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Attenuation of high-frequency body waves and its anisotropy in the External Dinarides

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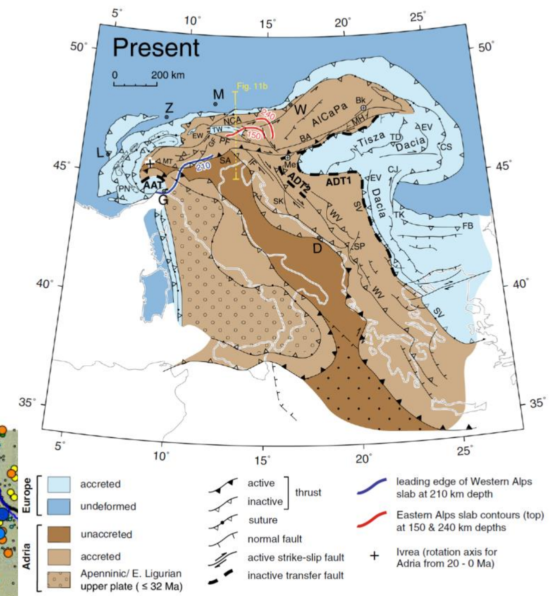
Founded in 1861

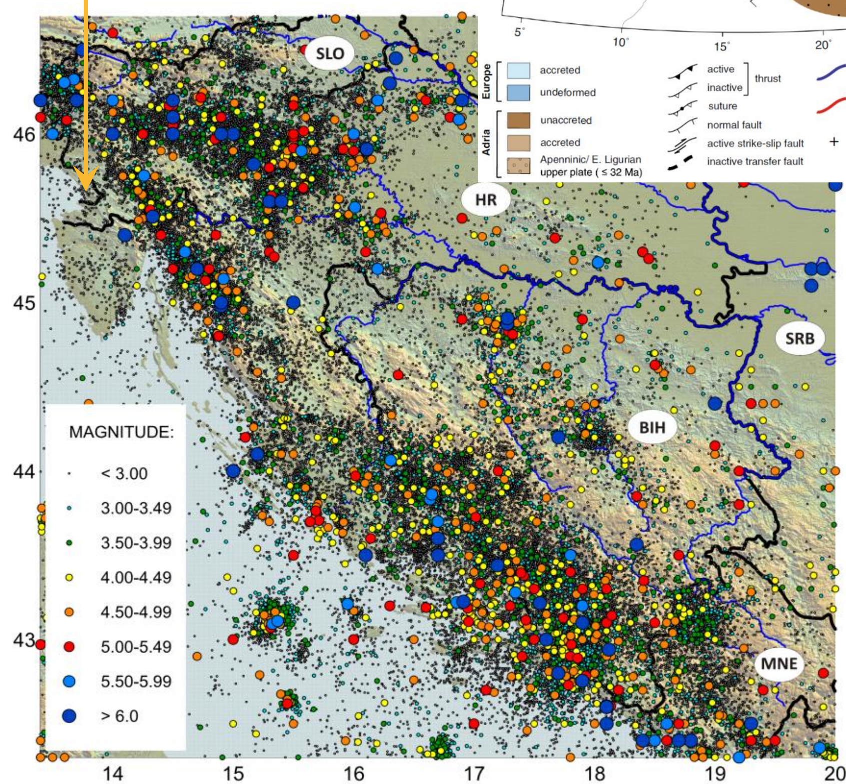
Why?

- The (External) Dinarides → complex, seismically active and *under-researched*
- High-frequency (1–24 Hz) body waves attenuation → local earthquake → structure of the crust, moment magnitude, seismic hazard
- Methods:
  - (Extended) coda normalization method → Q_P and Q_S
  - Multiple scattering: MLTWA method → Q_i and Q_{sc}

Handy et al. (2015)



