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Full-Waveform Inversion for Seismic Velocity and Moment Tensor Solutions beneath North Chile

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We present a new seismic tomography model including radial anisotropy based on Multiscale Full Seismic Waveform Inversion for the crustal and upper-mantle structure beneath northern Chile, which is a part of the Nazca-South America Plate boundary known for frequent megathrust earthquakes and volcanos. The forward and adjoint simulation based on a 3D model are accomplished with Salvus, which is a suite of spectral-element method solver of the seismic wave equation and of its adjoint, working in 2D and 3D tetrahedral, hexahedral, quadrilateral and triangular meshes. We perform the inversion running on the Piz Daint, hosted by Swiss National Computing Centre and invert waveforms from 78 events which are carefully selected for good coverage of the study region and depth range, yielding in total 6854 event-station pairs, 74% of which have effective time windows for full-waveform inversion. In order to mitigate the risk of convergence towards local minima, we divide the whole inversion procedures into three different time-period stages (40-80 s, 30-80 s and 20-80 s). The starting model is retrieved from the Collaborative Seismic Earth Model (Fichtner et al., 2018) and we proceed the inversion from lower to higher periods. We take advantage of the adjoint methodology coupled with preconditioned conjugate-gradient optimization scheme to update the seismic velocity model. Through full-waveform inversion, we effectively improve the resolution of the current model. The most conspicuous feature is the strong radially anisotropy for S wave velocity: the Vsv and Vsh within the subducted slab demonstrate an obvious different strength and shape.

Meanwhile, in order to alleviate the effect of inaccuracy of earthquake source parameters, in particular depth, on the seismic velocity model inversion and to update the moment tensor catalogue, we implementeded a seismic source inversion workflow based on Greens' Functions calculated for 1-D and 3-D seismic velocity models. We take a consecutive way to update our Greens' functions based on the updated Seismic velocity model from our adjoint inversion combined with the high-frequency analytic Greens' functions based on 1-D model for incorporating more body wave phases.