



Mountain-Building Processes in Four Dimensions (4D-MB)



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Heidrun Kopp (Kiel)
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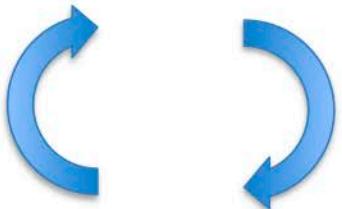
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Joachim Ritter (Karlsruhe)
Leni Scheck-Wenderoth (Potsdam)
Cornelia Spiegel (Bremen)
Frederik Tilmann (Potsdam)
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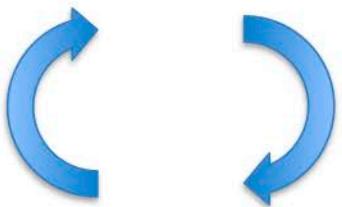
AlpArray

An interdisciplinary project to study
mountain-building processes – Target Alps

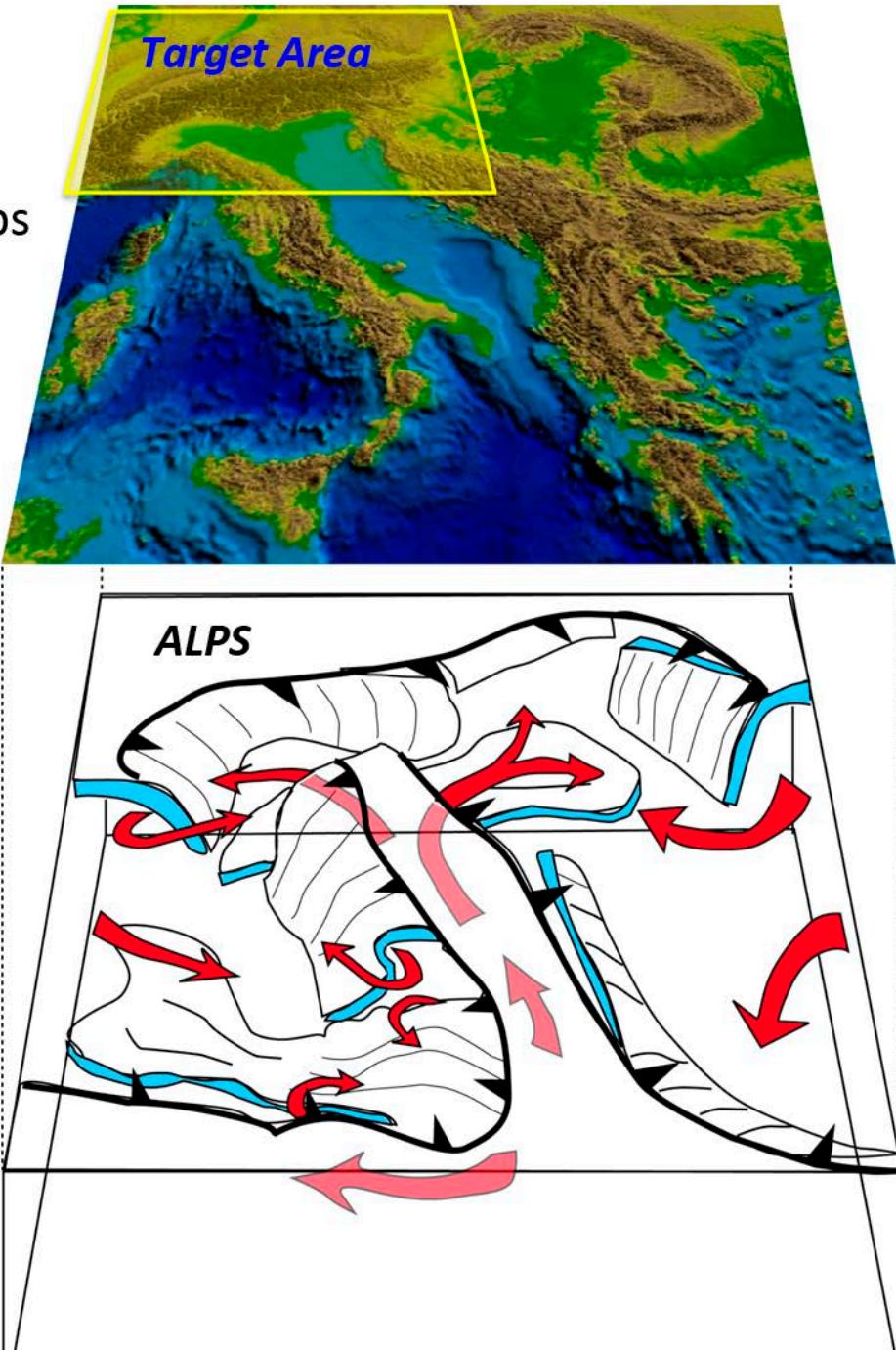
Surface processes



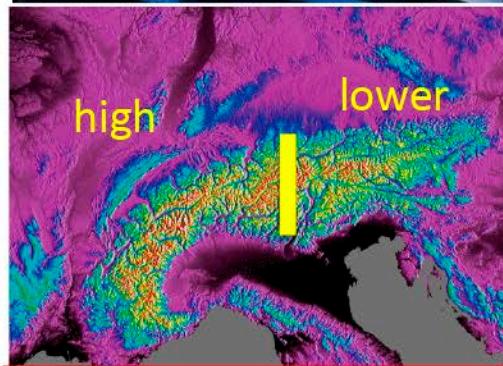
Crustal processes



Mantle processes



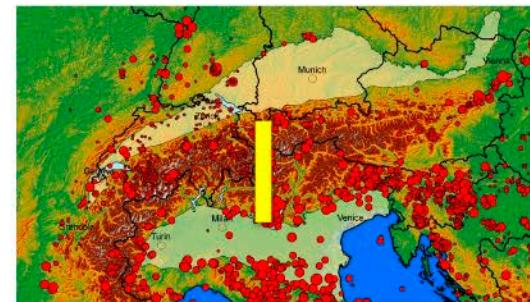
Excellent exposure



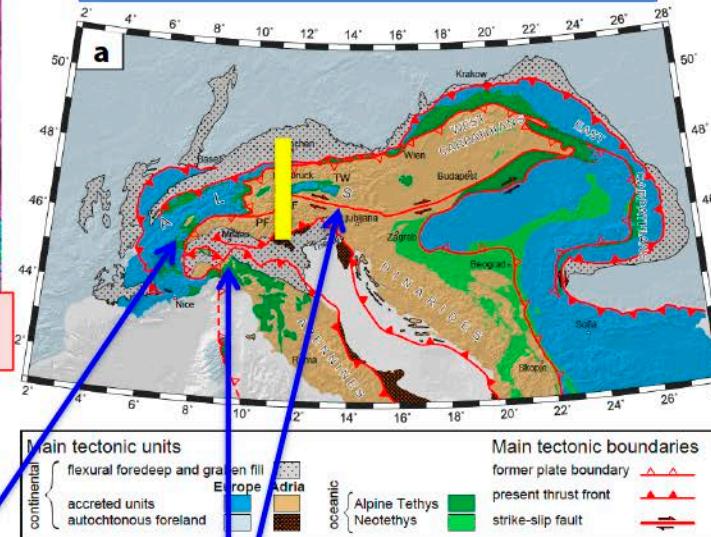
Contrasting morphology

Why the Alps ?

Seismic hazard

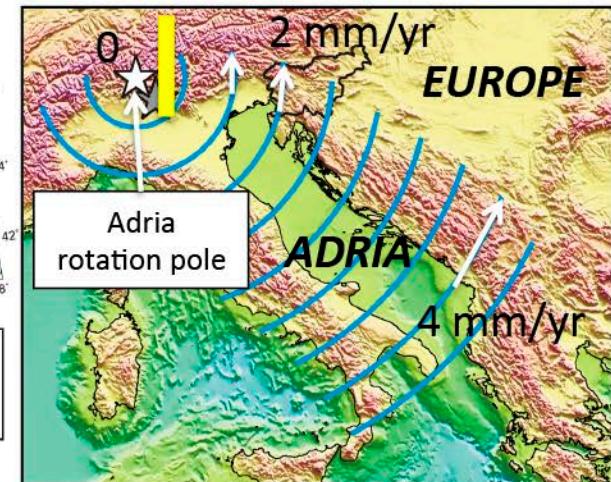


Complex deep structure



slab tear?

Convergence rate gradient

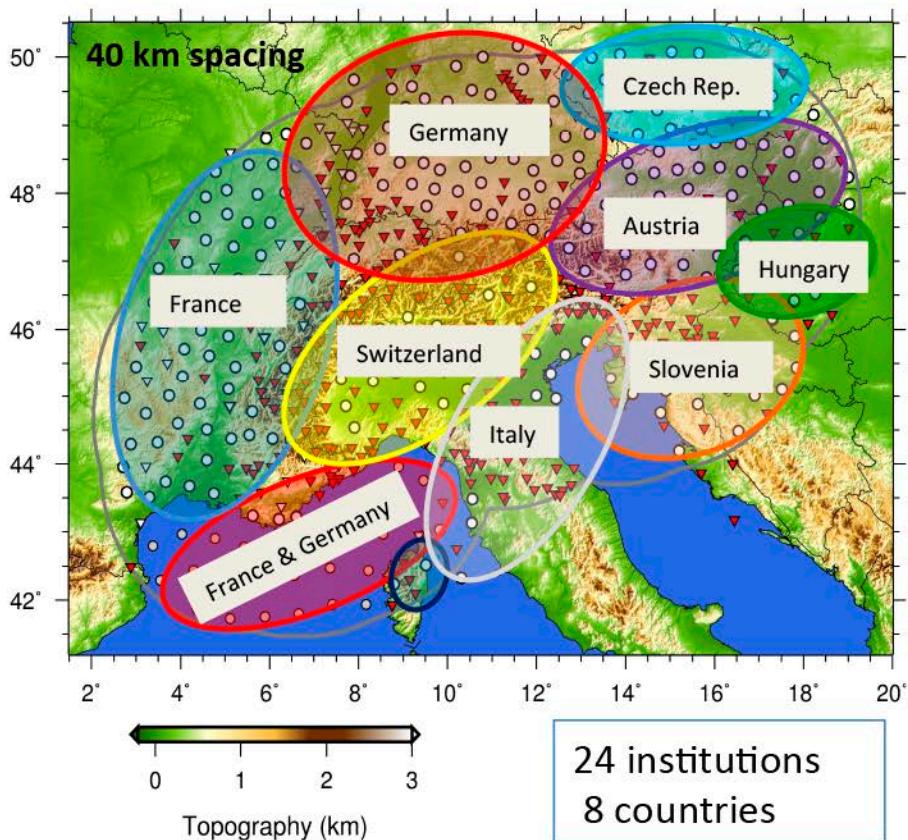
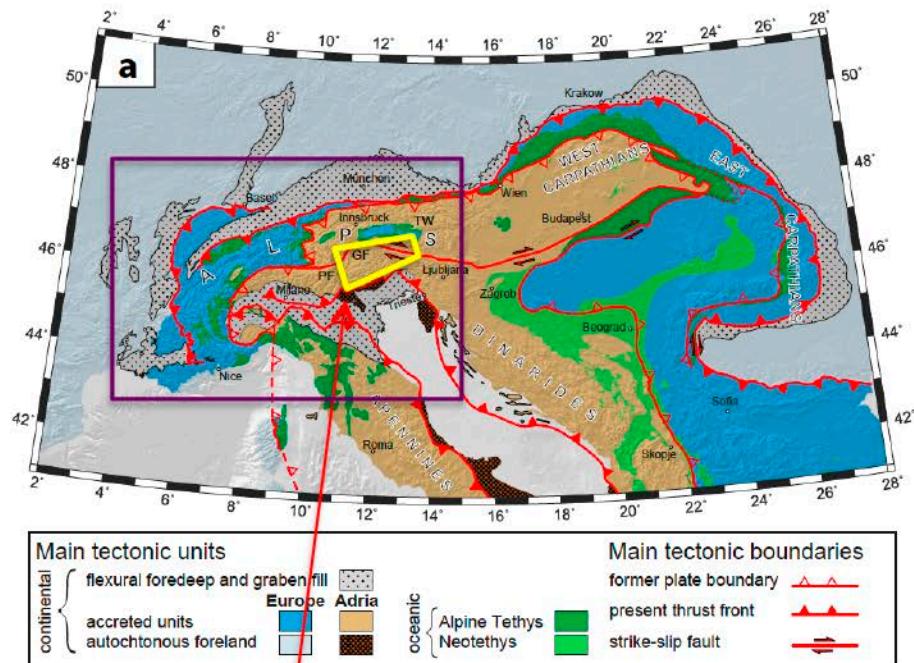


