Hurricane Wind Speed Prediction using Deep Learning and Machine Learning

Arsh Modak
Omkar Waghmare

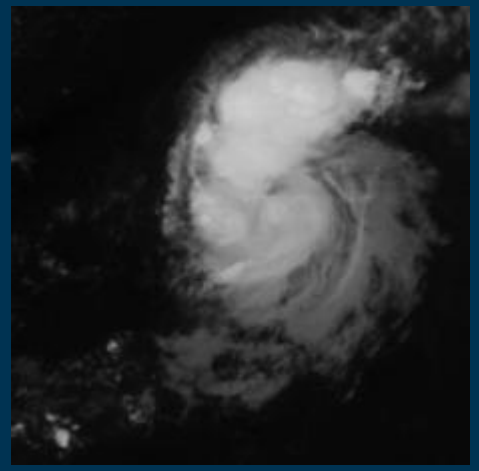
https://github.com/arshmodak/Hurricane-Wind-Speed-Prediction-using-Deep-Learning-and-Machine-Learning

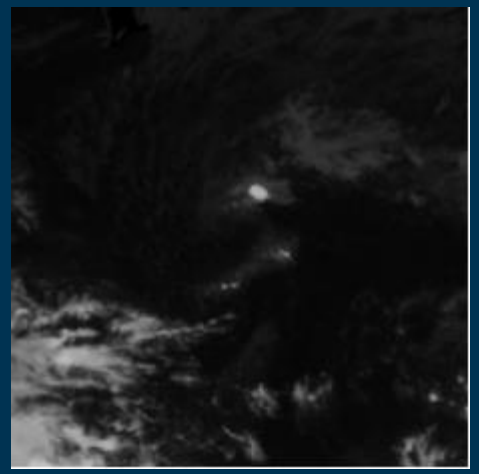
Summary

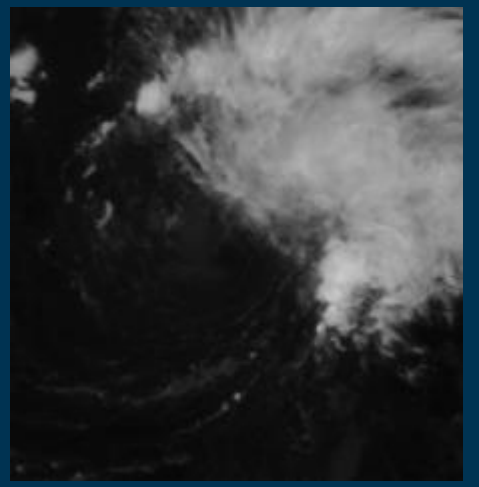
- Hurricanes/Tropical Cyclones are one of the costliest natural disasters globally because of the wide range of associated hazards.
- Hurricanes can cause upwards of 1000 deaths in a single event and are responsible for more than 100,000 deaths worldwide
- Direct measurements of the winds within a tropical cyclone are sparse, particularly, over open ocean. Thus, diagnosing the intensity of a tropical cyclone is initially performed using satellite measurements.
- According to the National Hurricane Center (NHC), an accurate assessment of intensity using satellite data remains a challenge.
- This is the reason why we want to design and develop a system using Deep Learning which predicts the hurricane's speed using satellite images.

The Dataset

- The dataset consists of 114,634 366x366 single-band images; 70,257 images in the train set and 44,377 in the test set.
- These images are captured using GOES (Geostationary Operational Environmental Satellites) which results in better capturing special structure of the storms.
- The dataset consists of images of over 500 different storms in the Atlantic and East Pacific Oceans, along with their corresponding wind speeds.







