

Earthquakes Risk Modelling with Quantile Approach

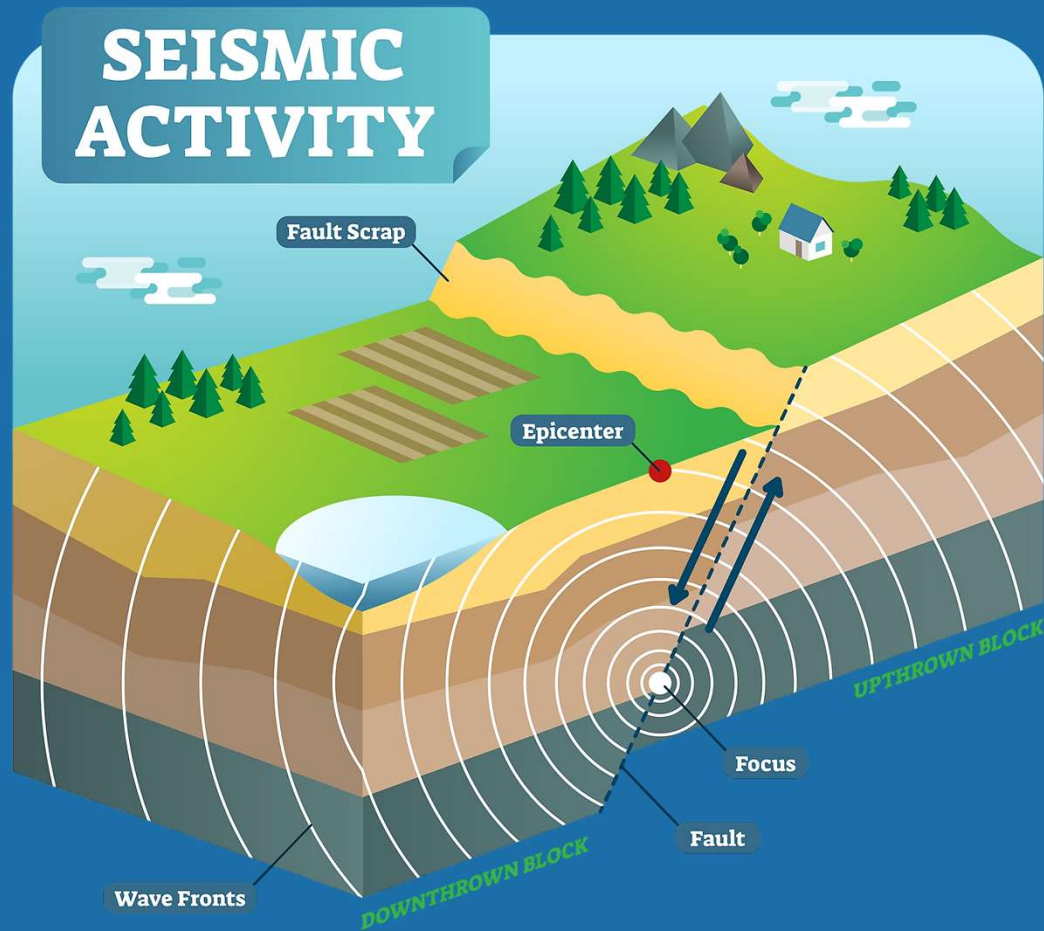
Insurance Data Science Conference, London
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Github repository:

https://github.com/claudio1975/Earthquakes_Risk_Modelling





Some questions to understand the earthquake event:

-What is an earthquake and how does it work?

-Why does it happen?

-Why Insurance Companies are interested in study the event?

A really short introduction of Quantile Regression

Quantile regression is a statistical method that estimates the relationship between a response variable and one or more predictor variables at different quantiles of the response distribution. Unlike mean regression, which estimates the conditional mean of the response variable given the predictor variables, quantile regression estimates the conditional quantiles of the response variable.

Mean regression



$$Q(\beta) = \sum_{i=1}^n (y_i - x_i\beta)^2 = \sum_{i=1}^n e_i^2$$

Median regression



$$Q(\beta) = \sum_{i=1}^n |y_i - x_i\beta| = \sum_{i=1}^n |e_i|$$

Quantile regression



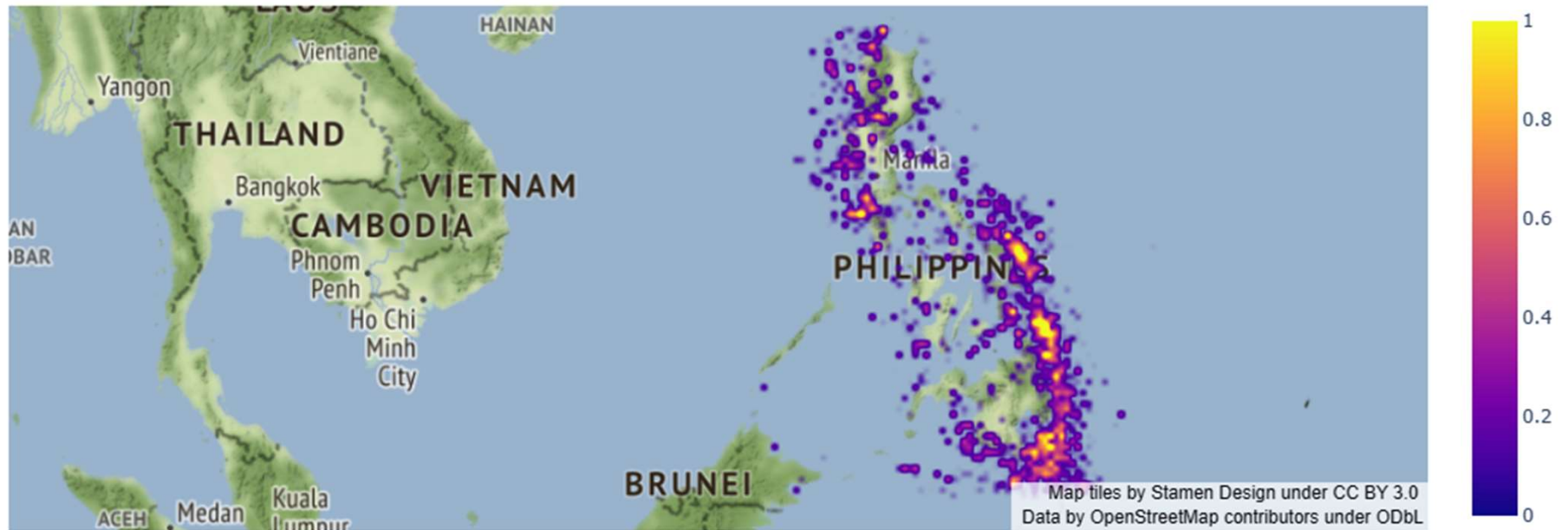
$$Q(\beta_q) = \sum_{i=1}^n q|y_i - x_i\beta| + \sum_{i=1}^n (1 - q)|y_i - x_i\beta|$$