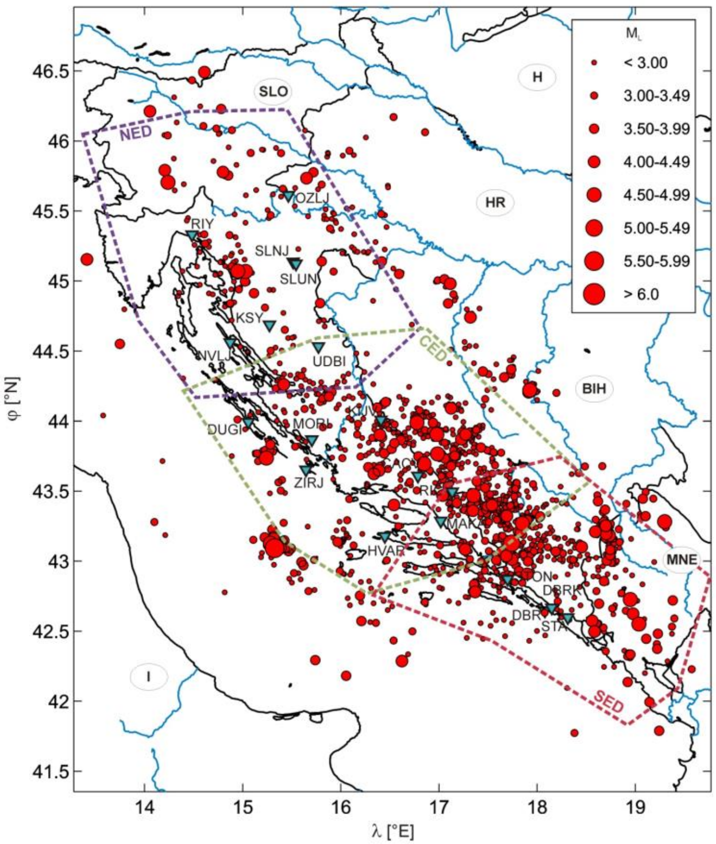
Trieste



Croatian Earthquake Catalogue (by the end 2013)

(Extended) Coda normalization method

- Aki (1980) + Yoshimoto et al. (1993)
- $Q_{P,S}$ → direct P- and S-waves → (upper) crust



Dasović (2015)

17 BB stations, 40 ≤ D ≤ 120 km, ML ≥ 2.0, 2002–2014:
1526 EQ, 2558 seismograms

spectral amplitude = RMS of v_T

$$v_T = \sqrt{v_Z^2 + v_{NS}^2 + v_{EW}^2}$$

geometrical spreading correction

$$\ln \frac{A_{P,S}(f)\,r}{A_c(f,t_c)} = -\frac{\pi f}{Q_{P,S}(f)\,v_{P,S}}\,r + const.$$

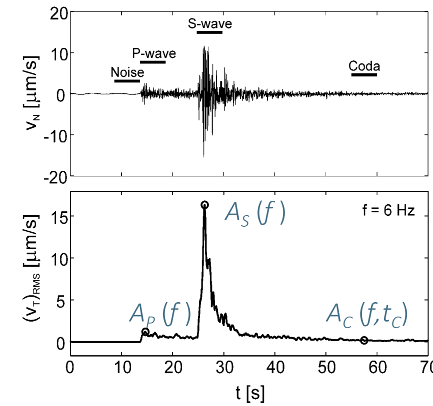
attenuation

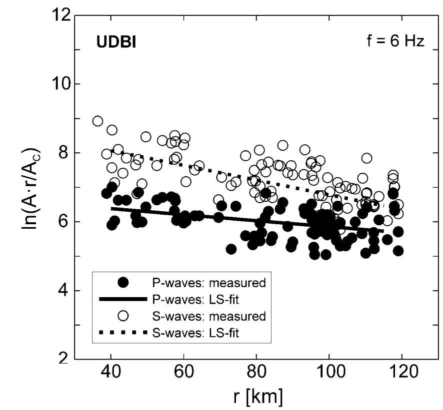
normalization → ~~source strength, site effects~~

