Anisotropy and Mantle Kinematics in the Eastern Mediterranean Region based on Shear Wave Splitting Measurements, Numerical Models and P-wave Tomography

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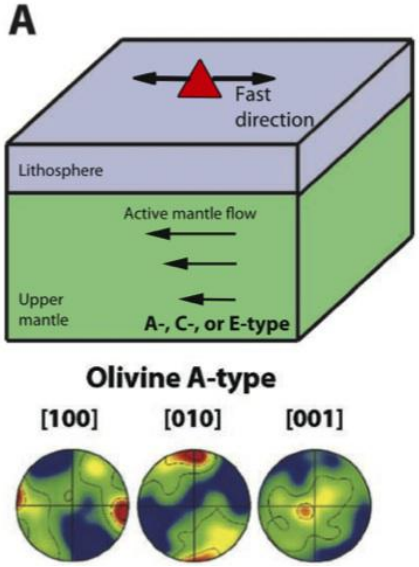
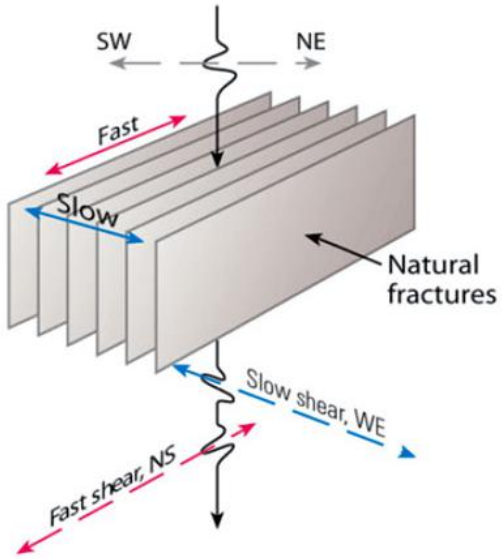
Seismic Anisotropy

Means: Elastic properties of the medium are not same in all directions !

Transversely Isotropic around vertical direction (**Layered earth model**)
Transversely Isotropic around horizontal direction (**Natural fractures**)



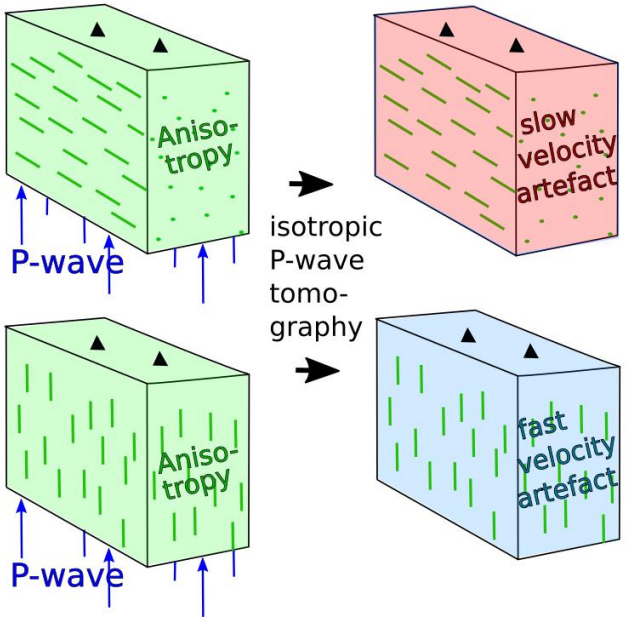


Long and Becker (2010)

- Splitting parameters:
  - Time Delay (TD) δt
  - Fast Polarization Direction (FPD)Φ

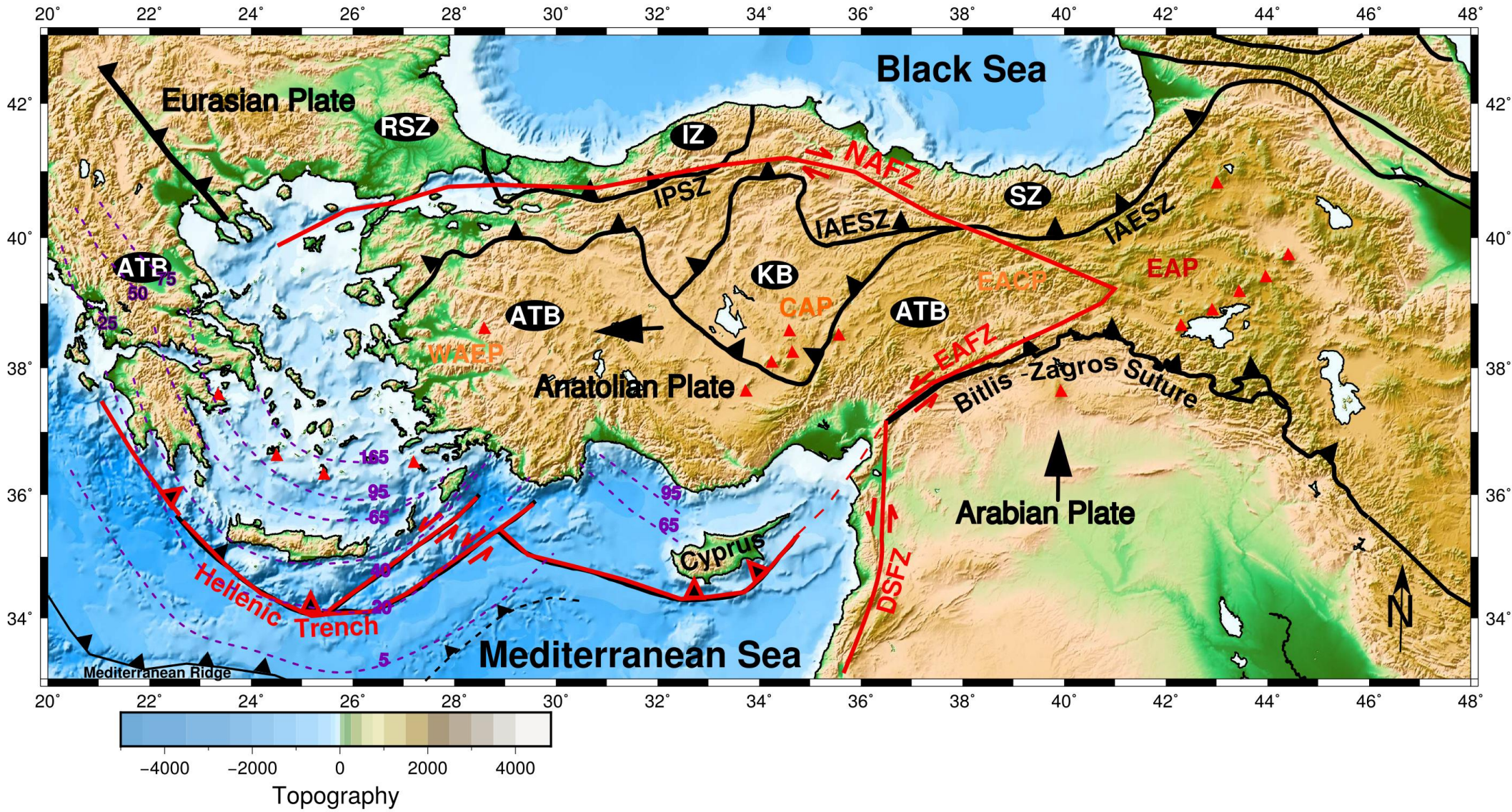
$$\delta t = L(\frac{1}{V_{S1}} - \frac{1}{V_{S2}})$$

