

GPS, tectonique,
mouvements verticaux et
référentiels

ITRF

International Terrestrial Reference Frame
ITRF

Search by DOMES number :

ITRS and ITRF

ITRF NEWS

General concepts

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Transformation parameters

Domes Numbers

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IERS Network

Network description

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Guidelines

Get coordinates

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Navigation Tools

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WEST EAST

SOUTH

ITRF Network

- ★ Four Techniques
- Three Techniques
- ▲ Two Techniques
- GPS Sites Only
- DORIS Sites Only
- SLR Sites Only
- VLBI Sites Only
- Other points

Velocity Vector

2005

Horizontal
 Vertical
 uncertainty

Tectonic Plates

None

Latitude Longitude

(Decimal degrees)

By default, all points are displayed

ITRF Solution: 05 00 97 96 94 Or And

Network : GPS DORIS SLR VLBI

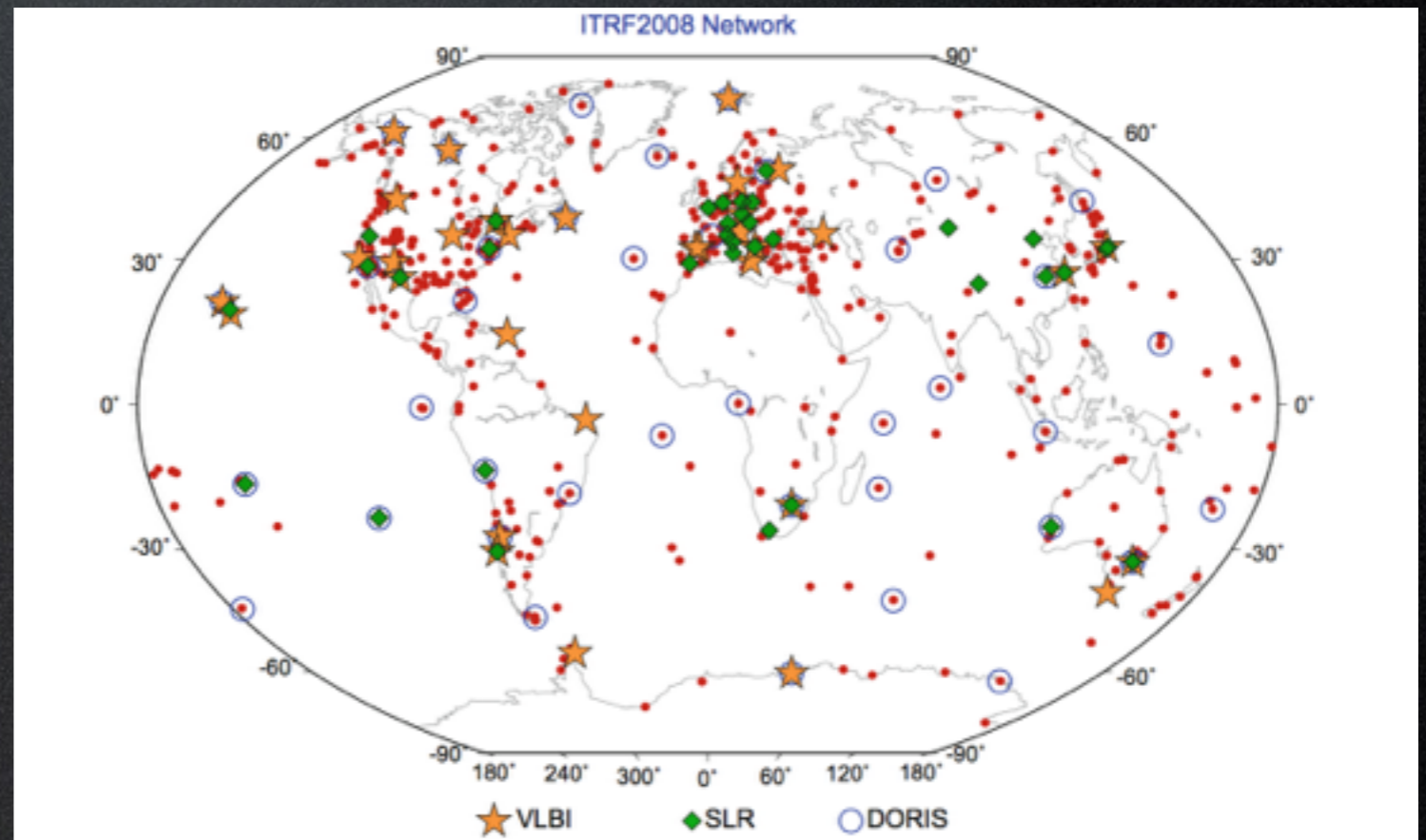
Point(s) selected

DOMES	Description	code	93	94	96	97	2000	2005
No point selected. Why select points?								

<http://itrf.ensg.ign.fr/GIS/>

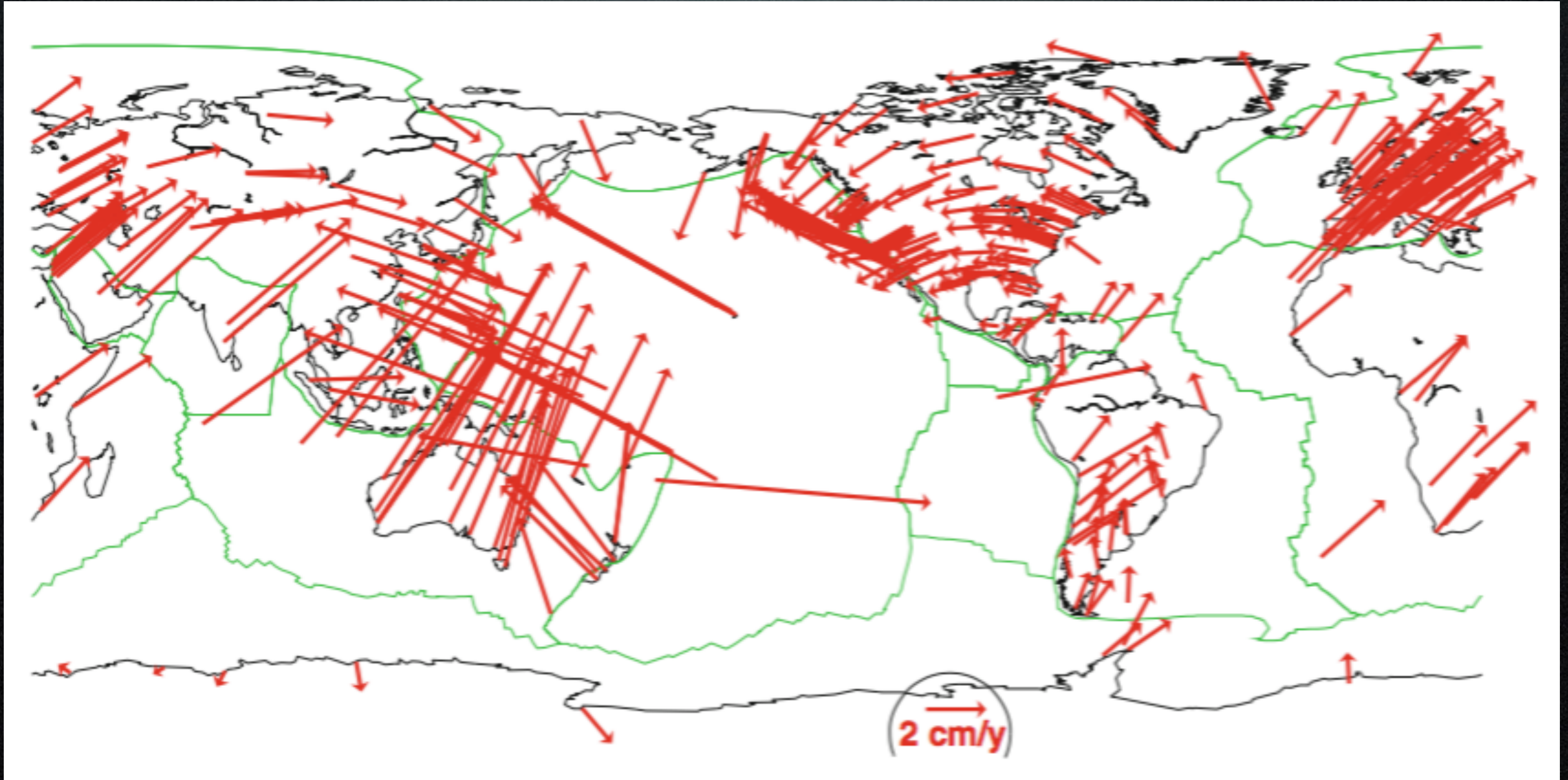
ITRF

- l'origine du référentiel est stable par rapport au centre de masse de la terre
- la quantité de mouvement des plaques lithosphériques est minimisée (condition rotation globale nulle, NNR : not net rotation)
- 934 stations présentent en 580 sites, 84 sites où plusieurs techniques sont colocalisées. 463 sites dans l'hémisphère nord et 117 au sud.



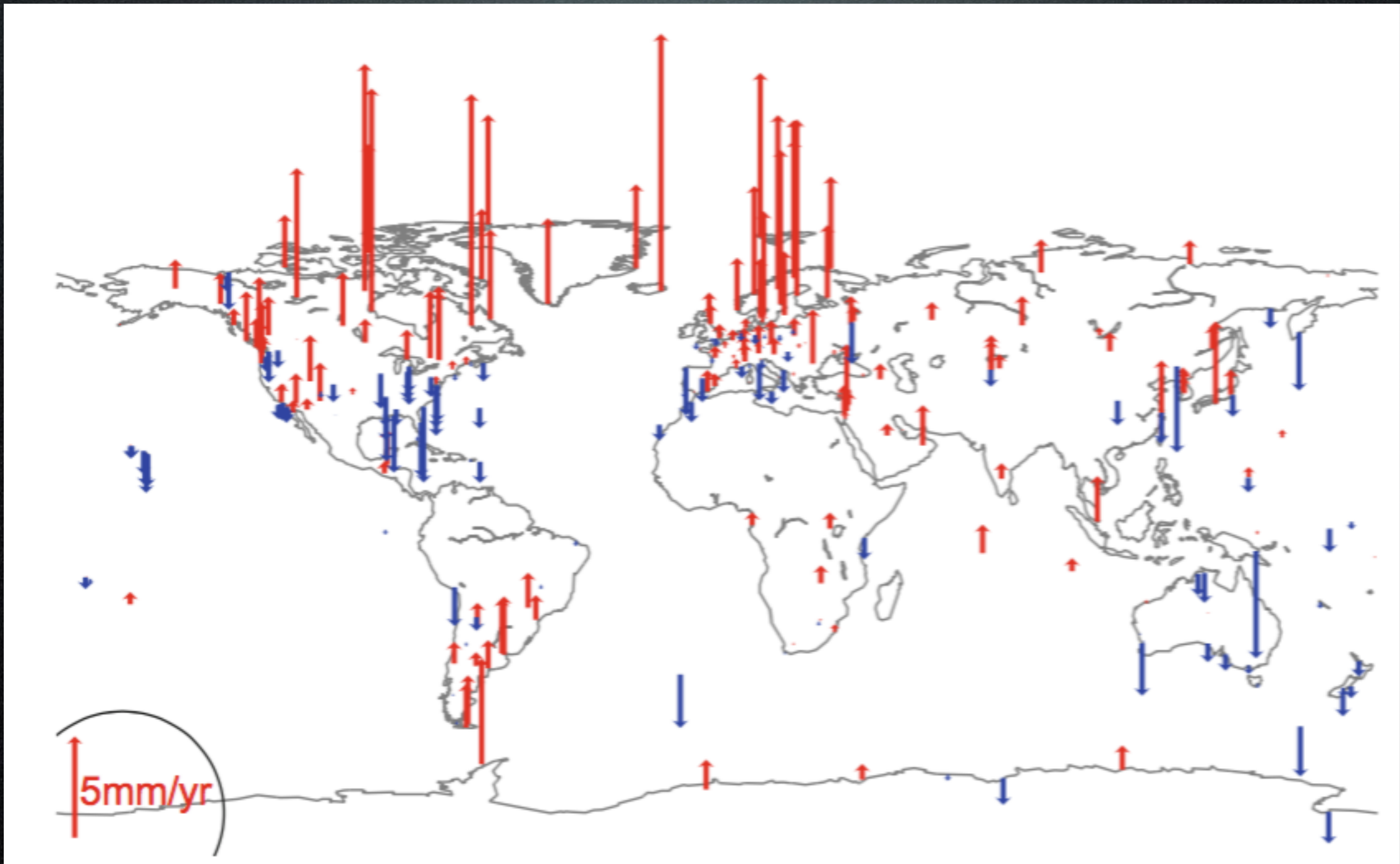
ITRF

- un champ de vitesses horizontales



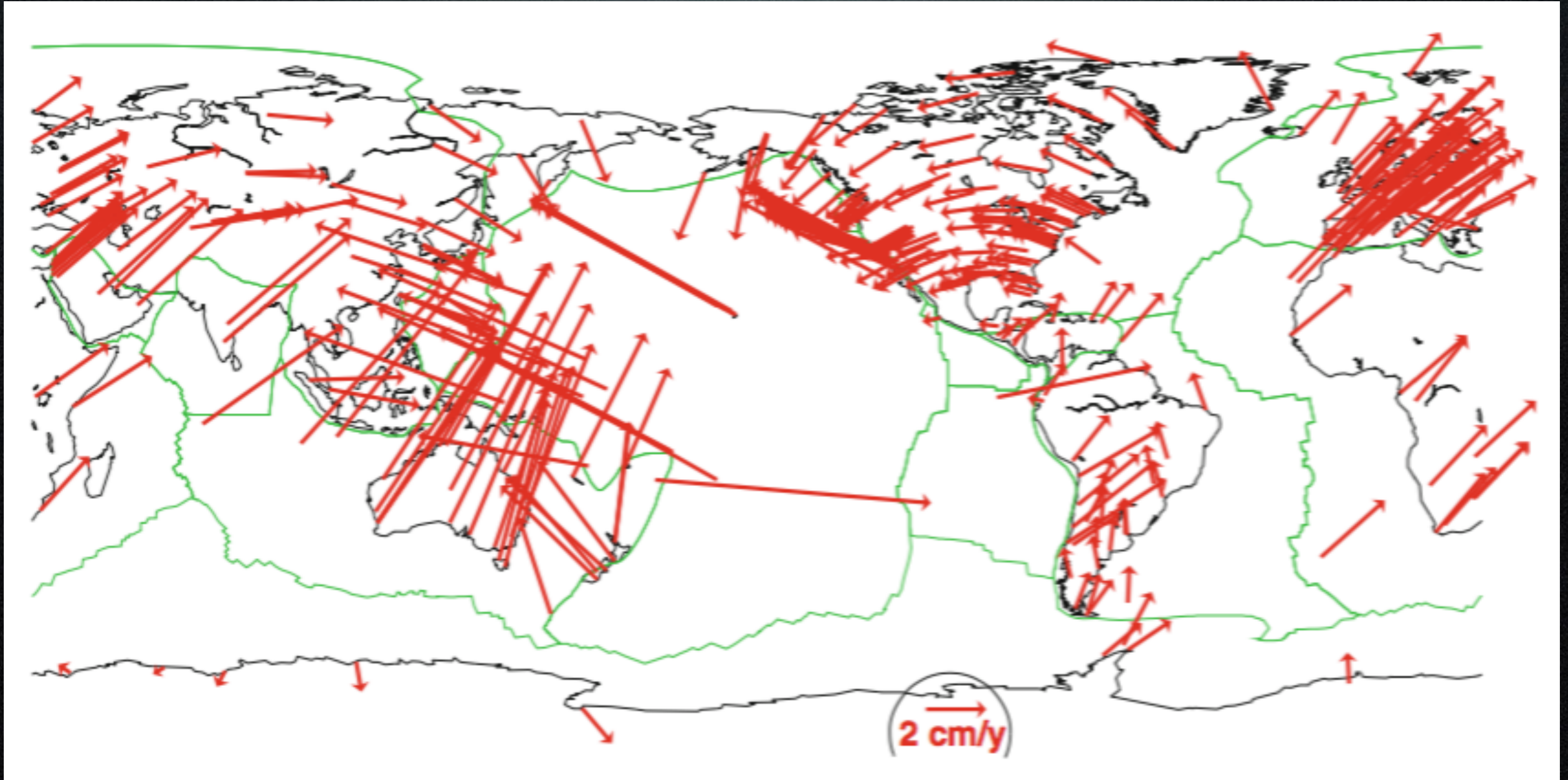
ITRF

- un champ de vitesses verticales



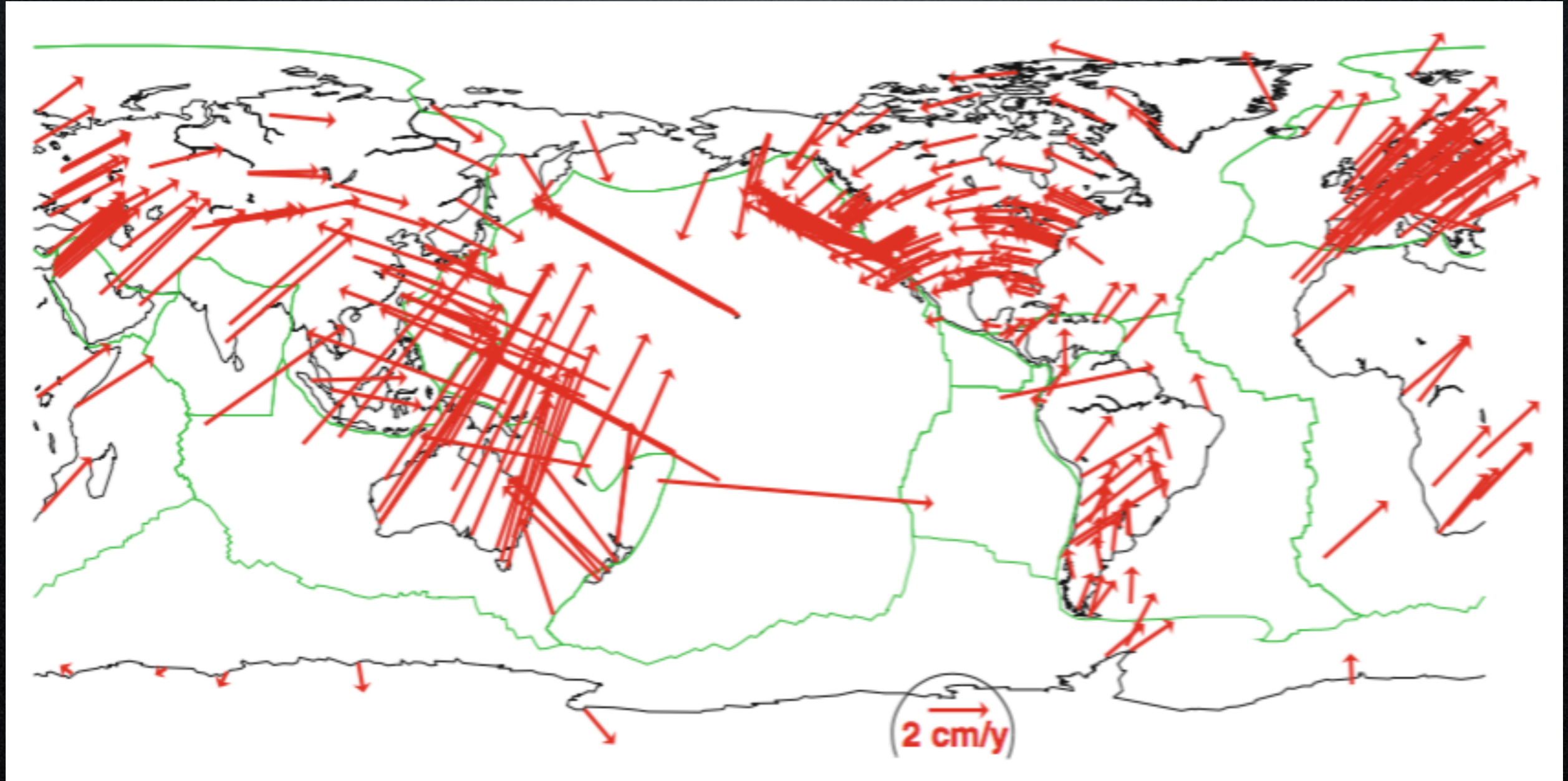
ITRF

- L'ITRF par rapport aux points chauds ?



ITRF

- L'ITRF pour la tectonique ?



Le GPS et les déplacements actuels en Himalaya



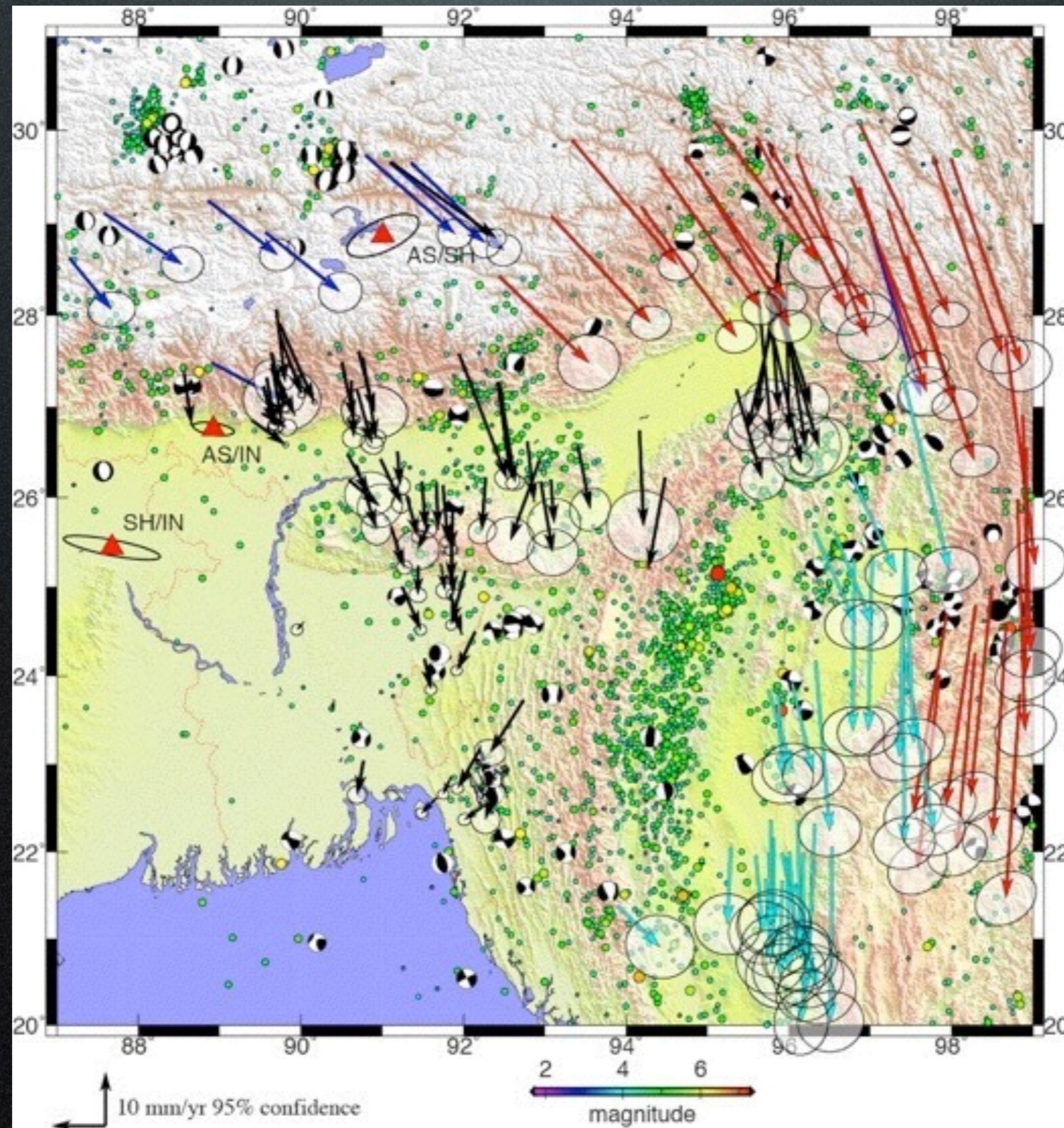
Les mesures épisodiques au Bhoutan



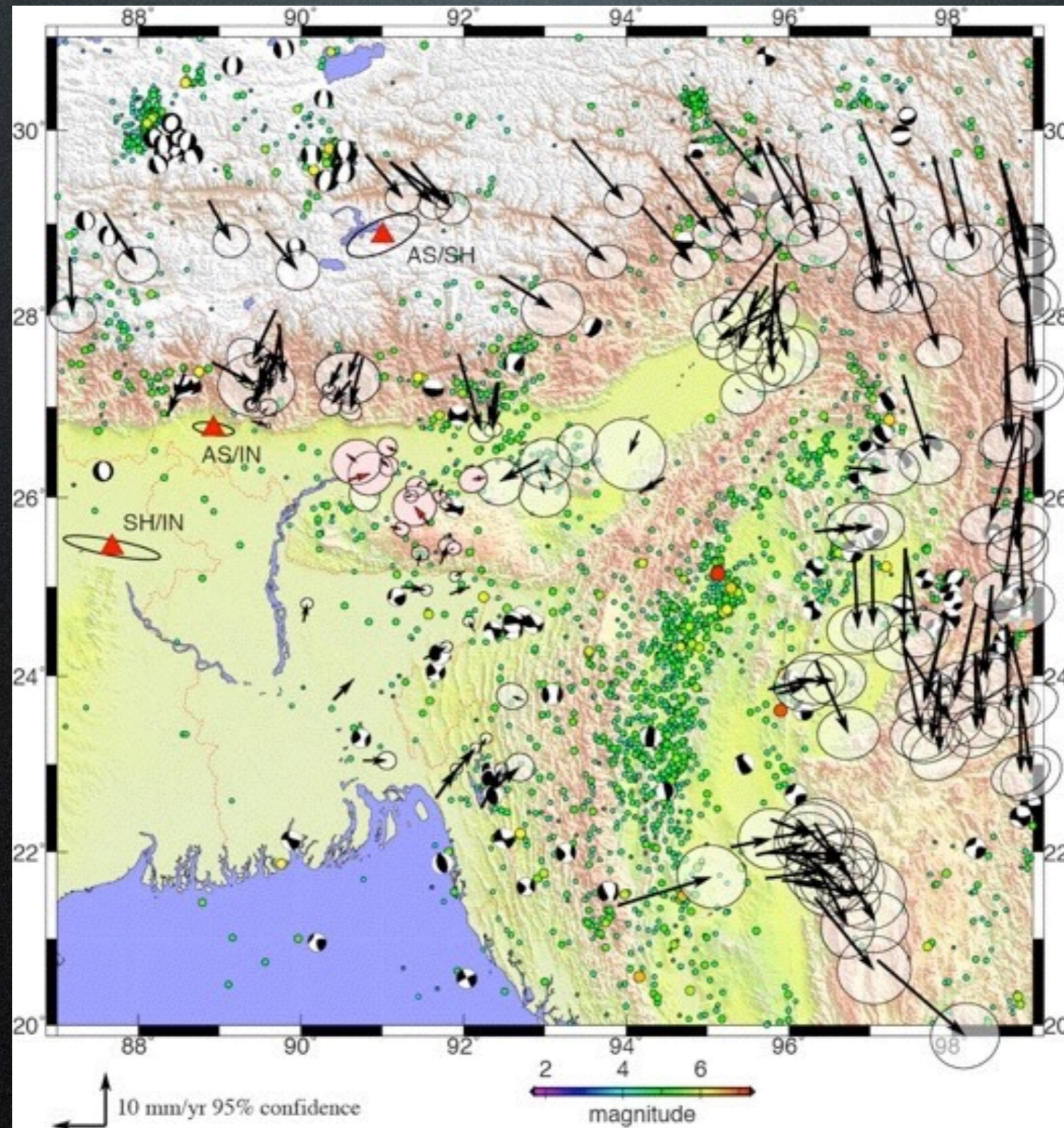
Les mesures épisodiques au Bhoutan



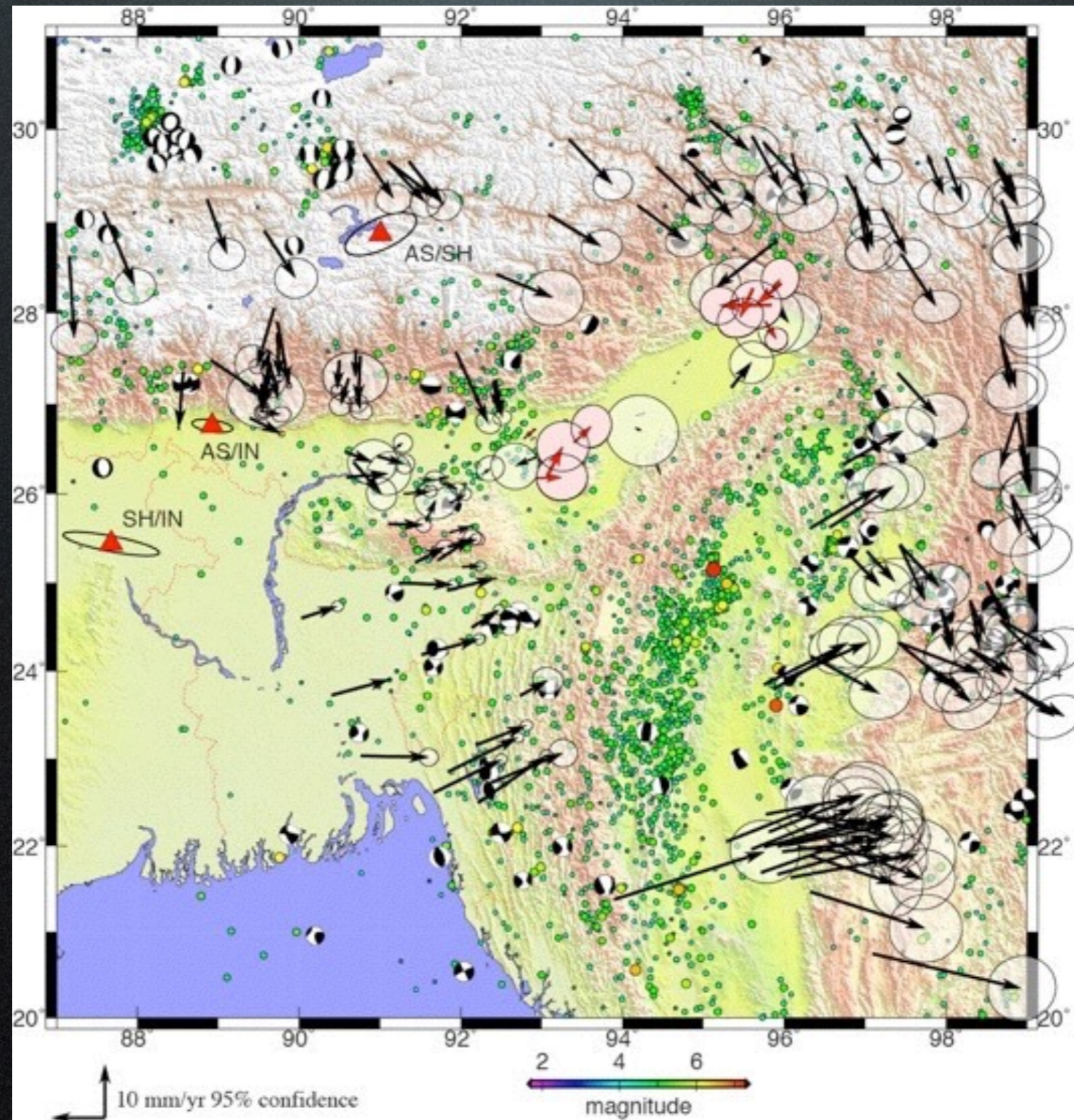
Le champ de vitesses actuelles par rapport à l'Inde



