Tufts UNIVERSITY | School of Engineering

Geospatial Liquefaction Hazard Model for Tokyo Bay, Japan

Introduction

In recent years there have been many devastating earthquakes which caused great economic loss, loss of life and tremendous damage to structure and infrastructure.

On March 11th 2011, the Great East Japan Earthquake was generated along the northeast of the Japan Trench with ruptured fault as large as 500 km × 250 km. This was the largest earthquake ever recorded in Japan and one of the five most powerful earthquakes in the world since modern recording began in 1900. In Kanto region including Tokyo bay area it has been observed that wide range of soil liquefaction was recorded mainly at the waterfront along the shore(Yasuda and Harada 2011; Bhattacharya et al., 2011).

In our study we are going to compare the predicted liquefaction with the observed liquefaction using geospatial data like Surface roughness, Shear wave velocity (Vs30), Peak ground acceleration (PGA) and Normalized Distance..

Project area

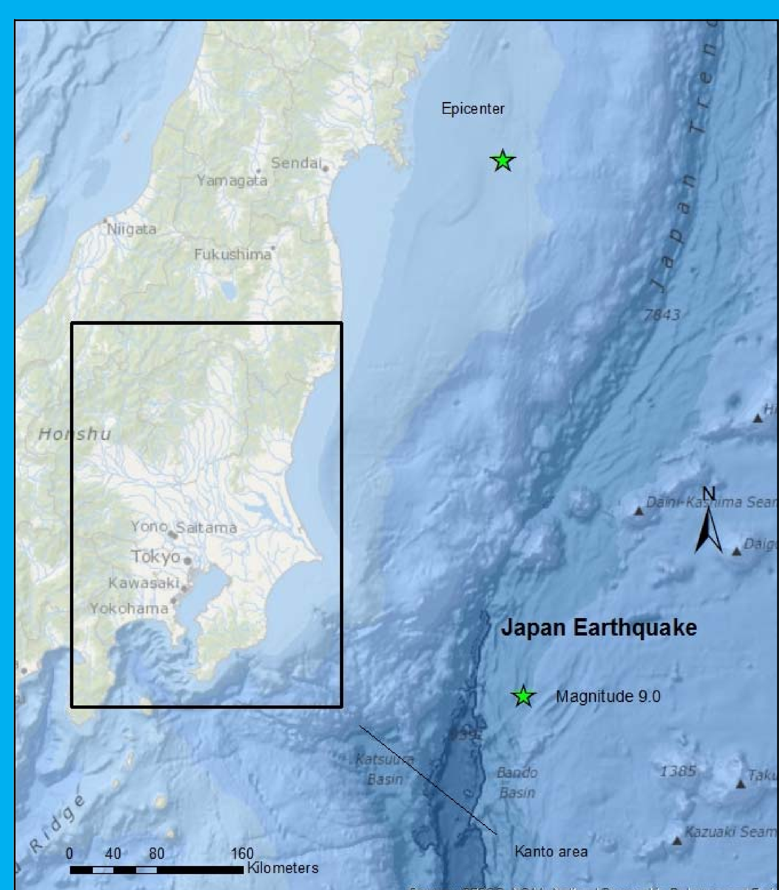

Figure 1

Methodology

1.Using the shake maps from USGS to generate a raster from polygon data.

2.Generating Vs30 raster from X Y points obtained from USGS Customized Mapping.

3. Calculating Topographic Index (TI) from the Japan DEM file with Geomorphometry and Gradient Toolbox.

4.Calculating Normalized Distance using the formula

$$ND = \frac{\text{Distance to Coast}}{\text{Distance to Coast} + \text{Distance to Mountain}}$$

5.Using the four variables PGA, Vs30,TI and Normalized Distance into the following equation.

