

Implementing Machine Learning for Weather Prediction

ClimateWins Project

Thought Experiments on Weather Prediction

Objective: ClimateWins, a European nonprofit organization, is interested in using machine learning to help predict the consequences of climate change around Europe.



Thought experiments can assist in formulating methods in the use of machine learning to predict extreme weather events.



Location:

Can machine learning models accurately identify future extreme weather events based on weather data from the last 60 years?



Timing:

If we determine that extreme weather events are increasing, can we predict when and how frequent these events will occur?



Climate Havens:

Can machine learning help forecast where the most climate-safe places to live in Europe over the next 25 or 50 years are?

Machine Learning Options

These machine learning models will likely be most effective in achieving ClimateWin's Goals:

Model/ Algorithm	What is it/ What is it good at	Application for ClimateWins
Artificial Neural Network (ANN)	<ul style="list-style-type: none">Supervised machine learning modelPattern recognition and intuitive results	Classifying weather events from structured data
Hierarchical Clustering	<ul style="list-style-type: none">Unsupervised learning modelAgglomerative clustering for classification	Classifying extreme weather events
Convolution Neural Network (CNN)	<ul style="list-style-type: none">Type of artificial neural networkGood for assessing images and numerical data	Working with weather radar images
Long Short-Term Memory (LSTM)	<ul style="list-style-type: none">Type of recurrent neural network (RNN)Good for handling temporal data	Forecasting weather events over long period of time
Generative Adversarial Network (GAN)	<ul style="list-style-type: none">Two neural networks, generates new data as the model learnsGood for creating visual record of what you want to predict	Creating images to reproduce and to simulate probability of weather events
Autoregressive Integrated Moving Average (ARIMA)	<ul style="list-style-type: none">Regression algorithm for identifying trends in a time series	Identifying weather trends over time
Apriori	<ul style="list-style-type: none">Unsupervised algorithm that classifies by associationGood for looking for common characteristics between features	Finding associations between different types of weather events (e.g. heatwaves & wildfires)
Hidden Markov Model (HMM)	<ul style="list-style-type: none">Time-based models for speech, text, and bioinformatics	Predicting probabilities in weather forecasting

Data Wishlist

The historical weather data set provided by ClimateWins alone would not be enough to determine their goals.

Here are some suggested additional data:

ClimateWins DATA SET:

- Collected by the [European Climate Assessment & Data Set project](#)
- From 18 weather stations across Europe
- Records from late 1800's to 2022
- Values such as temperature, wind speed, snow, precipitation, global radiation and more

+ Data on Extreme Weather Events:

'Answer' data sets identifying past extreme weather events (wildfires, heatwaves, storms, floods)

+ Data on Population Density:

Population data from European cities near the 18 weather stations from the main data set.

+ Data on Geography:

Geographical features in Europe, including landforms, bodies of water, and

+ Data on Infrastructure:

Information about the infrastructure in risk areas.

+ Weather Radar Images:

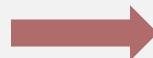
Images from weather radars during extreme weather events.

Thought Experiment on Location



Initial Thought:

Can machine learning models accurately identify future extreme weather events based on weather data from the last 60 years?



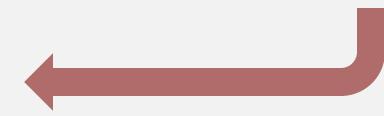
Follow-up Question:

Would models identify various types of events with equal accuracy? For example, would storms be easier to predict than wildfires?



Also:

Are there correlations between different types of events, such as heatwaves and wildfires? Would they compound risks in certain areas?



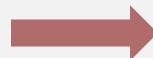
Steps for Analysis	Datasets Required	ML Model
Optimize a model to accurately identify extreme weather conditions.	<ul style="list-style-type: none">ClimateWins datasetExtreme weather events dataset	ANN
Observe correlations between different weather events.	<ul style="list-style-type: none">Extreme weather events dataset	Apriori
Predict level of risk where extreme events will hit, assessing population density as well as geography and infrastructure.	<ul style="list-style-type: none">Population datasetInfrastructure datasetGeography datasetPrediction results from first step	LSTM or HMM

Thought Experiment on Timing



Initial Thought:

If we determine that extreme weather events are increasing, can we predict when and how frequent these events will occur?



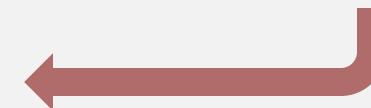
Follow-up Question:

How accurate will the predictions be? What time frames can we predict? Within weeks or months?



Also:

If we can predict when and how often these disasters will happen, will we be better prepared? Will there be enough time to make changes?



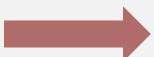
Steps for Analysis	Datasets Required	ML Model
For each weather event, determine if there is a trend of more frequent events occurring over the years.	<ul style="list-style-type: none">Extreme weather events dataset	ARIMA
Train model to predict the time and frequency of events, varying time frames for accuracy.	<ul style="list-style-type: none">ClimateWins datasetExtreme weather events dataset	LSTM
Analyze the population and infrastructure by location to determine the optimal time frame for disaster preparation.	<ul style="list-style-type: none">Population datasetInfrastructure datasetLocation results from trained model	LSTM or HMM

Thought Experiment on Climate Havens



Initial Thought:

Can machine learning help forecast where the most climate-safe places to live in Europe over the next 25 or 50 years are?



Follow-up Question:

Do we have enough information on different geographical areas? Are the available weather stations accurately representing the wide range of locations?



Steps for Analysis	Datasets Required	ML Model
Use weather radar images to train models to predict weather in areas between stations.	<ul style="list-style-type: none">ClimateWins datasetWeather radar imagesGeography dataset	GAN and ANN
Determine the <i>least</i> and <i>most</i> safe places are in the next 25 or 50 years, assessing by count of each type of natural disaster.	<ul style="list-style-type: none">Expanded ClimateWins dataset from previous stepExtreme weather events dataset	LSTM or HMM
Implement machine learning to predict flow of population into those 'safe' areas over the next 25 to 50 years.	<ul style="list-style-type: none">Population datasetExtreme weather events datasetLocation results	ANN or LSTM

Also:

Will predicting the 'safest' places to live unintentionally spur people to migrate instead of investing in preparation and improving infrastructure where they are living now?



Conclusion

Summary:

Thought	Data	Algorithms
Location	ClimateWins, weather events, pop, geo, infra	ANN, Apriori, LSTM, HMM
Timing	ClimateWins, weather events, pop, geo, infra	ARIMA, LSTM, HMM
Havens	ClimateWins, weather events, pop, geo, radar	GAN, ANN, LSTM, HMM

Why the thought experiment on **Location** has the most potential:

- Provides a risk assessment for defined locations.
- Timing of events can come secondary after determining high risk locations.
- Determining climate-safe havens carry more questions and uncertainty regarding population distribution.

Next Steps:



Collect data to run analysis:

The additional data sets will need to be collected, cleaned, and prepared for running the machine learning models.



Follow outlined steps and test accuracy:

Run the machine learning models, optimizing for accuracy. Make initial predictions for the following year and observe the performance of the model.

Thank you!

Feel free to [contact me](#) if you have questions or comments.

Visit the project on Github: 