Switches in subduction polarity

Ampferer 1928



Rich research history

Seismology**Geodynamics**

- **614 BB seismometers (394 perm, 220 temp)**
 - 85 % temp. stations running since 1st Sept. 2016
 - for Germany, old stations in **UNIBRAS**
- > 100 new stations of DSEBRA to be deployed
(Poster of W. Friederich et al., this meeting)**

Geodynamic targets

- Subduction-exhumation structures
- Sources - mountainous surfaces
- Sinks - fore- & hinterland basins

SPP Structure

The scientific heart of the SPP

Research Themes

1 Reorgan. of lithosphere
M. R. Handy

2 Surface response
C. Spiegel

3 Deform. of crust & mantle
L. Scheck-Wenderoth

4 Motion patterns & seismicity
K. Reicherter

...to realize the themes

Activity Fields

Geological activities
T. John

DSEBRA
W. Friederich, G. Rümpker

Thermomechanical modeling
B. Kaus

LOBSTER
H. Kopp

Swath
M. Weber

Research themes

Theme 1 - Probing reorganizations of the lithosphere

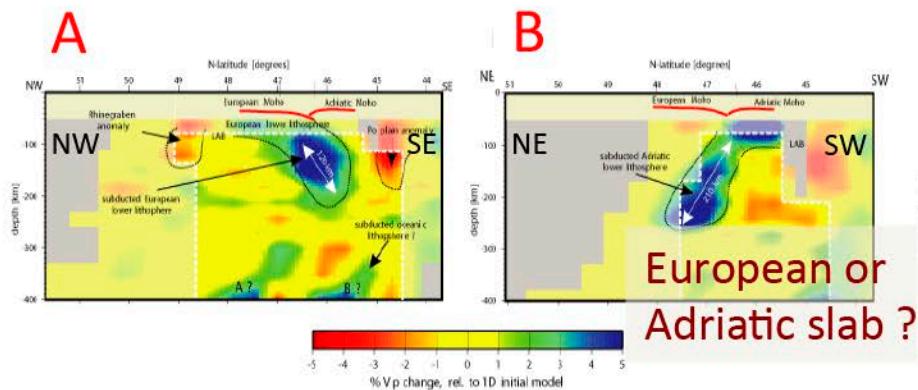
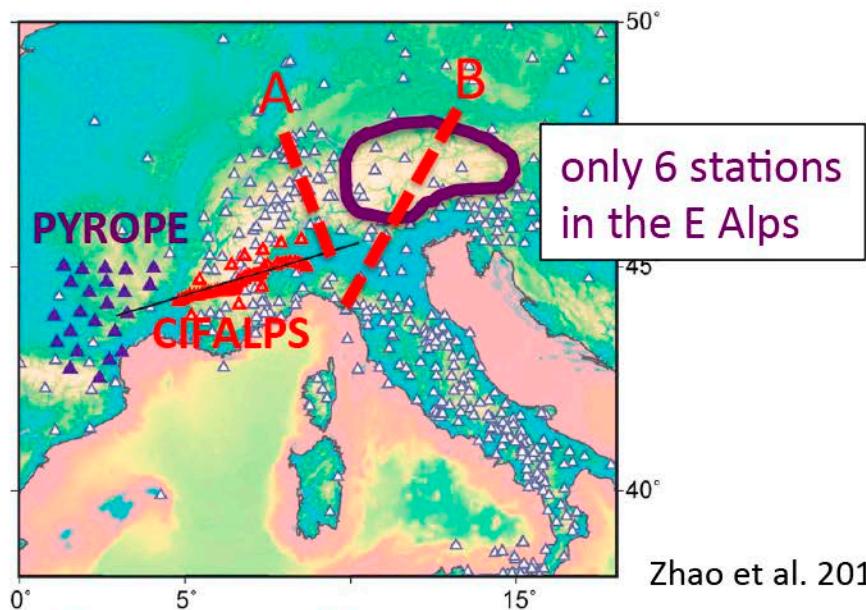
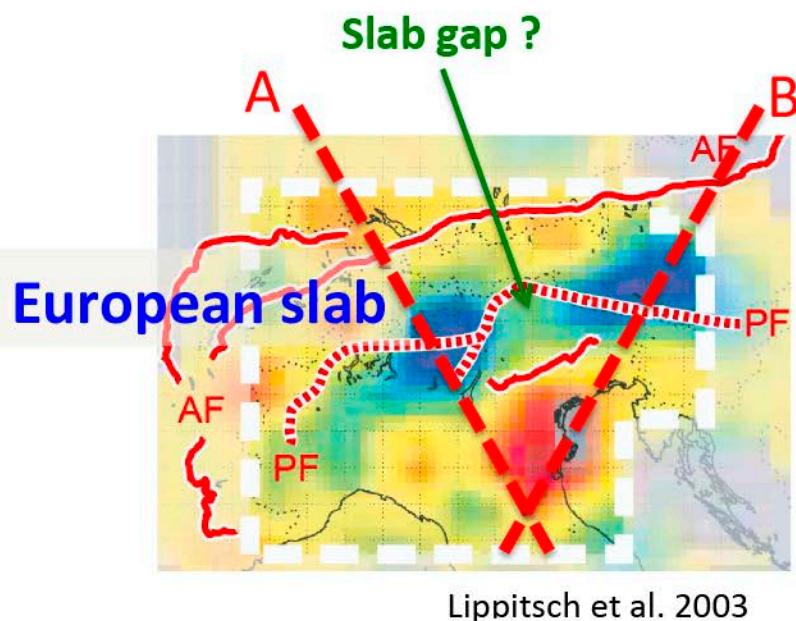
Theme 2 - Surface response to changes in deep structure

