A new global dataset of photosynthesis parameters

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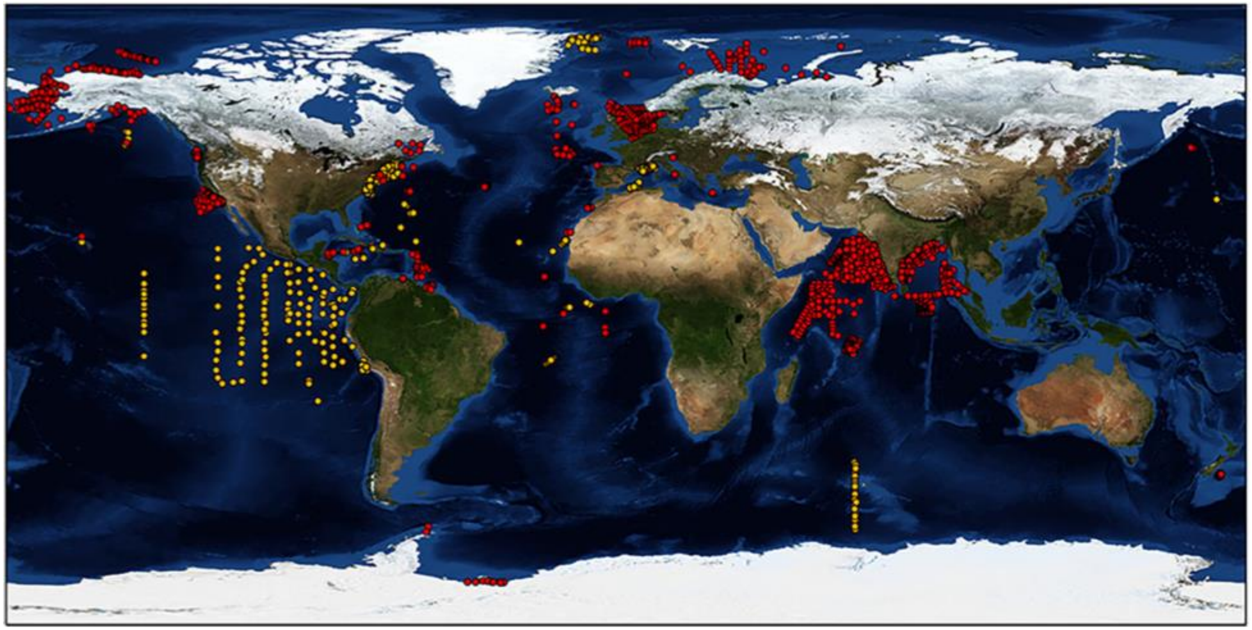
Motivation & Background

- Primary production models require PAR, K, chlorophyll and photosynthesis parameters - only the last cannot be estimated remotely.
- Relatively novel method applies inverse modelling techniques to data.
- Source dataset: Mattei & Scardi (2021) - 6084 profiles (1958–2017).

