The Slab Puzzle of the Alpine-Mediterranean Region: Insights from a new, High-Resolution, Shear-Wave Velocity Model of the Upper Mantle

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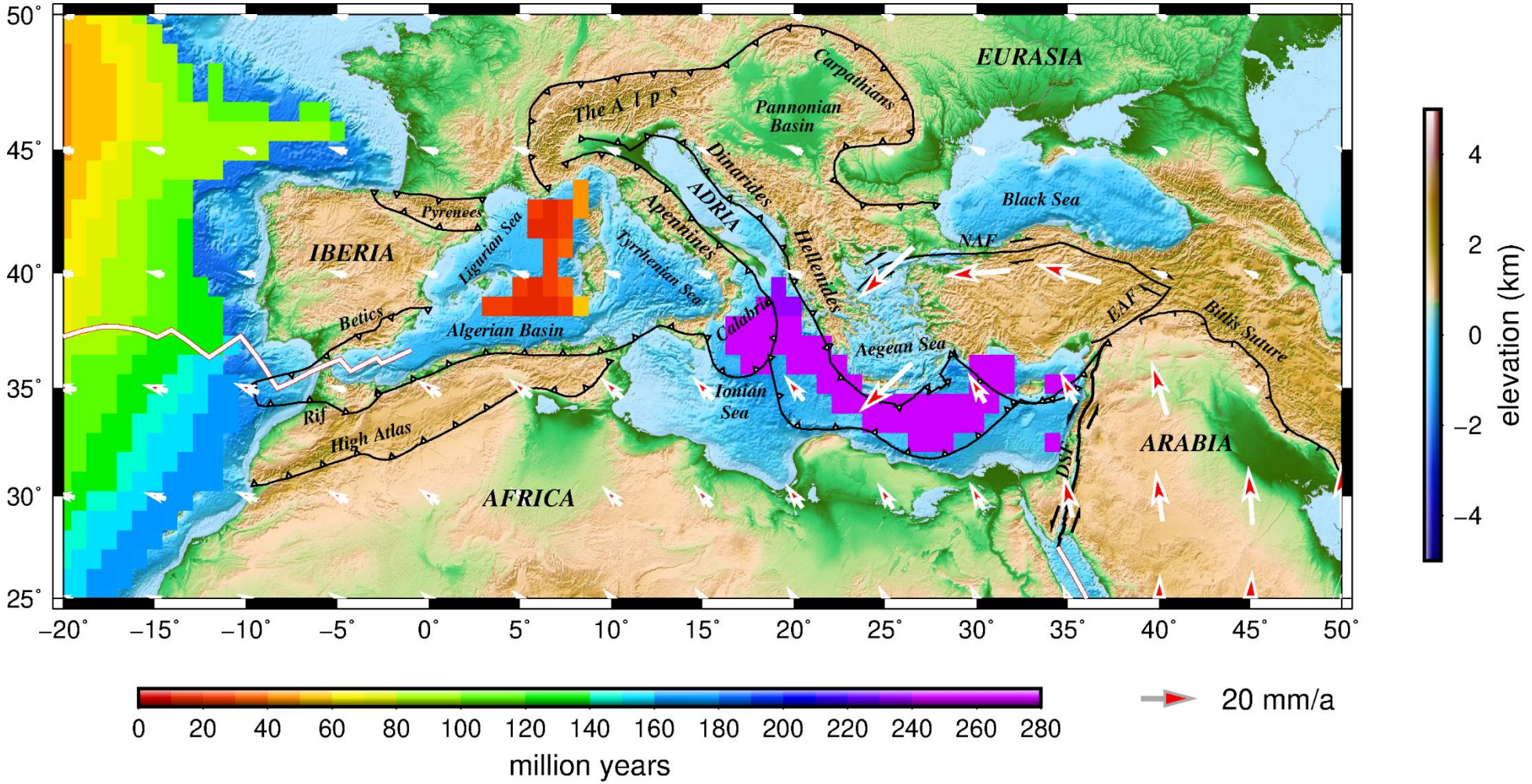
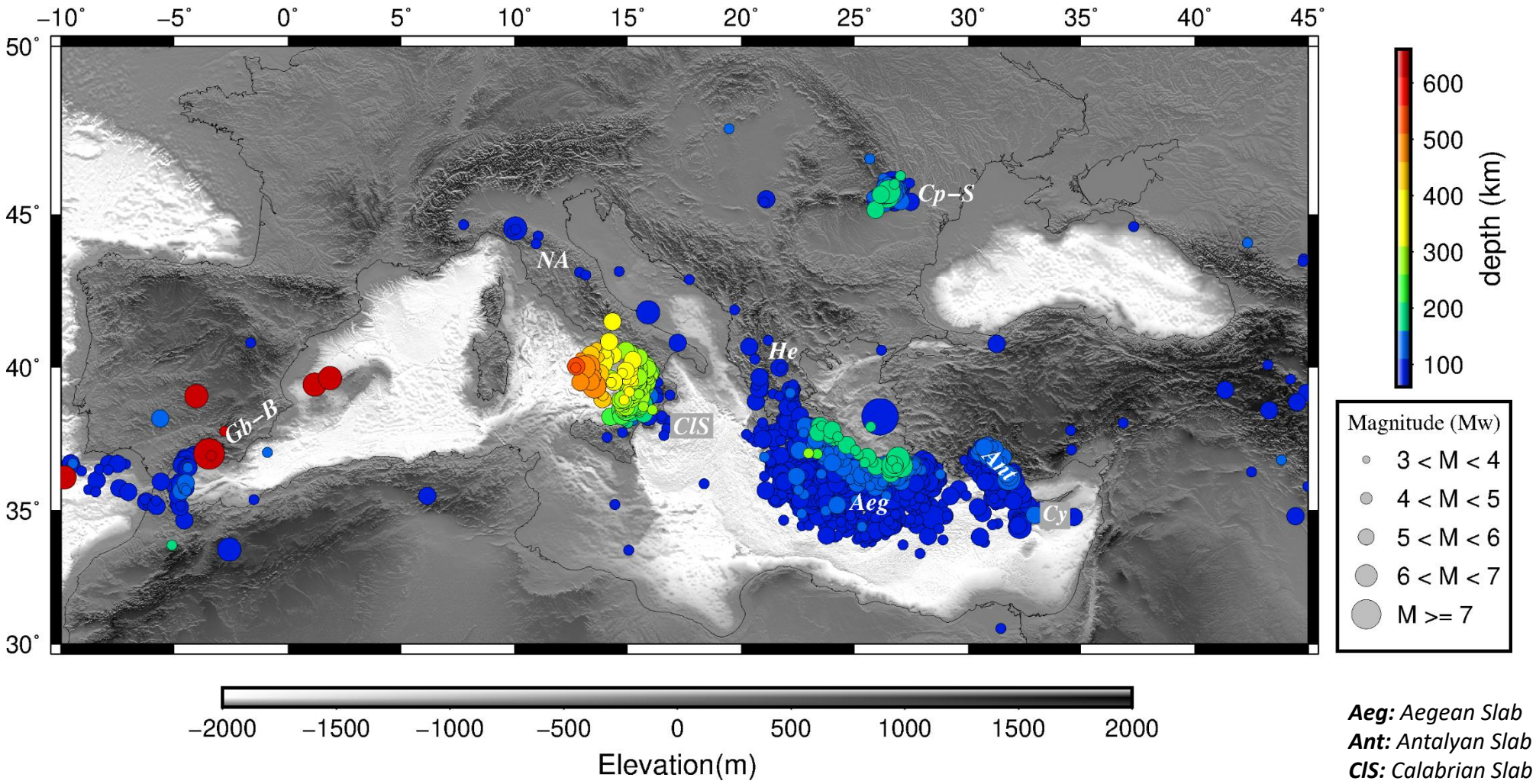


