Seastates-NET: A Machine Learning Forecasting Model for Understanding Wave-Current Interactions

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Thursday, September 25, 2025

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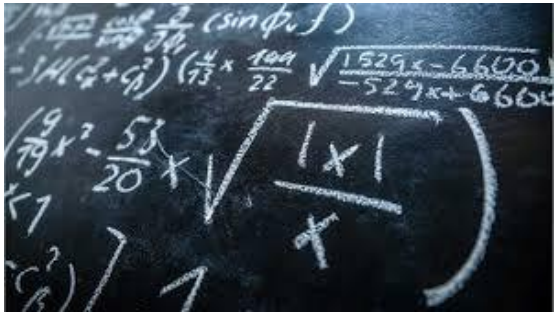

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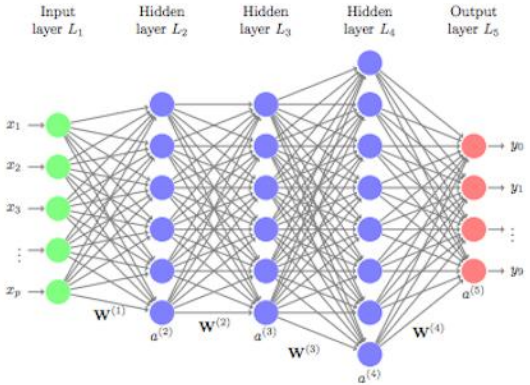

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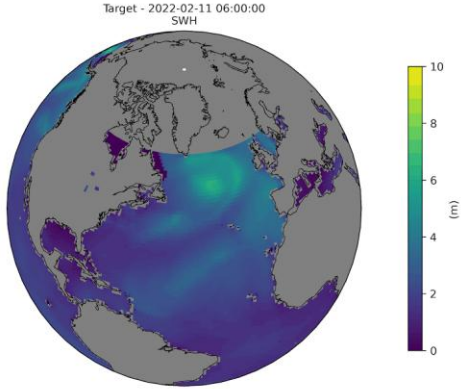
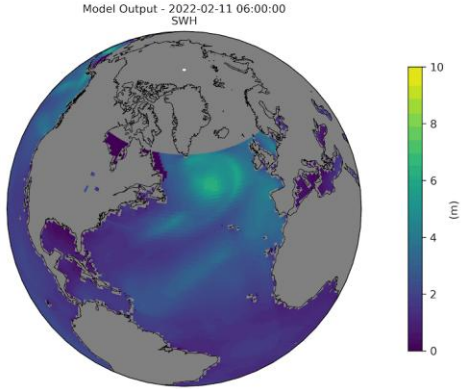
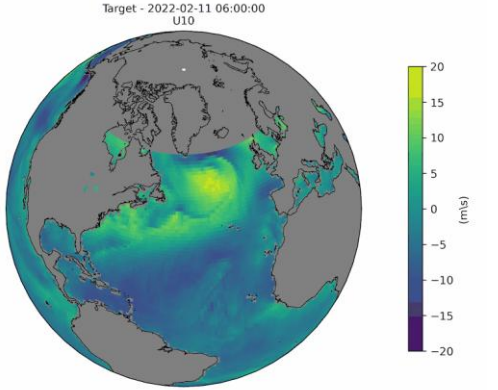
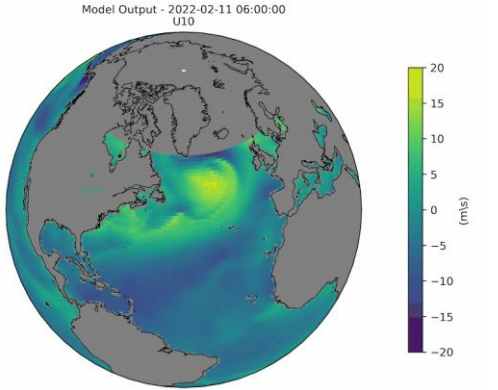
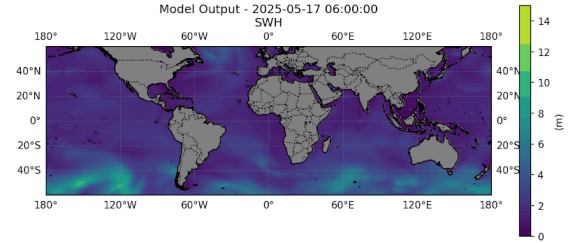