Project workflow



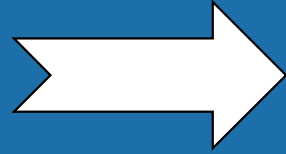
Use case: Predict Magnitude Philippine Earthquakes

Earthquake Magnitude Geographical Distribution

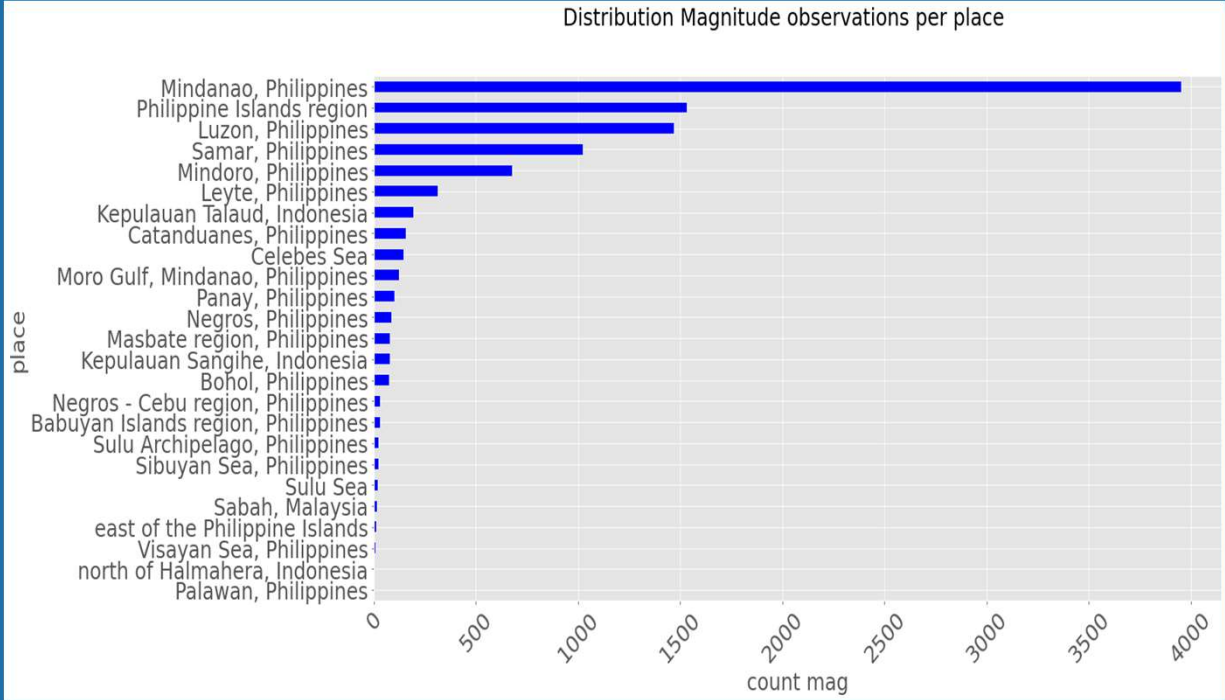


Insurance
Data
Science

Data Set Structure



Columns	Dtype	Count
Latitude	num	10188
Longitude	num	10188
Depth	num	10188
Mag	num	10188
MagType	cat	10188
Place	cat	10188
Type	cat	10188
LocationSource	cat	10188
MagSource	cat	10188



Data Analysis

Min Magnitude per place



	place	mag	depth	year	month	day	hour
0	Samar, Philippines	3.0	33.0	1998	4	22	19
1	Philippine Islands region	3.1	10.0	1992	4	3	19
2	Luzon, Philippines	3.2	10.0	1994	6	9	7
3	Mindanao, Philippines	3.3	33.0	1997	11	27	20
4	Mindanao, Philippines	3.3	85.8	1988	5	4	4
5	Celebes Sea	3.3	390.3	2007	3	4	14
6	Panay, Philippines	3.4	119.0	1986	2	9	16
7	Luzon, Philippines	3.4	73.4	2008	8	25	20
8	Philippine Islands region	3.5	33.0	1998	3	25	22
9	Luzon, Philippines	3.5	5.0	1993	6	26	6

