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Reply on RC2

Arianna Zampollo et al.

Author comment on "The mixed layer depth below the pycnocline (BMLD) as an ecological indicator of subsurface chlorophyll-a" by Arianna Zampollo et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-140-AC2, 2022

Dear reviewer,

We are very thankful for your time and your comments on the paper. According to all the reviewers, we identified some common issues that came across, and we have planned to improve the manuscript following all your advice.

The main points we want to work on are: i) better defining the scope of the paper by deleting the Chl-a shapes from the analyses, ii) simplifying the methods, and iii) providing the code to let users trying with the proposed algorithm.

Below, we describe the main changes we are going to introduce into the paper to address the above points.

The scope of the paper will be clarified by focusing on the BMLD (base of the pycnocline) and its use as a proxy for the depth of maximum Chl-a (DMC) in shelf waters. To date, the paper is packed with many details regarding the co-occurrence at the same depth of any density layer (that we will rename as "level") (e.g. AMLD, BMLD, DHP and Max N2) and DMC. The current structure of the paper reports first the comparison for all the profiles together (section 3.2) and then the comparison for each Chl-a shape (section 3.3). However, the length of the paper and the amount of information has increased the confusion among all the reviewers, who struggled to identify the main scope of the paper and often focused mainly on issues referred to Chl-a shapes. On the contrary, we have written this paper to promote a different point of view in investigating subsurface Chl-a by using density profiles. Hence, the main aim of the paper is to highlight the BMLD as a useful tool to predict and investigate DMCs in shelf waters. The vertical distribution of DMCs nearby BMLDs suggests that this variable has an ecological relevance when we investigate the vertical distribution of Chl-a subsurface patches, and we suggest its use in further research (enlarging these applications in the Discussion). However, this point does not come across easily, and we decided to delete all the analyses related to Chl-a shapes to focus mainly on the use of the BMLD and its potential. The following paragraphs will be deleted: 2.2 in the methods will not include Chl-a shape identification, 3.3 in the results, 4.1 and 4.2 in the discussion. However, understanding the physical processes underpinning the vertical distribution of each Chl-a shape is an open question, and the presented results showed how each shape exhibits a different association of DMCs with the pycnocline. Hence, we are interested in detailing this question in another paper, to avoid hiding the main scopes of this paper, which are i) proposing a method to extrapolate

the base of the pycnocline from density profiles and ii) evaluating its association with the vertical distribution of Chl-a (regardless the Chl-a shape).

The second and third points (*"simplifying the methods"* and *"providing the code to let users trying with the proposed algorithm")* are ensuring that the reader fully understands the method and its potentialities. For this reason, we will reduce the number of details regarding the algorithm in paragraph 2.4 and we will focus on the requirements, limitations, and circumstances in which the method can be used. Since paragraph 3.1 describes what is considered a correct or wrong identification, and is a repetition of the methods, we decided to integrate it into the methods together with figure A1. Moreover, we will upload the code of the function on GitHub, where an example will be also provided. The details regarding the structure of the function will be reported in the supplementary material to allow people to replicate, improve and use the code. Therefore, Figure 3 and part of the methods will be moved to supplementary materials.

The removal of Chl-a shapes from the paper will change the discussion section, which will be reduced and will focus on describing the relationship between density and Chl-a profiles. We will review the physical variables that are playing a role in the definition of BMLD and AMLD, and their association with the vertical distribution of maximum Chl-a in the water column. Figure A2 will be moved to the main text to better understand the vertical distribution of the depth-integrated Chl-a with regard to each density layer (AMLD, BMLD, DHP and Max N^2).

Here we respond to your main specific comments:

"To be clear in this point, I think there is likely a detailed analysis of the large profiles dataset that support the development and use of their algorithm instead of others, but at this stage this is not easily assimilated by the reader."

Thank you for the comment. We agree that the number of the information reported in the paper is too large and this leads all the reviewers to focus on different outcomes instead of focusing on BMLD and its potential. Your comments indicated to clarify the scope of the paper and we intend to do it by following the points we described in the first section of the response.

"If I understand properly, Chla profiles have not been classified or clustered following any systematic objective method but manually. Therefore, one of the main strengths of the work (i.e. providing automatic algorithms to process large amounts of profiles) weakens."

Unfortunately, we could not classify the Chl-a shapes using an automated algorithm although we tried a cluster classification of them. We followed a few papers that tried to classify the shapes of Chl-a, but their methods were not successful with our dataset. However, the main point of this paper is not to find a method to classify Chl-a shapes (which is still an open issue), but proposing a different way of investigating the relationship between density and Chl-a. The identification of BMLD in the water columns was not described before in the literature, and its use is a valuable tool to investigate subsurface processes (underlying the pycnocline structure). Therefore, this paper intends to focus on the BMLD and Chl-a, leaving aside the classification of Chl-a in shapes. In future analyses, we are interested in pursuing the investigation of different processes underpinning each Chl-a shape which will be more suitable for a different publication (different research questions from what we want to present in this paper).

"The discussion of Chla shapes is discussed regarding bibliography but not clearly related to the density profiles."

Considering the large number of changes that we are going to apply to this paper, the

discussion will be reviewed focusing on the density and Chl-a profiles, and the physical variables underpinning the surface and deep mixing layers.

"In the end I am not sure if the authors aim to infer subsurface Chla values from BMLD in case there no Chla profiles are available."

Since the relationship between BMLD and DMC can be described by a linear regression, the DMC can also be inferred by looking at the BMLD or DHP. This will be more clarified in the paper.

"The relationship of the developed tool and/or shelf seas primary production with man-made structures, as well as possible influence of climate change, is too indirect."

We agree that passing from the surface and deep mixing layers to man-made structures and climate change is a considerable step, however the mixed layer depth is influenced by physical variables that are likely to be affected by both climate change and man-made structures, especially those from the offshore renewable energy. Hence, we consider it essential to mention that understanding the vertical distribution of density and Chl-a is important to guide the investigation of disturbances' effects (climate change and offshore renewable energy) on the right physical variables. Identifying a tight overlap between BMLD and DMC suggests that physical variables close to the seabed (e.g. bottom temperature) are indeed key variables to address the effects of disturbances on primary production. On the contrary, the exclusive investigation of the surface processes (up to AMLD) may lead to partial conclusions about the effects due to climate change or man-made structures. Hence, describing the implications of BMLD in characterising the effects of climate change or man-made structures e.g. wind turbine foundations (which are likely to impact the mixing of the water column) on the ecosystem is useful to give a context of the potential uses of these variables in further investigations.

"The main goals stated along the paper, which are (i) providing a new analytical tool to systematically tag density profiles, (ii) helping to understand basic processes relating Chla and vertical density, and (iii) providing predictive capability for subsurface Chla at fine scales, are in my view not clearly addressed in the ms in its current status."

We hope that the points described at the beginning of this response will clarify the aims of the paper.