The Alpine Deep Structure from Surface Wave Tomography

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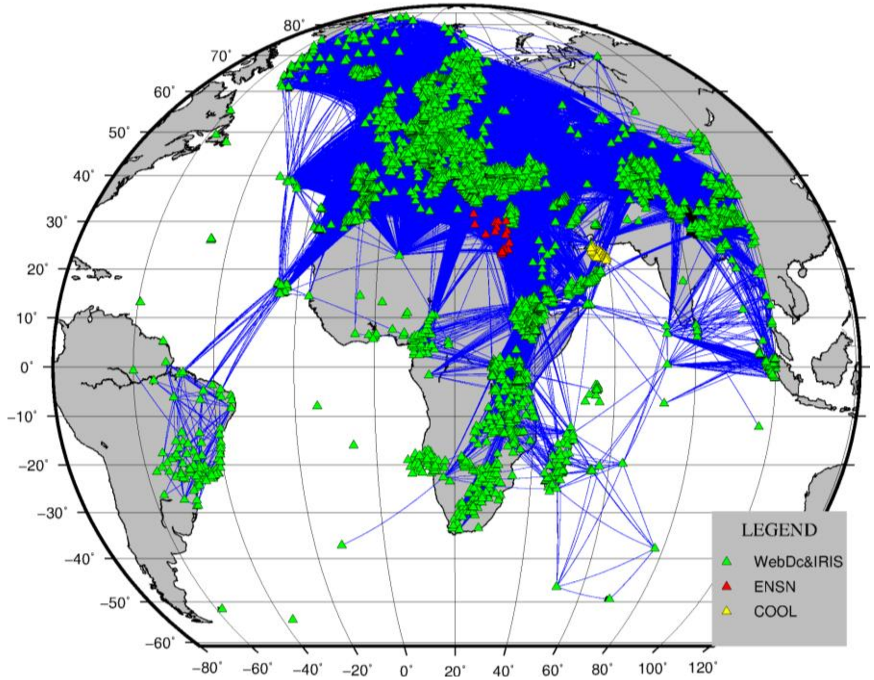
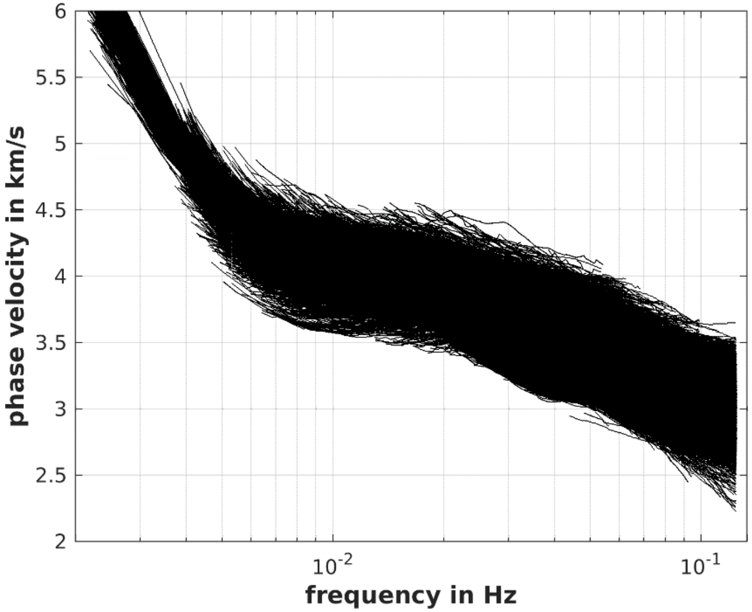
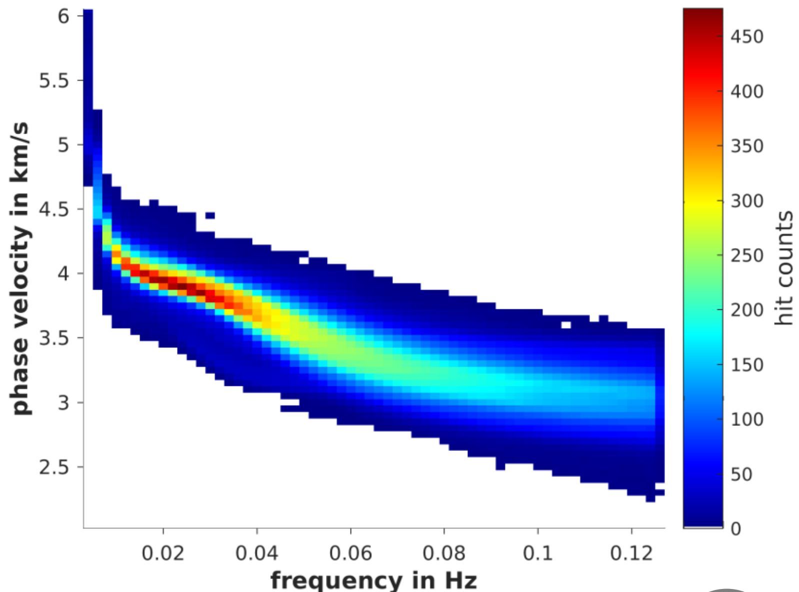
- Collision in the Alps driven by segmented slabs and slab break-off
- Understanding of Alpine tectonics requires knowledge of slab structure
- Presence of slabs may be detected by surface wave tomography from beneath the crust downwards to about 300 km depth
- Automated processing of all publicly available data from 1990-2015
- Stochastic inversion of fundamental mode phase velocity dispersion measurements for Vs structure

