Weather Pattern Analysis for Rain and Wind Alerts in Udaipur Region

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Objective

This report analyzes meteorological data across five regions in Udaipur district over 1000 days to identify weather patterns influencing rain and wind. The aim is to design a data-driven alert system for local farmers.

Dataset Summary

The dataset includes parameters such as:

- Temperature, Humidity, Dew Point
- Rain, Precipitation, Cloud Cover (low/mid/high)
- Wind Speed, Gusts, Direction
- Surface Pressure, Solar Radiation (shortwave, direct, diffuse)

Key statistics:

- **Avg. Temperature:** 23.35°C (SD: 6.49°C)
- **Avg. Relative Humidity:** 53.97%
- **Max Precipitation:** 40.6 mm
- **Max Wind Gusts:** Over 70 m/s

Correlation Matrix

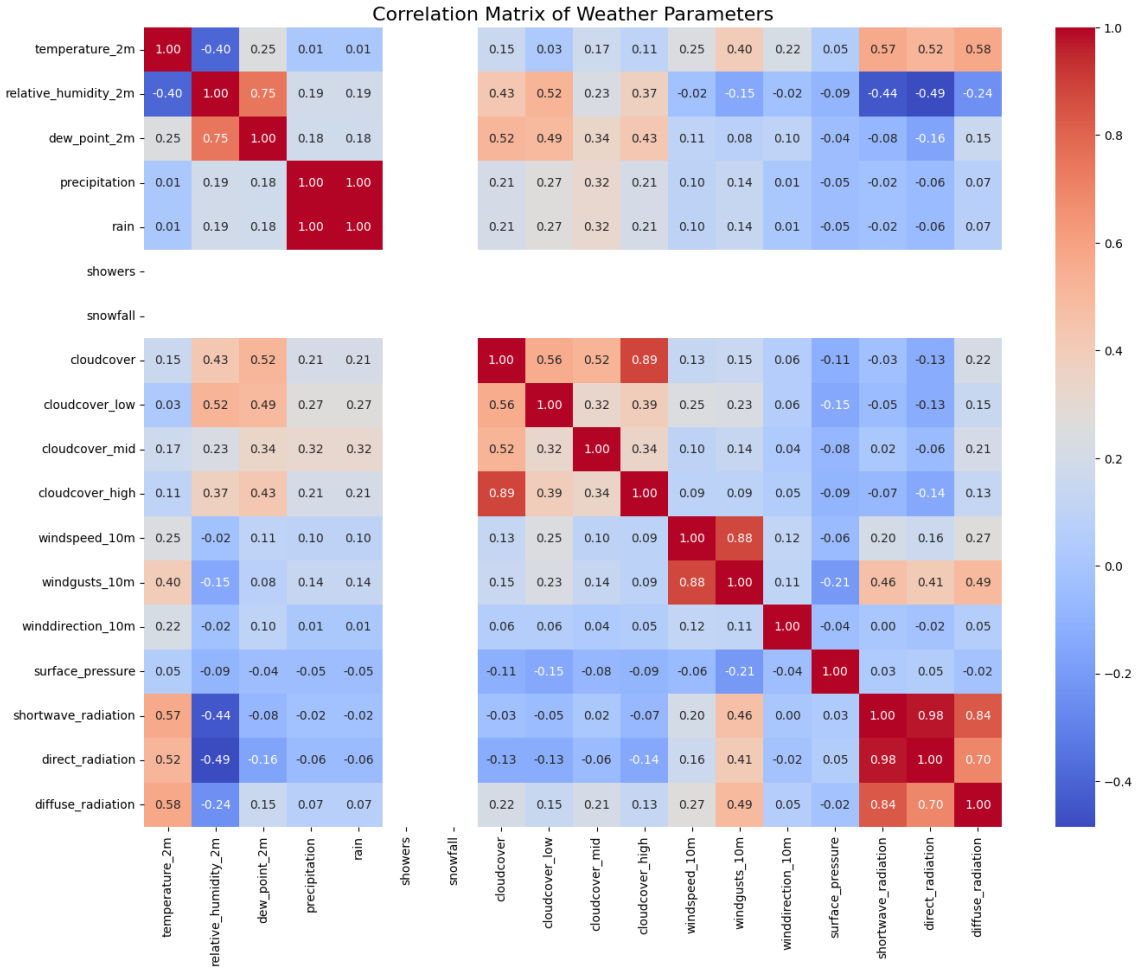

Figure 1: Correlation Matrix of Weather Parameters

Insights:

- Rain strongly correlates with precipitation and mid-level cloud cover.
- Wind speed aligns closely with gust intensity.
- Cloud cover is inversely related to solar radiation.

