The Abdus Salam
International Centre for Theoretical Physics

United Nations
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International Atomic
Energy Agency

H4.SMR/1775-24

"8th Workshop on Three-Dimensional Modelling of
Seismic Waves Generation, Propagation and their Inversion"

25 September - 7 October 2006

PLATE DEFORMATION - 2

Roberto Sabadini

Dipartimento di Scienze della Terra "A. Desio"
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PLATE DEFORMATION - 2

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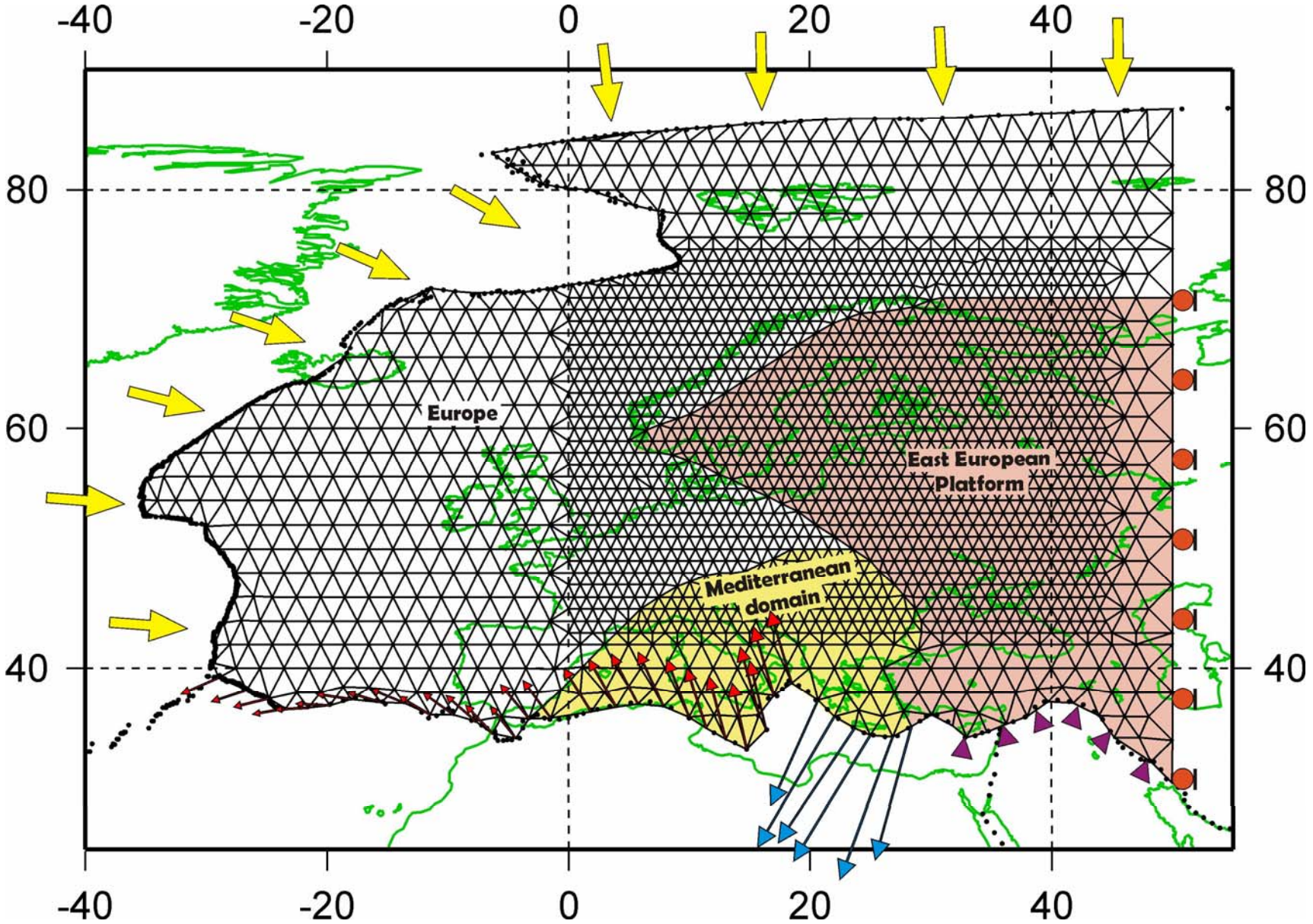
Università di Milano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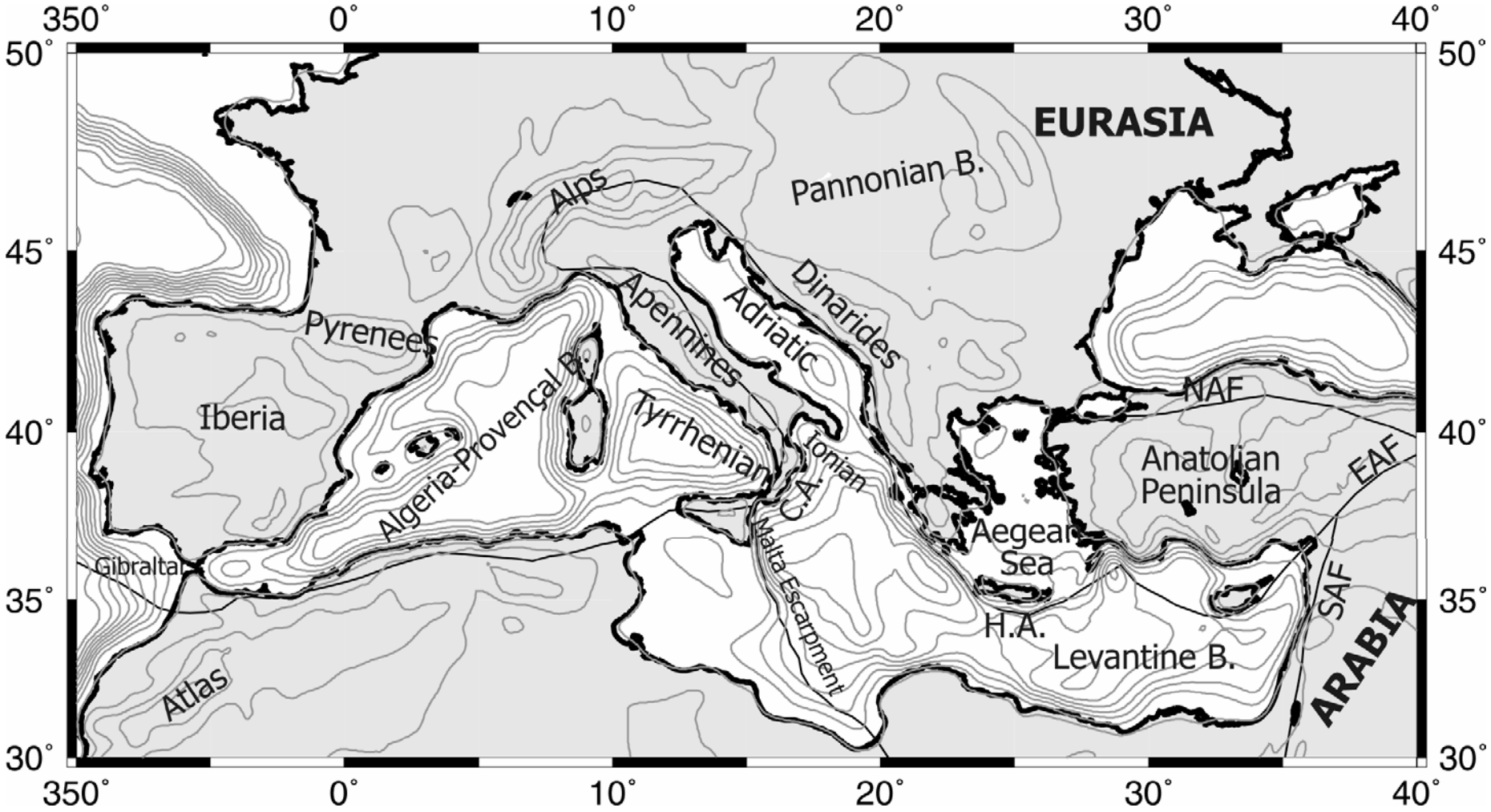
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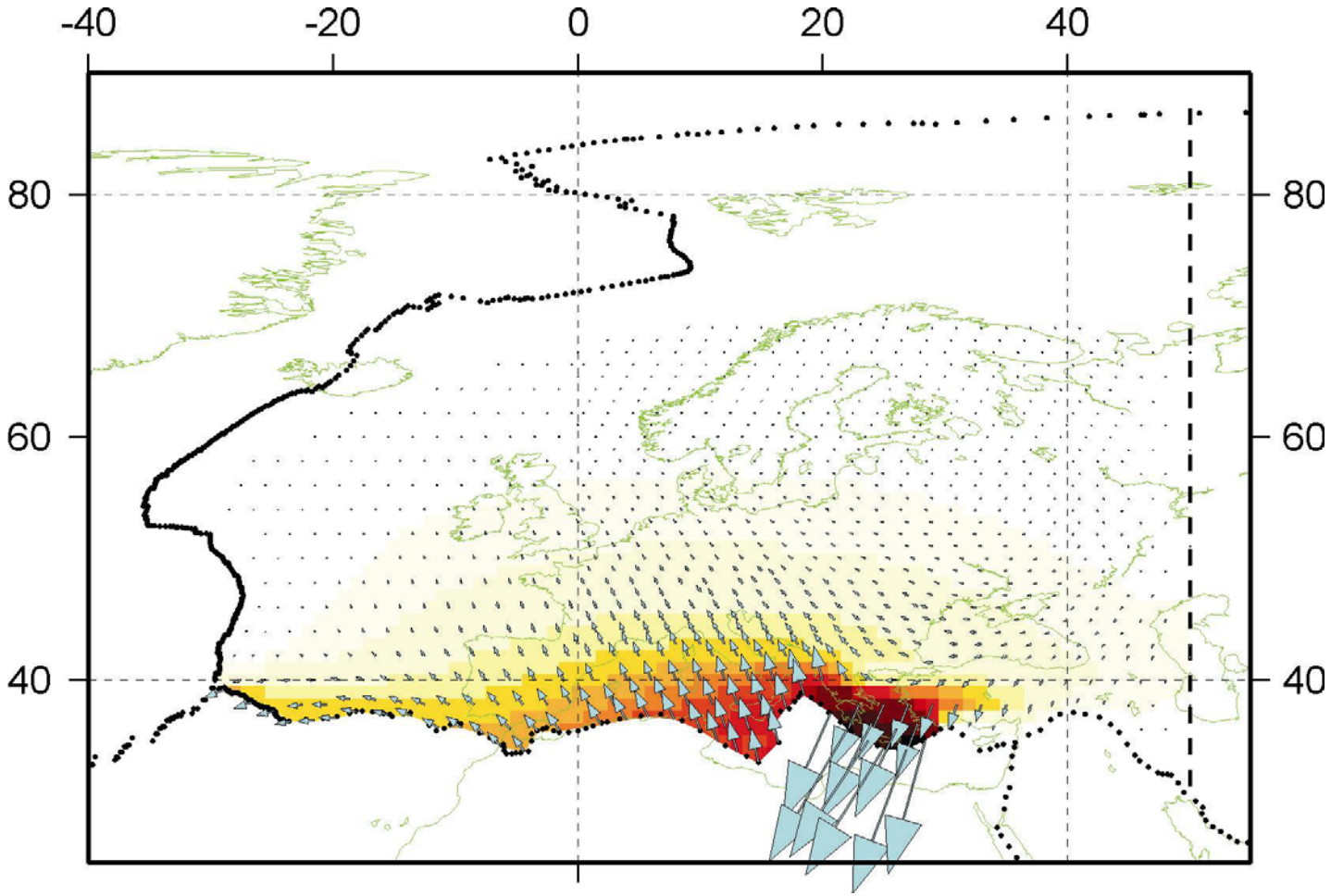
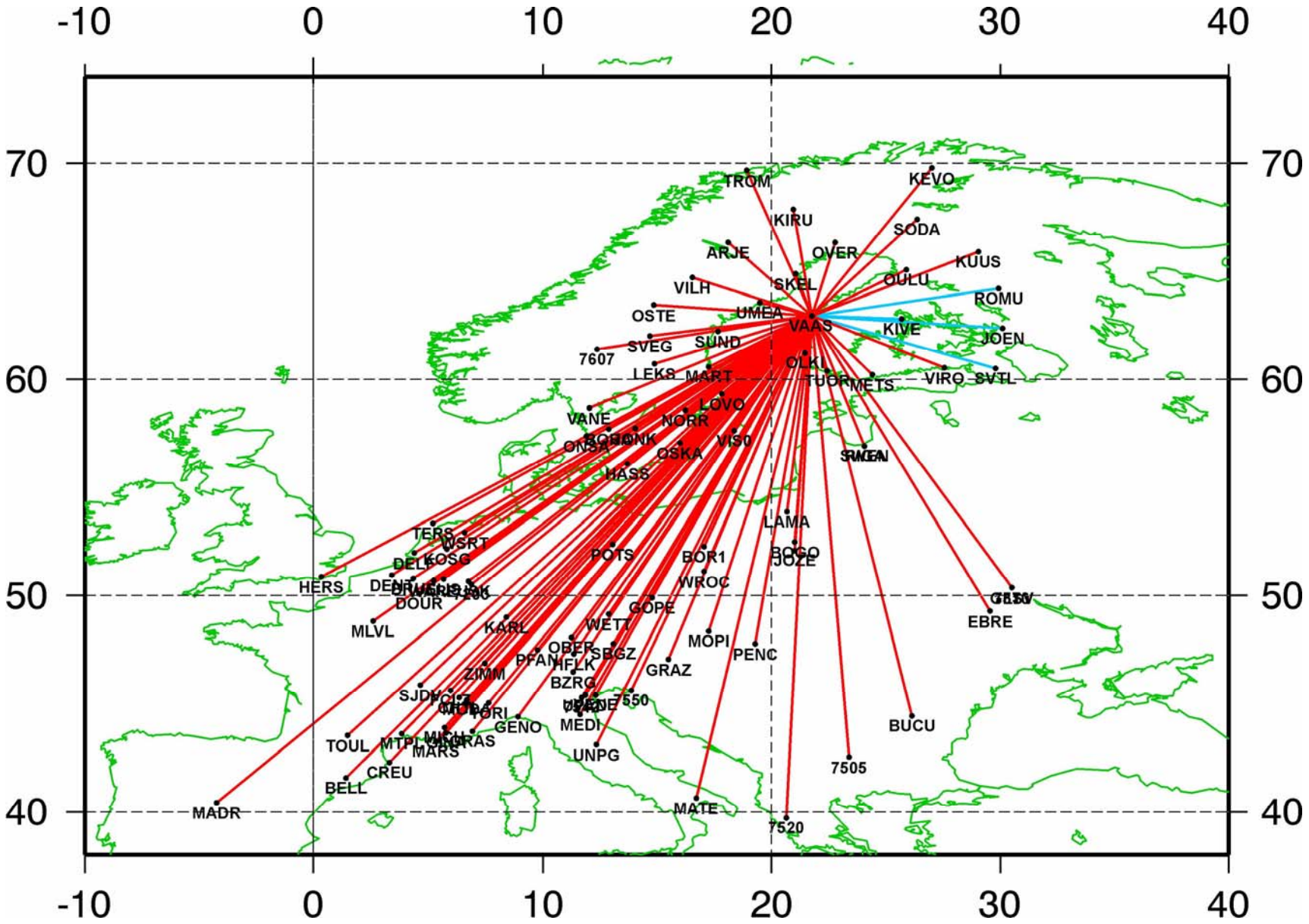
Implementation of numerical and analytical forward and inverse modeling of crust and lithosphere deformation



