Detailed Investigation of Seismic Anisotropy in the Upper Mantle of Northern Aegean Region

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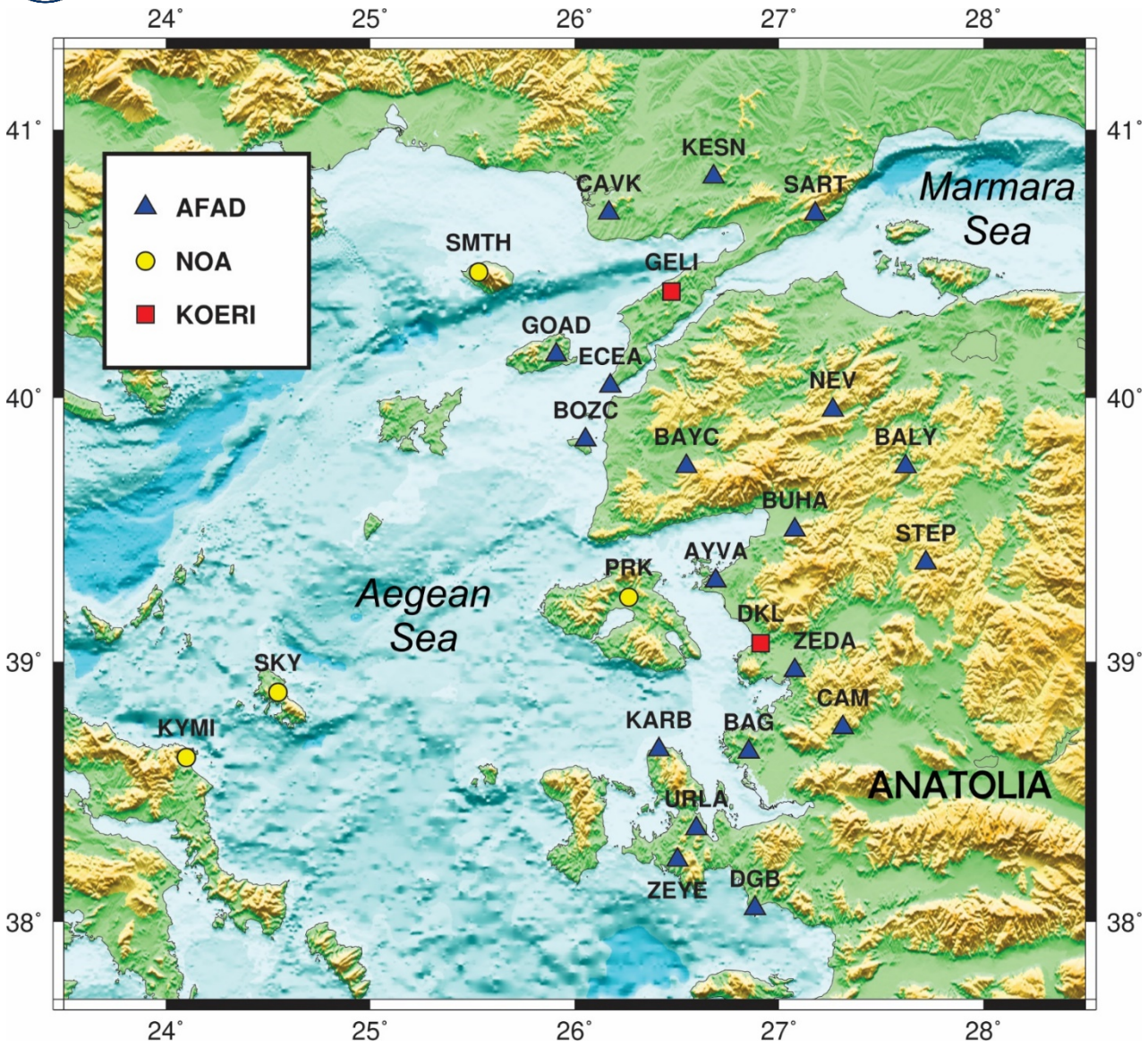
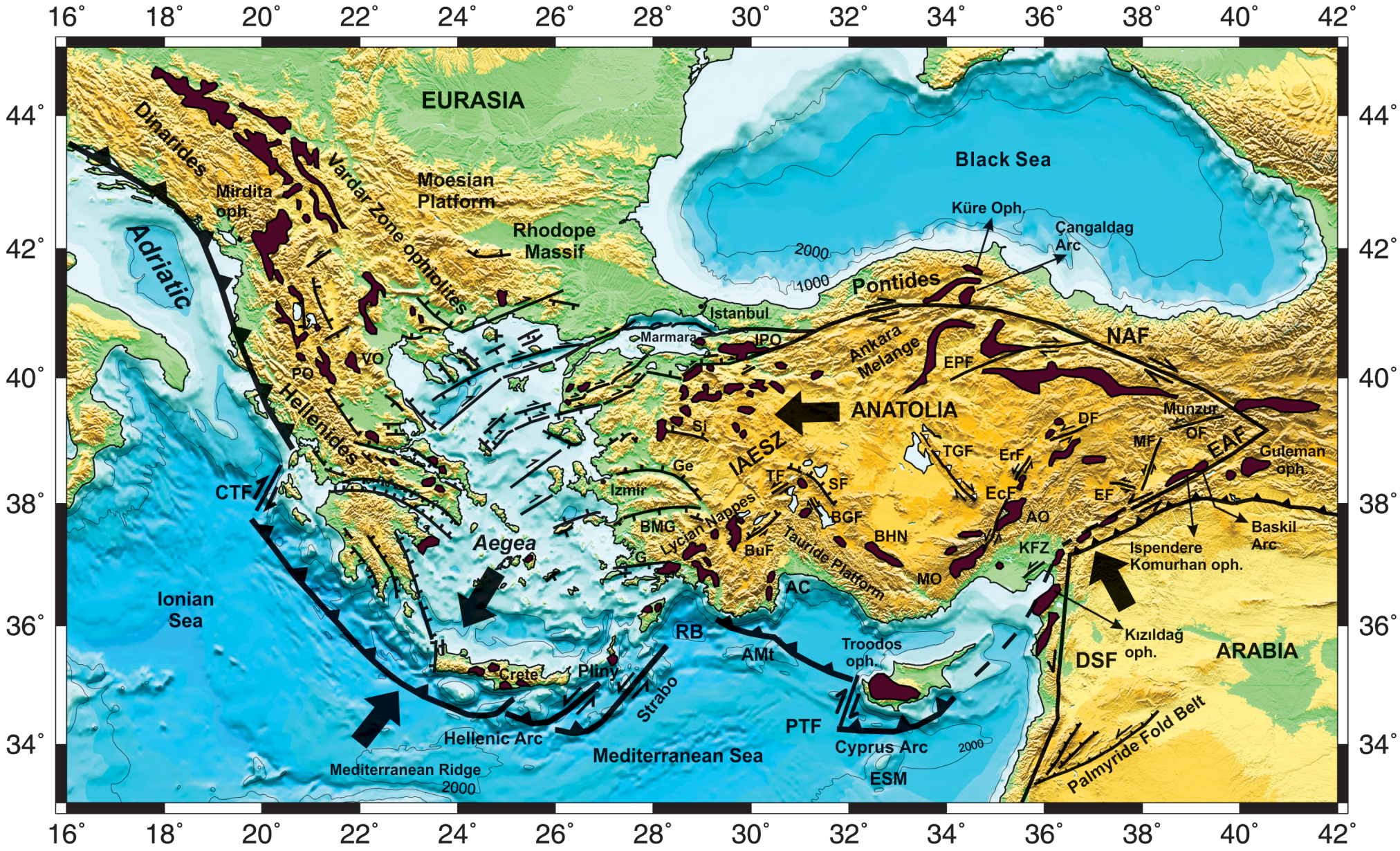
Study Region

