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Tomography image of double high-velocity heterogeneity beneath the Eastern Alps from the AlpArray data

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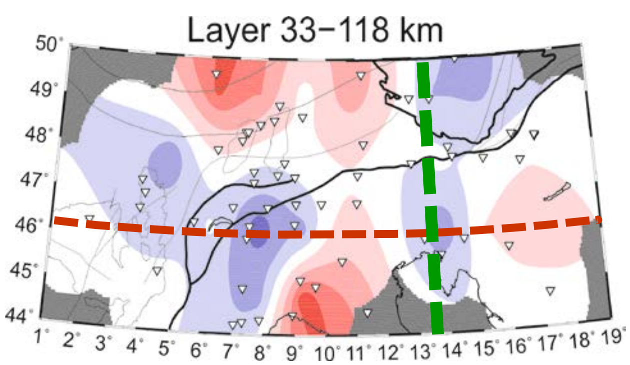
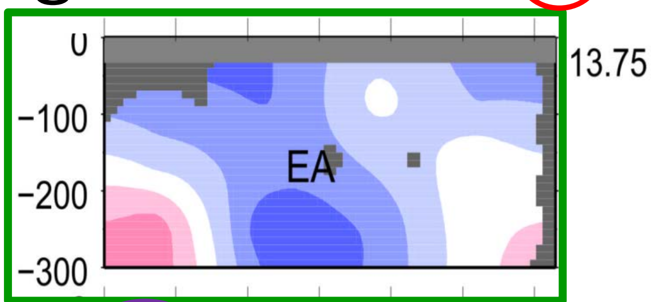
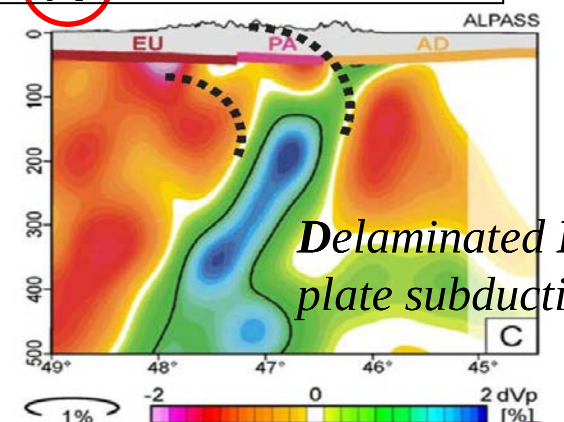
EGU 2020, TS7.6 The Alps and neighbouring mountain belts

Segmentation of the Alpine root and northward dip of subduction beneath the Eastern Alps in the pre-AlpArray studies



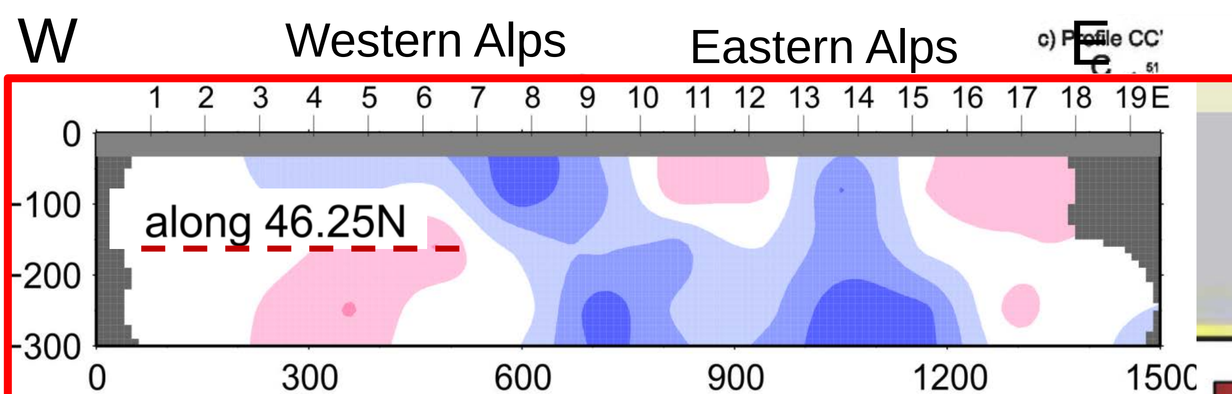
Babuška , Plomerová, Granet, Tectonophysics 1990

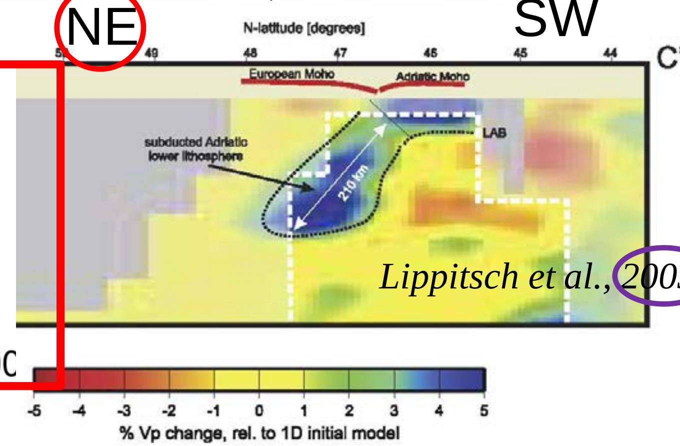




Mitterbauer et al., Tectonophysics 2011

Brückl et al., Tectonics 2011





Lippitsch et al., 2003

Two subductions –switched polarity and a gap in between the Western/Central and Eastern Alps lithosphere roots

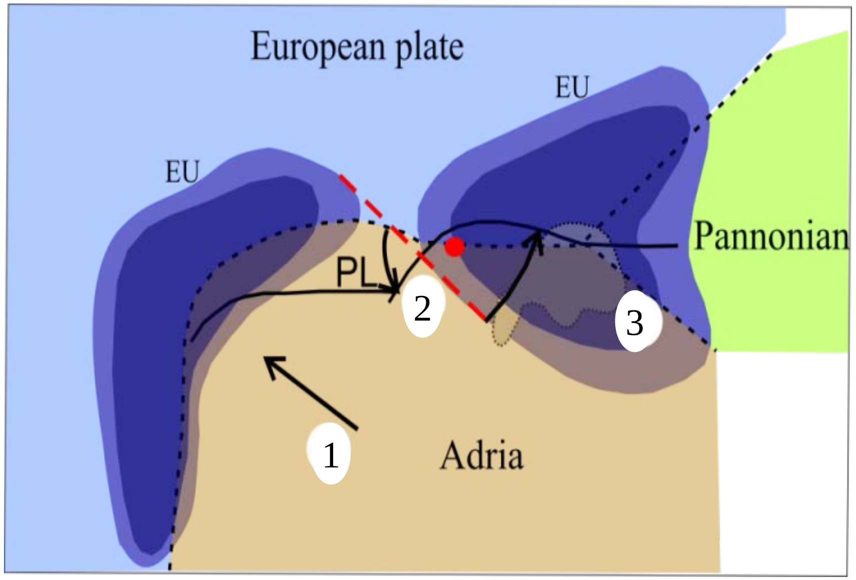
Western Alps - obliquely to the EAST

Eastern Alps- steeply to the North

- **different data sets and tomography codes**
- **consistent results**, but diff. interpretations

- *in touch in depth* or merged due to vertical *smearing*, or lower resolution in depth

Key processes involved in formation of the Eastern Alpine root

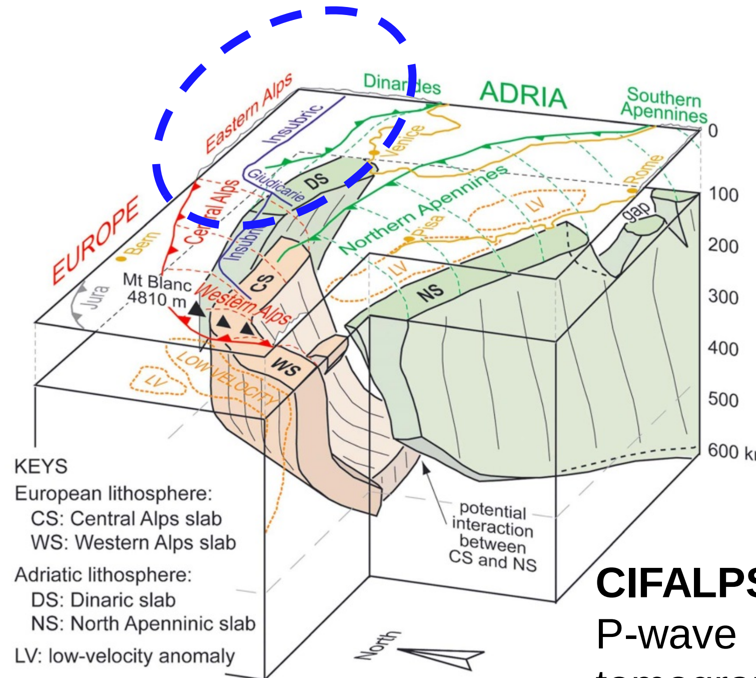


- Collision (1)
- Fragmentation (2)
- Rotation (3)

Redrawn from Babuška et al., Tectonophysics 1990

Triangular shape of the high-velocity heterogeneity beneath the E. Alps, centered at the eastern part of the Insubric line and facing the AlCaPa fragment, reflects the complex collision in the eastern part of the Alps and indicates a multi-slab scenario.

