SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Regional Ocean Forecasting with Hierarchical Graph Neural Networks

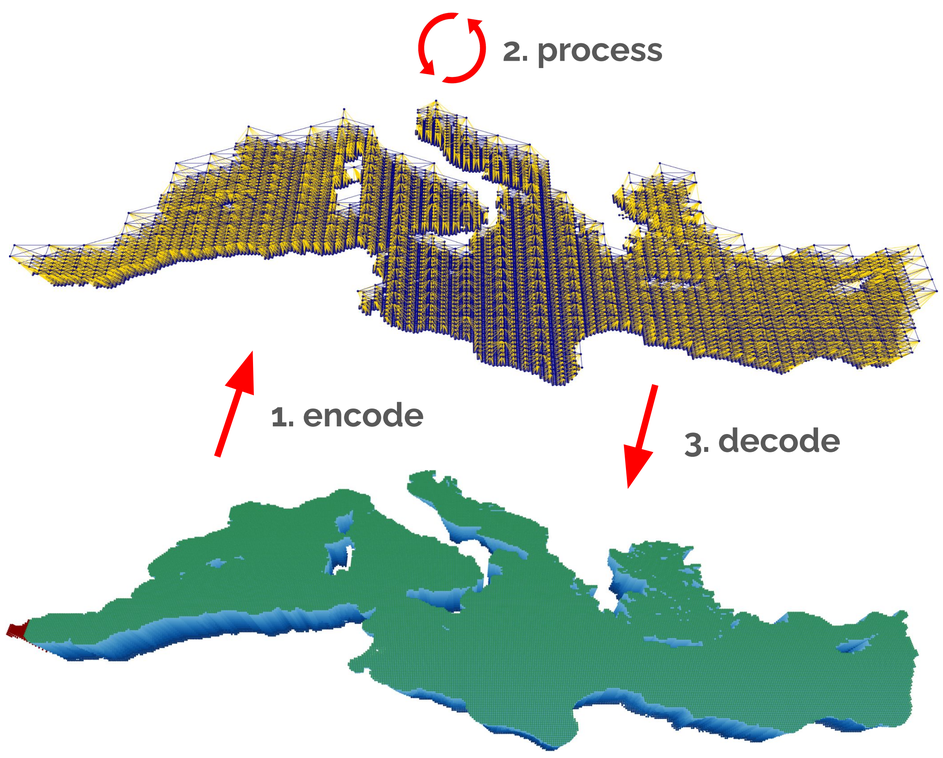
Daniel Holmberg[1], Emanuela Clementi[2] and Teemu Roos[1]
University of Helsinki[1], CMCC Foundation[2]

Motivation

Predicting ocean conditions is essential for sectors such as shipping, resource management, and climate adaptation. Although, traditional numerical solvers are quite compute heavy. Advancements in ML have revolutionized weather forecasting, offering accurate and much faster alternatives. Building on these ideas, we present SeaCast, a neural net designed for high-res, medium-range ocean forecasting.

Method

- Given initial sea states (X^{-1}, X^{0}) forecast $(X^{1}, ..., X^{T})$.
- Autoregressive approach where SeaCast predicts one step ahead and uses predicted state as input again.
- GNNs are used to 1) encode gridded data on a coarser mesh; 2) process this latent representation; 3) map back onto the original grid predicting the next state.



Mediterranean Sea Dataset

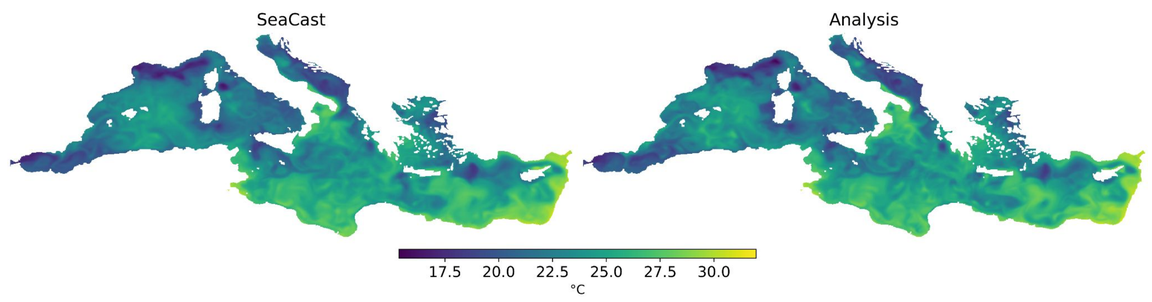
- 1/24° resolution physics (Med-PHY) data from CMEMS.
- Causal splits for training, validation, and test sets, comprising daily data from Jan 1987 to Aug 2024.
- Selected in total 18 vertical levels down to 200 meters.
- Temperature, salinity, zonal and meridional velocities forecasted across depths, and mixed layer height, sea surface height and bottom temperature at single level,
- Static features: lat, lon, sea depth and mean topography.
- Atmospheric forcing consists of 2m-temperature, 10m-winds and mean sea level pressure from ERA5 during training and 15-day ECMWF AIFS and ENS for testing.
- Boundary forcing at the Strait of Gibraltar via Med-PHY.

