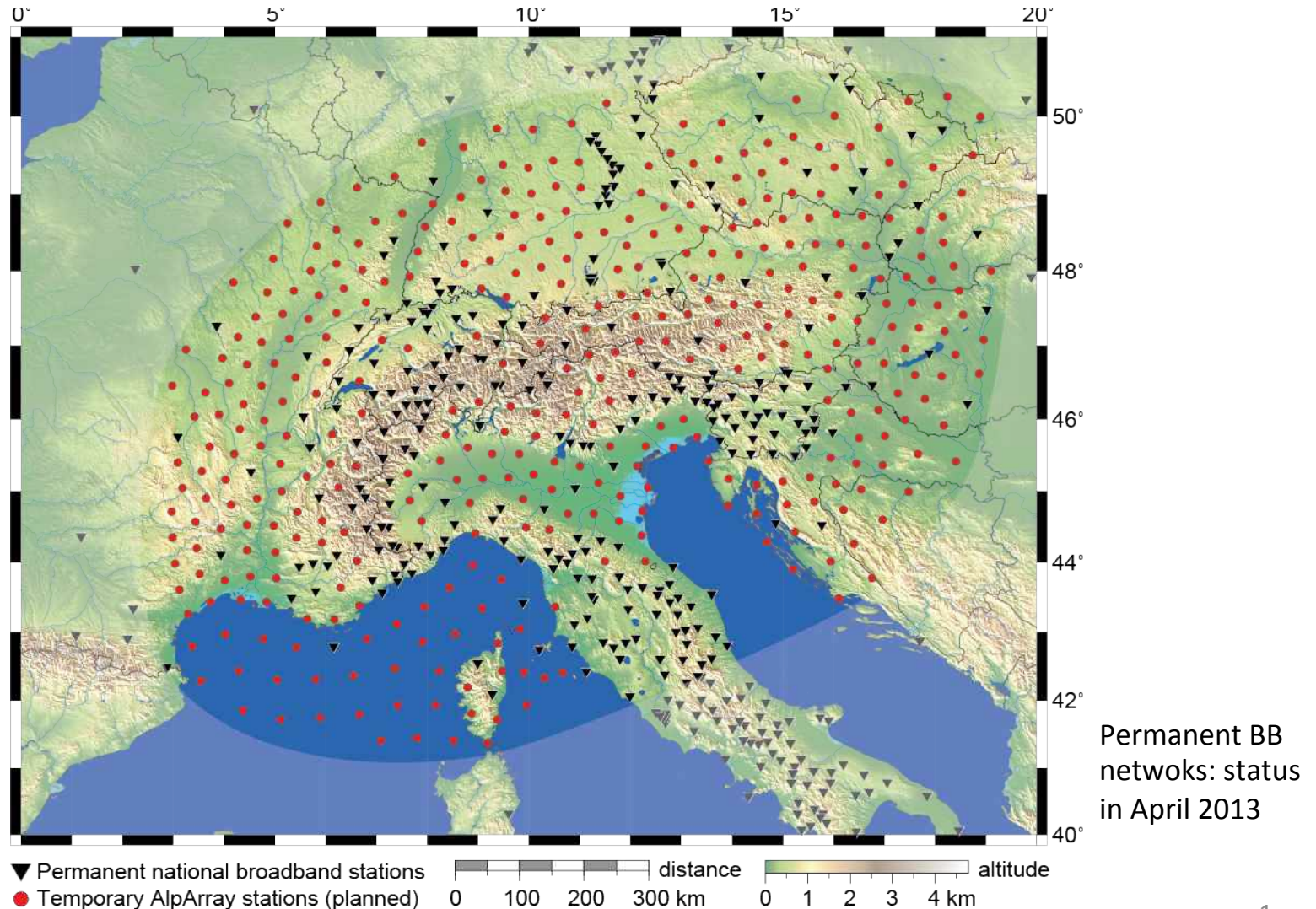


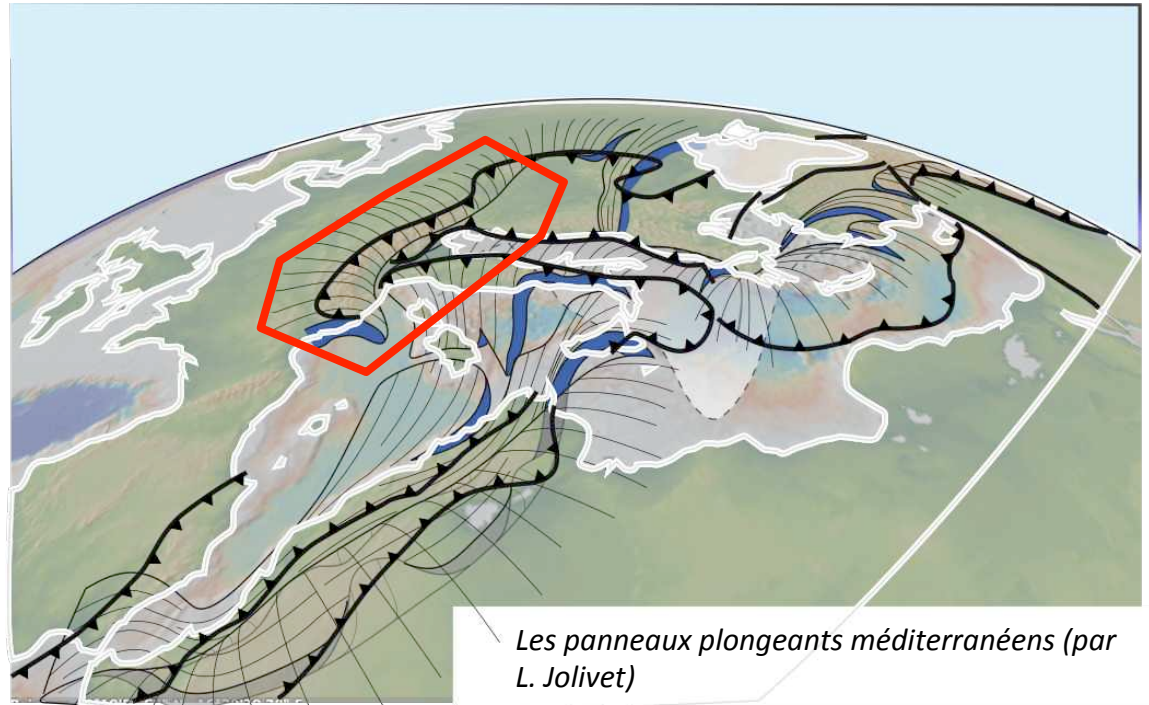
# AlpArray:

