Towards analysis ready primary production data

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Introduction

Several initiatives have sought to consolidate primary production measurements into unified datasets. Recent examples include the global compilation of more than 6000 in situ profiles by Mattei & Scardi (2021), the photosynthesis parameter dataset of Bouman et al. (2018), and earlier influential archives produced by Trevor Platt and collaborators. Long-term time series from stations such as HOT, BATS, and CARIACO also provide essential data for model development and testing. Here, we report ongoing efforts to unify these resources within a single framework.

Inverse modelling procedure

Photosynthesis irradiance and photosynthesis depth experiments are two standard ways of experimentally quantifying primary production. With the inverse modelling procedure by Kovač et al. (2016) we can use in situ primary production profiles to estimate the values of photosynthesis parameters, as shown in Figure 1.

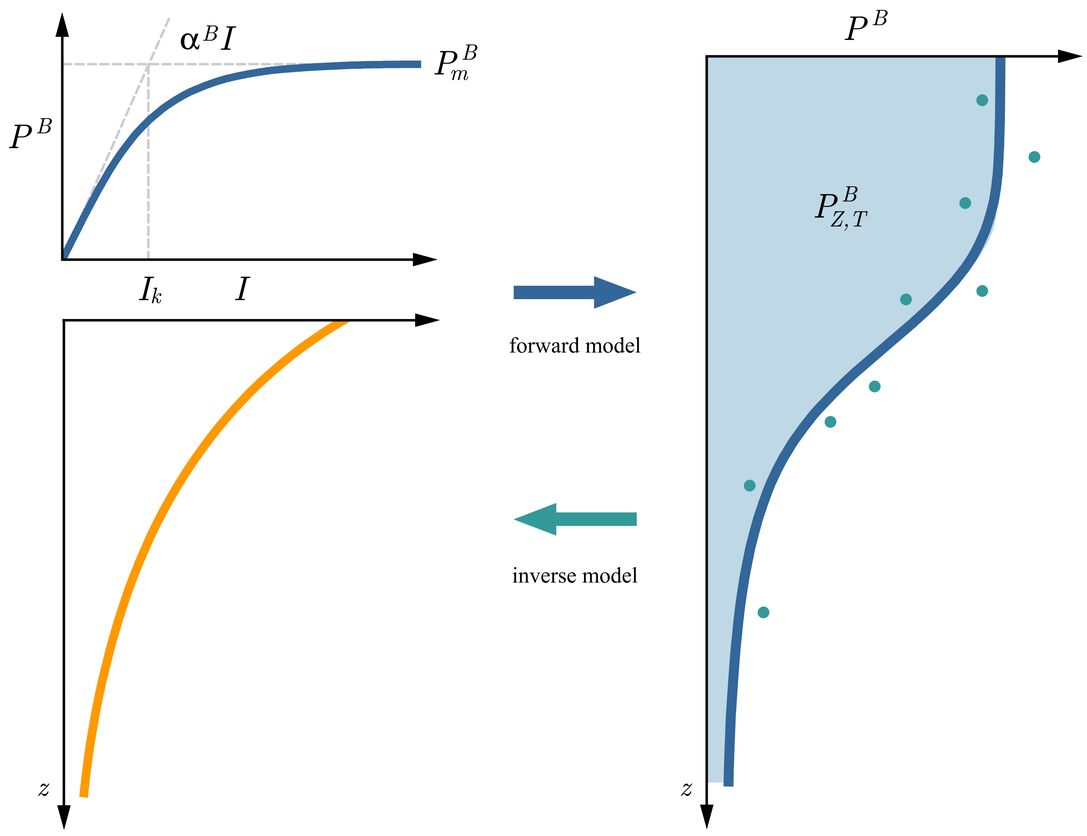

Figure 1: Graphical representation of the relation between the forward and inverse models. Both models are based on a functional relationship between production and light, expressed using photosynthesis irradiance functions (top left). These functions require information on the photosynthesis parameters: the initial slope α^B and the assimilation number P_m^B, which are typically estimated from in vitro photosynthesis irradiance experiments. With information on the biomass profile and underwater irradiance (orange curve, bottom left) a forward model calculates the daily production profile (blue curve on the right) and watercolumn production (blue surface on the right). An inverse model does the opposite. With an in situ measured production profile (green dots) an inverse model estimates the values of the photosynthesis parameters by minimizing the error between the model prediction (blue curve) and the measurements (green dots).

New global dataset of photosynthesis parameters

As part of our efforts to create easily accessible primary production data we are currently working on estimating photosynthesis parameters from a global dataset of in situ primary production profiles published by Mattei & Scardi (2021). Below are some metadata on the new global dataset which is now being developed.

