Predicting Europe's Weather Patterns with Machine Learning

Presented by: Jennifer Ignacio

Updated: July 8th, 2024

Objective & Overview

Objective: Predict weather patterns and identify Europe’s safest regions from extreme weather

1

Detect significant deviations in Europe's weather from historical norms

2

Analyze if unusual weather patterns in Europe are increasing over time

3

Forecast future weather and identify the safest European regions to live

Algorithm Overview: Machine Learning Tools

Random Forests

What They Do:
Combines multiple decision trees to improve predictive accuracy .

Application:
Feature importance analysis and risk assessments for identifying safe regions.

CNN & RNN

Convolutional Neural Networks & Recurrent Neural Networks

What They Do:
CNNs detect spatial patterns; RNNs capture temporal dependencies in sequential data.

Application:
Identify deviations in weather patterns and forecast future conditions.

GAN

Generative Adversarial Network

What They Do:
GANs create synthetic data by pitting two neural networks against each other.

Application:
Simulate future weather scenarios to predict potential climate changes.

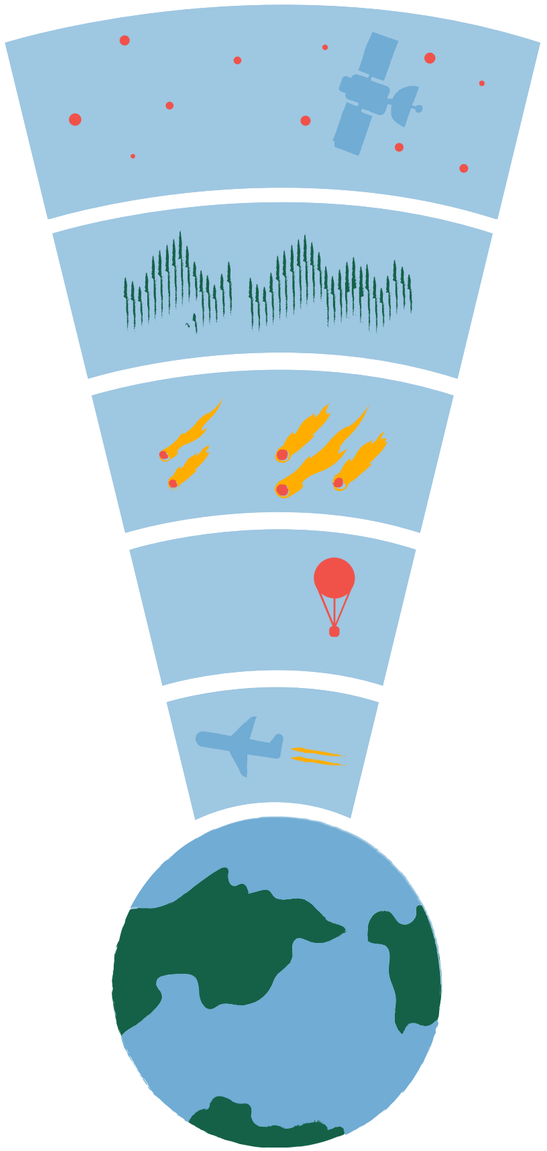
1 : Identifying Deviations in Weather Patterns

Concept: Investigate and identify weather patterns in Europe that significantly deviate from historical regional norms to understand potential climate change impacts.

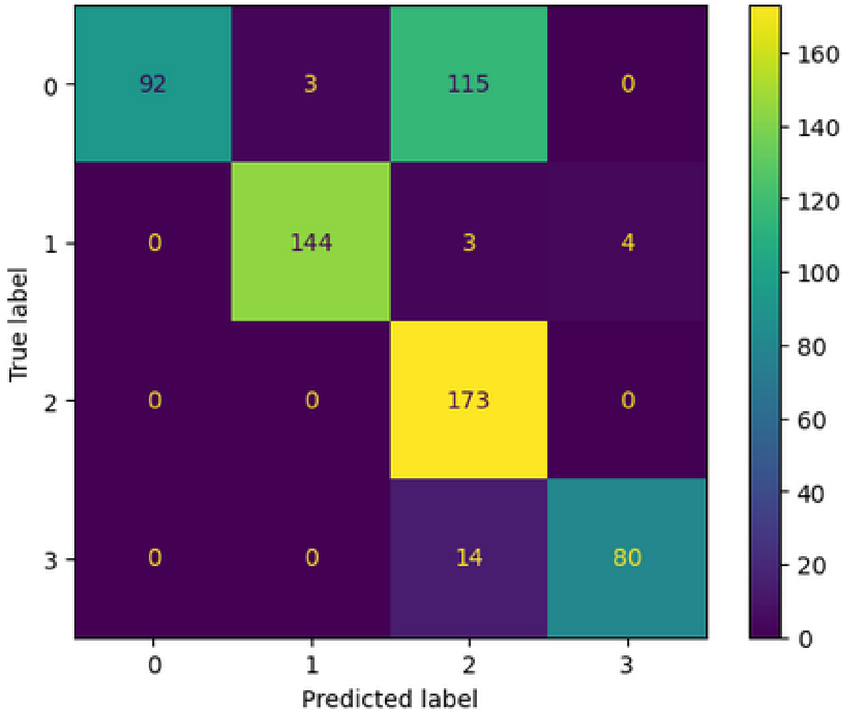
- **Data Collection:** historical weather data from various regions in Europe over the last 100 years.

