Towards a high-resolution v_S crustal velocity model for the Ivrea Geophysical Body: constraints from seismic ambient noise tomography

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Motivation

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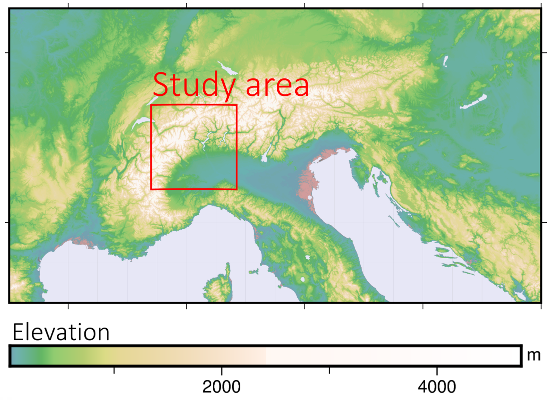
- Heterogeneous crustal structure at the boundary between **Europe** and **Adria**, in correspondence of the **Ivrea Geophysical Body** (IGB);
- Target area for the scientific drilling project **DIVE** (www.dive2ivrea.org).

Goal

- Obtain high-resolution constraints on **absolute v_S** distribution in the **crust**, via seismic **ambient noise** tomography (ANT).



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DIVE
DRILLING THE IVREA-VERBANO ZONE

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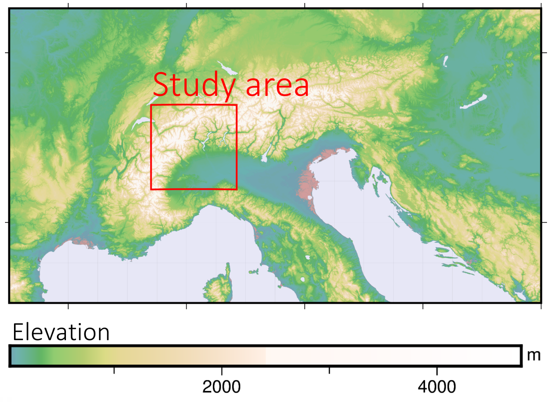


ANT Workflow

1. Seismic ambient noise pre-processing
2. Station-pair **cross-correlation** (CC)
3. Surface Rayleigh wave dispersion measurement via **FTAN** analysis (fundamental mode / group speed)
4. **2D surface** wave velocity maps at different periods (4s to 23s)
5. Inversion for local 1D $\mathbf{v_S}$**-depth** profiles

Preliminary results

Data

Seismic stations

Networks:

XK (*IA*-IvreaArray, Mobnet pool of IGCAS Prague)

Z3 (AlpArray temporary)

IV GU

CH MN YP

DIVE Balmuccia drilling site

PL Periadriatic Line

Adriatic side

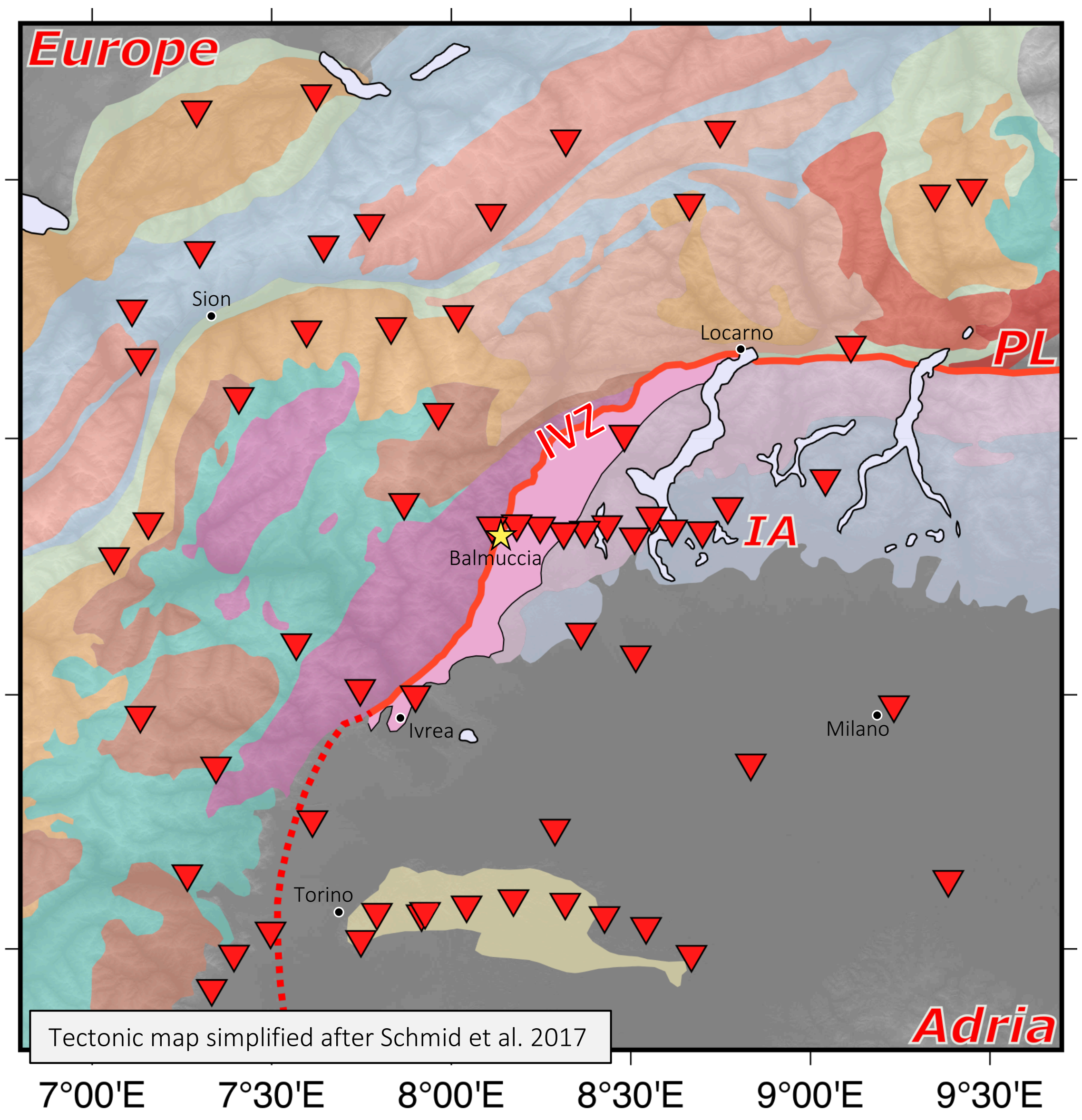
- Adria lower crust | Ivrea-Verbano Zone (IVZ)
- Adria upper crust
- Adria Mesozoic

