Title: Numerical modeling of free oscillations applied to superconducting-gravimeter data in a low-frequency seismic range

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Abstract: Deformations and changes of the gravitational potential of prestressed selfgravitating elastic bodies caused by free oscillations are described by means of the momentum and Poisson equations and the constitutive relation. For spherically symmetric bodies we transform the equations and boundary conditions into ordinary differential equations of the second order by the spherical harmonic decomposition and further discretize the equations by highly accurate pseudospectral difference schemes on Chebyshev grids. We thus receive a series of matrix eigenvalue problems for eigenfrequencies and eigenfunctions of the free oscillations. Since elastic parameters are frequency dependent, we solve the problem for several fiducial frequencies and interpolate the results. Both the mode frequencies and the eigenfunctions are benchmarked against the output from the Mineos software package based on Runge-Kutta integration techniques. Subsequently, we use our method to calculate low-frequency synthetic accelerograms of the recent megathrust events and compare them with the observed superconducting-gravimeter (SG) data. We estimate the quality factors of the longest radial modes directly from the SG records of the 2010 Maule and 2011 Tohoku earthquakes and then constrain the M_{rr} component of the centroid moment tensors. The ${}_0S_0$-mode amplitude enables one to obtain a relatively narrow interval of M_{rr} values, whereas the ${}_1S_0$-mode amplitude is more sensitive to the centroid depth. We also invert the SG data to jointly determine quality factors of the gravest spheroidal modes and the three low-frequency centroid-moment-tensor (CMT) components that generate the observed signal. We employ several-day records to better resolve both the quality factors and the CMT components and, with the already inverted quality factors and substantially shorter records, we obtain new estimates of the CMT components. The differences in CMT components calculated from the long and short records are smaller than those routinely produced by different seismic agencies.

Keywords: Free oscillations, matrix eigenvalue problem, superconducting-gravimeter data, quality factors, CMT inversion