Insight into poroelastic rebound deformation following the tohoku earthquake

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K. Wang, Hu, and He (2012) proposed 3 primary processes that dominate the deformation following an earthquake at subduction zones; (1) afterslip, (2) viscoelastic relaxation, (3) re-locking of subduction fault. However, if the upper crust was saturated by fluid, the crust must be treat as a fluid-saturated poroelastic medium instead of elastic medium. Coseismic stress change disrupt pore fluid equilibrium and cause fluid migration from high pressure to zone of low pressure. Fluid migration drive transient surface deformation which is known as poroelastic rebound. Pore fluid flow induced by coseismic stress change is usually ignored due to the fact that; (1) this effect occurs in short time at early postseismic deformation just around the rupture area, (2) and no clear evidence of fluid-rich existence in the upper crust of the rupture. Due to the fluids-rich existence detected in the upper crust (Z. Wang, Huang, Zhao, & Pei, 2012; Yamamoto, Obana, Kodaira, Hino, & Shinohara, 2014; Zhao, Huang, Umino, Hasegawa, & Kanamori, 2011), pore fluid flow induced by coseismic stress change can produce contribution to the surface deformation.
Therefore, poroelastic rebound should be included in the analysis of early postseismic deformation following the Tohoku earthquake. Previous modeling studies in poroelastic rebound used various values for undrained and drained Poisson’s ratio (e.g., Peltzer, Rosen, Rogez, and Hudnut (1998); Jonsson, Segall, Pedersen, and Bjornsson (2003)). Instead of just assuming the values of drained and undrained Poisson’s ratio, we use grid search to estimate undrained and drained Poisson’s ratio value by combining forward calculation of poroelastic rebound and afterslip inversion of inland and offshore GPS data. In total, we build 400 poroelastic rebound model with different combination of undrained and drained Poisson’s ratio. Grid search approach obtained optimum value of 0.23 and 0.29 for drained and undrained Poisson’s ratio, respectively. Poroelastic rebound produced by the optimum value of drained and undrained Poisson’s ratio estimated horizontal displacement up to 0.28 m in the rupture area. Majority of large uplift due to poroelastic rebound occurred in and around the vicinity of the rupture area where maximum uplift estimated up to 0.37 m around the maximum slip area of the mainshock.

Keywords: poroelastic rebound, undrained and drained Poisson's ratio, grid search, co- and after-slip inversion

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