Dear Emmanuel Boss,

We would like to thank you for your valuable feedback and thoughtful comments on the manuscript. Your suggestions have significantly contributed to improving the clarity and quality of the work, and we sincerely appreciate the time and effort you dedicated to reviewing it.

Below, we provide responses to the reviewer's comments. The reviewer's comments are shown in black, and our responses are in blue. Paragraphs from the manuscript that have been either unchanged or modified in response to the reviewer's comments are indicated in italics. The manuscript line numbers corresponding to each comment are included in square brackets for easier reference. This new version will be uploaded into the system when permitted. Some excerpts from the text have been copied into the responses for clarity.

[Old version Line #00]

1) Title and Abstract

[Title] If you are interested in predicting budgets, how about the integrated POC through the euphotic depth? through the MLD?

→ We are not focused on integrating POC. The main objective of this manuscript is to estimate *bpp* using the information of the upper layers of the ocean surface from I deleSentinel-3 Ocean and Land Colour Instrument (S3OLCI) data at an enhanced full 300 m resolution. Previous studies using satellite data were conducted with GlobColour at a 4 km resolution. We use the Sentinel-3 OLCI and the GlobColour satellite products for comparison purposes.

1) **[Abstract, Line #2]** Most organic carbon in the ocean is dissolved, not particulate.

   → We have revised this sentence in the updated version of the manuscript.
   Old: *As the second largest carbon reservoir on Earth, the ocean regulates carbon balance through Particulate Organic Carbon (POC), which links surface biomass production, the deep ocean, and sedimentation.*
   Changed to: *While most organic carbon in the ocean is dissolved, Particulate Organic Carbon (POC) plays a crucial role -despite its smaller proportion- as it links surface biomass production with the deep ocean and sedimentation processes.*

2) **[Abstract, Line #3]** Not in the anthropogenic age. Over thousands of years, yes.

   → We have removed this sentence in the updated version of the manuscript.

3) **[Abstract, Line #4]** You write a lot about POC in the abstract but never actually compute POC in this paper.

   → Thank you for your comment. You are correct that we do not directly compute POC in this paper. Instead, we use *bpp* as a proxy for POC, which is explicitly mentioned throughout the abstract and the manuscript. We reinforce this objective in the introduction and abstract new versions. We would also like to clarify that the focus of the paper is not on POC itself but on presenting a methodology with broader applications. Mentions of POC are intended to show potential uses of the method.

2) Introduction

4) **[Line #21]** You find them where measured nutrients are below detection, and they divide daily (based on molecular clocks). Loss processes are as important as growth inducing ones in determining the phytoplankton, as nearly everyday the daily production is being consumed.
→ Thank you for your comment. We have revised this sentence in the updated version of the manuscript:
"*These organisms require carbon compounds, along with light and nutrients, to survive and reproduce (Fallkowski98[1], GlobalAssessment_2014). Their presence and abundance reflect the interplay of resources and losses in the environment (Behrenfeld et al., 200), with populations maintaining daily division cycles even in regions where nutrients appear to be depleted beyond detection limits (Ribalet et al., 2015; Vaulot and Marie, 1999). The observed populations represent a balance where new biomass produced each day is matched by consumption through grazing and other loss processes (Landry and Hassett, 1982; Calbet and Landry, 2004), maintaining relatively stable populations despite continuous growth and turnover*"

5) **[Line #26]** Most of the carbon in the ocean is in dissolved organic and inorganic forms of carbon, not particulate.
→We have removed this sentence in the updated version of the manuscript.

6) **[Line #28]** Not correct. In the current state of emission of CO2, one can model the ocean uptake w/o taking biology into account, simply from chemical/physical equilibration (e.g. works by Gaelan McKinley). Phytoplankton will be important once the physical/chemical equilibrium is reached, e.g. once we stopped increasing atmospheric CO2. Not the current situation, unfortunately
→ We have removed this sentence in the updated version of the manuscript.

7) **[Line #29]** Reliable depends on the application, e.g. what is the tolerance for uncertainties.
→ **We have rewritten this sentence:**
"Bio-optical sensors installed on autonomous platforms have become a ***valuable*** *technology for acquiring in situ data on the ecological and physical status of water masses."*
→ **We have included information about uncertainty in the bbp measurements:**
"However, float-based measurements of bbp have a known uncertainty on the order of 10–15% (Bisson,2015). These uncertainties stem from instrumental drift, sensor calibration limitations, and the reliance on manufacturer calibration files rather than sensor-specific calibrations using dark counts. While autonomous platforms provide extensive spatial and temporal coverage, these factors must be considered when interpreting bio-optical datasets to ensure accuracy and reliability."

[1] Throughout this document, bibliographic references are written in the LateX format. It will be corrected in the final version.

8) **[Line #32]** Again, what are the uncertainties involved? Does it work in coastal ocean and the deep ocean where rivers and sediment resuspension of inorganic particles contribute significantly to bbp? Or when PIC is significant?
→ This question is answered in item #7. There are no coastal or deep ocean measurements in the experiments. However, we acknowledge that significant PIC concentrations can occur in regions such as the North Atlantic.