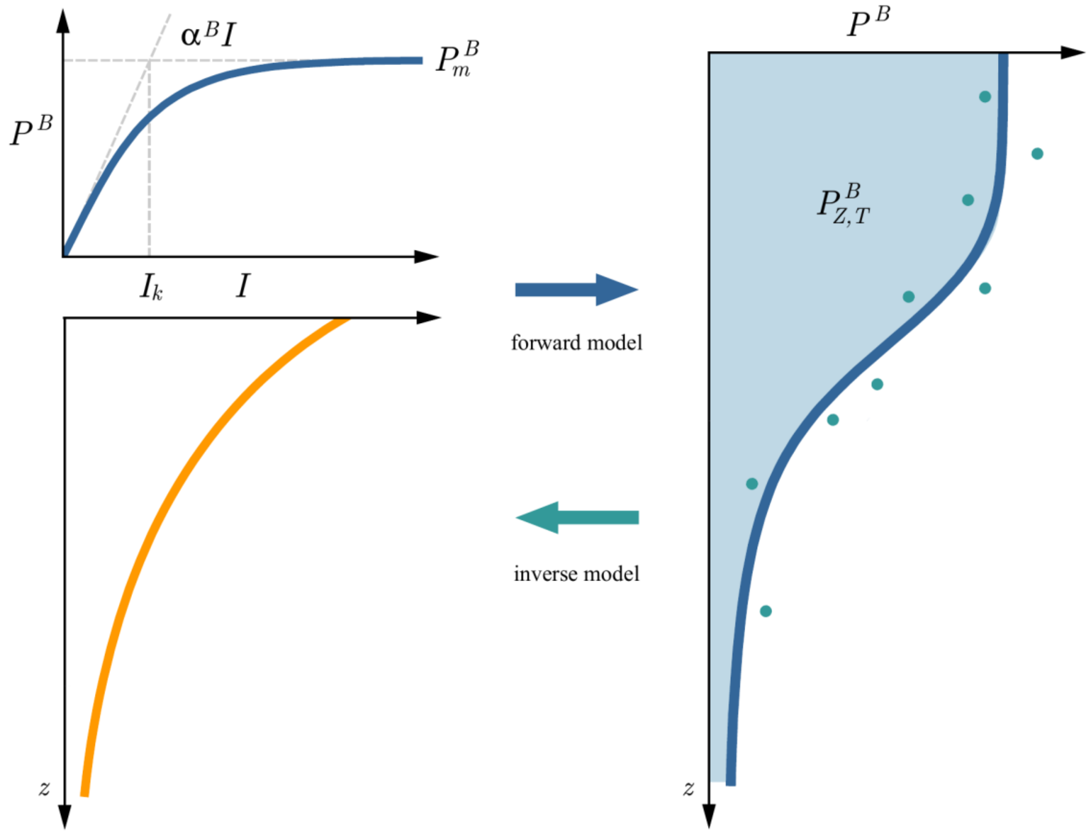


Mattei & Scardi (2021)

Modeling Framework

- Forward model:
  $P^B = p^B(I|\alpha^B, P_m^B)I(z,t)$
  $= I_0^m \sin(\pi t/D)\exp(-Kz)$
  $P_T(z) = B(z)\int_0^D p^B(I(z,t))\mathrm{d}t P_{Z,T}$
  $= \int_0^\infty P_T(z)\mathrm{d}z$

- Quantification of the model data mismatch:
  $\mathcal{P}(\alpha_B, P_B^m)$
  $= \sum_{n=1}^{N}\left(P_T^B(z_n|\alpha^B, P_m^B) - \tilde{P}_T^B(z_n)\right)^2 + \left(P_{Z,T}^B(\alpha^B, P_m^B) - \tilde{P}_{Z,T}^B\right)^2$



