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New 3D Pg and Sg Velocity Models for High-Resolution Seismotectonic Interpretations in the Central Alps

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The present-day deformation in the Central Alps is dominated by vertical uplift, at rates up to 1.5 mm/yr as indicated by high-precision levelling and GPS data. Understanding the driving mechanisms of this neotectonic uplift and its link to seismicity in the Central Alps requires accurate locations of current deformation processes within the upper crust. Especially the question if and how deformation in the crystalline basement is coupled with deformation in the overlaying nappe systems is key to understand the neotectonic processes. Seismicity provides important information on deformation in the uppermost crust, however, an accuracy of focal depths in the order of few kilometers and less is required to distinguish sources in the basement from sources in the sedimentary cover.

In this study, we demonstrate how insufficient crustal velocity models and inconsistent seismic phase selection can lead to biased hypocenter solutions, which hamper such high-resolution seismotectonic interpretations. We propose a relocation procedure combining a new high-resolution Pg and Sg 3D crustal model of the Central Alps with a dynamic seismic phase selection to overcome this bias and to improve accuracy of hypocenter solutions. The new tomographic model is based on more than 60,000 Pg and 30,000 quality-checked Sg phases of earthquakes, which occurred in the greater Central Alpine region between 1996 and 2019. In combination with a nonlinear, probabilistic earthquake location algorithm, the model was used to relocate more than 18’000 earthquakes, which occurred in this region over the past 36 years. The derived catalog includes a consistent error and quality assessment, calibrated against ground-truth events like quarry blasts.

The relocated seismicity in the Central Alps is interpreted together with additional information from the tomographic model, focal mechanisms, geophysical, geological and geodetic data. We focus our interpretation on the eastern Aar massif as well as on the Rawil depression, located in-between the outcropping Aar and Aiguilles-Rouge massifs. Both regions were recently affected by remarkable seismic events. The ML4.6 Urnerboden earthquake of 2017 occurred near the eastern termination of the Aar massif, while a sequence of about 350 events occurred in the Rawil earthquake lineament near the Sanetschpass in November 2019. Both sequences provide unique insights into active faults in the Central Alps and we image systems of sub-vertically oriented strike-

slip faults of variable strike, which root in the crystalline basement in both regions. Our results document the existence of active strike-slip fault systems in the External Crystalline Massifs of the Central Alps in regions of maximum change in uplift rates. We therefore discuss possible models relating the observed strike-slip kinematics to buoyancy-driven vertical tectonic processes.