## Probing Alpine geodynamics with the next generation of geophysical experiments and techniques



# Pourquoi les Alpes? Parce que les Alpes...

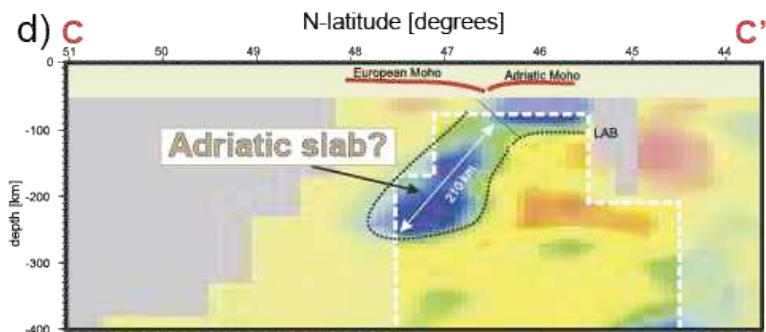
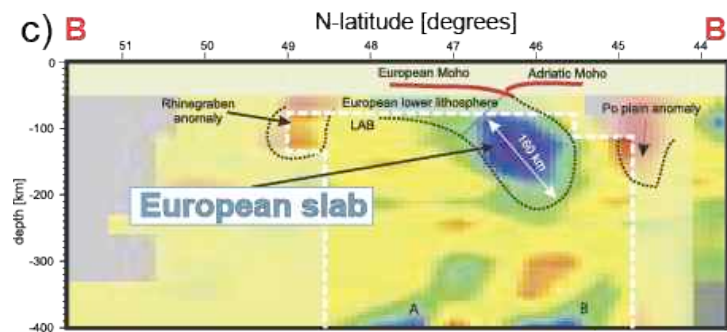
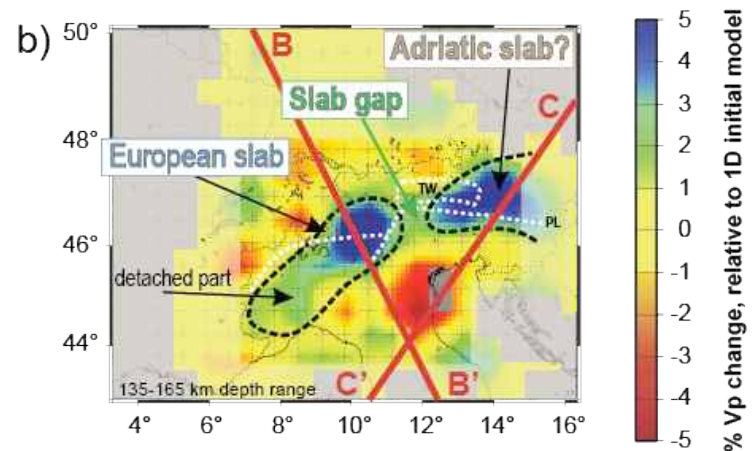
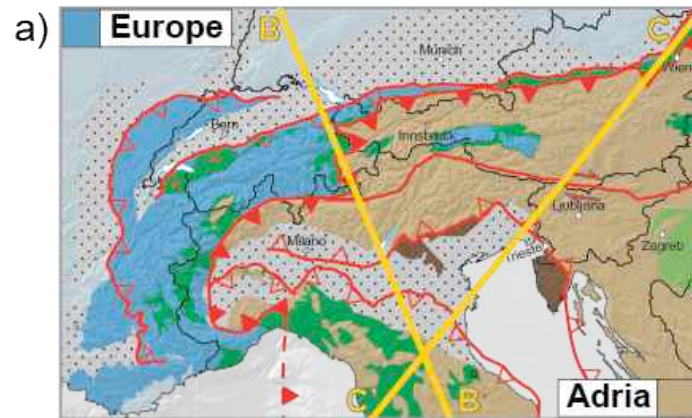
- ✓ La chaîne de montagne la plus étudiée au monde par la géologie: base de données exceptionnelle qui doit permettre d'avancer sur la compréhension des processus orogéniques à toutes les échelles
- ✓ Aléa sismique significatif + population dense
- ✓ Grande diversité de processus géodynamiques dans une région limitée
- ✓ Emergence de nouvelles questions: rôle de l'héritage structural dans la formation des chaînes de montagne, moteurs de l'extension, du soulèvement actuel des zones internes, ...
- ✓ De nouvelles données sismologiques de qualité + de nouvelles méthodes d'imagerie pour de nouveaux modèles géodynamiques et probablement de nouveaux concepts



# Pourquoi les Alpes? Parce que les Alpes...

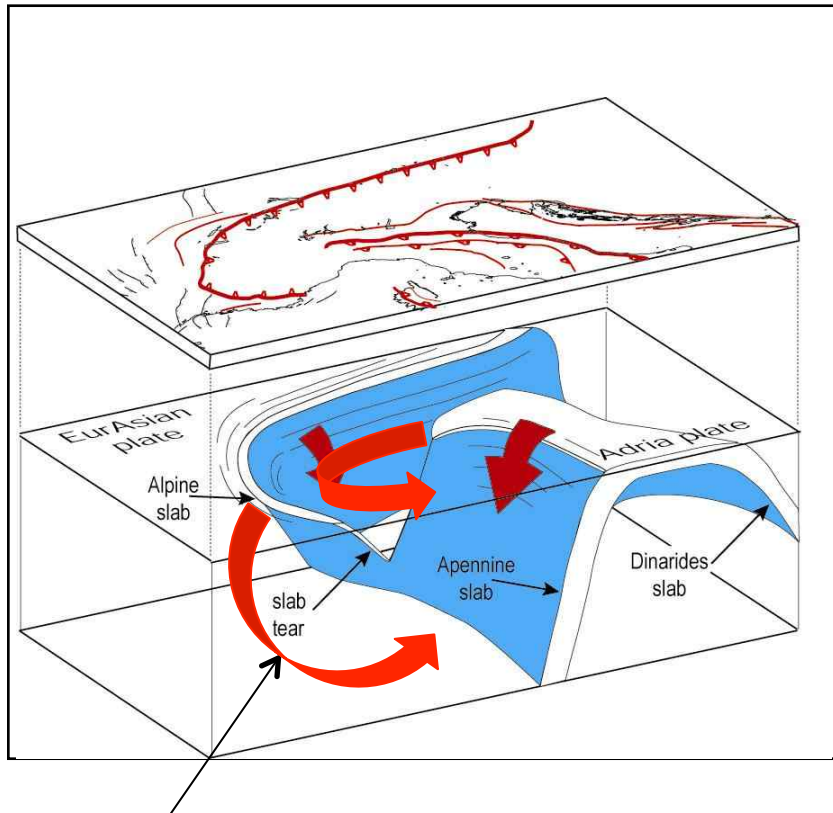
## Structure du manteau supérieur sous les Alpes: questions

Micro-plaques, subductions, panneaux plongeants détachés ou déchirés, lithosphères océaniques et continentales, subductions à vergences opposées? ...



