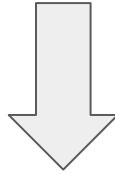


SECURE - WP 1



Enhancements of Existing Crustal Velocity Models and Seismic Datasets



WP 1.1 Crustal velocity models

WP 1.2 Strong motion and macroseismic dataset

WP 1.3 Geological and seismotectonic input data

WP1- Enhancements of Existing Crustal Velocity Models and Seismic Datasets

WP1.1

3D velocity models across the three SECURE
project target regions

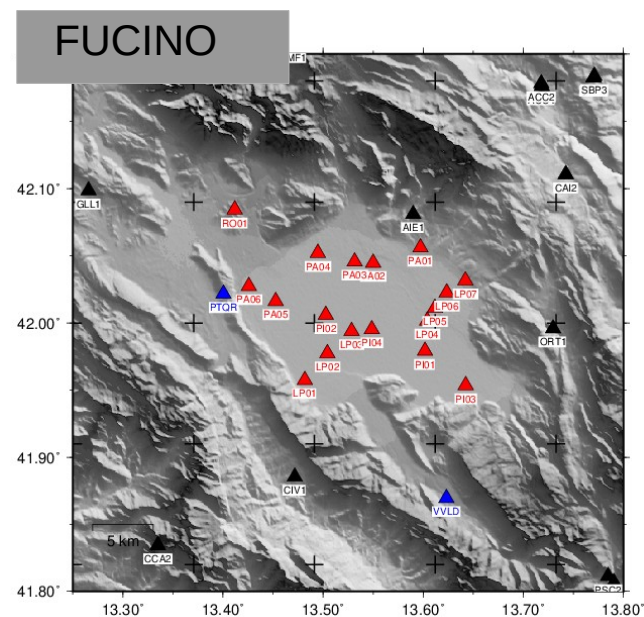
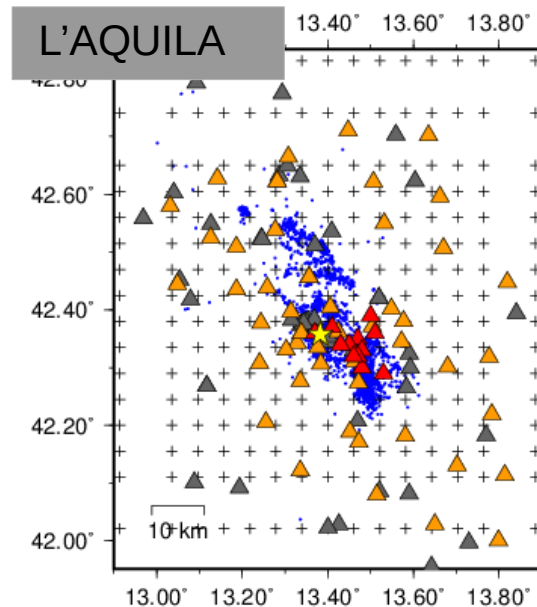
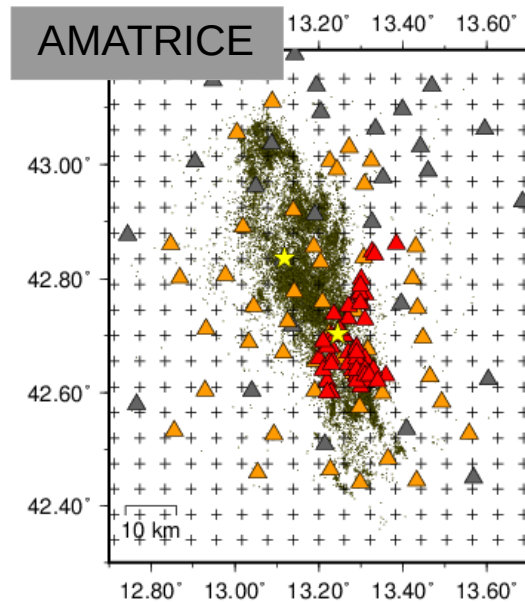
De Gori P. &

Anselmi M., Bagh S., Chiarabba C., Fonzetti R., Giacomuzzi G., Lucente F.P., Valoroso L.
INGV-Roma

WP1.1 D1 – Detailed Vp and Vs models of the crust including basin structures embedded in tomographic models (INGV-ONT-RM1)

Dataset: seismic data deriving from the main seismic sequences (L'Aquila 2009, Amatrice-Norcia 2016) and background seismicity (Fucino)

Objectives: improve the spatial resolution of the existing tomographic models by using seismic stations mainly deployed on alluvial plains to study amplification effects



ENHANCED VELOCITY MODELS

- **Starting LET model (V_p , V_p/V_s) for the upper crust** (model obtained with aftershocks data or background seismicity: grid 5x5x3 km or 6x6x3 km)
- **Starting Q_p , Q_s structure** (published models or values derived from velocity grids $Q_s=0.05*V_s(\text{m/s})$; $Q_p=2*Q_s$)
- **Resampling the LET model with a step size of a few hundred meters**
- **Integrating Topography**
Topography details (from geophysics and geology) are included at the top of the refined tomographic model
- ***Pfile*-determination**
To define the medium for waves propagation, rock density, V_p , V_s , Q_p , and Q_s models are reformatted into a *Pfile*.

AMATRICE-NORCIA - MODEL

Starting LET model Vp Vp/Vs (Chiarabba et al., 2018; De Gori et al, 2023) 5 x 5 x 3 km defined with aftershocks data;
Vp, Vs, $Q_p=2Q_s$, $Q_s=0.05V_s(\text{m/s})$

