RC1: 'Comment on bg-2023-48', Anonymous Referee #1, 03 Apr 2023
Citation: https://doi.org/10.5194/bg-2023-48-RC1

The paper titled "Chromophoric dissolved organic matter dynamics revealed through the optimization of an optical-biogeochemical model in the NW Mediterranean Sea" presents a coupled 1D physical-biogeochemical-optical modelling suite inbedded in a parameter optimization tool. The models are run at the Boussole site in the Ligurian Sea. The large observational database allows tuning the model parameters (except a few parameters who could not be sufficiently constrained by the observed variables).

The authors show a convincing case. The paper is very clear and well written and the figures are relevant. The fully coupled approach is novative. The parameter optimization is very relevant and seems to improve all model variables. The authors also present important possible limitations of the method and justify the choices made (e.g. in section 4.1).

We appreciate the constructive comments and suggestions from the Reviewer. We present our point-by-point responses to the Reviewer's comments below. The Reviewer's comments are in black, our responses follow each comment in blue. In each response, we detail the changes we propose to make to the manuscript in order to address these comments.

Therefor I have no major comments. I only would have been interested to see a couple of details explained:

(1) the authors state themselves that it remains a future objective to see how the optimized parameteres will behave in a 3D model. It is indeed well known that parameter optimization can be sensitive to particular configurations (see e.g. https://egusphere.copernicus.org/preprints/2023/egusphere-2023-363/#discussion for a very recent example). For example it can compensate poorly represented features by adapting other features as the authors also propose (line 570). Based on their experience, could the authors estimate if the model parameters would lead to realistic results in e.g. areas with more lateral contributions compared to the Boussole station ? The switch from one model to another (GOTM to NEMO) may also be discussed (if relevant). However if no trials have been realized yet, I do not suggest that the authors need to speculate.

Upscaling of the 1D results to the 3D Mediterranean domain is an ongoing activity. Thus, the comment raised by the reviewer is relevant. Even if we have not finalized trails to analyze these aspects yet, we will rewrite and expand the paragraph in the Discussion that covers the feasibility of applying the locally optimized parameters to 3D models, to cover those two aspects mentioned by the reviewer: the robustness of our results in areas with more lateral contributions compared to the BOUSSOLE station, and which can be the consequences of changing the transport model. The new paragraph will read as follows:

'CDOM cycling models are useful only if they are flexible enough (i.e. portable) to provide accurate predictions for a wide range of conditions occurring in marine ecosystems. In that case, they can be integrated into larger 3D models of BGC cycles. The possibility of applying

parameter optimization techniques in computationally efficient 1D models before using the resulting parameters in the 3D version seems advantageous. Furthermore, parameters optimized with surface data only (i.e. satellite retrieved) may present inconsistencies when simulating underwater biological fields (Wang et al., 2020). This is particularly problematic in oligotrophic regions where the deep Chl-a maximum (DCM) is relatively deep and poorly correlated with surface satellite observations (Cullen, 2015; Fennel and Boss, 2003). Optimizing parameter values at intensively sampled 1D sites can overcome this problem and improve the simulation of both vertical and seasonal variability. Further analysis will be required to determine whether the optimal parameter sets from the 1D version should be applied directly in the 3D model. This decision should balance the risk of a lower agreement between model and data in 3D than in the 1D counterpart, with the opportunity to preserve key features presented in this analysis. These features include seasonal dynamics and vertical gradients, and the higher-than-average CDOM light absorption coefficients (Sections 3.1 and 3.2). Since the approximation of a 1D configuration is reasonable at the BOUSSOLE site, we do not expect that our proposed parameter values are compensating for the absence of lateral transport. However, considering that biogeochemical optimization can be influenced by specific physical forcing and possible biases in circulation dynamics (Pasquier *et al*., 2023), further analysis is needed to upscale the present 1D results to the 3D Mediterranean domain, where lateral contributions and vertical mixing are different and can interact differently with the optimized biogeochemical processes.'

