

Analysis ready photosynthesis parameters data

Žarko Kovač^{1*}, Marija Bačekočić Koloper¹,
Shubha Sathyendranath², Gemma Kulk², Heather Bouman³

¹ Faculty of Science, University of Split, Ruđera Boškovića 33, 21 000 Split, Croatia *zkovac@pmfst.hr

² Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth PL1 3DH, United Kingdom

³ Department of Earth Sciences, St John's College, Oxford, St Giles, Oxford OX1 3JP, United Kingdom

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PHOTOCLIM
P H O T O C L I M . O R G

Introduction

In situ primary production measurements have played a fundamental role in the development of primary production models and remain an important resource for model development and validation. Recently, Mattei & Scardi (2021) assembled 6084 in situ primary production profiles, complementing the global compilation of photosynthesis parameters by Bouman et al. (2018). Long-term observations from fixed stations, including the Hawaii Ocean Time-series, Bermuda Atlantic Time-series, and Cariaco Ocean Time-Series, provide additional datasets for model evaluation and the assessment of long-term changes in primary production. Here, we present ongoing efforts to compile and expand datasets for primary production model development and testing. Further information is available on the PHOTOCLIM project website at www.photoclim.org.

Methods

We employ inverse modelling to extract photosynthesis parameters from in situ measurements of primary production profiles, by fitting the Kovač et al. (2016) analytical solution for normalized production at depth to the measured production profiles:

$$P_T^B(z) = P_m^B D \sum_{n=1}^{\infty} \frac{2(I_*^m e^{-Kz})^{2n-1} (2n-2)!!}{\pi (2n-1)! (2n-1)!!} - \sum_{n=1}^{\infty} \frac{(I_*^m e^{-Kz})^{2n} (2n-1)!!}{(2n)! (2n)!!}, \quad (1)$$

where $I_*^m = \alpha^B I_0^m / P_m^B$. We use the Levenberg–Marquardt algorithm constrained with the measured watercolumn production.

Time series of photosynthesis parameters

Here we show an example from the Hawaii Ocean Time Series (HOT) and the Bermuda Atlantic Time-series Study (BATS) programs. Both stations are over 30 years long and are now arguably the longest time series of photosynthesis parameters available globally. We are currently working on applying the same methodology to other time series stations which have in situ measurements of primary production.