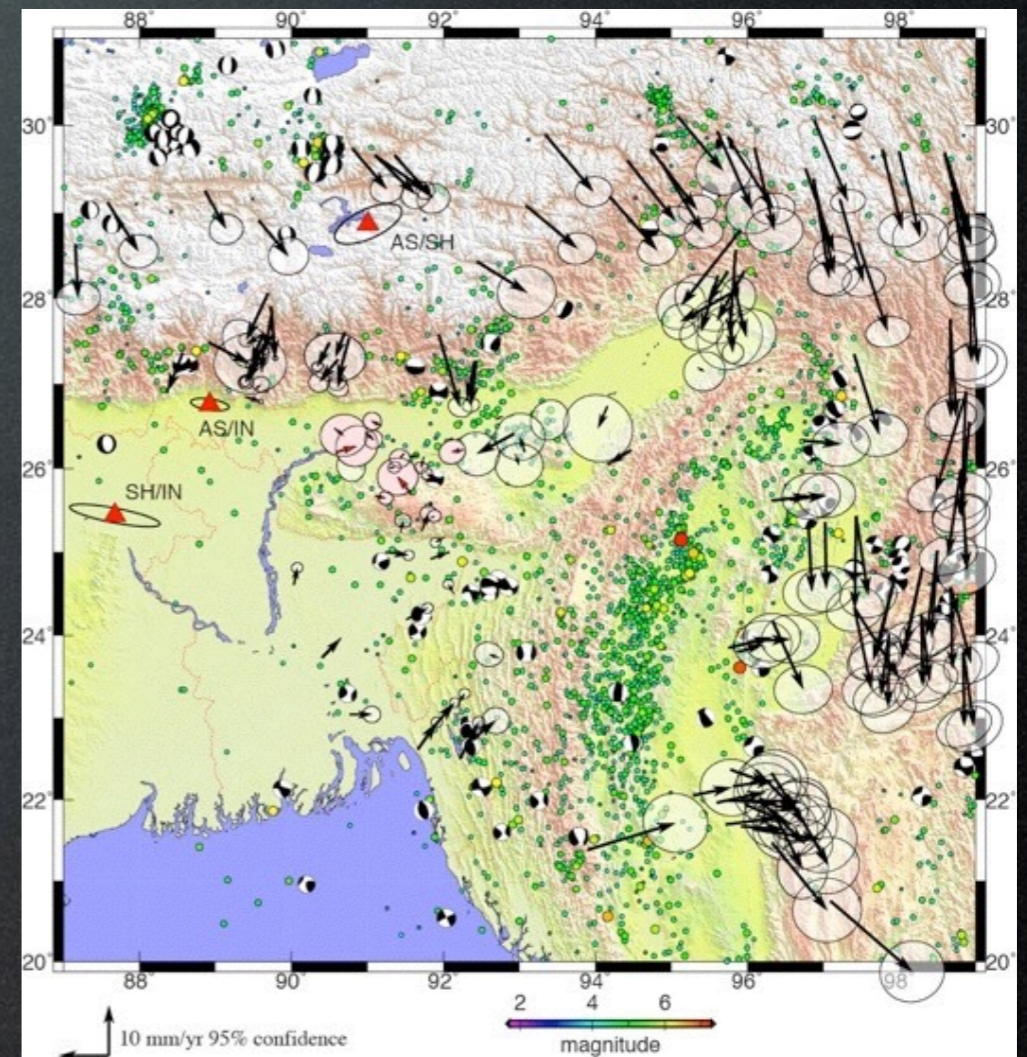
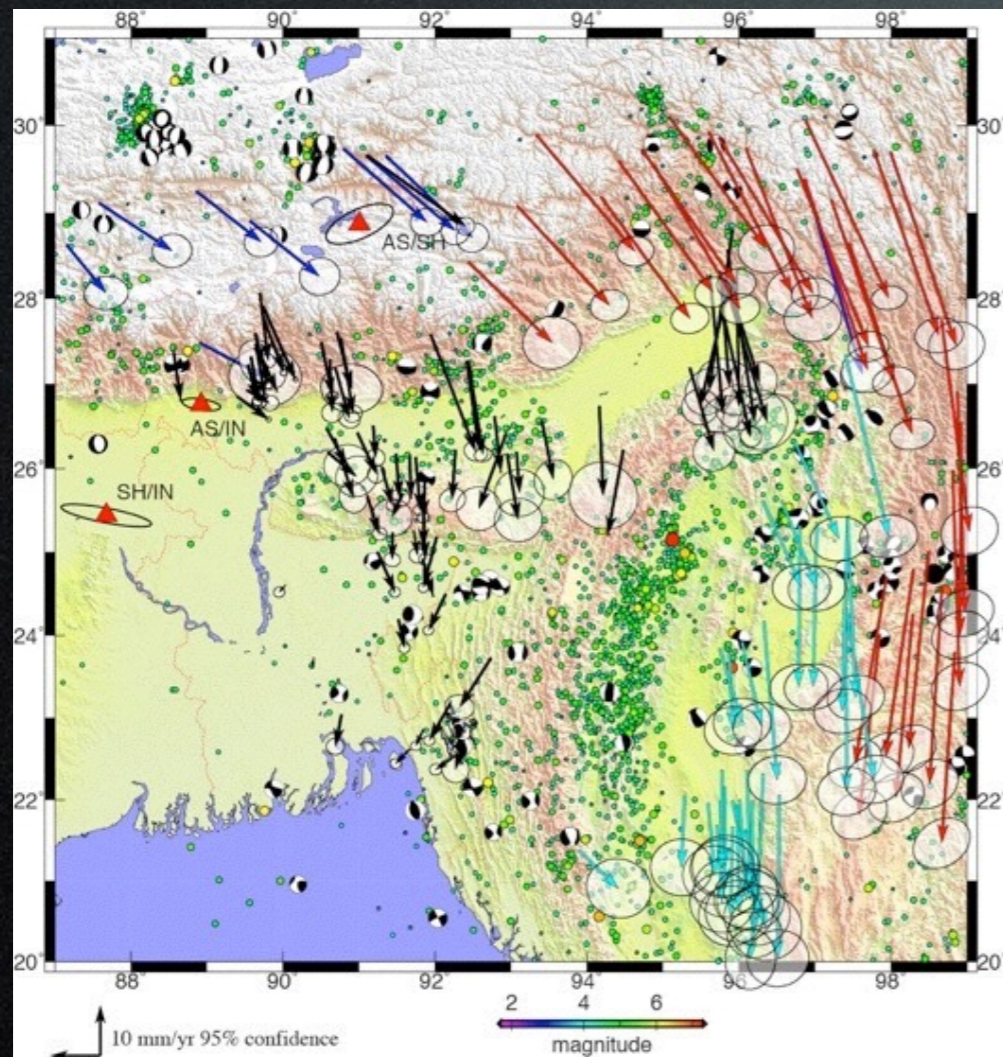
Le champ de vitesses actuelles par rapport au Shillong

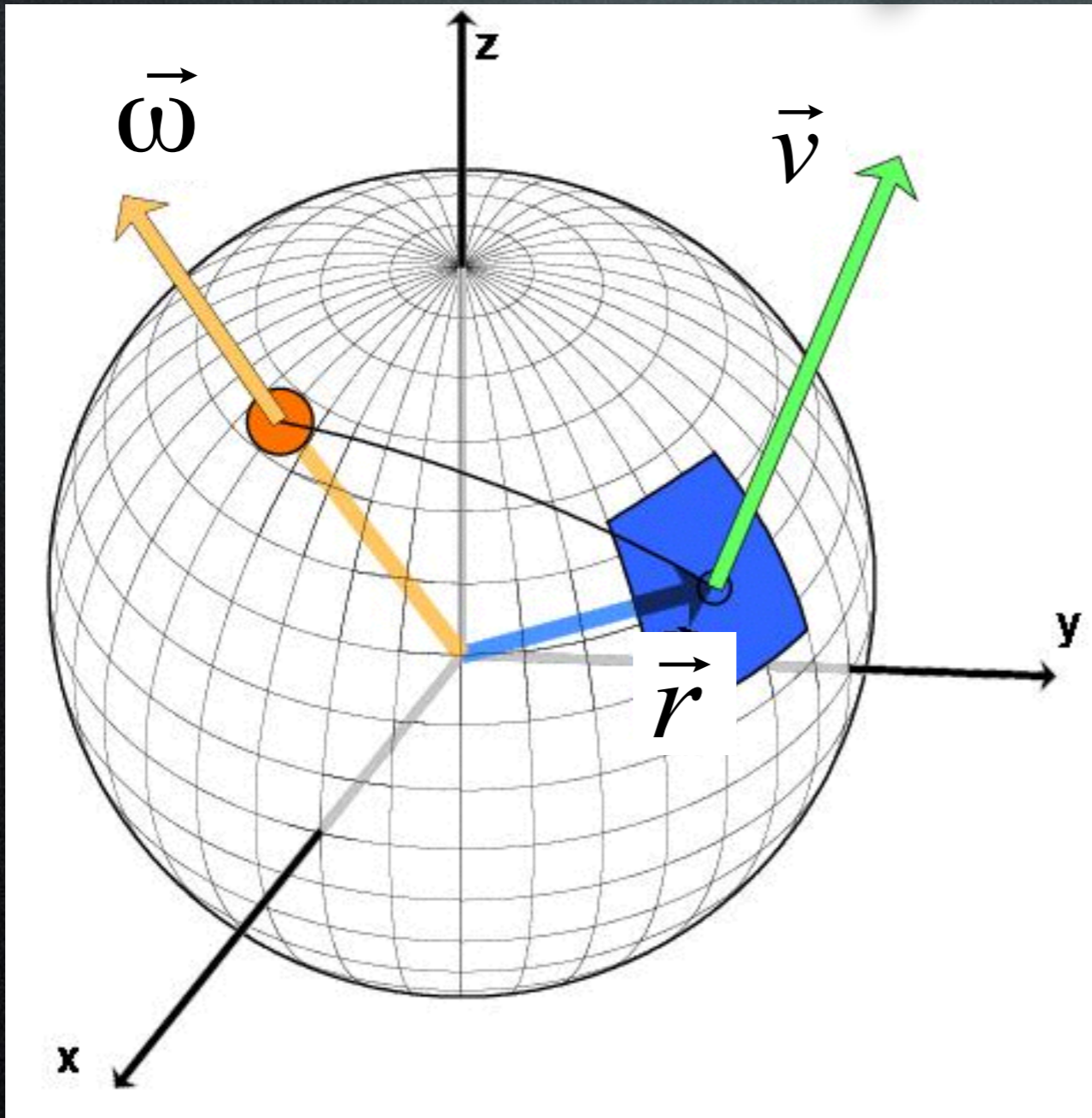
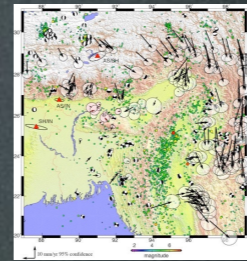
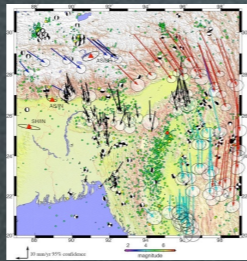


Le champ de vitesses actuelles par rapport à l'Arunachal Pradesh



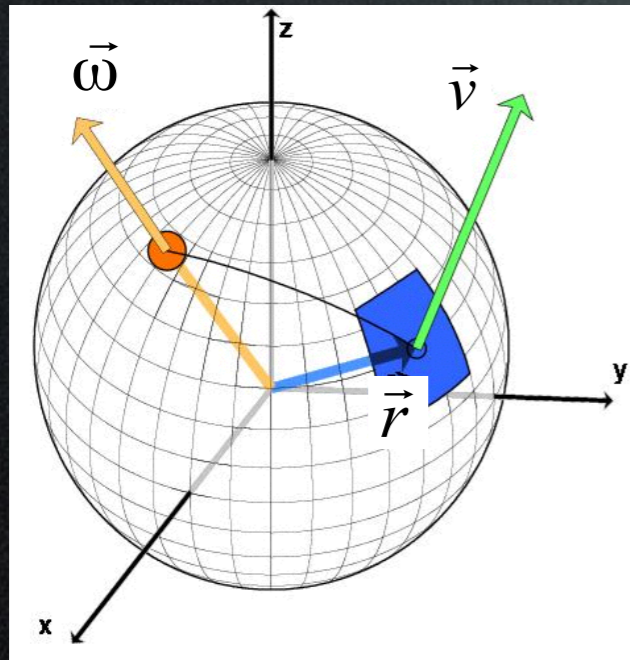
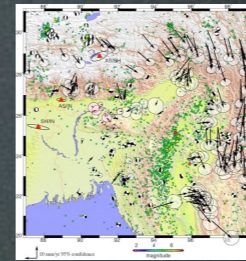
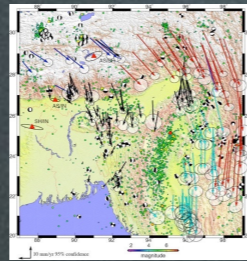
Les référentiels pour la déformation





$$\vec{v} = \vec{r} \wedge \vec{\omega}$$

- $\vec{\omega}$ est le vecteur rotation de la plaque
- \vec{r} est le vecteur position du point considéré
- \vec{v} est le vecteur de la vitesse au point considéré



$$\vec{v} = \vec{r} \wedge \vec{\omega}$$

$\vec{\omega}$ est défini par 3 composantes cartésiennes :

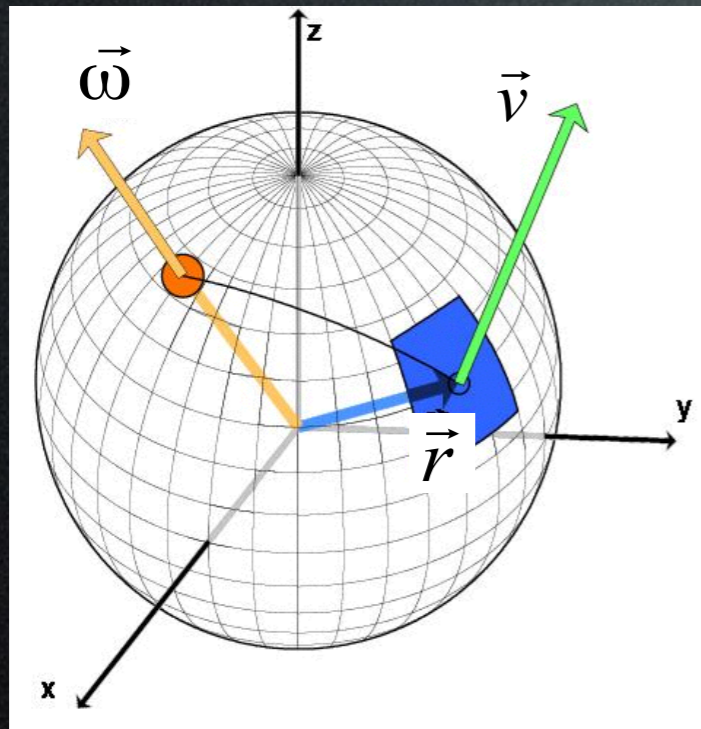
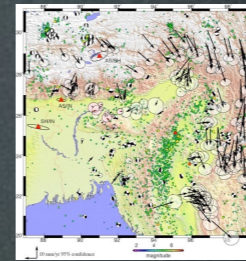
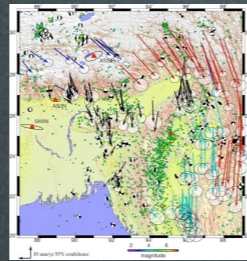
$$\omega_x, \omega_y, \omega_z,$$

C'est un vecteur dont l'origine est le centre de la Terre et qui coupe la surface de la Terre en un point donné.

Les coordonnées (latitude et longitude) de ce point ainsi que la vitesse angulaire correspondent vecteur eulérien de rotation :

$$\lambda, \varphi, \omega \text{ avec}$$

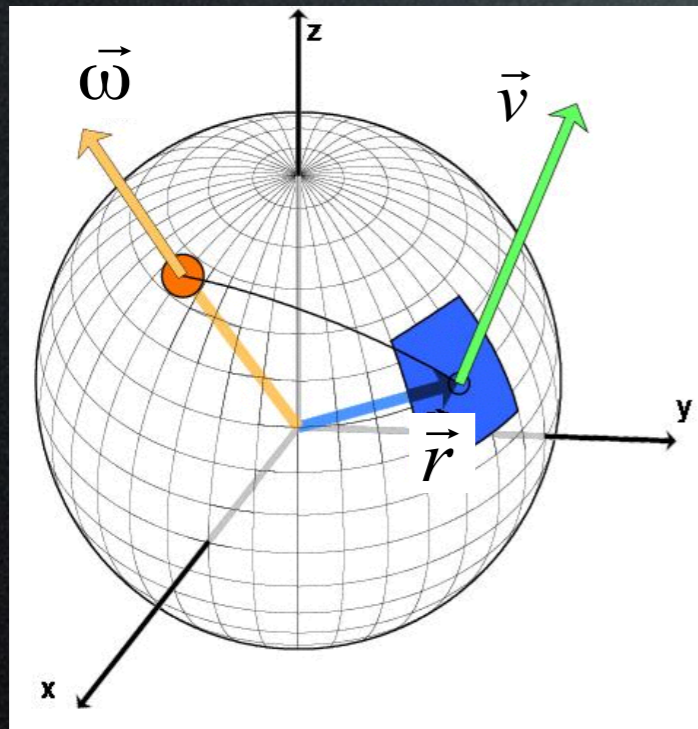
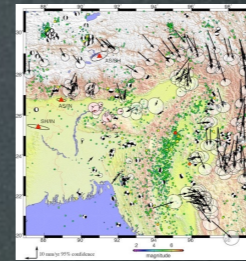
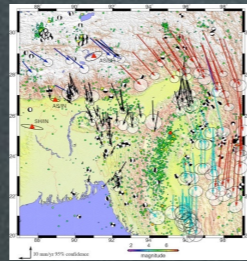
$$\omega = \sqrt{\omega_x^2 + \omega_y^2 + \omega_z^2}$$



Pole de rotation de l'Eurasie dans ITRF2000 (Altamimi et al., 2005)

Table 7. ITRF2000 Relative Rotation Poles

Plate	$\phi(^{\circ} \text{ N})$	$\lambda(^{\circ} \text{ E})$	Ω_x	Ω_y	Ω_z	Ω
EURA	73.032	128.99	-.000794	.000981	.004138	.248

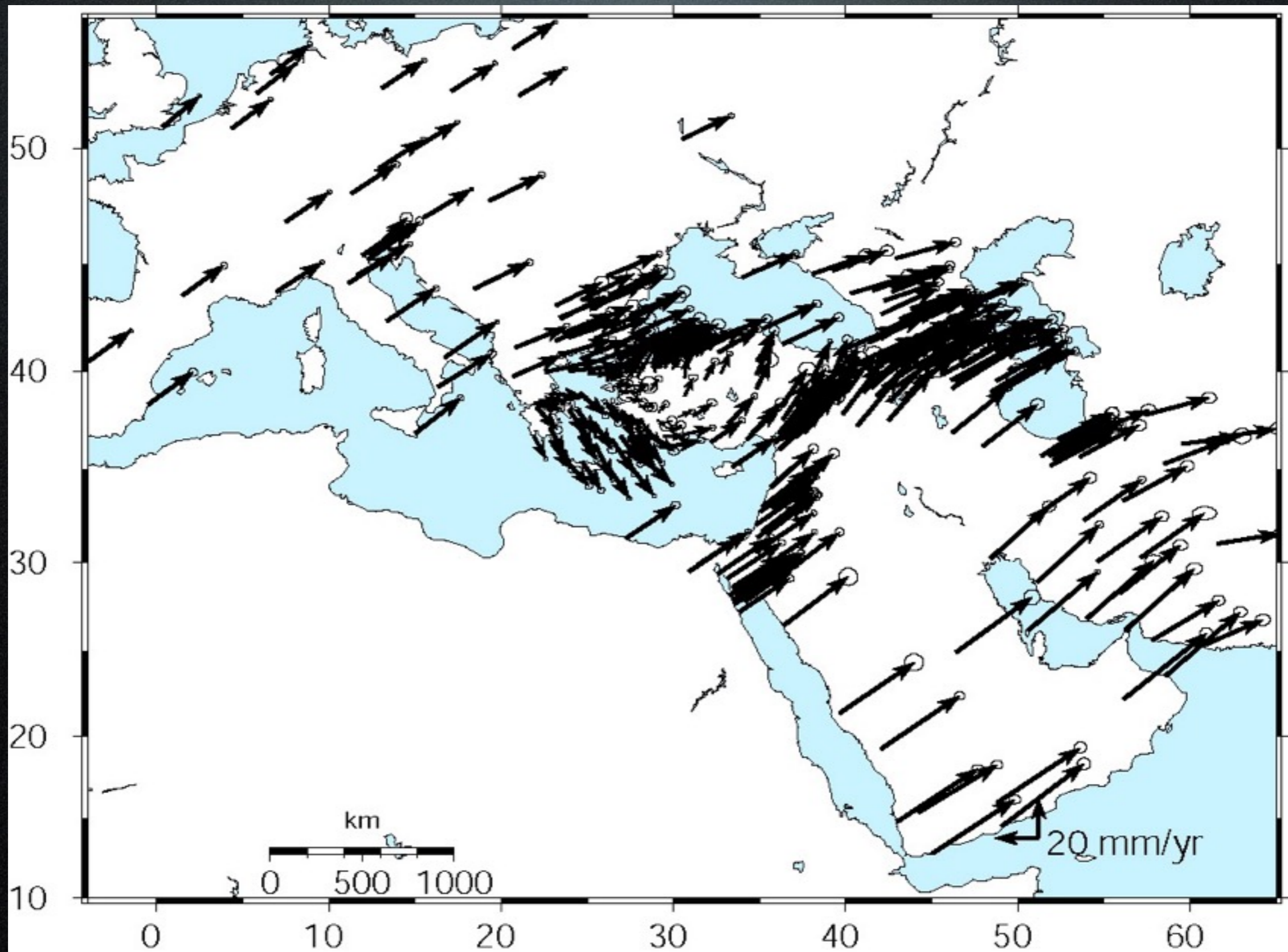


Le mouvement en un point de latitude λ et de longitude φ se trouvant sur une plaque dont le mouvement peut être décrit par le vecteur eulérien de coordonnées λ_p (latitude), φ_p (longitude) et ω (vitesse de rotation en $^\circ/\text{Ma}$) est donné par les formules suivantes :

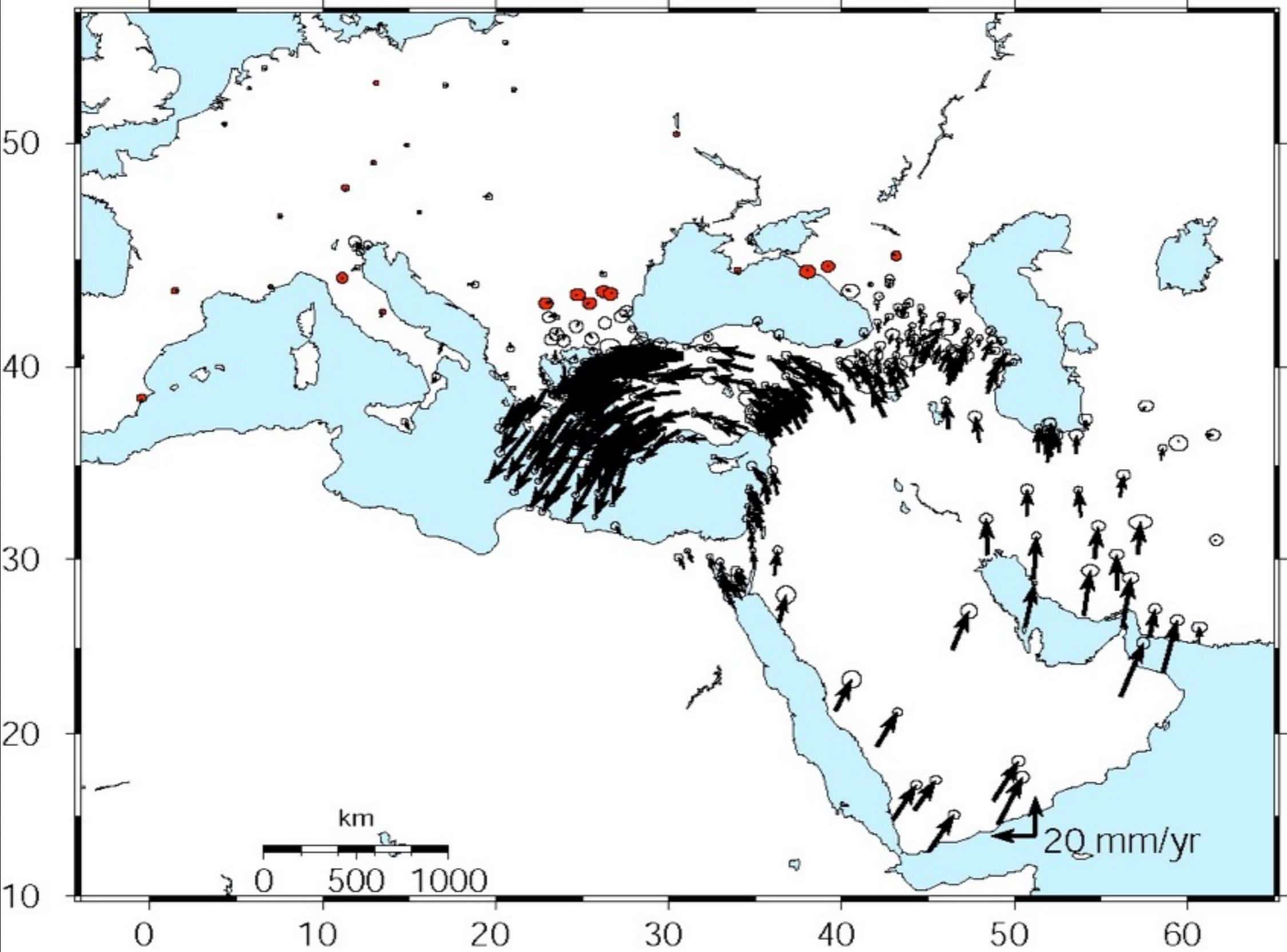
$$v_\lambda = \frac{1000}{9} \omega \cos \lambda_p \sin(\varphi - \varphi_p)$$

$$v_\varphi = \frac{1000}{9} \omega \left[\sin \lambda_p \cos \lambda - \cos \lambda_p \sin \lambda \cos(\varphi - \varphi_p) \right]$$

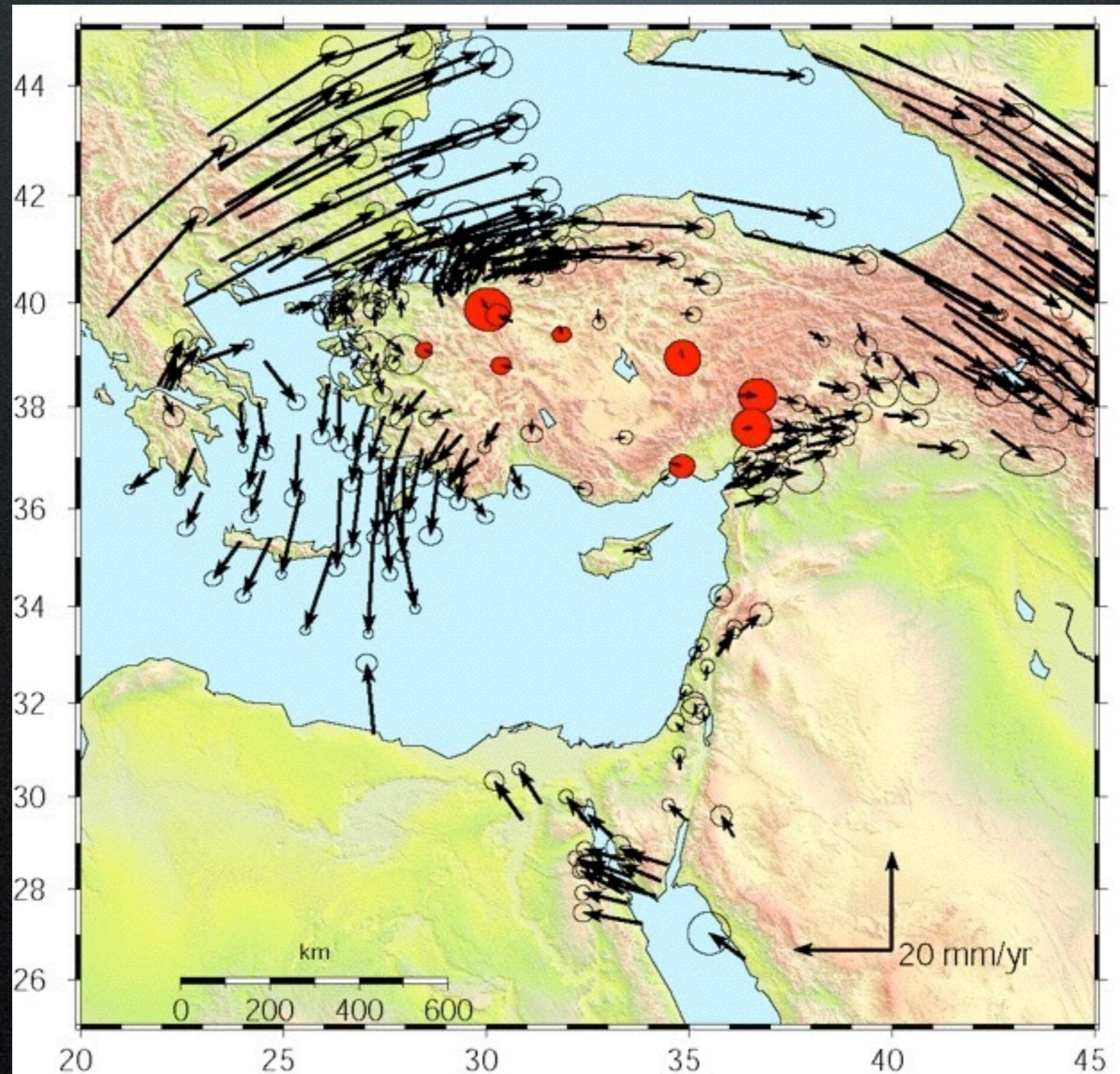
Champ de vitesse du Moyen Orient dans l'ITRF2008



