SeisModels.jl: A Julia package for models of the Earth's interior

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Software

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Summary

The interior structure of the Earth and other quasi-spherical planets reflects their history, development, present-day state and dynamics. Hence inferring their structure is of great interest, and requires the ability to rapidly compute their bulk properties such as total mass, moment of inertia, gravitational acceleration, interior pressure, and so on, in order to compare model predictions with data. `SeisModels.jl` is a Julia package designed to allow such computation.

`SeisModels.jl` can be used to represent arbitrary models of quasi-spherical bodies. In its current release, radially-symmetric bodies can be represented easily using spherical shells whose properties are linearly varying with radius, constant with radius, or parameterised by a set of polynomial coefficients. Density, elastic isotropic velocity (P-wave and S-wave), elastic radially-anisotropic velocity and attenuation are supported as basic model parameters, permitting the computation at arbitrary radius of gravity, pressure, mass, and so on. Inbuilt models include the Preliminary Reference Earth Model (Dziewoński & Anderson, 1981) ('PREM'), AK135 (Kennett, Engdahl, & Buland, 1995) and iasp91 (Kennett & Engdahl, 1991) for the Earth, and the Moon model of Weber, Lin, Garnero, Williams, & Lognonné (2011).

Due to Julia's multiple dispatch programming paradigm, extending `SeisModels.jl` to represent bodies of different types or ones parameterised differently to the inbuilt types is simple and incurs no performance penalty. The software has been benchmarked against independent implementations and computes properties quickly enough to test millions of models against data, enabling robust parameter searches or Monte Carlo sampling. For the example of working with PREM on a desktop computer with an Intel E5-1650 CPU, it takes only 12 ms to calculate the pressure at the centre of the Earth, whilst surface gravity is returned within 5 μs.

`SeisModels.jl` has been used for research projects and teaching, and provides the ability to read and write files in some standard formats. Currently supported are the file format used by the Mineos software to calculate normal mode eigenfrequencies and -functions, and the 'tvel' format used to calculate ray-theoretical travel times with the Java TauP (Crotwell, Owens, & Ritsema, 1999) and Python Obspy (Beyreuther et al., 2010) packages. `SeisModels.jl` is used by the `Mineos.jl` Julia module to directly compute normal mode properties for planetary models.

Documentation is available at a dedicated website (https://anowacki.github.io/SeisModels.jl/stable). The package comes with a test set which can be easily run by users—after adding the package, simply run `import Pkg; Pkg.test("SeisModels")` in Julia.

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