Proposed Plan

- Metadata extraction
- EDA on metadata
- Prepping Images for baseline model training
- Creating a MLP and CNN architecture for single-band images (baseline model)
- Prepping Images for pre-trained (converting single-band images to RGB images based on timestep)
- Training various pre-trained CNN architectures on the prepped images.
- Hyperparameter Tuning for CNN architectures.
- Extracting features from trained CNN to be used for ML algorithms such as Linear Regression, Decision Trees and Random Forest.
- Hyperparameter Tuning for ML models.
- Evaluation and Comparison for all trained models and their results.

Project Milestones

- **October 19:** Completing of preparation of images for baseline model and implementation and initial results of baseline model.
- **November 2:** Hyperparameter Tuning results for baseline model. Completion of preparation of images for pre-trained models (converting single-band images to RGB images based on timestep).
- **November 16:** Completion of pre-trained model training, hyperparameter tuning.
- **November 30:** Feature Extraction using CNNs and Implementation of Machine Learning Models
- **December 14:** Model evaluation and Performance Comparison. Completion of Final Report.

Metadata Extraction (Raw Data/ Folder Structure)

train_source_abs_001
train_source_abs_003
train_source_abs_005
train_source_abs_007
train_source_abs_009

features.json
image.jpg

{"storm_id": "abs", "relative_time": "1800", "ocean": "2"}

train_labels_abs_000
train_labels_abs_001
train_labels_abs_002
train_labels_abs_003