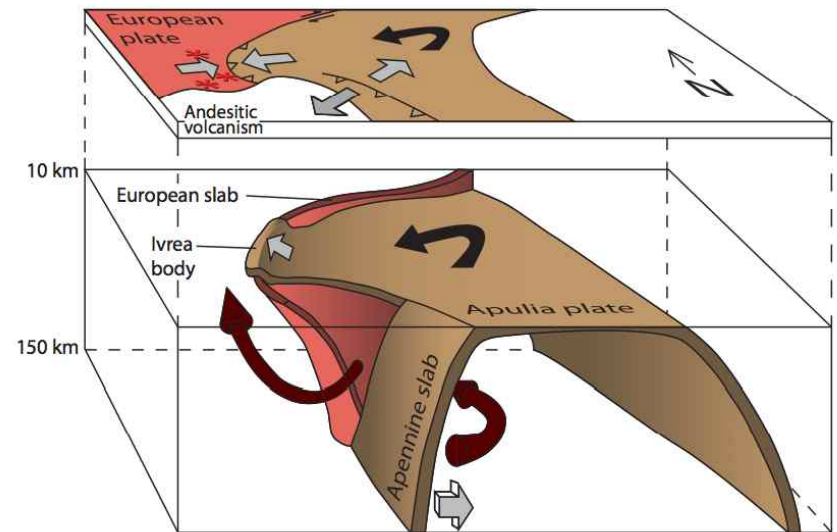
# Pourquoi les Alpes? Parce que les Alpes...

Transition Alpes-Apennins: subductions (?) de polarités inverses, flux mantellique, corps d'Ivrée



Expected mantle flow

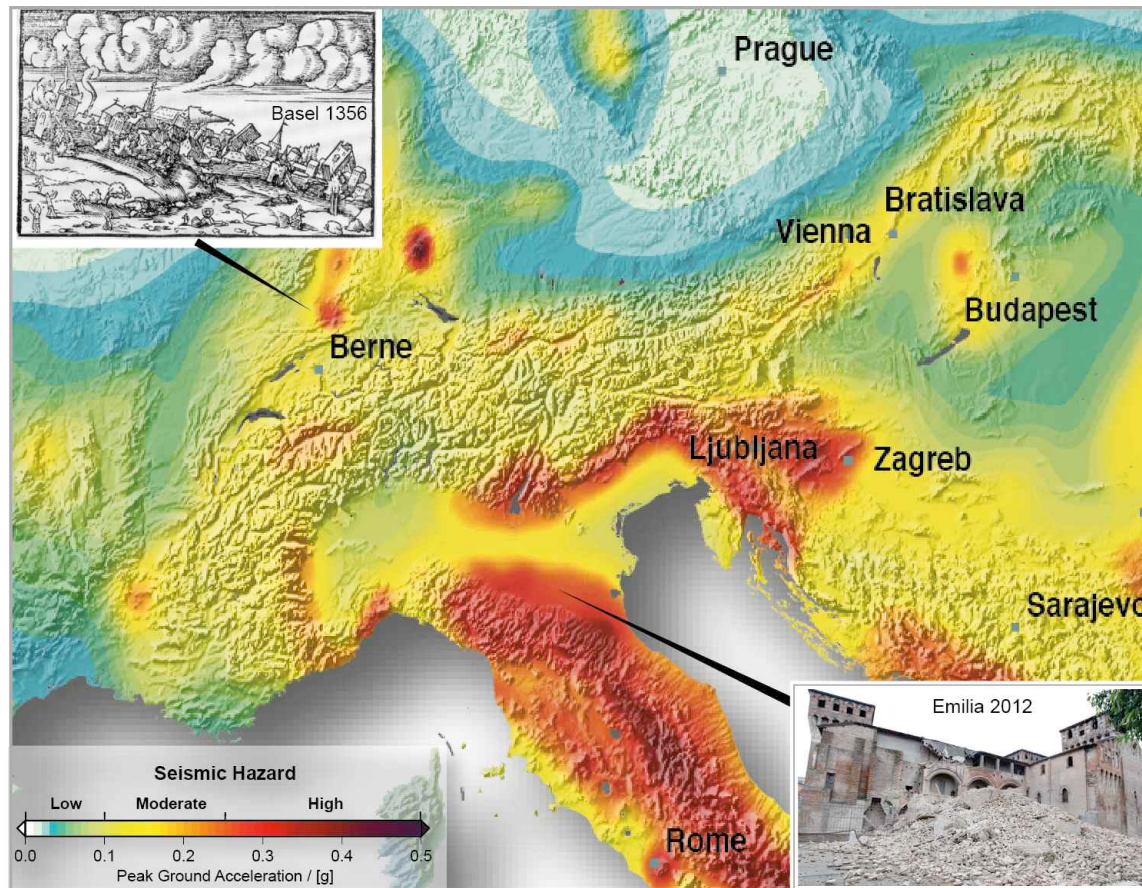
*Vignaroli et al. (2008)*



*Jourdan et al. (2013)*

# Pourquoi les Alpes? Parce que les Alpes...

## Aléa sismique



*Seismic hazard in the greater Alpine area according to the recently released SHARE project ([www.share-eu.org](http://www.share-eu.org)) model. Reality is depicted with the example of the historical Basel and the recent Emilia earthquakes.*

