



Forecasting Natural Gas Production in Alberta Through Wildfire Analysis

Yong Lee, Jacob Winch For Energy Hackathon 2024

Motivation

Natural Gas Generates 72.6% of Electricity in Alberta (2022)*

News |

Alberta wildfires hit Canada-US gas flow

NATURAL GAS — 07 Jun 2023 | 17:44 UTC

Wildfires in Alberta
Canada-US gas flow

Ashima Sharma May 19, 2023

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Canadian gas production Alberta wildfires heat up

HIGHLIGHTS

Output falls 400 MMcf/d from late May peak

Pipeline exports to the US rebound to 5 Bcf/d in June

Hot, dry weather forecast for southern Alberta

Environment

Alberta wildfires hit gas flow out of Canada to US, spiking prices

Reuters

May 18, 2023 5:10 PM MDT · Updated 9 months ago



Aa

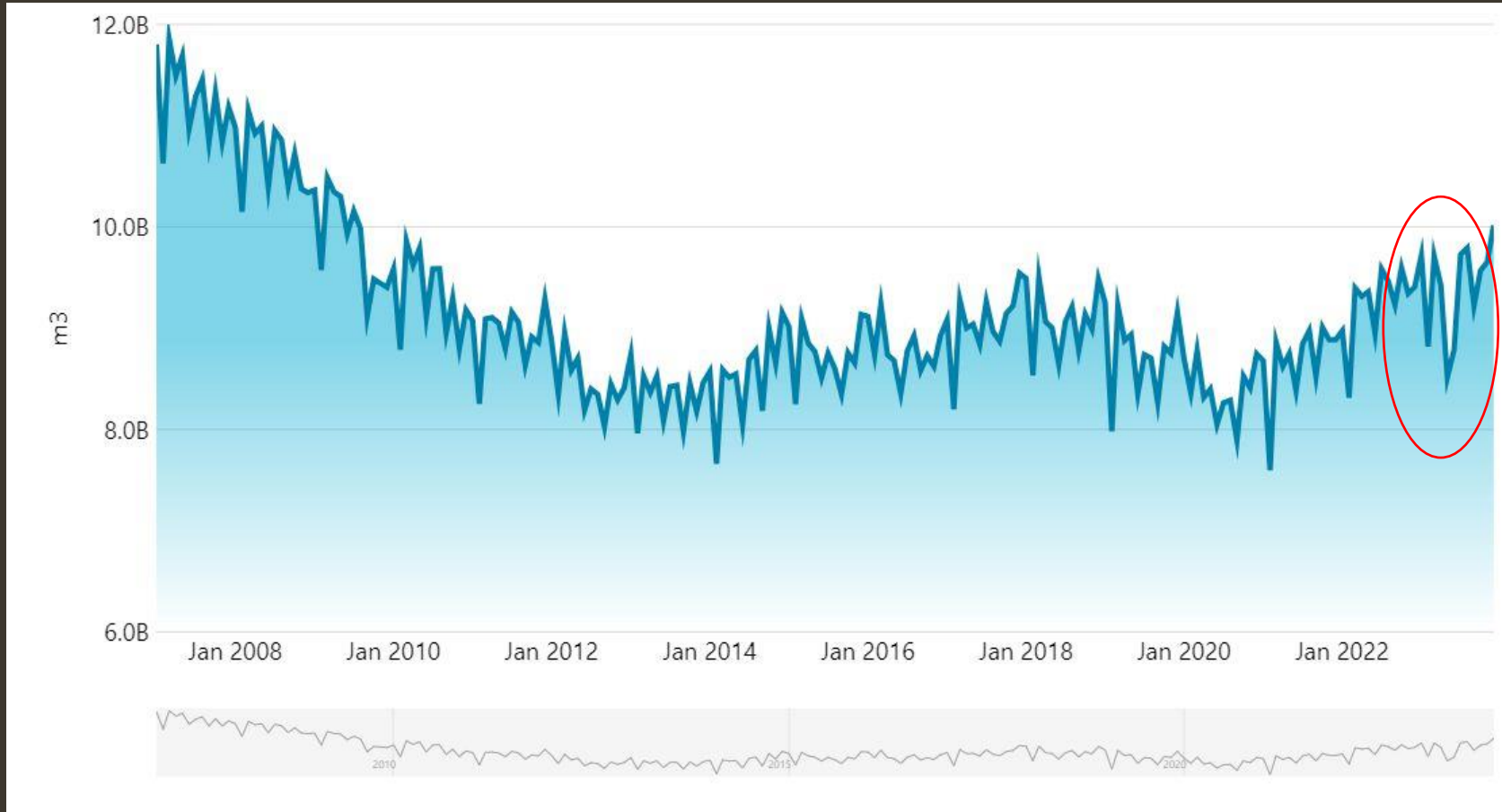


[1/4] Smoke rises above the southeast perimeter of the Paskwa fire (HWF030) as it burns near Fox Lake, Alberta, Canada, May 16. Alberta Wildfire/via REUTERS [Purchase Licensing Rights](#)



*Annual Electricity Data by AUC - <https://www.auc.ab.ca/annual-electricity-data/>

Alberta Natural Gas Production



In May 2023, marketable natural gas production was 8.5B cubic metres, down 9.66% from April 2023*. Compared to a historical average of 0.54% between 2007 and 2022. During May 2023, Alberta's wildfires were the worst the province has ever seen in the spring, with a record breaking 1,017,00 hectares burnt from the start of the fire season to May 23rd, 2023**.

