Systematic error correction in numerical ocean models with artificial neural networks

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EGU25 Abstract

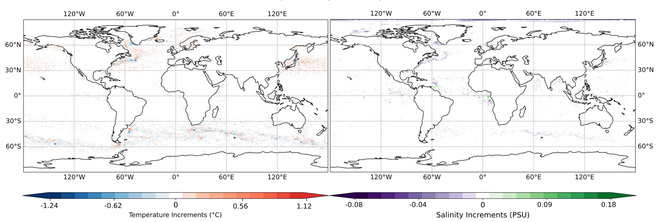
Introduction

Systematic errors come from:

1. Numerical approximations
2. Unresolved physical processes
3. Parameterization assumptions.

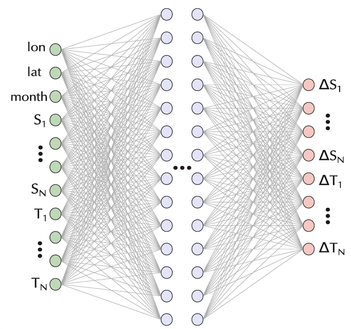
Reduce prediction accuracy.

Monthly Mean of Analysis Increment
0.5m Depth (AMJ) 2010–2022



Methods

Feed forward NN



Analysis increment learned from the ocean state

$$\Delta \mathbf{x} = f(\mathbf{x}, \theta)$$

NEMO tendency equation

$$\frac{\partial \mathbf{x}}{\partial t} = \mathcal{D}(\mathbf{x}) + \mathcal{P}(\mathbf{x}) + \frac{\Delta \mathbf{x}' \cdot dt}{\Delta t}$$

Loss function

$$\mathcal{L}(\Delta \mathbf{x}^{\text{true}}, \Delta \mathbf{x}^{\text{recon}}) = \frac{1}{\sum_i m(i)} \sum_i m(i) \left(\Delta \mathbf{x}_i^{\text{true}} - \Delta \mathbf{x}_i^{\text{pred}} \right)^2$$

$$m(i) = \begin{cases} 1 & \text{if } i \text{ not seafloor} \\ 0 & \text{if } i \text{ seafloor} \end{cases}$$

Training Dataset

Input	Predictors as monthly means from ECMWF ORAS6 (NEMO 4.0.6)
Target	Analysis increments of T/S from ECMWF ORAS6 (NEMOVAR)
Time span	2005 – 2022

Data preprocessing

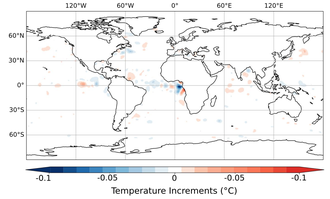
Low pass filter

Normalized by depth, month, and latitude bands (every 30°, from 90°N to 90° S)

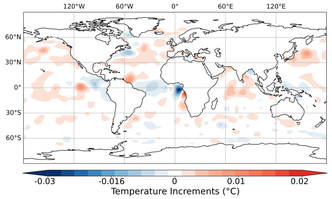
Subsampling with step of 10 grid point

Monthly Mean of Temperature Analysis Increment May 2005. 0.5m Depth

Filter scale: 25



Filter scale: 50

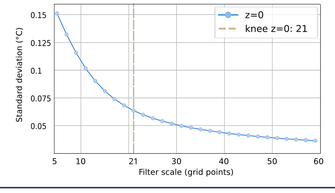


Filter scale	Consequence
Too low	retains high frequency noise
Too high	obscures systematic bias patterns

Comment:
Filter scale becomes a key hyperparameter!

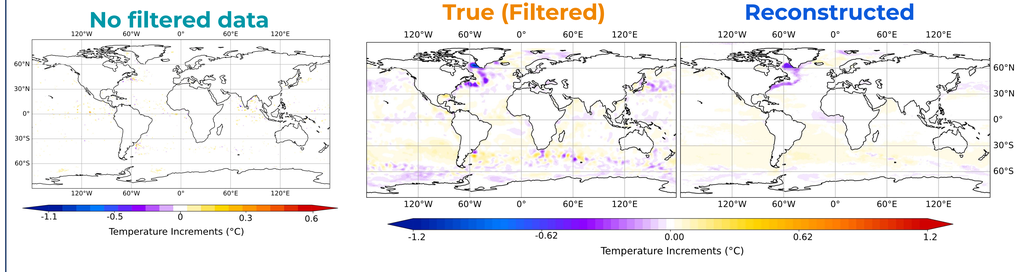
Minibatch design

Basin-balanced & time-shuffled batches → Avoid spatial and temporal bias



Results

Monthly Mean of Temperature Analysis Increment
January 2018. 16,5m Depth (Test Dataset)



Model architecture/hyperparameters

1. Batch size: 4096
2. Activation function: tanh
3. 3 × 1024 neurons + dropout (rate 0.2) after each hidden layer.

Comments:

1. Key patterns in the True analysis increment are recovered
2. Reconstructed appears as filtered version of the True (Chen et al., 2022, JAMES)

Future work

1. Explore strategies to mitigate the imbalance between informative and non-informative profiles
2. Explore use of additional predictors

Acknowledgements

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