Dataset

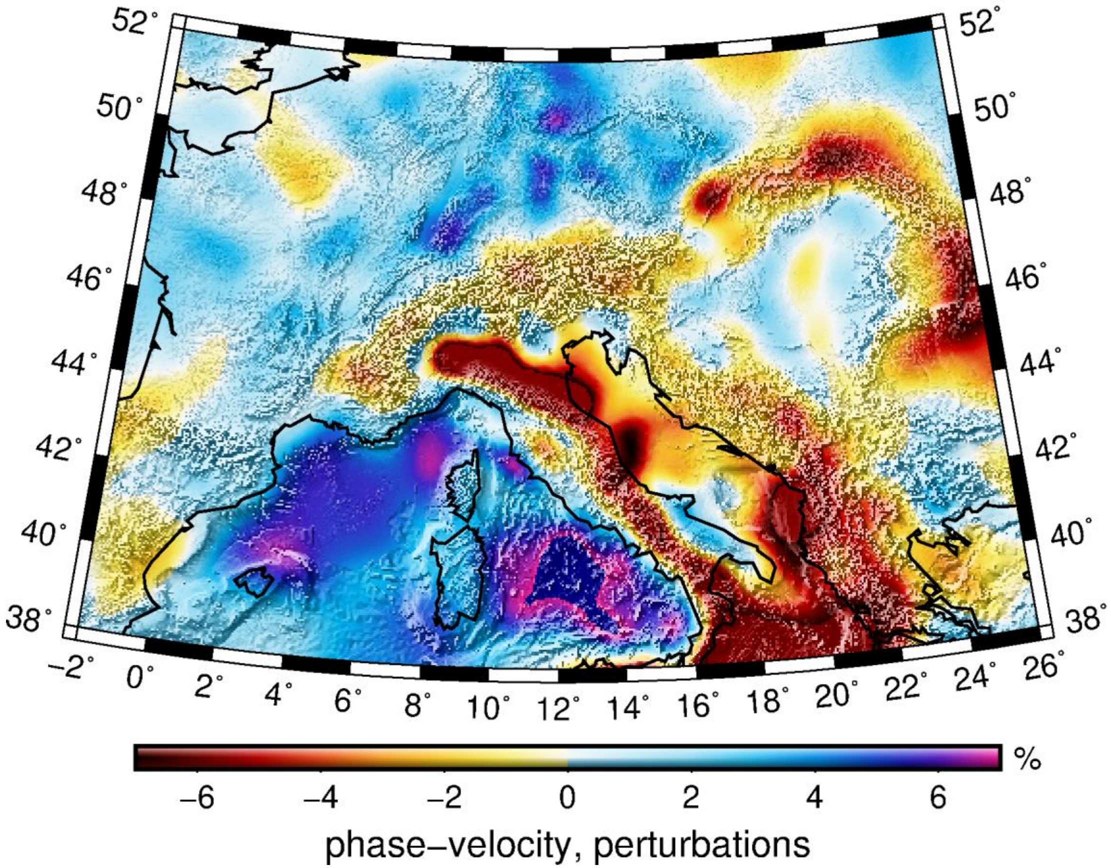
- Pre-AlpArray data
- Time period: 1990 - 2015
- ~ 4.500 stations WebDC
- ~ 3.5 millions of waveforms
- ~ 200.000 inter-station dispersion curves
- Period range: 8 - 300 s



