A new code for calculating post-seismic displacements as well as Geoid and gravity changes on a layered visco-elastic spherical earth

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Abstract: Tanaka et al. (2006, 2007) proposed the spherical dislocation theory (SDT) in a spherically symmetric, self-gravitating visco-elastic earth model. However, to date there have been no reports on easily adopted, widely used software that utilizes Tanaka's theory. In this study we introduce a new code to compute post-seismic deformations (PSD), including displacements as well as Geoid and gravity changes, caused by a seismic source at any position. This new code is based on the above-mentioned SDT. The code consists of two parts. The first part is the numerical frame of the dislocation Green function (DGF), which contains a set of two dimensional discrete numerical frames of DGFs on a symmetric earth model. The second part is an integration function, which performs bi-quadratic spline interpolation operations on the frame of DGFs. The inputs are the information on the seismic fault models and the information on the observation points. After the user prepares the inputs in a file with given format, the code will automatically compute the PSD. As an example, we use the new code to calculate the co-seismic displacements caused by the Tohoku-Oki Mw 9.0 earthquake. We compare the result with observations and the result from a full-elastic SDT, and we found that the Root Mean Square error between the calculated and observed results is 7.4 cm. This verifies the suitability of our new code. Finally, we discuss several issues that require attention when using the code, which should be helpful for users.