Complex contact of the Alps with the Apennines and Dinarides



CIFALPS
P-wave tomography

The high-velocity heterogeneity beneath the Eastern Alps is related to the Dinaric slab (DS, Adria).

Zhao et al., JGR 2016

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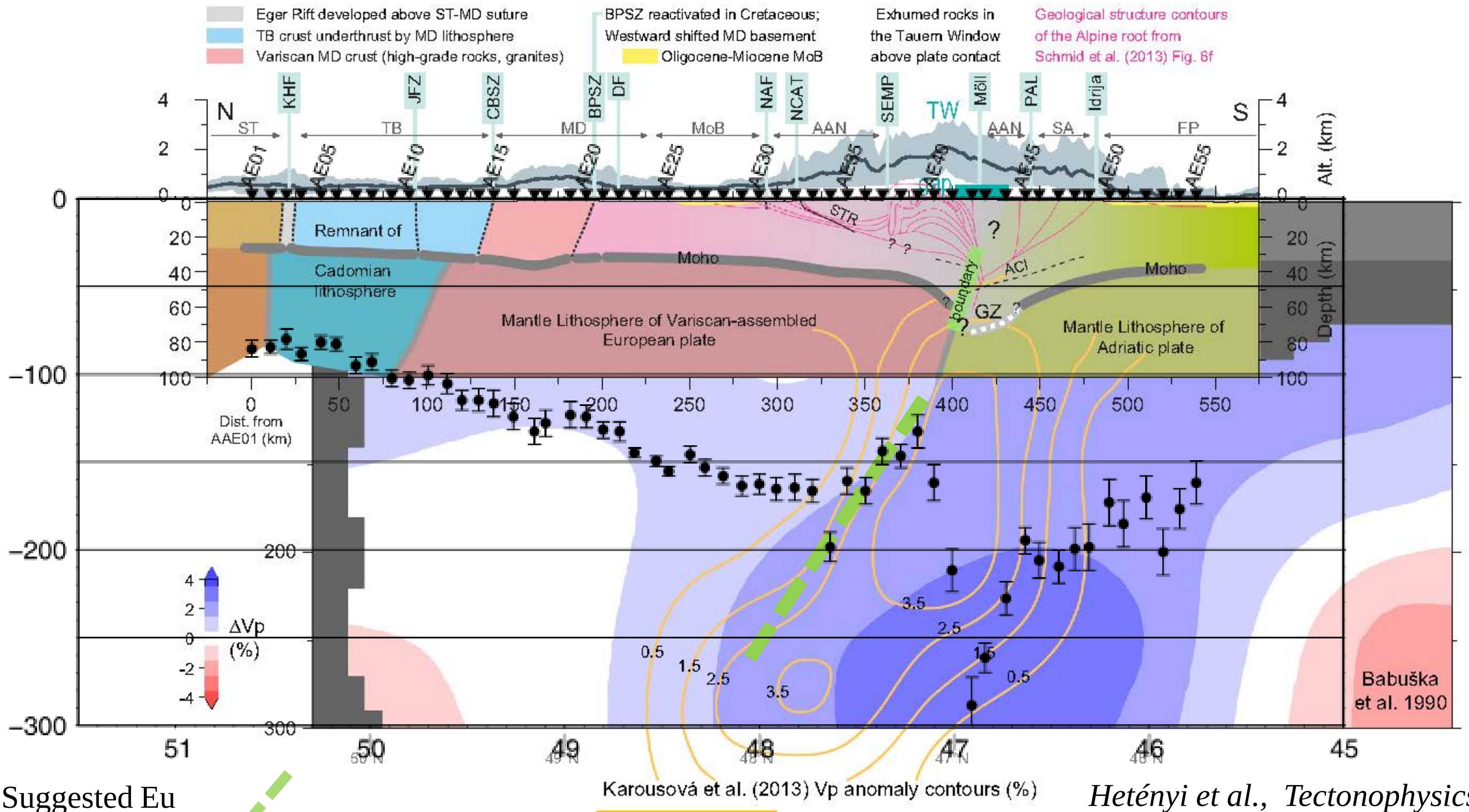
Tomography images of the E. Alpine root along with the crust from the AlpArray-EASI receiver-functions and LAB estimate



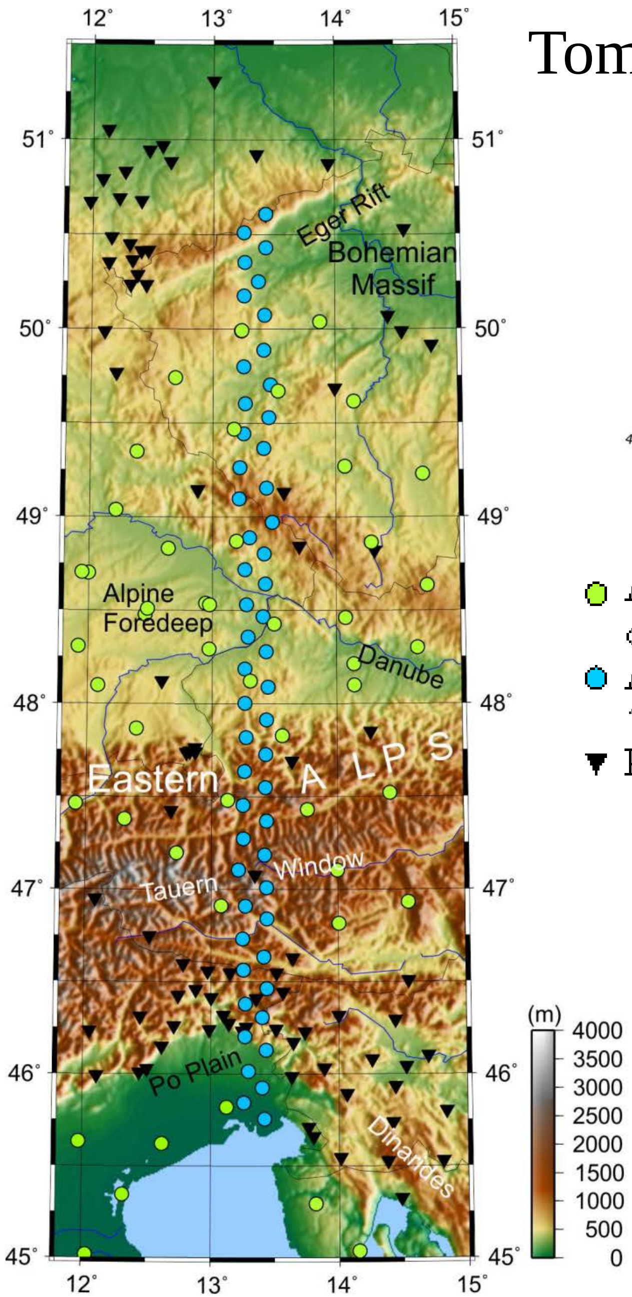
Hetényi et al., Tectonophysics 2018

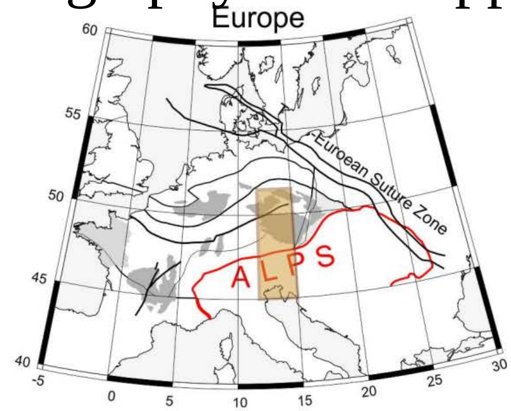
Suggested Eu and Adria plate boundary

Lab depths from static terms of relative travel time deviations of teleseismic P waves

Crust in superposition with tomography from sparse data from permanent observatories (1x1 deg lateral spacing) and 40x40 km grid from the BOHEMA III and the northern part of ALPASS experiments.