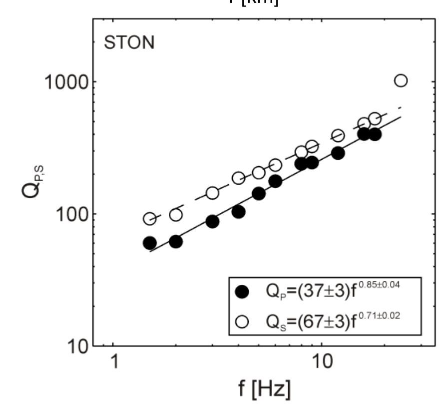
→ linear regression

$$Q_{P,S}(f) = Q_{0,P,S}\, f^{n_{P,S}}$$

→ log → linear regression



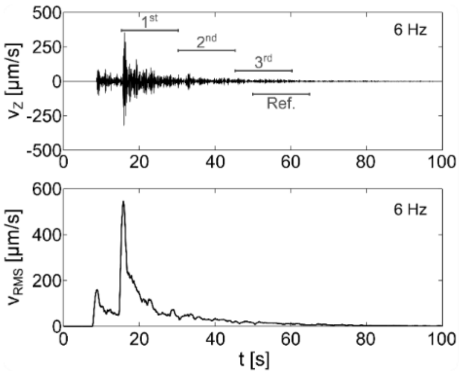




Dasović et al. (2015)

MLTWA method

- Hoshiba et al. (1991), Fehler et al. (1992), Hoshiba (1993)
- $Q_{sc} + Q_i \rightarrow$ **separate estimates!**



Majstorović et al. (in preparation)

theoretical energy → $f(B_0, Le^{-1})$

(isotropic multiple scattering homogeneous halfspace + radiative transfer theory)

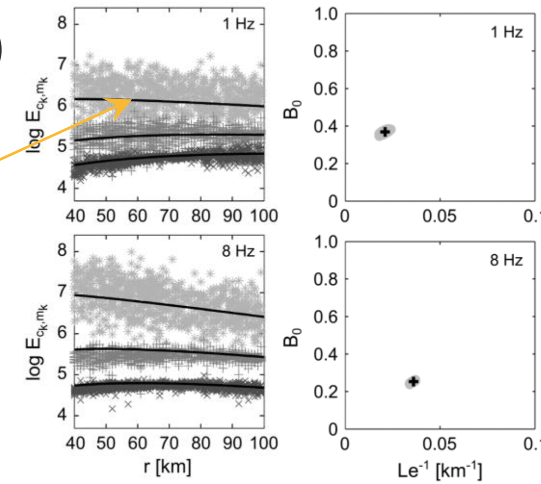
vs.

observed energy

* 1st window: 0–15 s

\+ 2nd window: 15–30 s

× 3rd window: 30–45 s



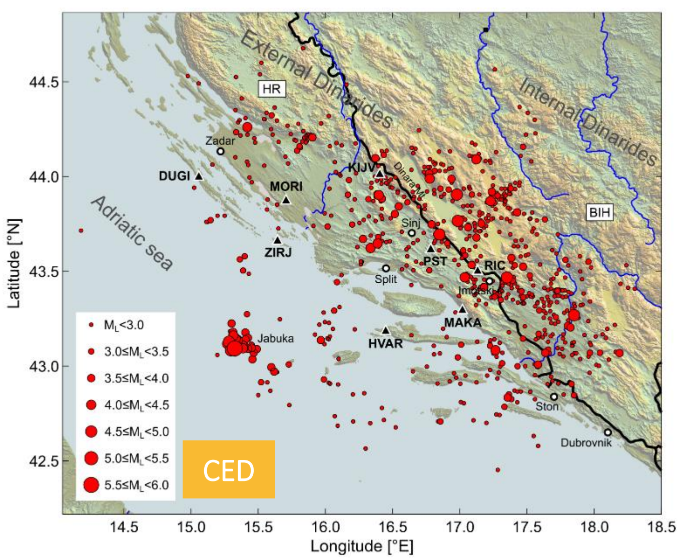
Majstorović et al. (in preparation)

$$B_0 = \frac{\eta_{sc}}{\eta_{sc} + \eta_i}$$ **seismic albedo**

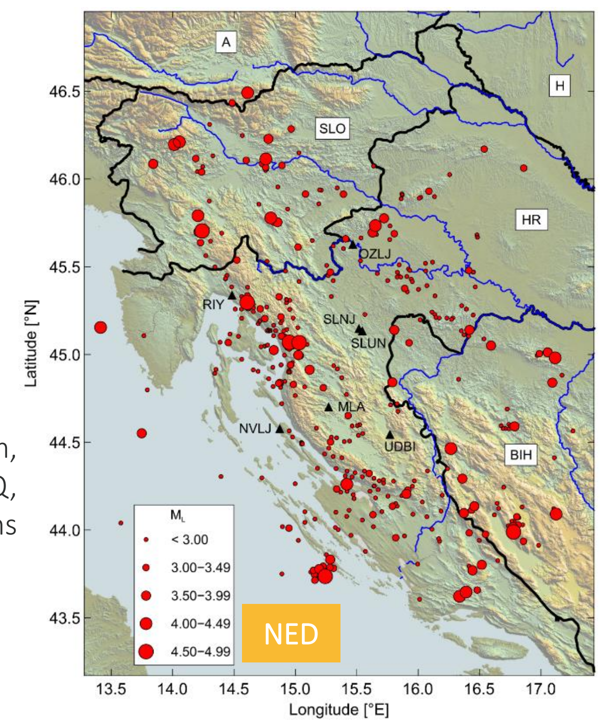
$$Le^{-1} = \eta_{sc} + \eta_i$$ **total attenuation**

