

Barboni et al. 2022, Review by A. Capet

The authors investigate the vertical structures of Mediterranean anticyclones and in particular the temporal evolution of the mixed layer depth in their core, with respect to that of the surrounding background sea state. The major originality of this research compared to similar studies is that the authors could gather sufficient in-situ data (multi-platform) to explore this topic on individual instances, rather than adopting the usual composite framework. Free of the smoothing effect of composite approaches, they are able to demonstrate important dynamics in the anticyclone evolution through the winter deepening of the mixed layer depth. In particular, they highlight the difference between cases where MLD deepening inside eddy cores is strong enough to reconnect with pre-existing subsurface homogeneous layer and cases where the subsurface homogeneous layer remains unperturbed, leading to the formation of multi-core anticyclones, with subsurface cores piling up from year to year. In my view, this study provides fresh insight into the process of anticyclone formation and evolution from year to year, as well as new keys for the interpretation of subsurface water masses' history. The manuscript is well written, although it could certainly be streamlined for more efficient delivery of the key results. I recommend publication, after a careful edition aiming for efficient reading. Some bits of advice in that sense are provided below.

MAJOR

1. The result section is hard to read as the author is 'very close to its subject', and directly addresses very specific graphical elements of the provided plots without the general, larger perspective statements needed to bring the reader there with him. I would advise some reformulation with those general guidelines in mind: 1) Before entering the details, explain briefly what you're going to show and why. 2) Avoid detailing graphical keys in the text, use the captions for this. 3) Focus the text on the key elements that the readers should acquire to apprehend the discussion.
2. Is Sect 4.1 (as an example) intended to describe one specific event (ERA1) or rather one type of event (connecting pre-existing subsurface core)? In the first case, mention "example of ..." in the section title. In the second case, it would be good to end the section with statements about such types of phenomena that are not specific to the chosen example.