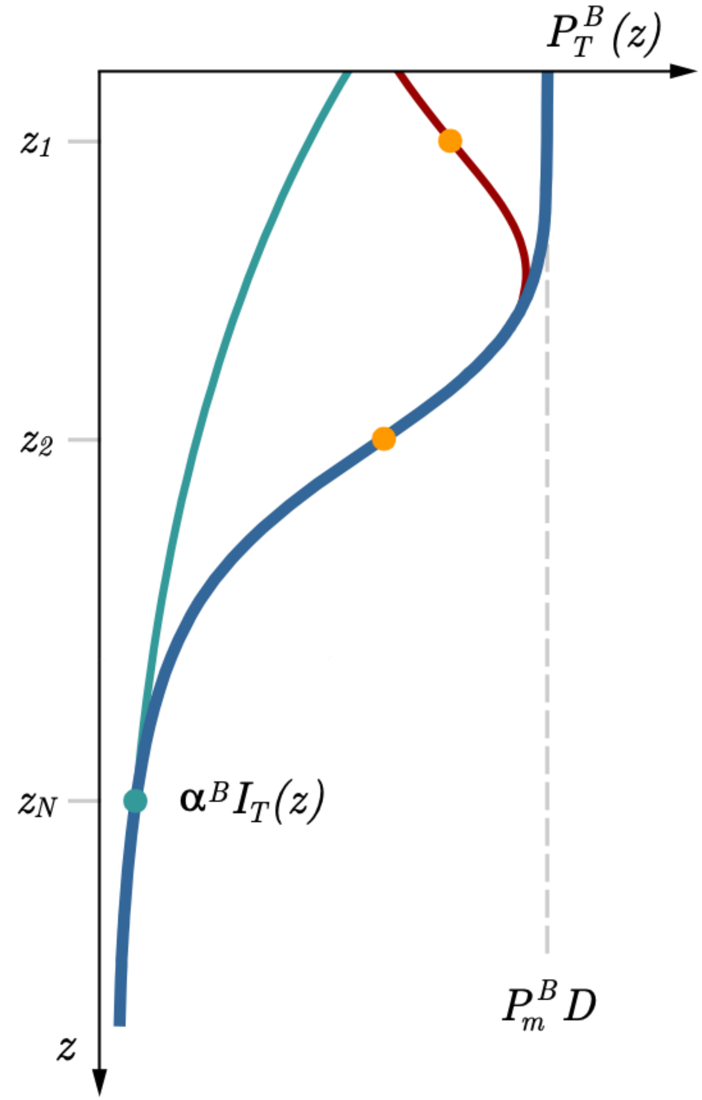
Inverse Model Details

- Initial estimates:

$$(P_m^B)_0 = \frac{\tilde{P}_T^B(z_2)}{D}$$

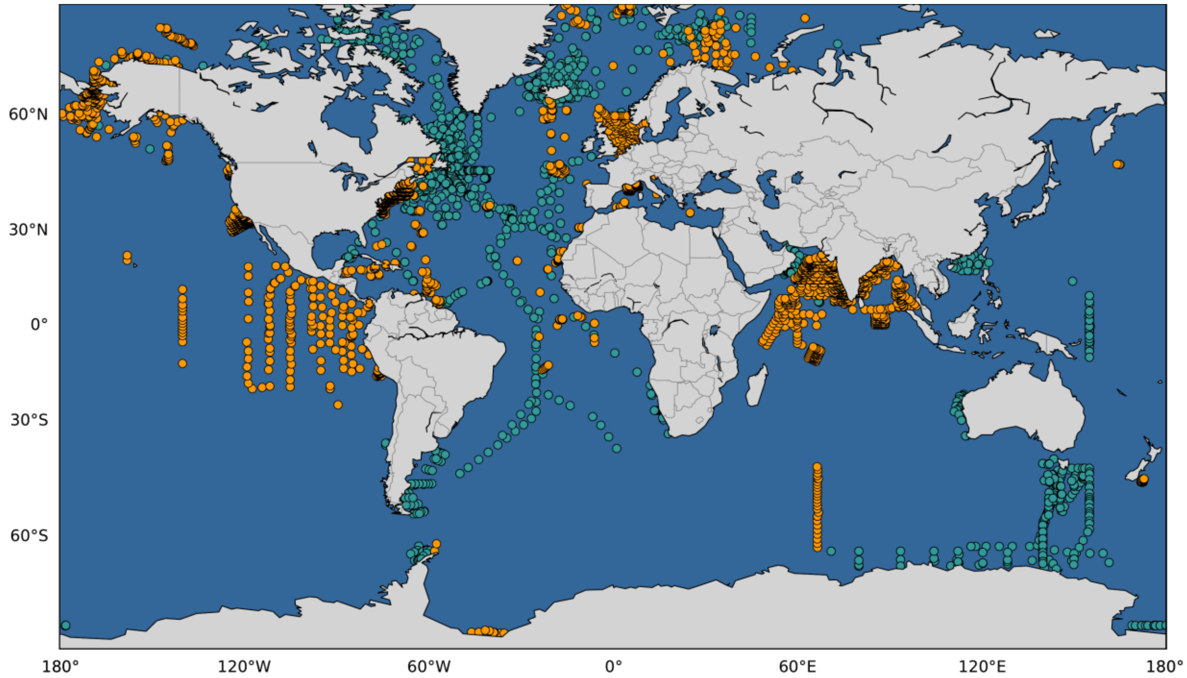
$$(\alpha^B)_0 = \frac{P_T^B(z_N)}{I_T e^{-Kz_N}}$$

- Optimization procedure: Nelder & Mead (1965) search algorithm, constrained by the analytical solution for water column production by Platt et al. (1990).
- Diagnostics for photoinhibition and vertical heterogeneity.