9) **[Line #33]** They depend on size, shape, internal structure and composition
→ We are referring to the water composition, not the phytoplankton

10) **[Line #35]** You are missing inelastic scattering.
→ We have rewritten this sentence in the updated version of the manuscript.
Old: These properties include absorption, scattering, and attenuation processes, which describe how light behaves and propagates through water
Changed to: "*These properties include absorption, elastic scattering, inelastic processes (such as fluorescence and Raman scattering), and attenuation, which describe how light behaves and propagates through water.*"

11) **[Line #37]** To a large degree, AOPs are only weakly dependent on light geometry.
→ The reference was taken from the Ocean Optics Web Book:
"Apparent optical properties are those properties that (1) depend both on the medium (the IOPs) and on the geometric (directional) structure of the radiance distribution, and that (2) display enough regular features and stability to be useful descriptors of a water body."
→ In the new version, we have removed the sentence.

12) **[Line #62]** The uncertainty is limited to the data available. ML does a poor job extrapolating to conditions not available in the training set.
→ Like any regression method, their performance depends on the coverage of the domain and quality of the training data. Uncertainties coming from the data and model itself are expected in fitting models, but the average uncertainty can be calculated using standard error model evaluation metrics, which are applied on the training and test data. We have changed this sentence in the manuscript for better clarification.

"This approach includes additional Sea Level Anomaly (SLA) with information about sub-mesoscale processes; it replaces satellite-derived products (bbp and chl-a) by simple reflectances at several wavelengths and explores machine learning-based techniques that are efficient at estimating retrievals, in addition to quantifying the uncertainty associated with the outputs, within the range of data on which the models have been trained. A significant improvement in the bbp predictions was revealed, especially near the surface layers."

13) **[Line #64]** How do you deal with the fact that bbp form floats and satellite often have significant deviations from each other (e.g. Bisson's paper)?
→ The methodology does not rely on satellite bbp retrievals as inputs. Instead, the model implicitly accounts for any discrepancies by learning the optimal function that

relates float-based bbp to the available satellite reflectances and derived IOP products.

14) **[Line #70]** These IOPs are inverted from reflectance. They do not have more information than what is available in reflectance. Here you suggest that they are somehow independent. As far as I know they are not.

→ IOPS from C2RCC are a Neural Network product. The IOPs used in the model were partly measured in situ (SIOPs), partly simulated with a bio-optical model (Hydrolight, Mobley 1994). Inelastic scattering was not included, but chl fluorescence is considered. First IOPS are inverted from the estimated reflectance, and later, there is a forward model to compute reflectance from IOPS and flag those reflectance that are out-of-scope. Our approach with the NN is that, although this derived data is not fully independent, the ability of the NN's to model non-linear relationships and the training in a big dataset of simulations may provide (or not) an improvement if compared with analytical or semi-analytical inversion models. Moreover, although the information is embedded in reflectance, derived features can help the model to handle the information efficiently, avoiding colinearities and other inherent characteristics of reflectance.

15) **[Line #71]** Not clear: do you mean the integrated POC per m^2 for the top 50 and top 250m of the ocean?
→ We do not integrate POC. We estimate the bbp at different depths.

2.1) Study Area

16) **[Line #80]** There is relatively little BGC-Argo data in the subtropical gyres, which makes training an ML for these regions relatively hard.
→ We are aware of that and that our dataset is not up-to-date. However, the dataset we used allows us to compare with previous studies.

17) **[Line #80]** What are 'differentiated trophic states'? How different is the vertically integrated POC between these environments?
→ We have modified the phrase**:**
"*These two areas exhibit distinct seasonal patterns throughout the year, experiencing significant differences in terms of nutrients, light availability, minimum and maximum temperature regimes, mixed layer depth (MLD) variations, thermocline levels, and mesoscale dynamics*"

18) **[Line #85]** Note that bbp has been found to also be a useful proxy of phytoplankton biomass in the upper ocean, one that does not suffer from photo-acclimation (e.g. works by Behrenfeld, Graff and Martinez-Vicente, Quu). Ignoring these work is not a good strategy for a study that wants to be taken seriously.
→ We acknowledge that our initial version did not sufficiently emphasise the relationship between bbp and phytoplankton biomass. To address this, we have added a dedicated paragraph in the **Introduction**, explicitly discussing the advantages of using bbp as a proxy for phytoplankton biomass compared to chl-a.

This revision ensures that the connection between bbp and phytoplankton is established in the introduction, but we still keep the 2.1 section focused solely on the study area description:

"Quantifying phytoplankton biomass and carbon content is crucial to understanding these ecosystem dynamics and their role in carbon cycling. Traditionally, chlorophyll-a (chl-a) concentration has been used as a proxy for phytoplankton biomass, but its interpretation is complicated by physiological photoacclimation, which affects intracellular pigment content without necessarily indicating changes in biomass. The Particulate Backscattering Coefficient (bbp) has been recognized as a stable optical proxy for phytoplankton biomass and carbon content (Martinez-Vicente_2013, Behrenfeld_2006, Graff_2015), as it is sensitive to the abundance, size distribution, and composition of suspended particles rather than pigment concentration alone. Unlike chl-a, which can underestimate biomass in stratified and oligotrophic waters, bbp remains relatively unaffected by photoacclimation effects, making it particularly useful for studying carbon fluxes across different oceanic regions and depth layers."