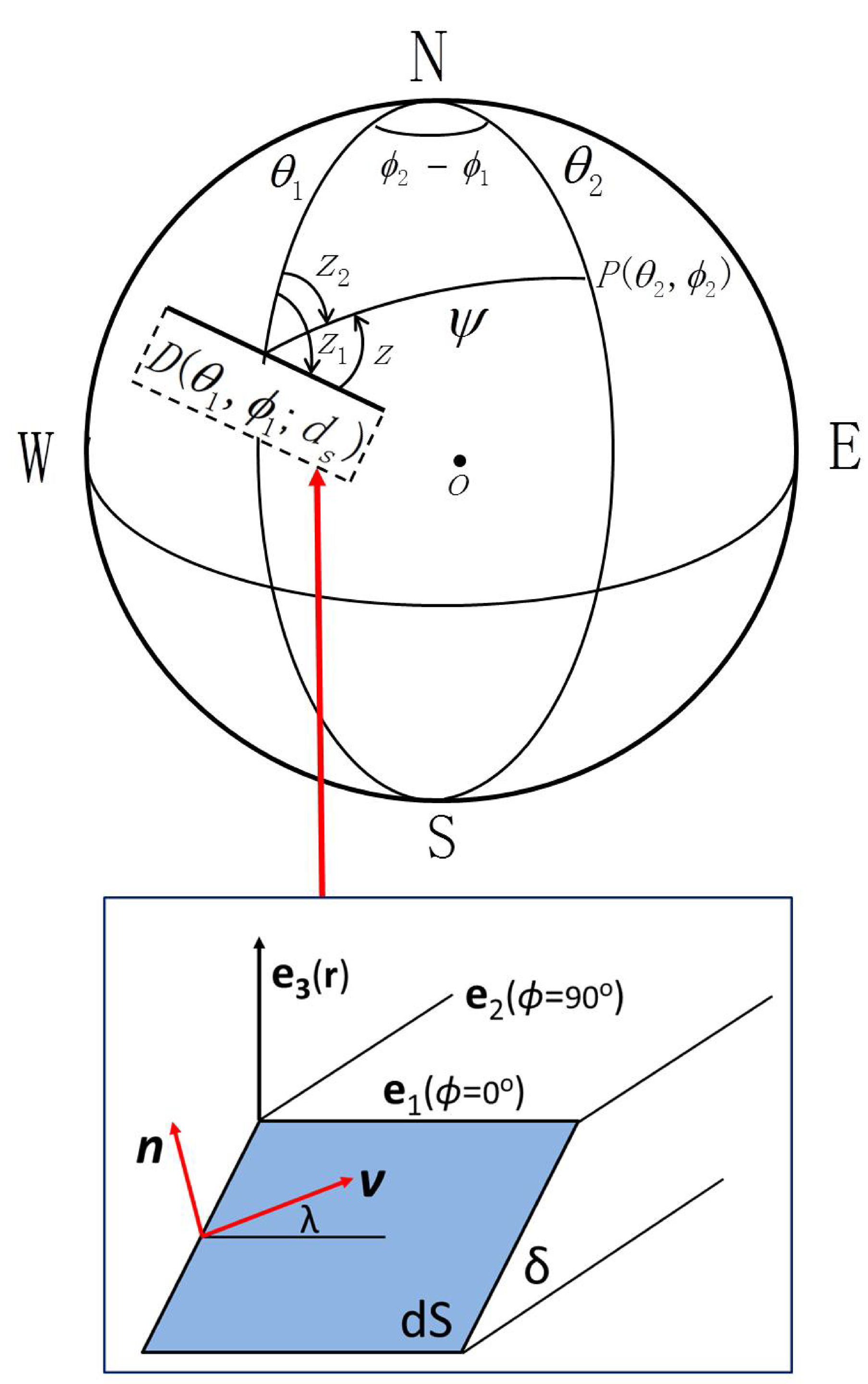

Fig. 1 Geometry of the dislocation D and the observation point P

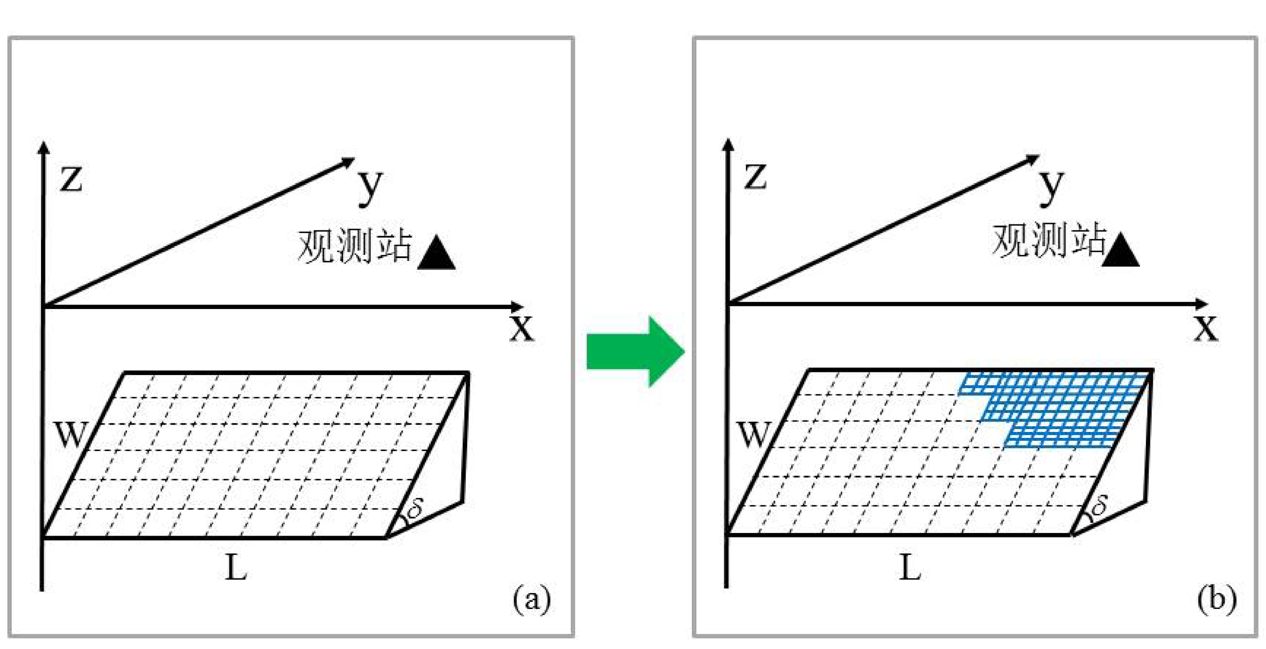

Fig.2 Sketch of the subdivision of a finite sub-fault. If the epicentral distance between the observation point and the center of one subfault is not ten times larger than the length of the longer side of the sub-fault, the code will automatically subdivide the sub-fault into smaller cells. We can then calculate the near field deformations with high accuracy via the segment-summation scheme (Fu and Sun 2004).

