Geophysical Research Abstracts
Vol. 17, EGU2015-7315, 2015
EGU General Assembly 2015

FrOsT: A new generation of normal mode seismology

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Normal mode seismology provides important constraints on earth structure, particularly at the largest spatial scales, and enables the imaging of density heterogeneities within the Earth. In addition, computational approaches built upon normal modes offer an efficient route towards obtaining synthetic seismograms and their sensitivity kernels (partial derivatives of the seismograms with respect to source or structural model parameters).

At present, it is difficult to compute normal modes at frequencies higher than around 100 mHz, and—as far as we are aware—no publicly-released codes can perform complete calculations in 3D earth models. However, these are software limitations, rather than inherent problems with the normal modes framework. We are therefore developing the Free Oscillation Toolkit (FrOsT), a suite of software for normal mode seismology designed to enable calculations for arbitrary 3D earth models, and to arbitrarily high frequencies. All codes will be released on an open-source basis in due course.

We demonstrate that improved radial integration and mode-counting techniques enable stable calculations at high frequency, and present initial benchmarks in 1D earth models. Through the use of the generalised spherical harmonic formalism, we show that it is straightforward to obtain strain and rotation seismograms, in addition to displacement fields, enabling a full range of data to be handled simultaneously. Finally, we provide an overview of expected future developments, including software to compute complete seismograms in 3D models through full mode coupling.