19) **[Line #86]** There is sustained surface production in all regions of the ocean (except extreme high latitudes during polar night), even when nutrient levels are undetectable.

→ The idea here is to remark on the differences between those two study areas, not the similarities. We can say something about it, but also about species or sizes and how important this is for a balanced food chain and conservation of ecosystems.

20) **[Line #88]** Yet molecular clocks show that the cells there divide daily. How come? And when you integrate vertically the biomass, the values are not orders of magnitude less than in the productive NA.

→We do not have integrated bbp in this experiment.

2.2) BGC-Argo Data

21) **[Line #103]** Most floats have significantly poorer vertical resolution.

"The BGC-Argo floats usually collect measurements from 1,000 m to the surface, with a depth resolution of ~1 meter, every 10 days."

We utilized a dataset prepared by Dr. Sauzéde, which has been featured in previous publications.This dataset includes floats from amol, bodc, coriolis, csiro and incois, not only French floats. The bbp profiles have been linearly interpolated onto the fixed output depths of retrieval, making the resolution homogeneous across all floats. We have also included this description in the manuscript.

22) **[Line #104]** This definition of the euphotic depth is useless. Phytoplankton care about absolute photon flux, not the relative one (e.g. Sverdrup, 1943, Behrenfeld and Boss, 2017). Recent studies using BGC-Argo suggest phytoplankton can grow at

extremely low light levels of light, e.g. https://www.science.org/doi/10.1126/sciadv.abc2678

→ We considered following an approach that focuses on the optical properties of the water column as a physical phenomenon rather than on biological responses to light availability, although we derive bbp. We think a light-field-based definition provides a consistent boundary for analysing water column dynamics in the two regions and allows standardised comparisons across our datasets. However, we have included references addressing phytoplankton growth under varying or low light conditions to acknowledge the biological importance of absolute light levels.

23) **[Line #107]** The flux of sinking carbon…Not in this day an age. Read papers by biogeochemists such as McKinley and Gruber.

→ We have removed this sentence.

24) **[Line #108]** Describe to the readers why spiciness is important and what it is. Most do not know it.

→ Thank you for pointing this out. We have added a description of spiciness in the revised version **:**.

"Spiciness reflects density-compensated variations in temperature and salinity, providing a tracer for water mass origins and mixing processes (Smith_2009). Since particle concentrations and optical properties often differ between water masses, spiciness anomalies can be associated with variations in the bbp. Warmer and saltier waters (higher spiciness) can enhance stratification, reducing vertical nutrient fluxes and potentially limiting biological production, leading to lower concentrations of organic particulate matter and thus lower bbp."

2.3) BGC-Argo and Satellite Match-up Databases

25) **[Line #111]** Not from all the BGC-floats. Are you only using the French ones?

→ We have floats from aoml, bodc, coriolis, csiro and in, not only French floats. See #21.

26) **[Line #119]** Your keeping 3 points after the decimal suggest your uncertainty is on the order of 0.1%. In fact, it is likely larger than 10% (bbp estimation)

→ The methodology was taken from the SOCA2020 method, and the processing is explained in Sauzède et al. (2016, 2020). These values come from it.

27) **[Line #126]** Are you using all available BGC-Argo float with bbp or only the French ones which have more vertical resolution? If you are using all of them, how do you change resolution?

→ We used a dataset that was prepared by Dr. Sauzéde and used in previous publications. This dataset includes floats from amol, bodc, coriolis, csiro and incois, not only French floats. See #21.

28) **[Line #133]** How will it change if you used more stringent criteria, such as those of Bailey and Werdell (5km, 3hrs)? BBp is observed to have diel cycles in many places in the ocean, and using all measurements may introduce bias.

→ Initially, our database also considered a 5-day window, and reducing the time constraint to 24 hours decreased the dataset from 4,115 to 763 samples. Given this significant reduction, further tightening the time criteria would compromise the dataset even further, making it challenging to maintain a sufficient number of samples for model training.

29) [**Line #138]** How far do you expect a water parcel in the ocean will move in 24hrs (typical ocean currents are ~10cm/s).
→ It will depend on the position of the float, on the horizontal currents in the area, on the wind intensity, and on latitude - to take into account other effects (e.g Ekmann spiral, geostrophic currents, etc.).

