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Assessing the Comprehensive Seismic Earth Model using normal mode data

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Advances in computational resources and numerical methods allow the simulation of realistic seismic wave propagation through complex media, while ensuring that the complete wave field is correctly represented in synthetic seismograms. This full waveform inversion is widely applied on regional and continental scales, where particularly dense data sampled can be achieved leading to an increased resolution in the obtained model images. On a global scale, however, full waveform tomography is still and will continue to be limited to longer length scales due to the large computational costs.

Normal mode tomography provides an alternative fast full waveform approach for imaging seismic structures in a global way. Normal modes are not limited by the poor station-earthquake distribution and provide sensitivity to density structure. Using normal modes, a more robust long wavelength background model can be obtained, leading to more accurate absolute velocity models for tectonic and mineral physics interpretations. In addition, it is vital to combine all seismic data types across accessible periods to obtain a more complete, consistent and interpretable image of the Earth's interior.

Here, we aim to combine the globally sensitive long period normal modes with shorter period full waveform modelling within the multi-scale framework of the Comprehensive Seismic Earth Model (CSEM). The multi-scale inversion framework of the CSEM allows exploitation of the full waveform capacity on both sides of the seismic spectrum. As the CSEM includes high-resolution subregions with velocity variations at much shorter wavelengths than normal modes could constrain, the question arises whether these small-scale variations are noticeable in normal mode data, and which modes respond in particular. We report here on experiments in which we address these questions. We separately investigate the effects of small-scale variations in shear-wave velocity and compressional wave velocity compared to the background model S20RTS, before we work towards CSEM updates that are consistent with normal mode data.