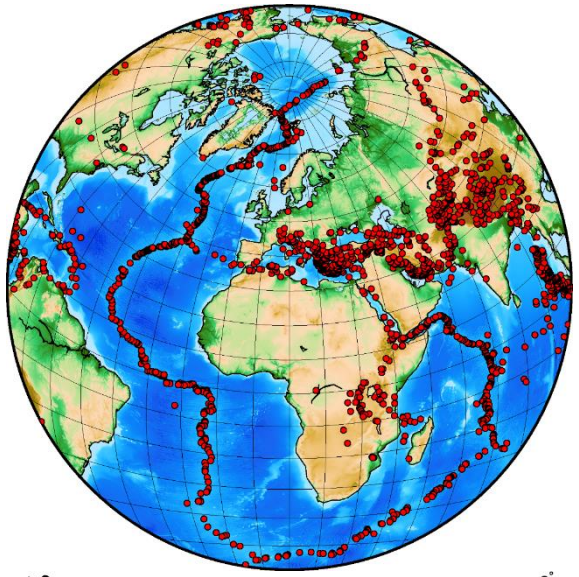
Topographic map of the Alpine-Mediterranean region with the age distribution of the oceanic lithosphere

Faccenna et al., 2014
Becker et al., 2015
Müller et al., 2008



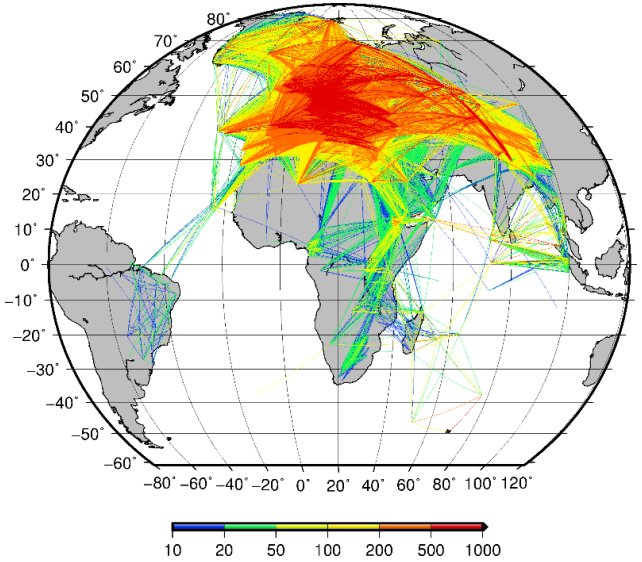
Intermediate-depth (70 - 300 km) and deep (>300 km) seismicity in the Mediterranean, ISC catalogue 1990 - 2019: clear Wadati-Benioff Zone down to 600 km only in Calabrian Subduction Zone, high seismicity down to about 200 km depth in the Aegean and Antalyan Subduction Zones

Aeg: *Aegean Slab*
Ant: *Antalyan Slab*
CIS: *Calabrian Slab*
Cp-S: *Southern Carpathian Slab*
Cy: *Cyprus Slab*
Gb-B: *Gibraltar-Betic Slab*
He: *Hellenides Slab*
NA: *Northern Apenninic Slab*