Marotta, A. M. et al., JGR 2004 – Combined effects of tectonics and glacial isostatic adjustment on intraplate deformation in central and northern Europe: Application to Geodetic baseline analysis.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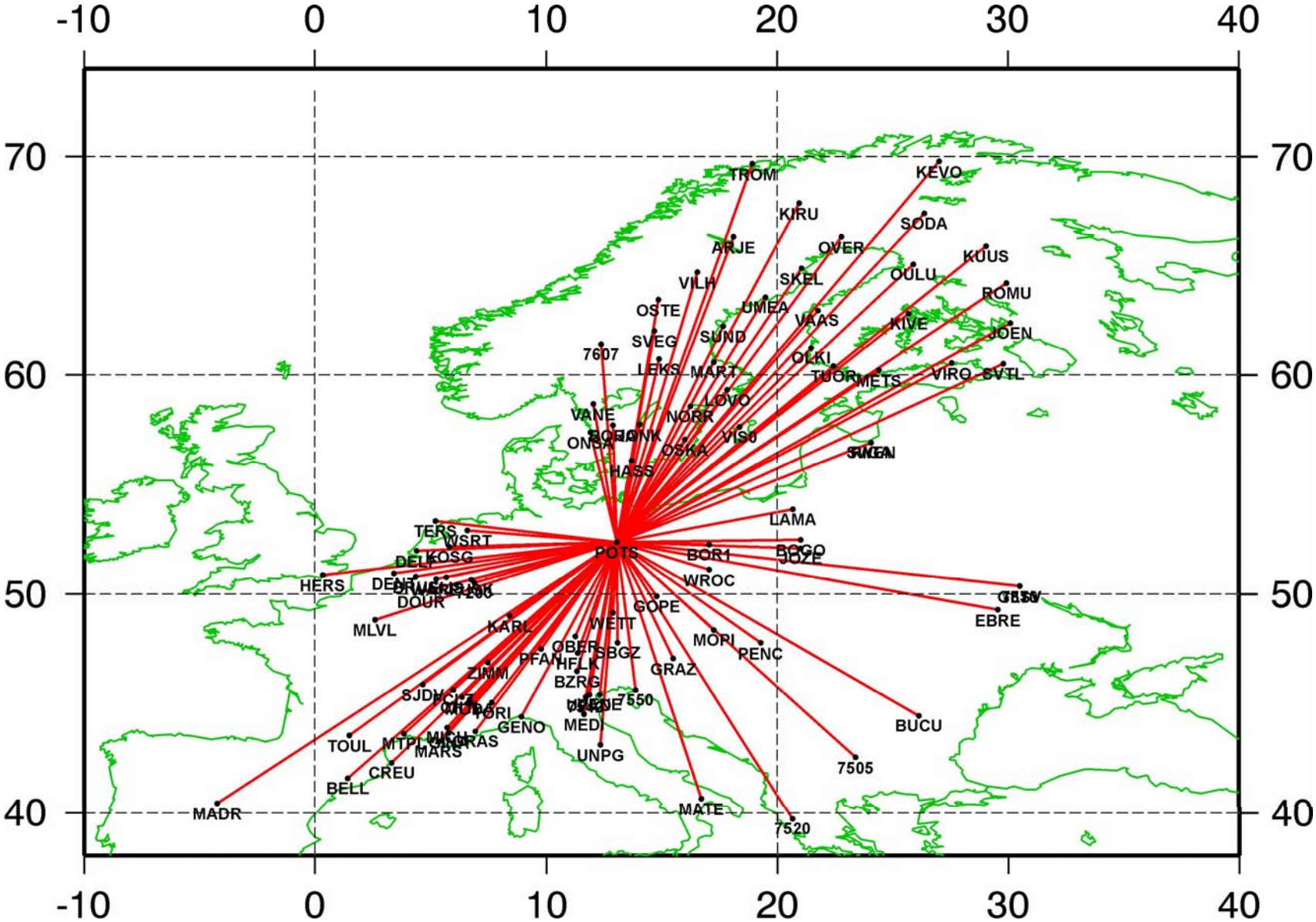
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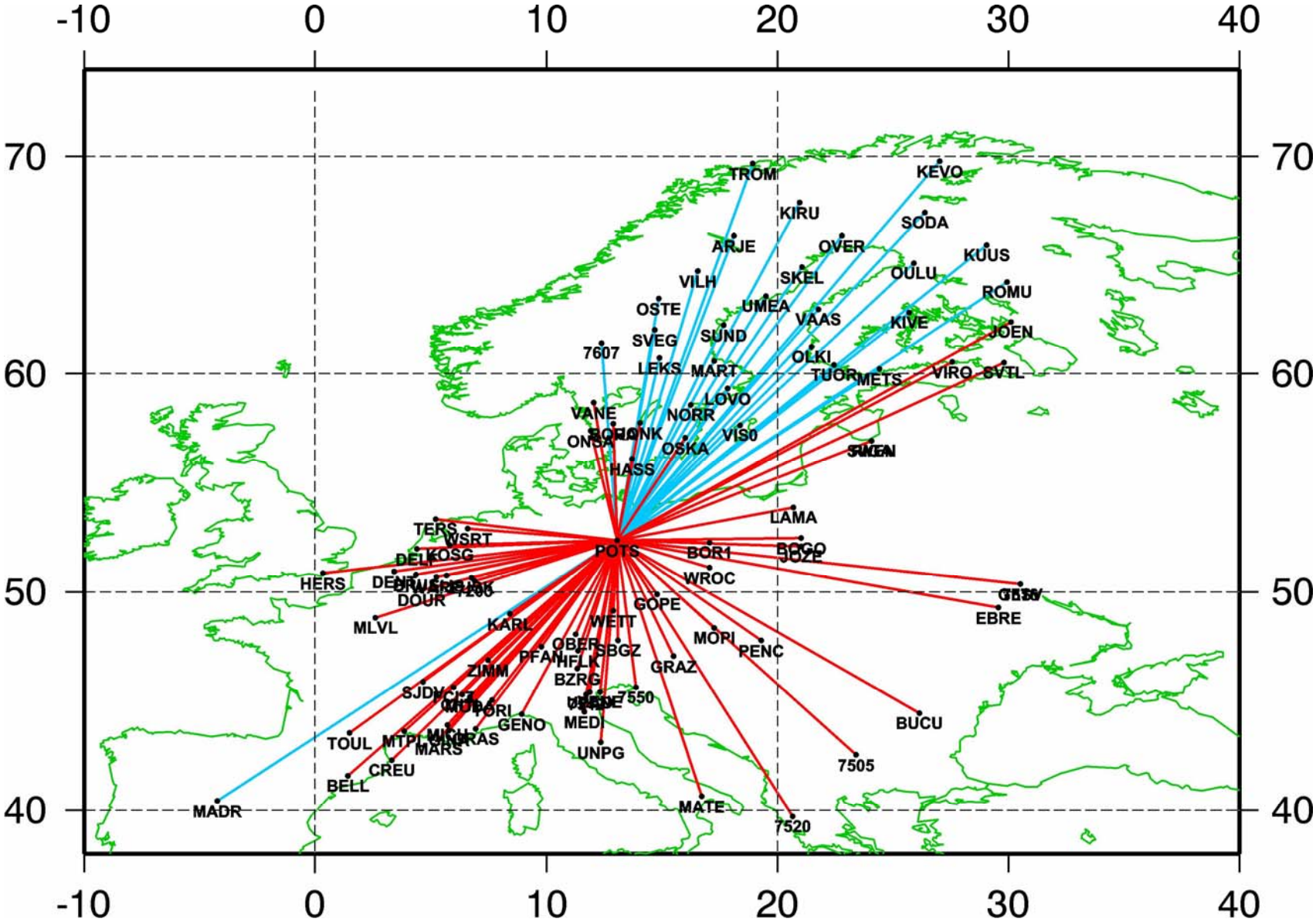
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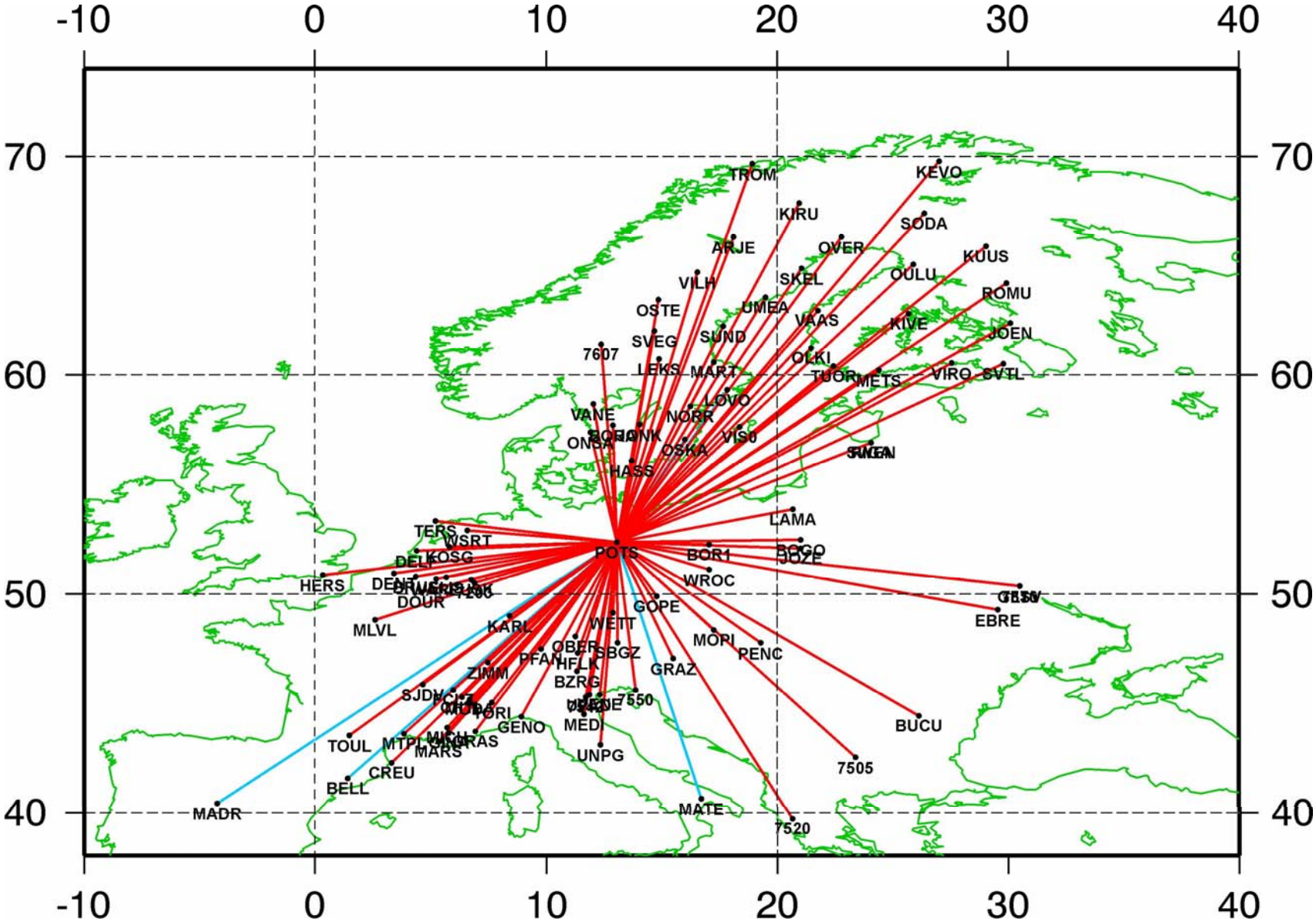
