The AI Revolution in Oceanography

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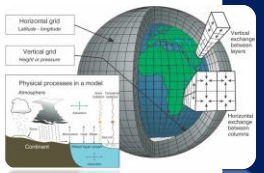
The Ocean Forecasting Challenge



Equation Resolving

- Rooted in established physical laws
- Highly interpretable

- Computationally expensive
- Memory Intensive
- Difficult to improve given more data

Machine Learning

- Competitive accuracy
- Fast prediction
- Performance improve given more data
- Learn more complex patterns not representable by equations

- Lack the versatility of equation resolving methods

Ocean vs Atmosphere

Water is denser than air

- Multi spatiotemporal-scale phenomena
- Various physics involved (ice, biochemistry, etc.)

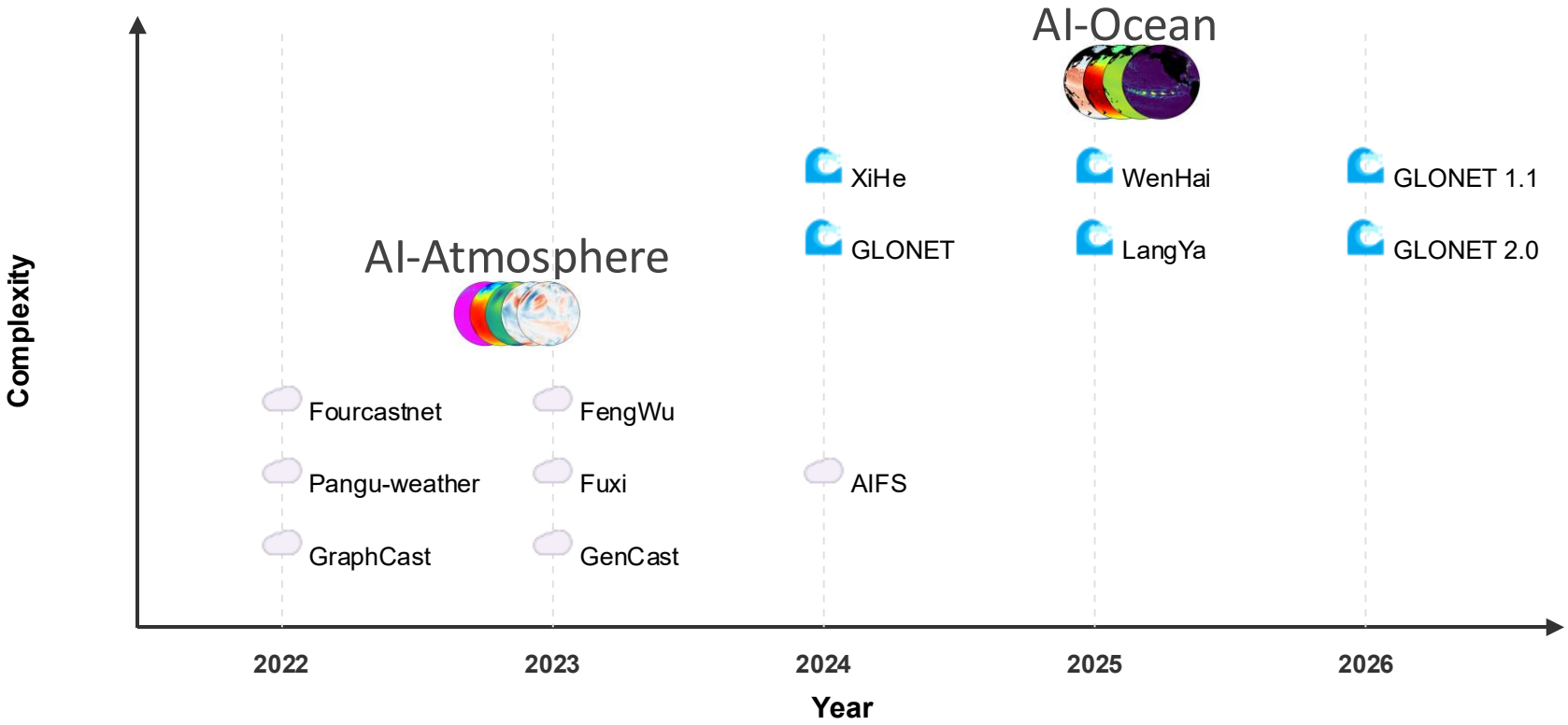
Land/bathymetry/islands are difficult to deal with

