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Internal stress changes due to point dislocations in a spherical earth

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A simple and complete theory about internal deformations due to point dislocations in a homogeneous half-space was proposed by Okada (1992). This theory has been used by many researches to estimate Coulomb stress changes due to an earthquake and has contributed to understanding of seismology. Although a homogeneous half-space is a first approximation of the earth, global deformation like broad stress changes due to a great earthquake have to be calculated in a more realistic earth model, spherically symmetric earth model. Sun and Okubo (1993) succeeded in calculating surface displacements and gravity changes due to point dislocations in a spherically symmetric earth model. However, internal stress changes and displacements have never been calculated because there exist some difficulties to realize the calculation in spite of early proposal of a fundamental method (Takeuchi and Saito, 1972). In this research, we propose a strategy to realize the calculation of internal deformations and present some computational results.

We shall

i) outline the strategy to calculate internal deformations,

ii) compare the stress changes in a homogeneous sphere with those in a half-space which were already solved and

iii) show the results in a stratified earth model such as PREM.

Our study shows that significant difference between a homogeneous sphere and a half-space model occurs when epicentral distance exceeds several hundreds kilometers. For example, epicentral distances at which difference of radial stress changes in two models reach 10% are 4, 5 and 6.5 degrees at observation depth at 10, 20 and 30, respectively (Figure). Angular distance of 4 degrees, which is 400km, roughly equals the length of fault that is thought to have slipped in the 2011 Tohoku-Oki earthquake.

Figure. Difference of radial normal stress changes due to a vertical-strike slip at depth of 32km in two models, a homogeneous sphere and a half-space.The horizontal axis is epicentral distance and vertical axis is difference between the two models in percentage. Red, green and blue points indicate observation depth of 10, 20 and 30km, respectively.

Keywords: internal stress change, spherically symmetric earth, point dislocation, stratification