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High-resolution global tomography: A full-wave technique for forward and inverse modeling

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In recent years, seismology has greatly benefitted from significant progress in digital data collection and processing, accurate numerical methods for wave propagation, and high-performance computing to explore crucial scales of interest in both data and model spaces. We will present a full-wave technique to address the seismic forward and inverse problem at the global scale, with a specific focus on diffracted waves in the lowermost mantle:

Our 2D spectral-element method tackles 3D wave propagation through spherically symmetric background models down to seismic frequencies of 1 Hz and delivers the wavefields necessary to construct sensitivity kernels. This specific approach distinguishes itself from the adjoint method in that it requires no knowledge about data structure or observables at the time of forward modeling by means of storing entire reference space-time wavefields.

To obtain a direct view of the interconnection between surface displacements and earth structure, we examine the time-dependent sensitivity of the seismic signal to 3D model perturbations. Being highly sensitive to such parameters as epicentral distance, earthquake radiation pattern, depth, frequency, receiver components and time windows, this effort suggests criteria for data selection to optimally illuminate a specific region within the earth. As shown with core-diffracted P-waves, we measure and model our observables (e.g. traveltimes, amplitudes) in multiple-frequency passbands, thereby increasing robustness of the inverse problem and path coverage. This allows us to selectively draw only upon frequency bands with high signal-to-noise ratio. We discuss the selection and usability of data for such a Pdiff tomographic setting, coverage maps and target regions. We also touch upon the validity of a 1D reference model and quantify the applicability range of the first-order Born approximation.