Advancements in Teleseismic Full Waveform Inversion: Towards High Resolution Imaging of Crust and Upper Mantle

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The densification of seismic deployments, improved data quality and advances in high-performance computing have facilitated the use of waveforms for seismological imaging. It is now feasible to image lithospheric structures at regional scale with unprecedented resolution by inverting teleseismic P and S waveforms. In this work, we first present the reformulation of the inversion problem by considering a full 3D covariance matrix, which allows us to account for the correlations between different model parameters such as density, Vp, and Vs. This new algorithm is validated with synthetic inversion experiments, which produce consistent and robust 3D models for density, Vp, and Vs. We then demonstrate the effectiveness of the method using two real datasets: one from Cascadia, a linear array of temporary broadband stations, and another from Taiwan, a compilation of temporary and permanent broadband stations. Structures at different scales are successfully imaged. For example, in Cascadia, we can clearly observe the subducted Juan de Fuca oceanic crust with a thickness of less than 8 km and the serpentinized mantle with reduced mantle velocity. the thickened crust beneath the Central Range extending down to 55 km and several low-velocity bodies associated with different magma reservoir systems are revealed. Teleseismic full waveform inversion offers an unprecedented level of detail in imaging underground structures, facilitating significant advances in our understanding of crustal and mantle dynamics.