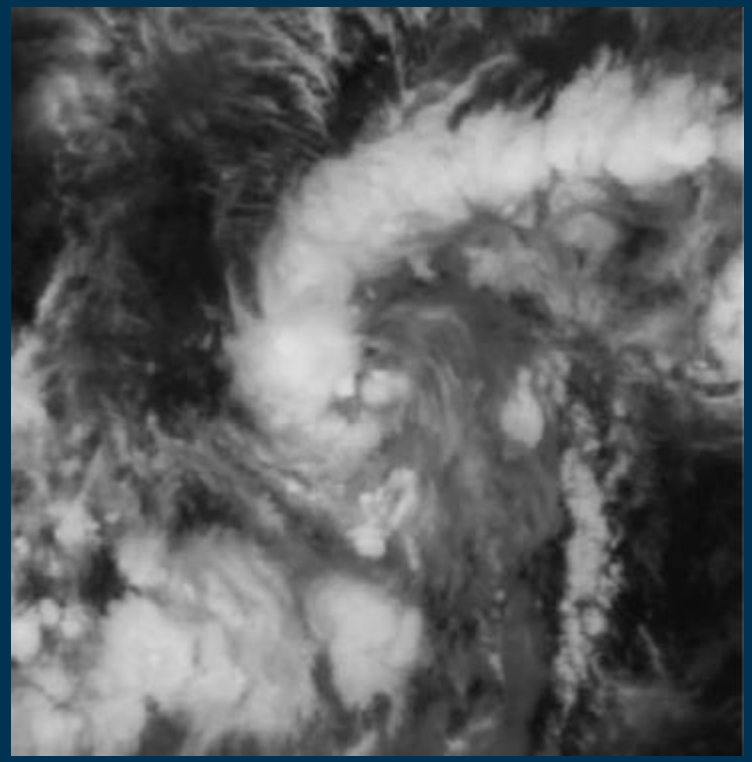
labels.json

{"wind_speed": "43"}

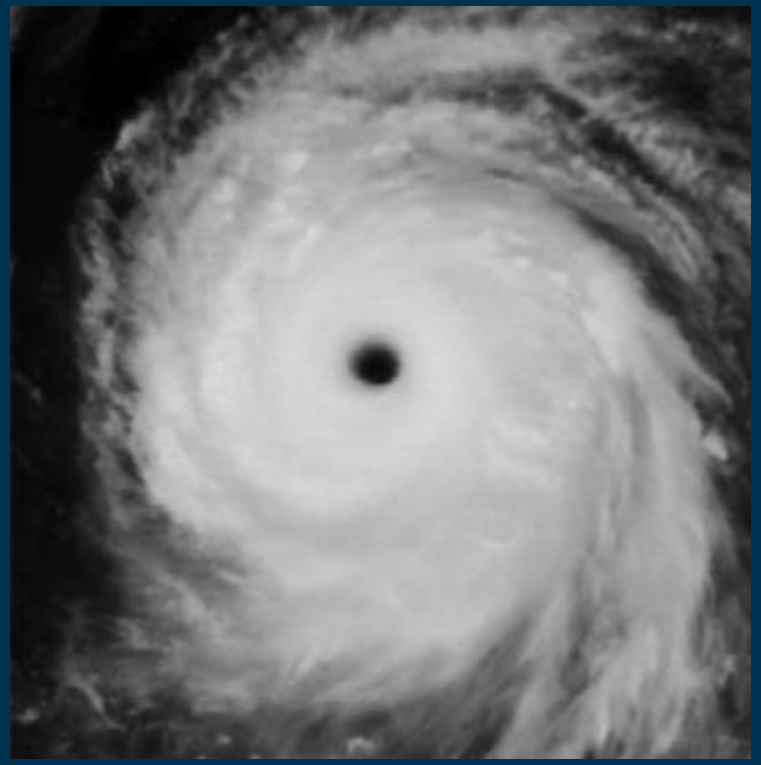
Metadata Extraction (Processed Data)

	image_id	wind_speed	storm_id	relative_time	ocean
0	abs_000	43	abs	0	2
1	abs_001	44	abs	1800	2
2	abs_002	45	abs	5400	2
3	abs_003	52	abs	17999	2
4	abs_004	53	abs	19799	2

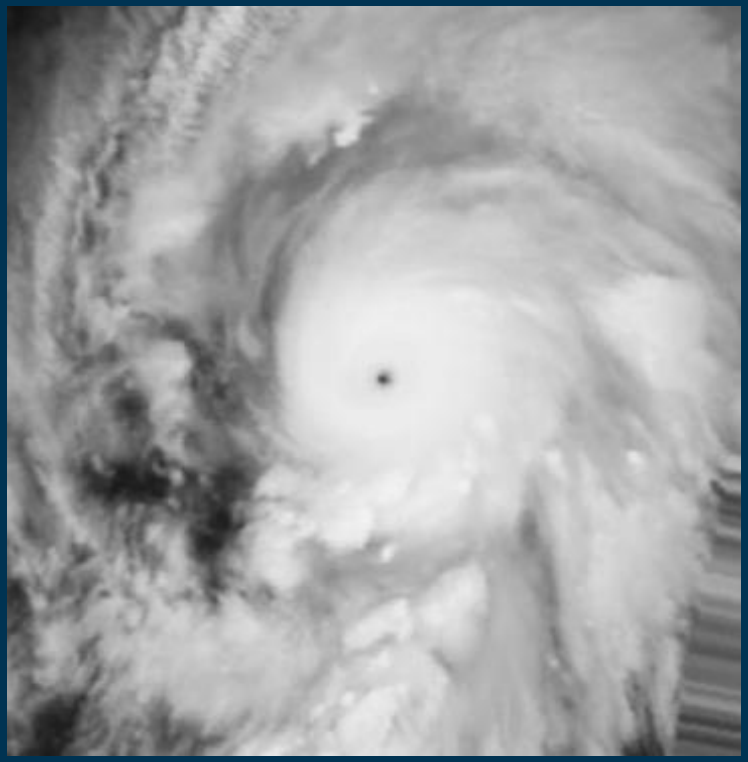
Preliminary Results: Images of Storms at Different Wind Speeds



