Weather Data Analysis

Domain: Weather & Climate Analytics

Abstract

This project analyzes historical weather data to identify temperature trends, seasonal patterns, humidity behavior, and relationships between key meteorological variables. The goal is to derive climate insights and support weather-aware planning and decision-making.

Executive Summary

- Historical weather records were analyzed across multiple meteorological attributes.
- Temperature trends, humidity distribution, wind behavior, and seasonal patterns were explored using visual analytics.
- Correlation analysis was performed to identify relationships between variables.

Outcome: The analysis highlights clear seasonal variations and interdependencies between weather attributes, enabling better climate understanding and forecasting insights.

Introduction

Problem Statement

Weather patterns directly impact agriculture, transportation, energy consumption, and disaster preparedness. However, raw weather data alone does not provide clear insights without systematic analysis.

Objectives

- Analyze long-term temperature trends

- Identify seasonal weather patterns
- Study humidity and wind behavior
- Explore correlations between weather attributes
- Generate climate insights and recommendations

Dataset Description

- **Source:** weatherHistory.csv
- **Type:** Historical weather observations
- **Granularity:** Time-based records
- **Common Attributes:**
  - Temperature
  - Humidity
  - Wind Speed
  - Weather Summary
  - Date/Time

Methodology

1. Load and inspect the dataset
2. Validate schema and data quality
3. Perform feature engineering (date, season)
4. Conduct exploratory data analysis
5. Perform statistical and correlation analysis
6. Derive climate insights and recommendations

In [11]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

sns.set(style="whitegrid")
```

```python
df = pd.read_csv("../datasets/weatherHistory.csv")
df.head()
```

Out[11]:

	Formatted Date	Summary	Precip Type	Temperature (C)	Apparent Temperature (C)	Humidity	Wind Speed (km/h)	Wind Bearing (degrees)	Visibility (km)	Loud Cover	Pressure (millibars)	Sum
0	2006-04-01 00:00:00.000 +0200	Partly Cloudy	rain	9.472222	7.388889	0.89	14.1197	251.0	15.8263	0.0	1015.13	c throug the
1	2006-04-01 01:00:00.000 +0200	Partly Cloudy	rain	9.355556	7.227778	0.86	14.2646	259.0	15.8263	0.0	1015.63	c throug the
2	2006-04-01 02:00:00.000 +0200	Mostly Cloudy	rain	9.377778	9.377778	0.89	3.9284	204.0	14.9569	0.0	1015.94	c throug the
3	2006-04-01 03:00:00.000 +0200	Partly Cloudy	rain	8.288889	5.944444	0.83	14.1036	269.0	15.8263	0.0	1016.41	c throug the
4	2006-04-01 04:00:00.000 +0200	Mostly Cloudy	rain	8.755556	6.977778	0.83	11.0446	259.0	15.8263	0.0	1016.51	c throug the

DATA VALIDATION & COLUMN INSPECTION

In [12]:

```python
print("Dataset Shape:", df.shape)

print("\nColumns:")
for col in df.columns:
    print("-", col)
```

```
print("\nData Types:")
df.info()

print("\nMissing Values:")
df.isnull().sum()
```

```
Dataset Shape: (96453, 12)

Columns:
- Formatted Date
- Summary
- Precip Type
- Temperature (C)
- Apparent Temperature (C)
- Humidity
- Wind Speed (km/h)
- Wind Bearing (degrees)
- Visibility (km)
- Loud Cover
- Pressure (millibars)
- Daily Summary

Data Types:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 96453 entries, 0 to 96452
Data columns (total 12 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   Formatted Date            96453 non-null  object
 1   Summary                   96453 non-null  object
 2   Precip Type               95936 non-null  object
 3   Temperature (C)           96453 non-null  float64
 4   Apparent Temperature (C)  96453 non-null  float64
 5   Humidity                  96453 non-null  float64
 6   Wind Speed (km/h)         96453 non-null  float64
 7   Wind Bearing (degrees)    96453 non-null  float64
 8   Visibility (km)           96453 non-null  float64
 9   Loud Cover                96453 non-null  float64
 10  Pressure (millibars)      96453 non-null  float64
 11  Daily Summary             96453 non-null  object
dtypes: float64(8), object(4)
memory usage: 8.8+ MB