Resampling LET model

300m on NS direction

250m on EW-direction

50 m along vertical direction at depths 0-1 km

200 m along vertical direction at depths 1-16 km

Integrating Topography

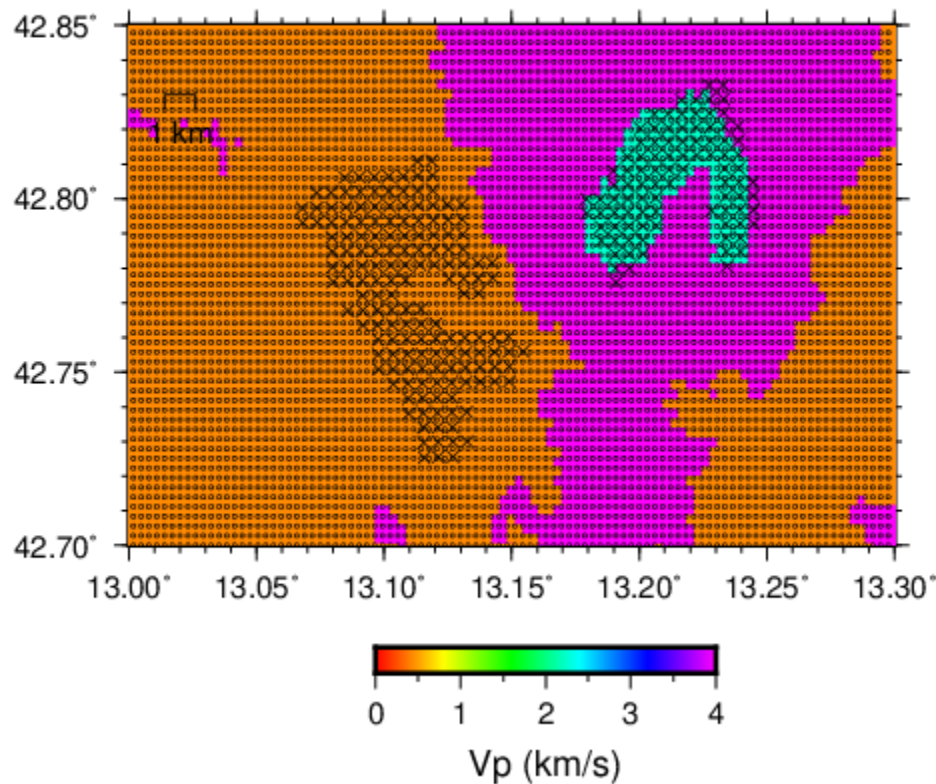
Velocity models of Norcia and Castelluccio basin (Di Giulio et al, 2020; Brozzetti et al, 2019) are included at the top of the tomographic model.

***Pfile*-determination**

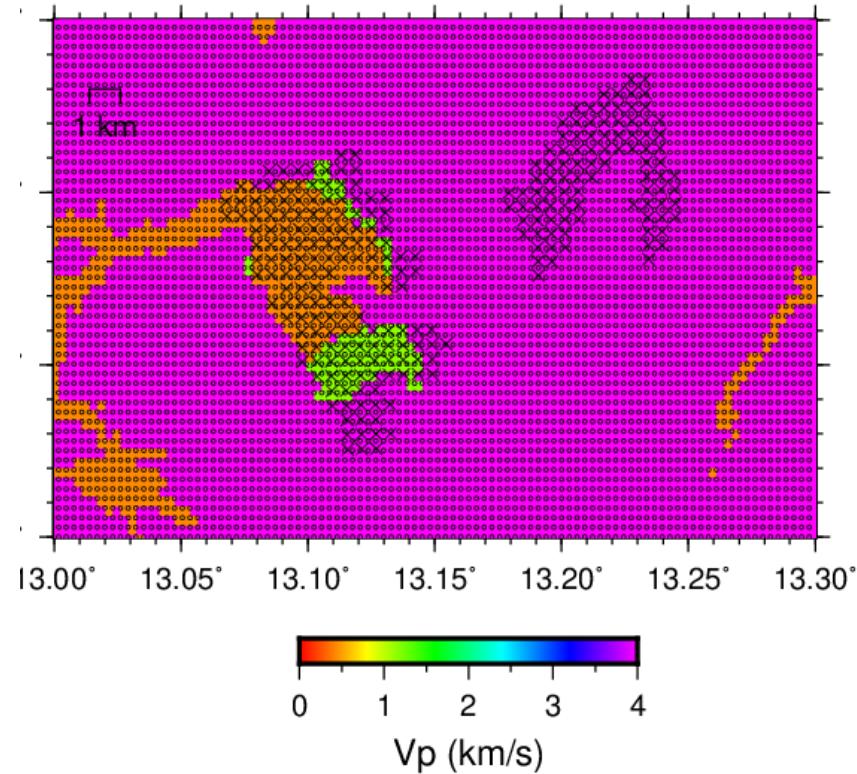
Accurate ground motion simulations for frequencies up to 3-5 Hz
(Pitarka et al., 2021; Akinci et al., 2024).

AMATRICE-NORCIA - MODEL

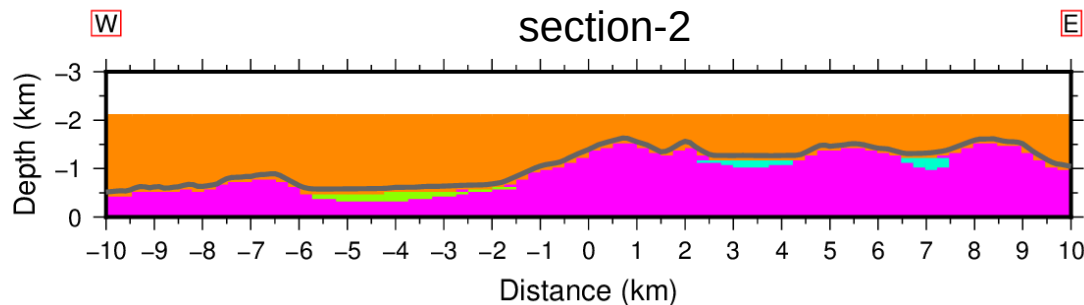
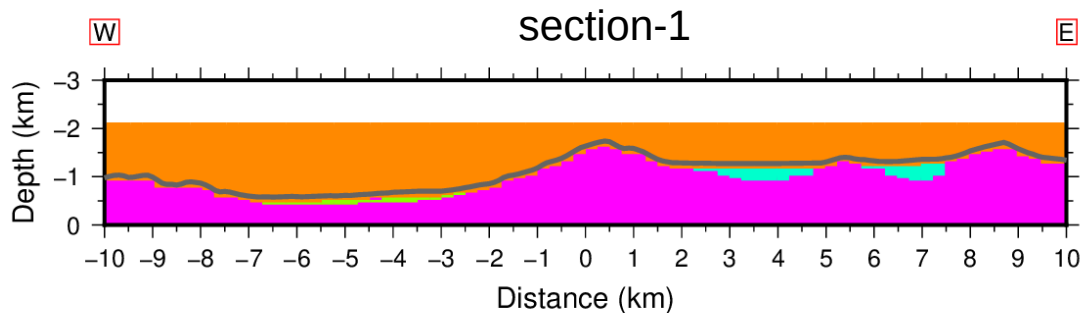
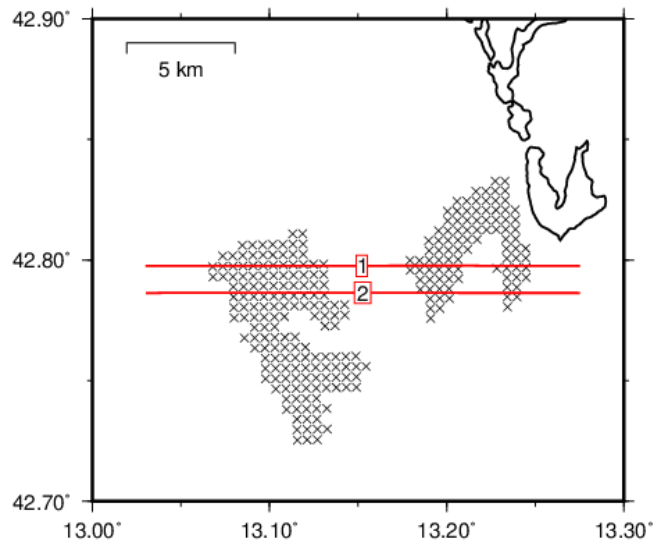
Depth = -1.25 km