X = 9.091390 + 1.512846 * ln (PGA) + 0.184749 * TI— 10.619602* ND -1.999176 * ln (Vs30)

6.Calculating the probability of Liquefaction using the following equation

Probability = 1/(1+Exp(-X))

Where :

PGA— Peak Ground Acceleration (g)

TI— Topographic Index

ND—Normalized Distance

Vs30—Shear Wave Velocity

Model Development

Age | Density | Saturation | Intensity

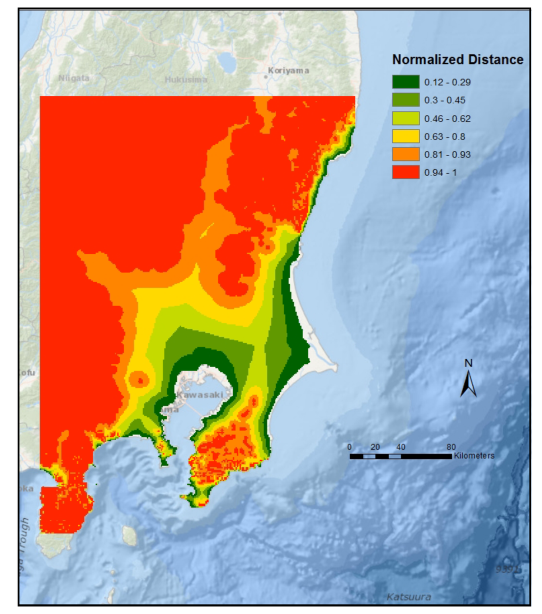

Figure 2

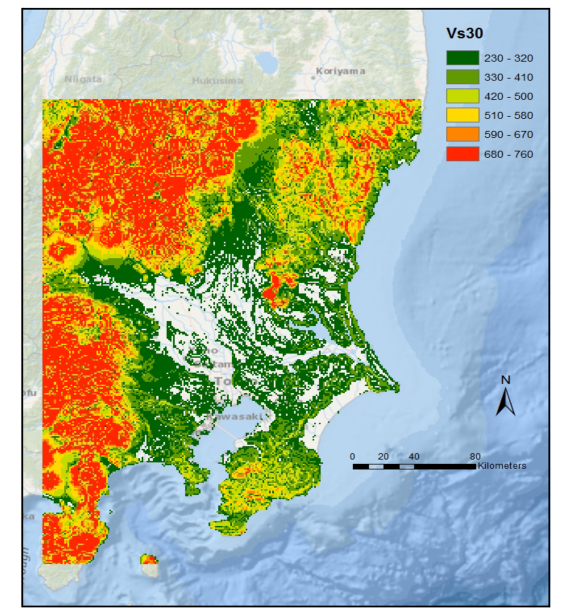

Figure 3

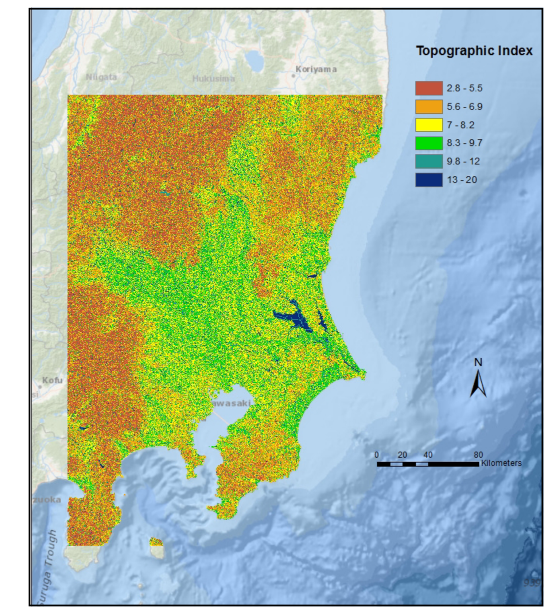

Figure 4

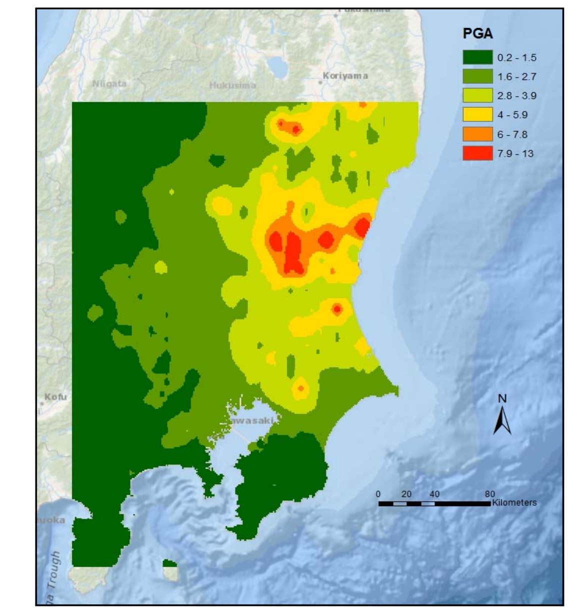

Figure 5

Normalized Distance

- Uses the soil/rock classification
- Distance to mountain calculated using Vs30 data
- ND= $\frac{D_{coast}}{D_{coast} + D_{mountain}}$

