Reconstructing in situ time series of primary production

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Introduction

Continuous in situ time series of primary production are a valuable resource for studying the response of primary production to climate change. However, such time series are scarce, numbering less than ten globally. Reasons for such a small number of time series is due to many factors, of which consistency in funding over decades is arguably the strongest constraint. Despite this, some of the time series are ongoing and are approaching length scales which are appropriate to study climate signals. However, data accessibility to these time series is a strong obstacle. Whilst some of the time series do have online interfaces which enable ease of access to data, others do not. Arguably, this significantly hampers their usage in oceanographic research, as considerable effort needs to go into obtaining such data. To address this issue and to facilitate ease of access to in situ time series of primary production we have started to collect such time series. The overall goal of this undertaking is to have a publicly available data base of in situ primary production time series complemented with all the statistical tools needed for data analysis. The statistical tools will be made available online along with the date sets.

The available time series

We have surveyed the literature and have found seven continuous time series of primary production with spans over 20 years. At each of these sites primary production is measured along with chlorophyll and other standard oceanographic parameters. These time series of primary production are listed below:

Station name	Time span	Location
Stončica	1962 - today	Adriatic sea
Kaštelanski zaljev	1962 - today	Adriatic sea
Bermuda Atlantic Time Series	1988 - today	Bermuda
Hawaii Ocean Time Series	1988 - today	Hawaii
Monterey Bay	1988 - today	California
La Coruña	1990 - 2016	Spain
Cariaco	1995 - 2017	Venezuela

At present we are working on collecting time series, as we still do not have access to all the above listed time series. We are also searching for more time series to put in the data base. In the literature there is also mention of 1148 annual time series from 483 locations worldwide and another 125 time series longer than 8 years with more than 10 measurements per year. If you are aware of more time series not listed here please contact zkovac@pmfst.hr in order to potentially add them to the data base.

Preliminary results

Here we show some preliminary results of parameter estimation for two stations: Hawaii Ocean Time Series and the Bermuda Atlantic Time Series. The parameters we estimated are used to describe the chlorophyll profile and the daily primary production profile. Both sets of parameters have a direct use in remote sensing applications as well as ecosystem models. Chlorophyll profile is described using the shifted Gaussian:

$$B(z) = B_0 + \frac{h}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(z-z_m)^2}{2\sigma^2}\right),$$

where B_0 is surface chlorophyll, z_m the depth of the deep chlorophyll maximum, σ the width of the deep chlorophyll maximum and $H = h/\sigma\sqrt{2\pi}$ is the height of the deep chlorophyll maximum. The daily production profile is described using:

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

where D is daylength, K the attenuation coefficient, α^B the initial slope and P_m^B the assimilation number. The results are shown on the figures to the right. The parameters were estimated for the entire duration of both time series and are given as histograms. We also plan to create time series of these parameters, something which was not done prior. Subsequently, time series analysis will be done on the raw data as well as the estimated parameters.

