Tsunami Early Warning

Yao Li *supervised by* Katsu Goda

Department of Statistical and Actuarial Sciences, University of Western Ontario

yli3285@uwo.ca

Abstract

This study uses both the traditional attributes, which is earthquake magnitude and location, and pluses the tsunami height collected by detecting stations to estimate the height of a tsunami on the coast. The result accuracy indicates the tsunami height data collected by the off-shore stations could be used to estimate reliable and robust tsunami source model for tsunami warning purposes.

Key words: tsunami, early warning, off-shore station, on-shore station, real-time tsunami height data

Introduction

Tsunami can cause a great disaster to a coastal region. If one can forecast the arrival of the tsunami ahead of time, it will greatly reduce the losses caused by the tsunami. This study focuses on forecasting the tsunami triggered by an earthquake. The Japan Meteorological Agency (JMA) is responsible for issuing the tsunami warnings in Japan. JMA originally used earthquake's magnitude and location, to forecasting the tsunami. However, only knowing where and how strong the earthquake is may not sufficient to forecast the tsunami. The 2011 Tohoku earthquake, an Mw 9.0 undersea mega-thrust event, is an example. To improve the accuracy of tsunami forecasting, detecting stations is used.

In this study, 119 detecting stations were used, and real-time data simulated in 8 different earthquake magnitude cases from 1 minute to 120 minutes. This study aims to find how well the tsunami model will be if the data which collected by the stations will be used.

Methodology

Data:

- The study area is Tohoku, Japan
- Total 4000 stochastic earthquake source models
- 119 stations record the tsunami height

$$Height = \beta 1 \times \text{Earthquake} + \beta 2 \times \text{Station}$$

Method:

- Multiple Linear Regression to fit model

Using a serious of input to predict the interested response variable

- Forward Selection + Knee Point to select best stations

Using AIC score to reward models with low error but also penalize redundant variables so that the model is not overfitting and find the most efficient number of stations at the knee point

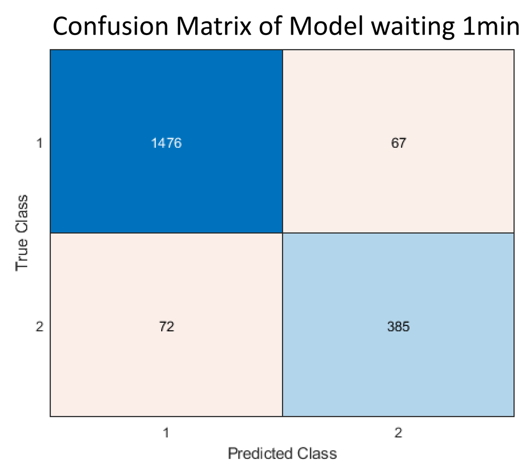
- Confusion Matrix to evaluate performance

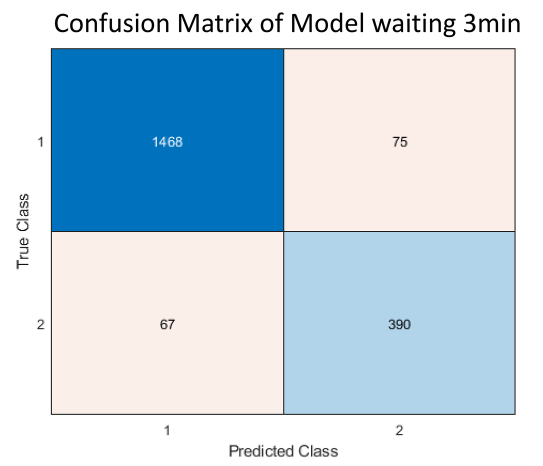
Results

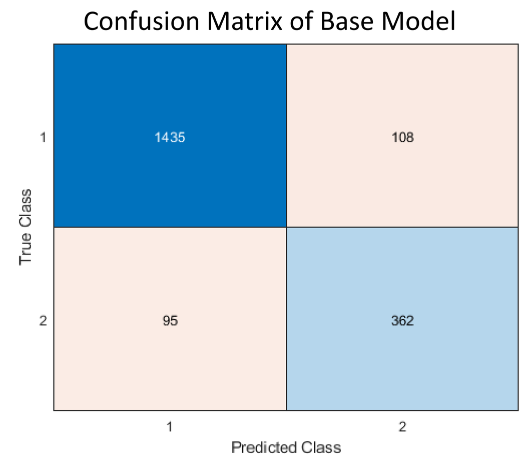
	Base Model	1 min	3min	5min	10min
2 Classes Accuracy	89.85%	93.05%	92.90%	93.40%	92.70%
5 Classes Accuracy	72.95%	78.1%	78.35%	77.65%	78.85%