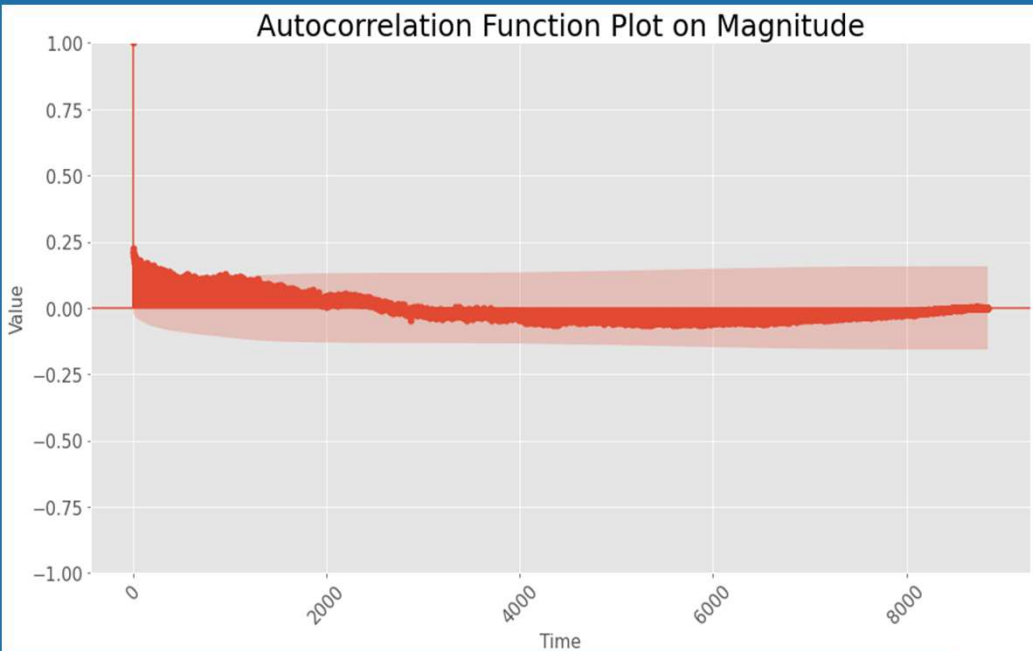
Max Magnitude per place



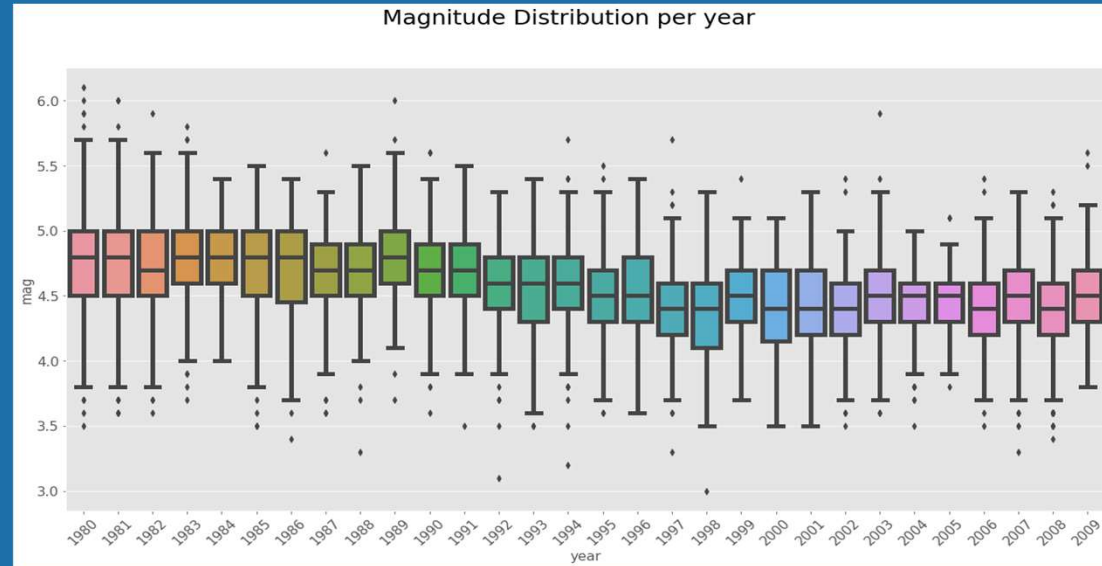
	place	mag	depth	year	month	day	hour
0	Mindanao, Philippines	6.1	104.0	1980	2	29	11
1	Mindanao, Philippines	6.0	63.0	1980	1	2	20
2	Mindanao, Philippines	6.0	33.0	1989	12	15	18
3	Philippine Islands region	6.0	145.0	1981	5	13	1
4	Bohol, Philippines	6.0	644.5	1981	9	4	11
5	Moro Gulf, Mindanao, Philippines	5.9	583.5	2003	5	26	23
6	Catanduanes, Philippines	5.9	33.0	1982	1	11	6
7	Mindanao, Philippines	5.9	49.0	1980	4	13	5
8	Mindanao, Philippines	5.9	178.0	1980	7	8	4
9	Mindanao, Philippines	5.8	114.0	1980	1	3	20

Time Series Analysis

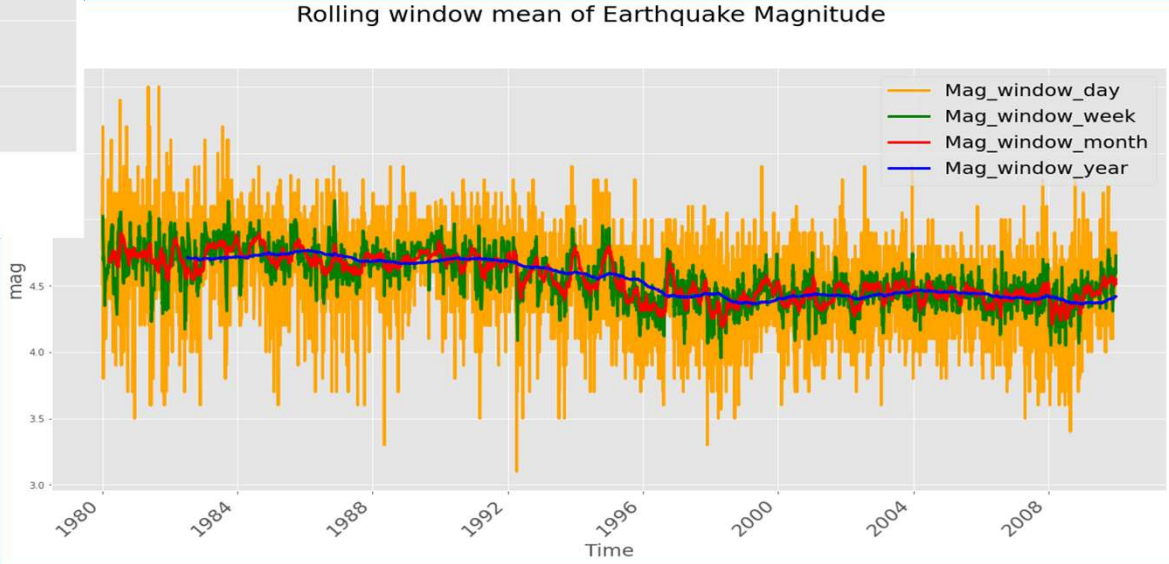
Autocorrelation Function Plot on Magnitude