Temperature Distribution by Location

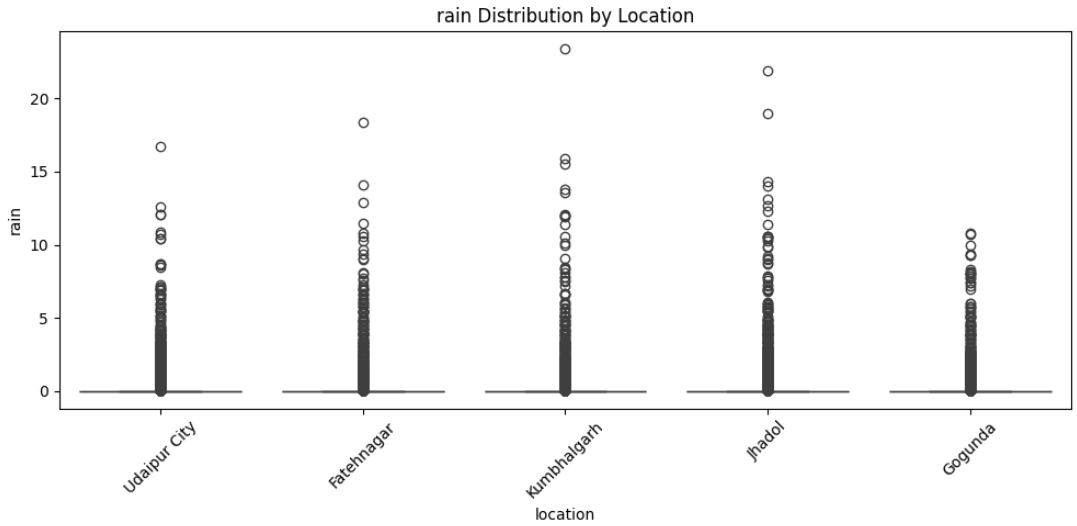

Figure 2: Box Plot: Temperature Variation Across Udaipur Locations

Observation: Fatehnagar and Udaipur City exhibit high variability, with extreme temperatures reaching 42°C.

PCA: Regional Weather Clusters

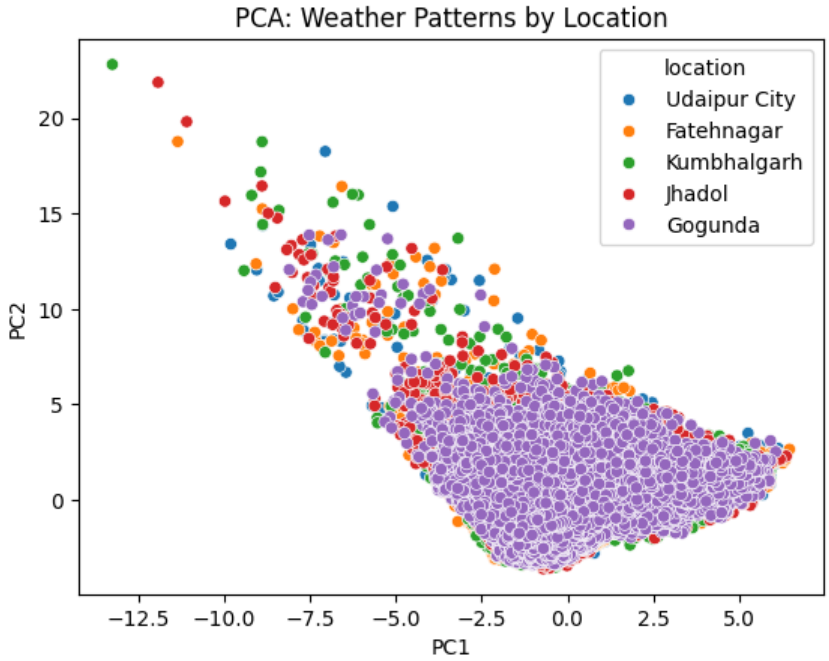

Figure 3: PCA Visualization of Location-wise Weather Clusters

Interpretation: Gogunda shows consistent weather patterns, while Fatehnagar and Kumbhalgarh demonstrate more diverse variability.