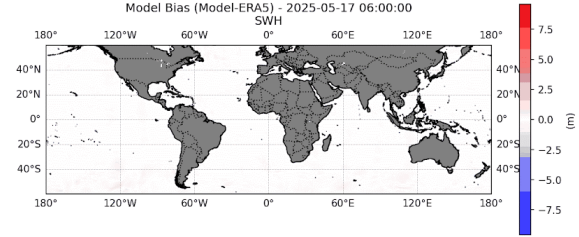


To what extent can machine learning based approaches produce physically coherent seastates forecasts ?

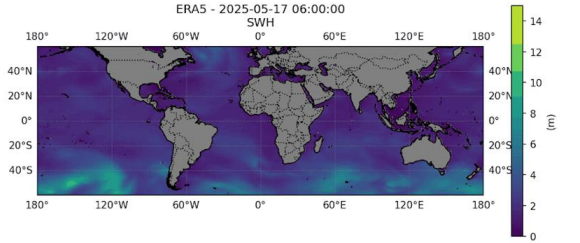


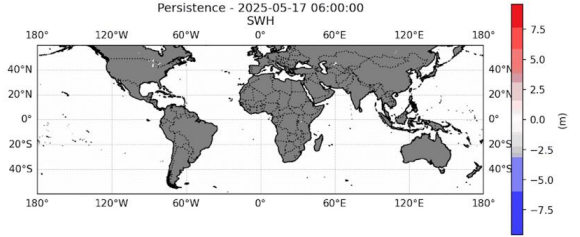


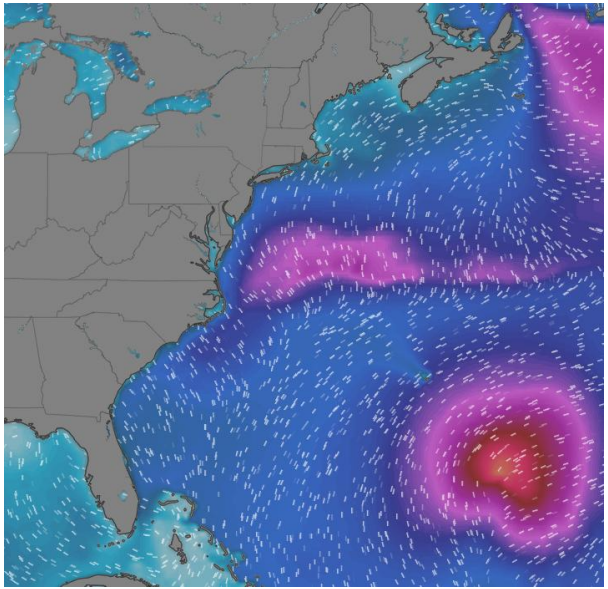




How to minimize error propagation and ensure temporal coherence of forecasts?

