Weather Conditions and Climate Change with ClimateWins

M A C H I N E L E A R N I N G

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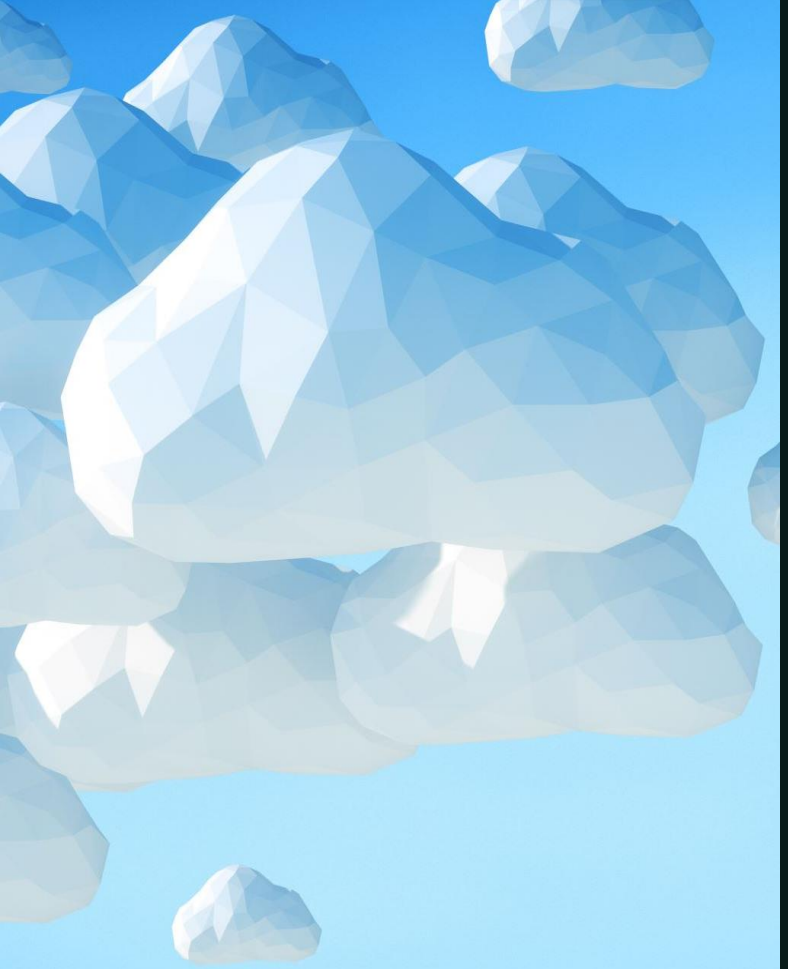
Objectives

- Identify weather patterns outside the regional norm in Europe
- Determine if unusual weather patterns are increasing
- Generate possibilities for future weather conditions over the next 25 to 50 years based on current trends
- Determine the safest places for people to live in Europe over the next 25 to 50 years

Machine Learning Algorithms - Overview

Random Forest	CNN/RNN	GANs
Uses Multiple Decision Trees that combine to create a ‘forest’. Each tree makes its own prediction & results are based on averages to improve accuracy	Deep learning models that use multiple hidden layers to process data. weights, losses, and learning rates are adjusted within the hidden layers to minimize errors and improve the model's accuracy	Generative adversarial networks (GANs) use two different neural networks working against each other
Application Can predict weather outcomes about temperature and precipitation by analyzing key features at individual weather stations	**Application** Can analyze complex weather patterns and forecast future weather events using the RNNs time series data	**Application** Can generate future potential changes in climate, including locations for extreme weather events
		



