🍁 Climate Change in Canada: Historical Analysis and Future Projections

Navigate to

- 🔘 📊 EDA Analysis
- ⚪ ❄️ Ice Loss Predictions
- ⚪ 🌡️ Temperature Predictions
- ⚪ 🌧️ Precipitation Predictions
- ⚪ 🌍 CO_2 Emissions Predictions

Project Goal:

This project analyzes historical climate data from Canada and uses machine learning models (Random Forest, Prophet and Gradient Boosting) to predict future trends in temperature change, sea ice loss precipitation patterns, CO_2 emissions. The goal is to empower policymakers, researchers, and civil society organizations to make data-driven decisions to combat climate change over the next five years.
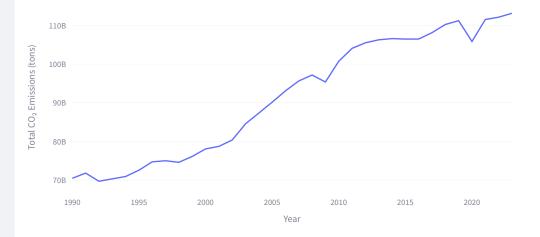
Prepared by:

Aysegul Dahi
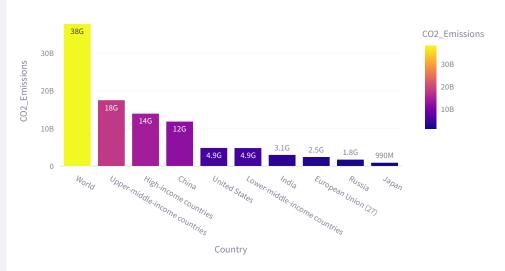
Student Number: *300387536*

📊 EDA Analysis: Global CO_2 Emissions

🔍 CO_2 Emissions Overview

🌍 Total Global CO_2 Emissions Over Time
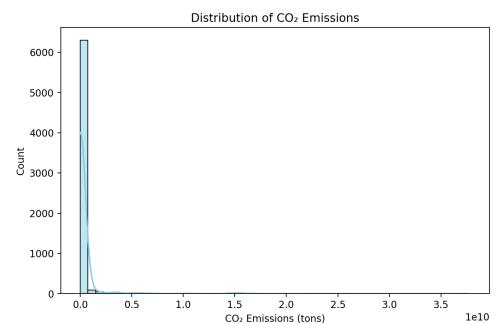
🏆 Top 10 CO_2 Emitting Countries (Latest Year)

🏅 Top 10 CO_2 Emitting Countries in 2023

📈 CO_2 Emission Distribution

Distribution of CO₂ Emissions
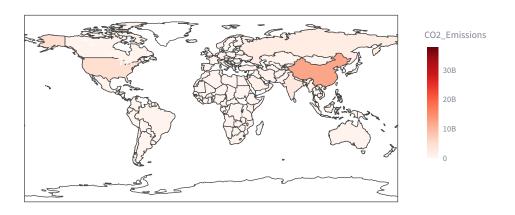

🗺️ Global CO₂ Emissions Map

🗺️ Global CO₂ Emissions Map - 2023

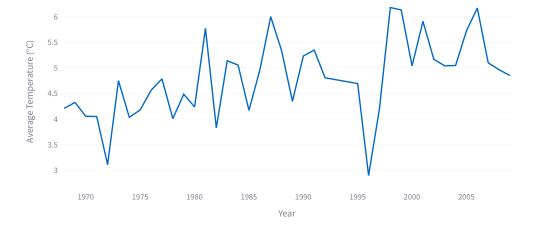- Global CO₂ emissions are rising steadily over time.
- China, the United States, and India are consistently the top CO₂ emitters.
- The global distribution of CO₂ emissions is heavily skewed toward a few countries.