Alert Thresholds

Defined thresholds for issuing alerts:

- **Rain Alert:** Rain > 5 mm/h
- **Wind Alert:** Wind Speed > 6 m/s
- **Solar Alert:** Shortwave Radiation > 200 W/m^2

Feature Importance (Baseline)

Random Forest classifier was applied using original meteorological parameters.

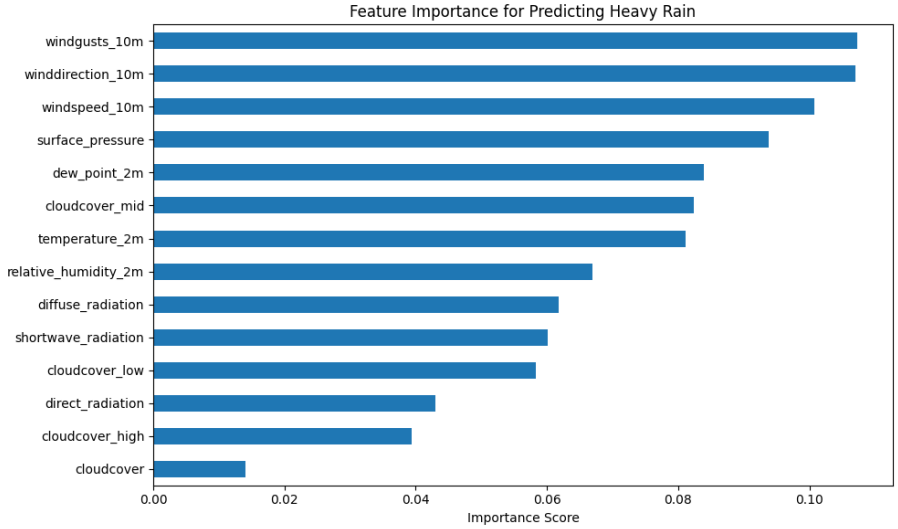

Figure 4: Feature Importance for Rain Prediction (Before Feature Engineering)

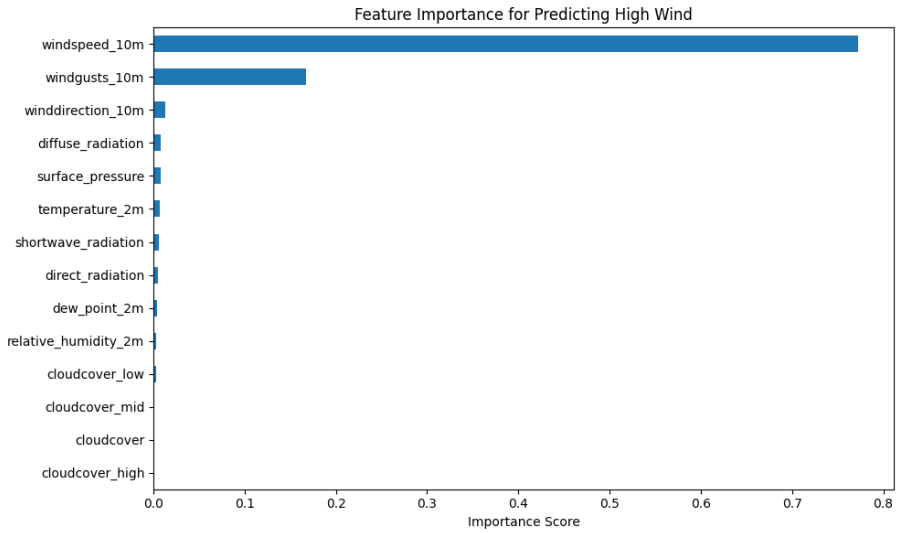

Figure 5: Feature Importance for Wind Prediction (Before Feature Engineering)

