CYCLONE ANALYSIS OF ODISHA

CE-594 , GEOHAZARD SCIENCE AND ENGINEERING

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By ,

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Cyclones in Odisha

Geographical Context:
Odisha lies on the **eastern coast of India**, adjacent to the **Bay of Bengal**—a region highly prone to tropical cyclones.

Historical Vulnerability:
The state has experienced **frequent and intense cyclones**, including devastating events like:

- **Super Cyclone (1999)**
- **Cyclone Phailin (2013)**
- **Cyclone Fani (2019)**
- **Cyclone Yaas (2021)**

Key concerns include:	High population density in coastal areas
	Significant agricultural and infrastructural exposure
	Rising frequency and intensity of cyclones due to climate change
Role of Data Analysis & Visualization:	Helps in Understanding cyclone patterns and trends
	Enhancing early warning systems
	Supporting disaster preparedness and mitigation

Methodology

1. Mean Squared Error (MSE)

$$MSE = {}^{1}/_{n} \sum_{i=1}^{r} (y_R - y_A)^2$$

2. Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{{}^{1}/_{n} \sum_{i=1}^{r} (y_R - y_A)^2}$$

3. Coefficient of Determination (R^2)

$$R^2 = 1 - \frac{\Sigma_{i=1}^{n} (y_R - y_A)^2}{\Sigma_{i=1}^{n} (y_R - \bar{y}R)^2}$$

Wei, M., Fang, G., Nikitas, N., & Ge, Y. (2024). Machine-learning-based tropical cyclone wind field model incorporating multiple meteorological parameters

Empirical Wind–Pressure Relationship

$$V_{max} = \mathrm{C} \left(P_{ref} - P_c\right)^n$$

C :Empirical constant (e.g., 6.7)

V_{max}:Maximum sustained wind speed

P_{ref} : Reference pressure (typically 1013 hPa)

P_c : Central pressure of the cyclone

n: Empirical exponent (e.g., 0.644)

Knaff, J. A., & Zehr, R. M. (2007). Reexamination of tropical cyclone wind–pressure relationships. *Weather and Forecasting*

