Geospatial Prediction of Climate Change Hotspots: Identifying Areas Most Affected by Climate Change using AI

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Presentation Flow

- Introduction
- Objective
- Datasets
- Methodology
- Results
- Conclusion
- Future directions

Introduction: Climate Change

Climate change refers to long-term shifts in temperatures and weather patterns.

https://www.usatoday.com/story/news/nation/2019/12/24/climate-change-predictions-2020-carbon-dioxide-weather-disasters/2622212001/

Introduction: Climate Change

Since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas.

- Greenhouse gas emissions (CO_2, CH_4, N_2O)
- Land-use changes and urbanization
- Industrial and agricultural activities

Introduction: Climate Change

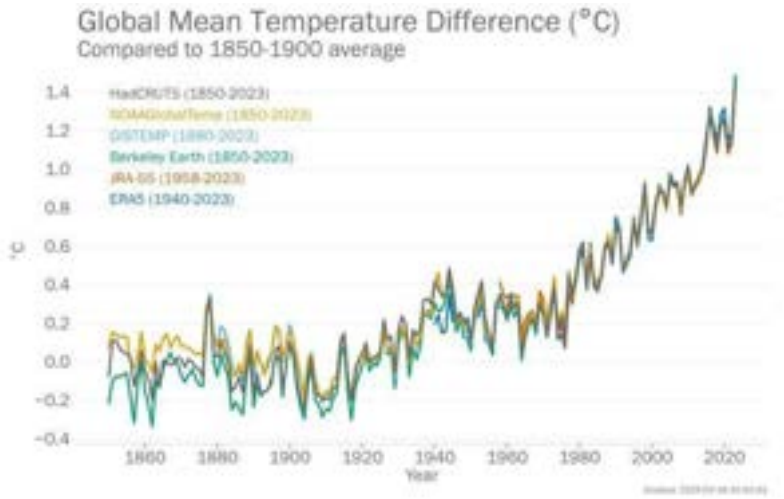
- Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures.
- The main greenhouse gases that are causing climate change include carbon dioxide and methane.
- These come from using gasoline for driving a car or coal for heating a building, for example.
- Clearing land and cutting down forests can also release carbon dioxide.
- Agriculture, oil and gas operations are major sources of methane emissions.
- Energy, industry, transport, buildings, agriculture and land use are among the main sectors causing greenhouse gases.

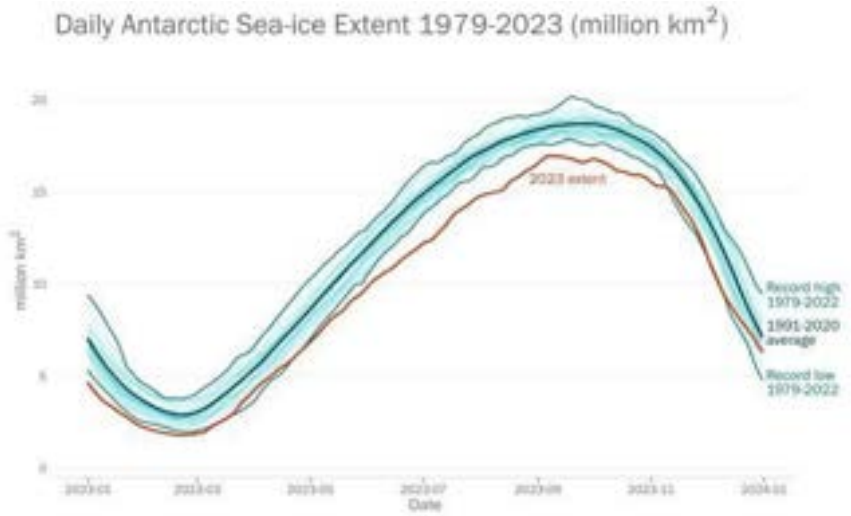
Evidence of Climate Change

- Rising global average temperatures
- Melting glaciers and polar ice
- Sea level rise
- Increase in extreme weather events (floods, droughts, heatwaves)

https://theconversation.com/solving-the-puzzle-of-sea-level-rise-by-reexamining-the-past-36331

Evidence of Climate Change





The global mean near-surface temperature in 2023 was 1.45 ± 0.12 °C above the pre-industrial 1850–1900 average.

2023 was the warmest year in the 174-year observational record.

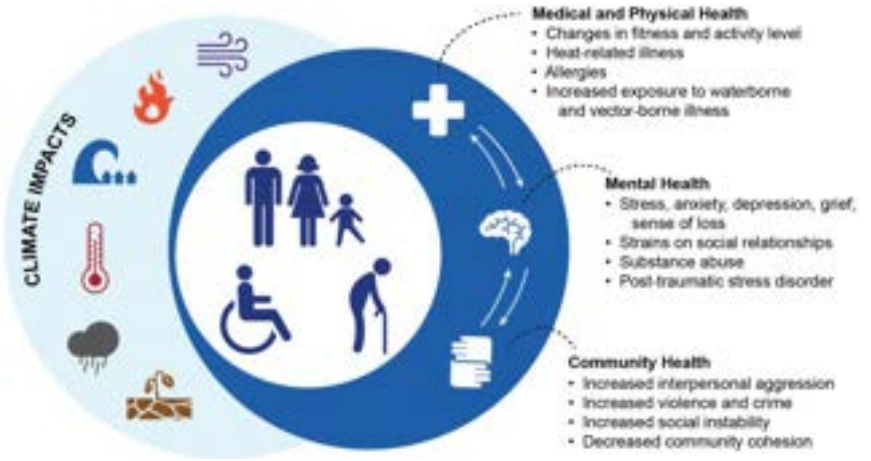
In 2023, global mean sea level reached a record high in the satellite record (since 1993), reflecting continued ocean warming (thermal expansion) as well as the melting of glaciers and ice sheets.

The rate of global mean sea level rise in the past ten years (2014–2023) is more than twice the rate of sea level rise in the first decade of the satellite record (1993–2002).

https://wmo.int/news/media-centre/climate-change-indicators-reached-record-levels-2023-wmo

Effects of Climate Change

- Threatens ecosystems and biodiversity
- Affects food and water security
- Increases health risks



https://keepleft.org.za/2019/10/15/the-impact-of-climate-change-on-food-security-and-poverty/

Objective

To identify regions at risk due to the impacts of global climate change by analyzing environmental, and climatic indicators.