*Natural Gas Production. Alberta Economic Dashboard. <https://economicdashboard.alberta.ca/dashboard/natural-gas-production/>

**2023 wildfires in Alberta worst record for Spring. CityNews Edmonton. <https://edmonton.citynews.ca/2023/05/23/worst-spring-wildfire-season/#:~:text=Last%20Updated%20May%202023%2C%202023,fires%20have%20burnt%201%2C017%2C000%20hectares.>

Data Ingestion, Cleaning, Compiling

- Alberta Wildfire data: 2006.Apr to 2021.Dec - 22914 Individual Fires
 - <https://www.alberta.ca/wildfire-maps-and-data>
- Natural Gas Historical Production in Alberta: 2007.Jan to 2023.Dec
 - <https://economicdashboard.alberta.ca/dashboard/natural-gas-production>
- ST50: Gas Processing Plants in Alberta: 2001.Nov to 2023.May
 - <https://www.aer.ca/providing-information/data-and-reports/statistical-reports/st50> - 1190 Individual Plants
- Nova Gas Transmission Ltd. (NGTL) Pipeline: 2006.Jan to 2023.Sep
 - <https://open.canada.ca/data/en/dataset/dc343c43-a592-4a27-8ee7-c77df56afb34>

Feature Engineering

Nova Gas
Transmission Ltd.
system (NGTL)

