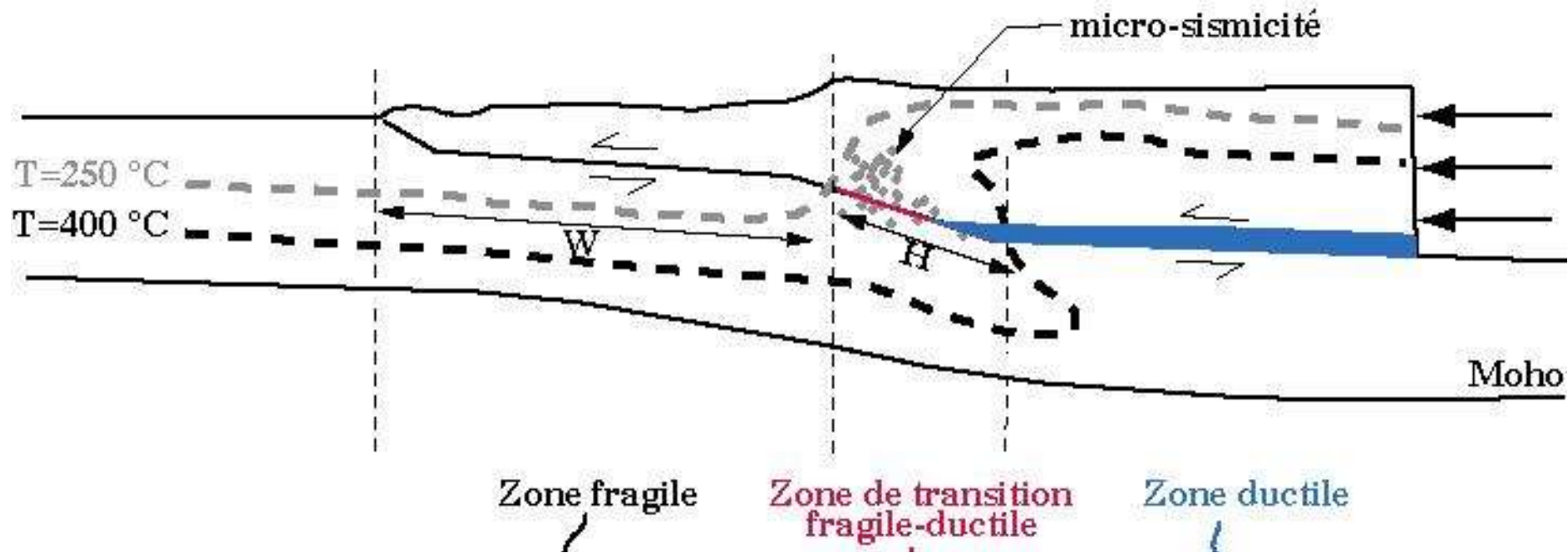


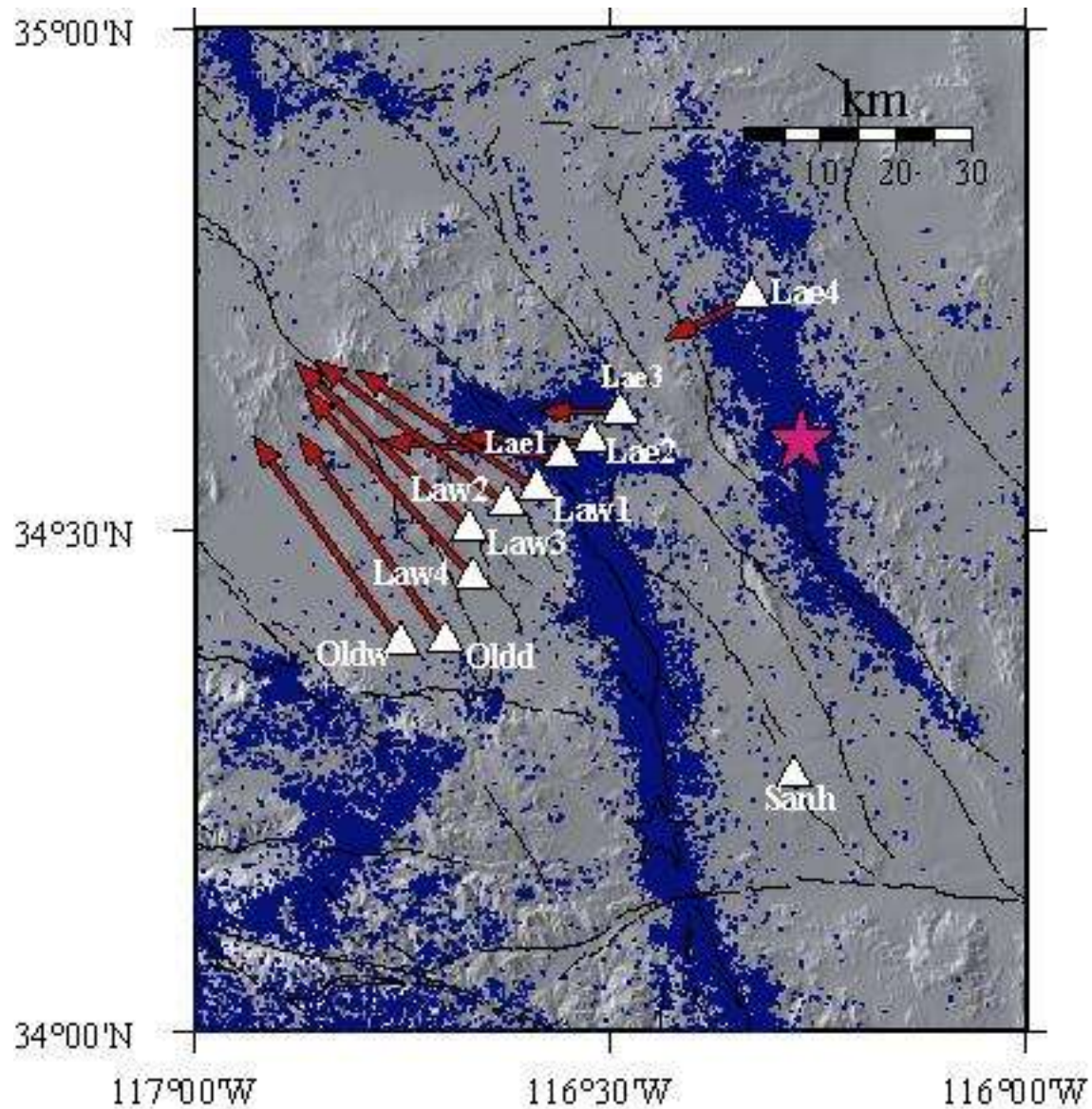
**Influence de la zone de transition fragile-ductile
sur le cycle sismique:
application à la modélisation
de la phase post-sismique du séisme de Landers**

Hugo Perfettini (IRD)
Jean-Philippe Avouac (Caltech)

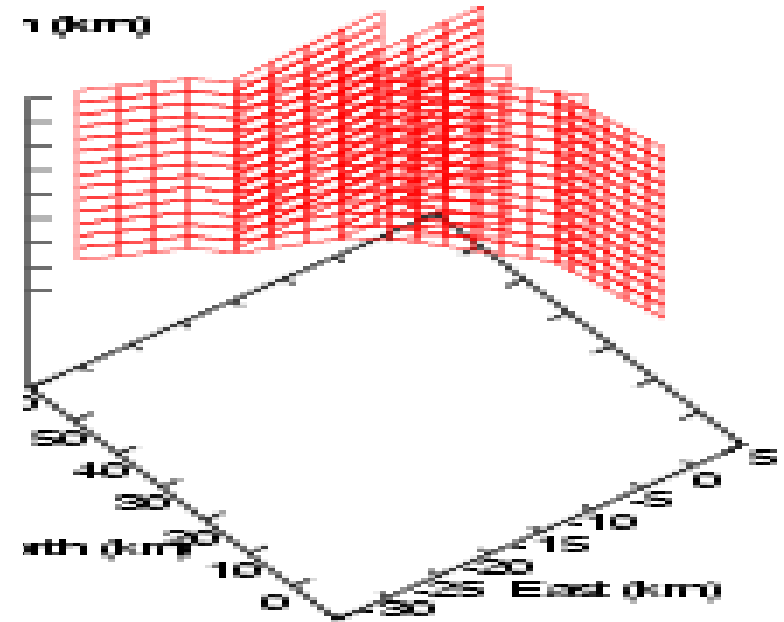
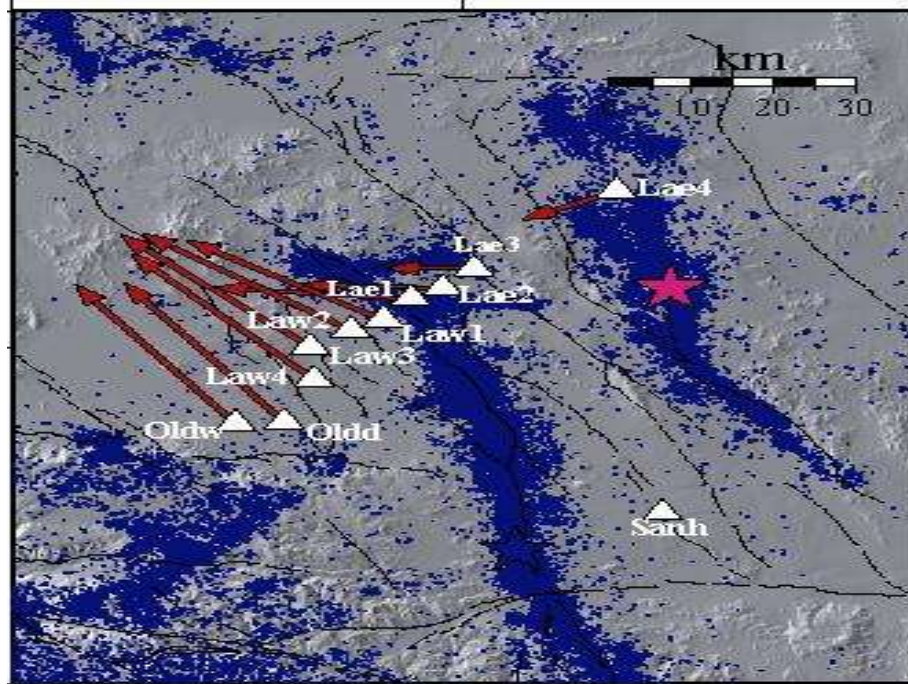
Modèle de faille (ex: Taiwan)



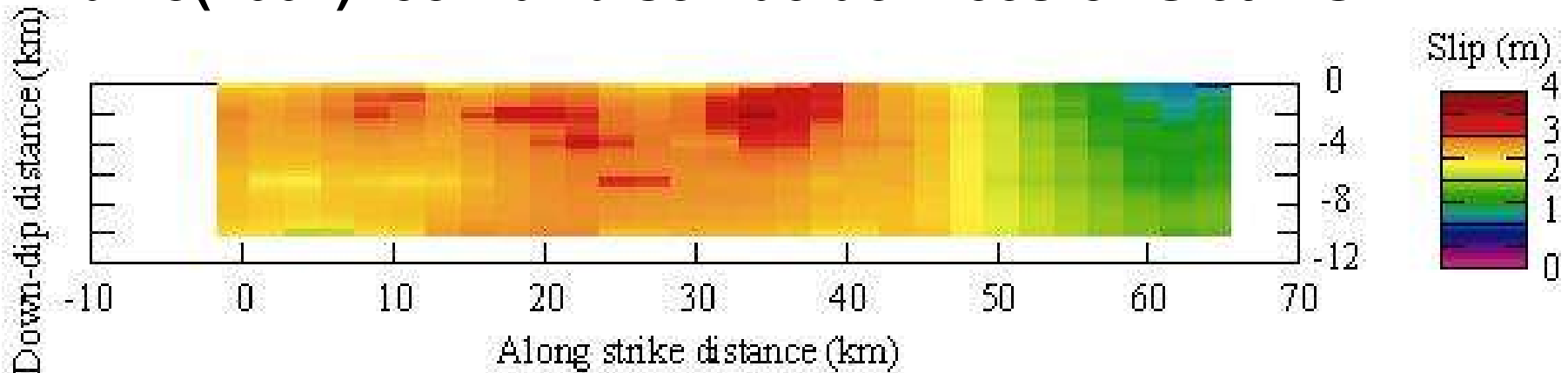
Le séisme de Landers (28 juin 1992, $M_w=7.3$)



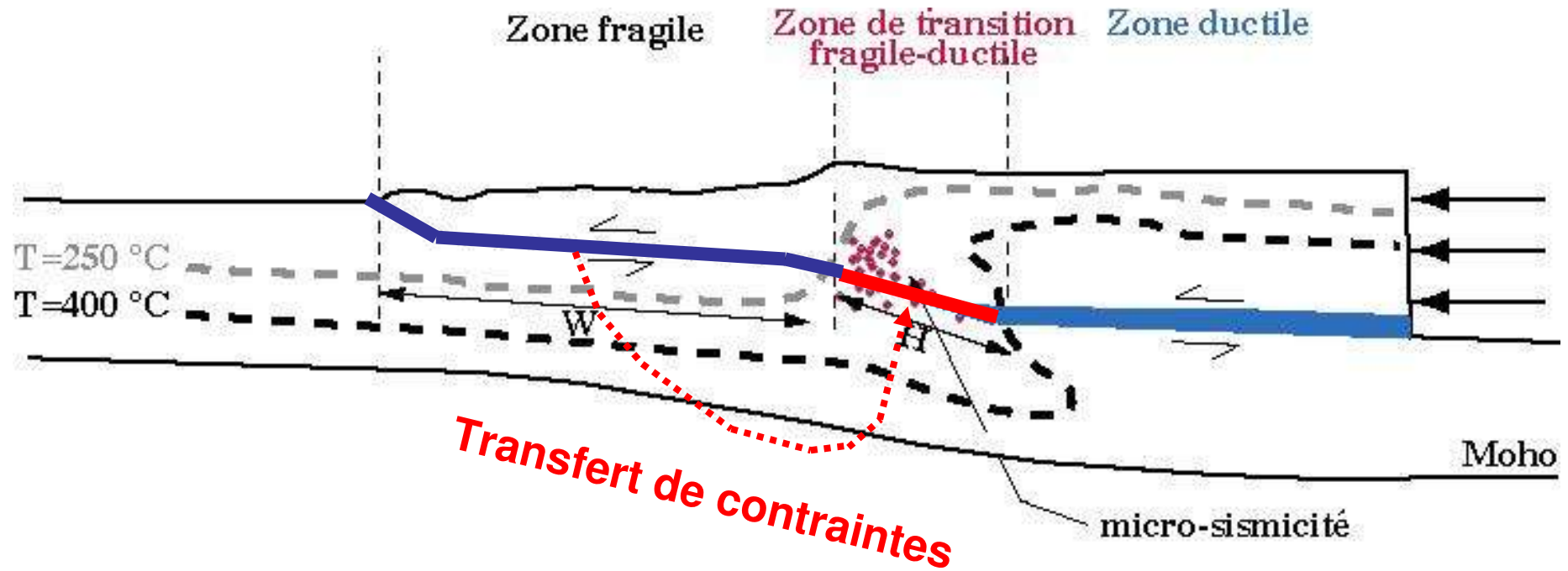
Glissement cosismique



Fialko(2004): combinaison de données GPS et InSAR



Réponse de la zone de transition fragile-ductile



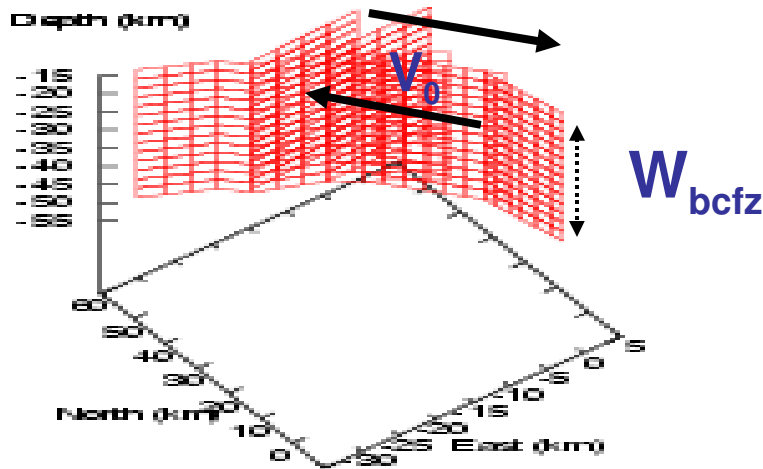
✓ Contrainte frictionnelle τ_f : $\tau_f(V) = \sigma \mu(V)$