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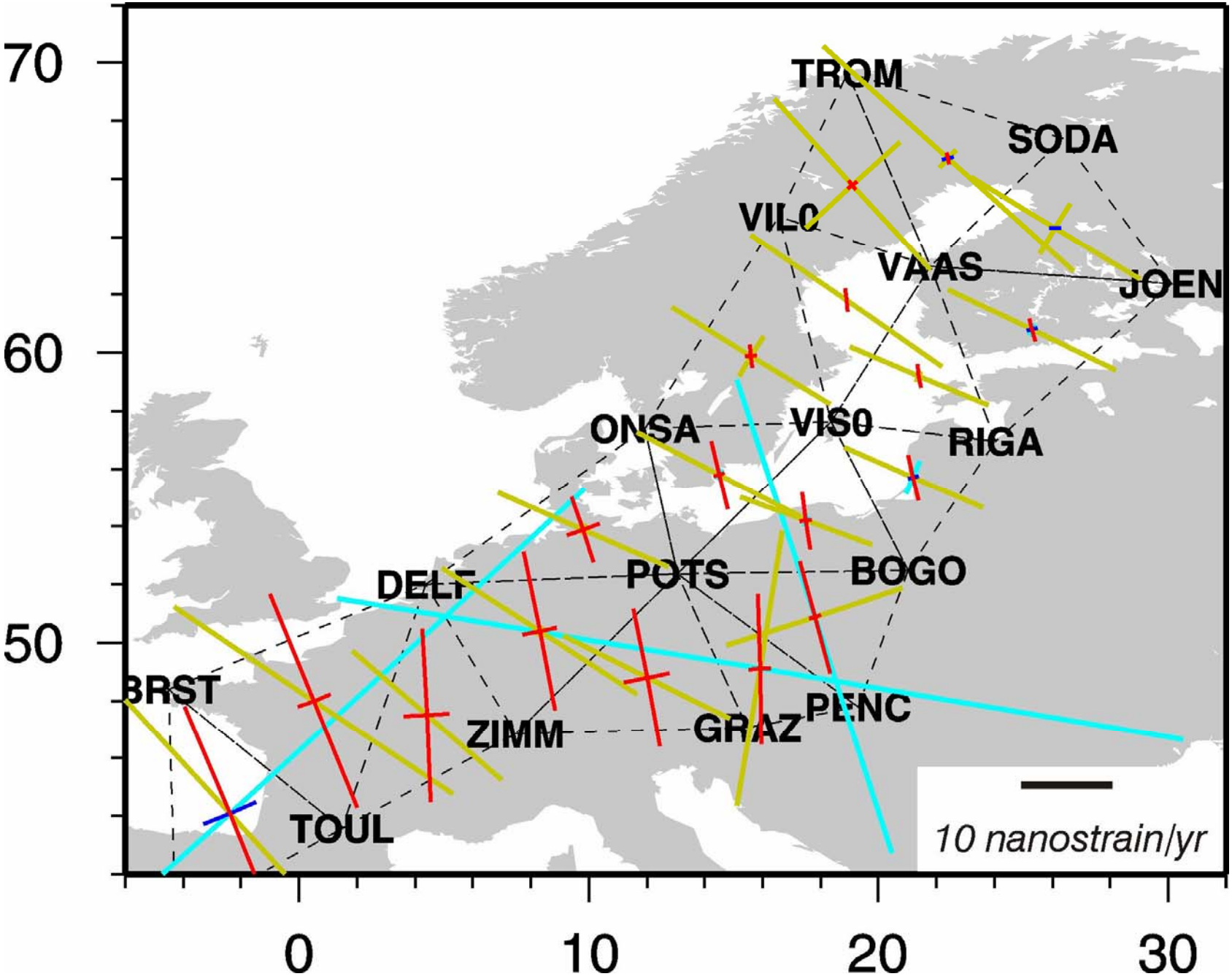
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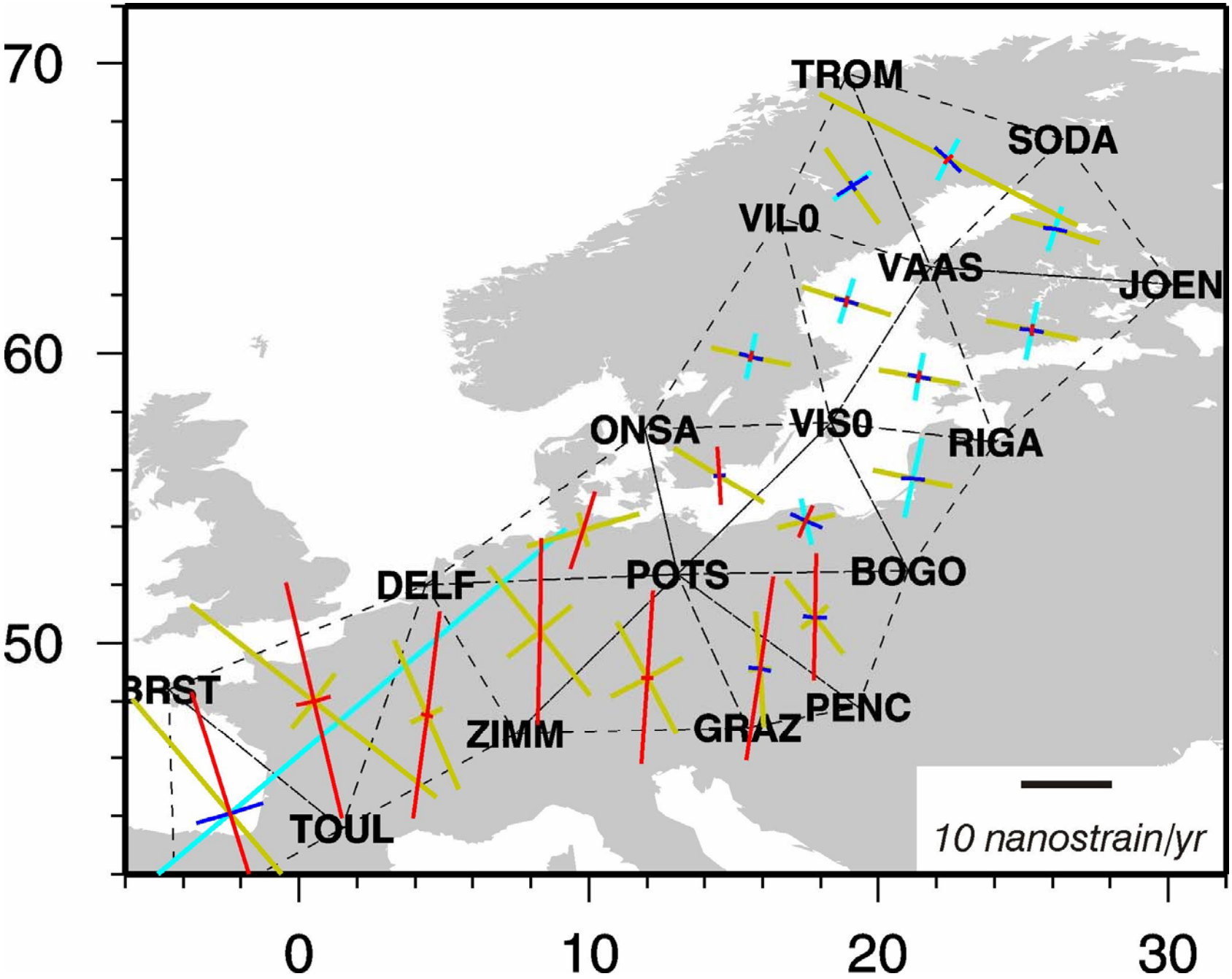
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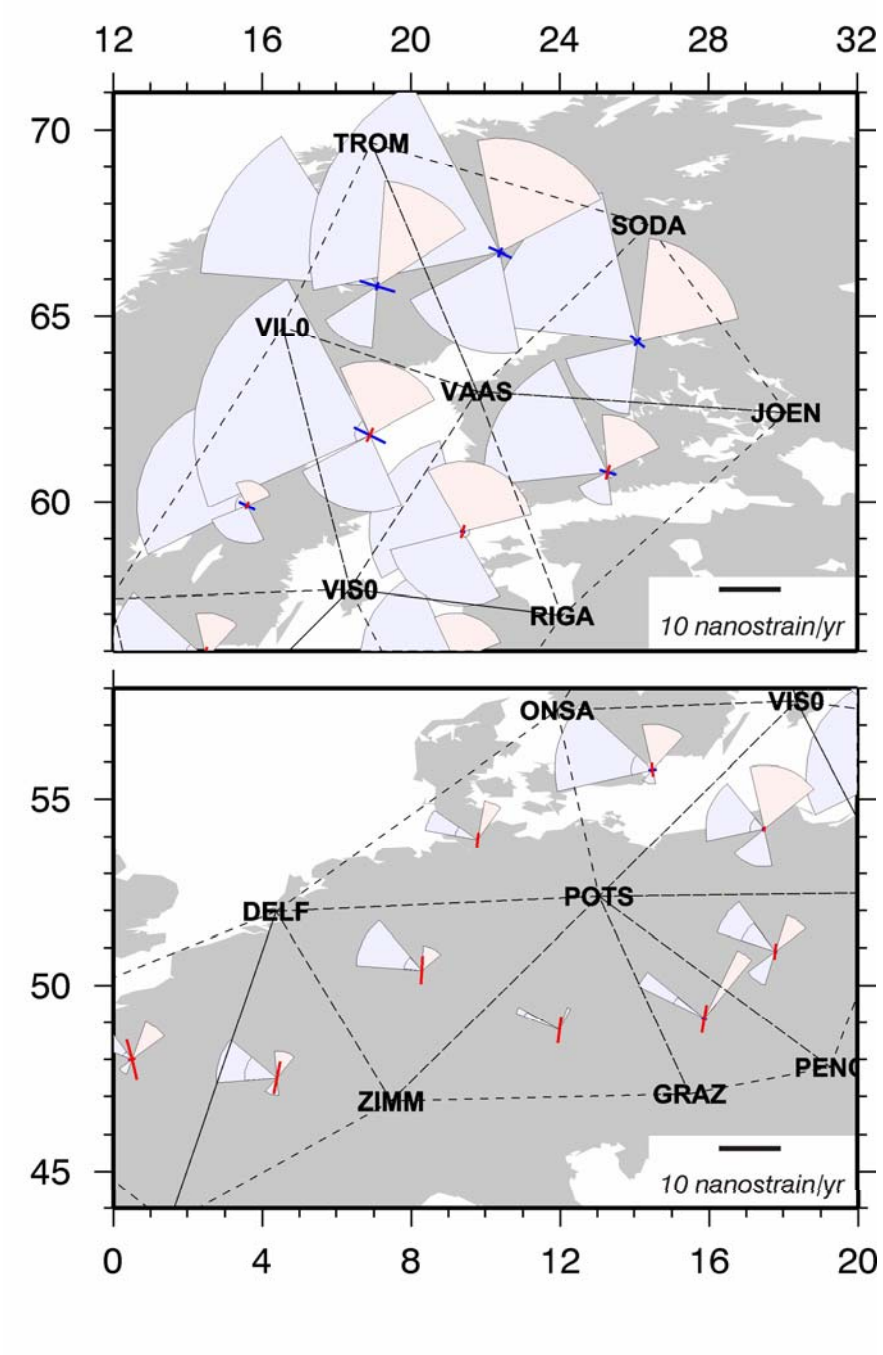
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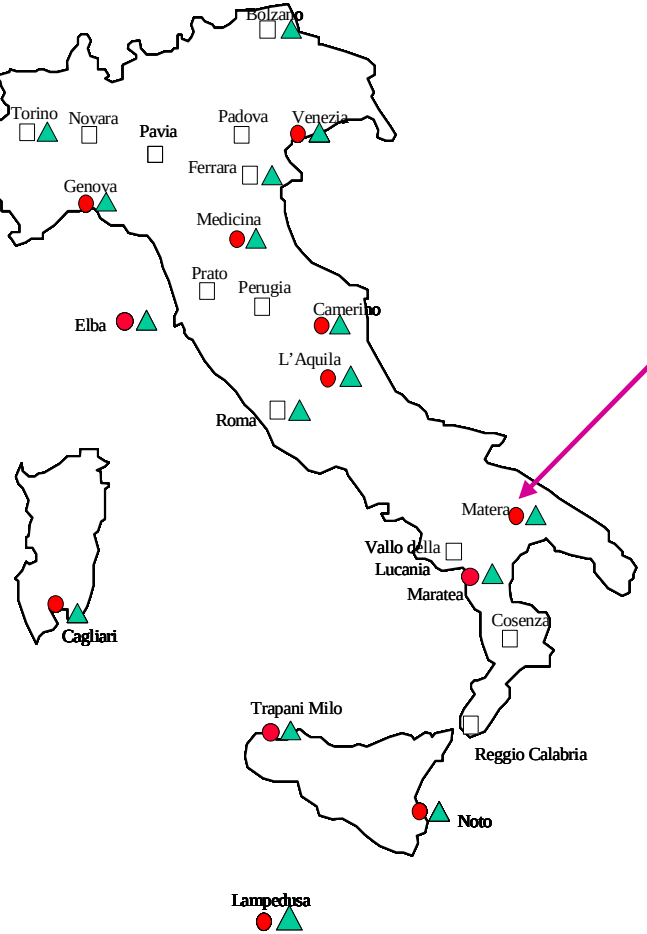
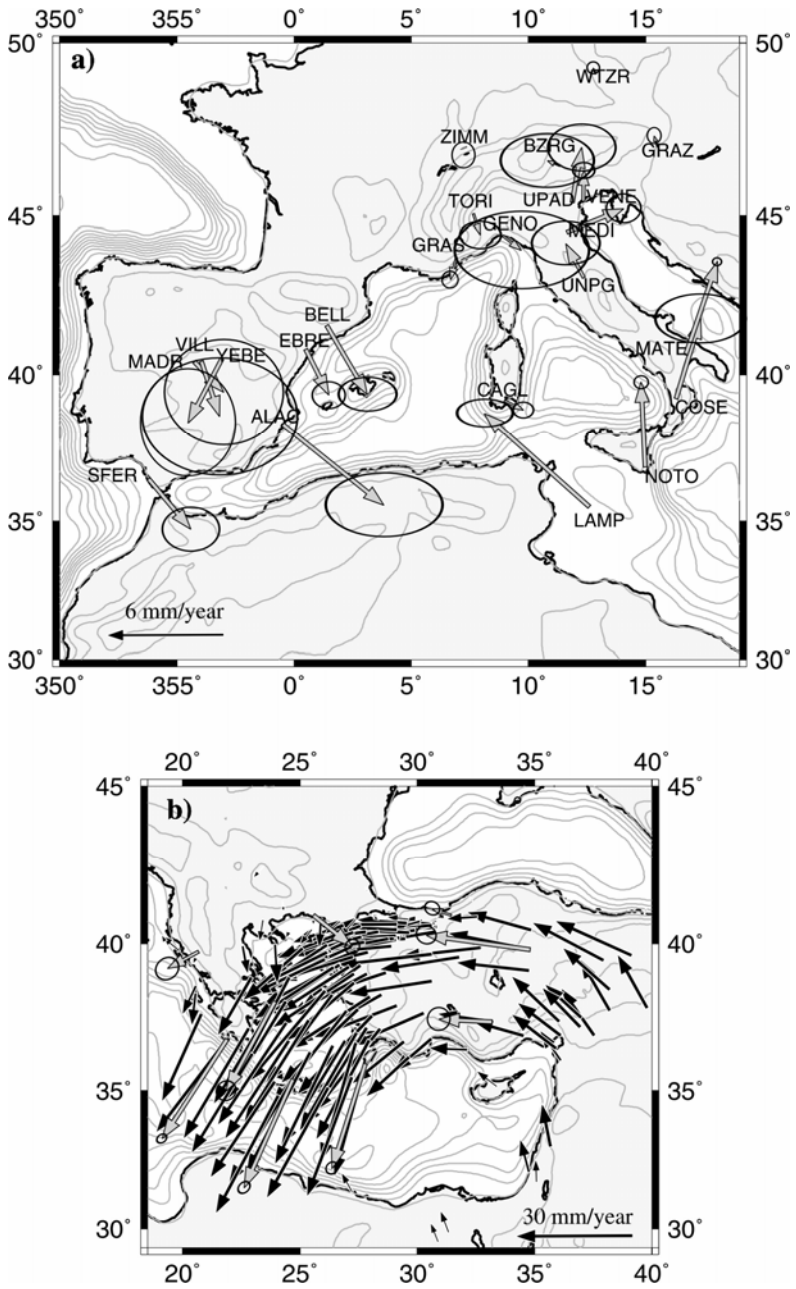
Rete GPS Fidiciale Italiana