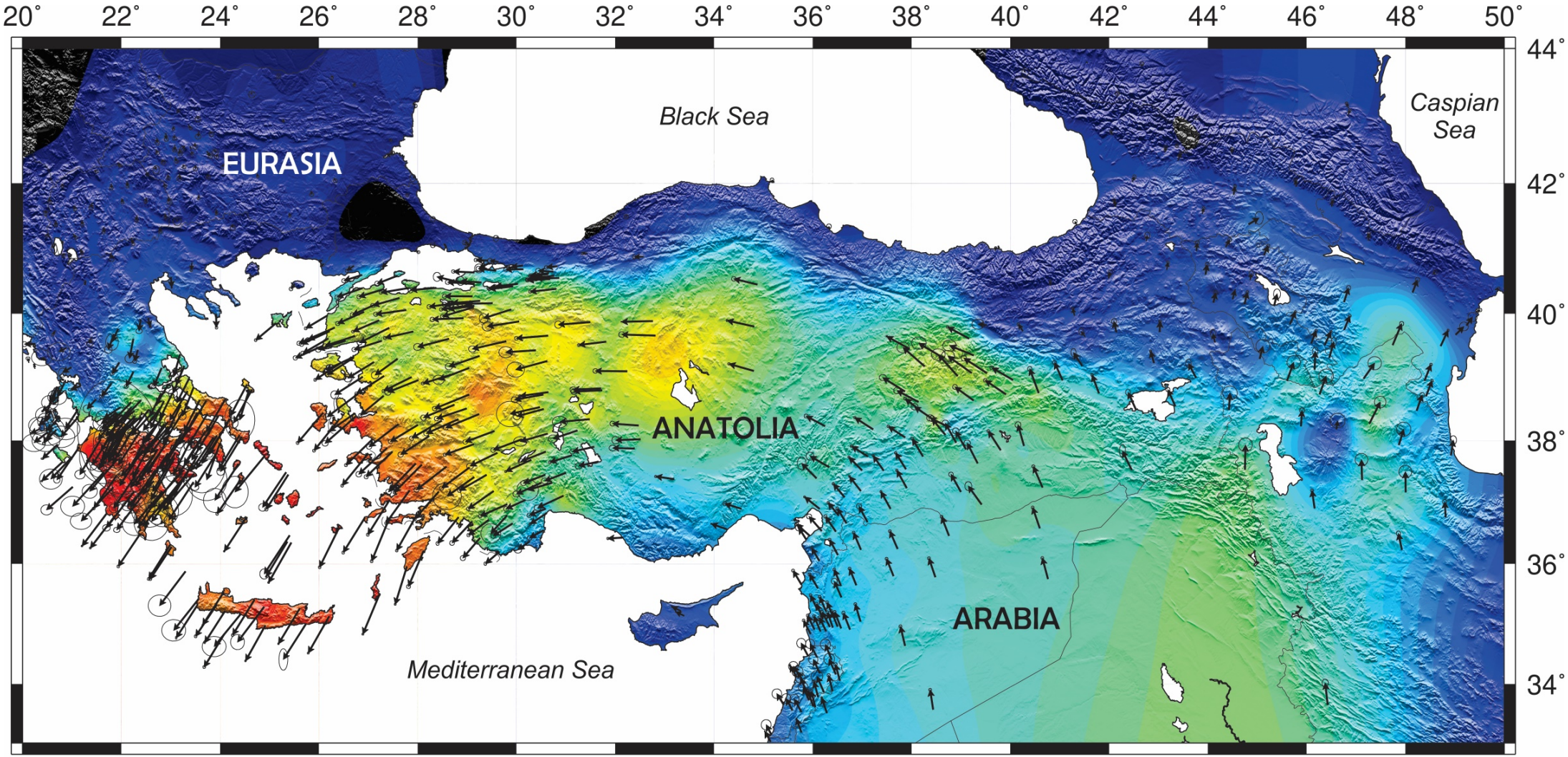


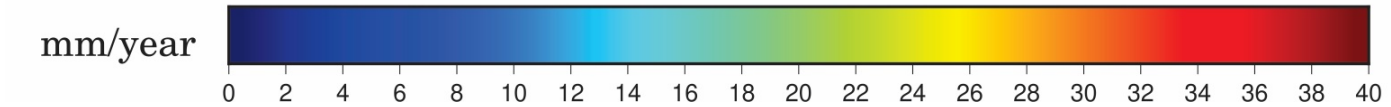
Purpose of the study

- To investigate anisotropic structures beneath NW-W Anatolia by analysing SKS phases recorded at 25 broad-band seismic stations.
- To get detailed information about geodynamic structures beneath NW-W Anatolia based on SKS splitting parameters
- To understand the relation between complex deformation at the crustal thicknesses and deeper structures.
- To discuss the two-layer anisotropy case for NW Anatolia.

(Gass and Masson-Smith, 1963; Şaroğlu et al., 1992; Robertson, 2002; Dilek and Flower, 2003; Taymaz et al., 1990, 1991, 2004, 2007; Hall et al, 2009; Yolsal, 2008; Yolsal-Çevikbilen and Taymaz, 2012; Fielding et al., 2013; Yolsal-Çevikbilen et al., 2012,2014; Yolsal-Çevikbilen, 2014)