- Atmospheric ML architectures does not fit the ocean

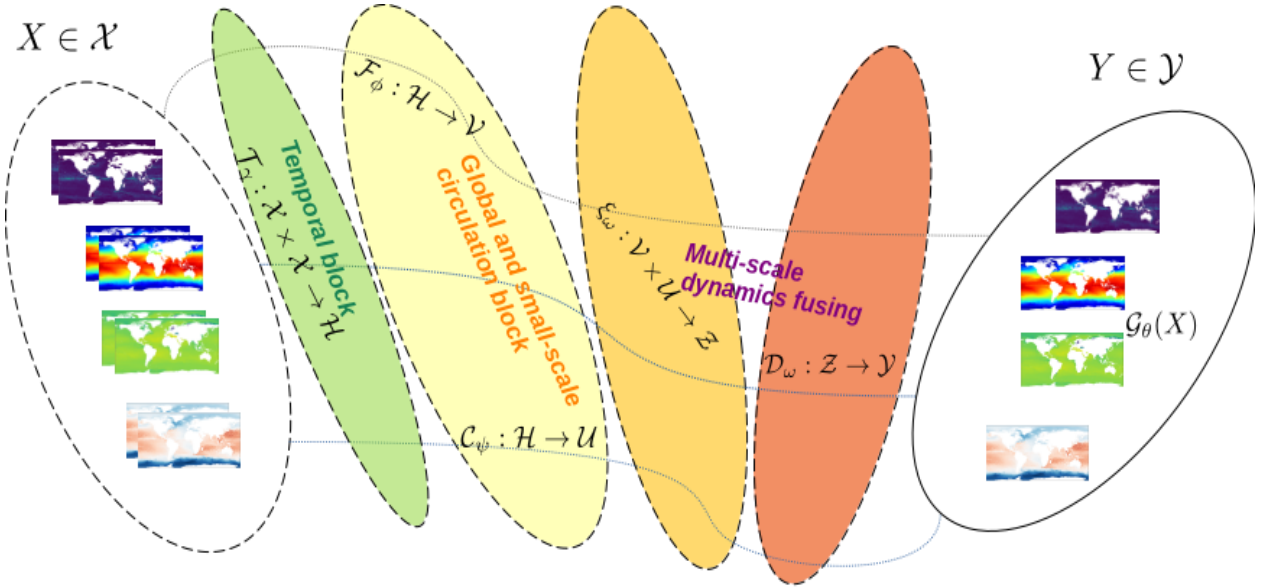
The ocean depth is barely observed

- Not enough data to train, nor to evaluate
- Need for advanced evaluation protocols

Machine Learning in Earth Forecasting Systems



GLONET: Mercator Ocean's Neural Network-Forecasting system



(t_i) $(t_{i+\tau})$

GLONET: Mercator Ocean's Neural Network-Forecasting system

Training

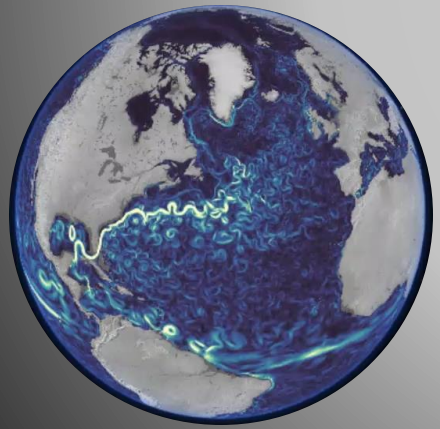
- 8x4 A100 nodes ~ 1 month

10-days inferences

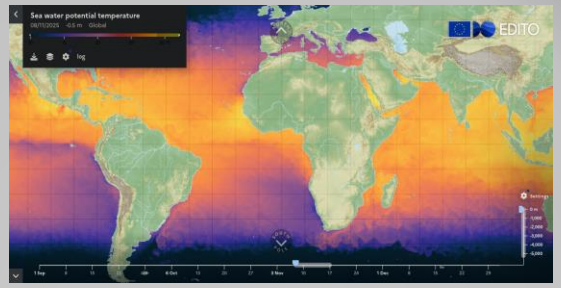
- CPU 16 cores ~ 7 min
- 12G VRAM ~ 30 sec
- A100 (40G VRAM) ~ 3 sec

