A local earthquake tomography model of the Fucino fault-controlled basin (central Apennines, Italy) obtained through a very dense temporary network

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Abstract

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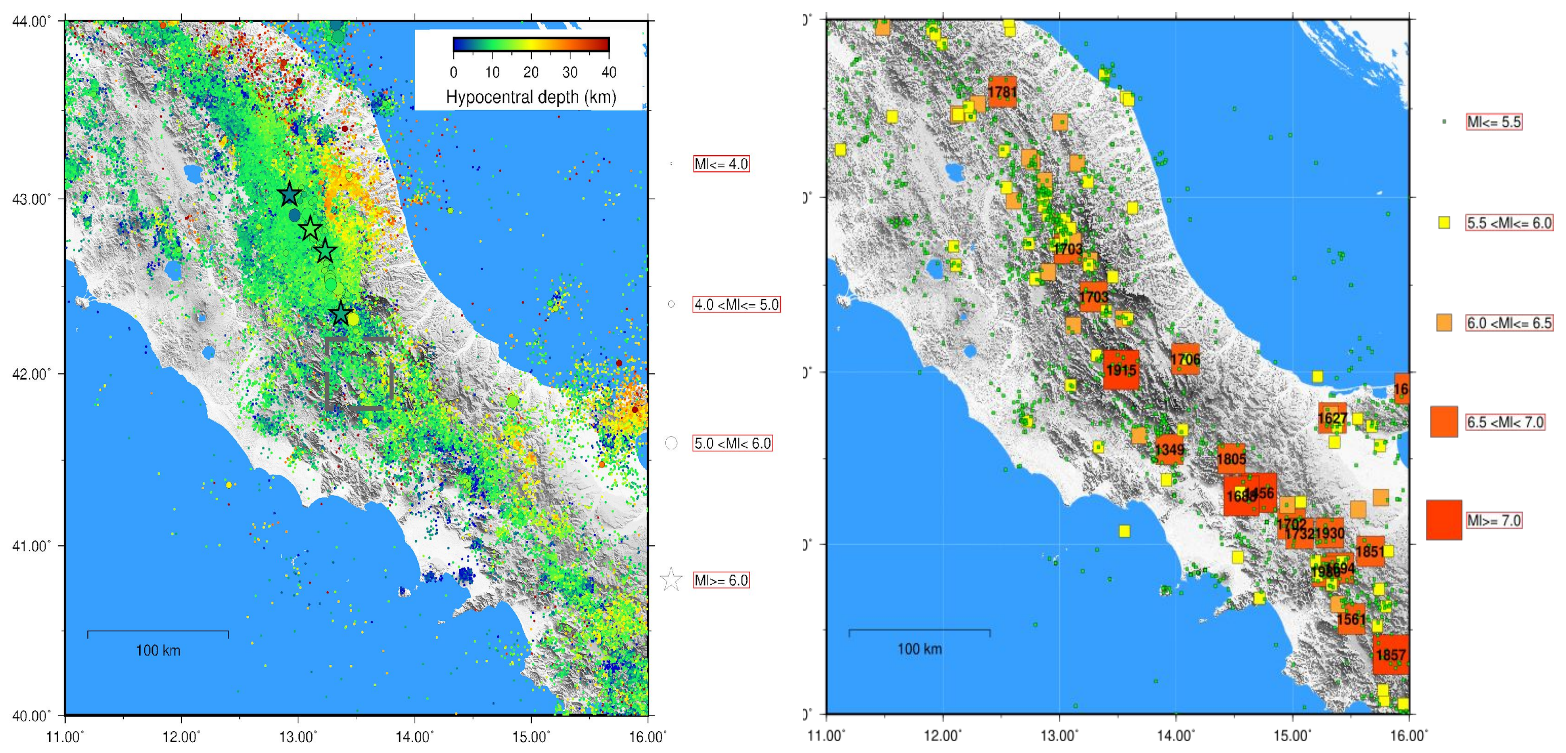
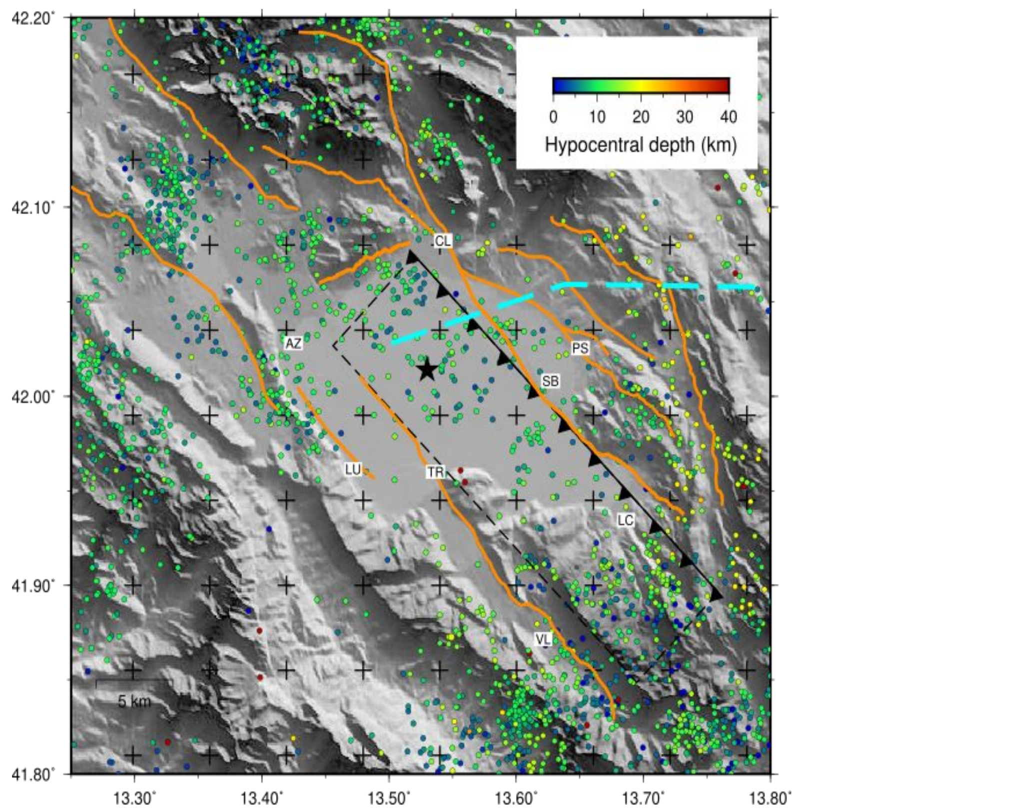
1. Seismicity of central Apennines and Fucino region