Rain Predictors (Baseline):

- Relative Humidity

- Mid/High Cloud Cover
- Dew Point

Wind Predictors (Baseline):

- Wind Gusts
- Surface Pressure
- Temperature

Feature Engineering

To enhance model performance, the following features were derived:

- **Temp-Humidity Interaction:** Product of temperature and relative humidity.
- **Pressure Trend:** Hourly difference in surface pressure per location.
- **Cloud Cover Ratio:** Low-level cloud cover as a fraction of total cover.
- **Wind Direction Variability:** Rolling standard deviation of wind direction (window = 3 hours).
- **Monsoon Indicator:** Binary variable for June–September months.

Post-Engineering Feature Impact

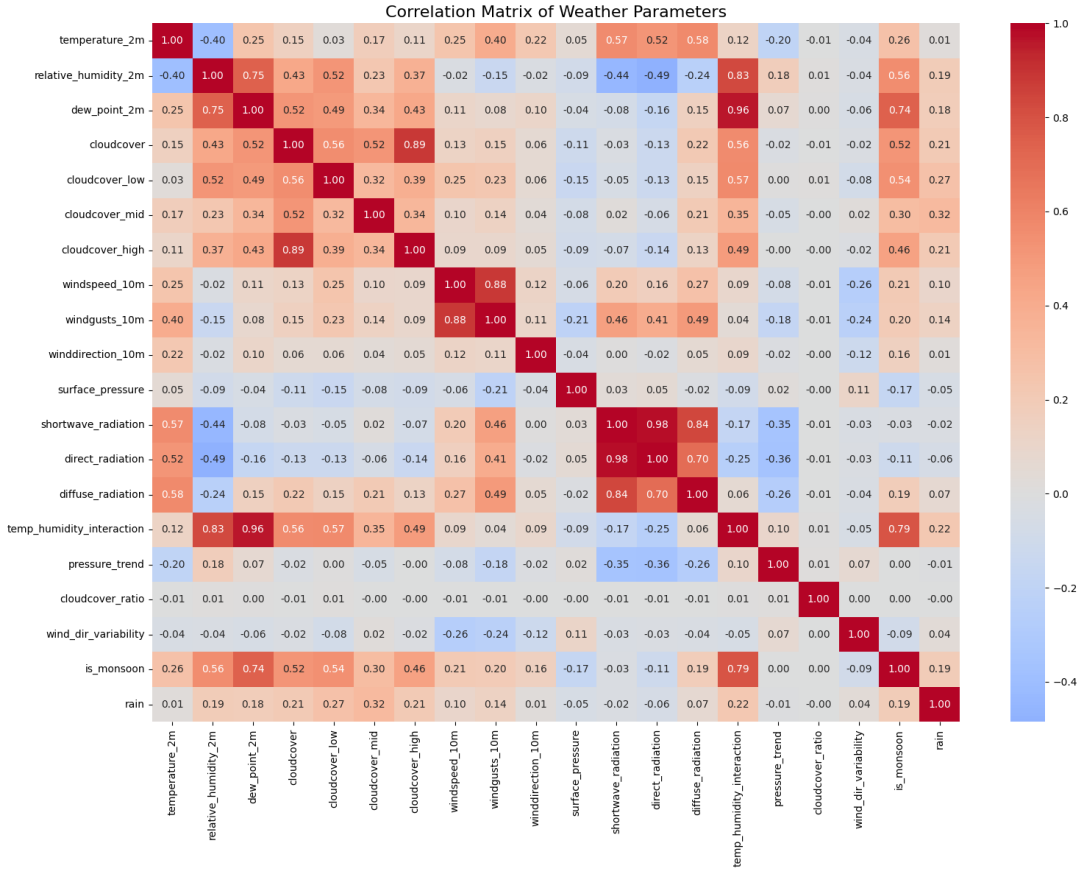

Figure 6: Modified Correlation Matrix After Feature Engineering

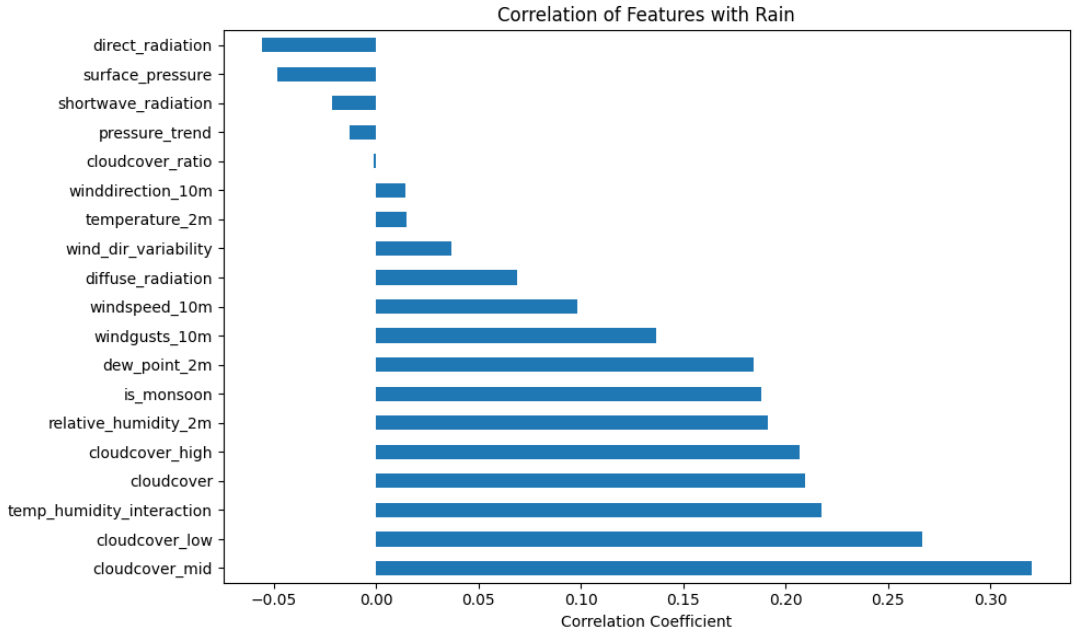

Figure 7: Updated Rain Feature Importance (After Feature Engineering)

Key Improvements:

- **Rain:** Temp-humidity interaction and monsoon indicator emerged as strong predictors.