365-days inferences

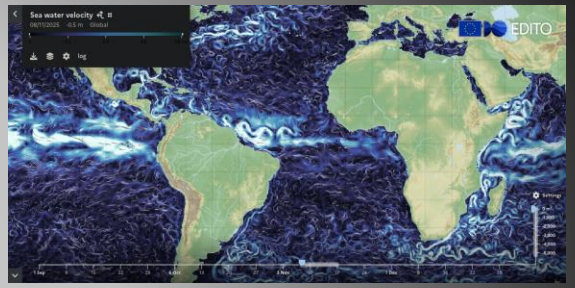
- A100 node ~ 3 min

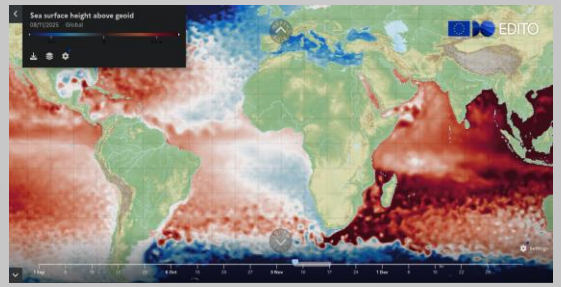


Temperature

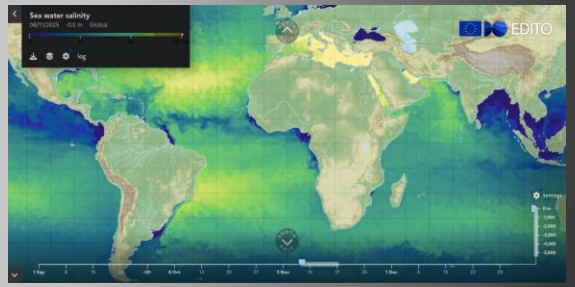


Currents





Surface Height



Salinity

Trained by: GLORYS12
Initialised by: GLO12
Forecast horizon: 10-day
Output grid resolution: 1/4°
Effective resolution: 1/12°

GLONET: Evaluation

XIHE

GLO12

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u} \cdot \nabla)\mathbf{u}$$