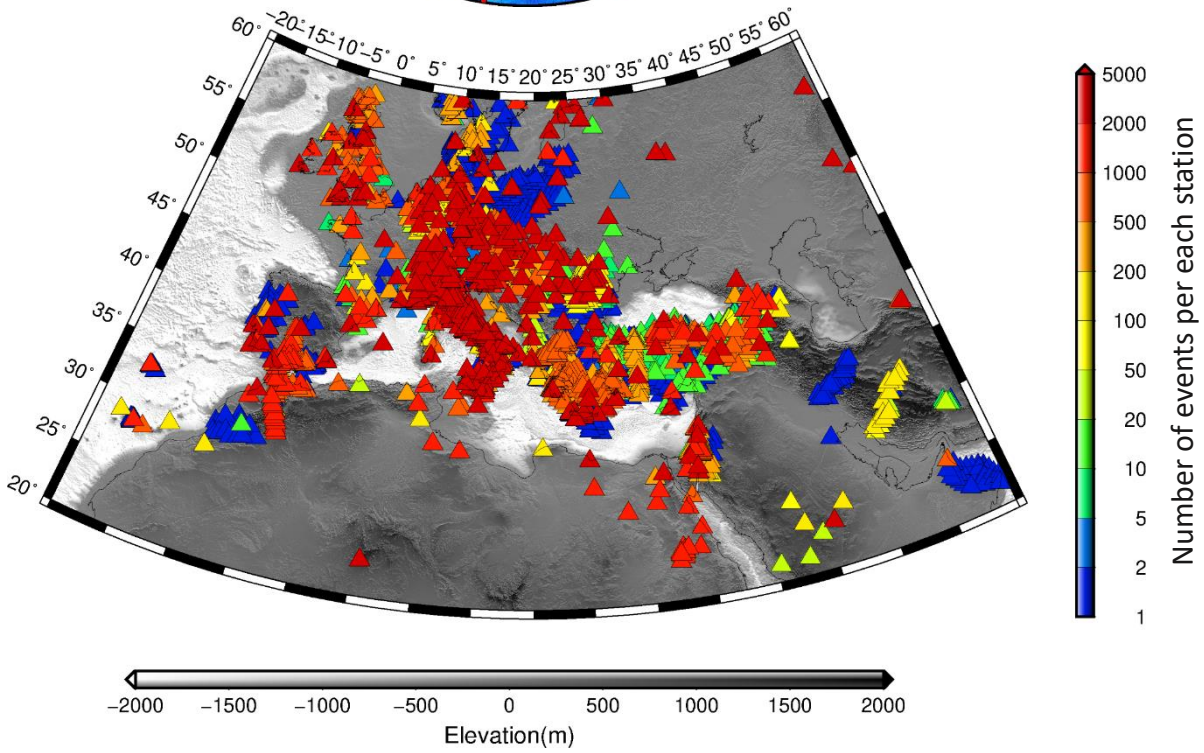


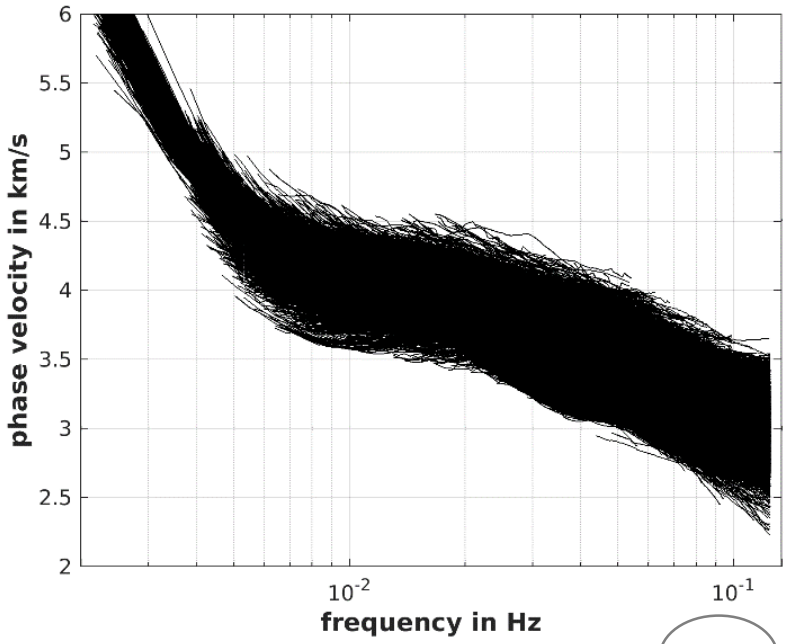
Dataset

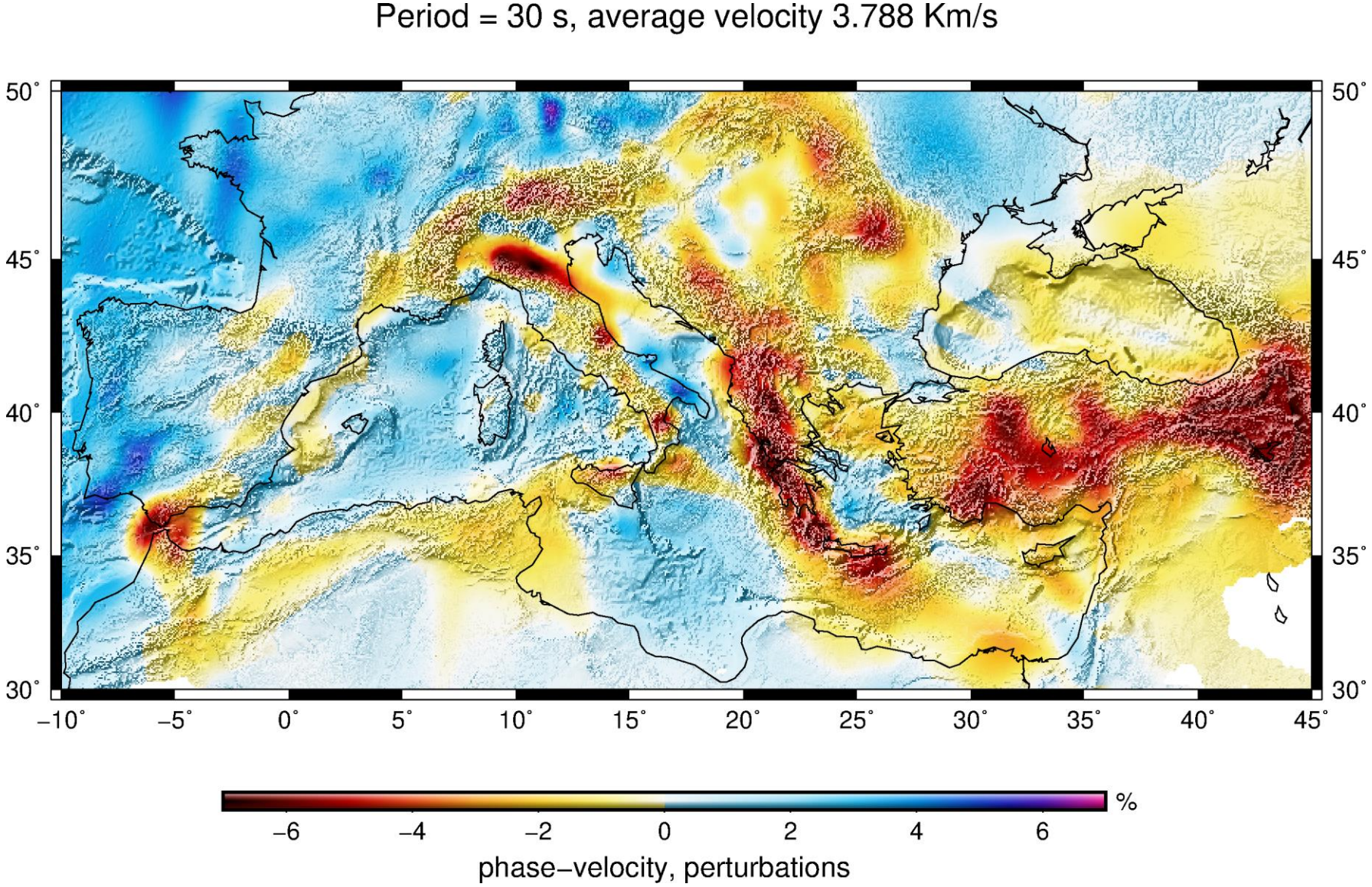
- Time period: 1990 - 2015
- ~ 25 years of data
- ~ 4.500 stations WebDC + ***ENSN (Egypt)***
- ~ 3.5 millions of waveforms
- ~ 200.000 inter-station dispersion curves
- Period range: 8 - 300 s