Theme 3 - Capturing deformation of the crust and mantle

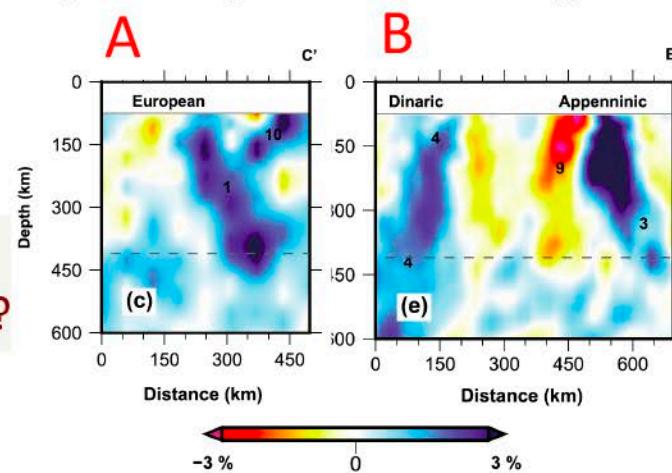
Theme 4 - Tracking motion and seismicity

Two SPP phases: 2017-2020 and 2021-2024

Theme 1 – One or two slabs? Switch in polarity?



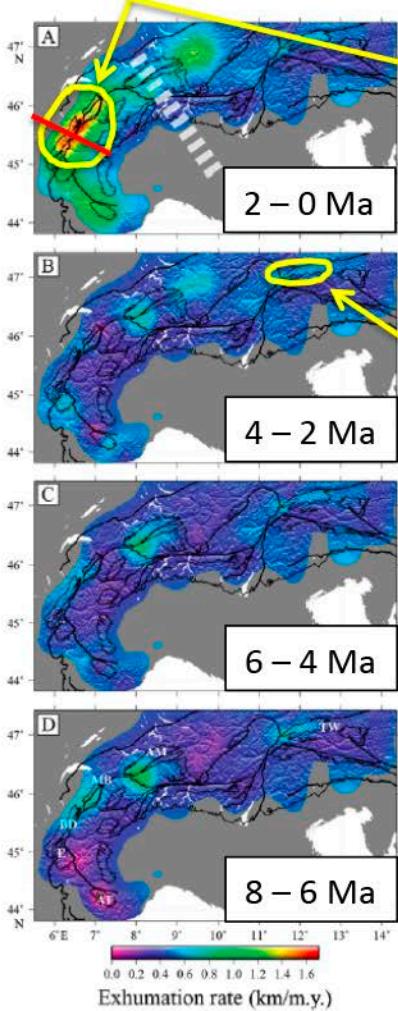
+V_p anomalies down to 200 km
=> Slabs above Oligo-Miocene breakoff?



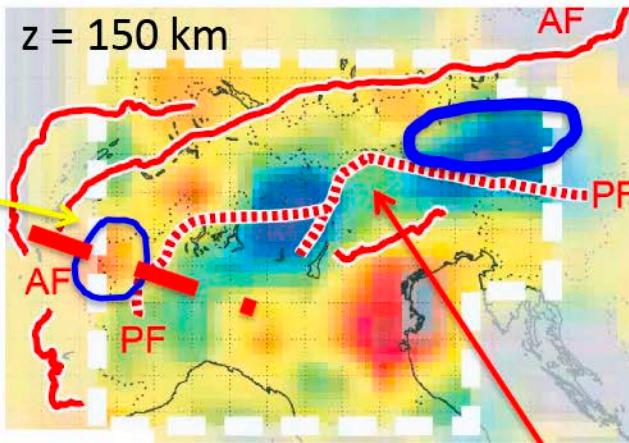
+V_p anomalies down to 450 km!
=> Slabs never broke off?

Theme 2 – Surface forcing (deglaciation, erosion) and/or mantle forcing (slab tearing) ?

Exhumation rate high in W. Alps



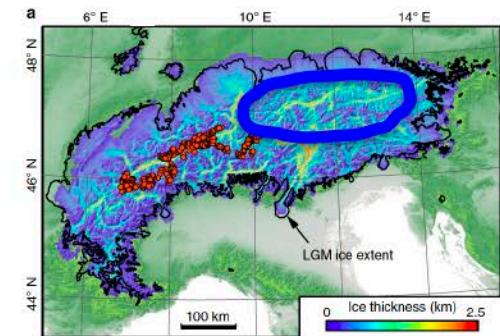
Fox et al. 2015



moderate in E Alps

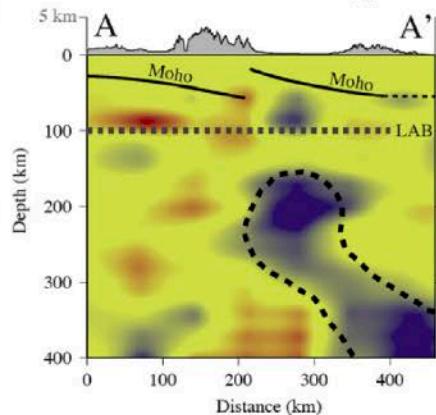
Lippitsch et al. 2003

Ice thickness at LGM

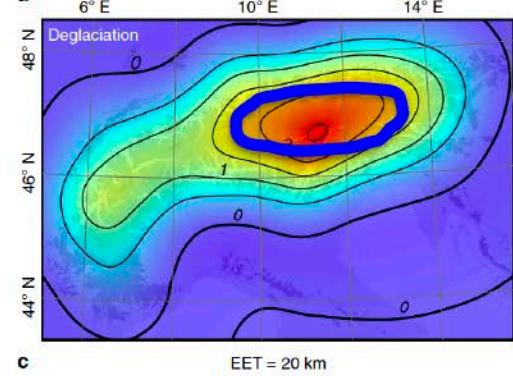


Slab tearing or deglaciation ?

Slab tearing ?



