Degree Amplitude Spectra of Co-seismic Deformations – Case Study of Alaska (1964, 2002) and Hokkaido (2003) Earthquakes

Wenke Sun[1]; Shuhei Okubo[2]

[1] ERI, Univ Tokyo; [2] ERI, Univ. Tokyo

Generally, there are two approaches to calculate co-seismic deformations: normal modes and quasi-static dislocation theory. The former was proposed by, e.g., Gilbert (1970) and Dahlen (1971, 1973), which is the basis for a series work by Chao and Gross (1987) and Gross and Chao (2001). Once the normal modes are obtained in advance for a SNREI model, co-seismic deformations (such as displacement) can be calculated by the normal modes and seismic moment tensor. The latter, the quasi-static dislocation theory, e.g., Sun and Okubo (1993) and Sun et. al. (1996) provides a set of dislocation Love numbers. A co-seismic deformation can be calculated by the dislocation Love numbers and the seismic moment or fault size of an earthquake. The normal mode theory is efficient in some applications, but this approach is difficult to calculate a near field deformation since it is impossible to prepare infinite normal modes. However, for a geodetic application, the quasi-static approach (Sun et. al., 1996) can deal with co-seismic deformations in any near or far fields. On the other hand, the normal modes are usually required for the whole domain of harmonic degree n and order m; while the dislocation Love numbers used in the quasi-static approach include only three orders: m=0, 1, 2. Furthermore, an asymptotic approach (Sun, 2004) of the quasi-static dislocation shows that co-seismic deformations can be calculated by a set of closed concise analytical formulations. According to Gross and Chao (2001), the normal modes can be used to estimate the degree variance (i.e., the power spectral density) of the gravitational potential anomaly, which gives the contribution of the degree n terms to the total variance, defined as the root-mean-square value per degree. Then the degree variance can be compared with the expected errors of GRACE measurements, so that one can observe the detestability of the satellite gravity missions. In this study, we derive theoretical formulations of co-seismic geoid and gravity changes and their degree variances, expressed by the dislocation Love numbers. These expressions are achieved using the quasi-static dislocation theory, e.g., by Sun and Okubo (1993), for a spherical earth as it is expressed in the form of spherical harmonics. The degree variances involve with not only the dislocation Love numbers, but also the geometrical position of the fault described by the dip-angle and slip-angle, and the dislocation factors. It is found that the degree variances for a shear fault movement include both the shear and tensile components; while the degree variances for a tensile fault also include the two components, but nothing to do with the dip-angle. The degree variances are proportional to the absolute values of the dislocation Love numbers. For each harmonic degree n, the only variable is the dislocation Love number, so that the root-square of the dislocation number is just its absolute value. Therefore, the dislocation Love numbers themselves give their degree variances, multiplied by the dislocation factors. We investigate co-seismic geoid and gravity changes by observing the distribution of their degree variances comparing to the expected sensitivity of the satellite gravity missions. Results for co-seismic deformations for large earthquakes are discussed with respect to their delectability. As an application of this research, a case study is made for the Alaska (1964, 2002) and Hokkaido (2003) Earthquakes. This study leads to the same conclusion as that of Gross and Chao (2001) using the normal mode scheme.