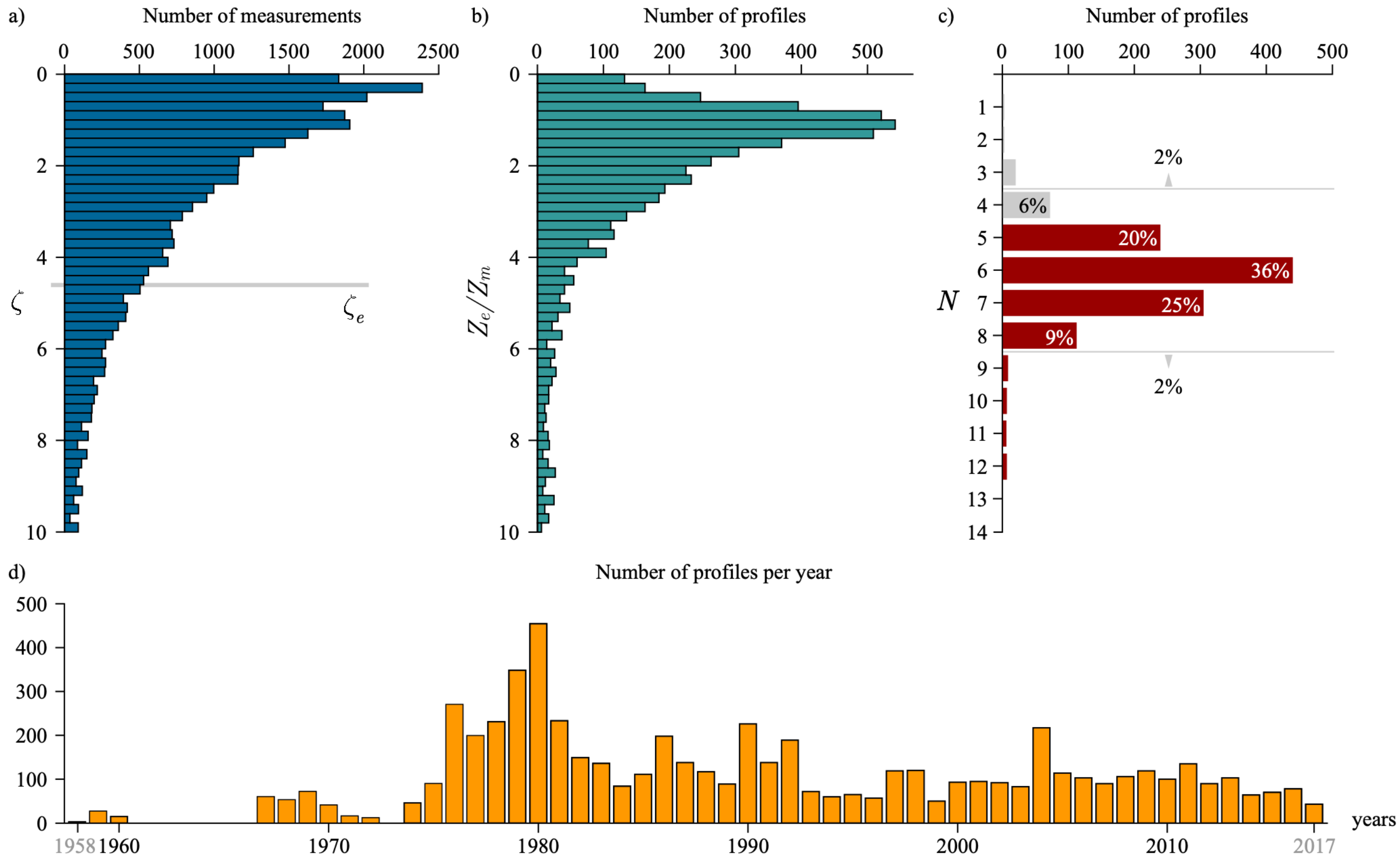
Dataset Overview

- Global distribution of Mattei & Scardi (2021) dataset.
  6084 profiles, 37,722 data pairs.
  Complementary to Bouman et al. (2018).

