Shear Strain Energy and Seismicity

Saito, T.[1], Noda, A[1], Yoshida, K[2], and Tanaka, S.[1]

1 *National Research Institute for Earth Science and Disaster Resilience, Tsukuba, Japan*

2. *Graduate School of Science, Tohoku University, Sendai, Japan*

Stress accumulation and release are fundamental concepts in the analysis of seismicity. We usually estimate the change of shear stress by assuming an earthquake fault. When the shear stress is estimated to be increased, we consider that the stress is accumulated. Instead of using the shear stress on a fault plane, the present study proposes to use the shear strain energy as a measure of the stress accumulation in the elastic lithosphere. The shear strain energy is defined as the strain energy of the deviatoric components of the strain. By supposing the numerous fault planes randomly distributed in space, we derived the relation between the shear strain energy and the root-mean-square averaged (RMS) shear stress on the faults (Saito et al. 2018 J. Geophys. Res). They also formulated the shear strain energy change caused by the stress change when the background stress is characterized by the three principal stress axes and the stress ratio. We show a few examples of the shear strain energy change and its relation to the seismicity. For the Kumamoto earthquake (M_W 7.0), we found a moderate correlation between the shear strain energy change caused by the main shock and the aftershock distribution (Figure 1). When the shear strain energy change increases and the RMS shear stress is larger than +0.2 MPa, the aftershocks tends to occur. For the 2011 Tohoku-Oki earthquake (M_W 9.0), in most part of the northeastern Honshu, the shear strain energy was decreased by the earthquake, because it caused the E-W extensional stress change on the background stress characterized by the E-W compression. However, in some regions, the orientation of the background stress is different from the surrounding (Yoshida et al. 2015 Tectonophysics). In some of such regions, the shear strain energy was increased by the Tohoku-Oki earthquake. We found that the seismicity became active after the Tohoku-Oki earthquake where the shear strain energy was increased by the earthquake.

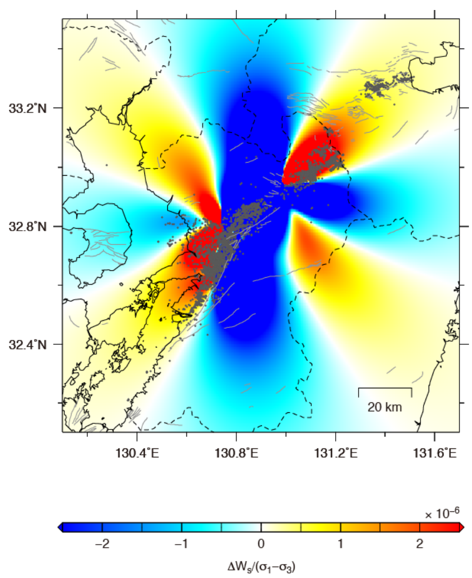

Figure 1. The distributions of the shear strain energy change caused by the 2016 Kumamoto earthquake (Red: positive, Blue: negative) and the aftershocks (gray dots). Many aftershocks occurred in the region where the shear strain energy was increased by the mainshock.