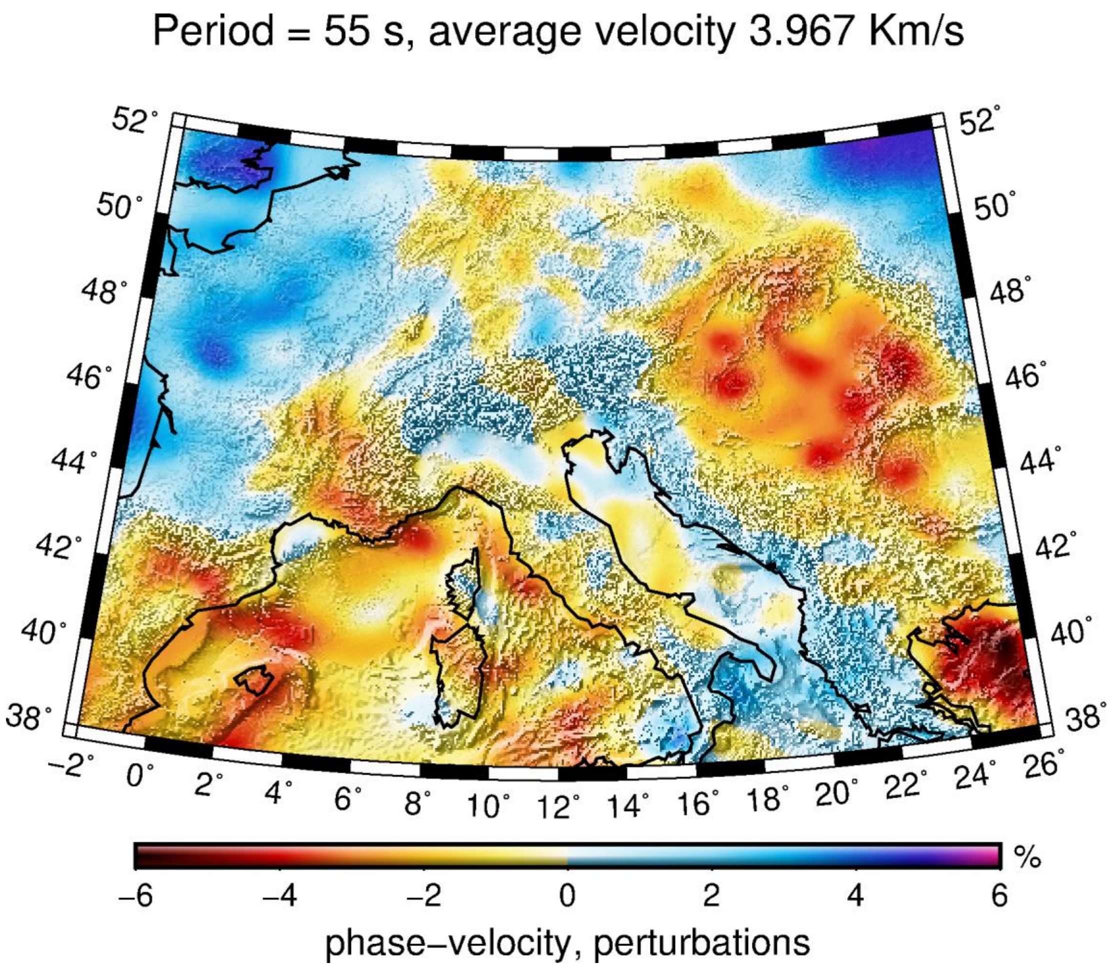




Period = 15 s, average velocity 3.335 Km/s



Isotropic Rayleigh wave phase velocity map at 15s sampling the depth range of ~ 15 – 30 km



Isotropic Rayleigh wave phase velocity map at 55s sampling the depth range of ~ 60 – 120 km

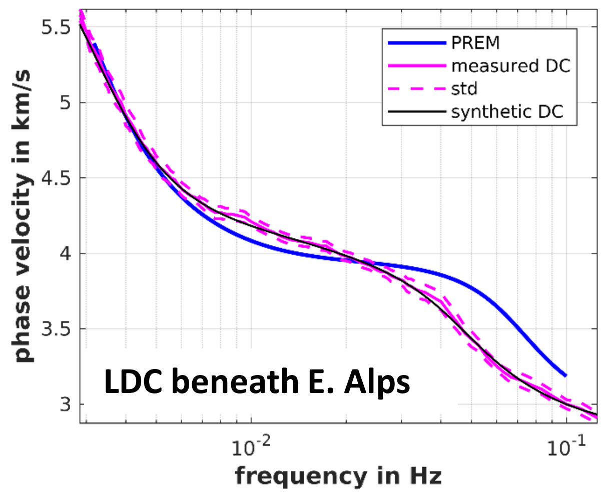
1-D depth-velocity models from local dispersion curves (example for the location indicated in the previous phase velocity maps)

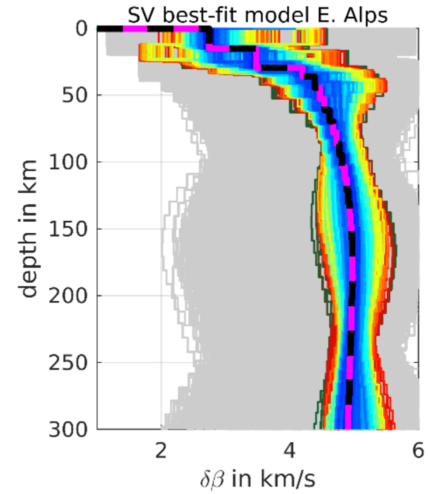
Particle Swarm Optimization algorithm (PSO)

