A DATA-DRIVEN ANALYSIS OF SALTWATER DISPOSAL WELL PERFORMANCE AND INDUCED SEISMICITY

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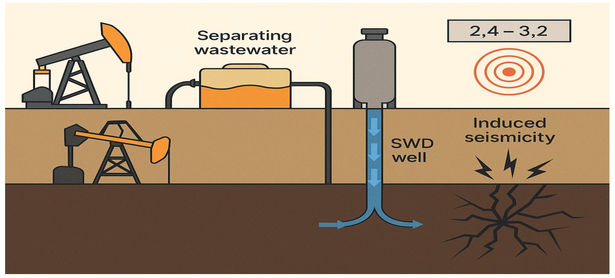
ABSTRACT

The increasing reliance on hydraulic fracturing for oil and gas extraction has led to a significant rise in saltwater production, requiring efficient disposal methods. Saltwater Disposal (SWD) wells, classified as Class II injection wells by the U.S. Environmental Protection Agency (EPA), serve as key infrastructure for wastewater injection. However, growing evidence and public concern suggest a potential link between SWD well operations and induced seismicity—where human activity, such as fluid injection, contributes to seismic events.



OBJECTIVE

This study aims to investigate the relationship between SWD well operations and the occurrence of earthquakes by integrating data from SWD wells in Oklahoma with earthquake records from the U.S. Geological Survey (USGS) for the years 2022 and 2023.A geospatial, data-driven approach is applied to evaluate how specific SWD well parameters may influence seismic activity.

DATA SOURCES & INTEGRATION

Data for this study is sources from the U.S. Geological Survey (USGS) for earthquake records and the Oklahoma Corporation Commission for Saltwater Disposal (SWD) well operations, covering the years 2022 and

USGS science for a changing world

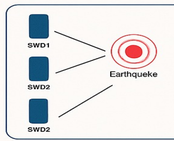
Earthquake Dataset

- Latitude, Langitude
- Recorded Magnitude

OKLAHOMA CORPORATION COMMISSION

SWD Well Dataset

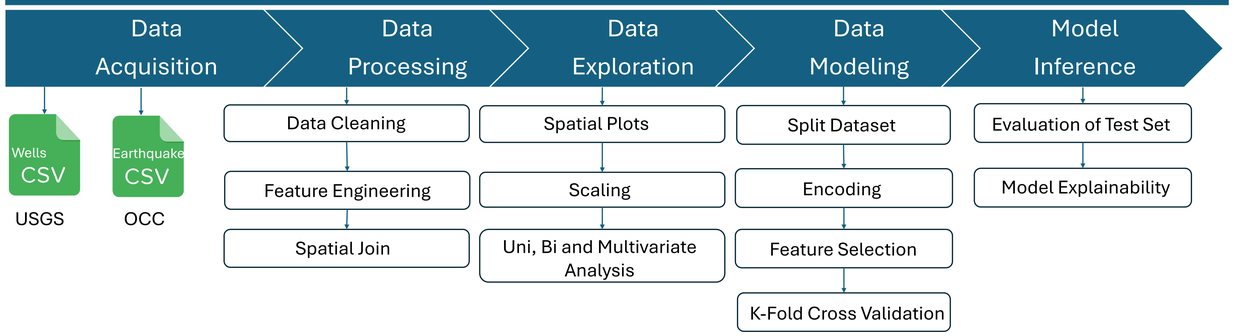
- Month wise Injection Volumes
- Pressure generated for well Plugback Depth



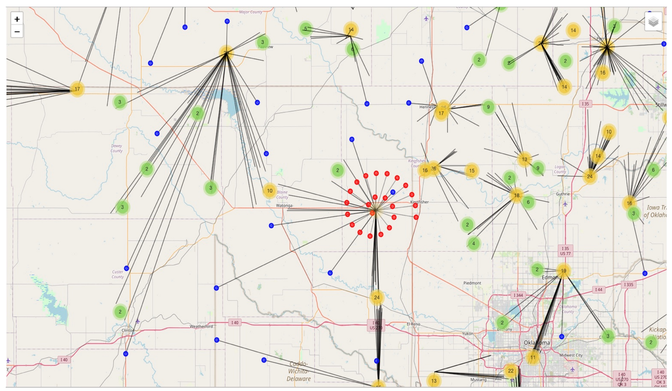
SPATIAL JOIN

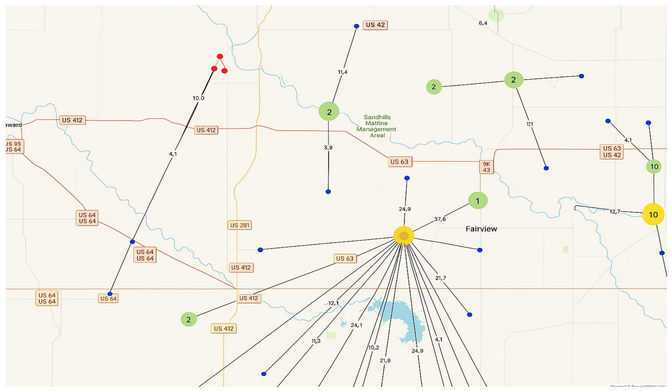
A Spatial Join was performed by identifying the nearest well for each observed earthqua-ke based on geographic proximity

