



Kevin Sheng



Sean Huang

Company Advisor: Dr. Christian Klose

Faculty Advisor: Prof. Andy Sun

Problem Statement & Objective

Insurance against mishaps: A major risk of the credit insurance sector is posed by **climate change and natural hazards**, causing great financial loss and threaten social welfare.



Into the unknown: Despite of the ever-increasing importance of climate risks, **the current widely-adopted scorecard approach does not allow for the necessary adjustments.**



Beating the odds: The objective is to develop an automated **data-driven credit rating model** that incorporates **climate hazard** data, especially in areas prone to extreme natural hazards.

Data & Scope



Credit Data

Financial obligor metrics



Socioeconomics Data

Demographics and governments



Hazard Data

Tracks, return periods, severities



Exposure Data

Damage, resilience, vulnerability

250K

Policies

3080

Counties

\$20B

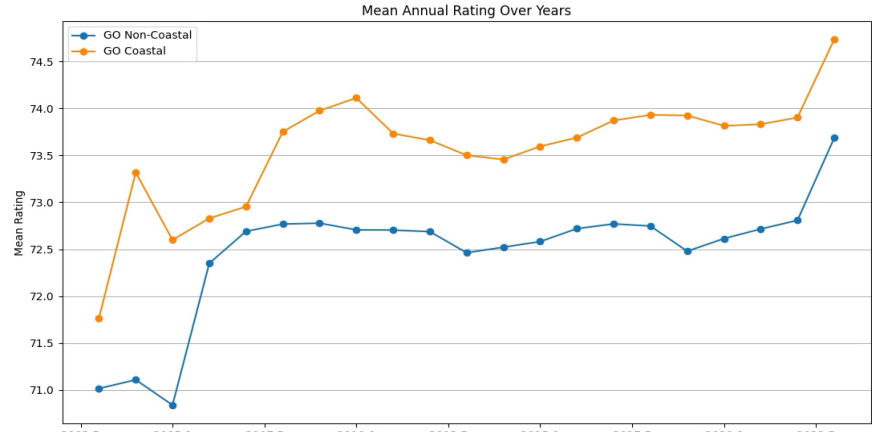
Assets

Methodology

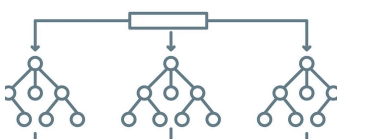
Rating Prediction

Multiple sources of obligor financials and internal data sets were parsed, joined, and cleaned prior to missing data imputation using missForest.

Ten additional Features were engineered to improve model performance.

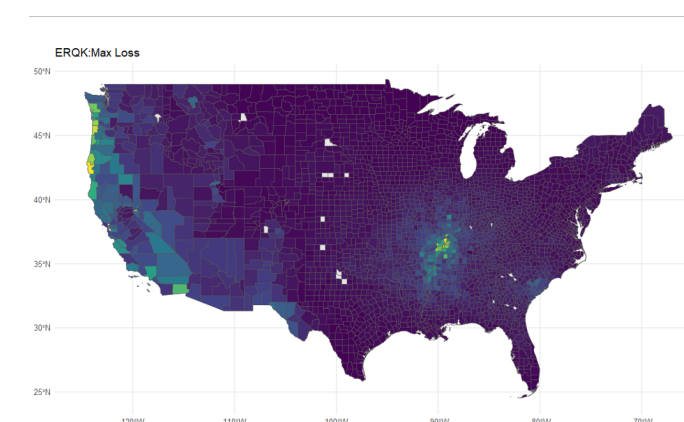


Since interpretability was required, Random Forest Regressor and Classifier were ultimately selected to create the bond-rating models without considering climate risks.