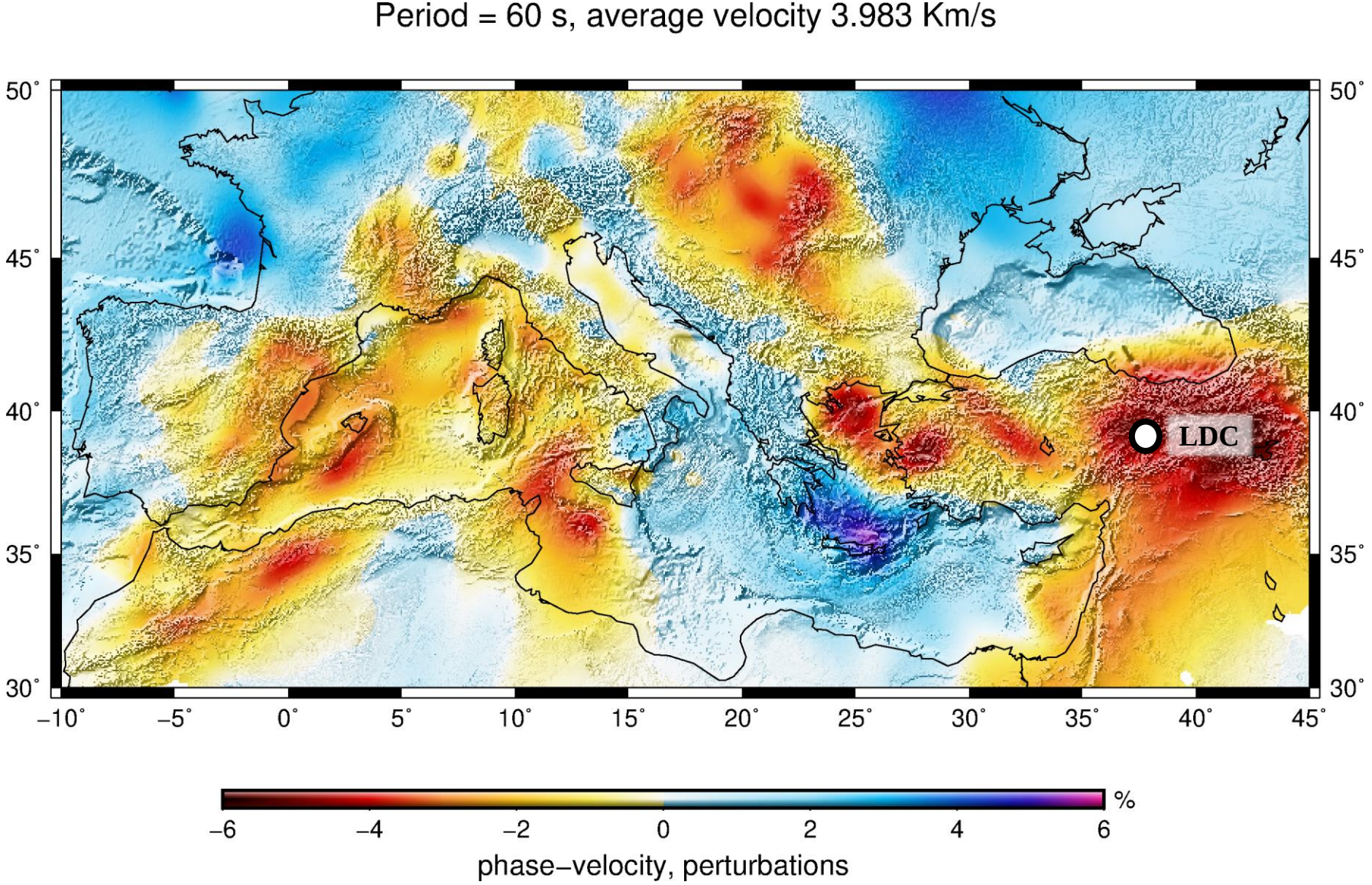
Number of events per each path







Isotropic Rayleigh wave phase velocity map at 30s sampling the depth range of ~ 20 – 60 km



Isotropic Rayleigh wave phase velocity map at 60s sampling the depth range of ~ 50 – 120 km

LDC: local dispersion curve beneath Anatolia is shown in the next slide

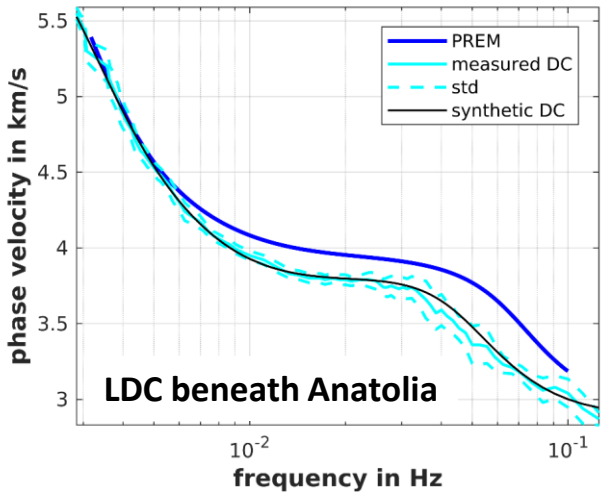
1-D depth-velocity models from local dispersion curves (example for the location indicated in the previous phase velocity maps)

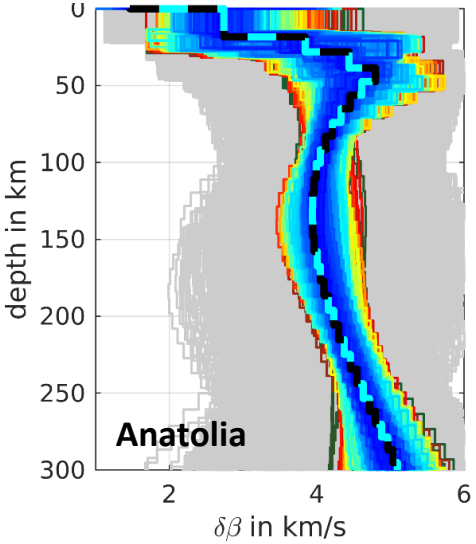
Particle Swarm Optimization algorithm (PSO)

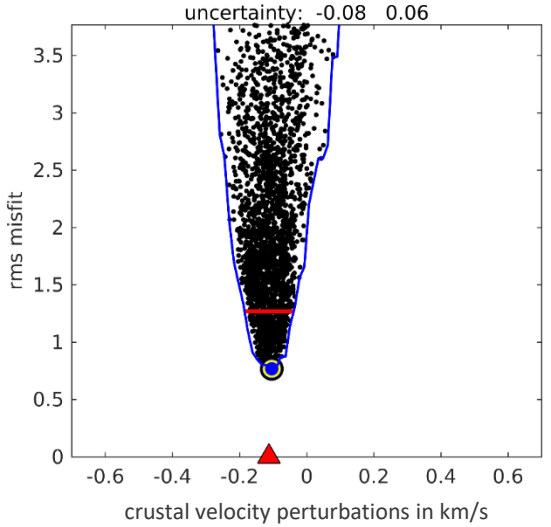
Kennedy & Eberhart, 1995

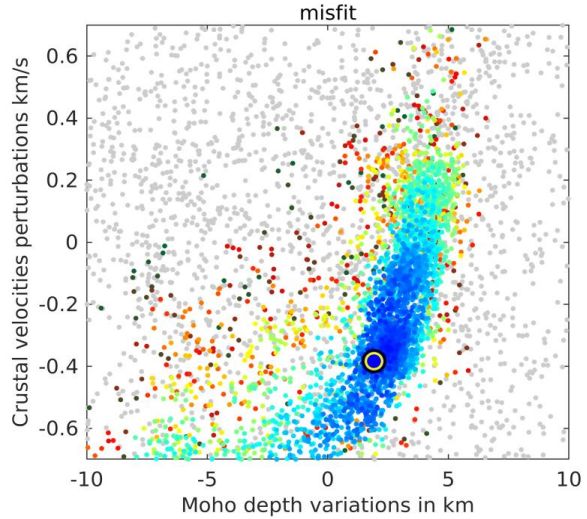
- stochastic inversion algorithm
- flexible parametrization (velocity perturbations + depth of discontinuities)
- flexible regularization
- estimation of uncertainties and investigation of trade-offs between parameters