Shear Wave Velocity

- Generated from customized Vs30 mapping on USGS
- Displaying X Y points and converting it into raster

Topographic Index

- A hydrologic parameter for saturation
- Derived from DEM 90 m resolution
- Using the Geomorphometry and Gradient Toolbox

Peak Ground Acceleration

- Predefined shake maps from USGS
- Conversion of polygon data to raster image

Probability Calculation

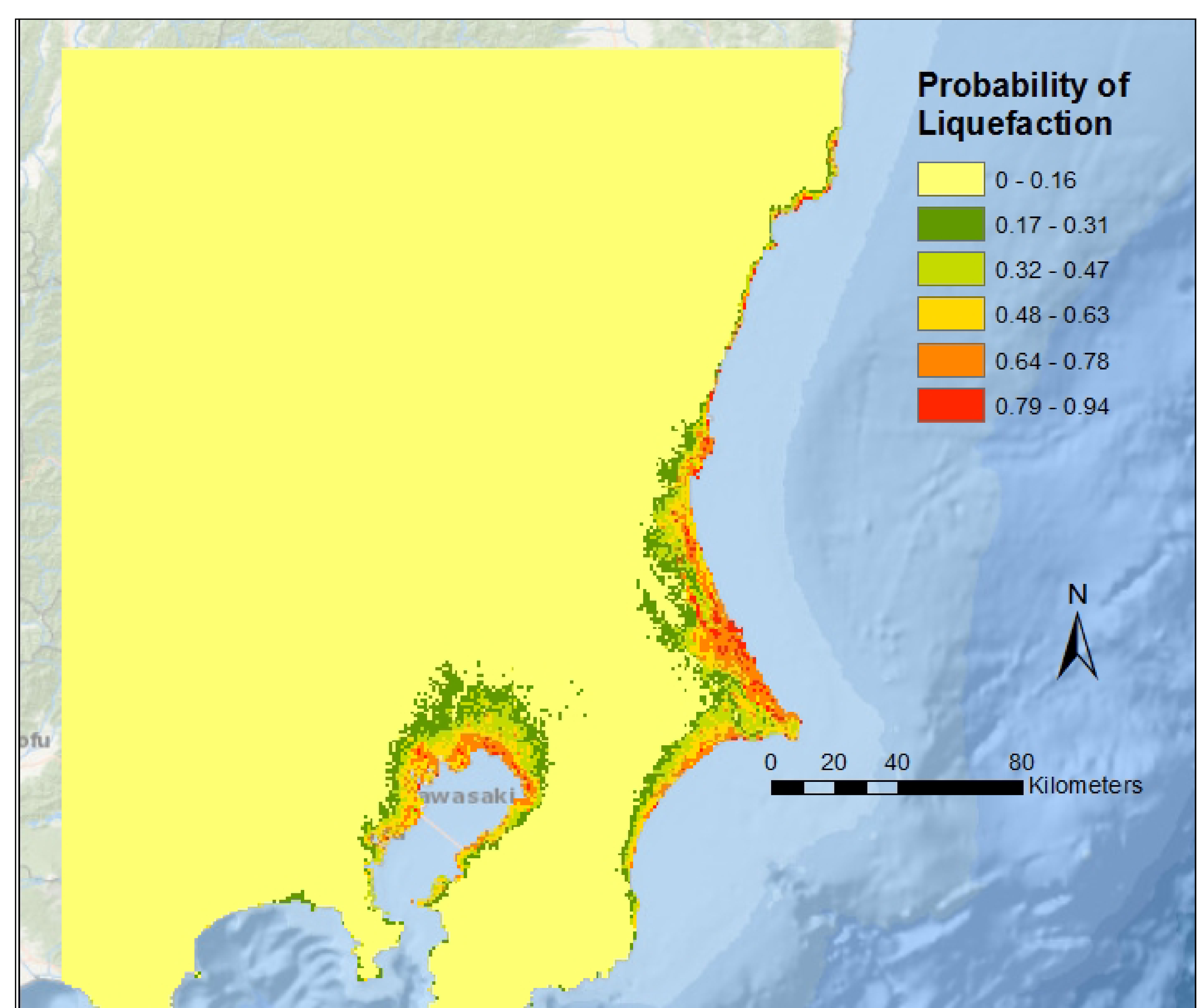

Figure 6—Predicted Liquefaction

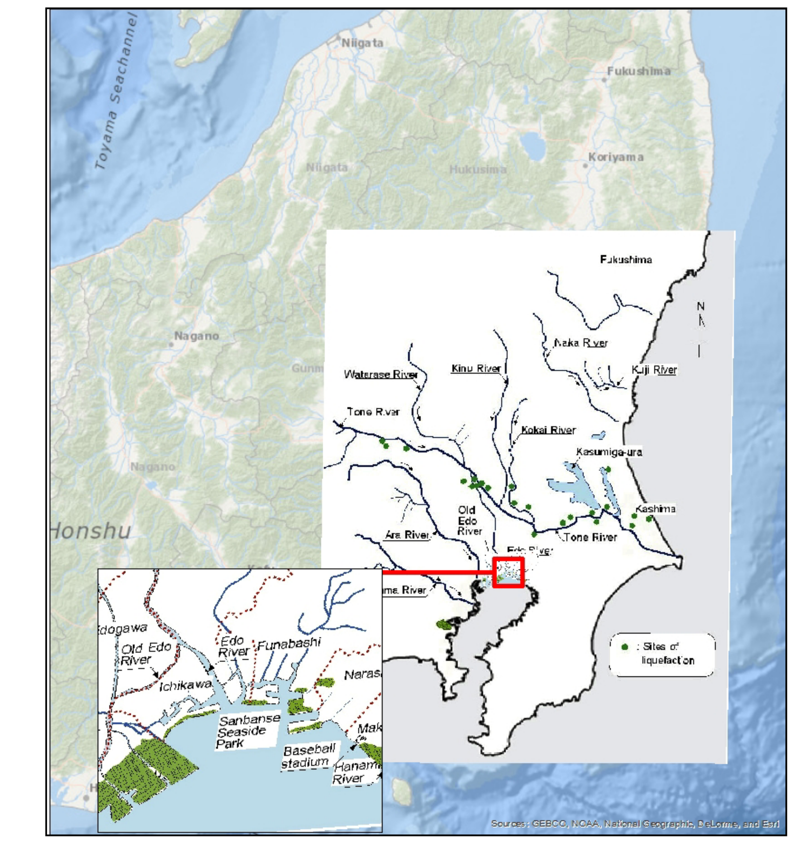

Figure 7– Observed Liquefaction

Result

1)The maps generated are the various variables used and Fig.6 is the predicted liquefaction according to the geospatial data and Fig.7 is the observed liquefaction.

2) As we can see that the predicted liquefaction hazard map developed by using the geospatial data is compared to the map of Kenji Ishihara.

Conclusion

1)We observe that the geospatial data gives a good comparison with the observed liquefaction in the Tokyo Bay area.

2) If there were some river layers that could have been used in the analysis we could have generated far better results.

3)Widespread liquefaction was observed in the Tokyo bay area especially in the zones of reclaimed land, fill areas or sites having young alluvium.

Cartographer : Sagar D. Shetty for CEE 187 December 2012

Department of Civil and Environmental Engineering

Coordinate System: WGS_1984_Web_Mercator_Auxillary_Sphere

Data Source : USGS, National Geographic Data Center, ArcGIS online

References

1)A Geospatial Liquefaction Model by Davene J. Daley

2)Liquefaction of soil in the Tokyo Bay area from 2011 Tohoku (Japan) earthquake by S. Bhattacharya, M. Hyodo, K. Goda, T. Tazoh, C.A. Taylor

3) Liquefaction in Tokyo Bay and Kanto regions in the 2011 Great East Japan Earthquake by Kenji Ishihara

4) Geologic and geomorphic evaluation of liquefaction case histories for rapid hazard mapping by K. Knudsen and J. Bott