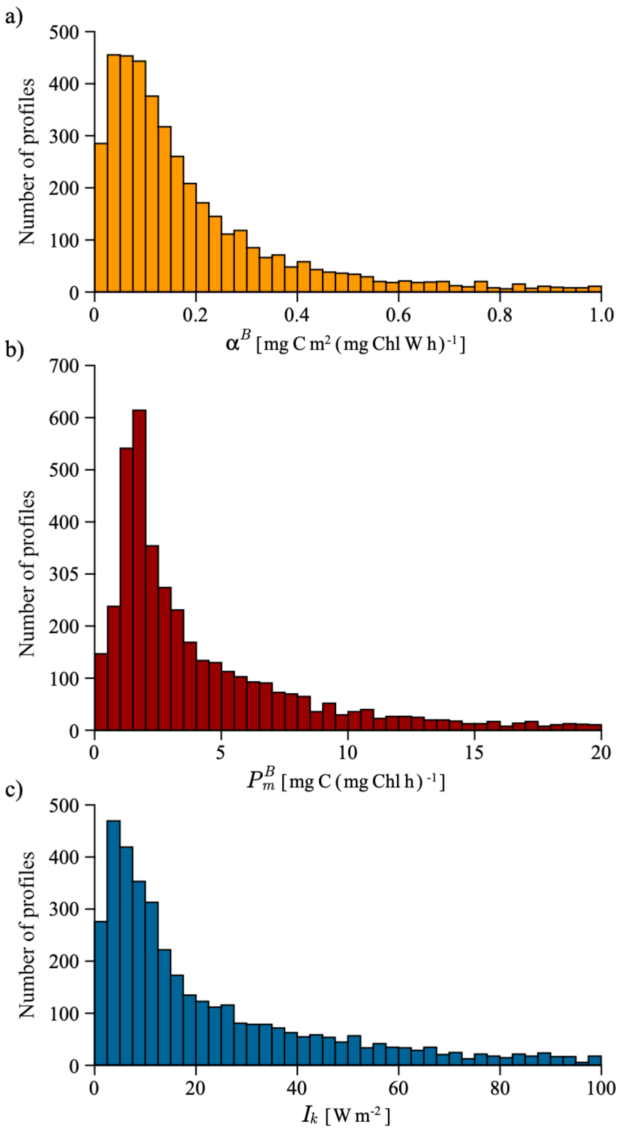


Dataset Characteristics

- Profiles within euphotic zone.
- ~72% profiles have ≥6 depths — adequate resolution.
- $\tilde{P}_T^B(z_n) > \tilde{P}_T^B(z_{n+1})$ - 4864 passed.



Estimated Parameters



- α^B: 0 - 0.6 mgC (mgChl)$^{-1}$ (Wm^{-2})$^{-1}$ h^{-1}
- P_m^B: < 10 mgC (mgChl)$^{-1}$ h^{-1}
- $I_k = P_m^B/\alpha^B$ typically < 50 Wm^{-2}