σ : contrainte normale effective; $V \propto d\varepsilon/dt$: taux de déformation

$\mu(V)$: coefficient de frottement

$\mu(V) = \mu'_* + a \log(V)$, $a > 0$ (Rate strengthening)

Paramètres du modèle



Rhéologie: $\Delta CFF = a\sigma \log(V^+/V^-)$

✓ ΔCFF : variation de contrainte de Coulomb induite par le séisme principal

✓ $a\sigma$: paramètre rhéologique

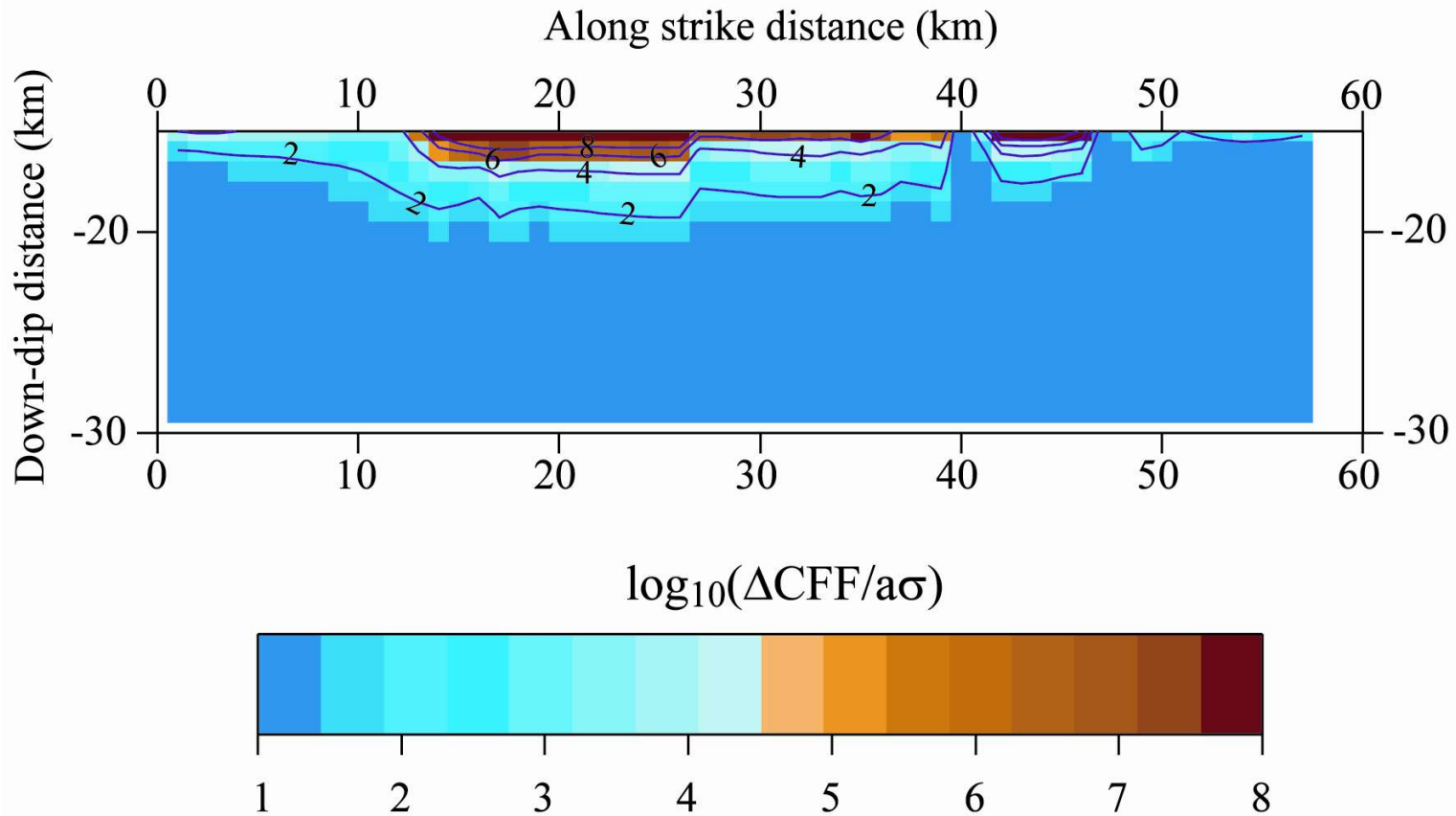
✓ V^+ (resp. V^-): Vitesse de glissement de la BCFZ immédiatement après (resp. avant) le séisme

Par souci de simplicité, le nombre de paramètres est limité à 4:

- 1) Dimension W_{bcfz} de la zone de transition fragile-ductile (BCFZ)
- 2) Vitesse long terme de glissement V_0
- 3) Vitesse initiale de glissement V^-
- 4) Paramètre rhéologique $a\sigma$

Réponse de la zone de transition fragile-ductile

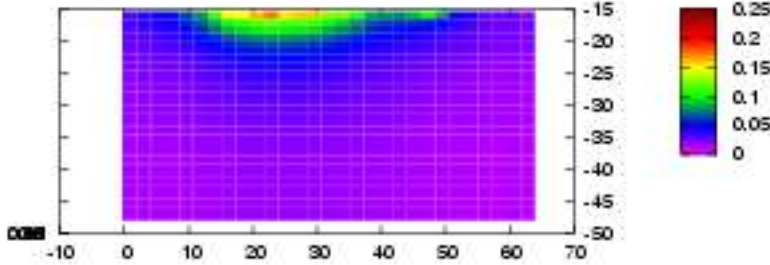
Transfert de contrainte cosismique dans la zone de transition fragile-ductile (BCFZ).



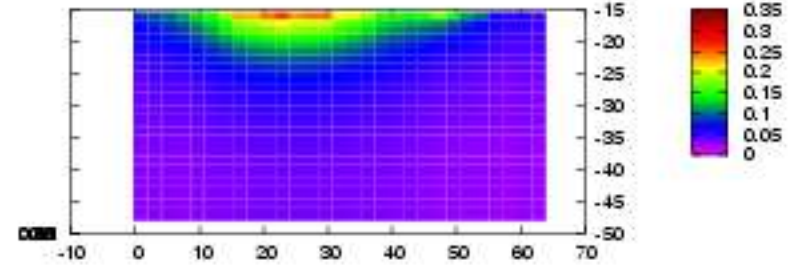
Historique du glissement de la BCFZ durant la relaxation postsismique

($a\sigma=6$ bars, $V_0=7$ mm/yr, $V=40 V_0$, $W_{bcfz}=35$ km)