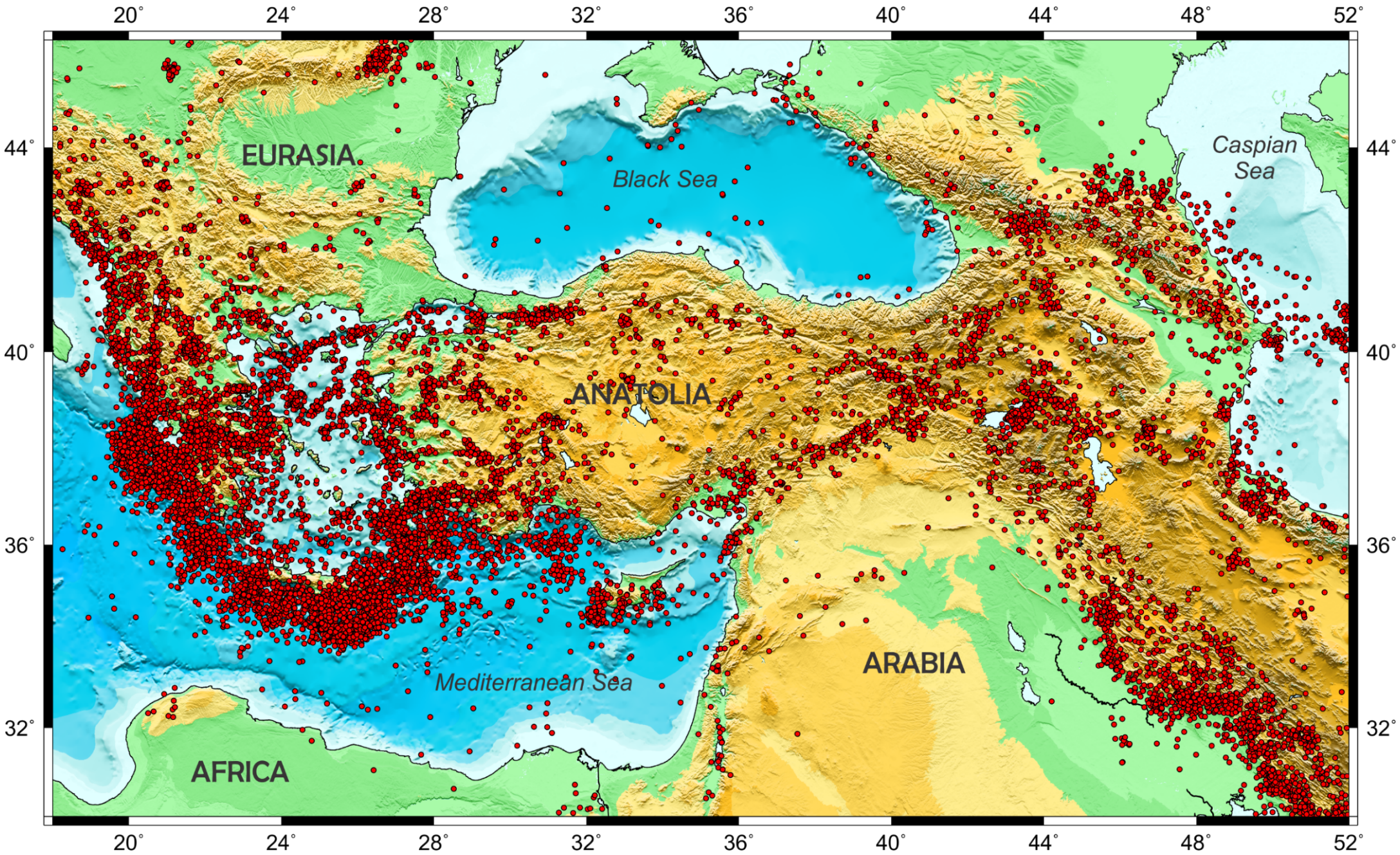






Nocquet (2012)

African Plate (6 mm / year)
Arabian Plate (20 mm / year)
Hellenic Arc (35 ± 1 mm/year) - NAF (25 ± 2 mm/year)
EAF (10 mm/year)



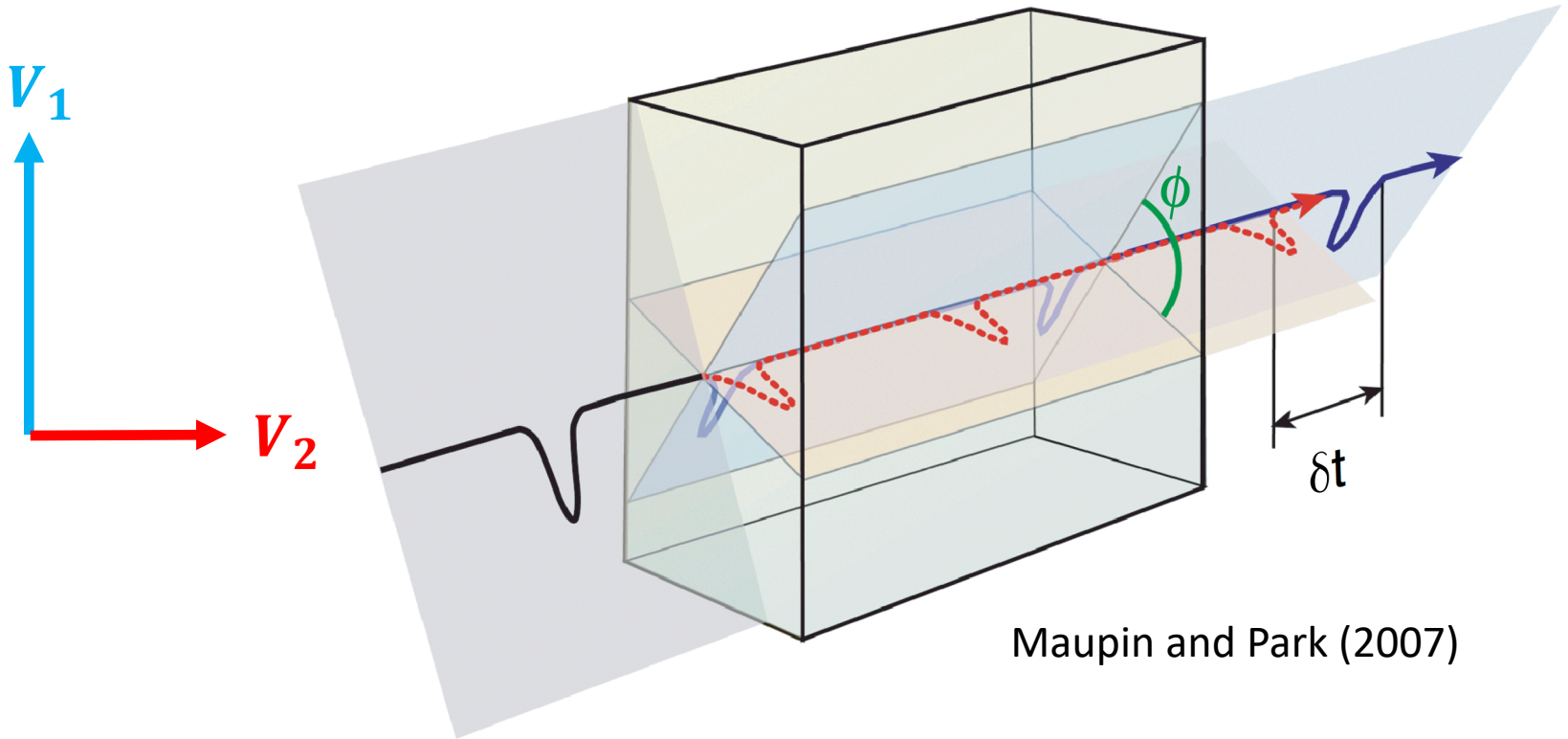
USGS NEIC (1970-2018) - M≥4

Seismic Anisotropy

What is Seismic Anisotropy?

The **speed** of seismic wave depends on its propagation **direction** in an anisotropic medium.

Accordingly, anisotropic materials cause seismic waves traveling through them to travel **faster** or **slower** depending on their directions.