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







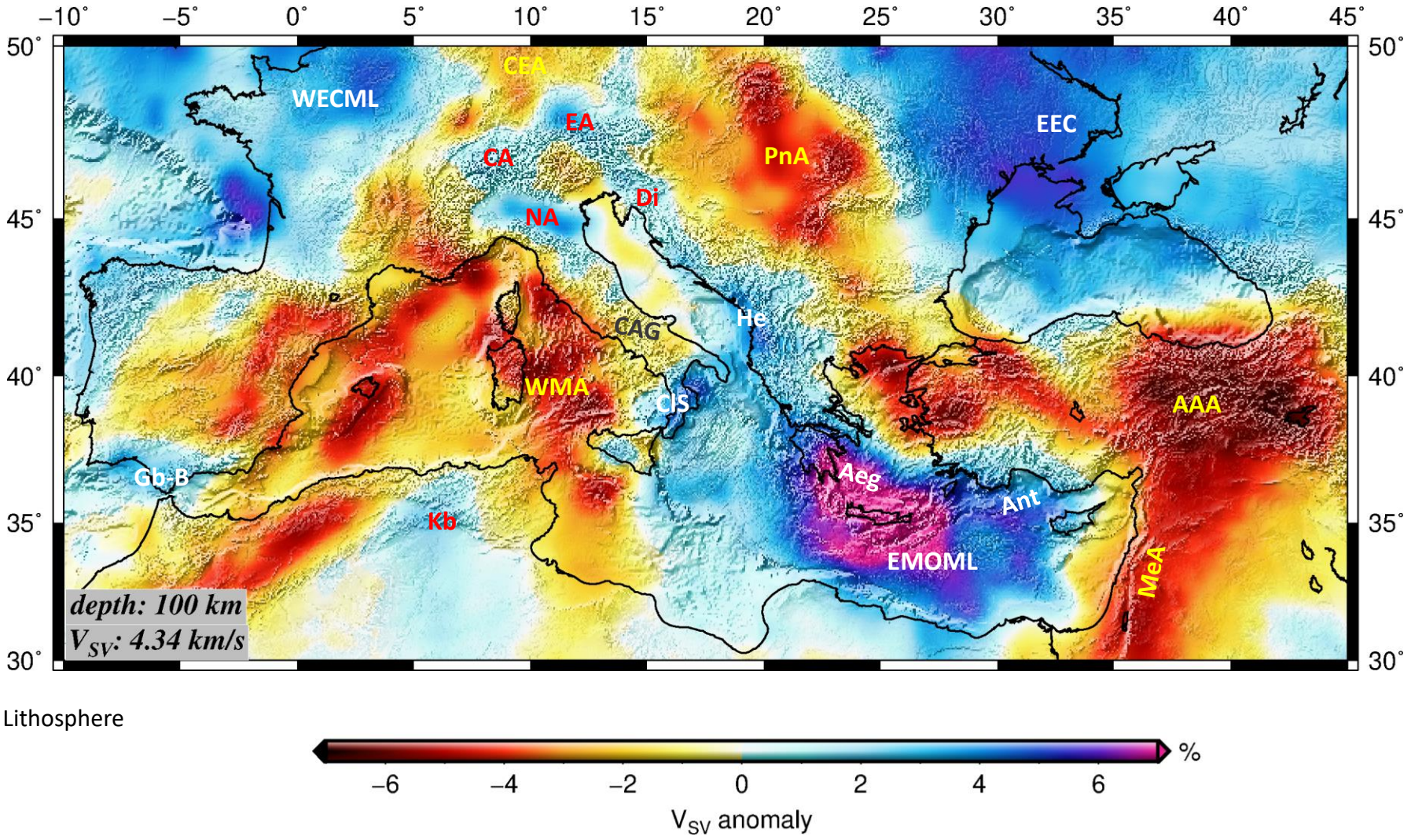


3-D Vs model of the Mediterranean (MeRE2020): lateral resolution locally < 100 km

AAA: Anatolian-Aegean Asthenosphere
CA: Central Alpine Slab
CAA: Central Anatolian Anomaly
CAG: Central Apenninic Gap
CEA: Central European Asthenosphere
ClS: Calabrian Slab
Di: Dinaridic Slab

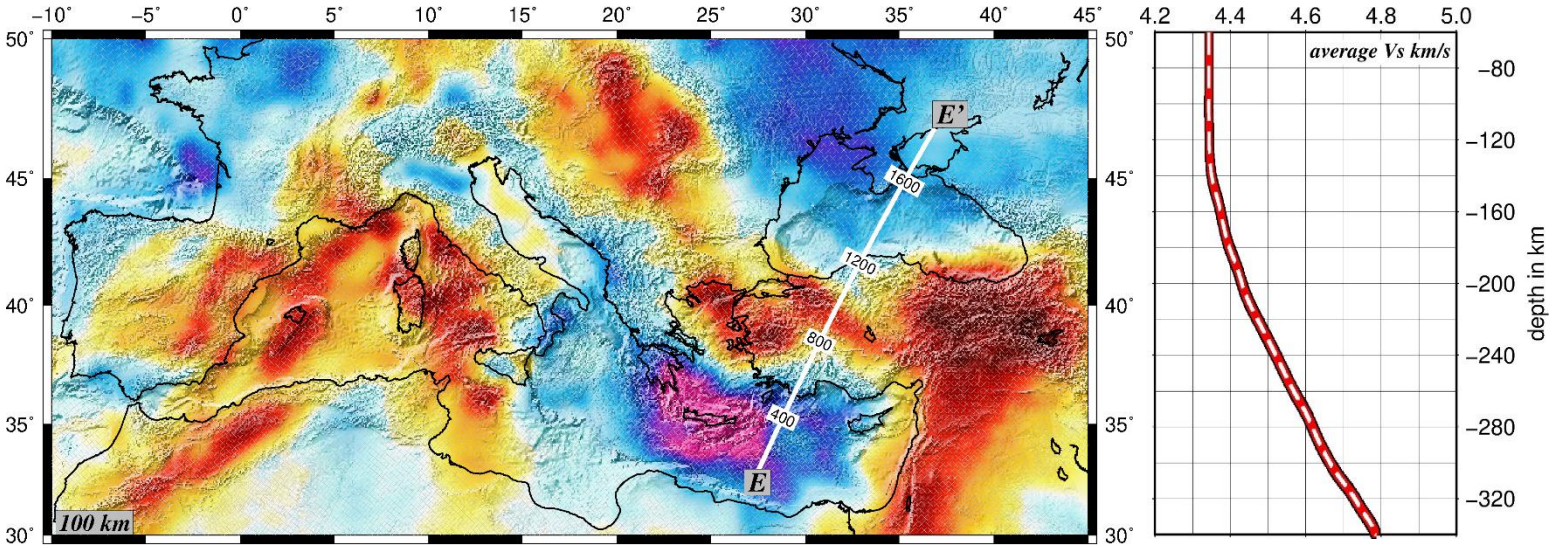
EA: East Alpine Slab
EEC: East European Craton
EMOML: Eastern Mediterranean Oceanic Mantle Lithosphere
Gb-B: Gibraltar-Betics Slab
He: Hellenides Slab

