SYMPOSIUM OP'24 — ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Super Resolution Data Assimilation for an operational ocean-sea ice data assimilation system

EDITO European Digital Twin Ocean

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1 - Introduction

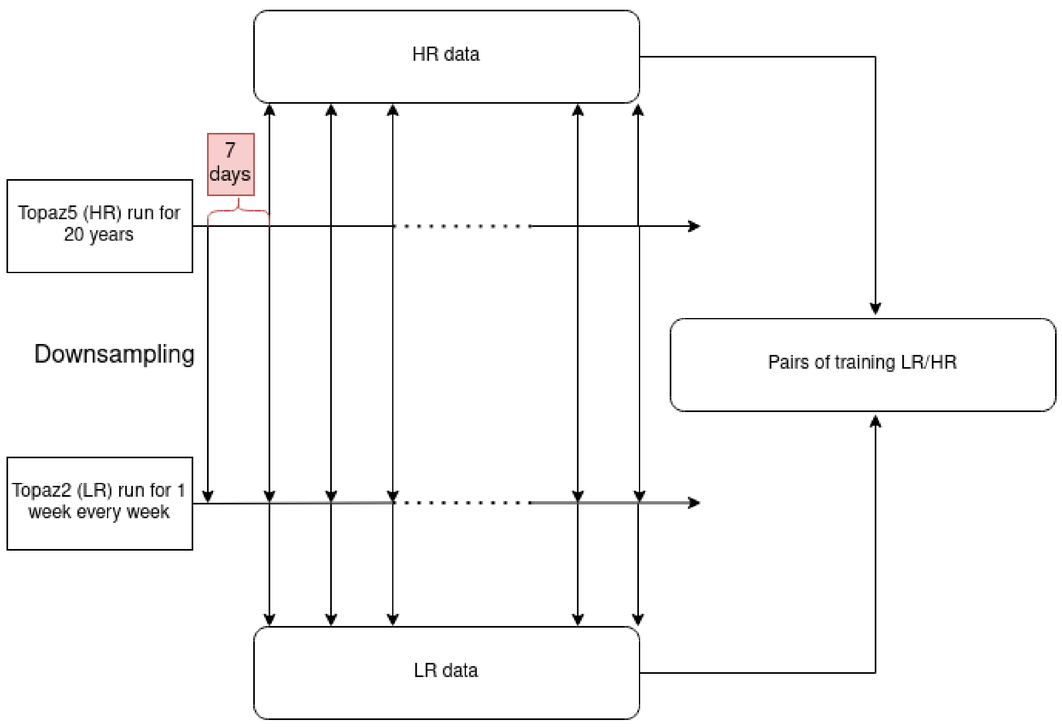
Super Resolution Data Assimilation (SRDA) (Barthelemy 2022) aims at reconstruction High Resolution (HR) fields out of a Low Resolution (LR) model, **allowing to both correct the LR model error and assimilate HR observations**. It thus enables analyses comparable to those obtained in a fully high-dimensional data assimilation system but at **a significantly reduced cost**

It consists in **training a deep Neural Network** (NN) to map low resolution model outputs into high resolution space, assimilating high resolution observations with the Ensemble Kalman Filter (EnFK) and then going back into the low dimension space to run the LR model for the next forecast step.

We apply this strategy to **TOPAZ**, a coupled ocean/sea-ice/Biogeochemistry data assimilation system for the North Atlantic Ocean and the Arctic, existing in two versions with different resolution: TOPAZ 2 (12 km) and TOPAZ 5 (6 km), but with same vertical resolution.