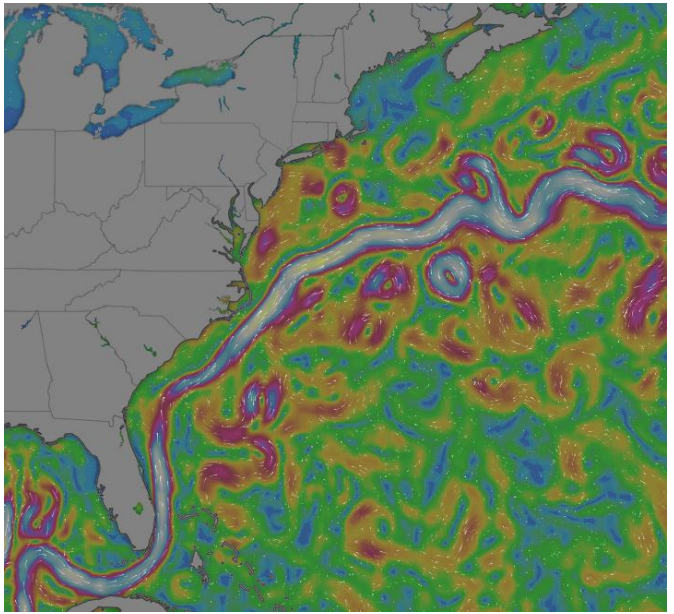




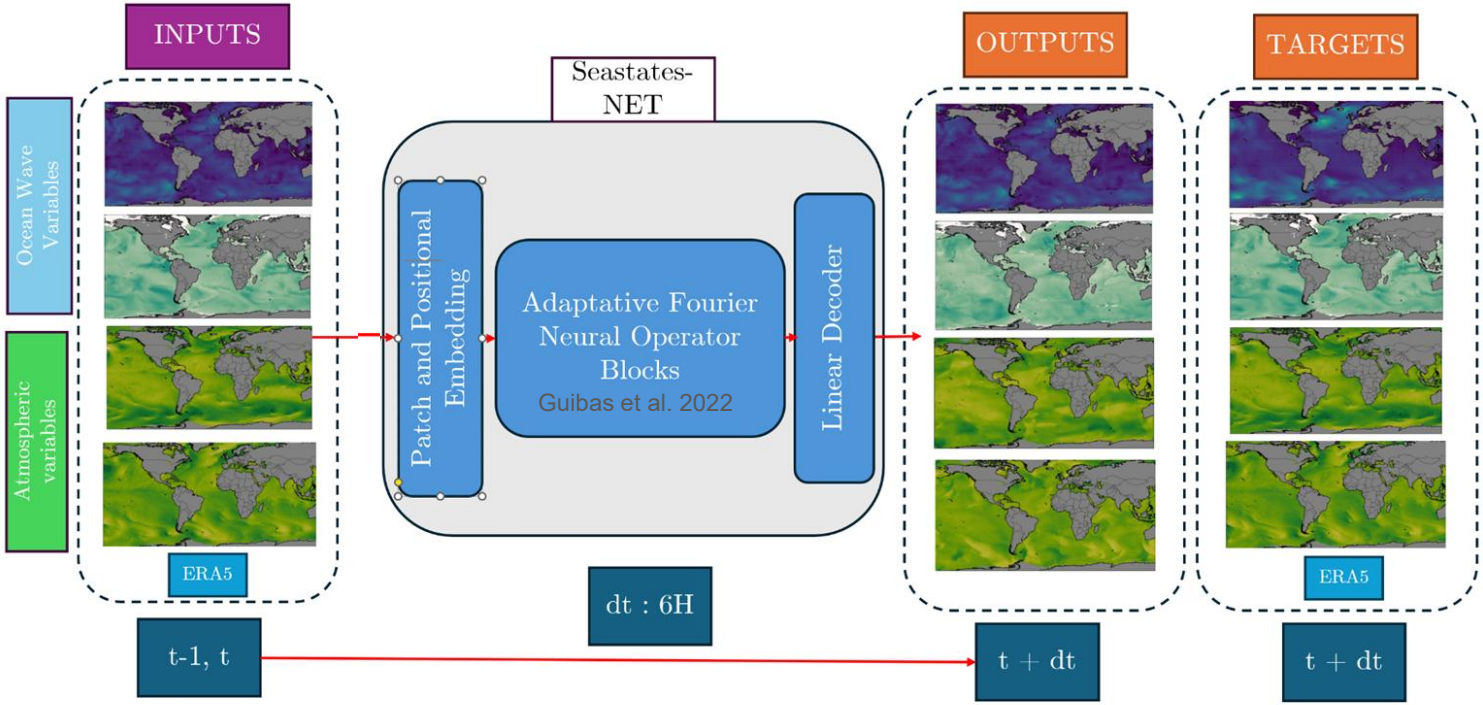


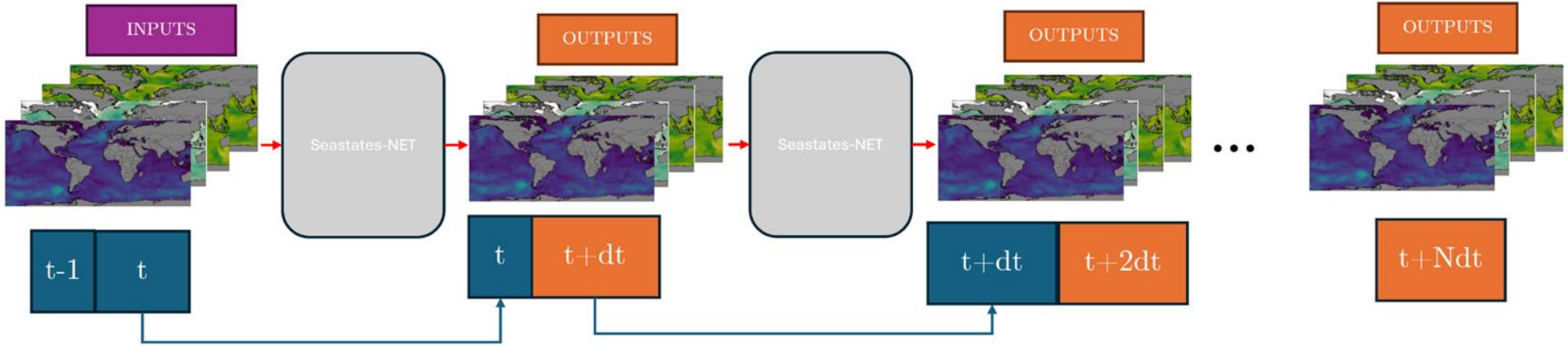
21/09/2025 16:00:00, SWH Forecast, IFS Forecasting