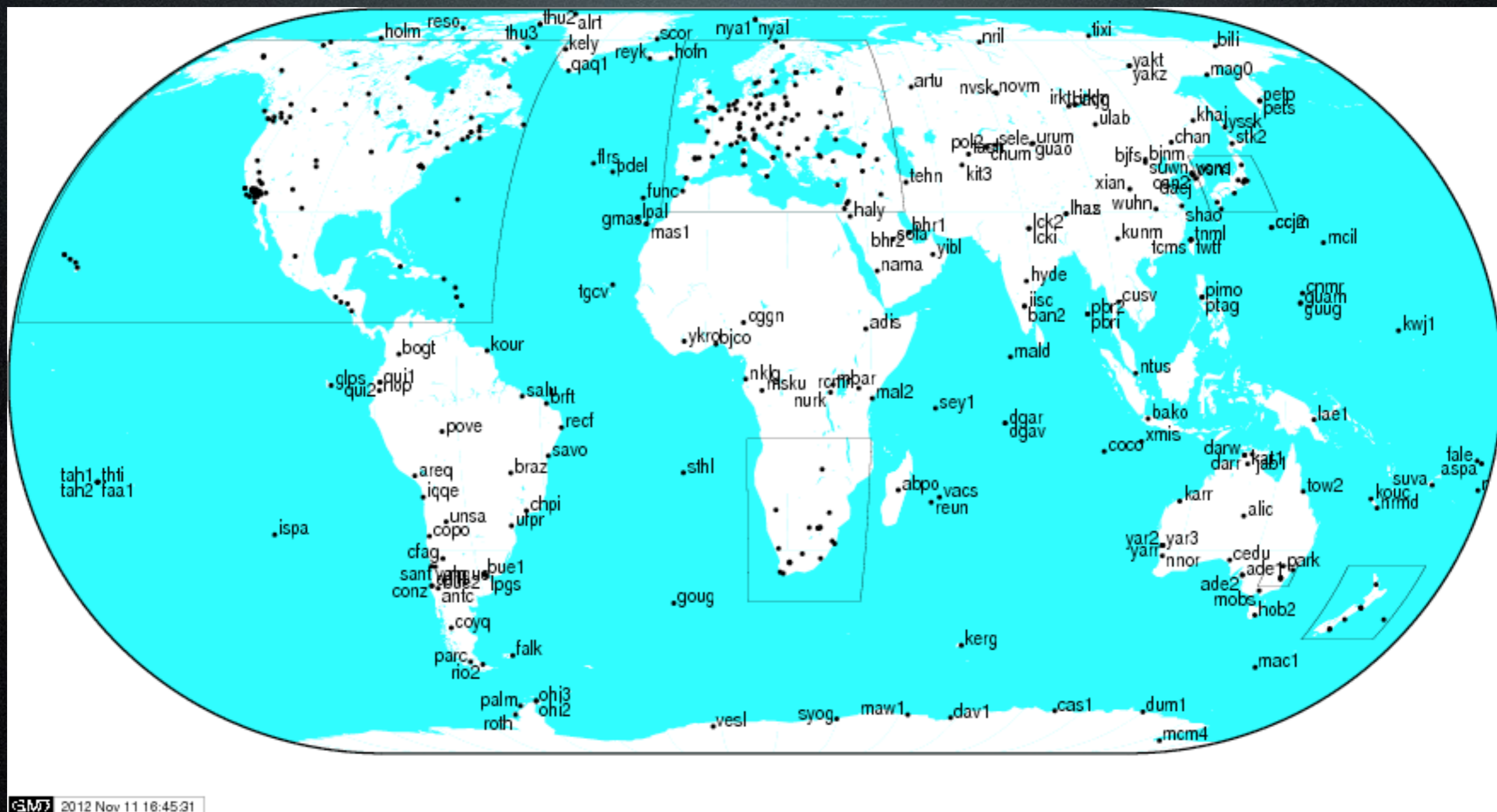
Champ de vitesse du Moyen Orient dans le référentiel Eurasie fixe



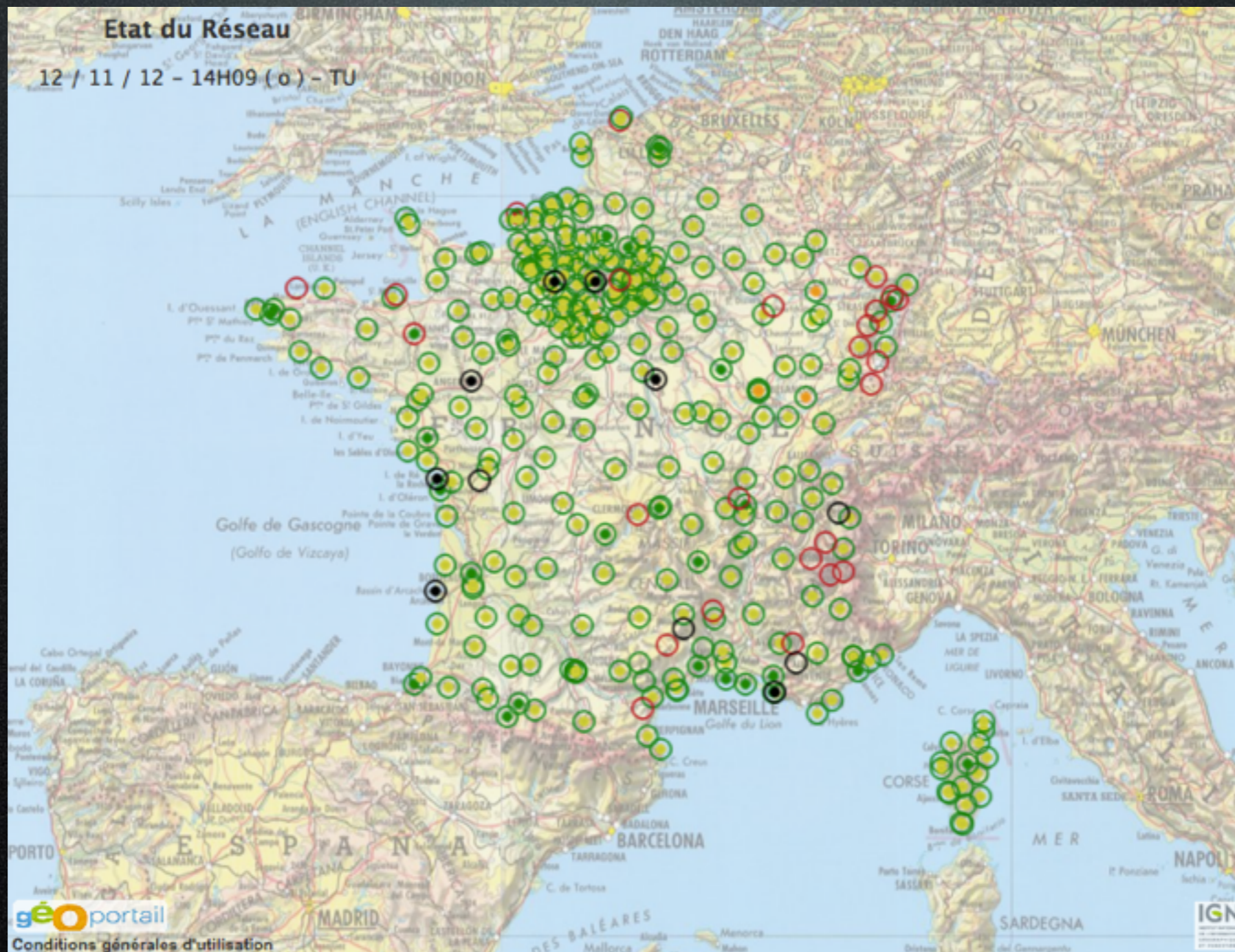
Référentiel Anatolie fixe



I'IGS - International GNSS Service



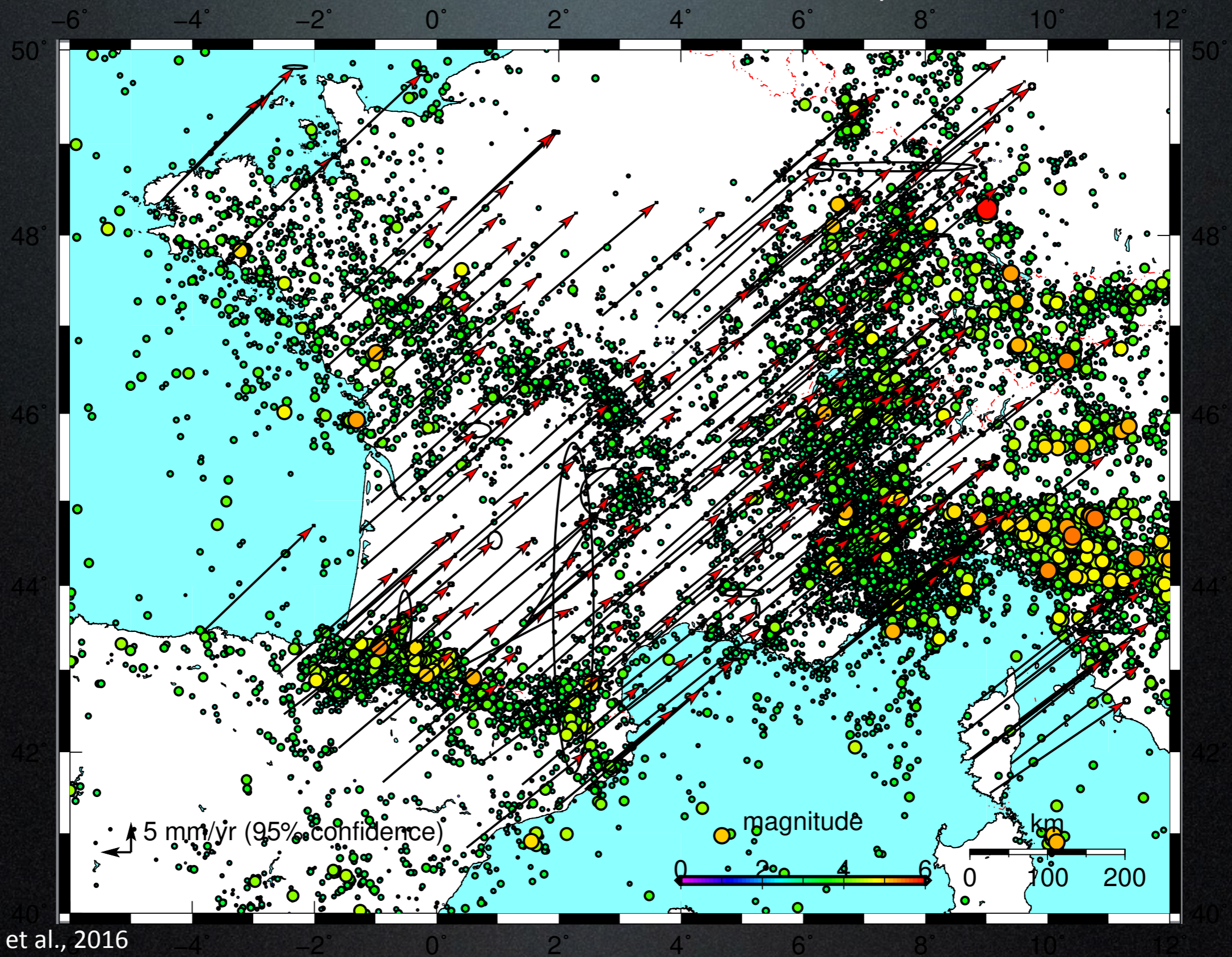
RGP - Réseau GPS Permanent



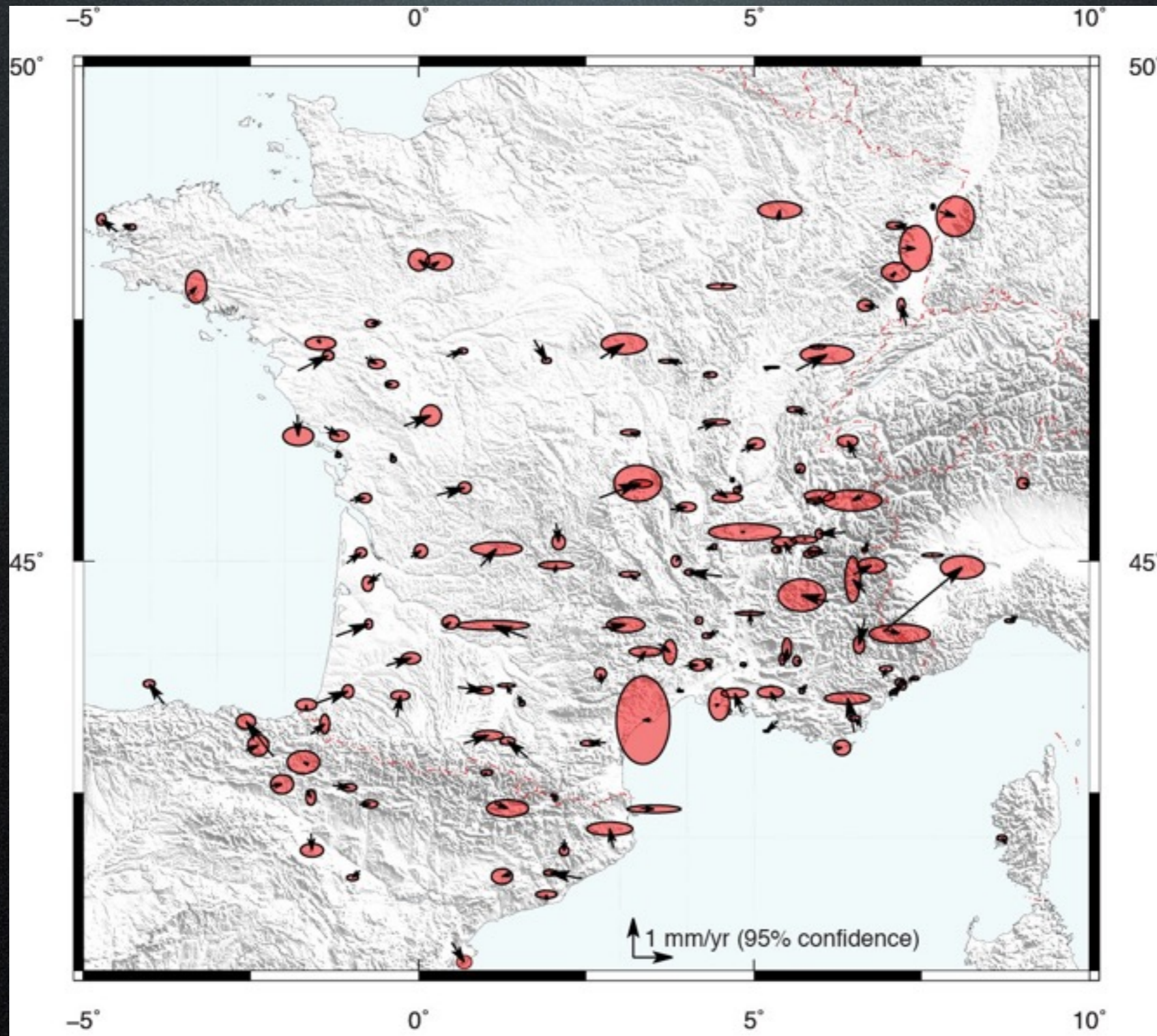
<http://rgp.ign.fr/>

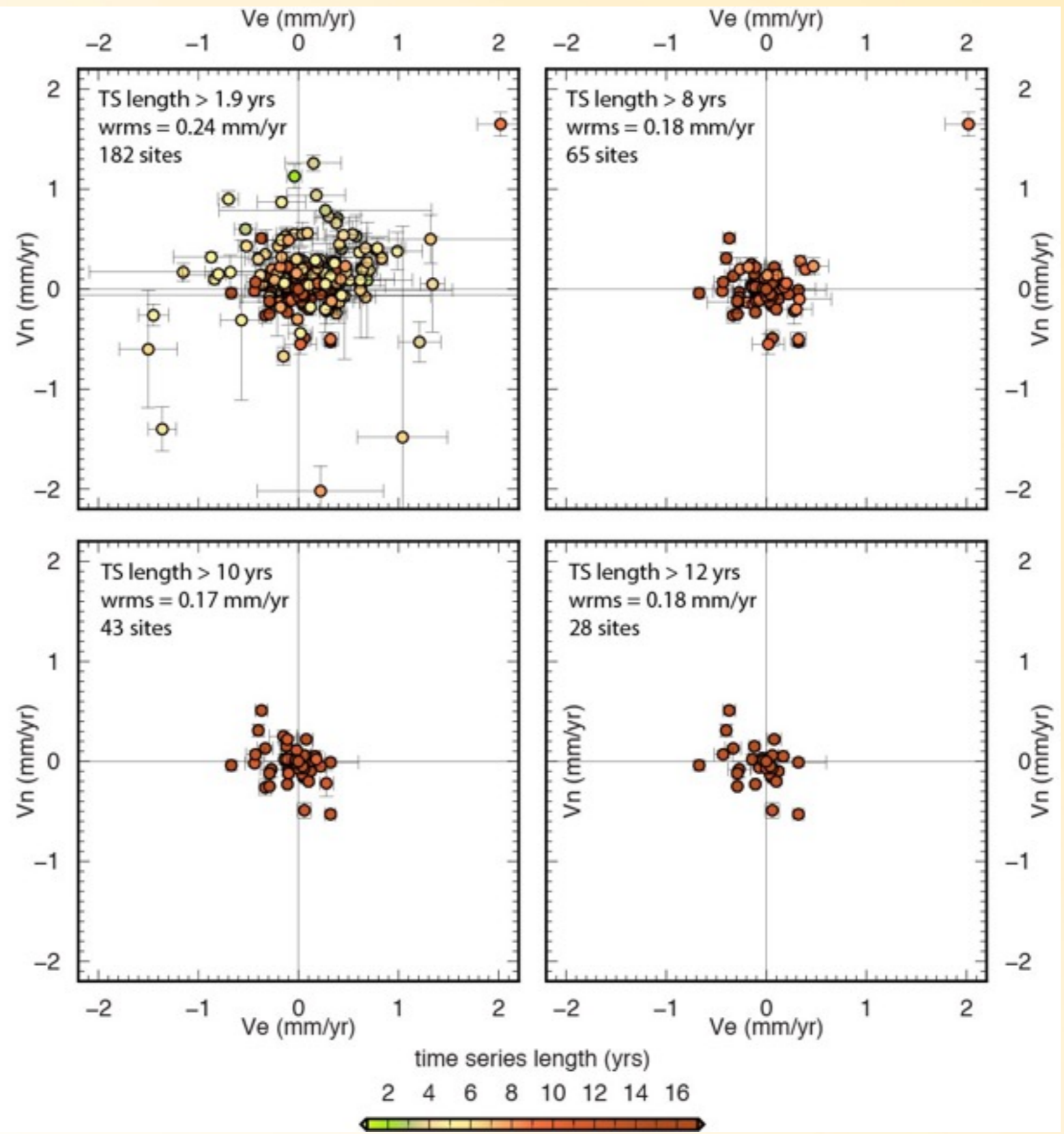
- EU/ITRF2008 :

53.730 ° N, -101.856 ° E et 0.256 °/Ma

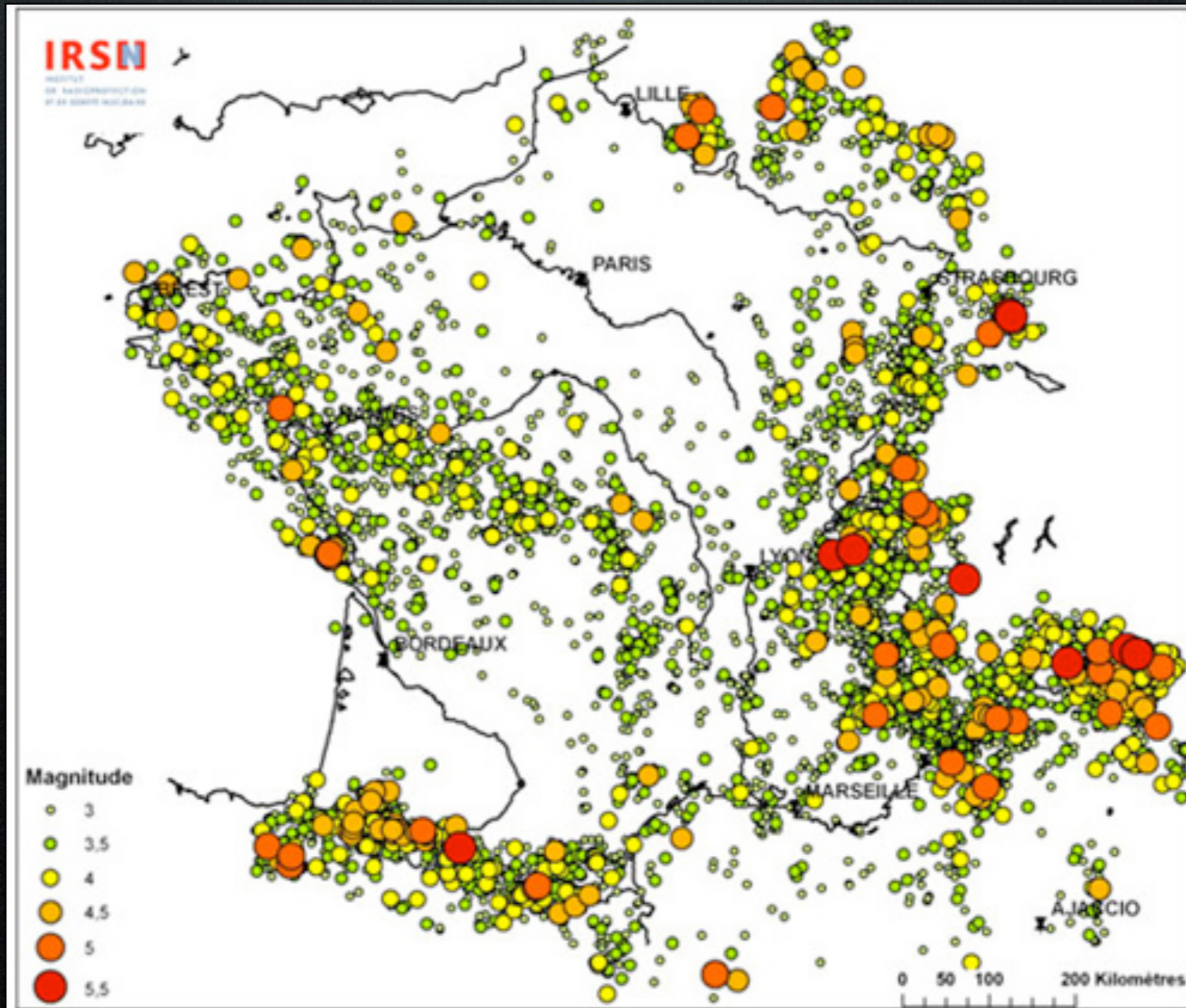


Tectonique active en France : les limites de la géodésie ?

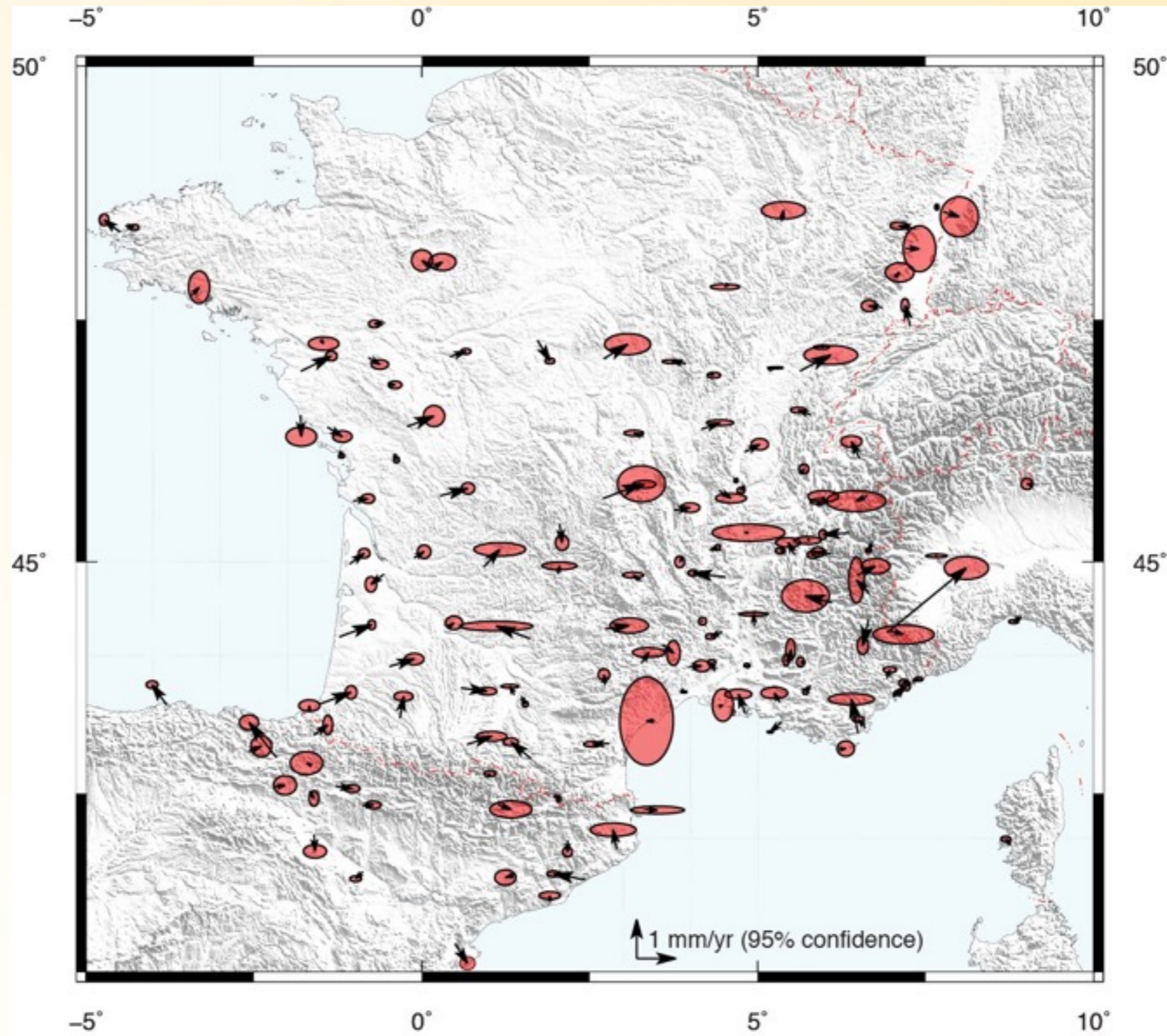




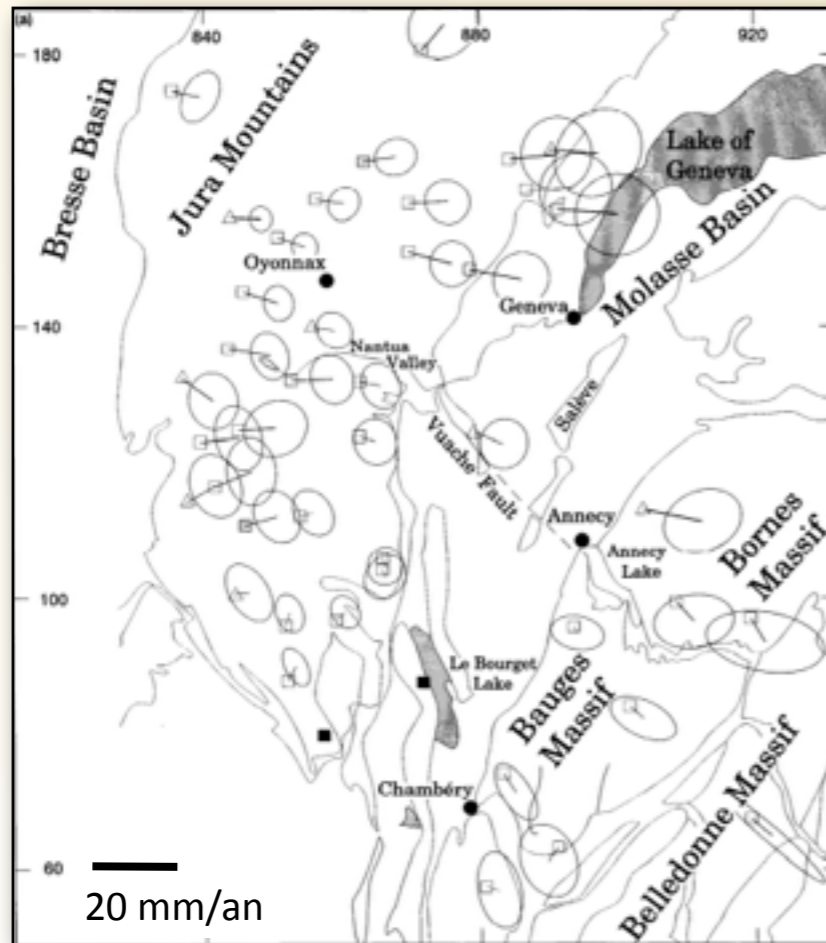
Pourtant de la sismicité existe en France



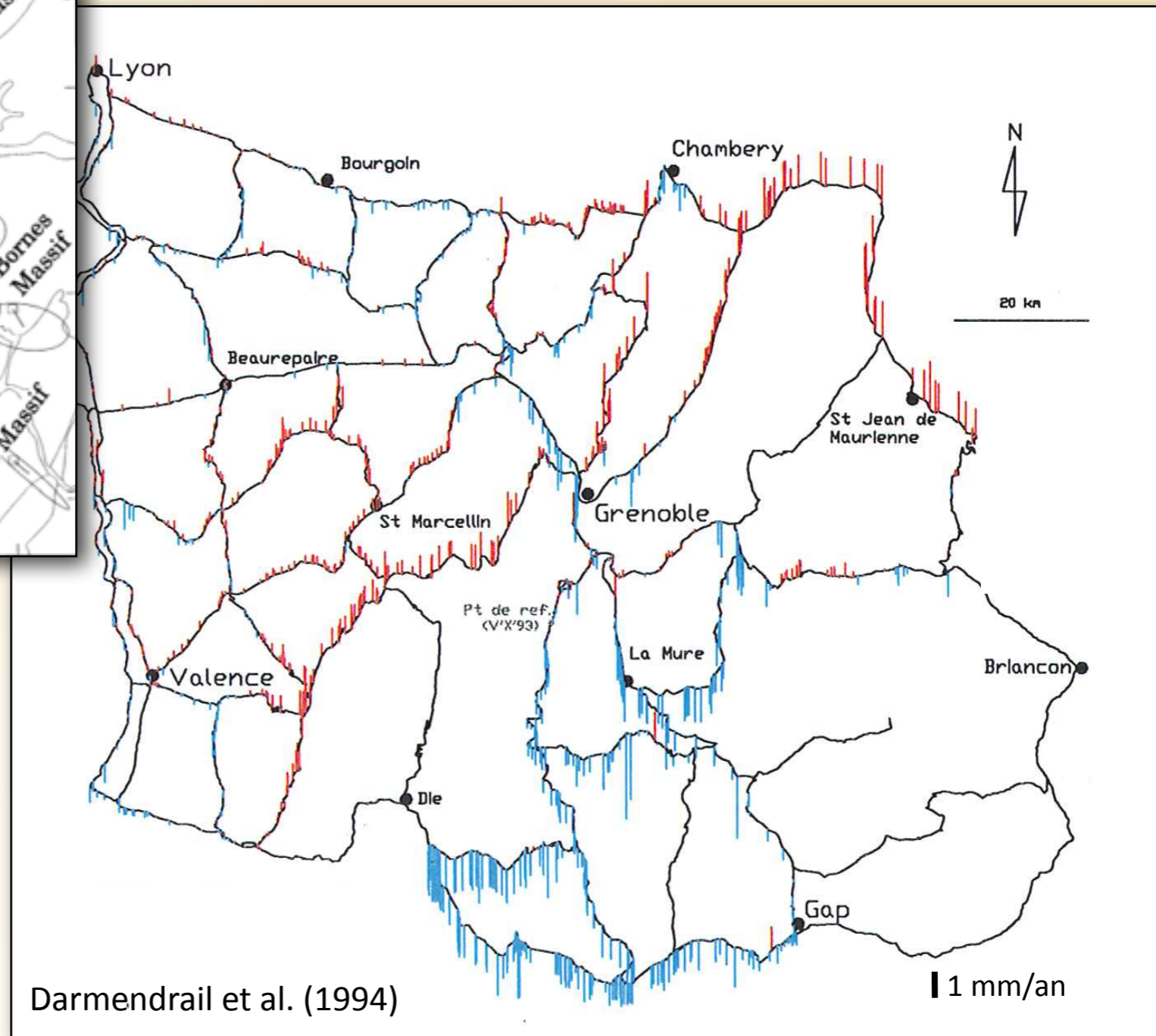
Tectonique active en France : les limites de la géodésie ?



