Estimation of Tropical Cyclone Intensity over Ocean using NOAA-20 ATMS Measurements through a U-Net Machine Learning Algorithm

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Introduction/Motivation

- Tropical cyclone (TC) intensity can be represented by maximum wind speed (MWS) and minimum surface pressure (MSP) around TC eyewall region. [1,2]
- **PROBLEM:** Earlier studies that estimate MWS and MSP do not consider the effect of atmosphere and surface states surrounding the TCs, which is important for rapid change near TC areas. [2,3].
- **PURPOSE:** U-Net algorithm was developed to predict wind speed and surface pressure images surrounding TC and to extract MWS and MSP

Methodology/Data

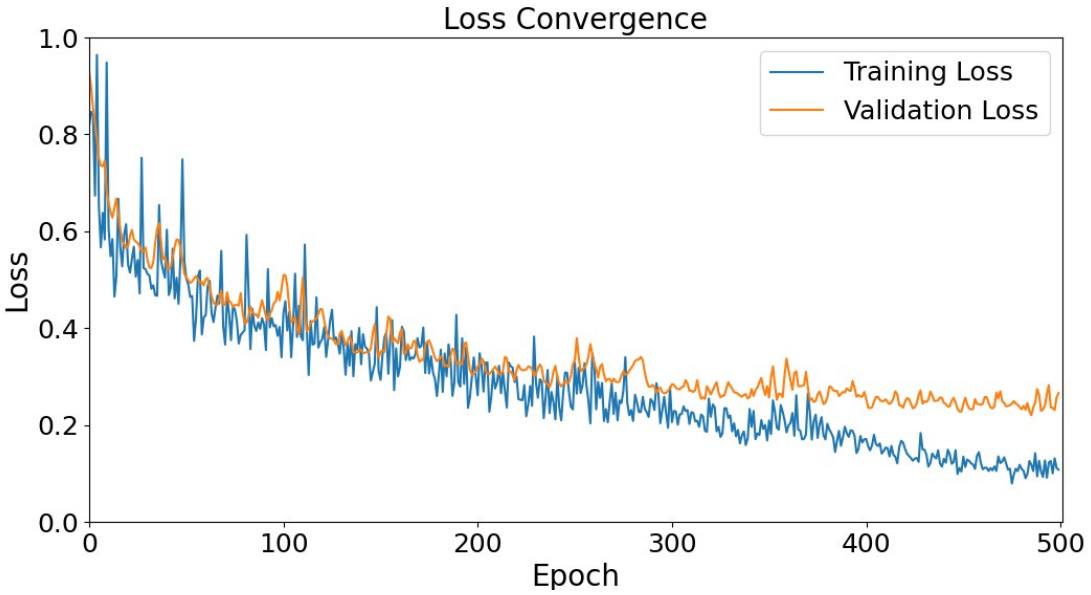
Main Modifications of U-Net for Regression problem [4,5]

- Loss Function: Binary Cross-Entropy -> Mean Squared Error
- Activation Function: Softmax -> Linear

DATASETS (from 2018 to 2021)

- NOAA-20 ATMS SDR & GEO data
- ECMWF Reanalysis v5 (ERA5)
- International Best Track Archive for Climate Stewardship (IBTrACS)

Input features: 22 channels ATMS Brightness Temperature, Satellite Zenith Angle, Latitude, Longitude (96 x 96 x 25)
Labels: Collocated ERA5 Surface Pressure, Wind Speed (96 x 96 x 2)
Train test split: Total 266 samples over pure ocean, 90% training set and 10% test set



Residual Stats (AI Pred - ERA5 label)	WS	Surface Pressure
Bias	0.133	0.481
Standard Deviation	1.947	2.674

Cloud Liquid Water <= 0.3

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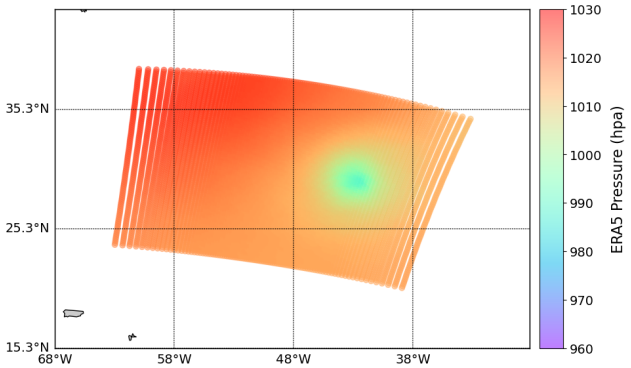