$$\eta_{i,sc} = \frac{2\pi f_c}{v_S Q_{i,sc}}$$

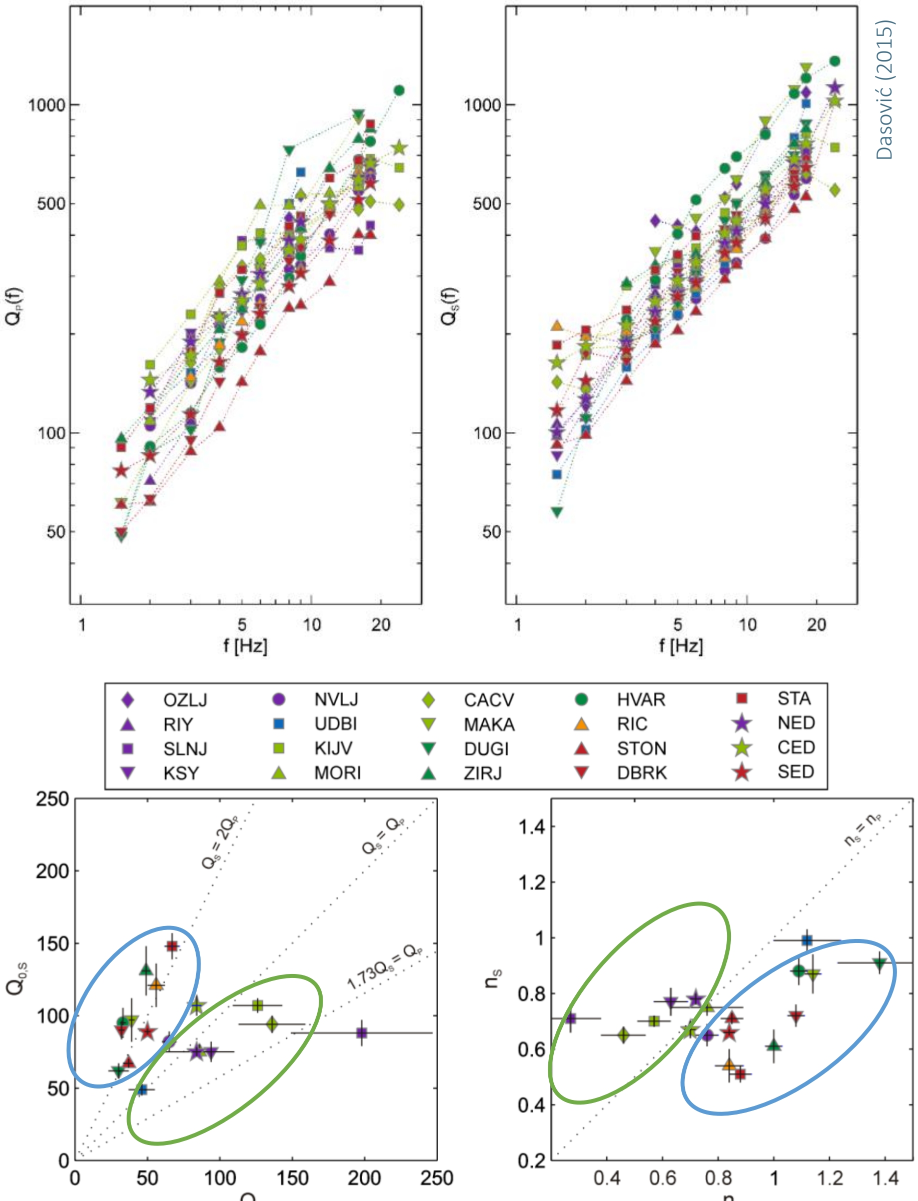
6 BB stations, $10 \leq D \leq 120$ km, $ML \geq 2.0$, 2003–2015: 415 EQ, 717 seismograms