European margin

- Helvetic Nappes
- European basement
- European upper crust
- High-pressure Subpenninic Units

Other units

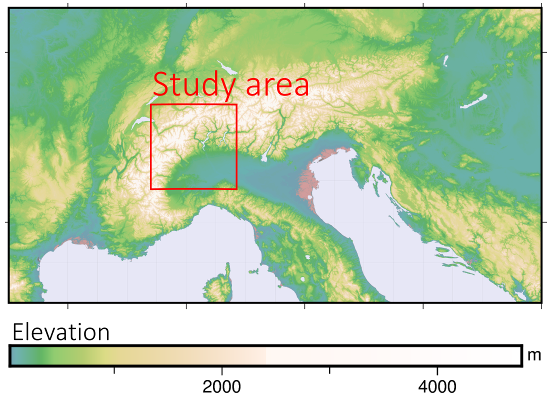
- Valaisan oceanic domain
- Brianconnais micro-continent
- Sesia, Dent Blanche
- Piedmont-Liguria Ocean
- Cenozoic plutons
- Cenozoic



Up to **9/12 months** of broadband summer data (June to September) across 2+ years of recording

Homogeneous pre-processing:

- Pre-filtering
- Instrument response removal
- Amplitude normalization
- Spectral whitening



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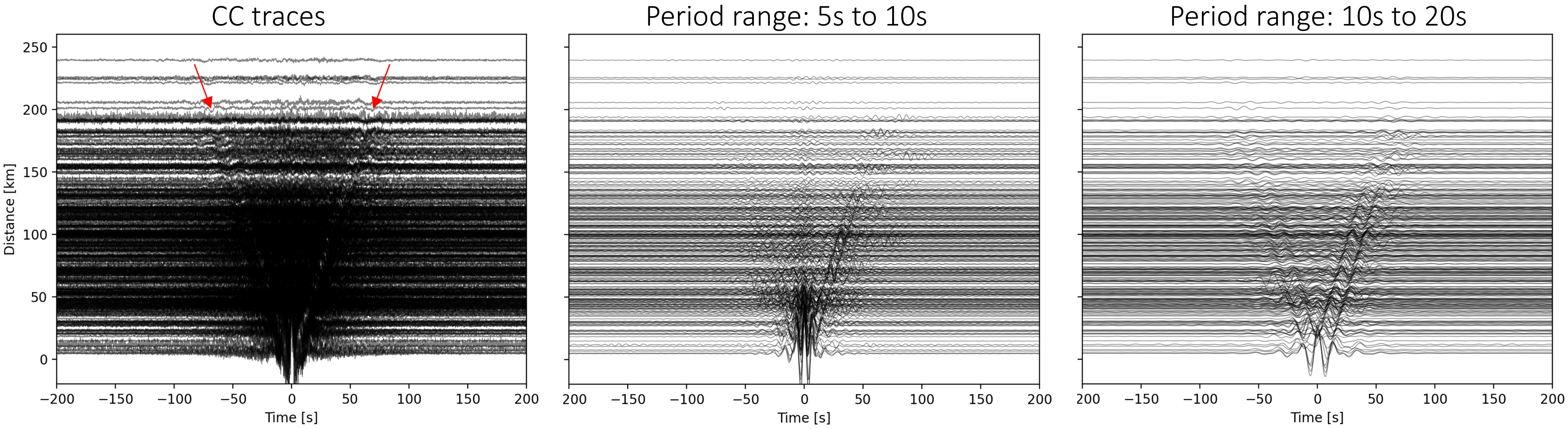
Seismic ambient noise cross-correlation (CC)

Subset of the data (ca. 300 out of 1400 traces)



CC traces:

- 10Hz sampling rate
- Max lag: 480s
- Length of the correlated segments: 3600s
- Overlap: 0.5

MSNoise package (Lecocq et al. 2014)