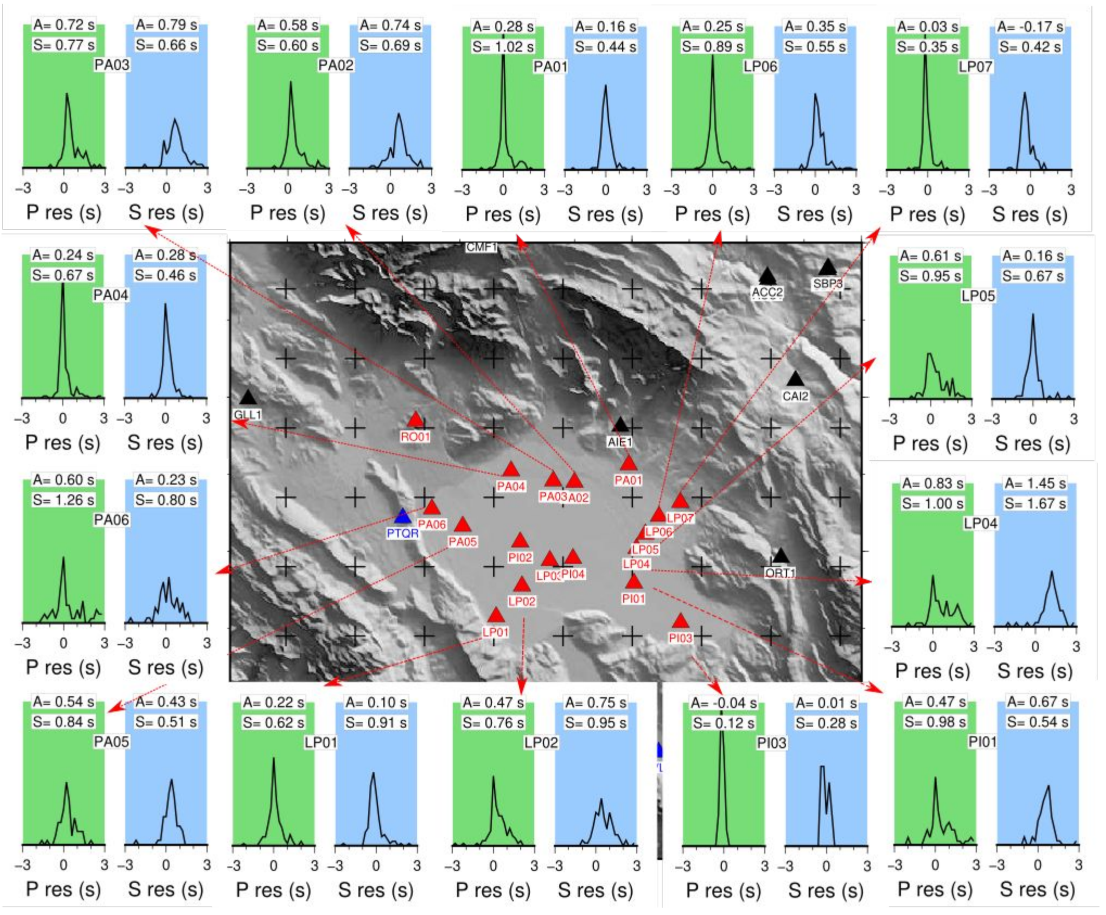


Instrumental seismicity (**left**) occurred from 2005 to 2022 (Menichelli et al., 2022) and historical seismicity (**right**, https://emidius.mi.ingv.it/CPTI15-DBMI15) of central Apennines (Italy). The bulk of seismicity occurs mainly in the upper crust in the depth interval 7-12 km and it is located along the topographic highs. Large earthquakes occur along the NW-SE trending normal faulting system, which accommodates about 2-3 mm/yr of extension across the mountain range. The most important events that occurred in the last 25 years are (see stars in the left figure): 1997 Mw 6.0 Colfiorito; 2009 Mw 6.1 L'Aquila; 2016 Mw 6.1 Amatrice; 2016 Mw 6.5 Norcia. The study area (dashed line on the left figure) lies about 35-40 km S of L'Aquila at the southern termination of these recent strong events and it represents the epicentral region of the strongest earthquake occurred in central Italy (January 13, 1915; Mw 7.0; Io= XI MCS, see figure on the right).



The instrumental seismicity occurring beneath the Fucino basin is scarce (see map). It is mainly located at 10-12 km depth on the north-western and south-eastern borders. The basin is bounded to the north and east by two main normal fault systems striking WSW-ENE and NW-SE, respectively (see orange lines on the map). The NW-SE fault system is the source of the Mw 7.0 1915 central Italy earthquake. The black star is the epicentral position taken from the parametric catalog (Rovida et al, 2020) while the black rectangle represents the surface projection of the proposed fault plane (from DISS database, https://doi.org/10.13127/diss3.3.0). The shallow architecture of the basin and fault systems (< 2 km depth) is defined by seismic commercial lines complemented by the CROP11 deep reflection profile (dashed light blue line), but the fault's geometry at seismogenic depths (i.e.; 5-15 km depth) is poorly known.