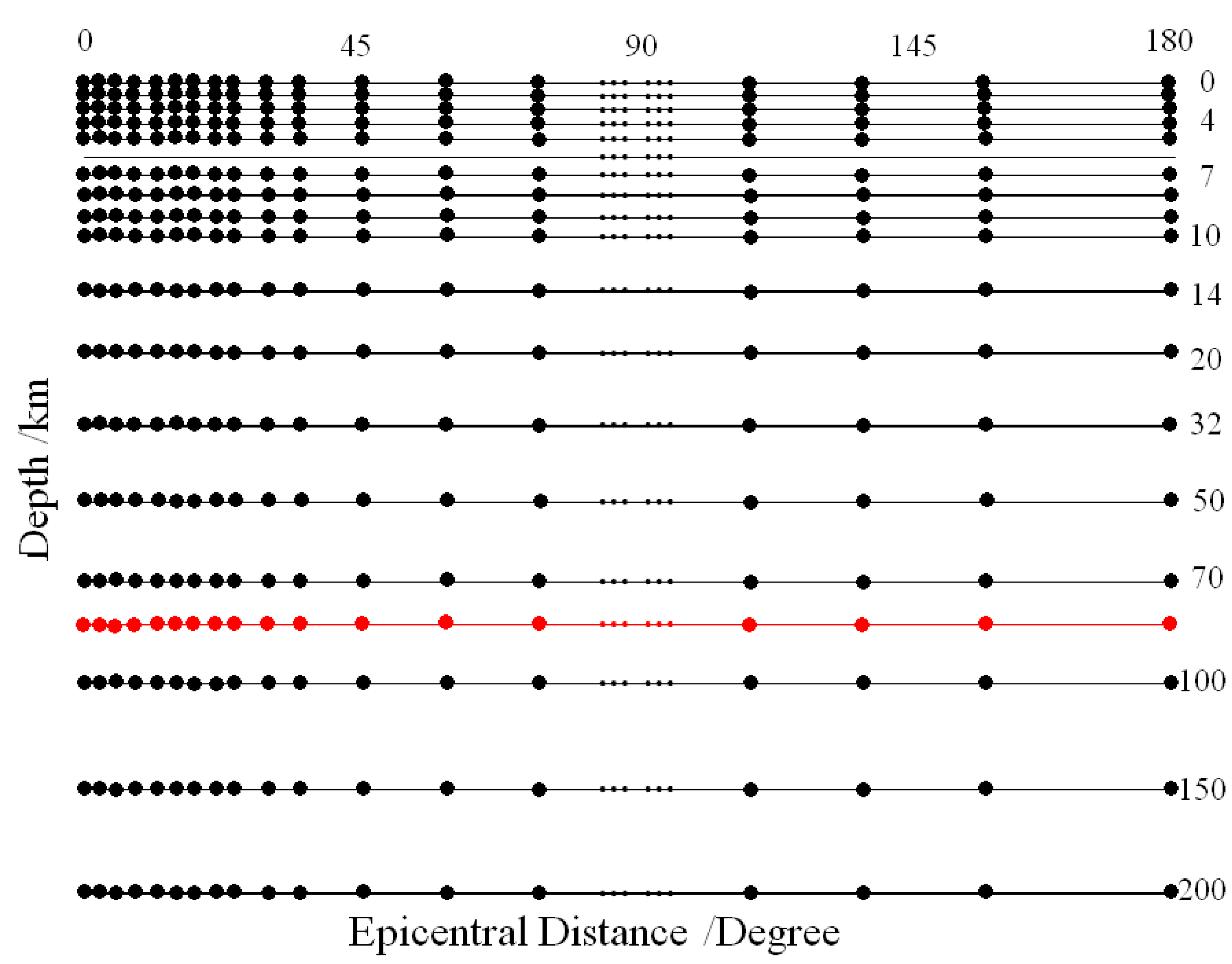

Fig.3 Sketch of a two-dimensional discrete frame of dislocation Green functions (DGFs) at a time point after earthquake.