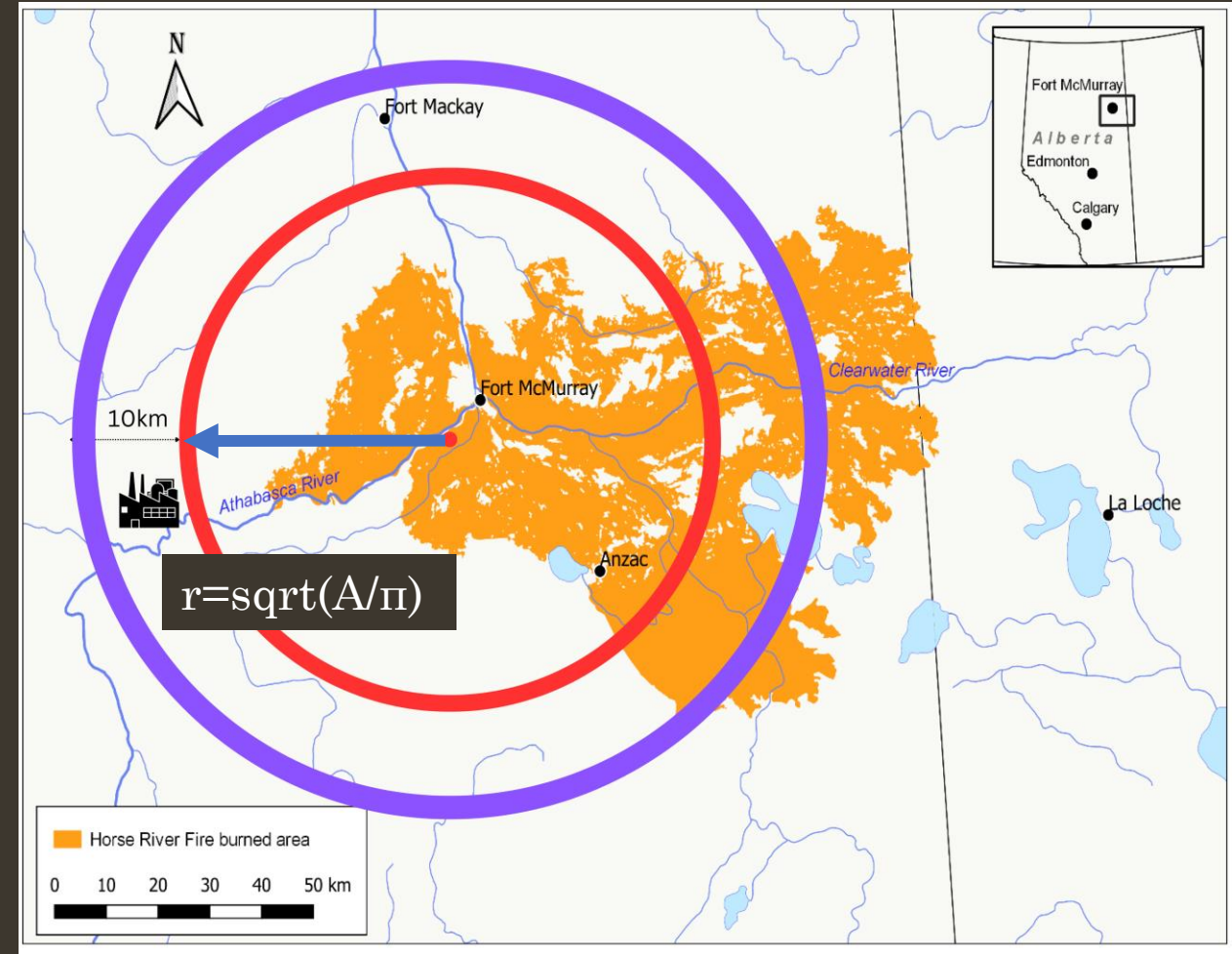


<https://www.cer-rec.gc.ca/en/data-analysis/facilities-we-regulate/2016/group1-companies/natural-gas/canadas-pipeline-transportation-system-2016-ngtl.html>

Gas Plant
Locations in
Alberta



BOE Reports. <https://boereport.com/2023/04/26/xi-technologies-alberta-gas-processing-a-summary/>

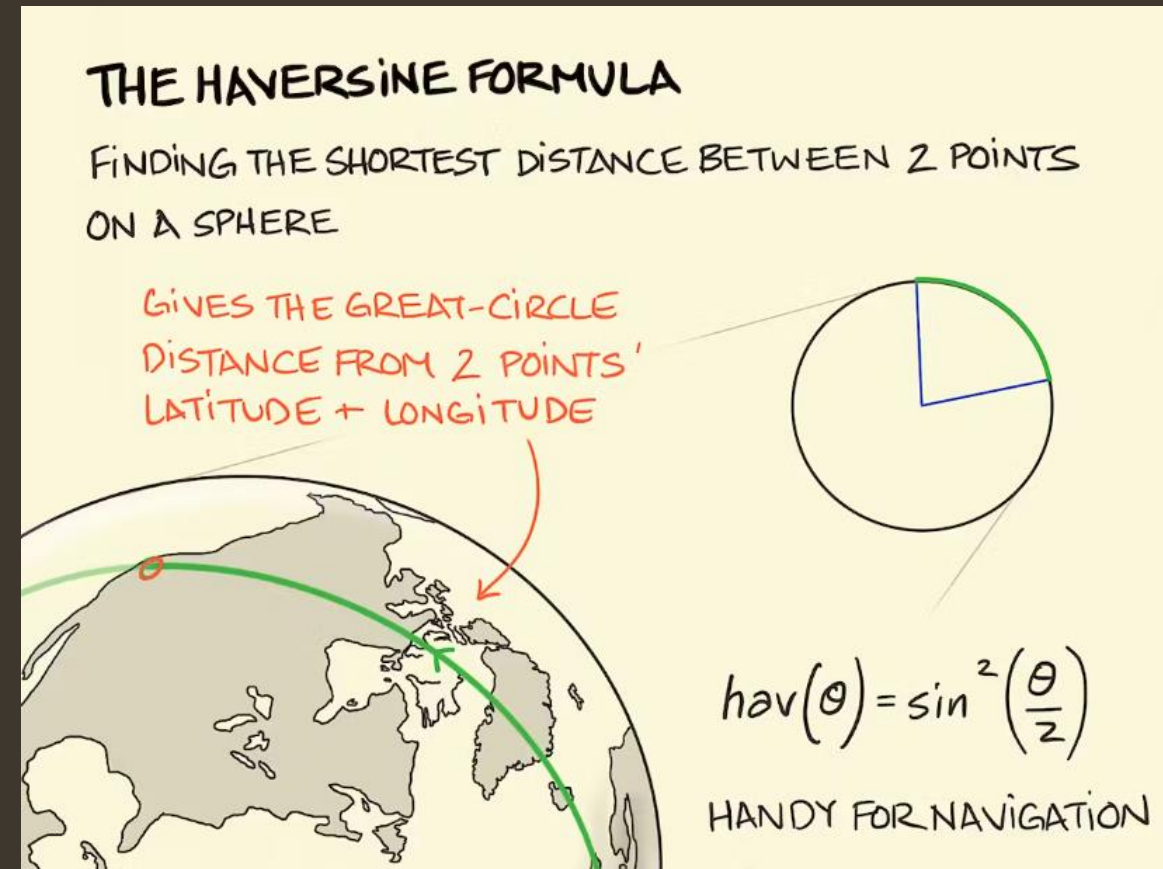


Incentives and Barriers to Homeowners' Uptake of Firesmart. <https://www.mdpi.com/2571-6255/5/3/80>

Example: 2016 Horse River Wildfire

Fire Impact on Facilities & Infrastructures

- Haversine Formula Use:
 - Calculated "as-the-crow-flies" distance between two points, factoring in Earth's curvature, using coordinates in radians.
- Distance in Meters:
 - Applied Earth's radius (~6371 km) within the Haversine formula to output distance in meters.
- Fire Impact Assessment:
 - Assessed if facilities are within a fire's impact zone by comparing the calculated distance to the fire's radius, assumed as a circle for simplicity.
 - Adds safety margins: 10 km* for gas plants and 5 km** for pipelines, based on industry safety standards, to account for indirect fire impacts.



