Solid Earth Discussions

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Comment on se-2021-13

Anonymous Referee #1

Referee comment on "Regional centroid moment tensor inversion of small to moderate earthquakes in the Alps using the dense AlpArray seismic network: challenges and seismotectonic insights" by Gesa Maria Petersen et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-13-RC1, 2021

This study uses an unprecedented dataset from dense seismic deployments (AlpArray) in the wider Alpine area and a versatile moment tensor inversion tool in order to show the viability of full moment tensor inversion for small regional events, and to produce a large set of solutions that bring forward our understanding of regional deformation. In my opinion, this represents a solid and useful contribution and should appear in Solid Earth.

Besides the value for Alpine seismotectonics, strength of this manuscript is the extensive testing to explore processing parameters. This provides important hints for setup and parameter choices (filter bands, etc.) in other moment tensor initiatives directed at small events. The authors also simulate less dense networks than AlpArray, which will be the case for most applications. Also, the work explicitly addresses the appearance and significance of non-DC components in moment tensor sources, without prejudice as weather these components are expressions of a plausible source process or artefacts from modelling.

Final moment tensor solutions are consistent within this dataset as well as in comparison with previous solutions, validating the inversion procedure and helping in the delimitation of seismotectonic domains in the region. Beyond analysis of the present moment tensor data set, the authors extend the discussion to previous seismicity, to provide a general seismotectonic summary for the wider Alpine area. This manuscript contains a lot of information and is suited to arouse curiosity and further questions, making it well suited for Solid Earth as an interactive journal. To start, here I propose points for further thinking or minor revision of this manuscript:

1) Effects of station coverage:

In section 2.2.4, tests show how the reduction of azimuthal coverage affects moment tensor estimates. However, formally, one single three-component station is sufficient to resolve a DC mechanism (if the Earth model and everything else is ok, in practise this should be avoided). Did the authors try the comparison using DC-constraint in inversion or comparing DC-components of full moment tensors? Is the DC information more stable than full moment tensors if the azimuths become narrow?

2) Geodynamic interpretation:

Earthquake and GNSS data agree on the characteristics of deformation in the SE-Alps and Apennines, but the western and central Alps appear more enigmatic. The results from moment tensor inversion (extensional stresses, with T- axes oriented rather perpendicular to the bending of the arc, and shallow depths) and GNSS data (absence of convergence, or any other significant regional strain) apparently provide support for previous models that attribute seismicity to gravity and buoyancy forces (e.g. Delacou et al., 2004, Geophys. J. Int 158, 753–774). The authors point out the coincidence between faulting in the Western Alps and uplift, but probably could add more thoughts whether the results could be interpreted in an active (tectonic) or passive (erosion or deglaciation) framework.

3) Technical details:

- How are crust2.0 models assigned: according to source side structure, receiver side structure, or both (given that QSEIS could handle two different crustal structures)?

- Small time shifts are allowed in time domain full waveform inversion and regulated with a penalty function, which may be to some extend a way to clear inconsistencies between time domain, envelope, cross-correlation and spectral inversion. Question: how small are these time shifts, and how penalizing the penalty function? To answer this question, maybe also a more general statement about the combination of data misfit is necessary.

- The authors identify as principle problem of first motion mechanism the fact that they are only representative for the rupture onset and cannot represent complex rupture processes. Two comments: Point source MT cannot represent general complex sources either; and second: there may be more relevant problems for first motion mechanisms in practise, like for example the instability of take-off angles for shallow events.