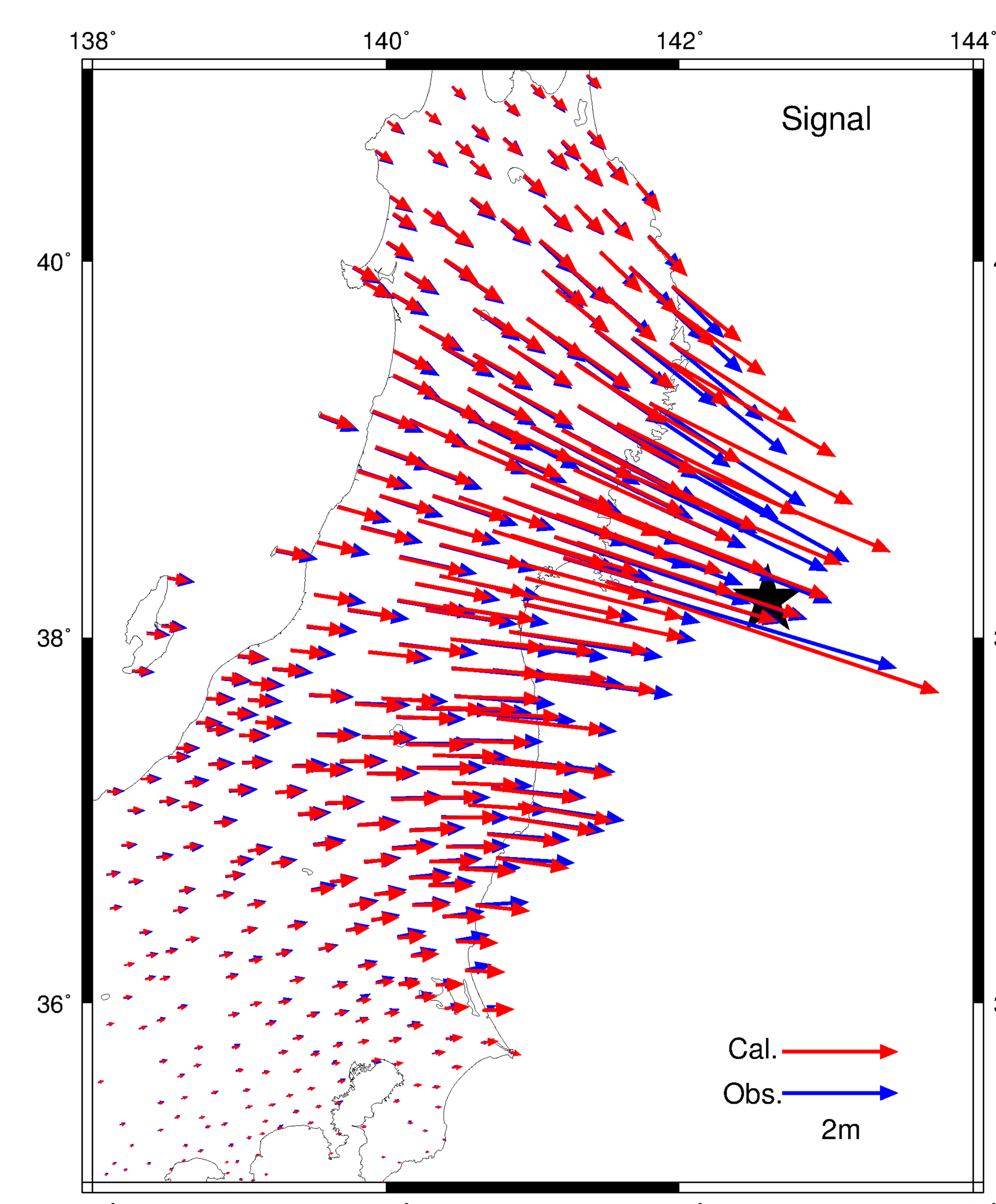

Fig. 5 Comparison of the results calculated using our new code with GPS observations. Red arrows represent the theoretical co-seismic horizontal displacements caused by the Tohoku-Oki Mw 9.0 earthquake. Blue arrows represent GPS observations.