<https://sketchplanations.com/the-haversine-formula>

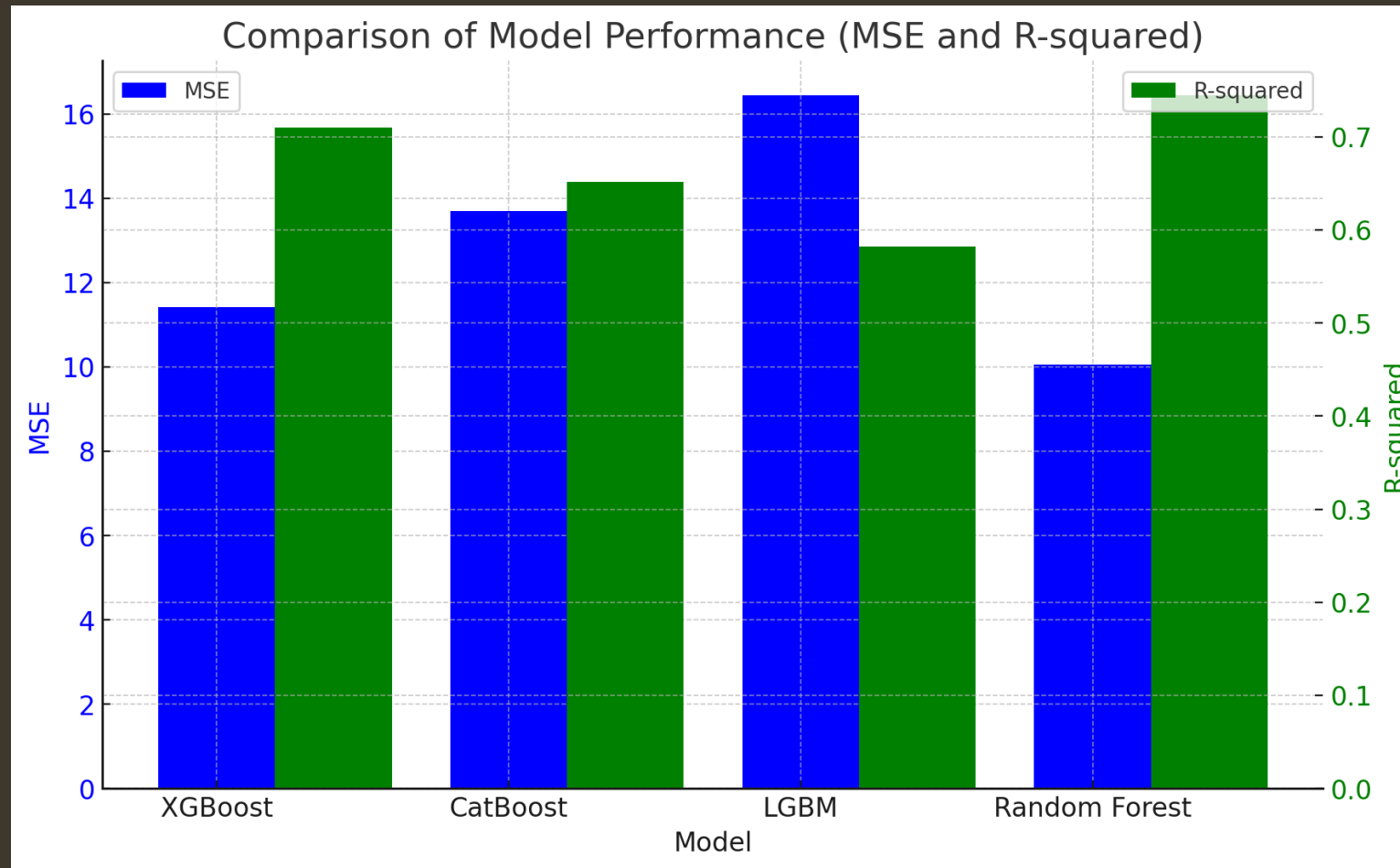
*<https://heatmap.news/guides/wildfire-evacuation-guide> **Arbitrary Assumption