Depth = -0.70 km



AMATRICE-NORCIA - MODEL



L'AQUILA- MODEL

Starting LET model Vp Vp/Vs (Chiarabba et al., 2020) 6 x 6 x 3 km defined with aftershocks data and background seismicity;
Vp, Vs, $Q_p=2Q_s$, $Q_s=0.05V_s$ (m/s)

Resampling LET model

300m on NS direction

250m on EW-direction

50 m along vertical direction at depths 0-1 km

200 m along vertical direction at depths 1-16 km

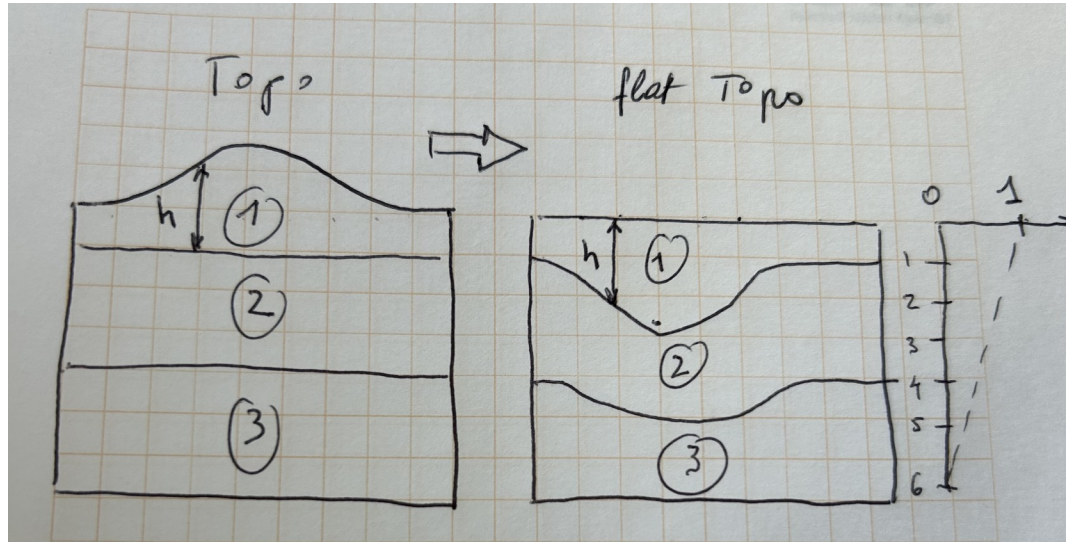
Integrating Topography

The Aterno basin velocity model is included in the tomographic model by means of the "squashing" approach

L'AQUILA- MODEL

Integrating Topography by “squashing” approach

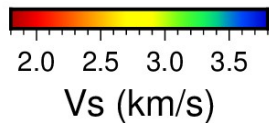
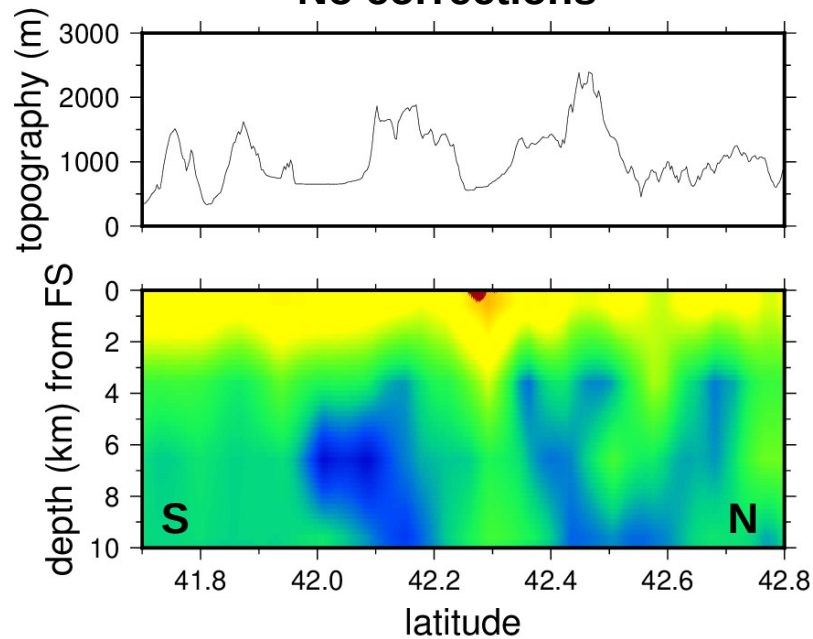
The squashing approach adjusts or "squashes" the topographic surface beneath the flat free surface preserving the relative depth of each layer's boundary with respect to the free surface. A tapering effect with depth is used to gradually reduce the influence of topographic features as we move deeper in the model