Tomography of the upper mantle along the EASI





- From the northern Bohemian Massif across the Eastern Alps toward the Adriatic see

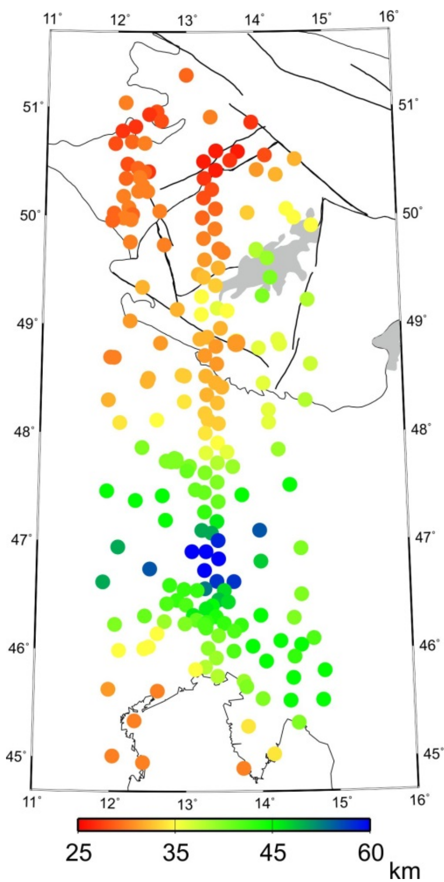
- AlpArray Seismic Network (AASN), doi: 10.12686/alparray/z3_2015
- AlpArray EASI , doi: 10.12686/alparray/xt_2014
- Permanent stations

Telinv code
Munzarová et al., GJI 2018
Isotropic mode

0 km = 13.3 E 48.5 N
block size 30 x 30 km
Total number of stations: 240
Number of events: 201
Number of rays in the model: ~30 000

Data were carefully pre-processed and corrected for crustal effects

Moho depth



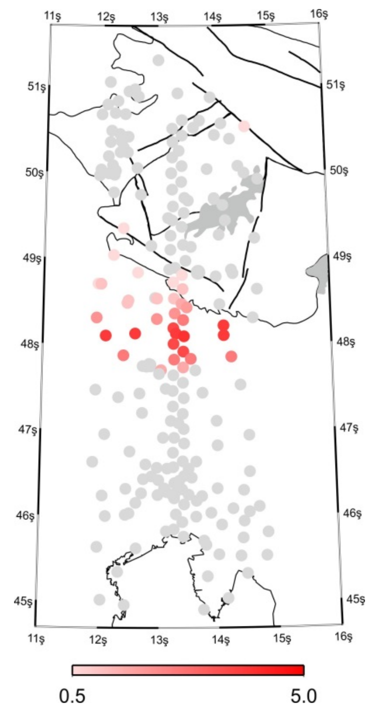
Crust corrections

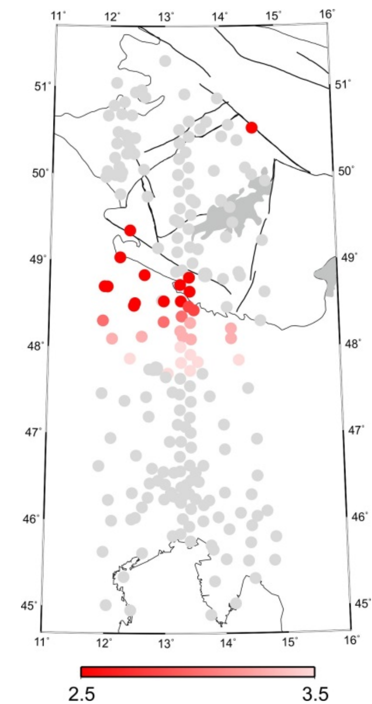
Compilation from different sources:

along EASI
Hetényi et al., 2018

in the BM
Karousová et al., 2012
south of BM, e.g.
Di Stefano et al., 2011
Hua et al., 2017
Tesauro et al., 2008

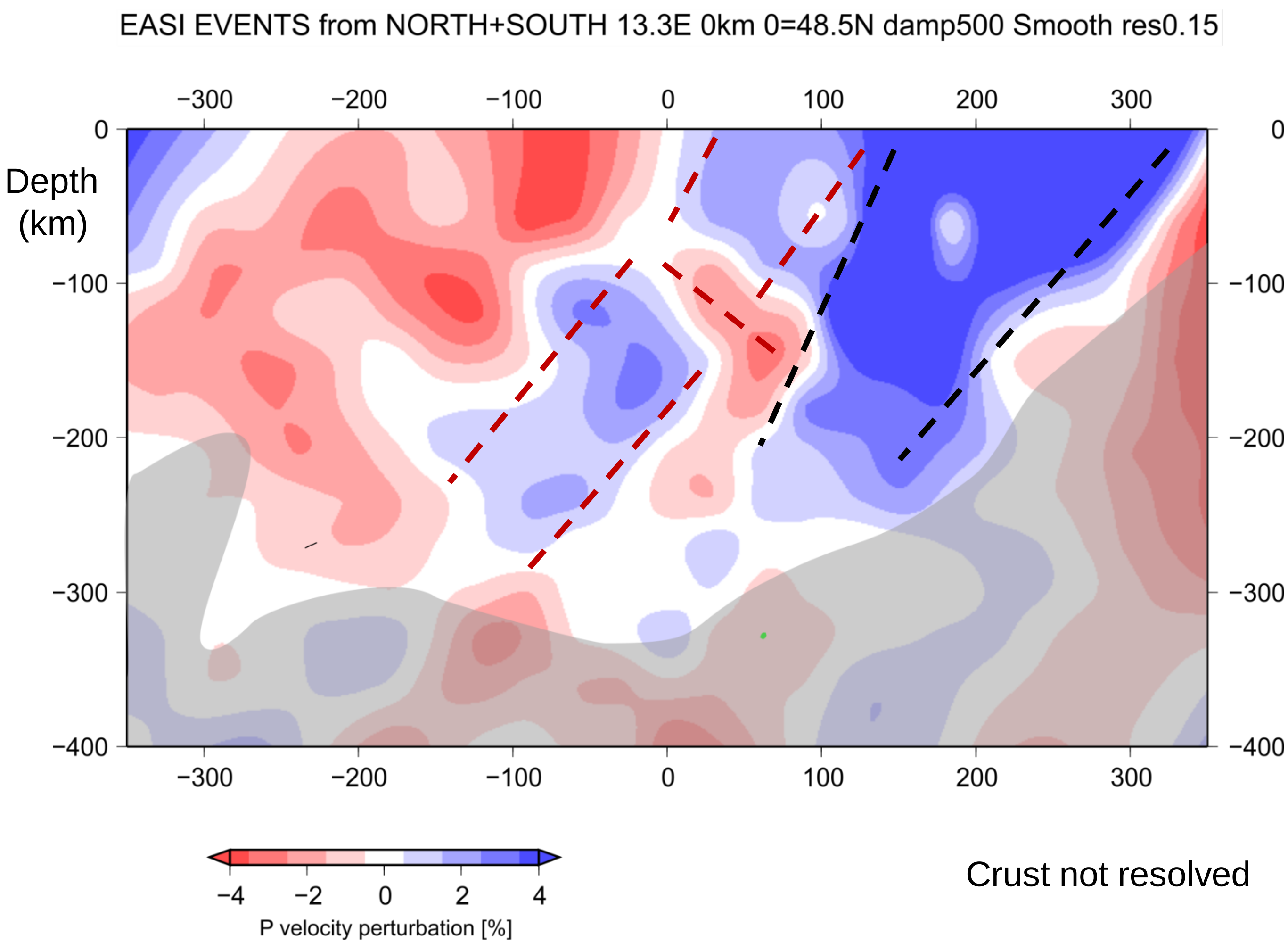
Corrections for sediment thickness and velocities





Preliminary P-wave tomography for 200km wide band along the EASI (a subset of data)

North dipping thick East Alpine root



Crust not resolved

Extended data set: EASI + AASN

- rays in 90° bands from South and North along the EASI
- Two sub-parallel heterogeneities
- Southern one more intensive
- Northern one weaker, tending to delaminate
- Slab thickness ~80-100 km

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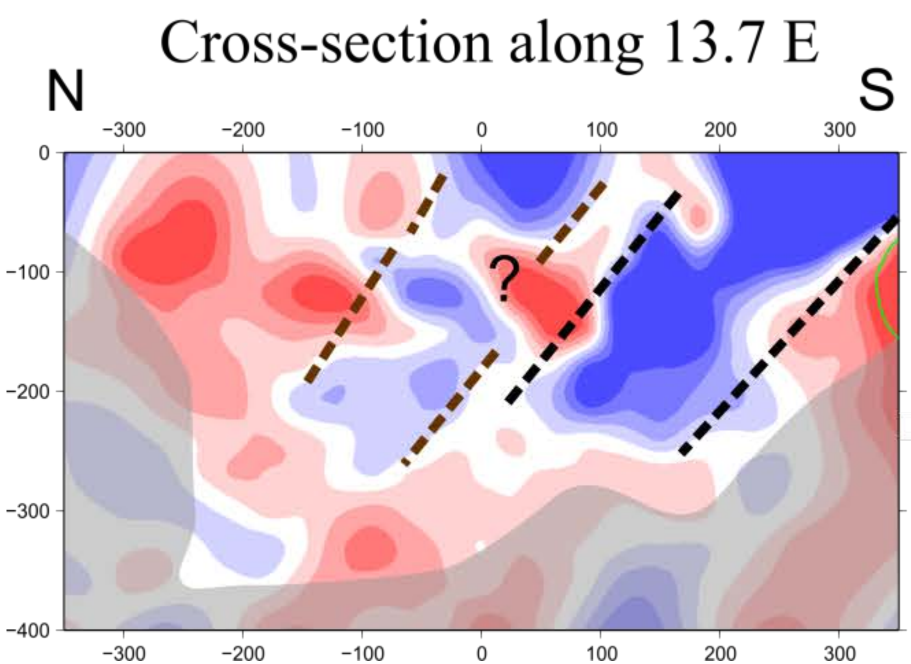
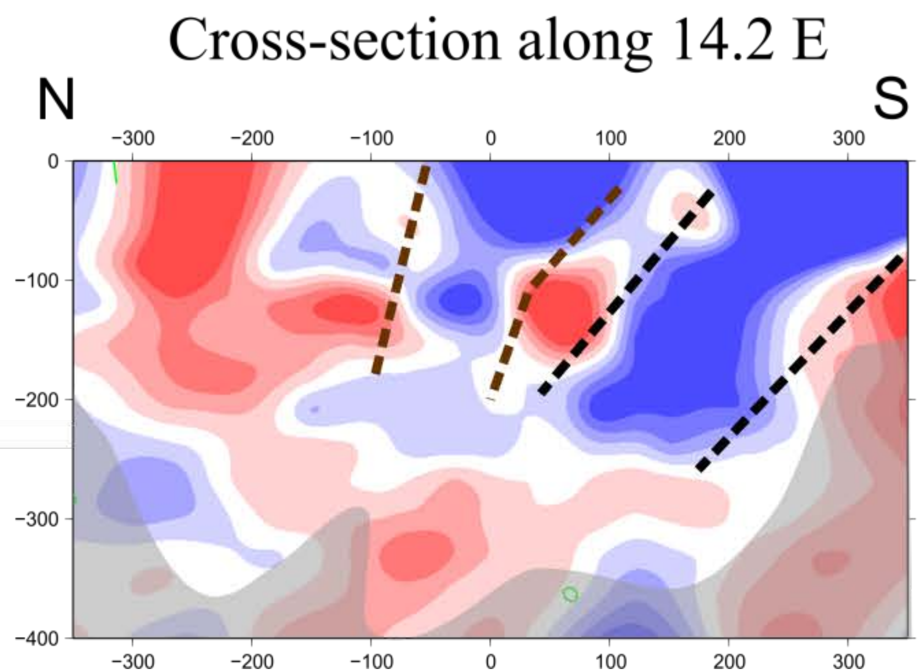
Lateral changes of mantle velocity structure