Datasets

We have used three datasets

- Dataset 1
- Dataset 2
- Dataset 3

Dataset 1

This dataset provides a comprehensive overview of key climate change indicators collected across different countries

- From the year 2000 to 2024.
- It includes 1000 data points
- Capturing various environmental and socio-economic factors that reflect the global impact of climate change.
- Features
  - Average temperature
  - CO2 emissions
  - Sea-level rise
  - Rainfall patterns
  - Forest Area (%)

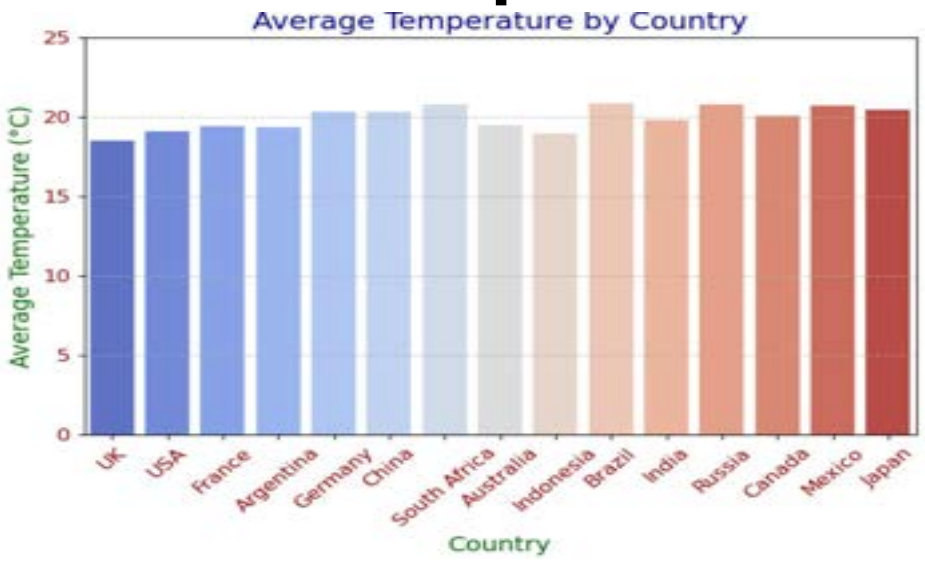
https://www.kaggle.com/datasets/bhadramohit/climate-change-dataset

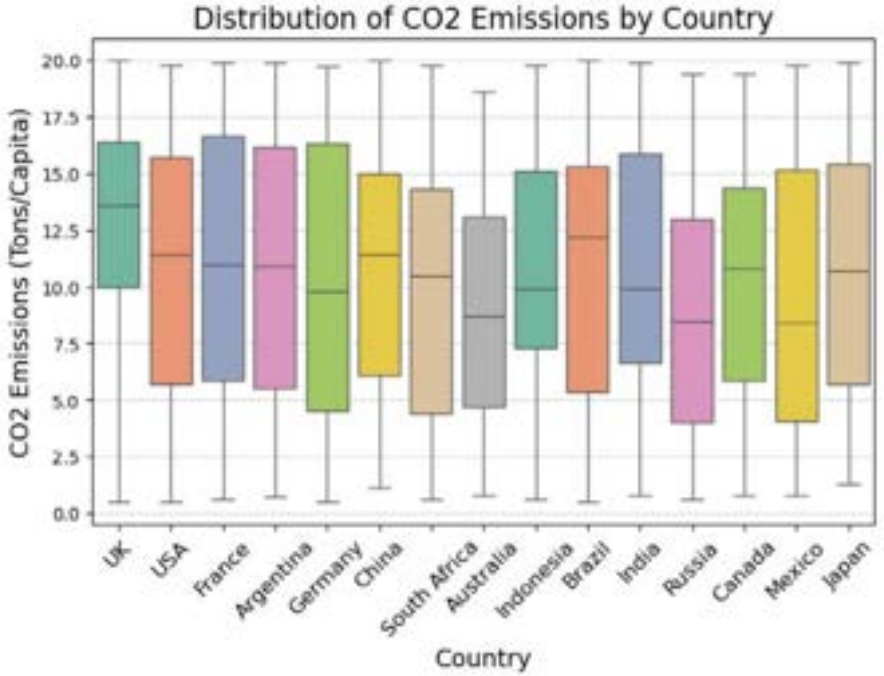
Dataset 2

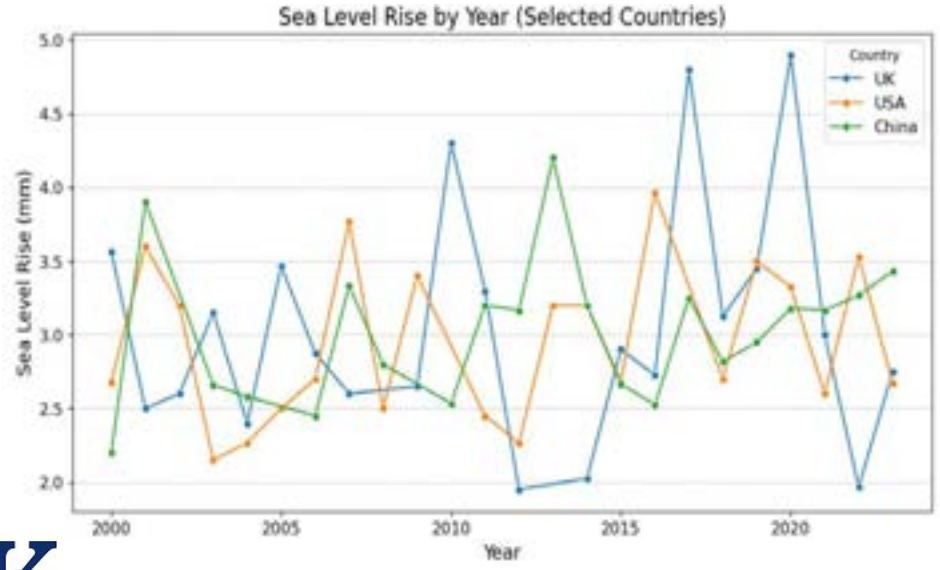
- This dataset provides a detailed exploration of global warming and climate change trends across
- 195 countries
- from 1900 to 2023.
- It includes 1,00,000 datapoints
- Features 26 (capturing environmental, economic, and societal factors impacting global warming). Key indicators such as
  - Temperature anomalies
  - CO2 emissions
  - Deforestation rates
  - Sea-level rise
  - Renewable energy usage
  - Deforestation_Rate
  - Industrial_Activity
  - Fossil_Fuel_Usage
  - Extreme_Weather_Events
  - Methane_Emissions