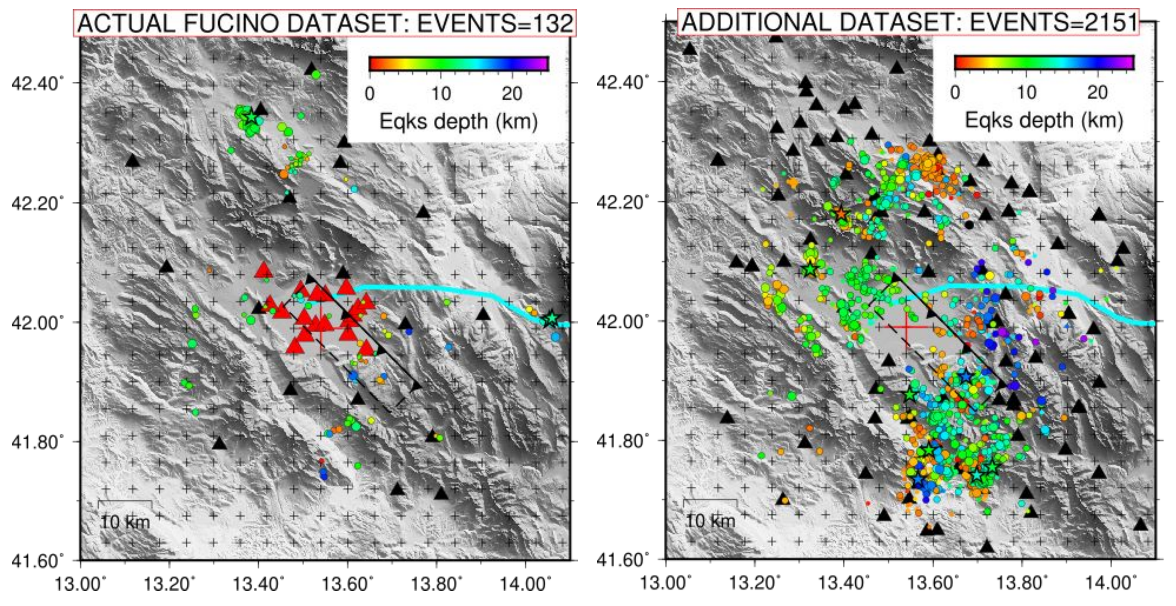
2. The Fucino seismic array and tomography setup



During the 2008-2009 time-window, 18 temporary seismic stations, operating in continuous mode at 125 Hz, were installed in the Fucino area to investigate the basin seismic response and local site effects (red triangles on the figures; Cara et al, 2011). This dataset was integrated by the permanent stations of the Italian seismic network and Abruzzo regional network installed on the surrounding ridges, to construct a new earthquake catalog and perform a local-scale passive tomographic survey.