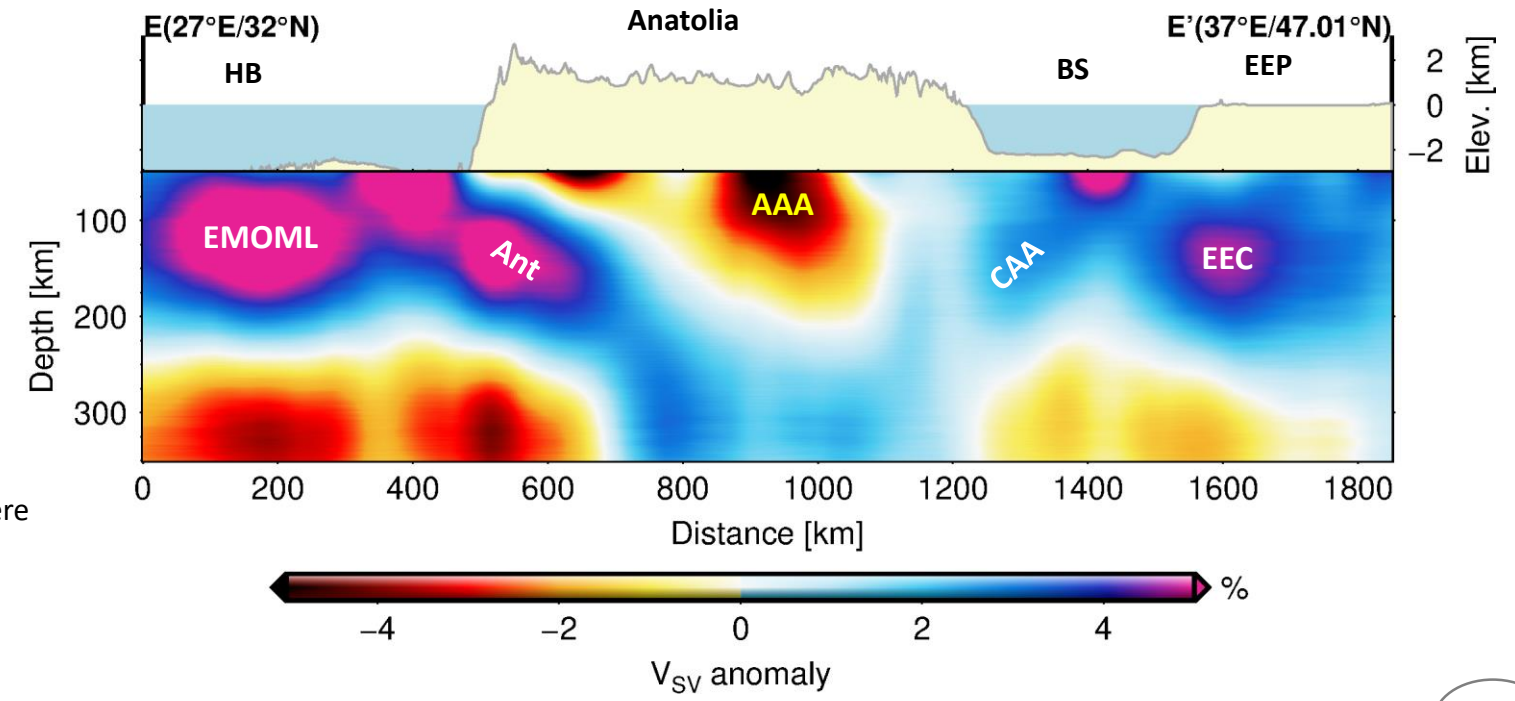
Kb: Kabylides Slab
MeA: Middle East Asthenosphere
NA: Northern Apenninic Slab
PnA: Pannonian Asthenosphere
WECML: Western European Continental Mantle Lithosphere
WMA: Western Mediterranean Asthenosphere



MeRE2020: *Antalyan Slab (Ant)*

- **NE-dipping high velocity anomaly beneath the Bay of Antalya**
- **Down to ~180 km depth, the geometry of the Antalyan slab is defined by intermediate-depth seismicity**
- **At 300 km the Antalya Slab is found beneath SW Anatolia**