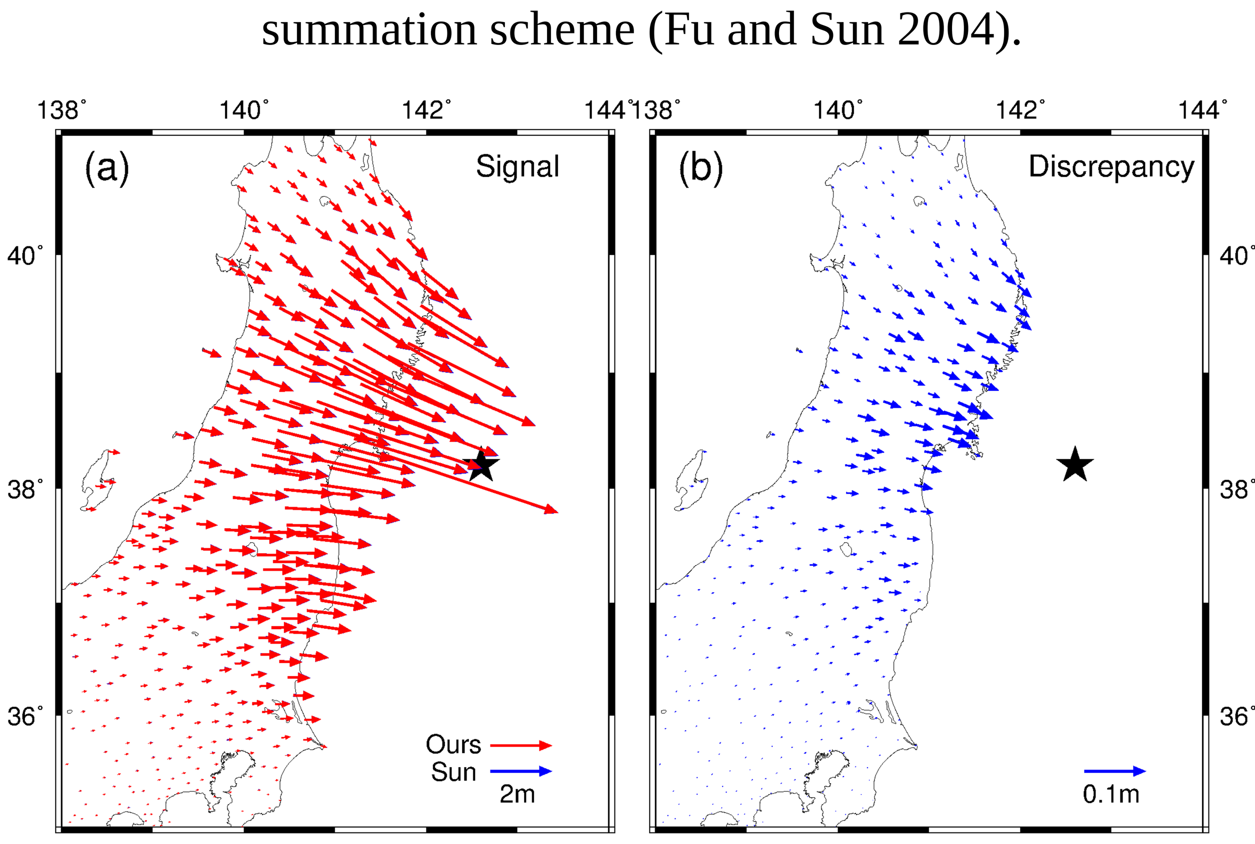

Fig.4 Comparison of the results from our new code with those from the elastic spherical dislocation theory (Sun et al. 2009). a Theoretical coseismic horizontal displacements caused by the Tohoku-Oki Mw 9.0 earthquake. Red arrows represent the results calculated using our new code. Blue arrows represent results calculated using the elastic spherical dislocation theory. b Discrepancies of two sets of theoretical results.