$$-\nabla p + \nu \nabla^2 \mathbf{u} + \mathbf{f},$$

GLONET

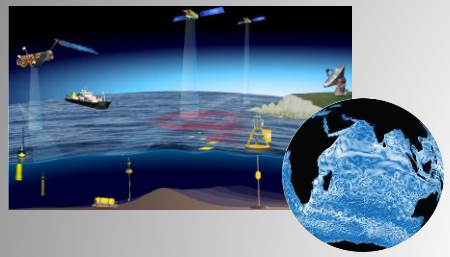
Reference model data

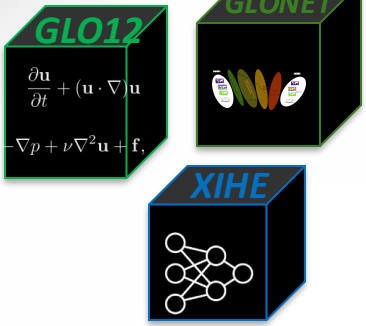
Observations data

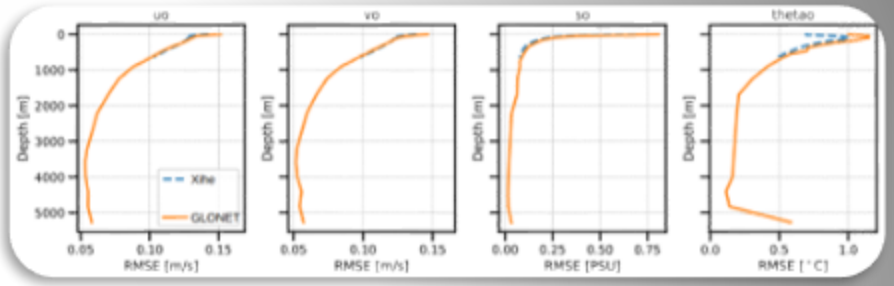
Physically-consistent processes

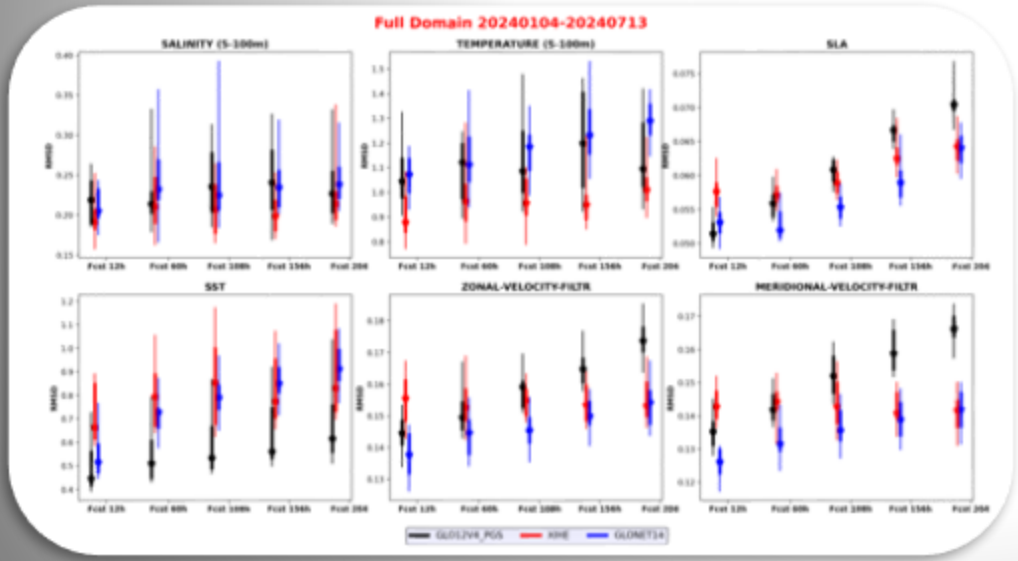
GLONET: Evaluation Against Observations and Reference Models