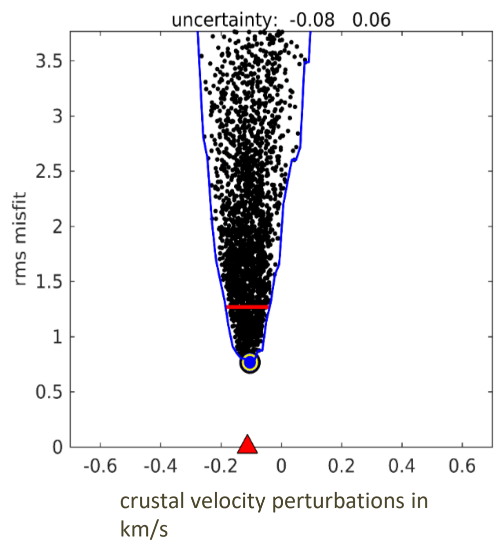
- stochastic inversion algorithm
- flexible parametrization (velocity perturbations + depth of discontinuities)
- flexible regularization
- estimation of uncertainties and investigation of trade-offs between parameters

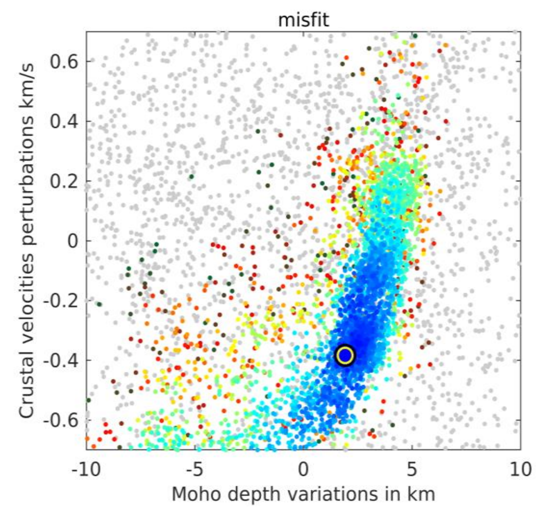
- random local search to speed up the convergence
- exploration of the entire model space