8 BB stations, $40 \leq D \leq 120$ km, $ML \geq 2.0$, 2002–2014: 750 EQ, 985 seismograms



(Extended) Coda normalization method



Dasović (2015)

Dasović (2015)

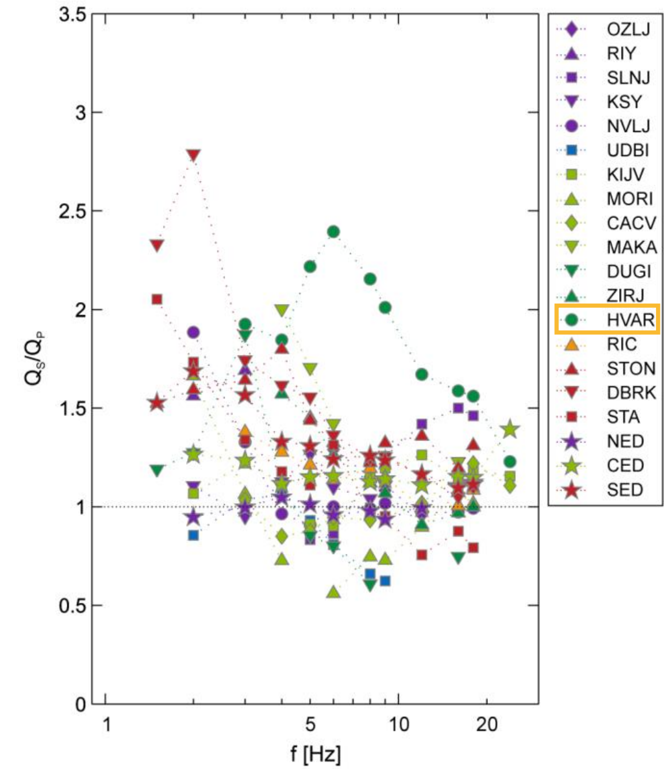
islands CED + SED

continent CED + NED

$Q_S / Q_P \rightarrow$ **scattering, fluid saturation**

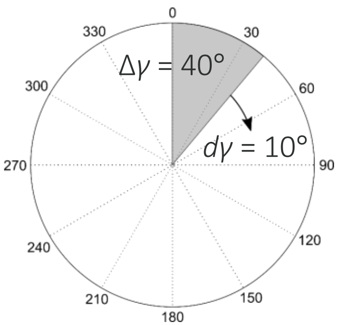
$Q_S / Q_P \geq 1 \rightarrow$ strong scattering, partialy saturated rocks

$Q_S / Q_P < 1 \rightarrow$ weaker scattering, fully saturated or dry rocks

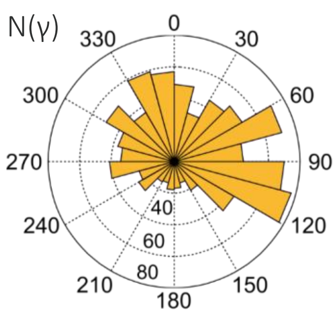


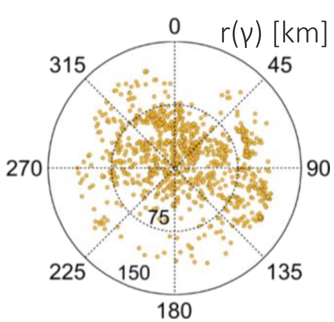
Dasović (2015)