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[15]: datasets
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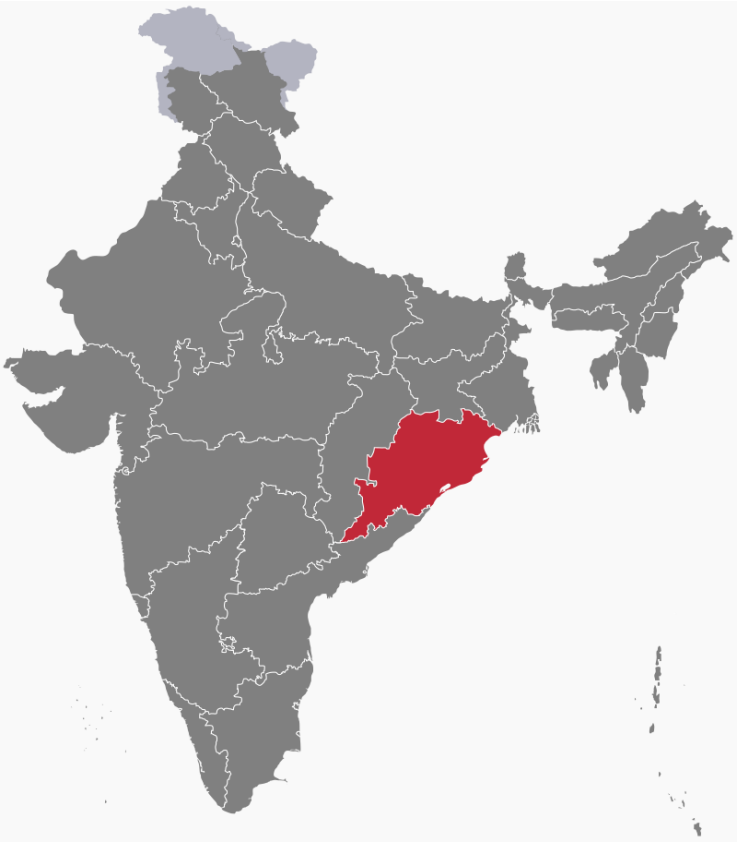
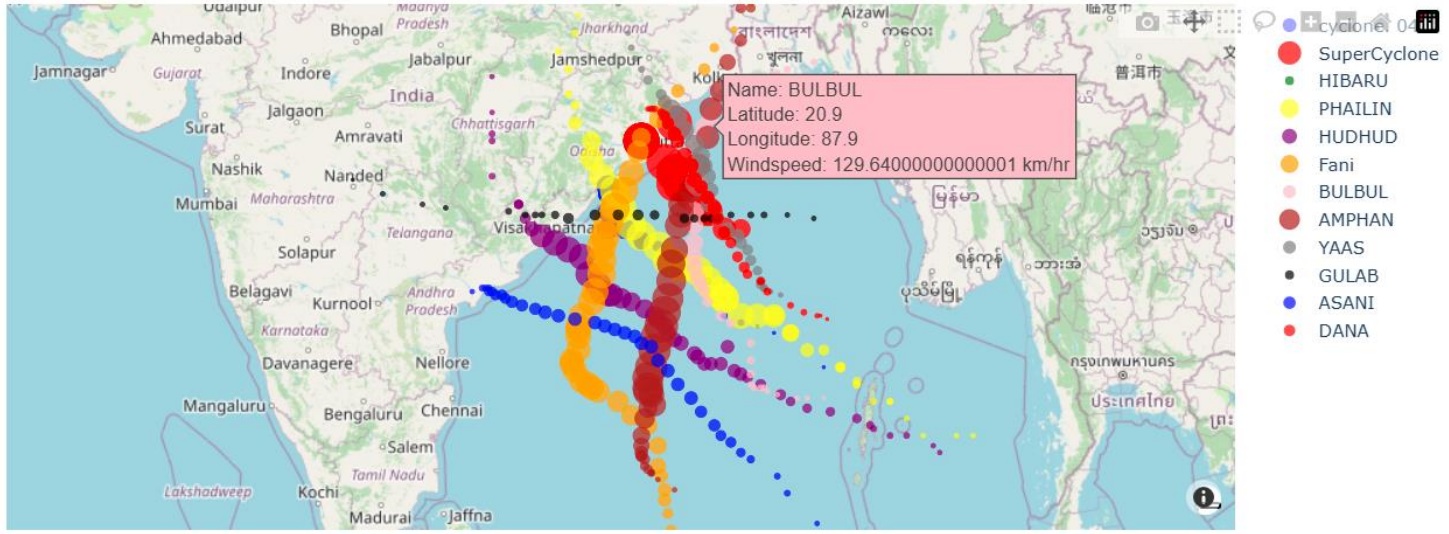
[15]:

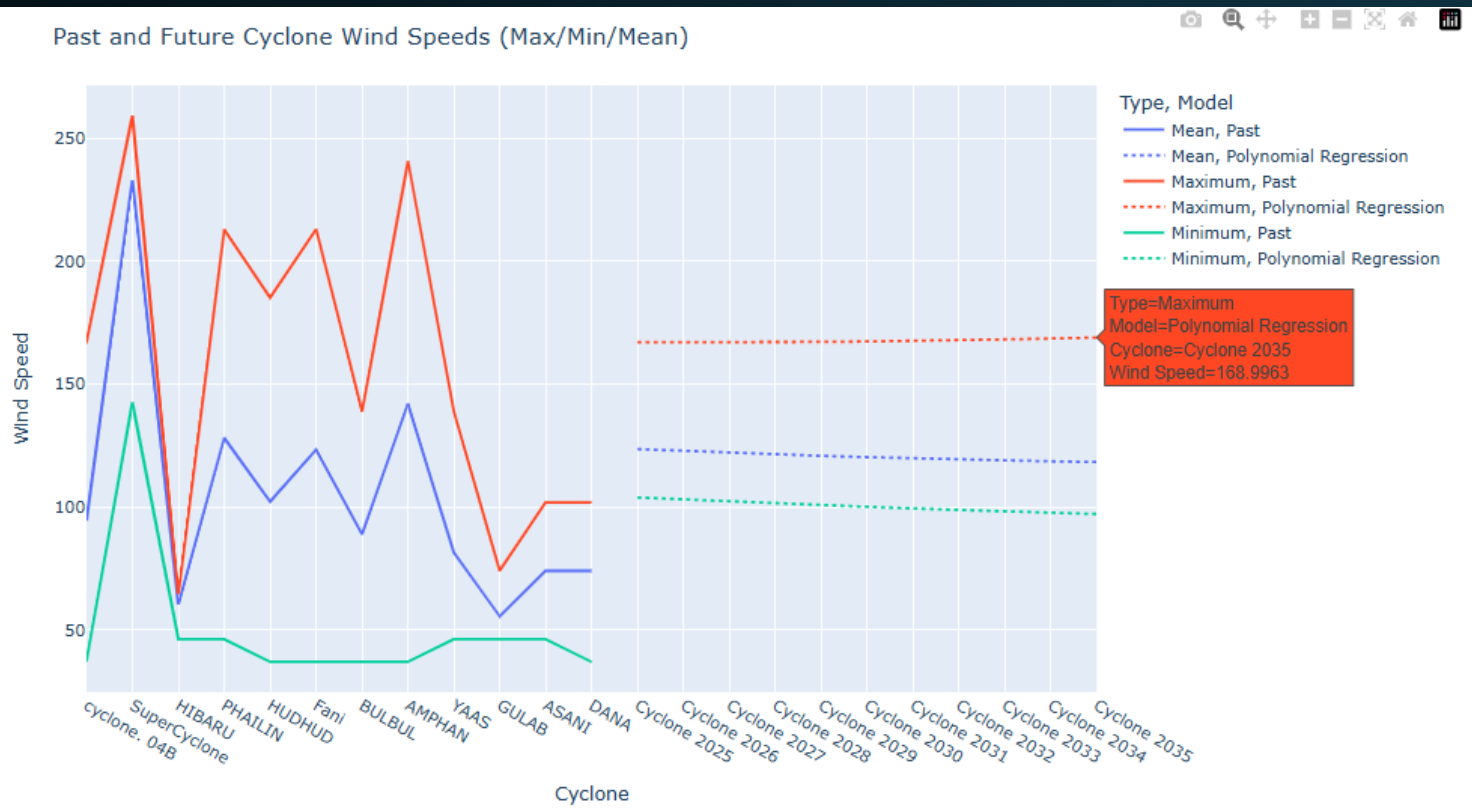
	Serial Number of system during year	Basin of origin	Name	Date(DD-MM-YYYY)	Time (UTC)	Latitude (lat.)	Longitude (lon.)	CI No [or "T. No"]	Estimated Central Pressure (hPa) [or "E.C.P"]	Maximum Sustained Surface Wind (km/hr)	Pressure Drop (hPa)[or "delta P"]	Grade (text)
0	1	BOB	cyclone. 04B	1999-10-15 00:00:00	300	13.5	92.5	1.5	1004	37.04	4	D
1	1	BOB	cyclone. 04B	1999-10-15 00:00:00	600	14.0	91.5	1.5	1002	37.04	4	D
2	1	BOB	cyclone. 04B	1999-10-15 00:00:00	1200	15.0	90.0	1.5	1002	37.04	4	D
3	1	BOB	cyclone. 04B	1999-10-15 00:00:00	1800	15.2	89.5	1.5	1002	37.04	4	D
4	1	BOB	cyclone. 04B	1999-10-15 00:00:00	2100	15.3	89.0	2.0	1000	55.56	6	DD