Model, https://weatherviz.amphitrite.fr/

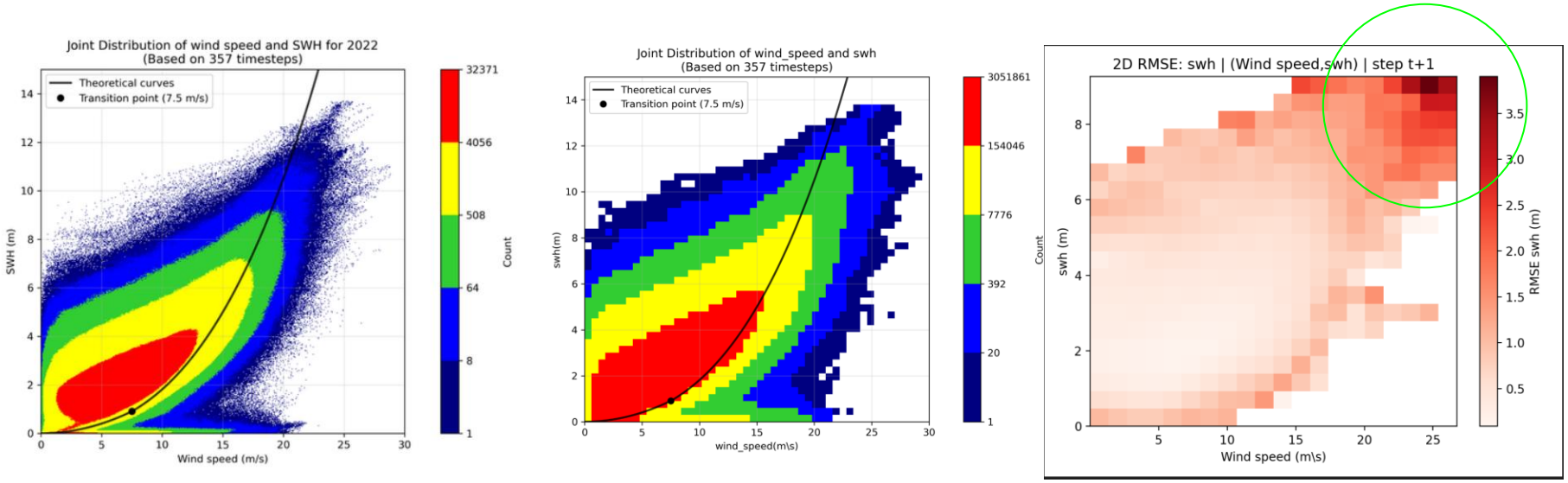
How to build on those experiments to integrate knowledge on interactions between ocean waves and currents?