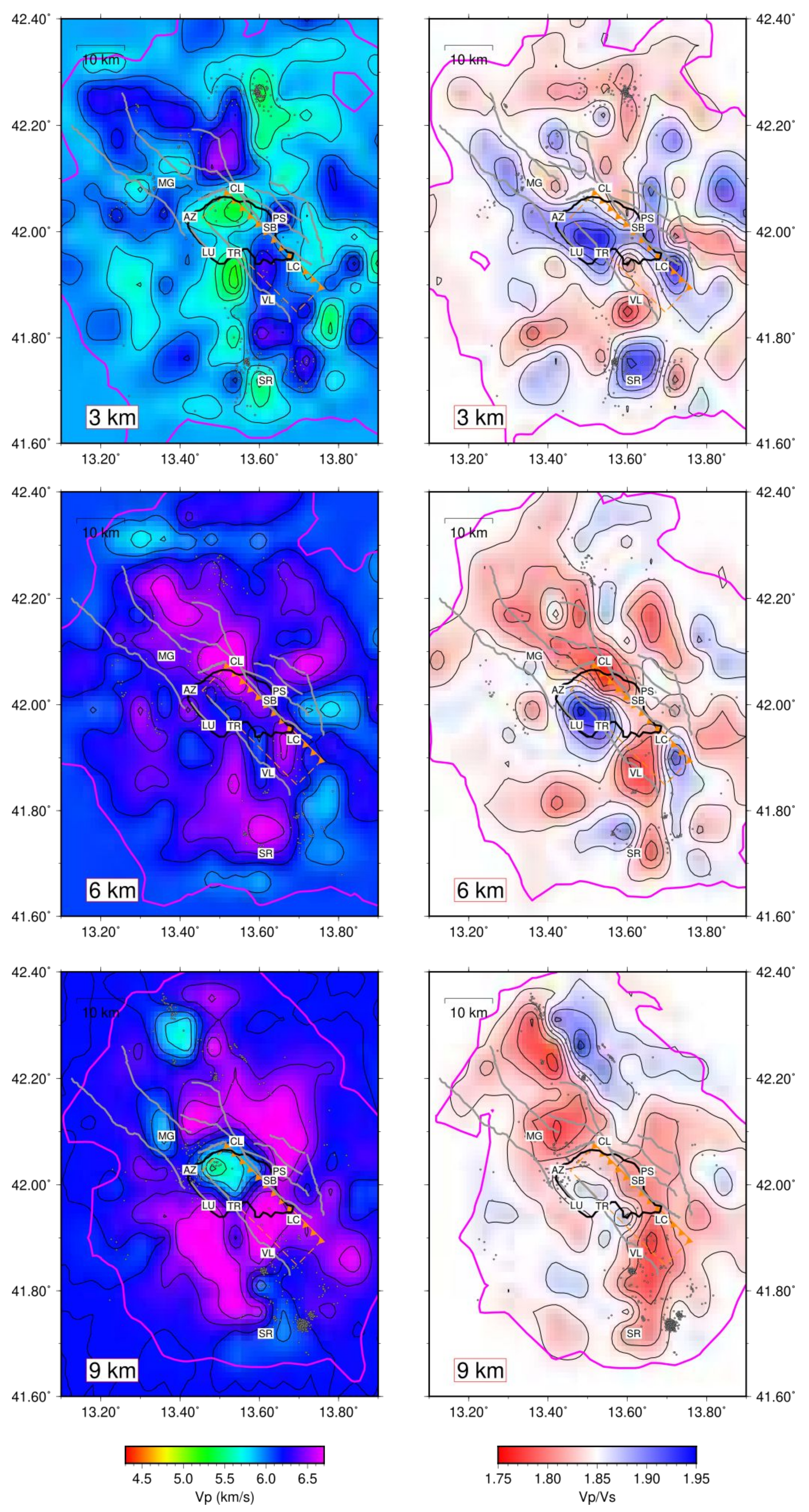
We used a standard (STA/LTA) algorithm to detect very local weak events. P- and S-wave arrival times of the detected earthquakes were hand picked and weighted according to a standard scheme. About 20% of the dataset has been analyzed.

On the **left** we report the histograms of P and S residuals at some stations of the basin after 1D location of the detected events. On the **right** we show the events used for tomography: the first panel displays the 132 events deriving from the Fucino array while the second shows the additional events that we will use to create a greater dataset useful for the tomographic inversion (grid: 5x5x3 km, inversion code: Simulps14 (Haslinger, F. 1998)).