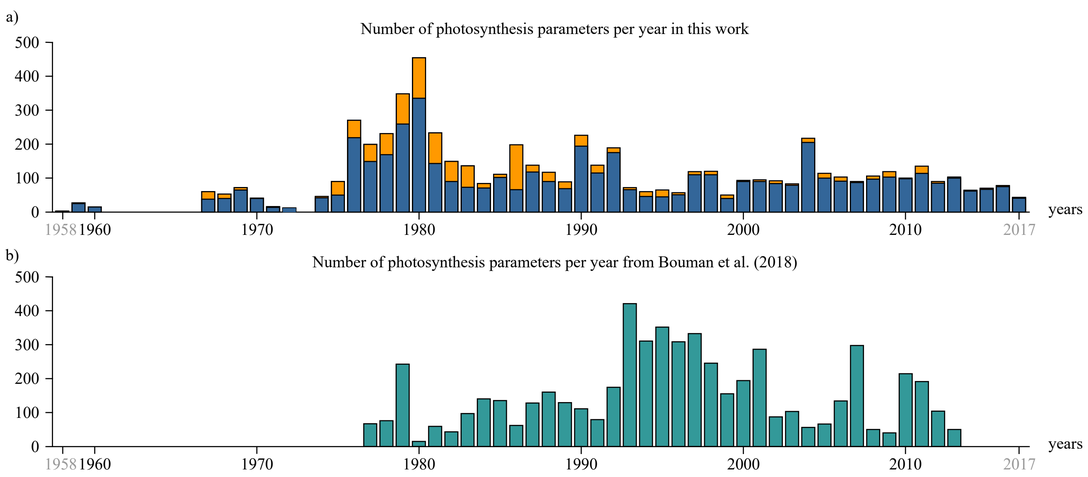

Figure 2: Time series of the global number of publicly available photosynthesis parameters. a) Parameter values estimated from in situ production profiles under natural light conditions estimated in this work. In blue is the number of successfully estimated photosynthesis parameters, whereas in orange is the number of available production profiles. b) Parameter values estimated from in vitro experiments under controlled light conditions, published by Bouman et al. (2018), given in green.

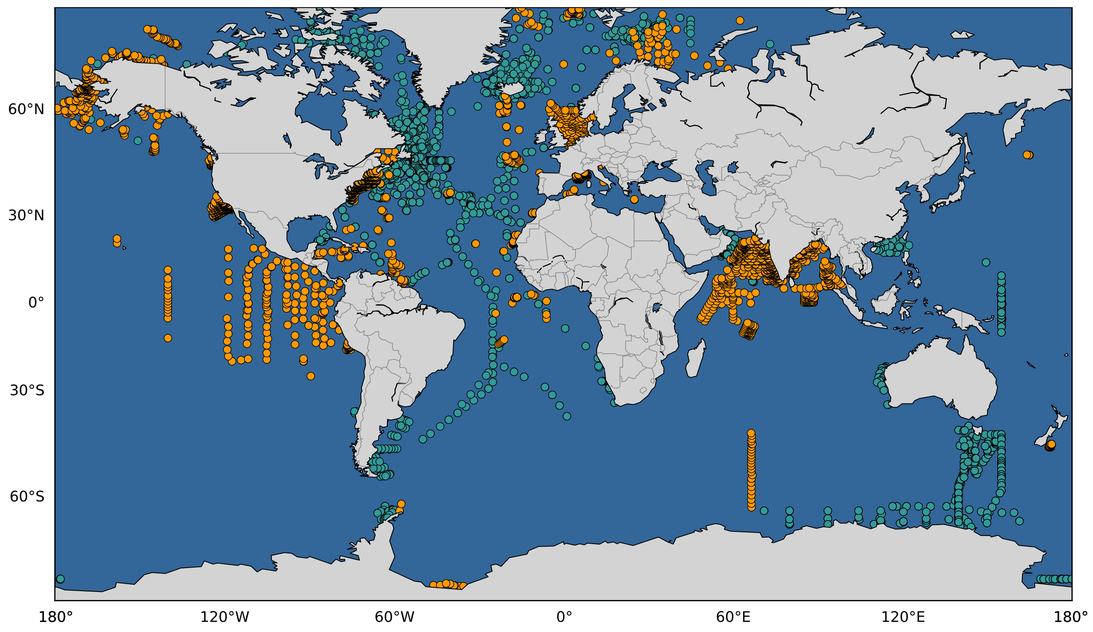

Figure 3: Map of the in situ production profiles from the Mattei & Scardi (2021) dataset (orange dots). In total there are 6 084 chlorophyll and production profiles in the dataset. Also shown is the published archive of photosynthesis parameters by Bouman et al. (2018), which contains 5 711 values of photosynthesis parameters globally in the time spam from 1977 to 2013 (green dots). The Mattei & Scardi (2021) dataset complements the Bouman et al. (2018) dataset by covering areas in which no photosynthesis parameters were published, creating an incentive for photosynthesis parameters estimation from in situ production profiles, which we are working on at present.

