Green function for internal deformation due to a point dislocation in a spherical earth: asymptotic solution at the higher degree for a stratified earth model

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Green functions representing the deformations (e.g. displacement and strain) due to a point mass load and point dislocations play important roles in geodesy and seismology. For example, the ‘surface’ Green function for a mass load (Farrell, 1972) has been used to calculate gravity and strain changes caused by ocean tides. The ‘surface’ Green function for point dislocations (Sun & Okubo, 1993) is necessary to interpret displacement and gravity changes caused by great earthquakes. The ‘internal’ Green function for point dislocations will enable us to estimate stress changes such as Coulomb’s static stress changes excited by great earthquakes. The asymptotic solution representing the behaviour of the solution at higher degree ($n \to \infty$) is useful because the solution at higher degree up to several thousands or tens of thousands are needed to obtain these Green functions. The asymptotic solutions for ‘surface’ deformation due to a point mass load and point dislocations were found by Farrell (1972) and Okubo (1988), respectively. However, asymptotic solution for ‘internal’ deformation due to point dislocations has not been obtained yet except for that of homogeneous sphere (Okubo & Takagi, 2014 JpGU). We need it for a stratified earth model.
In case of a spherically symmetric earth model with self-gravitation, deformation fields are divided into the spherical and toroidal fields and they are represented as 6th and 2nd order differential equations. We assume that ‘the solution for a stratified earth’ = ‘(i) the solution for a homogeneous sphere’ + ‘(ii) the effect of radial variance of the structure’. The effect (ii) is calculated by using the solution for a homogeneous sphere (i) that has already been obtained (Okubo & Takagi, 2014 JpGU). Although the effect (ii) is represented by an integral over the whole earth volume, we have only to consider the effect around the depth of the source and the depth where the deformation is evaluated at the higher degree.
We calculated the asymptotic solution for the toroidal field following the above idea and presented it in an analytical expression. We verified that the analytical expression agrees to numerical solution in an asymptotic sense when the degree n becomes large (over 10,000) as expected. In this presentation, we will show the asymptotic solution for the spheroidal field in addition to that for the toroidal mode, and discuss the usefulness of it.

Keywords: Green function, point dislocation, internal deformation, stratified earth, asymptotic solution

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