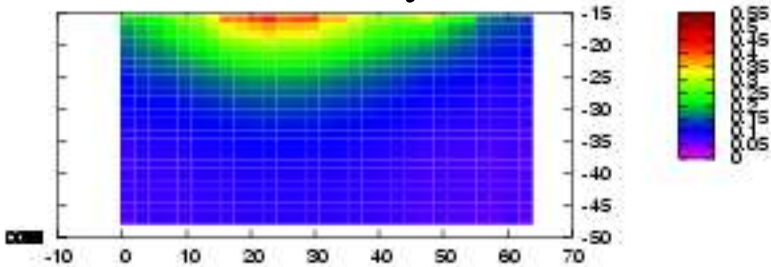
$\Delta t=6 \cdot 10^{-4}$ yr



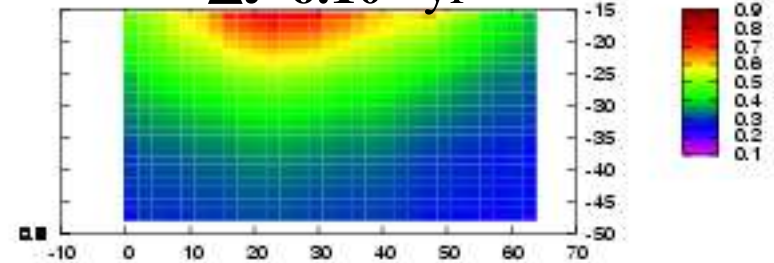
$\Delta t=6 \cdot 10^{-3}$ yr



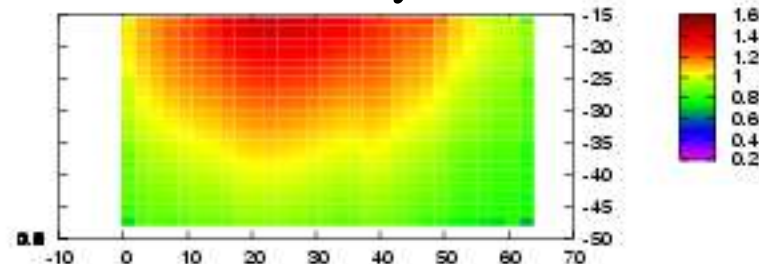
$\Delta t=6 \cdot 10^{-2}$ yr



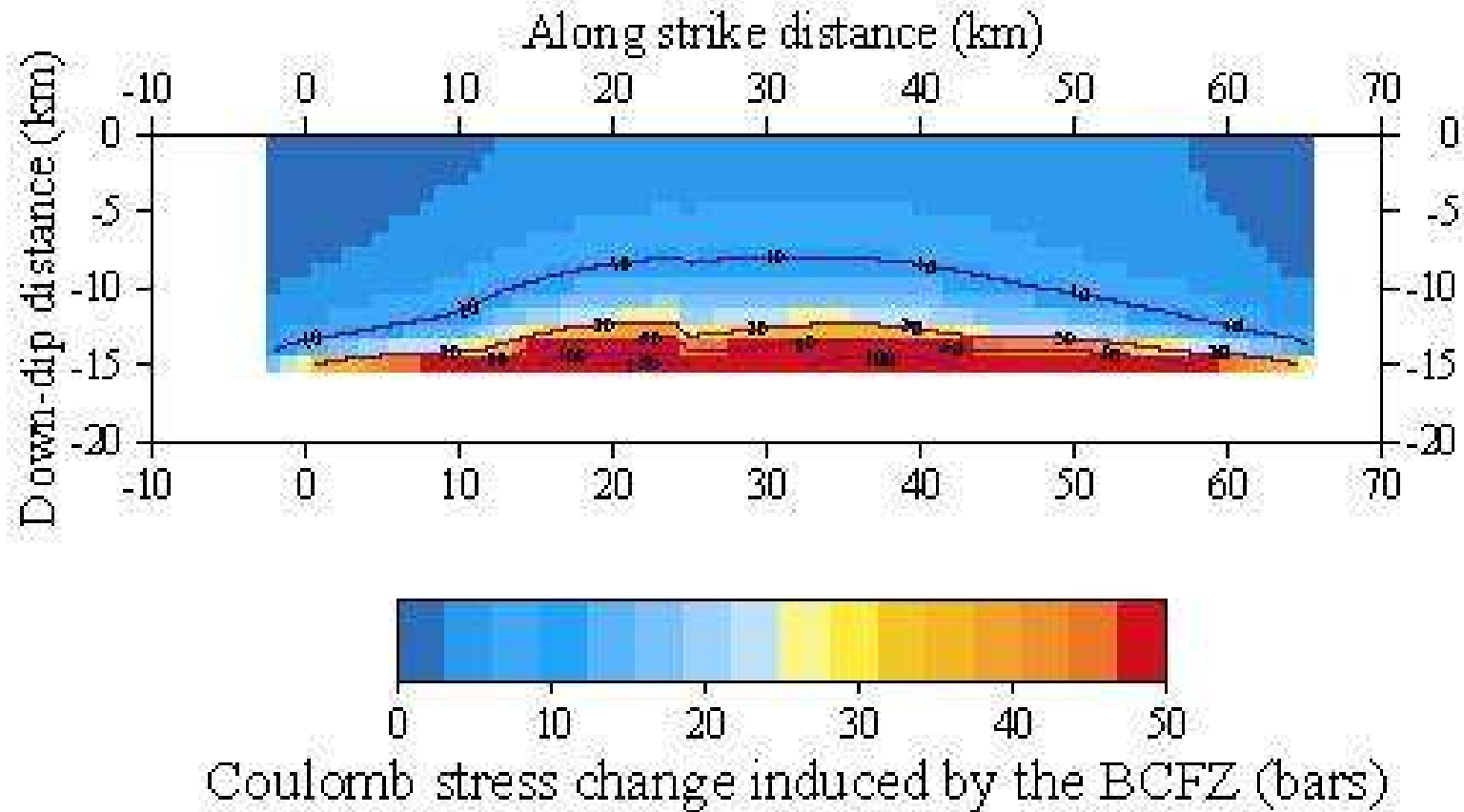
$\Delta t=6 \cdot 10^{-1}$ yr



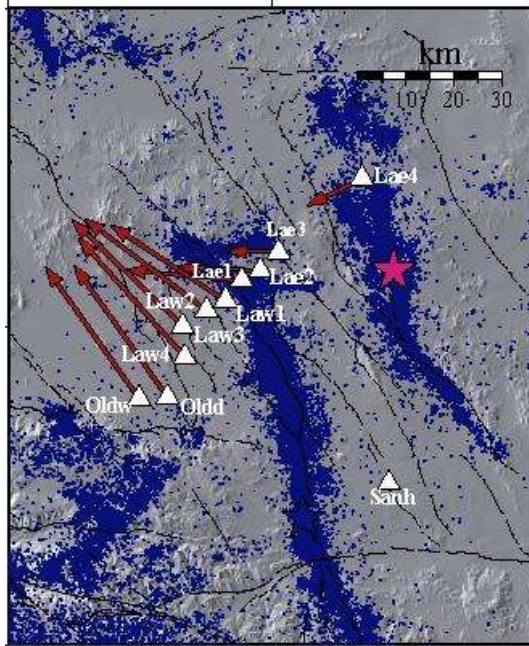
$\Delta t=6$ yr



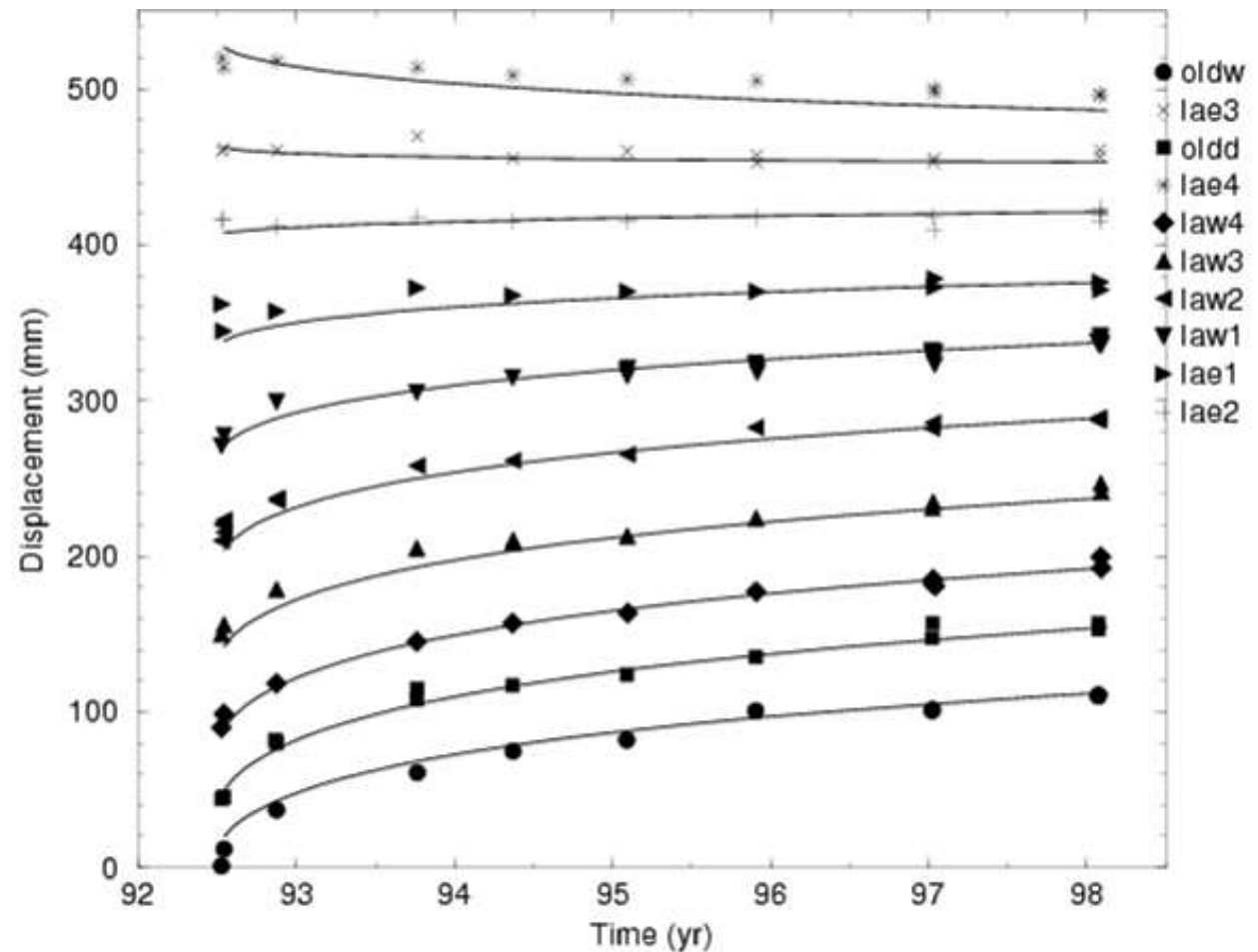
Rechargement de la zone sismogène par la relaxation de la BCFZ.



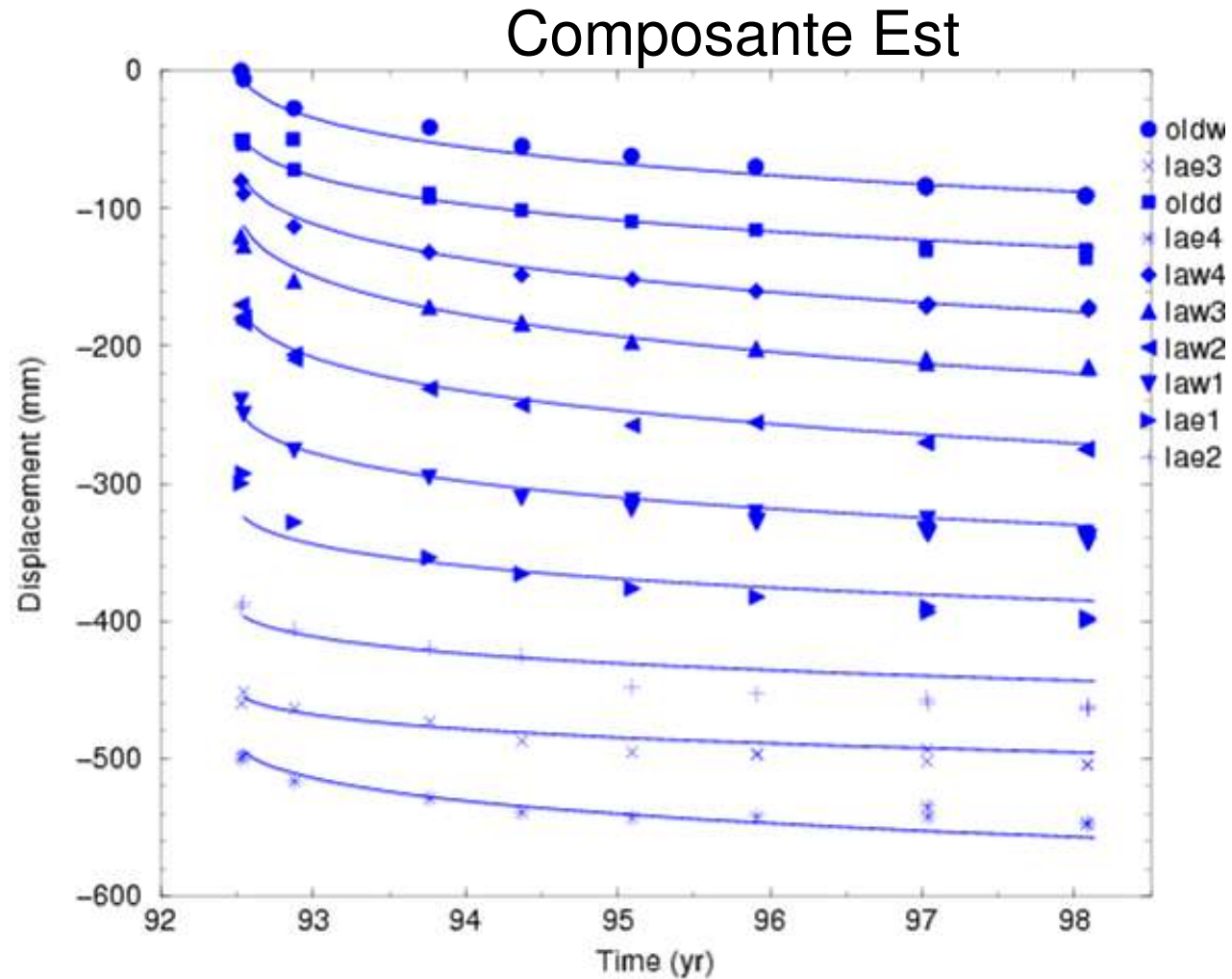
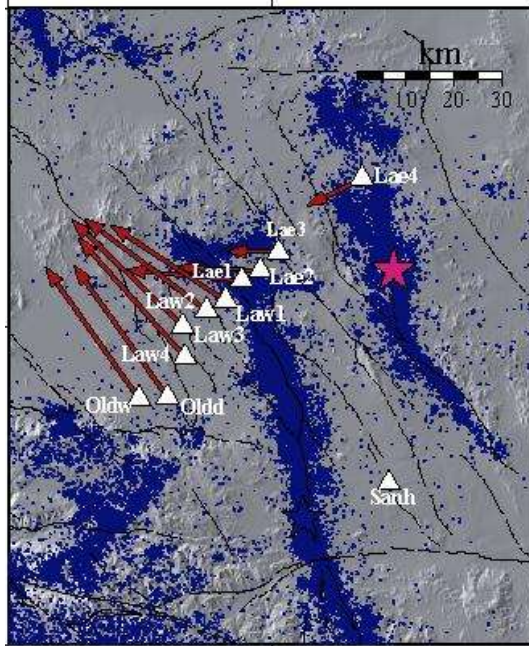
Déplacement post-sismique de stations GPS