From the original in situ dataset containing 6084 primary production profiles, we were able to estimate 4160 pairs of photosynthesis parameters. The newly estimated parameters increase the global coverage of the existing photosynthesis parameters data in many parts of the world oceans where such data were sparse (Figure 3).

Examples of time series data

We have also accessed in situ primary production data from two time series stations: Hawaii Ocean Time Series (HOT) and Bermuda Atlantic Time Series (BATS). We are currently working on constructing time series data on photosynthesis parameters at these two stations, which are both well over 30 years long. This will enable the creation of two of the longest time series of photosynthesis parameters.

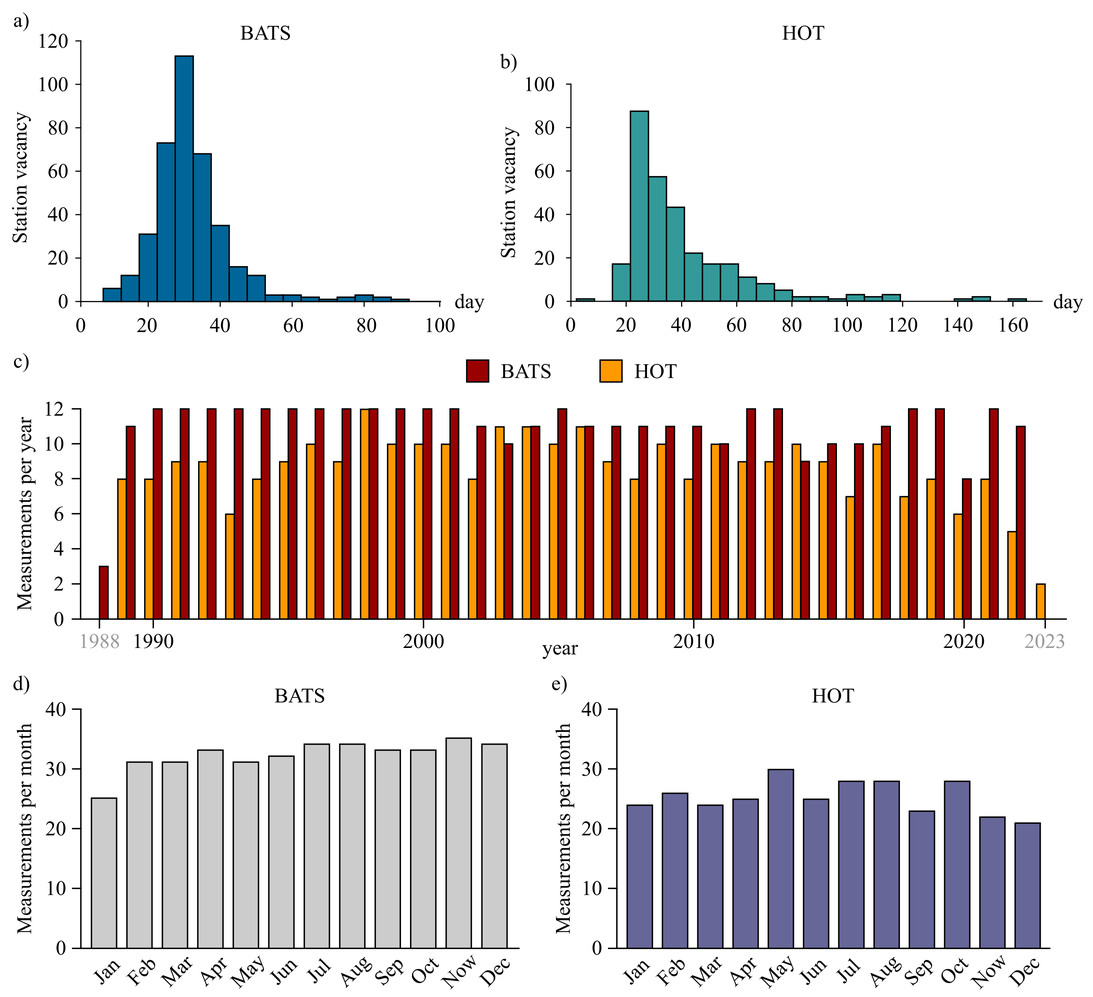

Figure 4: Analysis of available data at BATS (dark blue) and HOT (light blue) stations. Histogram of station vacancy for: a) BATS and b) HOT, calculated as the time between two consecutive visits to the station. c) Time series of the number of measurements per year for both stations. d) Number of measurements per month for BATS. e) Number of measurements per month for HOT.

References

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