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Complete synthetic seismograms based on a spherical self-gravitating Earth model with an atmosphere-ocean-mantle-core structure

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A hybrid method is proposed to calculate complete synthetic seismograms based on a spherically symmetric and self-gravitating Earth with a multi-layered structure of atmosphere, ocean, mantle, liquid core and solid core. For large wavelengths, a numerical scheme is used to solve the geodynamic boundary-value problem without any approximation on the deformation and gravity coupling. With the decreasing wavelength, the gravity effect on the deformation becomes negligible and the analytical propagator scheme can be used. Many useful approaches are used to overcome the numerical problems that may arise in both analytical and numerical schemes. Some of these approaches have been established in the seismological community and the others are developed for the first time. Based on the stable and efficient hybrid algorithm, an all-in-one code QSSP is implemented to cover the complete spectrum of seismological interests. The performance of the code is demonstrated by various tests including the curvature effect on teleseismic body and surface waves, the appearance of multiple reflected, teleseismic core phases, the gravity effect on long period surface waves and free oscillations, the simulation of near-field displacement seismograms with the static offset, the coupling of tsunami and infrasound waves, and free oscillations of the solid Earth, the atmosphere and the ocean. QSSP is open source software that can be used as a stand-alone FORTRAN code or may be applied in combination with a Python toolbox to calculate and handle Green's function databases for efficient coding of source inversion problems.