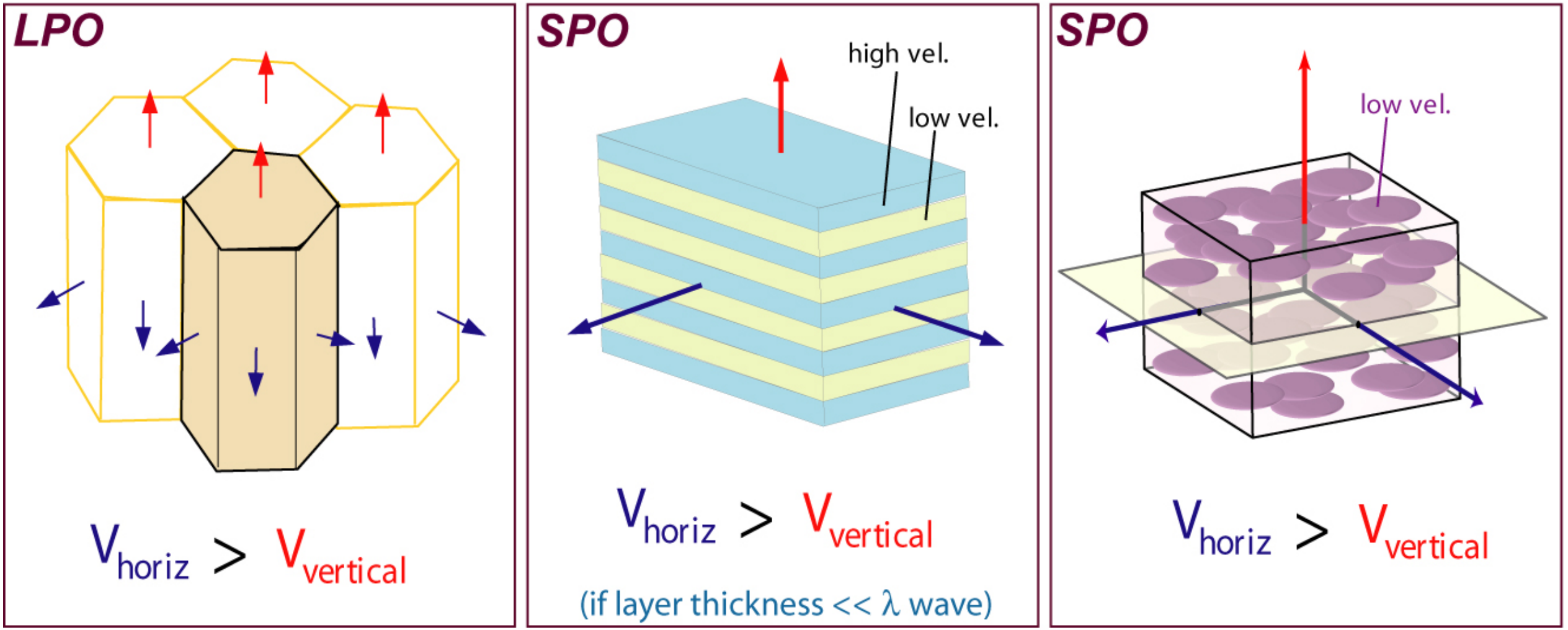


Maupin and Park (2007)

Fast Polarization Direction : The direction in a medium which results in fastest polarization of the S wave. It gives the direction of the seismic wave propagates faster.

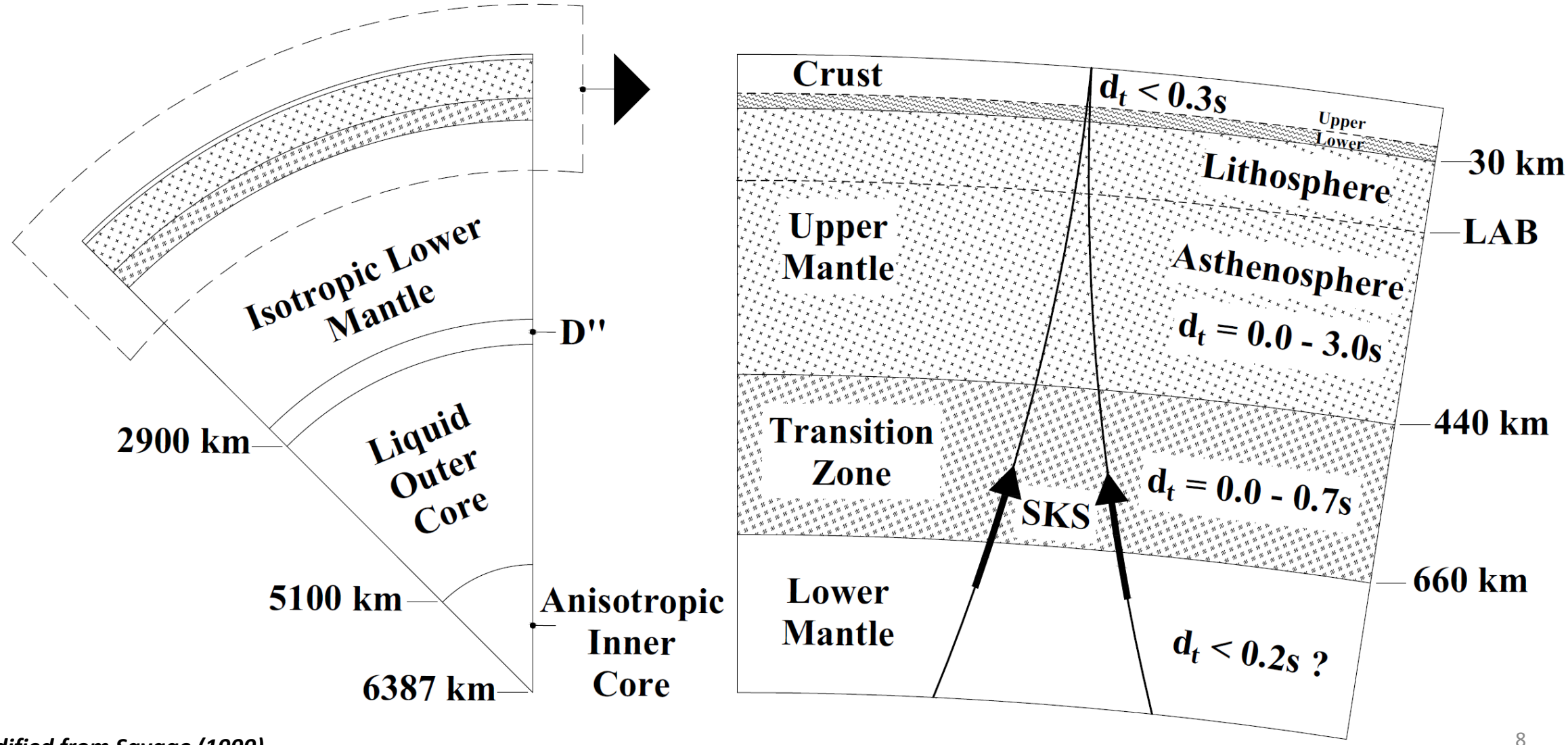
Delay time : Time separation between fast and slow components of split shear waves. It gives information about the thickness of anisotropic structure and/or strength of the anisotropy

- When rocks are deformed over geologic timescales; the alignment of mineral grains (lattice-preferred orientation, LPO) can lead to anisotropy of the rock.
- Additionally, anisotropy can be generated by an ordered assembly of individually isotropic materials of different wave speeds (shape-preferred orientation, SPO).



[after Moore,Garnero,Lay,Williams, JGR, 2004]

Anisotropic Layers Inside the Earth



Modified from Savage (1999)

Data and Methods

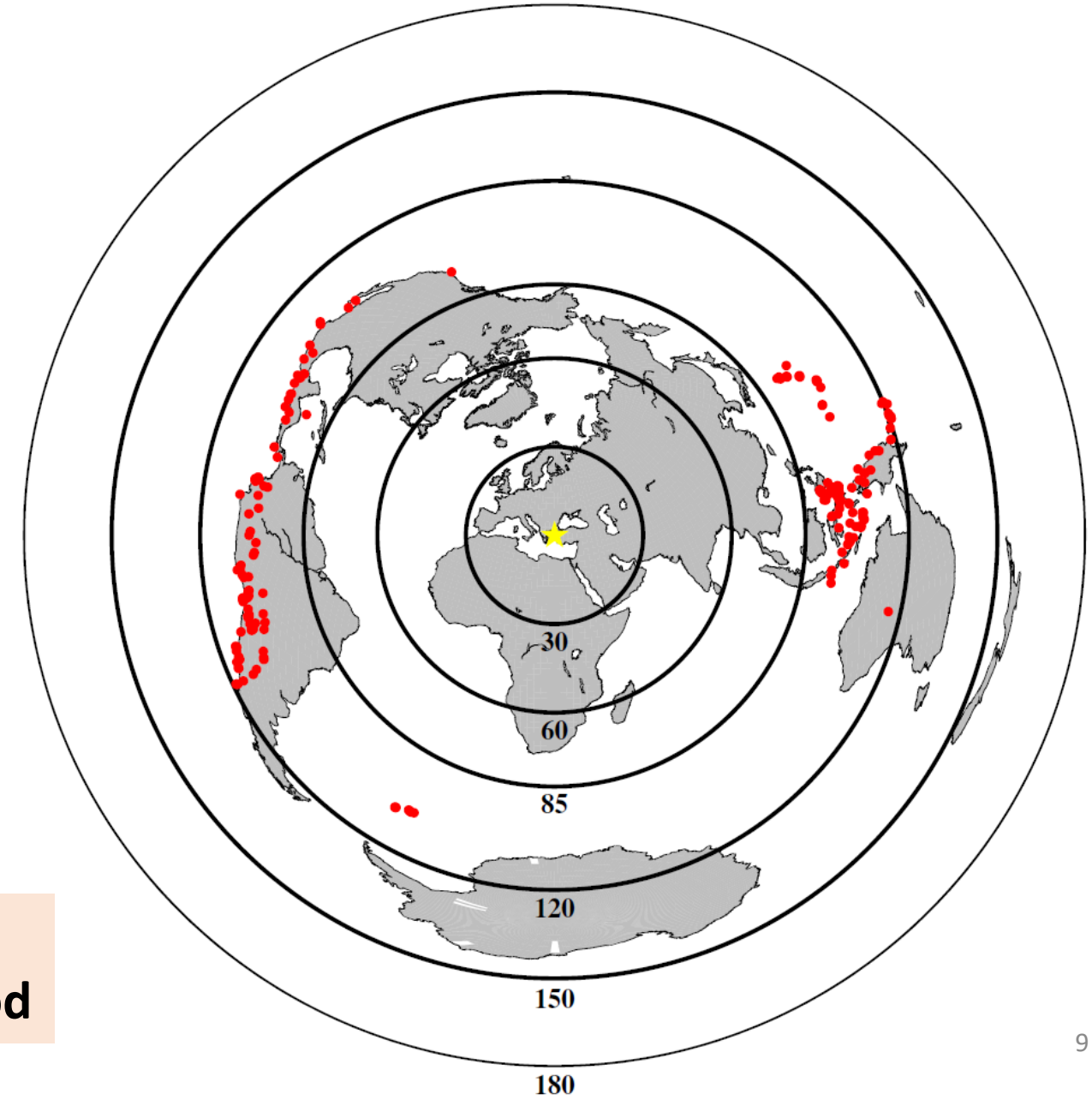
***Automated Shear Wave Splitting* Algorithm** (Teanby et al., 2004) based on **Eigenvalue Method (EV)** proposed by Silver and Chan (1991)