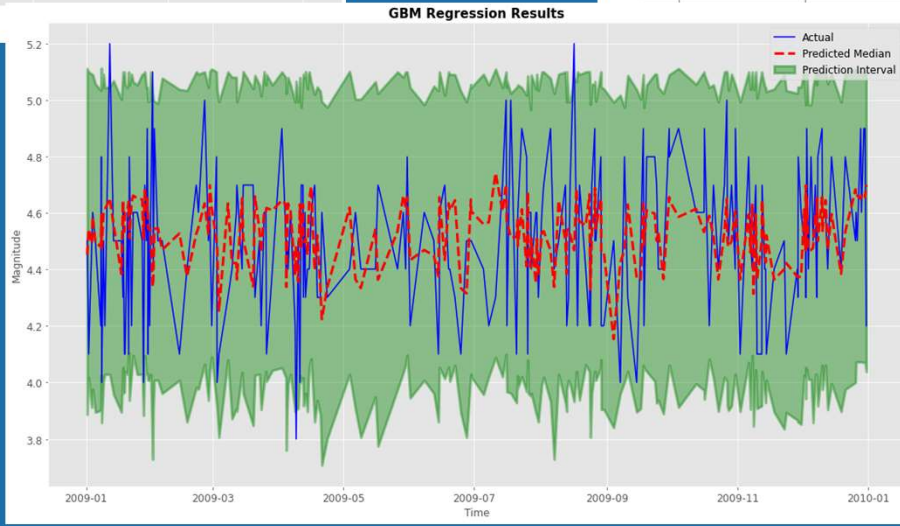
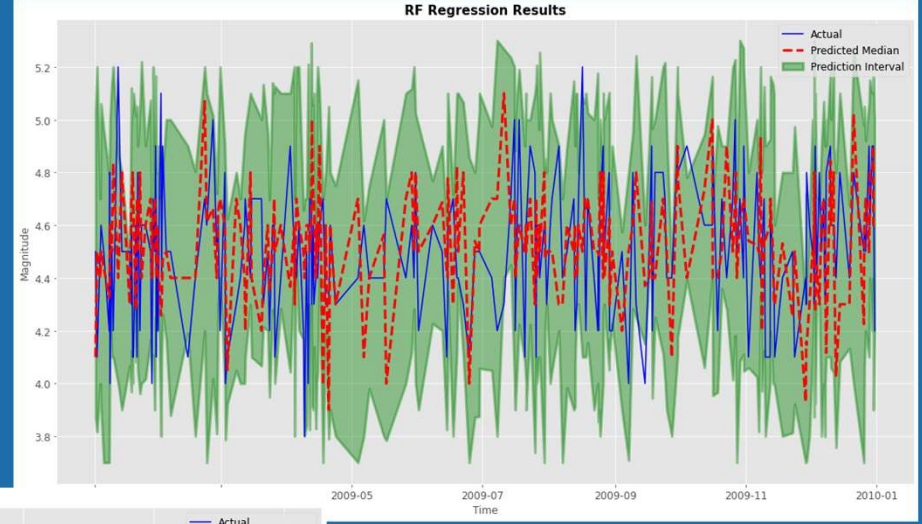
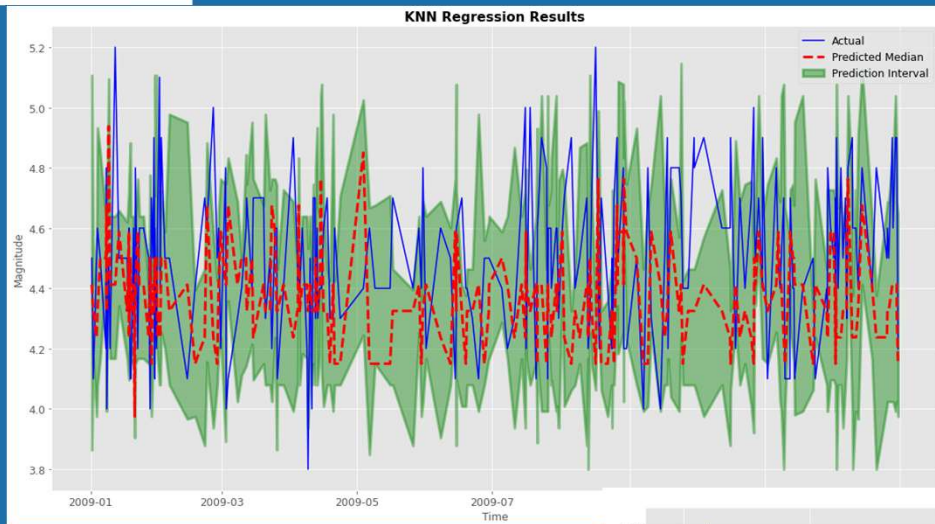
Magnitude Distribution per year



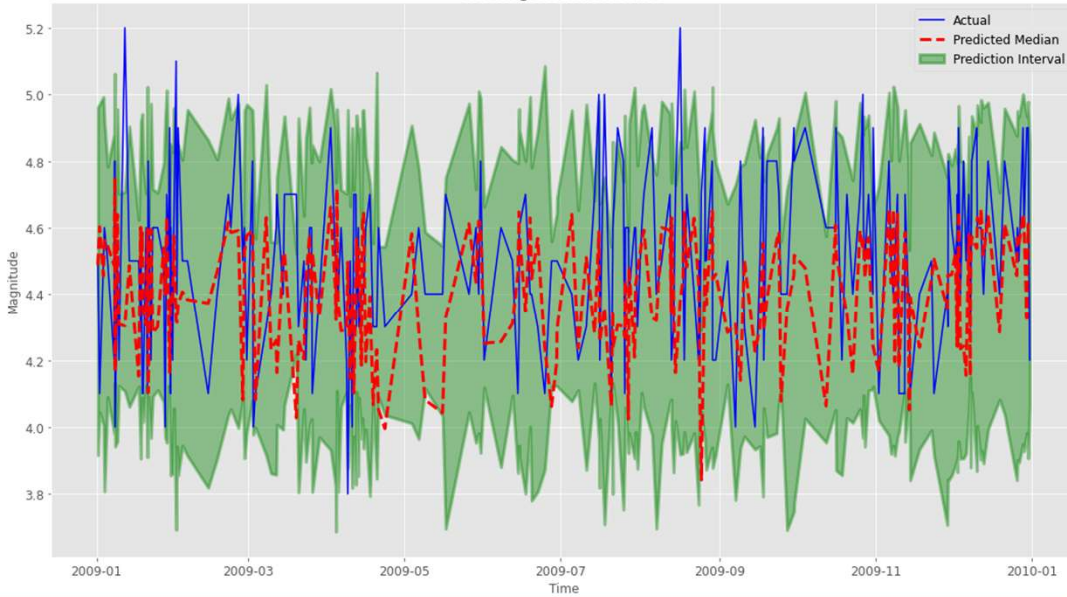
Rolling window mean of Earthquake Magnitude



