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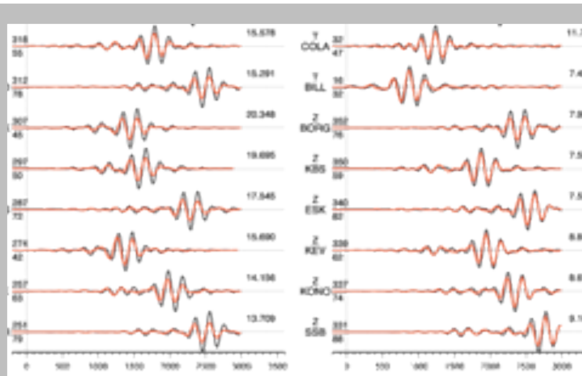

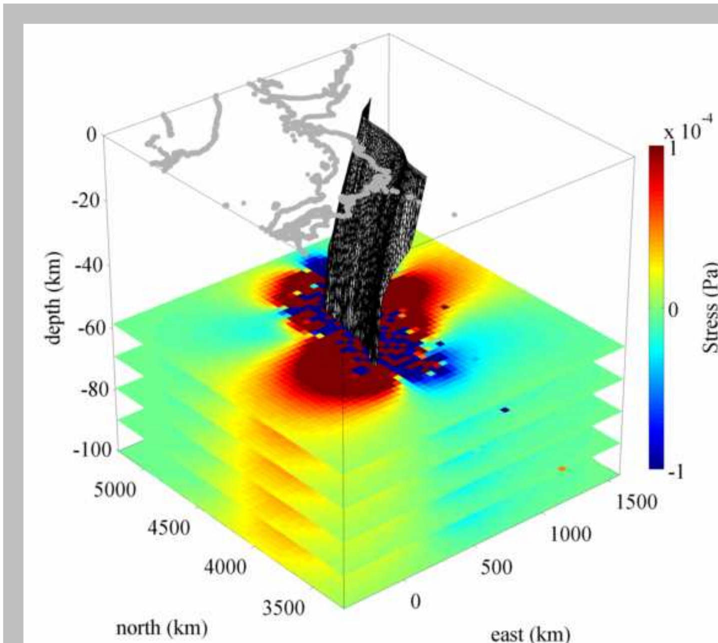

The M_W=9.0 Tohoku-Oki Earthquake occurred on March 11, 2011, offshore Honshu, Japan

Stress changes in the earth's crust due to the 2011 Tohoku-Oki earthquake

The March 11, 2011 M_W = 9.0 Tohoku-Oki Earthquake and subsequent tsunami resulted in over 15,000 deaths and more than \$300 billion in damage, including meltdown of the Fukushima II Nuclear Power Plant. This earthquake took place on the subduction interface between the Pacific plate and the Japan plate. Subduction zones in Sumatra, South America, and the Pacific Northwest are also capable of generating mega-earthquakes. Understanding the state of stress within the earth's upper crust before and after the 2011 Japan event is essential for assessing seismic hazards not only in Japan, but all around the world.

Boundary Element Method (BEM) models are a tool used to interpret tectonic deformation observations made by Global Position System (GPS) networks to estimate slip on faults. In these models, fault surfaces are discretized into dislocation elements in a linear elastic half-space. The slip on each dislocation element can be related to the resolved shear stresses at arbitrary observation positions in the elastic halfspace as $s = Gm$. Here, vector s represents the shear stresses resolved at each position due to slip on the dislocation elements, m is a vector representing the magnitude of slip on the dislocation elements, and G is a matrix of partial derivatives relating slip on a dislocation element to stress in the elastic halfspace. These partial derivatives have been derived for rectangular (Okada, 1992) and triangular dislocation elements (Meade, 2007).

This problem is computationally challenging because high-resolution representations of observed, or hypothesized, fault system geometries hundreds to thousands of elastic dislocation elements, and thousands to millions of observation locations at which to calculate stresses. In these models, matrix assembly is often rate-limiting. In particular, the Green's functions for individual triangular dislocation elements in a homogeneous elastic half-space involve calculations of stresses from six angular dislocations. For a fully discretized fault surface, this involves thousands of arithmetic and trigonometric operations.

In this project, we used CUDA to accelerate assembly of matrix G for the triangular dislocation cases. Parallelizing this matrix assembly can allow us to calculate stress changes at thousands of points in the Earth's crust due to slip on a geometrically complex fault. So far, earth scientists have been limited to calculating stresses at hundreds of points. This could fundamentally change the scale at which earth scientists study stress changes, fault interactions, and allow for more localized assessments of earthquake hazard.