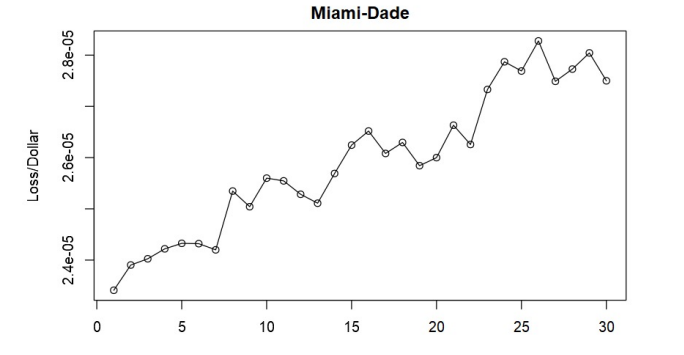


Credit Ratings without Climate Risks

Hazard Simulation



Monte Carlo simulations were done based on meteorological models and probability models. Social vulnerability and community resilience were incorporated.



3080 counties, 18 hazards
30 years, 1000 simulations

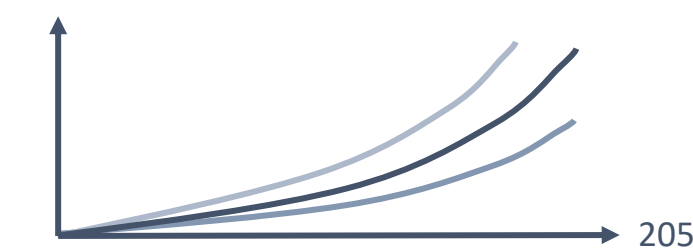
Risks due to Natural Hazards

Scenario Analysis

Simulation results impact a myriad features, such as full value per capita. With adjusted features, the rating prediction models then predict new ratings corrected for natural hazards.

A-  **BBB+**

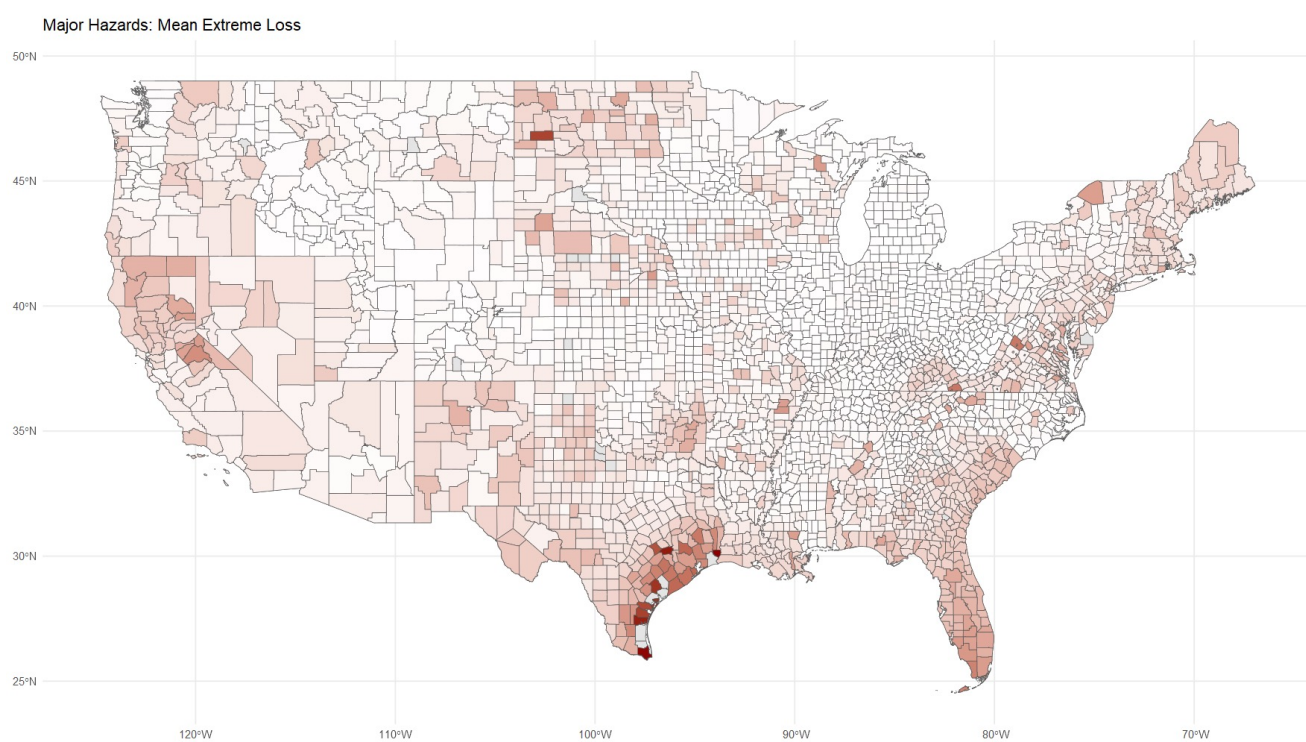
Under different simulation scenarios, the rating would adjust differently. Clustering analysis were conducted to understand the spatial distribution of risk accumulation.