North-South vertical slices eastward of the EASI





- The weaker northern high-velocity heterogeneity tends to delaminate

- Two steeply to the north dipping high-velocity heterogeneities

- Crust not resolved

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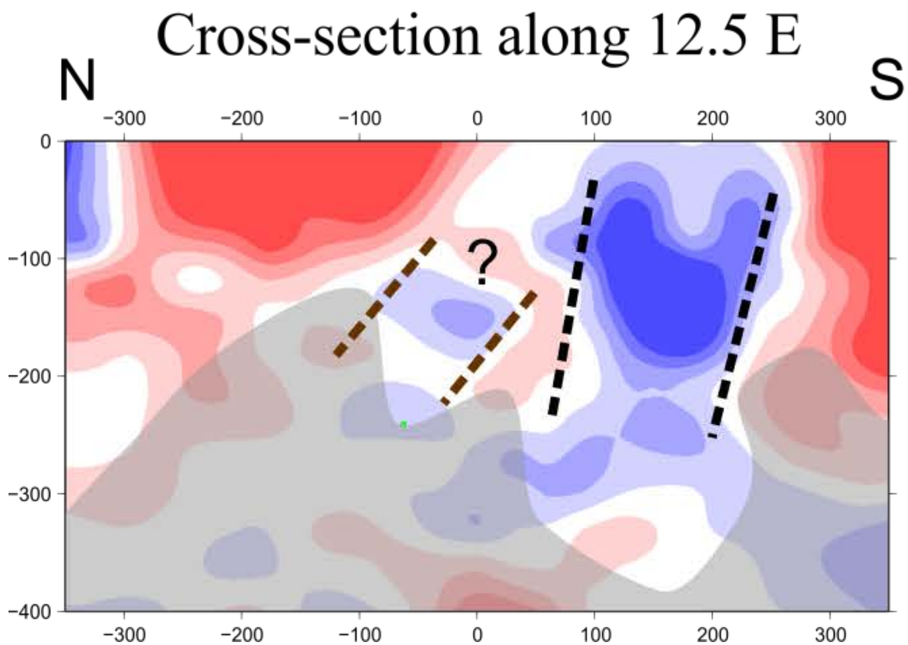
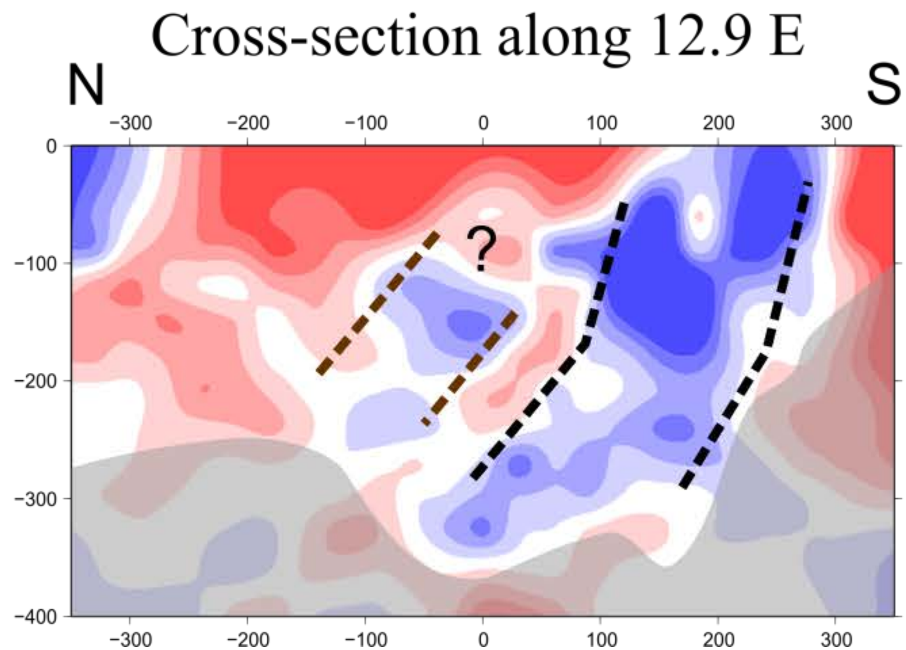
Lateral changes of mantle velocity structure

North-South vertical slices west of the EASI





- The weaker northern high-velocity heterogeneity moves deeper - delaminates
- Weak dispersed high-velocity perturbations below 200 km

- The northern heterogeneity weakens and delaminates
- No connection to shallower depth

- Crust not resolved

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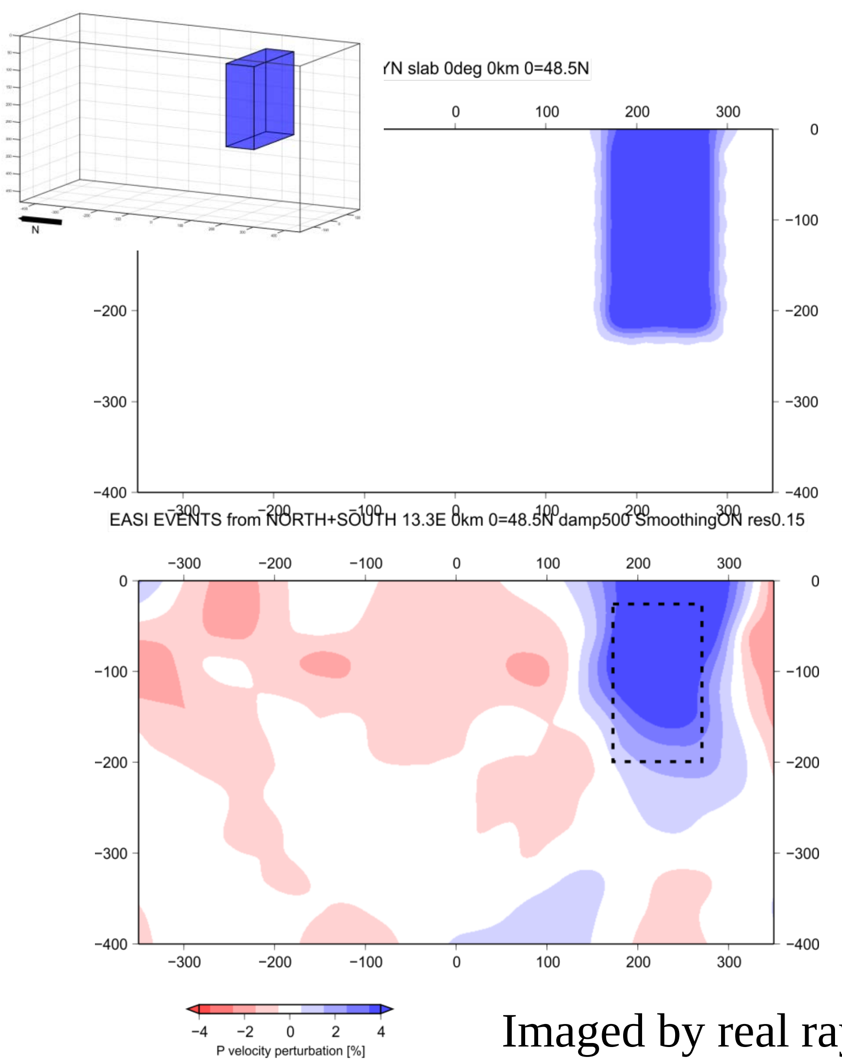
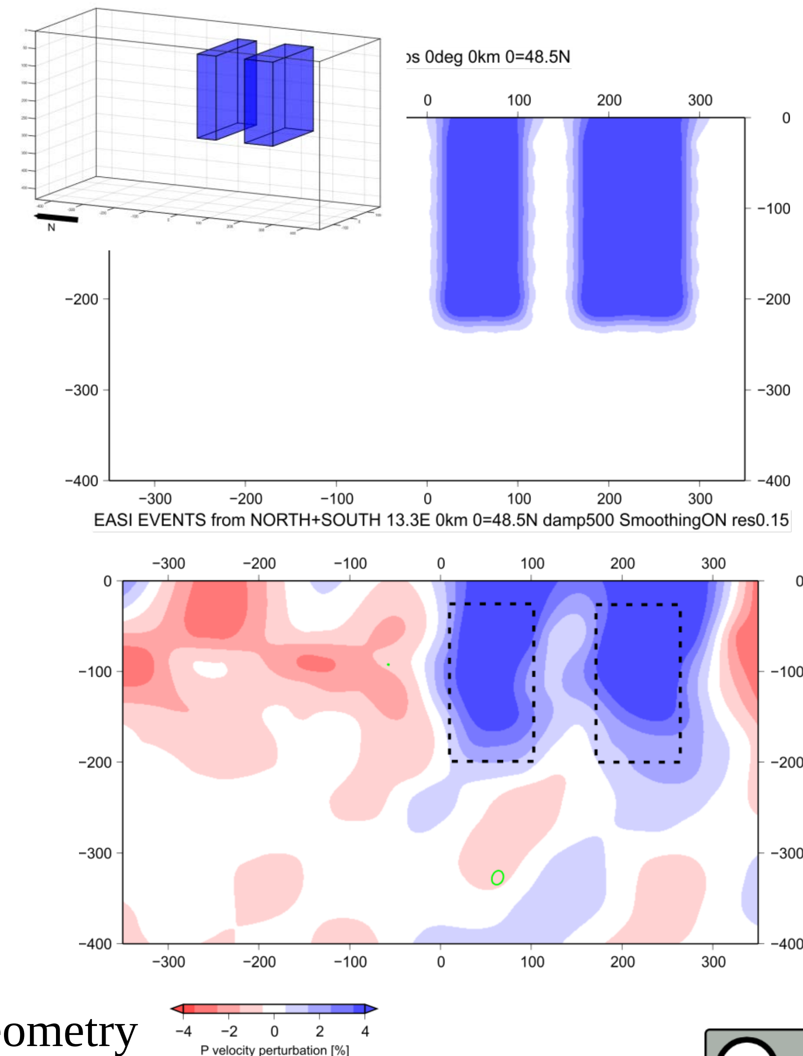
Synthetic tests – 5% high-velocity heterogeneities