Vitesse dérivées du nivellement

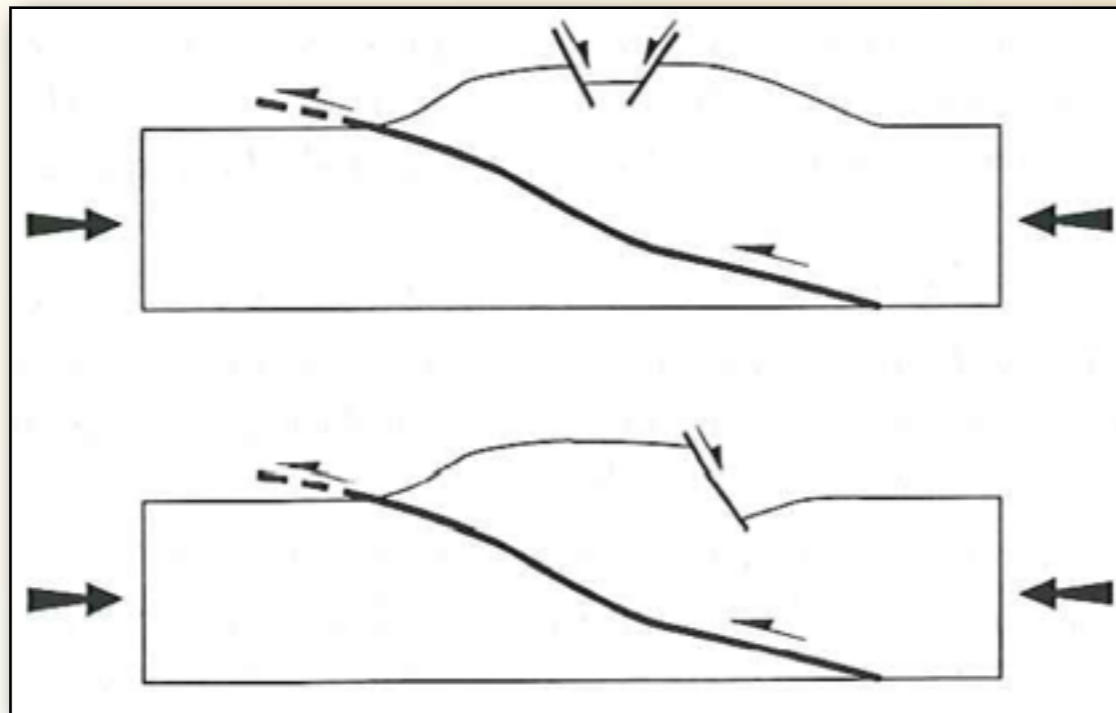


Jouanne et al. (1994)

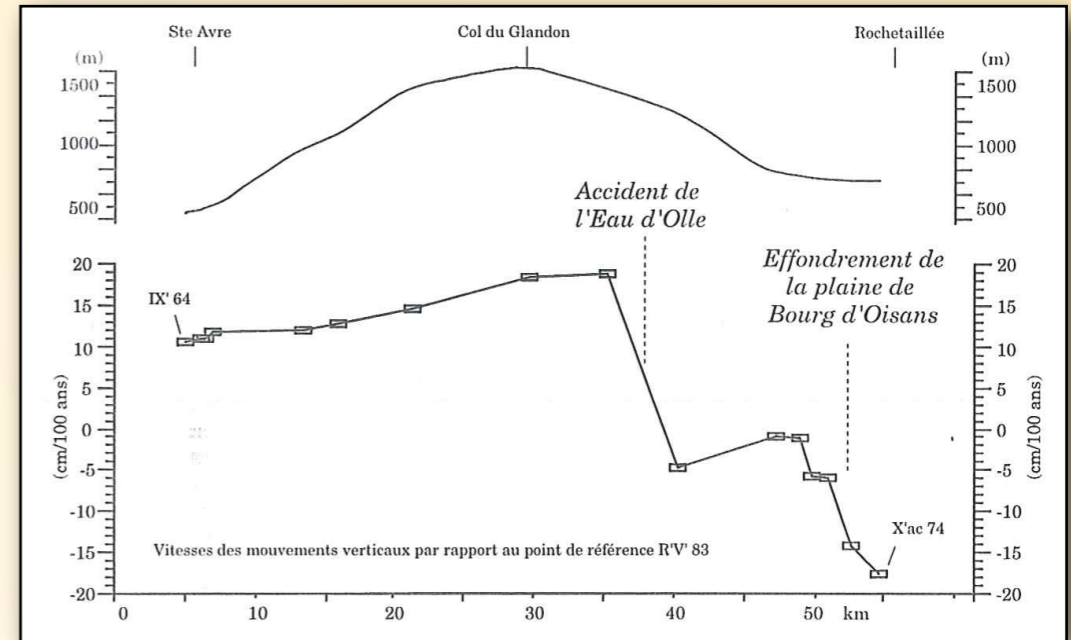


Darmendrail et al. (1994)

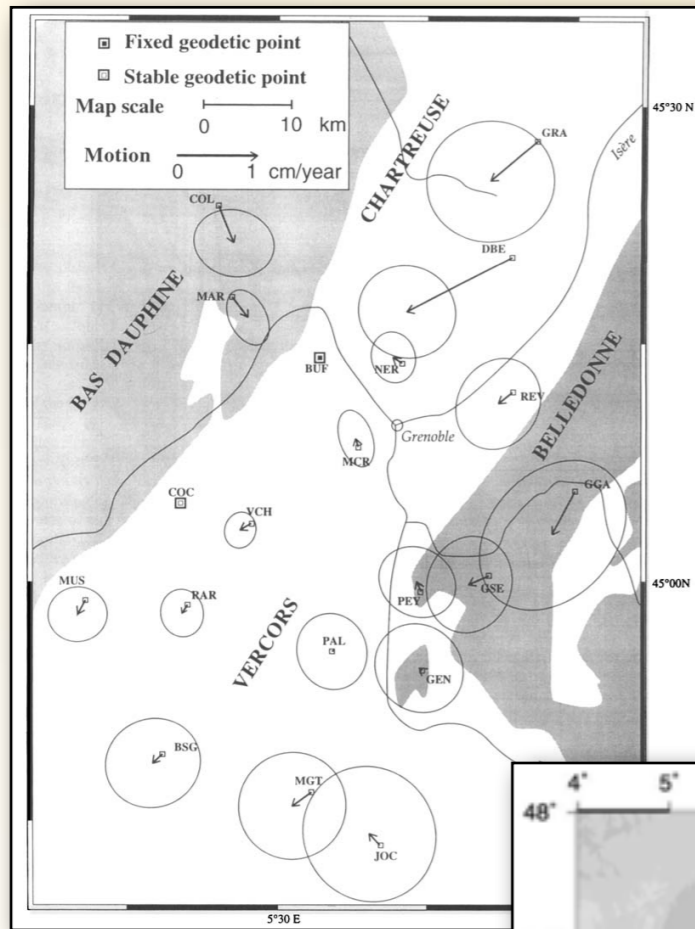
Interprétation des mouvements géodésiques: extension superficielle dans le cadre de la convergence Afrique-Eurasie



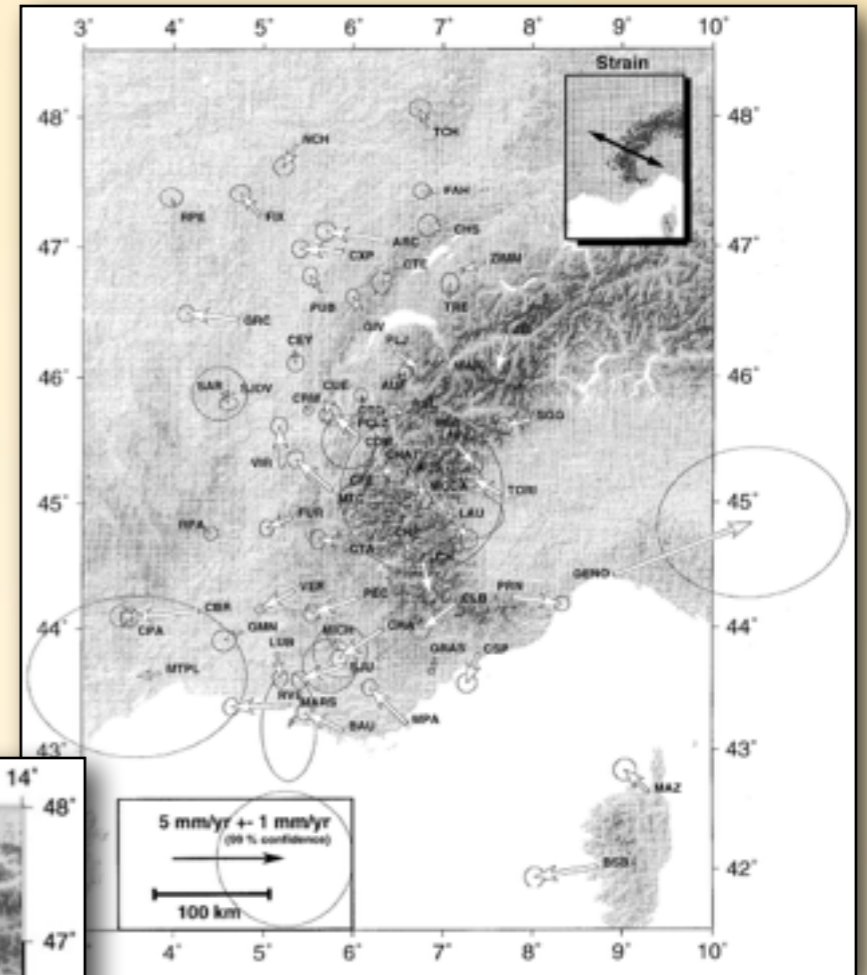
Darmendrail (1994)



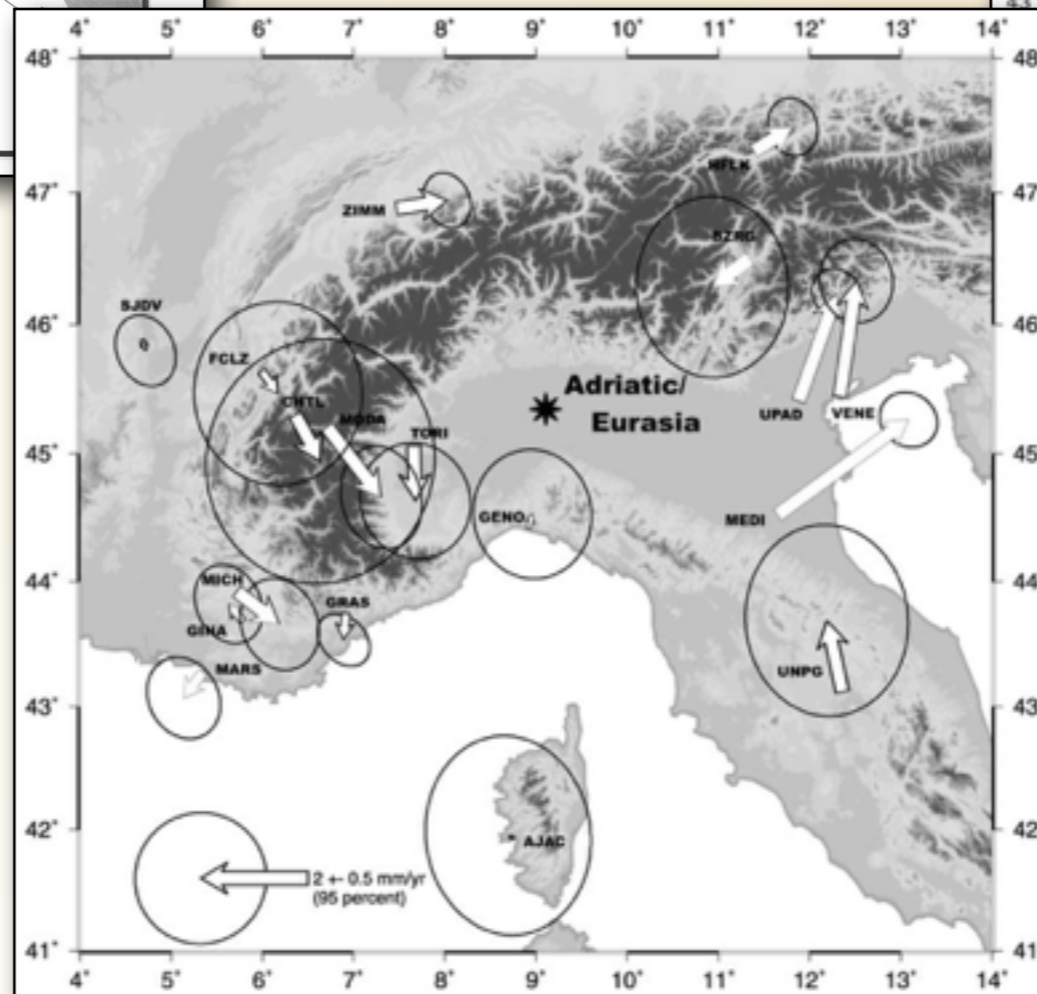
Vitesses horizontales dérivées du GPS



Martinod et al. (1996)

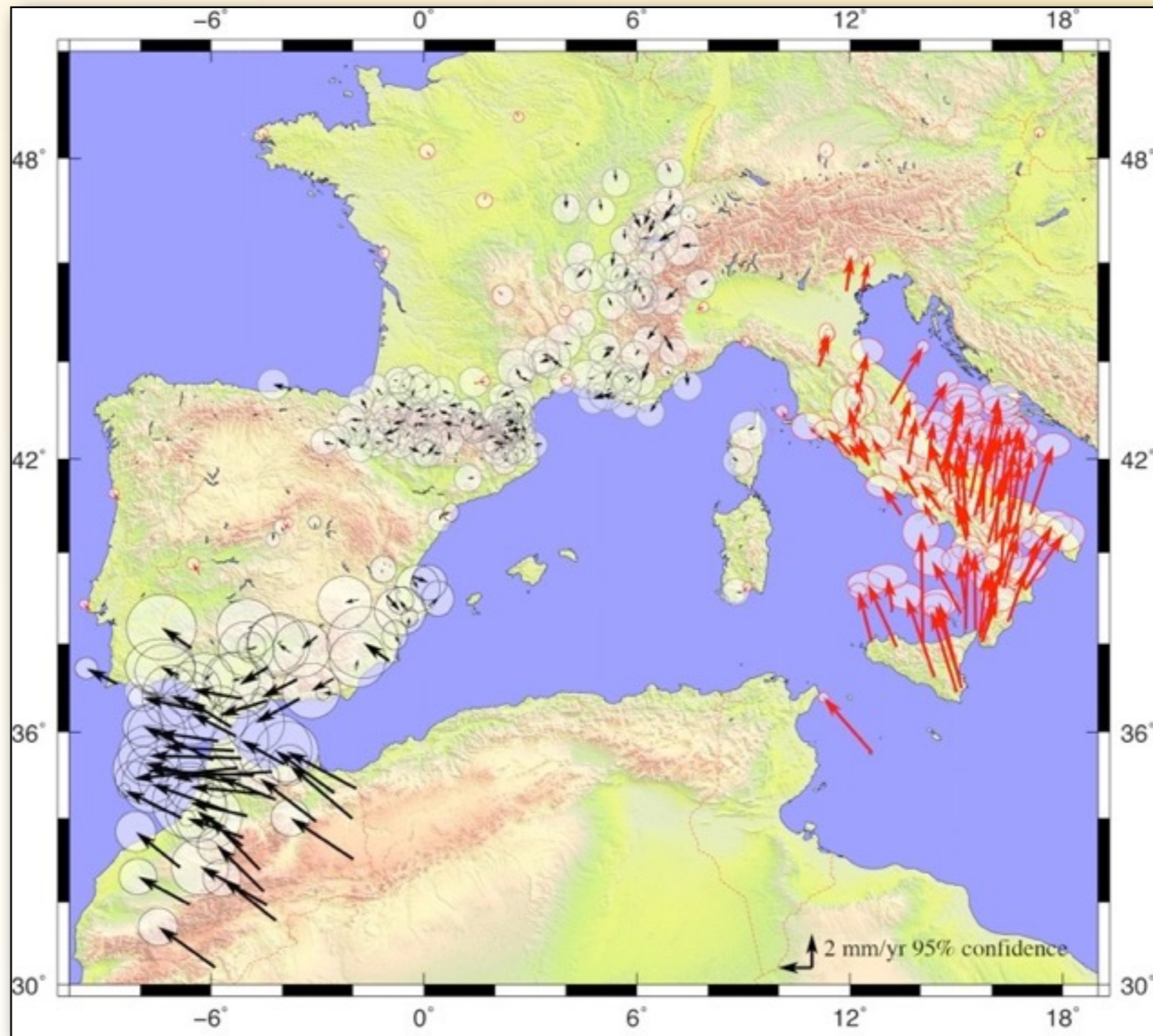


Vigny et al. (2002)

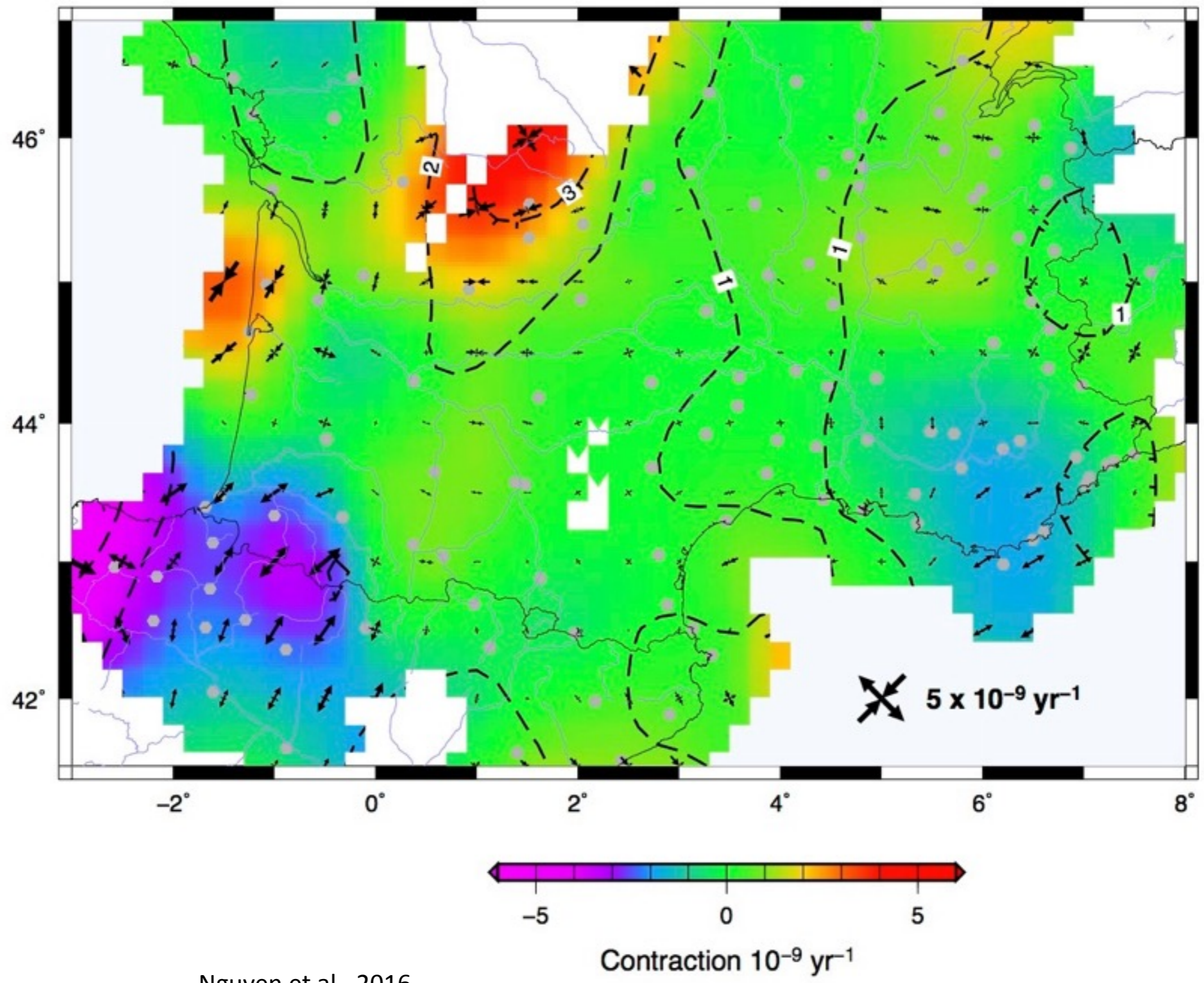


Nocquet et al. (2003)

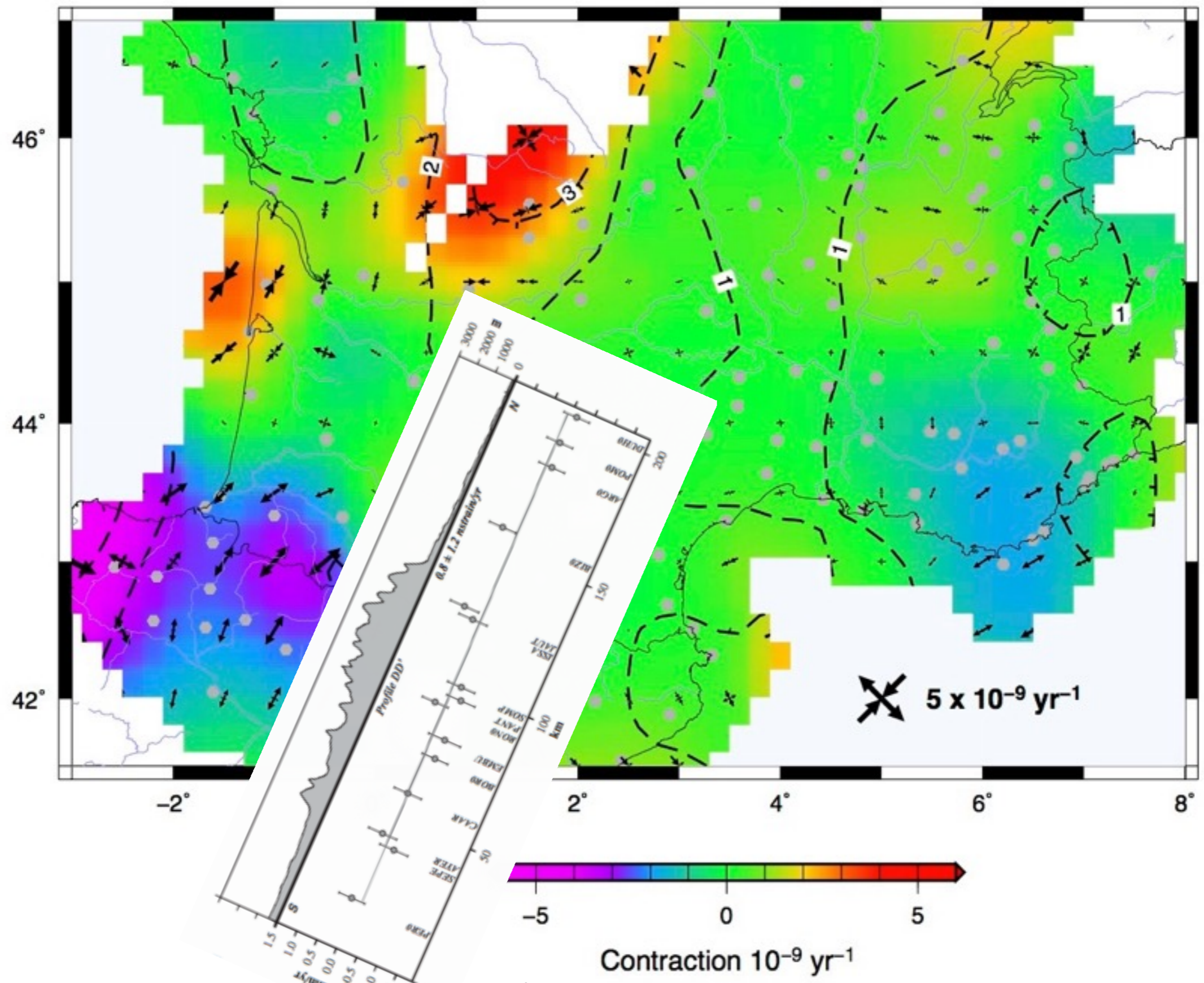
Vitesse horizontales dérivées du GPS



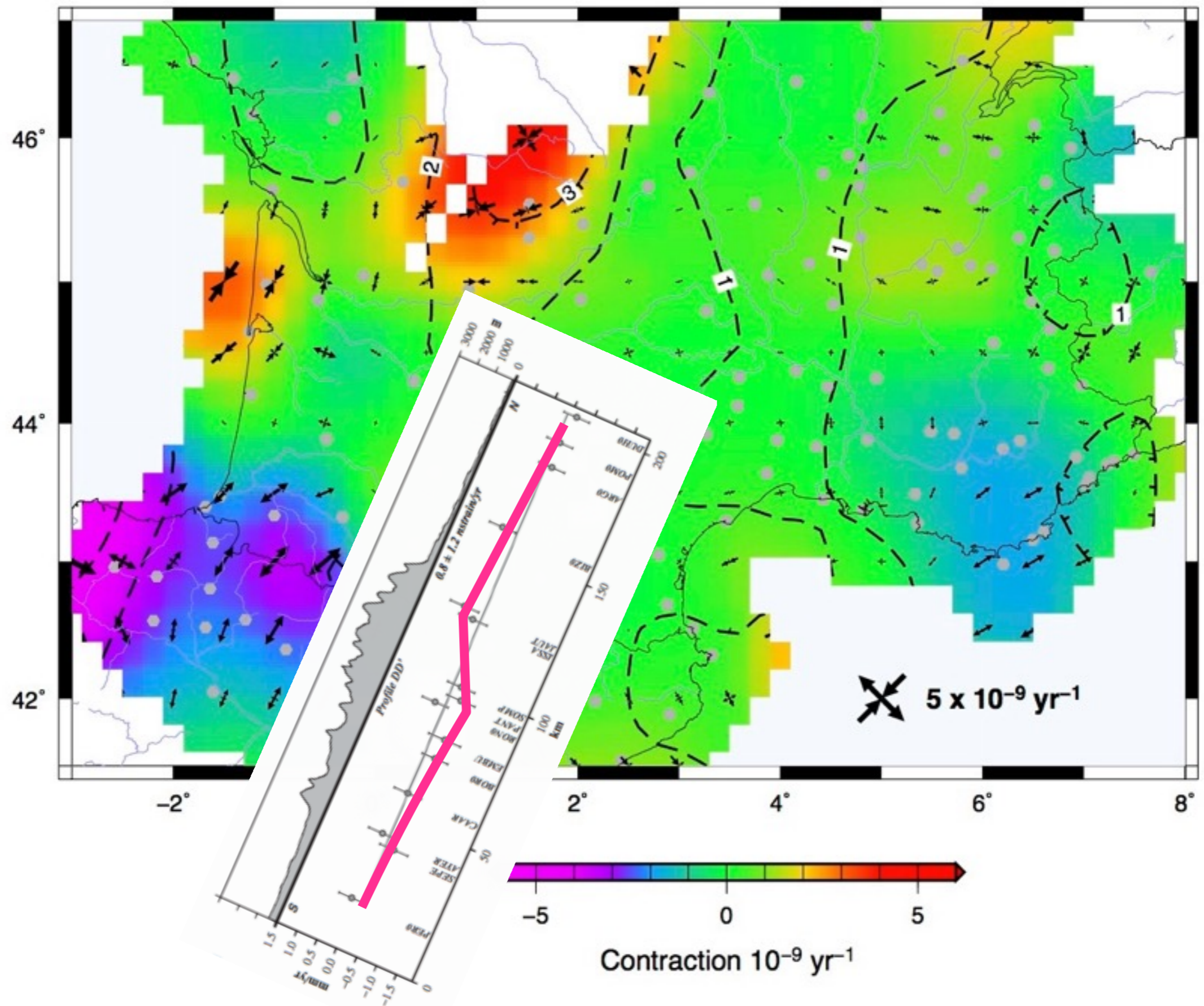
Koulali et al. (2011), D'Agostino et al. (2009 et 2011), Rigo et al. (2015)



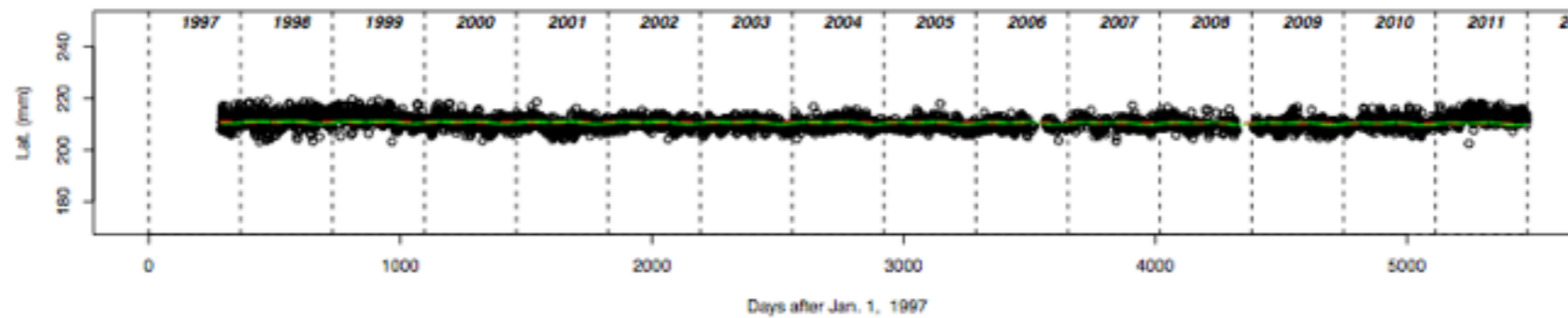
Nguyen et al., 2016



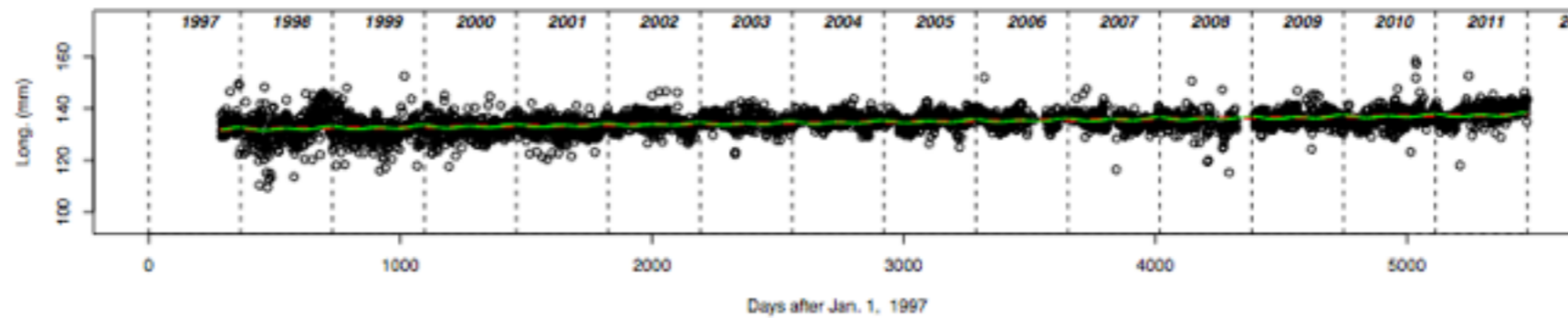
Rigo et al., 2015



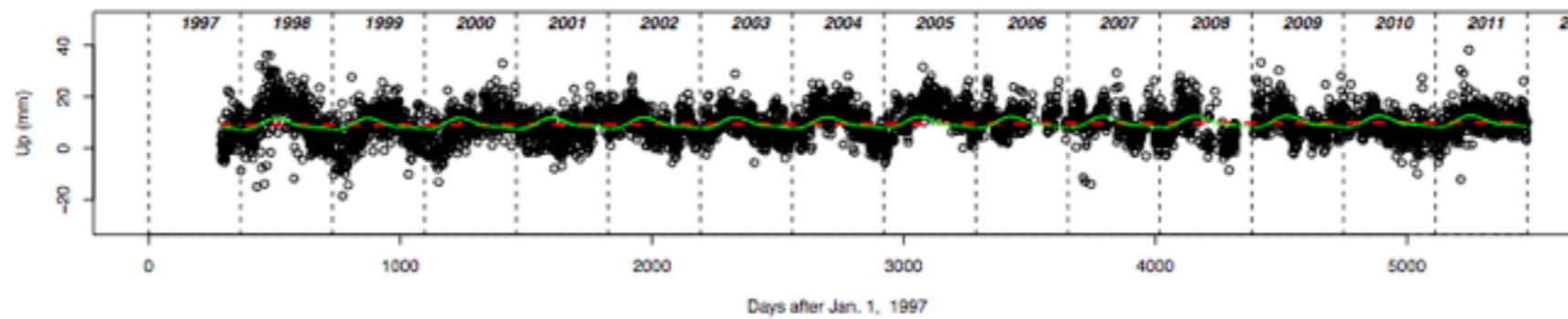
SJDV Lat. rate: -0.04 ± 0.01 mm/yr, col. error (-0.9): 0.03 ; RMS scatter: 2.35