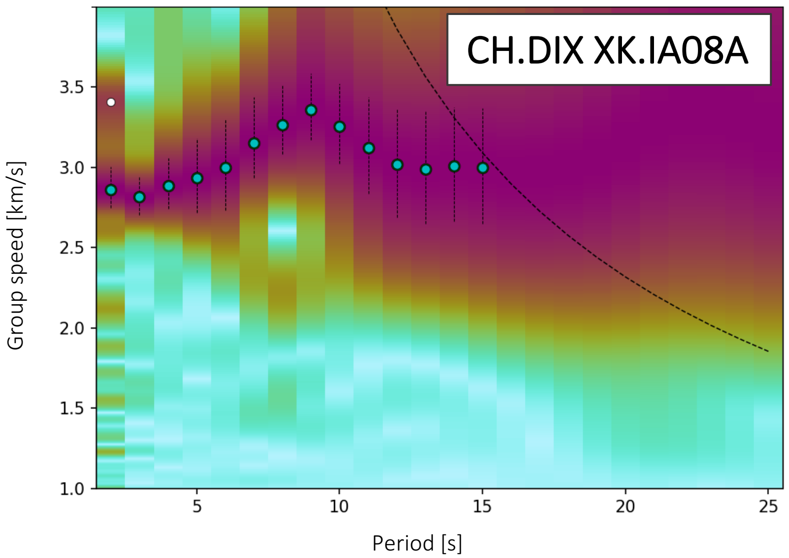
CC traces -> Input for dispersion measurement of surface Rayleigh waves (group speed / fundamental mode)

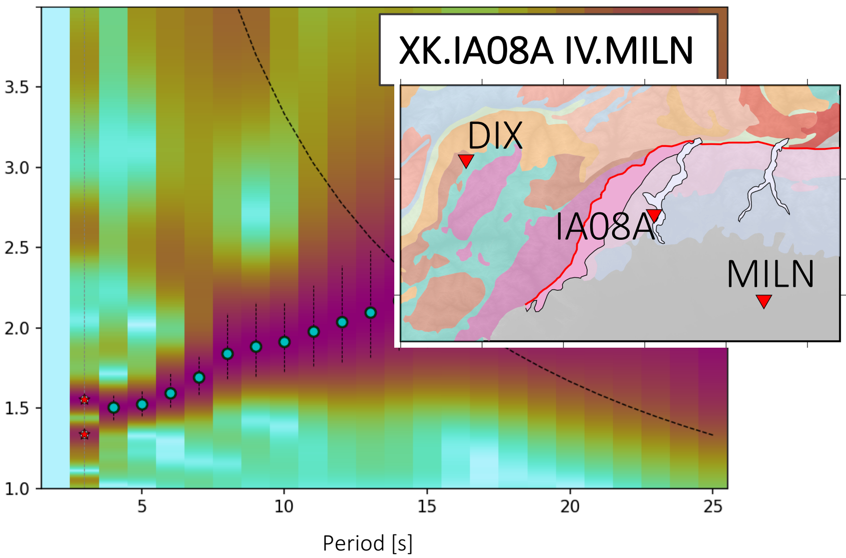
Dispersion measurement via frequency-time analysis (FTAN)

Dispersion measurement via Frequency-Time analysis, for **each station-pair** (**FTAN**, e.g. Levshin and Ritzwoller 2001):

1. Green's Function envelope computation
2. Narrow band-pass filtering
3. Rayleigh group velocity dispersion measurement (fundamental mode)