- **Algorithms**:
  - **CNNs & GANs:** Analyze spatial data to detect patterns and anomalies across different regions.Generate synthetic weather data and compare it to real data to identify anomalies.

  - **KNN & Decision Trees:** Use these for initial anomaly detection and to understand simpler relationships.



1. What Could This Look Like in practice?



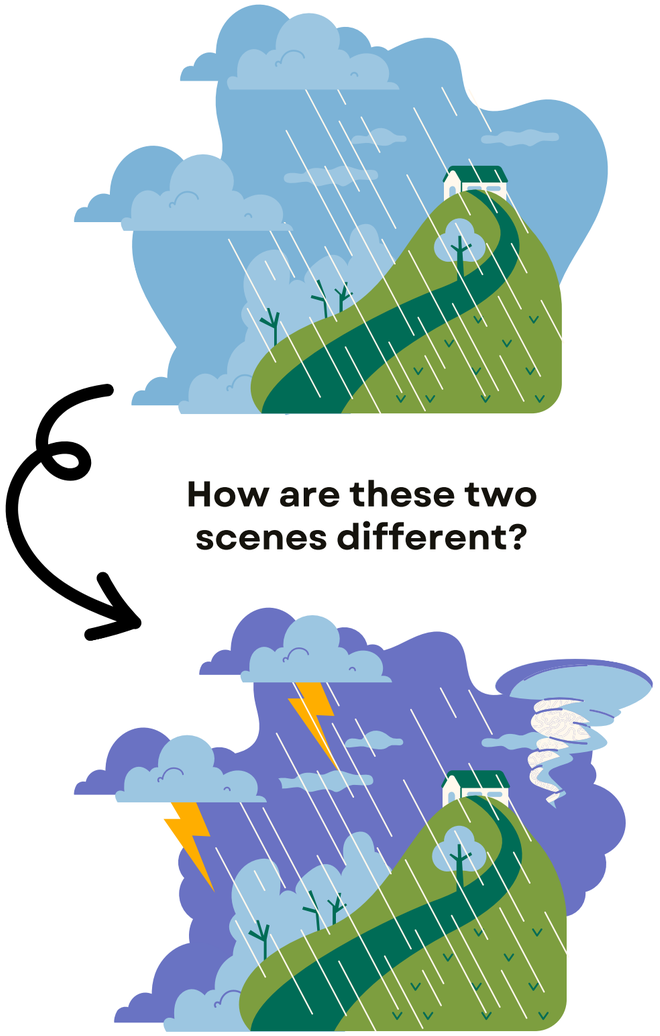
- Confusion matrix derived from CNN model categorizing weather condition.
- **Accuracy rate:** 94%

- Prediction display showing an example of an incorrect prediction.