Kennedy & Eberhart, 1995

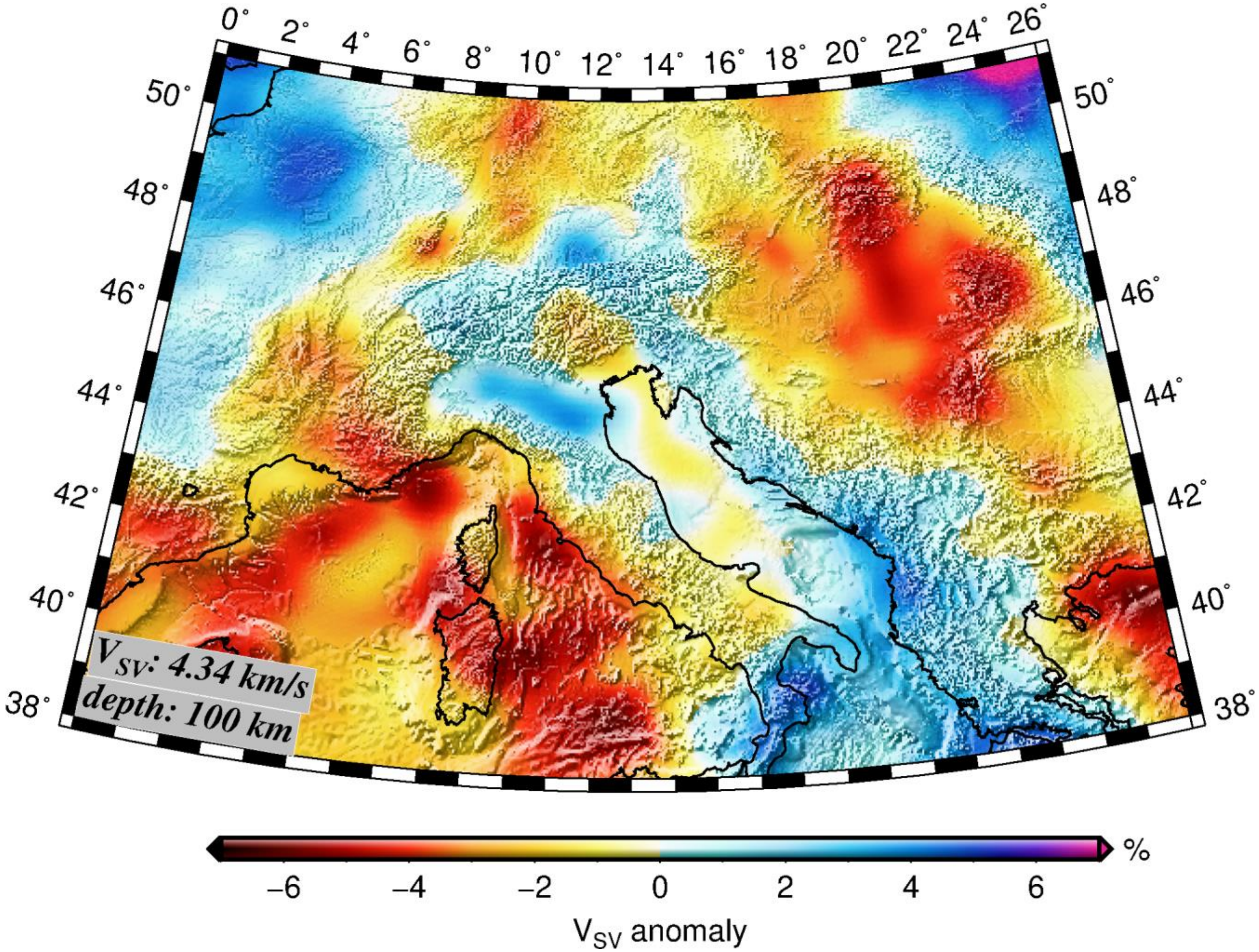




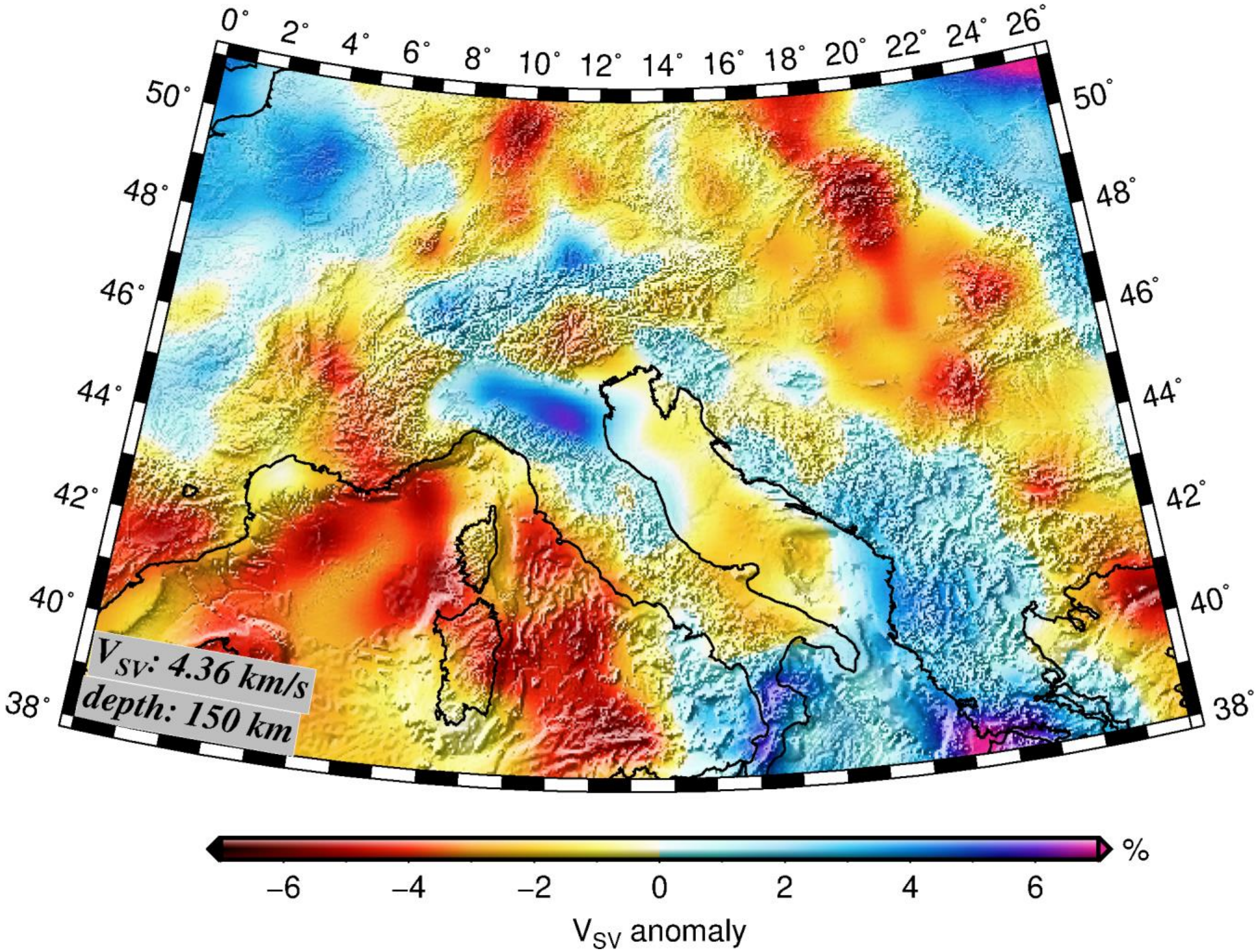


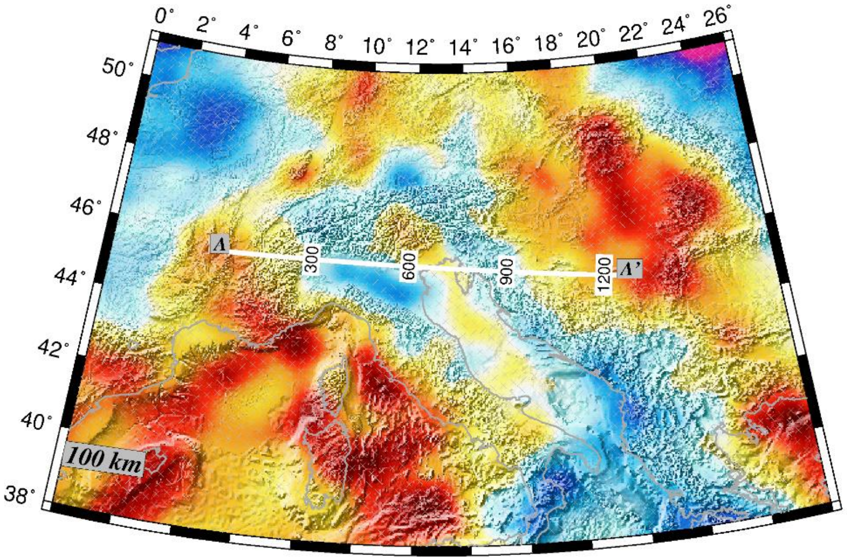