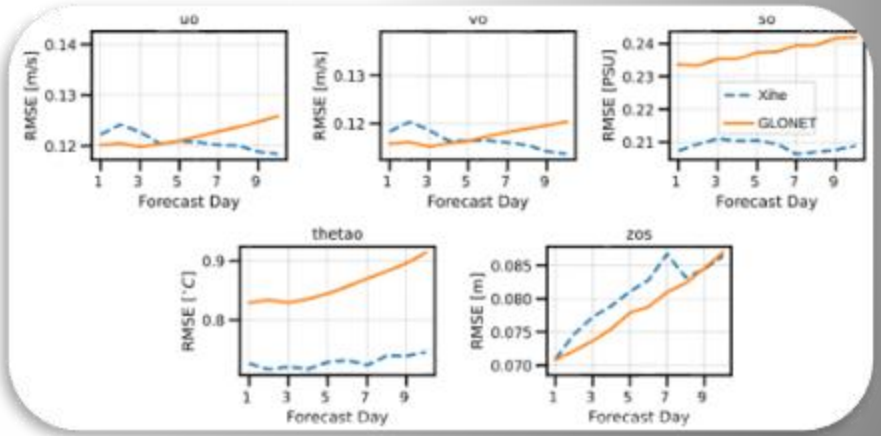
Observations



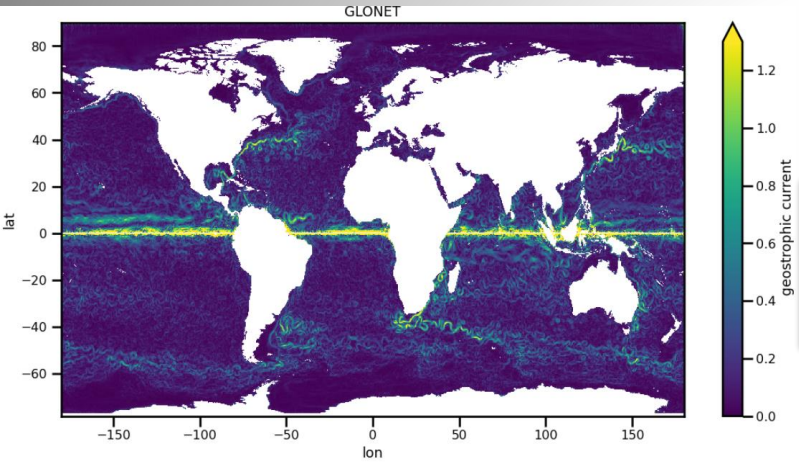


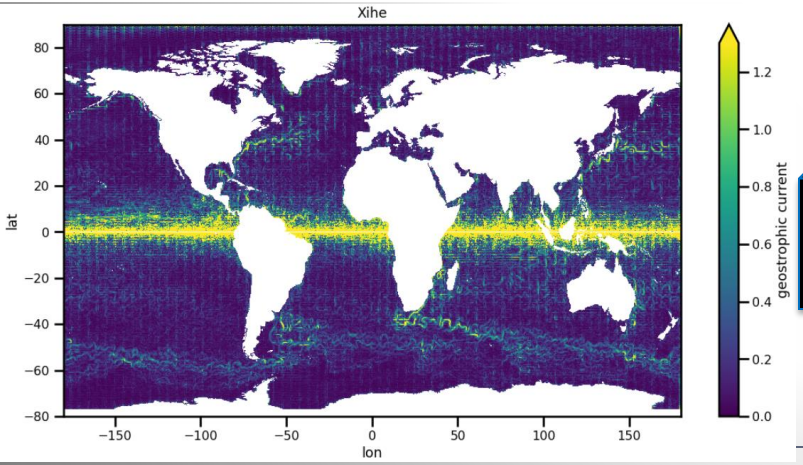


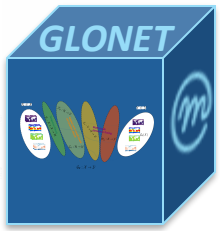


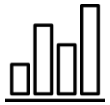


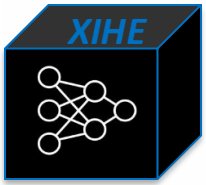
GLONET: Evaluation with Physically-consistent Processes

