Comparative Analysis of Weather Window Estimations: Physics-based Versus Machine Learning Wave Forecasting

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Background

- Activities at **Offshore Renewable Energy sites** are governed by **strict weather limits**
- More accurate, site-specific forecasts can provide **improved decision-making**
- **Physics-based** spectral wave **models** are traditionally used for wave forecasts, but incur significant **computational cost**
- **Machine learning** models can provide low-cost nowcasts and forecasts

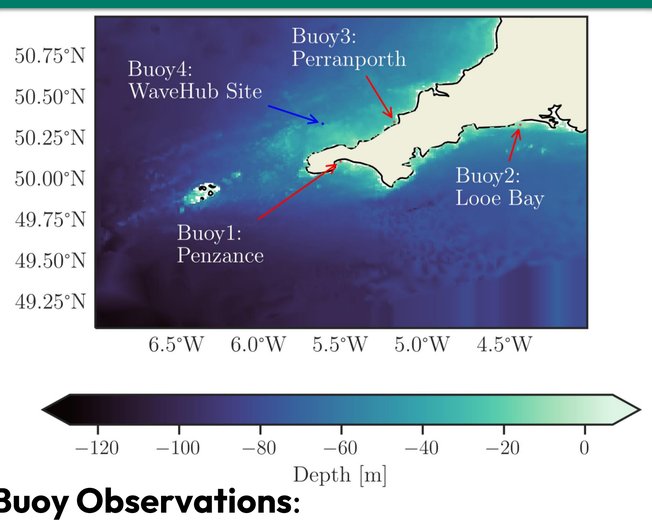
Objectives

Wave Data Source

In-situ Observations	Physics-based models
Relatively reliable	High-fidelity
Sparse data set	High-computational cost

Objectives: Compare weather windows predicted by **traditional numerical weather prediction (NWP) forecasts** against **machine learning (ML) forecasts**

Data & Methodology

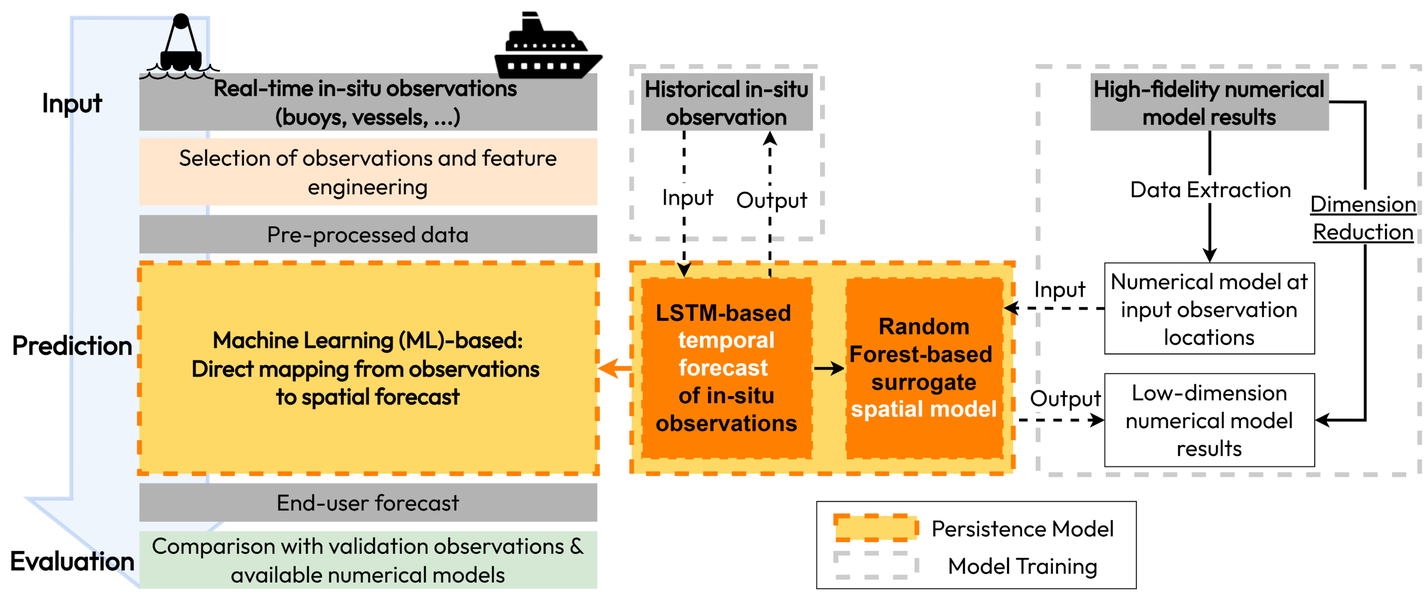


Buoy Observations:

- Input buoys (**red**): 2010-2020
- Validation buoys (**blue**): 2016

Numerical Weather Prediction (UKMO):