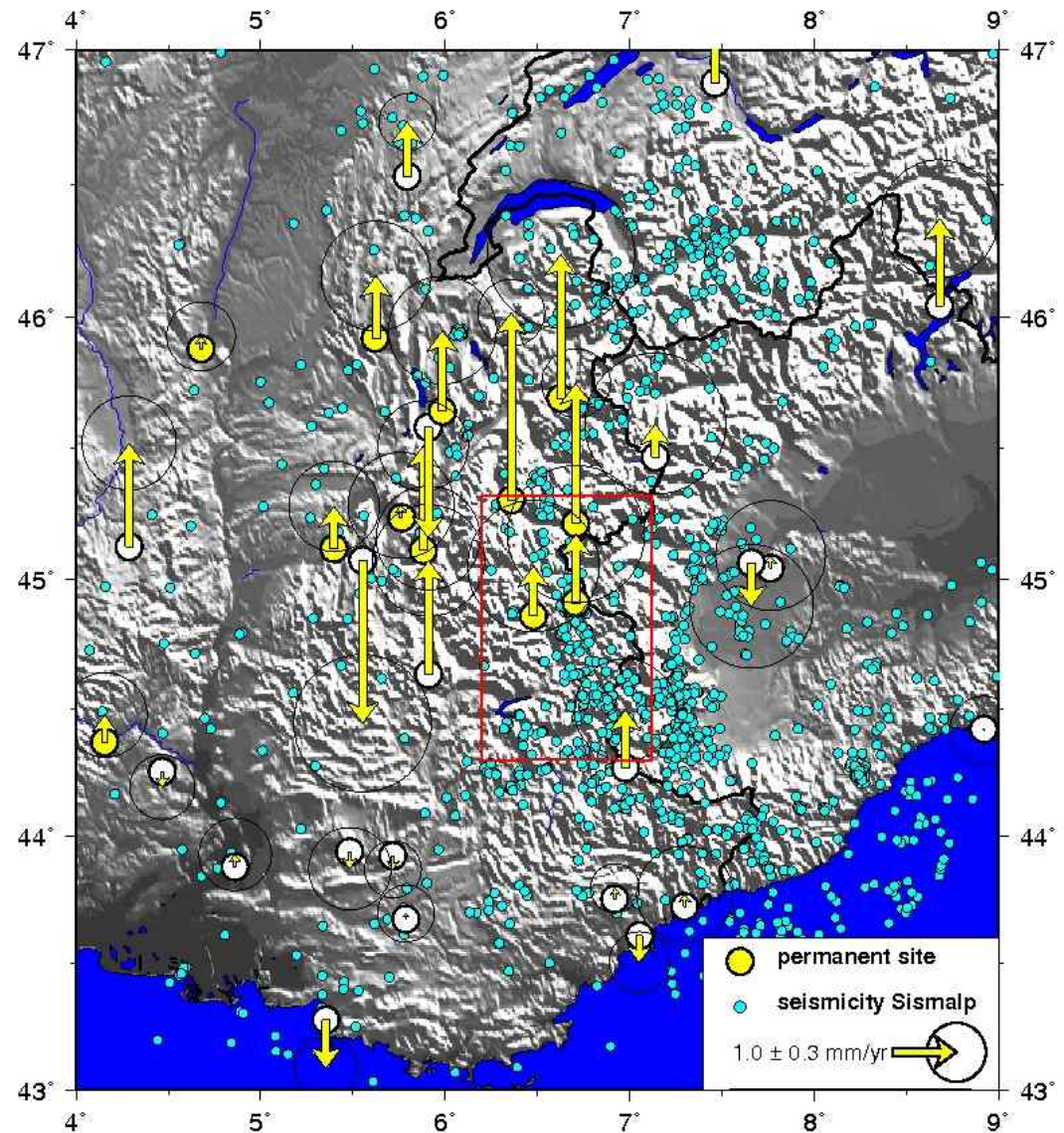
# GPS velocities



## Vertical velocities:

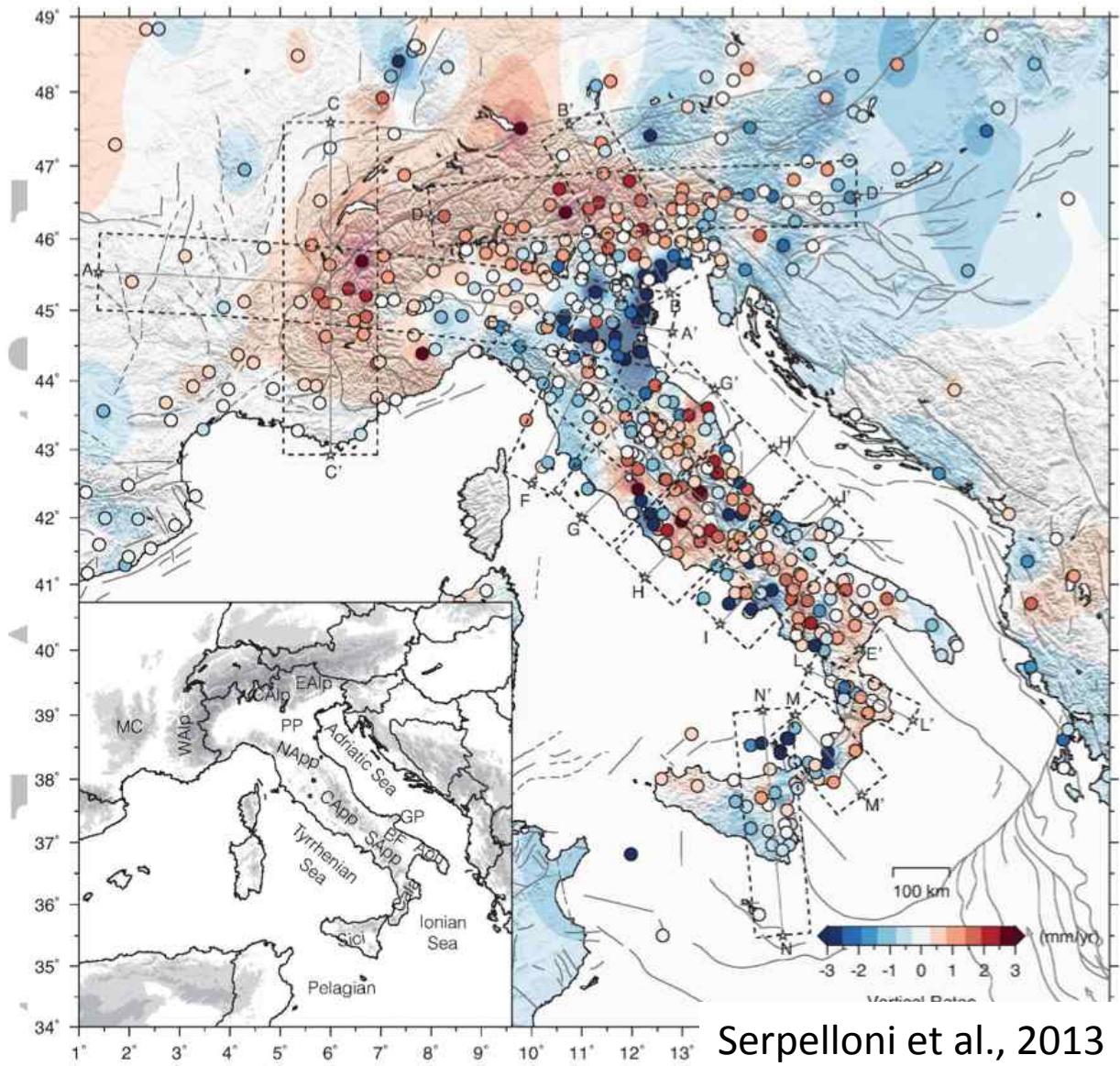
Permanent GPS stations in  
and around the southwestern  
Alps:

- older than 5 years



# Pourquoi les Alpes? Parce que les Alpes...

## Déplacements verticaux



# PRESENT-DAY UPLIFT RATES IN THE WESTERN ALPS

GPS uplift rates are still larger than the sum of individual processes

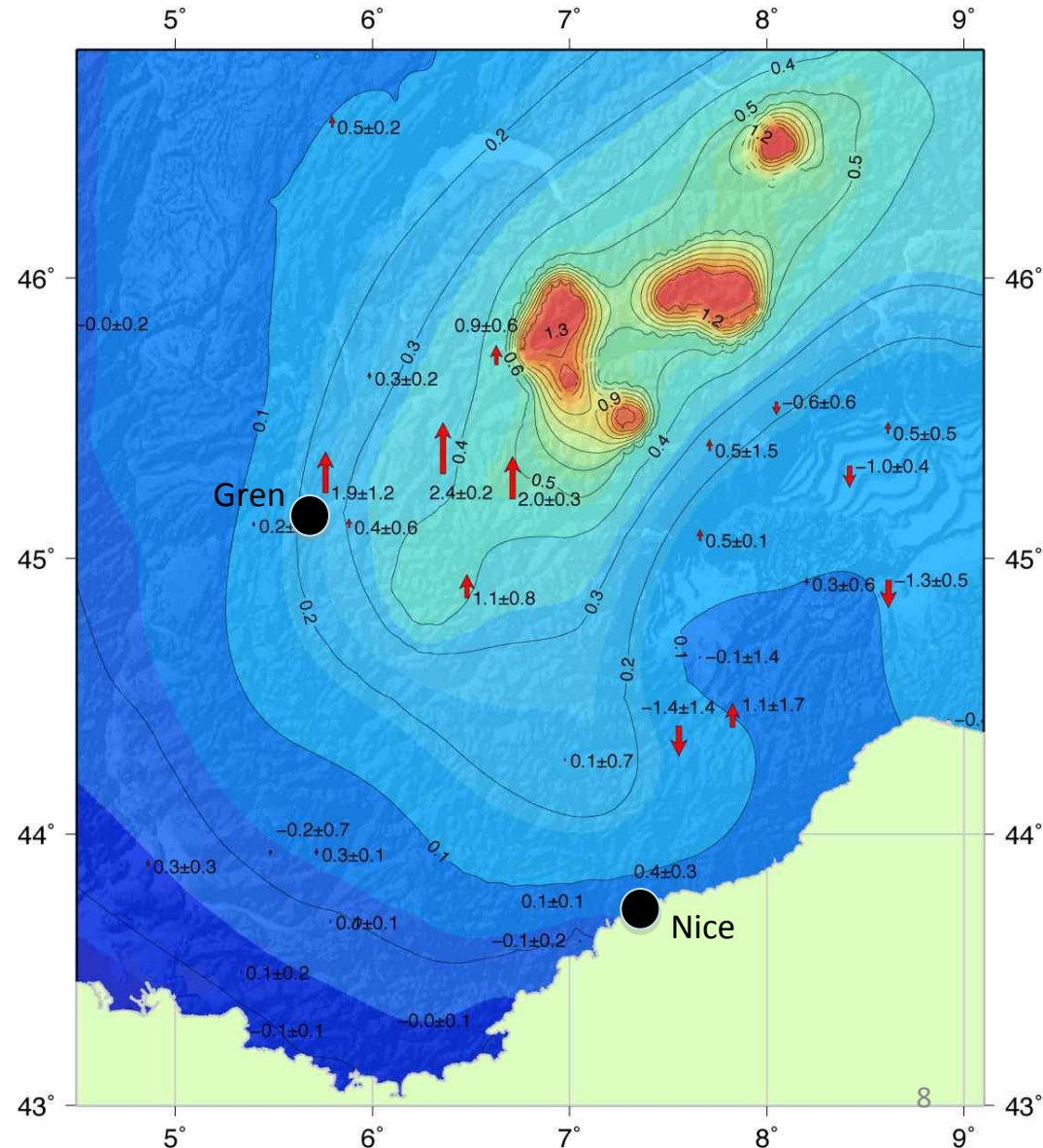
- GIA since Last Glacial Maximum
- GIA contribution since Little Ice Age (Glacier shrinkage)
- Response to erosional unloading

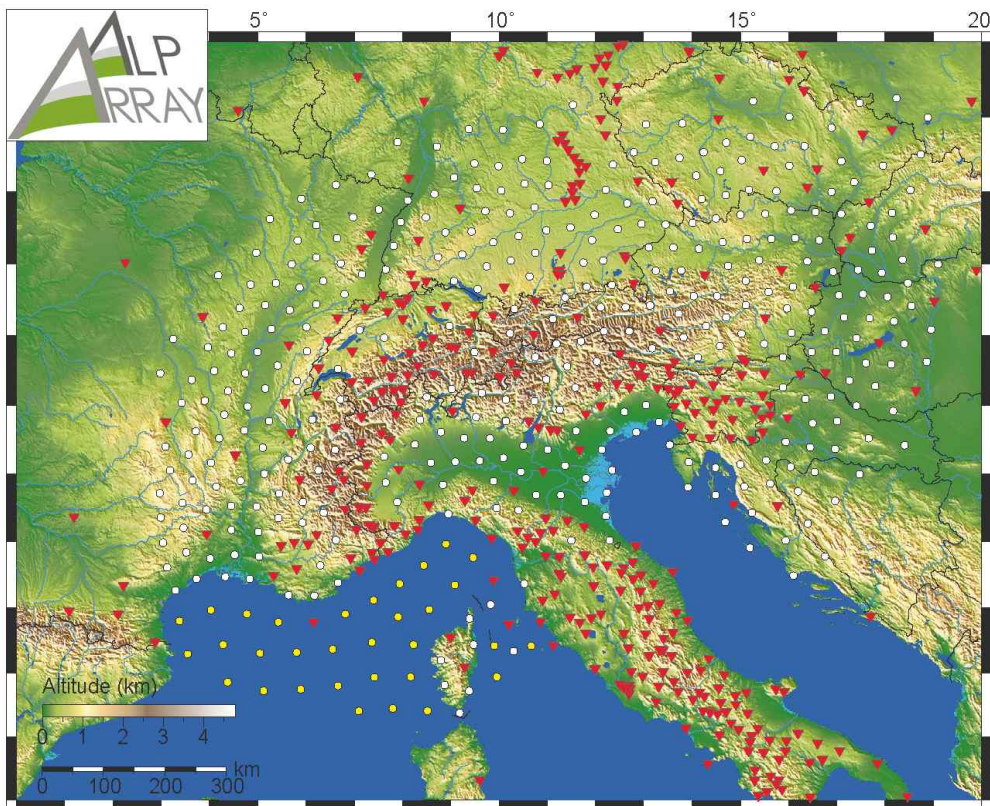
Model improvements required ?

Contribution of deep processes ?

- What is presently the motor of crustal deformation ?

- What is the source of seismicity ?