Wind Speed: 30 knots

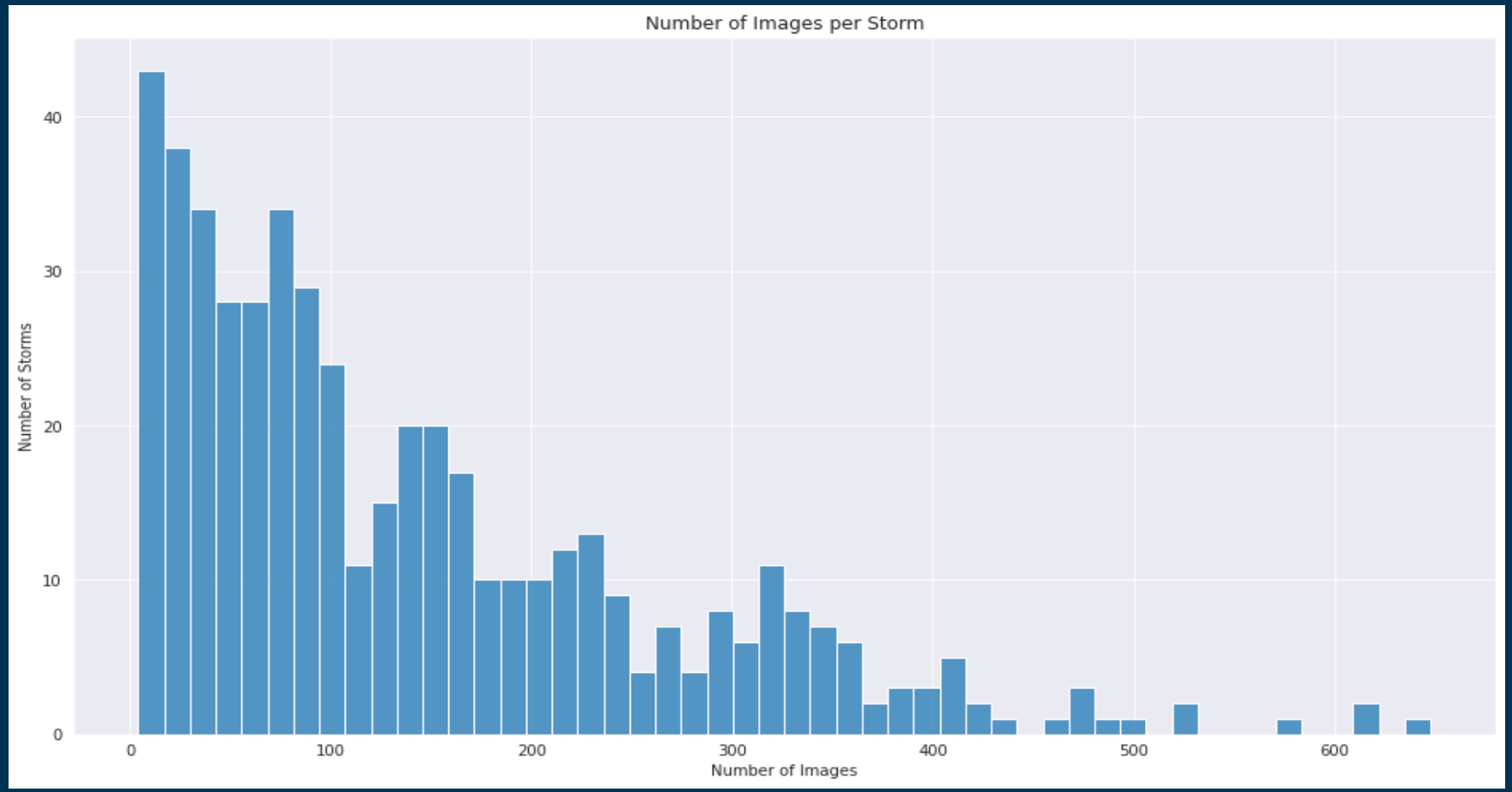


Wind Speed: 150 knots



Wind Speed: 185 knots