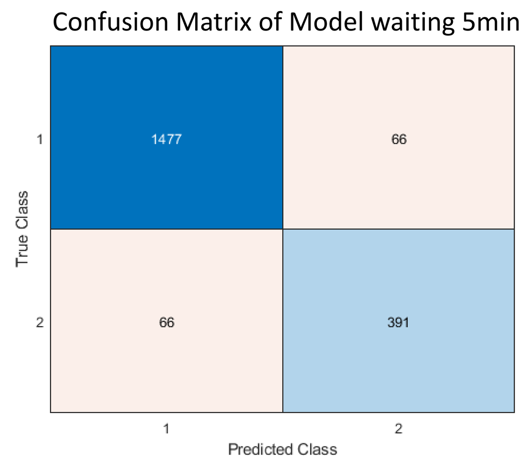
The tsunami height is cut in 2 classes:

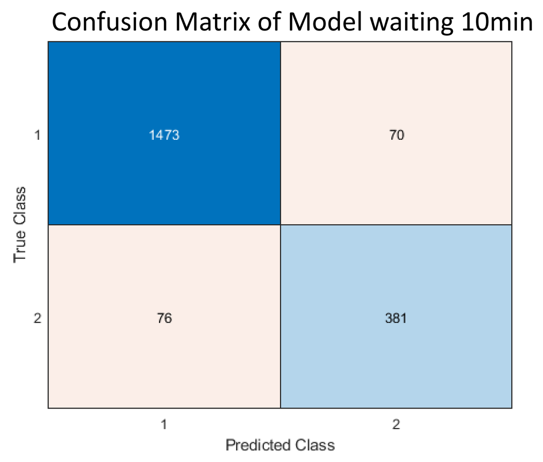
CLASS 1: height < 3m
CLASS 2: height ≥ 3m