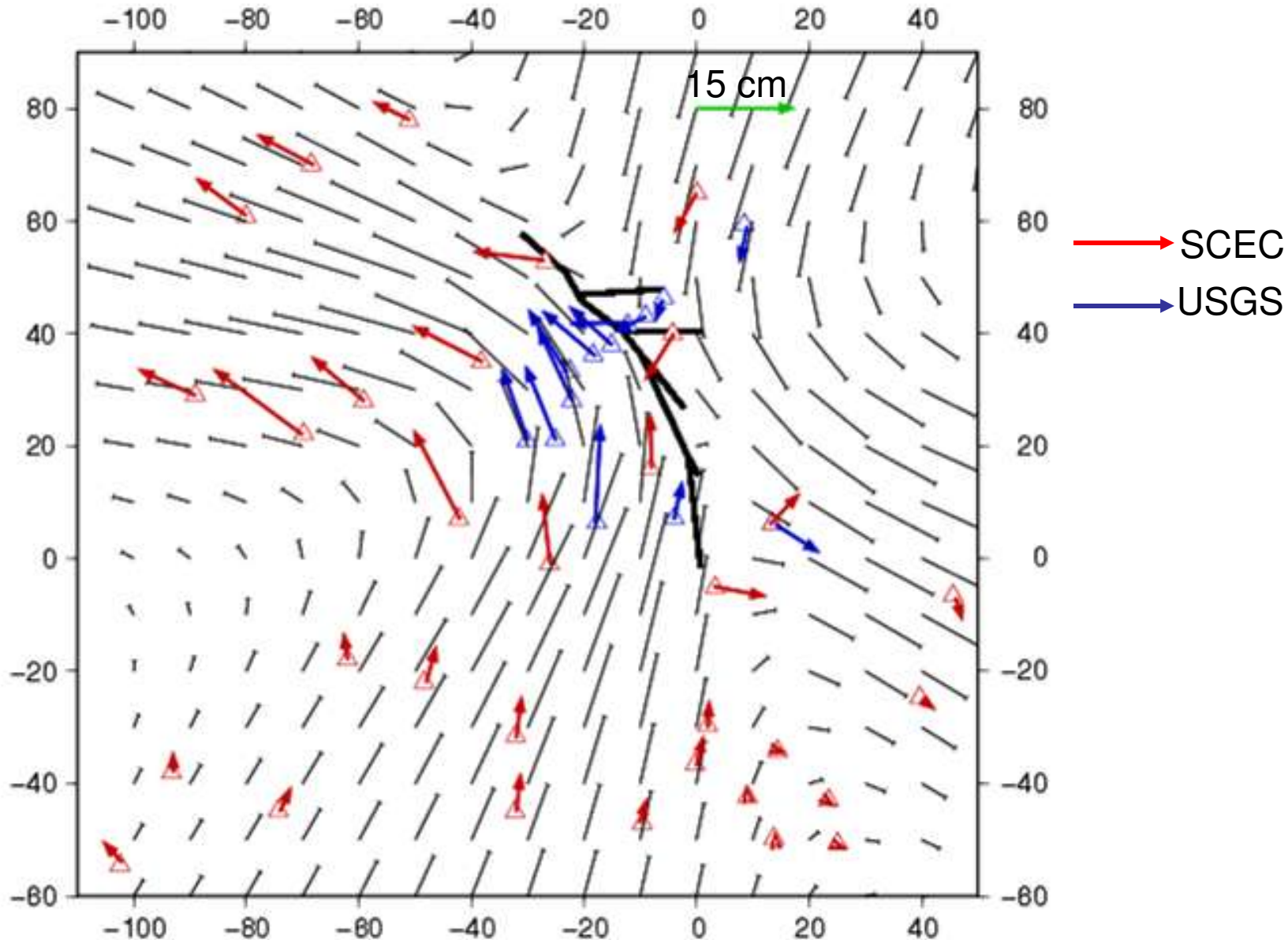
Composante Nord



Déplacement post-sismique de stations GPS

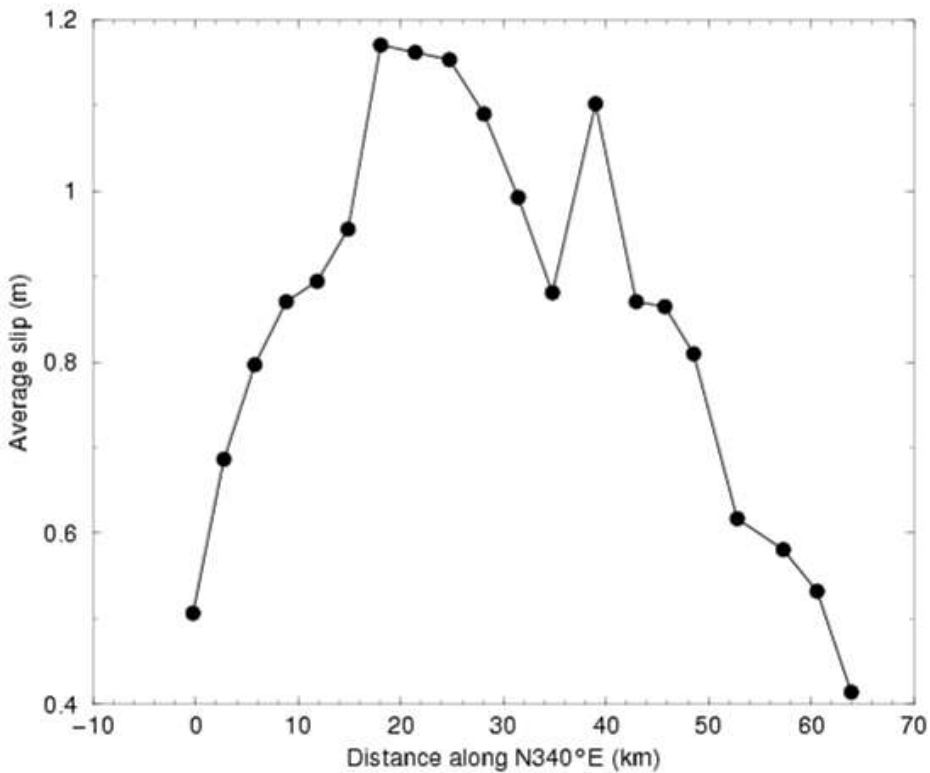


Champ de déplacement observé après 6 années de relaxation

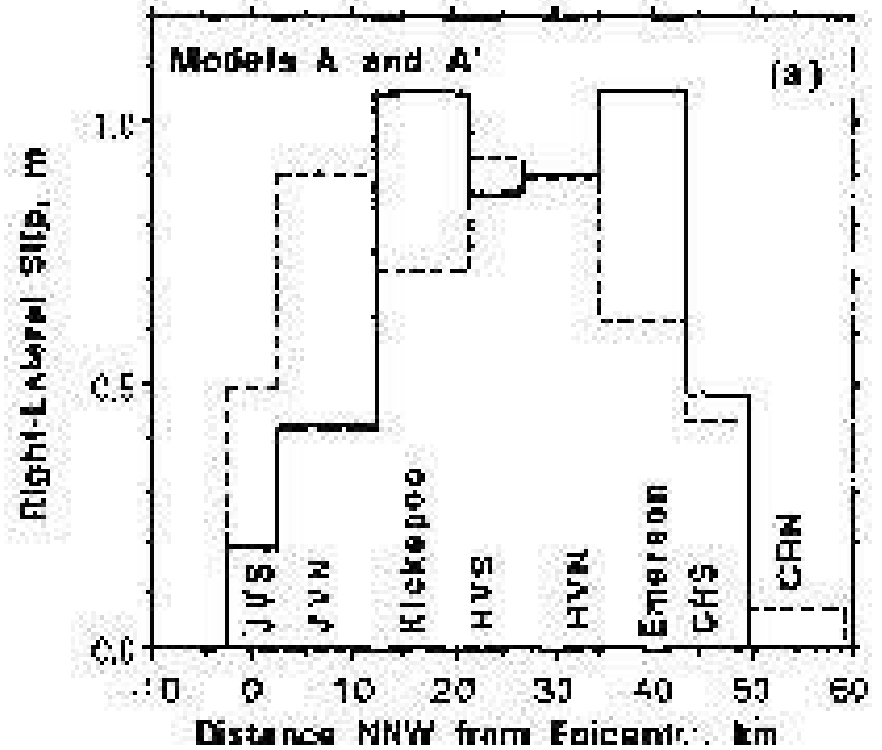


Glissement final sur la BCFZ

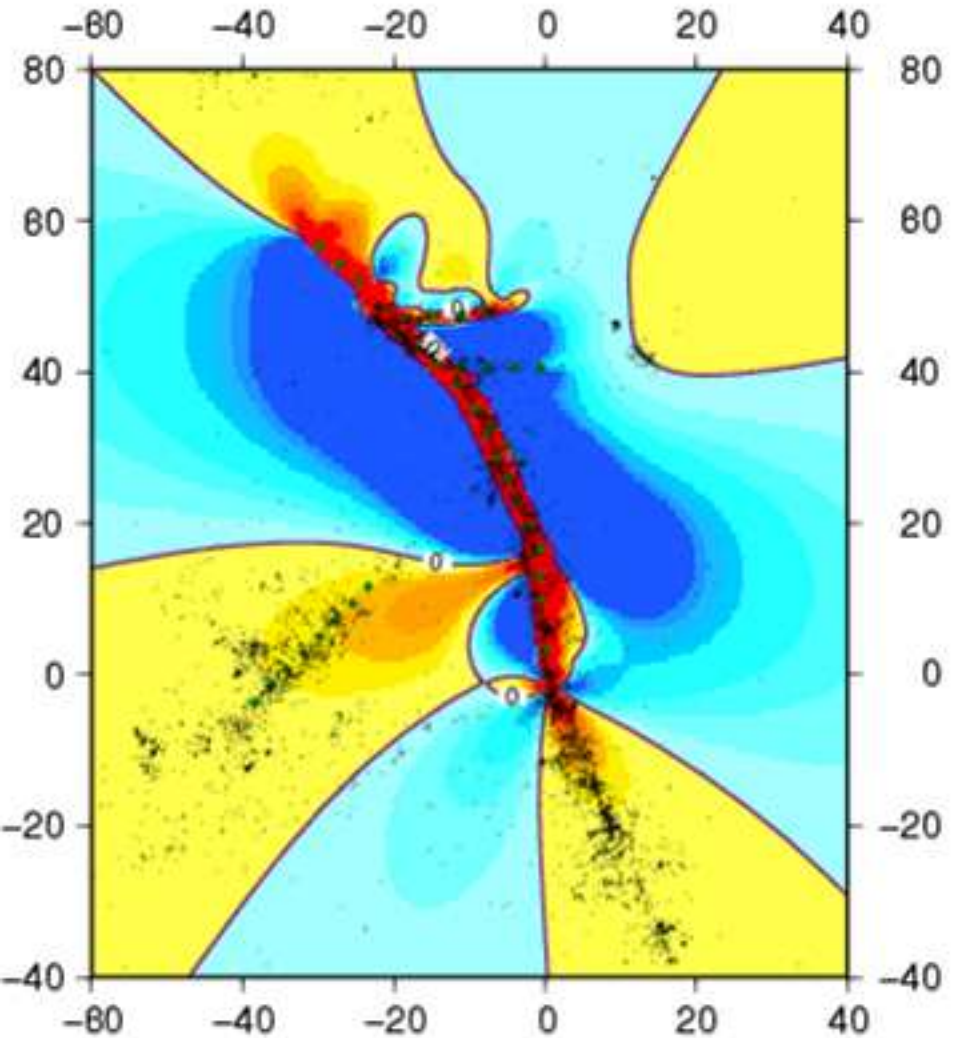
Modèle



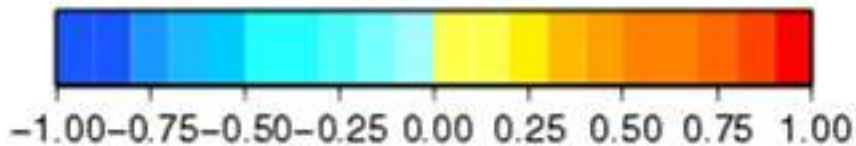
GPS (Savage & Svarc 1997)



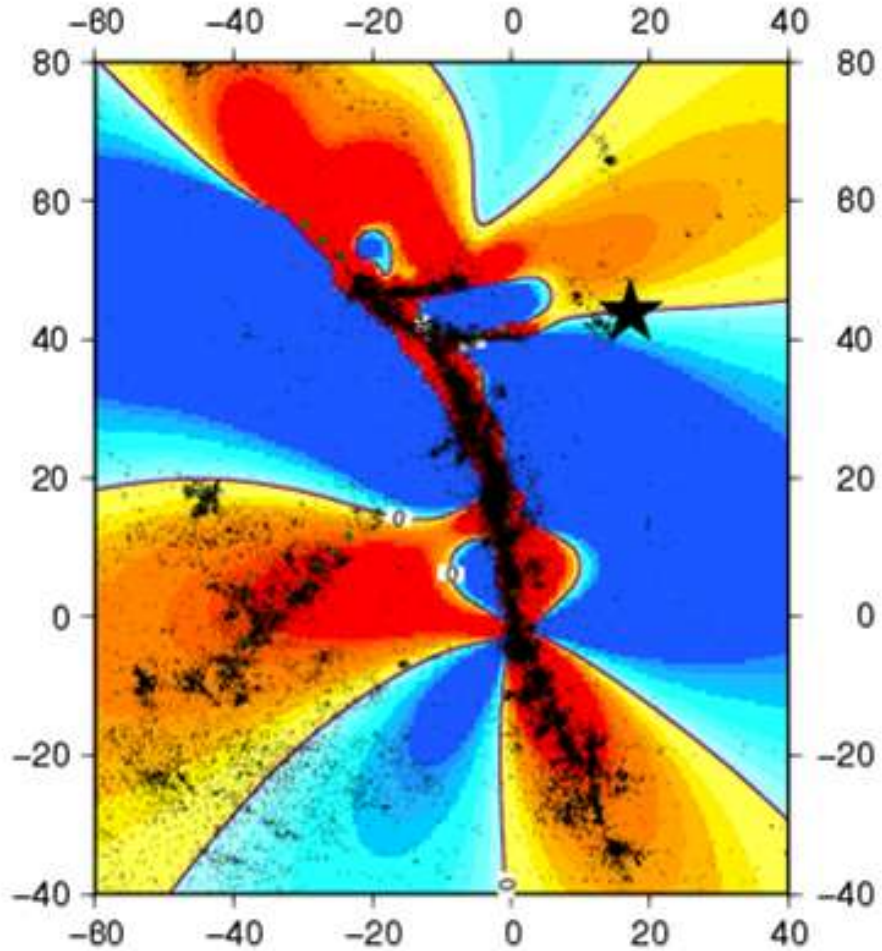
Variation spatiale de contrainte de Coulomb durant la phase postsismique



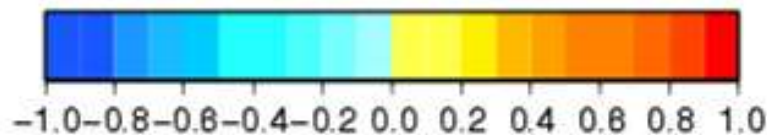
- $\Delta t = 0.06$ yr
- $z = 15$ km
- Calculé sur des failles réceptrices orientées N340E



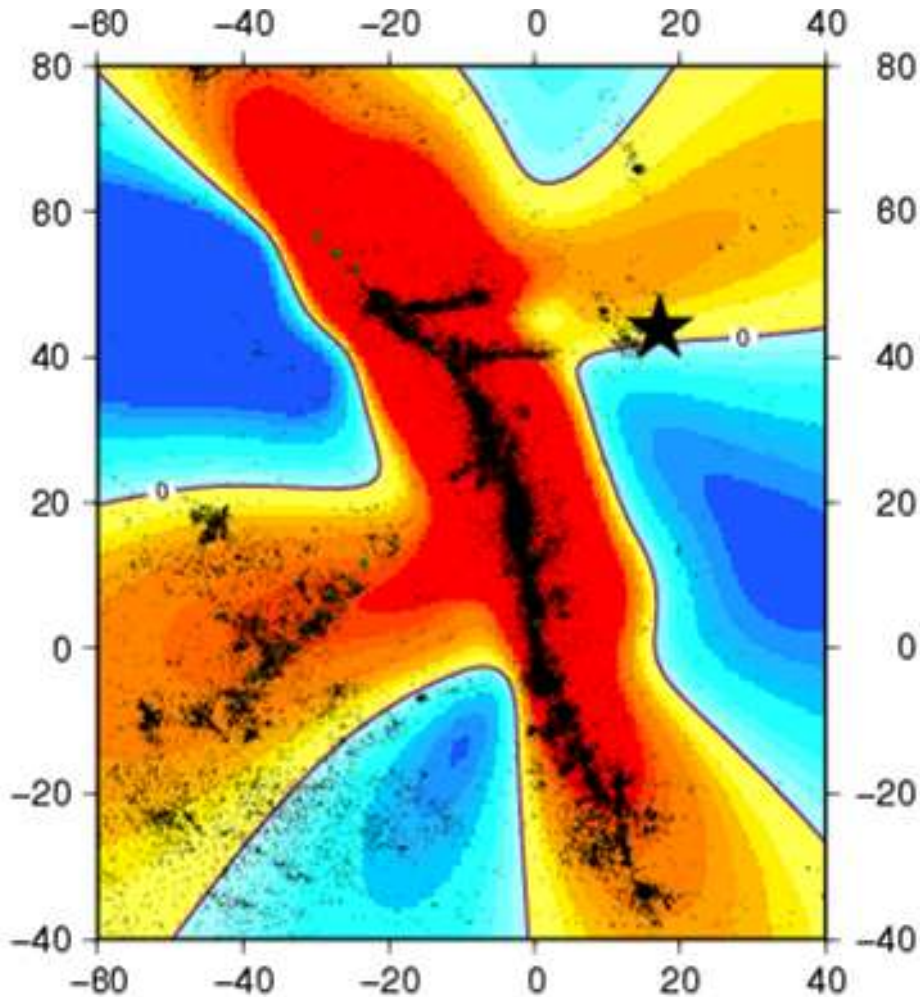
Variation de contrainte de Coulomb durant la phase postsismique



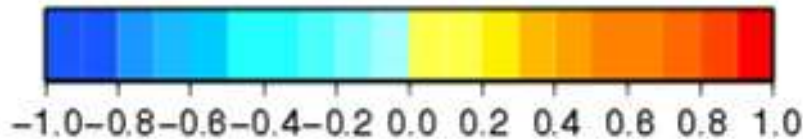
- $\Delta t = 6$ yr
- $z = 15$ km
- Calculé sur des failles réceptrices orientées N340E



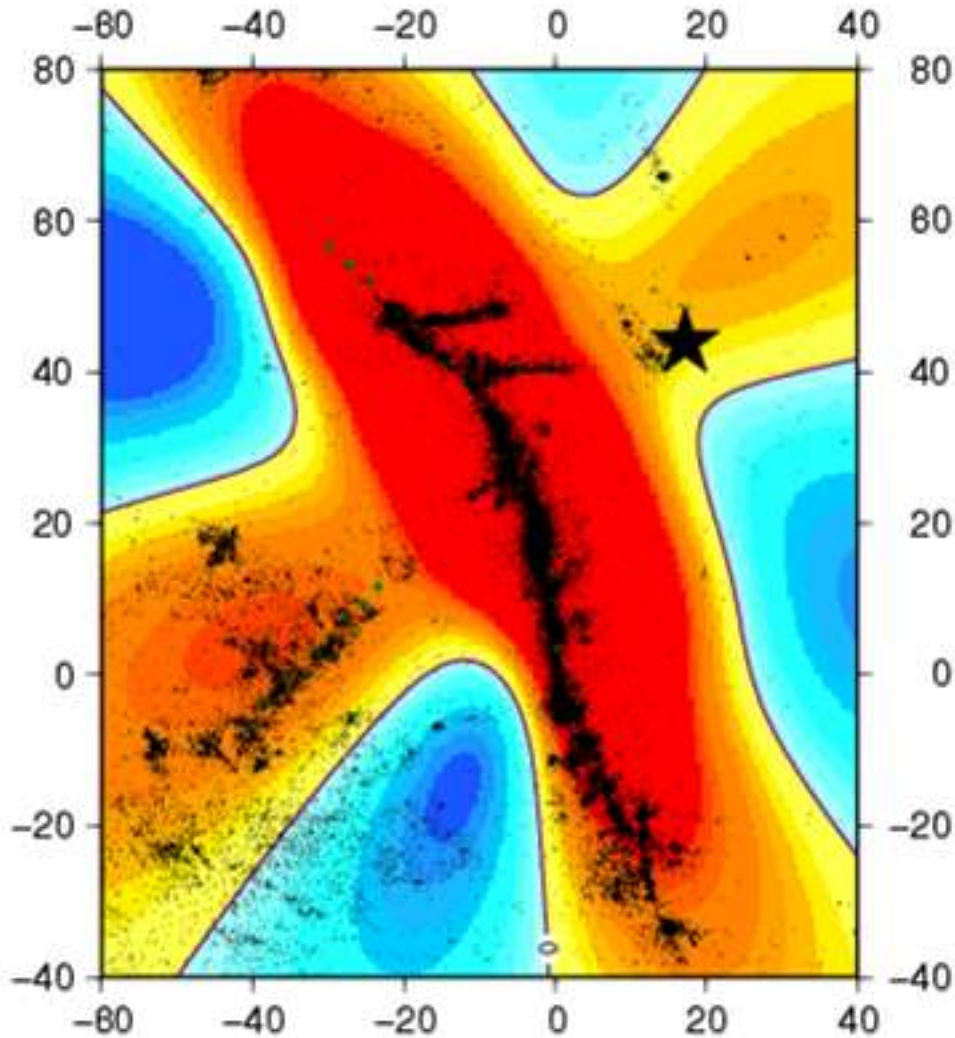
Variation spatiale de contrainte de Coulomb durant la phase postsismique