- **Wind:** Wind direction variability contributed to better gust prediction.
- **Pressure trend** helped anticipate sudden weather shifts.

API-Based Weather Comparison

To evaluate the consistency and reliability of free weather APIs used for alerts, data was collected from four APIs over 28 observations.

Descriptive Statistics Summary

Table 1: Descriptive Statistics from Weather APIs (n = 28)

	Open-Meteo				**OpenWeather**				**Yr.no**			
Metric	Temp	Hum	Rain	Wind	Temp	Hum	Rain	Wind	Temp	Hum	Rain	Wind
Count	28	28	28	28	28	28	28	28	28	28	28	28
Mean	25.50	83.36	0.00	15.42	25.40	80.11	0.11	7.29	25.58	80.01	0.09	5.88
Std	1.39	6.56	0.00	4.01	2.09	9.21	0.15	1.53	2.35	11.45	0.30	1.05
Min	23.70	71.00	0.00	8.10	22.93	61.00	0.00	5.10	22.40	60.90	0.00	4.60
25%	24.38	78.75	0.00	12.35	23.63	71.75	0.00	6.02	23.65	68.45	0.00	5.05
50%	25.10	85.50	0.00	15.25	24.74	81.00	0.00	7.00	24.75	82.75	0.00	5.85
75%	26.60	89.00	0.00	19.15	27.32	87.00	0.17	8.78	27.93	90.40	0.00	6.33
Max	28.30	90.00	0.00	22.50								