CA Canadian Cities Climate Overview (1968–2024)
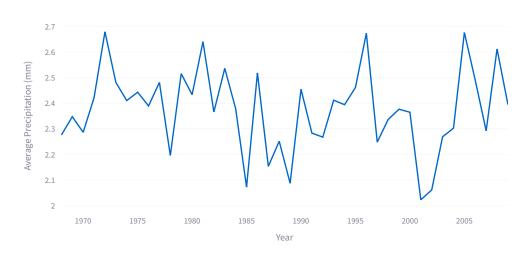
Dataset Shape: `(42, 31)`

📈 Average Temperature Change in Canadian Cities Over Time

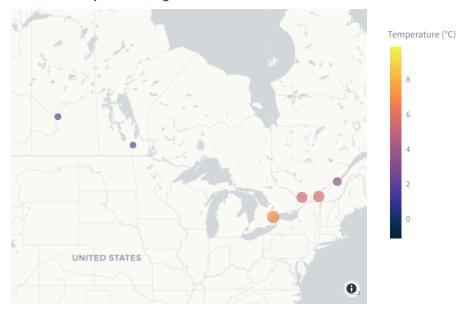**Average Temperature Across Canadian Cities (1968–2024)**

🌧️ Average Precipitation in Canadian Cities Over Time

Average Total Precipitation Across Canadian Cities (1968–2024)

Canadian Cities: Temperature Change Over Years

▶ ■   Year=1968.0
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      1968.0 1972.0 1976.0 1980.0 1984.0 1988.0 1992.0 1996.0 2000.0 2004.0 2008.0

Canadian Cities: Precipitation Change Over Years

▶ ■   Year=1968.0
⬤―――
       ｜‖‖‖‖｜‖‖‖‖｜‖‖‖‖｜‖‖‖‖｜‖‖‖‖｜‖‖‖‖｜‖‖‖‖｜‖‖‖‖｜‖‖‖‖｜‖‖‖‖｜
      1968.0 1972.0 1976.0 1980.0 1984.0 1988.0 1992.0 1996.0 2000.0 2004.0 2008.0

🔍 Key Insights for Canadian Climate

- Temperatures in Canadian cities show an increasing trend since the 1970s.
- Precipitation levels have moderately fluctuated across years, with slight increases in some regions.
- Warmer cities like Vancouver and Toronto consistently remain above national averages.
- Northern cities like Whitehorse show more extreme fluctuations in temperature and precipitation.

🧊 Sea Ice Loss and Global Temperature Trends (1968–2024)

Dataset Shape: `(57, 21)`

📉 Total Arctic Sea Ice Area Over Time
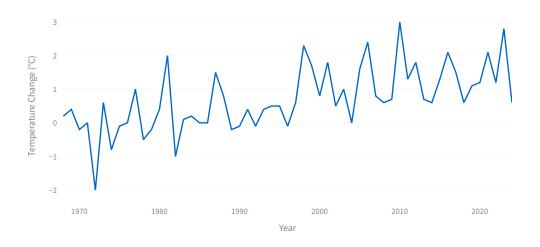
Total Arctic Sea Ice Area (1968–2024)
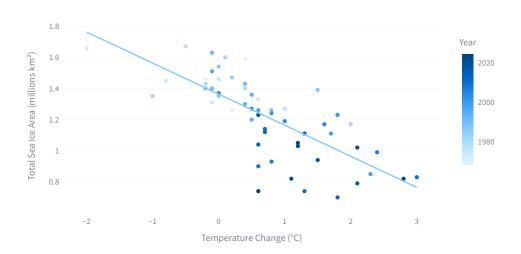
🌡️ Global Temperature Change Over Time

Global Temperature Change (1968–2024)
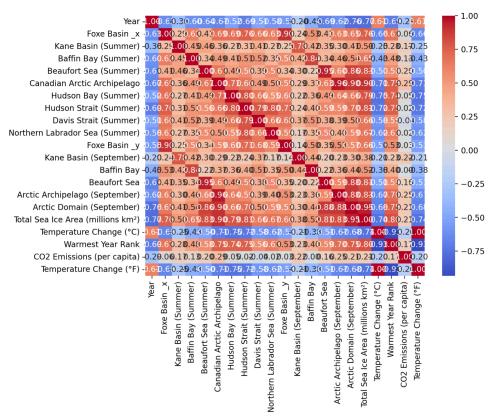
📊 Sea Ice Area vs Global Temperature

Sea Ice Area vs. Temperature Change

🧩 Correlation Heatmap

🔍 Key Insights on Sea Ice Loss

- Arctic Sea Ice Area shows a steady decline over the past five decades.