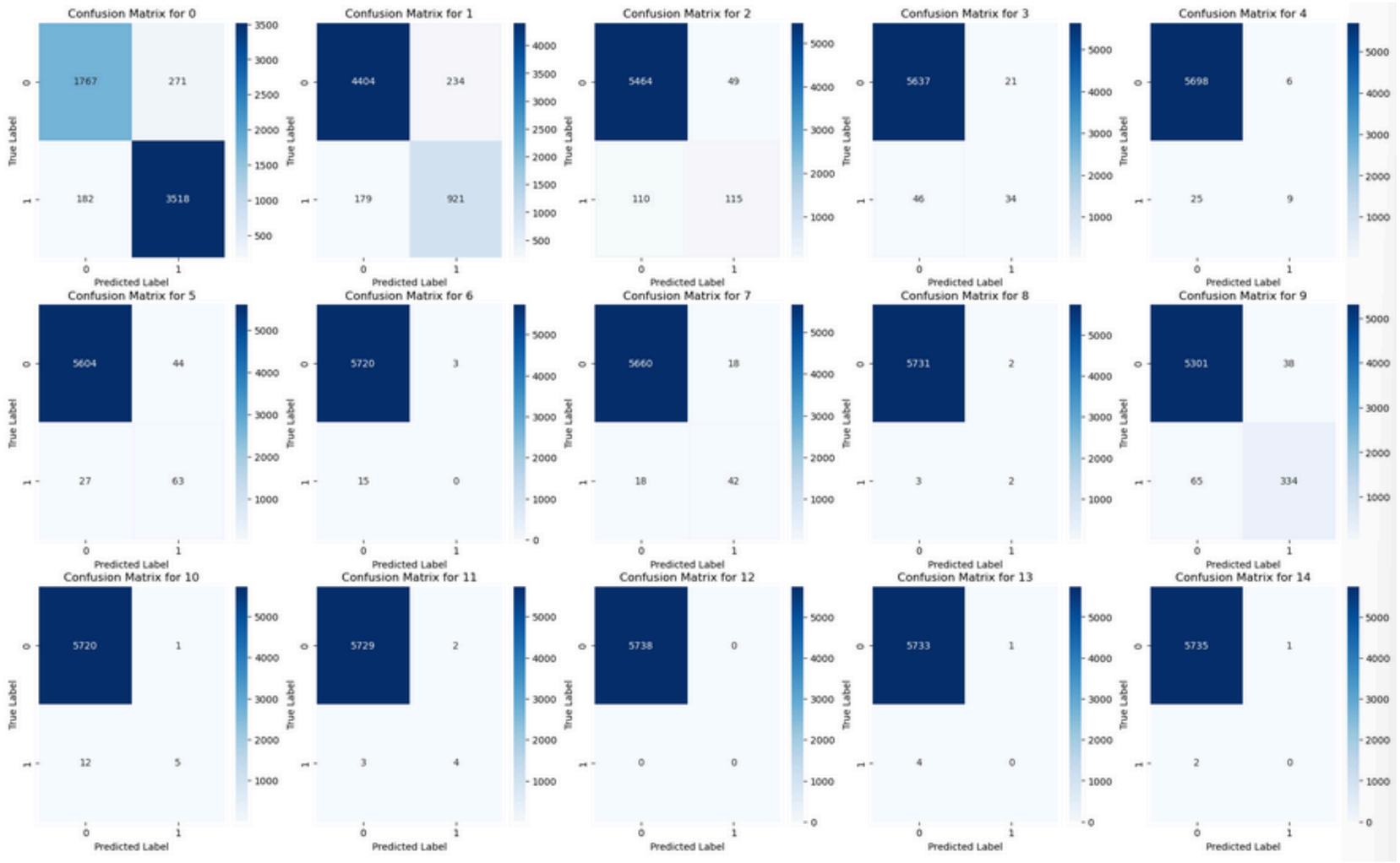
2 : Assessing Trends in Unusual Weather Patterns

Concept: Analyze historical data to determine if the frequency and intensity of unusual weather patterns are increasing, indicating shifts in climate behavior.

- **Data Collection:** Historical time-series data of weather anomalies
- **Algorithms:**
  - **RNNs(LTSMs) & Random Forest:** Analyze sequential data to detect trends and patterns over time. Model feature importance and detect trends in weather data.
  - **ANN & KNN:** Supplementary models for capturing non-linear relationships and trend comparison.



2. What Could This Look Like in Practice?



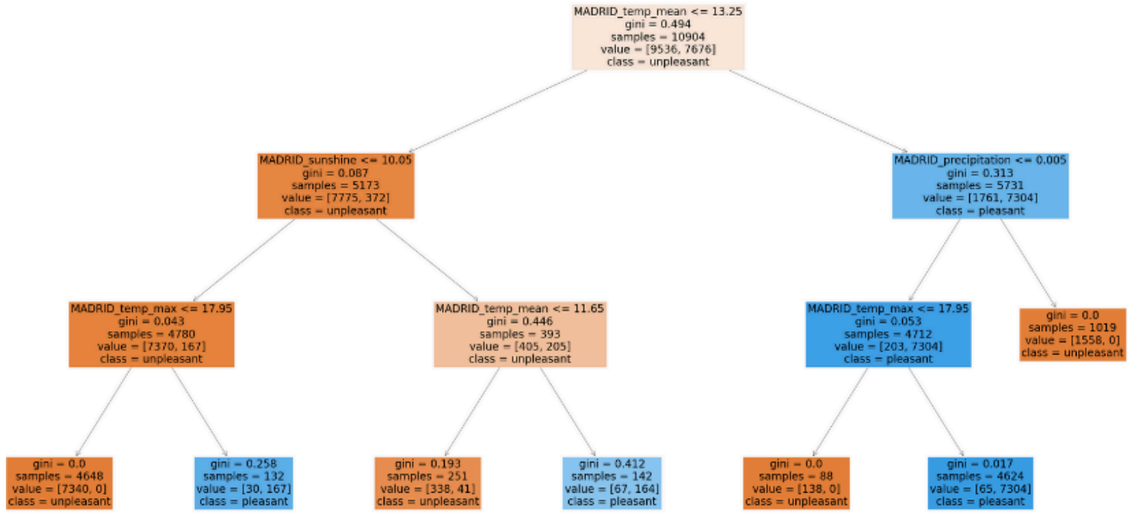
- Confusion matrix derived from RNN categorizing unpleasant/ pleasant weather at each weather station
- **Accuracy rate:** 87%