Study Areas




Name: BULBUL
Latitude: 20.9
Longitude: 87.9
Windspeed: 129.64000000000001 km/hr
Ahmedabad
Bhopal
Jabalpur
Jamshedpur
Jamnagar
Indore
India
Jalgaon
Surat
Amravati
Nashik
Nanded
Mumbai
Maharashtra
Telangana
Solapur
Belagavi
Kurnool
Andhra Pradesh
Karnataka
Davanagere
Nellore
Mangaluru
Bengaluru
Chennai
Salem
Tamil Nadu
Kochi
Madurai
Jaffna
Lakshadweep
Aizawl
SuperCyclone
HIBARU
PHAILIN
HUDHUD
Fani
BULBUL
AMPHAN
YAAS
GULAB
ASANI
DANA

Cyclone Trend



- The graph shows cyclone wind speed trends with polynomial regression forecasts (2025–2035).
- Past data shows high variability, with peaks during Super Cyclone, Phailin, and Amphan.
- Future projections suggest stabilization, with maximum wind speeds leveling around **169 km/h**, and mean/minimum values remaining steady.
- This indicates a potential steadying of cyclone intensity based on historical pressure and wind speed patterns.

Future Cyclone Wind Speed Forecast (2025–2034)

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Predicted Mean Wind Speeds for Next 10 Years: [149.80071154517645, 161.15845751312736, 183.50962761640548, 143.6280977434304, 151.2640527726995, 157.697
24059998407, 184.07984096653527, 162.87561507417996, 166.2324030018295, 150.68159311954224]
Predicted Min Wind Speeds for Next 10 Years: [45.70470241250587, 63.287963216076605, 83.04111400872353, 82.45131120408769, 56.270433643541764, 74.938873
10431455, 153.39946496588527, 52.41848716515233, 114.97980459575774, 43.08762637965265]
Predicted Max Wind Speeds for Next 10 Years: [217.1332608065277, 213.55202200860367, 291.3992317466473, 197.82519715174567, 228.2449613380013, 225.38339
126267238, 222.50210045985295, 255.56563666151487, 210.0769991010311, 283.9887199297955]
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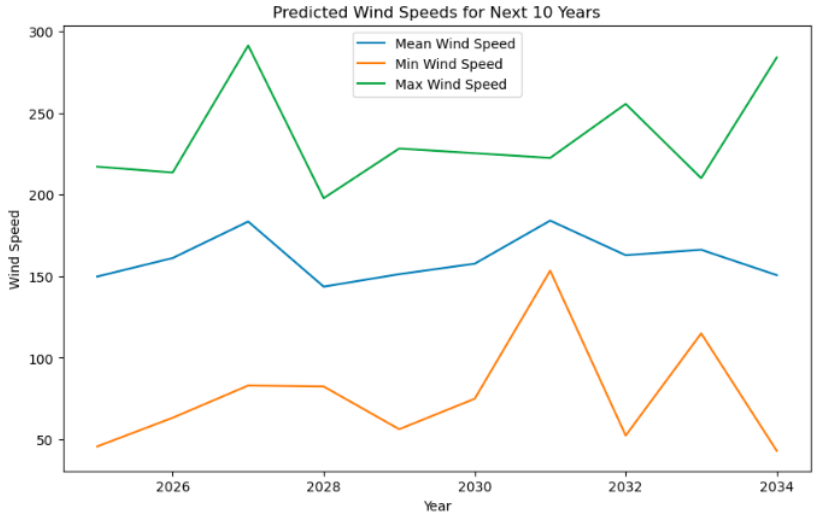
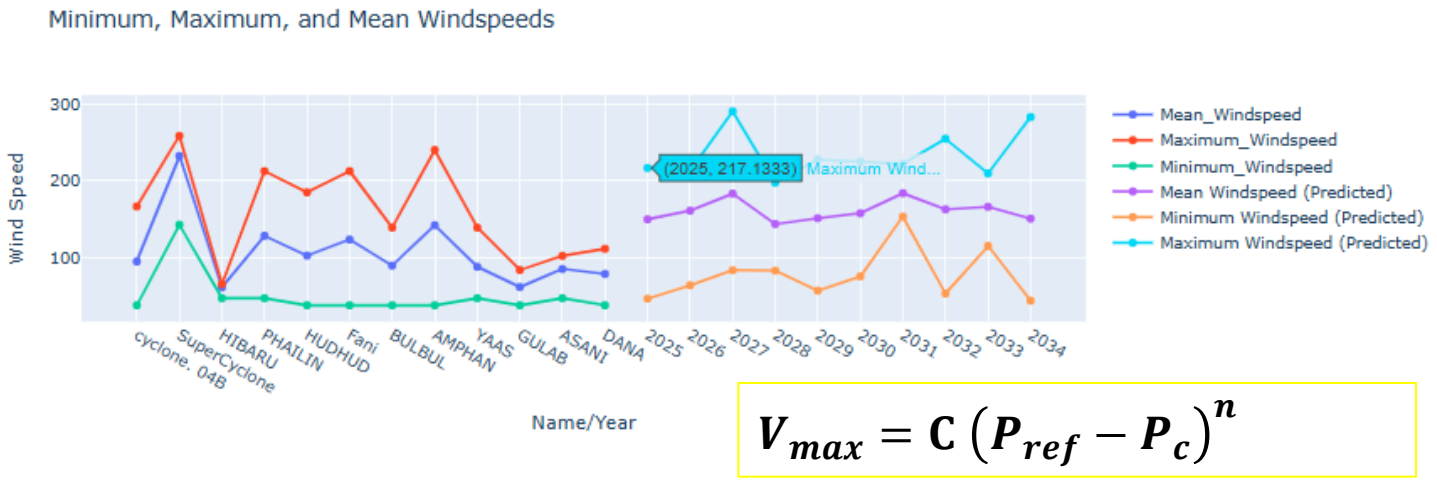
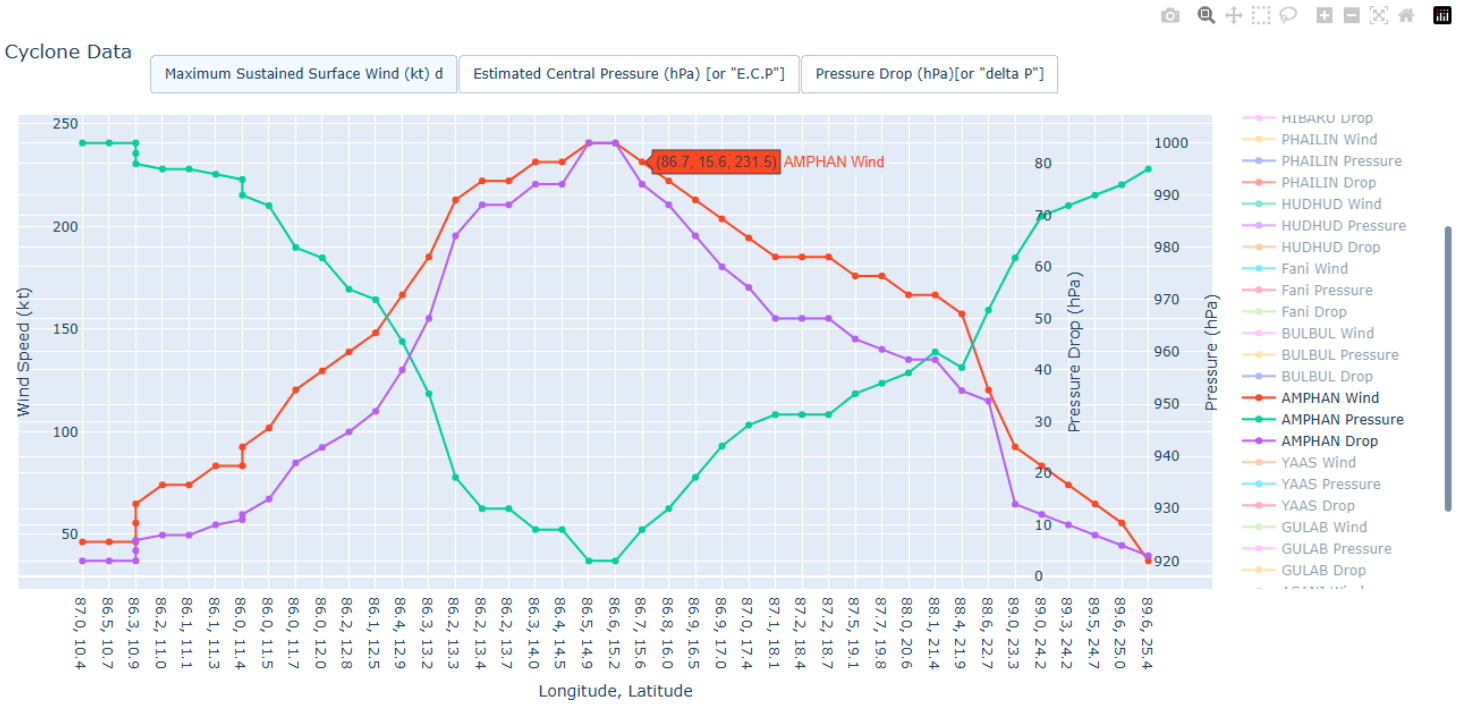