One vertical heterogeneity



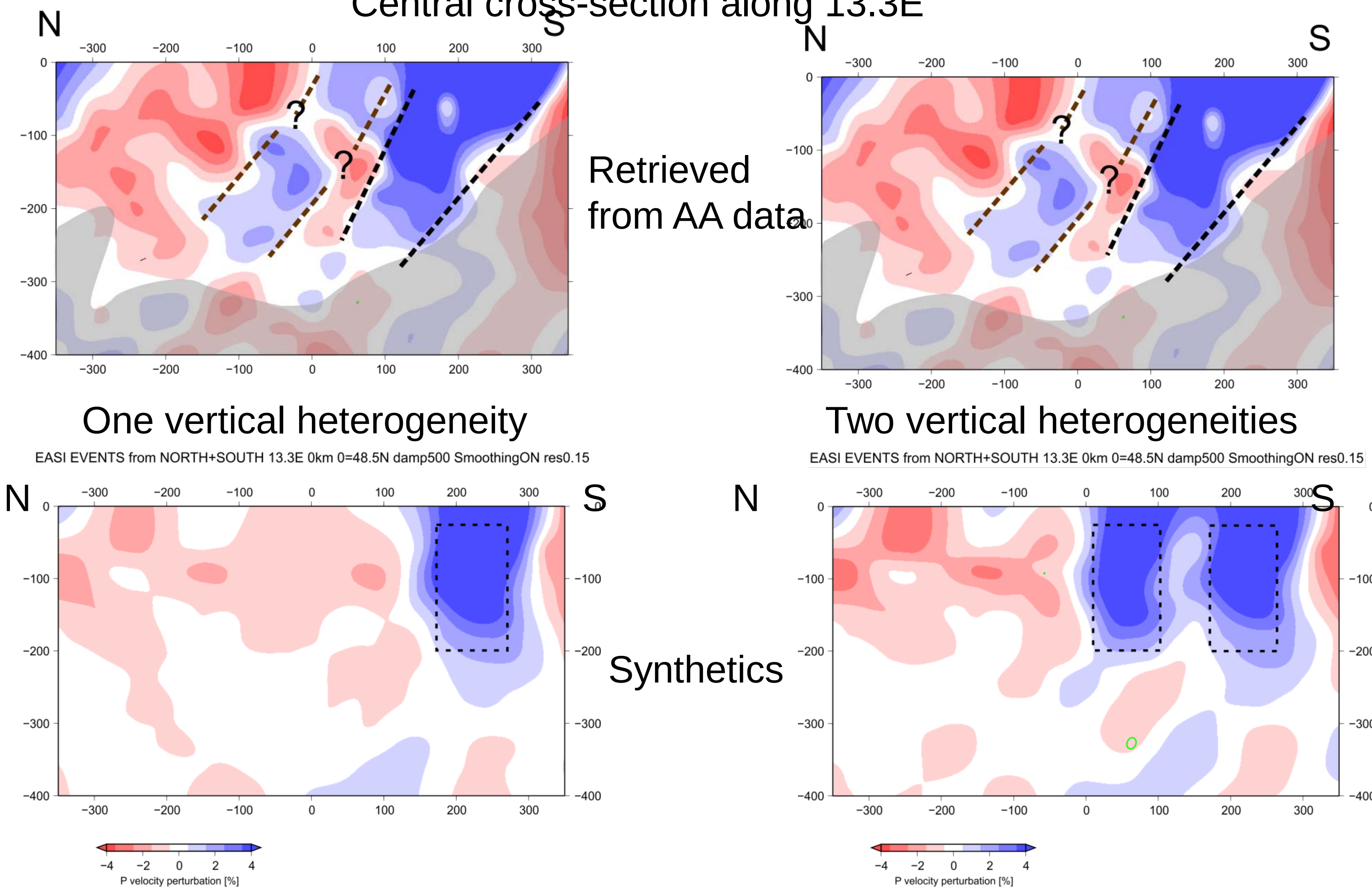
Two vertical heterogeneities



Imaged by real ray-geometry

Synthetic tests – 5% high-velocity heterogeneities

Central cross-section along 13.3E



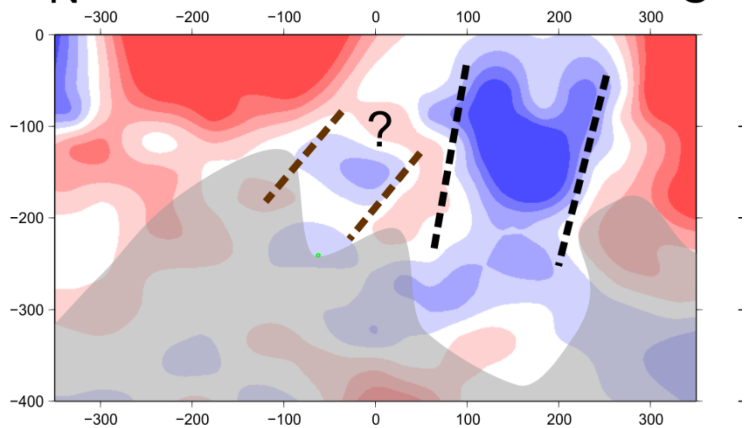
- No northward smearing due to ray geometry

