Replies to Reviewer #2's Comments

We appreciate the Referee's thorough review and constructive feedback. We have carefully addressed all comments and incorporated the necessary changes in the revised manuscript. Below, we provide point-by-point responses to each of the Reviewer's suggestions.

In this section 1.2 on probabilistic assessment, the explanation of the different diagnostics is not so easy to understand for someone who is not familiar with ensemble approaches. Few additional sentences illustrating the metrics would help to understand their meaning for non experts. I would also suggest to add references for readers interested in more details (for example: Section 12.B Statistical Concepts - Probabilistic Data - Forecast User Guide - ECMWF Confluence Wiki).

We thank the Reviewer for this helpful suggestion. In the revised manuscript, we have included additional clarifications of these metrics and cited further references for easier understanding.

Some additional information on the limitations, challenges for ensemble approaches and the use of hybrid methods in OOFSs would be useful to describe in this article to give a more complete and objective point of view. For example, does the "inflation" methods still need to be used or regularisation / localisation in case to small ensemble, …?

Thank you for highlighting the limitations and challenges associated with ensemble methods. While our article aims to offer a concise overview of ensemble forecast status, space constraints prevent us from addressing every challenge in detail, including issues such as inflation methods, regularization, and localization for small ensembles, which are more pertinent to ensemble data assimilation methods. In response to the reviewer's suggestion, we have added a short discussion on the auxillary techniques to mitigate for the loss in (small) ensembles spread and on hybrid methods (please refer to our reply to Comment 1.94). For those interested, relevant references are included to offer further insight.

The numbering of the different sections of the article needs to be revised: 1, 1.1, 1.2, 1.1.1, 2. The section 1.1.1 may be changed to 1.3.

We have changed all the Subsections to main Sections as suggested.

Line by line comments

Figure 2:

Virtual ensemble: for point 2. "Source" may be to vague: replace by model/system as in the text?

"Source" is replaced by "System".

"Adhoc selection": I do not clearly understand what it means.

We replaced it by "heuristic selection".

DA ensemble forecast: quantity -> quantify ?

Done. Thank you.

l.89: can you give few more details/references on the present limitations and method to overcome them to illustrate today limitations and challenges that still need to be addressed or recognized as a limitation for ensemble forecasts and ensemble DA analysis.

We thank the Reviewer for this suggestion. We have expanded our discussion in the revised manuscript to include additional details on the current limitations of ensemble forecasting and ensemble data assimilation. In particular, we highlight computational constraints, the challenges of designing representative perturbation schemes, and the trade-offs between accuracy and efficiency. We also provide references to methods such as localization, inflation, hybrid ensemble-variational approaches, and other advanced techniques that can help mitigate these challenges.

l.94: Hybrid methods or multi-scale analysis, with the use of lower resolution ensemble covariance than the HR analysis, should at least be mentioned even if not discussed here.

Thank you for the suggestion. We now mention the hybrid methods in the revised manuscript, as recommended. However, we have not expanded on multi-scale analysis, given that our primary focus is on ensemble forecasts rather than the intricacies of ensemble data assimilation. We hope this addresses the Reviewer's comment while allowing the manuscript to remain aligned with its main objectives.

l.109: OOFS acronym is not defined.

Thank you for pointing this out. We have now defined OOFS in line number 125 of the revised manuscript.

l.112: The increased/high resolution "tendency" is also to answer the user requests for higher resolution analysis and forecasts.

We have revised this sentence as suggested: "This was due to the need to resolve the mesoscale to sub-mesoscales processes to better describe the energy cascade in the ocean, and to meet user requests for higher resolution forecasts (e.g. D'addezio et al., 2019; Davidson et al., 2021)."

l.117: ever-increasing availability of computational power? Any more recent references than 2010 and 2011 to support it?

We have provided two more recent references following the Reviewer's comment.

l.119: table 1: As it is the view at a given date you may need to write it explicitly and mention that the table does not show the ensemble analysis and forecasting systems are under development in OOF centers.

The Table caption was revised for more clarity and reads now as "Summary of key operational ensemble forecasting systems worldwide".

Table 1: It would be nice to add the spatial resolution. In some OOF centers, the ensemble "system" is complementarity to a deterministic higher resolution system.

Thank you for the suggestion. We now report the spatial resolution of these models in Table 1.

l.123: Lack of physical HR data: There is today high-resolution satellite observations that are not fully exploited with fine scale observed as some SST, Ocean Colour products and now SWOT observations also going very close to the shore. The lack of HR data is true for the ocean interior.

We thank the Reviewer for this valuable comment. While there are indeed high-resolution observations available (e.g., from satellite SST, ocean color products, and SWOT), the coverage remains limited to only a few variables. In particular, obtaining high-resolution data for sea surface salinity and currents is still challenging, and, as the Reviewer correctly point out, the availability of such data is even more limited in the ocean interior. We have revised the sentence to clarify this limitation:

"Although high-resolution observations of some surface variables are now more accessible, the lack of dense, three-dimensional coverage, especially at subsurface levels, still leaves mesoscale and submesoscale processes poorly constrained by ocean analysis systems."

l.124: "poorly constrained" and not "poorly unconstrained"?

Corrected. Thank you.

l.130: Since the SWOT data are now available, the text must be updated.

We have revised the sentence to reflect the update. It reads now:

"Ensemble forecasts are also essential for providing the error statistics required by ocean analysis systems, thereby enabling better use of high-density observations from recently launched and upcoming satellite missions, such as Surface Water and Ocean Topography (SWOT) (Fu and Ubelmann, 2014)."