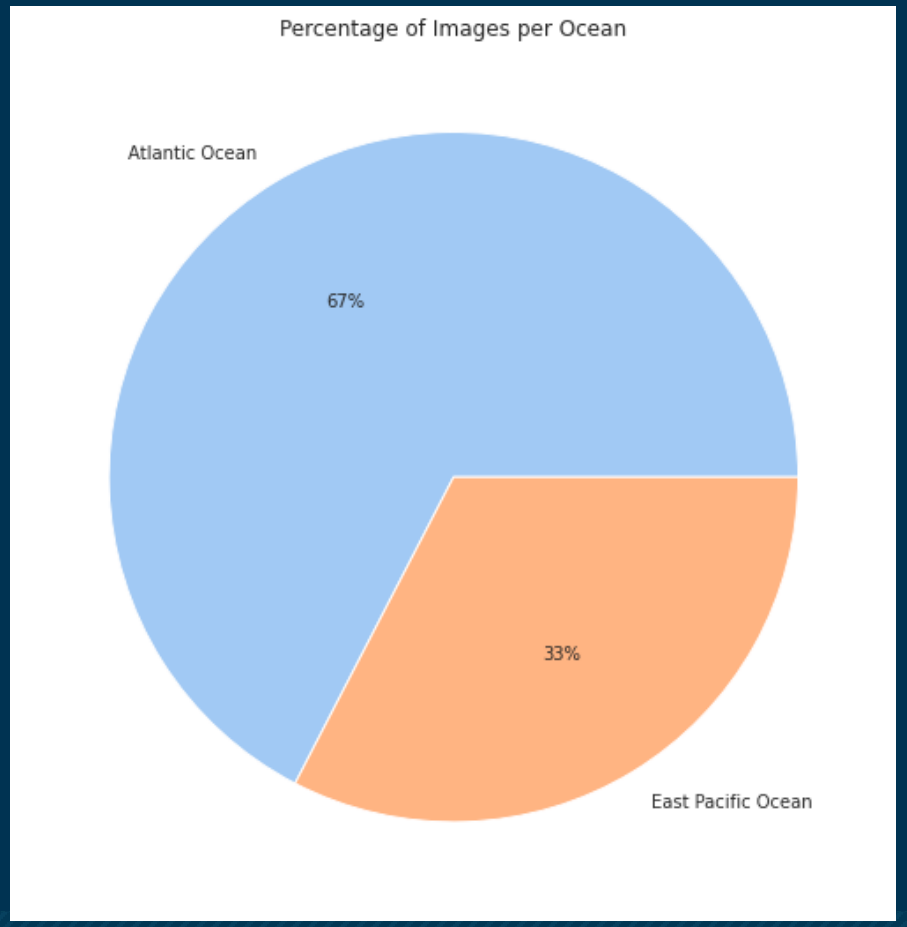
Preliminary Results: Number of Images for each Storm