$$V_{max} = C\left(P_{ref} - P_c\right)^n$$

- ❑ The graphs show predicted maximum, mean, and minimum wind speeds for cyclones from 2025 to 2034, based on historical data and regression modeling.
- ❑ While past cyclones show large variations, future predictions indicate:
- Maximum wind speeds may remain high but vary year to year, peaking around more than **200+ km/h.**
- Mean wind speeds are relatively steady, around **150–180 km/h.**
- Minimum wind speeds show moderate fluctuations, ranging from **25 to 100 km/h.**
- The forecast reflects a non-linear trend, capturing both stable and potentially extreme future cyclone events.

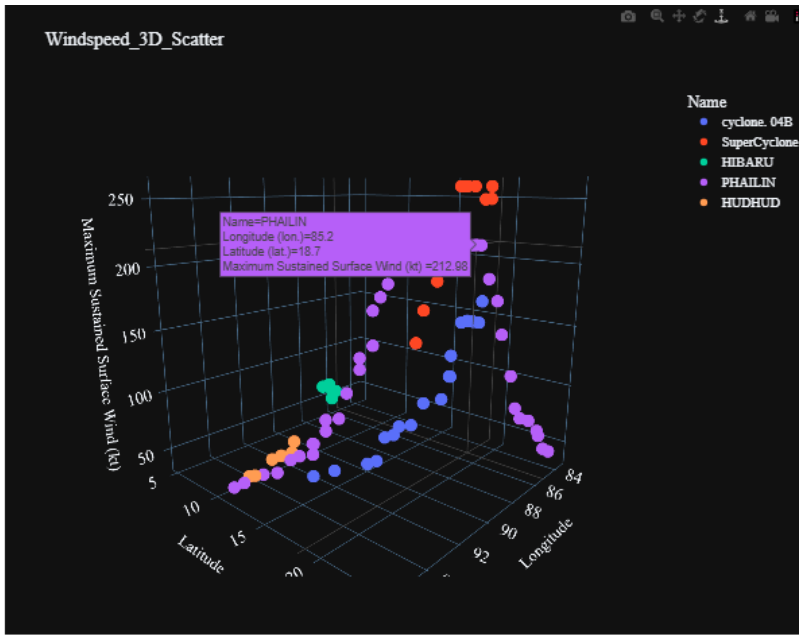
Wind Speed vs Pressure Dynamics

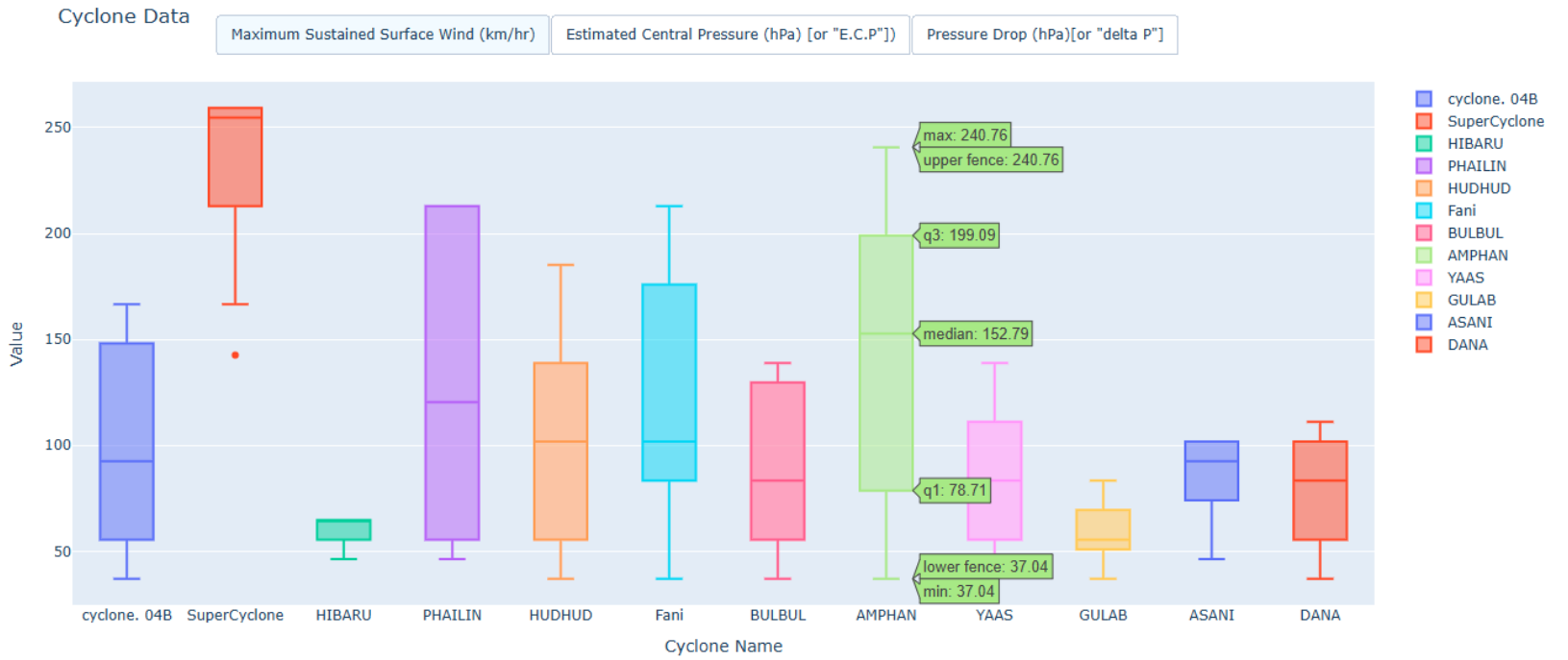


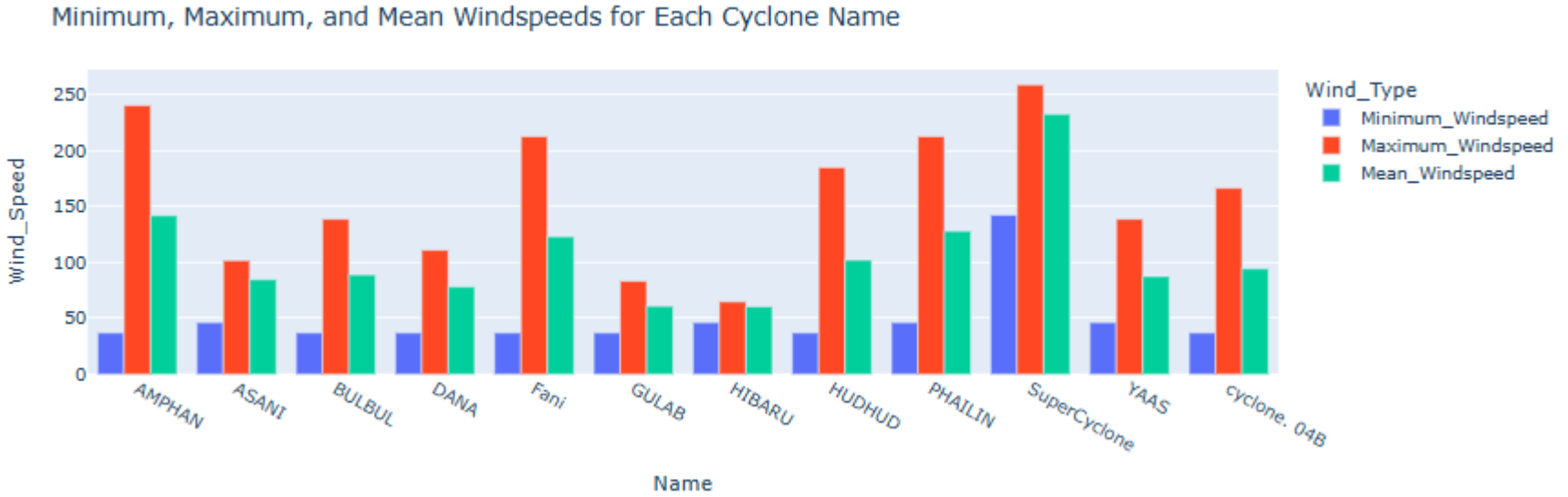
- **Windspeed** $\alpha \frac{1}{Central\ Pressure}$
- **Wind speed α pressure drop**

- This graph illustrates the **trajectory and intensity evolution** of Cyclone Amphan.
