Deriving benthic traits through deep learning methods

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A machine learning model (DINCAE) is used to map benthic traits from a point-based dataset. It gives a map and an error estimation.

Intro

- The **Black Sea continental shelf is poorly sampled**
- Dataset are built and given by S Chevalier (personal communication, 2025).
- We use **machine learning interpolation** for their non-linear capabilities resulting in traits maps.
- **27 traits are considered**, several of them will help us to compute **ecological processes** (e.g., vulnerability of species).
- A regular interpolation framework (**DIVAnd**) is **used to get a comparison** with the Machine Learning results.

Domain

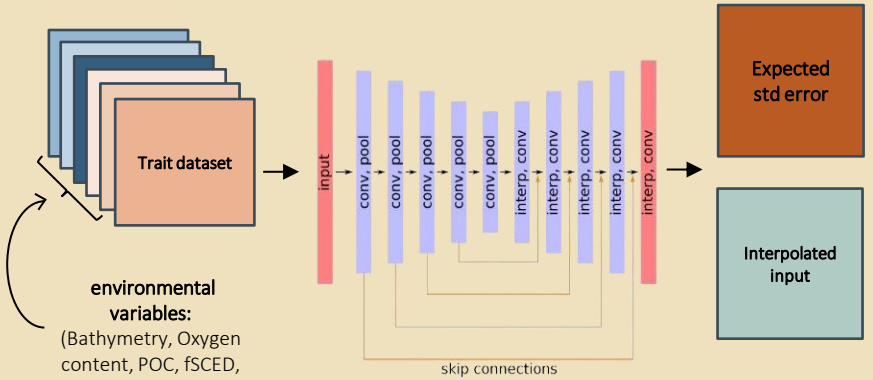
Period

Ten years average: 2008-2018

Method

Data-Interpolating Convolutional Auto-Encoder (**DINCAE***) is used.

It is a **U-Net** which compute convolutional and max pooling steps to **compress and decompress an image**.
Environmental variables are used to train the model.
The decompression of the image **results with interpolated field.**



Barth et al. 2022

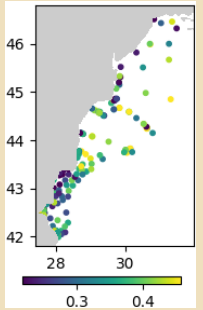
Aim

To demonstrate the **machine learning interpolation capabilities for biology.**
Seek for the most powerful environmental variables for the reconstruction.
Understand and guess **functional diversity** to map water-sediment interactions **and vulnerability patterns** over the shelf.

Results

An ablation **study is carried** to seek for the most important environmental factors.

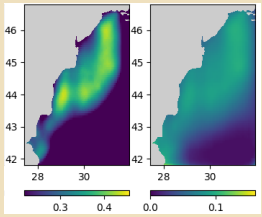
Substratum depth occupancy = 0 (fraction)



4 modalities: 0, 0-5, 5-15, >30cm. First one is represented on the map

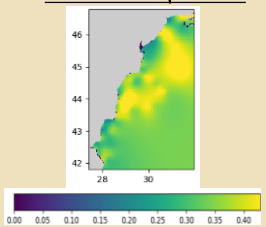
Training set : 90%
Validation set : 10%

DINCAE result



std error

DIVAnd interpolation



RMS (%)

Variable not considered	Error value
/	0.0938
Oxygen and bathymetry	0.1418
Sediment type	0.1007
fSCED	0.0973
sSCED	0.0936
POC	0.1048
DIVAnd baseline	0.1493

Computed with validation dataset

Discussion

- DIVAnd RMS error is almost always higher than DINCAE.
- **Oxygen and Bathymetry explains a significant portion** of the variability of traits
- **Temporal variable is not considered** due to the low amount of observations
- First convolutional U-net to map benthic traits

Further work

Combination of traits will be considered to **map ecological process at the shelf scale**

Source
Barth, A. et al. (2022) DINCAE 2.0: multivariate convolutional neural network with error estimates to reconstruct sea surface temperature satellite and altimetry observations. *Geoscientific Model Development*. [

* DINCAE.jl — Open-source tool