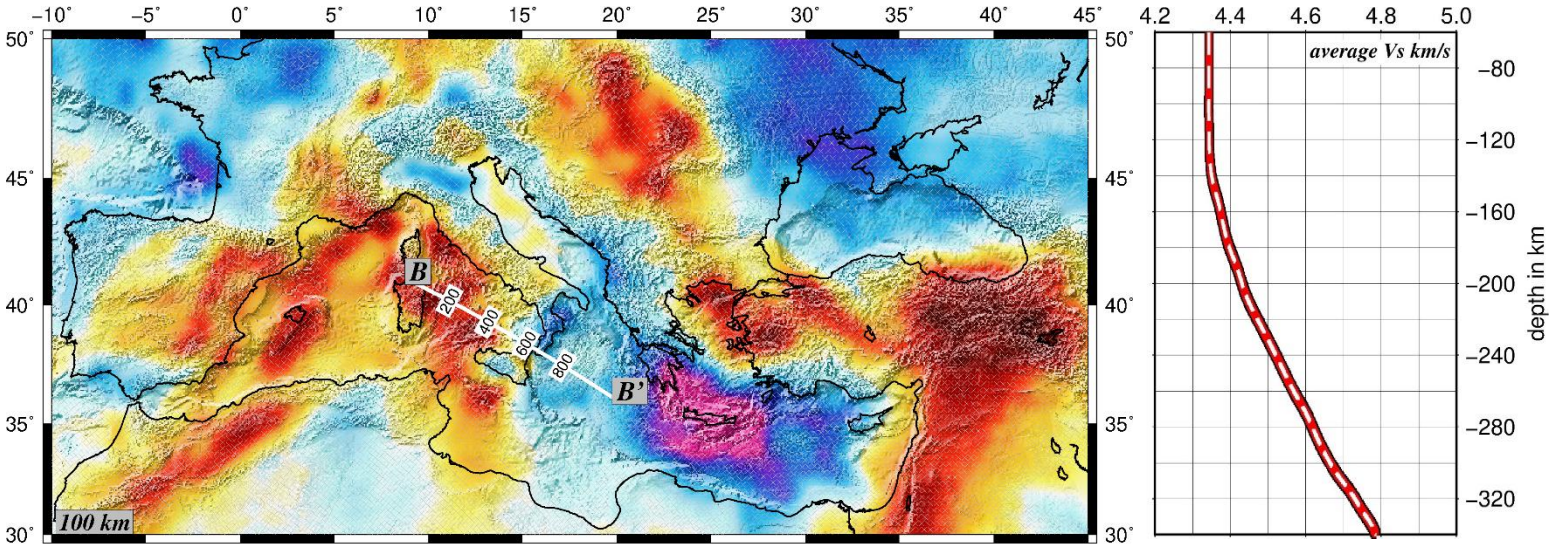


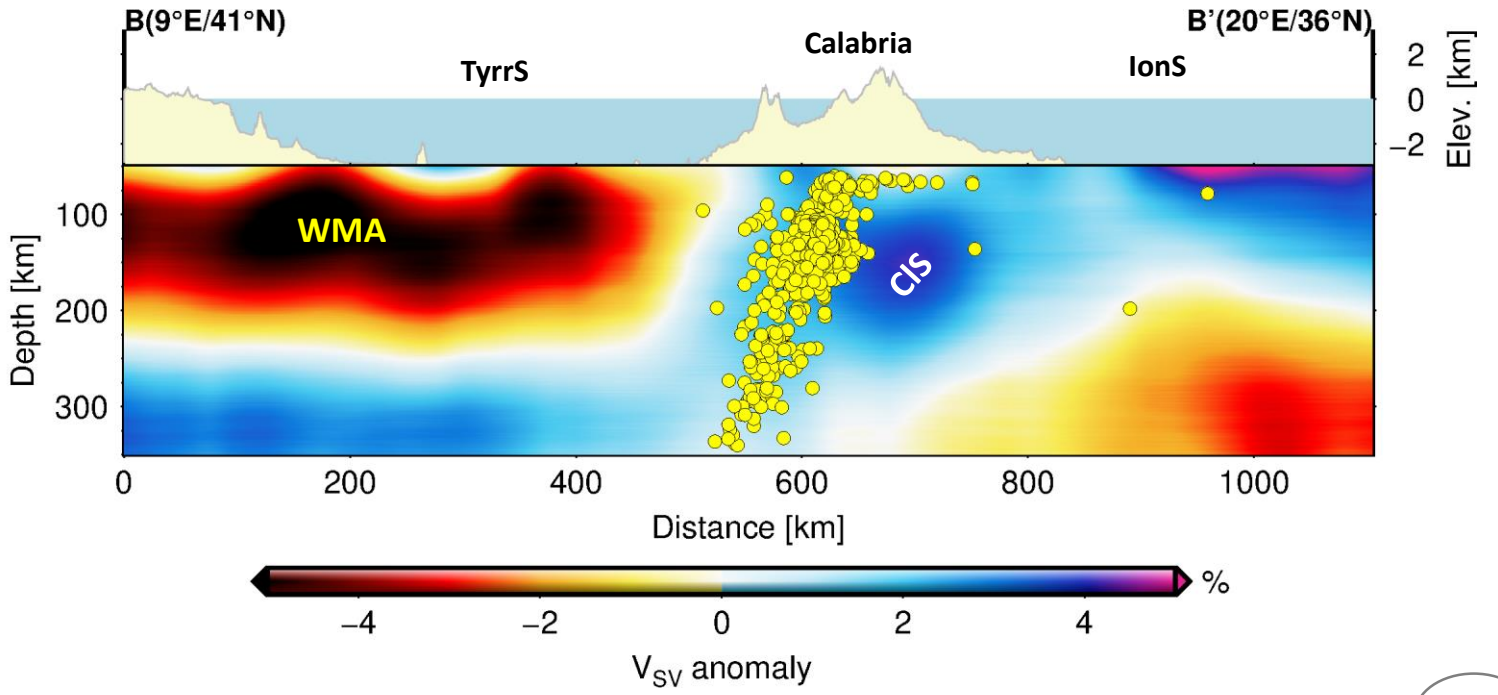


AAA: Anatolian-Aegean Asthenosphere
Ant: Atalyan Slab
BS: Black Sea
CAA: Central Anatolian Anomaly
EEC: East European Craton
EEP: East European Platform
EMOML: Eastern Mediterranean Oceanic Mantle Lithosphere
HB: Herodotus Basin

MeRE2020: *Calabrian Slab (ClS)*

- **NW-dipping high-velocities down to > 300 km depth beneath the Tyrrhenian Sea**
- **correlates well with the Wadati-Benioff zone below the Calabrian Arc**
- **we favour a continuous slab in the upper 300 km depth beneath the Calabrian Arc**





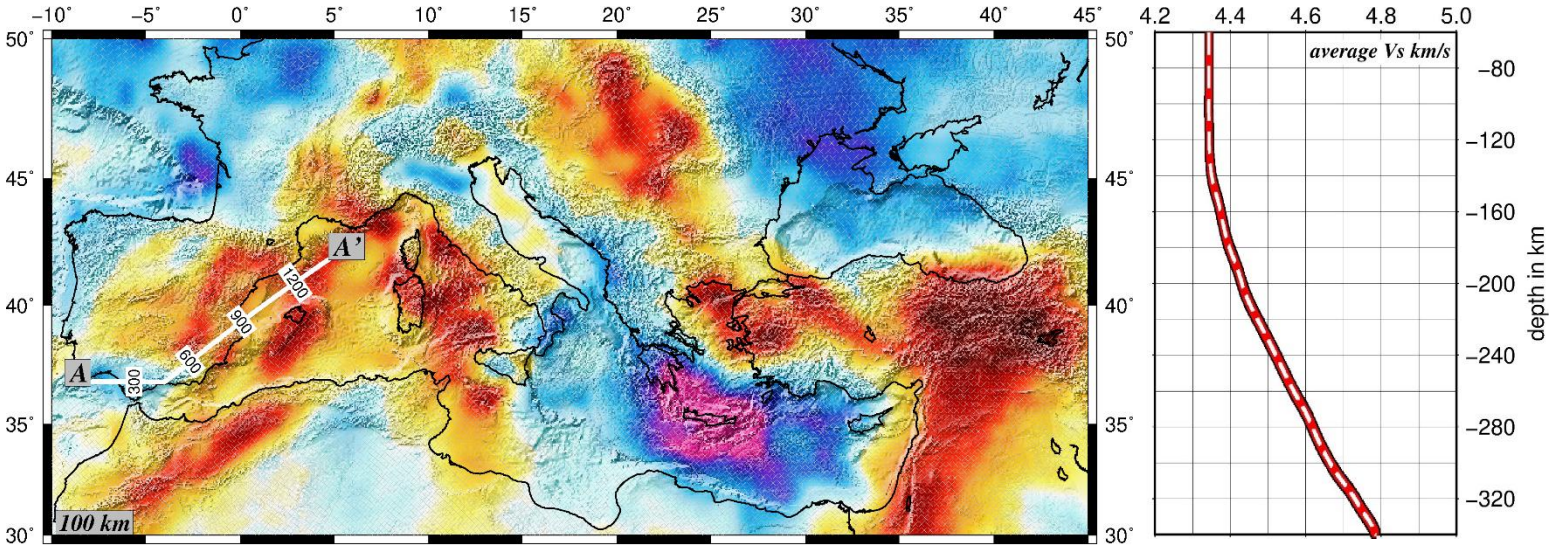
ClS: Calabrian Slab
IonS: Ionian Sea
TyrrS: Tyrrhenian Sea
WMA: Western Mediterranean Asthenosphere

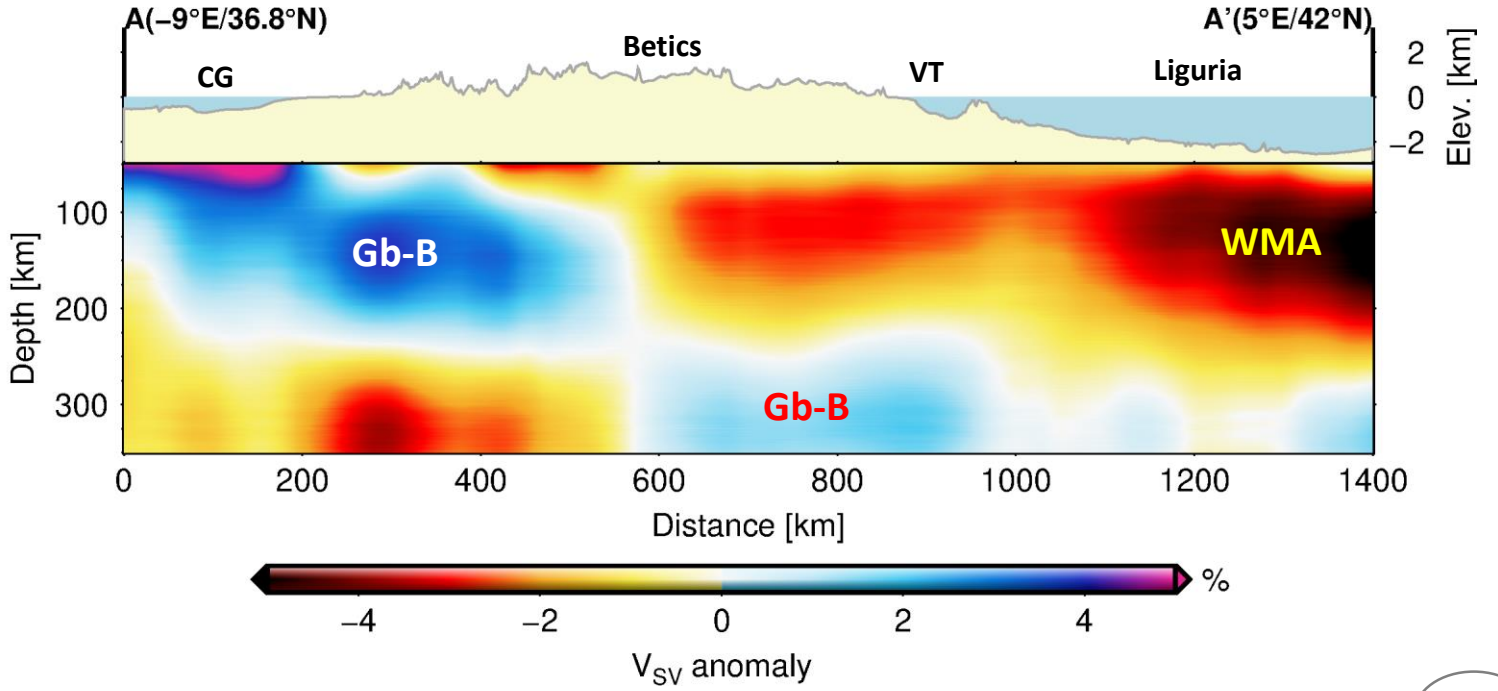
MeRE2020: *Gibraltar-Betics Slab (Gb-B)*