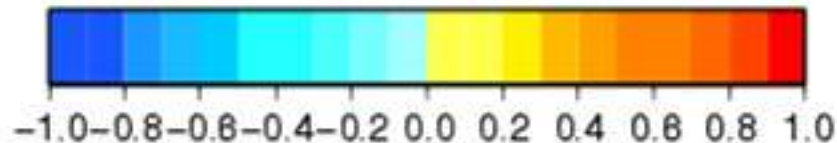
- $\Delta t = 6$ yr
- $z = 10$ km
- Calculé sur des failles réceptrices orientées N340E



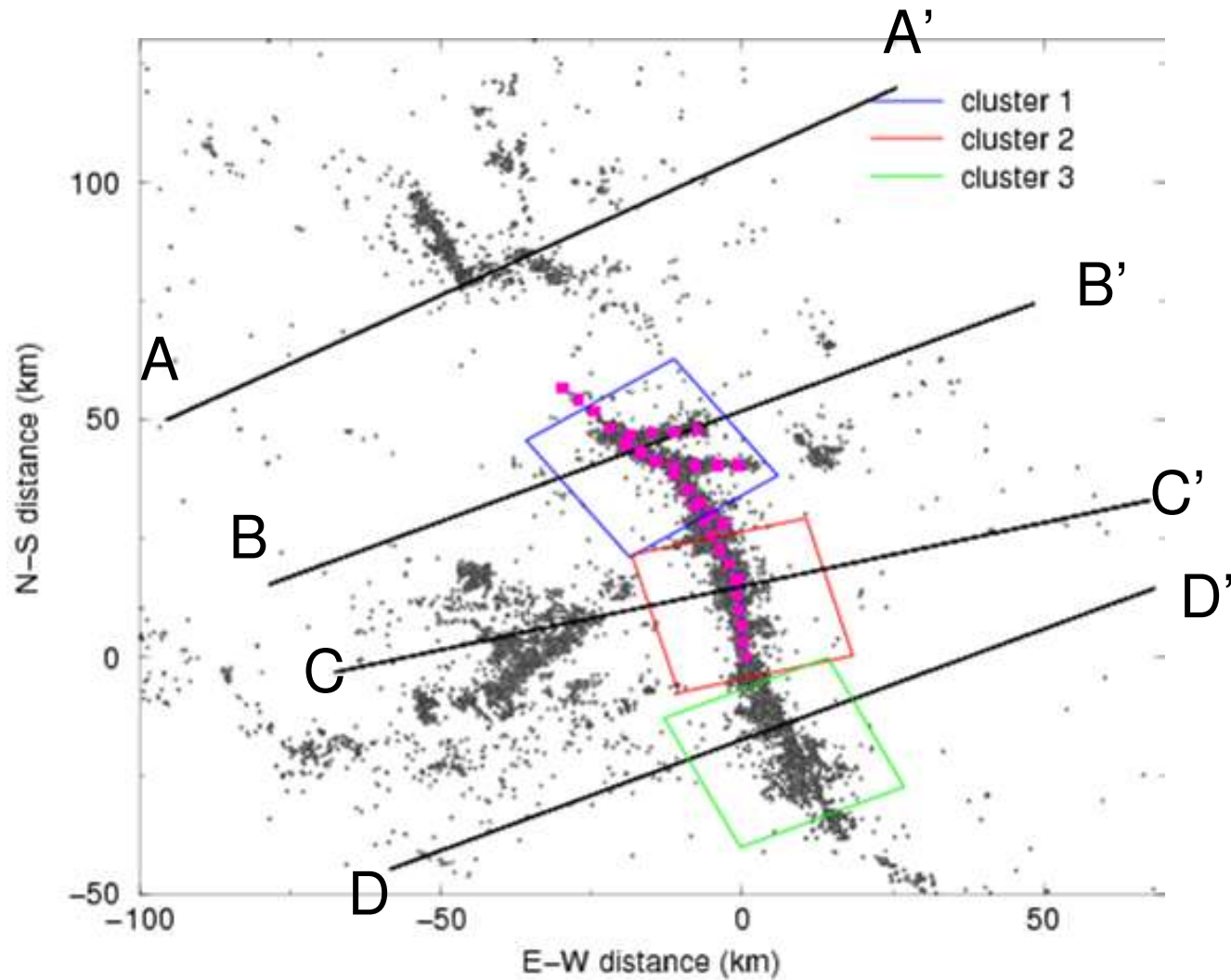
Variation spatiale de contrainte de Coulomb durant la phase postsismique



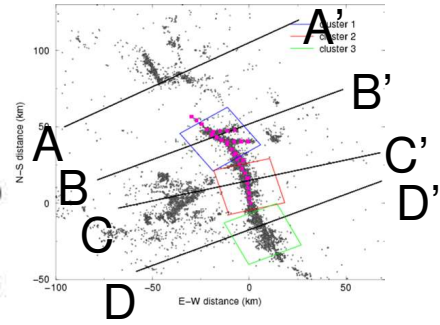
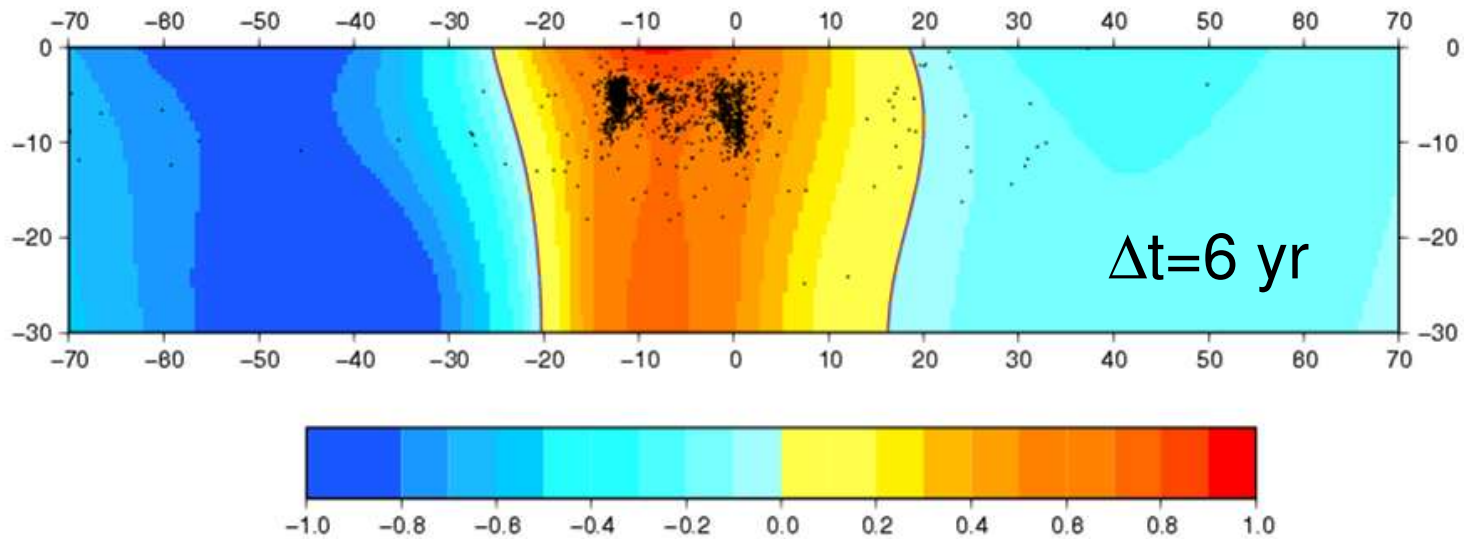
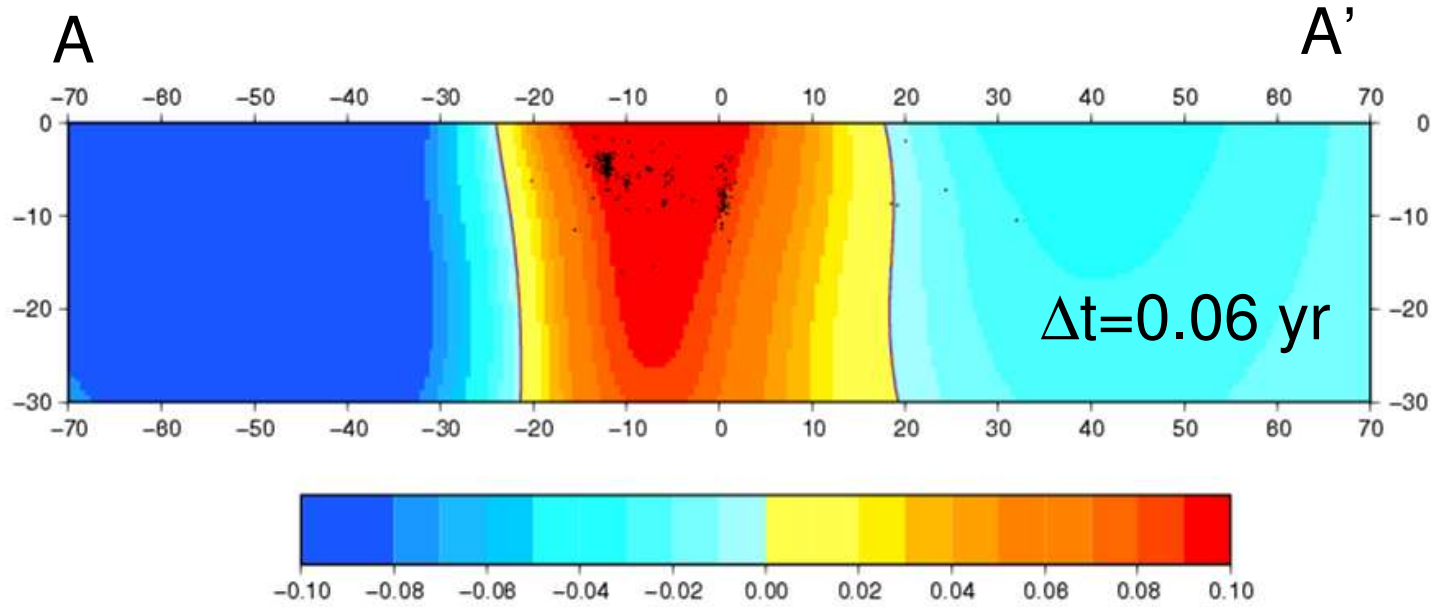
- $\Delta t = 6$ yr
- $z = 5$ km
- Calculé sur des failles réceptrices orientées N340E



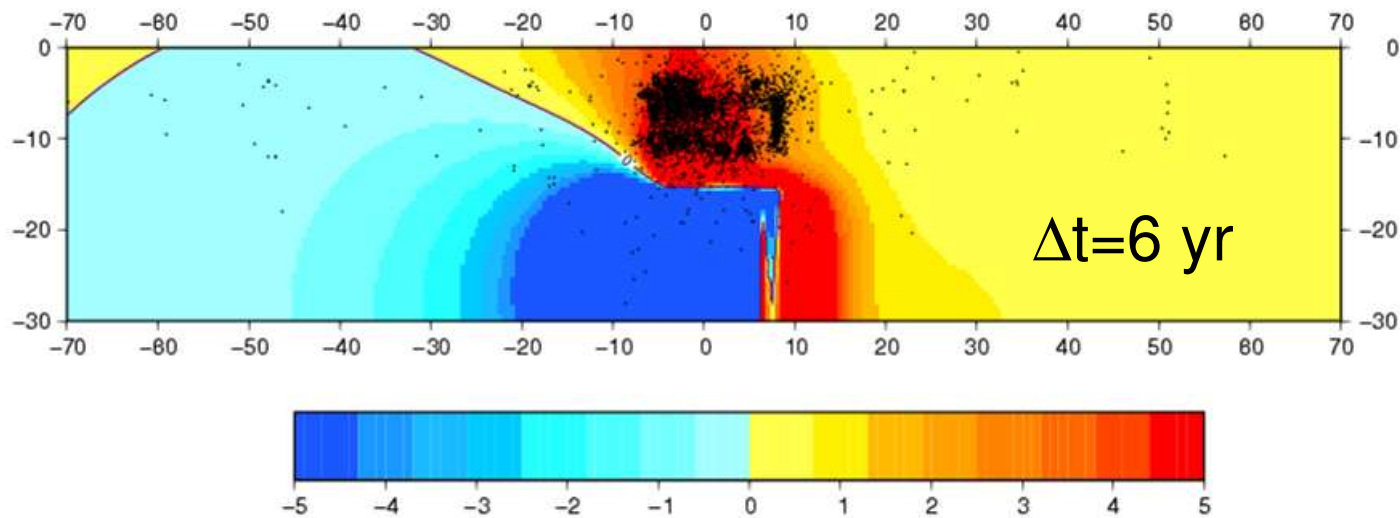
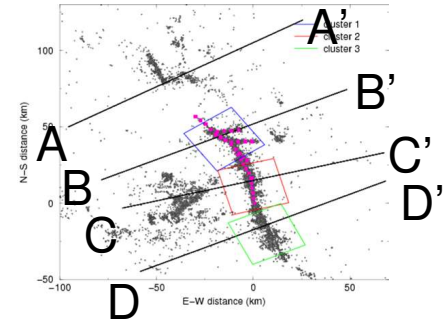
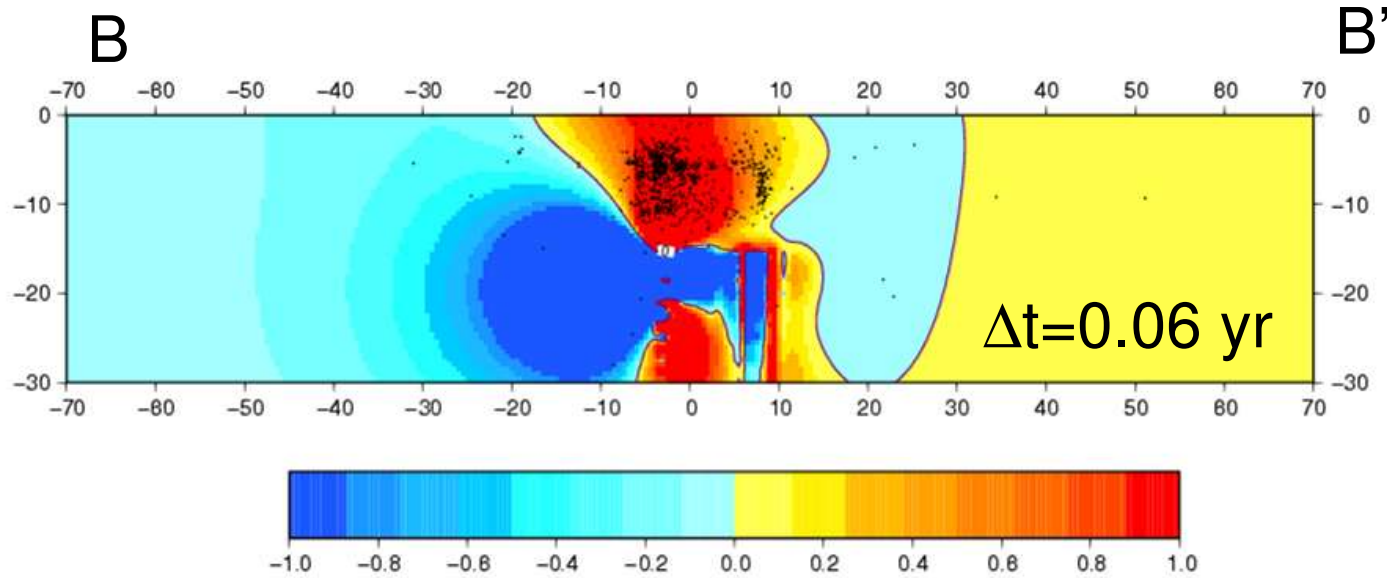
Variation spatiale de contrainte de Coulomb durant la phase postsismique