Effect of anisotropy on P-waves

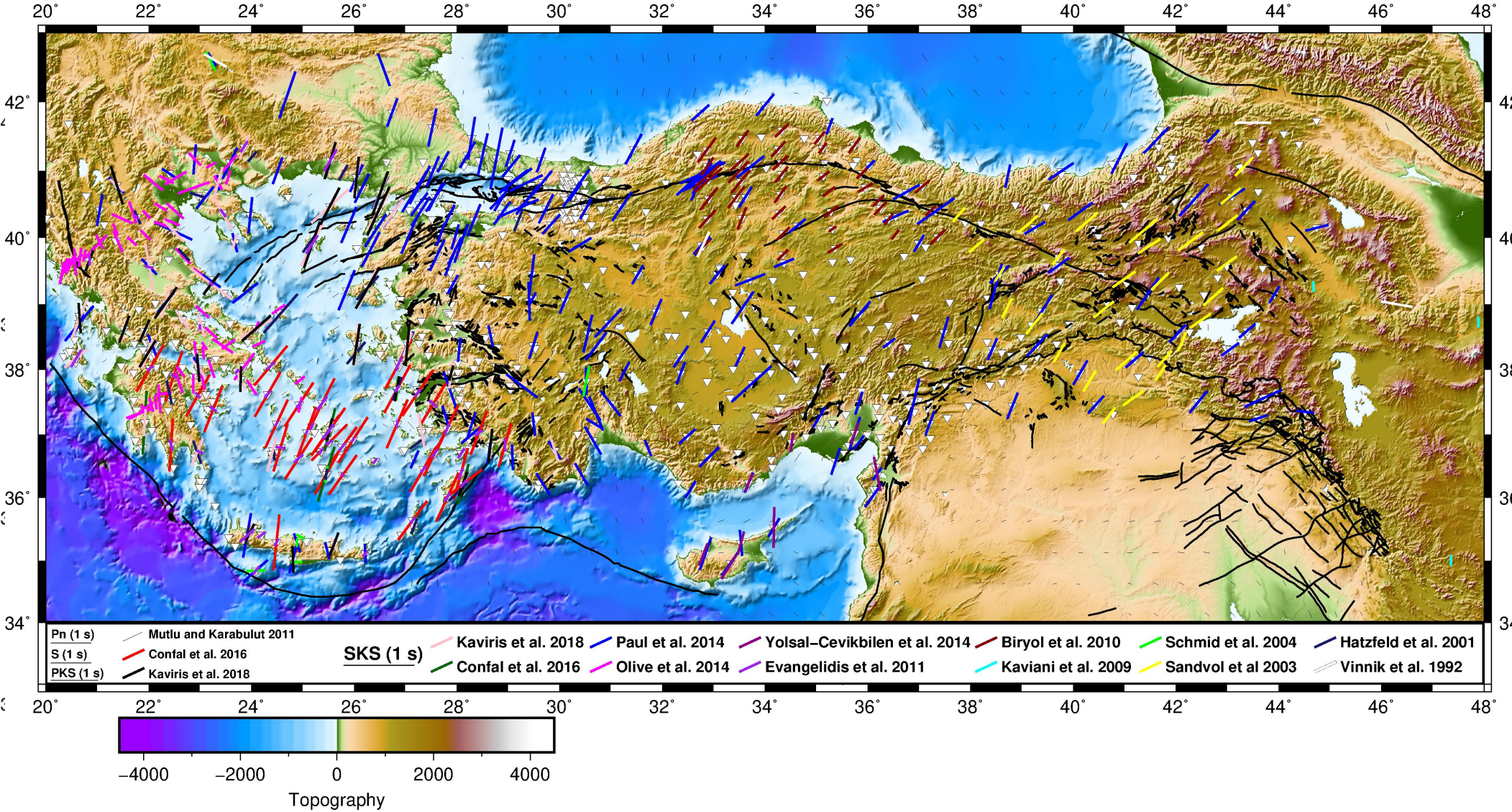


(OVER)SIMPLIFIED RULE OF THUMB:
FPD = direction of horizontal mantle flow beneath station

Study area:
Eastern Mediterranean and Anatolia

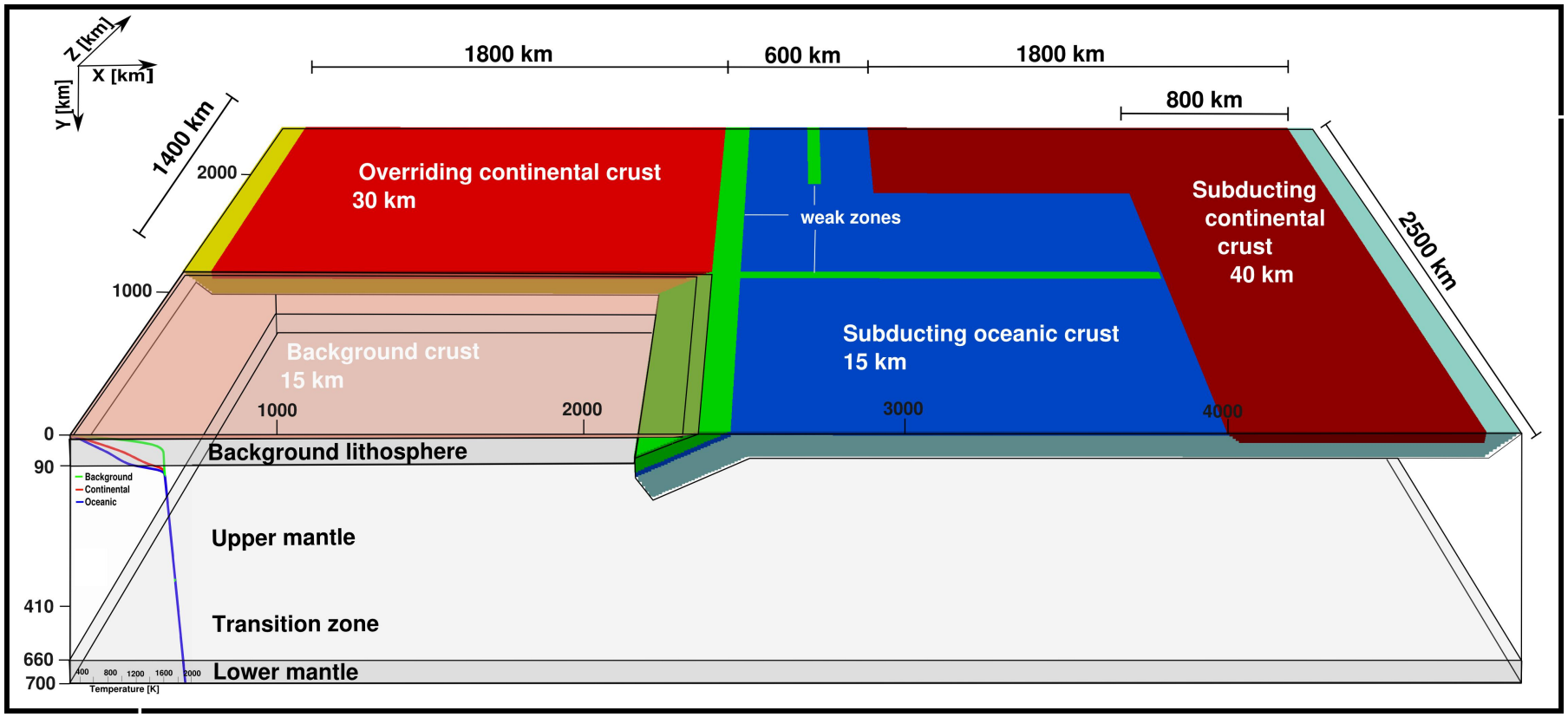


Seismic Anisotropy in the eastern Mediterranean



Splitting parameters from studies and splitting database by Wüstefeld et al. (2009) (http://www.gm.univontp2.fr/splitting/DB/)