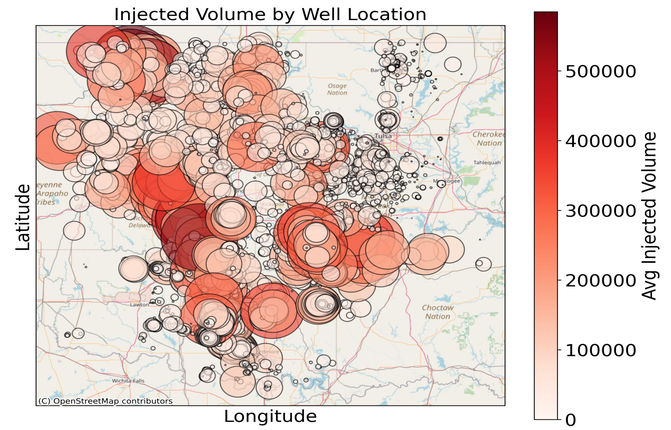
METHODOLOGY



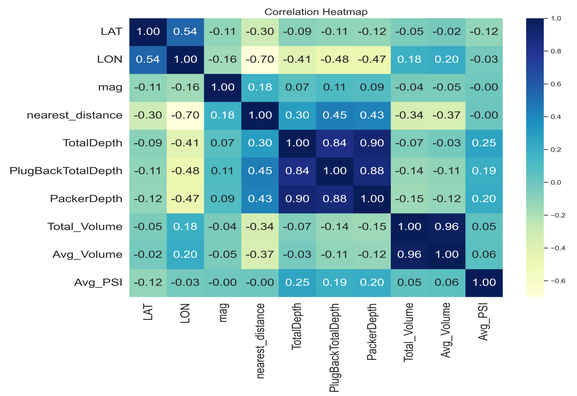
SPATIAL JOIN

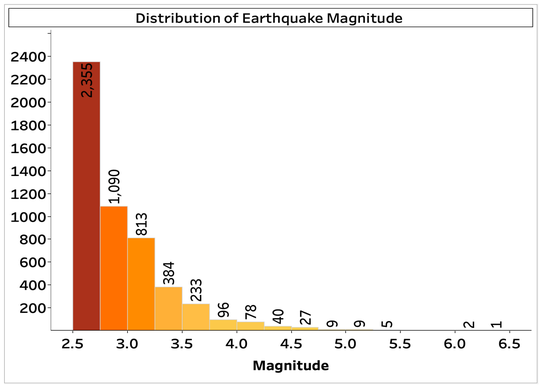


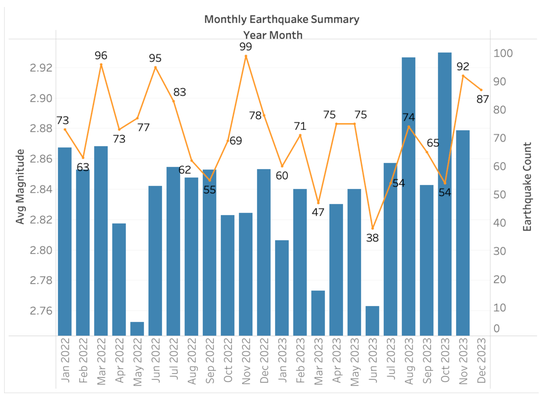




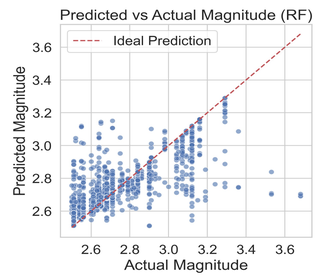
DATA EXPLORATION

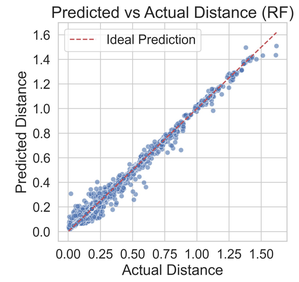






MACHINE LEARNING RESULTS





MODEL PERFORMANCE ON TEST SET

Model	MSE (Mag)	R^2 (Mag)	MSE (Distance)	R^2 (Distance)
Linear Regression	0.021	0.363	0.023	0.669
Random Forest	0.005	0.847	0.001	0.993
Gradient Boosting	0.009	0.727	0.002	0.968
XG Boost	0.009	0.729	0.002	0.968
Ensemble Voting	0.006	0.818	0.001	0.986

OBSERVATIONS

- **From January 2023 to December 2023, periods with higher cumulative monthly injection volumes often preceded increases in earthquake frequency.**
- **A Few earthquake events were observed far from any recorded injection well, indicating either incomplete well coverage or naturally occurring seismicity**

CONCLUSIONS & FUTURE WORK

- **Random Forest outperformed all other models, achieving the highest R^2 scores (0.847 for magnitude and 0.993 for distance), indicating its strong ability to capture complex relationships in the data.**
- **Latitude and Longitude showed high predictive power for estimating the nearest earthquake distance, suggesting spatial location is a key feature in seismic proximity modeling.**
- **Average injection volume contributed significantly to magnitude prediction; future work can explore temporal injection patterns and well activity timelines to further improve model accuracy.**

REFERENCES

UIC INJECTION WELLS

USGS EARTHQUAKES DATA

ACKNOWLEDGEMENTS

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