Thought Experiment #1

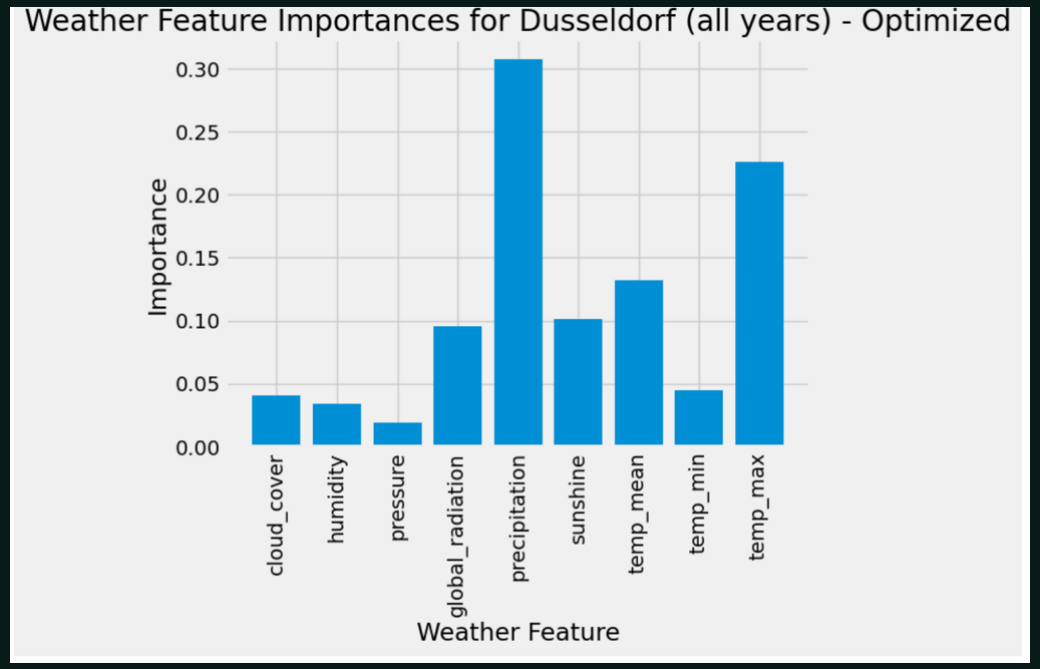
Detection and Classification of Unusual Weather Patterns

Goal: to seek out anomalies within weather patterns using satellite imagery and historical weather data

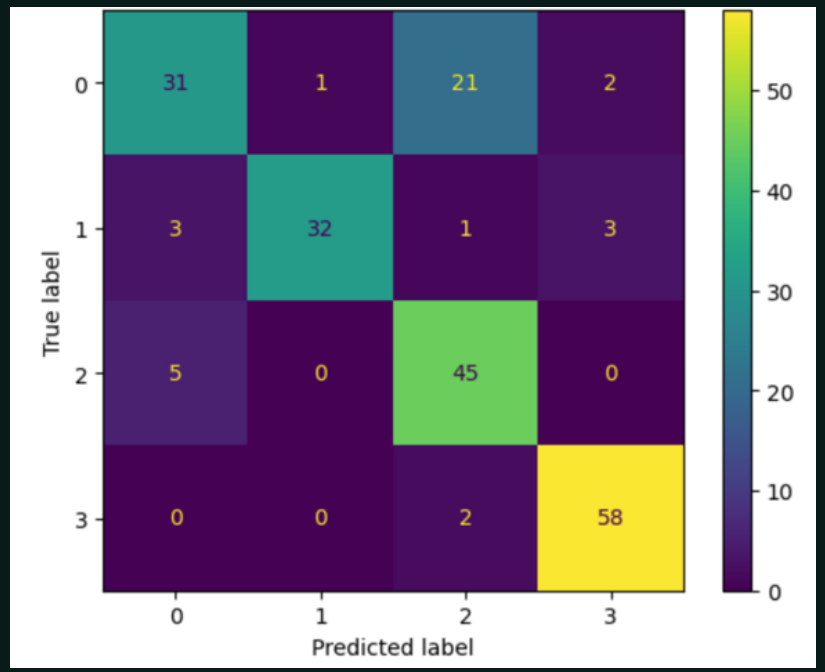
Approach: Use the **Random Forest model** to discover weather feature importances and **CNN models** to analyze satellite images – to search for unusual cloud formations and severe storms. Identify patterns over time to discover trends.