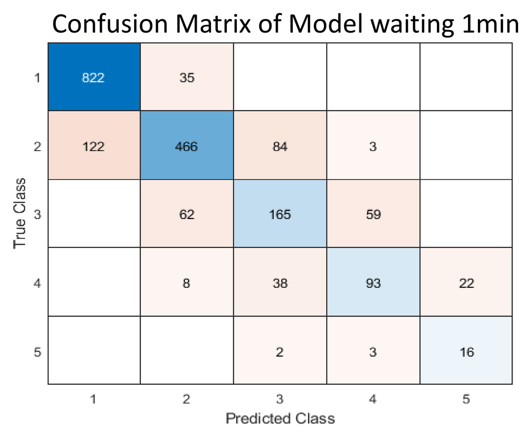


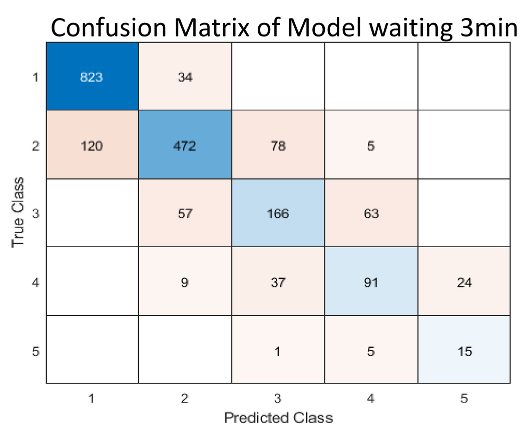


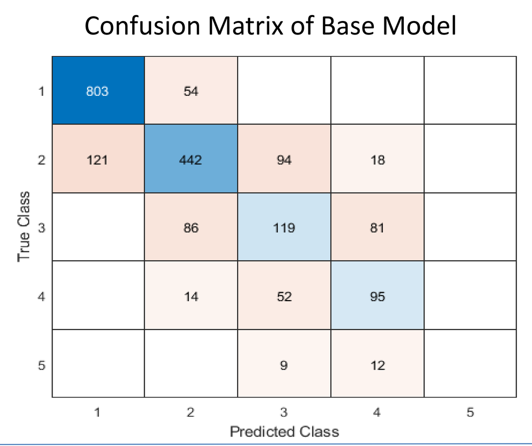


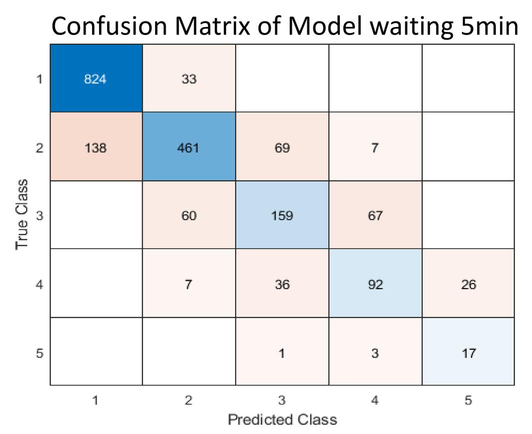
The tsunami height is cut in 5 classes:

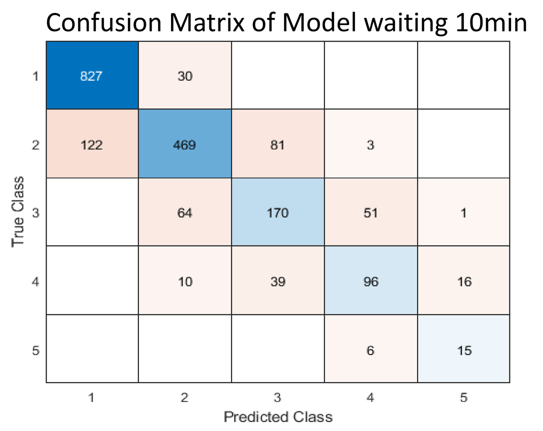
CLASS 1: height < 1m
CLASS 2: 1m ≤ height < 3m
CLASS 3: 3m ≤ height < 5m
CLASS 4: 5m ≤ height < 10m
CLASS 5: height > 10m