Visualization: API Comparison

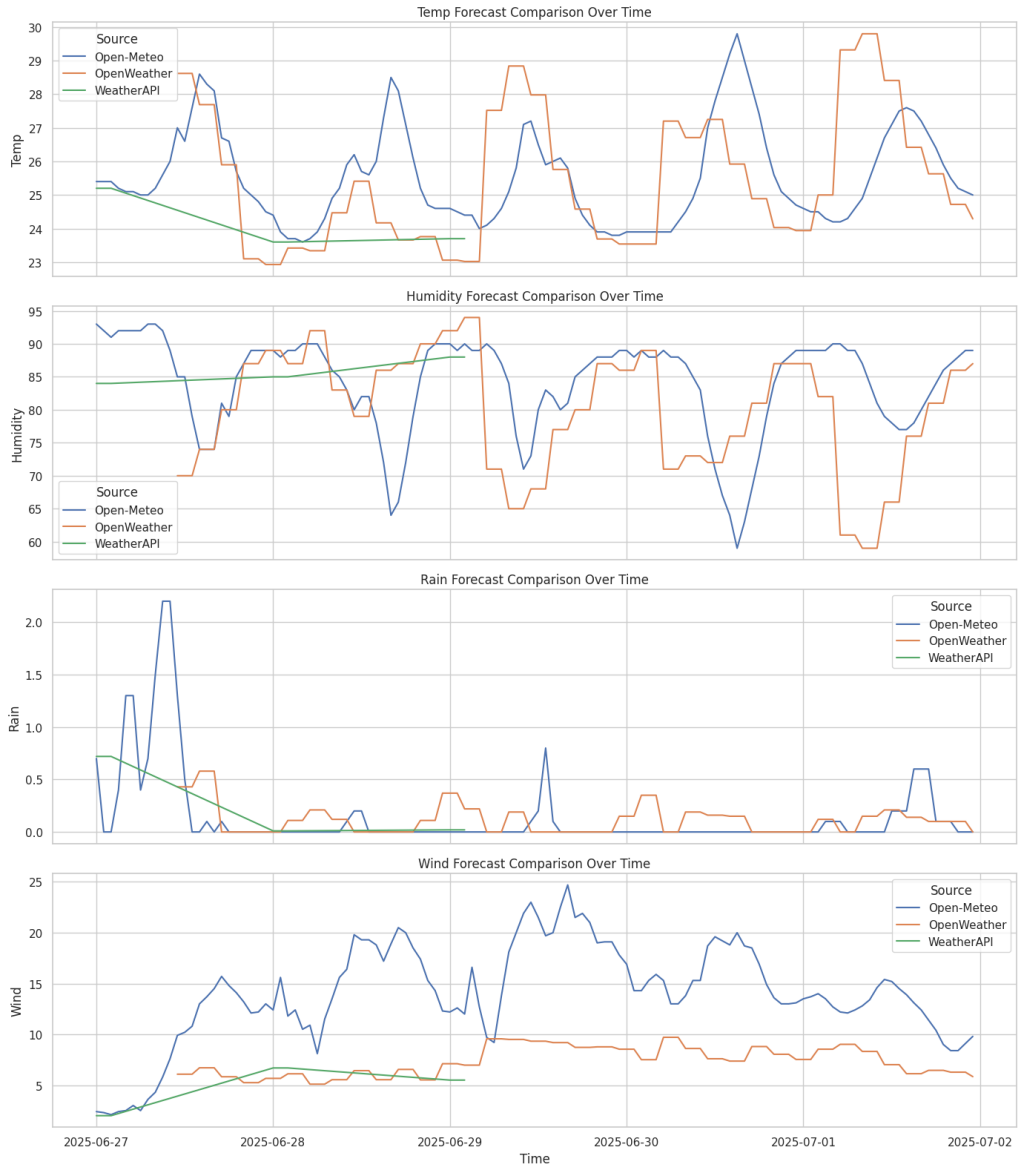

Figure 8: Comparison of Temperature, Humidity, Rain, and Wind Across APIs

Note: Due to the constraints of free-tier APIs, the data sample size is limited (28 entries). However, the comparison reveals general alignment in temperature and humidity, while rain reporting varies significantly across providers, with OpenWeather occasionally reporting light rain not seen in others. Wind predictions are most varied, with Open-Meteo reporting higher values on average.

Conclusion

The analysis yields the following actionable insights:

- Rain events correlate with cloud dynamics, humidity, and seasonal patterns.
- Wind prediction improves with gust tracking and wind variability features.
- PCA reveals region-specific weather characteristics valuable for localized alerts.