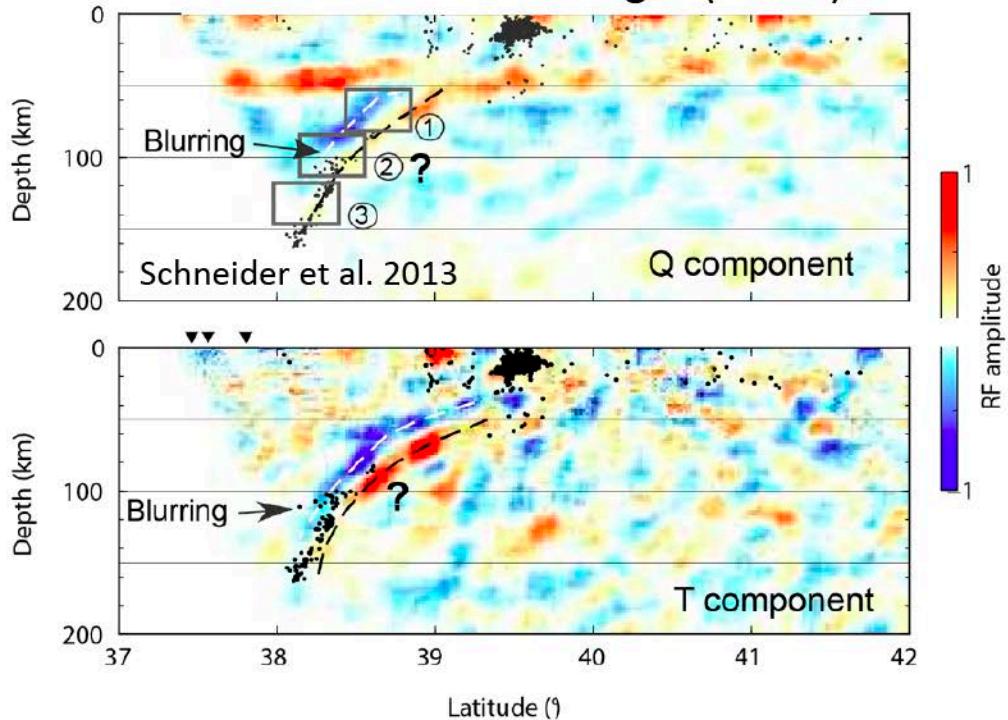
Recent surface uplift



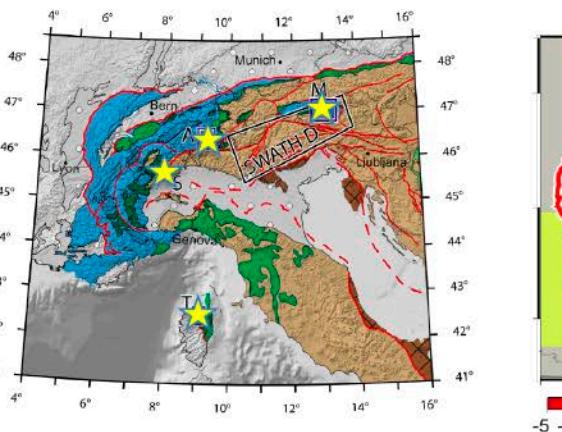
Mey et al. 2016

Theme 3 – Can we image evolving subduction structures?

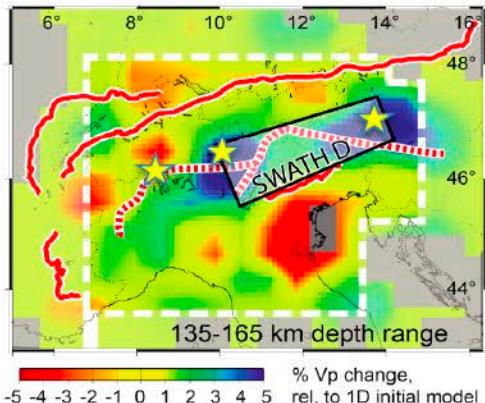
Receiver function images (Pamir)