Hazard-Adjusted Credit Ratings

Results

Hazard Simulation



Based on the simulation results, various statistics can be summarized.

For risk prediction purposes, we decided to focus on the **mean extreme events** (the heaviest rain matters!) for 7 major hazards identified through the simulations.

Earthquake, Coastal Flooding, Riverine Flooding, Wildfire, Tornado, Hurricane, Drought

Rating Prediction

Test Results

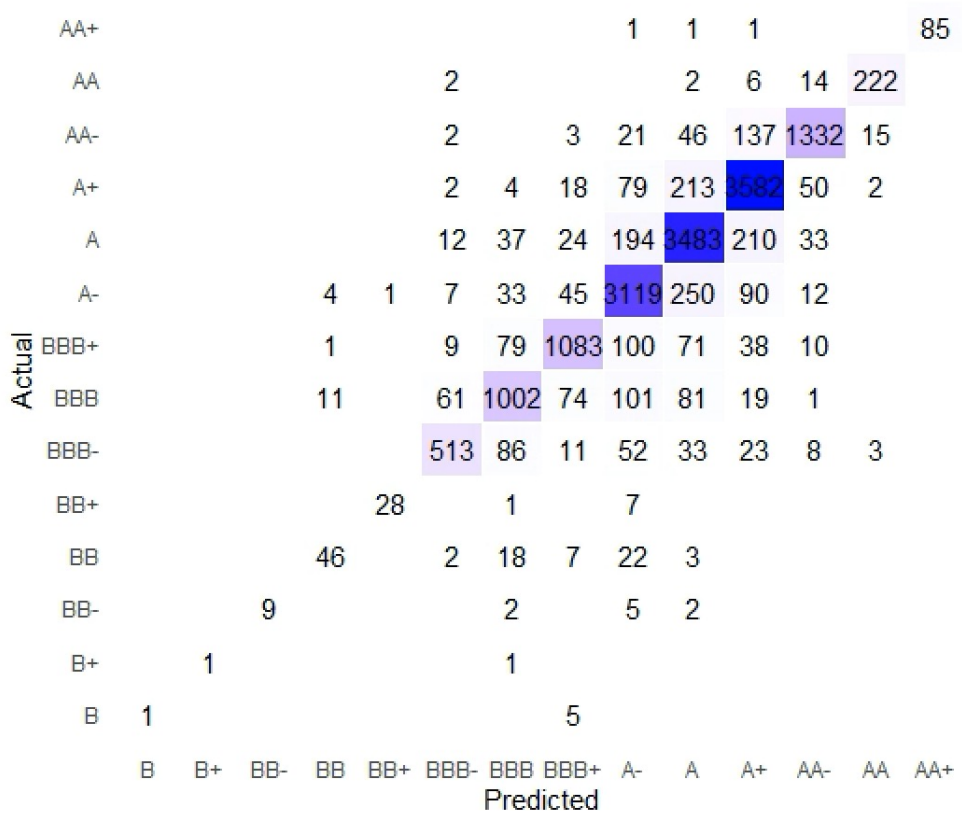
Classification Confusion Matrix
Percentage of Perfect Matches: 85.21 %
Percentage within +/- 1 notch: 90.01 %