Final Model Features

- # of Fire Size Class: ['A', 'B', 'C', 'D', 'E'].
 - A class = 0 to 0.1 ha
 - B class > 0.1 ha to 4.0 ha
 - C class > 4.0 ha to 40.0 ha
 - D class > 40.0 ha to 200 ha
 - E class > 200 ha
- Year: Fire year
- Month: Fire Month
- Gas Plant Frac Raw Gas Capacity (1000 m3/d): Gas Plant Fractionation: The process of boiling off the different hydrocarbons.
- Gas Plant Sweet Raw Gas Capacity (1000 m3/d): The Process of removing hydrogen sulfides.
- Gas Plant Flaring Raw Gas Capacity (1000 m3/d): Burning of natural gas
- Gas Plant Acid Gas Inj Raw Gas Capacity (1000 m3/d): Gas Plant Acid Gas Injection
- Gas Plant Mainline Strdle (1000 m3/d): Gas Plant Mainline Straddle. Recover NGL components
- Gas Plant Sulphur Recovery Raw Gas Capacity (1000 m3/d)
- Pipeline Gas Transmission Average Capacity (1000 m3/d):

```
features = [  
    'A', 'B', 'C', 'D', 'E',  
    'Year', 'Month',  
    'Gas Plant Frac',  
    'Gas Plant Sweet',  
    'Gp Acid Gas Flaring',  
    'Gp Acid Gas Inj',  
    'Gp Mainline Strdle',  
    'Gp Sulphur Rcvry',  
    'Avg Capacity (1000 m3/d)'  
]
```


