A comprehensive high resolution 3D P- and S-wave velocity model for the Alpine mountain chain using local earthquake data: Constraining crustal structure, lithologies and mountain-building processes

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Based on the unprecedented amount of densly recorded seismic waveform data and recent advances in machine learning techniques the main objective of this project was the computation of a comprehensive high resolution 3D P- and S-wave velocity model for the Alpine region including station correction terms. Additionally, event locations and associated uncertainties as well as the automatically determined seismic arrival times should be published. The 3D crustal model delivers travel time correction terms for teleseimic tomography studies and thus sharpen the image of subducted slabs in the upper mantle.

We used "SeisBench - A toolbox for machine learning in seismology" to assess the performance of several deep-neural-network based seismic picking algorithms and find PhaseNet to be most suitable. In order to consistently remove outliers from the P- and S- phase pick catalog we developed a purely data-driven pre-inversion pick selection method. We relocated a subset of 384 events while simultaneously inverting for the 1D P- & S-wave velocity structure including station corrections using the established VELEST as well as the recently developed McMC algorithms. This model yields the first consistent travel time based 1D S-wave model of the Greater Alpine region facilitating computation of synthetic travel times and the inclusion of S-phases during the localization process.

Furthermore, it yields the starting model for the final 3D velocity model which is based on records from more than 3000 events on more than 1100 seismic broadband stations. Comparing our hypocentres with event locations from other studies indicates a horizontal and vertical accuracy of ~2km and ~6km, respectively, when using a 1D velocity model and station correction terms for the Greater Alpine region.

Large scale features of the resulting velocity model are in good agreement with previous studies. The Molasse and Po basin in the northern and southern foreland, respectively, are showing up as prominent low velocity zones in the uppermost crust. Generally, the velocity isolines in the lower crust are in rather good agreement with Moho maps from previous studies and ambient noise tomographies.