2 - Creating the learning data set

Run the HR model for a long period → downsample output every week → run the LR model for 1 week from this downsampled file → at the end of the week get a training pair of matching LR/HR fields



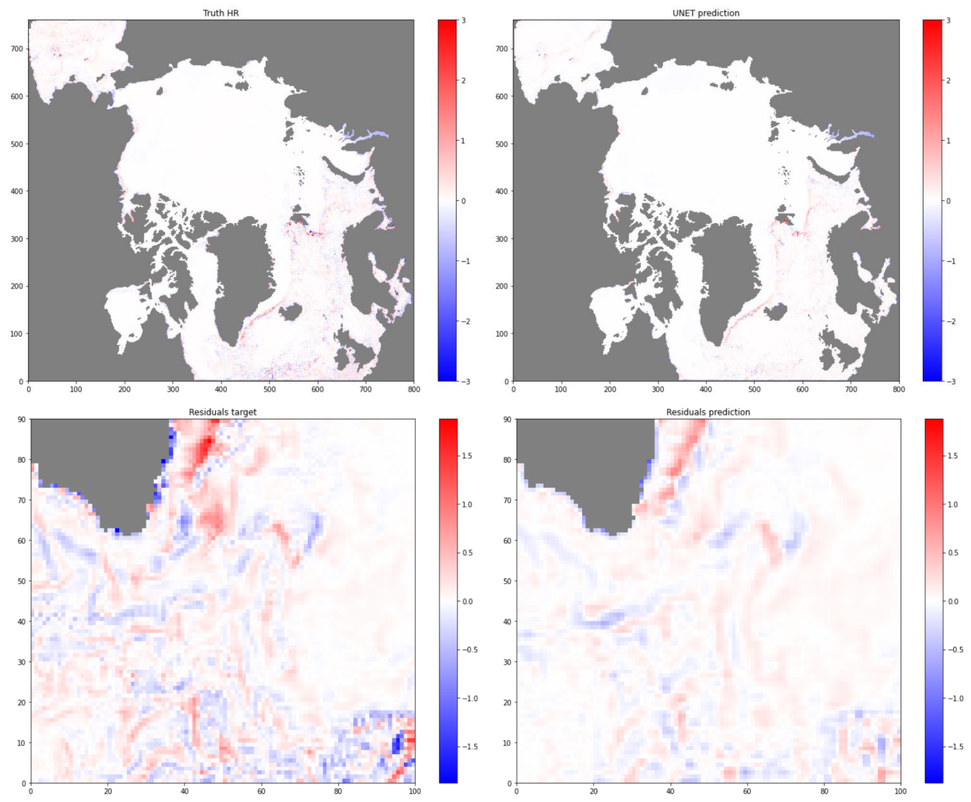
3 – NN architecture and training

Deep Residual Unet adapted from Maji, D. (2022)

- Predicts one variable at a time (over the full 3D domain) with several inputs (e.g. perdicts the HR Chlorophyll from the LR field, the land mask and the vorticity)
- Land mask used as an input and used in the loss function
- The input is a bilinear interpolation of the LR field, so the NN only predicts on the HR grid the residuals we need to add to get the HR field
- Super resolved fields can be used as an input to help super resolve other fields.