Matera ASI-CGS

- 12 ASI SITES
- 12 OTHER INSTITUTION SITES
- 16 HOURLY SITES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WTZR
ZIMM
BZRG
GRAZ
TORI
UPAD
VENE
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MEDI
GRAS
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BELL
EBRE
VILL
YEBE
MADR
MATE
CAGL
COSE
ALAC
SFER
NOTO
LAMP
6 mm/year
b)
30 mm/year
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355°
0°
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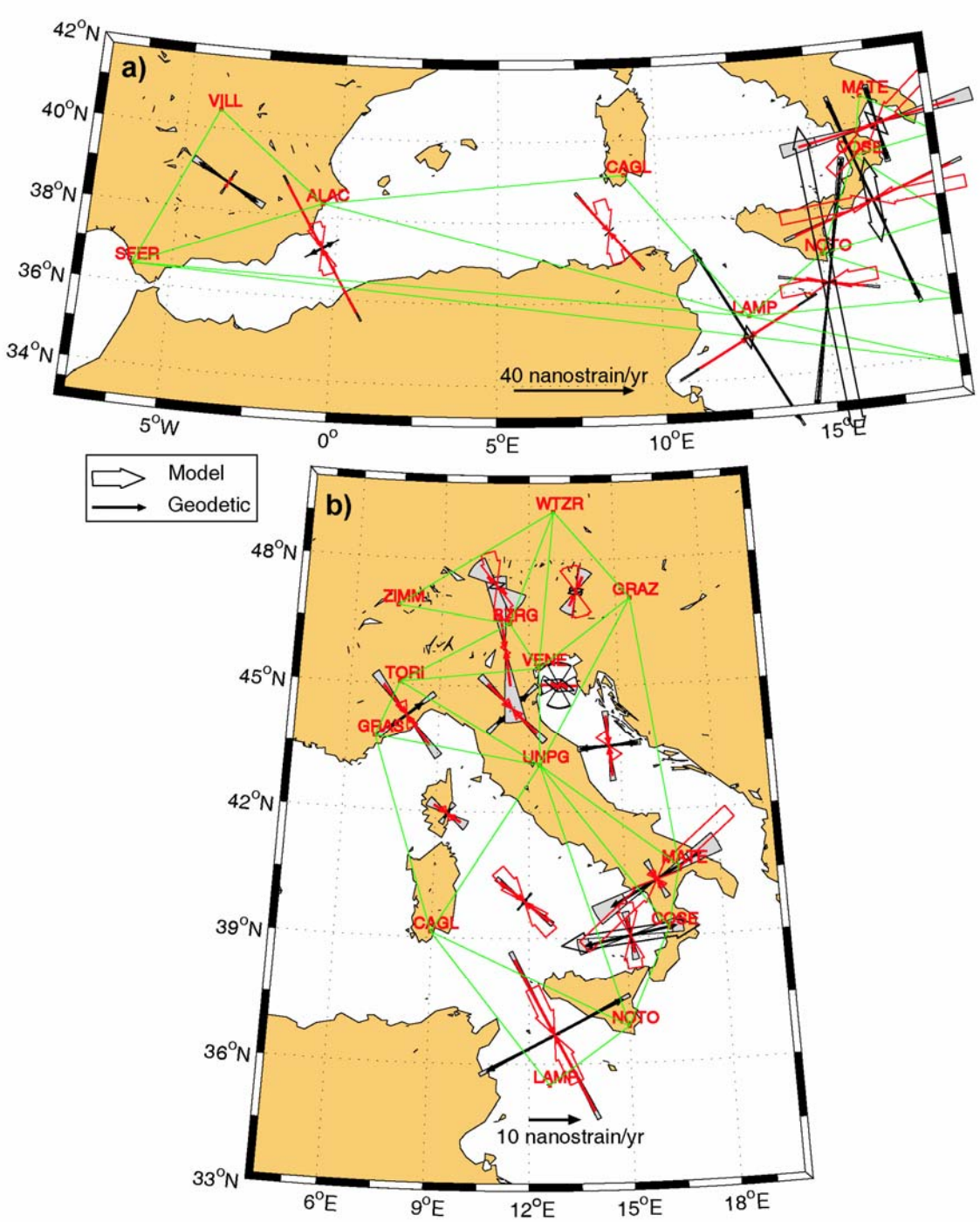
a)
42°N
40°N
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36°N
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VILL
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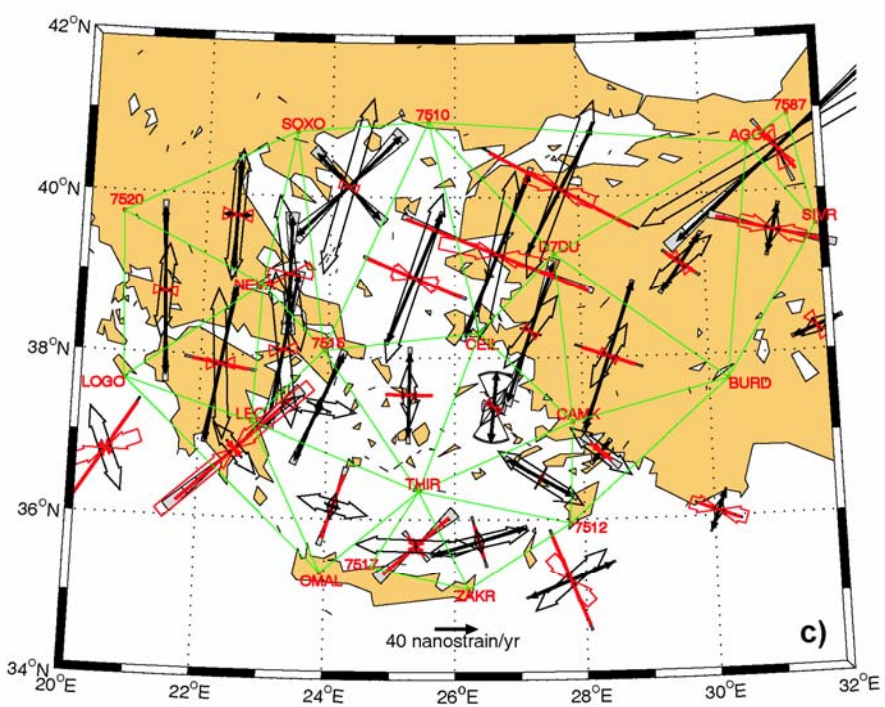
SFER
CAGL
MATE
COSE
NOTO
LAMP
40 nanostrain/yr
Model
Geodetic
b)
48°N
45°N
42°N
39°N
36°N
33°N
6°E
9°E
12°E
15°E
18°E
WTZR
ZIMM
BZRG
GRAZ
VENE
TORI
GRAS
UNPG
MATE
CAGL
COSE
NOTO
LAMP
10 nanostrain/yr