Perturbations retrieved from **AA data**

Westernmost

Cross-section along 12.5 E

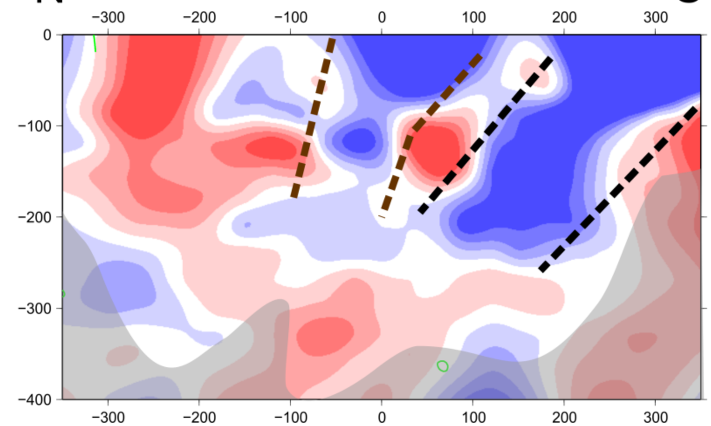
N S



Easternmost

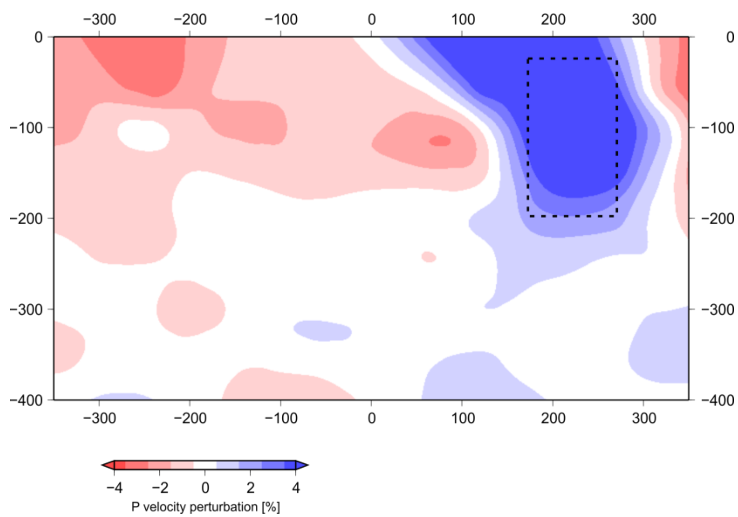
Cross-section along 14.2 E

N S

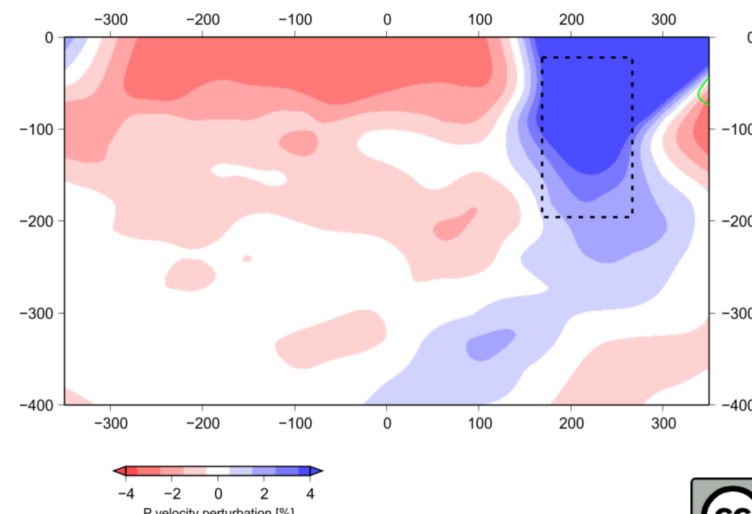


Synthetics with one vertical heterogeneity

EASI EVENTS from NORTH+SOUTH 13.3E −60km 0=48.5N damp500 SmoothingON res0.15



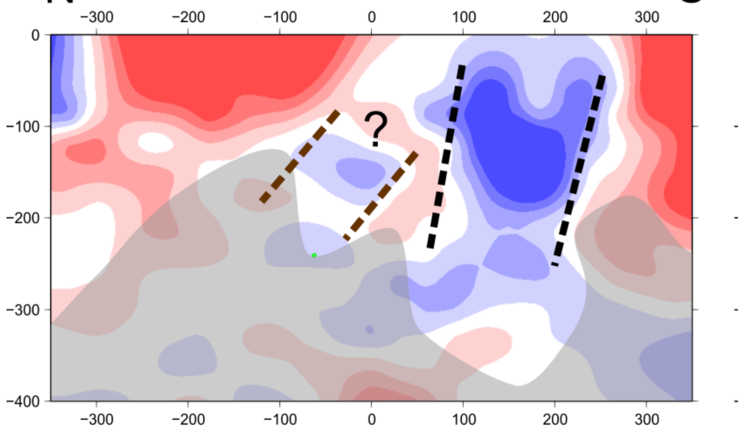
EASI EVENTS from NORTH+SOUTH 13.3E 60km 0=48.5N damp500 SmoothingON res0.15



Westernmost

Cross-section along 12.5 E

N S

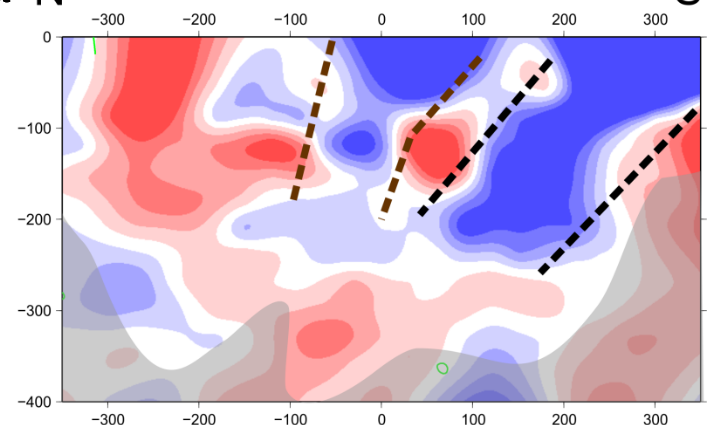


Perturbations retrieved from **AA data**

Easternmost

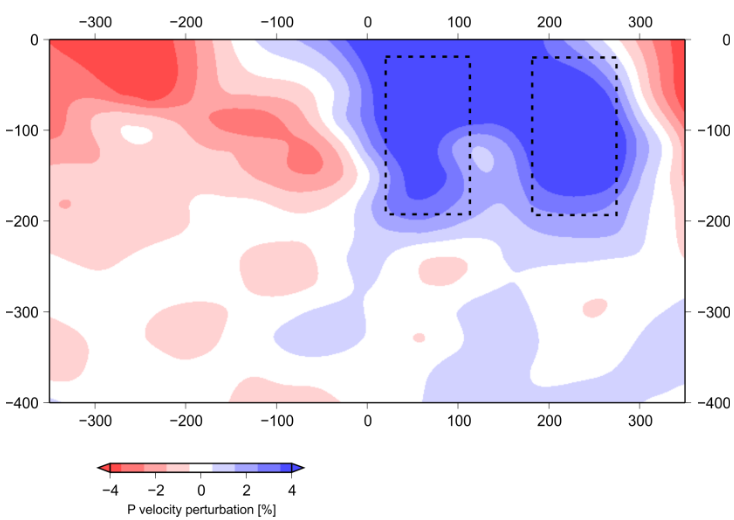
Cross-section along 14.2 E

N S

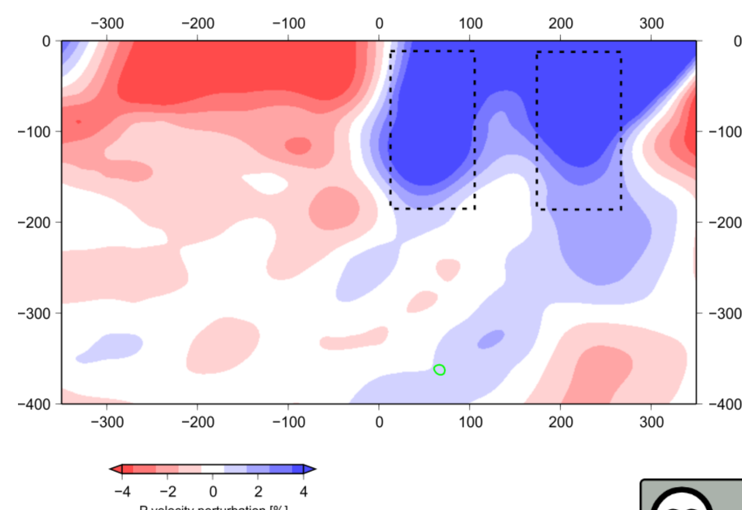


Synthetics with two vertical heterogeneities

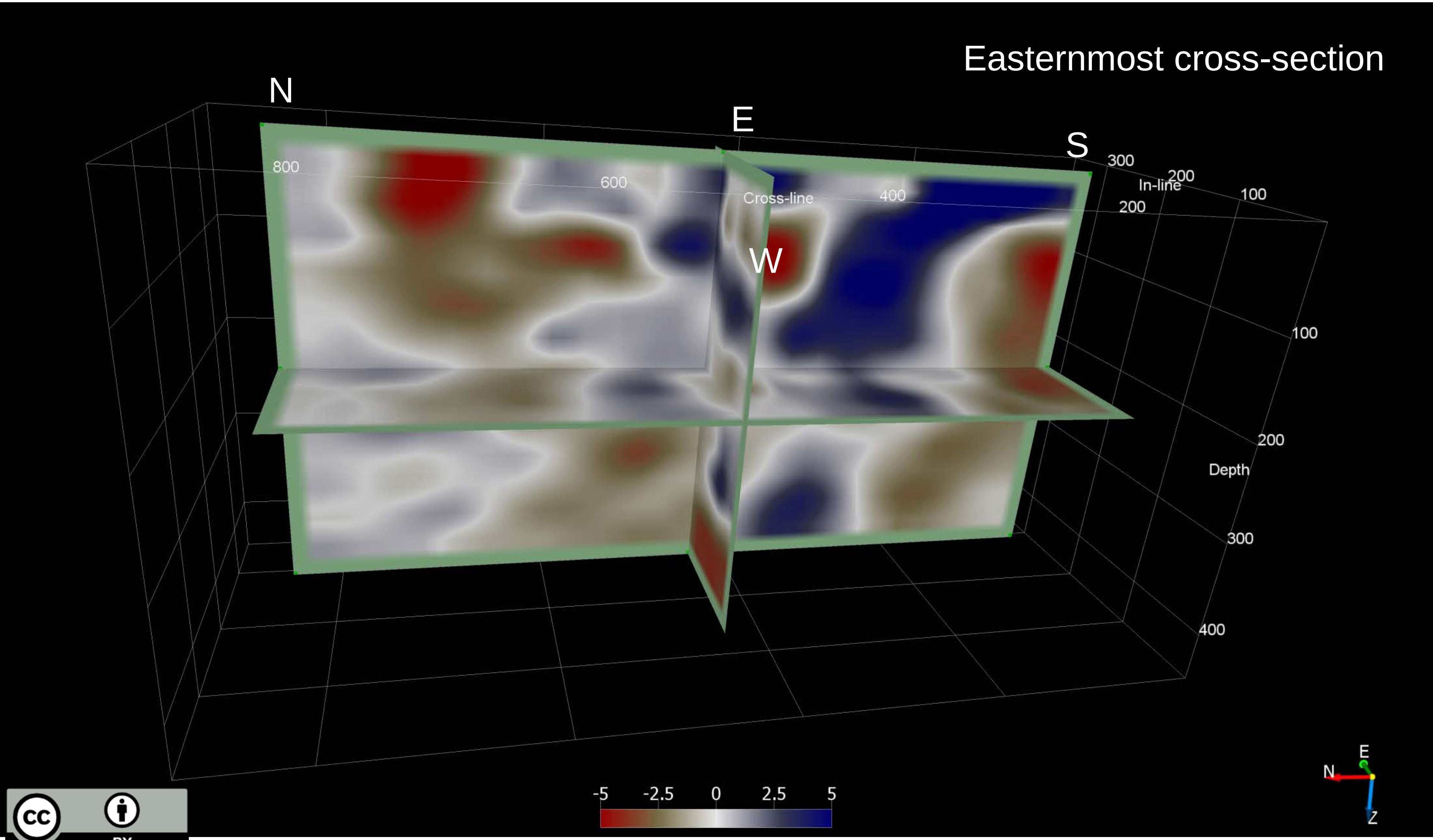
EASI EVENTS from NORTH+SOUTH 13.3E −60km 0=48.5N damp500 SmoothingON res0.15