- Global Temperatures have consistently increased.

- There is a strong negative correlation between global temperature rise and Arctic sea ice loss.

🍁 **Climate Change in Canada: Historical Analysis and Future Projections**

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- 🌍 CO_2 Emissions Predictions

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Aysegul Dahi

Student Number: *300387536*

🧊 Sea Ice Loss Predictions: Historical Trends & Future Outlook

🌞 Summer Predictions   🍁 September Predictions   📊 Model Scores

🌞 Summer Sea Ice Predictions

Select Summer Prediction Model:

Prophet ⌄

Future Summer Sea Ice Predictions (Prophet)

Year=2025

2025   2026   2027   2028   2029   2030

🧊 Summer Ice Loss Interpretation and Warnings

✅ No critical summer sea ice loss detected for 2030. Significant ice remains in all regions.

🍁 Climate Change in Canada: Historical Analysis and Future Projections

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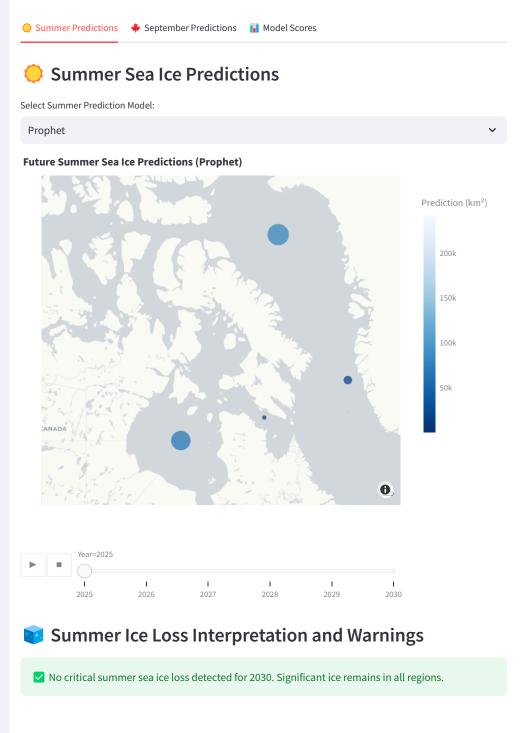- ◯ 🌍 CO_2 Emissions Predictions

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🍁 Climate Change in Canada: Historical Analysis and Future Projections

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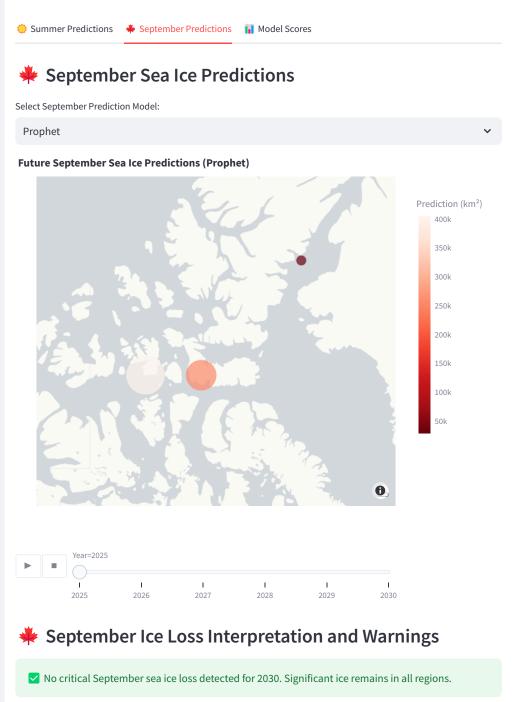
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🧊 Sea Ice Loss Predictions: Historical Trends & Future Outlook

🟡 Summer Predictions   🍁 September Predictions   📊 Model Scores

📊 Model Performance (R^2 Scores)

🟡 Summer Prediction R^2 Scores by Region and Model

	Region	Model	R2_Score
20	Baffin Bay (Summer)	Gradient Boosting	0.8805
18	Baffin Bay (Summer)	Prophet	0.3646
19	Baffin Bay (Summer)	Random Forest	0.6829
38	Beaufort Sea (Summer)	Gradient Boosting	0.8064
36	Beaufort Sea (Summer)	Prophet	0.4125
37	Beaufort Sea (Summer)	Random Forest	0.6279
92	Davis Strait (Summer)	Gradient Boosting	0.7784
90	Davis Strait (Summer)	Prophet	0.2765
91	Davis Strait (Summer)	Random Forest	0.6213
56	Hudson Bay (Summer)	Gradient Boosting	0.5596