3-D Isotropic Vs model of the Alpine area (100 km depth)



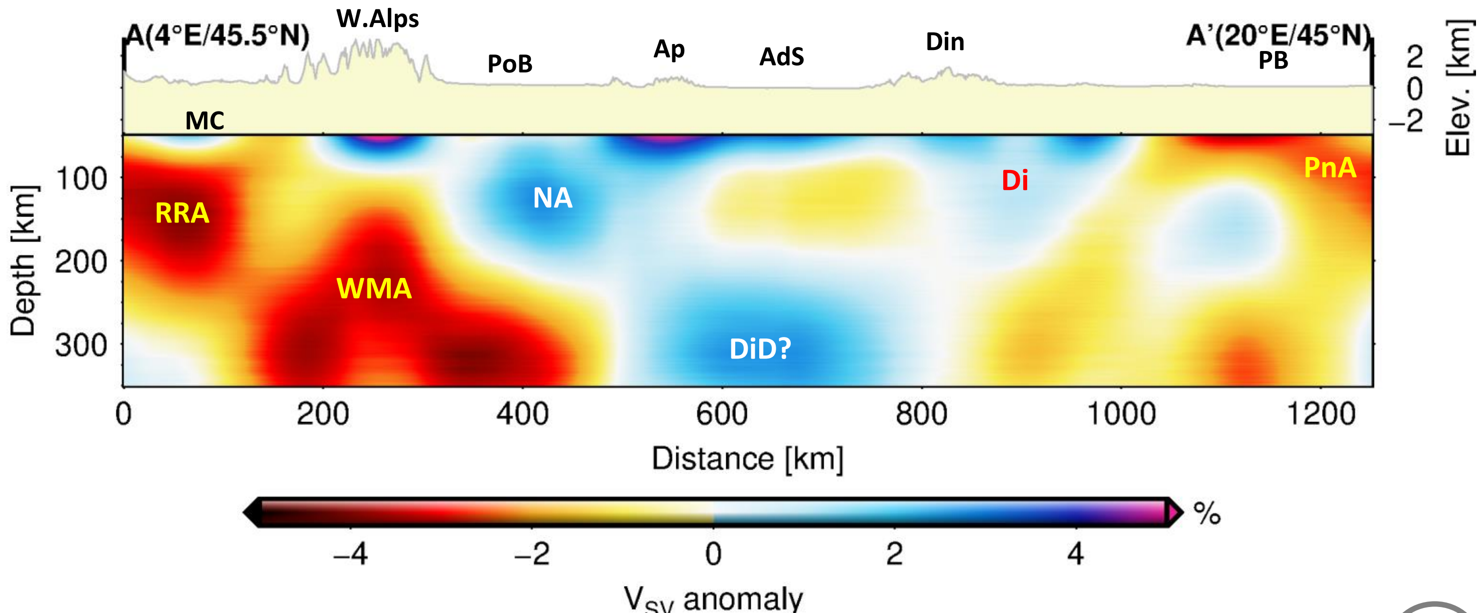
3-D Isotropic Vs model of the Alpine area (150 km depth)