21/09/2025 16:00:00, Oceanic Currents Forecast, ORCast Forecasting Model, https://weatherviz.amphitrite.fr/


INPUTS
Ocean Wave Variables
Atmospheric variables
ERA5
t-1, t
Seastates-NET
Patch and Positional Embedding
Adaptative Fourier Neural Operator Blocks
Guibas et al. 2022
Linear Decoder
dt : 6H
OUTPUTS
t + dt
TARGETS
ERA5
t + dt


INPUTS
Seastates-NET
OUTPUTS
Seastates-NET
OUTPUTS
OUTPUTS
t-1
t
t
t+dt
t+dt
t+2dt
t+Ndt



Analysis of Significant Wave Height / Wind speed joint distributions, at 6-hour lead time. (a) Target joint distribution from ERA5 reanalysis. The black curve is the theoretical relationship between winds speed and significant wave height for a fully developed sea, proposed by Hasselman et al (1988) [3]. **(b)** Seastates-NET estimated joint distribution. **(c)** Two dimensional RMSE, plotted for Significant Wave Height (SWH) .

Multistep training strategy
Backpropagation Through Time. (BPTT).
Vlachas et al, 2024

→

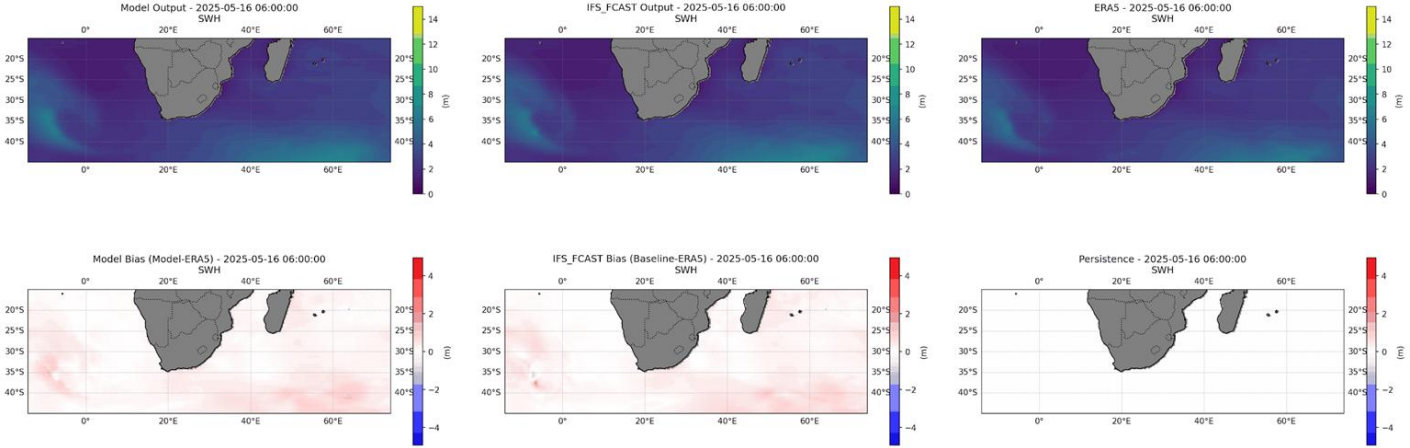
Constrain the model on **autoregressive rollouts** rather than on single time step forecasts

→

Sequentially feed the model with its **own forecasts**

Study wave-current interactions by:

- Using observations and model data in the training process
- Working at higher resolution



Thank you!

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