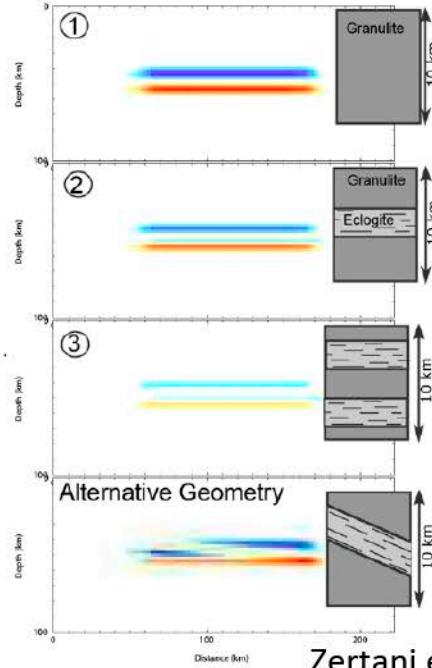
Target areas



Slab imaged / Swath

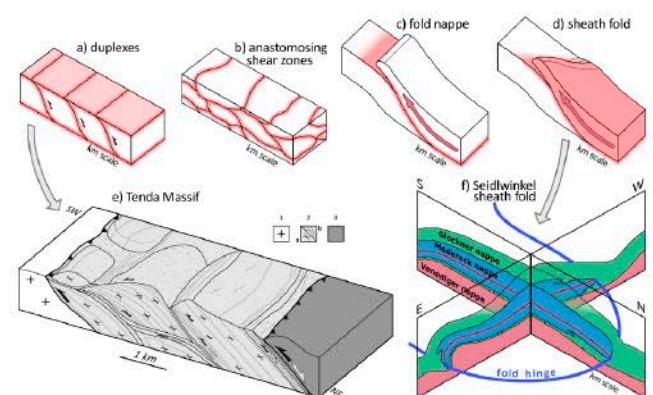


Slab top geometries & their images

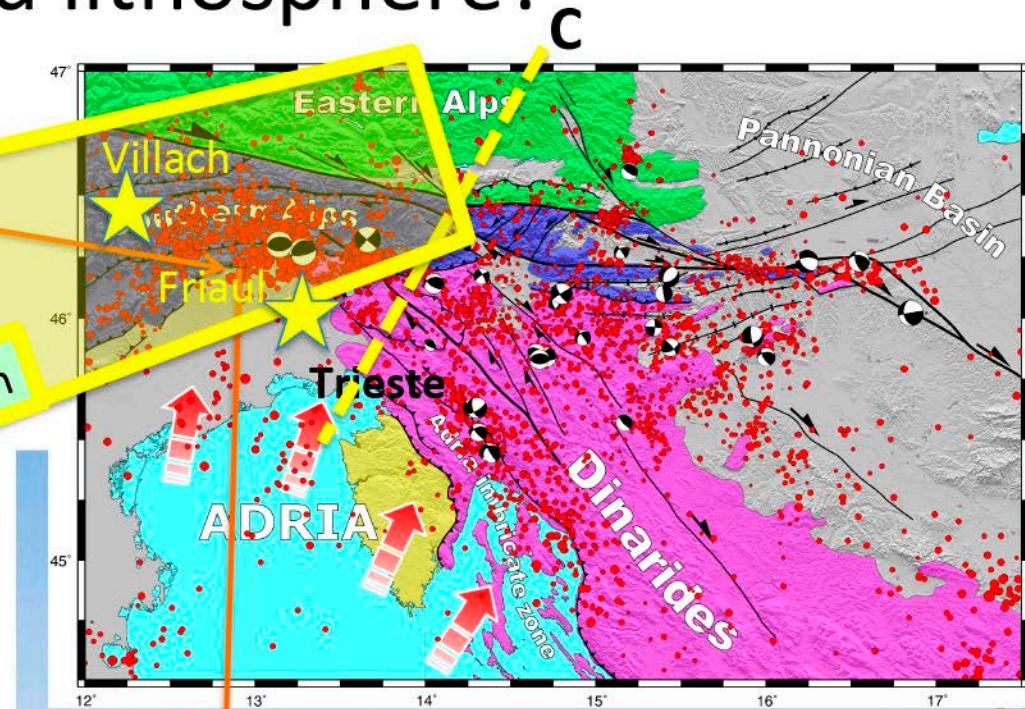
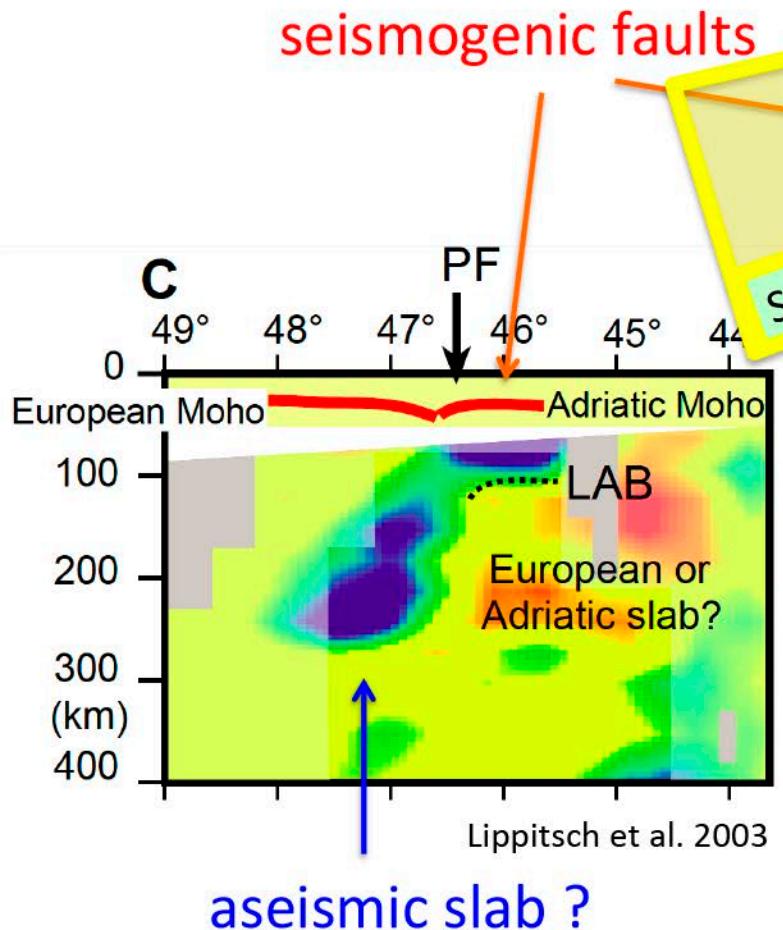