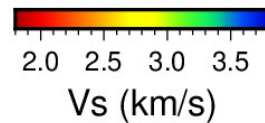
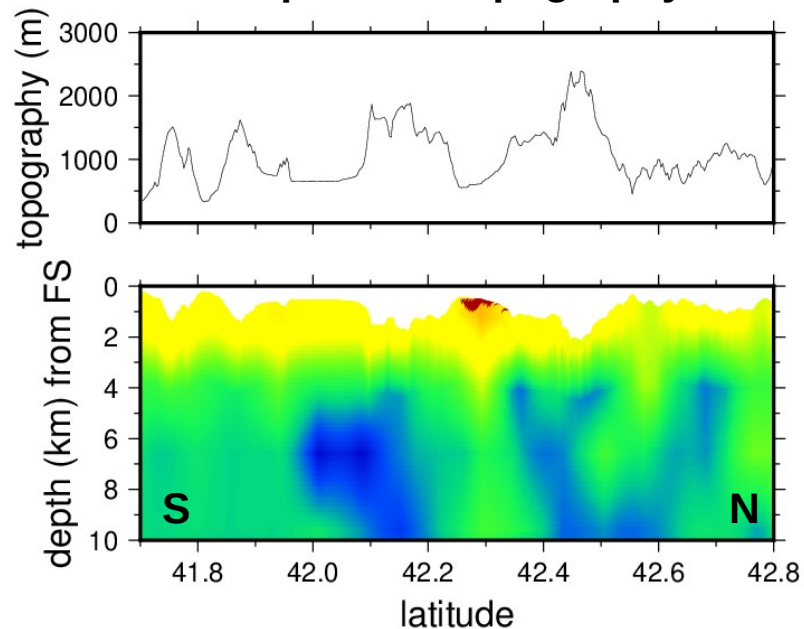
Arben sketch....

L'AQUILA- MODEL

No corrections



Squashed topography



FUCINO - MODEL

The Fucino area represents a small portion of Central Apennines and seismicity is investigated with the station spacing of Italian network (about 30 km in this region with a MI detection threshold of about 1.0).

We need of additional seismic stations and earthquake data to perform a reliable seismic tomography model (grid 5x5x3 km) similar to that of Norcia and L'Aquila.

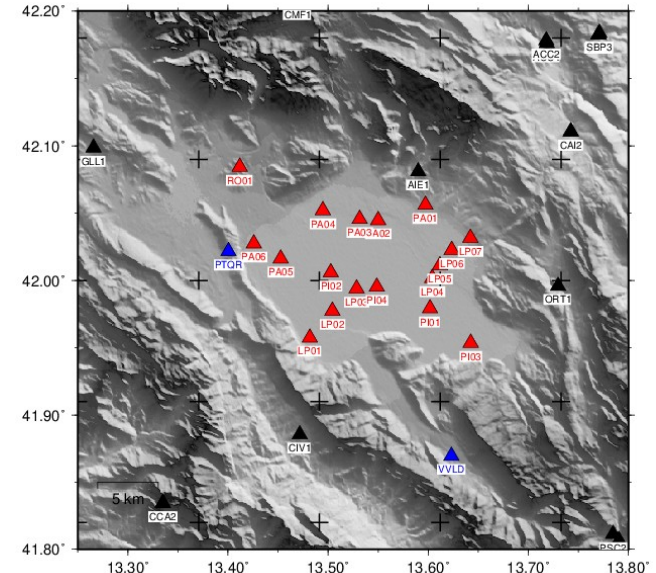
AVAILABLE DATASETS

- FIRB experiment (2003-2005) focused on the study of background seismicity of the Abruzzo region (Bagh et al., 2007)
- SLAM experiment (2009-2013) aimed to analyze seismicity in central Apennines (Frepoli et al., 2017)
- Bollettino Sismico for the recent seismicity integrated with data of 4 RAN accelerometric recordings.
(ex: 5 events of MI 1.0-1.5 occurred on 2026/03/5-8 on the Northern part of the basin)

FUCINO - MODEL

NEW DATASET: THE 2008-2009 SITE EFFECTS EXPERIMENT

- 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 (Cara et al, 2011).
- The array operated during the 2009 L'Aquila sequence and we search on continuous seismograms the local seismicity probably triggered by the strongest events occurred about 30-40 km northward
- This dataset is integrated by the permanent stations of the Italian seismic network to construct a new earthquake catalog and perform a local-scale passive tomographic survey.



FUCINO - MODEL

NEW DATASET: THE 2008-2009 SITE EFFECTS EXPERIMENT

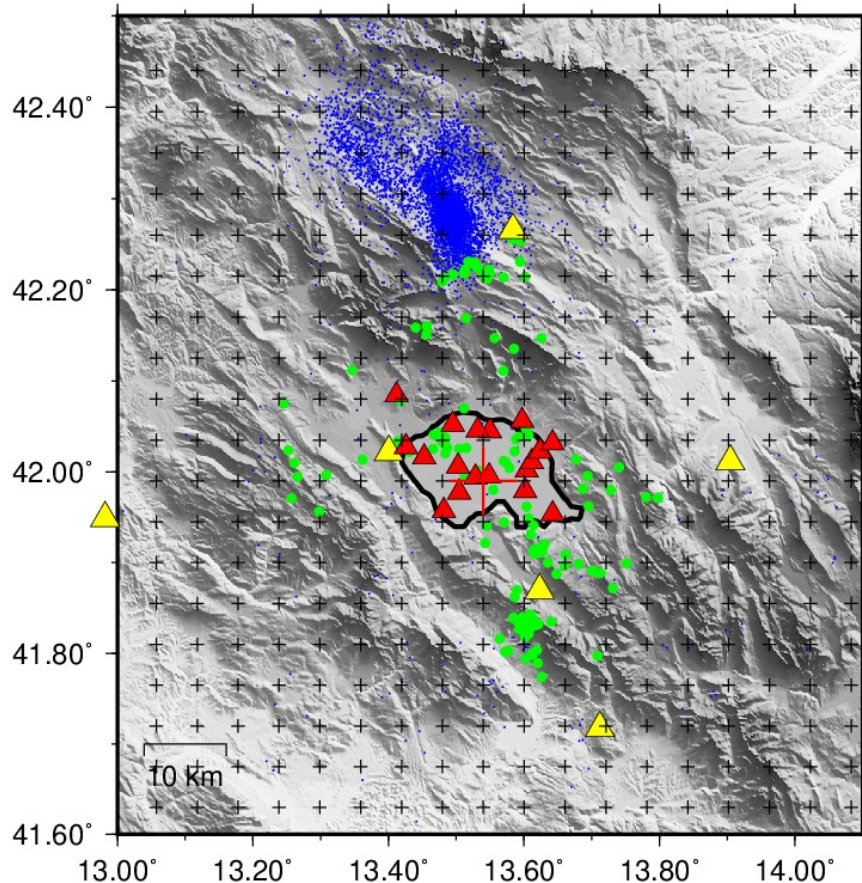
Data preceding the L'Aquila Mainshock (April 6th 2009 hh 01:32)

- We used a standard (STA/LTA) algorithm to detect very local weak events and manual picking to determine the P- and S-wave arrival times.
- We used a ML approach to detect P and S wave arrival times and event phase associations (by R. Fonzetti)
- Comparison between standard and ML procedures

Data post L'Aquila Mainshock

Only ML application to detect P and S waves arrivals.