42°N
40°N
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34°N
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22°E
24°E
26°E
28°E
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SOXO
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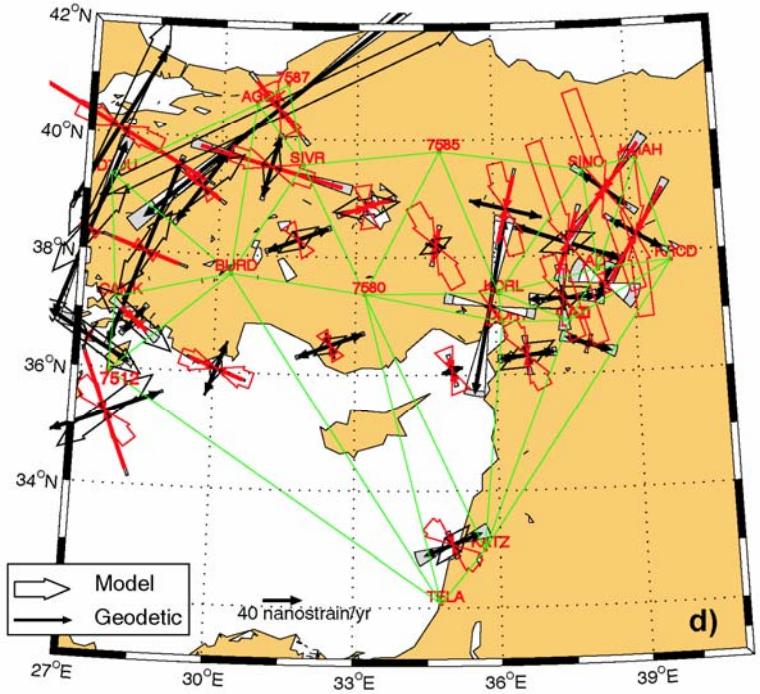
7587
AGIO
7520
SIVR
D7DU
DAV
7515
CEIL
LOGO
BURD
CAMK
THIR
7512
7517
OMAL
ZAKR
40 nanostrain/yr
c)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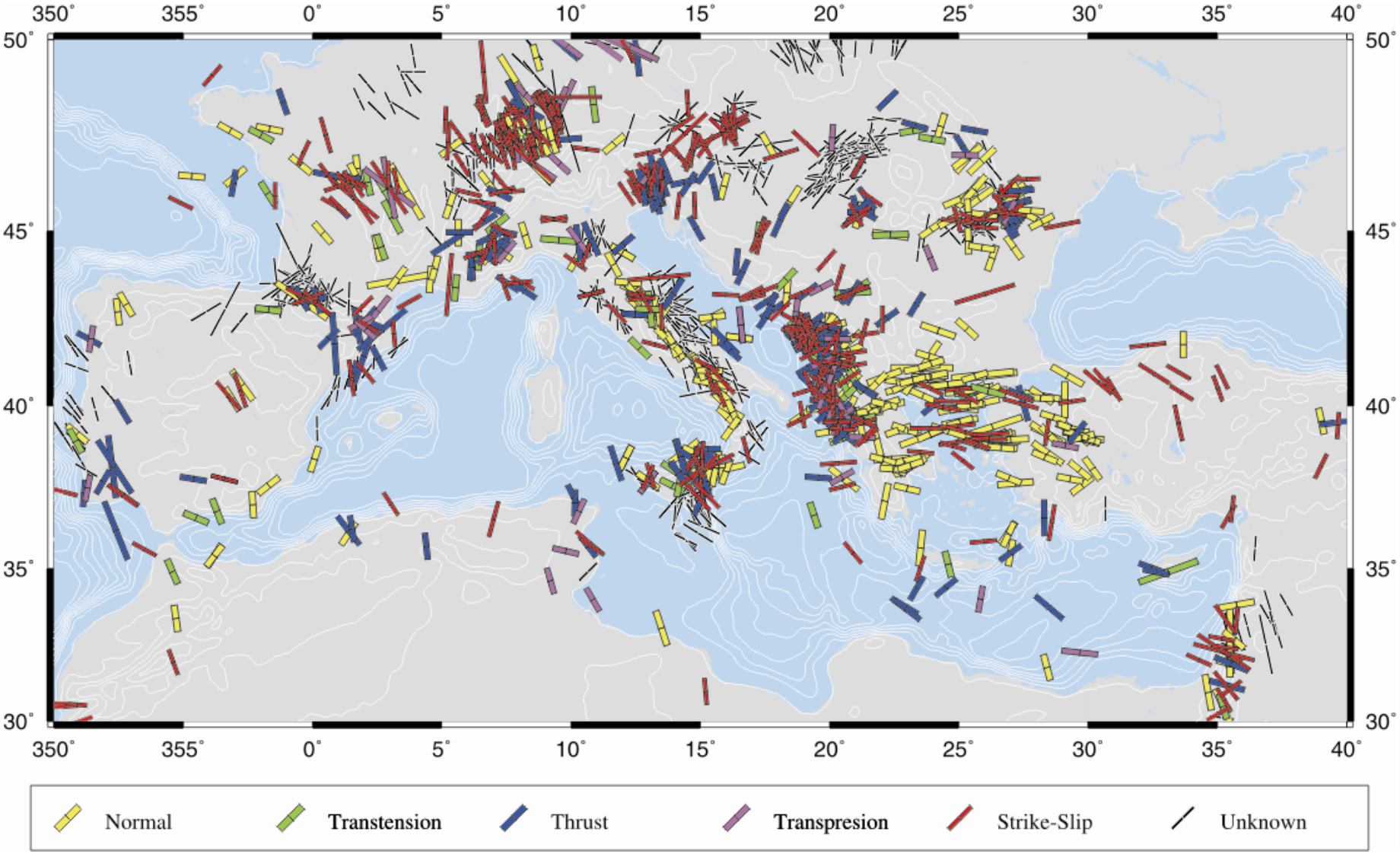
TSLA
Model
Geodetic
40 nanostrain/yr
d)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35°
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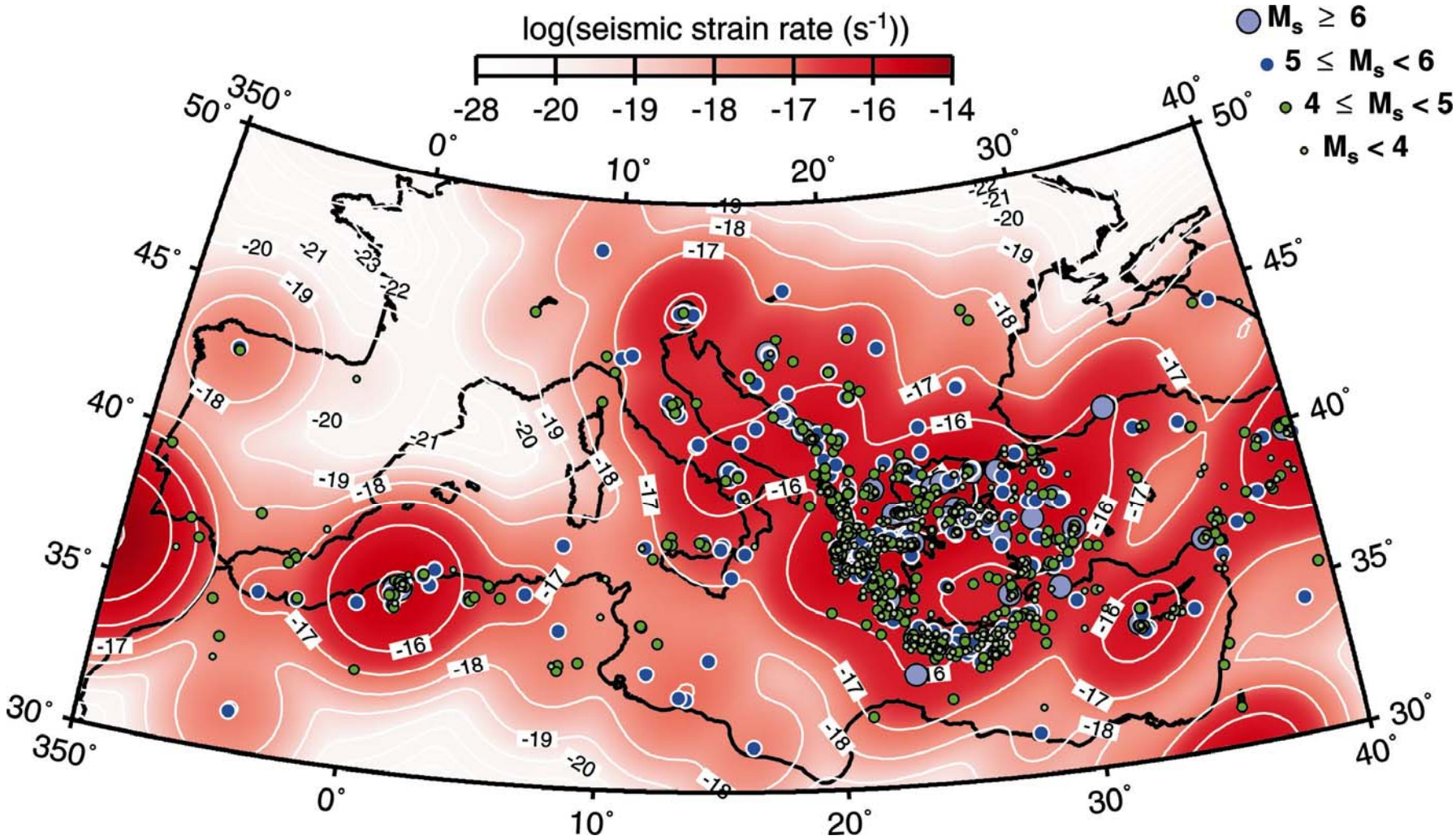
Normal
Transtension
Thrust
Transpresion
Strike-Slip
Unknown