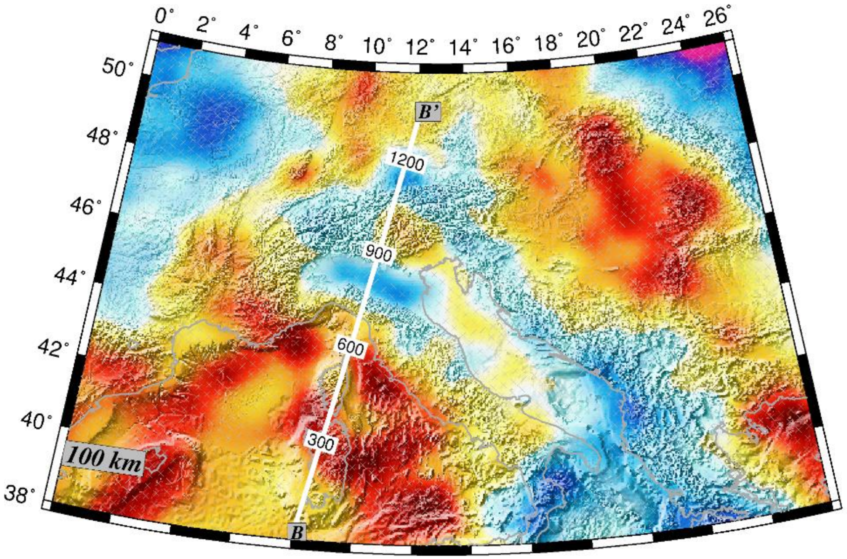




Ap: Apennines
Ads: Adriatic Sea
PoB: Po plain Basin
PB: Pannonian Basin
MC: Massif Central

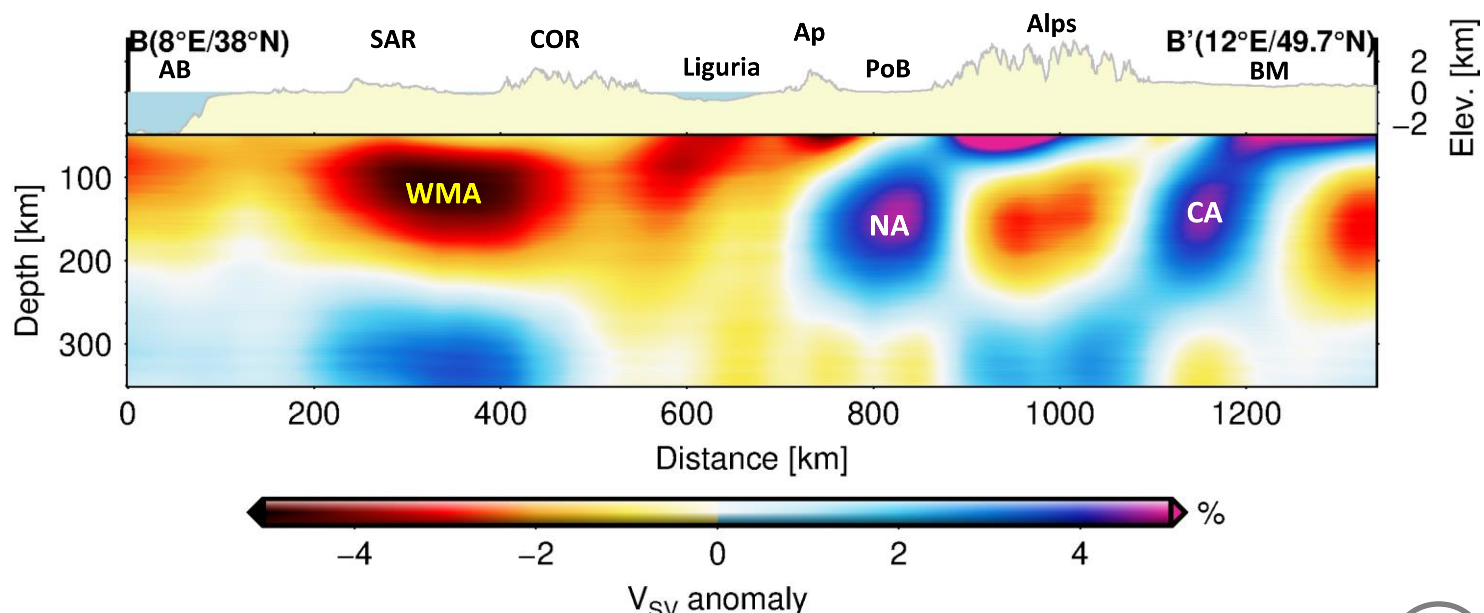
CAG: Central Apennines Gap
Di: Dinarides Slab
DiD?: Detached Dinarides Slab
NA: Northern Apenninic Slab
PnA: Pannonian Asthenosphere
RRA: Rhone-Rhine Asthenosphere
WMA: Western Mediterranean Asthenosphere

