Utilizing Neural Networks to Predict Water Temperatures in a Thermal Refuge

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Objectives

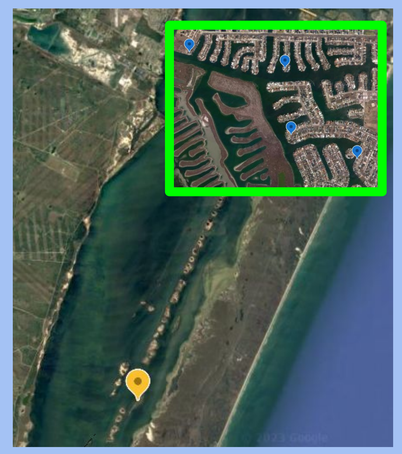
Create a machine learning model that can accurately predict water temperatures in the Laguna Madre, TX canals using an artificial neural network, to help with the management of thermal refuges.

Research Problem

Cold stunning syndrome is a condition which affects exothermic aquatic life when temperatures drop below 8° celsius (Shaver et al., 2017). Cold stunning leaves aquatic life lethargic and vulnerable to cold-related illnesses. Laguna Madre is a shallow lagoon system located in southern Texas along the Gulf of Mexico, where sea turtles and different fish species reside. During cold fronts, the waters of the Laguna Madre drop below the cold stunning threshold. The canals of the Laguna Madre have been shown to serve as a thermal refuge for aquatic life that seek warmth during extreme cold events.

Texas Parks and Wildlife Department (TPWD) is the overarching entity that manages thermal refuge areas in the state of Texas and facilitates the suspension of boating and fishing activities in these areas during freeze events.

This research aims to predict water temperatures in the Laguna Madre canals using machine learning models, for use by TPWD for conservation efforts. Various loss functions will be used to compare ML performance.



Map of the Upper Laguna Madre and Upper Laguna Madre Canalways.

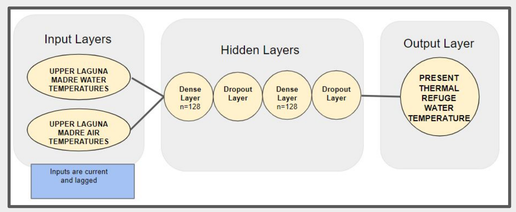
Methods

Neural Network Inputs:
- Water Temperature (TCOON BIRDIS)
- Air Temperature (TCOON BIRDIS)
- Canal Water Temperature (CBI)

Dataset Stratification:
- Training: 12/21/22 - 7/7/23
- Validation: 3/1/22 - 6/17/22
- Testing: 2/1/22 - 2/28/22

Base Architecture:
- 2 Hidden Layers
- 2 Dropout Layers
- Sigmoid Activation

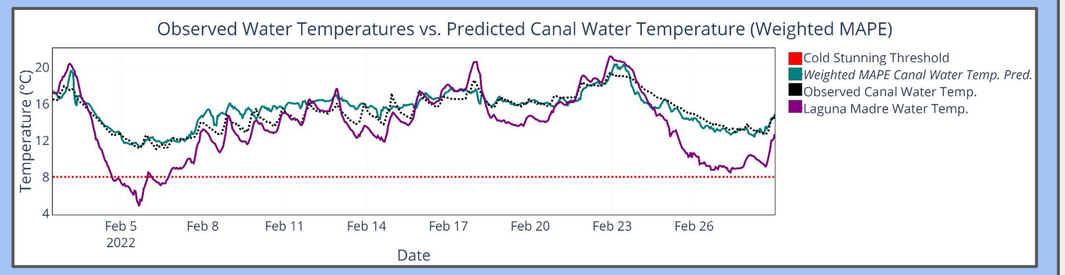
Performance Metrics:
- MAE (Mean Absolute Error)
- MAE15 (Mean Absolute Error Below 15°)
- MEM5 (Mean Maximum 5% Absolute Error)
- ME (Mean Error)