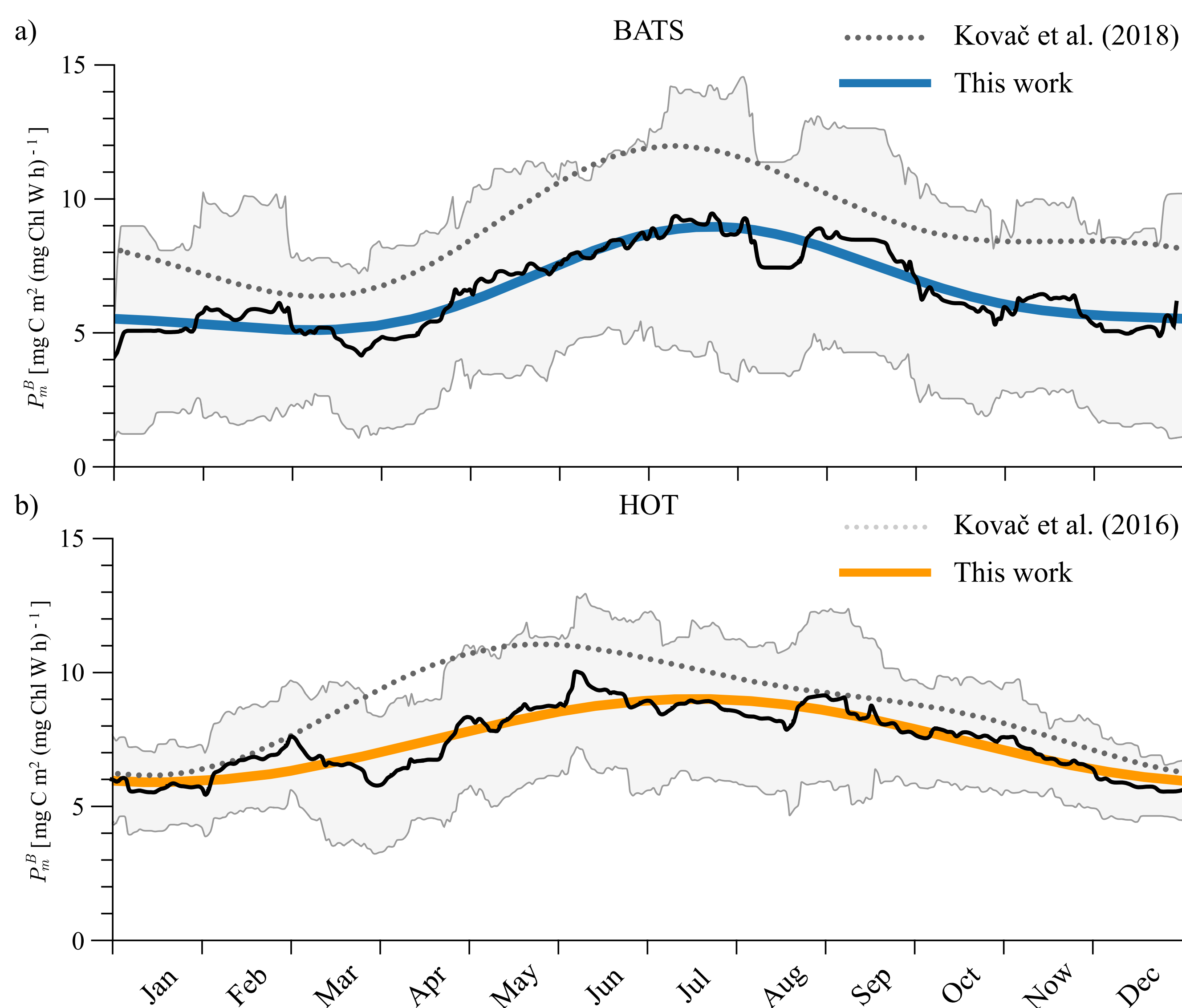


Figure 1: Seasonal cycle of the assimilation number at (a) BATS and (b) HOT. For each day of the year, the mean assimilation number is calculated using observations from all available years within a ± 15 -day window (black curves). A sum of two sine functions is fitted to these seasonal signals, shown in blue for BATS and orange for HOT. Earlier results based on time series that are 10 years shorter are shown as dotted grey lines: Kovač et al. (2018b) for BATS and Kovač et al. (2016b) for HOT. The grey shaded area represents ± 1 standard deviation around the mean seasonal cycle.

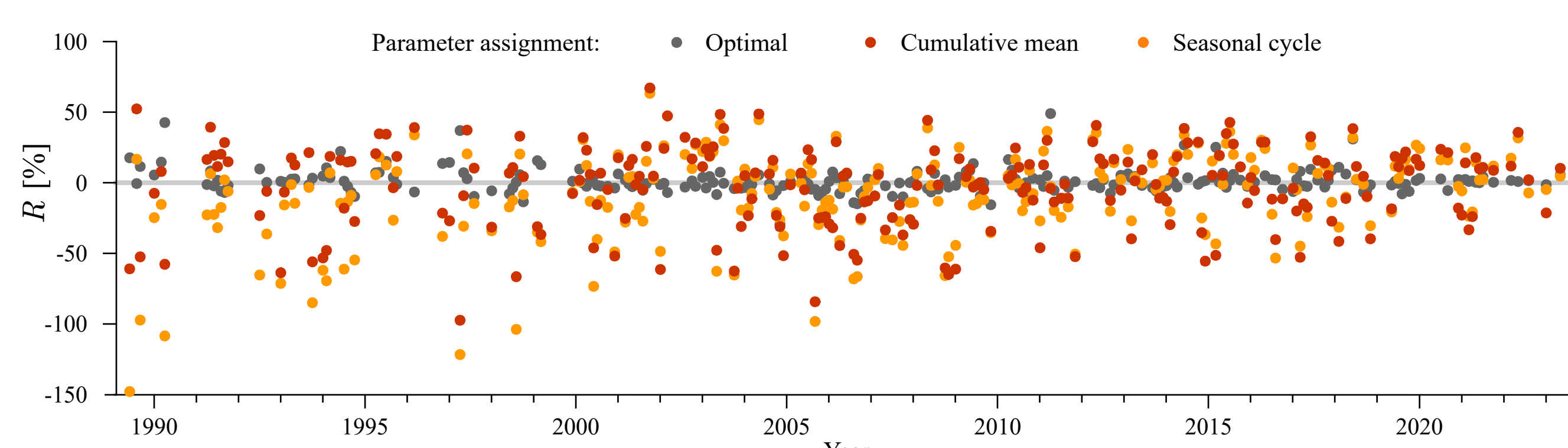


Figure 2: Relative model error in watercolumn production at HOT, expressed as a percentage, shown as a time series for different photosynthesis-parameter assignment approaches. Grey dots represent model runs with optimal parameters estimated for each cruise using the inverse method, red dots show models runs with cumulative mean parameters derived from all data available up to the respective cruise, and orange dots represent model runs with seasonal-cycle parameters estimated from the complete time series.