Zertani et al. 2016

Slab top geometries & their images

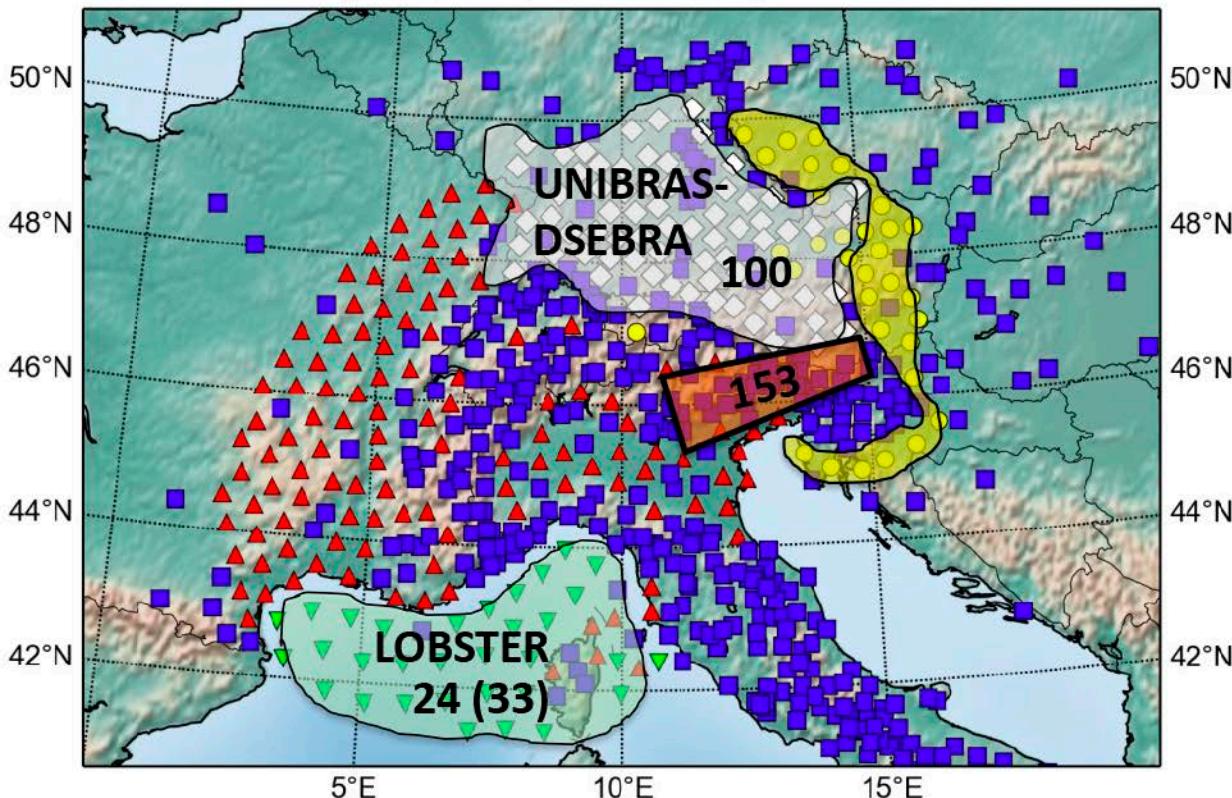


Theme 4 – How are active faults coupled with subducted lithosphere?



Seismological Activity Fields

Envisaged AlpArray network configuration in 2018



Permanent stations 2015
Temp stations F, I, CH, SL, etc.

German contributions
UNIBRAS/DSEBRA sta 2015-18
DSEBRA additional sta 2018
LOBSTER OBS 2017-18
Swath 2017-19

SPP contributions to the AA network:

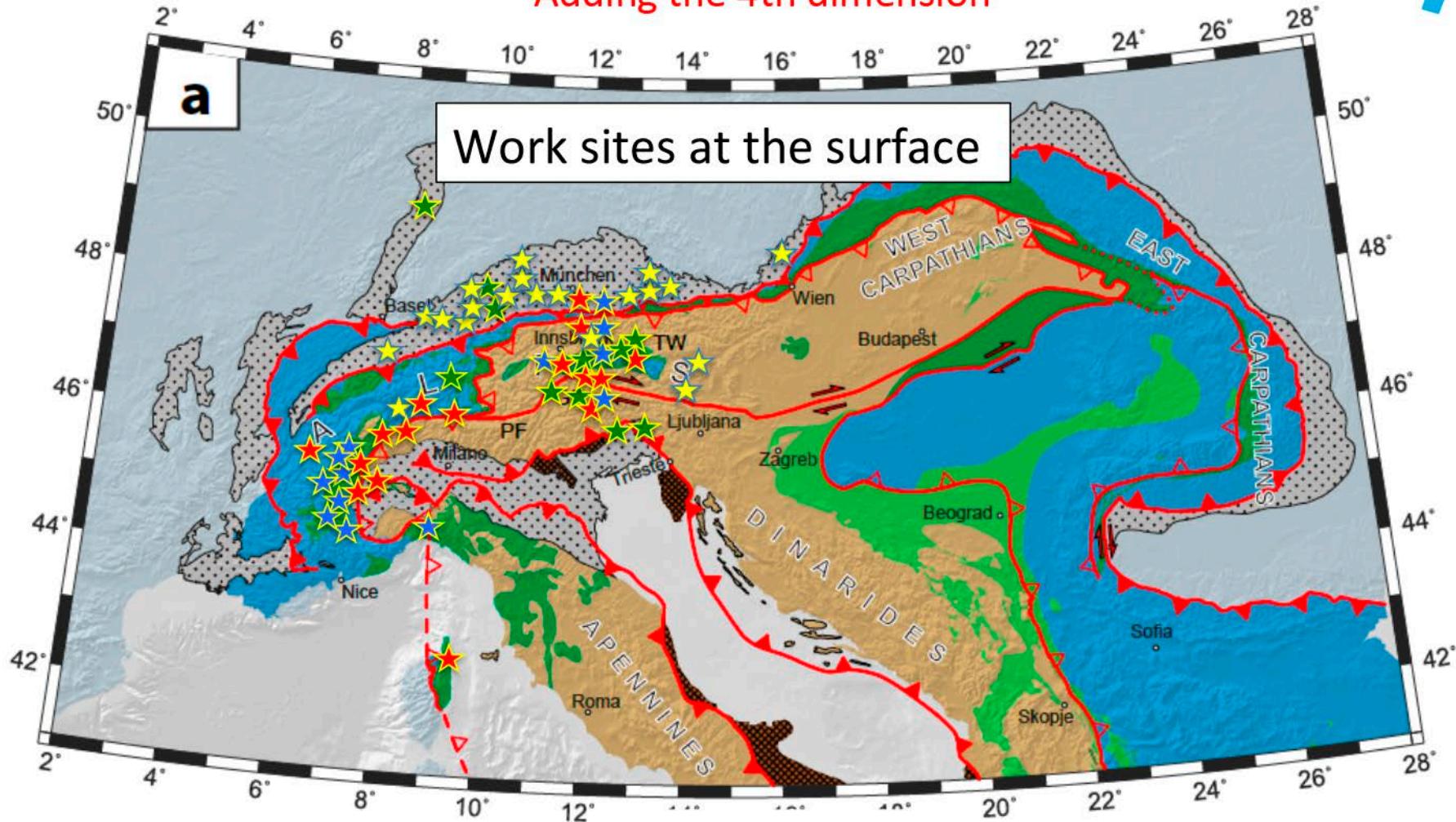
- Deployment & operation of 100 land stations (**DSEBRA**) & 24 of 33 ocean-bottom stations (**LOBSTER**)

SPP targeted study:

- Densified station **swath (153 stat)** deployment, operation, data acquisition & research projects