FUCINO - MODEL



THE PERFORMANCE OF ML

18 = N. of Fucino stations

6 = N. INGV permanent stations

Continuous Data from **2008 Oct – 2009 Aug**

~**6500** events detected by the codes:

Phasenet + Gamma (Instance model)

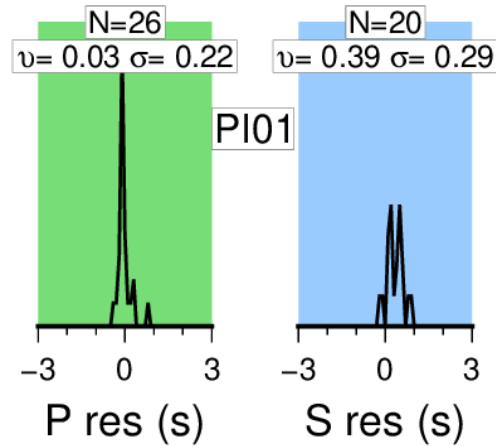
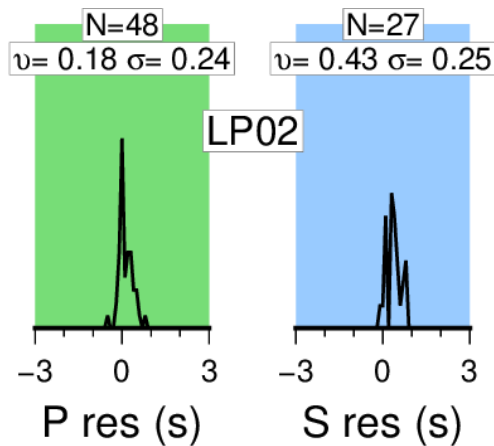
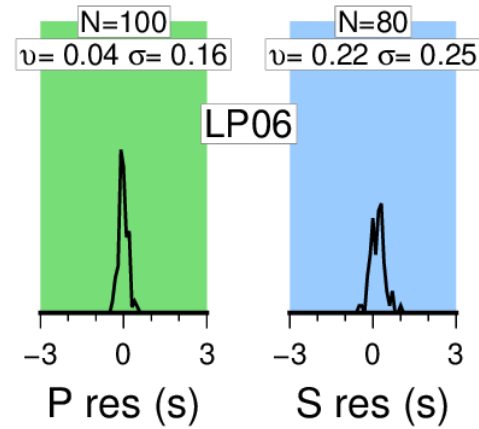
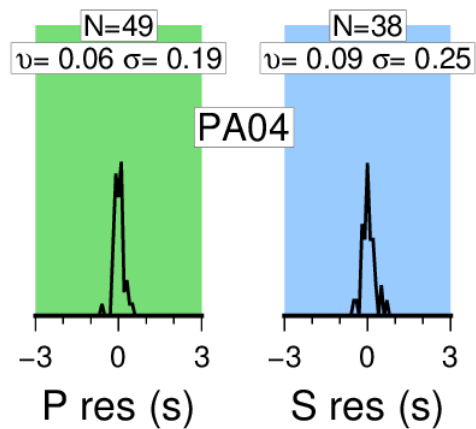
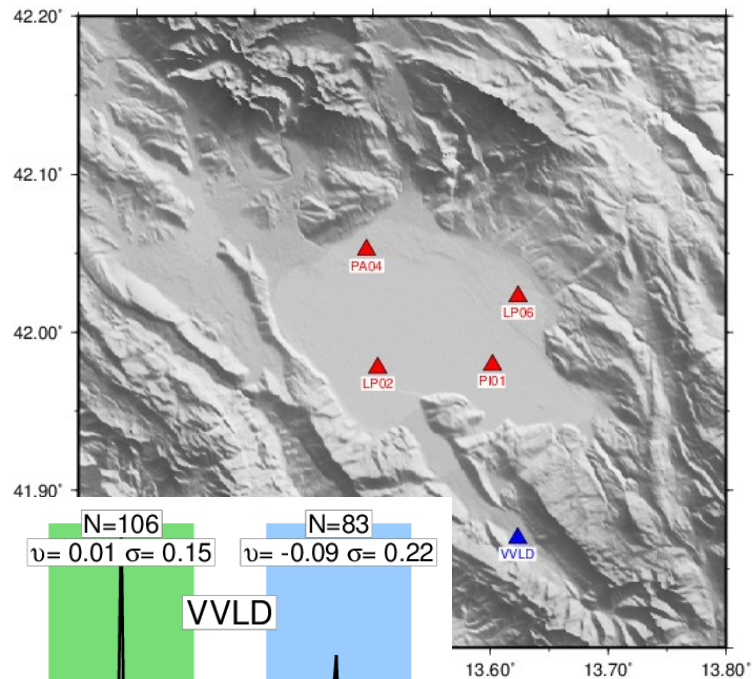
150 = N. of events usable for tomography