New global dataset of photosynthesis parameters

The Mattei & Scardi (2021) dataset contains 6084 chlorophyll and primary production profiles, comprising a total of 37722 individually paired measurements of chlorophyll concentration and primary production. The observations span the period from 1958 to 2017.

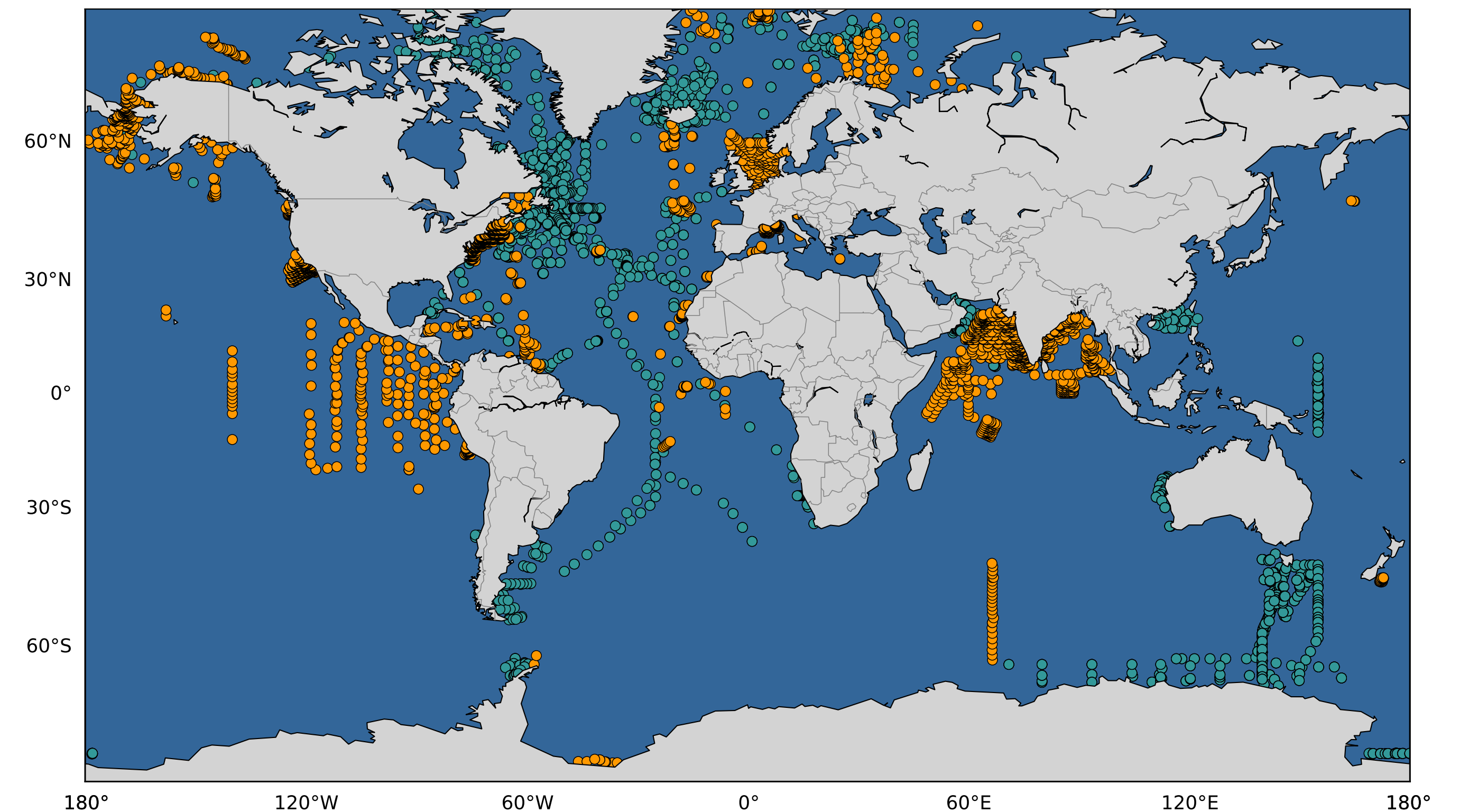


Figure 3: Map of the in situ production profiles from the Mattei & Scardi (2021) dataset (orange dots). Also shown are the published photosynthesis parameters compiled by Bouman et al. (2018) (green dots), which include 5711 globally distributed values collected between 1977 and 2013. The Mattei & Scardi (2021) dataset complements the Bouman et al. (2018) compilation by providing in situ production profiles from regions where photosynthesis parameters have not previously been reported.

