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Imaging the crust of the western Alps using travel times from 20,000 earthquakes.

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Located between France, Italy and Switzerland, the western Alps are a complex area were dense seismic networks have recorded a few $M_L < 2$ crustal earthquakes per day in the past 25 years. By merging data from more than 200 stations distributed in 5 different local networks, we built up a 20,000-event database over a 400×430 km^2 area. This database provides a unique opportunity to study the details of the western Alps structures, such as the Ivrea upper-mantle body (Italy) or the Digne sedimentary nappes (France).

Our method to carry out a high-resolution tomographic imaging of the Alpine crust and upper mantle is based on the inversion of P_g, P_n, S_g and S_n-wave arrival times from crustal events, for V_P and V_P/V_S fields as well as for event locations and station site-effect residuals. Because of the large size of the model box, we take the ellipticity of the Earth into account, and of course its surface topography. In order to model the Moho discontinuity, we build up an *a priori* Moho topography based on a selection of different studies published in the past 30 years. Using two different velocity models for the crust and the mantle separated by this *a priori* Moho discontinuity, we perfectly model the velocity jump and we also decorrelate those two domains. Local adjustments to this *a priori* Moho topography are performed, based on the velocity model obtained after a few iterations of the inversion process.

To invert this 600,000 data set we use a non-linear least-squares approach based on a stochastic description of data and model. The forward computation of travel times in the 3D model is performed by integrating slowness along the rays, which are determined by the Podvin-Lecomte algorithm (basically a finite-difference resolution of eikonal equation). The regularization of the velocity fields is achieved through a covariance norm on V_P and V_P/V_S, the kernel of which is of exponential type. The smoothing and damping parameters are adjusted by means of L-curves analysis.

In the past 25 years, a few events have caused damages in the western Alps and local networks have monitored a few swarms. Some faults have also been discovered just by looking at hypocentre alignments of low magnitude events, such as the 90-km-long Belledonne fault near Grenoble (France). Accurate locations are crucial to understand and describe this kind of fault. This new 3D velocity model, where a realistic Moho discontinuity allows us to work with both direct and refracted P and S waves, can be used to locate hypocentres using a probabilistic approach.