Distance : Δ= 85°-120°
Magnitude : $M_w \geq 5.5$
2008-2018
from **IRIS**, **EIDA** and **AFAD**

0.05 – 0.25 Hz (4 – 20 sec)
0.04 – 0.5 Hz (2 – 25 sec)
0.02 – 0.125 Hz (8 – 50 sec)
No Filter

Totally **17.147 SKS waveforms** were analyzed **807** good quality data (non-null) for **EV Method**

Red circles represents **209** different earthquakes that are analyzed at **SKS** splitting analysis



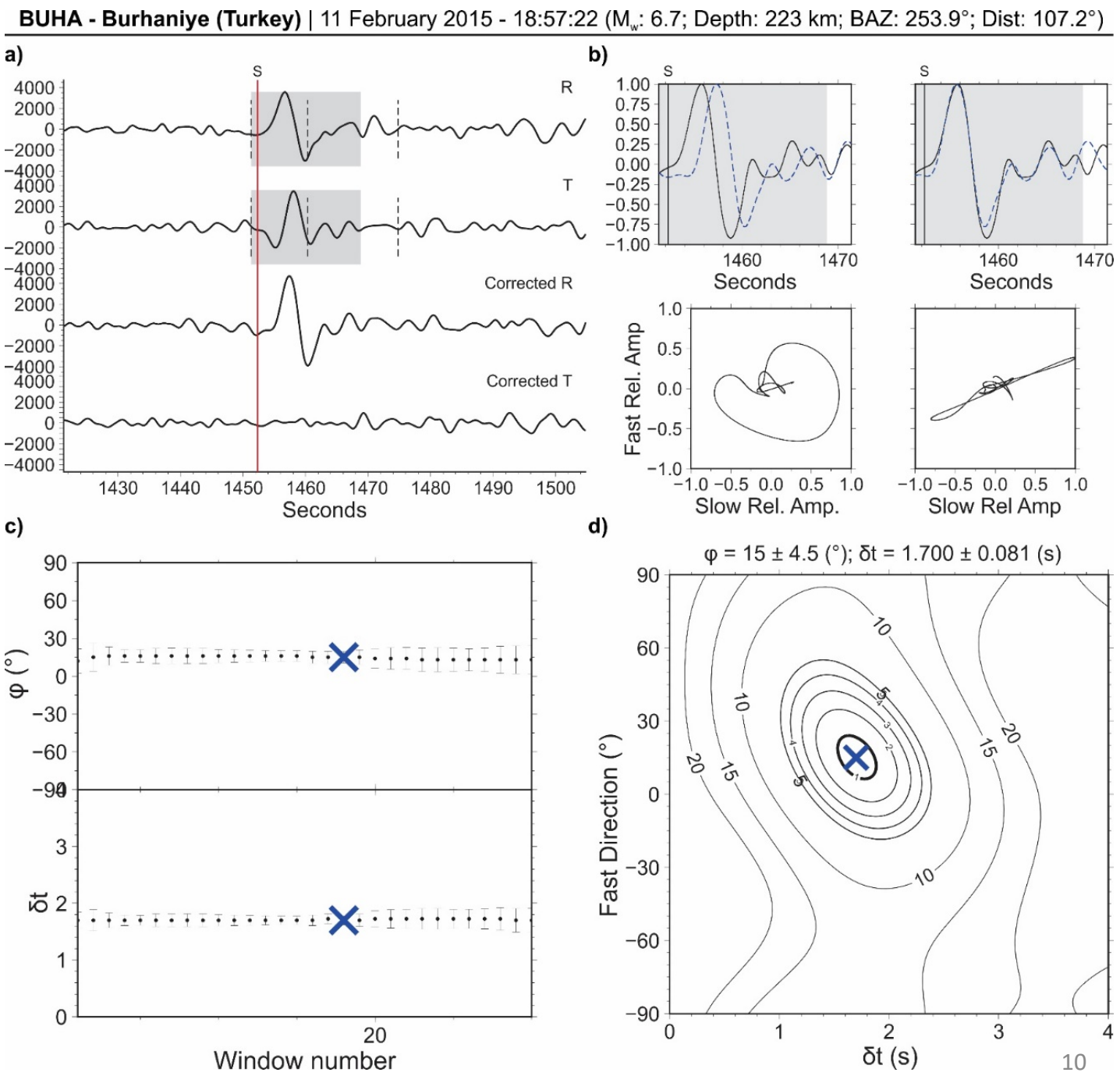
Example: Non-null measurement
BUHA-Burhaniye station

a) Radial and Transverse components before and after splitting correction

b) Particle motion of fast and slow components before and after splitting correction