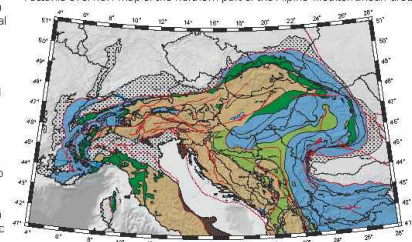
# AlpArray:

50° an initiative to advance understanding of Alpine geodynamics

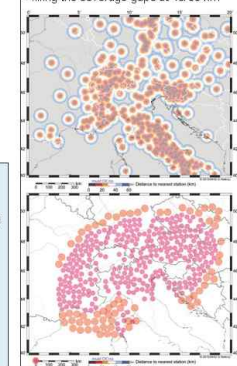
AlpArray is an initiative to study the greater Alpine area with a large-scale broadband seismological network. The interested parties (currently 67 institutes in 16 countries) plan to combine their existing infrastructures into an all-out transnational effort that includes data acquisition, processing, imaging and interpretation. The experiment will encompass the greater Alpine area from the Black Forest and the Bohemian Massif in the north to the Northern Apennines in the south and from the Pannonian Basin in the east to the French Massif Central in the west. We aim to cover this region with a high-quality broadband seismometer backbone by combining the ca. 220 existing permanent stations with additional 350 instruments from mobile pools, all of them to be deployed from 2014-2015 until 2017. In this way, we plan to achieve homogeneous and high resolution coverage (ca. 40 km average station spacing). Furthermore, we also plan to deploy a few densely spaced targeted networks along swaths across – and in regions of – key parts of the Alpine chain on shorter time scales. These efforts on land will be combined with deployments of up to 40-45 ocean bottom seismometers in the Mediterranean Sea. We also aim to implement the best practice for synchronizing mobile pool operation procedures and data handling, common data centre and data management procedure, free access to data to participants as soon as possible through **EIDA**. Data will be open to the public 3 years after the experiment ends.

The main scientific goal of AlpArray is to investigate the structure and evolution of the lithosphere beneath the Alps. A primary target is the geometry and configuration of subducting slabs and their polarity switch beneath the arc. Numerous regional questions such as seismic hazard will be tackled. Targets will be imaged at several depths (e.g., from near-surface structure down to upper mantle anisotropy), scales (e.g., from local seismicity to mantle transition zone thickness variations), using different methodologies in the sub-regions of interest. An overview of these targets and the methodologies intended to be applied in connection with the seismological measurements will be presented. The geodynamic interpretation of the acquired data will be complemented by other Earth Science disciplines such as state-of-the-art numerical and analogue modelling, gravity and magneto-telluric measurements, as well as structural geology. In conclusion, we hope to turn the strong community interest into a truly interdisciplinary and collaborative project in the key region for seismotectonic activity and dynamics of Europe.

Tectonic overview map of the northern part of the Alpine-Mediterranean area



Planning details:  
distance to nearest station in each point  
- filling the coverage gaps at 40/60 km



## AlpArray in brief:

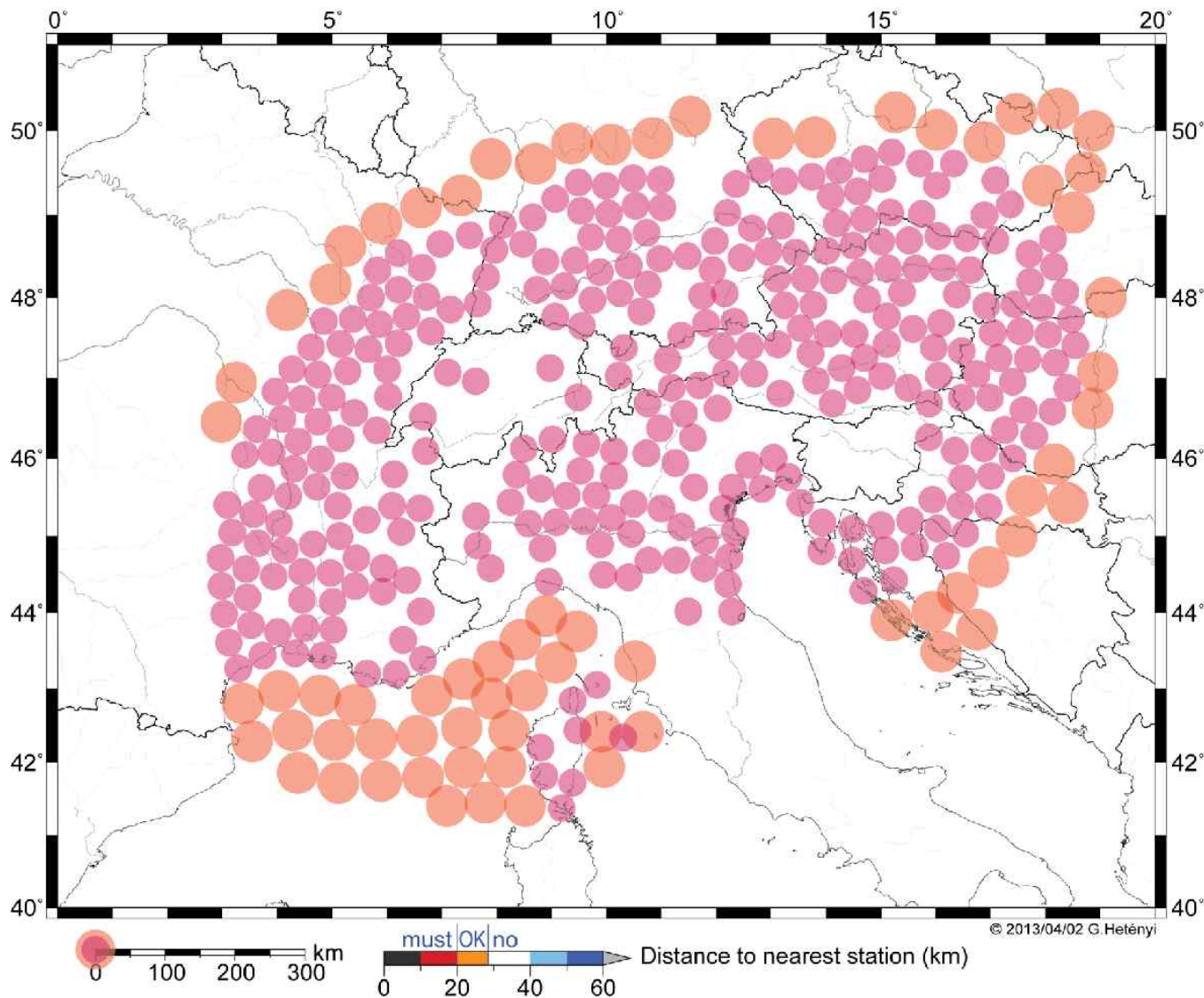
- ▼ 356 permanent broadband stations on map of which 227 within 250 km distance of the Alps
- + 350 stations to be deployed on land
- + 32-45 OBS to deploy in the Ligurian Sea
- = 40 km average station spacing obtained