Seismicity (M_s, NEIC 1903-1999) and calculated seismic strain rate



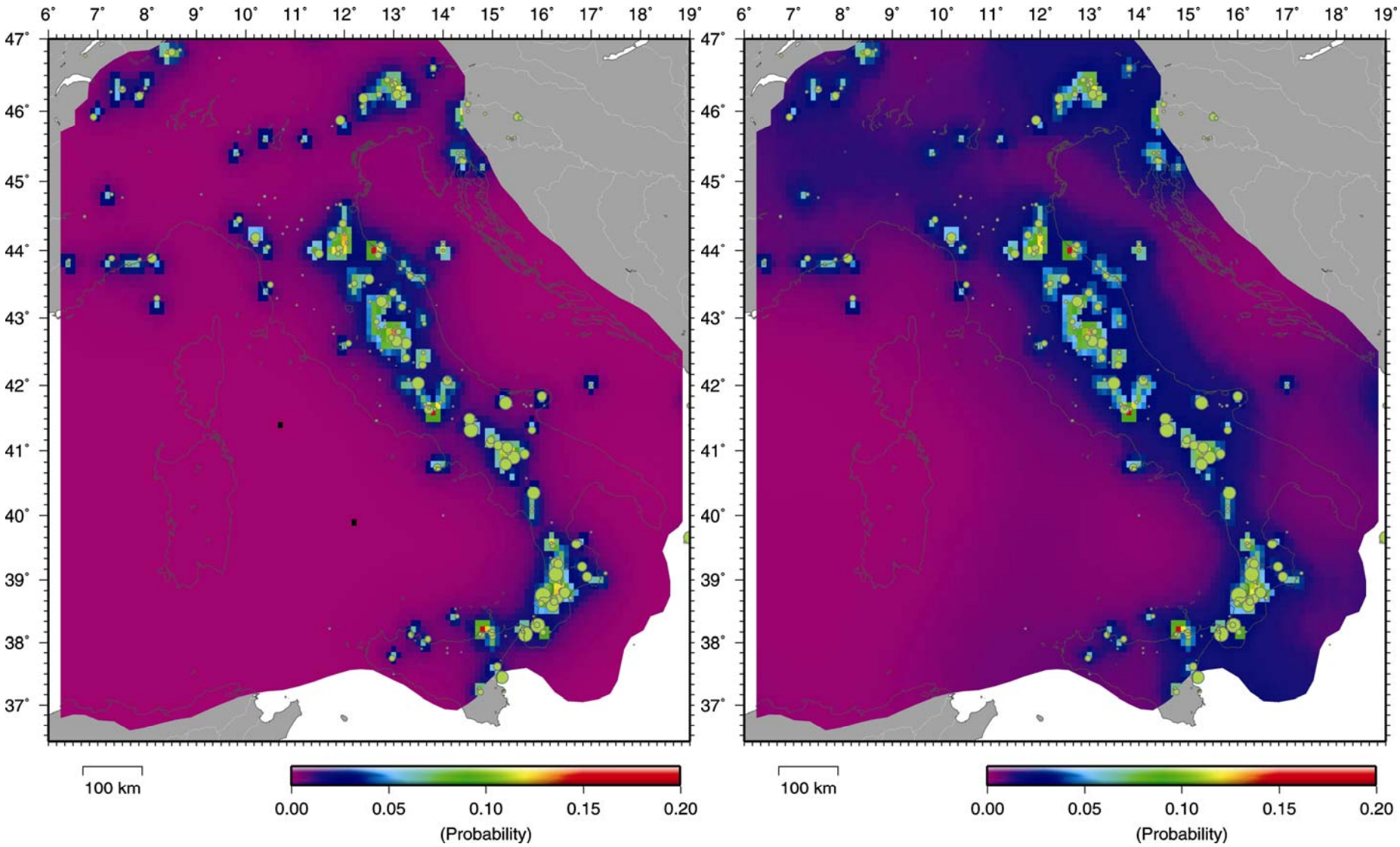
The probabilistic analysis supplies indications that can be useful but are not sufficiently reliable to characterize seismic hazard. Recent examples Kobe (17.1.1995), Bhuj (26.1.2001), Boumerdes (21.5.2003) and Bam (26.12.2003) events.

? GSHAP ?

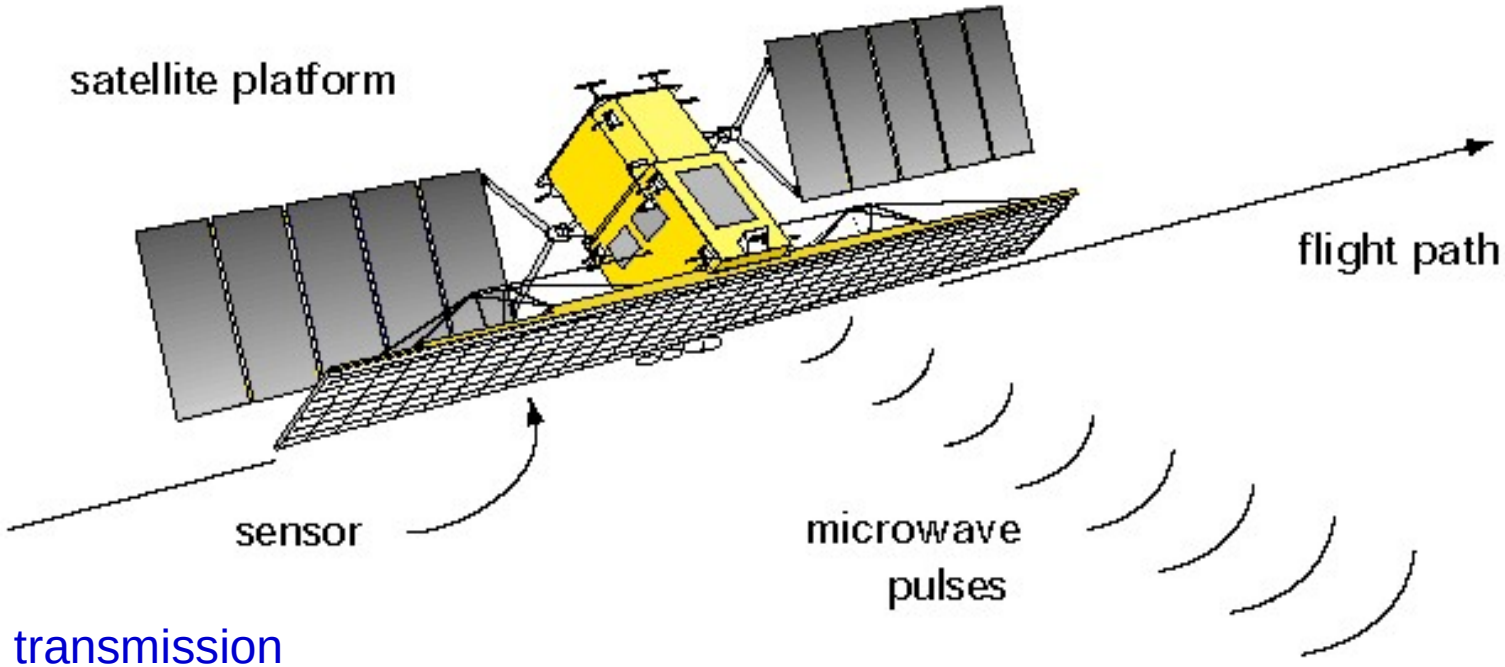
Kobe (17.1.1995), Gujarat (26.1.2001), Boumerdes (21.5.2003) and Bam (26.12.2003) earthquakes PGA(g)

	Expected	Observed
	with a probability of exceedence of 10% in 50 years (return period 475 years)	
• Kobe	0.40-0.48	0.7-0.8
• Gujarat	0.16-0.24	0.5-0.6
• Boumerdes	0.08-0.16	0.3-0.4
• Bam	0.16-0.24	0.7-0.8

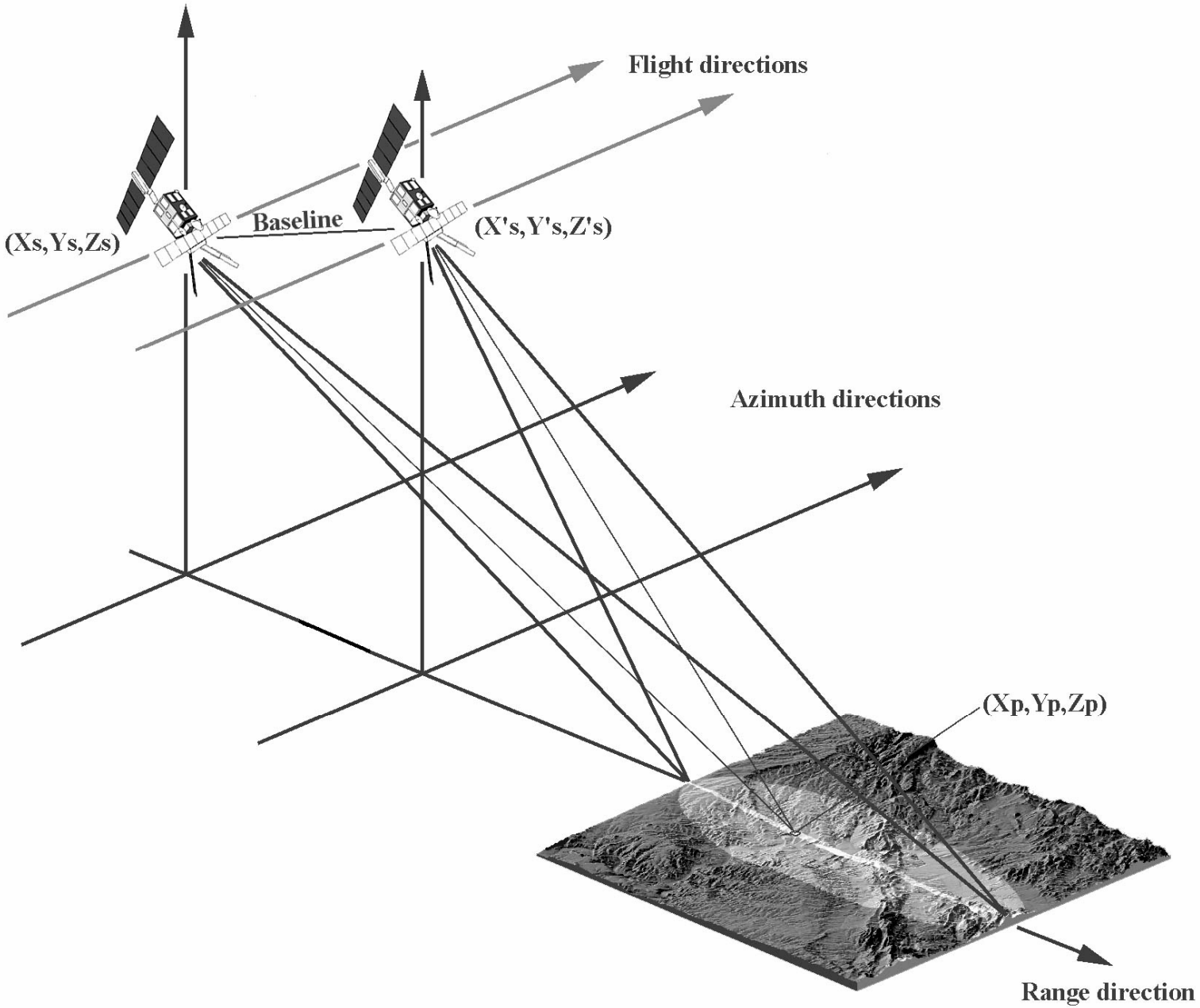
Feasibility of seismic hazard mitigation by means of
the synergic use of historical seismicity and geophysical modeling.