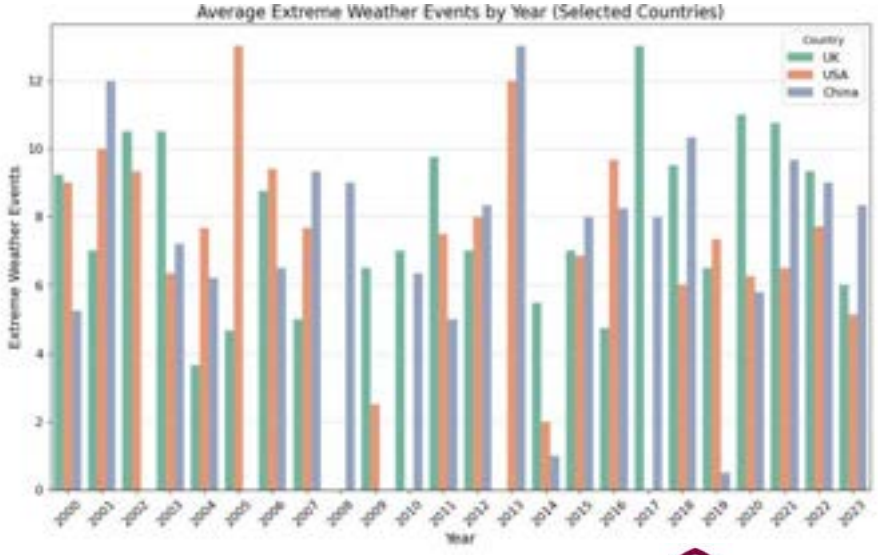
https://www.kaggle.com/datasets/ankushpanday1/global-warming-dataset-195-countries-1900-2023

Data Exploration









Dataset 3

- Data is collected from NOAA website.
- API Key Required to collect new data

Countries	150
Features	51
Stations	887
Year Range	1781-2025
Unique Years	216

https://www.ncdc.noaa.gov
https://www.ncdc.noaa.gov/cdo-web/search
http://www.ncei.noaa.gov/pub/data/cdo/documentation/GSOY_documentation.doc .

Dataset 3

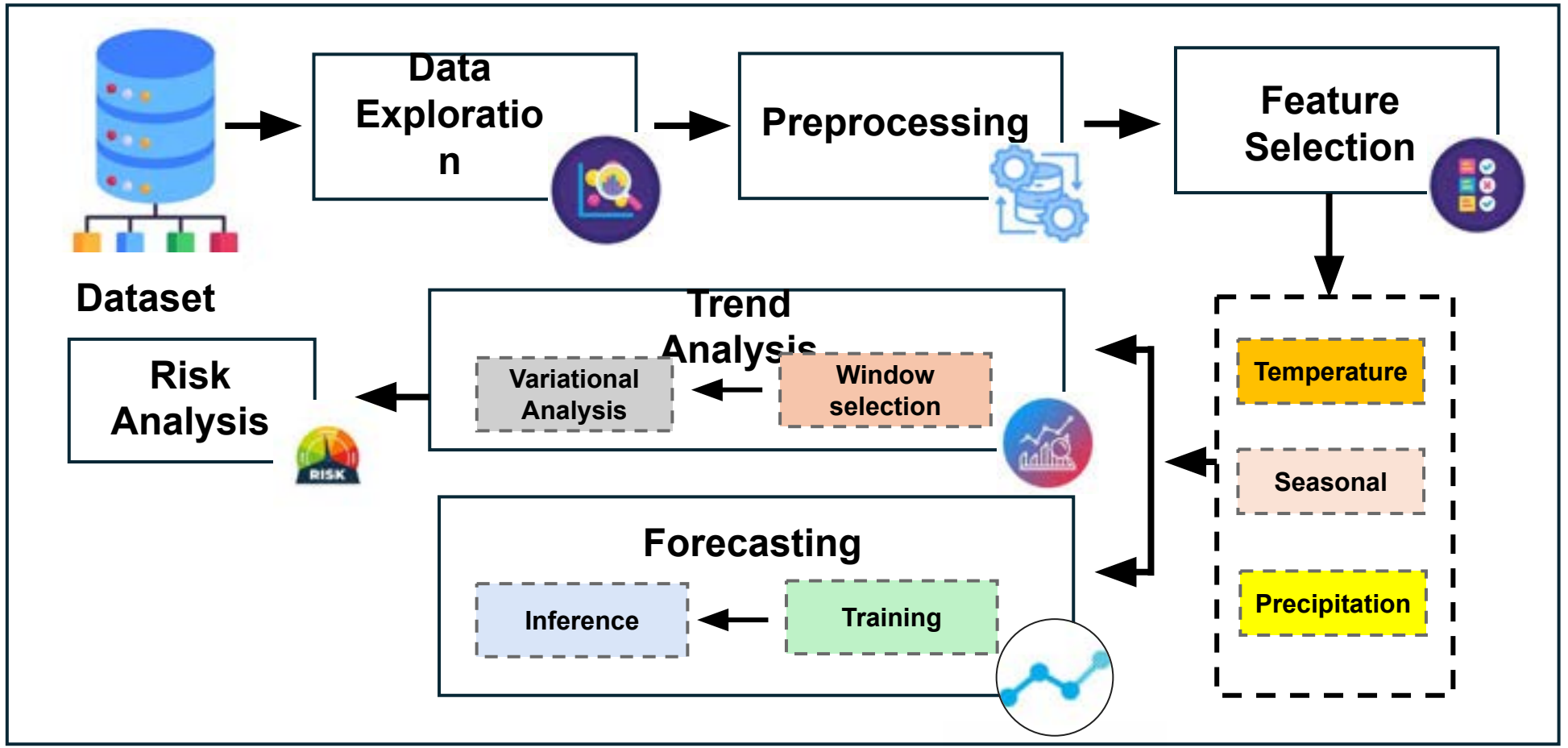
Precipitation Related Features	
DP01	Number of days with >= 0.01 inch/0.254 millimeter in the year
DP10	Number of days with >= 0.1 inch/2.54 millimeters in the year.
DP1X	Number of days with >= 1 inch/25.4 millimeters in the year.
PRCP	Total Annual Precipitation.