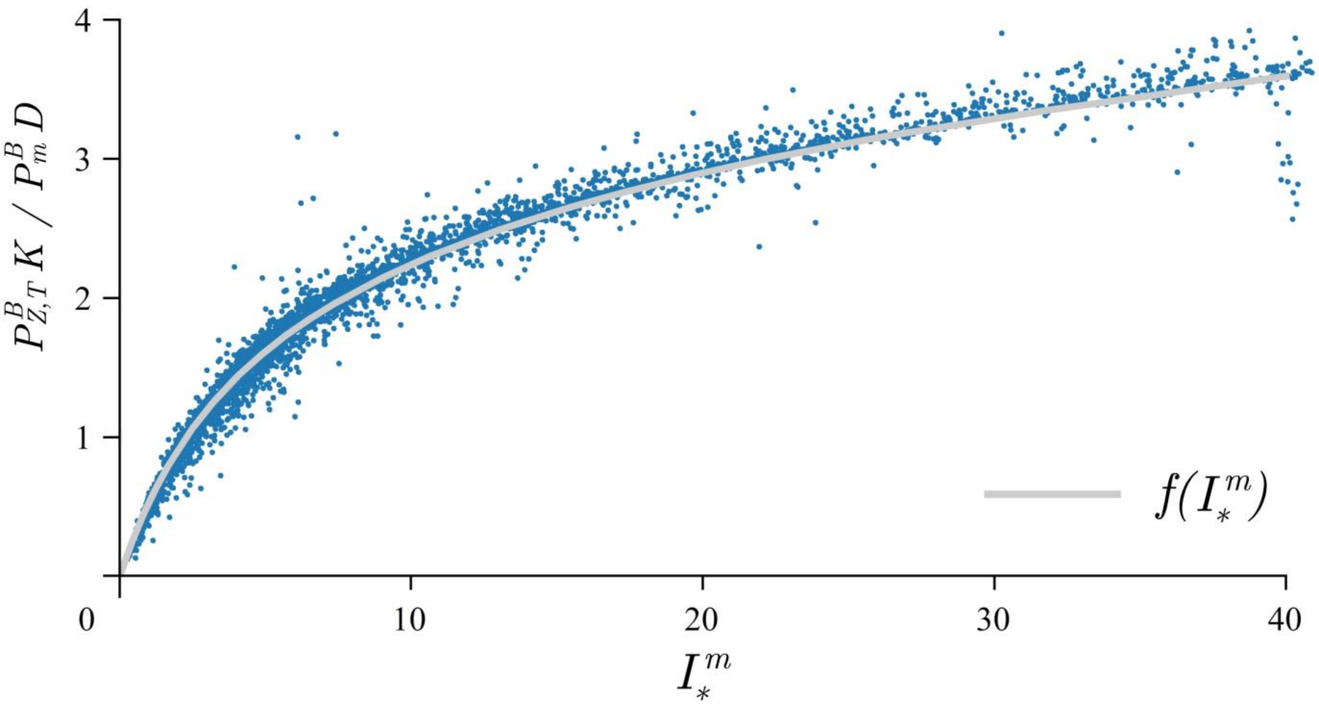
Model-Data Validation

- Analytical relation:

$$P_{Z,T}^{B} = \frac{P_m^B D}{K} f(I_m^*)$$

$$I_m^* = \frac{\alpha_B I_0^m}{P_m^B} \quad \frac{K P_{Z,T}^B}{P_m^B D} = f\left(\frac{\alpha^B I_0^m}{P_m^B}\right)$$

- Strong agreement between model and observed production.



Correlations amongst various p-I functions

Blackman (1905)

$$p^B(I) = P_m^B \frac{1}{2}\left(\alpha^B \frac{I}{P_m^B} + 1 - \left|\alpha^B \frac{I}{P_m^B} - 1\right|\right)$$

Baly (1935)

$$p^B(I) = P_m^B \frac{\alpha^B I}{P_m^B + \alpha^B I}$$

Smith (1936)

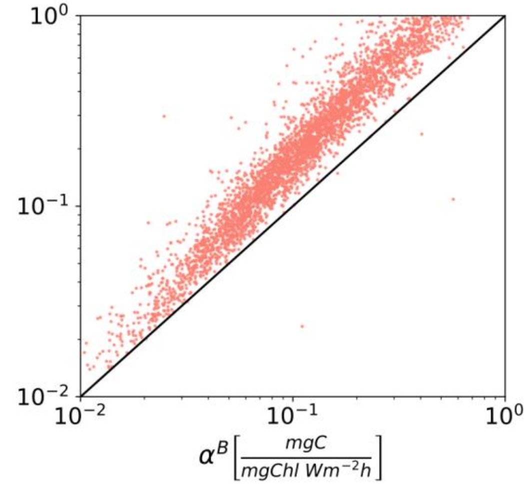
$$p^B(I) = \frac{\alpha^B I}{\sqrt{1 + \left(\frac{\alpha^B I}{P_m^B}\right)^2}}$$

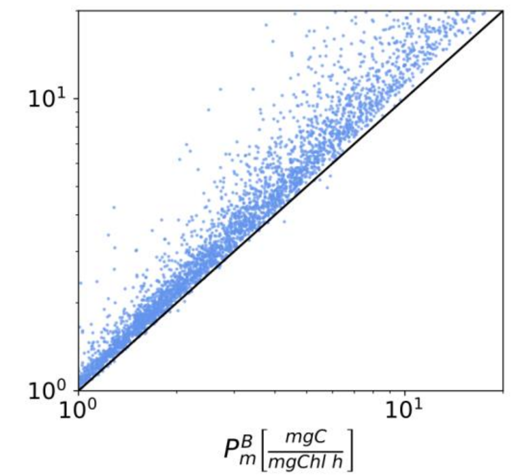
Jassby & Platt (1976)

$$p^B(I) = P_m^B \tanh\left(\frac{\alpha^B I}{P_m^B}\right)$$

Platt et al. (1980)