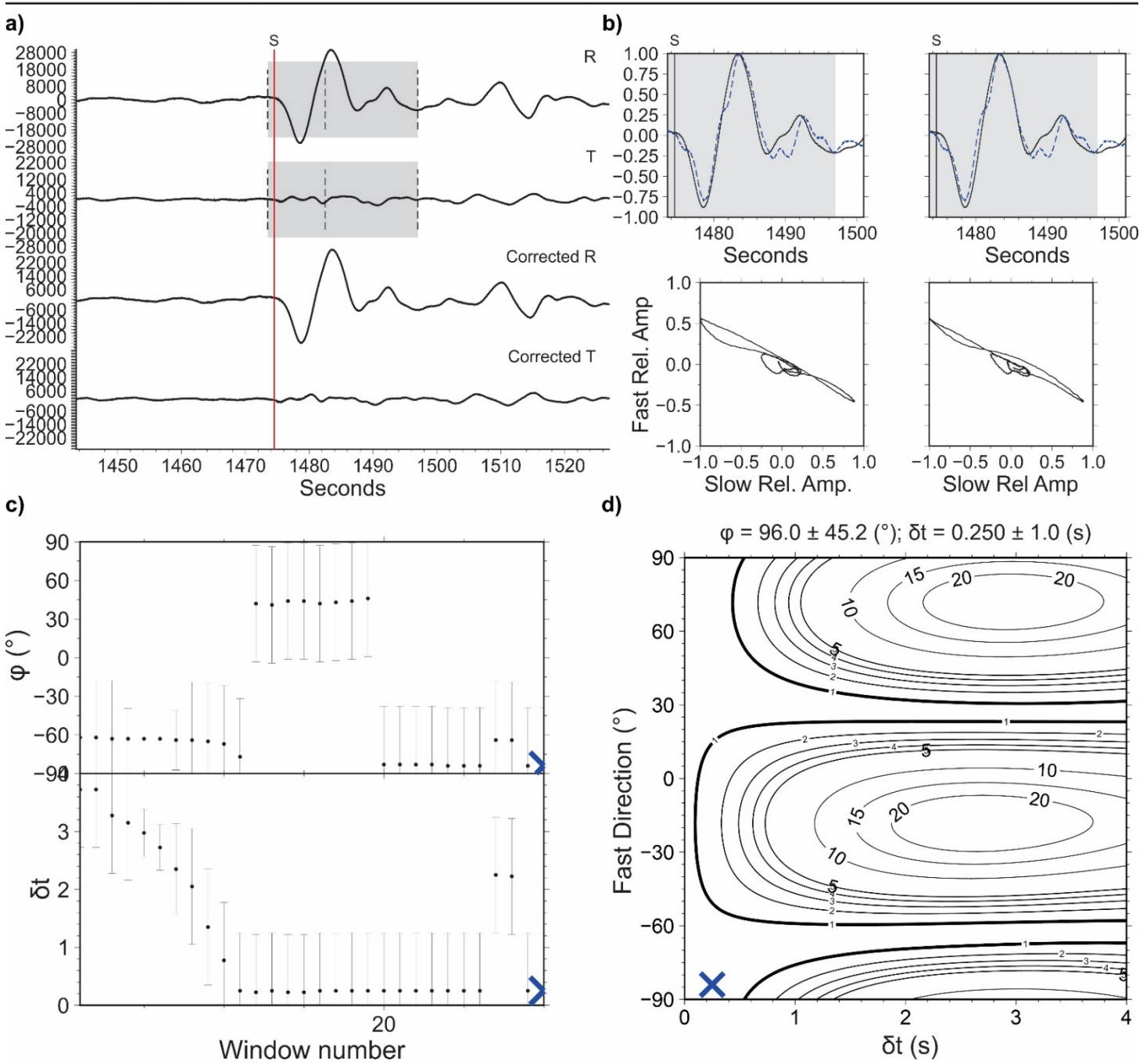
c) FPD and DT pairs for each calculation window

d) Misfit surface

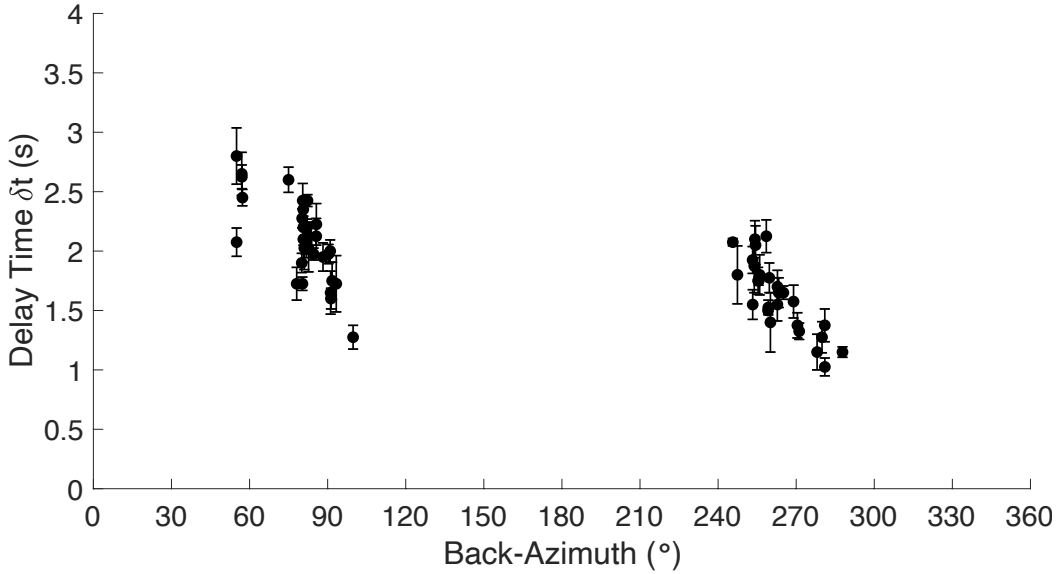


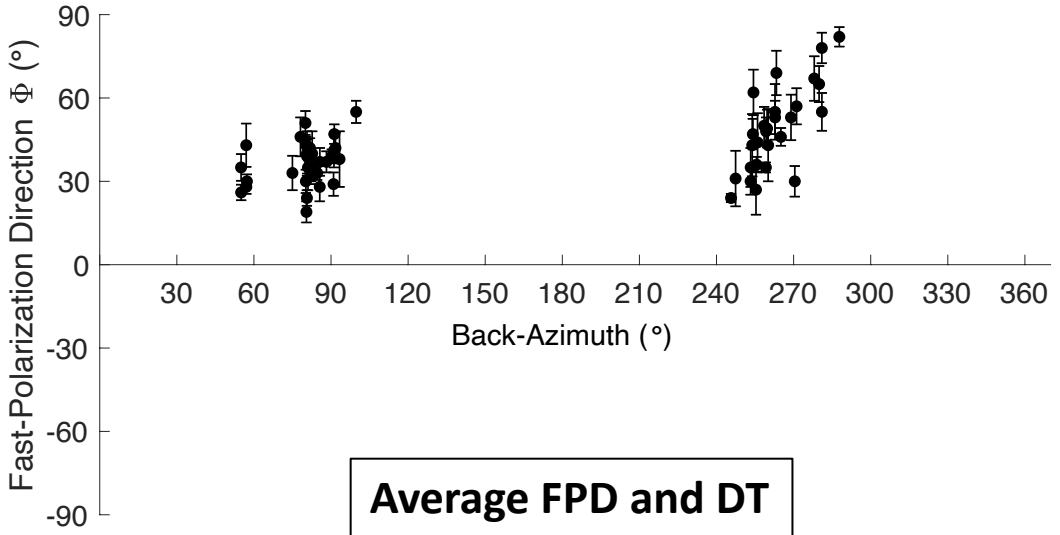
Example: Null measurement BALY-Balya station