30) [**Line #139]** Once the match-up between satellite and float is performed…what does it mean?
→Modified to:
"*Once the match-up between satellite and float is established, a baseline quality control is applied to ensure that the satellite-measured reflectances are not affected by sensor noise or transient atmospheric disturbances, maintaining radiometric consistency"*

31) **[Table 1]** Why use only PAR at the surface? What about the euphotic depth (as determine from an isolume)? Wouldn't you think subsurface light matters?
→ PAR comes from satellite observations (GlobColour), not from floats (Table 1). The main idea behind SOCA is to only use Argo (T/S) floats. Because SOCA does not integrate float parameters as inputs because the application is independent from BGC-Argo floats and only uses satellite + Argo (T/S data). If we use the euphotic depth determined from the float, it severely restricts the applications.

32) **[Line #141]** Are you log transforming some of the measurements?
→Yes, we apply a base-10 logarithmic transformation to the bbp to reduce data skewness and improve algorithm performance. All metrics and plots are subsequently transformed back to the original linear scale from log space. It is properly described in the data section.

33) **[Line #145]** This is very little data. Are you sure you used all that is available in those waters? You could have also used the Med where there is the most data and coverage.
→ We are using data of opportunity. Using the same dataset as in another published work allows us to compare results properly. We could plan to add more data from other regions, and we would be happy to do it if something is already available in a new project.

34) [**Line #156**] Are the IOPs derived from the reflectance data? If the answer is yes, how can they provide independent information the the ML?
→ Explained in item #14

3.1.1) Shallow waters: from 0 to 50 meters depth

35) [Line #224] R^2 a good metric? It is typically very influenced by the dynamic range of the variables involved and provide no information on goodness of fit.

→ R2 is not a good metric by itself, but we also calculated MAE (Mean Absolute Error) and MAPD (Median Absolute Percentage Deviation). R2 is also used profusely within both the OC and the ML communities. To complete the overview, we have added the bias and the relative error on the profiles and the Median Absolute Percentage Deviation (MAPD) in statistics in Table 3-4, Figure 3 (50m depth, S3OLCIBGC and GCGOBGC), Figure 5 (250m depth, S3OLCIBGC and GCGOBGC) and Figure 7 (250m depth, S3OLCI and S3IOPS).

Table 3. Statistics by region at 50 m and 250 m depth models with satellite and BGC-Argo. Median Absolute Percentage Deviation (MAPD) is expressed in % and Mean Absolute Error (MAE) in m^{-1}.

Depth	Region		GCGOBGC	S3OLCIBGC	S3IOPs	S3OLCI
50 m	North Atlantic	R^2	0.72	0.78	0.74	0.77
		MAPD	8.19	10.77	13.46	12.96
		MAE ($\times 10^{-4}$)	3.11	2.86	3.04	2.89
	Subtropical Gyres	R^2	0.87	0.86	0.88	0.84
		MAPD	5.60	5.54	5.61	5.56
		MAE ($\times 10^{-5}$)	4.16	4.50	4.39	4.81
250 m	North Atlantic	R^2	0.84	0.81	0.80	0.80
		MAPD	3.37	5.24	6.38	6.18
		MAE ($\times 10^{-4}$)	0.85	1.02	1.12	1.09
	Subtropical Gyres	R^2	0.90	0.89	0.88	0.88
		MAPD	4.97	5.36	5.98	5.47
		MAE ($\times 10^{-5}$)	3.19	3.46	3.74	3.74

Table 4. Validation with independent floats by region at 50 m and 250 m depth models with satellite and BGC-Argo data. MAPD is expressed in %, MSE and RMSE in m^{-1}.

Depth	Region		GCGOBGC	S3OLCIBGC	S3IOPs	S3OLCI
50 m	North Atlantic	R^2	0.26	0.44	0.44	0.41
		MAPD	38.48	33.74	27.96	32.5
		MAE $\times 10^{-4}$	7.00	5.91	5.61	5.67
		RMSE $\times 10^{-4}$	9.05	7.38	7.05	7.13
	Subtropical Gyres	R^2	0.65	0.63	0.64	0.63
		MAPD	5.06	4.90	5.69	5.99
		MAE $\times 10^{-5}$	2.93	3.08	3.09	3.12
		RMSE $\times 10^{-5}$	3.60	3.73	3.67	3.73
250 m	North Atlantic	R^2	0.32	0.31	0.29	0.29
		MAPD	6.56	6.38	6.41	6.37
		MAE $\times 10^{-4}$	7.50	7.68	7.44	7.47
		RMSE $\times 10^{-4}$	10.4	10.5	10.6	10.7
	Subtropical Gyres	R^2	0.58	0.53	0.54	0.56
		MAPD	7.38	8.34	8.28	8.06
		MAE $\times 10^{-5}$	3.88	4.19	4.18	4.02
		RMSE $\times 10^{-5}$	4.92	5.32	5.34	5.13