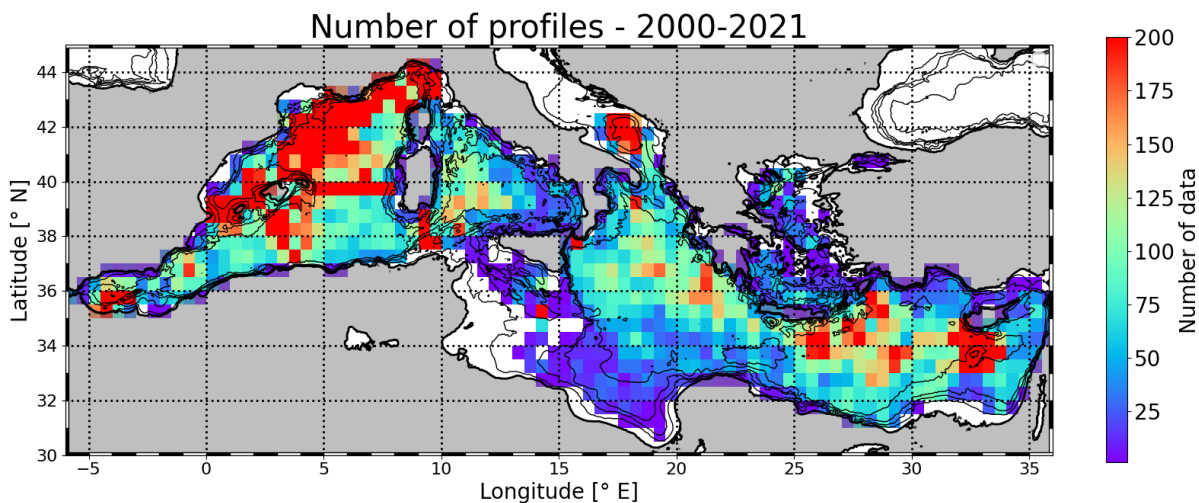
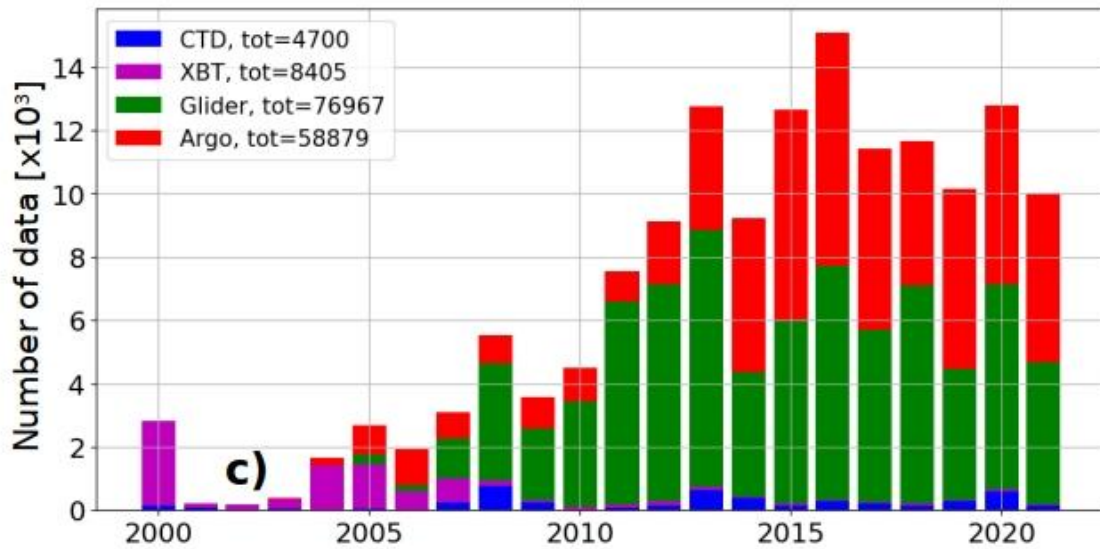
We thank the reviewer for these constructive comments and his interest in the submitted study. Results section of the manuscript was rewritten for more readability in this sense, letting more descriptive details to the figures captions (which fonts are slightly increased). In particular an introductory paragraph opens Section 4 before detailing the two winter mixed layer evolution patterns observed ('connecting' and 'non-connecting'), that are illustrated by the examples in Fig.4 (Eratosthenes-1) and Fig.5 (mostly Eratosthenes-2). Transitions between results subsections are also introduced.

MINOR

1. (Sect 2.1): Mention here already the multi-platform nature of the datasets (Argo, XBT, gliders, etc ..). It would then be relevant to provide the relative abundance of profiles

obtained from each platform type. Also mention here explicitly, although briefly, that DT profiles are favored in case of spotted duplicates with NRT datasets.

We were indeed quite brief on the dataset description, as it was intended to be published separately in a data paper, in order to analyze with more details the mean eddy impact on climatology. The following figures should answer this question :



- L122: It may be worth providing this website as a hyperlink.
- It would make sense to switch Sect 2.1 & 2.2, to have MLD extraction methods presented just after the profile dataset from which MLD is extracted.

The sections were switched and the paragraph on the description of the sections in the introduction was modified to stay consistent.

- L138: Instead of 'this' use explicitly 'the main thermocline' (if I've understood correctly).

5. L140: Please state explicitly the reasons that led to your choice of method. For instance, 'As we aim to characterize MLD as the lower boundary of the upper mixed layer while accounting for small-scale restratification event, we opted for the following methodology mixing the threshold and gradient approaches.' (rephrase as required).

Modified by 'To capture such small-scale restratification events, we built the following methodology combining both threshold and gradient approaches'

6. L145 "than" -> "then"
7. L152-153: The problem is not that there are double-gradient profiles, but rather that the threshold method overestimates MLD in that case. I'd rephrase, for instance: "[...] 22 of them were identified as double gradient profiles, and led to an overestimation of the MLD when using the threshold method." The next sentence suggests that switching the method reduces the number of double-gradient profiles. Instead, it reduces the number of cases where these situations resulted in an MLD overestimation. Please rephrase this to solve this confusion.

Rephrase by : "22 (5.5 %) of them were identified as double gradient profiles, resulting in an overestimated MLD when derived with the threshold method. Moving to our methodology, this issue is now only encountered for 2 profiles (0.5 %)."