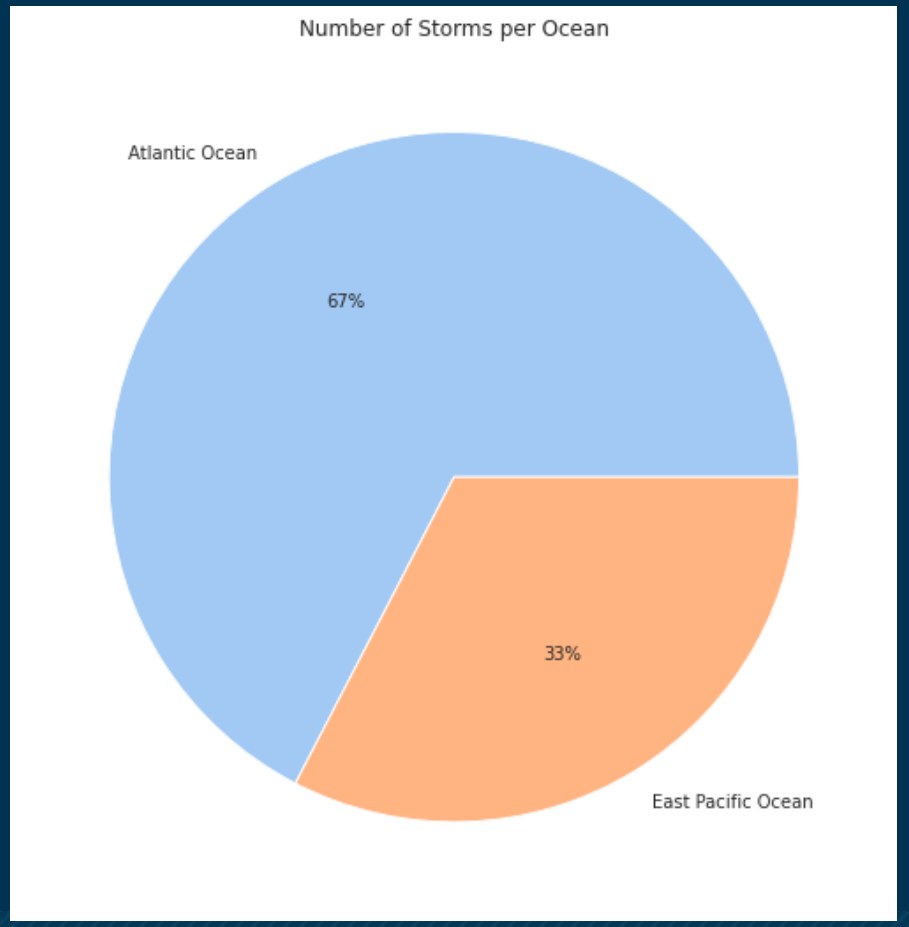


	wind_speed
count	70257.000000
mean	50.344008
std	26.795277
min	15.000000
25%	30.000000
50%	43.000000
75%	62.000000
max	185.000000