Null measurement:
A measurements that detects no splitting on a shear wave

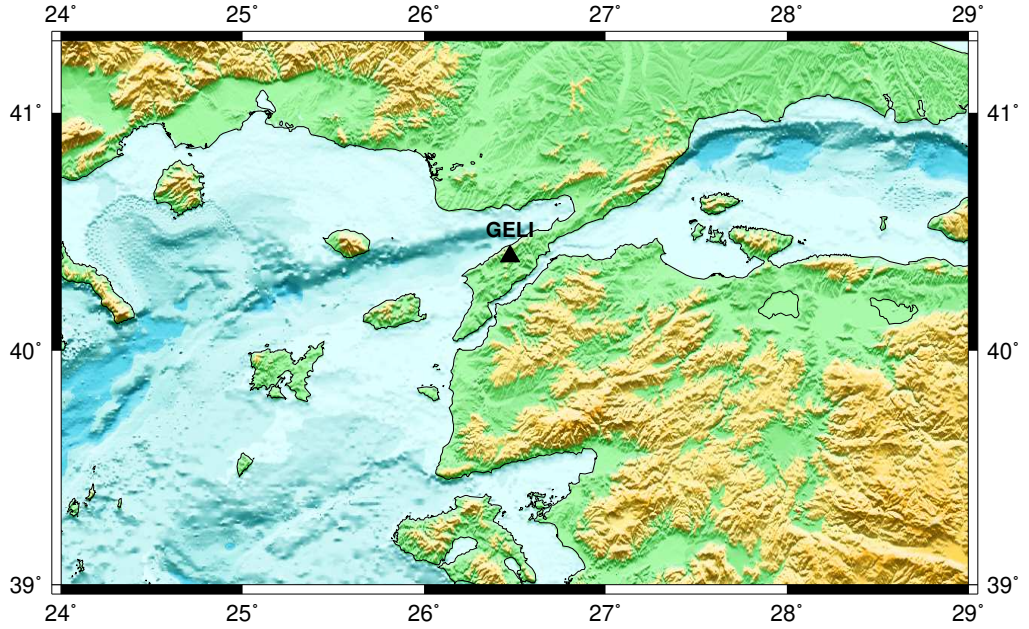


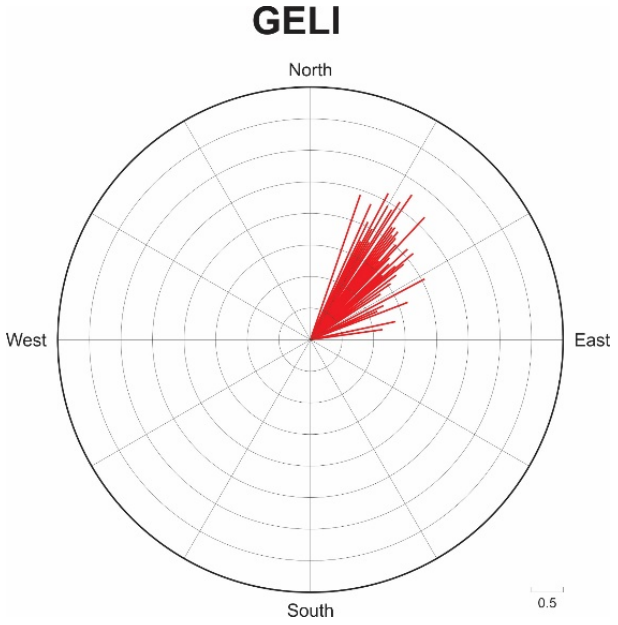
# of Good Quality non-Null SKS Meas. = 61





Average FPD and DT
FPD: 41.4° ± 5.6
DT: 1.89 sec ± 0.121





Back-Azimuthal variations of FPD and DT raise doubt about two-layer anisotropy especially in the northern part of the study area.

Results & Discussion

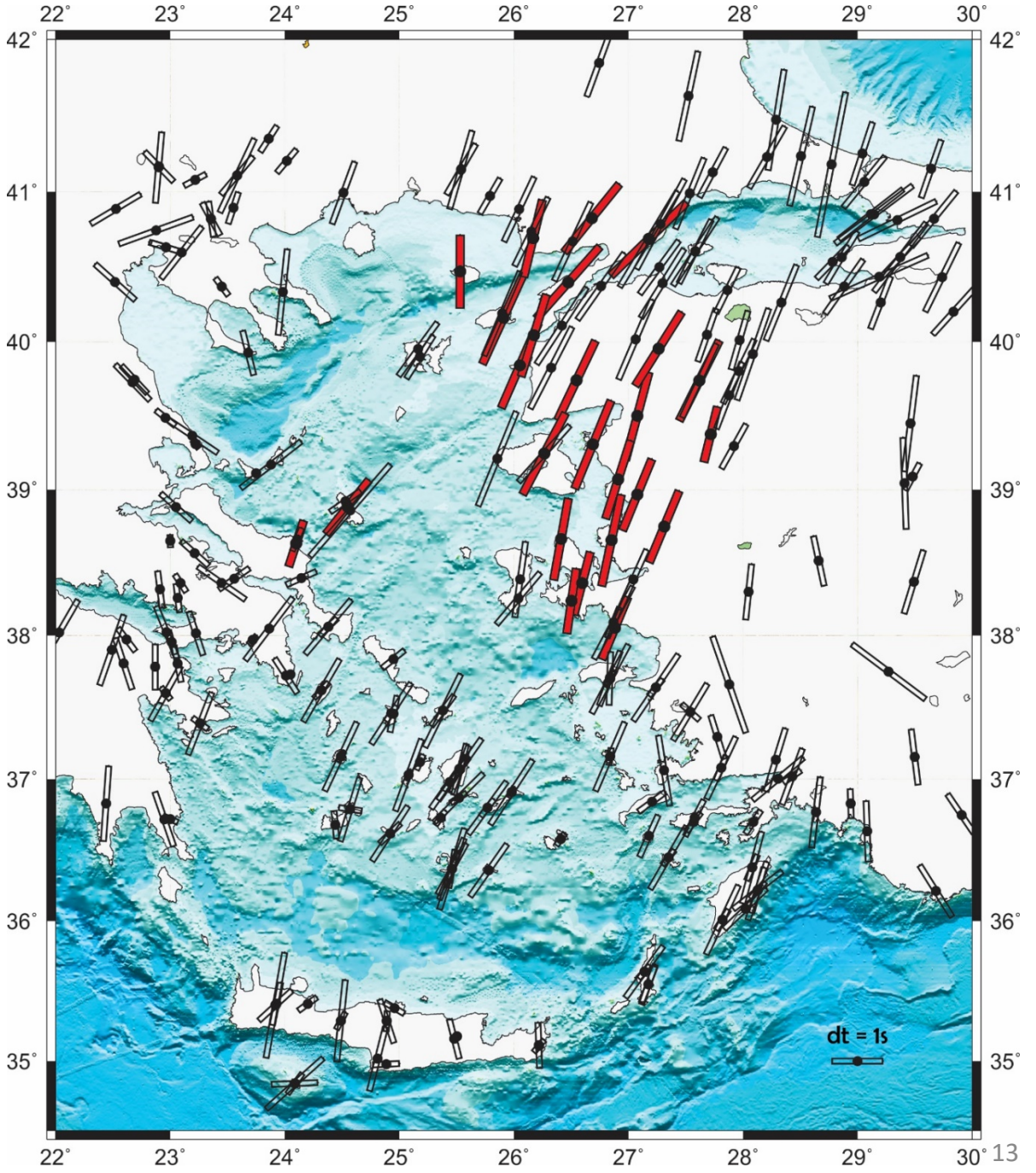
- **Uniform NE-SW aligned FPDs**
- **large delay times (~1.6 sec)**
- **asthenospheric-origin single layer seismic anisotropy**

Red bars represent the FPD and ∂_t of **25 broad-band seismic stations** obtained from **eigenvalue method.**