🍁 September Prediction R^2 Scores by Region and Model

	Region	Model	R2_Score
20	Arctic Archipelago (September)	Gradient Boosting	0.8188
18	Arctic Archipelago (September)	Prophet	0.3862
19	Arctic Archipelago (September)	Random Forest	0.6658
38	Arctic Domain (September)	Gradient Boosting	0.874
36	Arctic Domain (September)	Prophet	0.5834
37	Arctic Domain (September)	Random Forest	0.7549
2	Kane Basin (September)	Gradient Boosting	0.2425
0	Kane Basin (September)	Prophet	0.1135
1	Kane Basin (September)	Random Forest	0.3989

✅ A higher R^2 score indicates better model performance and prediction accuracy.

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🌡️ Temperature Predictions: City-Wise Trends & Model Performance

🌡️ Future Temperature Maps   📊 Model Scores

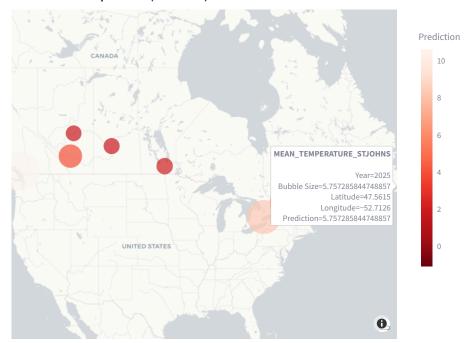## 🌡️ Future Temperature Predictions (2025-2030)

Select Temperature Prediction Model:

Random Forest   ⌄

Predicted Future Temperatures (2025-2030)

Interpretation:

🔥 Higher temperatures shown in darker red.

🔥 Increasing bubble size indicates warmer average temperatures in Canadian cities by 2030.

🍁 Climate Change in Canada: Historical Analysis and Future Projections

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🌡️ Temperature Predictions: City-Wise Trends & Model Performance

🌡️ Future Temperature Maps   📊 Model Scores

📊 Model R² Scores by City

	City	Model	R2_Score
6	MEAN_TEMPERATURE_CALGARY	Gradient Boosting	0.4062
12	MEAN_TEMPERATURE_CALGARY	Prophet	0.1635
0	MEAN_TEMPERATURE_CALGARY	Random Forest	0.1948
23	MEAN_TEMPERATURE_EDMONTON	Gradient Boosting	0.3305
29	MEAN_TEMPERATURE_EDMONTON	Prophet	0.0831
17	MEAN_TEMPERATURE_EDMONTON	Random Forest	0.249
40	MEAN_TEMPERATURE_HALIFAX	Gradient Boosting	-0.0584
46	MEAN_TEMPERATURE_HALIFAX	Prophet	0.1901
34	MEAN_TEMPERATURE_HALIFAX	Random Forest	0.0769
57	MEAN_TEMPERATURE_MONCTON	Gradient Boosting	-0.0972

✅ A higher R² Score means better prediction accuracy for that city and model.

🌧 Climate Change in Canada: Historical Analysis and Future Projections

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🌧 Precipitation Predictions: City-Wise Trends & Model Performance
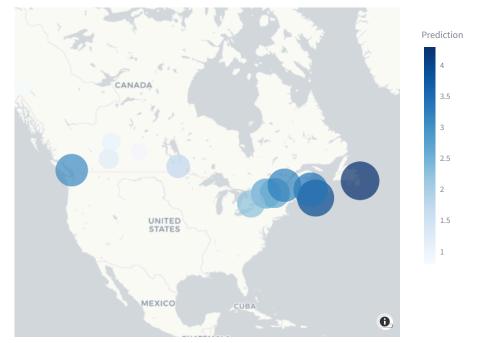
🌧 Future Precipitation Maps   📊 Model Scores

🌧 Future Total Precipitation Predictions (2025-2030)

Select Precipitation Prediction Model:

Random Forest	⌄

Predicted Future Precipitation (2025-2030)

Year=2030

2025   2026   2027   2028   2029   2030

Interpretation:

🌧 Larger bubbles and darker blue indicate higher predicted precipitation totals in the future.