Period range **2s to 24s**





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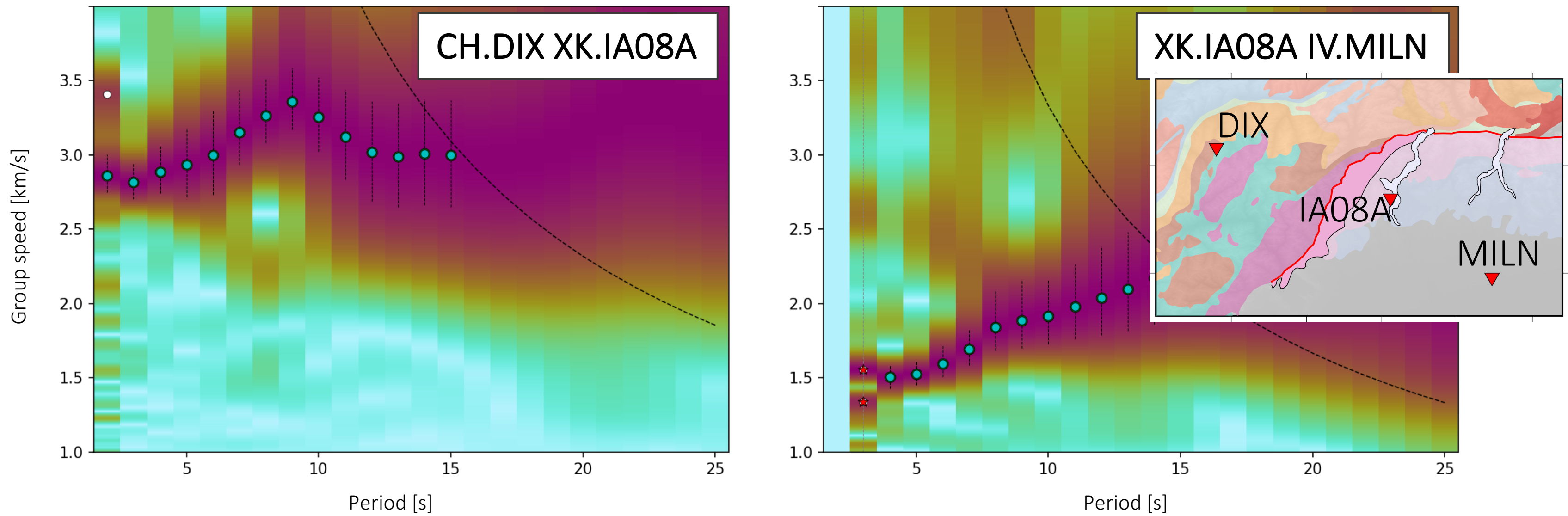
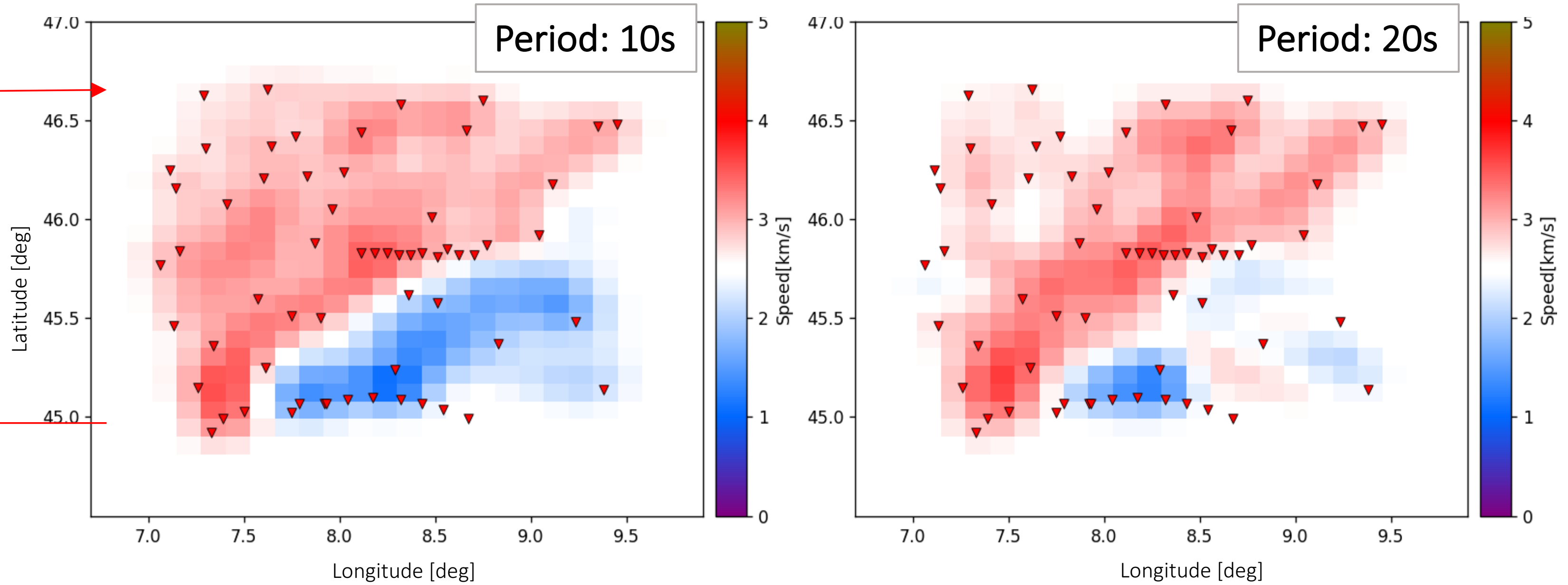


2D surface group velocity maps via fast-marching surface tomography (**FMST**, Rawlinson, 2005)

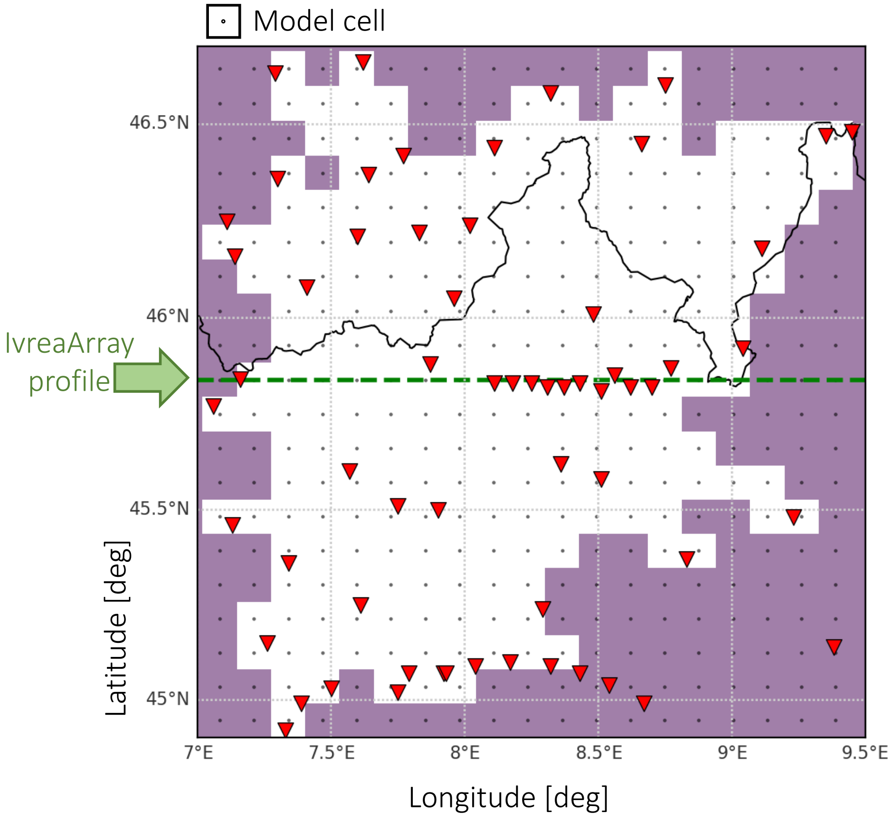
2D maps (one for each period) -> input for local 1D v_S-depth inversion