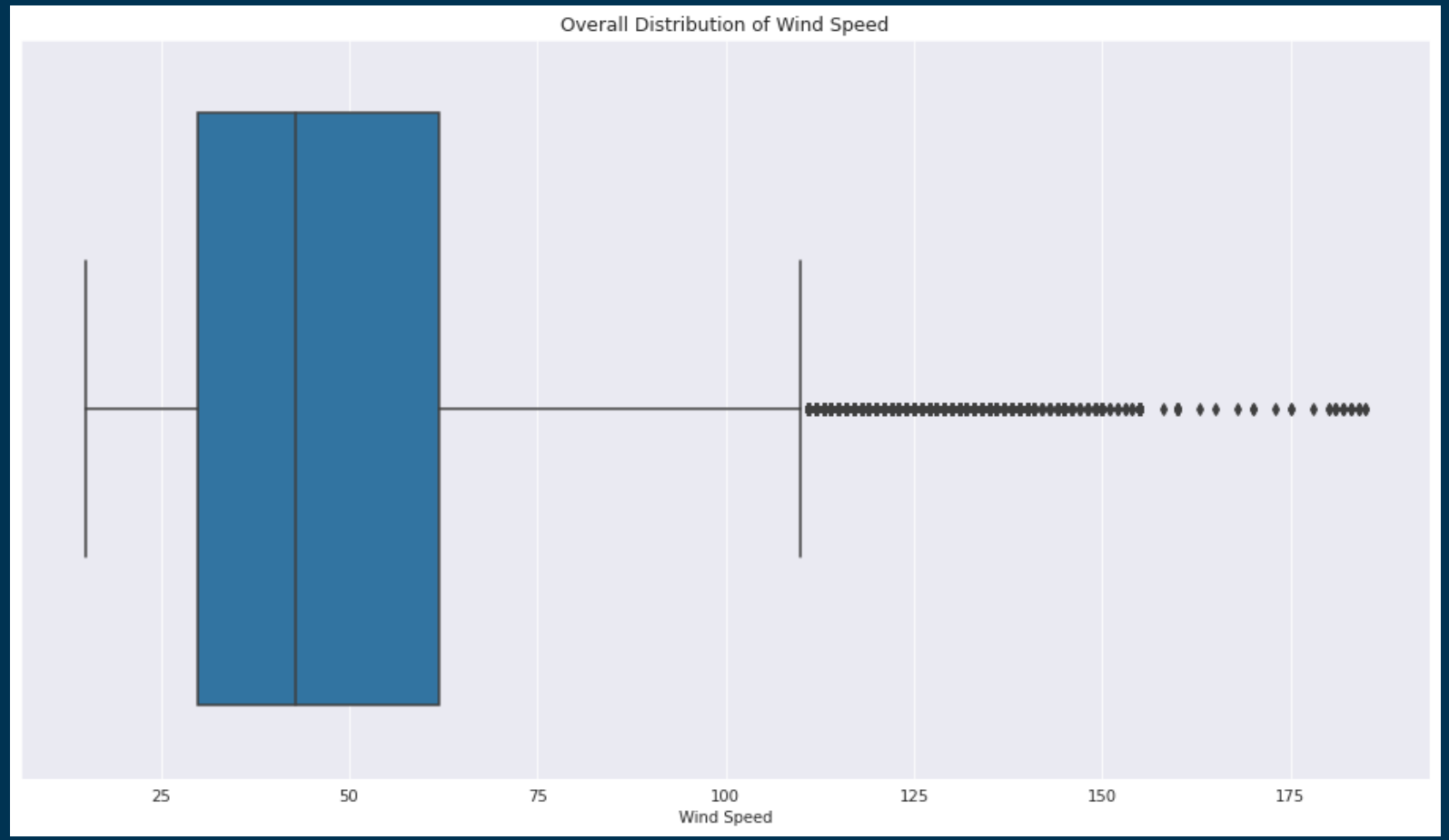
We have anywhere from 4 to 648 images per storm. This shows that our data is pretty imbalanced.

