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Interactive comment on "Coupling physics and biogeochemistry thanks to high resolution observations of the phytoplankton community structure in the North-Western Mediterranean Sea" *by* Pierre Marrec et al.

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Anonymous Referee #2

Referee Comment (RC): This paper presents a solid dataset collected during a cruise in the northwestern Med Sea, when a fine-scale physical structure (eddy) occurred. The authors describe the structure from different points of view and obtain a pretty exhaustive picture of its features, also tackling the potential functions exerted and providing rates estimates. The manuscript is interesting in its approach and provides useful

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information on biological functioning of eddies. In my opinion, the authors put too much emphasis on the technology used rather than on the results obtained, which could be eviscerated more. As a suggestion, they should make a stronger effort in building a global picture from their data about how these eddies work and what contribution they bring to global ocean budgets.

Authors Comment (AC): We do appreciate the positive and constructive comments addressed by anonymous referee #2. We would like to sincerely apologize for our relatively late responses regarding the reactive comments addressed by anonymous referee #2. This delayed response impeded a really interactive discussion between us, which is an important aspect of publishing in Biogeosciences. Your comments have allowed us to improve the overall quality of our manuscript. We have addressed all the comments relative to your recommendations below. As we used an innovative approach by deploying simultaneously several novel platforms of observation, we wanted to fully describe our methods. However, as you mention, we emphasized too much on the technology used, which impacts the highlighting of the main scientific findings of our study. Reviewers #1 addressed us several comments in order to enhance the consideration of the main findings and the main aims of our discussion. We hope that, by taking into consideration his/her comments, it could partially fulfill your suggestion. We think that the description of how the fine-scale structure works might be sufficiently characterized in our study. We agree that we should further insist and discuss on the contribution of such structure in the global ocean budgets, even if, as mentioned by Mahadevan (2016) it is still difficult to quantify how fine-scale processes affect the global state of the ocean. The main goal of our study was to present and test an original combination of new approaches to better observe and characterize the Ocean, in order to better understand how a fine scale structure works in order to apply them at a larger scale to finally quantify the contribution of these processes at a global scale.

RC: Specific comments follow:

RC: Abstract Line 15 – please define “fine-scale” AC: With the term “Fine-scale” we

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refer to ocean dynamics features occurring at scales smaller than about 100km; consequently, the term includes i) a fraction of the mesoscale processes (e.g. large coherent eddies), with scales close to the first internal Rossby radius and ii) the submesoscale processes, with scales smaller than the first internal Rossby radius (e.g. intense vortices, fronts and filaments). This description of the "fine-scale" term is now included in the introduction of our revised manuscript. We added at line ??? a recent reference concerning the fine-scale dynamics in the studied area (Morrow et al, 2017) https://www.ocean-sci.net/13/13/2017/os-13-13-2017.pdf. In addition, the approximate size and duration of the observed fine-scale structure is now mentioned in the revised manuscript in the Results 3.1. Section. We choose to use this term since the studied structure has a complex dynamics and the meso or submeso scale terms would be too restrictive. We are indeed working on a deeper physical description of this structure, but that work is beyond the main purpose of this manuscript.

RC: Line 21. Synechococcus detection is not novel with these cytometers. AC: In the revised manuscript we have mentioned: 'For the first time with this optimized version of the AFCM, we were able to fully resolved Prochlorococcus picocyanobacteria, in addition to the easily distinguishable Synechococcus." Indeed, with the previous versions of the Cytosense instruments, Prochlorococcus were out of reach (too dim and too small) and only a part of the Synechococcus were properly detected. The original Cytosense technology was optimized for large particles (large phytoplankton and chains of cyanobacteria).

RC: Line 23. It is not clear whose 1 m resolution belongs to. For a CTD is not much. AC: We acknowledge that our description of this sampling system was not clear in the abstract. In the revised manuscript we have mentioned: 'A high-resolution vertical pumping system deployed during fixed stations allowed to sample water at a fine-resolution (below 1 m).'

RC: Line 27 – replace "characterized with "and was marked" AC: Done

RC: Introduction In general, this section needs a reorganization to better harmonize the different topic presented. AC: We agree that some parts of the introduction needed some reorganization and we have performed some substantial modifications in the revised manuscript. We have merged and fully reorganized paragraphs 3 and 4 relative to the Mediterranean Sea and moved them just before Section 4.1. as an introduction to our discussion and less insisted on the methodology used (2 sentences deleted). We hope that these modifications and the consideration of the subsequent recommendations will allow to better emphasize on the scientific aims of our study.

RC: Page 2 Line 17-18. This sentence is not clear, maybe you intend “Phytoplankton assemblages are highly”? AC: Thank you for this suggestion.

RC: Line 26. Fine-scale variability of phytoplankton is known since more than a decade, e.g. work by Jim Mitchell, Laurent Seuront, just to name two. AC: Thank you for these two references. We took notice of them and these studies have been mentioned in the revised manuscript. We have modified this sentence according to your recommendation by mentioning the main findings of these reference studies (and from others too) and we have argued that during the last decade numerous studies focused on this fine-scale variability and more particularly on the fine-scale variability of the phytoplankton community structure. Although patchiness and fractal distribution of phytoplankton were observed and described since more than a decade (i.e. Platt, 1972), in our study (and in the references mentioned) the phytoplankton community is described at a functional or an ecological trait. That’s why we choose to consider these last decade references only.