Missing Values:
```

Out[12]:
```
Formatted Date               0
Summary                      0
Precip Type                517
Temperature (C)              0
Apparent Temperature (C)     0
Humidity                     0
Wind Speed (km/h)            0
Wind Bearing (degrees)       0
Visibility (km)              0
Loud Cover                   0
Pressure (millibars)         0
Daily Summary                0
dtype: int64
```

FEATURE ENGINEERING

In [13]:
```python
# Convert date column to datetime
import pandas as pd

# ---- Robust datetime parsing for mixed timezones ----
if "Formatted Date" in df.columns:
    # Parse datetime with timezone handling
    df["Formatted Date"] = pd.to_datetime(
        df["Formatted Date"],
        utc=True,          # REQUIRED for mixed timezones
        errors="coerce"    # Invalid parsing → NaT
    )

    # Drop rows where datetime conversion failed
    df = df.dropna(subset=["Formatted Date"])

    # Convert timezone-aware datetime to timezone-naive
    df["Formatted Date"] = df["Formatted Date"].dt.tz_convert(None)

    # Feature engineering
    df["Year"] = df["Formatted Date"].dt.year
    df["Month"] = df["Formatted Date"].dt.month
    df["Month_Name"] = df["Formatted Date"].dt.month_name()

df.head()
```

Out[13]:

	Formatted Date	Summary	Precip Type	Temperature (C)	Apparent Temperature (C)	Humidity	Wind Speed (km/h)	Wind Bearing (degrees)	Visibility (km)	Loud Cover	Pressure (millibars)	D Summ
0	2006-03-31 22:00:00	Partly Cloudy	rain	9.472222	7.388889	0.89	14.1197	251.0	15.8263	0.0	1015.13	P clc throug the
1	2006-03-31 23:00:00	Partly Cloudy	rain	9.355556	7.227778	0.86	14.2646	259.0	15.8263	0.0	1015.63	P clc throug the
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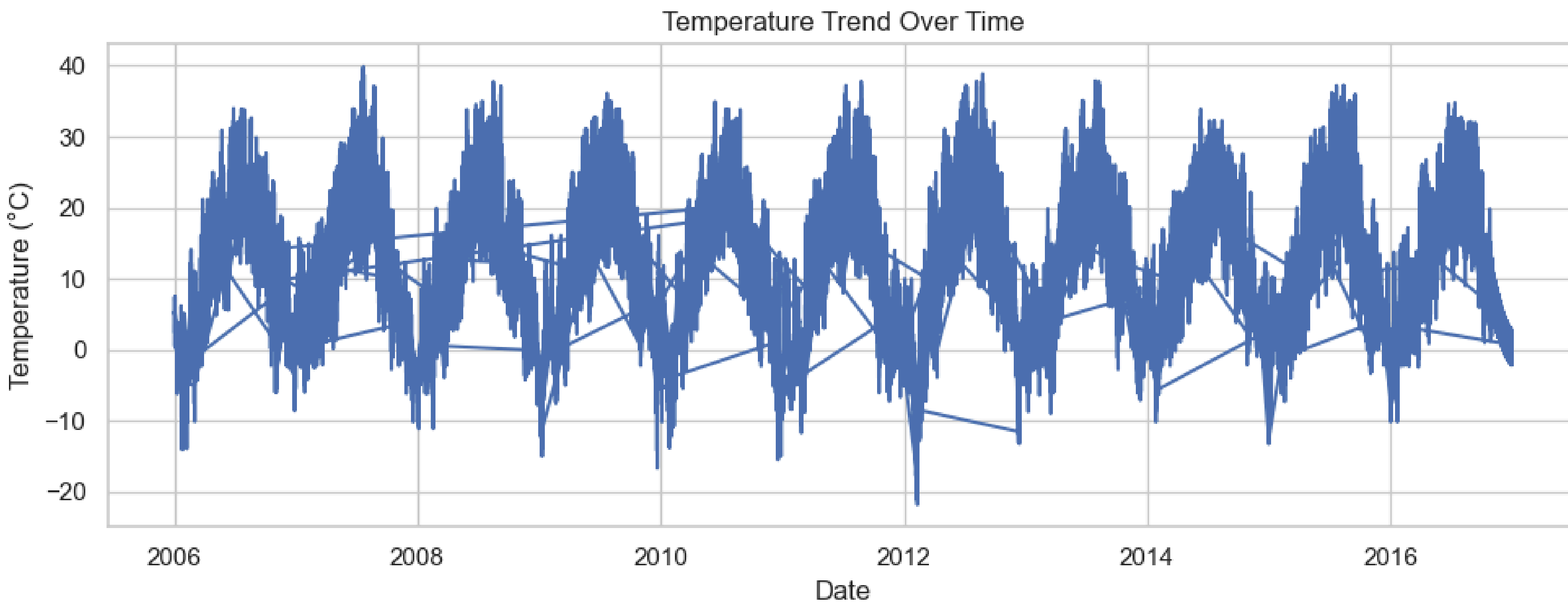
EXPLORATORY DATA ANALYSIS

Temperature Over Time

In [14]:

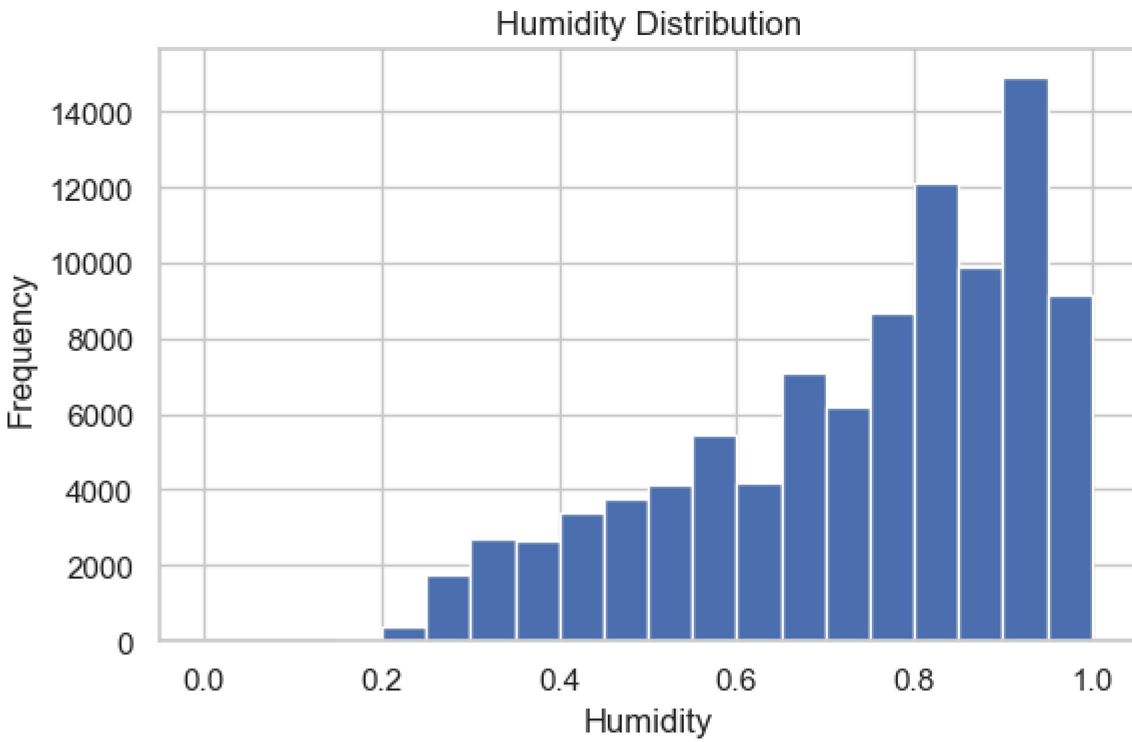
```
plt.figure(figsize=(10, 4))
plt.plot(df["Formatted Date"], df["Temperature (C)"])
plt.title("Temperature Trend Over Time")
plt.xlabel("Date")
plt.ylabel("Temperature (°C)")
plt.tight_layout()
```