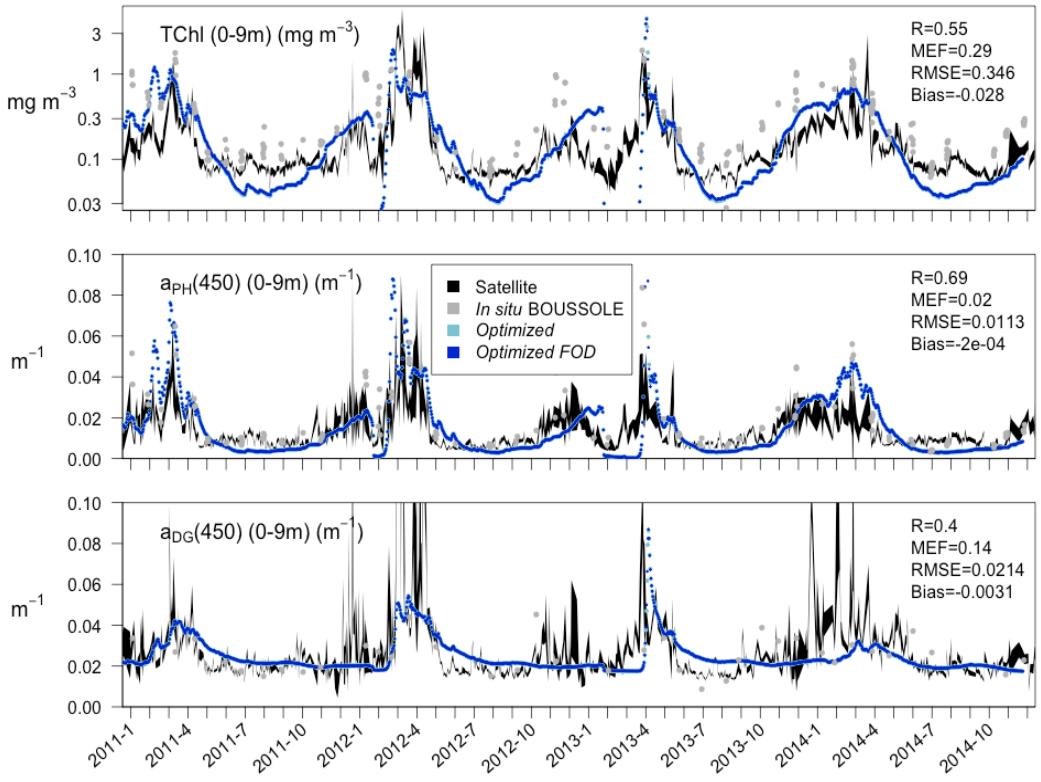
(2) can the authors explain if there is any limit imposed on parameters ranges during the creation of new values by the genetic algorithm ? Positivity, statistical distribution, inter-relations or consistency between pairs of parameters, ... ?

The limit imposed on parameters ranges is the range itself that is given as a minimum and maximum value (indicated in Table A1), being the minimum always positive. Therefore, this imposes positivity for all of them. The statistical distribution of parameter values is handled by ParSAC, the initial populations of parameters are distributed uniformly between minimum and maximum values. Regarding inter-relations between pairs of parameters, the unique constraint is that all parameters included in the optimization must appear independently of each other in some process. In case two parameters appear always in the same process, we chose one to be optimized. This does not exclude correlations between parameters, that we have acknowledged as a limitation of our results in the discussion (Section 4.1). We have not imposed any condition for the consistency between pairs of parameters, or any trade-off among them.

We will rewrite Section 2.4.1 'Parameters optimized' to clarify earlier the conditions that we imposed to the parameter list to be optimized and the parameter ranges. The new text will read as follows:

'The potential number of independent parameters included in the optimization problem is limited by the observations available and by the fact that optimized parameters must appear in some process independently. A total of 25 optical and BGC parameters were optimized (**Table A1** in Appendix A), all of them were given a positive range of values for initialization and evolution, without conditions or trade-offs for the consistency between pairs of parameters. The rest of the parameters not included in the optimization kept constant values (**Table 1**).'

(3) the model-satellite comparison is realized over the 9 upper meters. Can the authors justify this choice e.g. in relation to observed optical depth during the year ? Are the model variables simply averaged over the layers corresponding to these 9 meters ?
Yes, model variables are just averaged over nine meters throughout the whole seasonal cycle. In the 4-year time series considered, the first optical depth -FOD- (computed as $z_{EU}/4.6$) ranges from 4.8 to 28 m. However, 90% of the values (percentiles 0.05 to 0.95) range from 7.9 to 15.1 m. As a result, the time series of Figure 7 averaged over the first optical depth (dark blue in the figure below) are very similar to the time-series averaged over the first 9 m of the water column (light blue as the original Figure 7, almost indistinguishable). There is a slight difference in the summer periods when the FOD is slightly deeper than 9 m. We will include a new version of Figure 7 that averages the *Optimized* results over the first optical depth and will mention in the text the range of values the FOD takes throughout the year.



(4) there is a type line 800, "parameterisation" (without "s")
Thanks, this will change to: "We have proposed a simplified parameterisation to account for the effects of light and nutrients on CDOM production."