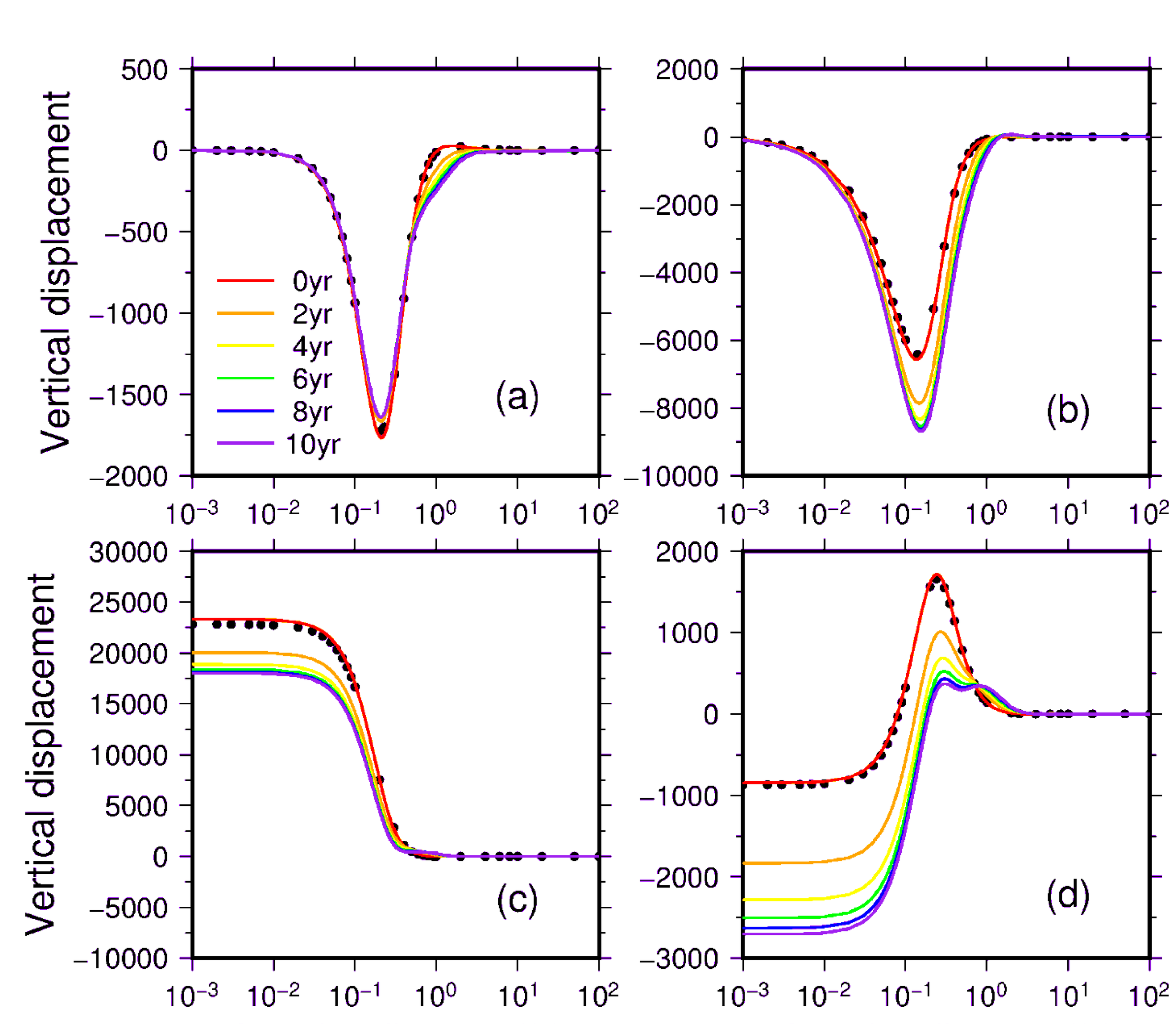

Fig.6 DGFs of vertical displacements for four independent seismic sources with a depth of 32 km. The time that passes by after the event is set to be 0, 2, 4, 6, 8, and 10 years, respectively. Dots indicate the co-seismic results calculated by the elastic spherical dislocation theory (Sun et al. 2009). The figure shows a for vertical strike-slip, b for vertical dip-slip, c for tensile on a horizontal plane; and d for tensile on a horizontal plane.