Results – Evaluation Metrics for each Model



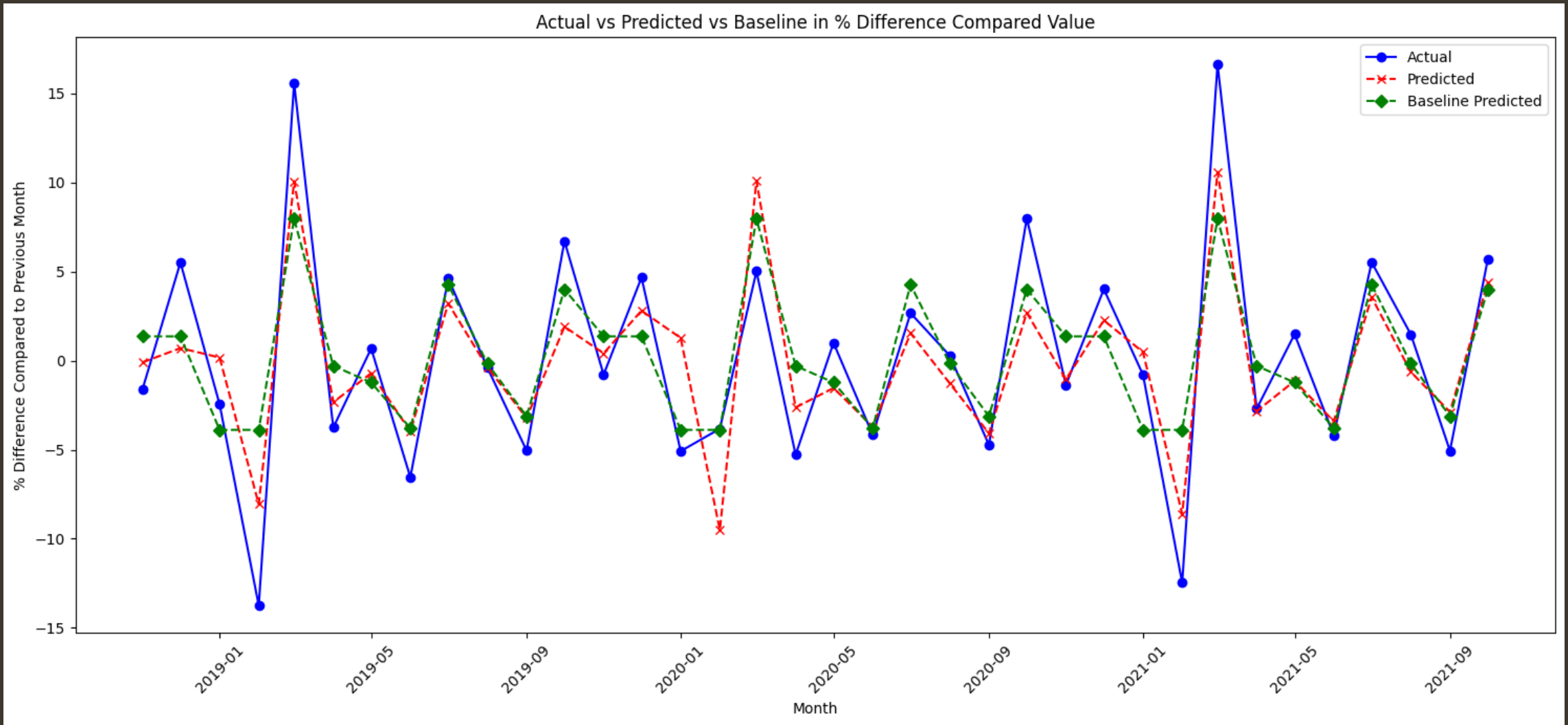
XGBoost MSE: 11.4192, R-squared: 0.7095

CatBoost MSE: 13.6907, R-squared: 0.6517

Random Forest MSE: 10.0460, R-squared: 0.7444

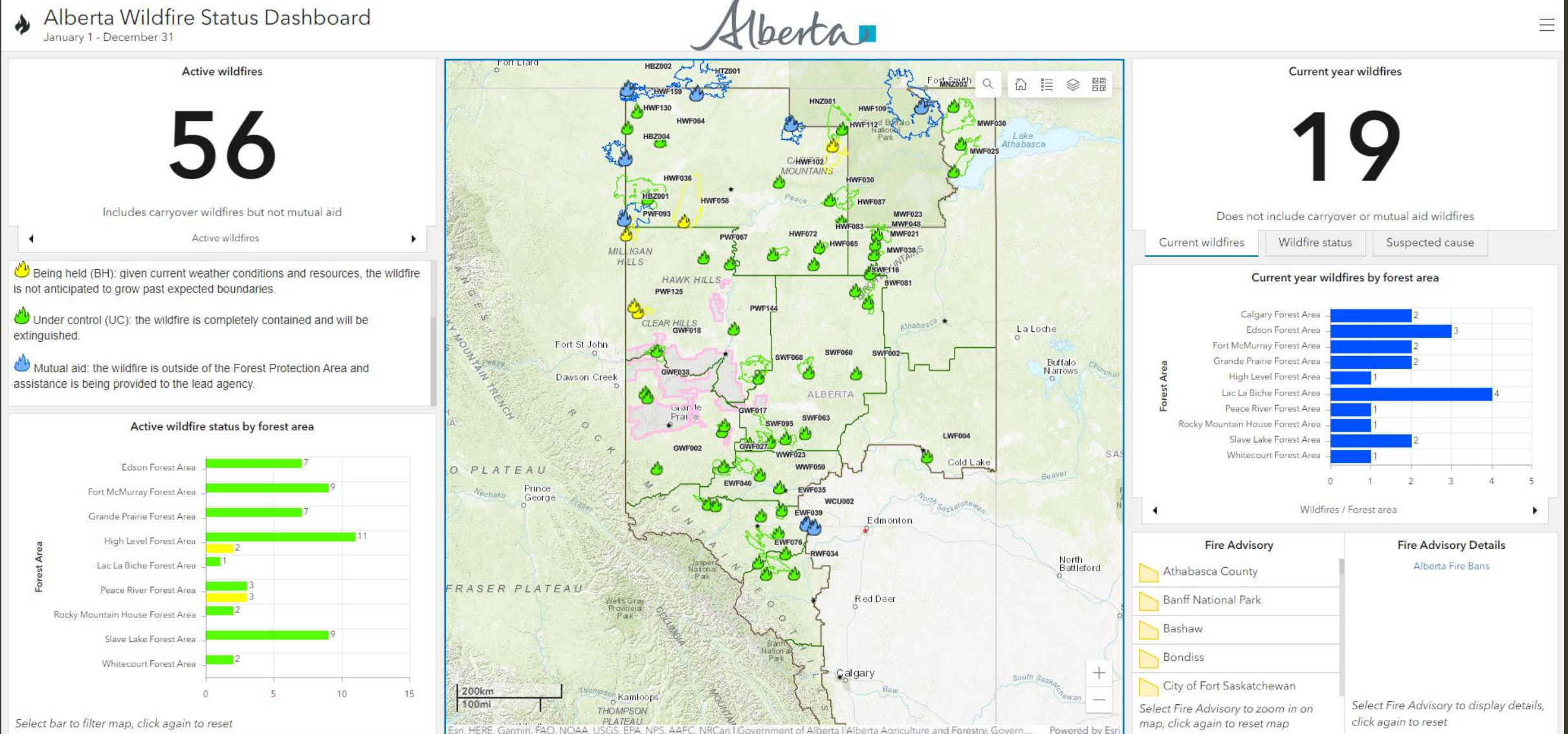
LightGBM MSE: 16.4402, R-squared: 0.5818

Results - % Difference Compared to Previous Month



Random Forest Regressor(Best Performing) MSE: 10.1542, R-squared: 0.7417
Baseline (Seasonal Pattern) MSE: 13.6521, R-squared: 0.6527