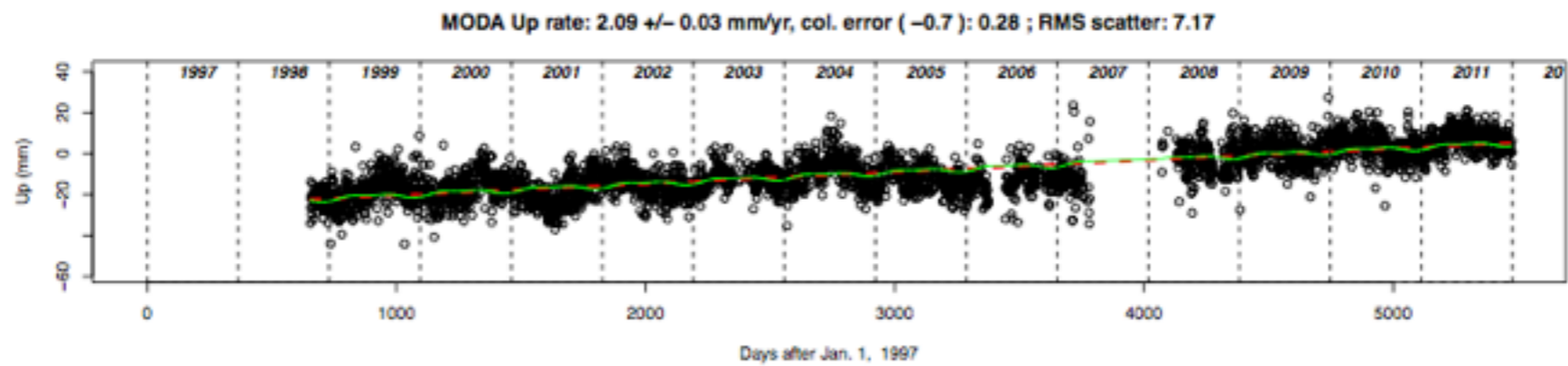
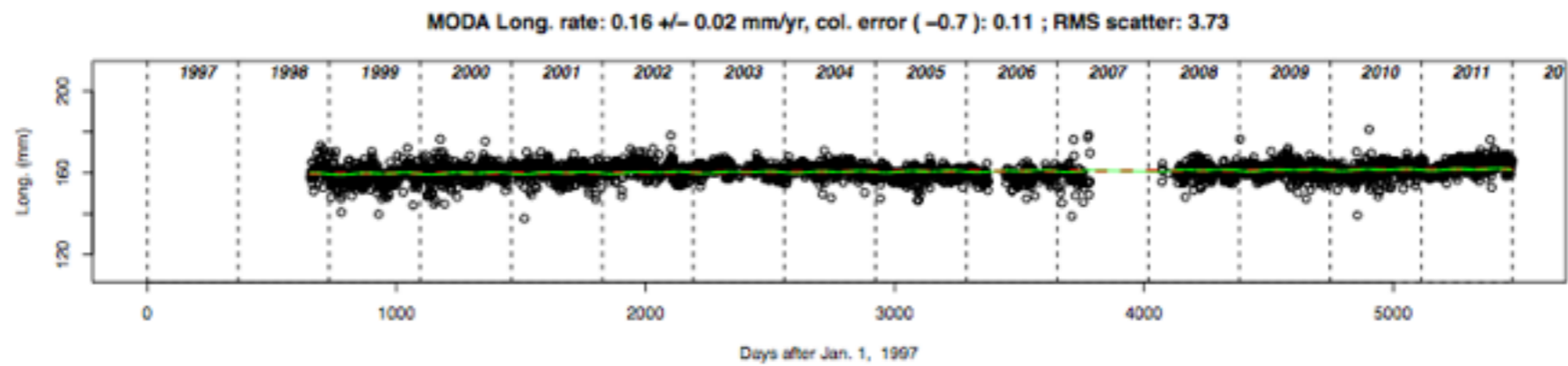
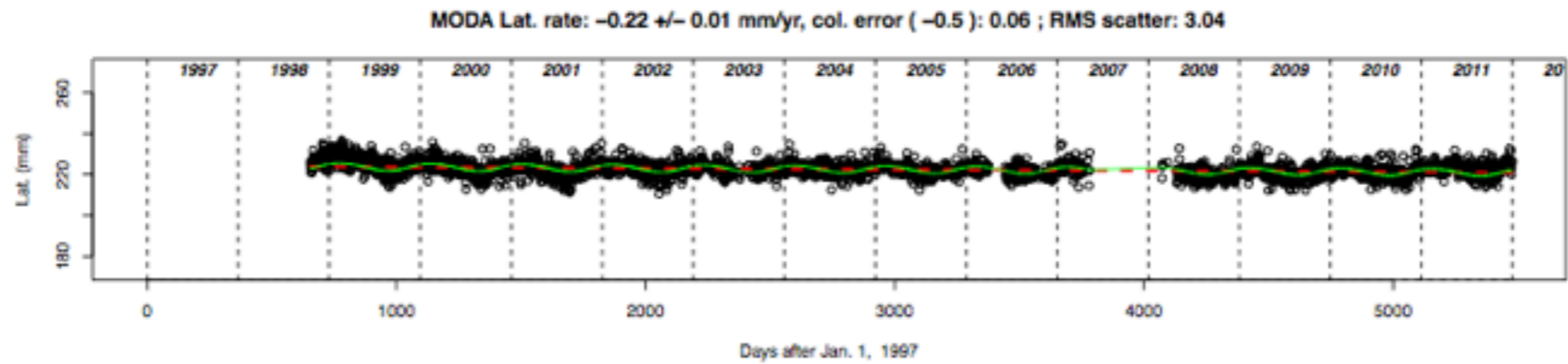


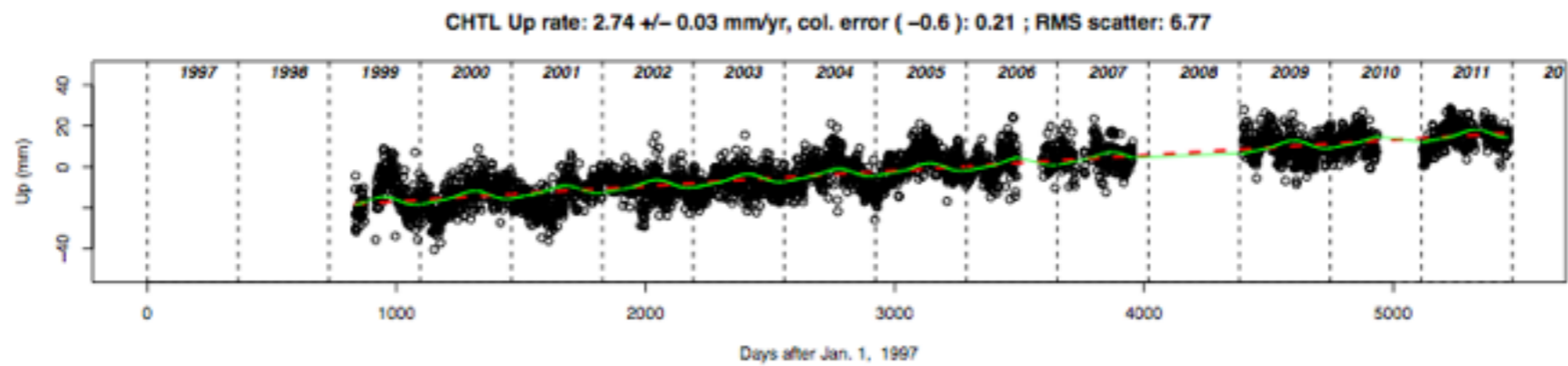
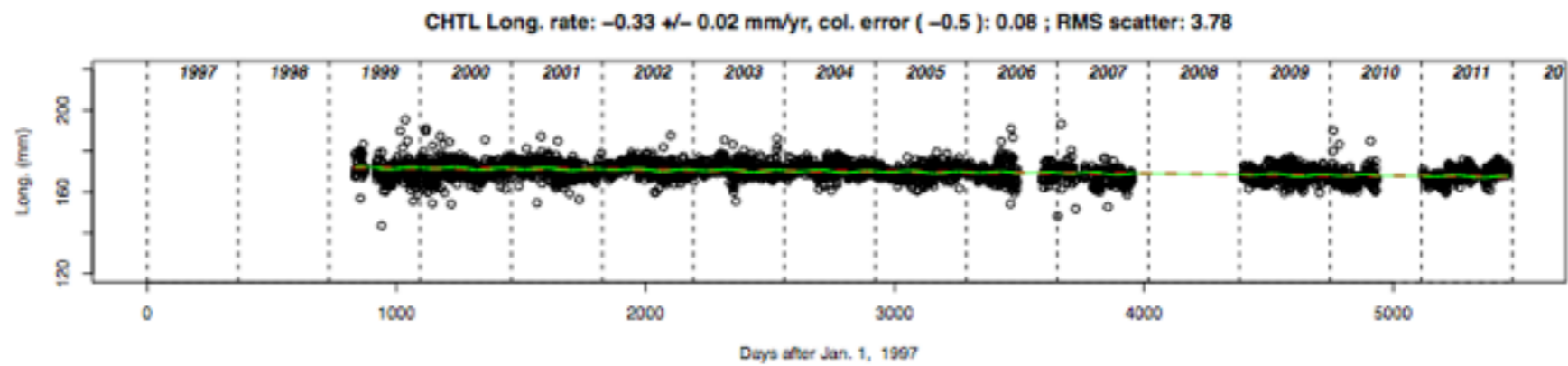
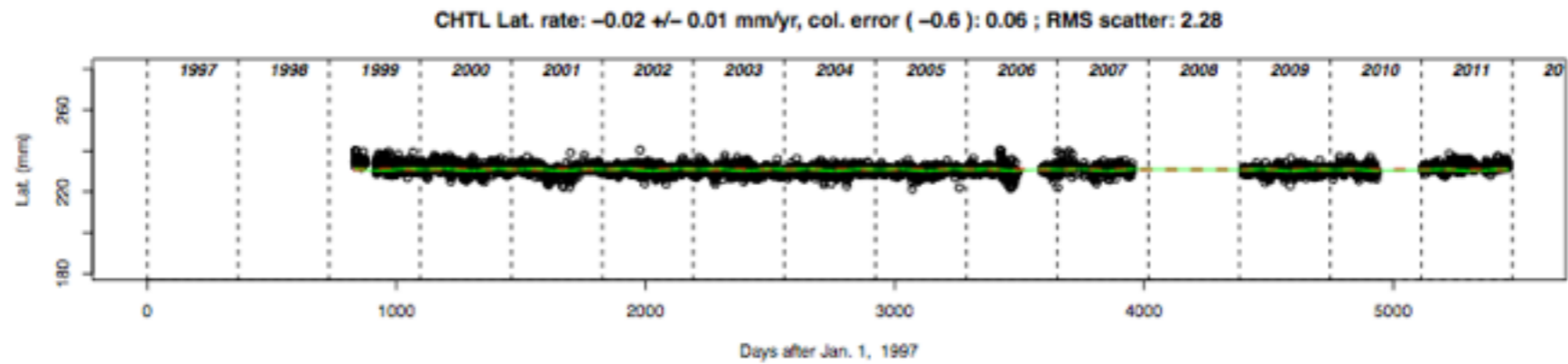
SJDV Long. rate: 0.41 ± 0.01 mm/yr, col. error (-0.6): 0.03 ; RMS scatter: 3.56



SJDV Up rate: 0.08 ± 0.02 mm/yr, col. error (-0.6): 0.07 ; RMS scatter: 6.19

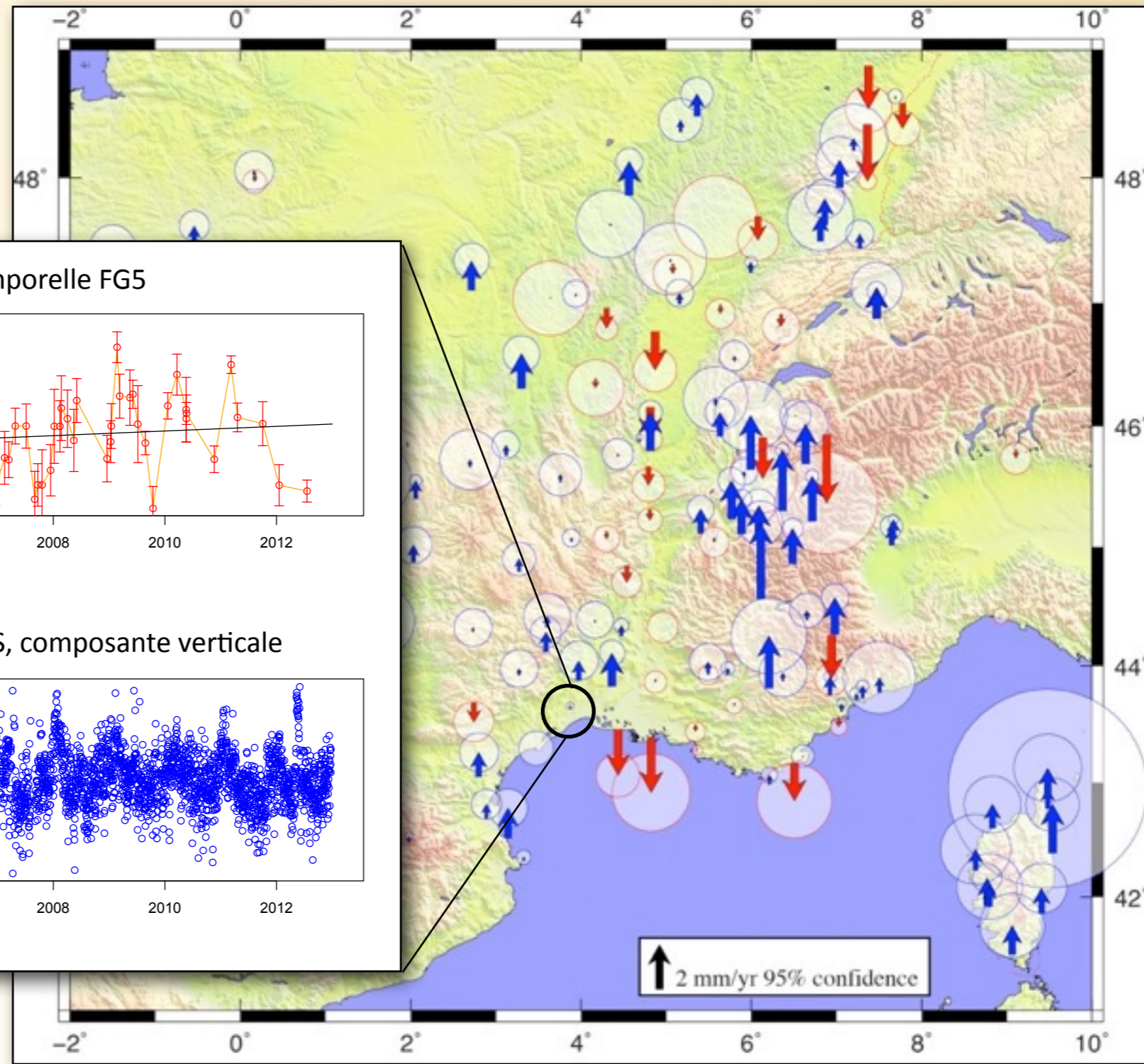
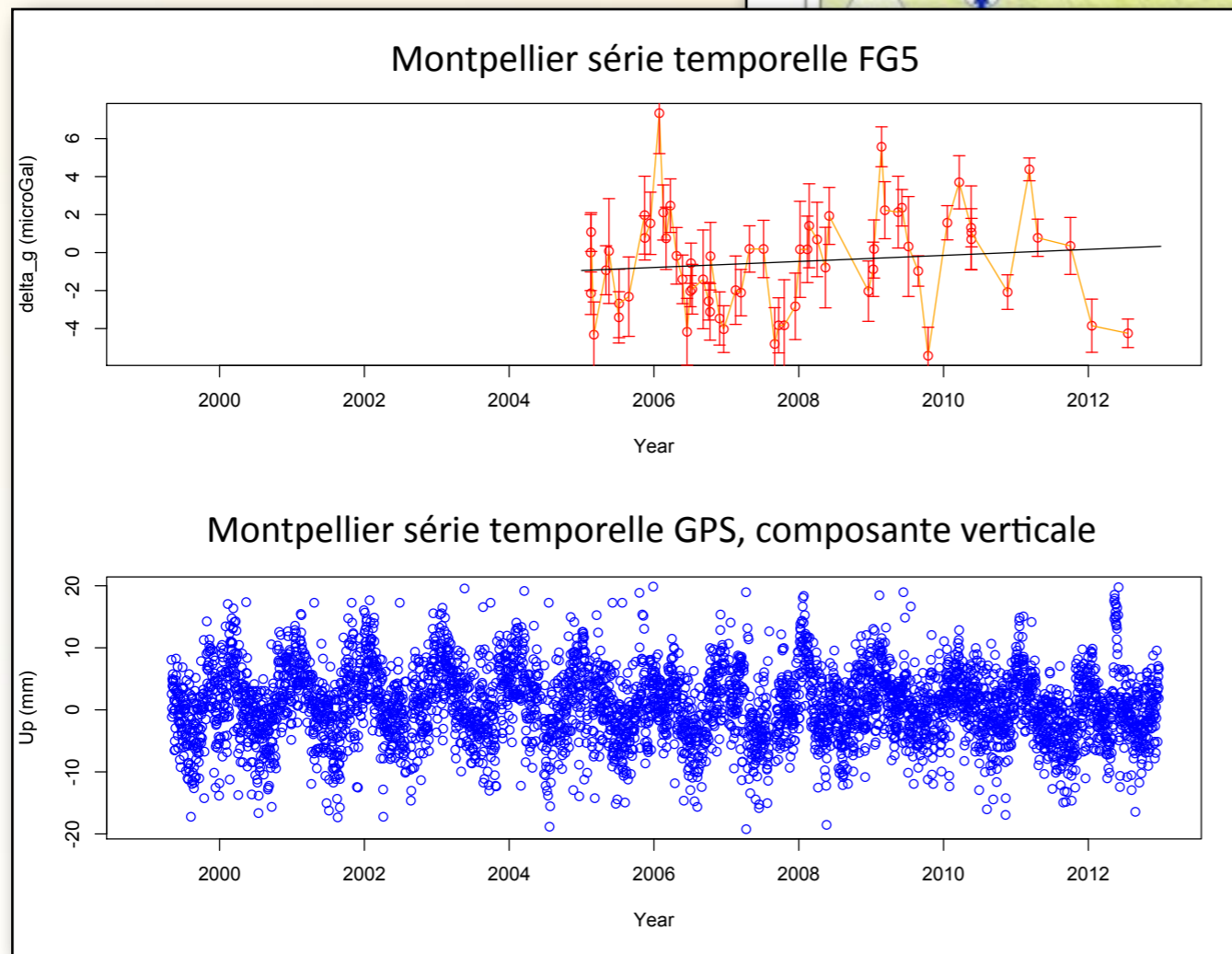


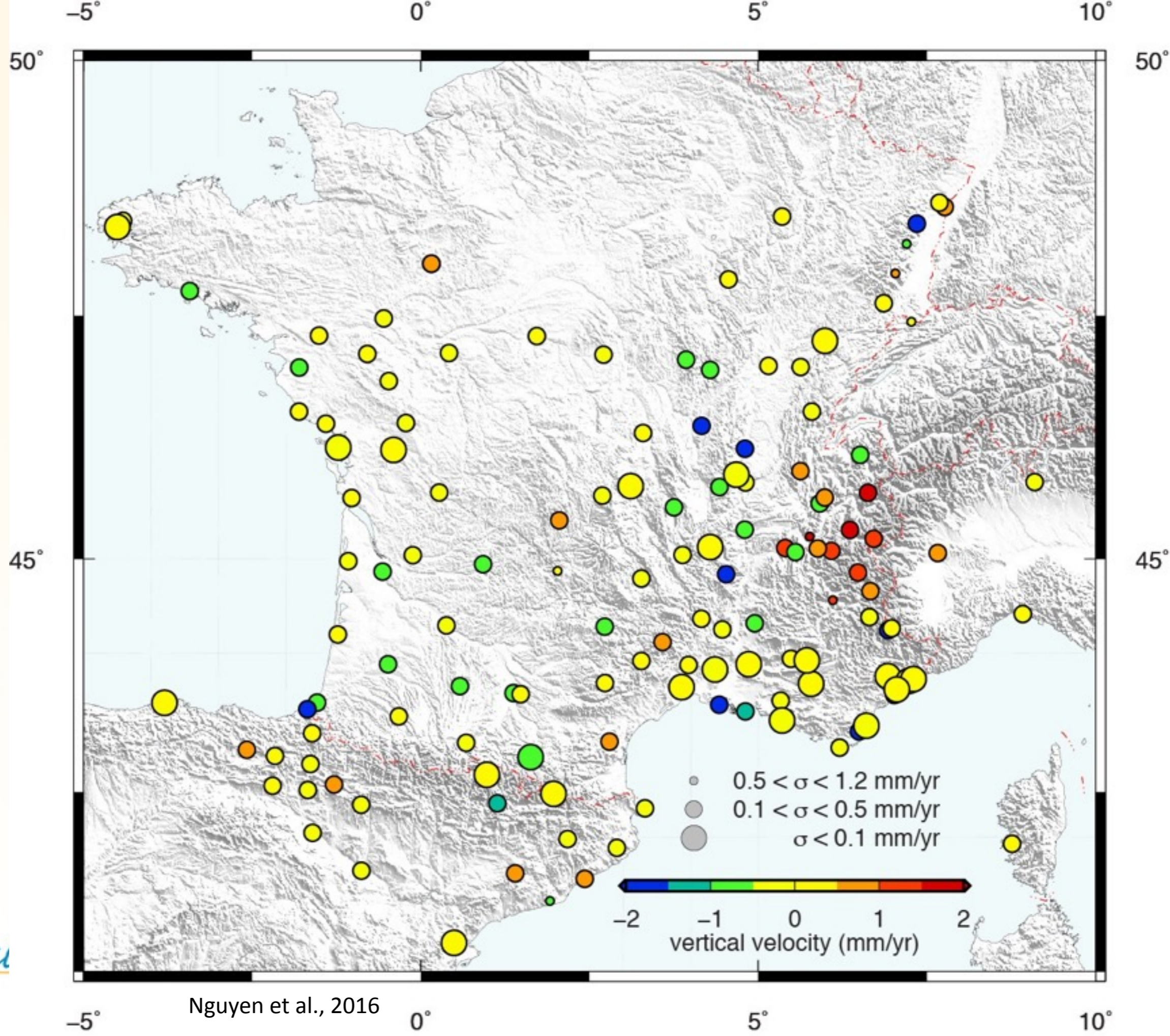




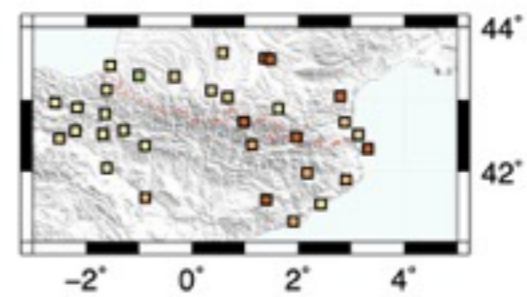
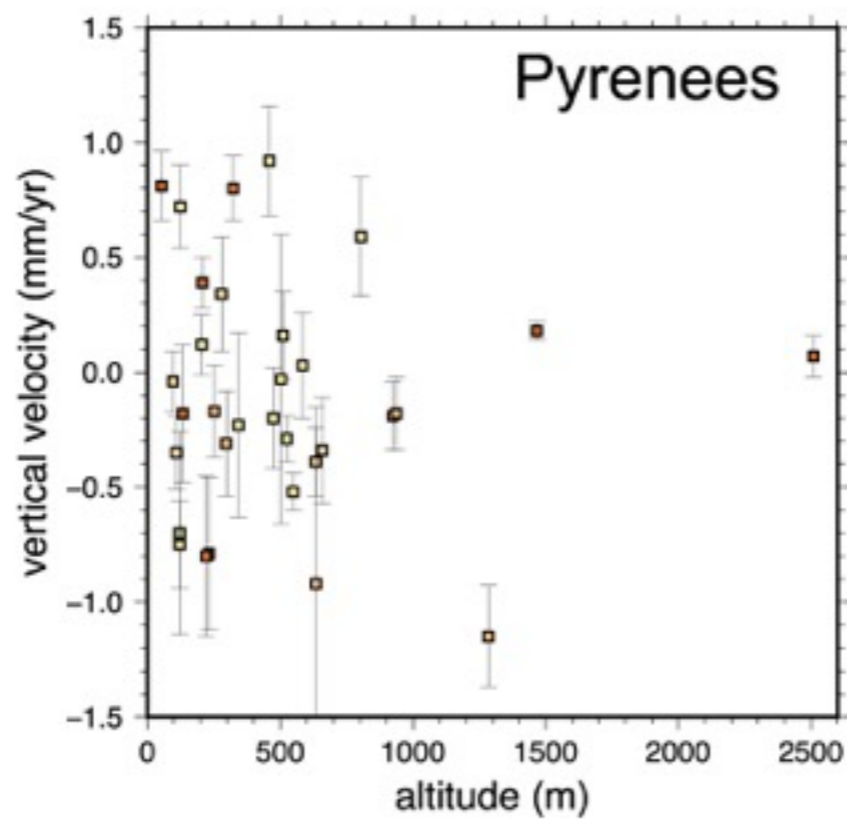
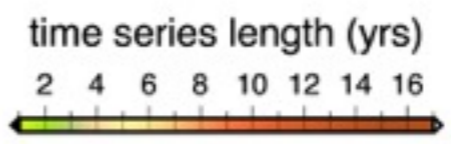
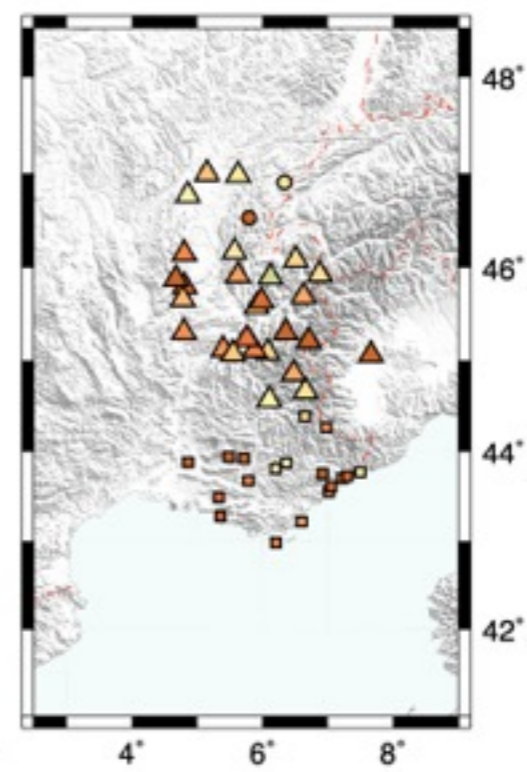
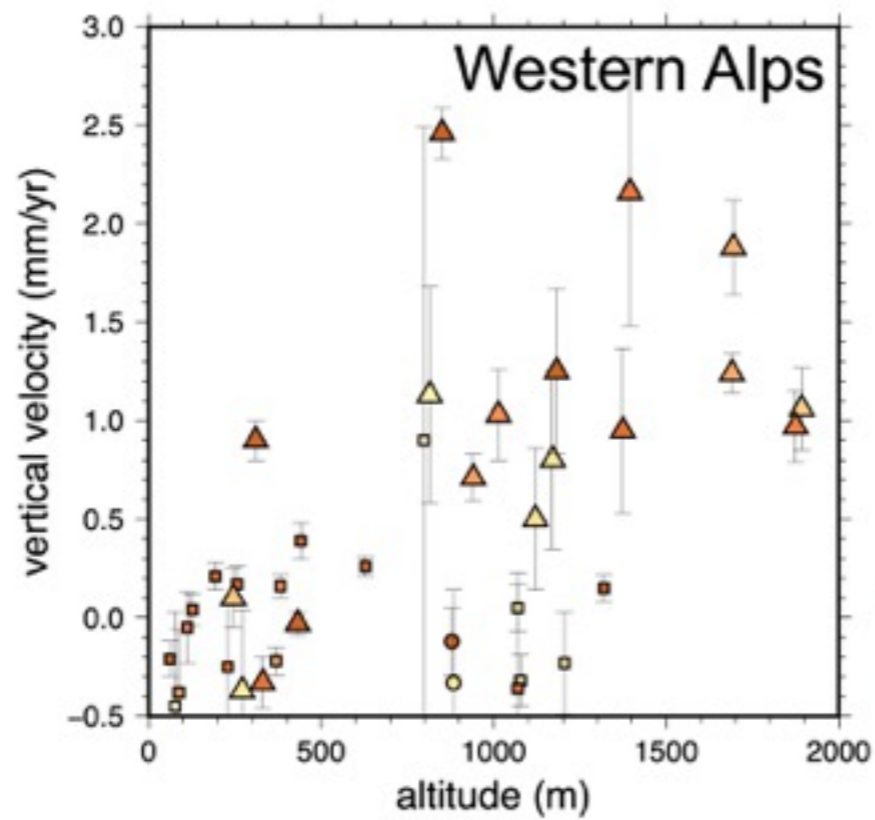
Solution PPP OREME - Géosciences Montpellier