RMS < 0.5 s

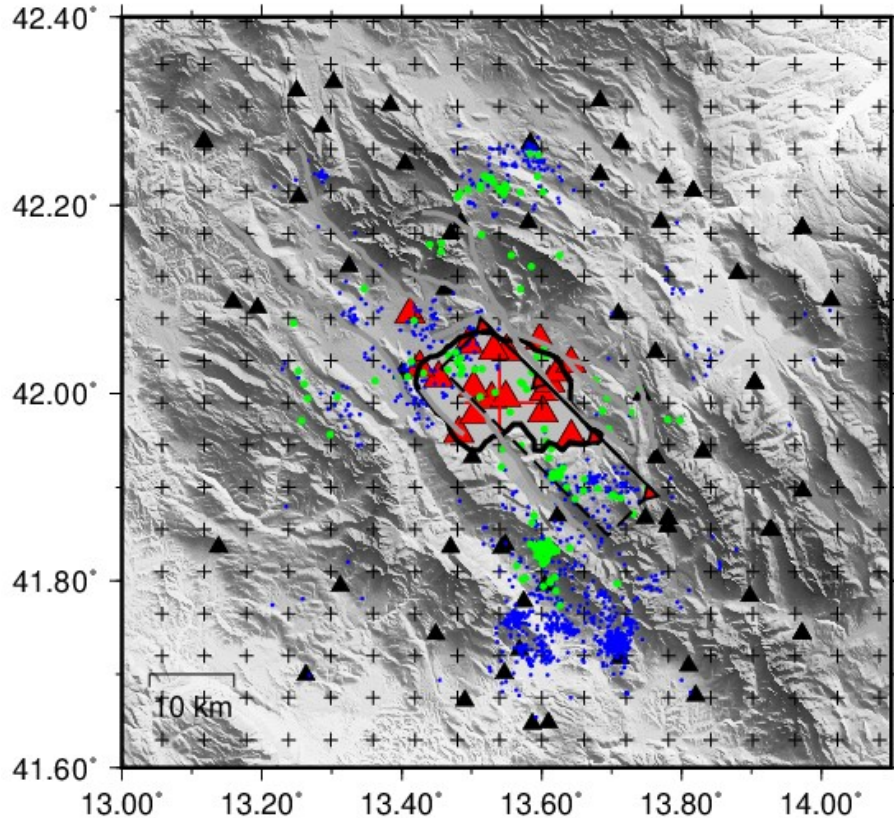
GAP < 180 degrees

4P + 1S

FUCINO - MODEL



FUCINO - MODEL



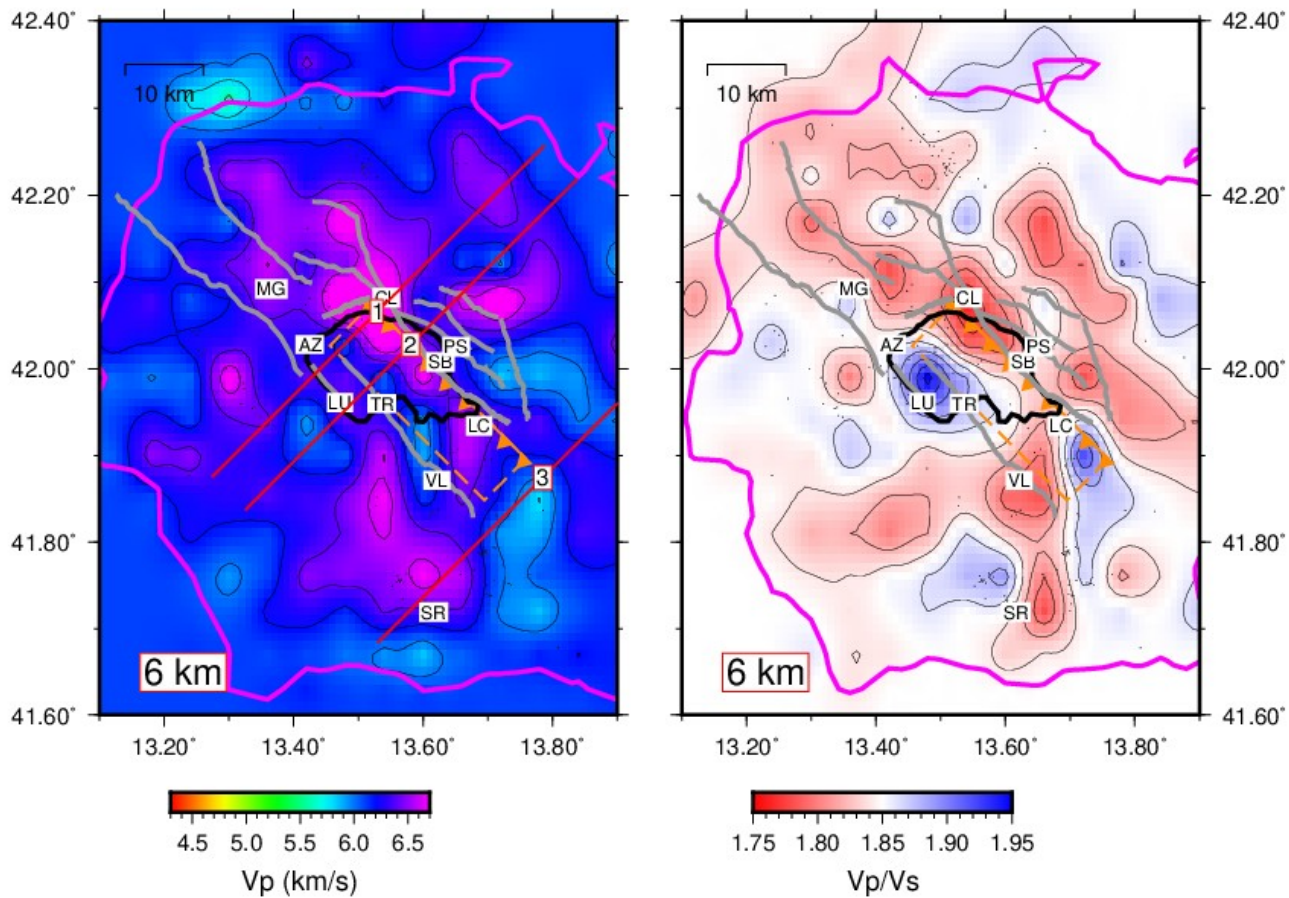
LET MODEL

18 = N. of Fucino stations

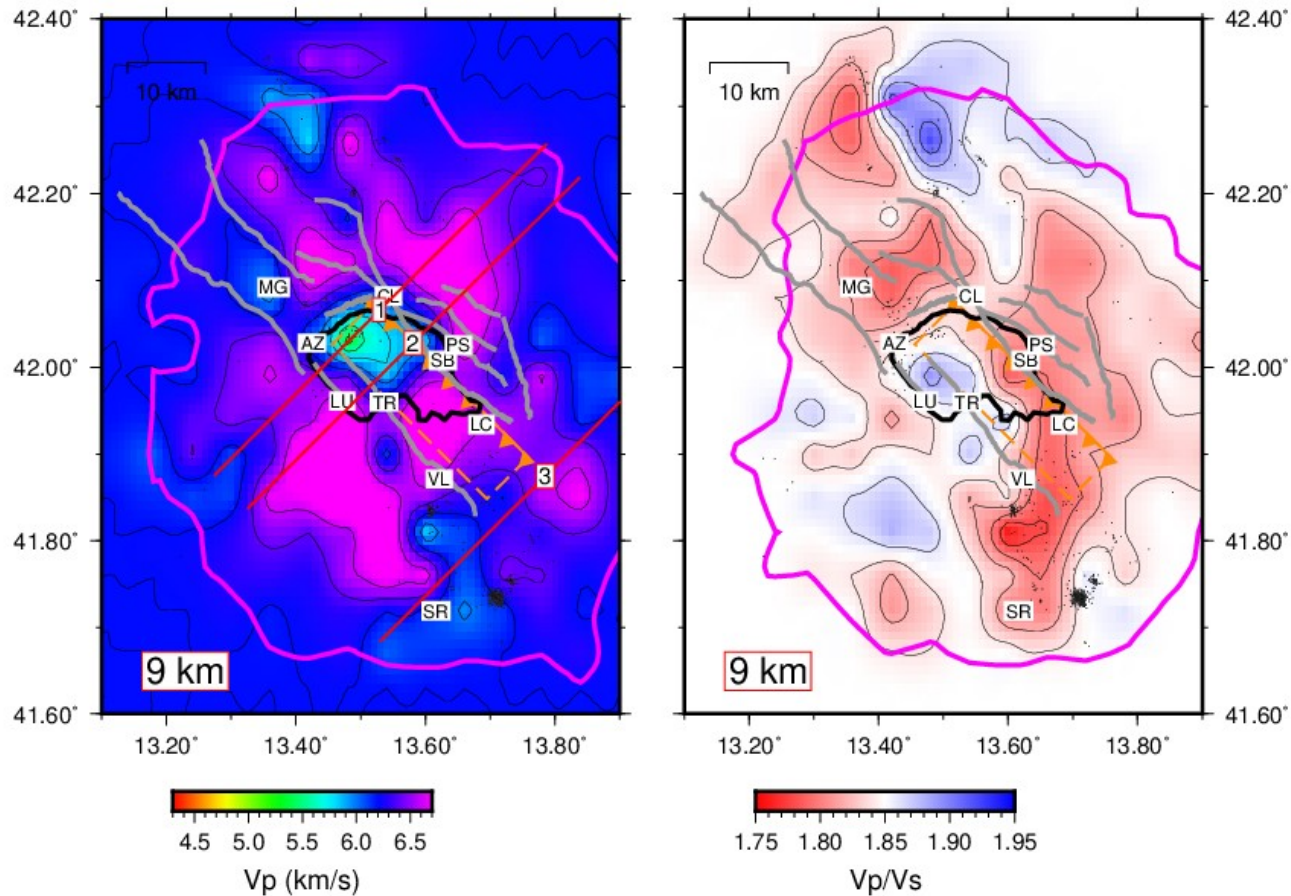
150 = N. of events recorded from
Fucino stations **from October 2008
to May 2009**

