Short-term neural forecasts of ocean dynamics from sparse satellite observations

Daria Botvynko[1], Pierre Haslée[1], Lucile Gaultier[2], Bertrand Chapron[3], Clément de Boyer Montégut[3], Anass el Aouni[4], Julien le Sommer[5], Ronan Fablet[1]

[1]Lab-STICC, UMR CNRS 6285, IMT Atlantique, Odyssey, INRIA, IMT Atlantique, Brest, France

[2]OceanDataLab, Locmaria-Plouzané, France

[3]LOPS, UMR CNRS 6523, Ifremer, Plouzané, France

[4]Mercator Ocean International, Toulouse, France

[5]CNRS, IRD, Univ. Grenoble Alpes, Grenoble, France

Abstract

The uptake of AI-based solutions for earth system modeling, monitoring and forecasting is growing quickly. Among others, short-term neural weather forecasts relying on “end-to-end” neural schemes (Bi et al., 2023; Lam et al., 2023) reaching state-of-the-art performance are striking examples of this trend. Recent studies (***Febvre et al., 2023***; Martin et al., 2023, Garcia et al., 2025) support the potential of end-to-end deep learning schemes to improve the monitoring of the oceans from available observation datasets. In this study we develop a short-term ocean forecasting workflow given the specifics of ocean observation systems. We define the forecasting task as the training of end-to-end neural schemes for the forecasting of ocean states from multi-source and sparse observation data. We develop the pipelines for (i) data processing; (ii) training, validation and testing of forecasting models; (iii) evaluation of forecasted oceanic variables (SLA, SSC, SST and MLD). We evaluate the performance of the studied forecasting models, namely Unet and 4DVarNet architectures, by comparing them to the reference ocean observations, e.g. Nadirs, SWOT, Argo and others. We demonstrate how end-to-end approaches outperform state-of-the-art assimilation-based and data-driven ocean forecasts. We discuss how end-to-end neural forecasts are improved by incorporating observational datasets as inputs either during the training phase or at the inference stage. Especially, through a focus on satellite altimetry, we exhibit how the space-time sampling of the observation data can drive the forecasting performance.