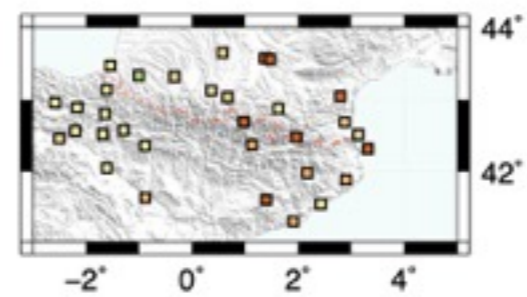
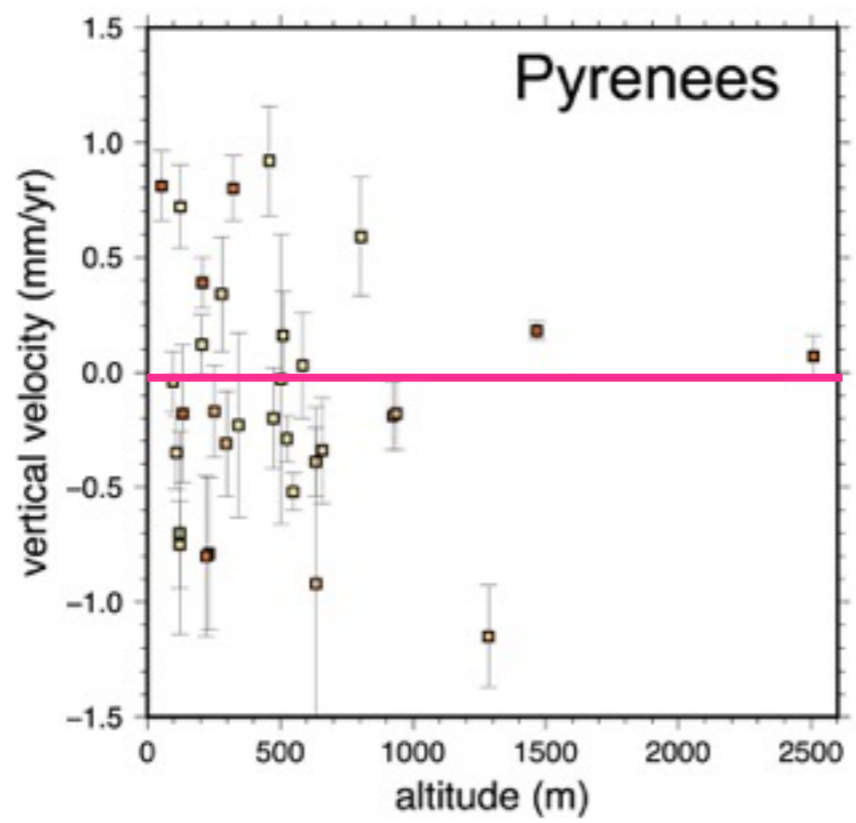
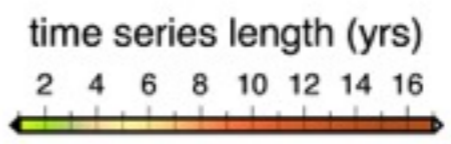
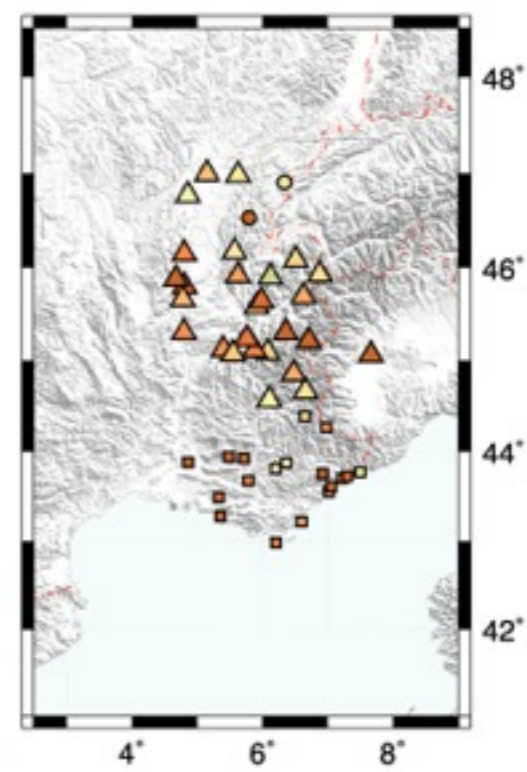
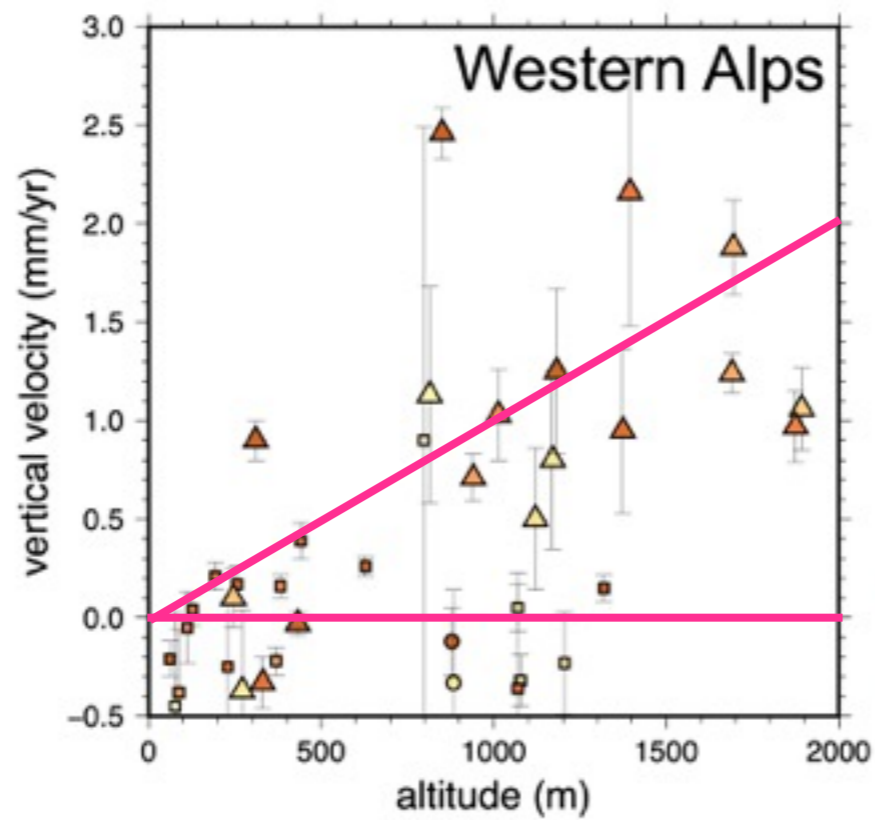
Vitesses verticales dans le référentiel absolu défini par les orbites des satellites GPS



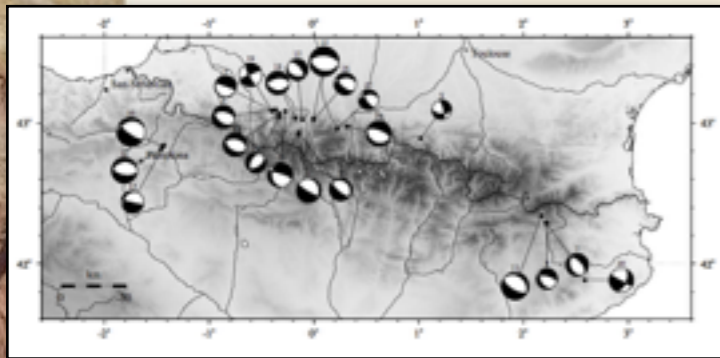


Nguyen et al., 2016

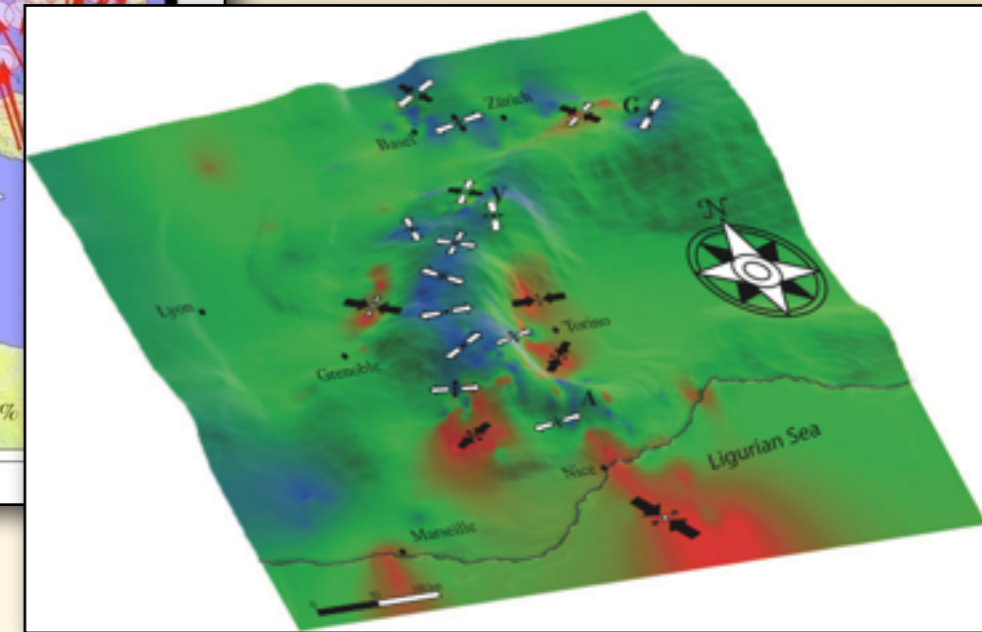
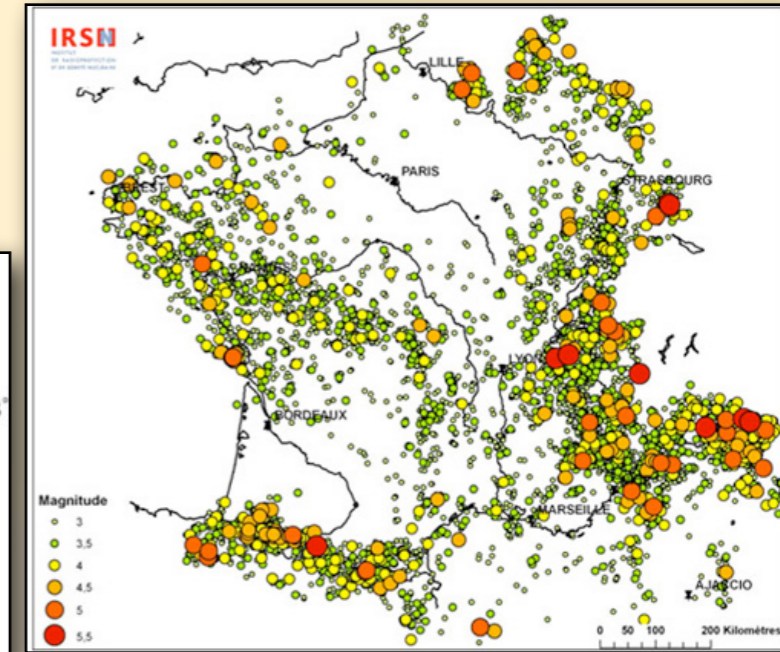
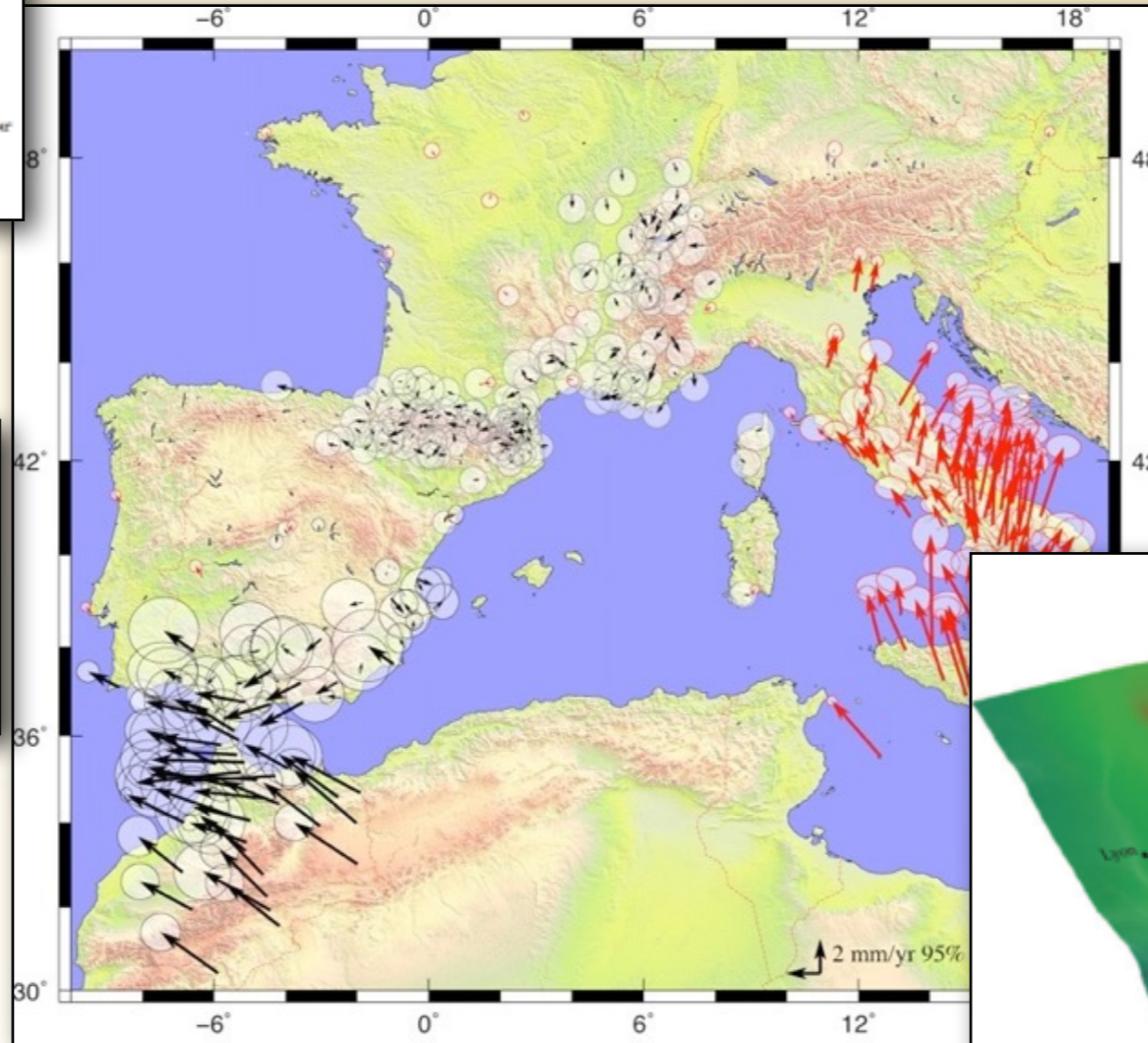
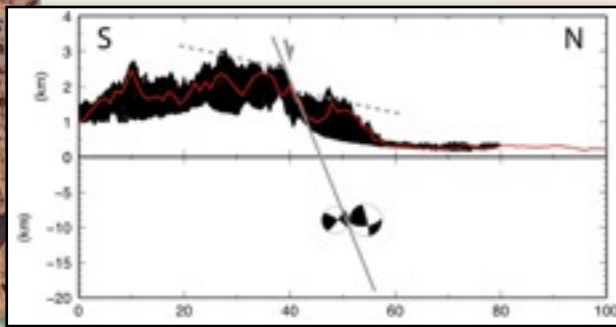




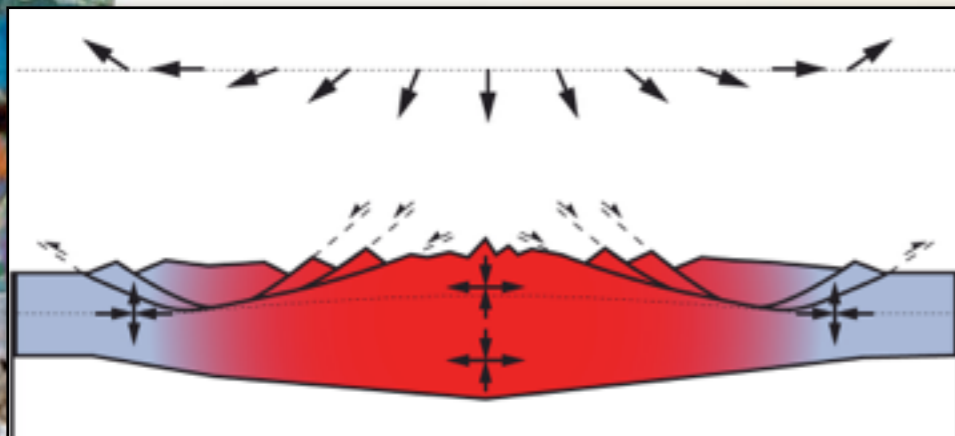
L'exception française



Chevrot et al., 2011

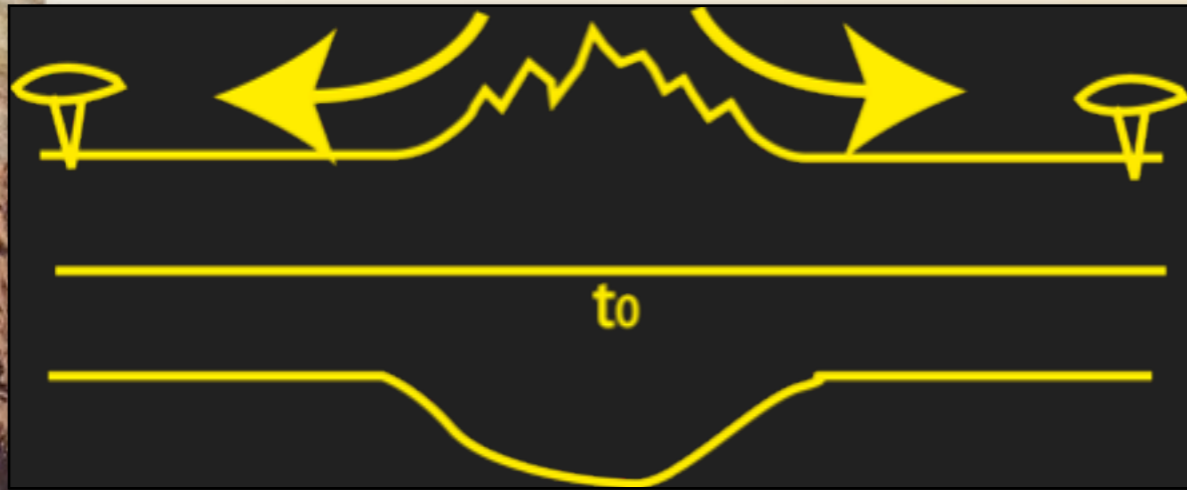


Sue et al., 2007

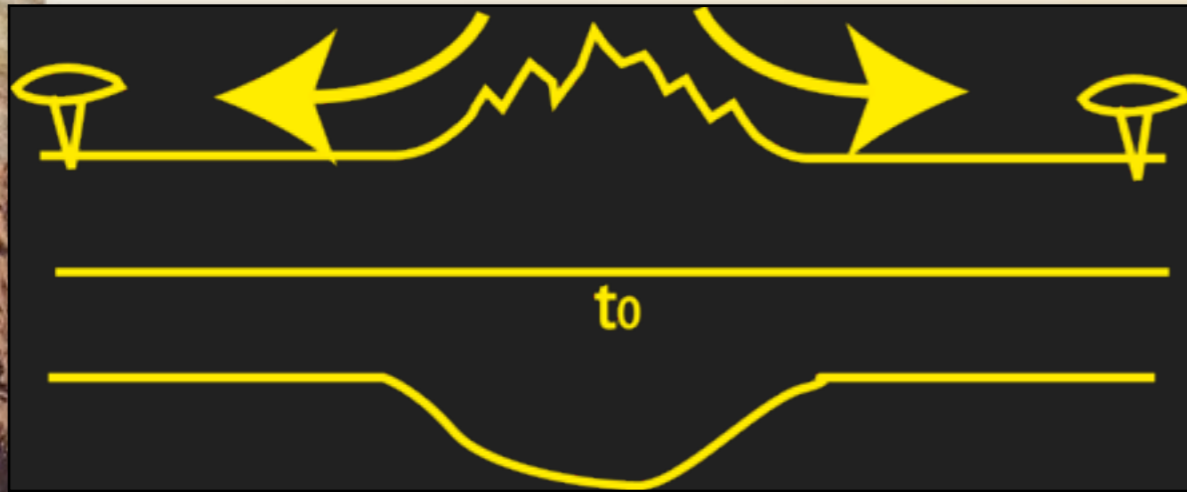


Quel est le mécanisme permettant d'expliquer des vitesses verticales 10 fois plus rapides que celles horizontales ?

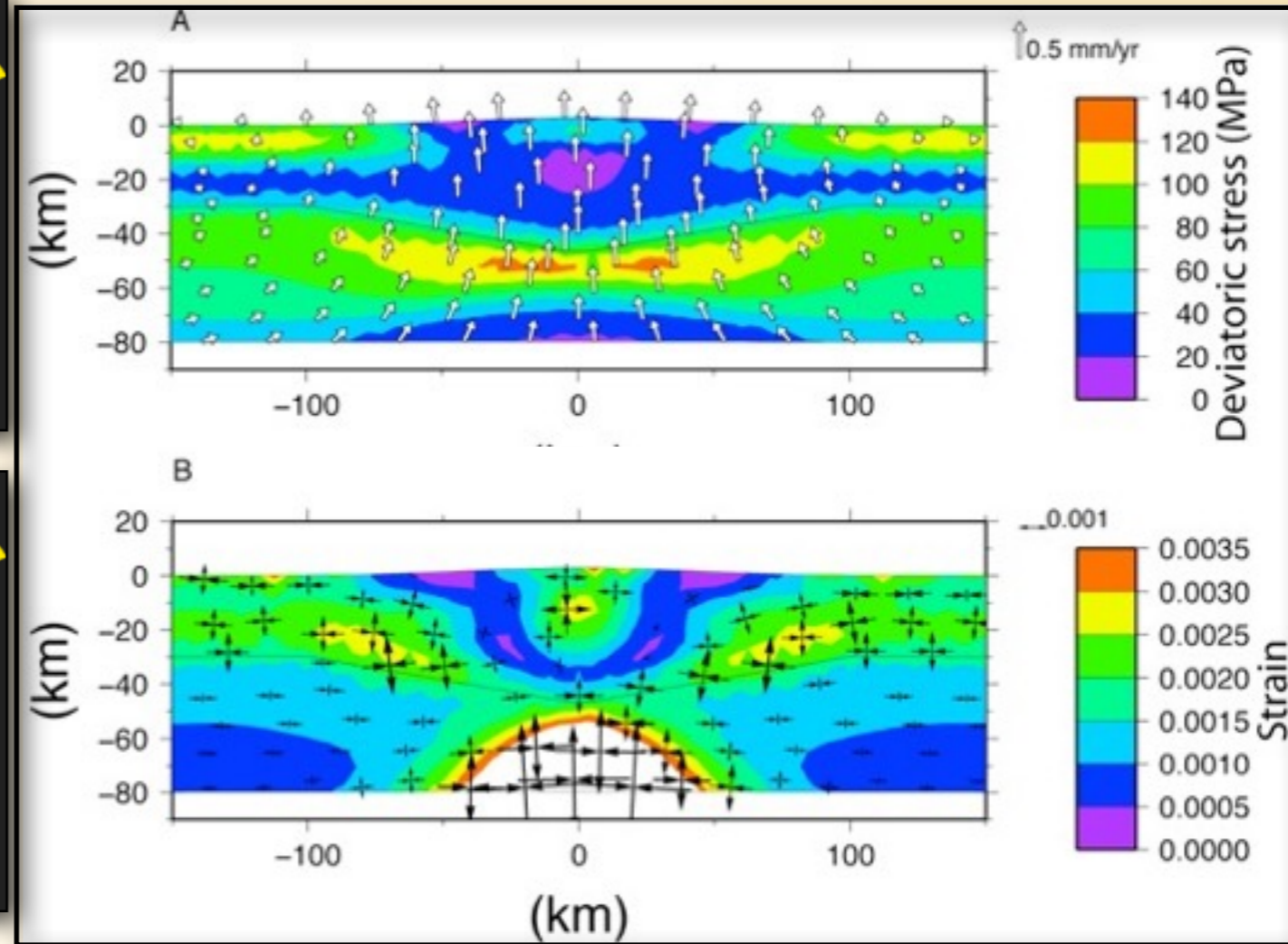
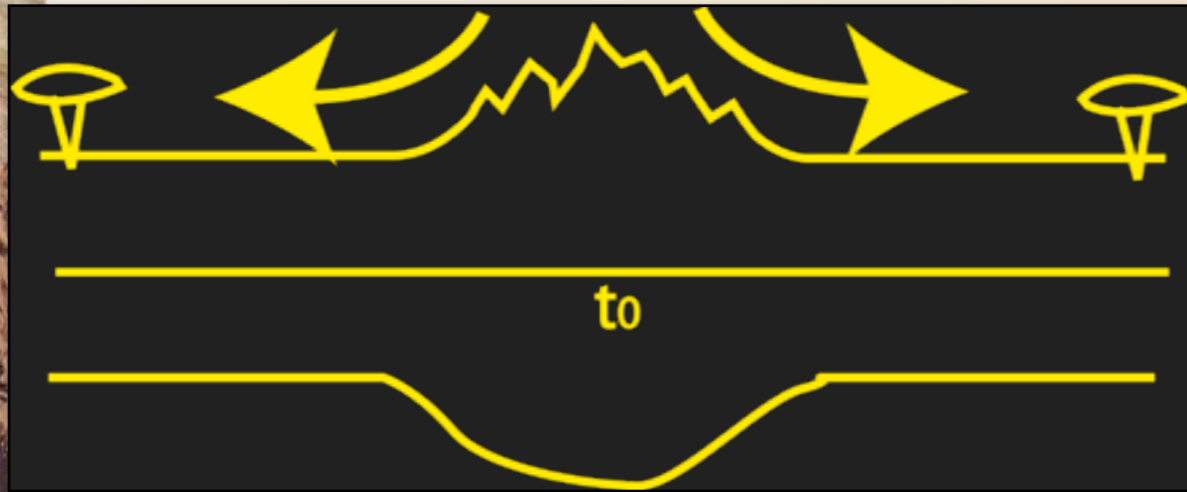
Erosion = tectonique active ?



Erosion = tectonique active ?

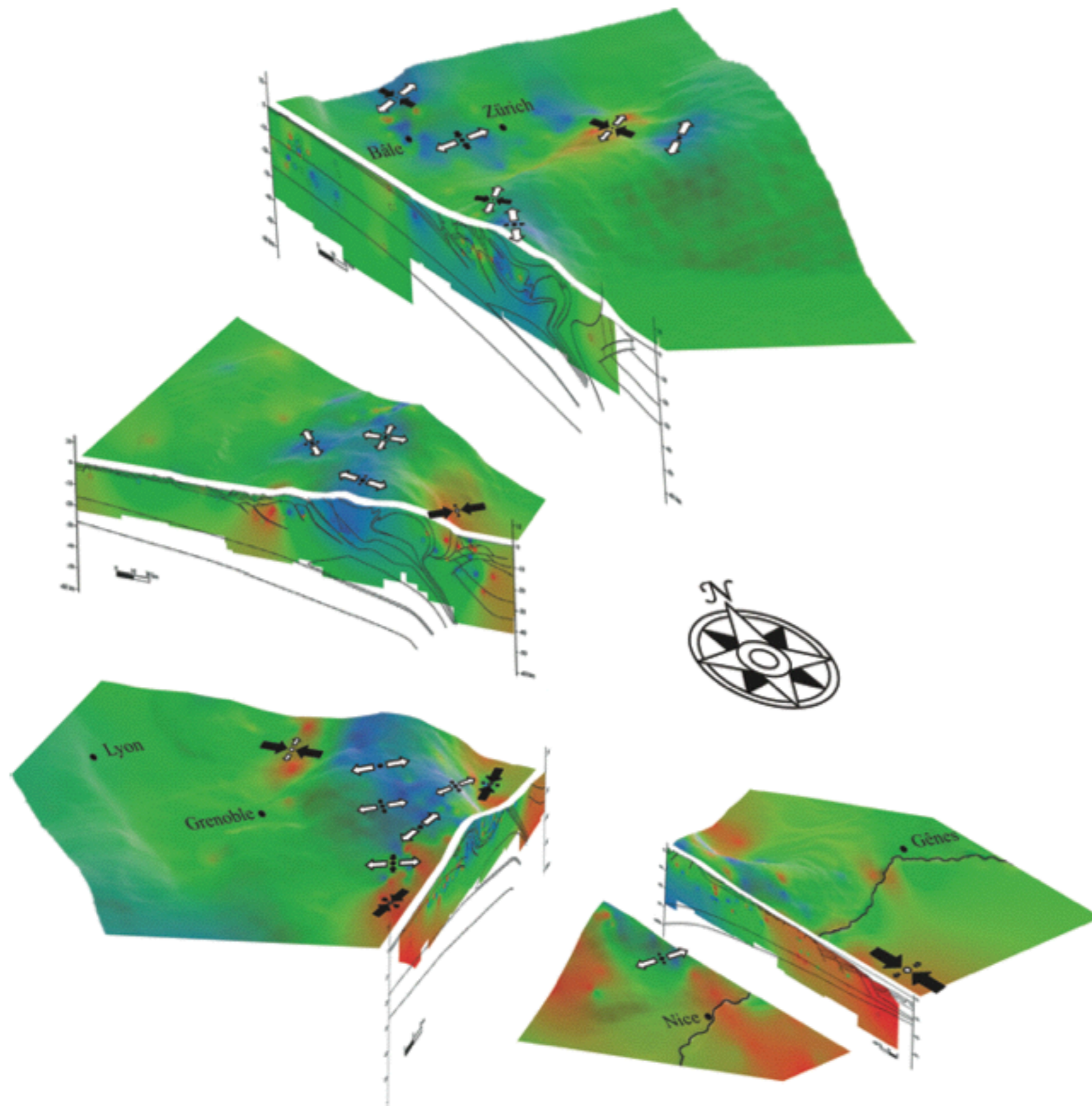


Erosion = tectonique active ?