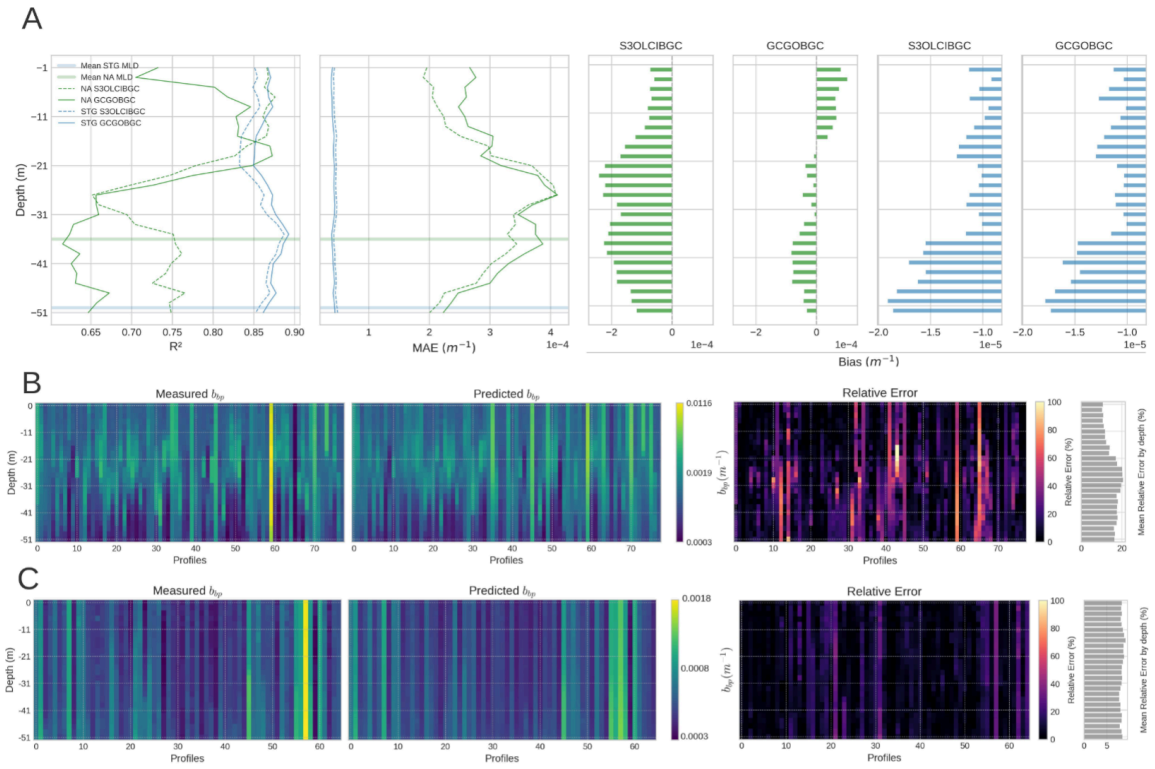

Figure 3. Model performance for estimating shallow water b_{bp} profiles (0–50 m). **(A)** Depth-resolved metrics comparing model predictions using S3OLCIBGC and GCGOBGC as inputs: Coefficient of determination (R^2), Mean Absolute Error (MAE), and bias. Shaded horizontal lines indicate the average Mixed Layer Depth (MLD) per region. **(B -C)** Measured and predicted b_{bp} profiles in NA (B) and STG (C) using S3OLCIBGC. The rightmost bars show the mean relative error by depth.