```
plt.savefig("../visualizations/weather/temperature_trend.png")
plt.show()
```



Humidity Distribution

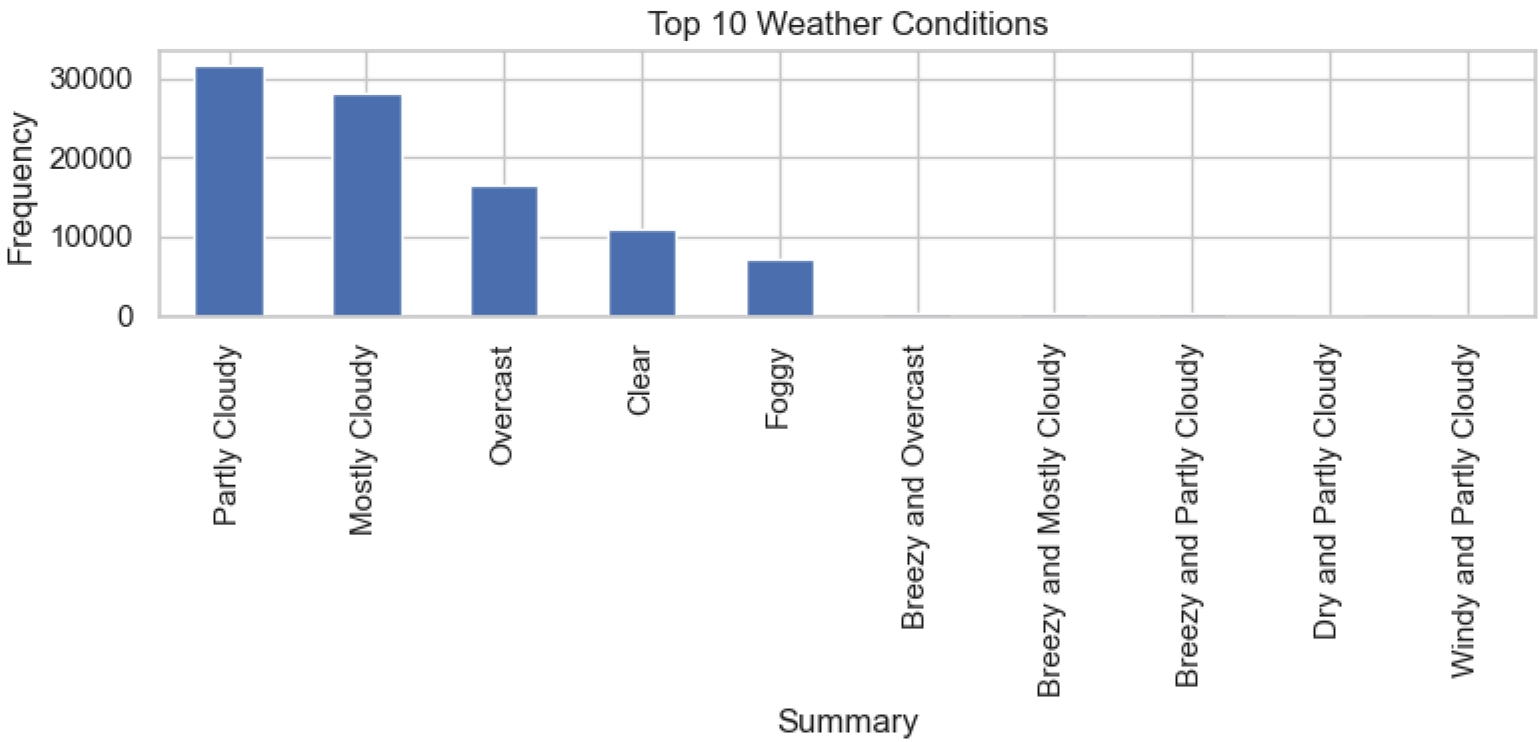
In [15]:
```
plt.figure(figsize=(6, 4))
plt.hist(df["Humidity"], bins=20)
plt.title("Humidity Distribution")
plt.xlabel("Humidity")
plt.ylabel("Frequency")
plt.tight_layout()
plt.savefig("../visualizations/weather/humidity_distribution.png")
plt.show()
```



Weather Condition Frequency

In [16]:
```
weather_counts = df["Summary"].value_counts().head(10)