Data Needed: historical weather data & satellite imagery

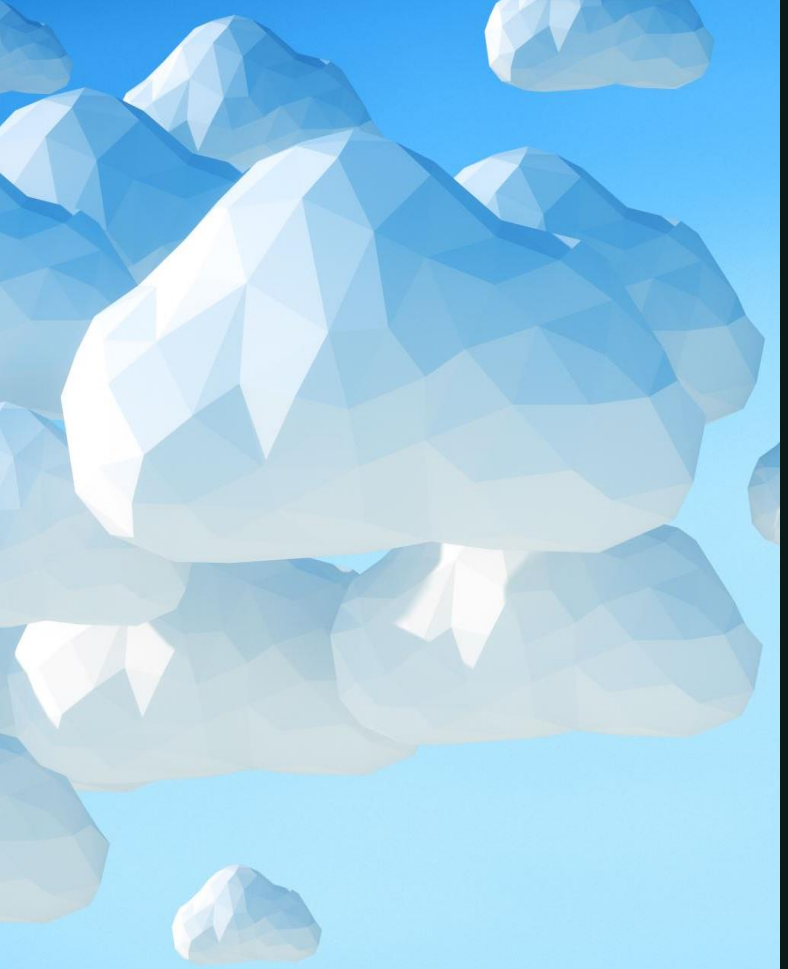
Thought Experiment #1 - Application



The optimized Weather Feature Importances for Dusseldorf – using a Random Forest model and creating this chart we can see that precipitation and temp_max are the top two features to differentiate between 'pleasant' and 'unpleasant' weather.
Best GRID search score is: 1.0 (100%)



Using Cloudy, Rain, Shine & Sunrise as the True and Predicted labels, we can see we have high values along the diagonal and low nearly every other square which means the model is performing well (83% accuracy)



Thought Experiment #2

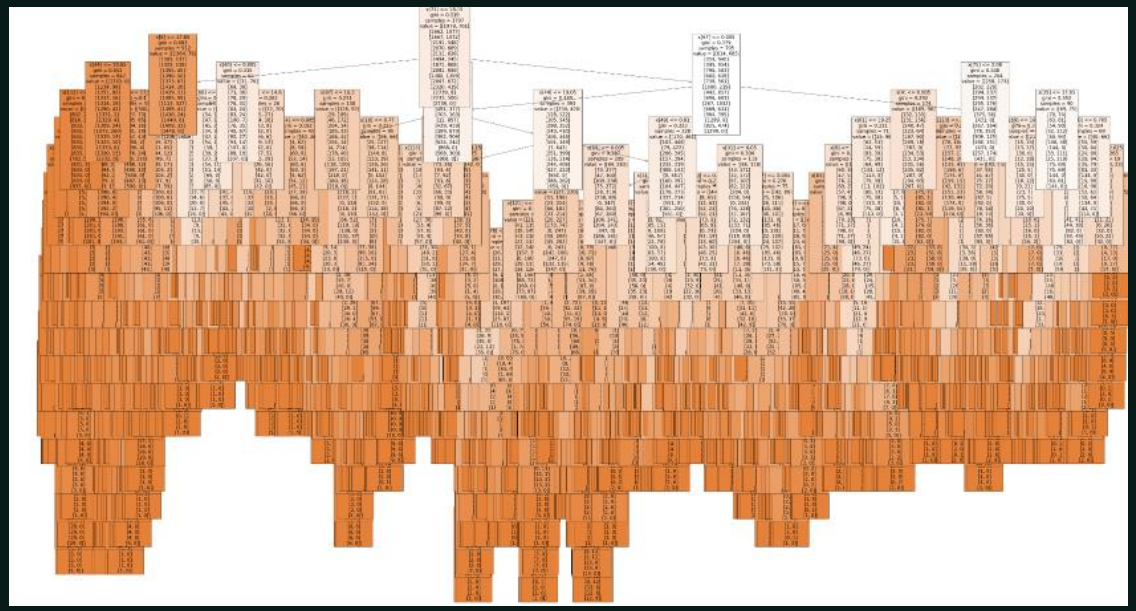
Find the Safest Places to Live

Goal: Determine the safest places for people to live in Europe over the next 25 to 50 years

