Response to the Reviewer #1 for sp-2022-11

We thank the reviewer for the constructive feedback on our manuscript. Below are our point by point responses to the issues raised on the general aspects and minor suggestions. The reviewer comments are highlighted with italic typeset with grey fonts while our response is in default typeset.

This short manuscript describes the evolution of upper ocean salinity content in the Mediterranean Sea by using state-of-the-art global and regional reanalyses and objective analyses. As such, it is of interest for the Mediterranean climate community. It is concise, well written, and easy to read. There are, however, a few aspects that need to be improved before the manuscript is suitable for publication. Given that all the points below are relatively easy to address, I recommend a minor revision.

Thank you.

General points

1) Not clear why the reference S_ref is calculated over 1993-2014 and not the full period. By doing this, the salinity anomaly figure / diagnostics (as the mean in Table 2) basically represent the difference between <1993-2021> minus <1993-2014> so the anomaly of the latest 7 years, which is somehow subjective and not necessarily easy to interpret. I would expect S_ref to be the full period, otherwise it needs to be justified with some arguments.

Thanks for the opportunity to clarify this issue. We completely understand the concern of the reviewer. We would like to emphasise that this study is a contribution to the Ocean State Report (OSR) 7 which will be proposed as an Ocean Monitoring Index (OMI) if it is published. The period to calculate the mean is chosen to be consistent with the previous contributions to OSR and current OMIs provided in the Mediterranean Sea, from the beginning of the OSR . Since the salt content anomaly OMI will be updated every year, as in example as in Fig. 4d, we would like to keep the mean that is used to calculate anomalies fixed. We note that the longer timeseries come from MEDREA24 and observational products, while GREP products are now available only to the end of 2019 even if they are regularly extended. With the hope that it clarifies our reasoning, we added a sentence as "This period is chosen to be consistent with the Ocean Monitoring Indicators produced previously in the Mediterranean Sea and other Copernicus Marine domains."

2) Combining different datasets (reanalyses and objective analyses) could be better mentioned in section 2 and 4. There are some intrinsic issues with that, in my opinion. The spread resembles mostly the offset between the products (see also point 4). The trend of the two groups of products are inherently different (Table 1), likely due to the sharp changes in the WMED around 2005-2006. For the latter, it is not easy to understand whether this is only due to a regime shift, or the Argo deployment, or a combination of them. Reanalyses seem qualitatively similar in the shift, but this can also be due to an unconstrained state before 2005. At the same time ARMOR/CORA may be constructed from a climatology that already ingests

We thank the reviewer for insightful comments. We respond to them below.

i) mention how ARMOR/CORA are constructed (how the background is taken?)

We added the explanation "In the CORA, the objective analysis is performed on measurement's anomalies relative to a first guess, at the 15th day of each month while in the ARMOR3D the first guess is adopted from World Ocean Atlas 2018. Both products use an objective analysis method proposed by Bretherton et al., (1976)." in the data and method section.

ii) mention the asymmetry between the two families of products;

We decided to add the sentence in the conclusions to underline the asymmetry as "The products with dynamically constructed ocean reanalyses and objectively analysed observations show significantly large spread at the beginning of the period of investigation while the uncertainty reduces possibly with the emergence of ARGO profilers which allowed a wider spatial and higher frequency sampling in the ocean."

iii) be less sharp about the causes of the 2005-2006 shift.

Thanks, we replace "which may be related to the climate regime shift in the basin (Schroeder et al., 2016) corresponding to a major deep water formation event at the beginning of the Western Mediterranean Transition (Zunino et al., 2012)" between L101-103 with "for which one of the many possible reasons is the regime shift as discussed in (Schroeder et al., 2016) corresponding to a major deep water formation event at the beginning of the Western Mediterranean Transition (Zunino et al., 2012)."

3) Being the computation over the 0-300 m layer, I suggest stressing (title, abstract, conclusions) that the analysis refer to the upper ocean salinity content and anomaly, otherwise the study seems to consider the full water column

Thanks, we agree. We made it clear in the title, abstract and conclusions. The title now reads as 'The dynamical role of upper layer salinity in the Mediterranean Sea". Considering the comment from both reviewers, we replaced "salinity content" with "upper layer salinity".

4) the discussion about the spread in Section 3 should state that the spread on the content (and not that on the anomaly, not shown) is representative of the offset of the dataset, rather than their variations, and thus should be interpreted (see also point 2). This holds for both basin and local scale discussions.

We agree with the reviewer while thinking that the offset dominates the variations possibly due to the large differences in the products, lower bound is dominated by the GREP and upper by the CORA and ARMOR3D. We added our interpretation as "The spread is representing the offset of the products more than their variability in the entire Mediterranean Sea, as well as in its eastern and western subdomains."

Minor points / typos

L11 with the warming Earth -> in a warming climate

Thanks, we changed the term.

L12 with a large uncertainty -> with large uncertainties

Thanks, we made it plural.

L15 better to state in the abstract which type of products are actually used

We added "reanalysis and in-situ objective analysis " in the abstract.

L20 salinity content and anomaly EVOLUTION or CHANGE

We added "evolution". Now it reads as "This paper investigates the salinity content and anomaly evolution in the Mediterranean Sea using observational and reanalysis products."

L28 changes in -> changes of the essential ocean variables

Thanks we substituted "in" with "of"*.*

L35 "due to strong mixing" deserves a more sound reasoning here. I suggest dropping it

Agreed. We remove "due to strong mixing"

L59 The mean salinity (S)

Thanks. The mean of salinity is S with an overbar in the equation (1) so we replace it in the text accordingly.

L75 "itself" to remove

Thanks, removed.

L93 also ARMOR/CORA are affected, in principle, by the the observational sampling; this sentence suggests only reanalyses are. Better to rephrase the sentence.

We thank the reviewer and append the phrase "while the observation-based gridded products become more confident." to the end of the sentence to appreciate the improvement in CORA/ARMOR3D.