Preliminary results

Neighborhood Algorithm (NA) inversion for local **1D v_S-depth** profiles.
Dinver package (Wathelet et al. 2008)

- 234 cells ($\sim 10km\ x\ 10km$)
- 6 horizontal layers over a half-space
- Each layer has a 5 sub-layers gradient
- 50500 explored models for each cell



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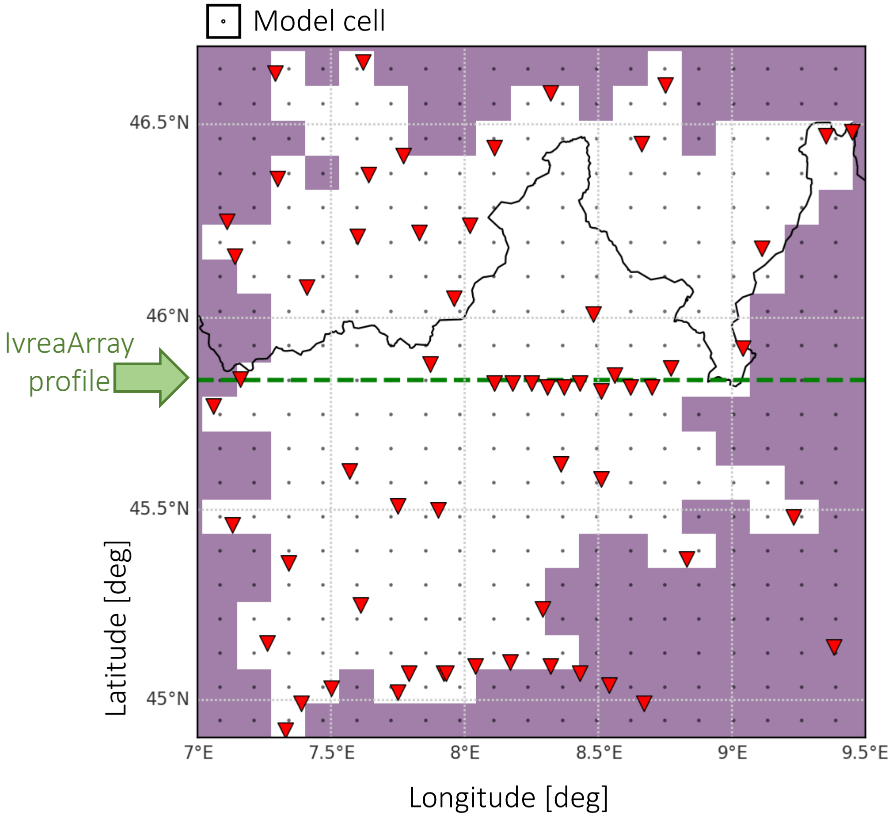