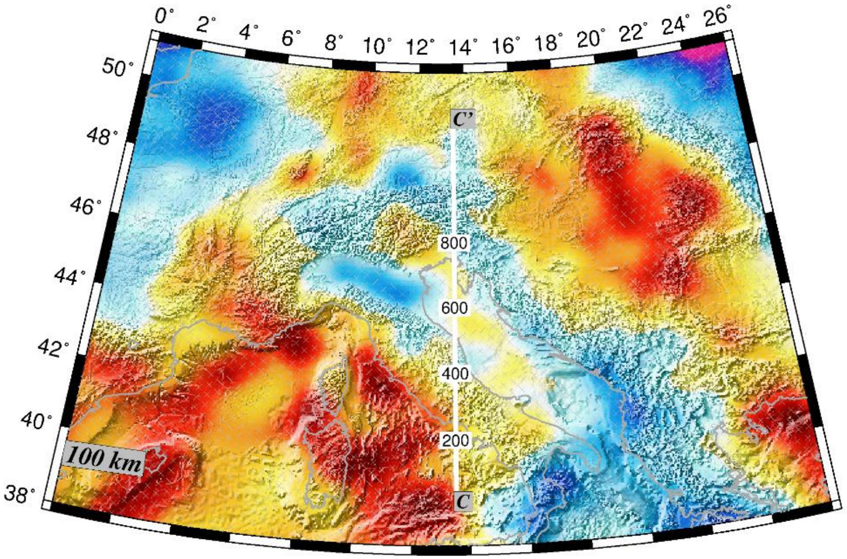




Ap: Apennines
Ads: Adriatic Sea
TyrrhS: Tyrrhenian Sea
SAR: Sardinia
COR: Corsica
PoB: Po plain Basin
PB: Pannonian Basin
BM: Bohemian Massif

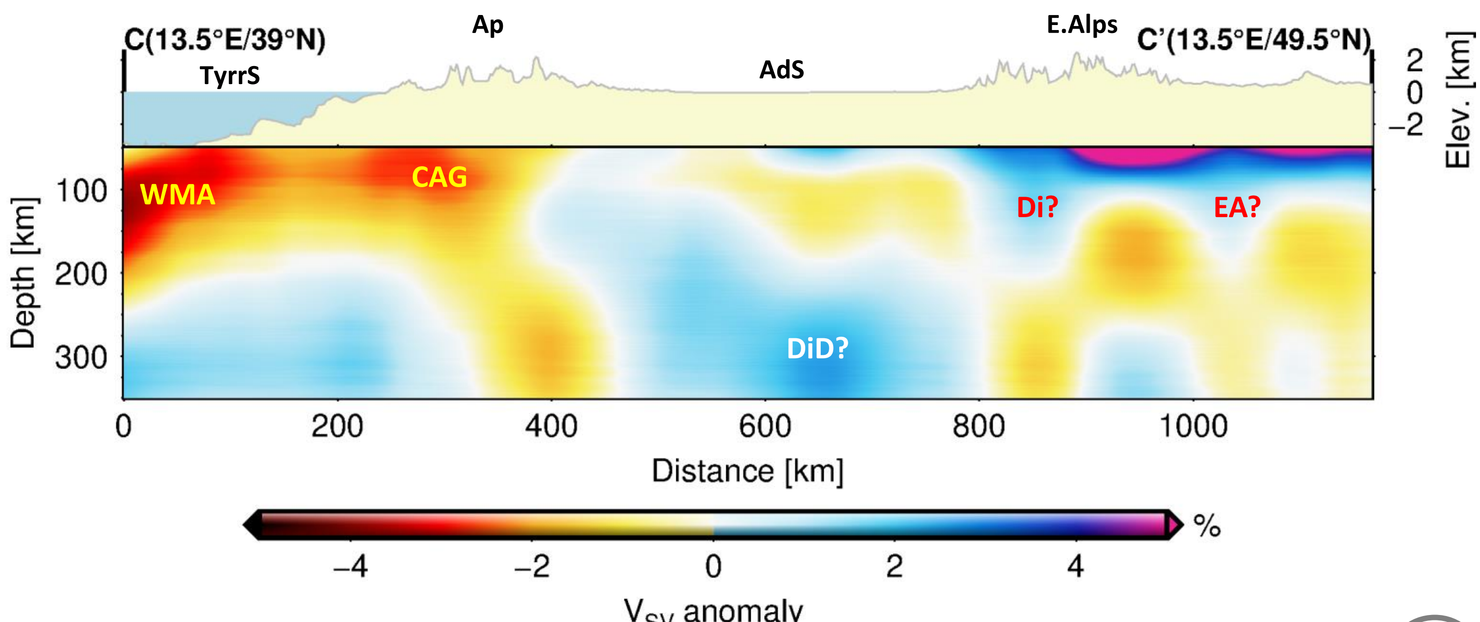
NA: North Appenninic Slab
CA: Central Alpine Slab
WMA: Western Mediterranean Asthenosphere





Ap: Apennines
Ads: Adriatic Sea
TyrrhS: Tyrrhenian Sea

CAG: Central Apennines Gap
Di?: Dinarides Slab
DiD?: Detached Dinarides Slab
EA?: Eastern part of the Eurasian Slab
SeA: Serbian Asthenosphere
WMA: Western Mediterranean Asthenosphere



Conclusions:

- Presence of slab segments and slab gaps can be detected by consistent imaging of the upper mantle using surface wave tomography
- Lateral resolution varies between about 75 km and 200 km
- Southwards subduction of Adriatic mantle lithosphere beneath northern Apennines
- Southwards subduction of Eurasian mantle lithosphere in the central Alps
- Support for slab break-off in the western and eastern Alps at about 100 and 150 km depth, respectively
- Bivergent subduction of Adriatic and Eurasian mantle lithopshere at shallow depth beneath the eastern Alps?
- Slab gap beneath the northern Dinarides from 150 km and downwards