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Regional fast-marching tomography in intracontinental settings: preliminary analysis of limitations and potential

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Seismic tomography can be applied to different scales. Over the last two decades, monitoring systems, technical innovations and methodologies have substantially improved, resulting in accurate tomographic images at the global and local scales. Nowadays it is easy to perform travel-time tomography with local seismicity thanks to the increasing density of seismic stations. Nevertheless, it is unlikely to have earthquakes that properly cover the whole studied area at the requested depths. For this reason, many tomographic images are obtained with teleseisms and both far and local earthquakes.

Here, we realized a Local Earthquake Tomography (LET) in an area of high seismic hazard in central-southern Italy, extending from L'Aquila to Benevento, to benchmark the iterative non-linear Fast-Marching code FMTOMO (Rawlinson and Sambridge, 2004) at intracontinental scale. The primary aim is to analyse and discuss the influence of both the inversion parameters and the grid sizes on the inversion results. Special attention was devoted to setting damping factors and smoothing parameters and to study how they can affect the tomographic images and their reliability.

We used 5712 local events (0.2<ML<5.1) recorded by 38 stations of the Italian Seismic network; we jointly inverted 71221 P and S arrival times to obtain Vp and Vs model. We selected earthquakes having: (1) a root-mean-square (RMS) residual less than 0.5 s, (2) more than 10 phases (P and S), (3) azimuth gap less than 180, (4) residual of each phase less than 0.5 s, (5) a depth between 0.5 and 30 km. We used a single layer of 35 km in depth and a grid area extending 162 km in latitude and 245 km in longitude with a node spacing of about 5 km in each direction. As a starting velocity model, we chose a mono-dimensional one of Trionfera et al. (2020).

Using these well-localized earthquakes, we observed low residuals variability despite a full investigation of damping and smoothing parameters. Furthermore, the regularization parameters we obtained are one or two order of magnitude lower than those estimated at the wider scales.

Because of the uncertainties in the depth of events, the fast-marching code needs several nodes above and below the grid set for earthquakes to move sources during each hypocentral inversion. As a consequence, when inverting for both velocity and hypocentral location, FMTOMO performs the calculation even for a wide boundary area without earthquakes, which causes a loss of computational speed.

After properly tuning the inversion parameters, FMTOMO gives reliable and high-resolution tomographic images. We found a good agreement with surface geology and regional tectonic structures, demonstrating that the code works well in areas with such complex geology.