- **high velocity anomaly beneath the Gibraltar Arc down to ~200 km**
- **intermediate-depth seismicity terminates at 150 - 180 km depth**
- **presence of a shallow slab and a slab tear below about 220 km**

- **at depths > 230 km SE Iberia, high velocity anomaly indicates a detached Betics slab segment**

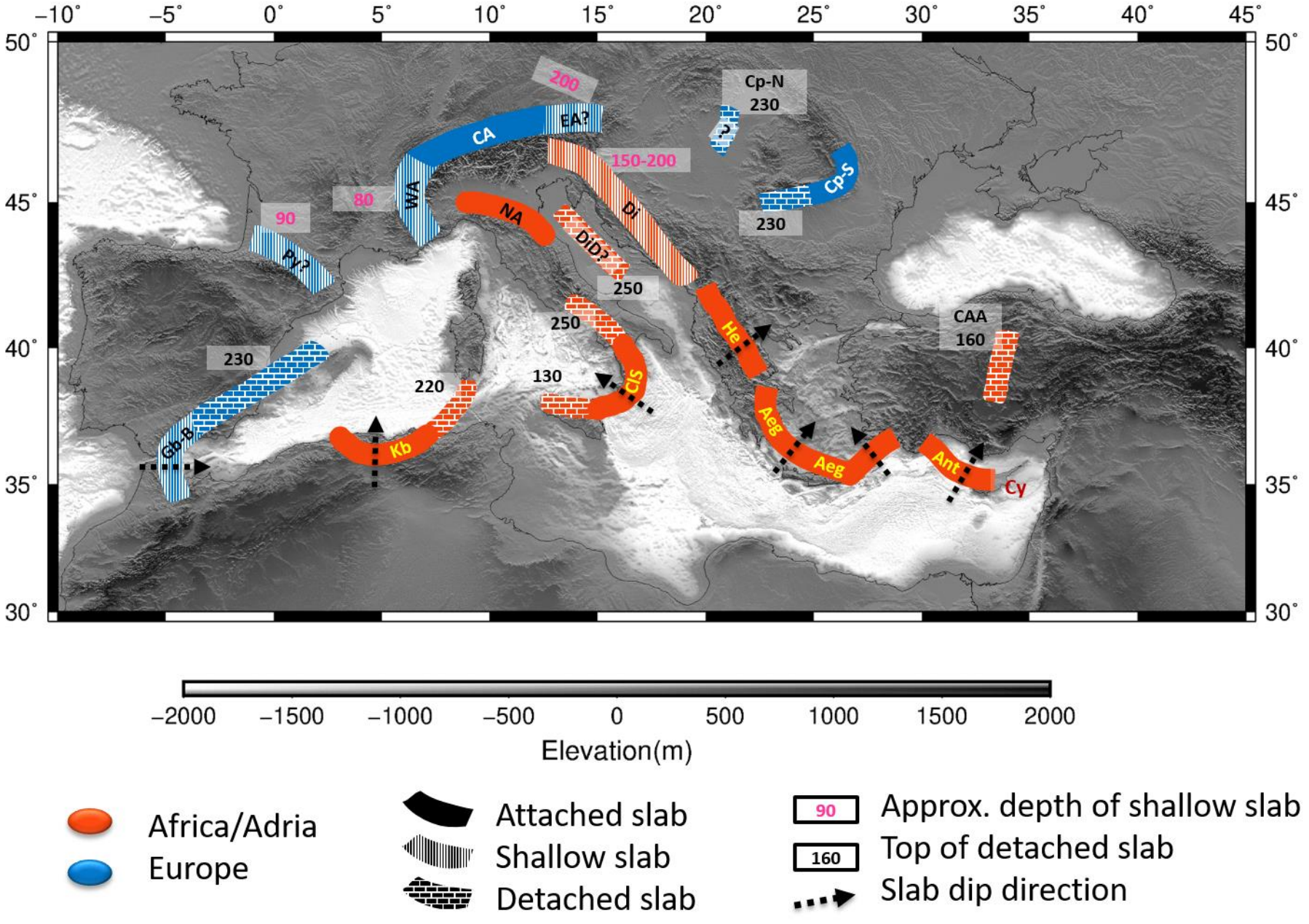
CG: Gulf of Cadiz
Gb-B: Gibraltar-Betics Slab
WMA: Western Mediterranean Asthenosphere
VT: Valencia Trough





Slab configuration in the Mediterranean

Aeg: Aegean Slab
Ant: Antalyan Slab
CA: Central Alpine Slab
CAA: Central Anatolian Anomaly
ClS: Calabrian Slab
Cp-N: Northern Carpathian Slab
Cp-S: Southern Carpathian Slab
Di: Dinaridic Slab
DiD: Detached Dinaridic Slab
EA: Eastern Alpine Slab
Gb-B: Gibraltar-Betics Slab
He: Hellenides Slab
Kb: Kabylides Slab
NA: Northern Apenninic Slab
Py: Pyrenees Slab
WA: Western Alpine Slab



Conclusions:

- New, high-resolution, 3D tomographic model (***MeRE2020***) of the Mediterranean upper mantle down to ~ 300 km from Rayleigh wave phase velocities
- MeRE2020 reveals that tectonics in the Mediterranean is driven by highly fragmented, attached, detached, and shallow slabs
- The presence of the slab segments is revisited taking also the spatial distribution of intermediate-depth and deep seismicity into account
- Laterally variable very thick oceanic mantle lithosphere beneath the Eastern Mediterranean
- Slab fragmentation and horizontal tearing result in a rather large number of slab segments that vary in their lateral length along strike between 200 and 800 km (in total ~ 14 slab segments are identified)
- Slab gap beneath Dinarides at depth > 150 – 200 km, slab gap beneath central Apennines
- Shallow slab in Alboran Subduction Zone, detached slab along the Betics and Valencia Trough
- The geometry of the suggested inventory of slab segments needs further refinement and is a prerequisite for quantitative geodynamic modelling of plate kinematics and plate deformation in the area