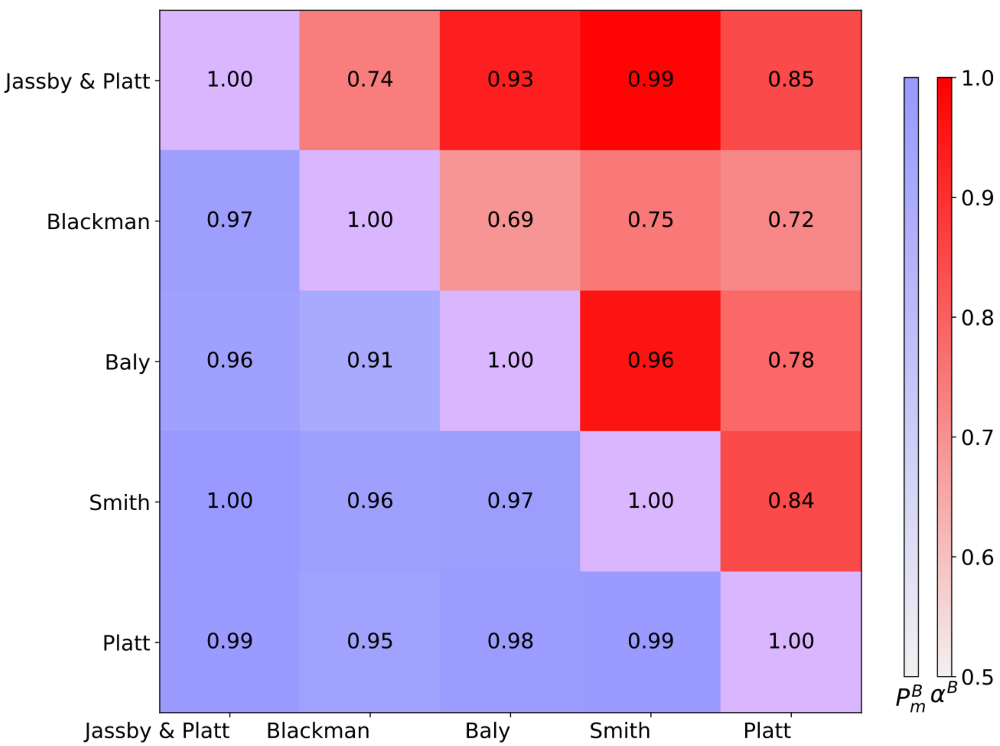
$$p^B(I) = P_m^B\left(1 - \exp\left(-\frac{\alpha^B I}{P_m^B}\right)\right)$$

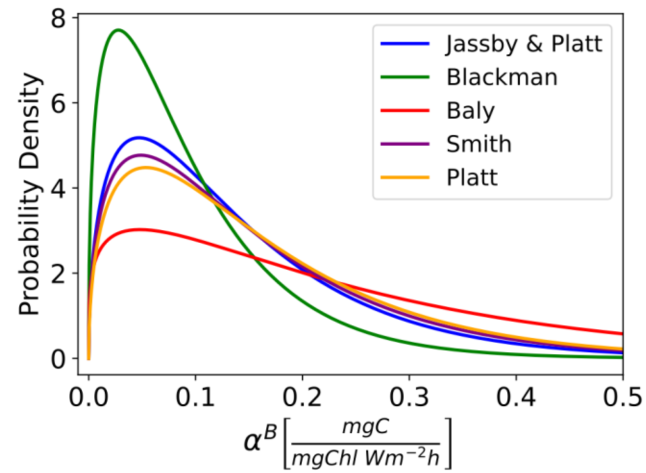


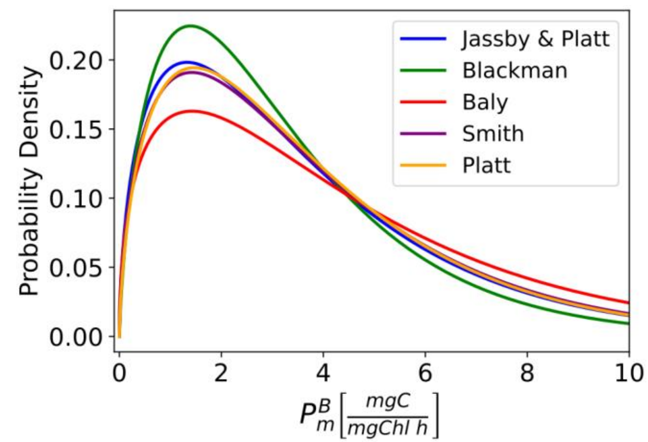


Pairwise scatterplots of α^B (red) and P_m^B (blue) for Baly vs Jassby & Platt photosynthesis irradiance functions.