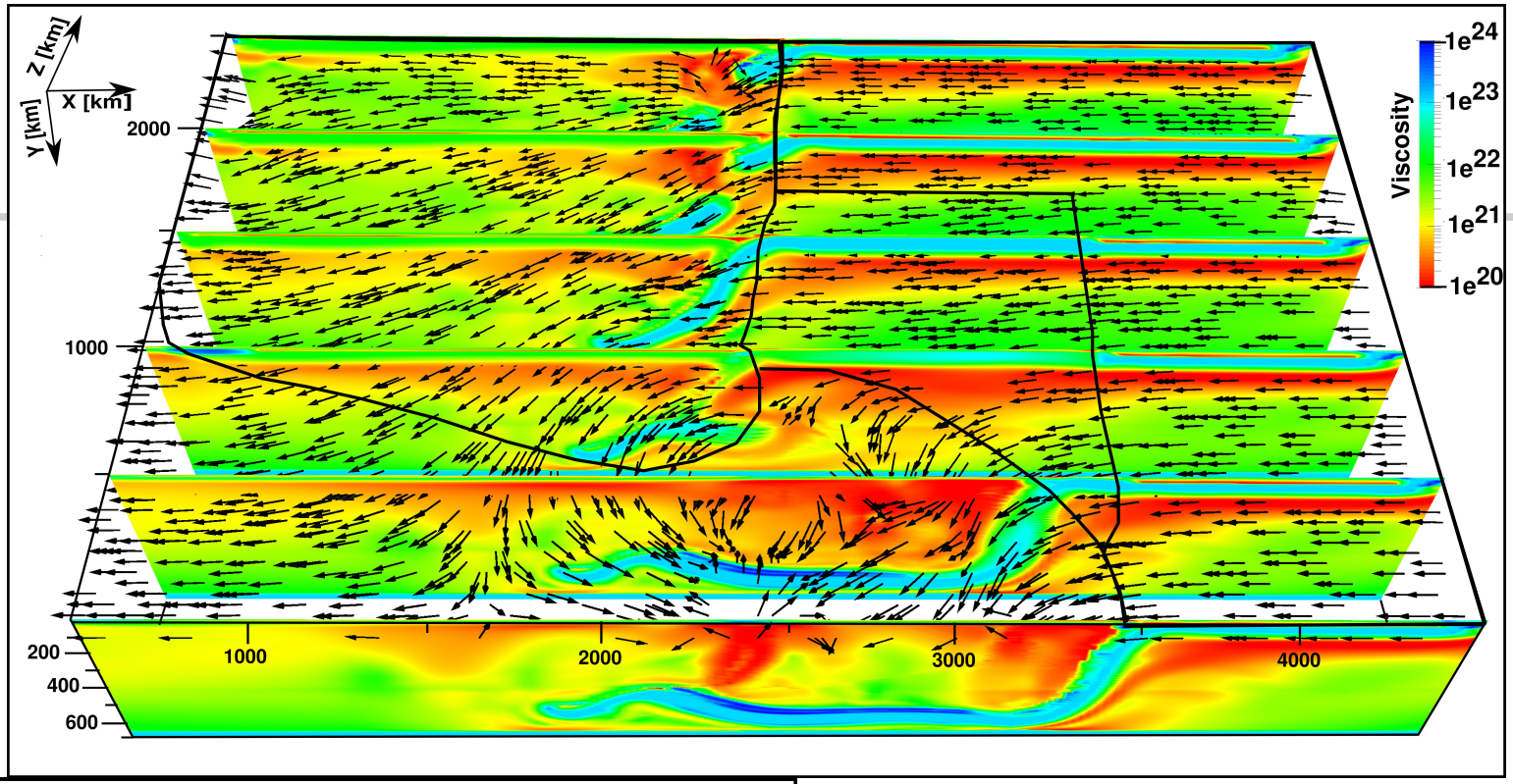
3D Numerical model:

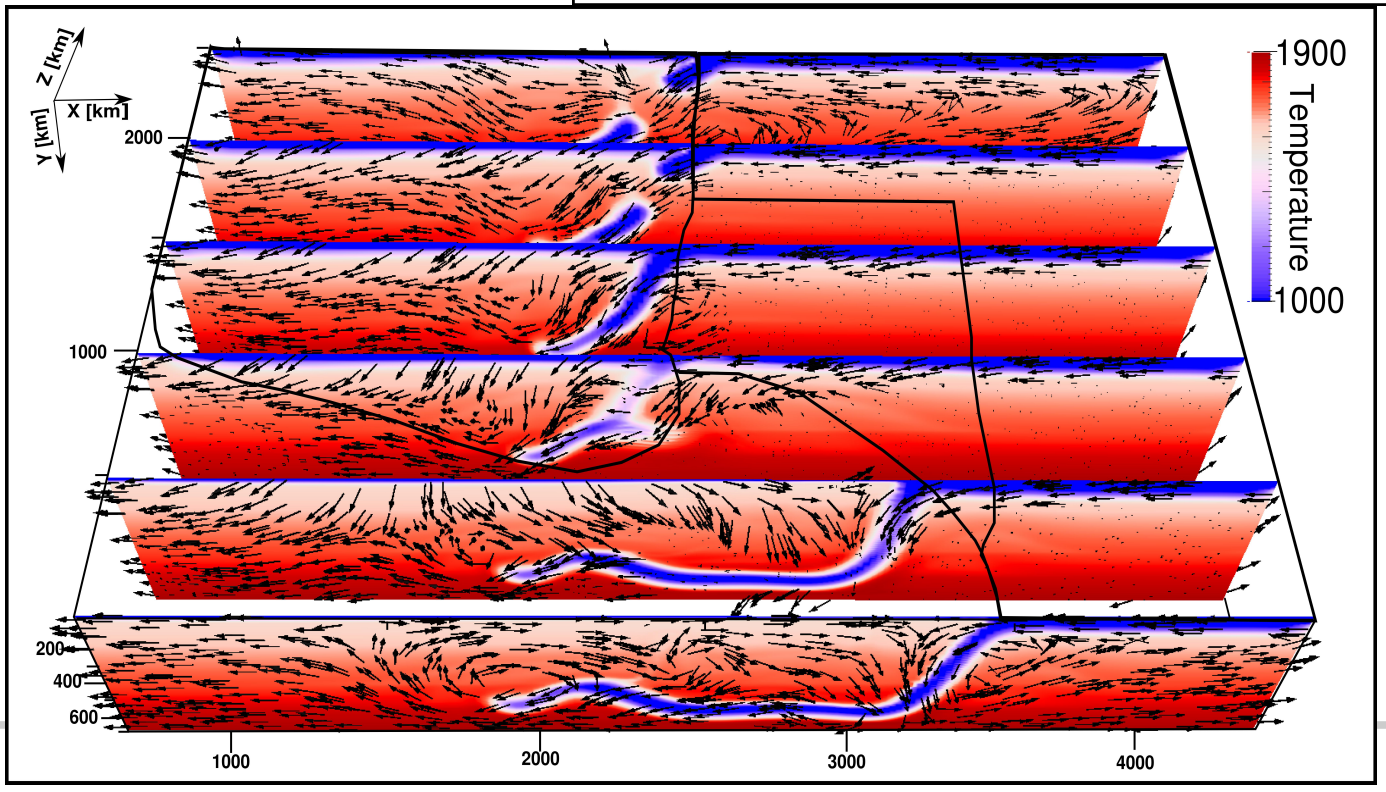


Starting model for Numerical simulation of 3-D mantle flow and anisotropy evolution mimicking the tectonics of the Eastern Mediterranean over past 22 Ma
Confal et al. (2018), EPSL

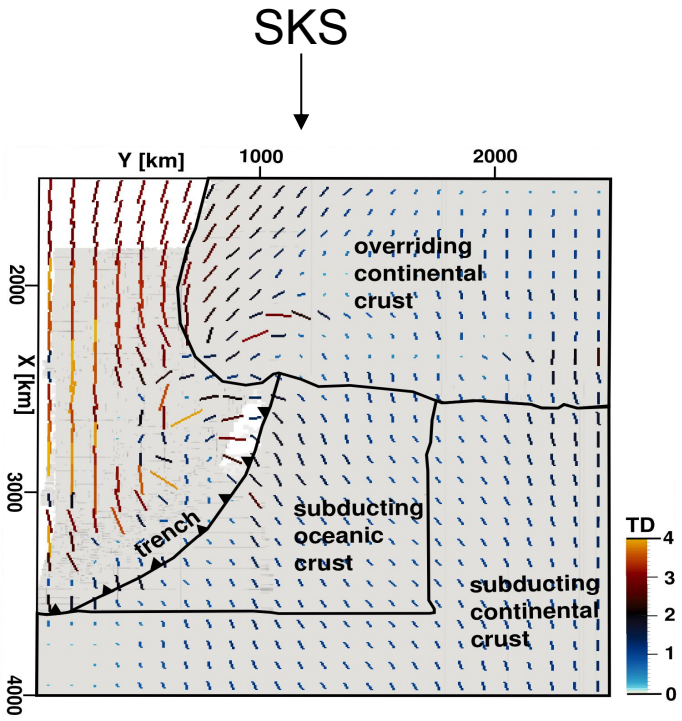
3D Numerical model:

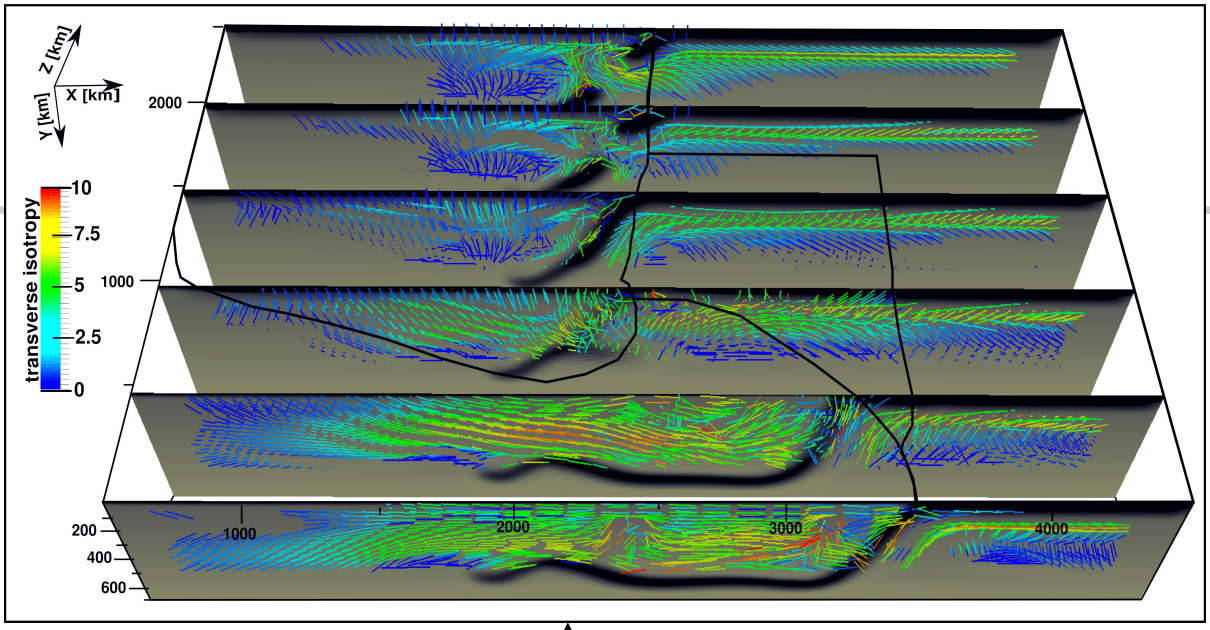
modelled velocity, viscosity+ temperature fields





3D Numerical model

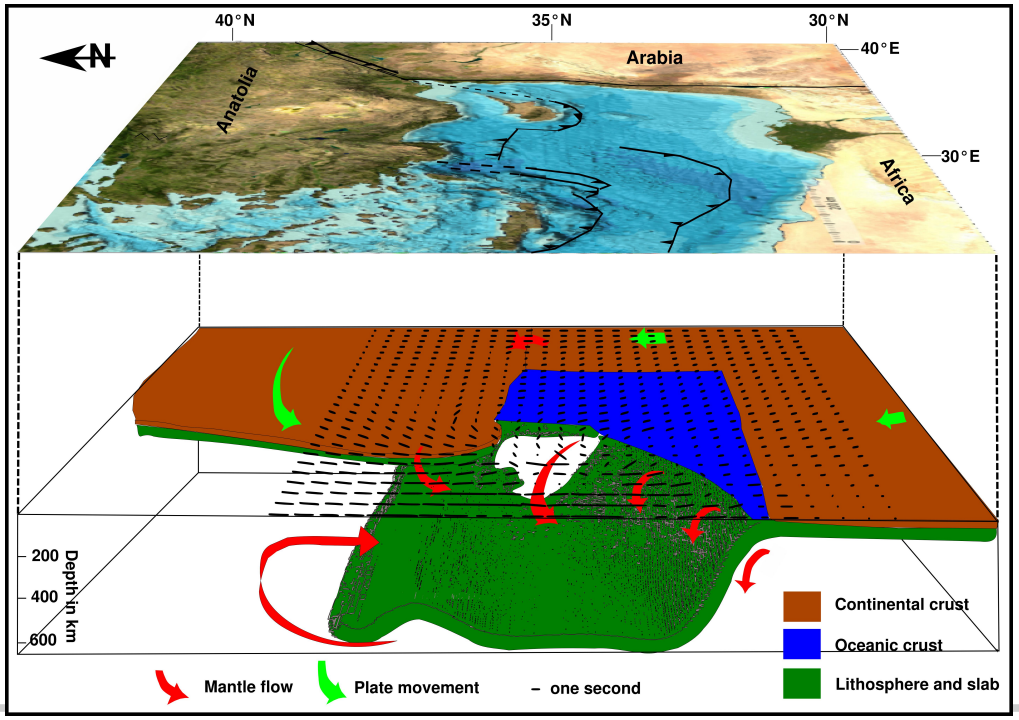




transverse isotropy field

Interpretation and comparison with current plate tectonics

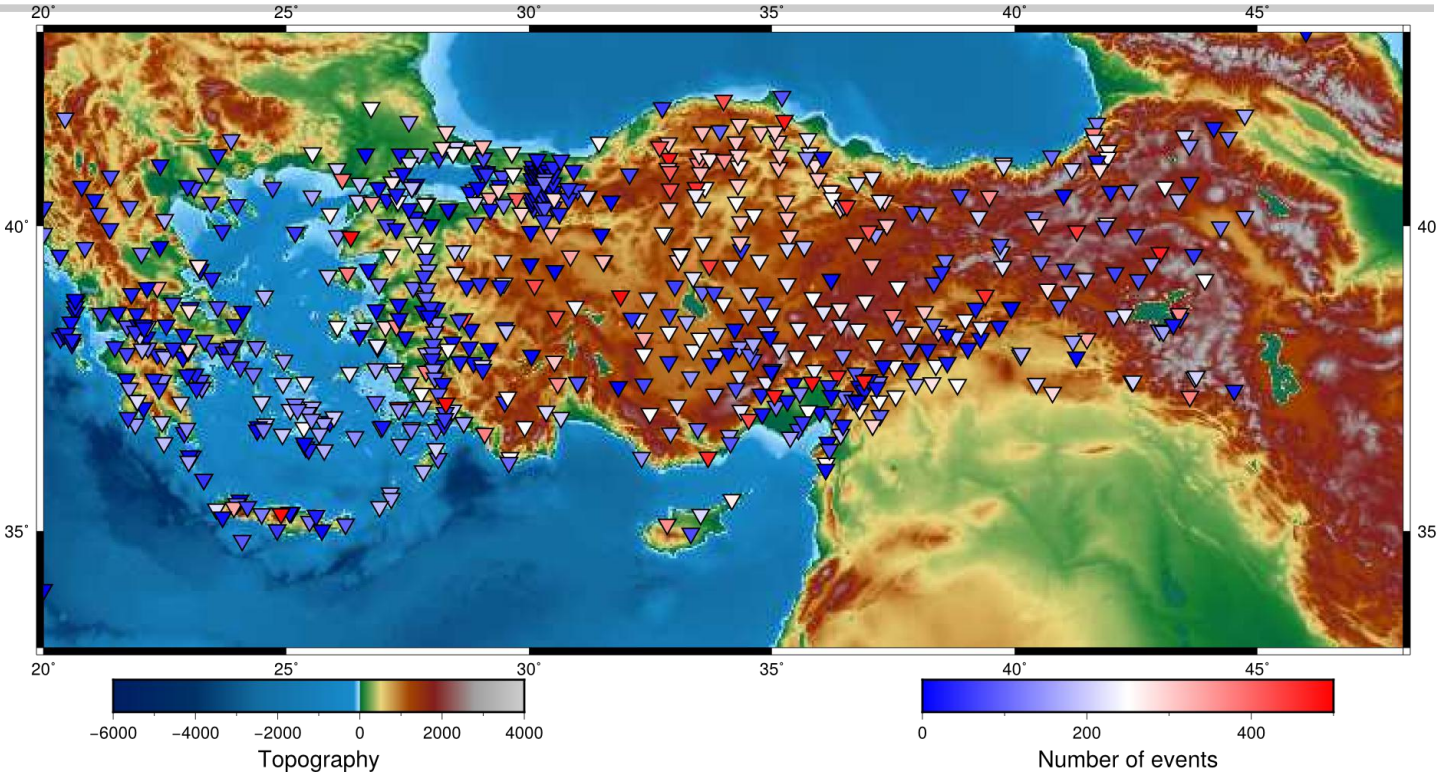
- modelled SKS fit to actual SWS measurements



P-wave tomography Methodology

Data:

- 557 events (out of 1135)
- magnitude: >= 5.5
- 30-90° epicentral distances
- 2005-2010, 2013-2015
- recorded at 686 stations
- 107283 good cross-correlated P-waveforms

