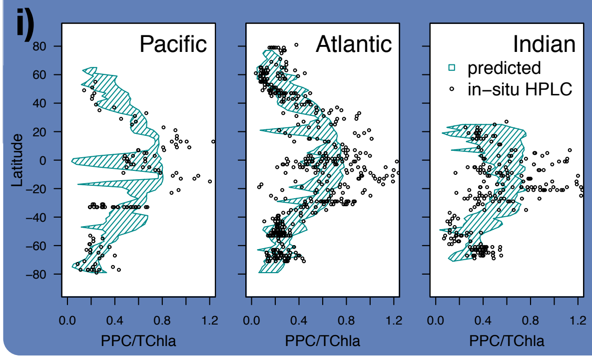
Observations

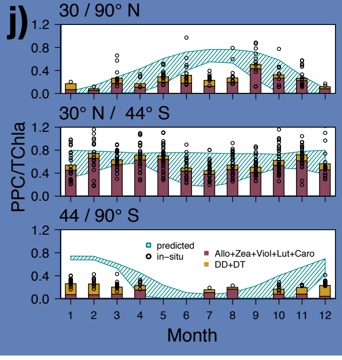
We compared our photoprotection index to *in situ* observations of PPC normalized by total Chla, both determined by HPLC [5].

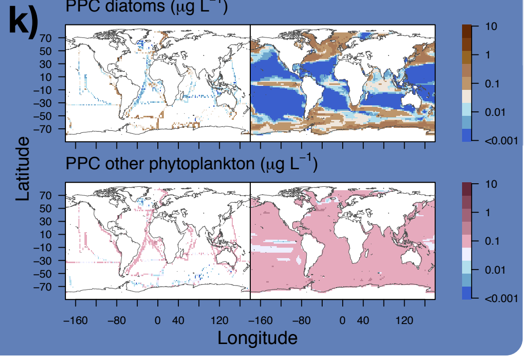


Predicted PPC values (0-15m) (**h**) were highly correlated to observations (**f**). The gradient in depth (**g**) was steeper than observations (**e**). The latitudinal trend was captured by the model in all ocean basins (**i**) with maximum PPC content in tropical ocean and minimum in temperate and polar regions.

Seasonality of PPC and the contribution of phytoplankton groups varied with latitude (**j**). In tropical ocean PPC content remained constant along the year with a high contribution of highly protected phytoplankton. At higher latitudes seasonality was noticeable with larger presence of diatoms (**k**).







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[1] Geider RJ *et al.*, Limnol. Oceanogr. **43**:679-694, 1998.
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[3] Cullen JJ, Can. J. Fish. Aquat. Sci. **39**:791-803 1982.
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Acknowledgements

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Conclusions and outlook

Modelled photoprotective carotenoids (PPC) content was in agreement with *in situ* observations. PPC deviate light through the non-photochemical path and their presence is crucial for the coupling of light absorption to carbon fixation in the ocean. They also shape the absorption spectrum and can be highly relevant under variable spectral regimes.

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