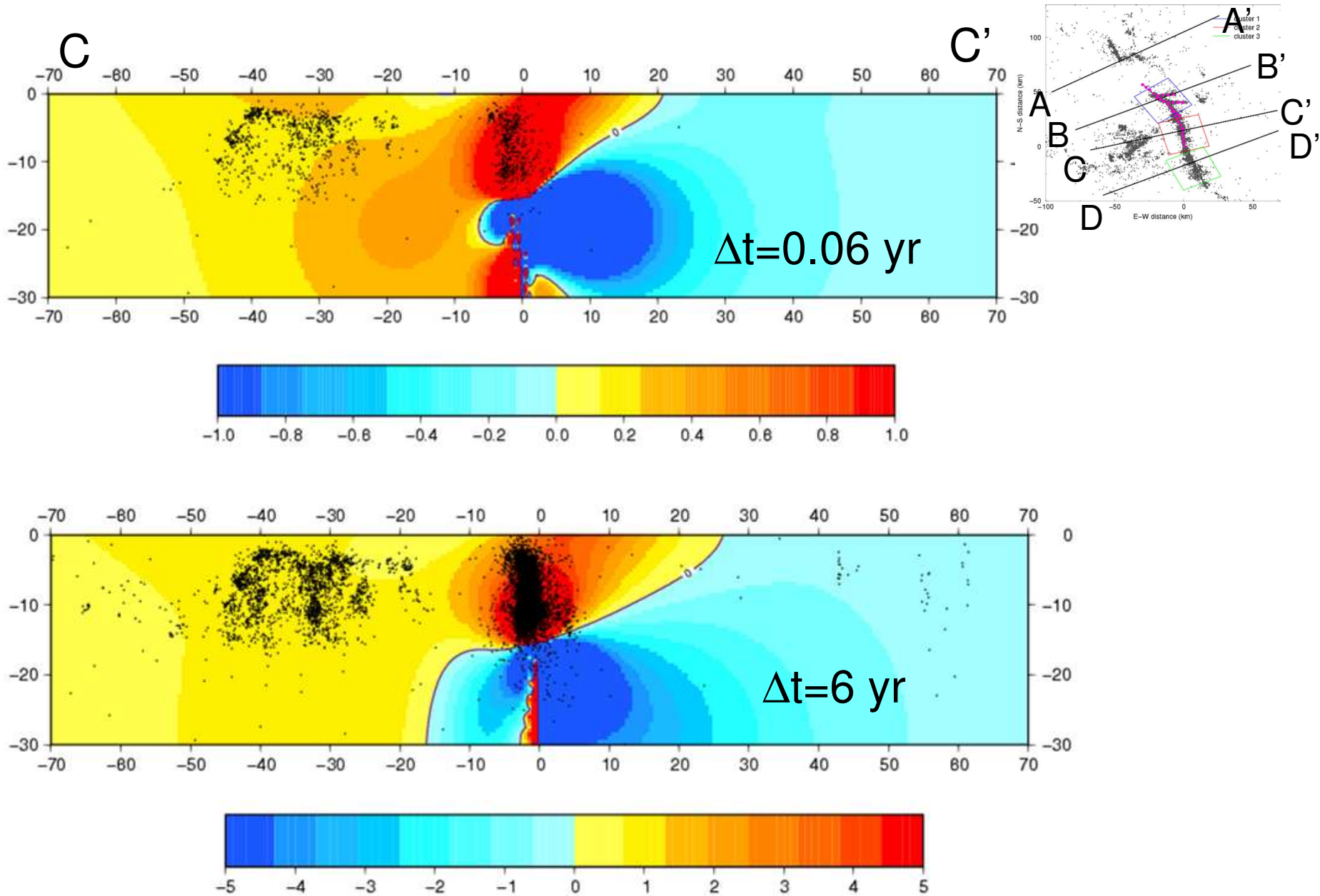
Variation spatiale de contrainte de Coulomb durant la phase postsismique



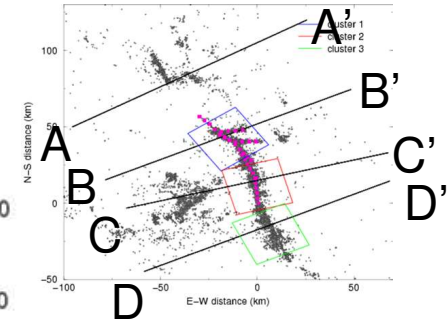
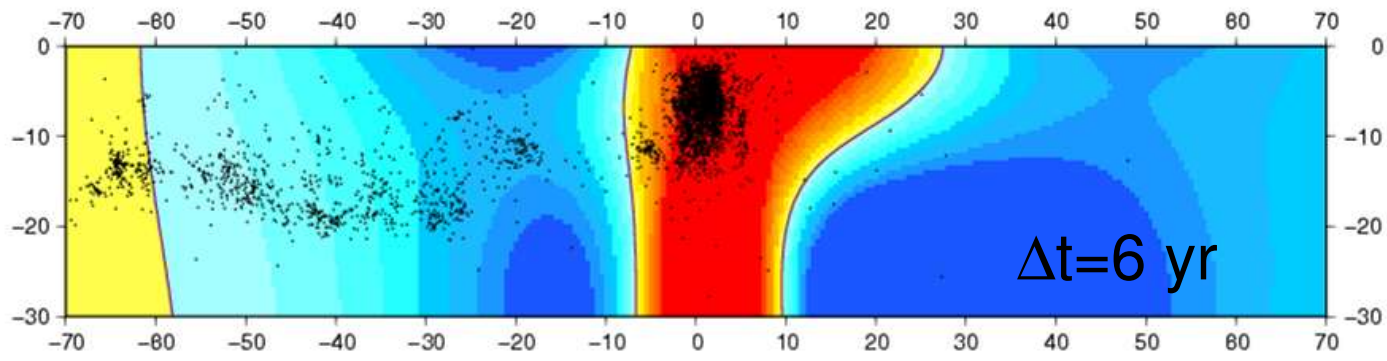
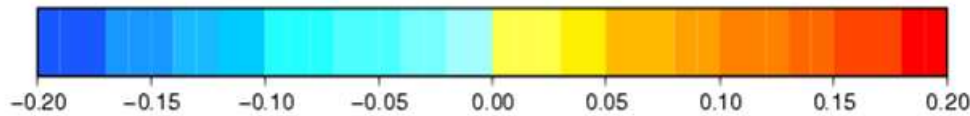
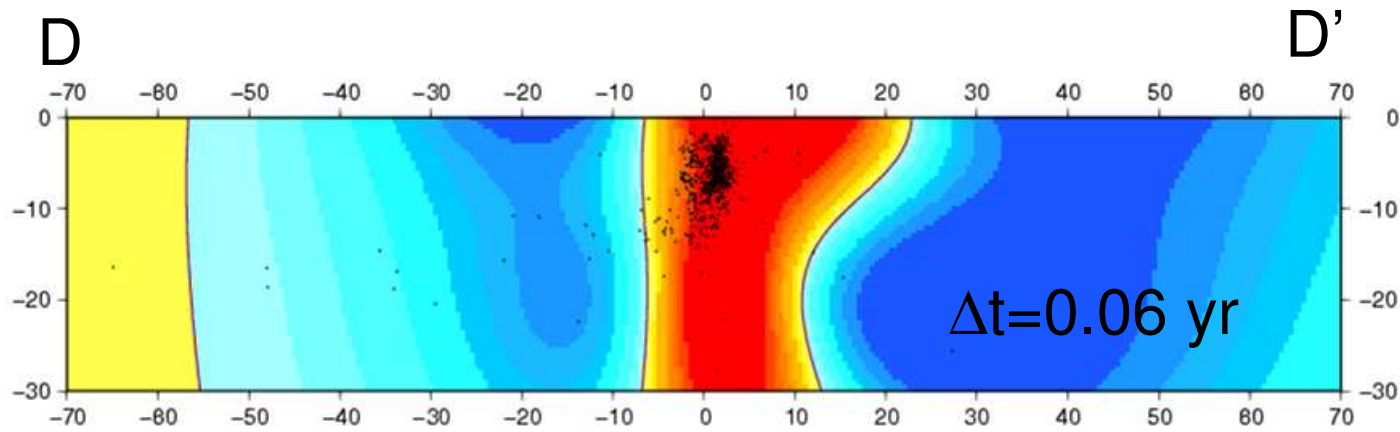
Variation spatiale de contrainte de Coulomb durant la phase postsismique



Variation spatiale de contrainte de Coulomb durant la phase postsismique



Variation spatiale de contrainte de Coulomb durant la phase postsismique



Lien entre sismicité et contrainte de Coulomb

Hypothèse du modèle

$$R(r;t) \sim d(\Delta CFF(r;t))/dt$$

Nombre cumulé de séismes

$$\Rightarrow N(r;t) = N(r;0) + \alpha(r) (\Delta CFF(r;t) - \Delta CFF(r;0))$$

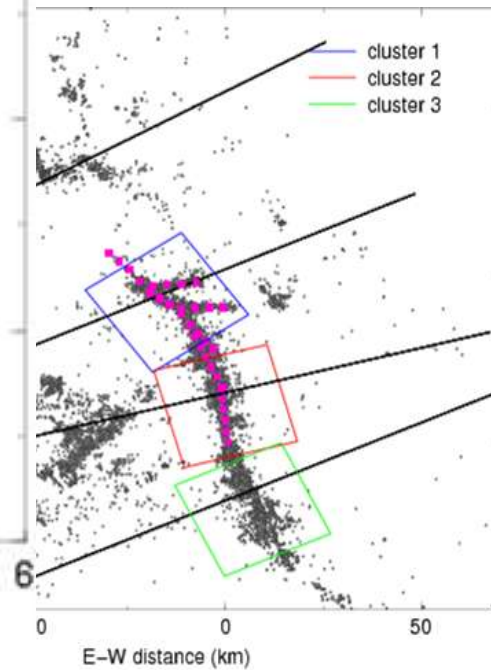
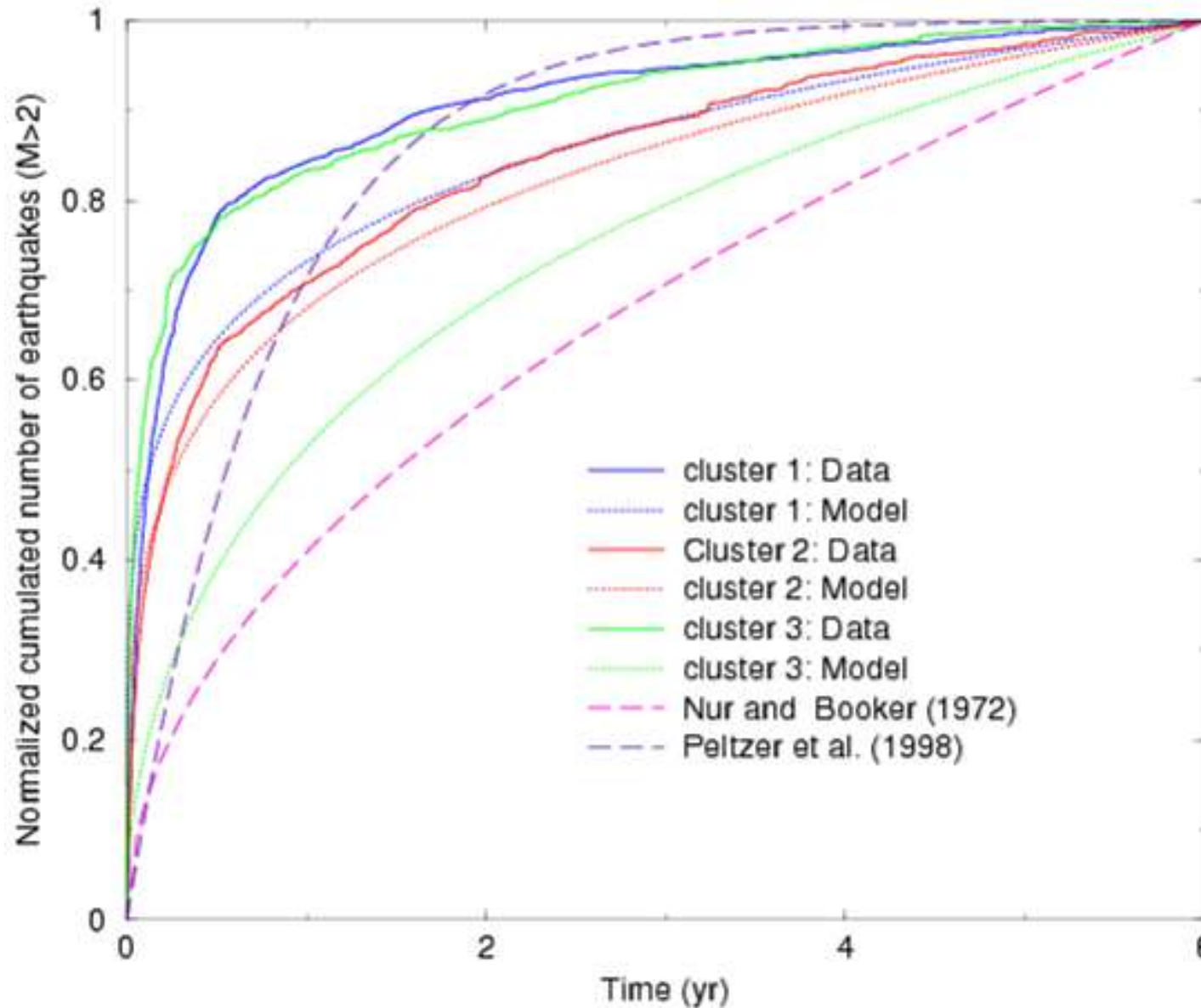
donc la quantité