## AlpArray:

- ✓ backbone: vers une image de résolution homogène (~40 km) de la structure croûte+manteau sup. sous tout l'arc alpin
- ✓ réseaux ciblés denses (qqes km) sur objectifs particuliers (sud Fossé Rhénan, Mer Ligure, ...)
- ✓ acquisition, synthèse d'autres données géophysiques (gravimétrie)
- ✓ modélisation géodynamique

Projet d'échelle européenne (16 pays intéressés dont l'Allemagne, la Suisse, l'Autriche, l'Italie, la G-B., la France,) sans financement européen: fédération de projets nationaux sur financements nationaux et utilisant les infrastructures nationales

# Carte des stations temporaires du backbone AlpArray (04/13)



## Updated plans

FR 93 +6

IT 53 +2

DE 52

AT 44

CZ 28

HR 25

HU 24

CH 6

SK 8

PL 2

SI 1

(BA 6)

**Land: 350**

**OBS: 32 → 39-45**



Dans l'état actuel de RESIF-RLBP: 99 stations temporaires nécessaires à terre en France + OBS en mer Ligure et Golfe du Lion. En 2015: 15 stations RESIF-RLBP en plus, donc 15 stations temporaires en moins

# AlpArray complementary experiments

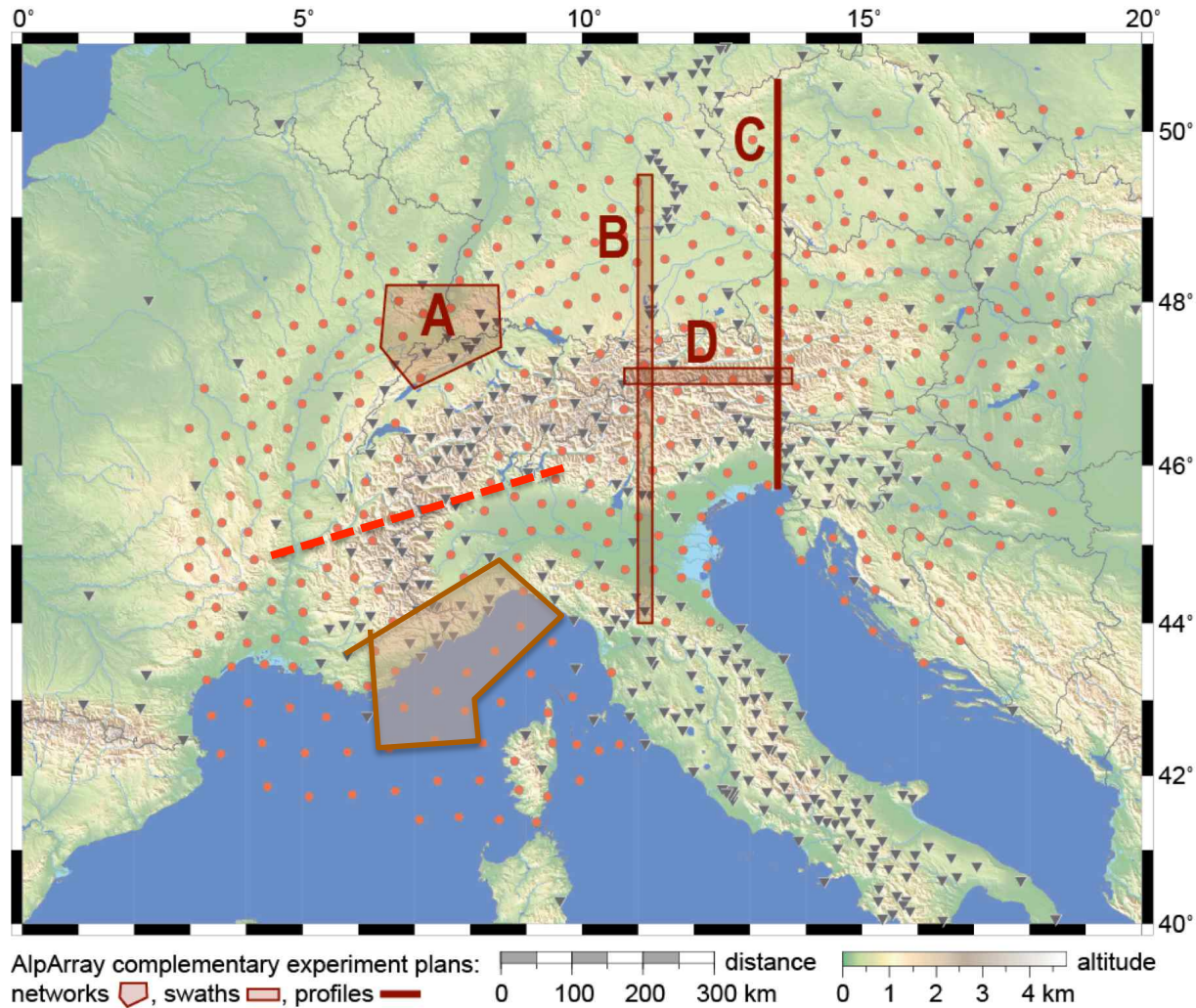
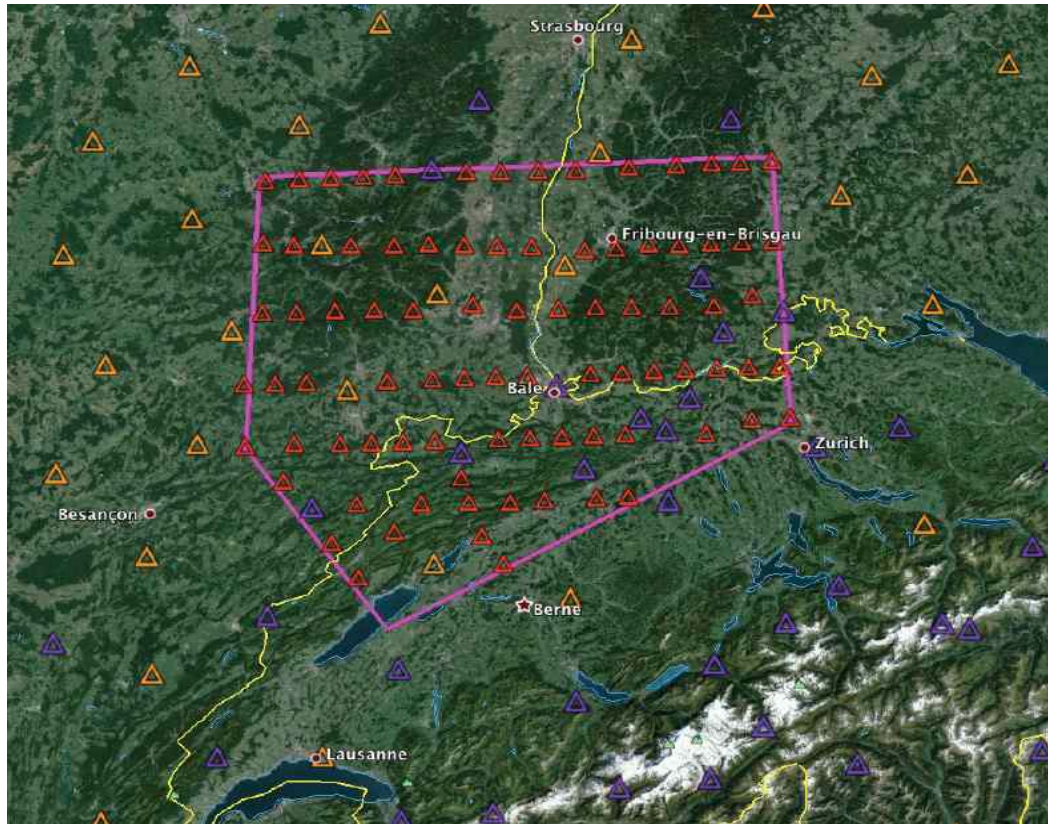