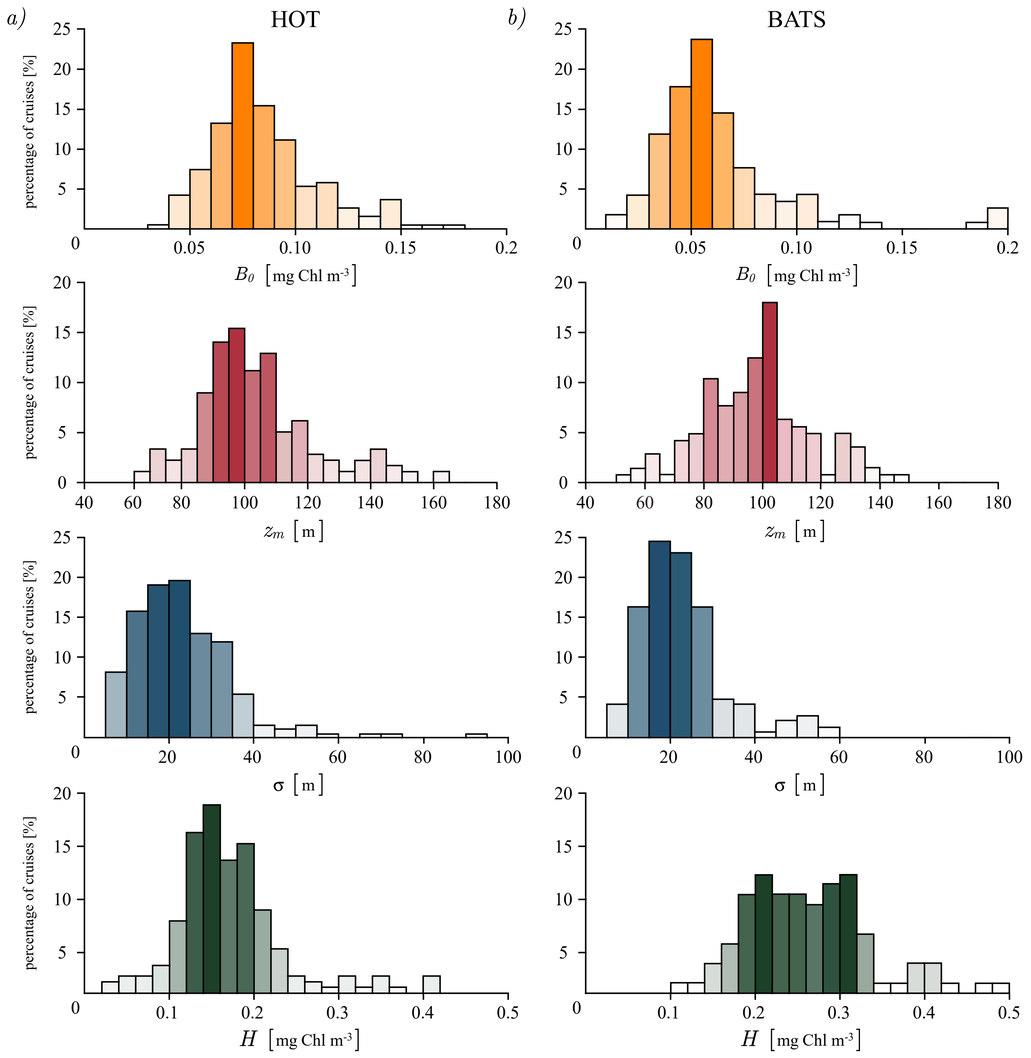

Figure 1: Histograms of parameters describing the chlorophyll profile at a) the Hawaii Ocean Time Series (HOT) and b) the Bermuda Atlantic Time Series (BATS). From top to bottom we have: surface chlorophyll B_0, depth of the deep chlorophyll maximum z_m, width of the deep chlorophyll maximum σ and height of the deep chlorophyll maximum H.

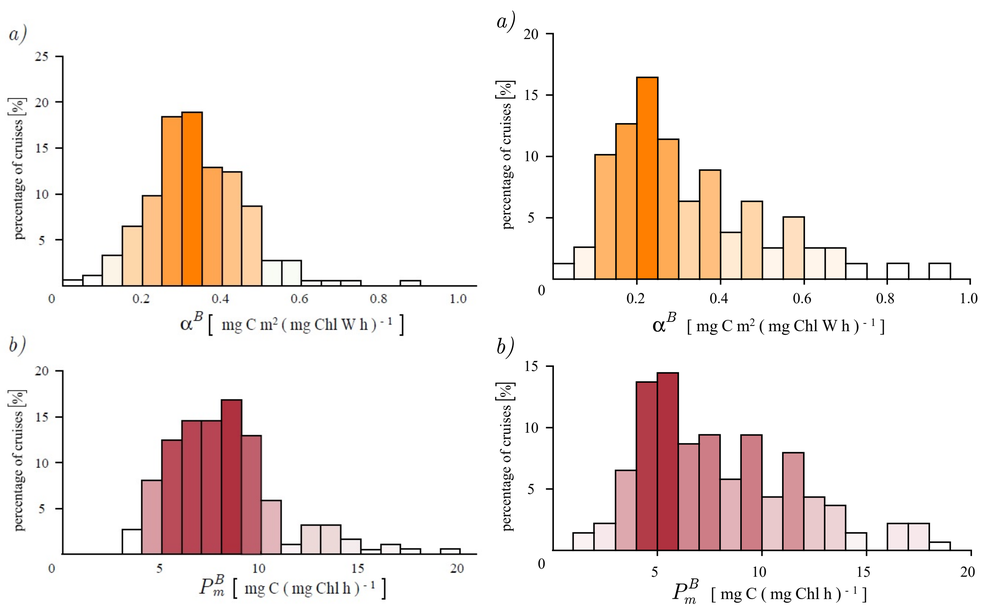

Figure 2: Histograms of parameters describing the daily primary production profile at a) the Hawaii Ocean Time Series (HOT) and b) the Bermuda Atlantic Time Series (BATS). From top to bottom we have: the initial slope α^B and the assimilation number P_m^B.

Planned work on open access notebooks

The overall goal of this project is to increase the usage of primary production time series. To facilitate data usage we are working on making data analysis tools for these time series publicly available. Such tools will include standard statistical analysis, as well as model-data comparison tools. At present we are coding the following notebooks:

1. Raw data display
2. Chlorophyll analysis
3. Primary production analysis
4. Model-data comparison

If you are interested please write an e-mail to zkovac@pmfst.hr to gain access to the notebooks for testing. Once the notebooks are finished and tested they will be made freely available online.