The free oscillations, or normal modes, of the Earth provide important constraints on the long-wavelength structure of our planet. Calculations using normal modes are also necessary if the effects of gravity are to be fully modeled in seismic waveforms, which becomes important at low frequencies, in particular if we wish to image density.

To implement these calculations in a 3D Earth, we typically initially compute the normal modes (eigenfunctions) of a spherically-symmetric model such as PREM. These form a complete set of basis functions, which may then be used to describe the seismic response of laterally heterogeneous models. This procedure is known as ‘mode coupling’. In order to implement the calculation, it is necessary to select a finite subset of modes (invariably defined by a frequency range) to be considered. This truncation of the infinite-dimensional equations necessarily introduces an error into the results. Here, we consider the fundamental question: if we wish to calculate synthetic spectra in a given frequency range, how many modes must we couple for the resulting spectra to be sufficiently accurate in a given 3D model?

To investigate this question, we compute spectra in the 3D model S20RTS up to 3mHz, but allowing coupling with all modes up to 6mHz. We then explore how the spectra change as we reduce the upper frequency used in the coupling. We compare this to the effects introduced by altering the 3D density structure of the model. Moreover, we repeat the calculations with a model composed of random numbers. We find that the coupling cutoff frequency depends on the power spectrum of heterogeneity. In this work we investigate the relation between power spectrum of the 3D model and the cutoff frequency in more detail. Clearly, if we wish to image Earth’s density structure accurately, it is important that the truncation error is small compared to the density signal.