Computational Complexity

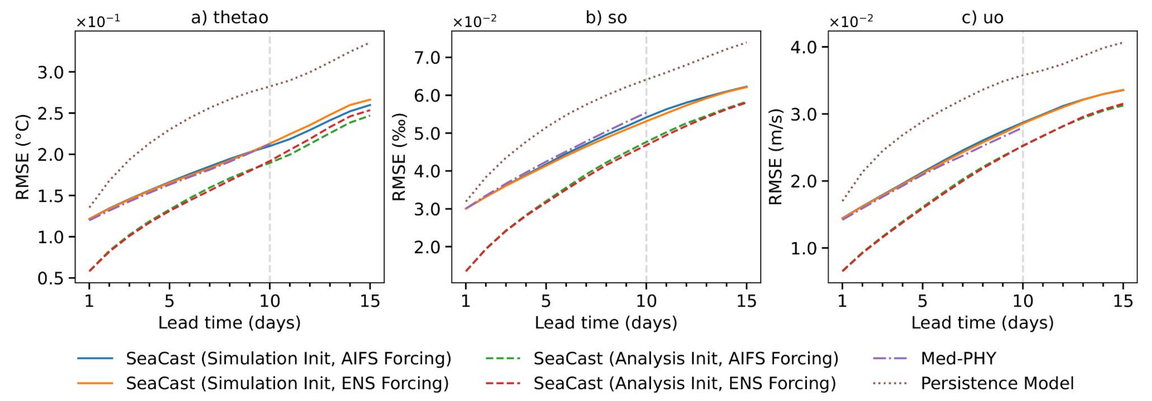
- Training SeaCast took 2 days on 32 AMD MI250x GPUs.
- Produces a 15-day forecast in 11.2 seconds on 1 GPU.
- Med-PHY takes approx. 135 minutes to run a bulletin, consisting of a 1-day simulation followed by a 10-day forecast, using 413 CPU cores (incl. 141 depths & waves).

Comparison to Analysis Fields

- SeaCast-AIFS 10-day lead forecast for temperature at 22.7 m depth initialized on 1.8.2024, and the corresponding analysis.

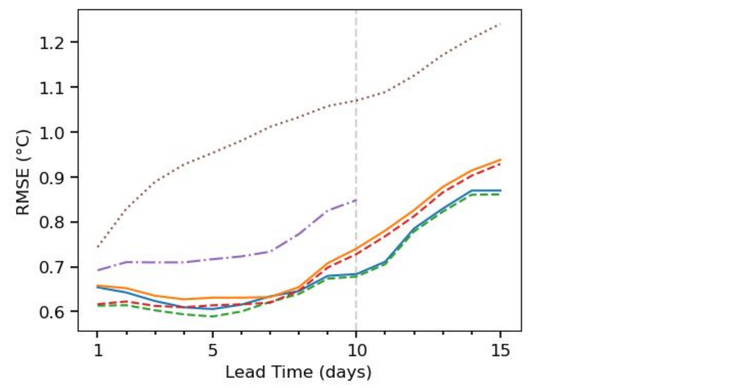


- Depth-averaged RMSE for temperature, salinity and zonal velocity comparing models, forcings and initializations.

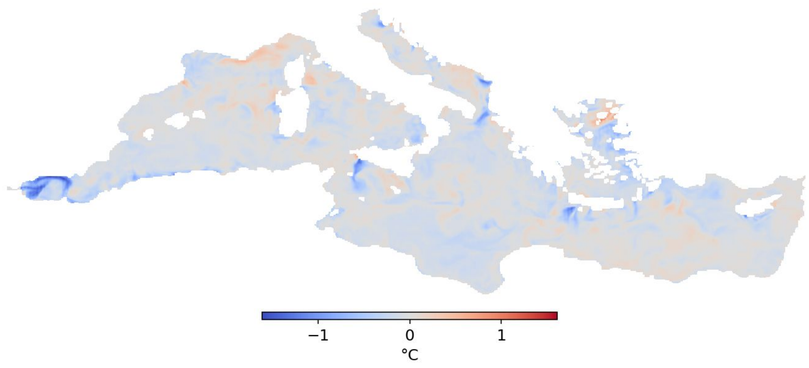


Comparison to Satellite SST

- RMSE w.r.t. satellite SST for the models at different lead times.



- RMSE difference between SeaCast-AIFS and Med-PHY w.r.t. satellite SST. Blue indicates higher skill for SeaCast-AIFS.



Contact and Paper

- SeaCast is available on the arXiv via the QR code.
- in/holmberg-daniel @dholmbrg
- daniel.holmberg@helsinki.fi

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici
UNIVERSITY OF HELSINKI FACULTY OF SCIENCE
Climate Change AI

Ocean Predict In partnership with unesco Intergovernmental Oceanographic Commission
2021 2030 United Nations Decade of Ocean Science for Sustainable Development