SAR: data acquisition



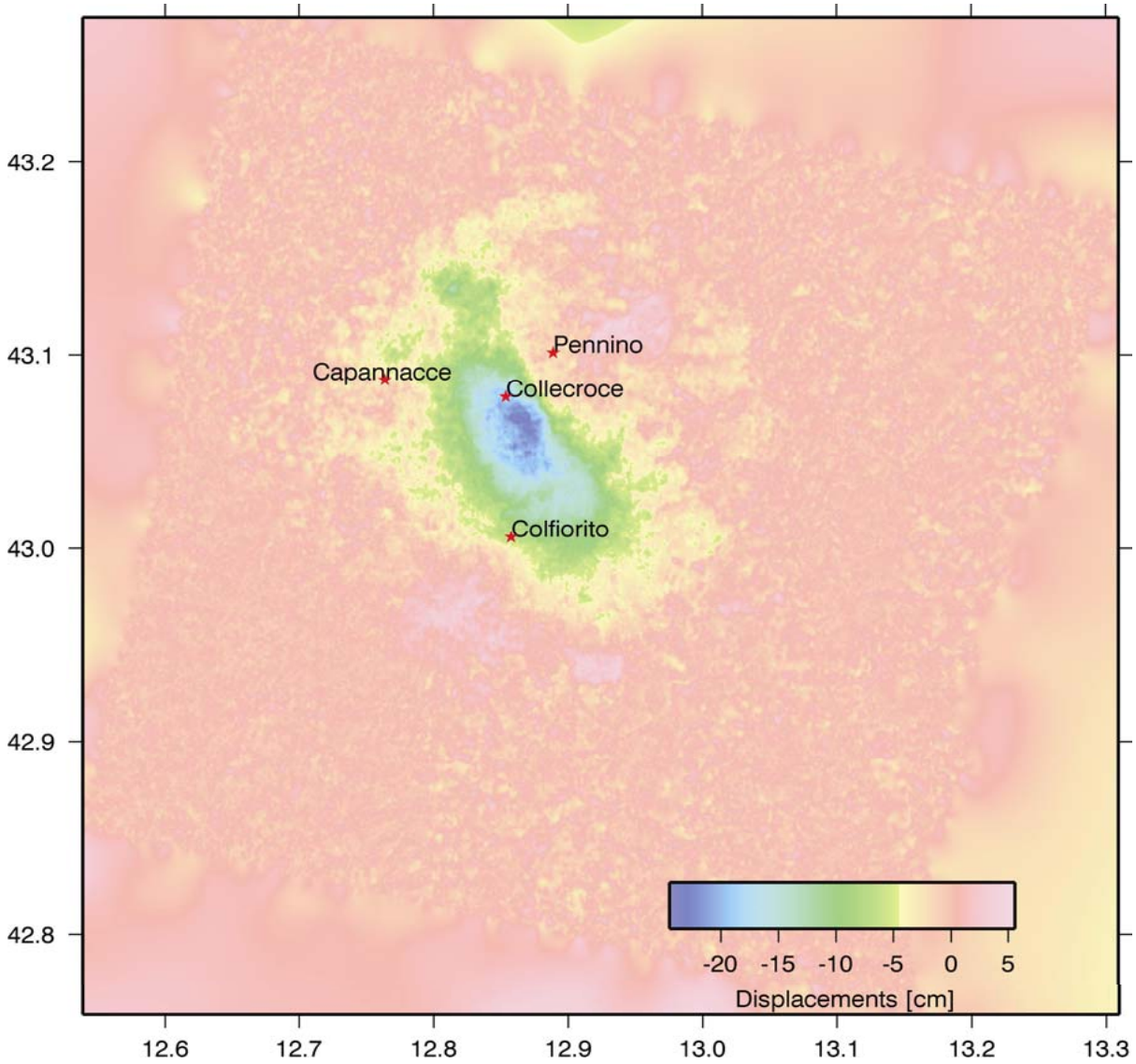
- Pulse transmission
- Propagation, interaction with surface ➔ echoes
- Acquisition of echoes, with a delay: $t = 2 R / c$
  ➔ the system measures distances
- Transmission of pulses along the orbit ➔ 2D sampling of terrain

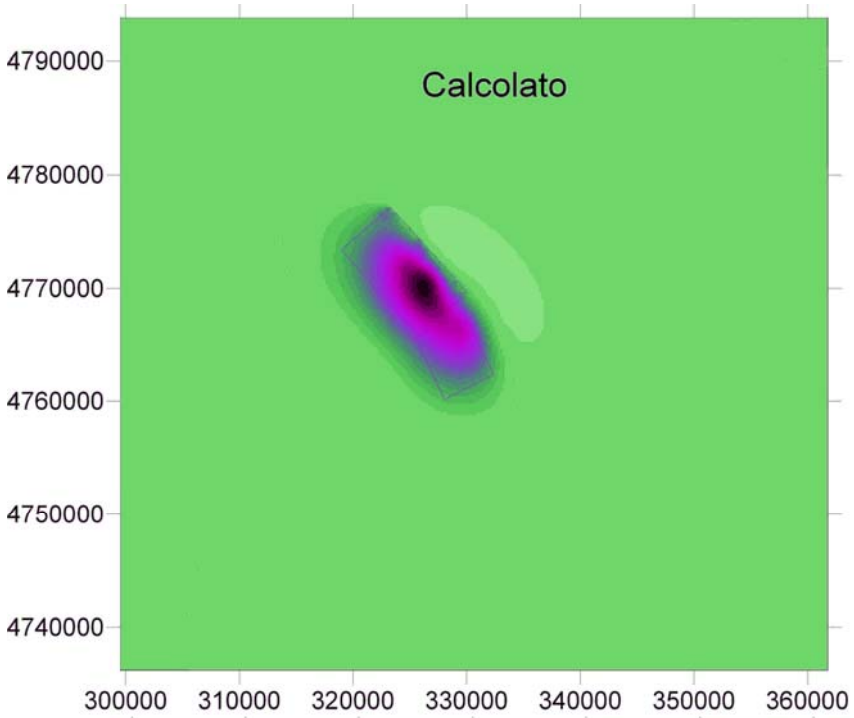

Flight directions
(Xs,Ys,Zs)
Baseline
(X's,Y's,Z's)
Azimuth directions
(Xp,Yp,Zp)
Range direction

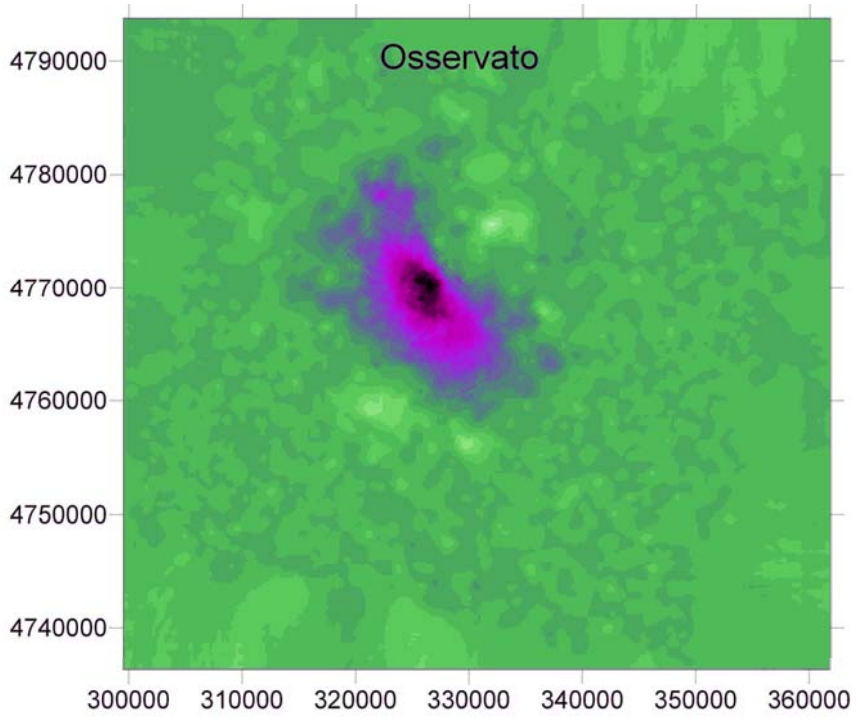
Methodology for detecting the vertical movements during the

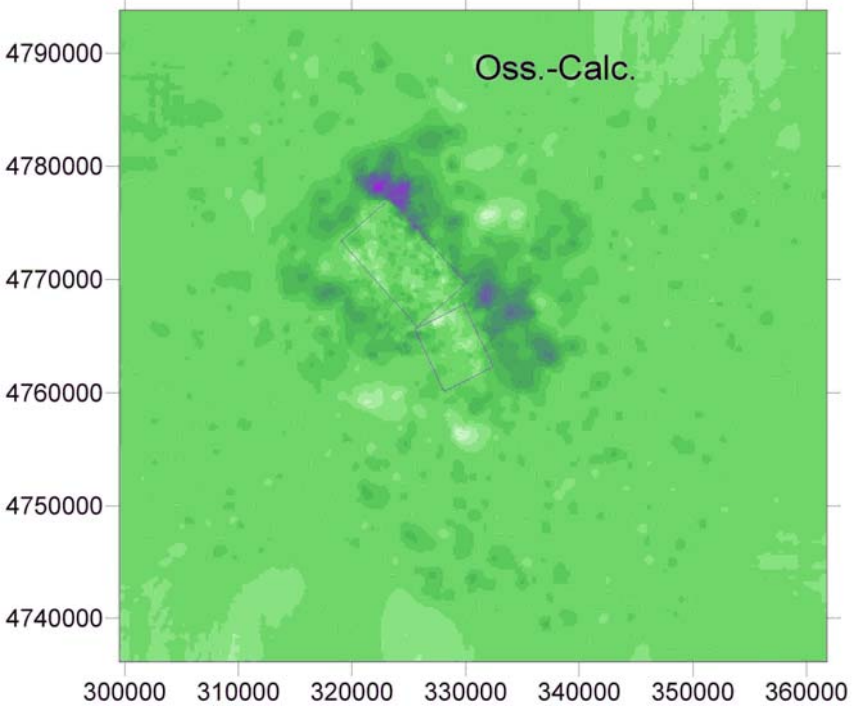
pre-seismic, co-seismic and post-seismic phases in earthquake prone areas

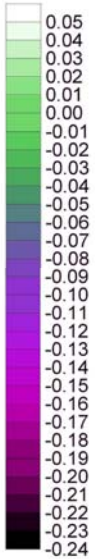
(**Crippa B. et al., An advanced slip model for the Umbria-Marche earthquake sequence: coseismic displacements observed by SAR interferometry and model inversion, GJI, 2005, in press**).