$$\overline{N(r;t)} = [N(r;t) - N(r;0)] / [N(r;t_{\max}) - N(r;0)]$$

où t_{\max} est la période d'observation est directement comparable à

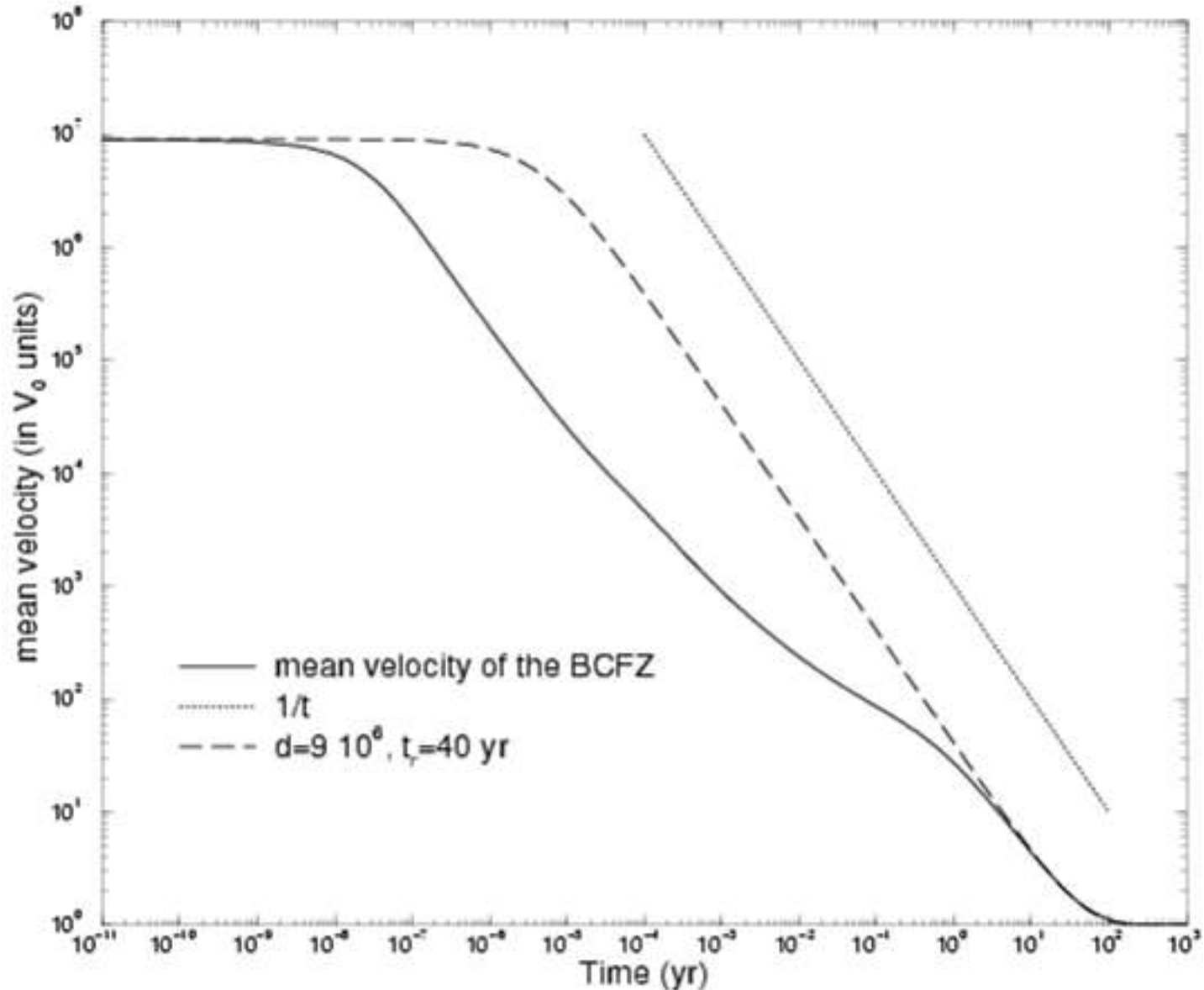
$$\overline{\Delta CFF(r;t)} = [\Delta CFF(r;t) - \Delta CFF(r;0)] / [\Delta CFF(r;t_{\max}) - \Delta CFF(r;0)]$$

Variation temporelle de la sismicité

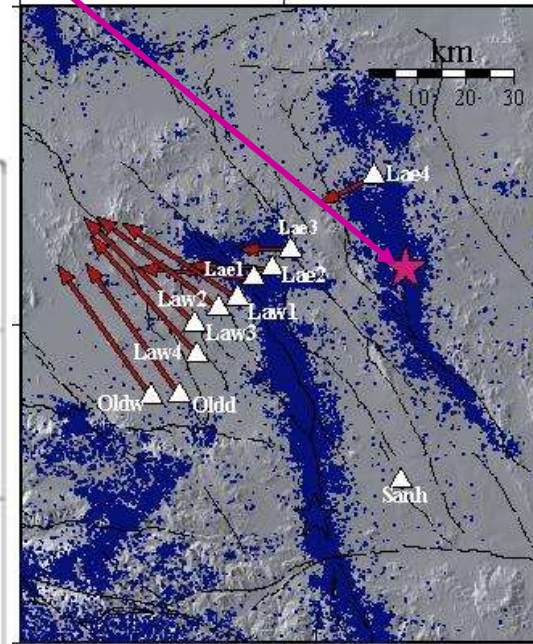
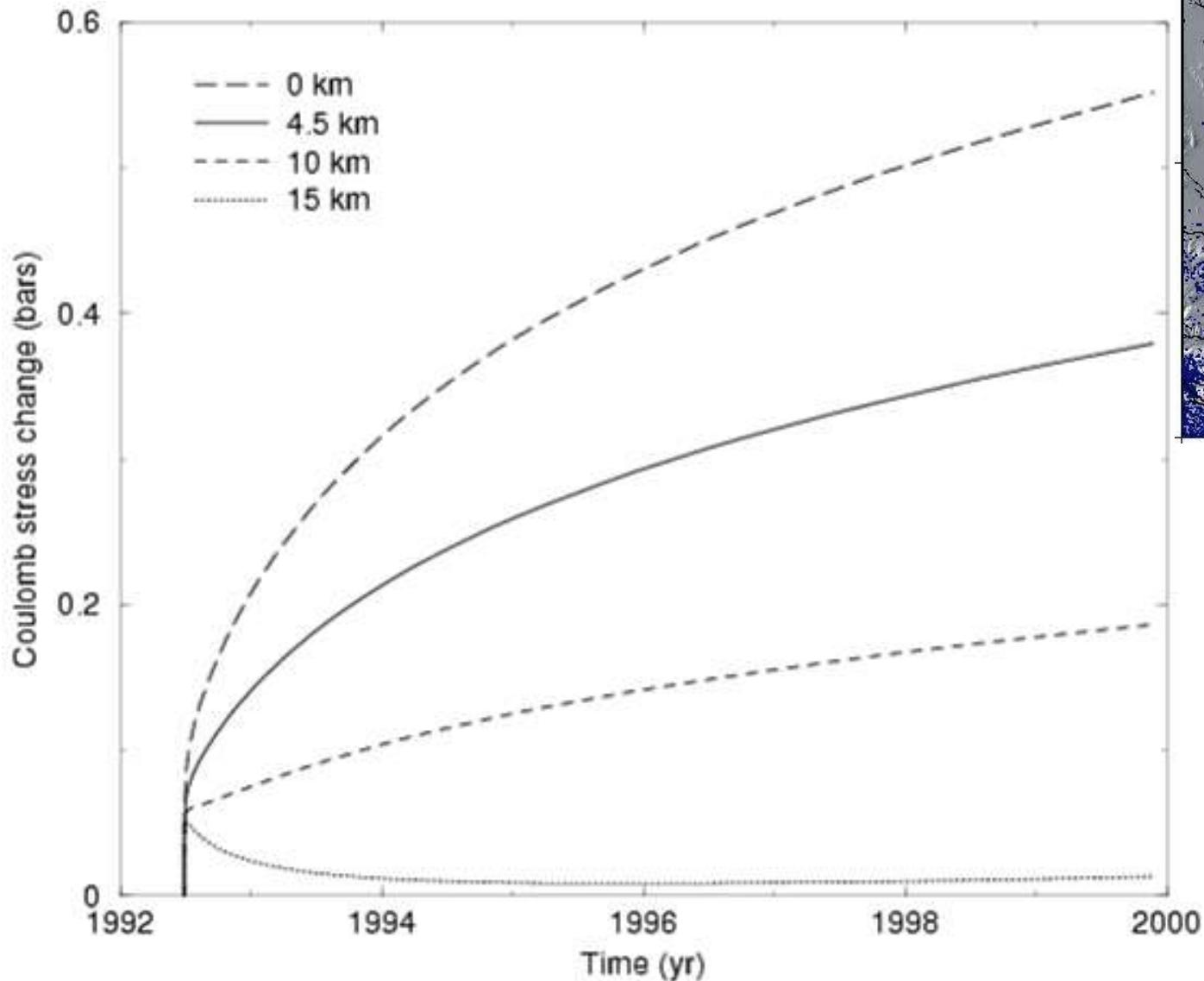


Vitesse moyenne de la BCFZ au cours du temps

$$R(t) \sim \langle V(t) \rangle \sim 1/t \Rightarrow \text{Loi d'Omori}$$

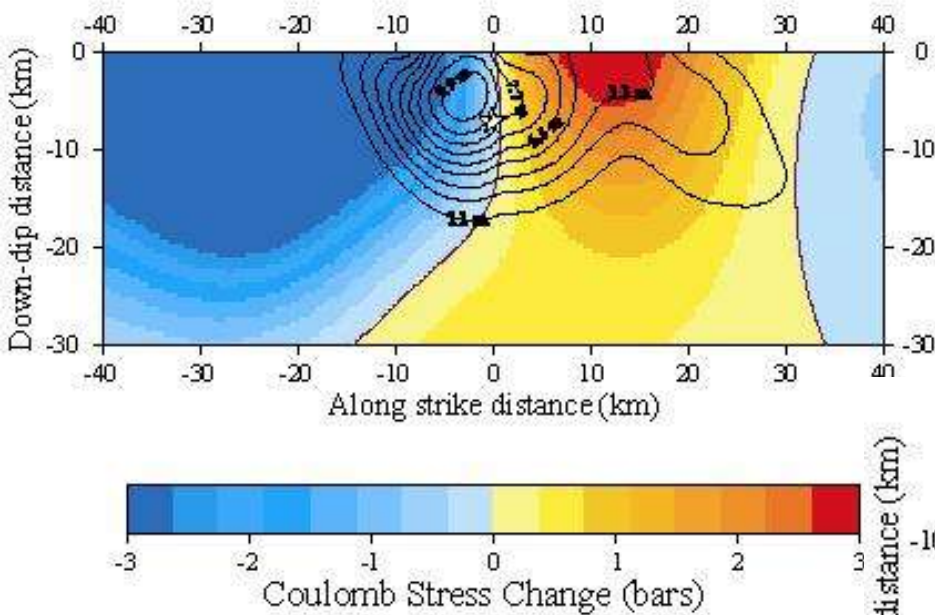


Effet de Landers sur Hector Mine (16 octobre 1999, Mw=7.1)