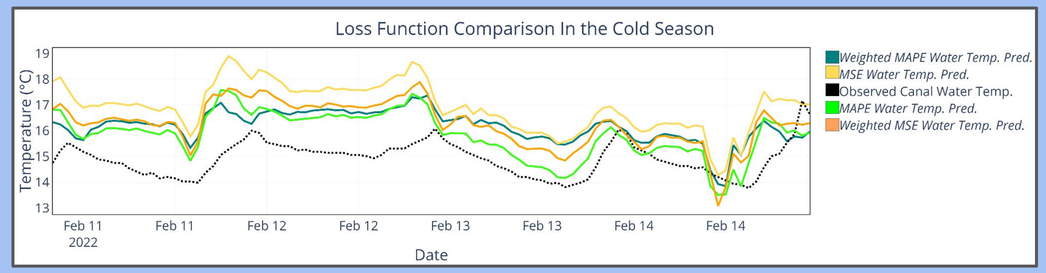


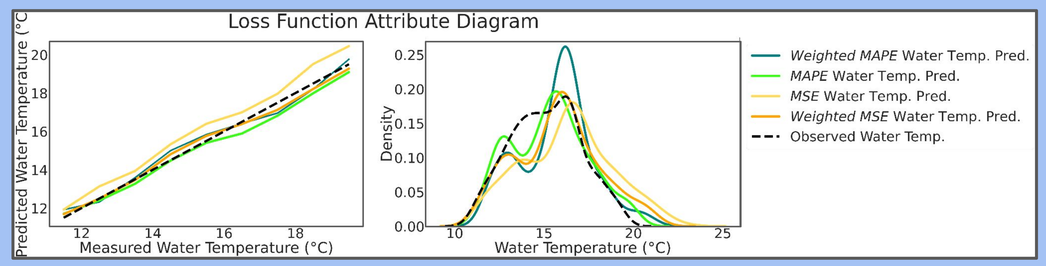
Experimental Loss Functions

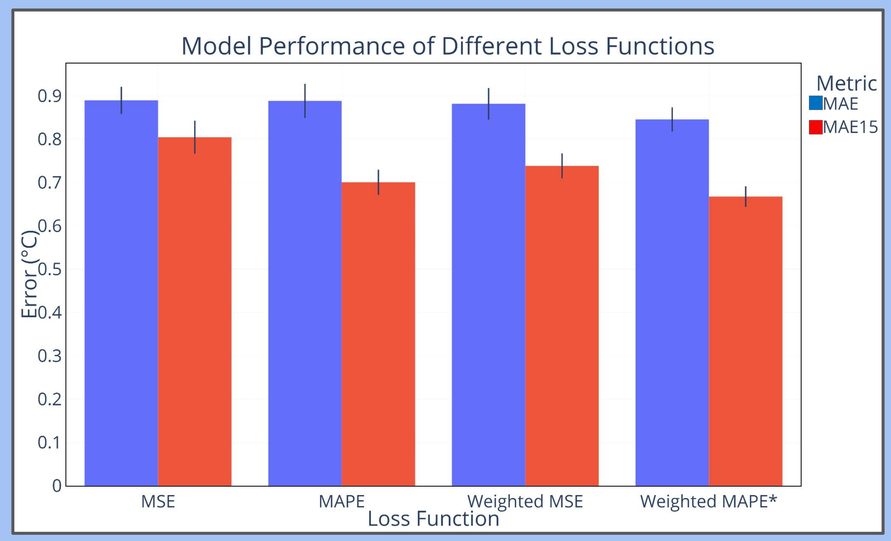
MSE (Mean Squared Error)	$\left(y_{true} - y_{pred}\right)^2$
MAPE (Mean Absolute Percent Error)	$\frac{\lvert y_{true} - y_{pred} \rvert}{y_{true}}$
Weighted MSE	$\frac{150\left(y_{true} - y_{pred}\right)^2}{y_{true}}$
Weighted MAPE	$\frac{150\left\lvert \frac{y_{true} - y_{pred}}{y_{true}} \right\rvert}{y_{true}}$

Results









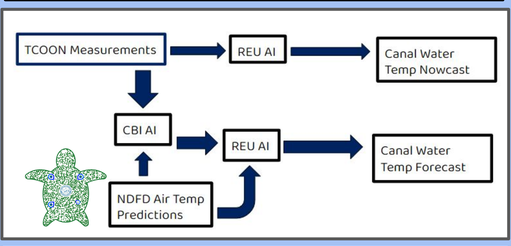
Conclusions

The newly created thermal refuge model provides real-time water temperature predictions for Laguna Madre canalways that serve as thermal refuges for marine life. This will be extremely valuable to community stakeholders interested in aquatic conservation efforts.

Weighted MAPE loss function displayed the highest performance (MAE15: 0.67) in comparison to the MSE loss function (MAE15: 0.80)

The model that uses a Weighted MAPE loss function is in the process of being operationalized in real time.

Nowcast/Forecast



Acknowledgements

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