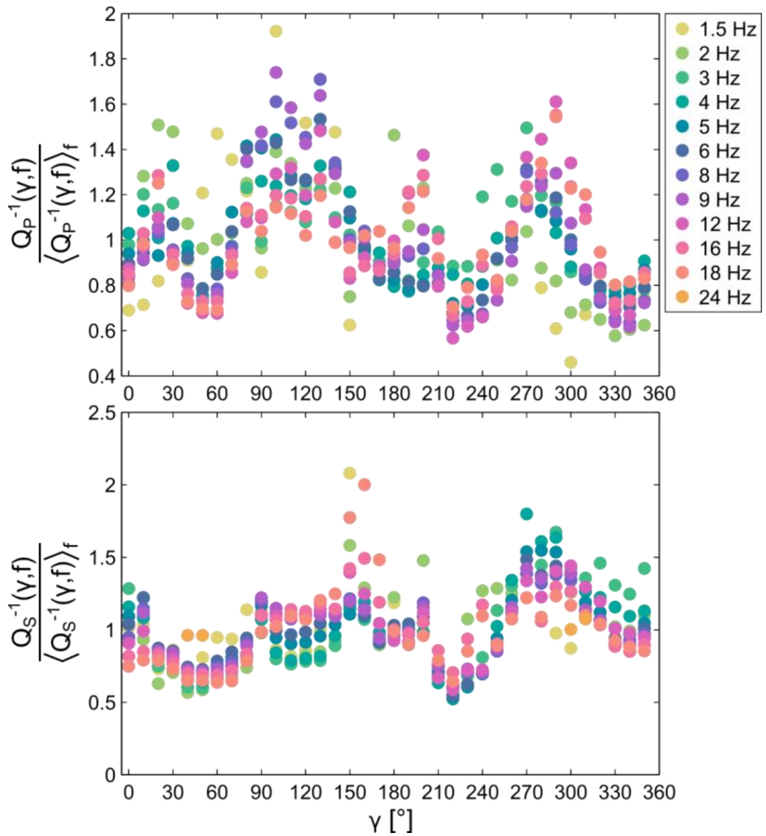
(Extended) Coda normalization method

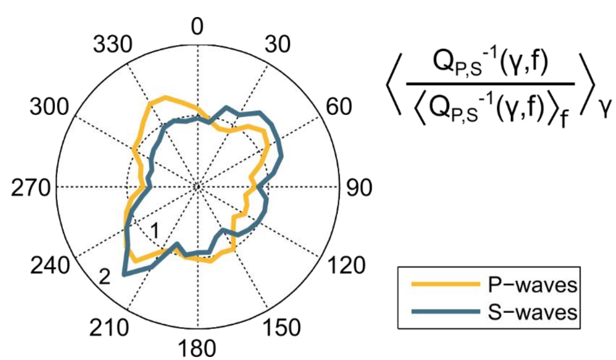


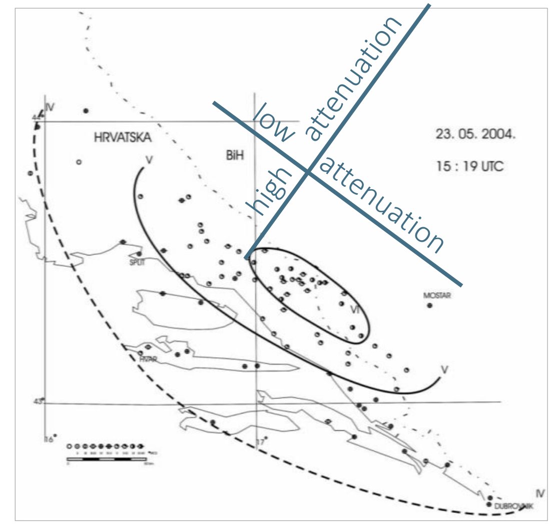
STON: $D \leq 120$ km, $ML \geq 2.0$, 2003–2015: 940 EQ