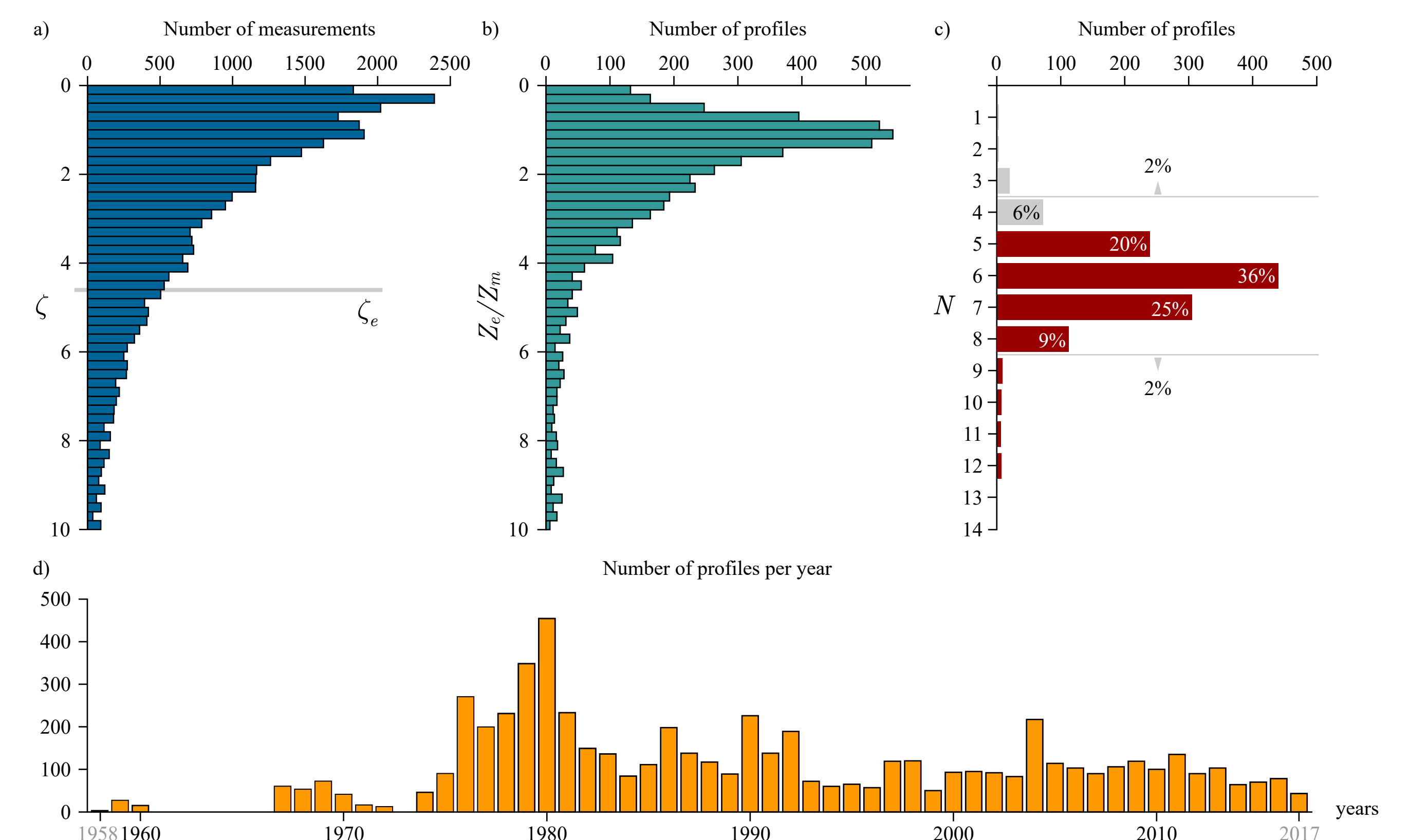


Figure 4: Distribution of auxiliary variables. (a) Histogram of measurement depths expressed as optical depth, with each individual measurement treated as one entry; the euphotic-zone depth, ζ_e , is indicated by the grey line. (b) Histogram of the ratio of euphotic depth to mixed-layer depth, with each profile treated as one entry. (c) Histogram of the number of measurement depths per profile; the grey arrows indicate that the percentages refer to all profiles below or above the grey line. (d) Time series showing number of globally measured primary production profiles annually.