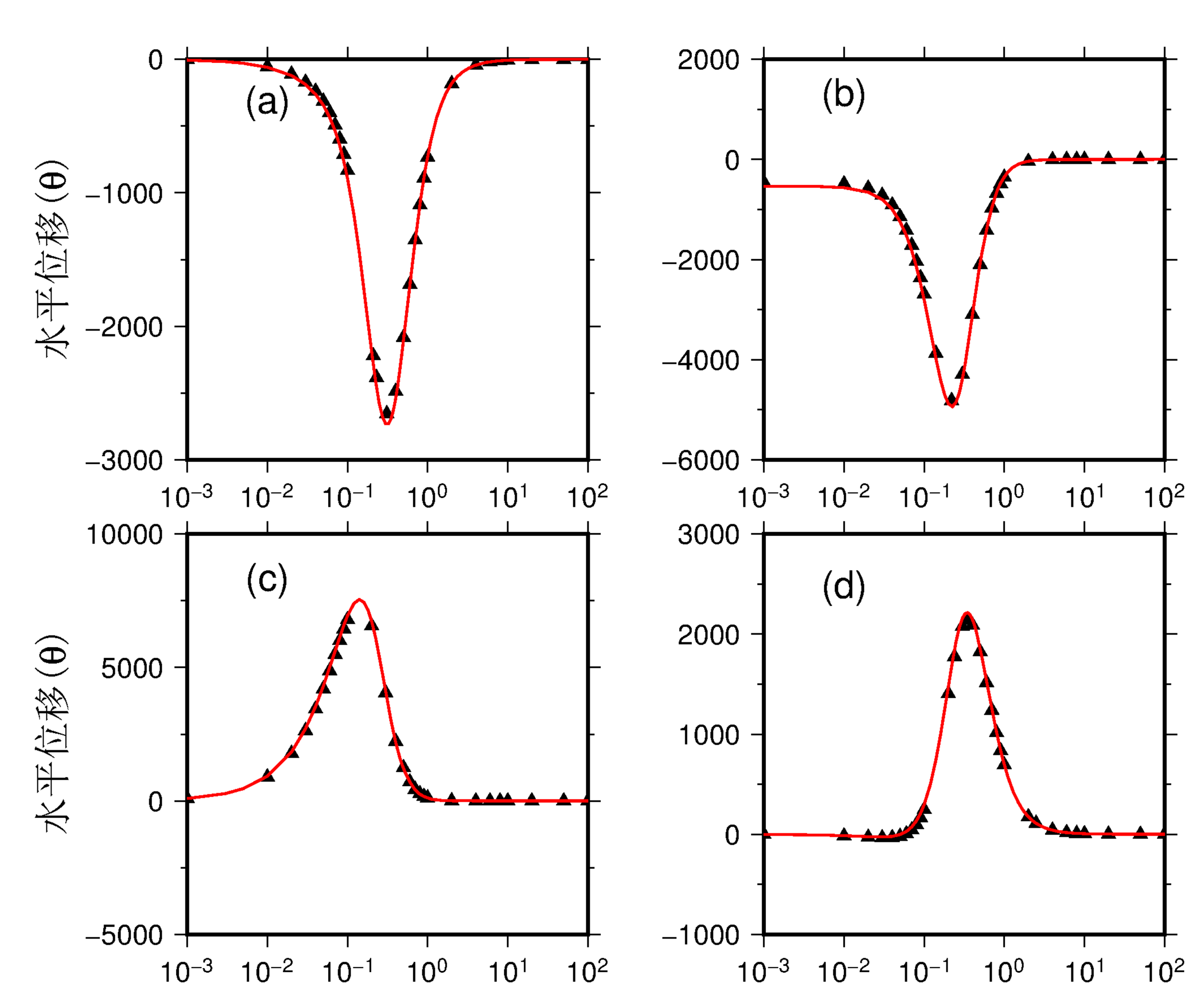

Fig.7 Comparison of the co-seismic Green functions from our new code with those from the elastic spherical dislocation theory (Sun et al. 2009). Both results agree with each other very well.

Reference: Gao, S., G. Fu, T. Liu and G. Zhang (2017), A new code for calculating post-seismic displacements as well as Geoid and gravity changes on a layered visco-elastic spherical earth, *Pure and Applied Geophysics*, 174: 1167-1180 .