~1500 additional events from the
SLAM project and background
seismicity studies

FUCINO - MODEL

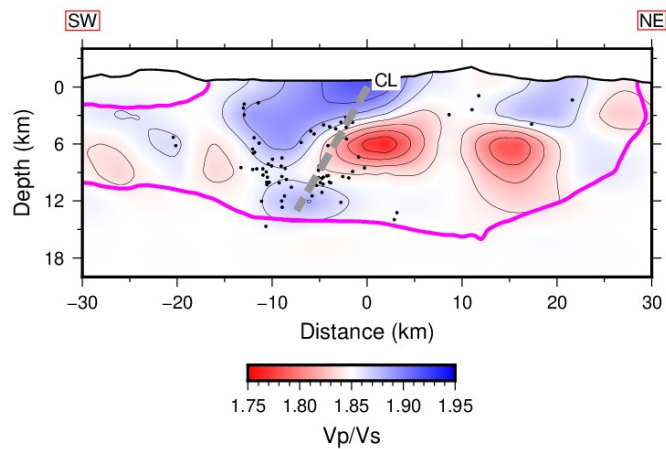
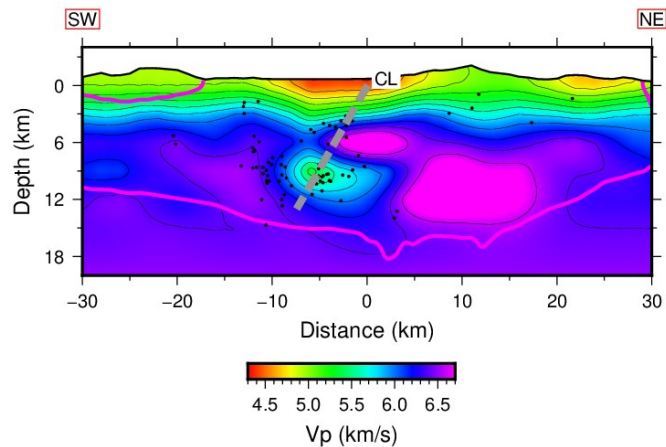


FUCINO - MODEL

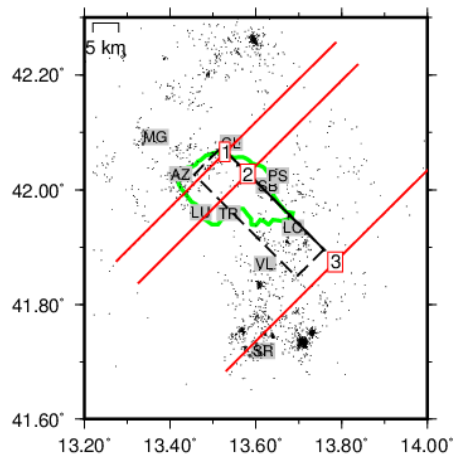
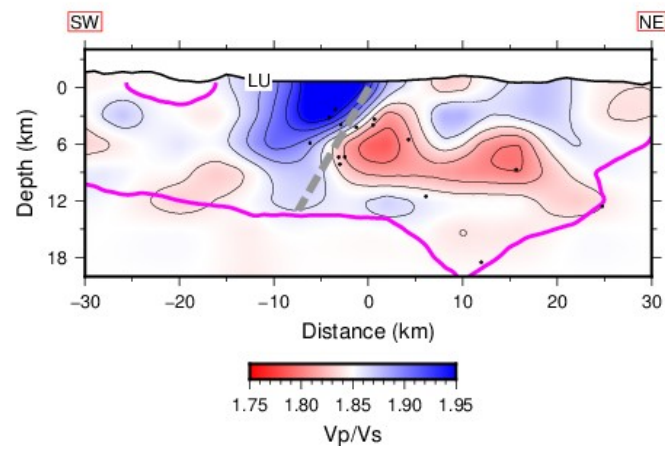
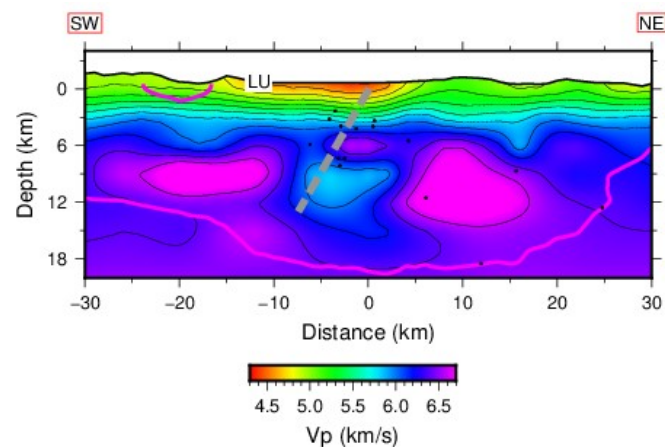