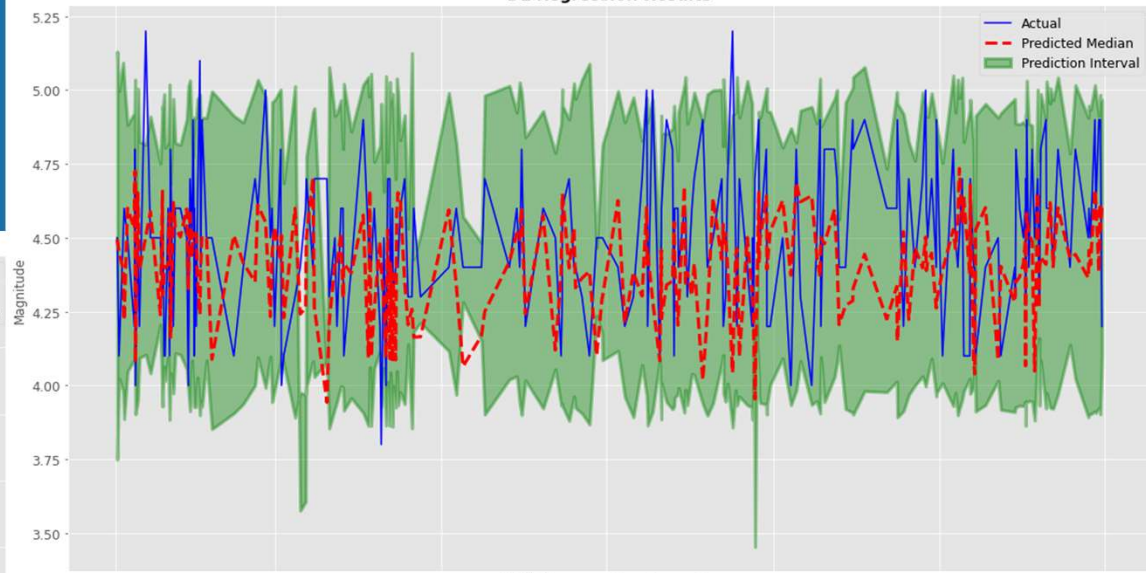
Projection Results



NN Regression Results



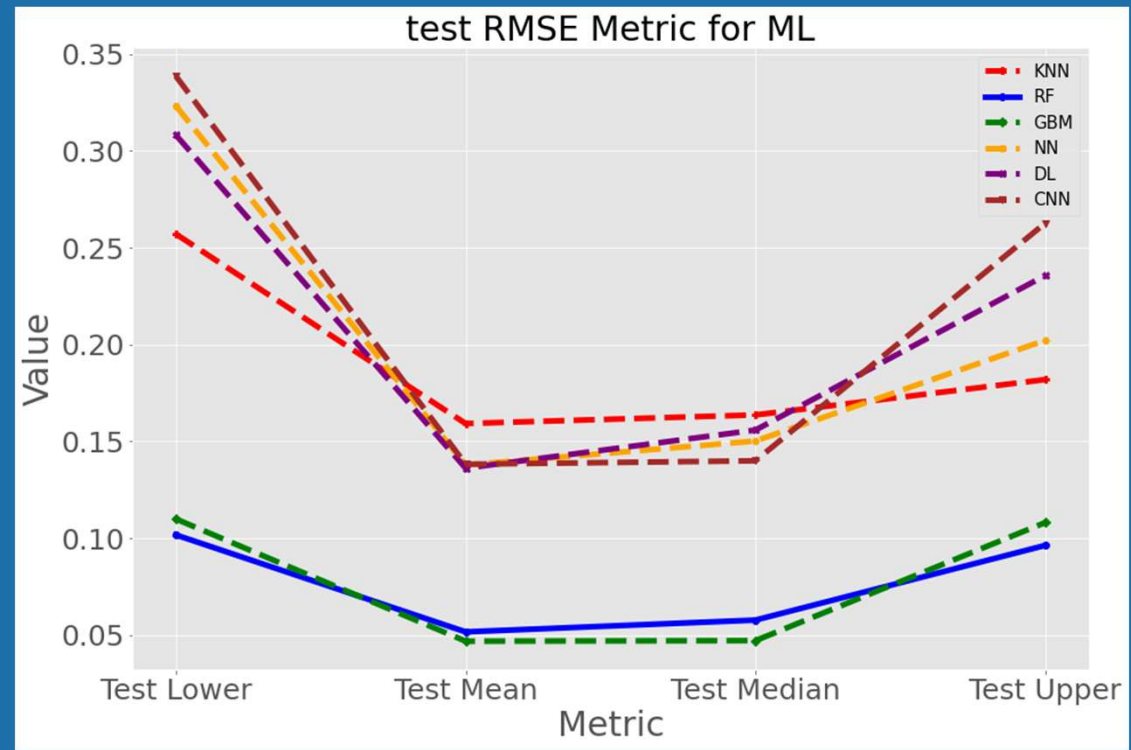
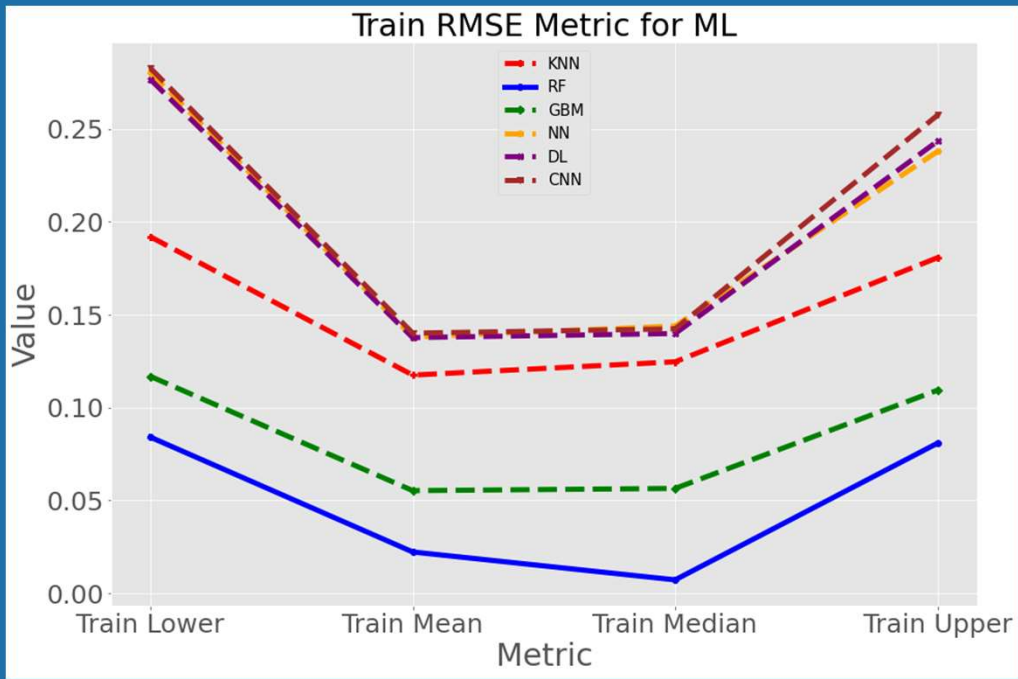
DL Regression Results