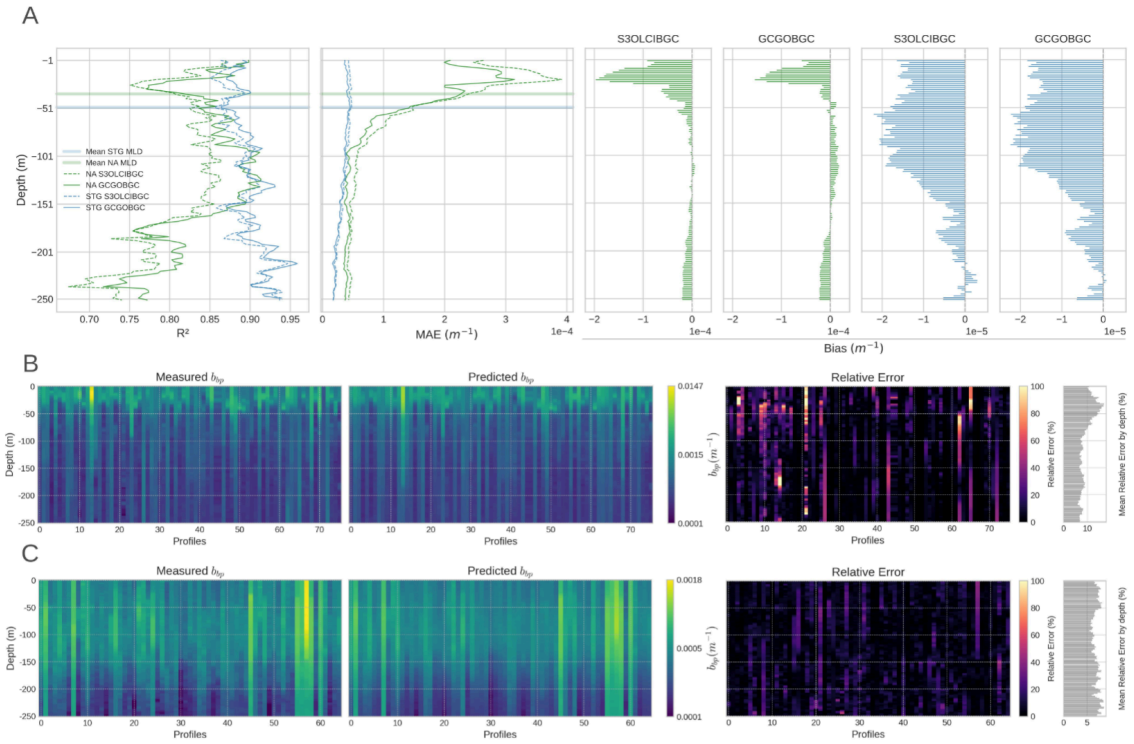

Figure 5. Model performance for estimating deep water b_{bp} profiles (0–250 m). **(A)** Depth-resolved metrics comparing model predictions using S3OLCIBGC and GCGOBGC as inputs: Coefficient of determination (R^2), Mean Absolute Error (MAE), and bias. Shaded horizontal lines indicate the average Mixed Layer Depth (MLD) per region. **(B -C)** Measured and predicted b_{bp} profiles in NA (B) and STG (C) using S3OLCIBGC. The rightmost bars show the mean relative error by depth.

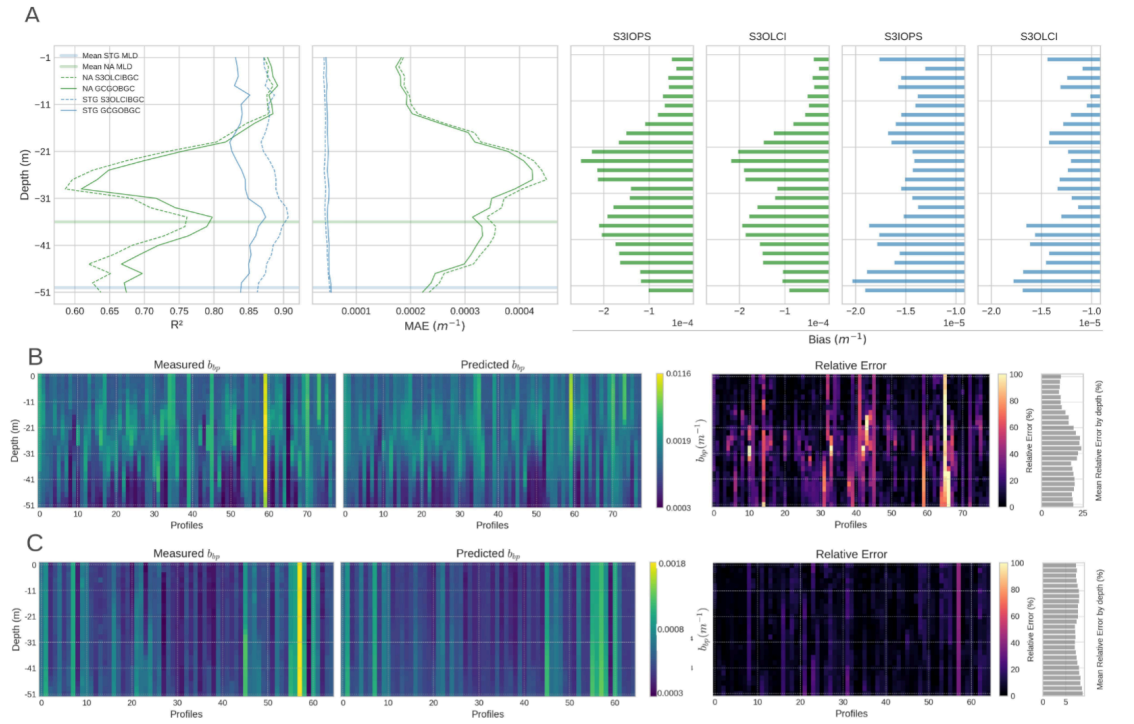

Figure 7. Model performance for estimating shallow water b_{bp} profiles (0–50 m) with only satellite data. **(A)** Depth-resolved metrics comparing model predictions using S3OLCI and S3IOPS as inputs: Coefficient of determination (R^2), Mean Absolute Error (MAE), and bias. Shaded horizontal lines indicate the average Mixed Layer Depth (MLD) per region. **(B-C)** Measured and predicted b_{bp} profiles in NA (B) and STG (C) using S3OLCI. The rightmost bars show the mean relative error by depth.

36) **[Line #224]** Are three points after the decimal significant?

→ The interesting thing is to look at the values at different depth layers in Figure 2 and see how the models behave differently at different depths due to the different inputs, although the general metrics are pretty similar.

37) [**Line #233**] What do you mean by 'good quality'. Can you quantify it?

→ We are using the statistics derived from the test/validation, and based on that (coefficients and errors), we can say that the information provided adds value to the results. We have replaced “good quality” with the word “meaningful”. We hope this in fine.