8. L164: 'is' -> 'if'
9. Eq(2), first line: I would expect to retrieve the form of Eq (1), in the cases where $\tau_1 = \tau_2$, or if $B=0$, but this isn't the case with the given form. Shouldn't the parentheses $(t-t_{max})$ be squared?

We chose a fitting function for the MLD deepening inside-eddy that is not a double Gaussian, but instead a double exponential (Eq.2). Fitting function for the background MLD (Eq.1) is then not retrieved in the limit $B \rightarrow 0$, however we used a double exponential because it allows a degree of freedom on the MLD time derivative. I.e. df/dt is not bounded to 0 in $t=t_{max}^{AE}$

10. Sect4. : It would ease the reading to include a few preamble lines to Sect 4 presenting the different cases explored, before jumping to the specific subsections.
11. L251: Here and elsewhere, avoid providing the graphical keys of figures in the main text. That's what captions are made for.
12. L262: Red (as in the text) or orange (as in the figure caption inset)?
13. L267: remove "extremely". What is 'mode waters'?
- "mode waters" was indeed weakly defined and we preferred to describe this homogenous layer as "likely formed by convection the previous winter".
14. L266-273: This is very hard to read. Please attempt rephrasing.

15. L277: Please provide the delay.

16. L279: '[..] forms a subsurface eddy' or "has been used as a criterium to define subsurface eddies"?

Indeed such positive density anomaly "has been used as a criterium to define subsurface eddies" (see Assassi et al 2016)

17. L301 "4b" -> "5b".

18. L302 (Fig4)

19. L326: "(temperature gradient < 2.5...)" ?

Indeed, and to be more precise, temperature gradient below 2.5×10^{-3} °C/m in absolute value

20. L396: "enough deep" -> "deep enough".

21. L403: 'comparing' -> 'by comparing' ?

22. L444: "The Irapetra eddy 'IS' a recurrent ... " + give refs inside parentheses.

23. L469: 'calling' -> "which calls for"

24. L485 "thinning"?

"Thinning" was indeed not accurate, we preferred "isopycnals doming and subsequent stratification weakening" in the revised manuscript.

25. L519/520: I'd used 'mixed layer' instead of 'mixing' layer. As you mentioned earlier, you only have access to density/temperature gradients, not actual mixing rates.

26. L537: Not only heat can be exchanged. For instance, I believe this mechanism to be particularly relevant for oxygen studies.

This mechanism could be very important for oxygen, but also nutrient input to the euphotic layer. Discussion in section 5.5 is improved in this sense. We refer in particular to Krom et al (1992) and Moutin and Prieur (2012) who both observed a 'connecting' mixed layer in 1989 and 2008.

27. L538: "with consequences that remain to be investigated".

FIGURES

1. FIG1: $MLD_{\{\sigma\}}$ and $MLD_{\{T\}}$ should be defined explicitly in the text (e.g. L159-160).

Introduced in the text

2. FIG2 : “One” -> “profile” (2 times)

3. FIG4 :

- a. The (very small) legend on the map insets mentions ‘profiles inside the anticyclones’ in orange. Yet, those appear as black on the figure? Or is it that all the indicated profiles don’t meet the “inside” criterion? But then some of those should be ‘ambiguous’ profiles, no? Please check carefully.

In situ profiles labeled as ‘inside’ must indeed be cast inside the structure at the considered date. However profiles constituting the background are outside of any eddies (at ± 2 days as explained in Section 3.2) at the same time of the year at ± 10 days, but can be 1 year later or earlier. They can then appear inaccurately as inside a structure because they were cast at a time no detected eddies was present.

Note that profiles positions for the background slightly changed in maps in Fig.4,5 and 10 due to a small code mistake that does not affect the analysis.

- b. Table 1:

For MM4, use a dash “-”, instead of “NaN”.

4. A1 :

- There seems to be a mistake between a) (Δ years) and b) (Δ days).
- Adopt the same blue color for the selected parameters and method in each panel.