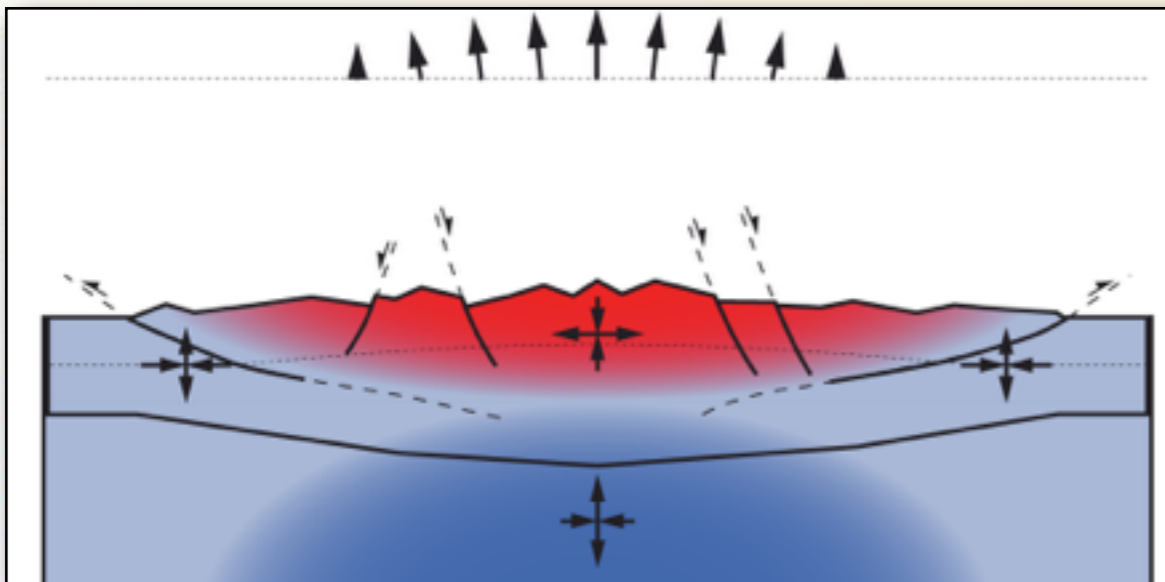
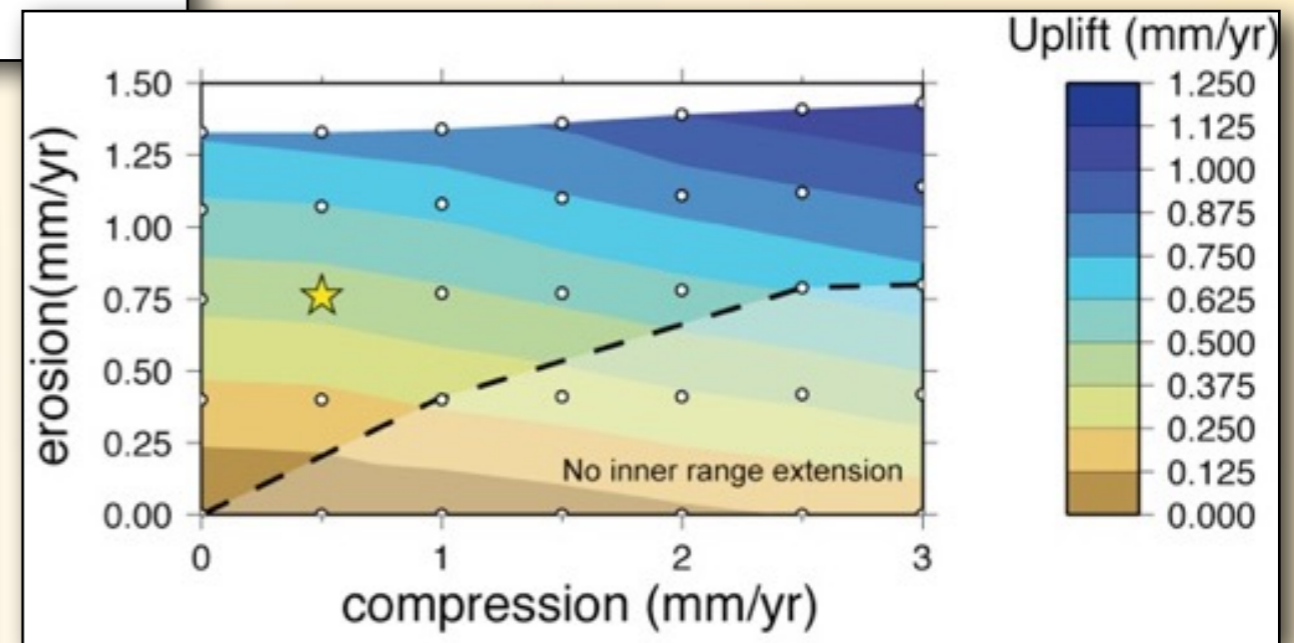
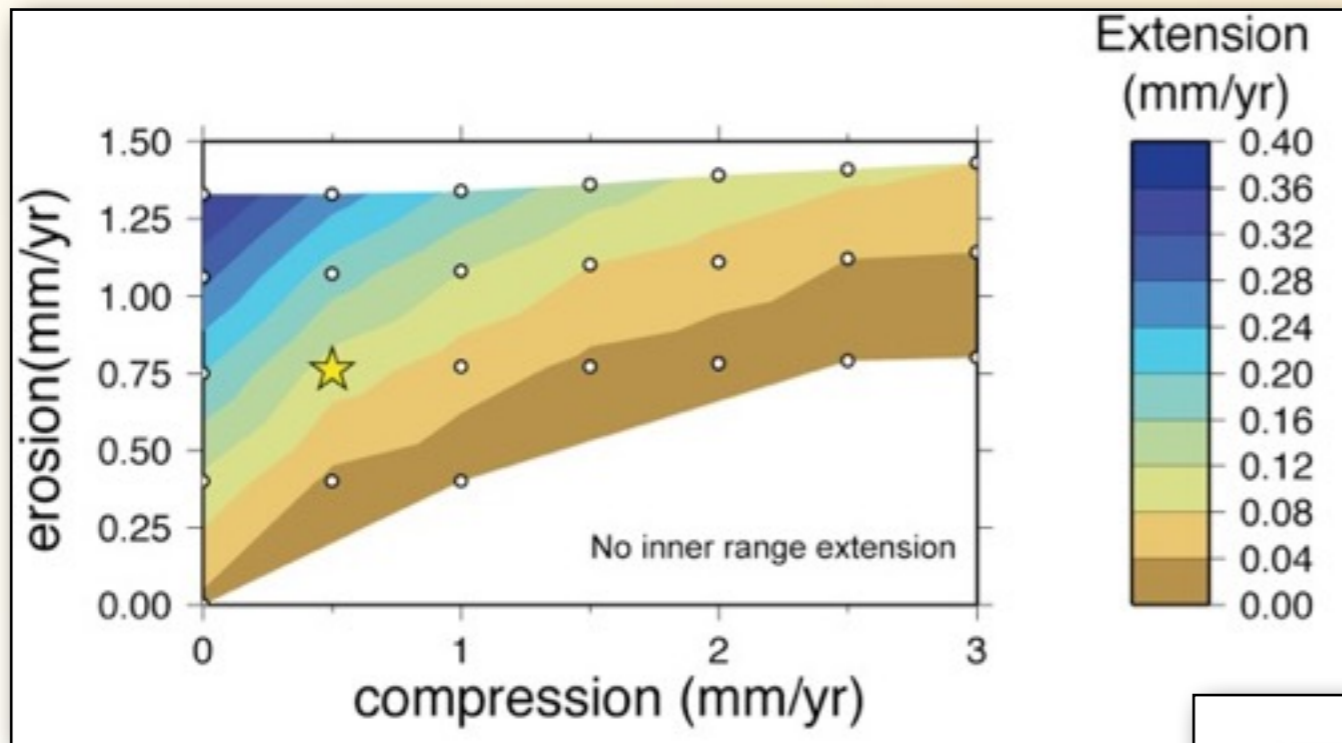


Vernant et al., 2013

le rebond isostatique associé à l'érosion peut expliquer la sismicité, les tenseurs de déformation et les mouvements géodésiques

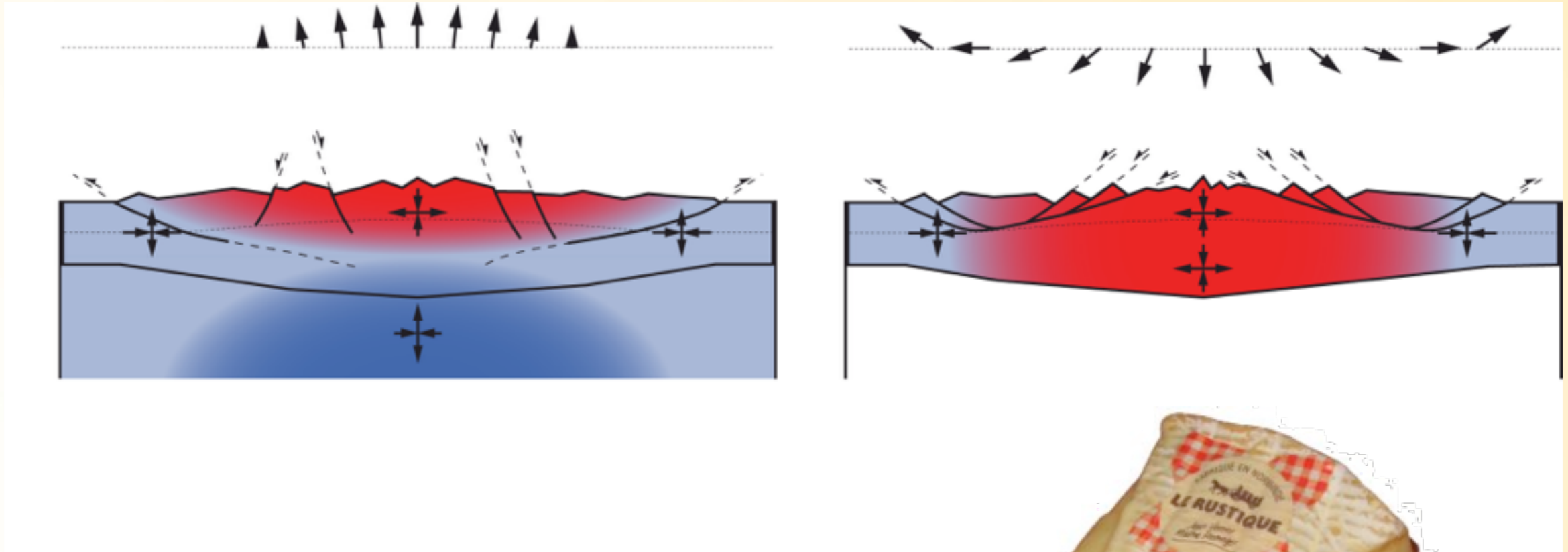


Erosion = extension dans les zones internes des chaînes à faible convergence



Vernant et al., 2013

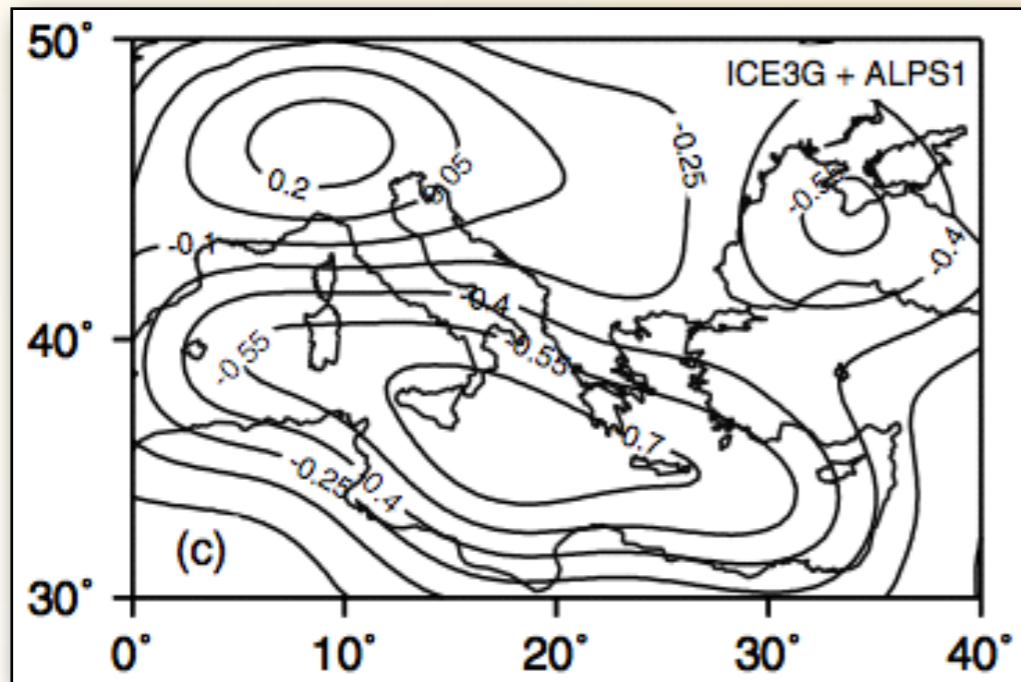
**=> remise en cause du modèle classique
d'effondrement gravitaire**



Autres sources de mouvements verticaux

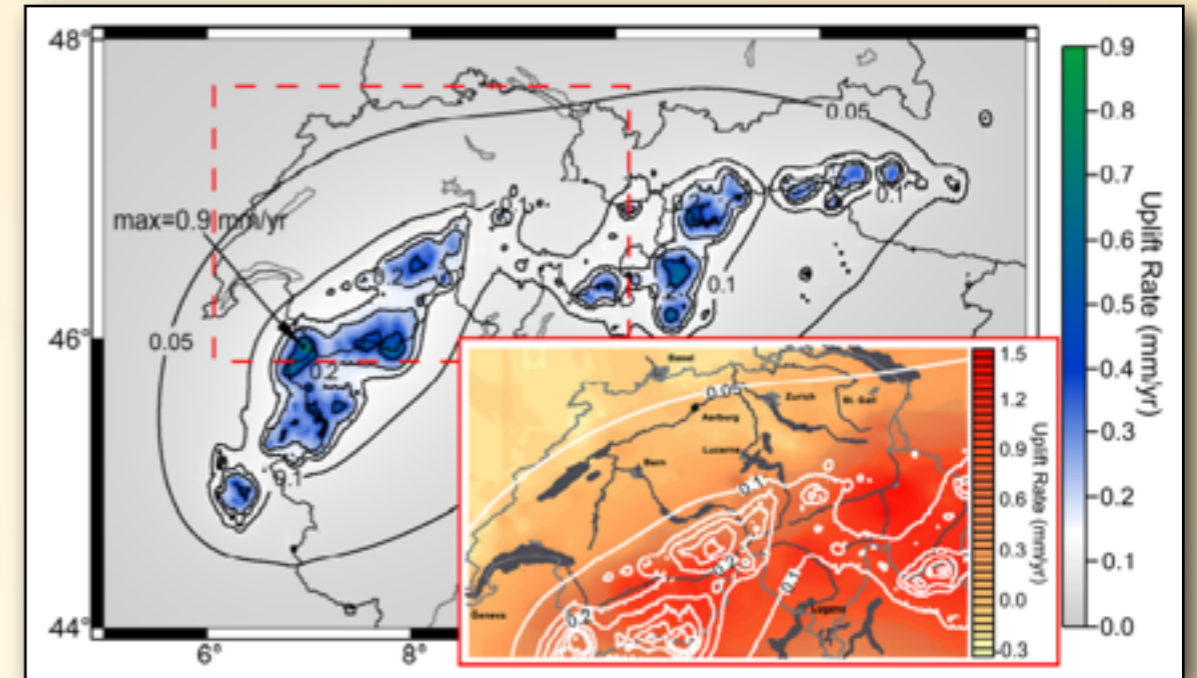
Le rebond isostatique associé aux déglaciations

Effets du dernier maximum glaciaire



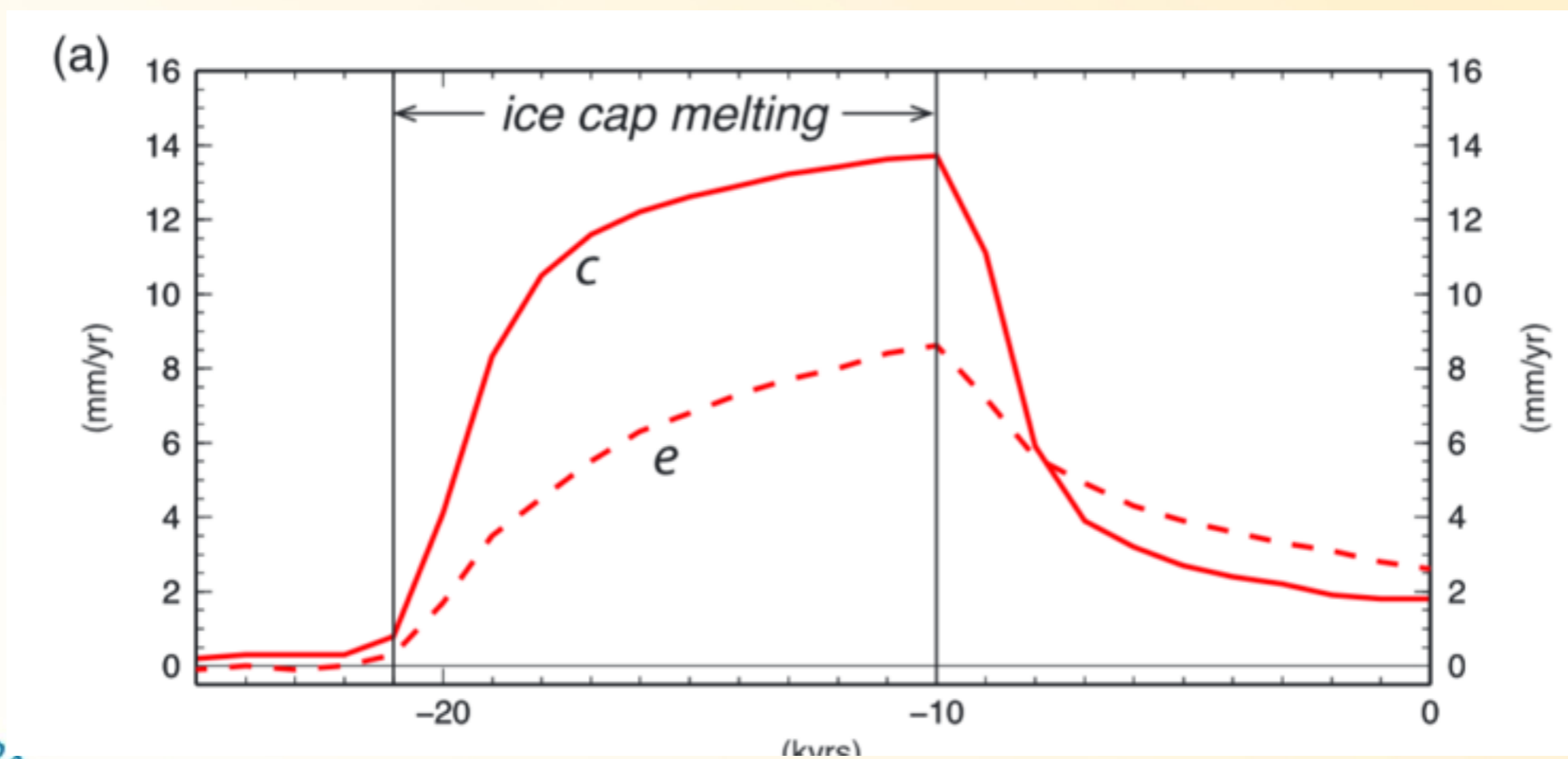
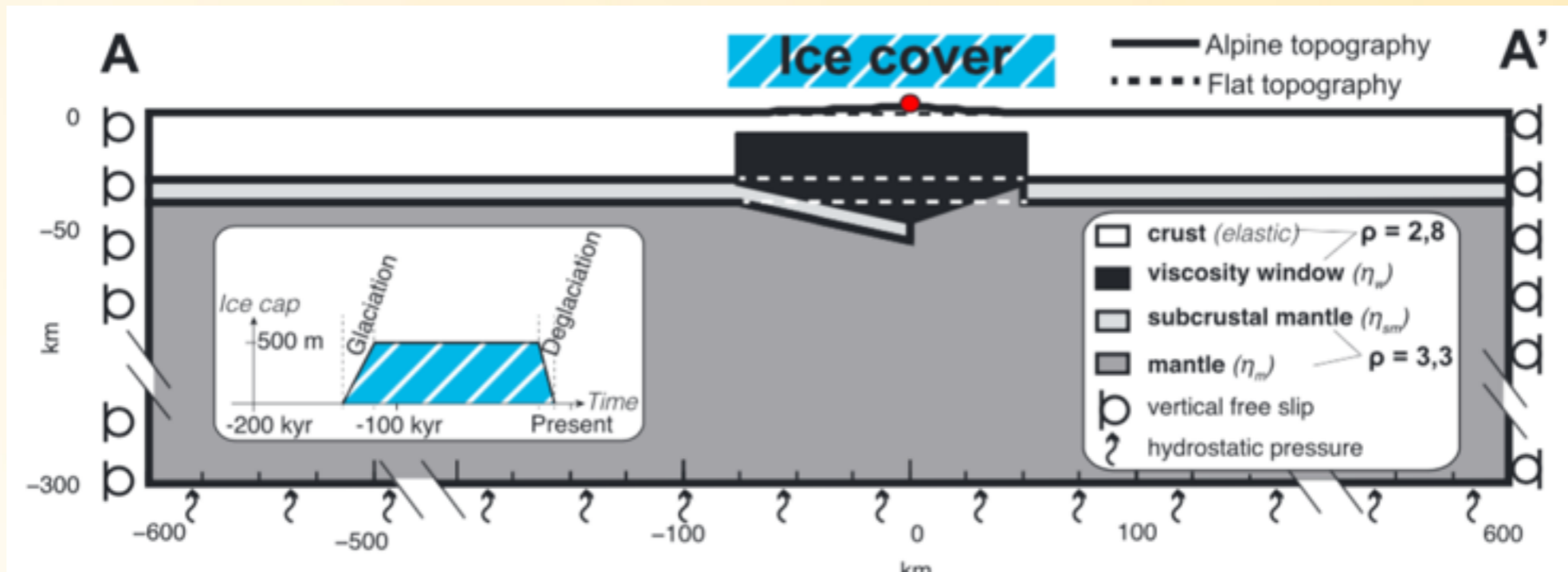
Stocchi et al. (2005)

Effets du petit âge glaciaire

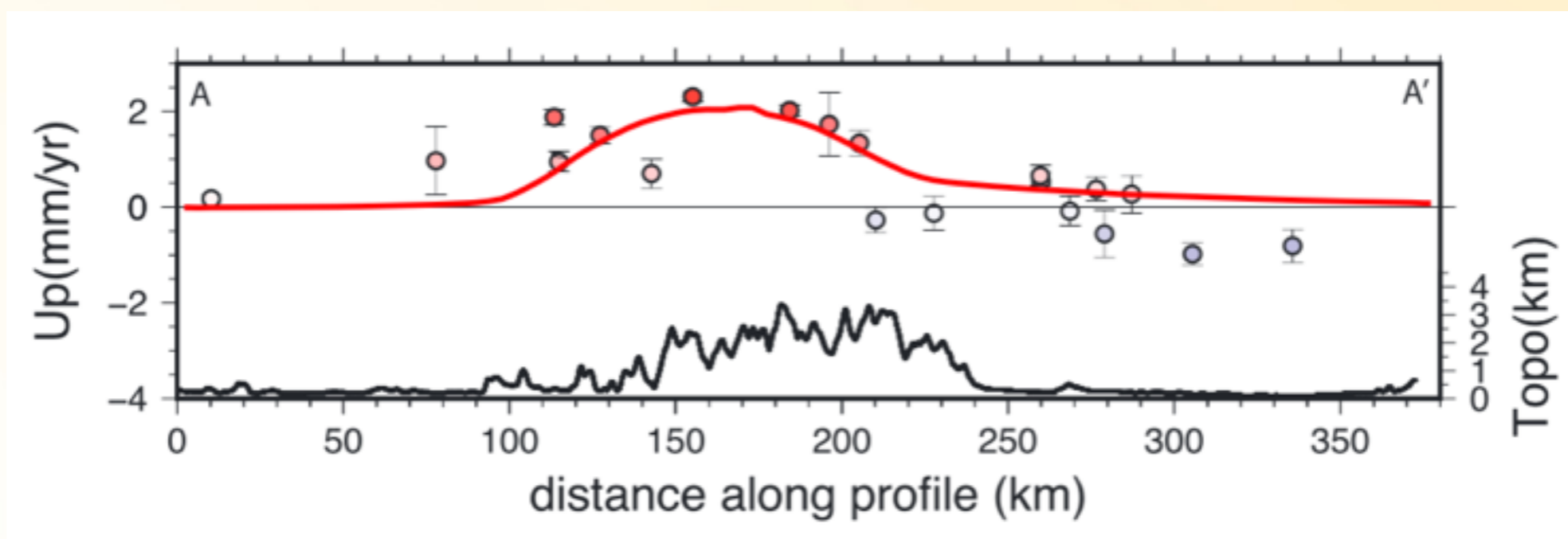
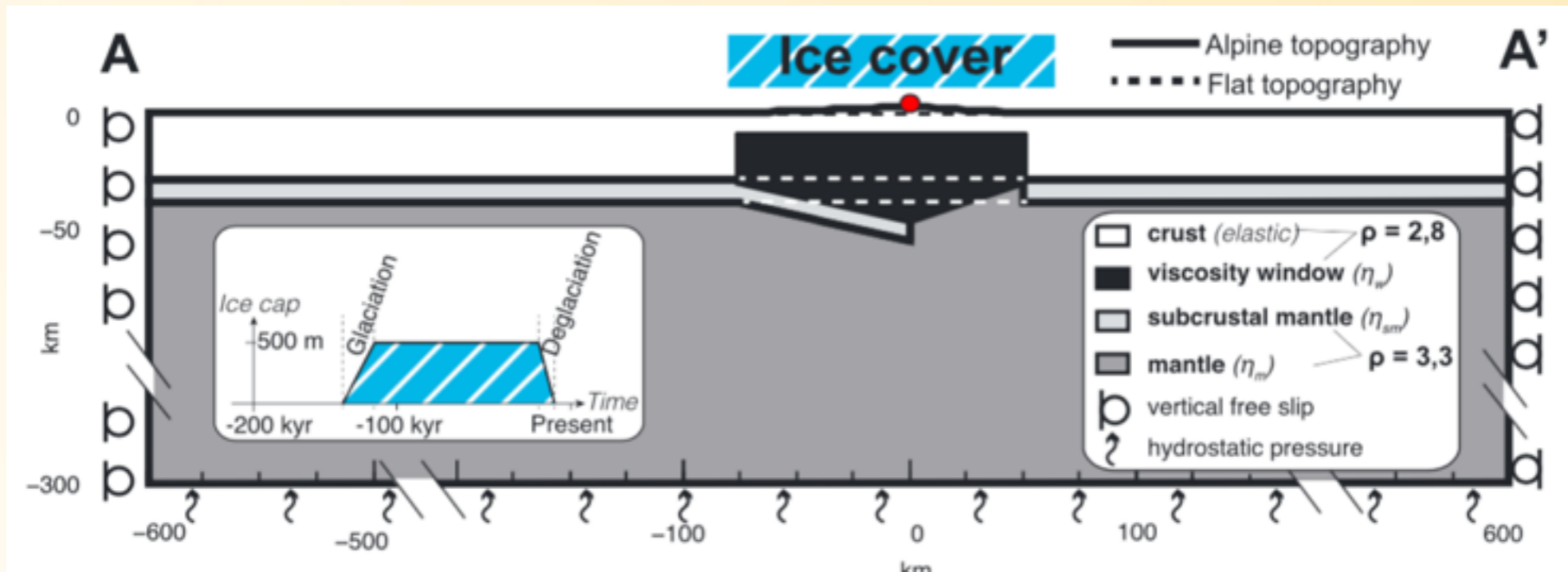


Barletta et al. (2006)