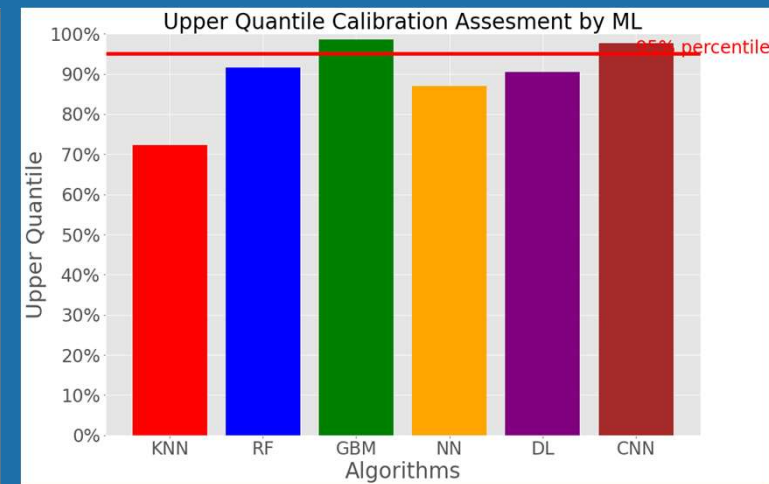
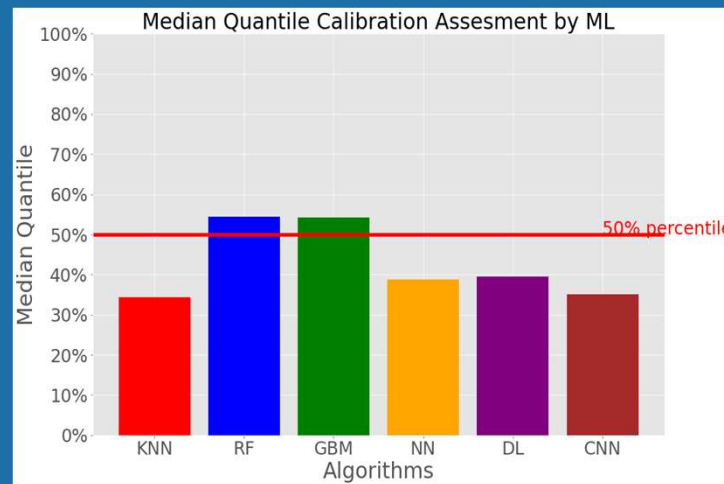
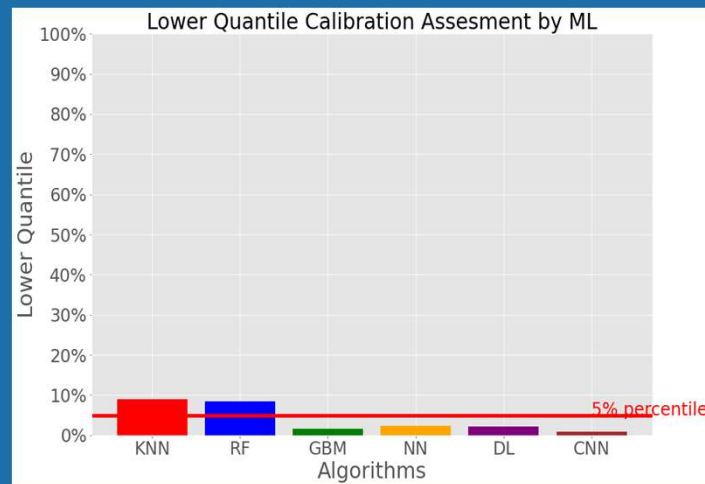
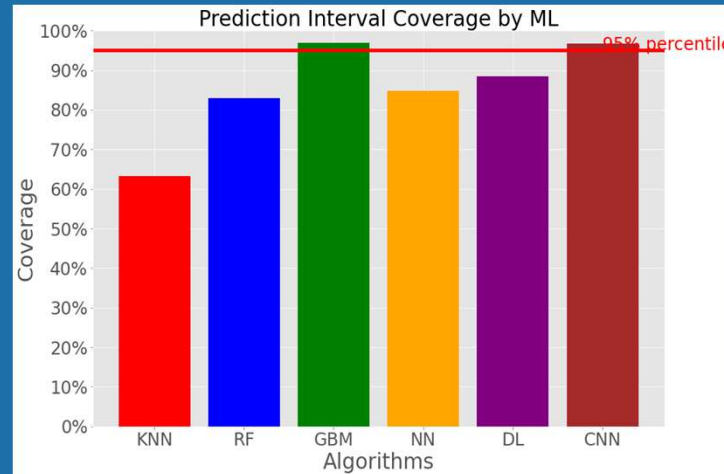
CNN Regression Results