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🌧️ Precipitation Predictions: City-Wise Trends & Model Performance

🌧️ Future Precipitation Maps   📊 Model Scores

📊 Model R² Scores by City

	City	Model	R2_Score
6	TOTAL_PRECIPITATION_CALGARY	Gradient Boosting	0.1008
12	TOTAL_PRECIPITATION_CALGARY	Prophet	0.0356
0	TOTAL_PRECIPITATION_CALGARY	Random Forest	0.2515
24	TOTAL_PRECIPITATION_EDMONTON	Gradient Boosting	-0.018
30	TOTAL_PRECIPITATION_EDMONTON	Prophet	0.0773
18	TOTAL_PRECIPITATION_EDMONTON	Random Forest	-0.1467
42	TOTAL_PRECIPITATION_HALIFAX	Gradient Boosting	-0.5975
48	TOTAL_PRECIPITATION_HALIFAX	Prophet	0.0629
36	TOTAL_PRECIPITATION_HALIFAX	Random Forest	-0.4135
60	TOTAL_PRECIPITATION_MONCTON	Gradient Boosting	-0.3052

✅ A higher R² Score indicates better model prediction accuracy for each city.

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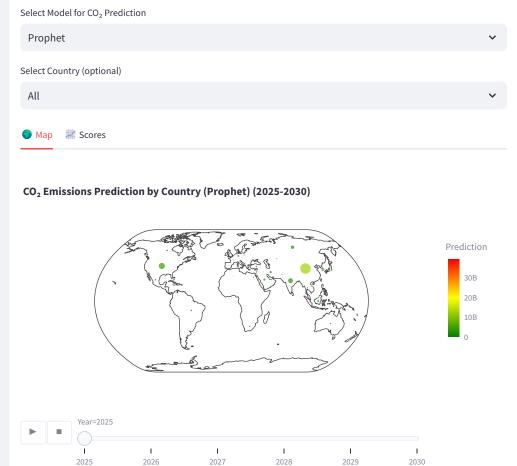- 🔴 🌍 CO_2 Emissions Predictions

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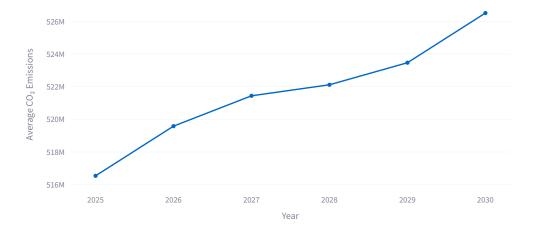
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🌍 CO_2 Emissions Predictions

Select Model for CO_2 Prediction

Prophet ⌄

Select Country (optional)

All ⌄

🌍 Map   📈 Scores

CO_2 Emissions Prediction by Country (Prophet) (2025-2030)

Year=2025

▶ ◼ ──○────────────────────────────

2025   2026   2027   2028   2029   2030

📊 Global Average CO_2 Emissions Trend (Historical + Predicted)

Global Average CO$_2$ Emissions Over Time

🌍 CO$_2$ Emissions Predictions

Select Model for CO$_2$ Prediction

Prophet	⌄

Select Country (optional)

All	⌄

🌍 Map   📈 Scores

📈 Model R2 Scores by Country

	Country	Model	R2_Score
0	Afghanistan	Prophet	0.8248
1	Albania	Prophet	0.5142
2	Algeria	Prophet	0.9646
3	Andorra	Prophet	0.8547
4	Angola	Prophet	0.6474
5	Antigua and Barbuda	Prophet	0.9933
6	Argentina	Prophet	0.8732
7	Armenia	Prophet	0.2315
8	Aruba	Prophet	0.0017
9	Australia	Prophet	0.9825

📊 Global Average CO$_2$ Emissions Trend (Historical + Predicted)

Sidebar

🍁 **Climate Change in Canada: Historical Analysis and Future Projections**

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Global Average CO₂ Emissions Over Time