Regression

	Accuracy	R ²	MSE	MAE
Regression	75%	0.72	8.32	1.19

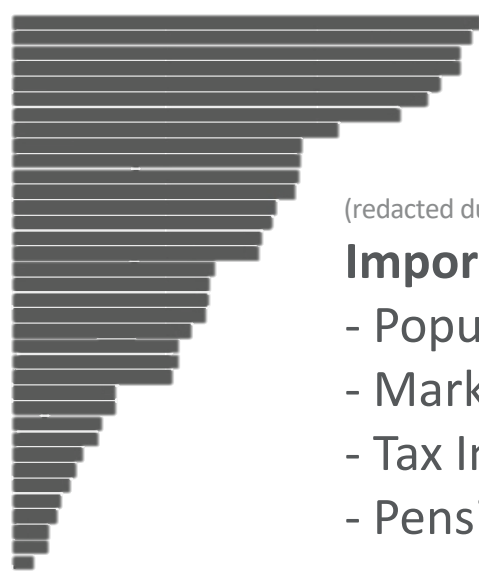
Classification

	Accuracy	Mean AUC	Mean Recall	Mean Precision
Classification	85%	0.92	0.91	0.91



Perfect match:
When the predicted mapped letter rating is the same as the actual letter rating

The +/- 1 notch error band:
The one predicted rating letter above & below the actual letter rating



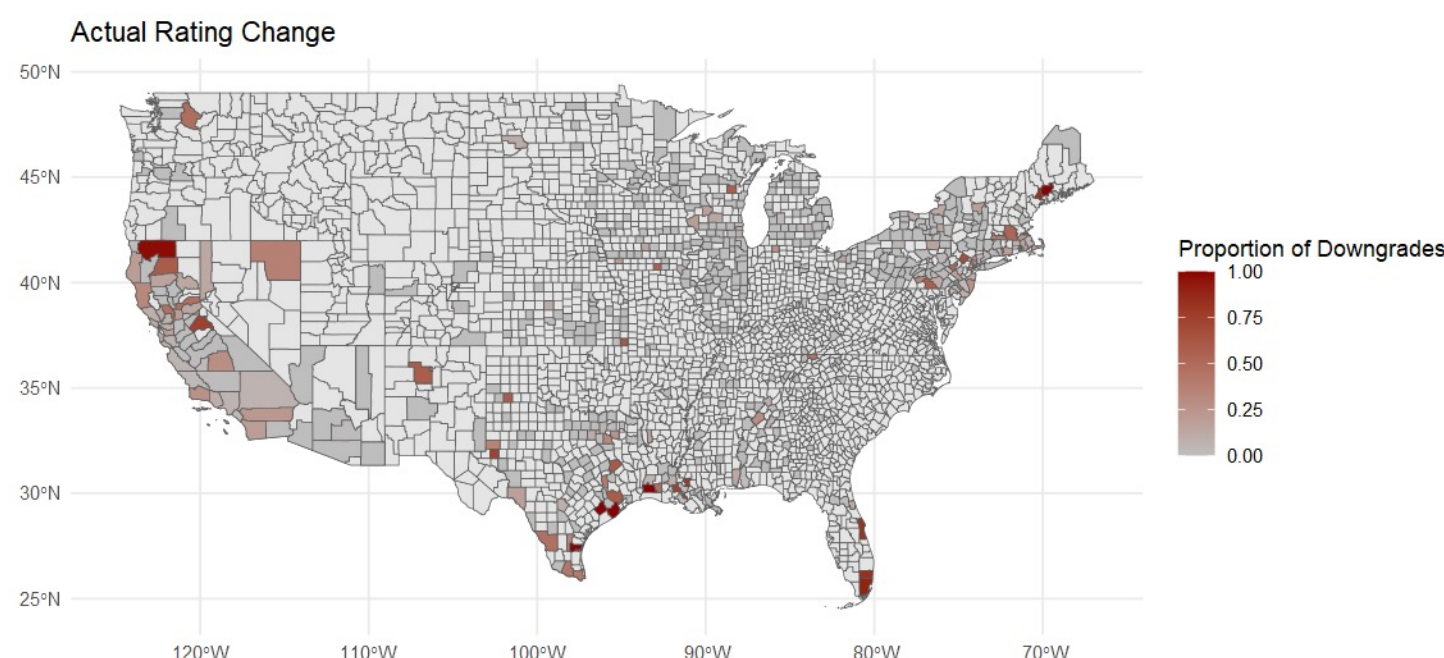
(redacted due to confidentiality)