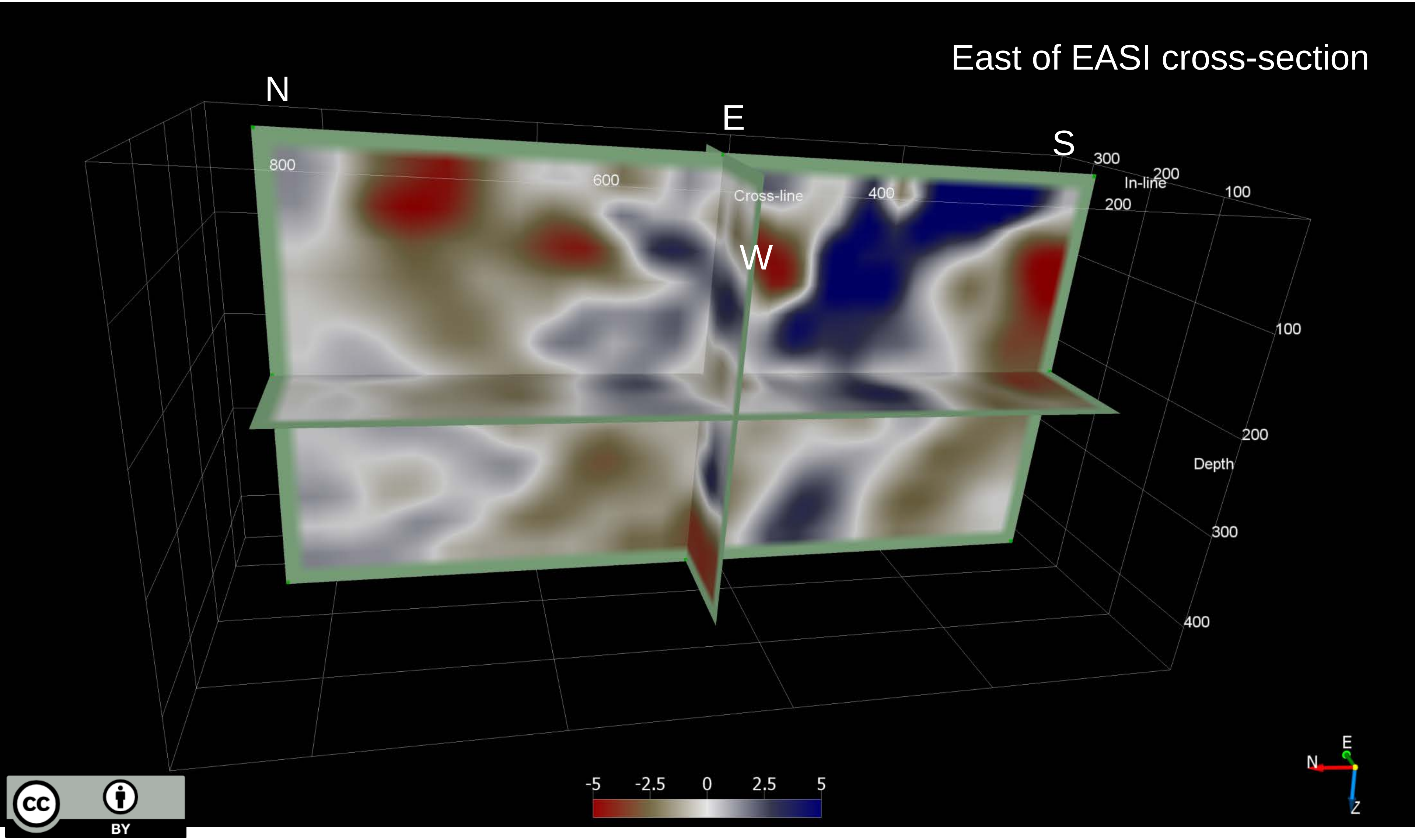
EASI EVENTS from NORTH+SOUTH 13.3E 60km 0=48.5N damp500 SmoothingON res0.15



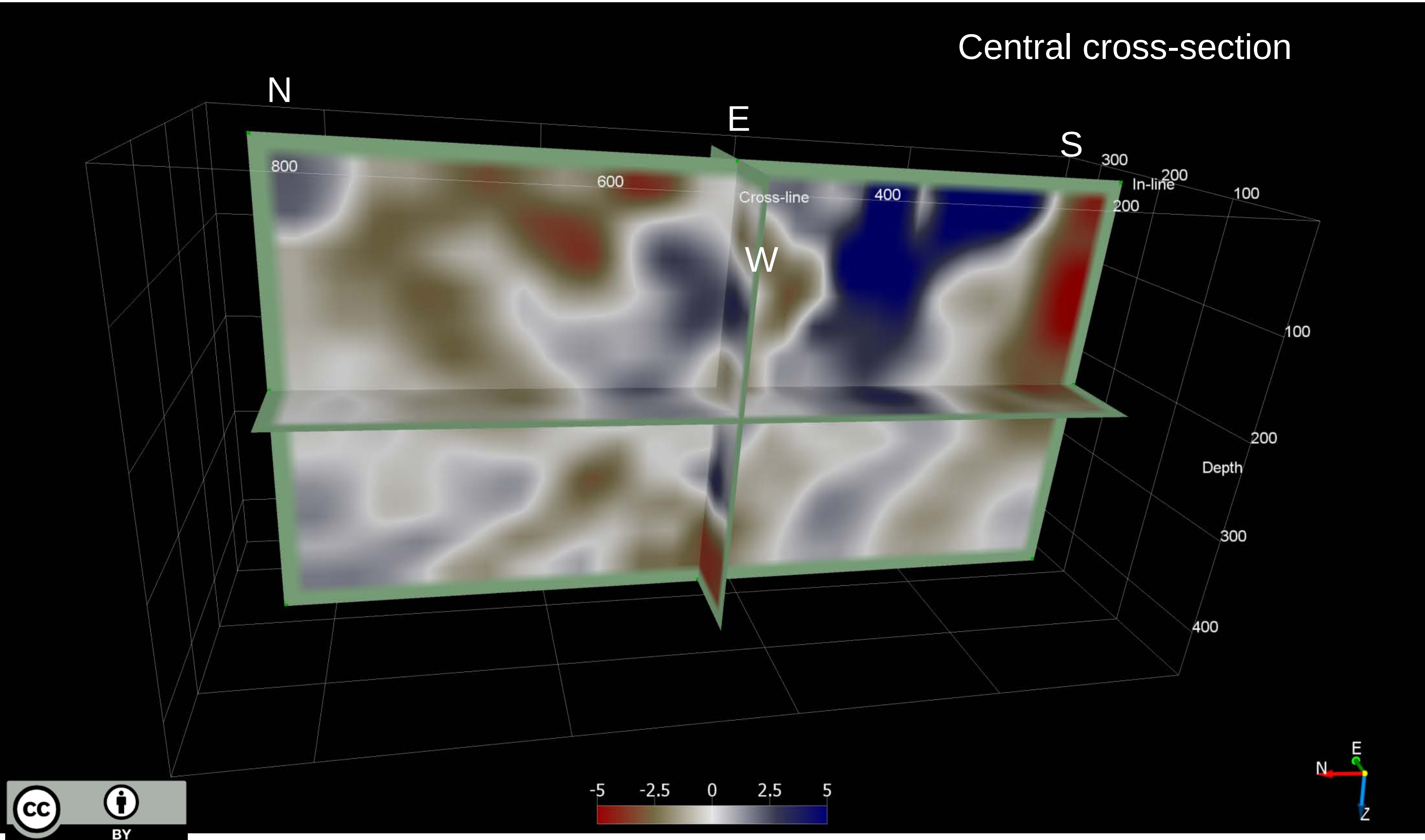
3D images of lateral variations of intensity and shape of the two sub-parallel heterogeneities beneath the Eastern Alps