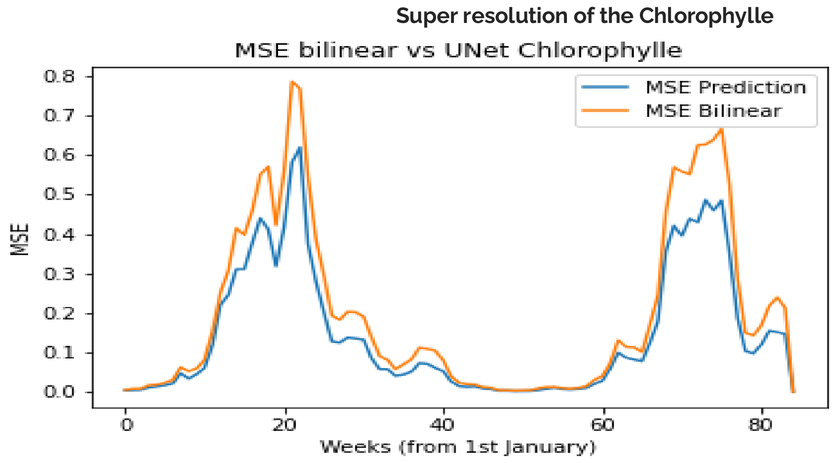
4 - Some results

Super resolution of the surface temperature

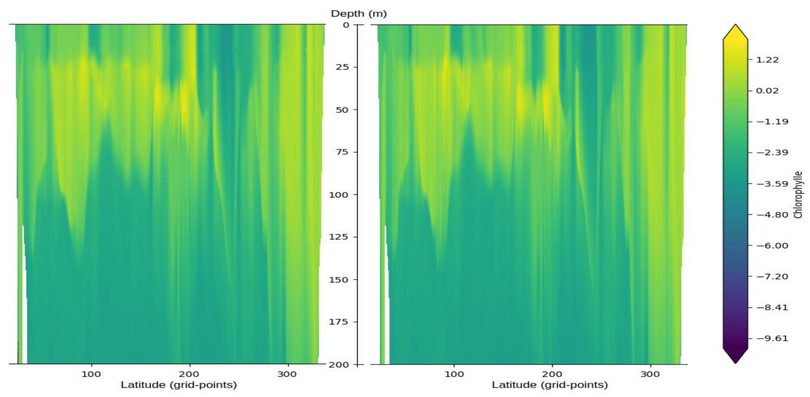


- Improvement in RMSE of ≈ 25% over bilinear interpolation -> no double penalty effect
- Correction of the model errors related to the coarser grid along the sea-ice edge, the coastlines, in the Gulf of Ob and the Atlantic.

Super resolution of the Chlorophylle



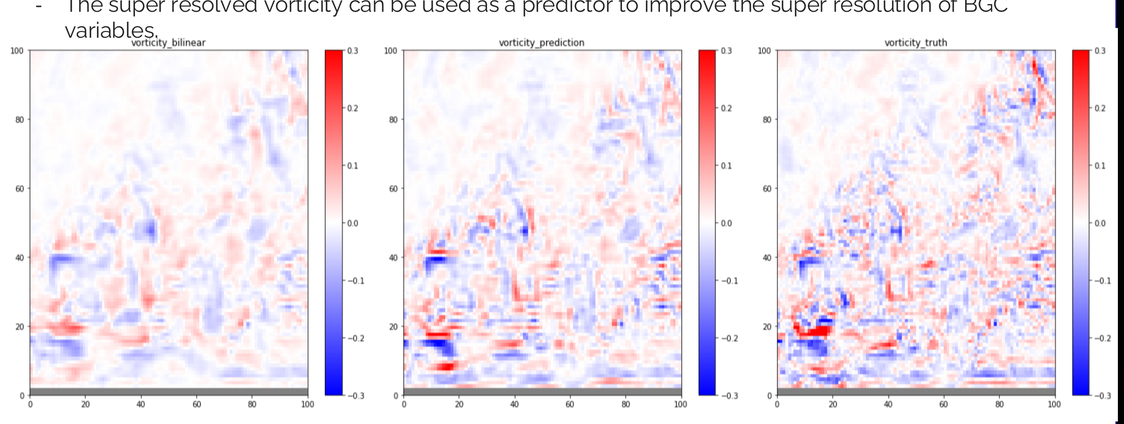
- Improvement in RMSE over all the weeks, especially during chlorophyll bloom periods.



- Reconstruction of a vertical profile by the neural network (left) VS the ground truth (right)

Super resolution of u and v: effect on the vorticity

- The vorticity computed from u and v computed through a bilinear interpolation (left), Unet prediction (middle) and ground truth (right). Improvement in RMSE of ≈ 14%.
- The super resolved vorticity can be used as a predictor to improve the super resolution of BGC variables.



5 - On going work

Comparison of the 3 data assimilation runs: one fully LR run and one SRDA run compared against a fully HR run.

For 1 cycle, **the SRDA and LR runs requires almost the same computational resources** and time, which is **close to 8 times less than the HR run**

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