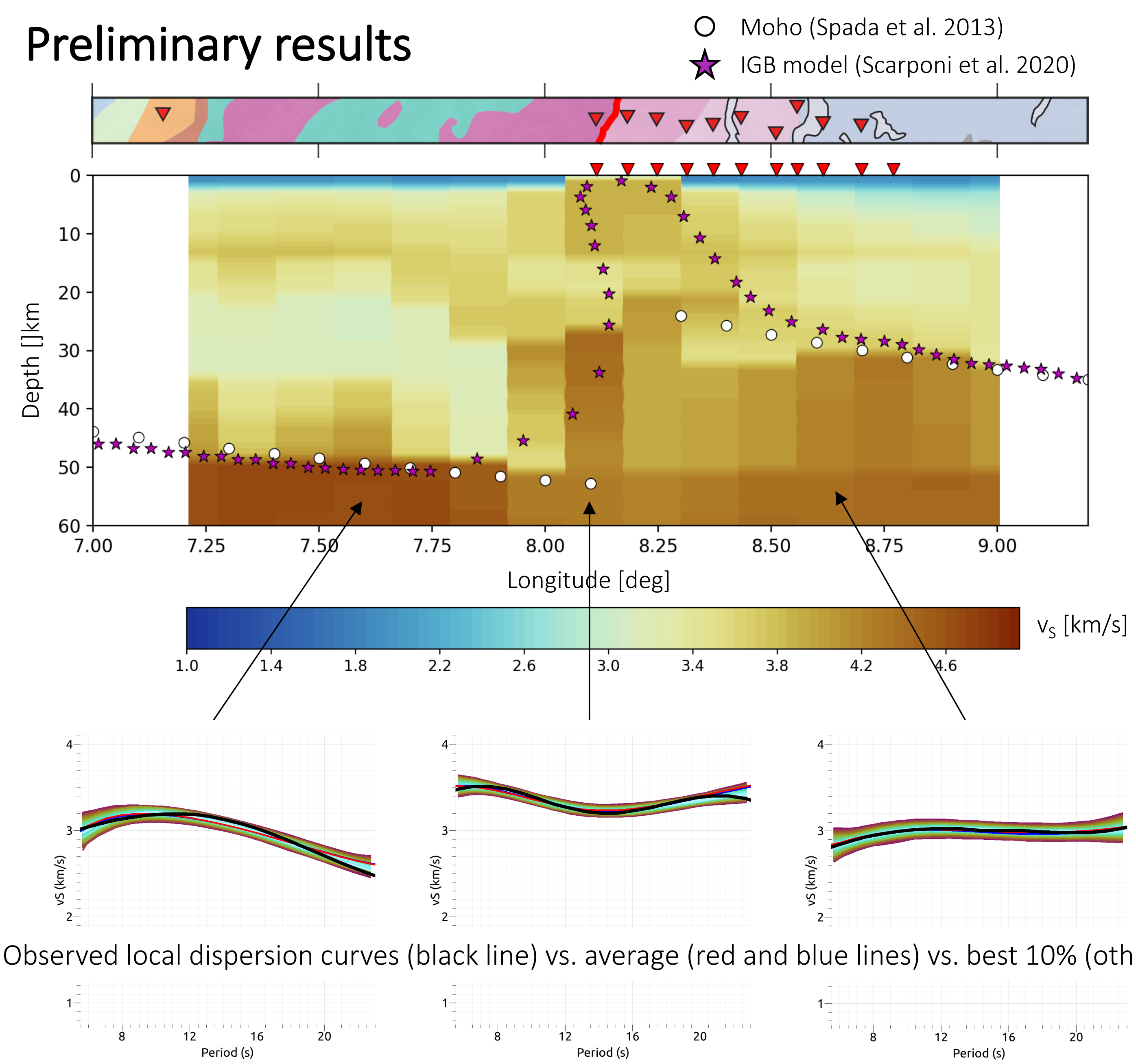

Observed local dispersion curves (black line) vs. average (red and blue lines) vs. best 10% (other)

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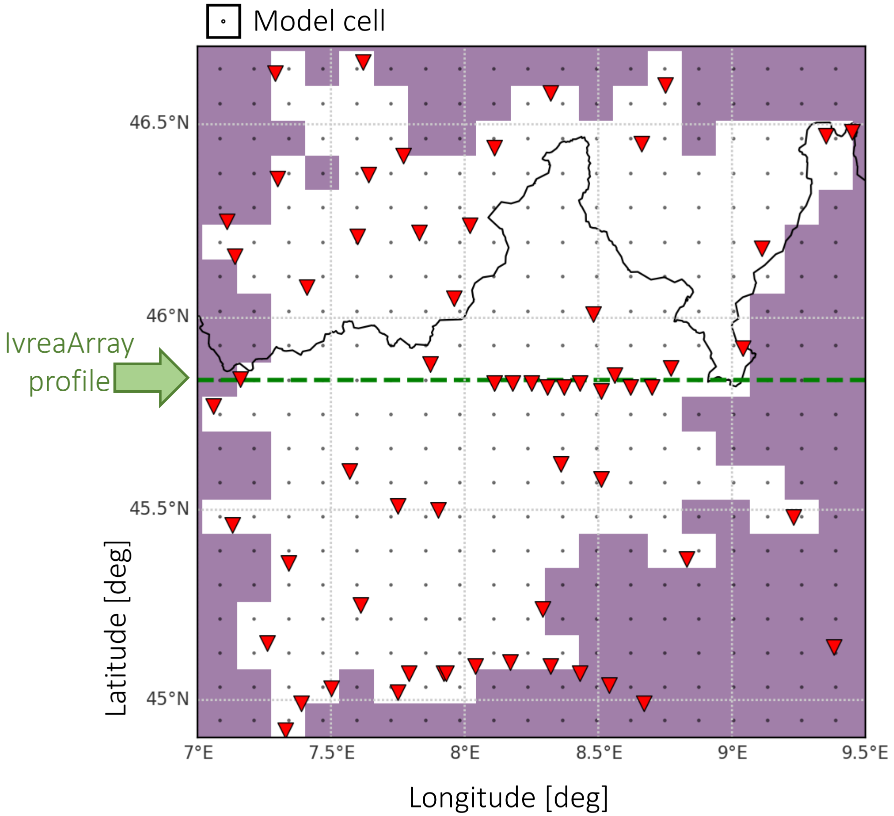