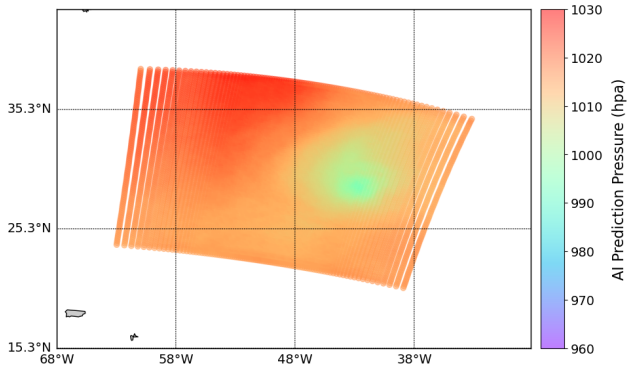

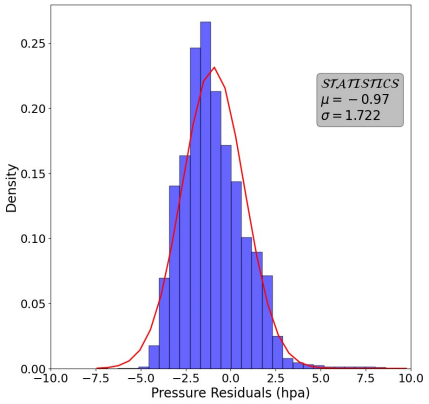

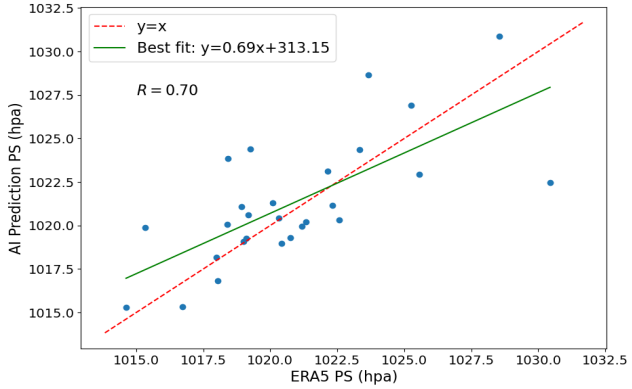

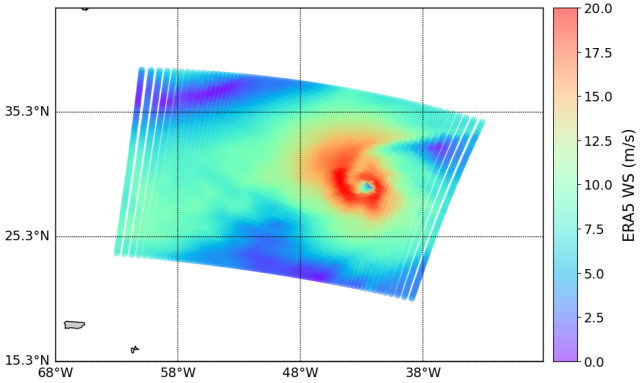

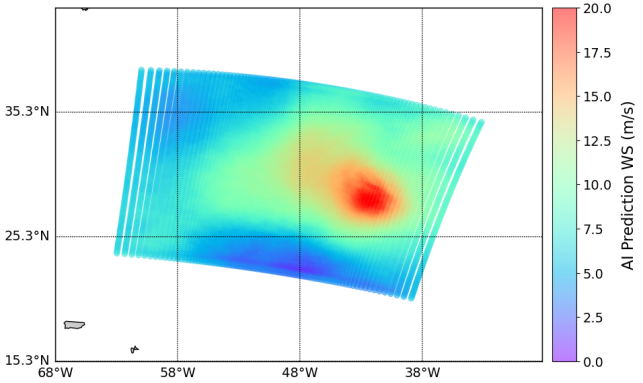

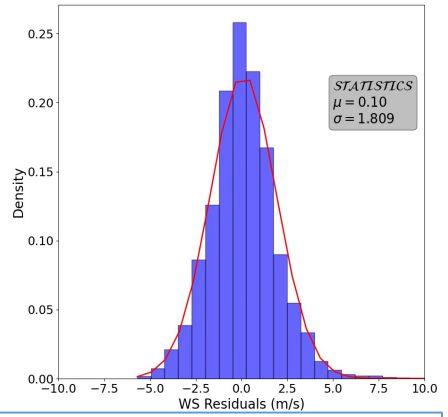

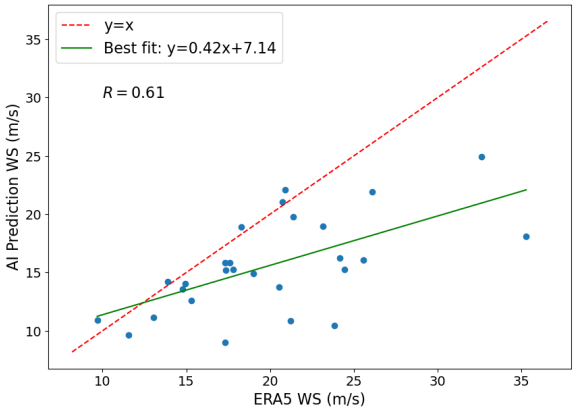

Results/ Future Work

- Residual biases and standard deviations of 0.15 ± 1.95 m/s for wind speed and 0.48 ± 2.67 hpa
- Prediction and Label maps have similar location color distributions for surface pressure; differences in WS may be due to insufficient sample size or epochs.
- Extracted MWS and MSP from 27 prediction images showed a positive correlation with ERA5 data.
- ❖ Future work includes adding more epochs and samples, possibly making predictions around eyewall closer to the label.
- ❖ **A paper related to this research is currently undergoing internal review**

References

[1]. Liu et al., IEEE JSTARS, 15, 2022
[2]. Tian and Zou, JGR, 2016
[3]. Hong et al, JOAT, 33, 2016
[4]. Ronneberger et al. MICCAI, 9351, 2015
[5]. Liu and Boukabara, RSE, 140, 2014