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Pushing the limits of CMT inversion with large seismic networks: Challenges and results for small to moderate earthquakes in the Alps

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The AlpArray seismic network (AASN) was operated from 2016 to 2019 by a European initiative aiming for new insights into the orogenesis of the Alps as well as into past and recent geodynamic and tectonic processes. The network included more than 620 temporary and permanent broadband stations with a spacing of 50 - 60 km. It was accompanied by the even denser Swath-D seismic network in the Eastern Alps (~150 stations with 15 km spacing). While the extensive network provides an excellent station coverage for seismicity studies, the large number of stations (up to 100) poses new challenges to MT inversions. Automated quality control and the choice of appropriate configurations becomes crucial for the inversion process. Weak to moderate magnitude events and the complex heterogeneous tectonic setting in the Alps force us to push the limits of full waveform moment tensor inversions.

We develop semi-automatic, adaptive approaches for a standardized quality assessment of large seismic networks and for the selection of appropriate waveform fitting targets and frequency ranges. The earthquake source optimization framework 'Grond' uses a Bayesian bootstrap-based probabilistic inversion scheme with flexible integration of different waveform attributes in time and frequency domain to provide full or deviatoric moment tensor solutions including uncertainties. The entire workflow from station quality control to moment tensor inversion can handle more than 100 stations simultaneously. The large number of stations allows to study the influence of azimuthal gaps. Further, we are able to compare the inversion results of various methods and configurations in time- and frequency domain using different frequency ranges and epicentral distances. We inverted approximately 100 full moment tensor solutions for events down to Mw 3.1 occurring within the operating time of the AASN. For this magnitude range a combination of frequency-domain spectra and time-domain waveform fitting of surface waves (Z, R and T component, 0.02-0.07 Hz) provides most stable results. In case of distorted absolute amplitudes a combination of frequency spectra and maximum cross-correlation fitting proved to be useful. We find that for smaller events (Mw < 3.0) surface waves are not observed and higher frequency body waves are strongly influenced by complex heterogeneities along the travel path. To extend the source analysis to even weaker events the standard MT inversion approach is

combined with network similarity cluster analyses, enabling the association of weaker events to larger ones and therefore the reconstruction of the geometry of active faults.

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