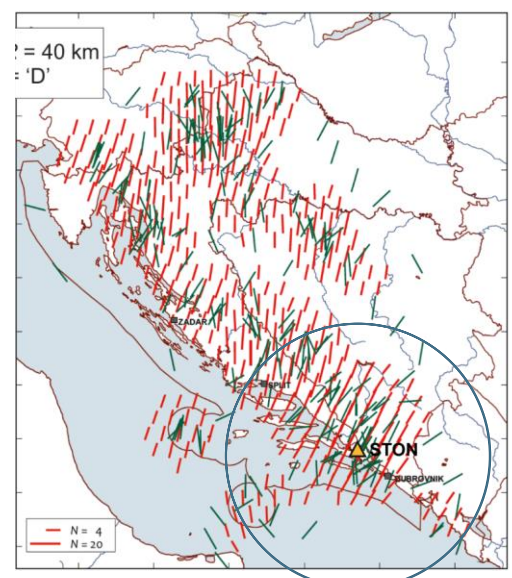






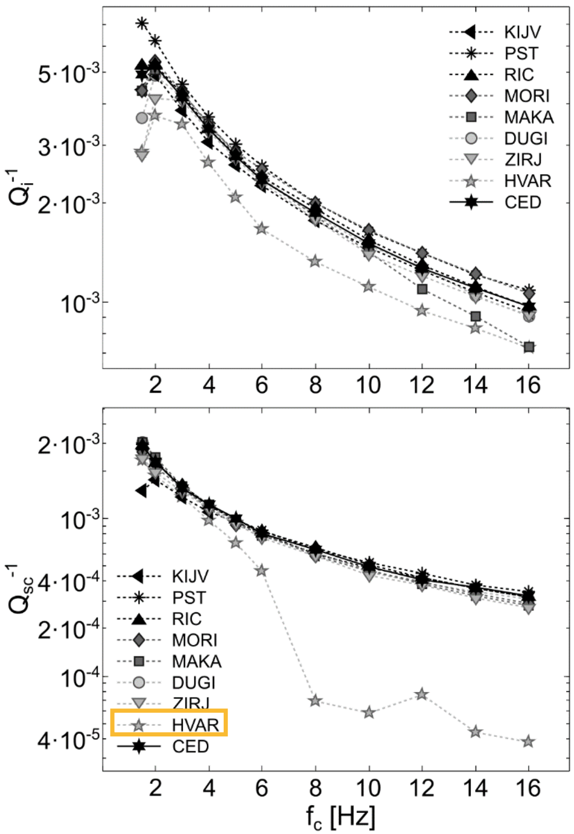
Ivančić et al. (2006)

→ Attenuation anisotropy!