Evaluation Results



Quantile Calibration Assessment



KNN

RF

GBM

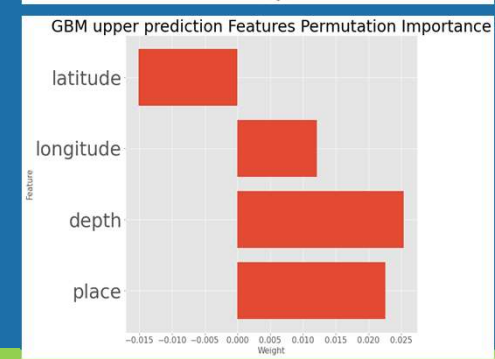
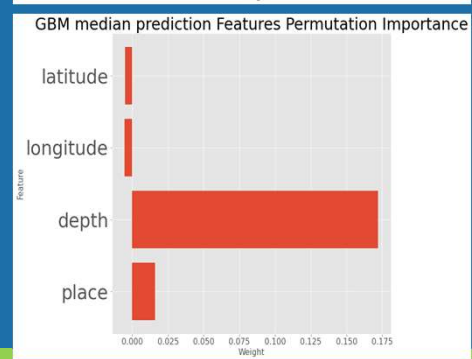
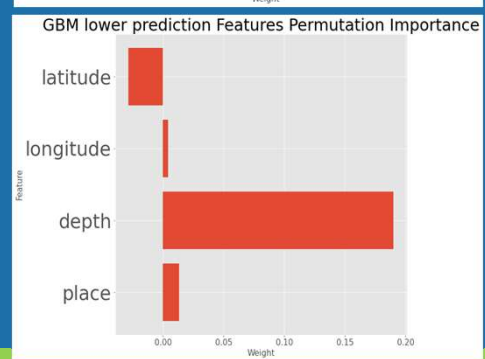
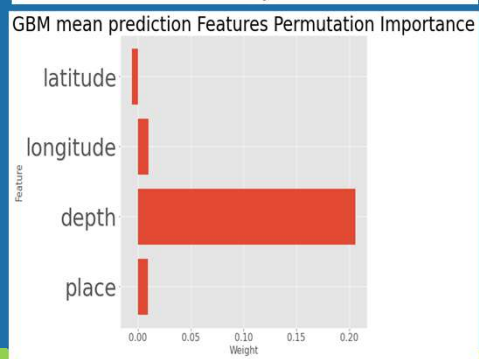
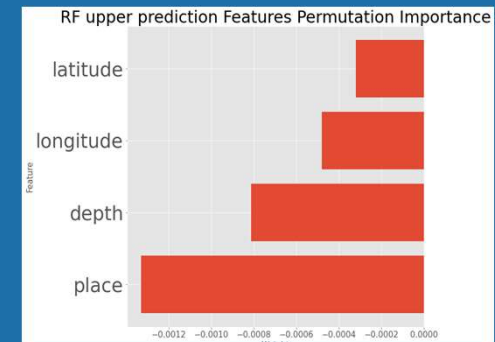
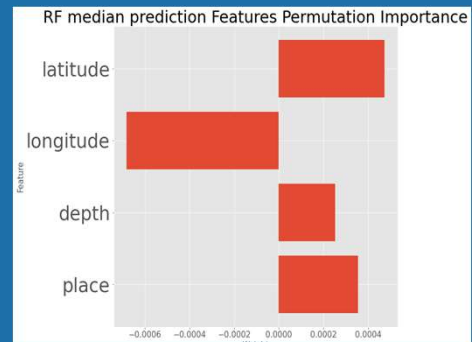
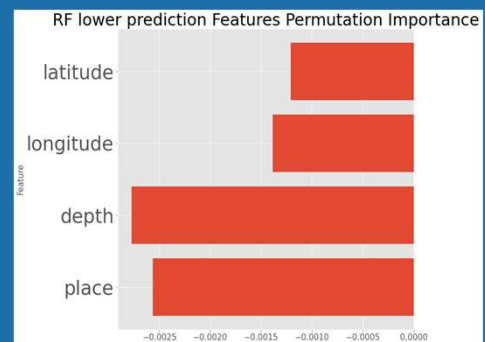
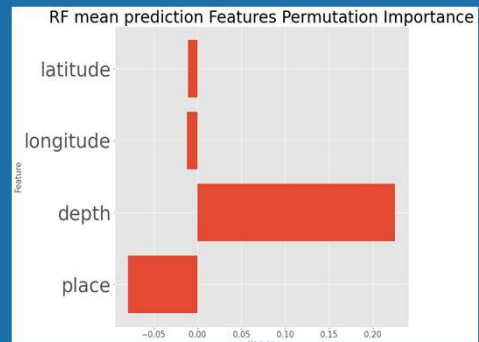
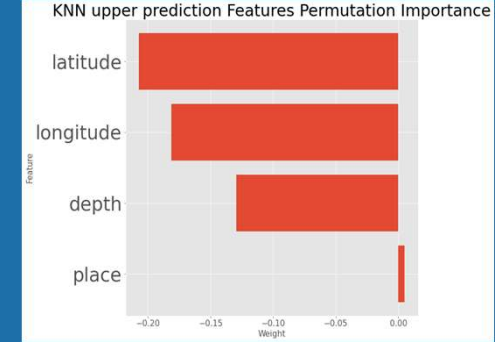
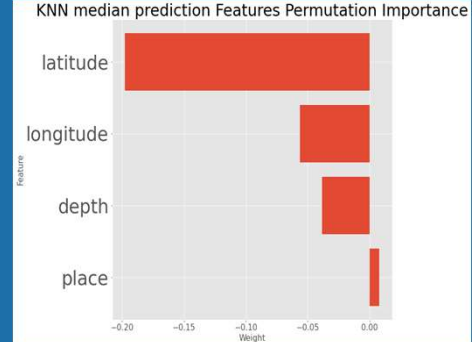
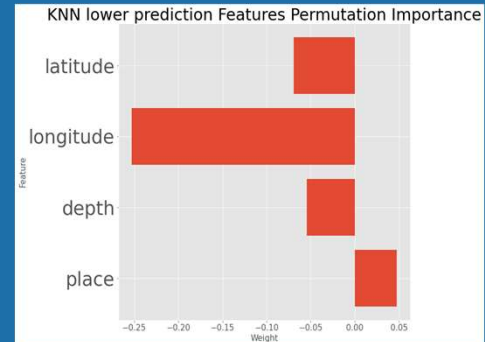
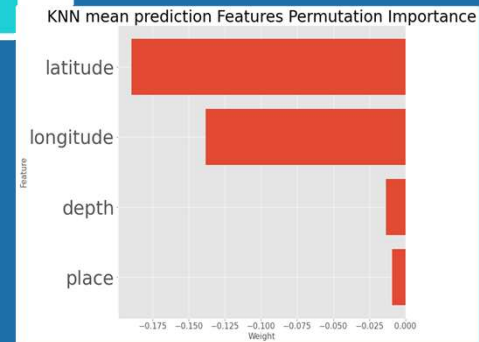
Feature Importance

mean prediction

lower prediction

median prediction

upper prediction



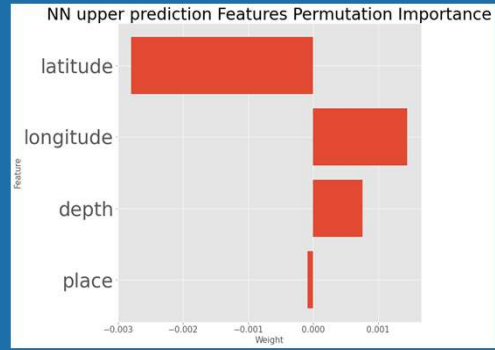
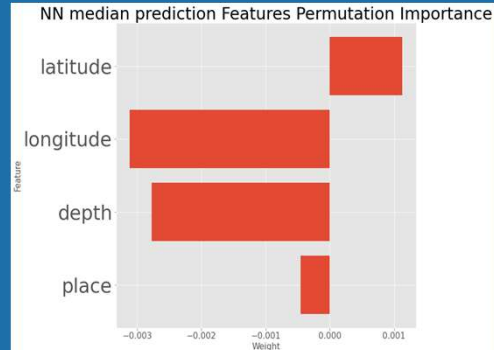
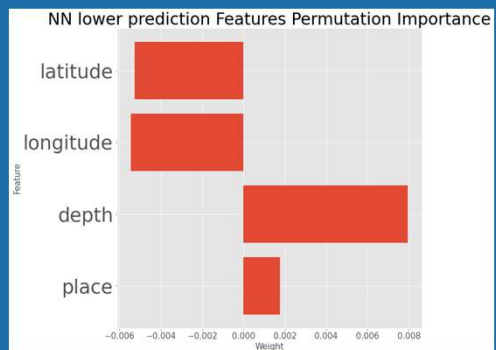
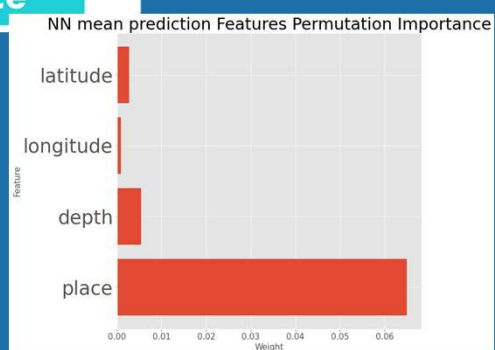
mean prediction