38) **[Line #237]** This is the value at the surface. Since you are deriving a vertical profile it may have limiting information w/o more about the vertical attenuation of the light.

→ Sure. The research aims to determine if ML algorithms can use surface optical information, together with information about non-optical parameters, such as salinity, density, temperature, and spiciness, to derive in-depth optical properties up to a specific depth. Also, to evaluate the algorithm level of importance of the surface reflectance for estimating bbp at the two different depths.

39) **[Line #241]** Here you are speculating. These assertion can be tested, e.g. by providing seasonality. DOY with latitude is directly linked to daily PAR and solar zenith angle.

→We think we are not speculating, as the seasonality of phytoplankton in NA is well known. We have included some bibliographic references to support this hypothesis about why this feature is relevant for the model **[Line 263 - 265]**:

“The feature DOY, which accounts for the temporal component, reflects the seasonality that affects phytoplankton cycles and, consequently, the POC dynamics in these regions. This seasonality has been studied in various works, such as Honjo_1993 and Sanders_2014”

40) **[Figure 2]** Can you also provide the relative errors? Units? The average reader will not know how to read your plots. There are no units anywhere (e.g. m^-1).

→Thanks for pointing it out. We have changed the violin plot to depth-resolved model bias, providing the values in bbp units. We have also included the units in the profiles and an additional plot for depth-resolved relative errors.

See response #35 for tables and figures.

41) **[Line #245]** Do you mean the maximal surface biomass? The maximal vertically integrated biomass?

Modified to:

“The maximum mixed layer phytoplankton biomass usually occurs from June to August, coinciding with higher water temperatures (Yang2020)”

42) [Line #255] Are vertical gradients in R^2 the same as vertical gradients in bbp?

→ Vertical gradients in R^2 for the NA region are correlated with the increase of the errors with depth. It can be observed in the new figures, which are included in response #35. Right bar plots show the mean relative errors with depth.

43) [Line #263] is high biomass a sign of a better ecology? What is the meaning of this value judgement? Based on it a trophic outflow of a river laden with chemicals from aquaculture is the best ecology.

→ Our intention was not to imply a value judgement about ecosystem quality or health. We referred to "more favourable ecological conditions for phytoplankton" specifically in the context of conditions that support higher phytoplankton growth (e.g., due to nutrient input from upwelling or water mass divergence), not as an indication of overall ecological integrity. To avoid confusion, we have rephrased this sentence for clarity:

"At the edges of the gyres—near eastern and western boundary currents, subpolar and equatorial regions—nutrient-rich waters are often introduced by divergence and upwelling, creating conditions that are more favorable for phytoplankton growth"

44) Figure 3 too small

→ We have changed it for a better visualisation, and we use distinct colours for the different types of features in the new version.

Figure 4. Feature importance for the models trained with S3OLCIBGC and GCGOBGC to estimate bbp in shallow waters (0–50 m) in the NA and STG. Features are grouped by category according to colour: (1) blue represent spatial and temporal descriptors, including day of year (doy), latitude, and longitude;

(2) dark blue represents sea level anomaly (SLA); (3) purple indicates Mixed Layer Depth (MLD); (4) green corresponds to satellite reflectance bands from either Sentinel-3 OLCI or GlobColour with their central wavelengths; and (5) pink, red, orange, and light purple correspond to the first five principal components (PCs) derived from BGC-Argo profiles of density, temperature, salinity, and spiciness, respectively.

3.1.2 Deep waters: from 0 to 250 meters depth

45) [Line #273] Aren't they also dynamic in the STGs?
→ We are just trying to describe the NA observations.

46) [Line #274 - #297]I thought the MLD is dynamic and changes throughout the year, even more so in the NA.
→MLD is dynamic, but in our observations, the mean depth for the MLD was 30 m. We have pointed out this information in the new version to avoid misunderstandings.

"A decrease in accuracy is observed around 30 meters, coinciding with the average MLD observed in our dataset (Figure (A)). While the MLD is inherently dynamic and varies throughout the year, this mean depth represents a critical boundary in our observations"

47) [Line #278] You keep mixing opinions and results. Separate your discussion from results so it is clearer to the reader what you
→We have removed our interpretation of the results in this section.

48) [Line #281] I thought SLA reflects horizontal changes in properties, e.g. eddies.
→This feature is not discussed in the new results, as we focus in greater detail on other, more relevant features

49) [Line #285] (STG) I thought the water column was highly stratified there, or is it that while the water is stratified bbp is more homogeneous, as was seen in Kitchen and Zaneveld 1990 from beam attenuation.
→ We have changed this sentence according to the comments:
"*In the STG region, model performance exceeds that of the North Atlantic, likely due to the more optically homogeneous conditions despite the strongly stratified nature of these oligotrophic waters (Figure 5C). Similar patterns have been observed in stratified waters, where optical properties like beam attenuation remain relatively homogeneous (Kitchen_1990).*

50) [Line #287] In many regions the relative increase in actual biomass is minimal, see Kitchen and Zaneveld 1990. The relative change with depth < 10%. What kind of relative changes do you see in bbp/POC?
→ We have changed this sentence according to the comments.