Season Related Features	
CDSD	Cooling Degree Days (season-to-date). Running total of monthly cooling degree days through the end of the season. Each month is summed to produce a season-to-date total. Season starts in January in Northern Hemisphere and July in Southern Hemisphere
HDSD	Heating Degree Days (season-to-date). Running total of monthly heating degree days through the end of the most recent month. Each month is summed to produce a season-to-date total.

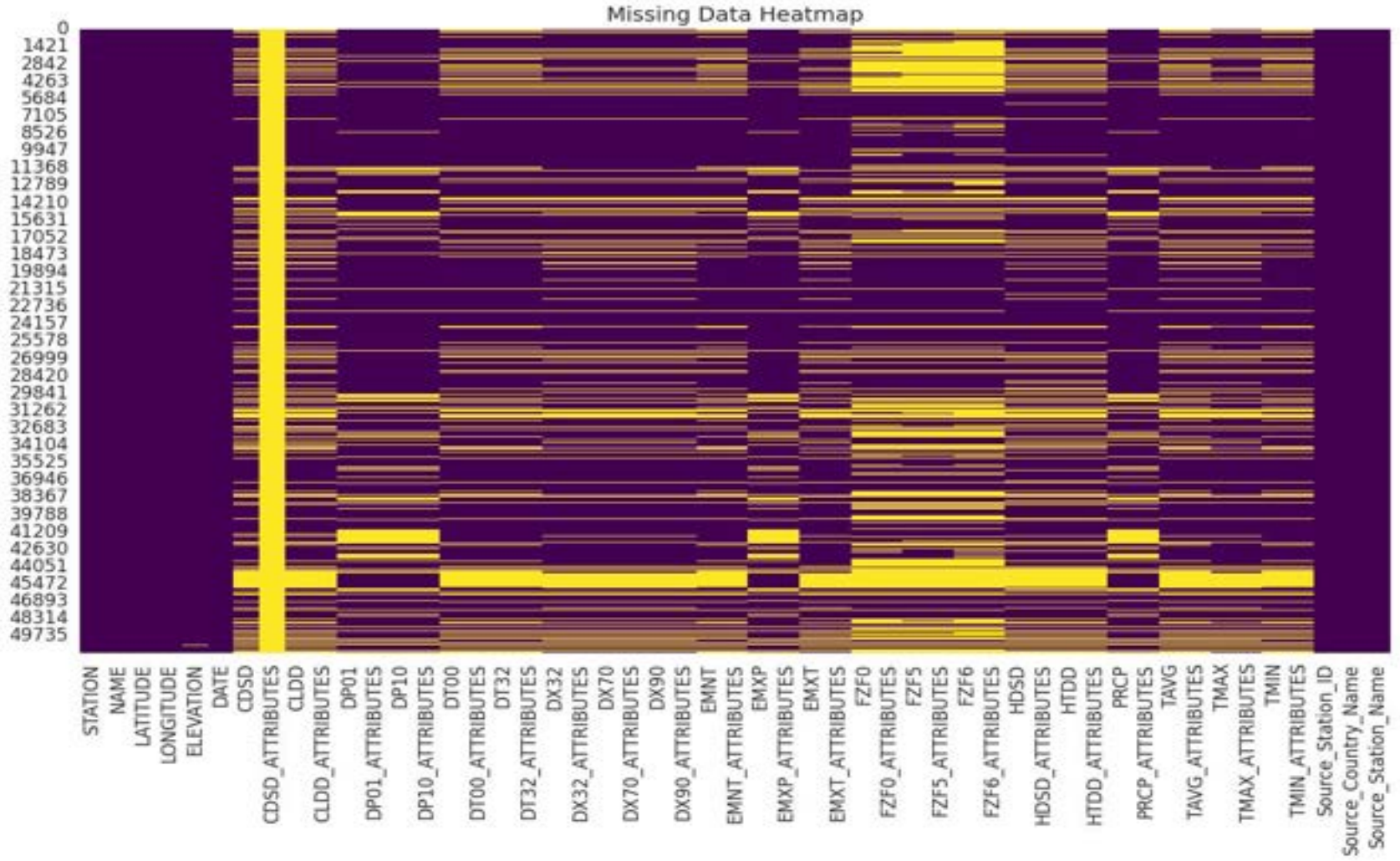
Dataset 3

Temperature Related Features	
TMAX	Average Annual Maximum Temperature. Average of mean monthly maximum temperatures
TMIN	Average Annual Minimum Temperature. Average of mean monthly minimum temperatures
TSUN	Annual total sunshine in minutes.
TAVG	Average Annual Temperature. Computed by adding the unrounded monthly average temperatures and dividing by 2.
HTDD	Heating Degree Days. Computed when daily average temperature is less than 65 degrees Fahrenheit/18.3 degrees Celsius. HDD = 65(F)/18.3(C) – mean daily temperature. Each month is summed to produce an annual total.
EMNT	Extreme minimum temperature for year. Lowest daily minimum temperature for the year. Given in Fahrenheit units on PDF output.
EMXT	Extreme maximum temperature for year. Highest daily maximum temperature for the month/year.
DT32	Number of days with maximum temperature <= 32 degrees Fahrenheit/0 degrees Celsius.
DX32	Number of days with maximum temperature <= 32 degrees Fahrenheit/0 degrees Celsius.
DX70	Number of days with maximum temperature <= 70 degrees Fahrenheit/21.1 degrees Celsius
DX90	Number of days with maximum temperature >= 90 degrees Fahrenheit/32.2 degrees Celsius.

