Reviewer 2:

Review of the paper "*On the reconstruction of ocean interior variables: a feasibility data-driven study with simulated surface and water column observations*"

by Aina García-Espriu, Cristina González-Haro, and Fernando Aguilar-Gómez

This study investigates the feasibility of reconstructing ocean interior variables, specifically temperature and salinity profiles, using AI-based algorithms applied to simulated satellite surface data and in situ buoy observations. Leveraging an Observing System Simulation Experiment (OSSE) with outputs from a numerical ocean reanalysis model from the EU Copernicus Marine Service, the authors compare the performance of Random Forest Regressors (RFR) and Long-Short Term Memory (LSTM) networks. The results show that both models reasonably capture the spatial and temporal variability of ocean interior conditions (particularly for salinity), with RFR offering higher accuracy in direct reconstructions and LSTM demonstrating better extrapolation capabilities with ground truth observations. The findings highlight the potential of data-driven approaches to enhance 4D ocean reconstruction and contribute to future digital twin ocean frameworks, while also identifying current challenges in capturing vertical variability and reducing biases. Nevertheless, the study lacks some aspects that should be integrated at least at the discussion level.

We would like to thank the reviewer for her/his valuable comments. Our response is given in blue, and the number of lines corresponds to those of the new manuscript with track changes.

Major Points

I could not fully understand how surface information is synthesized from the Copernicus Marine Service numerically modelled data. To the best of my understanding, the aim is to provide insights on a potential 4D reconstruction that exploits satellite-based surface observations. In particular, the Authors claim the intention to perform reconstructions at the spatial resolution provided by space-based microwave sensors. However, it seems surface observations are directly extracted from modelled surface data. To be consistent, an assessment of the type and effective resolutions of satellite input data should be performed, and the synthetic input data should be adjusted accordingly. For example, present-day satellite-based sea surface heights/currents/temperature could differ significantly with respect to the outputs of a hydrodynamic model. A discussion on how this could impact the results of the 4D reconstruction could be beneficial.

We thank the reviewer for this comment; it made us realize that the text of the manuscript was not clear enough. The main question of this work is to assess how in situ and satellite observing systems can be leveraged to reconstruct ocean interior properties. To do so, we based our study on an Observing System Simulation Experiment (OSSE) in which we use the outputs from an ocean numerical model as the ground truth, and simulate a real observing system of the ocean, taking the surface of the model as a simulation of satellite observations, and vertical profiles in the same locations as the real Argo floats. We have tried to clarify this point in the new version of Figure 3 and make the text clearer (lines 181-197). In addition, we have included a new section, 2.1 Surface Remote sensing products, that summarizes the main spatial and temporal resolutions and uncertainties of some of the available remote sensing products for the variables we use in our study.

On the same note, I think the paper lacks discussions on the capability of current satellite missions and, more importantly, future missions for Earth observations in the microwave band, how this could impact e.g. sea surface temperature and salinity monitoring and which could be the impact of such missions on the proposed ocean 4D reconstruction. I think this should also be integrated into the discussion section, at least.

We agree with the reviewer; we have included a small paragraph in the discussion section to contextualize our approach and how it could benefit from new simultaneous SST and SSS observations provided by the CMIR mission. (see lines 446-449)

Minor Points

I was wondering if the proposed reconstruction methodology is able to provide un uncertainty estimate to verify if the profiles provided in Figure 10 can be considered significantly different. Could the Authors quickly comment on that?

Currently, our model does not provide uncertainty estimates for the reconstruction. Our primary objective was to assess the feasibility of the reconstruction approach rather than to deliver a ready-to-use data product. At this stage of development, we did not consider uncertainty quantification to be essential for demonstrating the methodology's viability. That said, we fully acknowledge that uncertainty estimation will be crucial for future work aimed at producing an operational data product and should be incorporated in practical applications.

Have the Authors tried to inter-compare the feature-resolution of the reconstructed fields versus the ground truth? Are you expecting significant differences?

We have included a new section (5.4 Spatio-Structural Validation) in which we further qualitatively discuss the feature-resolution using the singularity analysis, and we show that the LSTM gives a better feature reconstruction when comparing with the ground-truth (lines: 380-389)

Could the Authors also provide a broad overview of which could be the "real in-situ and satellite" data more suitable for their future applications?

We have included a new section (2.Current Sampling of the Ocean) where we summarize the current satellite and real in situ products available, regarding the spatial and temporal resolution, and the uncertainties of each variable we used in our study.

Typos

In general, please always use Copernicus Marine Service instead of CMEMS when referring to data generated within the EU Copernicus Marine Service.

We updated all the appearances in the text.

Line 88: earth-> Earth

We updated the word accordingly.