Alberta Wildfire Status Dashboard on ArcGIS



<https://www.arcgis.com/apps/dashboards/3ffcc2d0ef3e4e0999b0cf8b636defa3>

Real-time Wildfire Data available on CIFFC



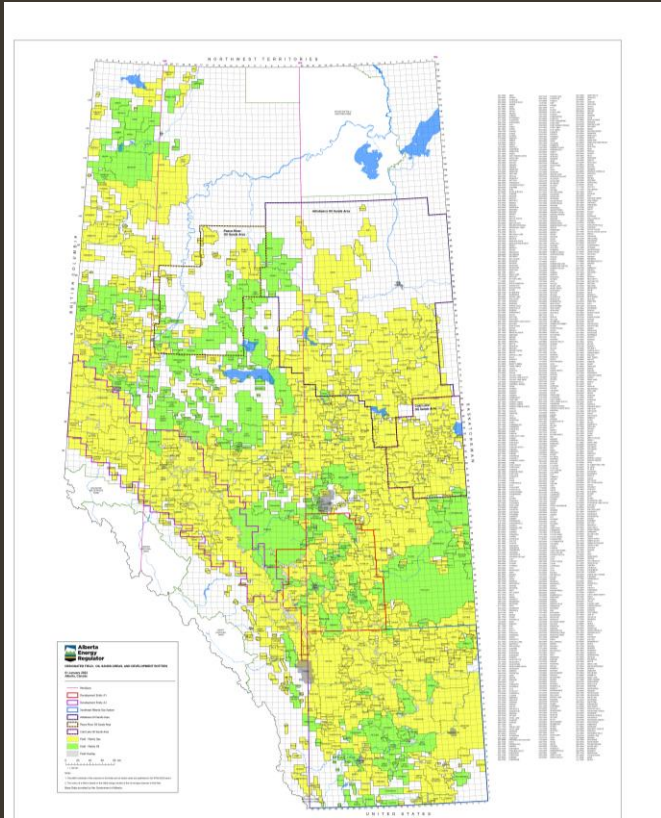
https://geoserver.ciffc.net/en/national-fires?filter_agency_code=All&stage_of_control=All&response_type=All&page=1&order=wildfire_agency_fire_id&sort=desc

- The Canadian Interagency Forest Fire Centre (CIFFC) is a not-for-profit corporation owned and operated by the federal, provincial and territorial wildland fire management agencies

Our model predicts a *9.49% decrease* in Natural Gas Production for February 2024 in Alberta.

Difficulties Faced & Limitations

Isolating individual wells impacted by wildfires



Map-90: Designated Oil and Gas Fields, and Oil Sands Deposits. <https://www1.aer.ca/productcatalogue/187.html>

In addition to gas processing plants and pipelines we also tried to incorporate individual gas wells. However, we struggled with isolating the location of each well.

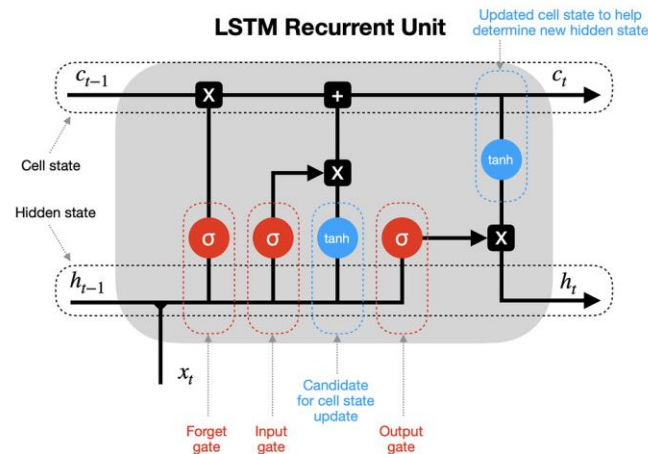
Attributing Causality

Due to a multitude of factors influencing natural gas production (e.g. geopolitical influences, fluctuating demand, etc.) it is difficult to determine if an increase in wildfires in Alberta singlehandedly causes variation in natural gas production. However, we can confidently say that at least some of the change is due to wildfires.

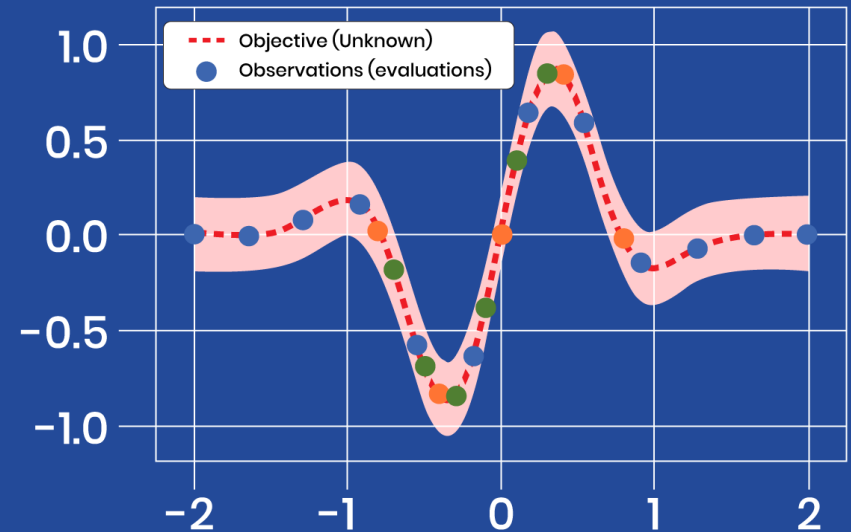
Trial Review: Opportunities for Improvement