plt.figure(figsize=(8, 4))
weather_counts.plot(kind="bar")
plt.title("Top 10 Weather Conditions")
plt.ylabel("Frequency")
plt.tight_layout()
plt.savefig("../visualizations/weather/weather_condition_frequency.png")
plt.show()
```

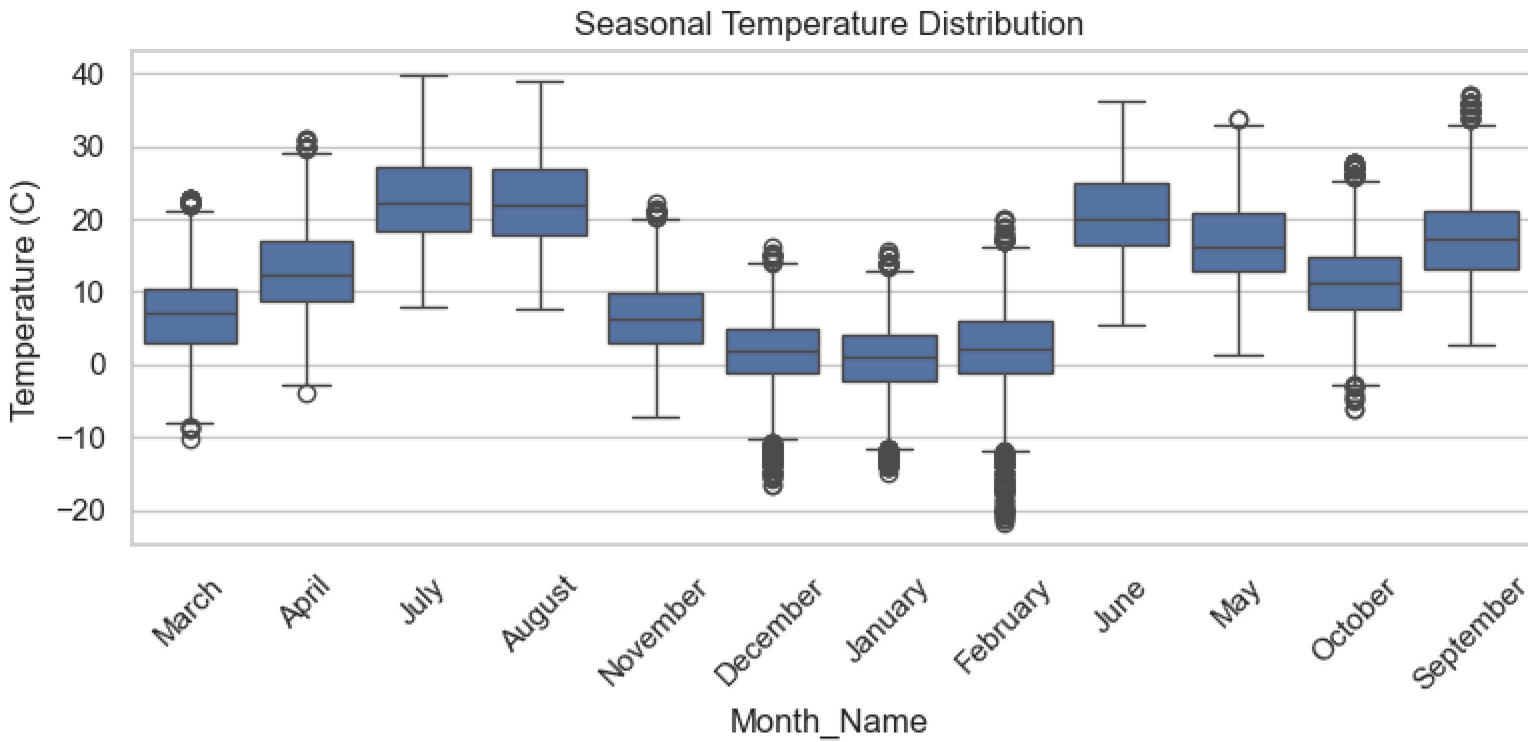


ADVANCED WEATHER ANALYSIS

Seasonal Temperature Trends

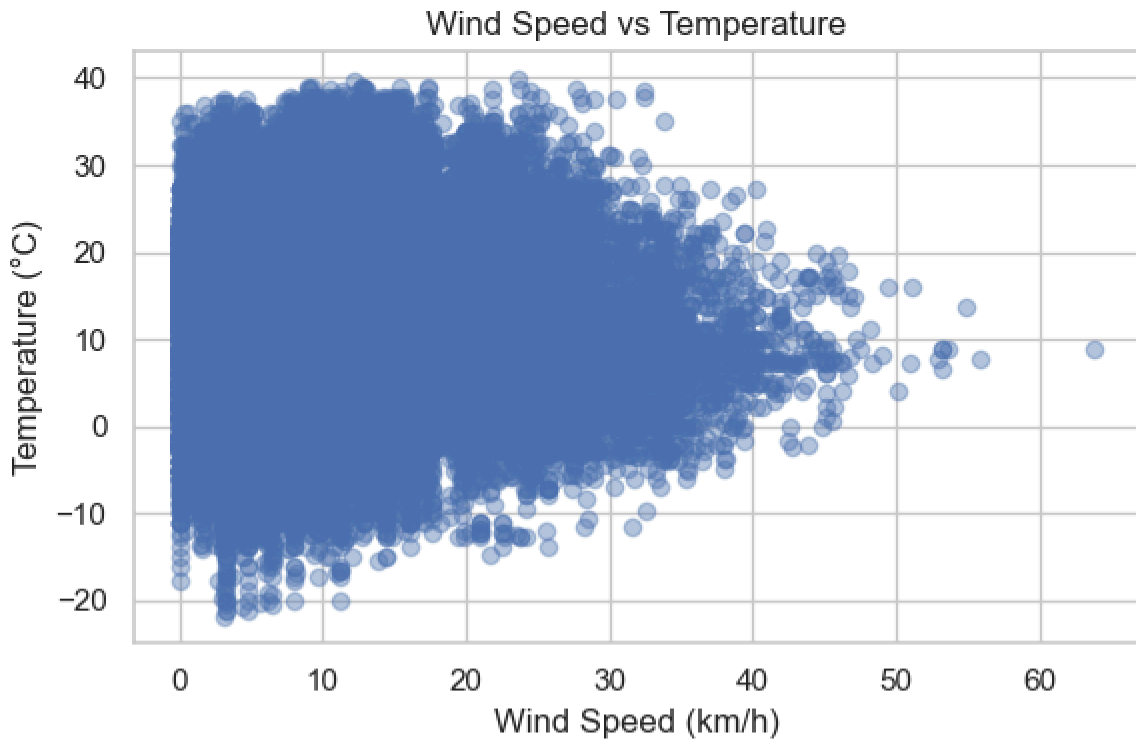
In [17]:

```
plt.figure(figsize=(8, 4))
sns.boxplot(x="Month_Name", y="Temperature (C)", data=df)
plt.xticks(rotation=45)
plt.title("Seasonal Temperature Distribution")
plt.tight_layout()
plt.savefig("../visualizations/weather/seasonal_temperature.png")
plt.show()
```



Wind Speed vs Temperature

In [18]:
```
plt.figure(figsize=(6, 4))
plt.scatter(df["Wind Speed (km/h)"], df["Temperature (C)"], alpha=0.4)
plt.title("Wind Speed vs Temperature")
plt.xlabel("Wind Speed (km/h)")
plt.ylabel("Temperature (°C)")
plt.tight_layout()
plt.savefig("../visualizations/weather/wind_vs_temperature.png")
plt.show()
```

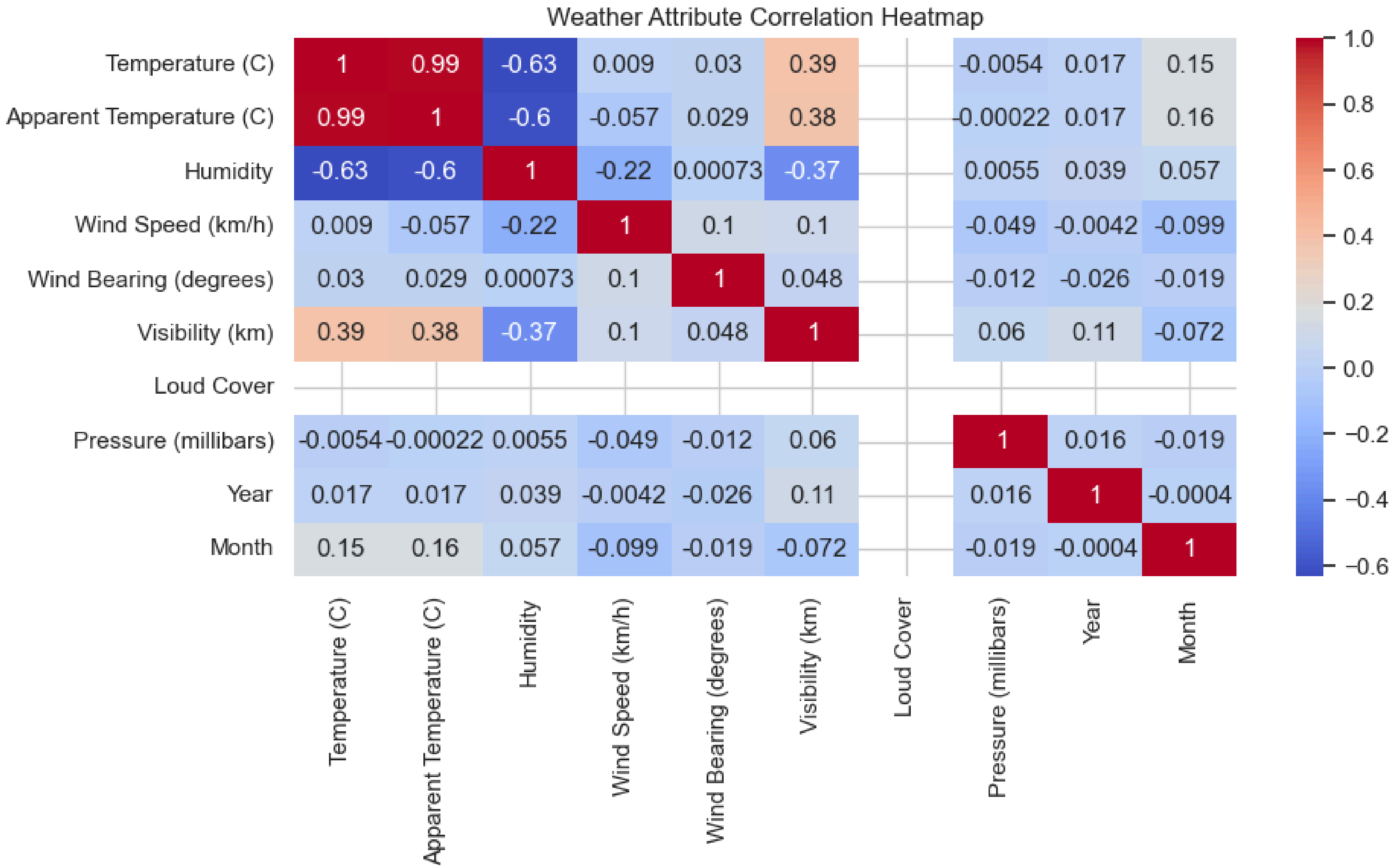


Correlation Heatmap

In [19]:

```
numeric_df = df.select_dtypes(include="number")

plt.figure(figsize=(10, 6))
sns.heatmap(numeric_df.corr(), cmap="coolwarm", annot=True)
plt.title("Weather Attribute Correlation Heatmap")
plt.tight_layout()
plt.savefig("../visualizations/weather/correlation_heatmap.png")
plt.show()
```



STATISTICAL ANALYSIS

In [20]:
```
df[["Temperature (C)", "Humidity", "Wind Speed (km/h)"]].describe()
```

Out[20]:

	Temperature (C)	Humidity	Wind Speed (km/h)
count	96453.000000	96453.000000	96453.000000
mean	11.932678	0.734899	10.810640
std	9.551546	0.195473	6.913571
min	-21.822222	0.000000	0.000000
25%	4.688889	0.600000	5.828200
50%	12.000000	0.780000	9.965900
75%	18.838889	0.890000	14.135800
max	39.905556	1.000000	63.852600

Key Findings

- Temperature exhibits clear seasonal variation.
- Humidity levels are skewed towards moderate values.
- Wind speed shows weak to moderate correlation with temperature.

Climate Insights & Recommendations

Insights

- Seasonal patterns significantly influence temperature behavior.
- Certain weather conditions dominate the dataset.

Recommendations

1. Use seasonal trends for weather forecasting models.
2. Prepare infrastructure planning based on historical extremes.
3. Monitor wind and humidity interactions for climate studies.

Conclusion & Future Scope

This analysis demonstrates how historical weather data can uncover meaningful climate patterns and trends.

Future Scope

- Extreme weather detection
- Predictive climate modeling
- Regional climate comparison studies

In [20]:

```

```