lower prediction

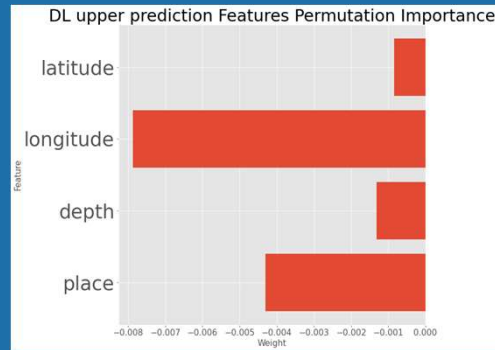
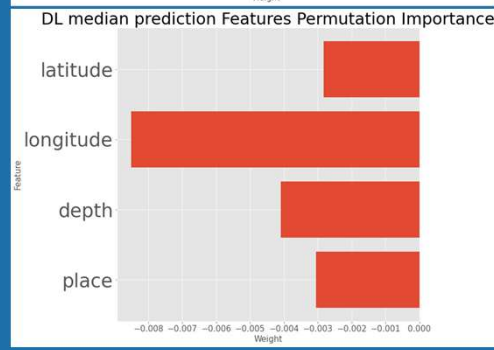
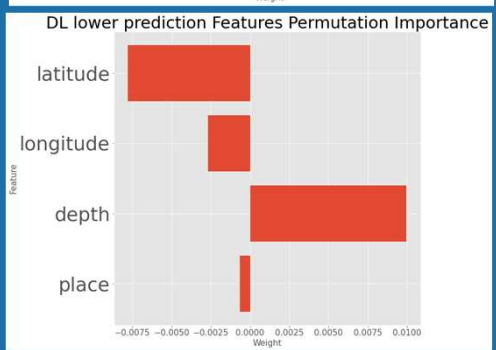
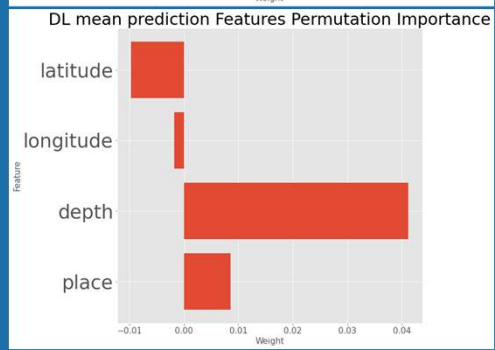
median prediction

upper prediction

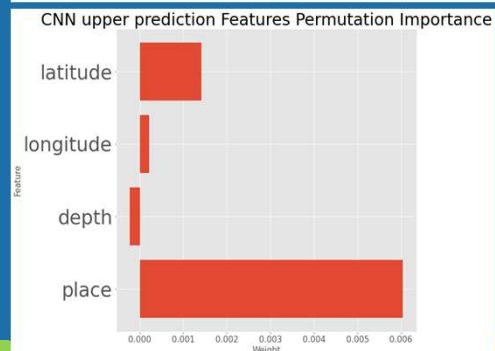
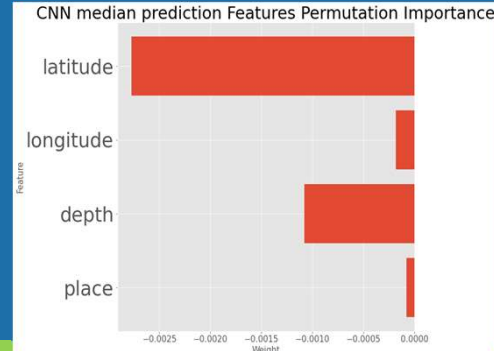
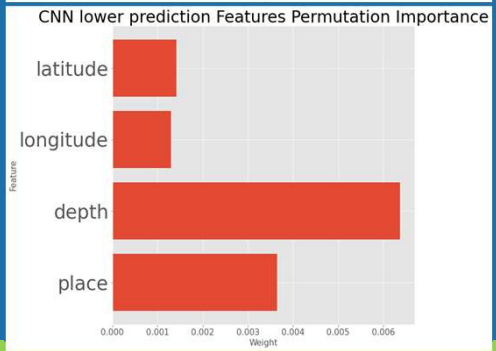
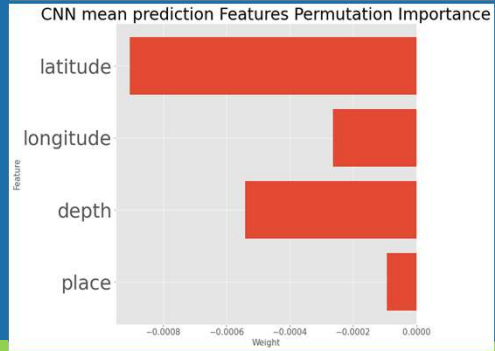
NN



DL



CNN



What I learned

- For extreme events, more data, better quality data and more features are required to perform better predictions and to better comprehend the phenomenon.**
- Quantile regression is able to handle the uncertainty associated with the prediction of the event.**
- There is no single model that performs well at every quantile point.**

References

- M. H. A. Banna et al. (2020). “Application of Artificial Intelligence in Predicting Earthquakes: State-of-the-Art and Future Challenges”, IEEE
- J. Pai, L. Yunxian, A. Yang, C. Li (2022). “Earthquake parametric insurance with Bayesian spatial quantile regression”, Insurance: Mathematics and Economics
- P.J. Brockwell, R.A. Davis (2016). “Introduction to Time Series and Forecasting”, Springer
- S. Akkar, A. Ilki, C. Goksu, M. Erdik - Editors (2020). “Advances in Assessment and Modeling of Earthquake Loss”, Springer
- M. Merz, T. Fissler, M. V. Wuthrich (2021). “Deep Quantile and Deep Composite Model Regression”, arXiv
- M. Merz, R. Richman, A. Tsanakas, M. V. Wuthrich (2021) “Interpreting Deep Learning Models with Marginal Attribution by Conditioning on Quantiles”, SSRN
- V.F. Pisarenko, D.V. Pisarenko (2021). “A Modified k -Nearest-Neighbors Method and Its Application to Estimation of Seismic Intensity”, Springer

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