Geodynamic Activity Fields

Adding the 4th dimension

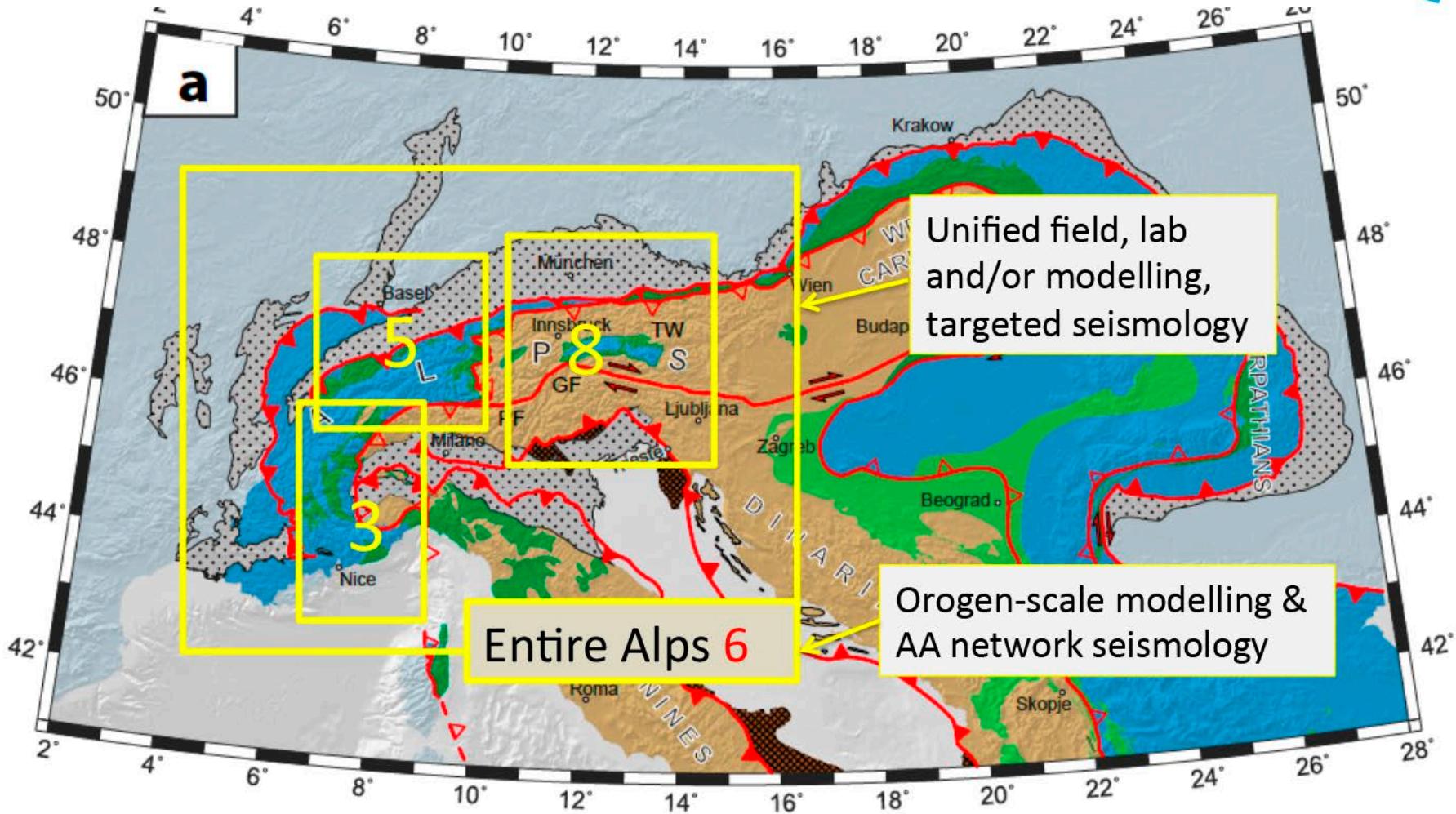


Main tectonic units

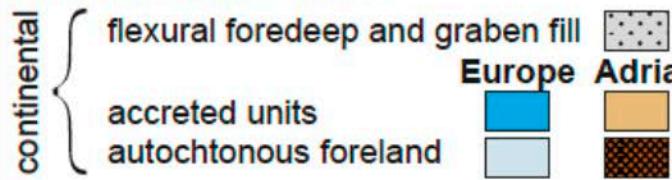
- continental {
flexural foredeep and graben fill Europe Adria
accreted units
autochthonous foreland

- 1 - Reorg. of the lithosphere
2 - Surface response to deep processes
3 - Deform. of crust & mantle
4 - Motion patterns & seismicity
- } Research Themes

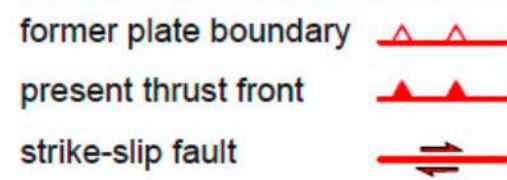
Location of funded projects (22)



Main tectonic units



Main tectonic boundaries



Schedule for 4D-MB - 1st Phase

Activity Field	Activity	Preparation	1 st Funding Phase	Research Theme
Land	Deployment & data aquire Model results	UNIBRAS	DSEBRA	1, 2, 3, 4
Marine	Deployment & data aquire Model results	LOBSTER		
Swath	Deployment & data acquire Model results	SWATH		
Geology	Structural & thermo-chronological analysis of active & fossil fault Petrophysical studies of high-P rock Determine burial, denudation & uplift rates	field		2, 3, 4
Thermo-mechan model	Develop lithospheric model of the Eastern Alps Thermo-mechanical modelling of crust & mantle	develop		1, 3, 4
	Synthesis & Publication			1, 2, 3, 4

2017

2018

2019

2020

What happens beneath the clouds ?

A photograph of a mountain range, likely the Himalayas, during sunset or sunrise. The sky is filled with dense, layered clouds. In the foreground, a snow-capped mountain peak is visible, its white surface contrasting with the warm orange and yellow hues of the setting sun. Behind it, more mountain peaks are visible, partially obscured by the clouds. The overall scene is one of tranquility and natural beauty.