Important Features

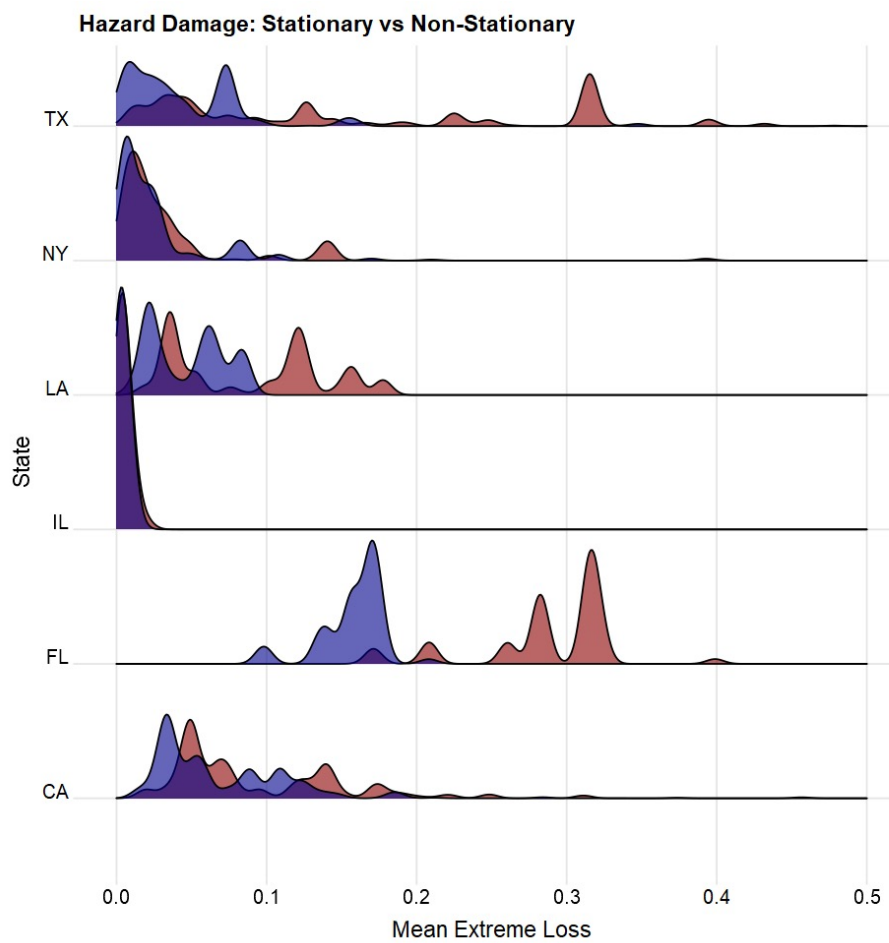
- Population
- Market Value
- Tax Income
- Pension Liability

*Regression model yielded slightly worse results

Scenario Analysis



Non-Stationary scenario had higher loss due to hazard and led to **80% more rating downgrades** compared to stationary scenario



Business Impact

Data-Driven Portfolio Steering

Our models provide a more accurate, natural hazard risk-adjusted outlook of Assured Guaranty's current portfolio exposure, serving as a guidance for the business to adjust their risk exposure on a portfolio level.

Automated Risk Discovery

The models suggest an alternative approach to the conventional scorecard methods, leading to a more automated and more accurate hazard-adjusted ratings, which better capture the risk that the company could face.

Machine Learning Pipeline

This project builds a machine learning pipeline that enables further expansions and implementations, demonstrating as a proof-of-concept the potential of the methodologies.

20K

Rating Downgrades

\$34M

Value at Risk

\$13B

Reserves

Future Direction



Real-time credit risk dashboard

The model output can be visualized in a live dashboard for broader audiences



Refine hazard simulation models

The model parameters can be better tuned to project different scenarios more accurately



Integration with other risk models

Our model can be integrated with other risk assessment models to streamline the workflow

“The hardest thing in the world is to simplify your life.
It’s so easy to make it complex”

----- Yvon Chouinard

“I’m as proud of many of the things we haven’t done as
the things we have done.”

----- Steve Jobs