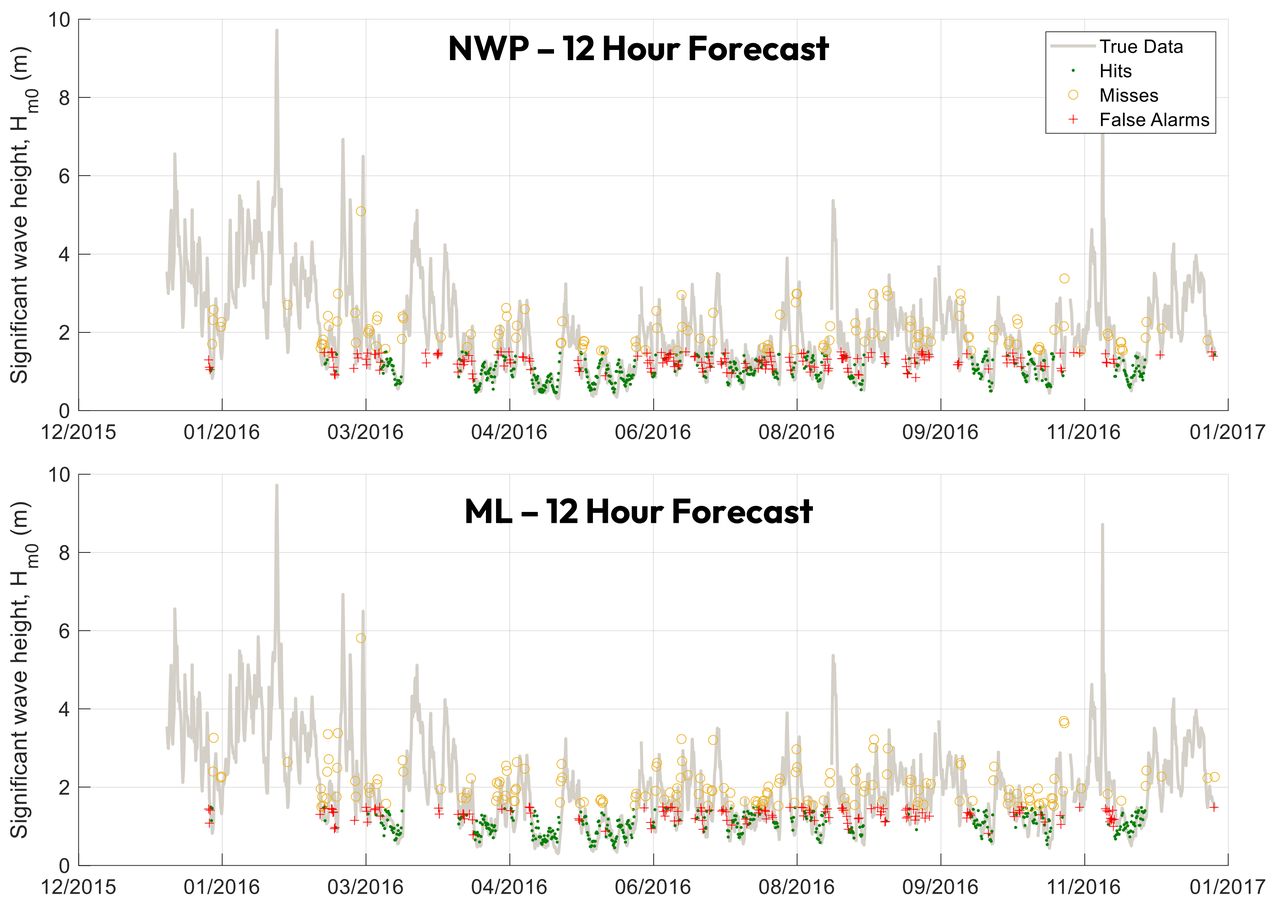
- 1980-2009 (training)
- 1.9 km x 1.5 km resolution



Weather Windows:

- Computed at WaveHub using both ML Forecast & Traditional NWP Forecast
- Benchmarked against validation buoy
- H_{m0} threshold of 1.5 m; minimum duration 4 hours

Results



True Windows

	NWP	ML
Nowcast	91%	82%
6 Hour Forecast	82%	79%
12 Hour Forecast	78%	71%

Missed Windows

	NWP	ML
Nowcast	9%	18%
6 Hour Forecast	18%	21%
12 Hour Forecast	22%	29%

False Windows

	NWP	ML
Nowcast	90	17
6 Hour Forecast	140	84
12 Hour Forecast	167	129

Summary and Conclusions

- Machine learning forecasts can be used to predict weather windows with similar accuracy to NWP forecasts
- Machine learning weather windows less likely to be false alarms, however, machine learning more likely to miss valid windows
- All results are downsampled to match NWP frequency; machine learning forecasts are lower cost and can therefore be updated more frequently given available in-situ measurements
- Future work will use ML to predict window rather than H_{m0} as a proxy for the weather window

Royal Academy of Engineering

Chen et al. 2021: Using machine learning to derive spatial wave data: A case study for a marine energy site

Chen et al. 2022: A real-time spatio-temporal machine learning framework for the prediction of nearshore wave conditions