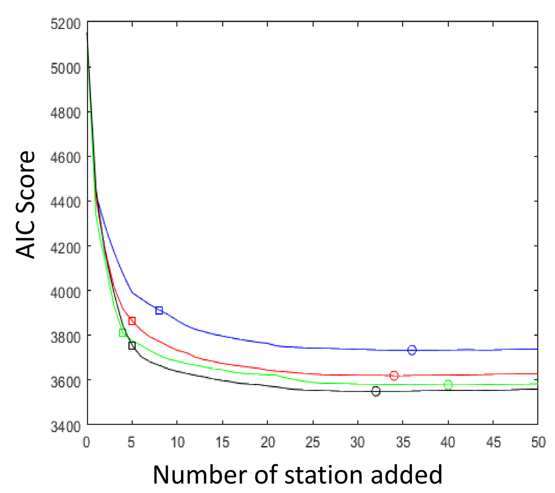




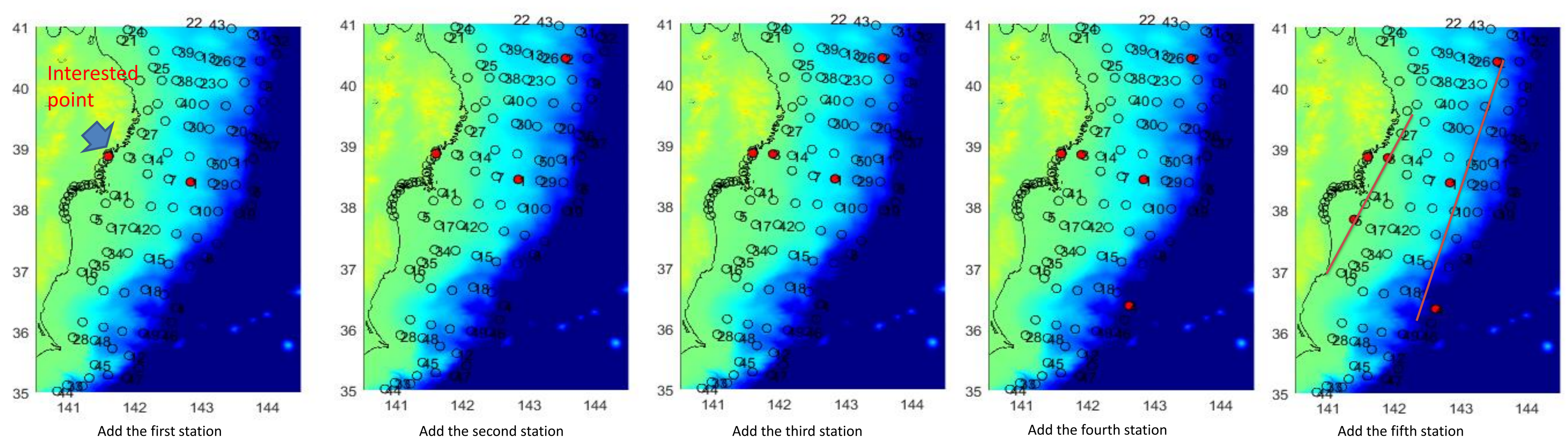






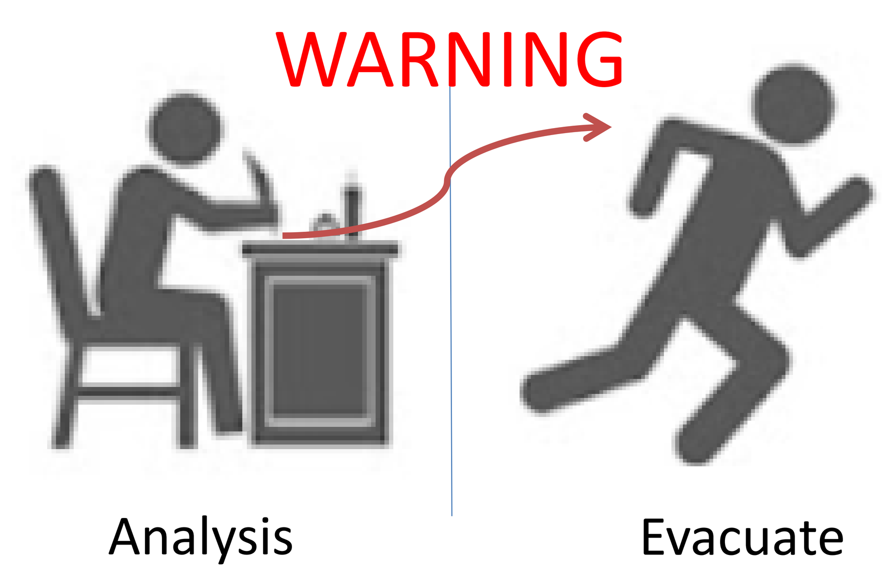


The left figure indicates that the knee point is around 5 stations. So, the location of the first 5 stations are plotted below and in a selected order. The shape of the selected stations are like two layers, one is far and the other is close to landside.



Discussions / Future works

- Time trade-off



More time spend on analysis will lead to more accurate warning but also will reduce the amount of time for evacuation.

- Test different onshore location

There are 20 on-shore stations can be used as interested point. So, next step is changing the location of the interested point and see how the model will work

Conclusion

The performance of those model that using the information provided by off-shore stations is better than the base model which only uses earthquake's magnitude and location to forecasting the tsunami. The five classes confusion matrixes show that the base model can not forecast any tsunami whose height is over than 10 meters. That is to say using off-shore stations can improve the accuracy especially when mega tsunami is triggered. The tsunami height data collected by the off-shore stations could be used to estimate reliable and robust tsunami source model for tsunami warning purposes.