3D images of lateral variations of intensity and shape of the two sub-parallel heterogeneities beneath the Eastern Alps



3D images of lateral variations of intensity and shape of the two sub-parallel heterogeneities beneath the Eastern Alps



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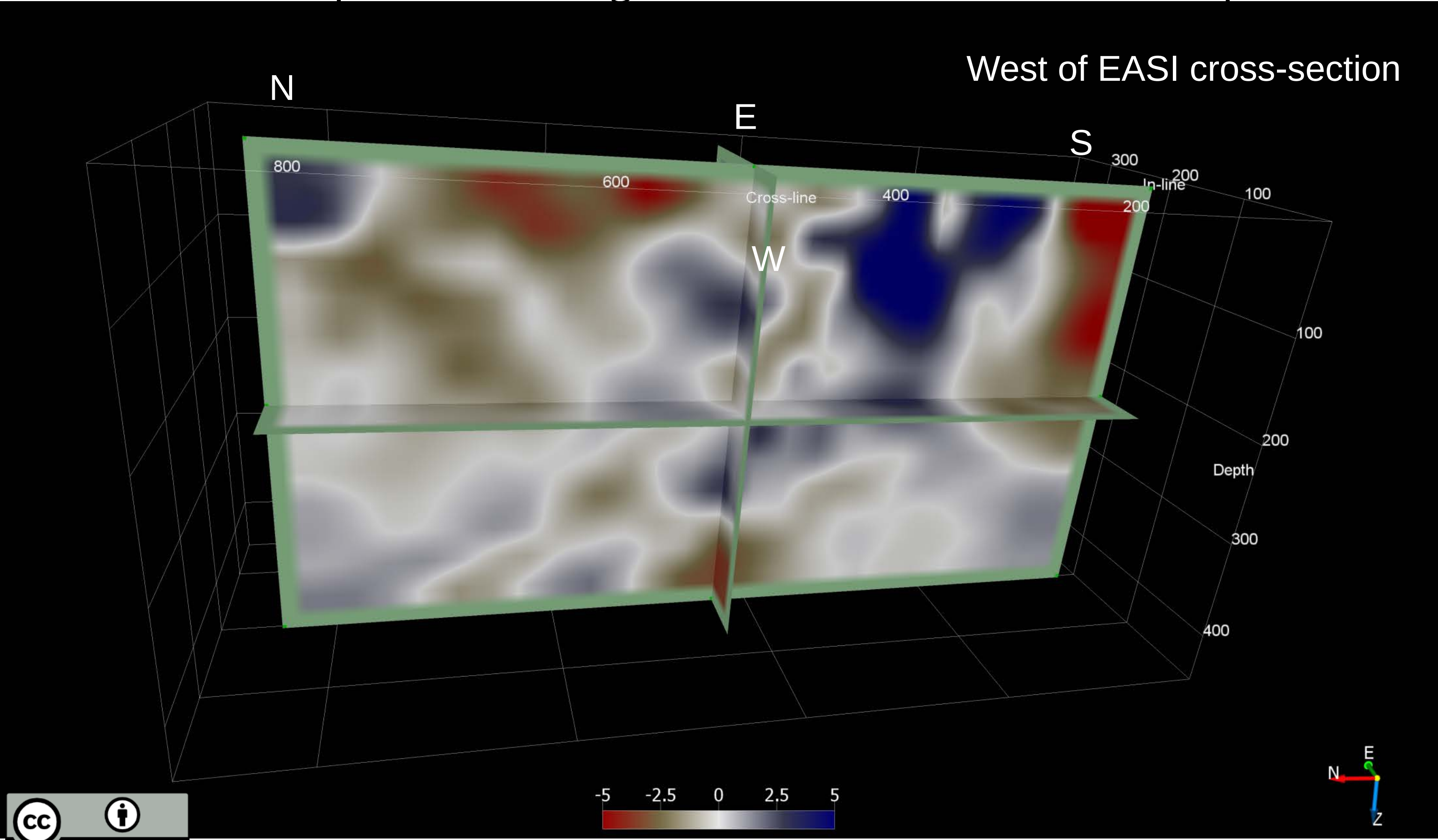
3D images of lateral variations of intensity and shape of the two sub-parallel heterogeneities beneath the Eastern Alps



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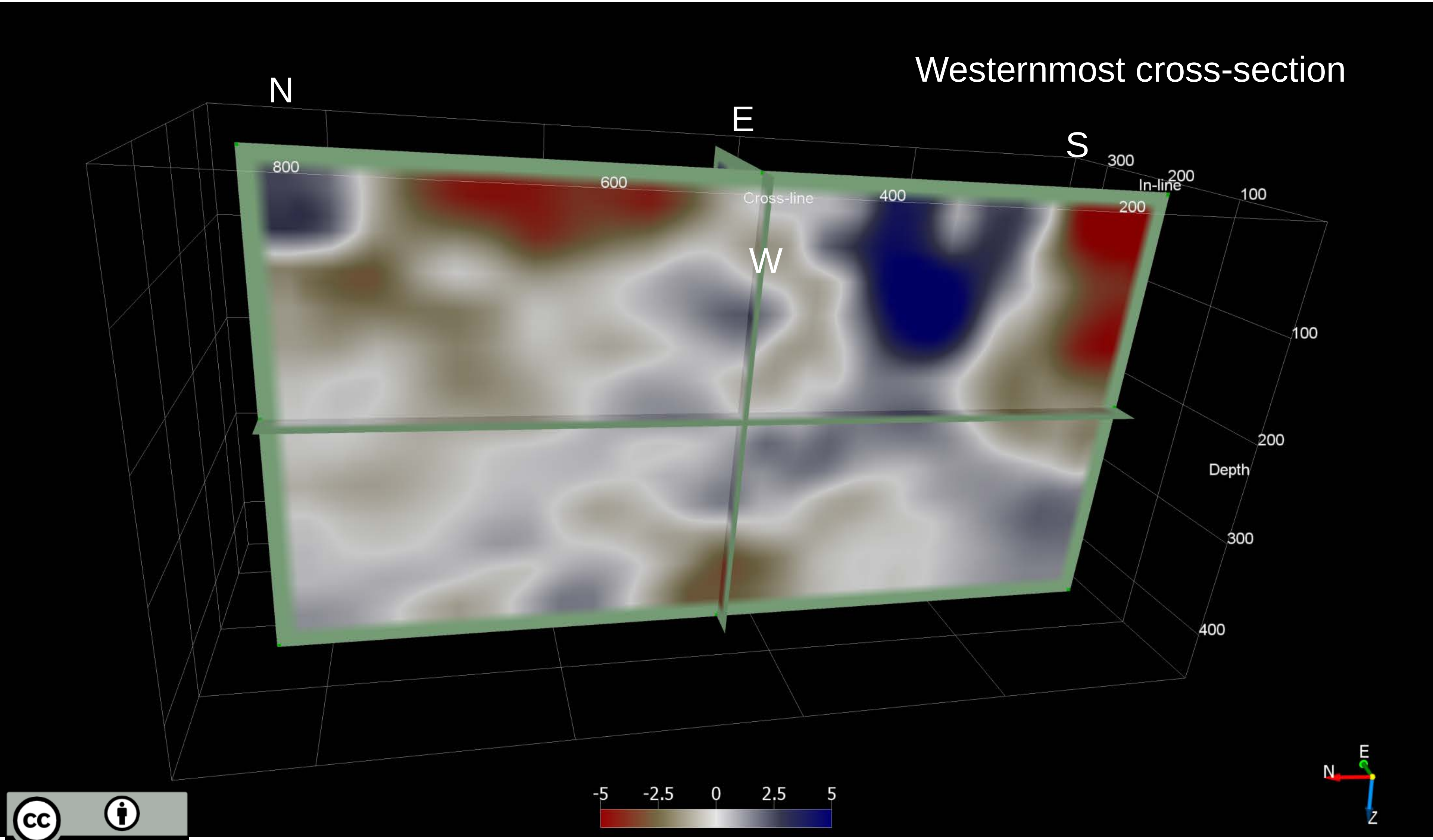
3D images of lateral variations of intensity and shape of the two sub-parallel heterogeneities beneath the Eastern Alps



Conclusions

Isotropic teleseismic P-wave tomography with the AlpArray data (including EASI data) **imaged beneath the Eastern Alps**

- **Two** high-velocity sub-parallel **northward dipping heterogeneities,** separated ~50km on average.
- Each of the two **slabs** is **~80-100km thick** and can be traced **down to ~200km.**
- The **southern heterogeneity** is more distinct, i.e., with perturbations **stronger** than those in the northern one.
- We associate the southern heterogeneity with the **northward subduction of the Adriatic slab.**
- The weaker **northern heterogeneity delaminates at ~100km** depth and diminishes in direction towards the Central Alps; it loses connection to shallow mantle depths at all.
- The weaker northern heterogeneity can represent a **remnant of an early phase subduction,** either
  - ✓ **EU slab with switched polarity** or
  - ✓ a **preceding phase** of the **Adriatic subduction**
- Tomography **resolution is high enough** to resolve the **existence of two neighbouring heterogeneities** from carefully preprocessed and crust corrected data .