RC: Page 3 Lines 7-8. I suggest to move “Eddy Stirring . . .McGillicuddy)” before “Mesoscale . . .” at line 3. AC: Done

RC: Check spelling of McGillicuddy. AC: Done

RC: Page 4 line 8. Should read “ depletion in surface waters ” AC: Done

RC: Lines 12-22 I suggest to move this to page 3 line 16 and insert the info that you found a patch of cold water AC: Done

RC: Lines 22-end. I would describe here the scientific aims of the cruise, not the list of methodologies used. AC: We have better presented in the modified version the scientific aim of the cruise but we think that it is also important to describe the innovative methods used to address these scientific aims as it is a major innovatory aspect of this study.

RC: Page 5 line 6. Delete “in relation with their environment” AC: Done

RC: Results Page 13 line 16. Should define Case I waters or insert a reference AC: We choose to insert the Morel et al. (2006) reference.

RC: Page 14 line 22. I suggest to modify as “A post-campaign validation against conventional flow cytometry showed a good fit of data (Student ... Supplements)” AC: Done

RC: Discussion Page 21 about the ecotypes of Prochlorochoccus. I am surprised that with the fine sampling resolution the two ecotypes are never seen together, as a bimodal distribution of red fluorescence. You may insert a short comment on this lack and possible explanations (have you observed them with conventional flow cytometry?)

AC: We thank you very much for this comment. We have now included a new figure in the supplement materials (Fig. S5), which presents the FLR distribution of Prochlorococcus obtained from samples analysed by conventional flow cytometry (in the laboratory) in the cold core (STA9) and warm boundary waters (STA5) over the first 35 m using the PASTIS high vertical resolution sampling system. We have also represented the FLR vertical distribution at STA11, the only station where we sampled the water column beyond the DCM. We never observed in surface waters the occurrence of Prochlorococcus population with significantly higher FLR (and/or SWS) values (Fig. 12 for AFCM and S4 for conventional flow cytometry) which might be representative of the

LL ecotype. AFCM measurements were only performed on surface seawater samples using the flow-through water supply. At the opposite, conventional flow cytometry analyses were performed on the first 35 m and revealed that we could be in the presence of both ecotype (HL and LL) together around the mixed layer depth in cold core waters (from 15-20 m depth). However, we did not observe any clear bimodal distribution of FLR (or SWS, data not shown) signals (Fig. S4 and new Fig. S5 in supplements). The DCM (i.e. 40 m depth), where the LL ecotype is supposed to be the main ecotype, was sampled only at one occasion, during the STA11 CTD-Rosette (Fig. S2, S4 and S5). Campbell and Vaulot (1993, Fig. 4) clearly show that a bimodal distribution of FLR intensities can be observe when 2 ecotypes are present together in "similar" proportion around the DCM. By "similar", we mean a sufficient abundance of both ecotypes, which make possible to clearly identify the bimodal distribution of FLR. Blanchot and Rodier (1996) also identify such a bimodal distribution in few locations. They clearly explained that in other location, ecotypes (sub-populations) co-occurrence cannot be observed from bimodality of the FLR distribution because both ecotypes were not abundant enough to be clearly seen. In these locations both ecotypes still existed, but their concentrations were very different and thus the two peaks could not be evidenced, the larger peak overpassing the smaller one. In the revised manuscript we mention Fig. S5 and strengthen our discussion about the two Prochlorococcus ecotypes distribution over the water column.

Campbell, L., & Vaulot, D. (1993). Photosynthetic picoplankton community structure in the subtropical North Pacific Ocean near Hawaii (station ALOHA). Deep Sea Research Part I: Oceanographic Research Papers, 40(10), 2043-2060. Blanchot, J., & Rodier, M. (1996). Picophytoplankton abundance and biomass in the western tropical Pacific Ocean during the 1992 El Niño year: results from flow cytometry. Deep Sea Research Part I: Oceanographic Research Papers, 43(6), 877-895.

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Figure S5: FLR distribution of Prochlorococcus populations at STA7 (warm boundary waters, in red) and at STA9 (cold core waters, in blue), expressed in terms of cell density. Data comes from conventional flow-cytometry measurements performed from 30 m depth to the surface using the PASTIS pumping system to collect the water at various depths. The dotted lines represent the mean of the normal distribution for Prochlorococcus surface ecotype (HL – High-Light) and the dashed line represents the mean of the normal distribution for Prochlorococcus deep ecotype (LL – Low-Light). The same representations for the deep-cast STA11 – CTD-rosette also reflects the presence of at least 2 different Prochlorococcus populations discriminated from the distribution of their FLR values. Co-occurrence of both ecotypes can be observed at STA9 and STA11 but a clear distinction of the FLR distribution of each ecotype is not possible.

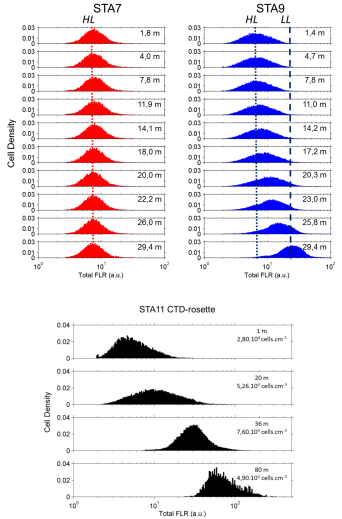

Fig. 1. Fig S5

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