=> Pas suffisant

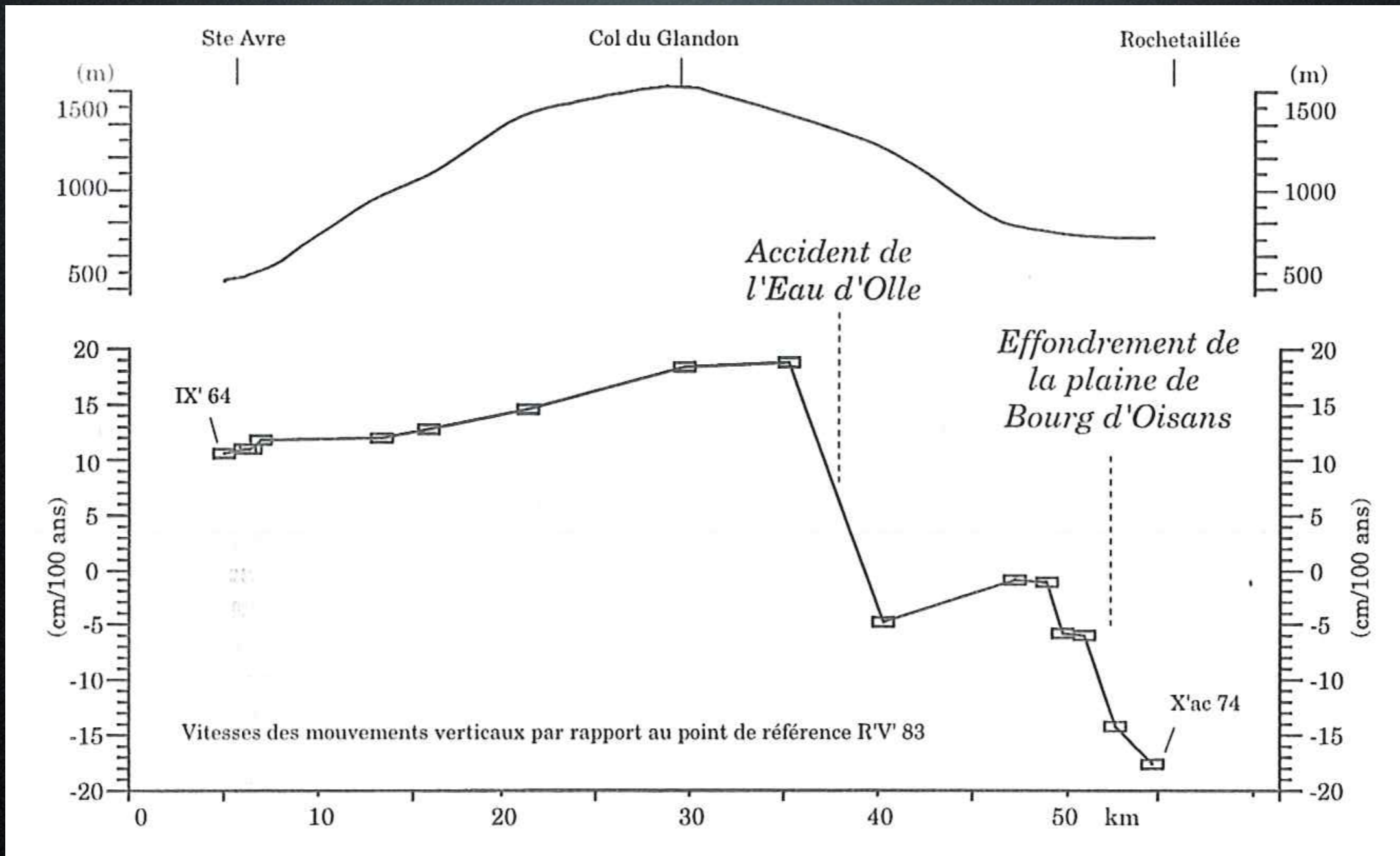


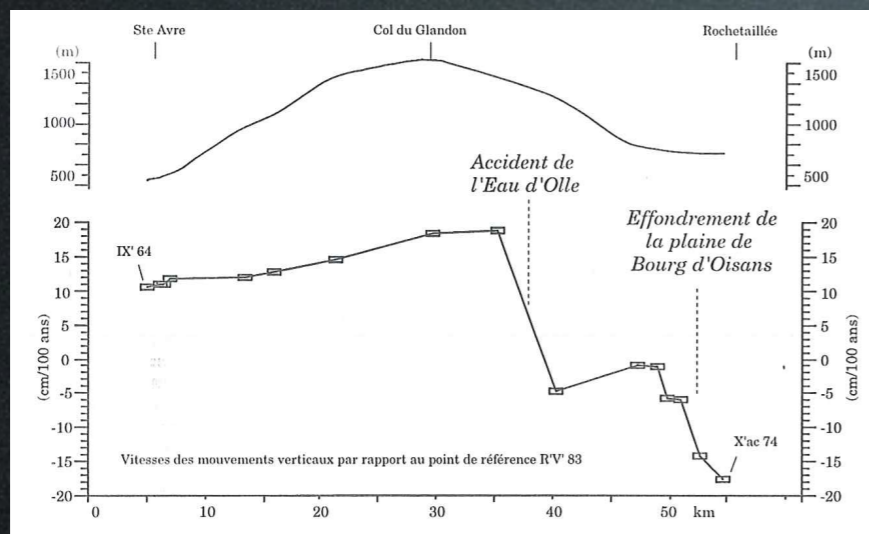
Chéry et al., 2016



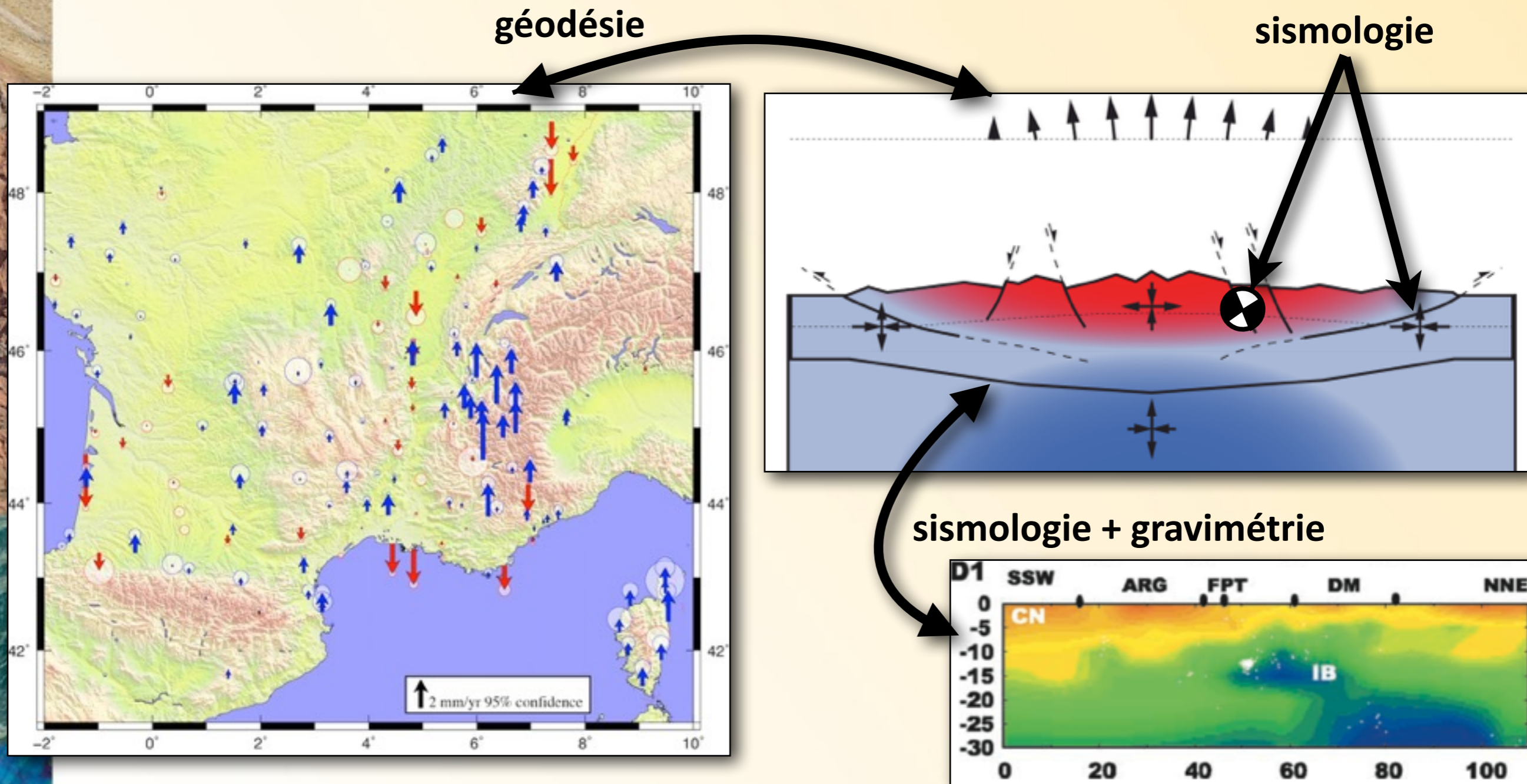
Chéry et al., 2016

Nivellement





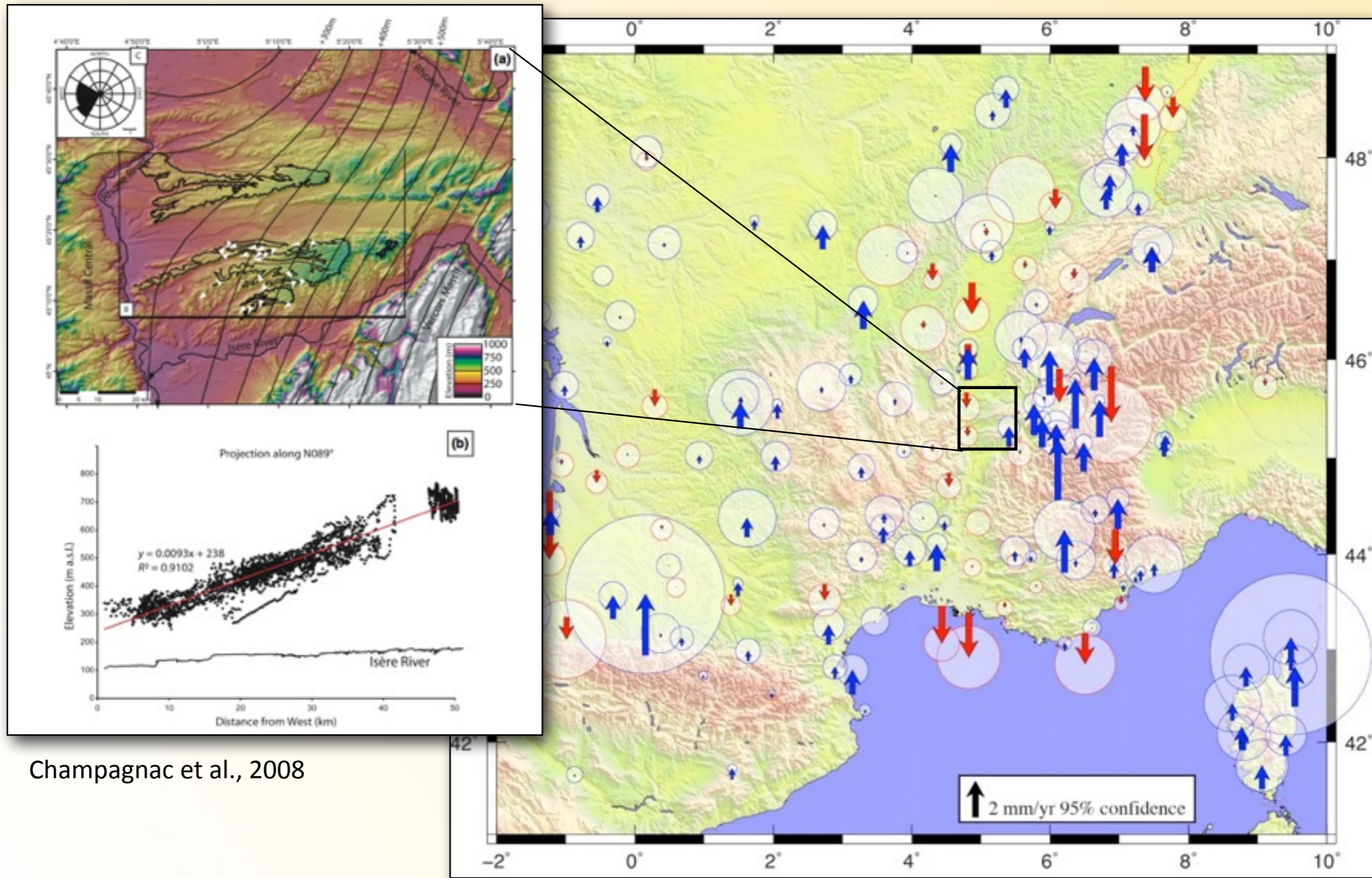
Revisiter la sismotectonique en France



Chaînes françaises = excellente opportunité pour :

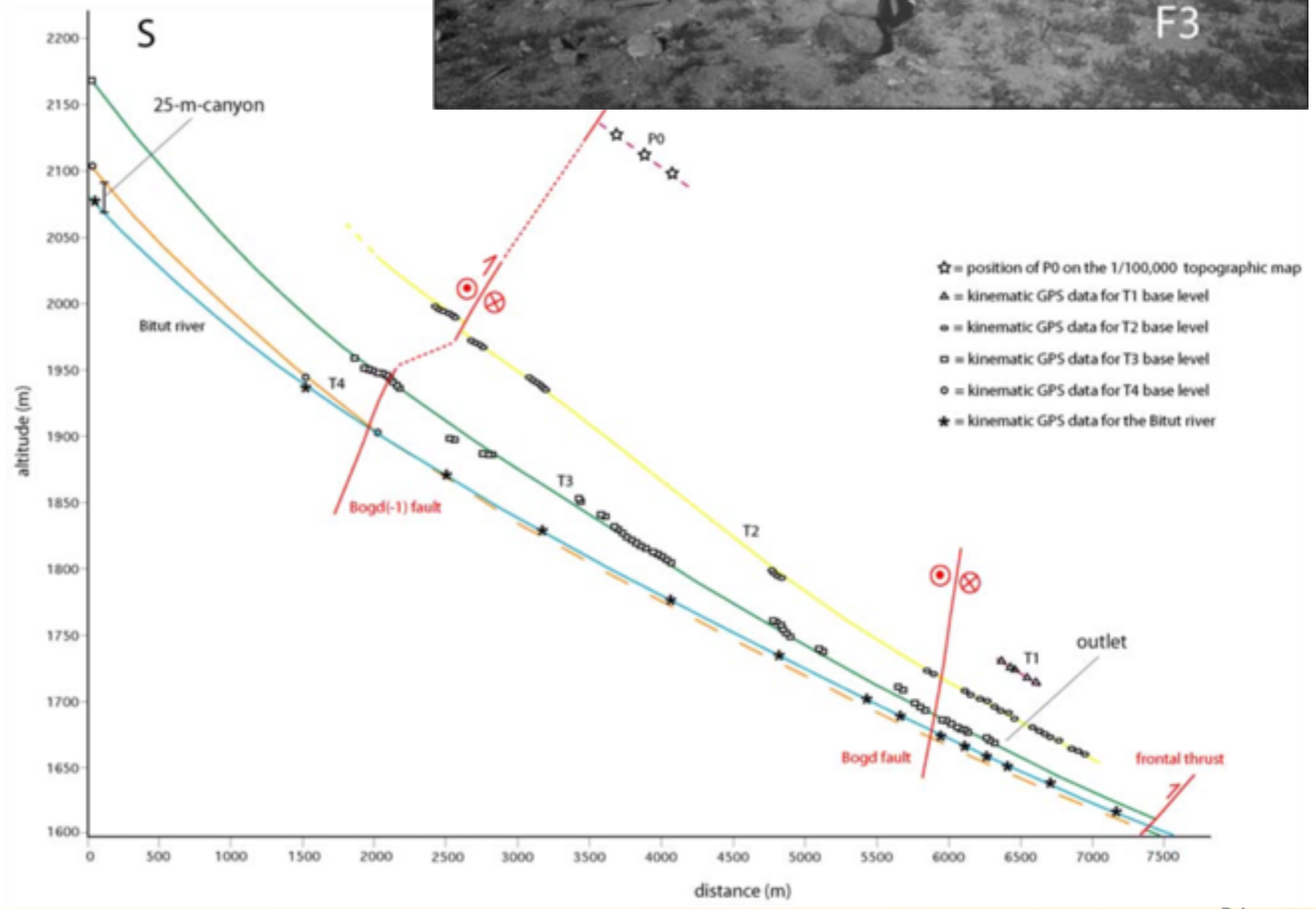
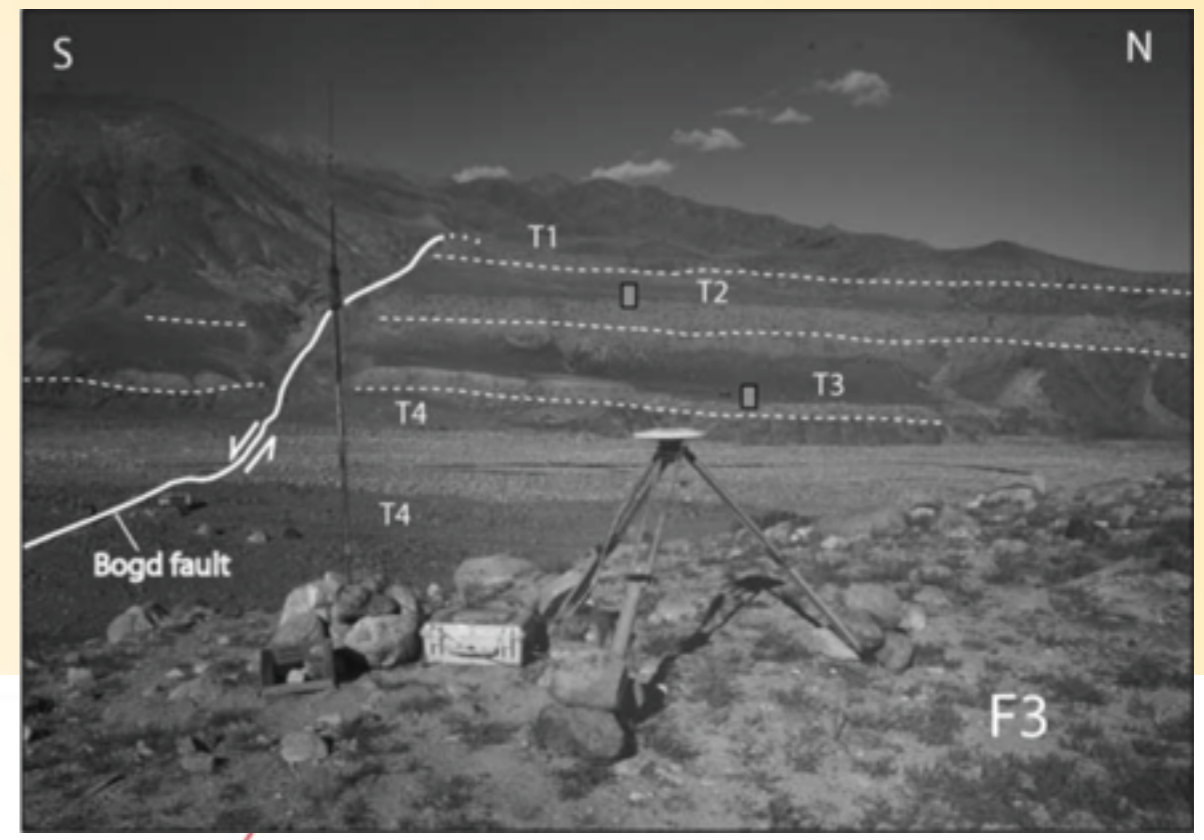
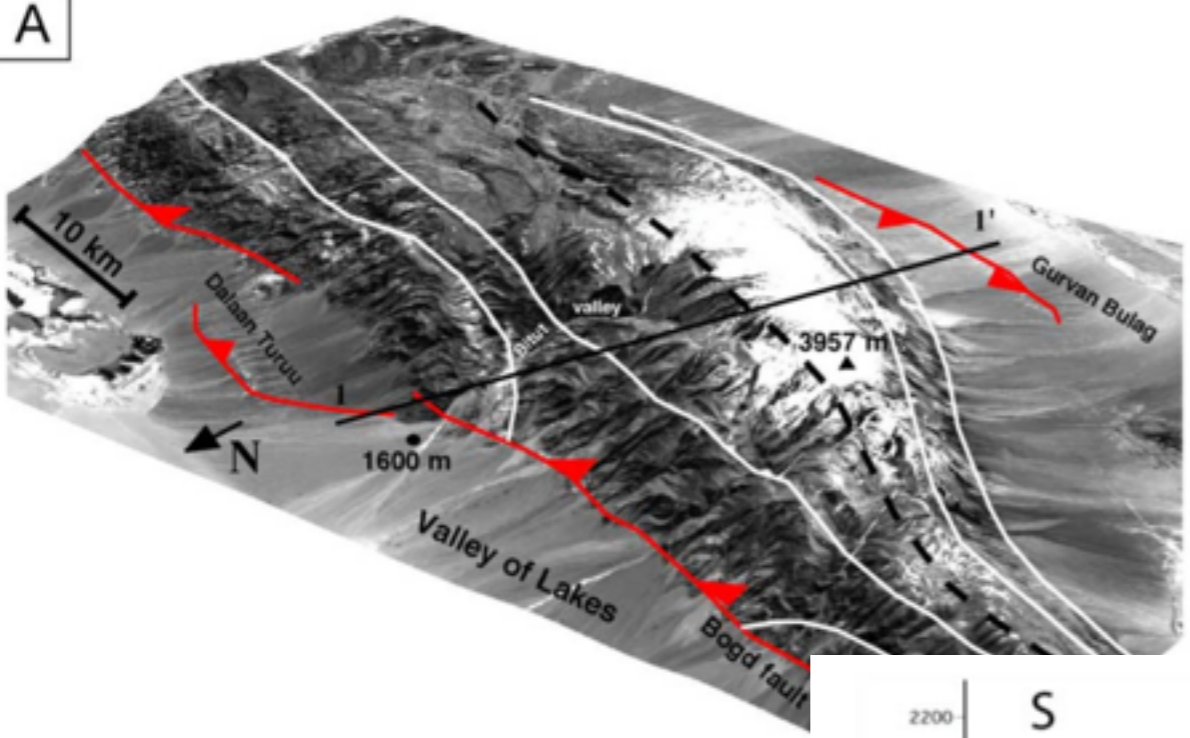
- mieux préciser la géodynamique actuelle de ces chaînes
- réviser l'estimation de l'aléa sismique en France

Autres évidences de mouvements verticaux



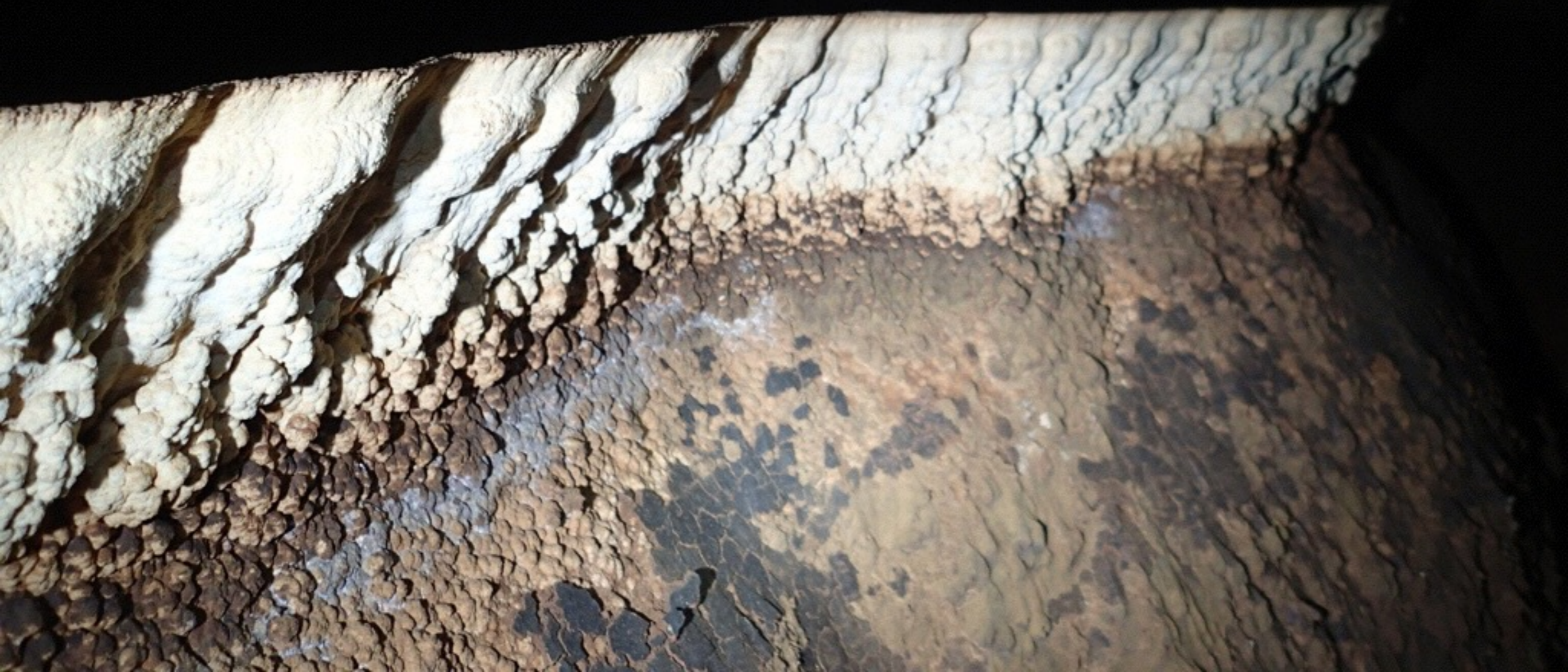
Champagnac et al., 2008

A

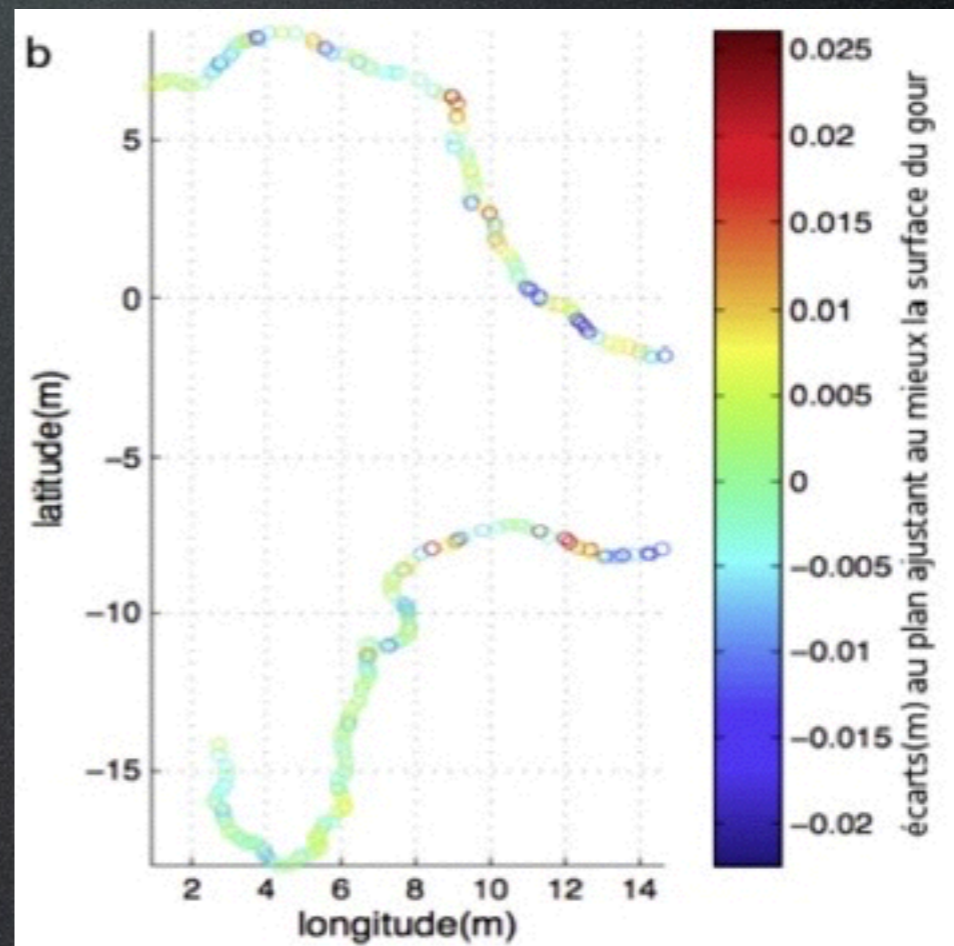
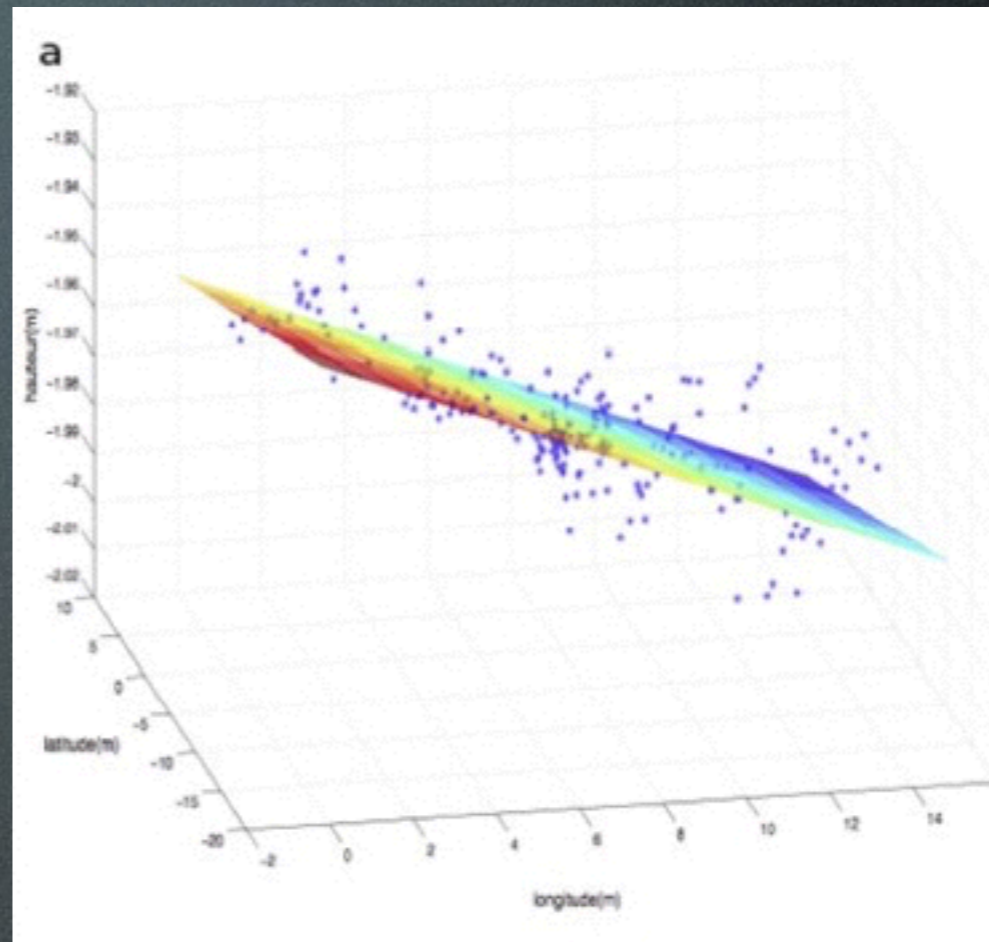
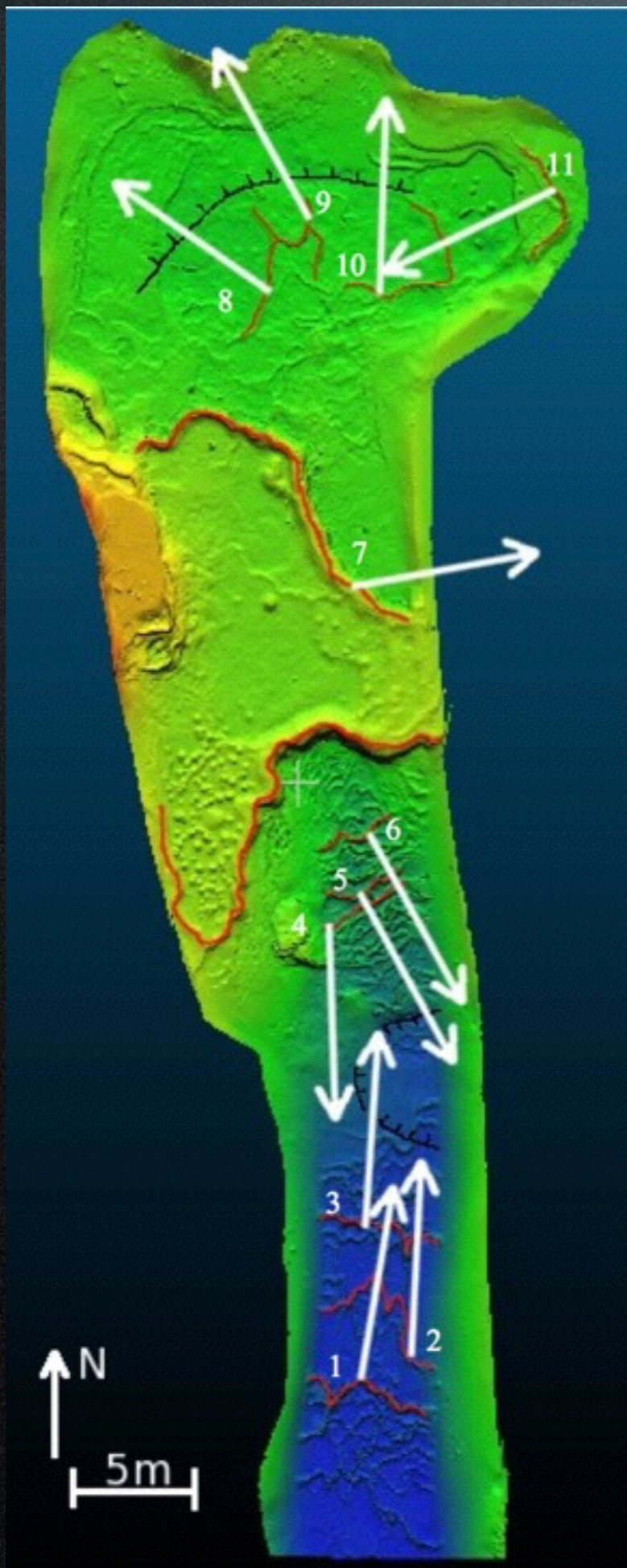


Vassallo et al., 2007

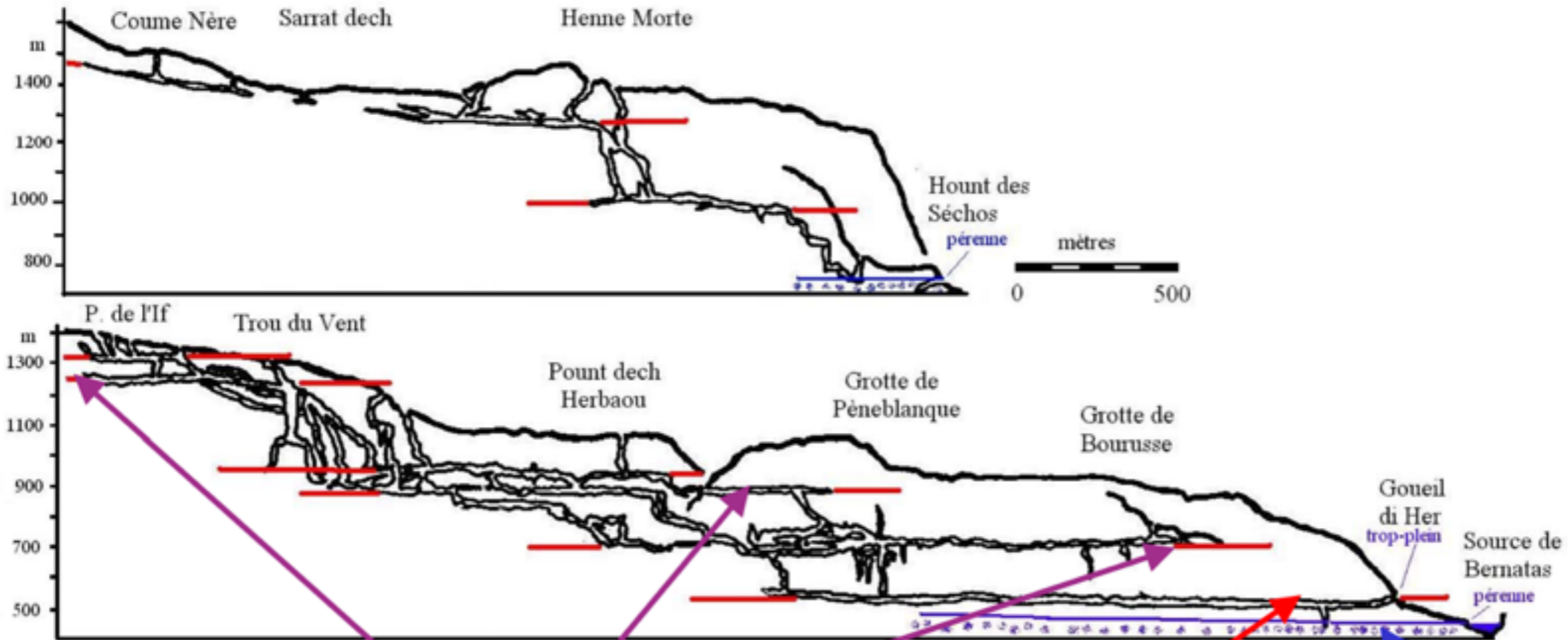
l'inclinométrie dans le karst







les vitesses d'incision à l'aide des karsts fossiles



Niveaux de drainage anciens non fonctionnels

Niveau de drainage ancien à fonctionnement saisonnier

Niveau de drainage actuellement fonctionnel