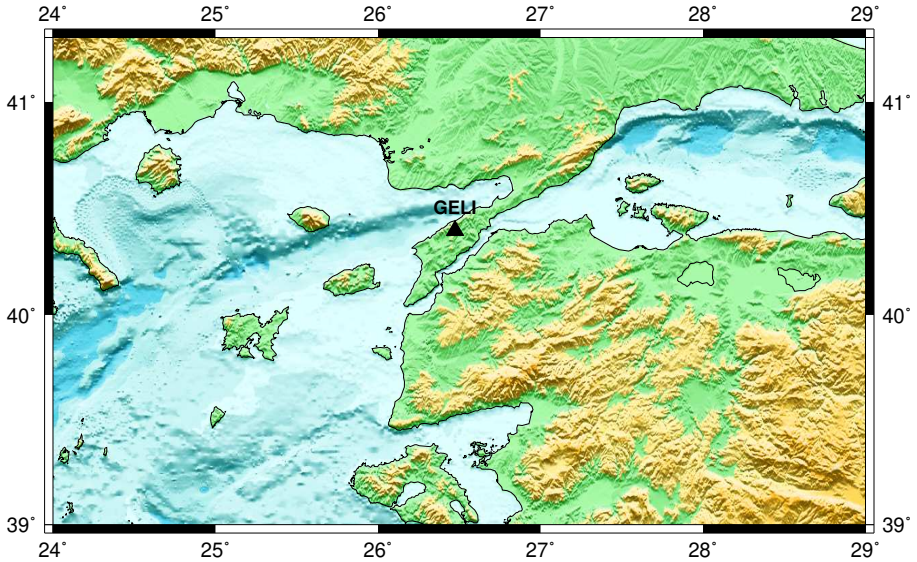
Average FPDs were calculated with
Von Mises approach (Cochran et al. 2003)

White bars represent the results of prior anisotropic studies;

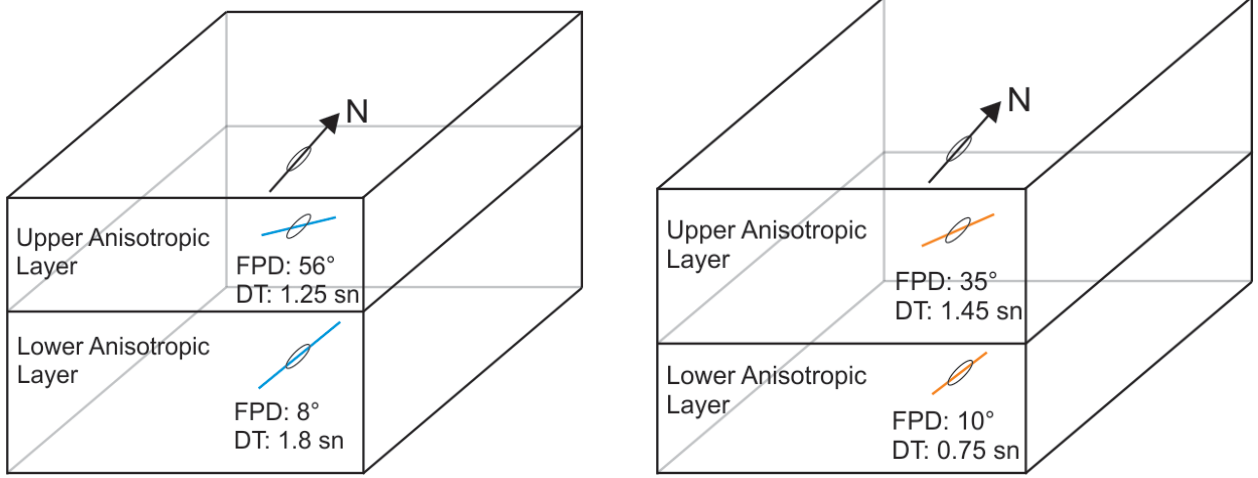
- *Vinnik et al. (1992)*
- *Hatzfeld et al. (2001)*
- *Schmid et al. (2004)*
- *Evangelidis et al. (2011)*
- *Paul et al. (2014)*
- *Olive et al. (2014)*
- *Confal et al. (2016)*

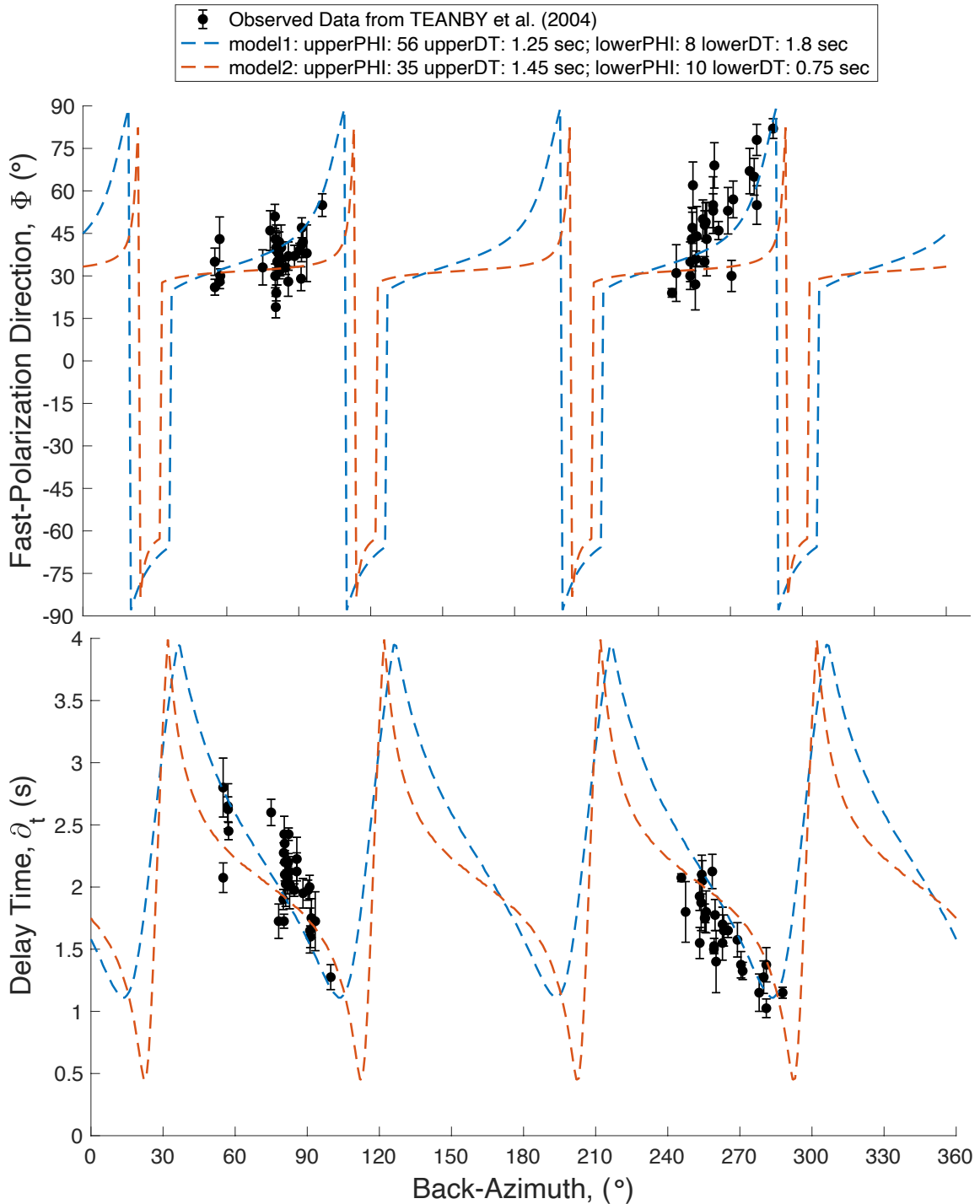


Two Layer Anisotropy



First model which is recommended is well correlated with observed splitting parameters. Also it is very similar model of Lemnifi et al. (2017).





Conclusion

- Uniform NE-SW aligned fast polarization directions and large delay times indicate the asthenospheric-origin seismic anisotropy beneath the study region.
- Upper mantle flow induced by roll-back of the subducted African slab generates trench perpendicular mantle wedge anisotropy at the back-arc region.
- Applying more than one filter for each individual earthquake data and selecting the best filter frequencies visually, increase the number of SKS splitting measurements.
- A single layer sub-horizontal anisotropy is proposed for the study area. However, beneath the seismic stations at north back azimuthal variations of the splitting parameters make a suspicion on depth dependent anisotropy.

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