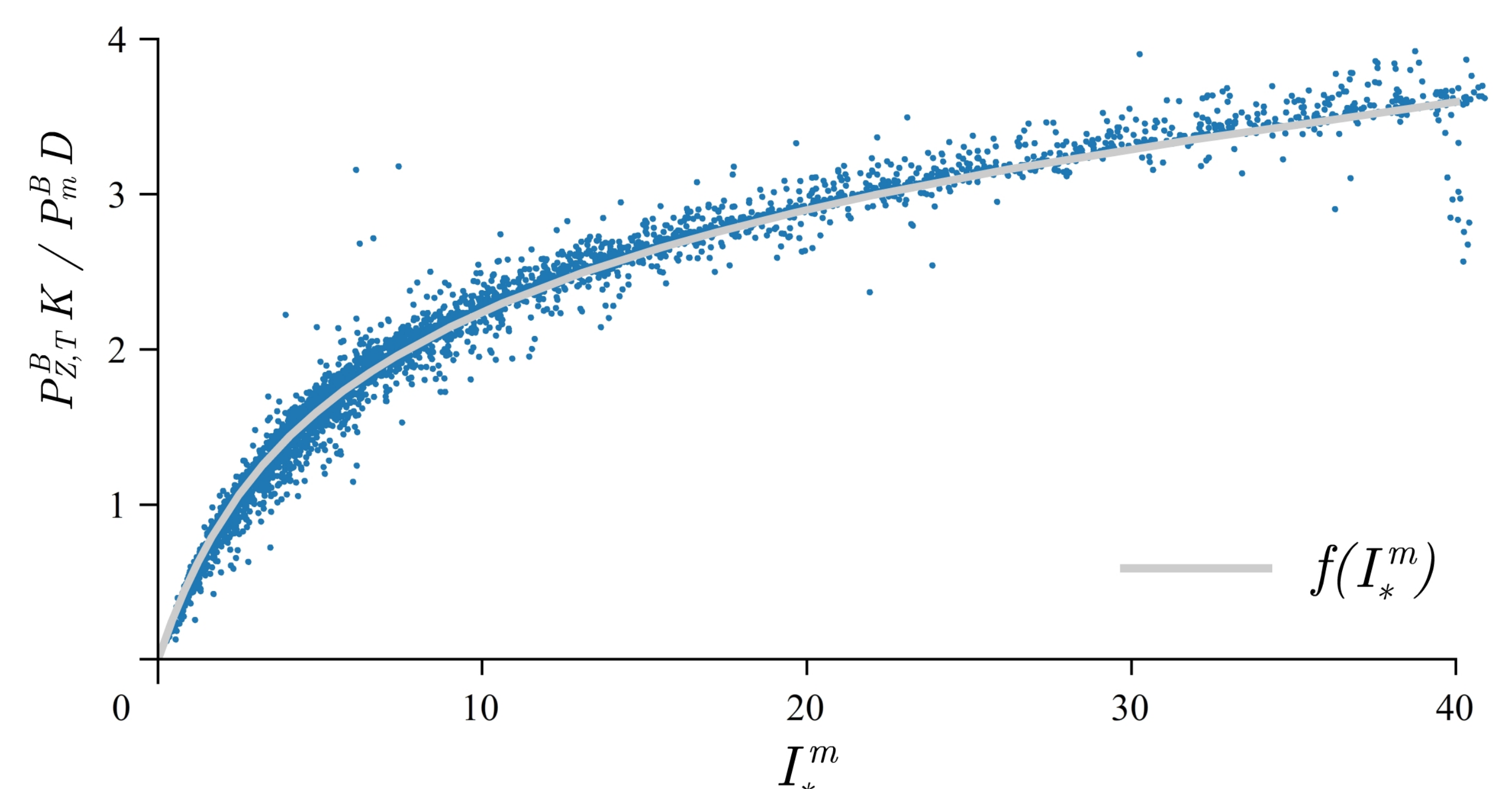


Figure 5: Comparison of measured normalised watercolumn production (blue points) versus the analytical solution for normalised daily watercolumn production by Platt et al. (1990) (solid grey curve). The abscissa represents the dimensionless noon irradiance I_*^m , while the ordinate gives the normalised watercolumn production divided by $P_m^B D / K$.

References

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