Herak et al. (2006) – ESC2016-480

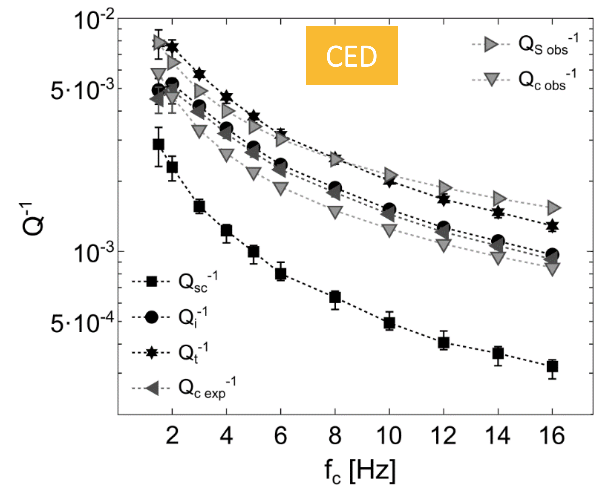
MLTWA method

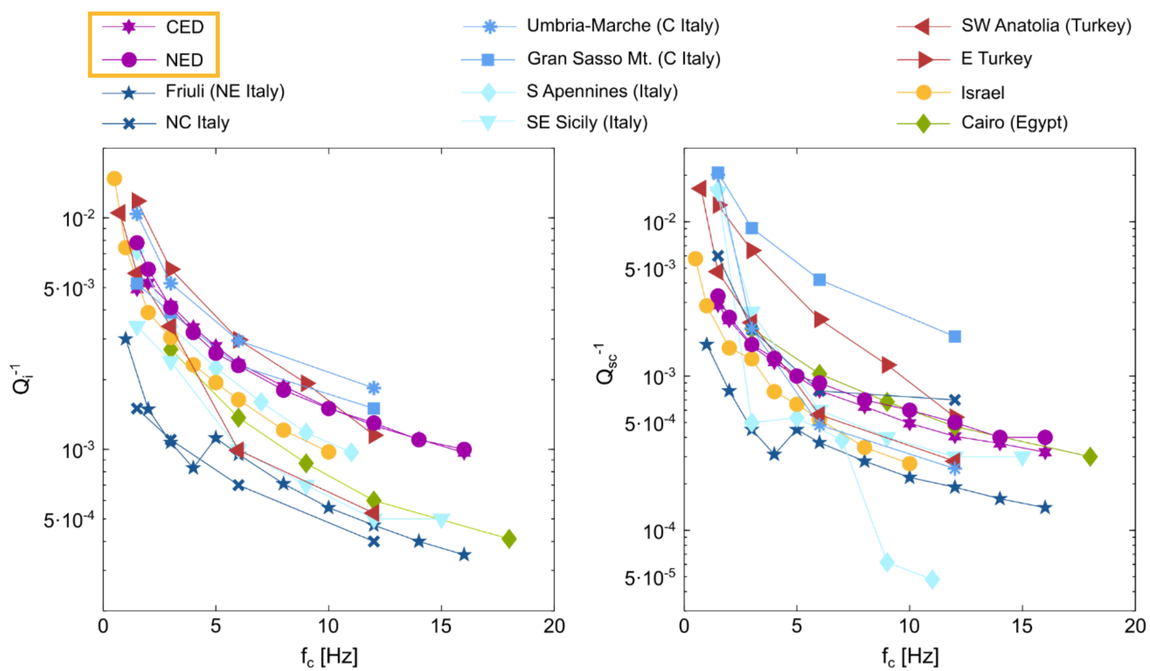


Majstorović et al. (in preparation)

$$Q_i^{-1} > Q_{sc}^{-1}$$
$$Q_t^{-1} \approx Q_{S,obs}^{-1}$$
$$Q_{C,exp}^{-1} \approx Q_{C,obs}^{-1}$$

Majstorović et al. (in preparation)



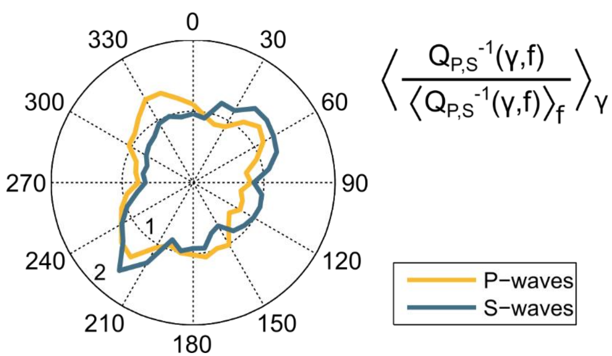


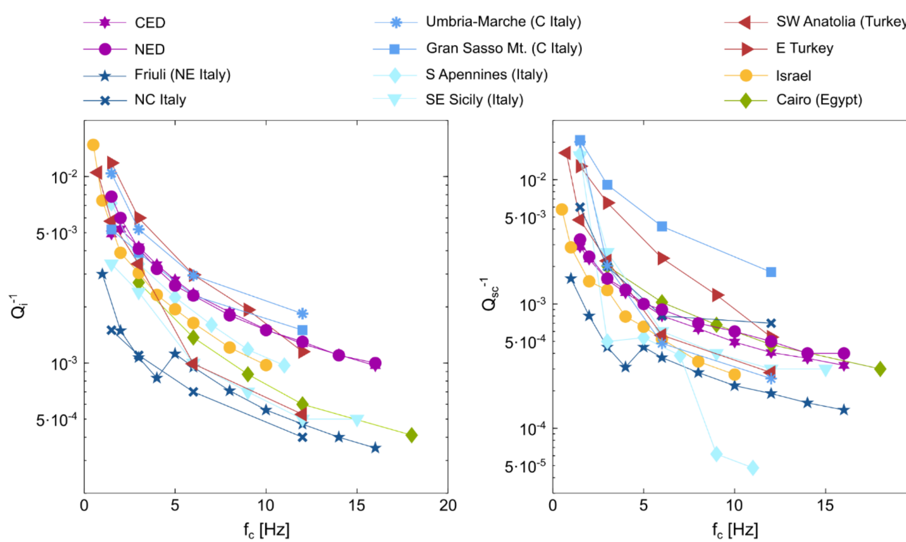
$B_0 < 0.5$ → intrinsic attenuation dominates

Le = 4.8 km (1.5 Hz)–27.0 km (16 Hz) → CED

To conclude...

- Attenuation of high-frequency body waves is high in the External Dinarides
- In general: P-wave atteuation > S-wave attenuation ($Q_P < Q_S$)
- Intrinsic attenuation domninates over scattering attenuation ($Q_i^{-1} > Q_{sc}^{-1}$)
- Anisotropy of the attenuation of P- and S-waves
  - high attenuation parallel to P-axis
  - Low attenuation parallel to the strike od the Dinarides





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Aknowledgments

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