Inter-Model Correlations

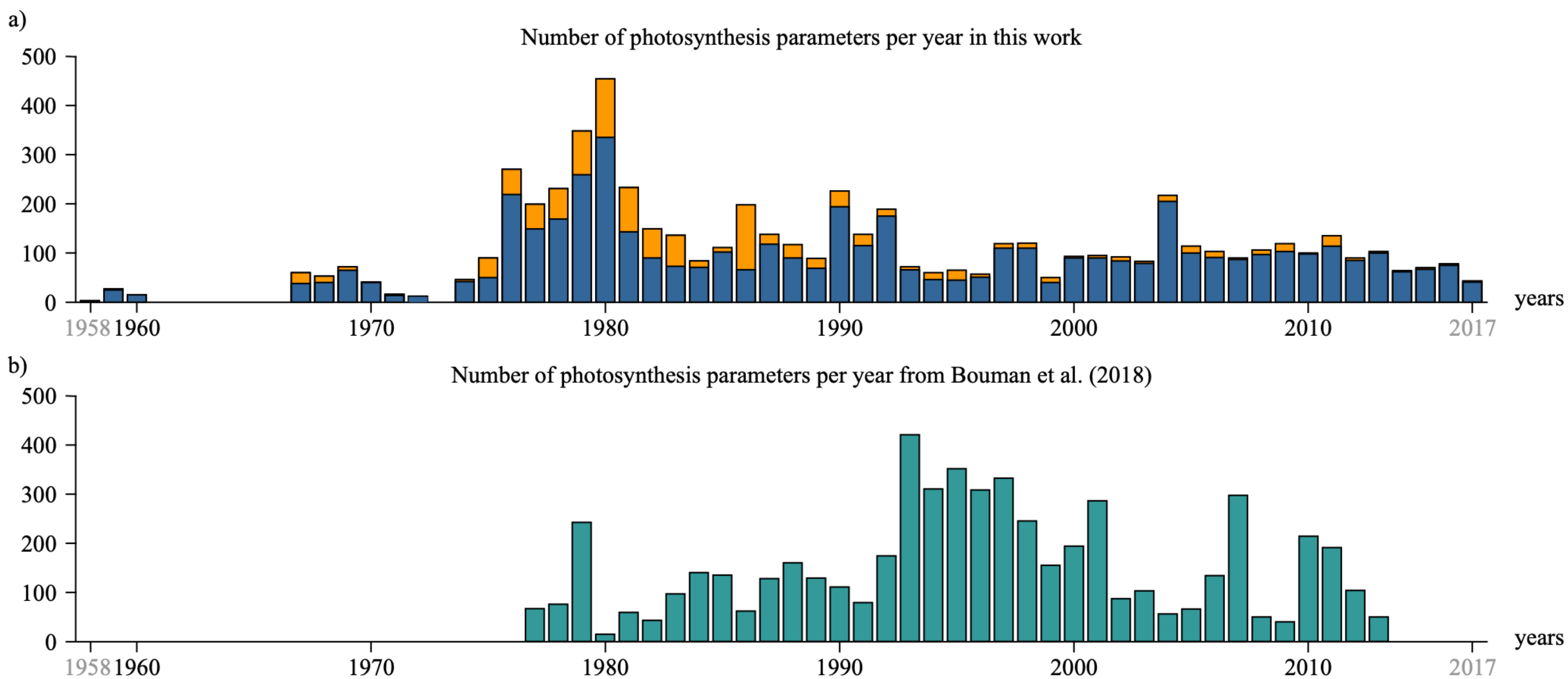






Temporal Coverage

- M&S dataset: 1958–2017.
- Bouman archive: 1977–2013.
- Combined coverage approx. 60 years.
- Doubles global temporal extent of available parameters.



Discussion & Limitations

- Vertical uniformity assumption not always valid in stratified waters.
- Non-spectral model for α^B
- Variable depth resolution introduces uncertainty.
- Spectral quality differences in simulated incubations.
- Despite simplifications, method robust and consistent across basins.

Conclusions & Implications

- Derived α^B and P_m^B for > 4800 profiles globally.
- Dataset complements Bouman et al. (2018).
- Improves model parameterisation and regional time-series analysis.
- Provides foundation for global primary-production modeling.

Future Work

- Develop time series of α^B and P_m^B.
- Apply Bayesian and machine learning approaches.
- Spectral correction for α^B.
- Global data hub for PP profiles.

Thank you!

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