51) [Line #291] Look at integrated bbp. You be surprised to find they are much less different than you think based on surface bbp values.
→ This is fact good news since it supports the validity of the surface estimation of bbp when trying also to understand what is happening in depth.

3.2 S3OLCI: results of Sentinel-3 OLCI without BGC-ARGO data

52) [Line #297] Is this any surprise?
→Not really, we are just describing the results.

53) [Line #302] Is this significant? Again, if the IOP source is reflectance one would expect no difference…
→ IOPs are not directly derived from reflectance. See response #14 for more details.

54) [Line #312] Again, please separate results from discussion/speculations for easier reading.
→ We have removed our interpretation of the results.

55) [Figure 6] Interesting that the distribution of measured has a single peak while the predicted has two.

→ The bimodality in predicted bbp probably reflects the limited representation of transition values in the training data.

56) [Figure 6] Will be useful to have RMSE stats as well as MSE.

→ We have added new statistics to complete the overview. New tables and figures are in response #35.

57) [Line #332] Is it true in a relative sense as well? Also, based on Fig. 6 the histogram of distributions seems better for NA while that for predicted STG is bi-modal a feature not seen in the measured data.

→ We have included MAPD (Median Absolute Percentage Deviation) to have relative references. See response in item #35.

58) [Table 4] You have not defined MAE anywhere (I assume it is the mean absolute error but I may be wrong as it has no units here).

→ Thanks for pointing it out. It is defined now, together with other statistics used.

59) [Table 4] Please add RMSE and keep only significant units. Provide the units to the data that has units.

→ Thank you for pointing it. It has been included together with Median Absolute Percentage Deviation (MAPD), depth-resolved bias plots, and Mean Absolute Error (MAE). See response in item #35 with the modified tables and figures as suggested.

60) [Line #340] Are ML model not empirical?

→ Yes, they are considered empirical if we understand them as data-driven approaches. However, we refer here to classical/traditional statistical methods such as univariate t-test, ANOVA, Pearson's and Spearman correlation, linear regression, etc. We have clarified it in the manuscript.

61) **[Line #355]** How do you explain the fact that surface populations are observed to divide at near maximal rates in those waters?

→ We would prefer not to speculate. We would be grateful if you could help us with this explanation.

62) **[Line #360]** That was in the predicted data, not the measured.

→ You are right, but it is related to the lack of samples for the same range in the in situ data that we used to train the model. Since this is an independent float, the distribution of the in situ data of this float could be not represented in the training set.

63) **[Line #365]** Does it all sink? A small portion? STG are known to be regions with very efficient recycling of nutrients.

→We have slightly modified the sentence with the aim of making it clearer:

"This organic matter is subsequently transformed through respiration, particle aggregation, zooplankton grazing, feces production, and microbial decomposition (Siegel et al.,2014), before eventually a fraction of it sinks to deeper layers"

64) **[Line #373]** Which database? Why didn't you use an up-to-date one?

→ We are working with "data of opportunity". The dataset was ready, and previous works have used it, so they were available for comparison. We will be happy to apply the model to extend the dataset, if available. Always open to collaborate!

65) **[Line #377]** ??? Not clear. Bisson was focused on bbp at the surface. You could say that if you compared the same deliverable, rather than the depth distribution.

→We were referring to the SOCA2020, which shows a similar approach.

66) **[Line #378]** Why do you expect a relationship between CDOM and POC?

→ Increase in photoproduction of CO2 from CDOM (Belanger et al. 2006) due to increase in UV radiation and decrease in sea ice. CDOM refers to the yellow substance, which is a fraction of the DOC pool. Organic carbon is separated into POC and DOC. POC has a high seasonality, and half of the primary production is channeled into DOC via direct release, sloppy feeding, or after the death of phytoplankton. In the open ocean DOC exceeds POC by an order of magnitude.

POC can be estimated over the global ocean with satellite data (Liosel et al. 2002, Stramski et al. 2008); however, DOC estimations are still challenging (Aurin et al., 2018 and Siegel et al., 2002). There is a potential use of aCDOM to improve DOC estimations (especially in coastal waters) together with physical variables like SST or salinity. If CDOM can really improve DOC estimations and we can do it globally with satellites, a better understanding of the relationship between DOC and POC can also be analysed temporally and spatially.

67) **[Line #380]** Where? Did you use all the floats profile available? If yes, for what dates? Best if you provide a data repository in Zenodo so other can replicate your results.

To better compare our results with the SOCA2020 method presented in Sauzède et al. (2020), we used the same database, specifically including all available bbp profiles up to 2018 from two restricted areas that represent two distinct trophic regimes: the North Atlantic Ocean (NA) and the oligotrophic Subtropical Gyres (STG).

68) **[Line #381]** If you want others to use your result (and cite you), provide the ML model you have created.

→ We will provide the code and model using GitHub on the ISP site in accordance with our group policy of publishing developed models in open access (https://github.com/IPL-UV).