Simulation-based disaster risk analysis using data science techniques

Shuji Moriguchi[1], Kenjiro Terada[2], Hasuka Kanno[3] and Kenta Tozato[4]

1. Research interests

Numerical simulations are becoming more and more important for disaster risk reduction. However, highly developed numerical methods generally have high computational costs. In fact, a number of simulation cases are needed to properly evaluate disaster risk due to uncertainties and variabilities involved in disasters. It is, therefore, necessary to obtain meaningful information from minimum number of calculation cases. Our research group is now trying to maximize the potential of disaster simulations with the help of various data science techniques.

Figure 1 shows an example of rockfall risk analysis in which the Gaussian Mixture Model (GMM) [1] is used to represent the spatial distribution of exceedance probability of the rockfall energy. In this example, based on the analysis results of rockfall paths and energy estimated by Discrete Element Method (DEM) [2,3], the spatial distribution of exceedance probability is obtained. In this study, the GMM, which is usually used for cratering data, is utilized to interpolate the simulated results in space.

Another example is a correlation risk analysis of tsunamis for multiple costal cities as shown in Fig. 2. In the illustrations, the maximum tsunami height is employed as a risk index, and the values are estimated with different combinations of input parameters by tsunami simulations. Response surfaces of the maximum tsunami height at selected coastal cities are then obtained from the simulated results, and then the Monte Calro (MC) simulation is performed to obtain sufficient number of results. The results of the MC are analyzed with the help of the Principal Component Analysis (PCA) to examine a correlation of tsunami risk between coastal cities.

2. Perspectives for collaboration

Possible collaborators in UW would be those who are interested in using data science techniques in the disaster risk analysis based on numerical simulations. Experimental research is also welcome because experimental results would be helpful to develop our research.

Acknowledgments:
The other contributors are: Takuma Kotani[a], Shinsuke Takase[b] (a:Tohoku University; b: Hachinohe Institute of Technology)

References:

1) McLachlan, G. J. and Basford, K. E., 1988. Mixture Models: Inference and Applications to Clustering, Marcel Dekker.
2) Cundall, P.A. 1971. A computer model for simulating progressive, Large scale movement in blocky rock systems. Proc. of intern. symp. on Rock Fracture, Ⅱ–8.
3) Cundall P. A. and Strack O. D. L., 1979. A discrete numerical model for granular material, Geotechnique, 29, pp.47-65.

[1] Associate Professor, International Research Institute of Disaster Science, Tohoku University, Japan (s_mori@irides.tohoku.ac.jp)
[2] Professor, International Research Institute of Disaster Science, Tohoku University, Japan (tei@irides.tohoku.ac.jp)
[3] Graduate Student, Department of Civil and Environmental Engineering, Tohoku University, Japan (hasuka.kanno.r7@dc.tohoku.ac.jp)
[4] Undergraduate Student, Department of Civil engineering and Architecture, Tohoku University, Japan (kenta.tozato.t2@dc.tohoku.ac.jp)