FUCINO - MODEL

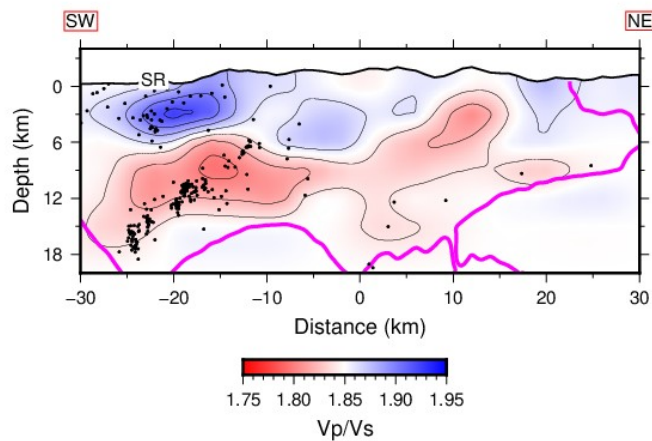
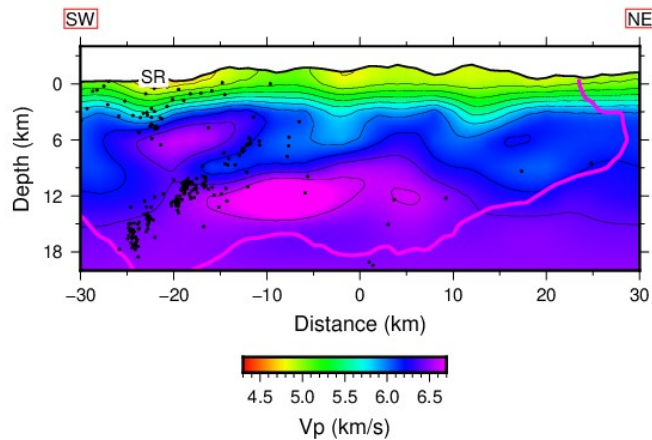
sect-1



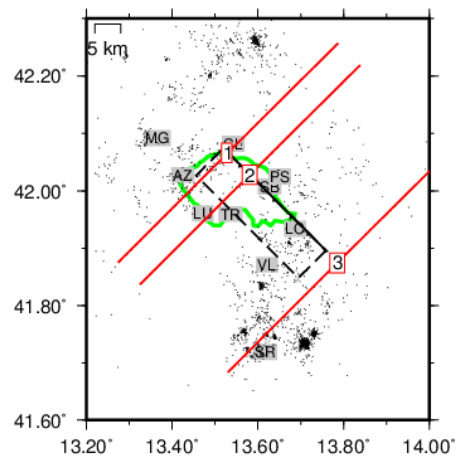
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FUCINO - MODEL

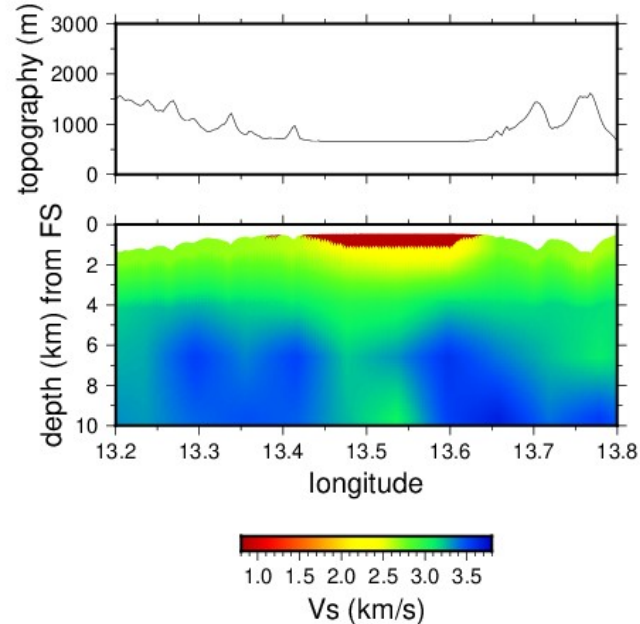
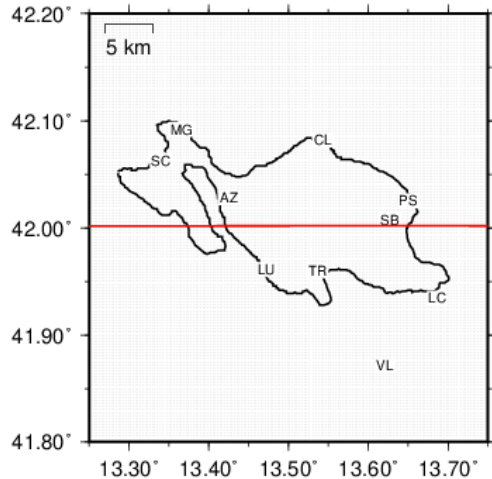


sect-3



***p*-file FOR AREA 3**

- The geological model of the basin (Burrato & Vannoli presentation) will be used to better define the shallow portion of LET model.
- Topography is integrated in the LET model by using the “squashing” approach



FUTURE DEVELOPMENTS

- *P-file* by using Q_p and Q_s attenuation tomography.
- Could Q_p and Q_s 3D models help to better define the ground motion particularly at high frequencies?