- As the cyclone intensified (left to right), wind speed increased while central pressure decrease significantly.
- The strong direct correlation between wind speed and pressure drop (ΔP) confirms the empirical **pressure–wind relationship**.
- These dynamics highlight the critical role of pressure data in estimating cyclone strength and forecasting landfall impacts.

Other Plots


Windspeed_3D_Scatter
Name
cyclone. 04B
SuperCyclone
HIBARU
PHAILIN
HUDHUD
Name=PHAILIN
Longitude (lon.)=85.2
Latitude (lat.)=18.7
Maximum Sustained Surface Wind (kt) =212.98
Maximum Sustained Surface Wind (kt)
Latitude
Longitude


Cyclone Data
Maximum Sustained Surface Wind (km/hr)
Estimated Central Pressure (hPa) [or "E.C.P"])
Pressure Drop (hPa)[or "delta P"]
Value
max: 240.76
upper fence: 240.76
q3: 199.09
median: 152.79
q1: 78.71
lower fence: 37.04
min: 37.04
cyclone. 04B
SuperCyclone
HIBARU
PHAILIN
HUDHUD
Fani
BULBUL
AMPHAN
YAAS
GULAB
ASANI
DANA
Cyclone Name


Minimum, Maximum, and Mean Windspeeds for Each Cyclone Name
Wind_Speed
Wind_Type
Minimum_Windspeed
Maximum_Windspeed
Mean_Windspeed
AMPHAN
ASANI
BULBUL
DANA
Fani
GULAB
HIBARU
HUDHUD
PHAILIN
SuperCyclone
YAAS
cyclone. 04B
Name

Conclusion

Accurate cyclone wind speed prediction is vital for risk management. Empirical models using pressure–wind relationships, especially those based on pressure drop and gradient wind balance, provide reliable estimates. By learning from historical data and accounting for cyclone structure, these models improve forecasting for future events.

Reference

Wei, M., Fang, G., Nikitas, N., & Ge, Y. (2024). Machine-learning-based tropical cyclone wind field model incorporating multiple meteorological parameters. *Journal of Wind Engineering and Industrial Aerodynamics*, *255*, 105936.

Knaff, J. A., & Zehr, R. M. (2007). Reexamination of tropical cyclone wind–pressure relationships. *Weather and Forecasting*, *22*(1), 71-88.