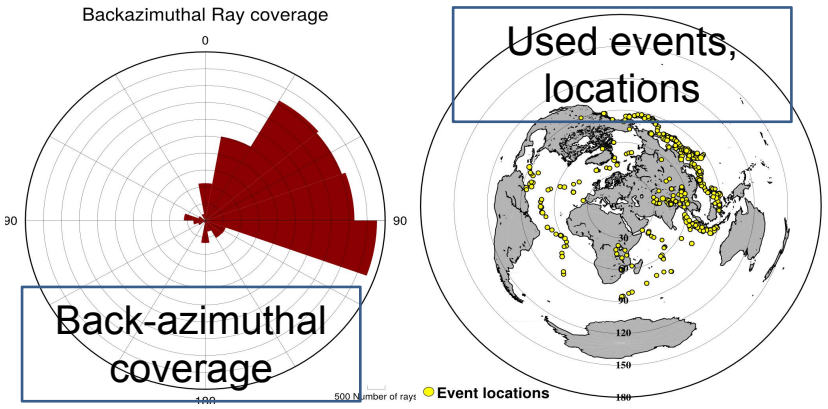


Method:

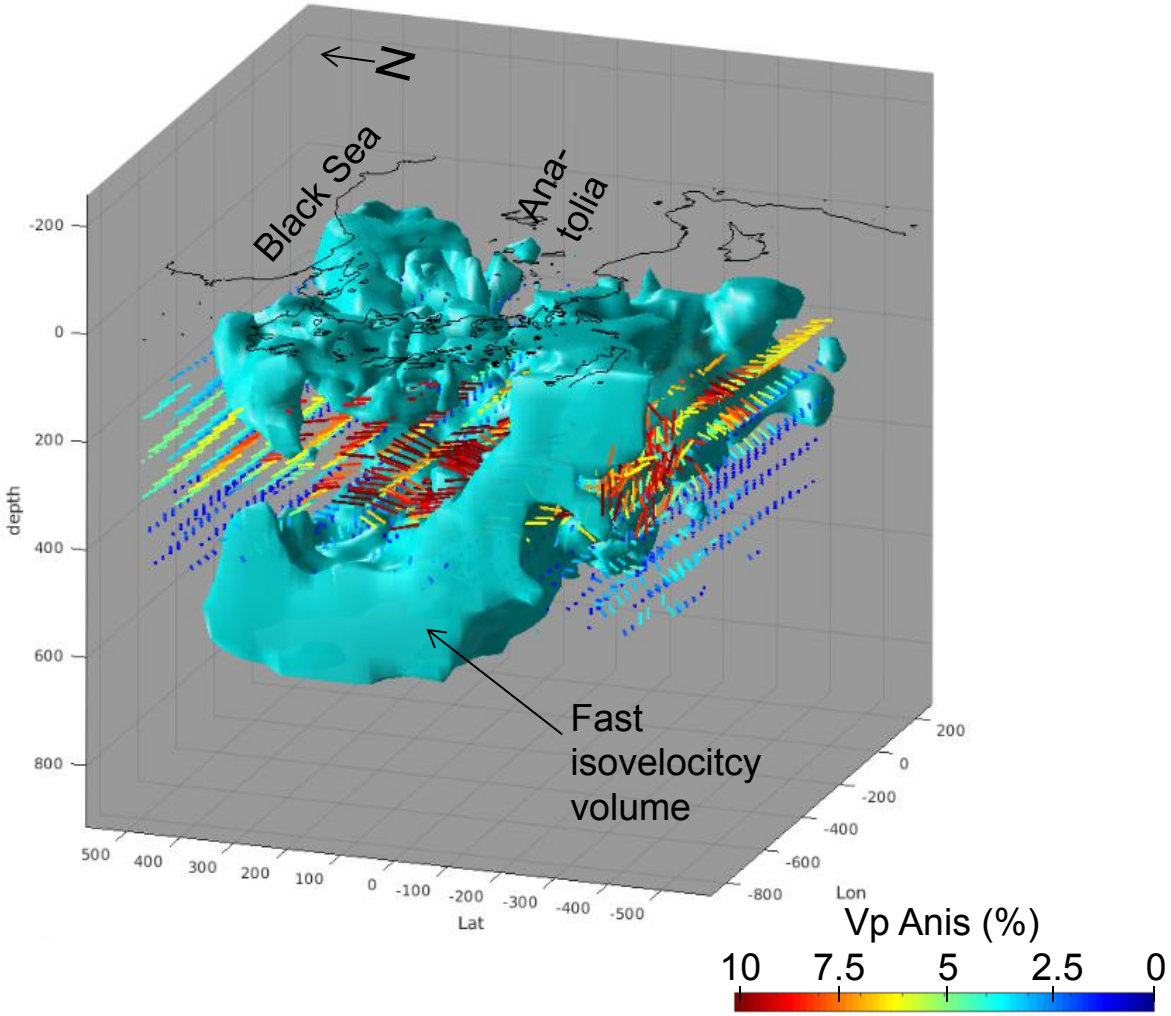
- AK135 1D velocity model
- hybrid ray tracing method (Bezada et al., 2013): combines raypath dependency and finite frequency sensitivity (with Born kernels, Schmandt & Humphreys, 2010)
- center frequencies: short (44.6% 0.3 HZ), intermediate (32.6% 0.5 HZ), long period bands (22.9% 1 HZ)

Anisotropic tomography

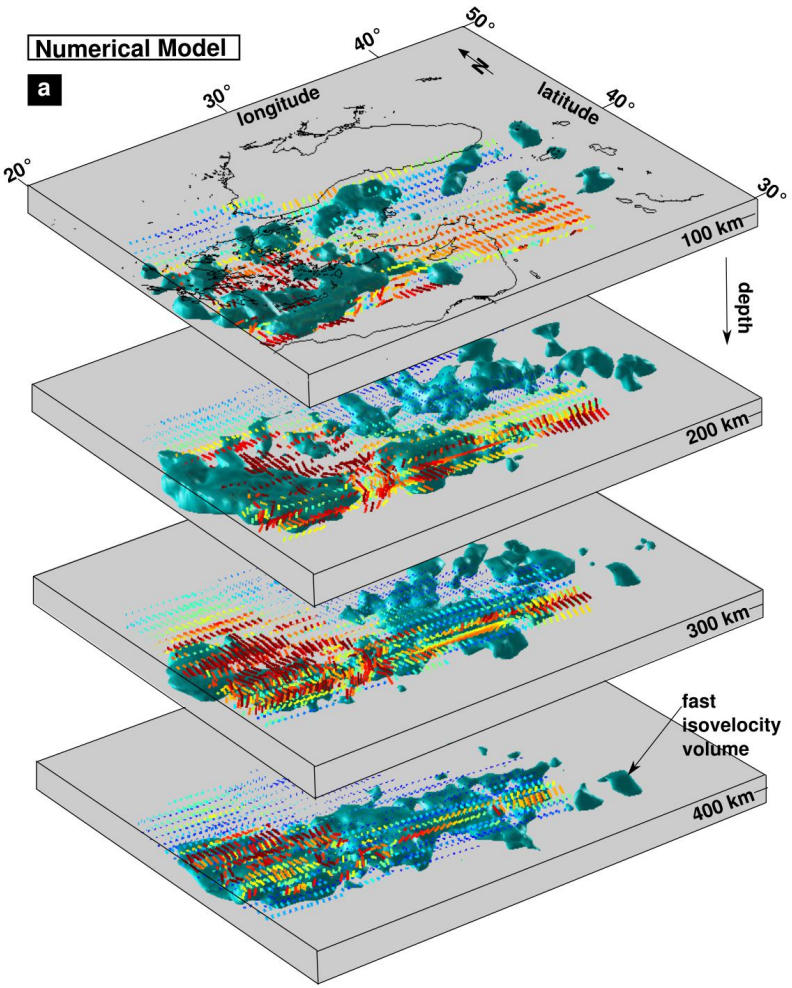
- inverting with apriori anisotropy field
- model improvement in three iterations
- Synthetically tested in Bezada et al. (2016)