Approach: Use the **Random Forest model** and K-Means algorithm clusters followed by PCA analysis with **Dendrograms** to discover climate risk factors across Europe

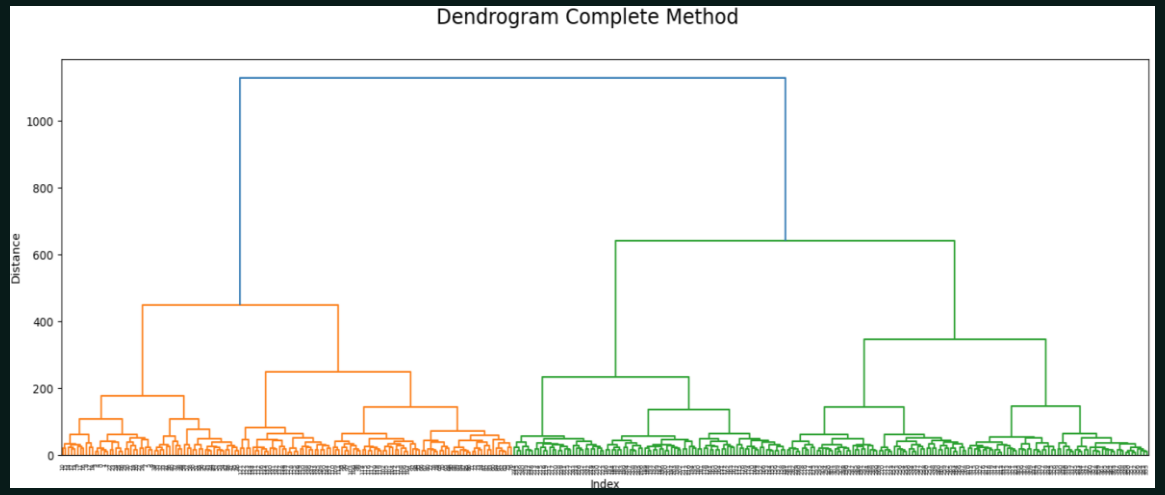
Data Needed: historic and current weather data, data on disaster resilient infrastructure (intense heat, extreme winds, flooding, etc) geospatial data

