Potential Tsunami Scenarios in the Northeast Pacific from Stress Diffusion caused by the Tohoku-Oki Event in March 11, 2011.

David A. Yuen[1], Helen Huimin Jing[2], and David Lloyd George[3]

[1] School of Environmental Studies, China University of Geosciences, Wuhan, Hubei ,China and Department of Earth Sciences, University of Minnesota, Minneapolis, MN, U.S.A.

[2] Department of Mechanical Engineering, Ningbo University, Ningbo, Zhejiang, China

[3] U.S. Geological Survey, Volcanic Observatory, Vancouver, Washington, U.S.A.

The unexpected 2011 Tohoku-Oki earthquake and the attendant devastating tsunami have forced us to reevaluate traditional earthquake risk analysis methods, such as Gutenberg-Richter magnitude-frequency relationship, with an awareness of the possibilities of very large megathrust earthquakes and potential tsunami threats near subduction zones with extremely long length and the accompanying landslides. We emphasize here the importance of a thorough study on possible tsunami scenarios for hazard mitigation around the Northeast Asia. The Izu-Ogasawara Trench, also known as the Izu-Bonin Trench, stretches from Japan to the northernmost section of Mariana Trench, where the Pacific Plate is being subducted beneath the Philippine Sea Plate, as well as the Nankai Trench, are subduction zones with the potential for tsunamigenic earthquakes. John B. Rundle's stress forecasting analysis based on advanced pattern recognition techniques (http://www.openhazards.com/blogs/john), which reveals recently a sharp increase in the probability for stress-build up near Chi Chi Jima, suggests that western Japan and South Korea might be at risk of potentially large tsunamogenic earthquakes. We will conduct numerical experiments by using a series earthquakes with a range of magnitudes between M 8.5 and 9.0 along the Izu-Ogasawara Trench and Nankai Trench. The detailed modeling of inundation of small-scale coastal regions based on Geoclaw software can be utilized to estimate the area submerged by flood water along the coast. Run-up heights at various sites and tsunami hazards along the Korean Peninsula coast and Kyushu will be evaluated quantitatively from the run-up calculations. This work will provide some safety guidelines for the Korean and Japanese populace. The physical basis of this idea comes from stress diffusion in the lithosphere-asthenosphere system, an well cherished idea promulgated by Walter Elsasser more than 40 years .

Stress diffusion following a large earthquake can impact the earthquake risk in the surrounding area. The important parameter is the viscosity distribution

In the shallow upper mantle, which dictates the time-scale. Two years ago the Tohoku-oki M 9.1 earthquake occurred with deadly consequences. But the danger remains from the stress release to the surrounding regions .Seven years before this traumatic event the Boxer Day 2004 Sumatra M9.3 earthquake took place and many people , close to 300,000 perished around the Indian Ocean. Subsequent to this horrendous event 3 major earthquakes with magnitudes exceeding M8 happened around Sumatra in 2005, 2007, 2012 (the great transform event). These events should not be surprising at all because of the phenomenon of earthquake migration due to stress diffusion in a viscoelastic lithosphere-asthenosphere system (Elsasser, 1967, Melosh, 1977) recently French group (L. Fleitout, C. Vigny, 2012}, see also abstracts from Fall AGU, 2012) has shown stress diffusion from 2004 earthquake helped to trigger the great strike-slip event of M8.6 in April, 2012. Recently John B. Rundle in a number of blogs have stressed the migration of hotspots to Chichi Jima and Iwo Jima and also many M5 earthquakes have taken place around Japan since March 2011. Reference paper by Ando, 1975 and his argument of a large earthquake to come because of the number of M5 greater earthquakes following a main shock. In this talk we will focus our utmost attention on two scenarios of potential earthquakes which may occur in the near term, like in the next 10 to 25 years, in Norheast Asia and their potential tsunami impact. Extremely large earthquakes M9 occur more frequently than people used to think , according to McCaffrey (2008) .

Model Description

In order to study the impact on the Korean Peninsula and Jeju Island from a potential tsunami caused by earthquakes along the Izu-Ogasawara Trench and Nankai Trench respectively, we carried out tsunami simulation runs, using the modern software package **Geoclaw**. This advanced software package is based on high-resolution Godunov shock-capturing finite-volume schemes with adaptive-mesh refinement (AMR). It employs a special Riemann solver for resolving the moving wet-dry interface problem at the inundation front. The prediction of run-up is indispensable to evaluate the tsunami hazards in coastal regions. However, tsunami run-up exhibits distinct flow characteristics compared to tsunami propagation. As the water depth decreases in coastal areas, the non-linearity gains prominence and discontinuities representing bores , which are solitary in nature ,can appear in the model numerical solutions. Godunov shock-capturing finite volume methods and adaptive mesh refinement makes this powerful but easy-to-use software well-suited for handling these problems with multiple-scales in both space and time. Below we show some characteristics of tsunami waves from Tohoku-Oki earthquake captured by this method. One can see that this effort represents a major computational undertaking to follow the waves crossing the Pacific.