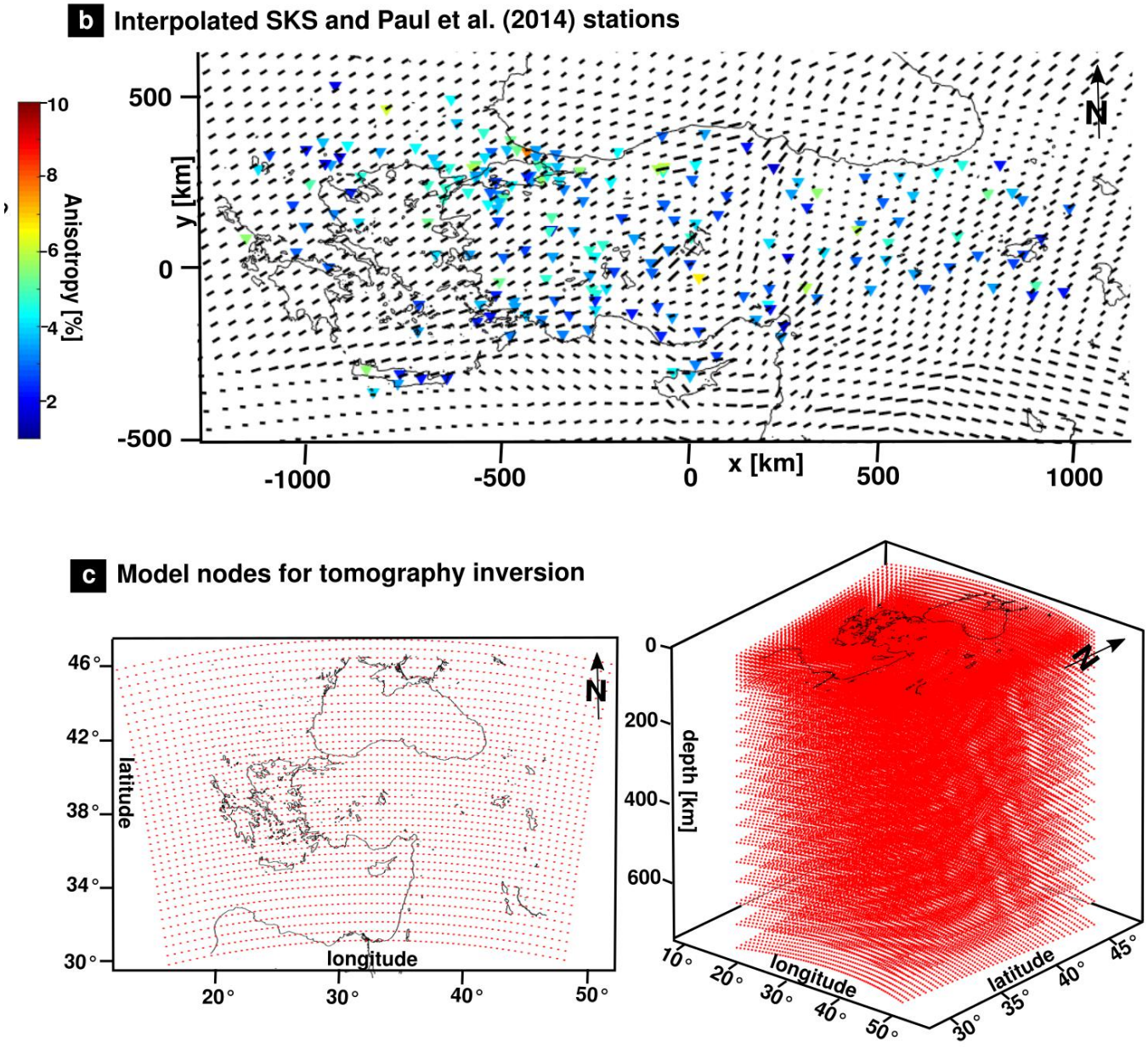
P-wave Tomography
Correcting for anisotropy from Numerical Model



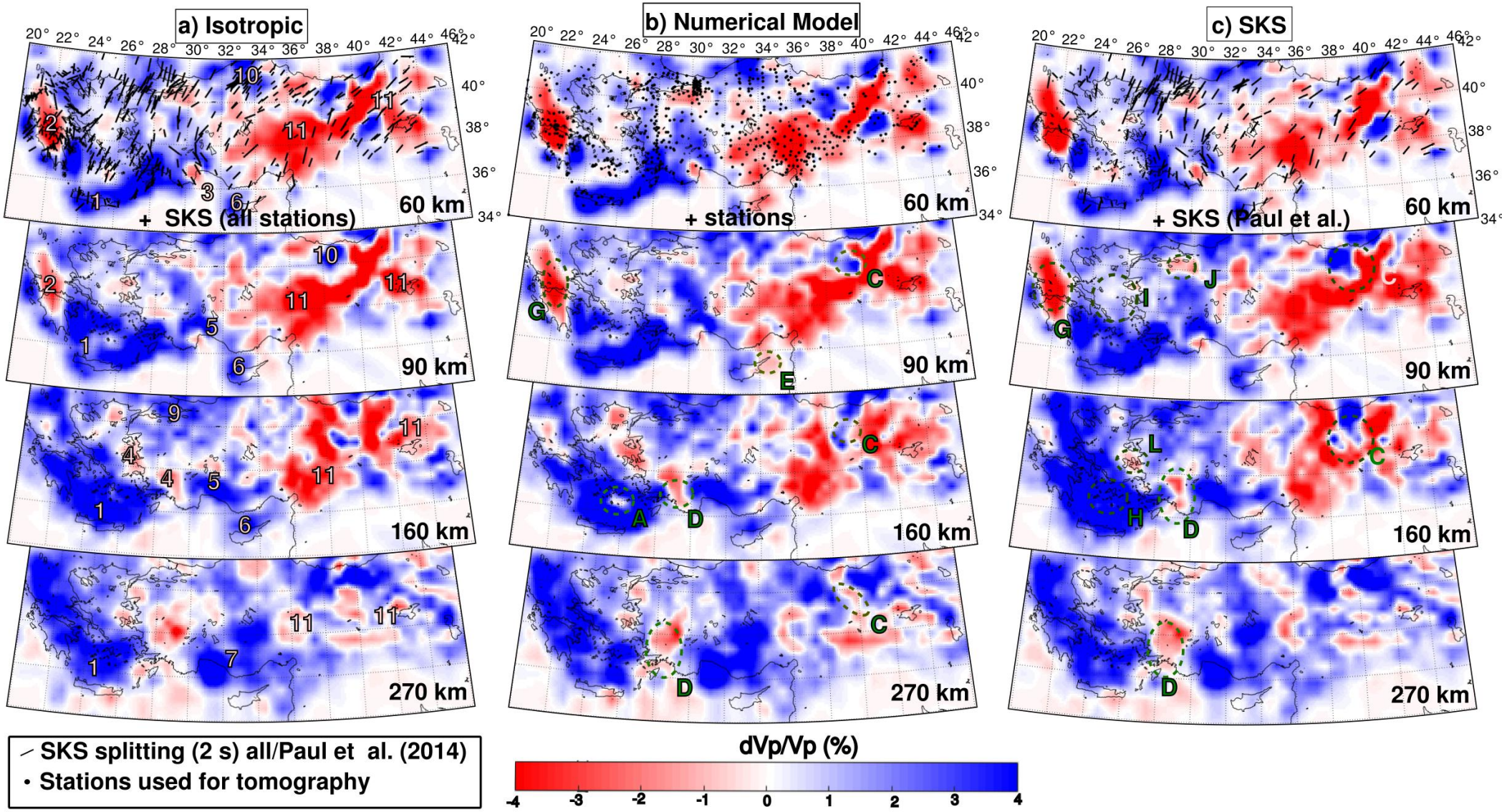
Anisotropy is divided by 2 for tomography