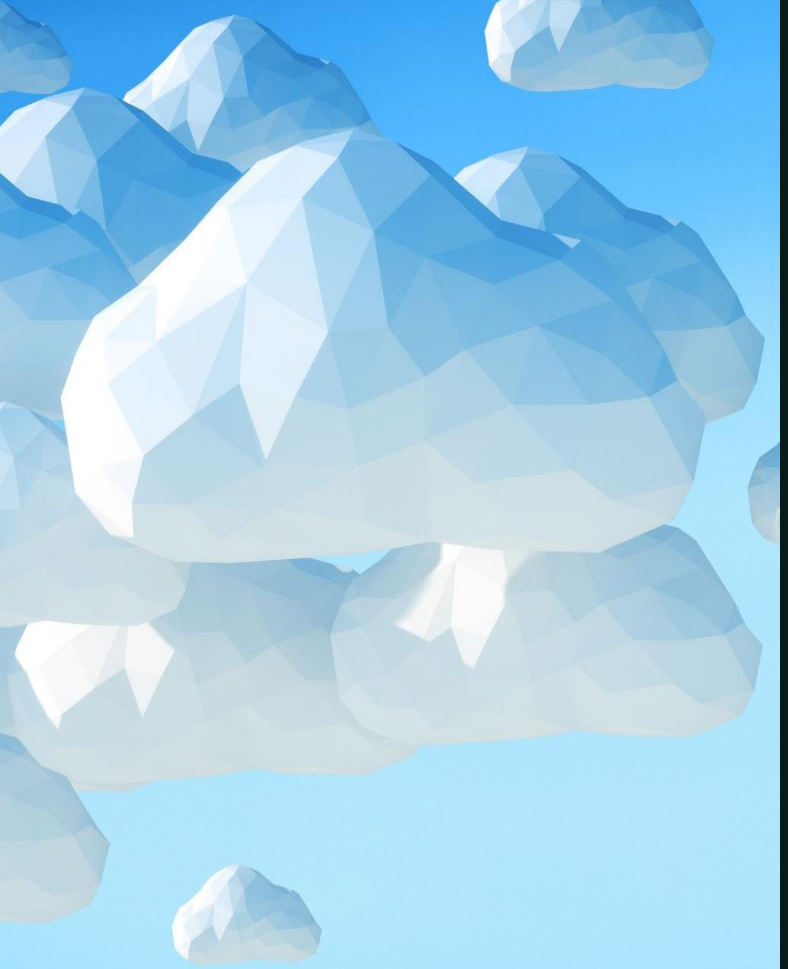
Thought Experiment #2 - Application



Above, we reduced the data to look at all 15 weather stations, but for only a single decade. The 2010s were chosen. The model accuracy is 58.4% - this resulted in a hard-to-read Random Forest!

Shown below is a Dendrogram using the Complete Method. PCA analysis was used to reduce components. We can see distinct clusters here with less overlap.





Thought Experiment #3

Potential Weather and Climate Futures

Goal: Generate possibilities for future weather conditions

Approach: Train GANs to predict extreme weather events and climate change using historical weather data. CNNs can classify different weather conditions breaking them into categories.

Data Needed: Historical and current weather data, satellite imagery, climate projections

Thought Experiment #3 - Application

Regional Climate Projections for Europe. RCP 8.5 (Representative Concentration Pathway 8.5) is a greenhouse gas concentration trajectory used in climate modeling and research. It informs policymakers about potential impacts, including extreme weather events. This is used as an illustrative example.

https://www.dkrz.de/en/projects-and-partners/projects/focus/regional-climate-projections-for-europe

Example of predictios made by a CNN model catergorizing 4 different weather conditions

Summary

Thought Experiment #1 Detection and Classification of Unusual Weather Patterns	Thought Experiment #2 Find the Safest Places to Live	Thought Experiment #3 Potential Weather and Climate Futures
Pros • Random Forests are excellent for handling structured data and determining feature importances • CNNs excel in processing and analyzing unstructured data (e.g., satellite imagery) to detect spatial patterns like unusual cloud formations or storm structures **Cons** • Risk of overfitting • Complexity of models can lead to extra time and cost	**Pros** • Random Forests are well-suited for analyzing complex and diverse datasets • Clustering allows for segmentation of regions based on shared climate risks • Dendrograms provide an easier way to understand hierarchical relationships revealing patterns in climate risk **Cons** • Combining Random Forest, K-Means, PCA, and Dendrograms increases the complexity • The models may struggle to accurately project 25–50 years into the future	**Pros** • Explore multiple scenarios • GANs can create or 'generate' realistic data • Once trained, the model can be used for other geographic locations **Cons** • Require significant computational resources • Can be difficult to train

Recommendations

Which thought experiment has the most potential for Climate Wins?

Thought Experiment #1 - Detection and Classification of Unusual Weather Patterns

- Provides highly accurate practical results in real time and effectively combines two powerful models for anomaly detection and trend identification, providing comprehensive insights into weather patterns.

Algorithms needed: Random Forest model, CNN model

Data needed:

- dataset-weather-prediction-dataset-processed.csv
- Dataset-Answers-Weather-Prediction_Pleasant_Weather.csv
- Satellite imagery

Collected by European Climate Assessment & Data Project

Next Steps

After implementing Random Forest & CNN models, Thought Experiment #3 - Potential Weather and Climate Futures could be considered. This would provide first steps to long range planning of the safer areas to live, for more resilient infrastructure to be built or modified and a better overall view of climate change in the future.

Social & Ethical Considerations

Equity – ClimateWins should consider all people, including the most vulnerable regions and regardless of socio-economic status, that all would have access to safe living to prevent inequality. Safety measures should be implemented for the public good.

Communication – communicate findings to the public with clear steps to prevent worry, apathy or political concern, also that there may a degree of uncertainty when it comes to long range planning and predictions.

Any questions?
Thank you for watching this presentation!

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