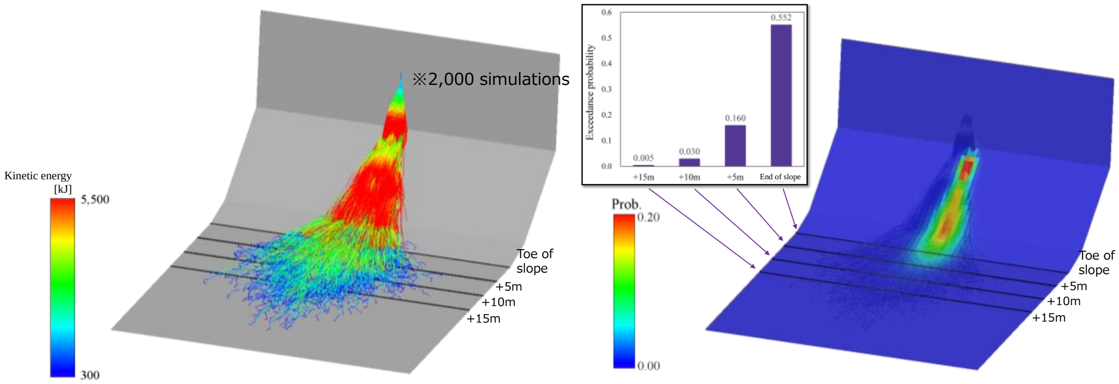
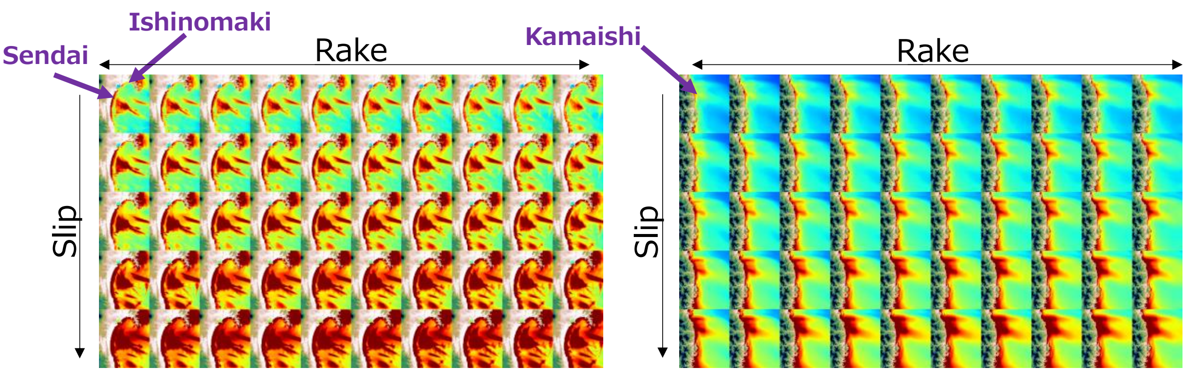
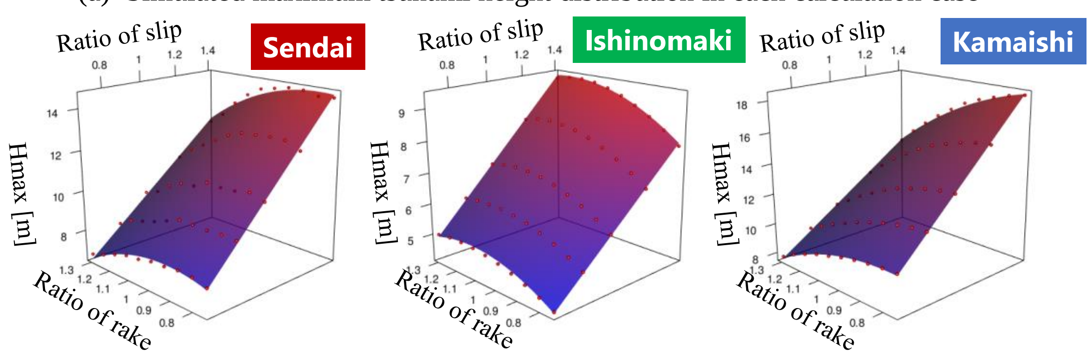


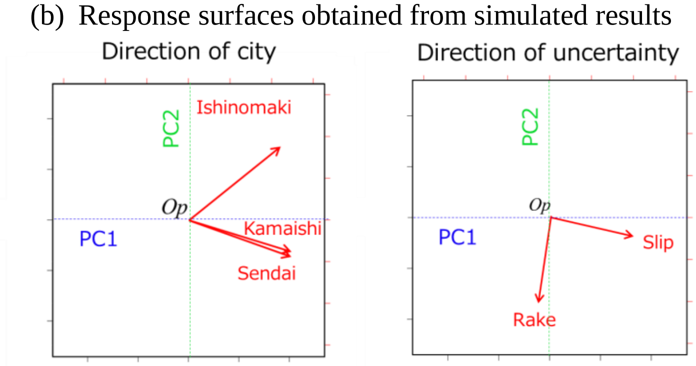
Fig. 1 Quantification of spatial risk distribution of rockfalls using Gaussian Mixture Model



(a) Simulated maximum tsunami height distribution in each calculation case



(b) Response surfaces obtained from simulated results



(c) Results of principal component analysis

Fig. 2 Tsunami risk analysis considering correlations among coastal cities