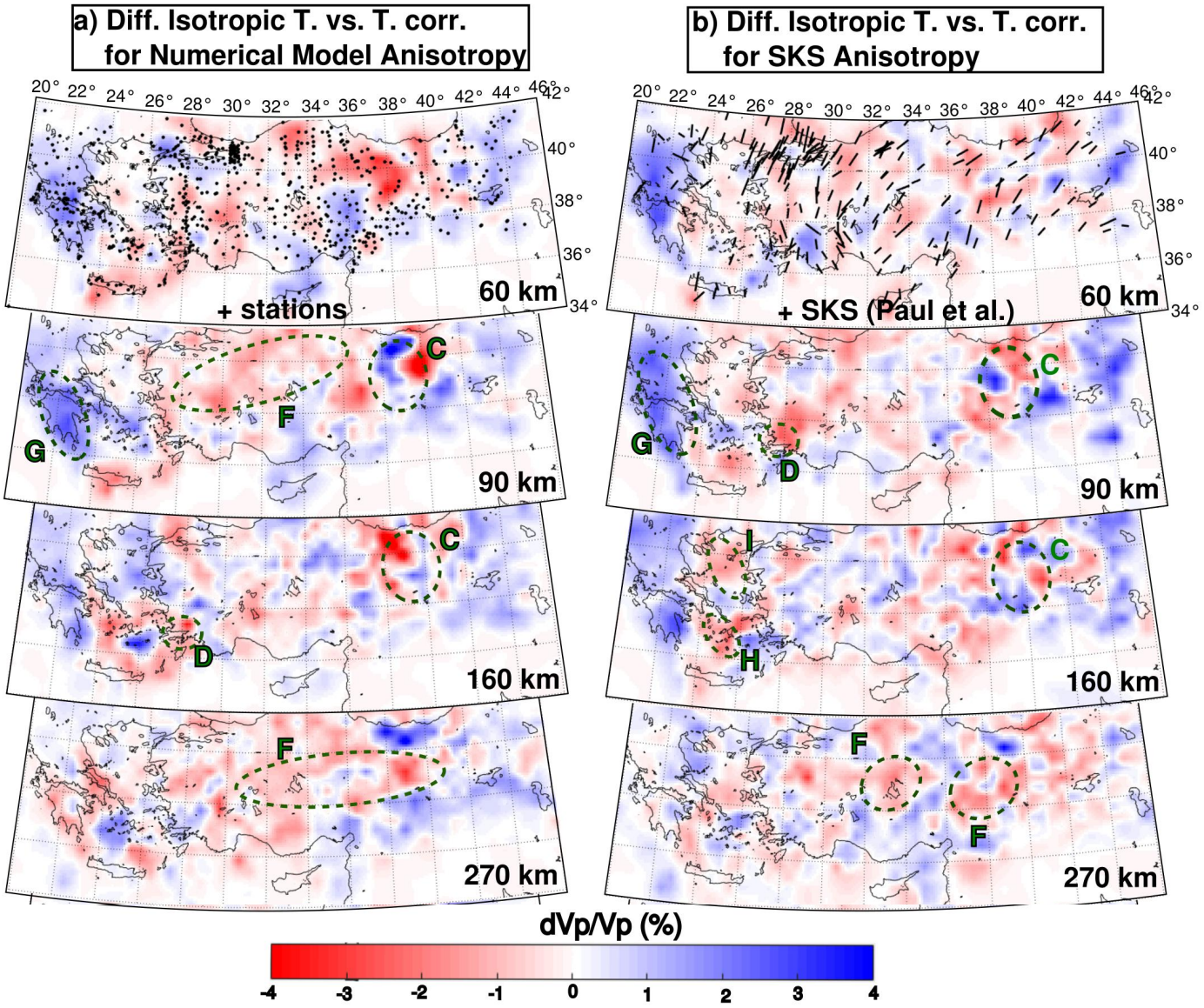
P-wave Tomography
Correcting for Anisotropy from SKS Splitting Measurements



