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Seismotectonics of the Western Alps: new insights on seismogenic source characterization

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Due to the low to moderate seismicity of the European Western Alps, few focal mechanisms are available to date in this region, and the corresponding current seismic stress and strain fields remain partly elusive. The development of dense seismic networks in the past decades now provides a substantial amount of seismic records down to low magnitudes. The corresponding data, while challenging to handle due to their amount and relative noise, represent a new opportunity to increase the spatial resolution of seismic deformation fields.

The aim of this study is to assess spatial variations of the tectonic regimes and corresponding stress and strain fields, which will provide new insights into active seismic deformation in this area. The dataset comprises more than 30,000 earthquakes relocalized in a 3D crustal velocity model, and more than 2200 focal mechanisms newly computed in a consistent manner. We inverted this new set of focal mechanisms through several strategies, including a seismotectonic zoning scheme and a Bayesian inversion, which provides a probabilistic 3D reconstruction of the faulting style in the Western Alps.

The global distribution of P and T axes plunges confirms a majority of transcurrent focal mechanisms in the overall alpine realm, combined with pure extension localized in the core of the belt. Extension is found clustered, instead of continuous along the backbone of the belt. Compression is robustly retrieved only in the Po plain, which lays at the limit between the Adriatic and Eurasian plates. High frequency spatial variations of the seismic deformation are consistent with surface horizontal GNSS measurements as well as with deep lithospheric structures, thereby providing new elements to constrain homogeneously deforming zones.

We interpret the ongoing seismotectonic and kinematic regimes as being controlled by the joint effects of far-field forces –imposed by the counterclockwise rotation of Adria with respect to Europe- and of buoyancy forces in the core of the belt, which together explain the high frequency patches of extension and of marginal compression overprinted on an overall transcurrent tectonic regime.

These results shed new lights on seismicity distribution and tectonic regime variations both regionally and at depth. They appear complementary to geodetic constraints on active faults and to existing structural studies, thus allowing us to bring new insights into future seismogenic zoning schemes.