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The Western Alps lithospheric structure, preliminary results from Full-Waveform Inversion of CIFALPS data

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The Western Alps, although being intensively investigated, remains elusive when it comes to determine its lithospheric and sublithospheric structures. Such information are crucial for the understanding of processes and mechanisms of orogeny as well as the evolution of the dynamics of the Alps. In this context, the CIFALPS experiment was conducted to address the lack of seismological data amenable to high-resolution seismic imaging of the crust and the mantle. This experiment was based on a temporary network (from August 2012 to September 2013) composed of 55 broadband seismic stations deployed along a 350 km long WSW-ENE profile across the Alps from the Rhone valley (France) to the Pô plain (Italy). The average inter-station spacing of 5 km makes the array amenable to high-resolution lithospheric imaging by Full-Waveform Inversion (FWI) of teleseismic data.

We develop a FWI method that is suitable for teleseismic configuration. A simulation in an axisymmetric global earth performed with the AxiSEM software provides a background wavefield that is injected at the edges of the computational domain to perform full wavefield simulation in the lithospheric target. The misfit between the resulting synthetic wavefield and the recorded wavefield is iteratively minimized with gradient-based method to update the P and S wave velocities of the lithospheric model. The gradient of the misfit is computed with the matrix-free adjoint state method.

We apply FWI to the CIFALPS data to identify the promise and pitfalls of this technology compared to more conventional traveltime tomography or receiver function analysis.
Of particular interest is the careful analysis of the respective role of the forward-scattering and backward-scattering regimes in the spatial resolution of the imaging.
Potential difficulties are related the footprint of the source effects in the FWI, the sensitivity of the FWI to the accuracy of the initial model and the computational burden resulting multi-source elastic modeling.

The aim of this study is to start addressing these methodological issues with the CIFALPS case study.