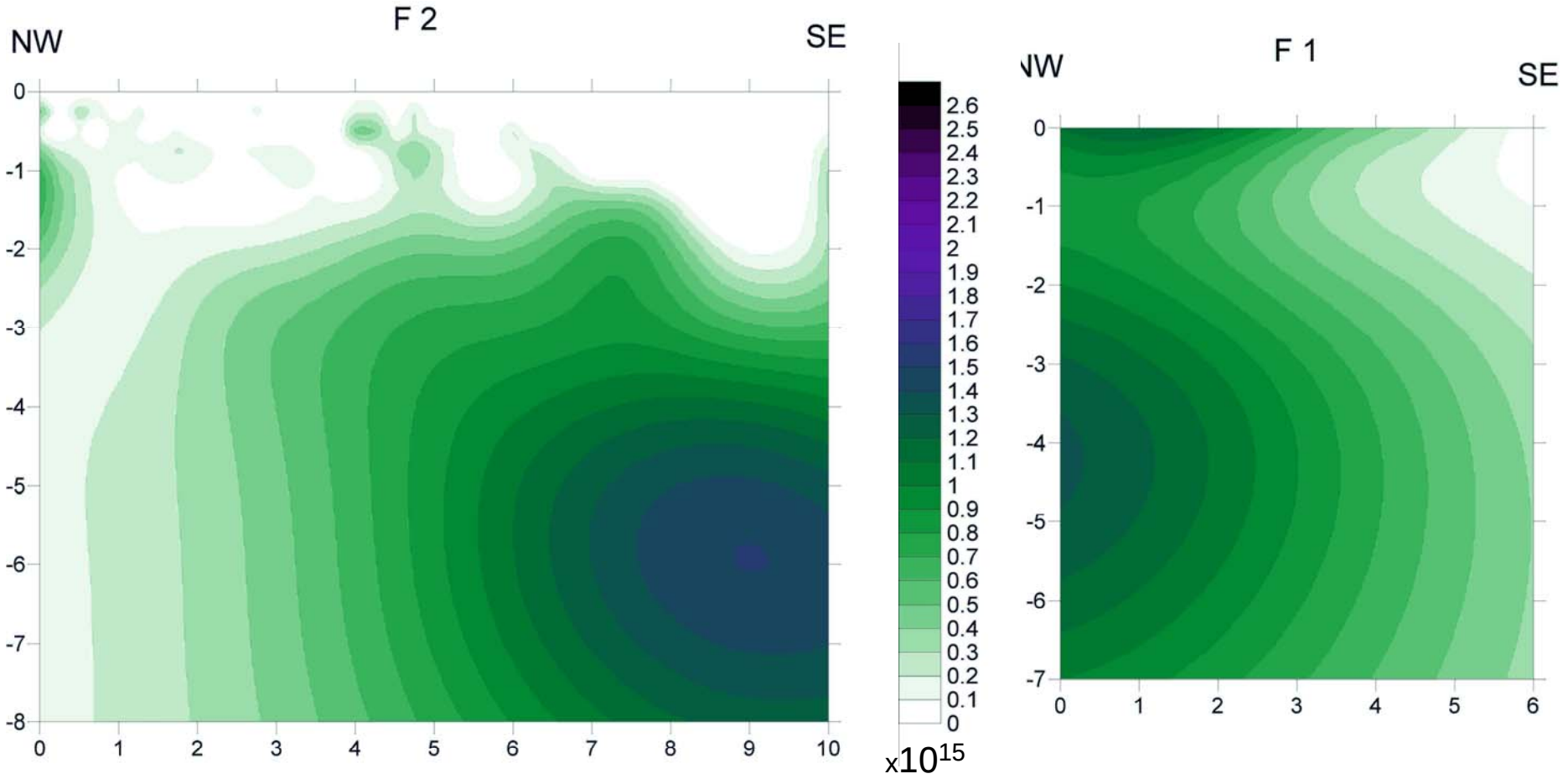


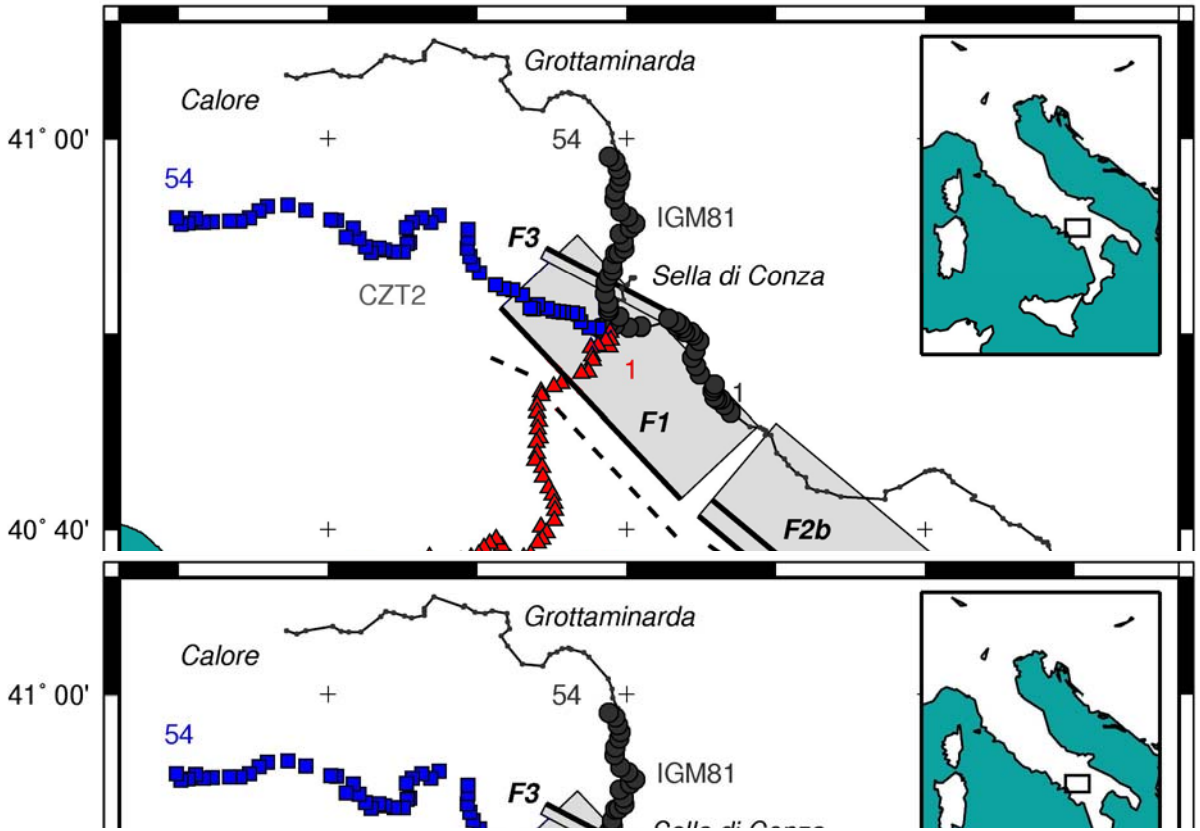


m

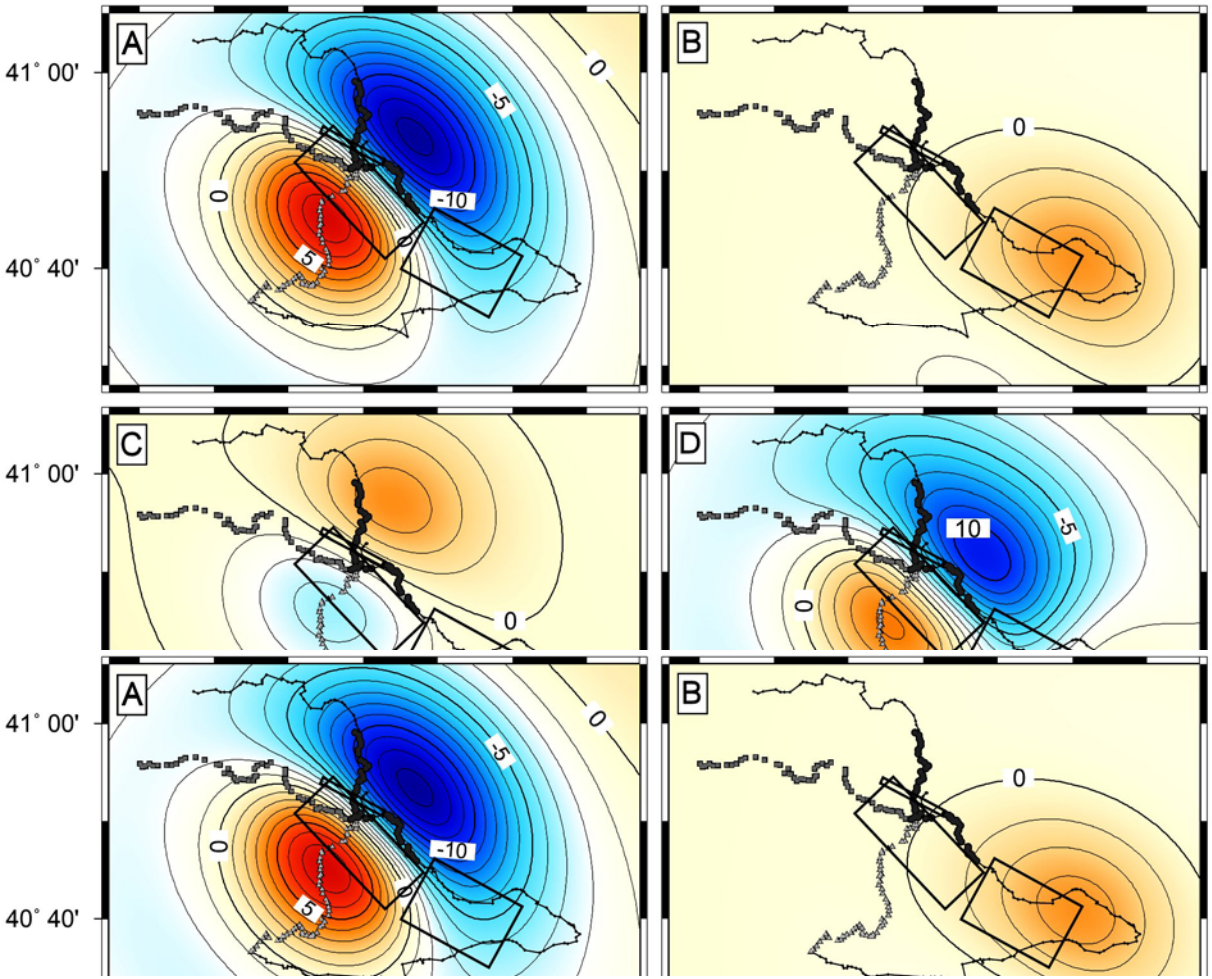
Comparison between predicted crust and lithosphere deformation patterns and SAR retrieved ones to verify the feasibility of seismic hazard mitigation by means of the synergic use of DInSAR and geophysical modeling (**Crippa B. et al., An advanced slip model for the Umbria-Marche earthquake sequence: coseismic displacements observed by SAR interferometry and model inversion, GJI, 2005, in press**).

•Methodology, based on the combined use of SAR data and forward geophysical models, for estimating the state of stress and strain within the volume embedding the active faults in order to improve our understanding of the mechanism of earthquake generation (**Crippa B. et al., An advanced slip model for the Umbria-Marche earthquake sequence: coseismic displacements observed by SAR interferometry and model inversion, GJI, 2006**).





Dalla Via, G. et al., Lithospheric rheology in southern Italy inferred from postseismic viscoelastic relaxation following the 1980 Irpinia earthquake, JGR, 2005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D
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41° 00'
41° 00'
40° 40'
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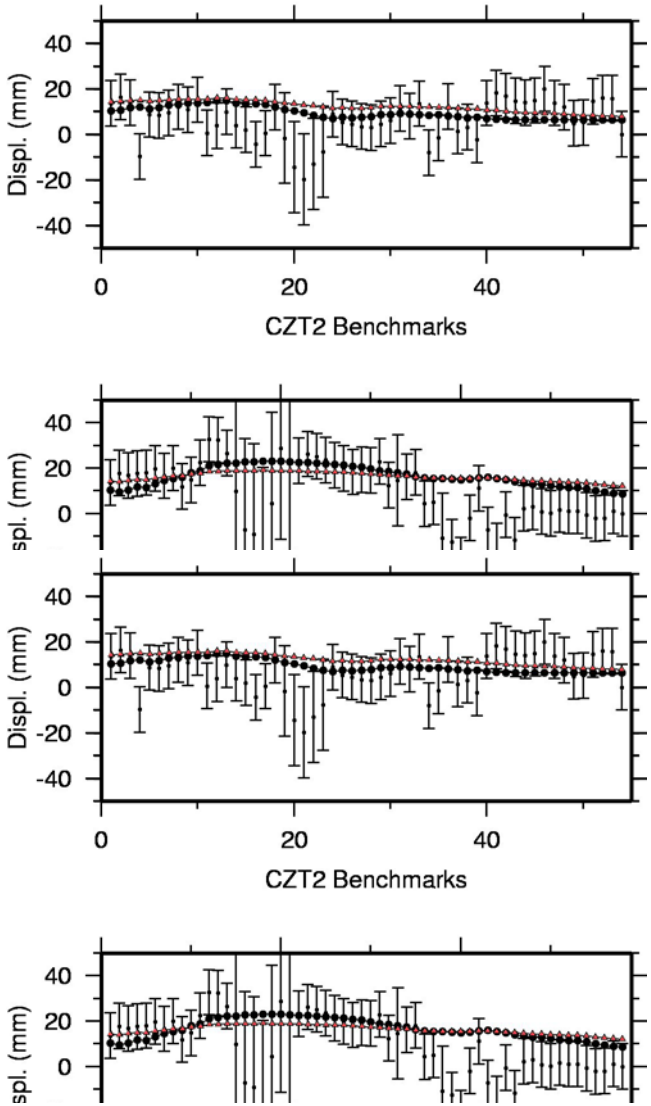

Dalla Via, G. et al., Lithospheric rheology in southern Italy inferred from postseismic Viscoelastic relaxation following the 1980 Irpinia earthquake, JGR, 2005

CONCLUSIONS (1)

- **Although the seismic classification of the Italian territory has been recently revised, the evaluation of seismic hazard continue to be based on the traditional probabilistic approach, i.e. on the probabilistic analysis of earthquake catalogue and of ground motion information, retrieved by macroseismic observations and instrumental recordings, that may lead to severe underestimations of seismic hazard.**

- **Recently this approach showed its limitation in providing a reliable seismic hazard assessment, possibly due to the insufficient information about historical seismicity, which can introduce relevant errors in the purely statistical approach mainly based on the seismic history. Indeed, some areas where low seismic hazard was foreseen, and consequently were not included in the seismic classification, have been subsequently struck by relatively strong and damaging earthquakes (e.g. the Sicily, September 2002, and the Molise, October 2002, earthquakes).**

CONCLUSIONS (2)

- **To overcome the mentioned limitations and, above all, to improve the pre-seismic information which may lead to an effective mitigation of seismic risk, we are proposing an innovative approach, that combines EO data and new advanced approaches in seismological and geophysical data analysis.**

- **The proposed system, in fact, is proposing a deterministic approach to the estimation of seismic ground motion, integrated with the space and time dependent information provided by EO data analysis through geophysical forward modeling. The reason of the proposed integration of different geophysical observables appears almost obvious analyzing the earthquake "life cycle", i.e. its process of preparation and occurrence: the lithosphere accumulates stress, according to strain and strain rates fields due to tectonic movements, which is partly released during the earthquake occurrence.**