3 : Projecting Future Climate Scenarios and Safe Regions

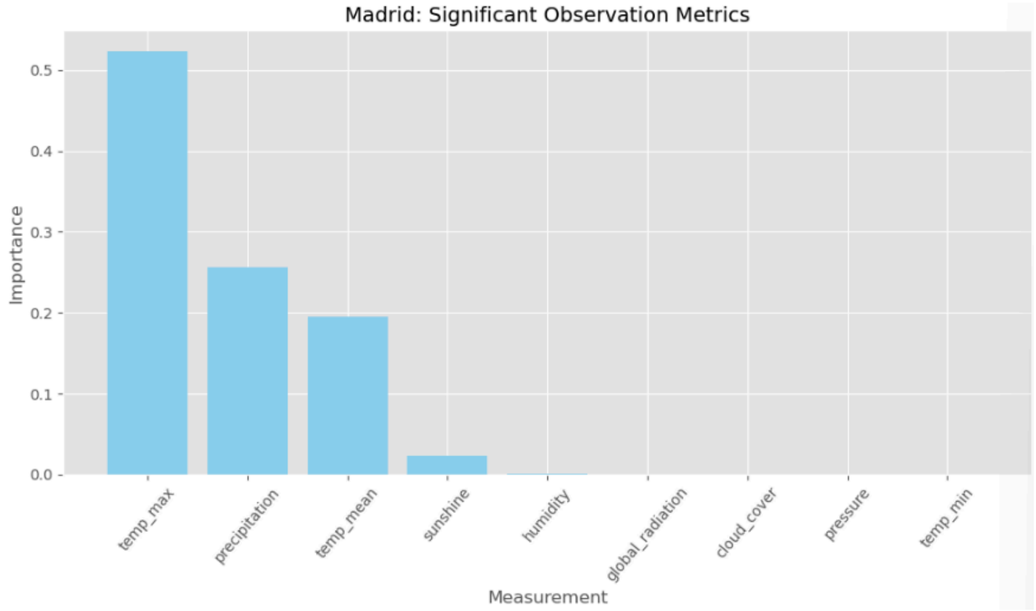
Concept: Generate future weather condition scenarios for the next 25 to 50 years and identify regions in Europe that will be safest for habitation based on these projections.

- **Data Collection:** Historical time-series data of weather anomalies
- **Algorithms:**
  - **Random Forests & GANs:** Conduct risk assessments, factor in predicted weather conditions, and assess regional safety. Generate multiple future weather scenarios to simulate different climate conditions.
  - **Decision Trees and KNN:** Supplementary models for risk categorization.
  - **CNN & RNN:** Spatial analysis and pattern recognition

3. What Could This Look Like in Practice?



- Random forest for Madrid's weather station categorizing pleasant and unpleasant weather data points.
- **Accuracy rate:** 99%



- Plot of Madrid random forest's feature importance.

Social & Ethical Considerations

Implication 1:
Understanding which regions are experiencing abnormal weather patterns can help policymakers and communities prepare for and mitigate the impacts of climate change.

Implication 2:
Identifying increasing trends in unusual weather patterns can prompt proactive measures to address and adapt to potential changes in climate behavior.

Implication 3:
Identifying safe regions for habitation helps governments and communities plan for future infrastructure, development, and disaster preparedness, ensuring the safety and well-being of the population.

Results & Summary

Results

- **High Accuracy in Weather Categorization:** The CNNs categorized weather conditions with a 94% accuracy rate and combined with GANs, it will accurately categorize and depict unusual weather from usual historical weather.
- **Lower Accuracy for Temporal Data:** Despite using optimizations, RNNs have a smaller accuracy compared to CNNs, indicating it's harder to utilize the temporal component of the data effectively.
- **Effective Risk Categorization:** Random Forests have a high categorization accuracy for determining unpleasant and pleasant weather data, which could be very helpful for categorizing risk based on possible extreme weather conditions created by GANs.

Greatest Success Rate

- **Thought experiment 1**'s use of CNNs for spatial pattern recognition and high accuracy in detecting weather condition anomalies provides a robust foundation for predicting future climate impacts.
- Combining Thought Experiment 1's framework with Random Forests' categorization power will provide ClimaWins with comprehensive insights to detect climate anomalies and predict future weather impacts effectively.

Thank you!

Questions?