Methodology



Data Exploration



Preprocessing

Handle Missing data (Removing the features with 80% missing data)

Dropping the duplicate entries

Group data by country

Averaging the data per year of all station for each country

Trend Analysis

Identifying the year for analysis

Defining the range
Period 1: 2000-2012
Period 2: 2012-2025

Average for each period
Period 1
Period 2

Measure Percentage change over the two period

Identify high risk areas

Forecasting

Identifying the year for training and testing the model

Training data is further divided into train and validation set

Training model

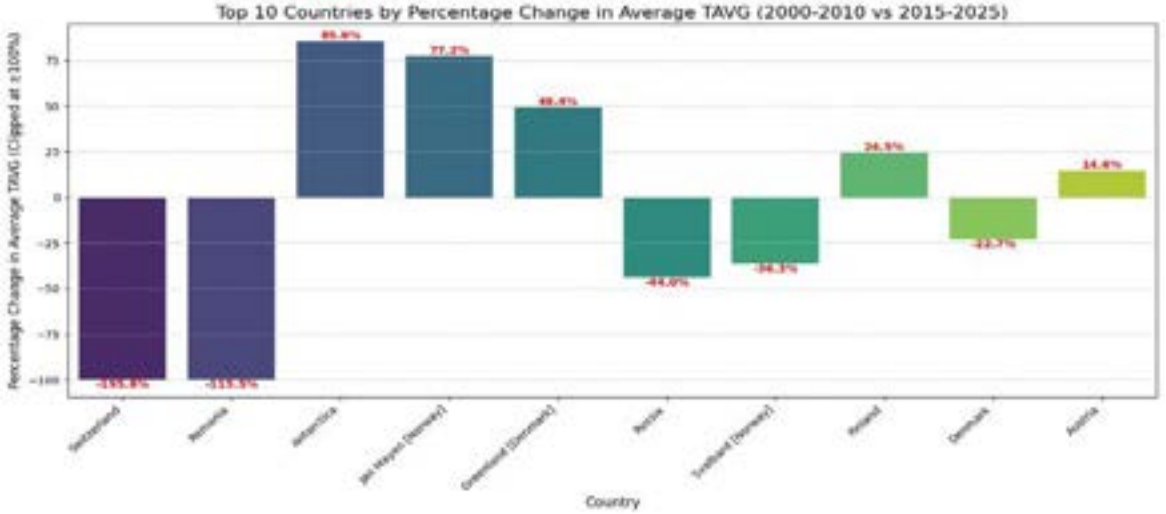
Evaluation

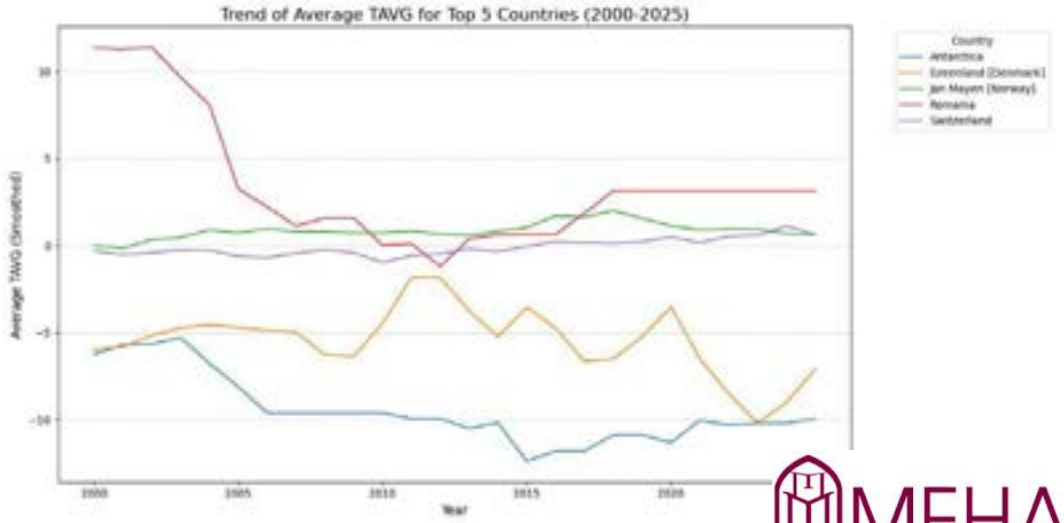
Forecasting for 2026-2031

Results: Trend Analysis

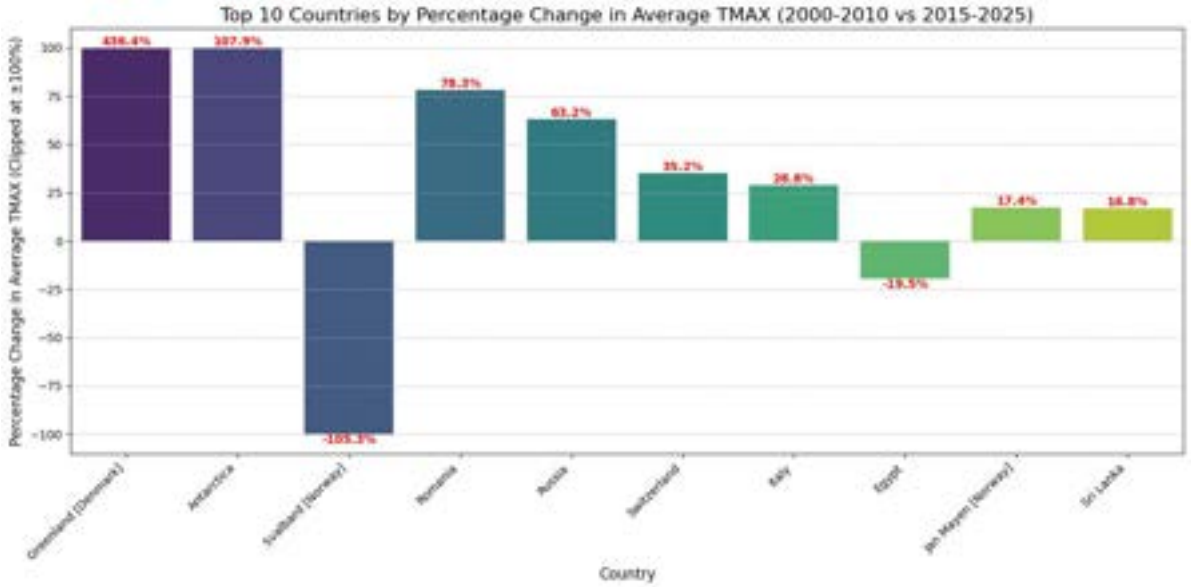
Average Annual Temperature.

