5th ECMWF-ESA ML workshop
Bologna
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Improving Sea Level Height warnings in Venice with hybrid sub-seasonal forecasts

MedEWSa

The city of Venice is highly vulnerable to **coastal floods**. Early warnings of these events help increase the preparedness of involved stakeholders. The increased frequency and intensity of High Water events is linked to the rise in average global Sea Level Height (SLH) and to the combination of astronomical tide and weather-driven SLH surge. The project MedEWSa aims to improve the calculation of the meteorological contribution with the use of AI algortirhms, extending the time horizon of the current **Early Warning System** to the sub-seasonal scale. We employed the Probabilistic Coral Reef with Substrate Layers (PCRO-SL) to detect the relevant lagged drivers of SLH anomaly. These drivers were used to train multiple fine-tuned Neural Networks and Tree-Based algorithms. After evaluating the performances, the best model was **operationally implemented**, providing Venice Municipality with an extended prediction of Sea Level Height.

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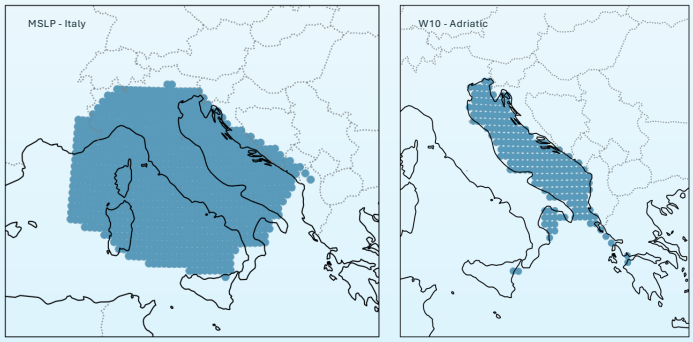
1. Drivers of SLH meteorological component in Venice

The drivers were selected among a list of clustered meteorological variables (e.g.: mslp, wind, wind stress) in the Euro-Mediterranean domain. The PCRO-SL, using obs as target, detected the most influential ones together with their lags.

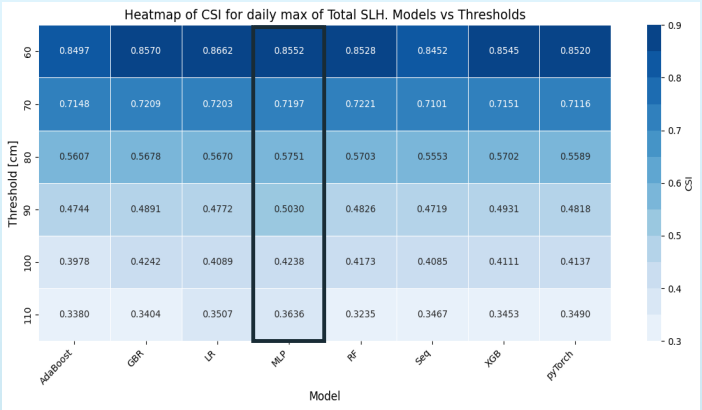


Variable	Area	Min. lag [days]	Max. lag [days]
MSLP	Italy	0	6
MSLP	Mediterranean + Tunisia	0	6
Geop. H. 500hPa	Central Atl. + N. Africa	3	6
Zonal wind 10 m	Italian Ionian Sea	1	5
Meridional wind 10 m	Greek Ionian Sea	5	6
Meridional wind 10 m	Adriatic Sea	0	0
EW wind stress 10m	Adriatic Sea	0	0
EW wind stress 10m	Italian Ionian Sea	0	1
NS wind stress	Adriatic Sea	0	1
Pressure difference	Venice – Otranto St.	0	5
Precipitation	Po Valley	0	1
Precipitation	Northern Adriatic	1	4

2. Selection of prediction model

Using the selected predictors, 8 commonly available models were fine tuned and trained (ERA5 vs obs., 2004-2019) and tested (ERA5 vs obs., 2019-2024). Predictions of **daily maximum component of SLH** and **total SLH** are evaluated.

Model	Correlation	RMSE
Linear Regression (LR)	0.88	7.83
MultiLinear Perceptron (MLP)	0.90	7.27
Keras/TensorFlow Sequential (Seq)	0.90	7.28
pyTorch MLP (pyTorch)	0.89	7.61
Random Forest (RF)	0.88	7.84
Adaptive Boosting (AdaBoost)	0.87	8.21
Gradient Boosting Regressor (GBR)	0.89	7.65
Extreme Gradient Boosting (XGB)	0.89	7.56

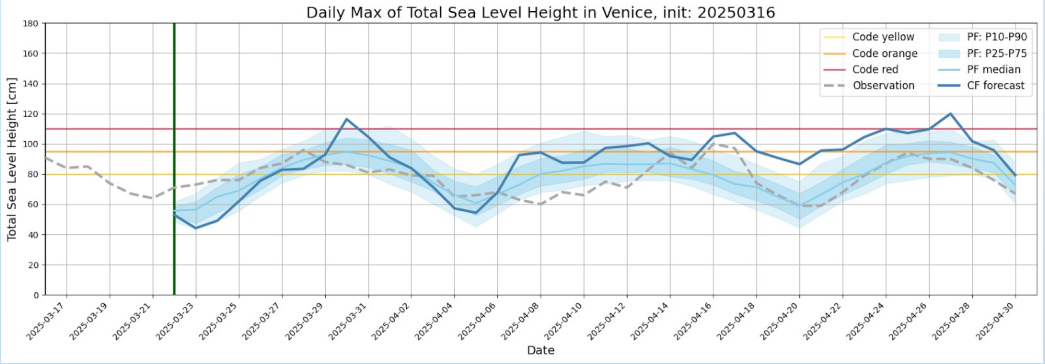


Critical Success Index: CSI = (Hits) / (Hits + FalseAlarms + Misses)

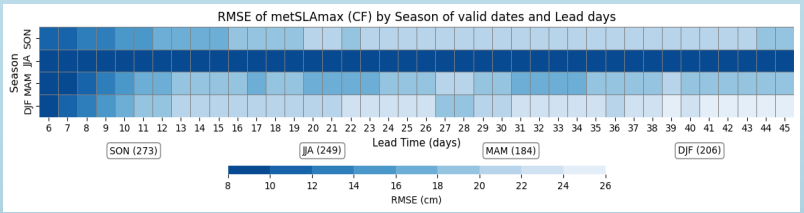
3. Model application

The MLP, best performing model, is applied to the historical archive of sub-seasonal ECMWF (control and perturbed) forecasts. Predictions of the anomalies of the clustered variables are used as input, accounting for their lags.

TOTAL SEA LEVEL HEIGHT
=
METEOROLOGICAL COMPONENT (with MLP)
+
ASTRONOMICAL TIDE (harmonic constituents)
+
SEASONAL CYCLE (calculated on 2004-2024)



4. Model verification



RMSE of daily maximum meteorological of Sea Level Anomaly (metSLAmax) for each season and each lead time

5. Conclusions and next steps

Thanks to the use of a fine tuned MultiLinear Perceptron we are able to construct daily series of predicted maximum sea level in Venice for the next 46 days by using forecasts of clustered meteorological variables. This product is operationally transferred to the Tide Prediction Center of the Venice Municipality, increasing its preparedness to extreme events.

By applying the module (and its verification procedure) to perturbed forecasts we plan to investigate which features in the variables bring to better scores, aiming to develop an AI-based member subsampling.

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CITTÀ DI VENEZIA