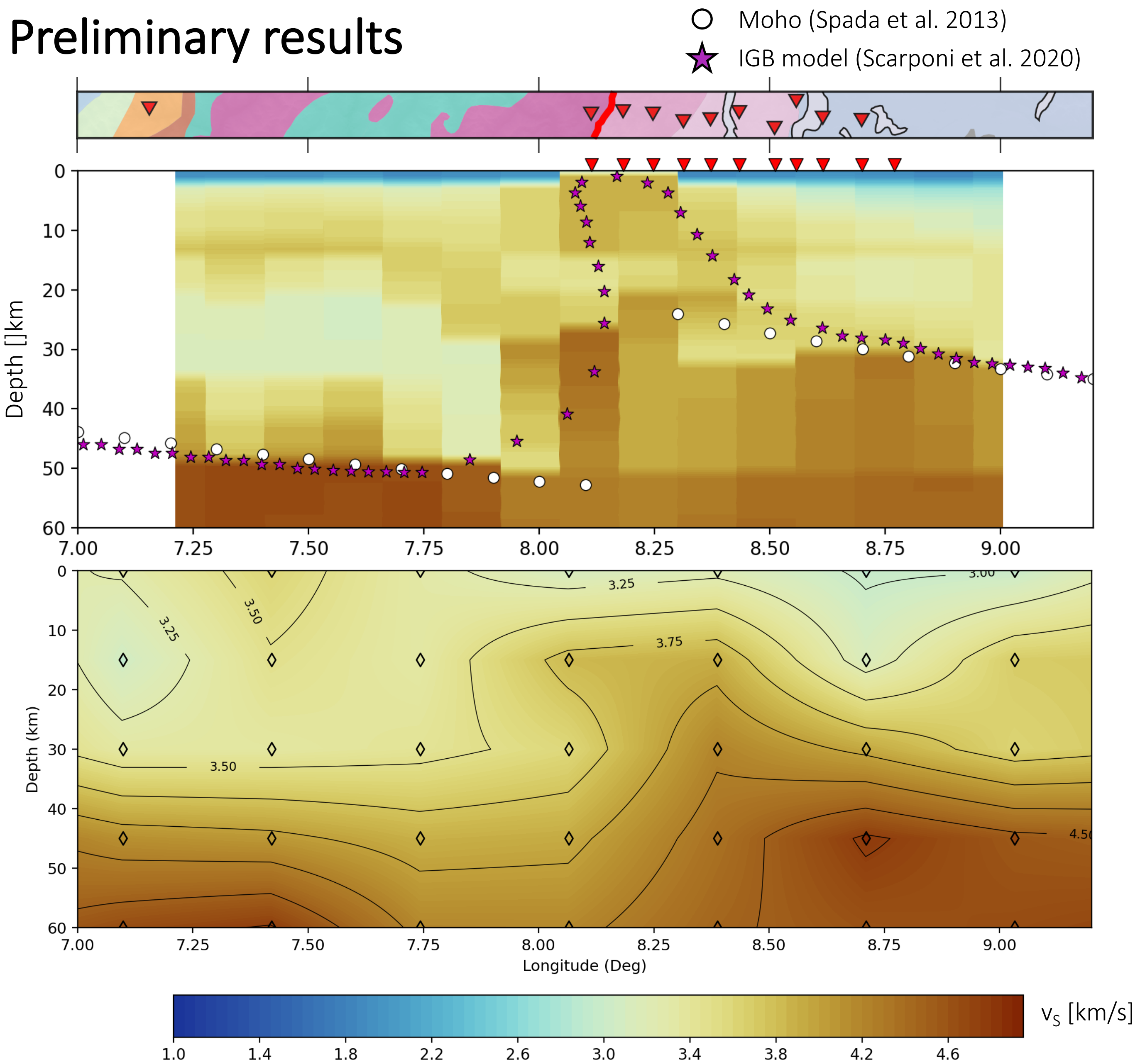

Comparison with Diehl et al. 2009 (conversion from v_P with constant v_P/v_S of 1.78)

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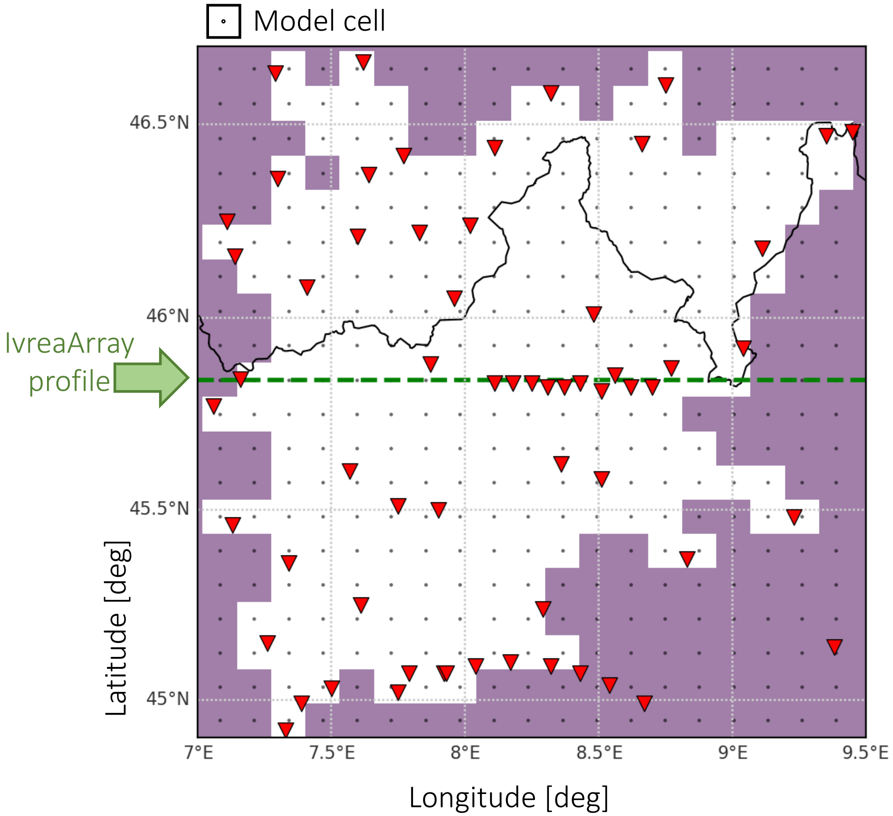