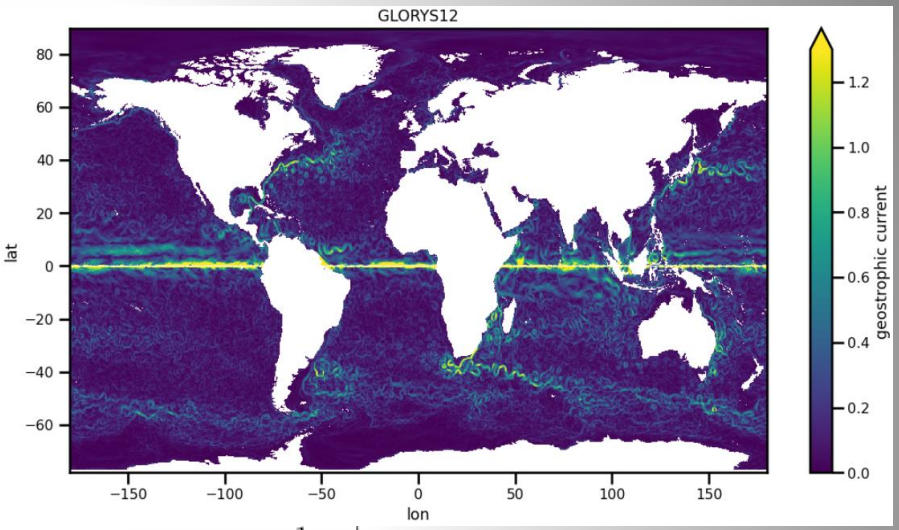






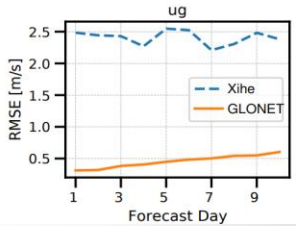


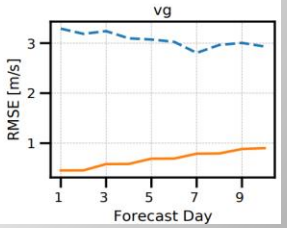


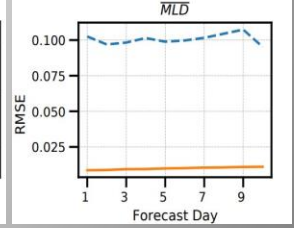


$$\mathbf{v}(\phi, \theta, t) = gf^{-1}\nabla^{\perp}\eta(\phi, \lambda, t)$$

$$\mathrm{MLD} = \min\{z \mid \rho(z) - \rho(0) \geq \Delta\rho\}$$







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GLONET: Mercator's End-to-End Neural Global Ocean Forecasting System

Anass El Aouni, Quentin Gaudel, Charly Regnier, Simon Van Gennip, Olivier Le Galloudec, Marie Drevillon, Yann Drillet, Jean-Michel Lellouche

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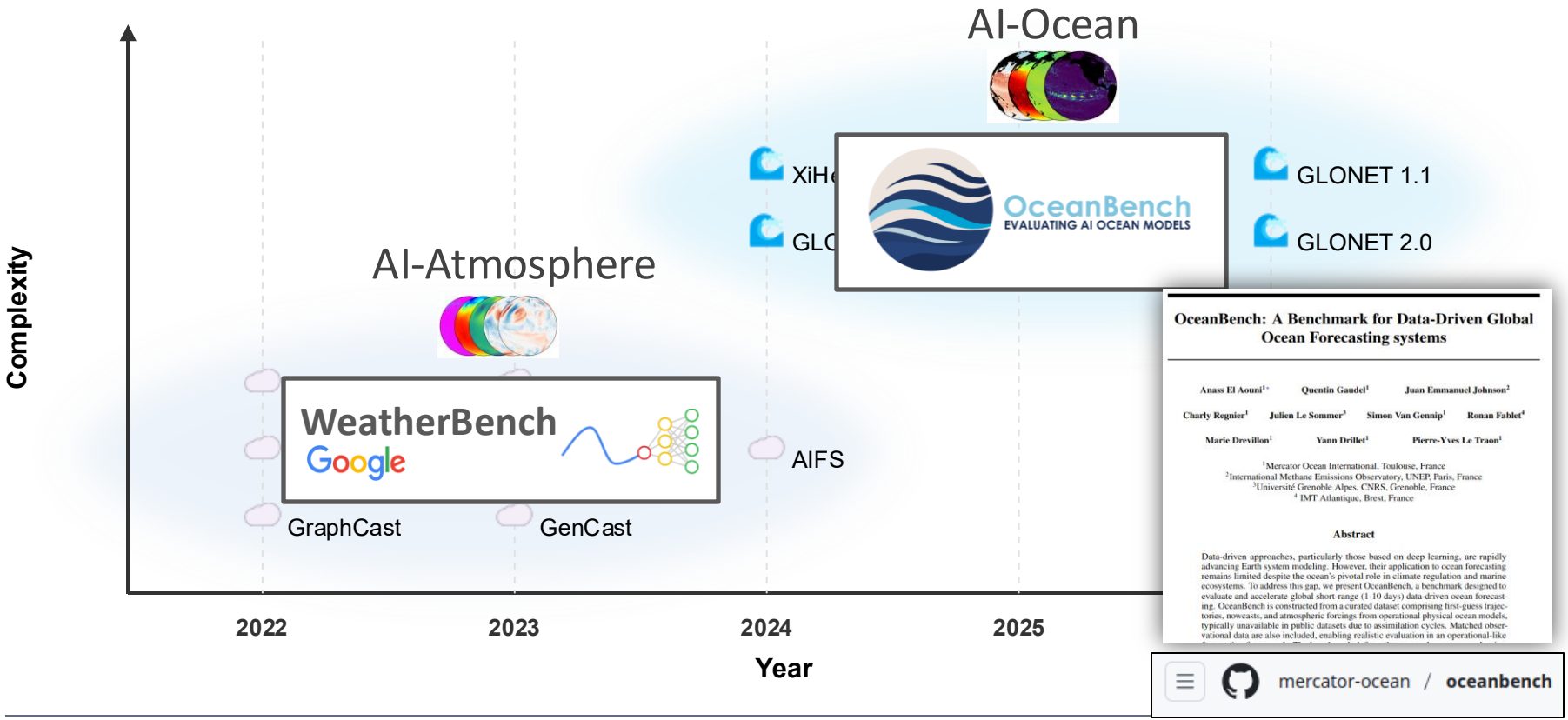
https://glonet.lab.dive.edito.eu