COUNTRY	Avg_TAVG_Period1	Avg_TAVG_Period2	TAVG_Change_Percent
Antarctica	-6.538000	-12.133333	85.581727
Jan Mayen [Norway]	0.653846	1.158333	77.156863
Greenland [Denmark]	-4.402273	-6.576667	49.392531
Finland	3.005128	3.741667	24.509386
Austria	5.635897	6.460000	14.622384

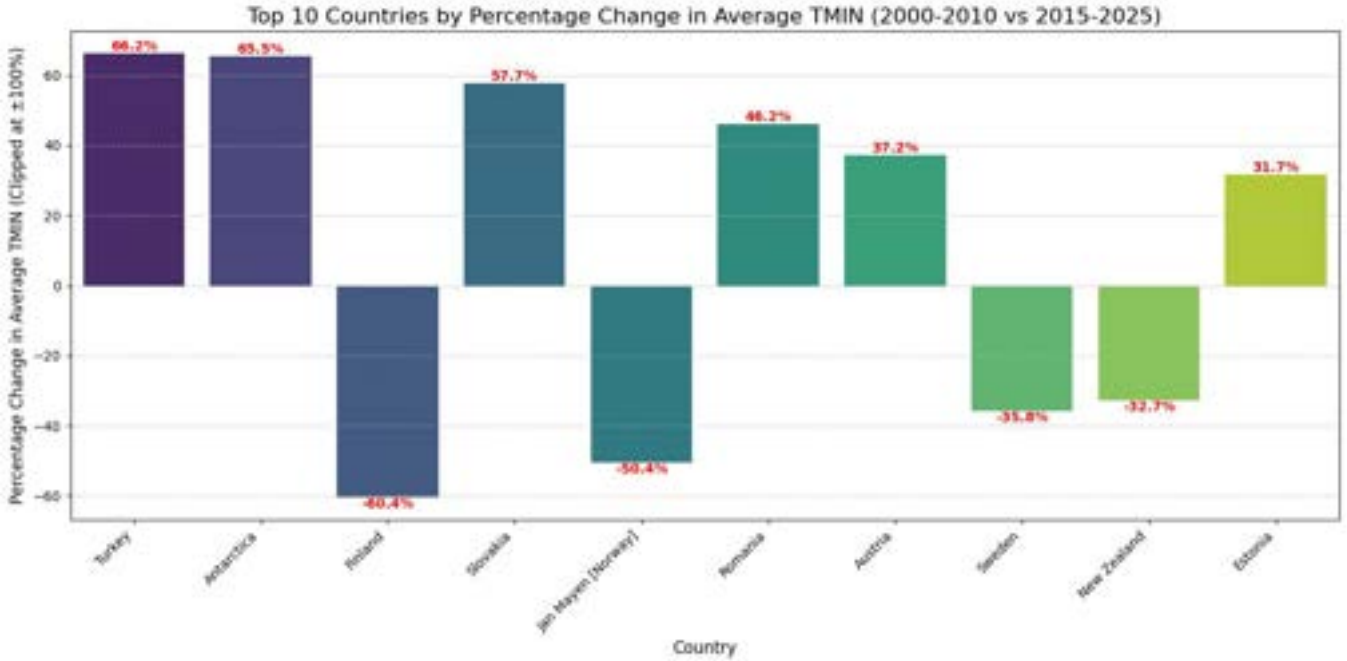




Results: Trend Analysis

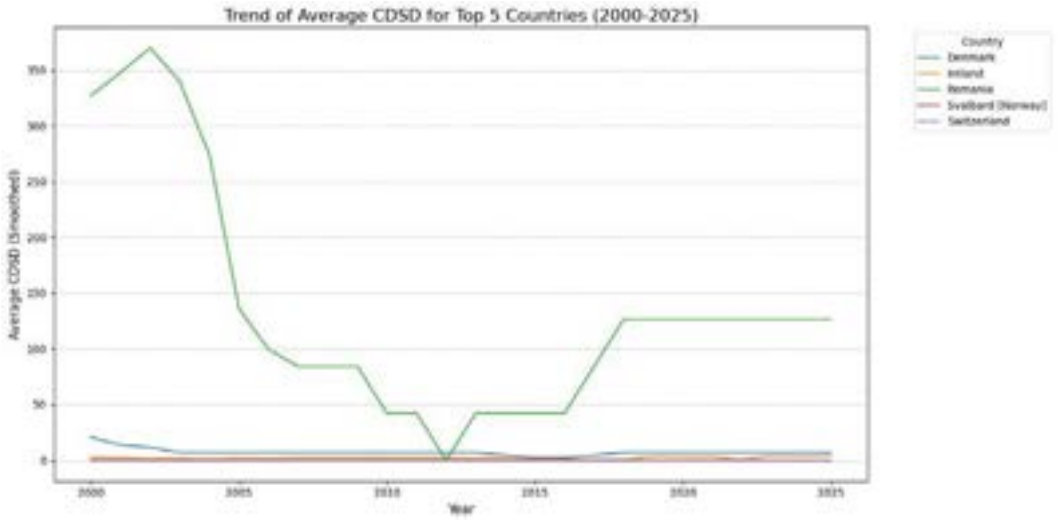


Average Annual Temperature.
Average of mean monthly maximum and minimum temperatures