Preliminary Results: Distribution of Oceans



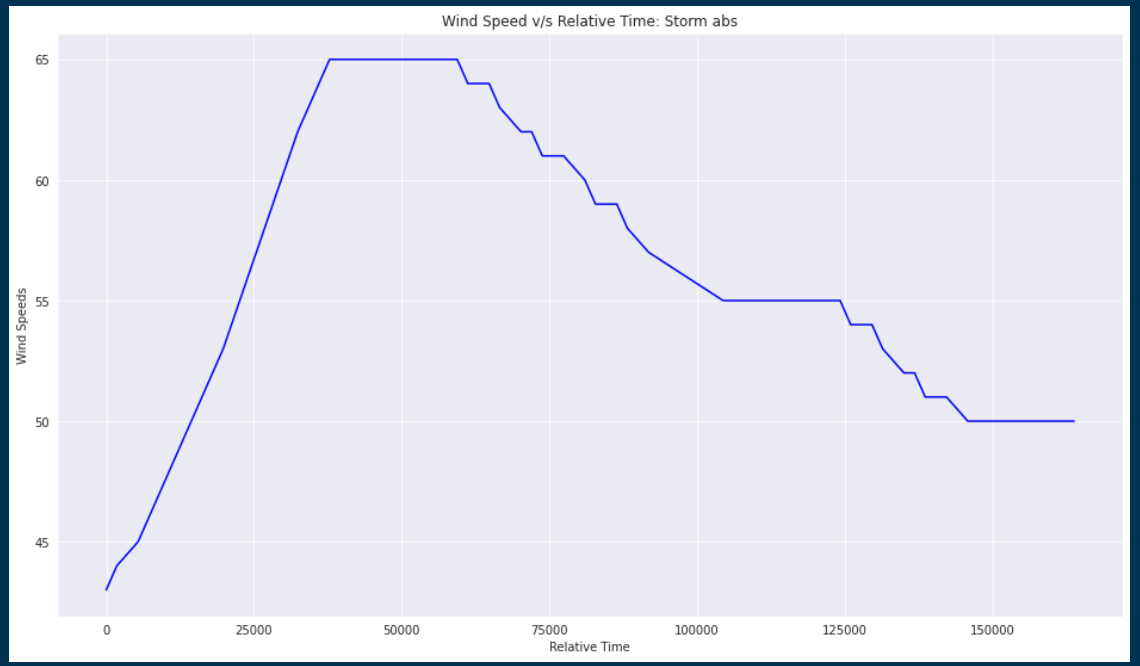


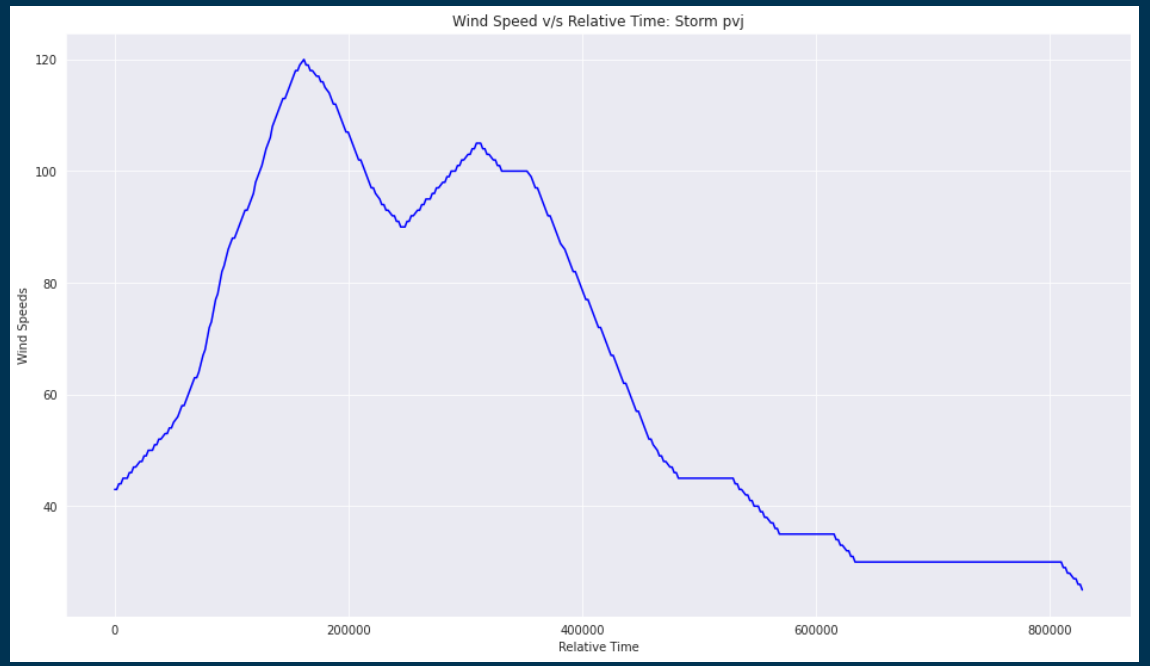
Preliminary Results: Distribution of Wind Speeds



- The wind speeds range from1 5 to 185 knots
- Speeds above 110 are considered as outliers as there are not many storms with such extreme speeds that have been recorded in the dataset.
- Given that majority of storms lie between 30 to 62 knots, it is important that we are able to accurately estimate storms with higher wind speeds as they are the most destructive.

Preliminary Results: Wind Speed v/s Relative Time per Storm





References

- https://ieeexplore.ieee.org/document/9149719
- https://mlhub.earth/10.34911/rdnt.xs53up
- https://www.drivendata.co/blog/wind-dependent-variables-winners/

Thank You