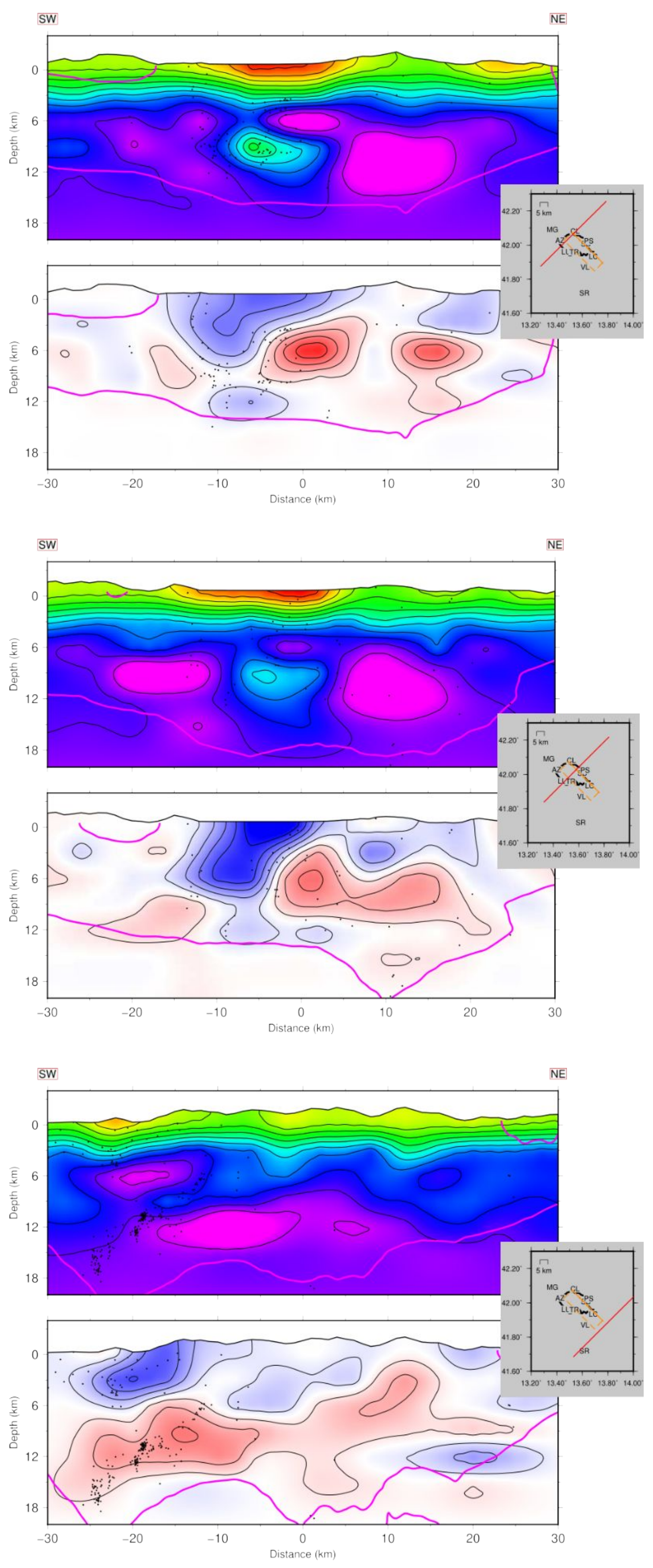


3. Tomography: Results

Horizontal slices



Vertical cross-sections



4. Conclusions

- The preliminary model defines a complex velocity structure down to 15-18 km with strong lateral Vp and Vp/Vs variations and Vp reversals. The complete pool of seismic events recorded by the Fucino basin array will allow performing an higher-resolution tomography to image in more detail the crustal structure at seismogenic depth (5-15 km depth) and the active fault systems in the Fucino and surrounding regions.
- From 3 to 9 km depths, Vp patterns are dominate by NW-SE striking high-Vp anomalies (from 5 to 6.5 km/s) that delineate carbonate thrust-sheets of the Apenninic platform units (Mesozoic-Tertiary).
- The Fucino basin filled by Plio-quaternary deposits corresponds to an evident shallow Vp body (> 4.5 km/s) and to a remarkable Vp/Vs positive anomaly that extends down to 9 km depth. This structure may be related to strongly fractured and fluid saturated rock volumes associated to the basin-bounding fault systems.
- Under the basin a strong Vp reversal (down to 5 km/s) is retrieved at 9 km depth. This low-Vp body is associated with ordinary Vp/Vs (1.85) and may represent basinal and flysch sequences (Tertiary). A basinal thrust-sheet tectonically sandwiched between carbonate platform units has been dubitatively interpreted in the CROP11 seismic section just in this zone (Patacca et al., 2008).
- To the southwest of the Fucino basin, SW-dipping high-Vp (Vp > 6 km/s), high-Vp/Vs wedges clearly delineate platform carbonate units overthrusting basinal sequences. Here, relocated seismicity aligns along SW-dipping structures at the bottom of the high-Vp carbonate wedges and may delineate inherited thrust-faults reactivated in the extensional regime. Overall, the velocity structure and relocated seismicity suggest a key role played by inherited compressive structures in the velocity and earthquake spatial patterns.

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