- December 2024: **Daily forecasts**
- May 2025: **MyOcean viewer**
- February 2026: **On-demand**

Benchmarking Earth Forecasting Systems



OceanBench: A Benchmark for Data-Driven Global Ocean Forecasting systems

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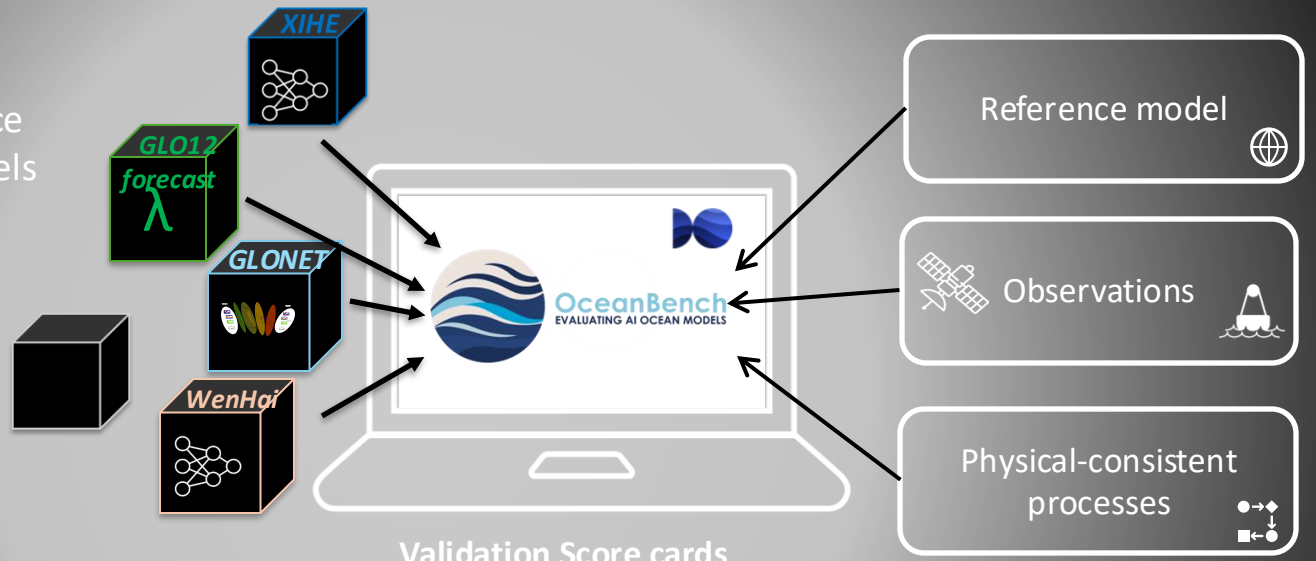
Abstract

Data-driven approaches, particularly those based on deep learning, are rapidly advancing Earth system modeling. However, their application to ocean forecasting remains limited despite the ocean's pivotal role in climate regulation and marine ecosystems. To address this gap, we present OceanBench, a benchmark designed to evaluate and accelerate global short-range (1-10 days) data-driven ocean forecasting. OceanBench is constructed from a curated dataset comprising first-guess trajectories, nowcasts, and atmospheric forcings from operational physical ocean models, typically unavailable in public datasets due to assimilation cycles. Matched observational data are also included, enabling realistic evaluation in an operational-like