Results: Trend Analysis

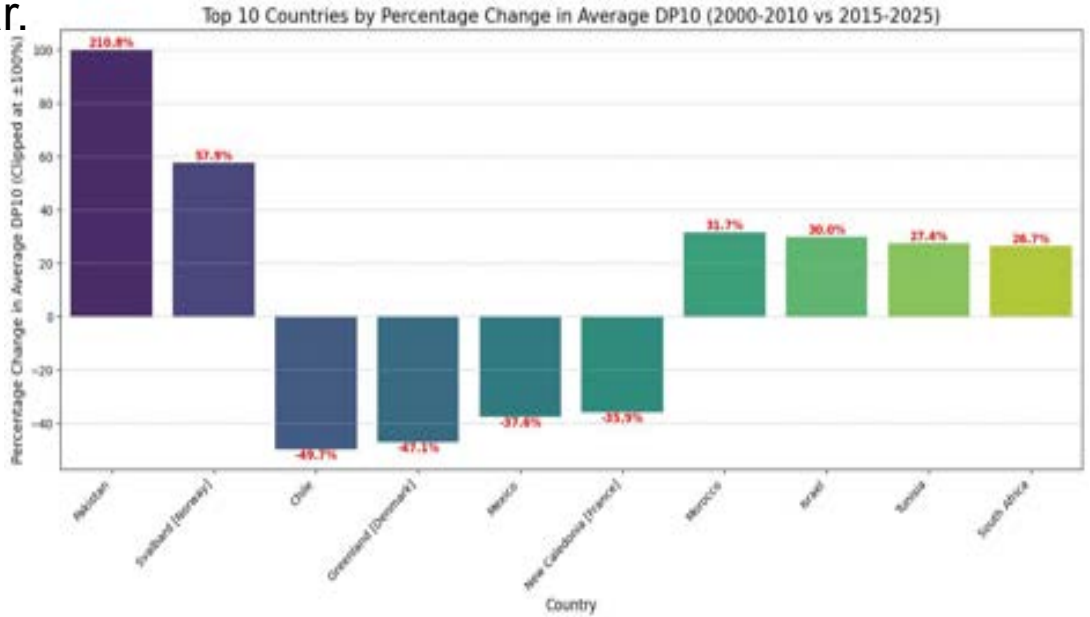
Cooling Degree Days (season-to-date) (CDSD)



Cooling Degree Days (season-to-date) (CDSD)				
	Country	**Avg_CDS_ Period1**	**Avg_CDSD_ Period2**	**CDSD_ Change_Percent**
1	Svalbard [Norway]	0.000000	0.025000	2.500000e+09
2	Switzerland	0.000000	0.010000	1.000000e+09
3	Ireland	1.200000	2.454545	1.045455e+02
4	Denmark	3.932436	7.322222	8.620068e+01

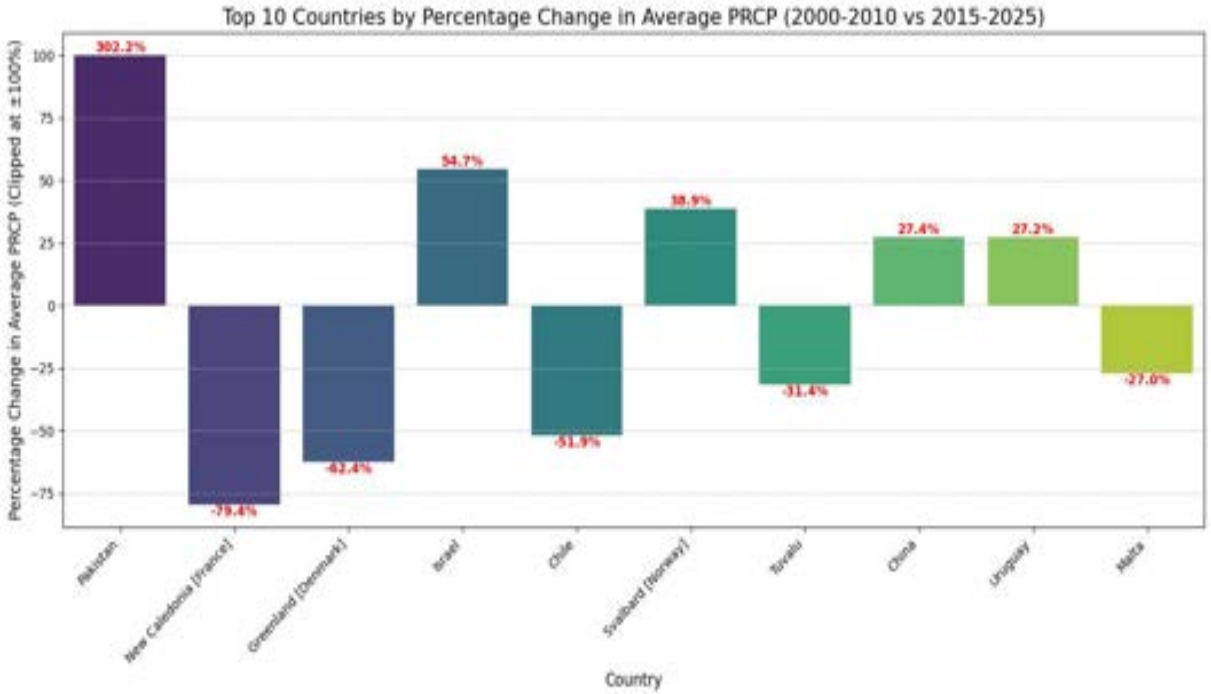
Results

Number of days with >= 0.1 inch/2.54 millimeters in the year.