Figure 6: A few examples of **AlpArray complementary experiments** to be carried out in addition to the pan-Alpine seismic network (dimmed symbols) to address targets of special importance and regional-scale problems. See text

# Upper Rhine Graben targeted network

Aims: better understanding the mechanisms of the rifting process in the URG and deciphering the real influence of the Alpine orogeny. Also, the imaging of the crustal features and the recognition of microseismicity patterns will lead to a much better assessment of seismic risk.



## Partners

- Ecole et Observatoire des Sciences de la Terre (Strasbourg- France)
- Karlsruhe Institute of Technology (Karlsruhe – Germany)
- ETH and Swiss Seismological Service (Zurich – Switzerland)

## Experiment

Number of stations: 90 + permanent and AlpArray backbone

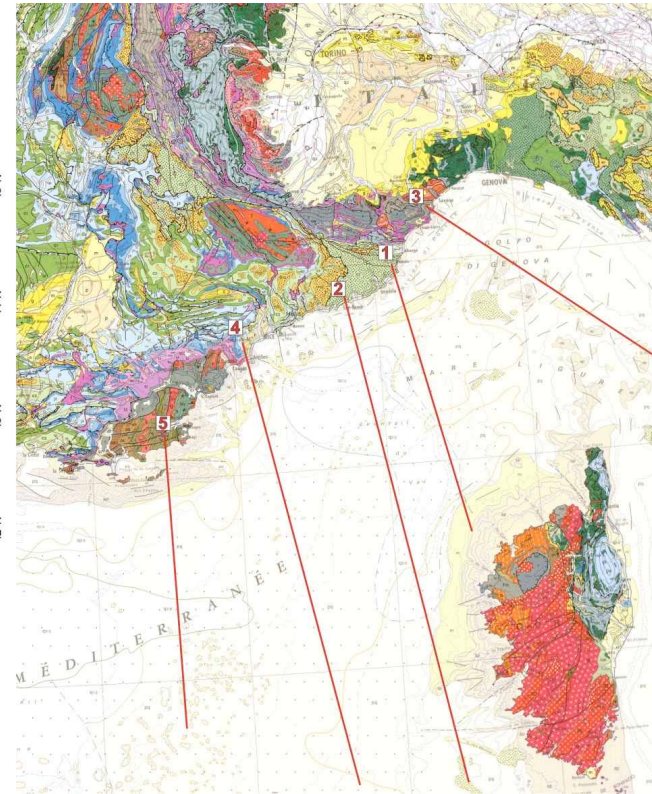
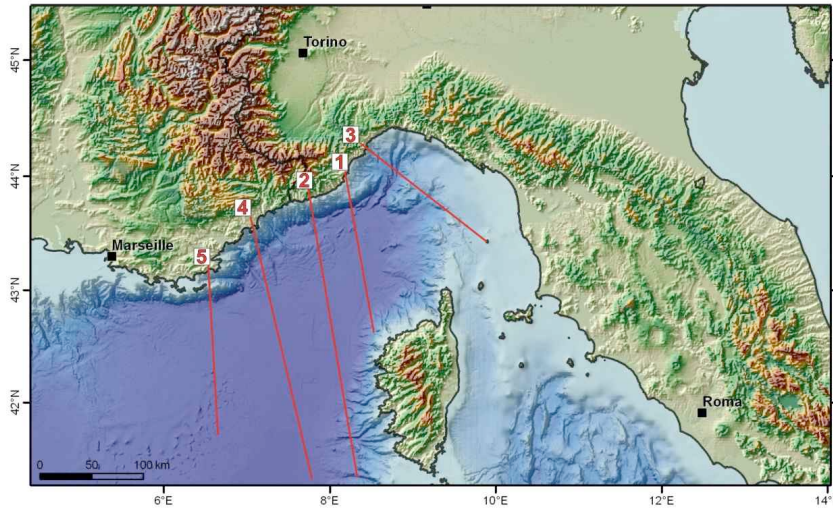
Station spacing: 10 to 20 km

Equipment: middle band and short period 3C seismometers (mostly provided by partners)

Deployment: 1 year starting in 2016?

# THE SOUTHWESTERN ALPS, THE APENNINES AND THE LIGURIAN BASIN JUNCTION

Proposed by GéoAzur



## Objectives:

- geometry of the Moho discontinuity in the basin, the margin and the coastal area
- nature and distribution of the main crustal domains : continental, transitional and oceanic
- how is the observed inversion of the margin accommodated ?
- relative influences of buoyancy and tectonic forces in the present-day deformation
- What are the major structures that can generate a strong earthquake ?

## **AlpArray – Current status in May 2014**

- Proposals funded in Austria (PI G. Bokelmann), Czech Republic (PI J. Plomerova): ready to start in the summer 2014 (by a complementary experiment)
- Proposals rejected in France (pre-proposal to ANR), and in Germany (for land instruments and science); proposals to get ship time for OBS part accepted in France and Germany.
- Switzerland, GB, ...: waiting for results of evaluation
- Difficult! But we will not give up.

## **France:**

- accélérer l'installation de stations permanentes RESIF-CLB;
- soutien financier+RH obtenu à Grenoble (ISTerre+OSUG) pour recherche de nouveaux sites (temporaires-permanents); projet-clé de la prospective ISTerre 2015-2019.
- Possibilités en cours d'exploration à IPGS & GéoAzur.
- Projet ANR en 2015.