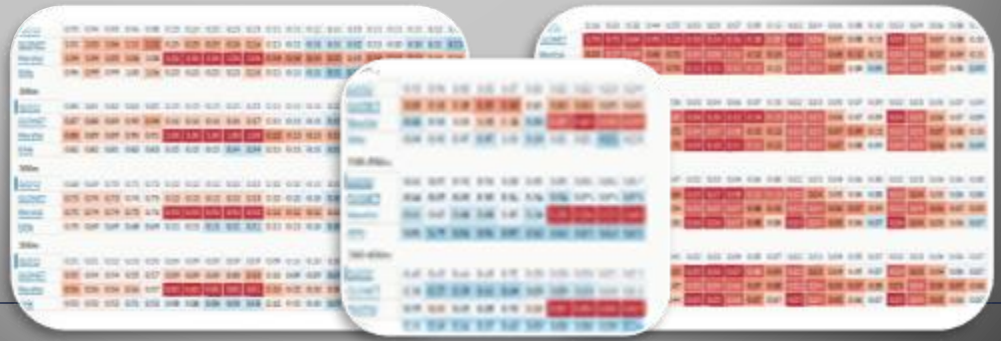
mercator-ocean / oceanbench

OceanBench: A Benchmark for Ocean Forecasting Systems

Open and collaborative service for benchmarking ocean models including AI-based models.

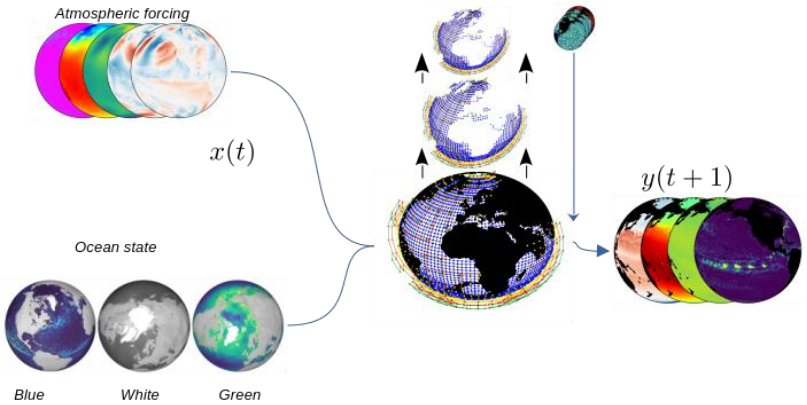


Validation Score cards

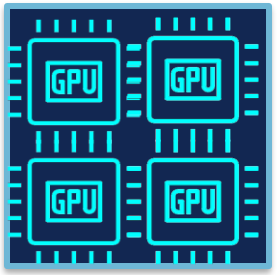


Others & Future Works - Community

Physics/Biogeochemistry/Ice

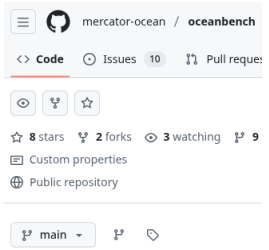


Progressive training
Latent dynamics

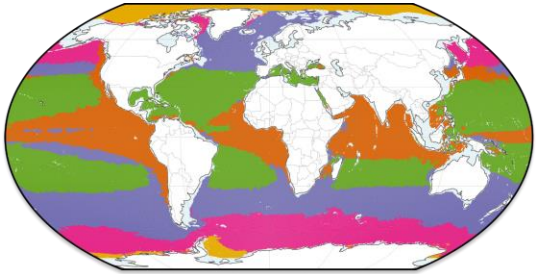


Collaborative project

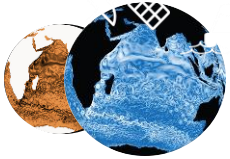
OceanBench
EVALUATING AI OCEAN MODELS



Seasonal/climate horizon



Data assimilation/reanalysis



High spatiotemporal resolution