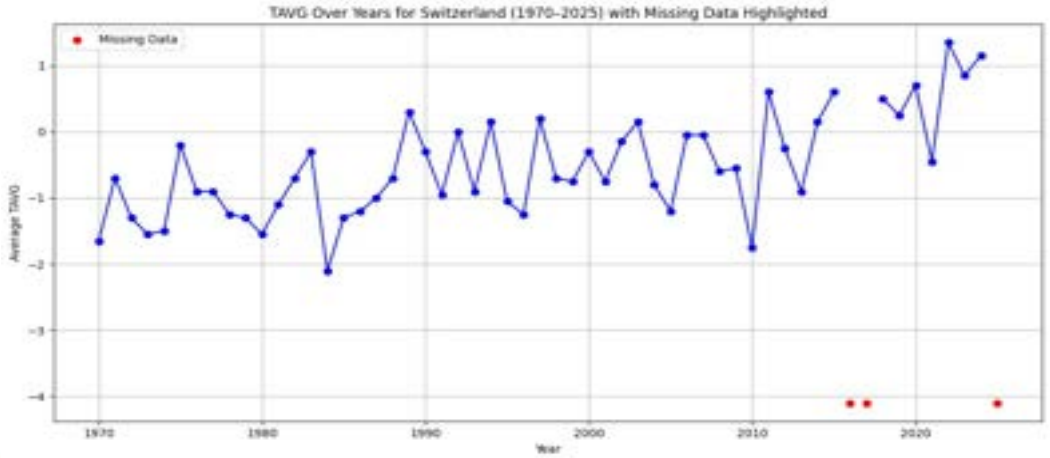
	COUNTRY	Avg_DP10_Period1	Avg_DP10_Period2	DP10_Change_Percent
92	Pakistan	6.687500	20.785714	210.814419
112	Svalbard [Norway]	19.000000	30.000000	57.894737
83	Morocco	13.000000	17.125000	31.730769
57	Israel	1.538462	2.000000	30.000000
117	Tunisia	29.500000	37.583333	27.401130

Total Annual Precipitation (PRCP)



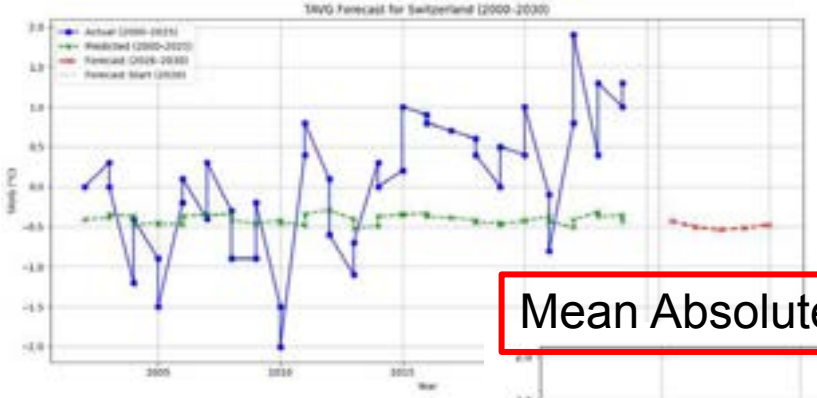
Results : Forecasting

Linear Interpolation

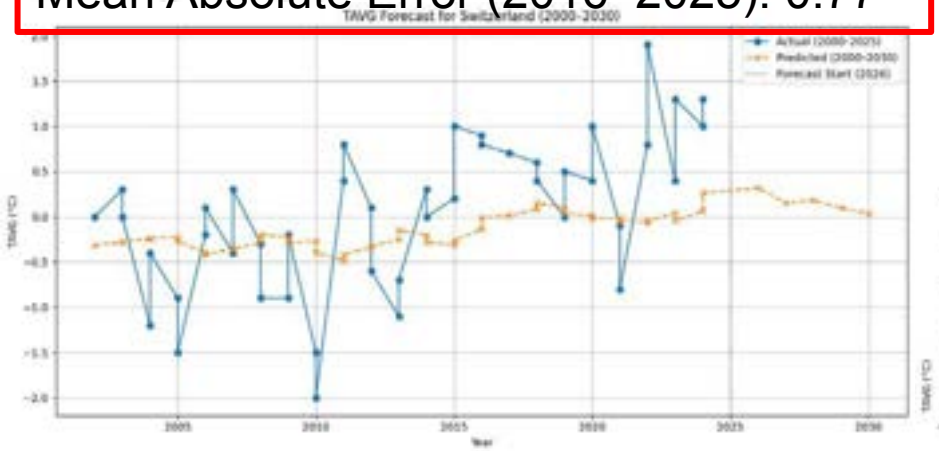


Results :Forecasting

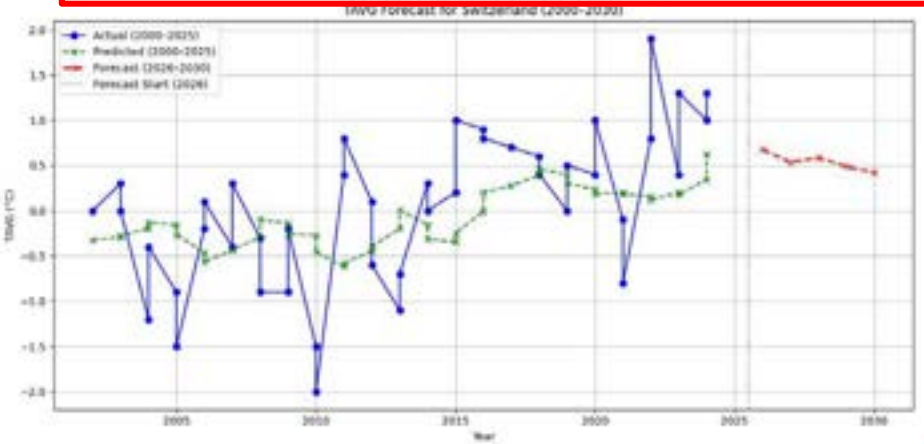
Mean Absolute Error (2016–2025): 1.2



Mean Absolute Error (2016–2025): 0.77



Mean Absolute Error (2016–2025): 0.61



Conclusion & Future directions

- Temperature, precipitation and seasonal features are important measure to identify the climate change
- Identify high risk area can help in design the policy to handle the climate change
- Station_wise analysis for each country
- Analysis of addition features
- Analysis the unstructured data for identify the patterns

Acknowledgement

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