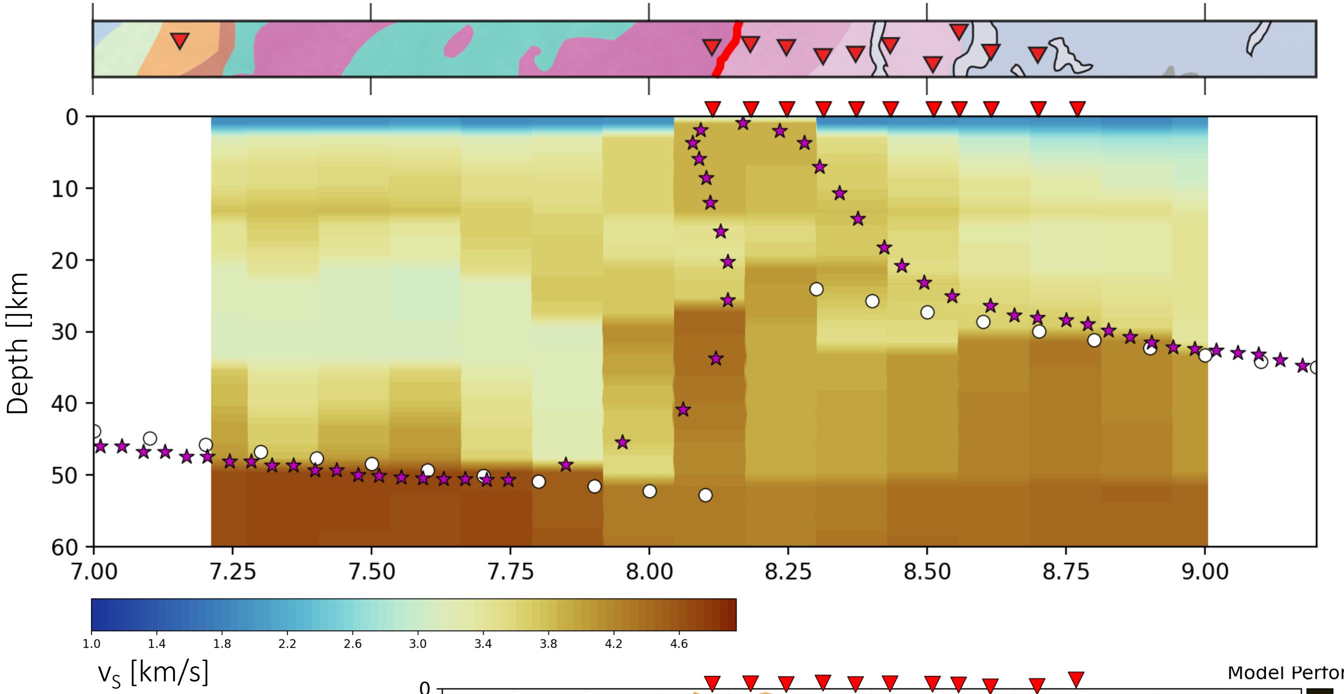

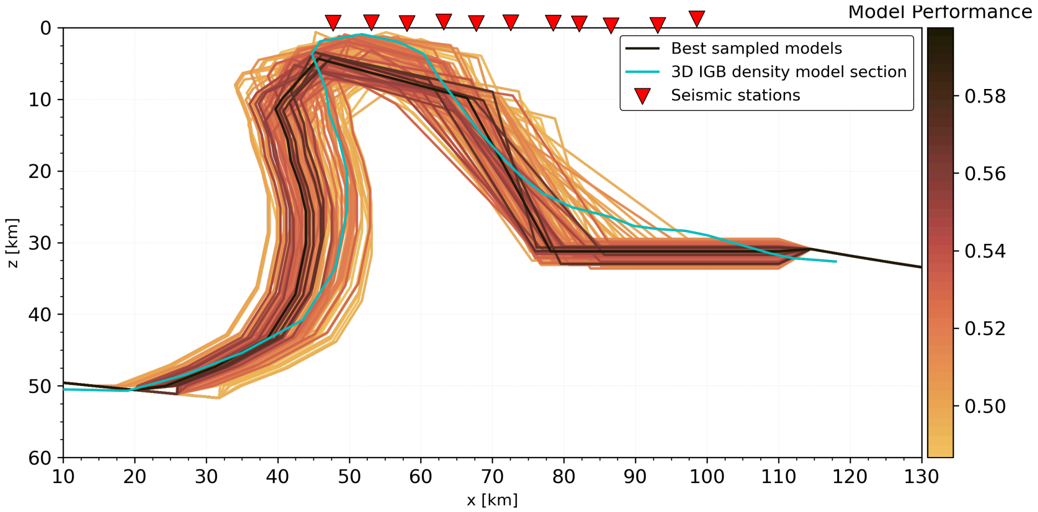

Comparison with Scarponi et al. 2021 (Receiver functions + gravity joint inversion)

Current status

Preliminary conclusions

- ANT images the IGB at very shallow depths
- Agreement with previous gravity and joint RF + gravity modelling (Scarponi et al. 2020, 2021)
- Agreement with LET (Diehl et al. 2009), with IGB detected at even shallower depths
- Moho depth coherent in the Europe and Adria plates with respect to LET

Future steps

- Evaluate a priori constraints to improve parameterization for v_S
- Consider including longer periods (i.e. higher sensitivity in the lower crust)

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