- Possible Application of Deep Learning Models
 - Long Short-Term Memory (LSTM) - R-squared 0.007
- Hyperparameter Tuning
 - Bayesian Optimization
 - Overfitting

LONG SHORT-TERM MEMORY NEURAL NETWORKS



Bayesian Optimization

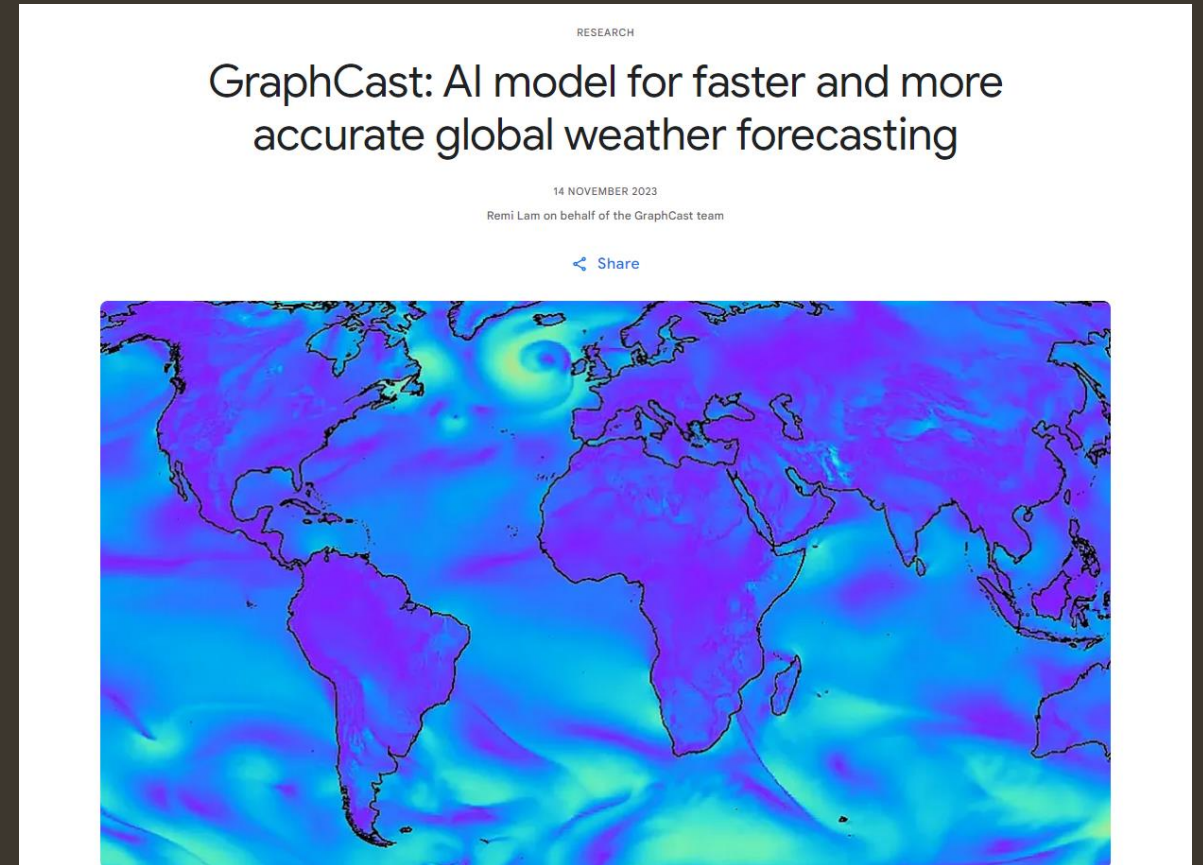


What's Next?

Incorporating state of the art wildfire prediction models to forecast impacts to Alberta's natural gas production.



AI for Wildfire Prediction. AltaML. <https://www.govlab.ai/wildfire-prediction>



Google Deepmind. <https://deepmind.google/discover/blog/graphcast-ai-model-for-faster-and-more-accurate-global-weather-forecasting/>

Thank you!



<https://github.com/gjftns7220/2024APICEnergyHackathon>

Tools Used:

- Jupyter Notebook
 - Sklearn
 - XGBoost
 - CatBoost
 - LightGBM
 - Numpy
 - Pandas
 - Matplotlib
 - Tensorflow
 - Keras
- Canva
- Google Colab