P-wave tomography



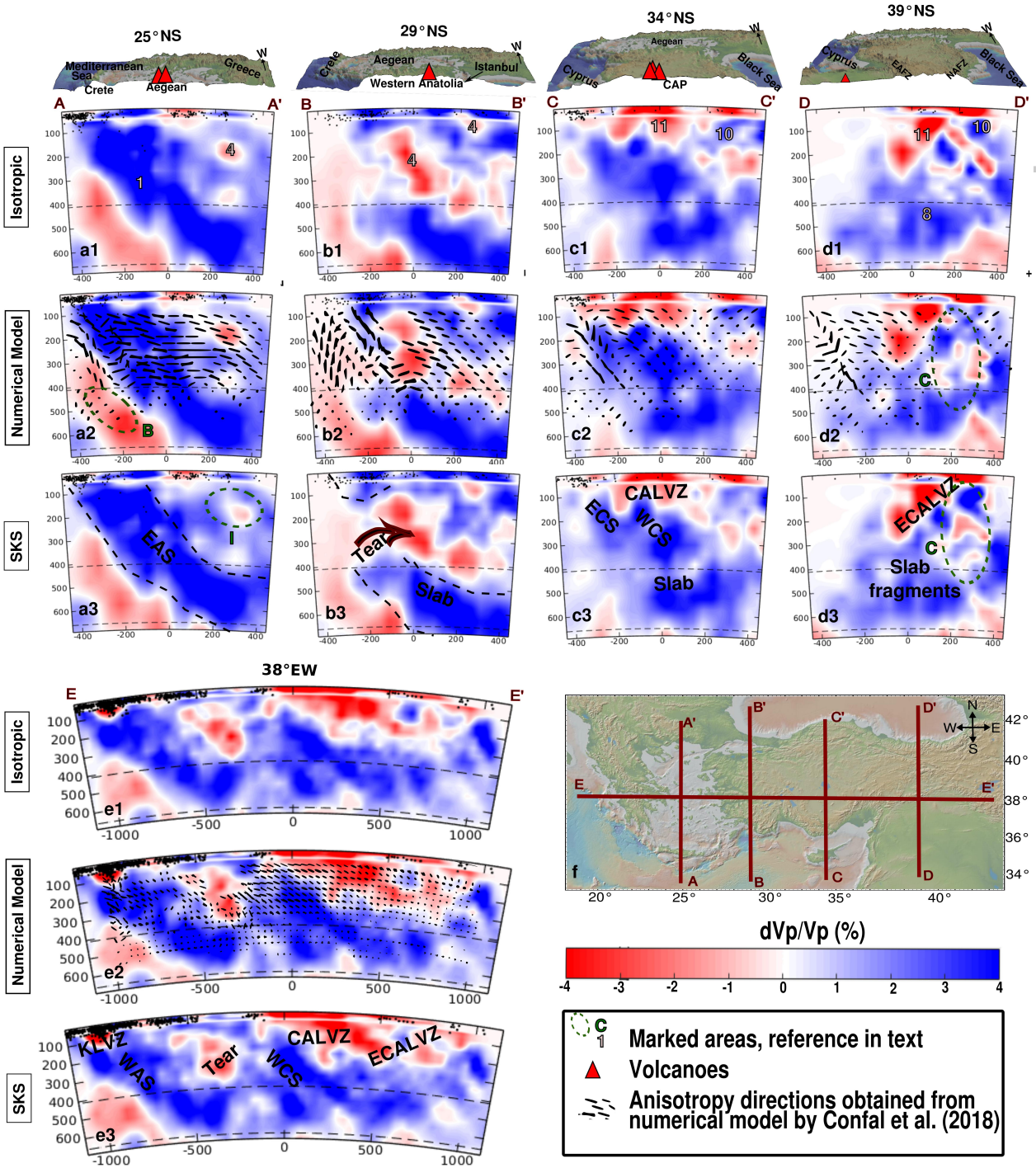
P-wave tomography Discrepancies



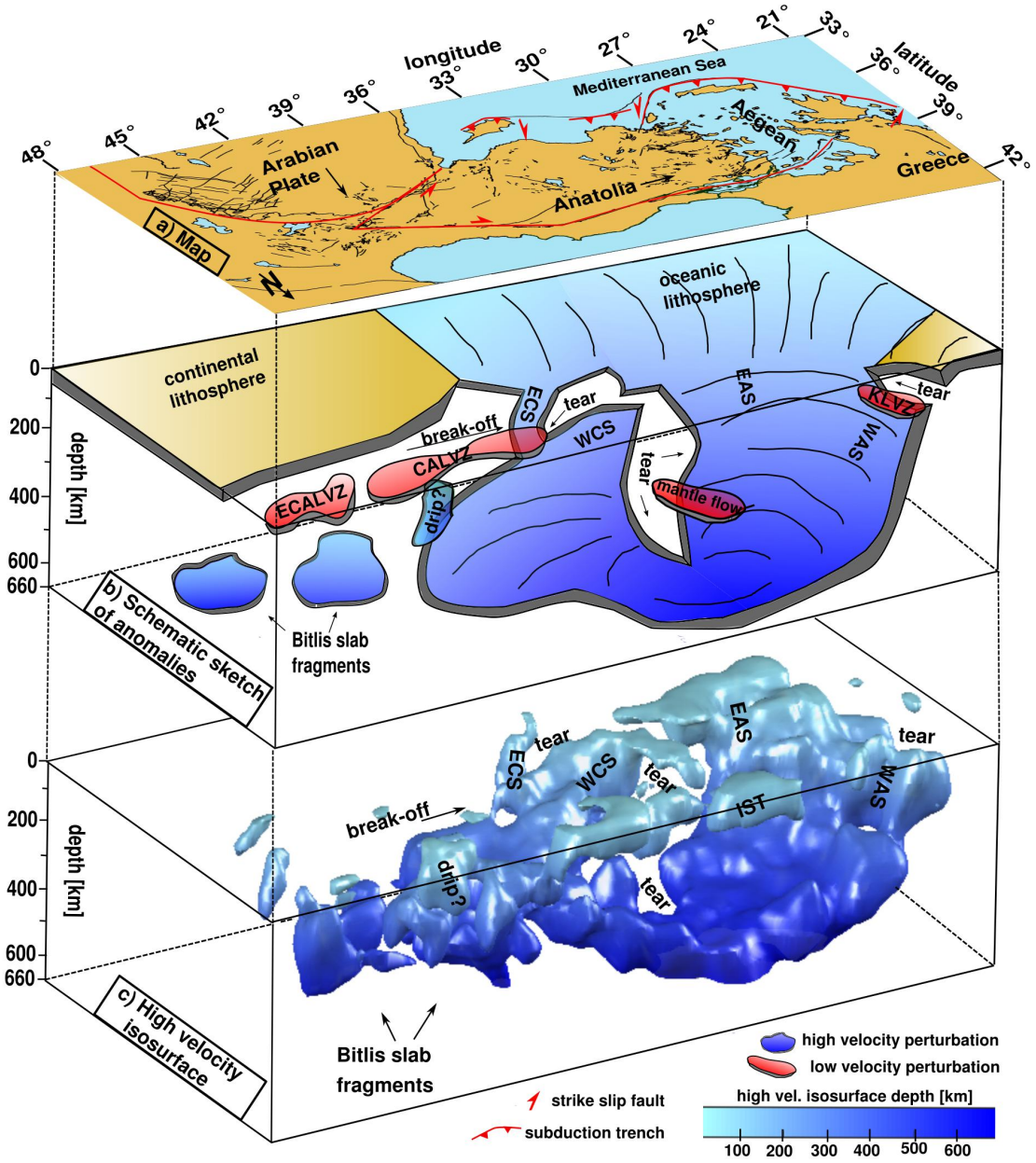
P-wave tomography cross-sections

- Main similar first-order structures
  - Tears in the slab
    - northwestern Greece
    - southwestern Anatolia
    - Cyprus
  - Central/Eastern Anatolian low-velocity zones
  - High-velocity zone beneath Pontides

- Differences between models
  - Slab geometry in southern Aegean
  - Sub-slab low-velocity anomaly
  - Intensity of low-velocity through tears



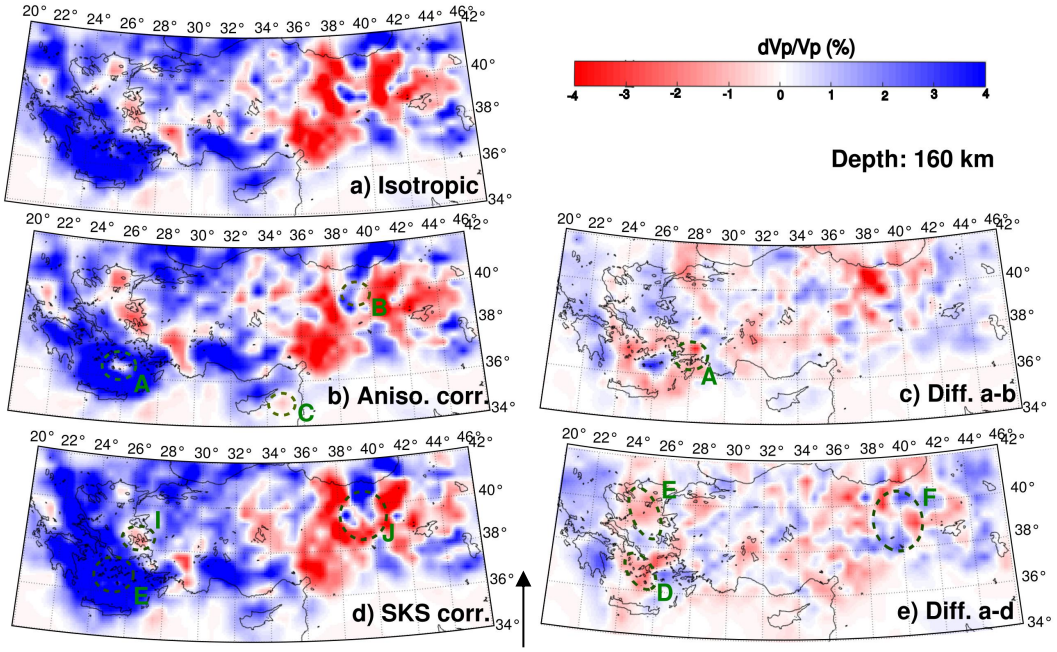
P-wave tomography
Tectonic Interpretation



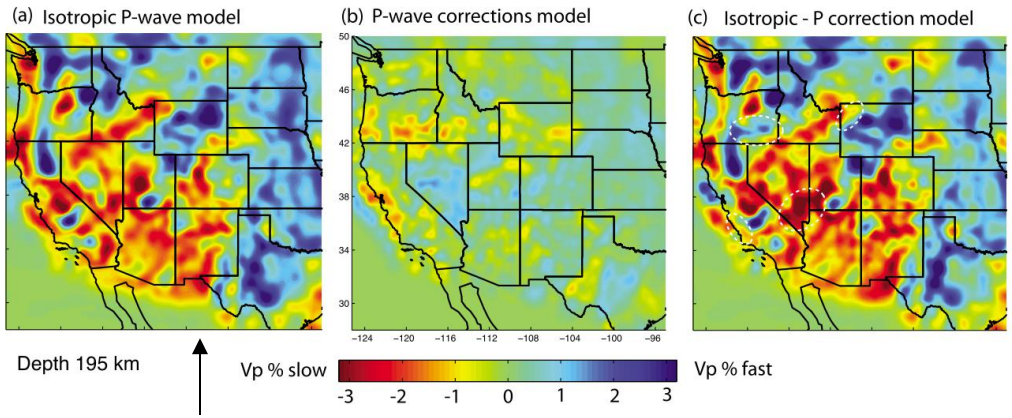
Conclusion

- Up to 2 % dVp/Vp differences
- Biggest discrepancies around the active subducting slab (dipping/vertical axis of symmetry)
- Azmuthal anisotropy only produces small changes in the inversion
- Variance reduction increase small (1.6%)

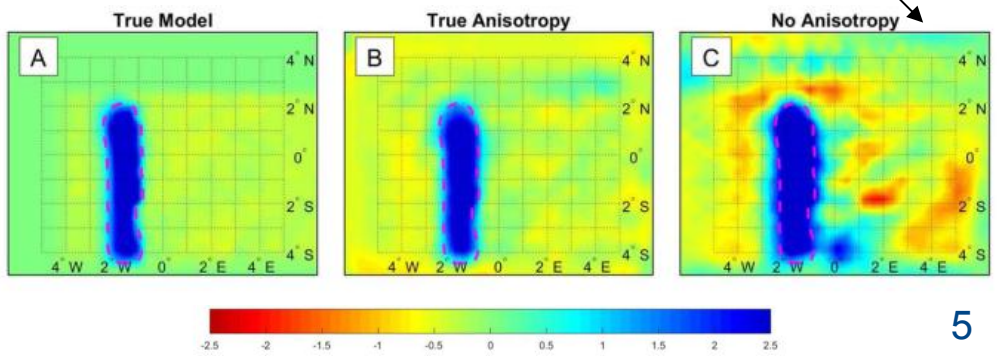
- Inverting data corrected for anisotropy, enabled low and high-velocity anomalies to be better validated by the data and therefore interpreted with higher certainty



This study



Driscoll et al. (2011) and Bezada et al. (2016)



Thank you!

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Synthetic Tests

Random noise added:

standard deviation = 0.1 s →

standard deviation = 0.2 s →

Anisotropy from numerical Model added: →