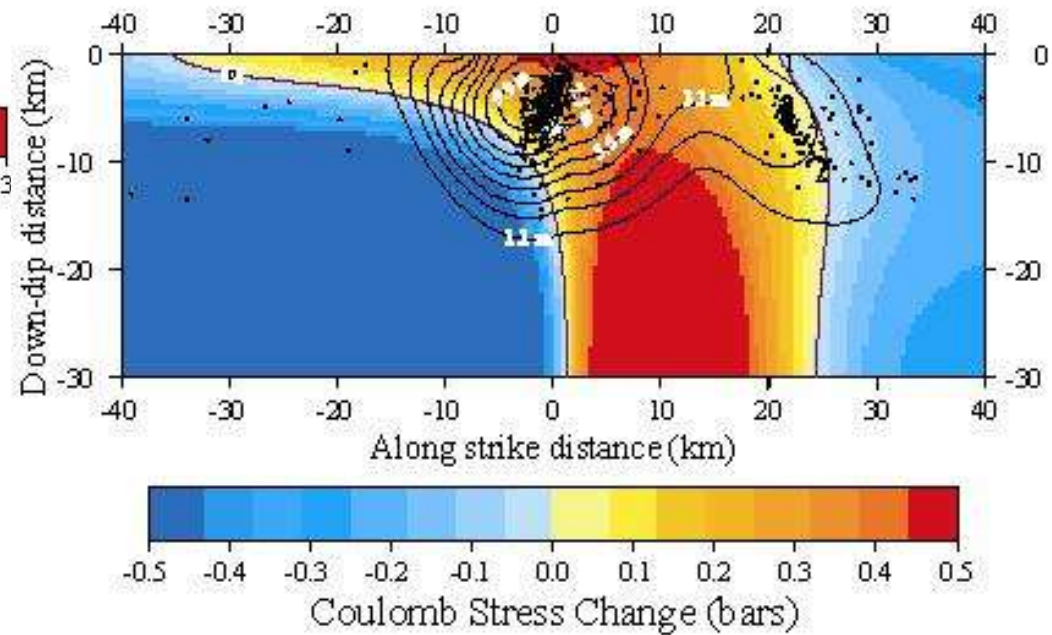


Effet de Landers sur la rupture de Hector Mine

contribution cosismique



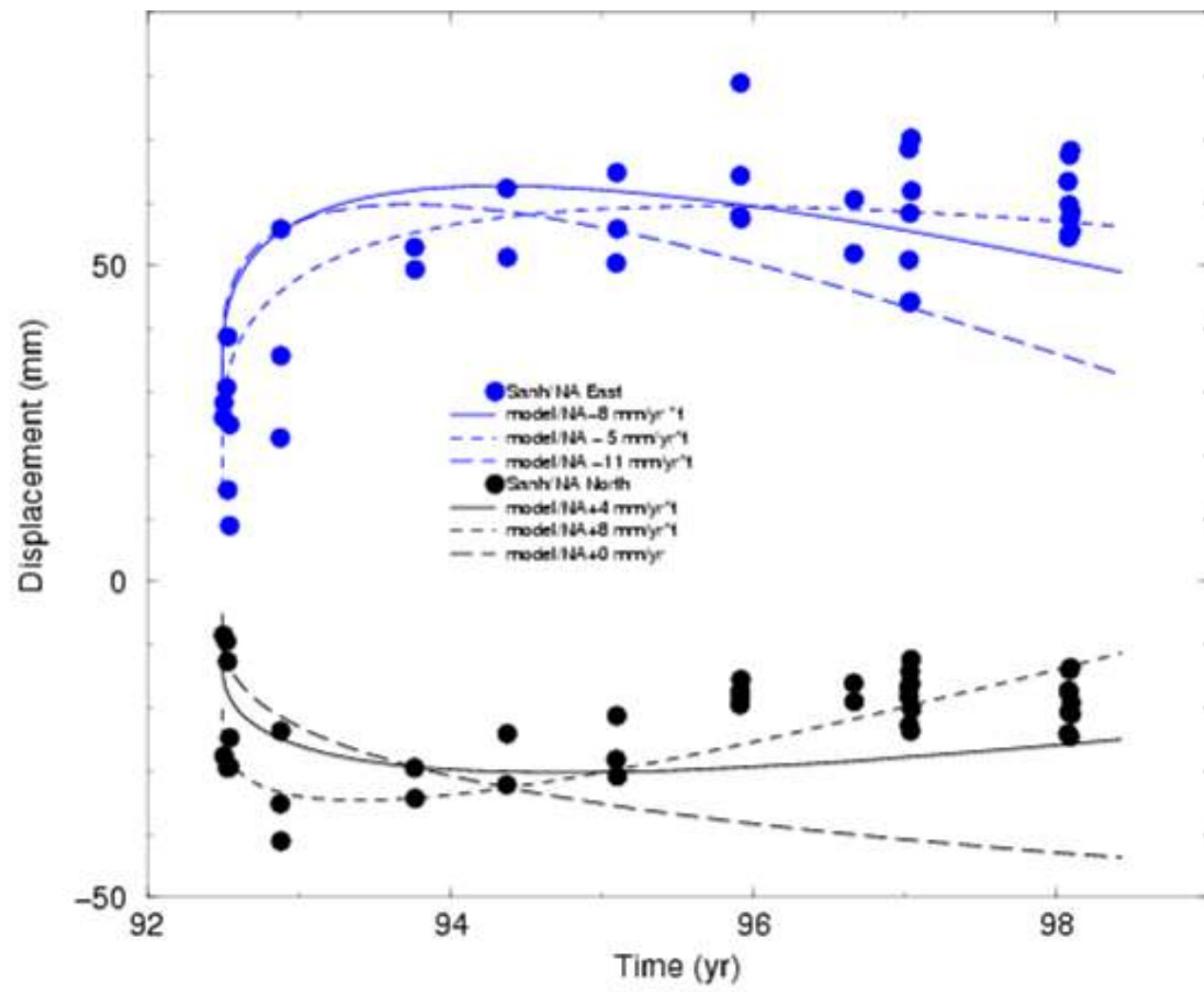
contribution postsismique



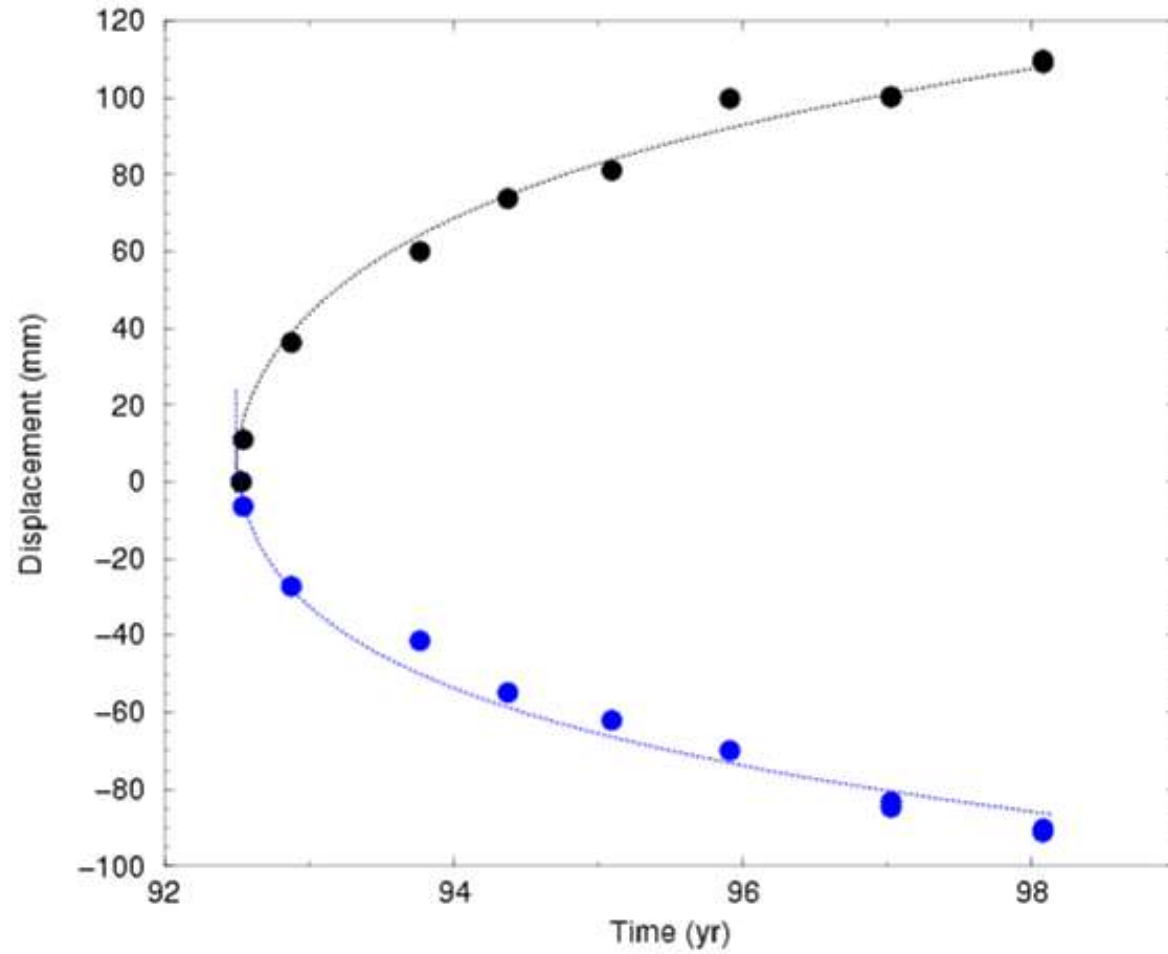
La distribution de glissement observée semble mieux corrélée avec le chargement postsismique...

Conclusions

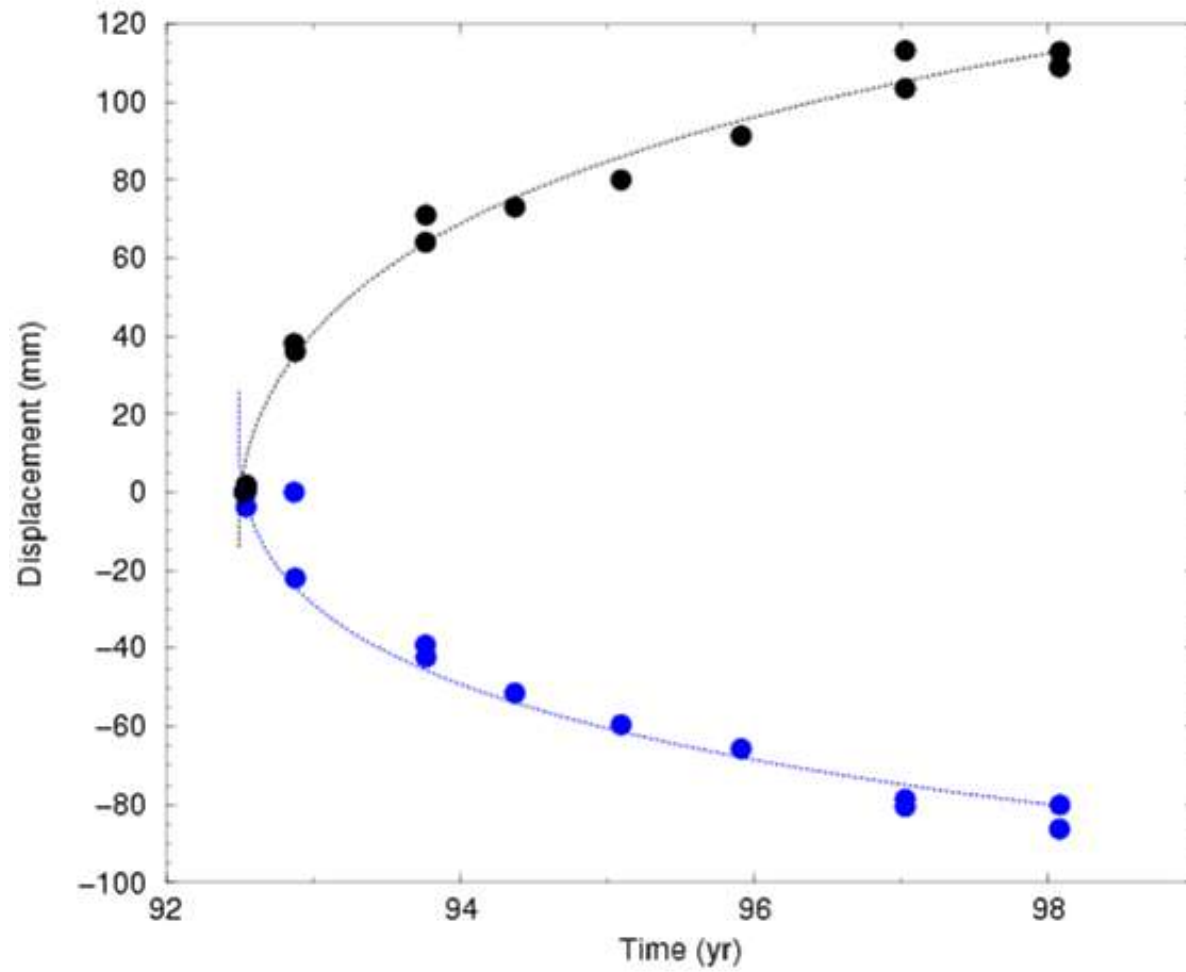
- Un modèle 3D basé sur la relaxation de la zone de transition fragile-ductile permet de modéliser simultanément l'évolution spatio-temporelle de la déformation et de la sismicité.
- La rhéologie à utiliser est de type durcissement avec la vitesse: $d\varepsilon/dt \sim \exp(\tau^* \text{cste})$ (propre aux processus activés thermiquement)
- Le séisme d'Hector Mine semble avoir été influencé par le séisme de Landers: épicentre chargé, glissement cosismique corrélé avec le chargement postsismique.



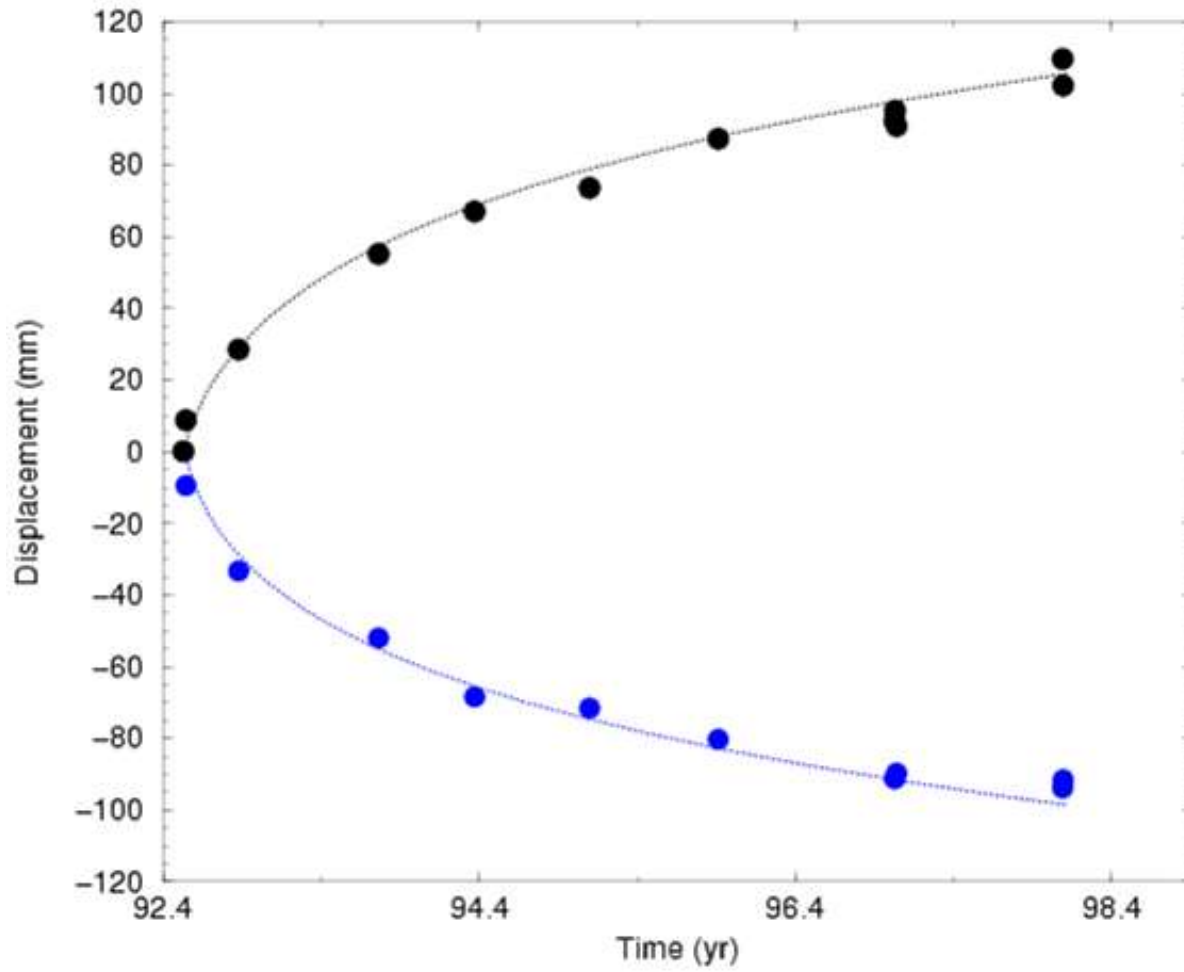
Oldw/Sanh



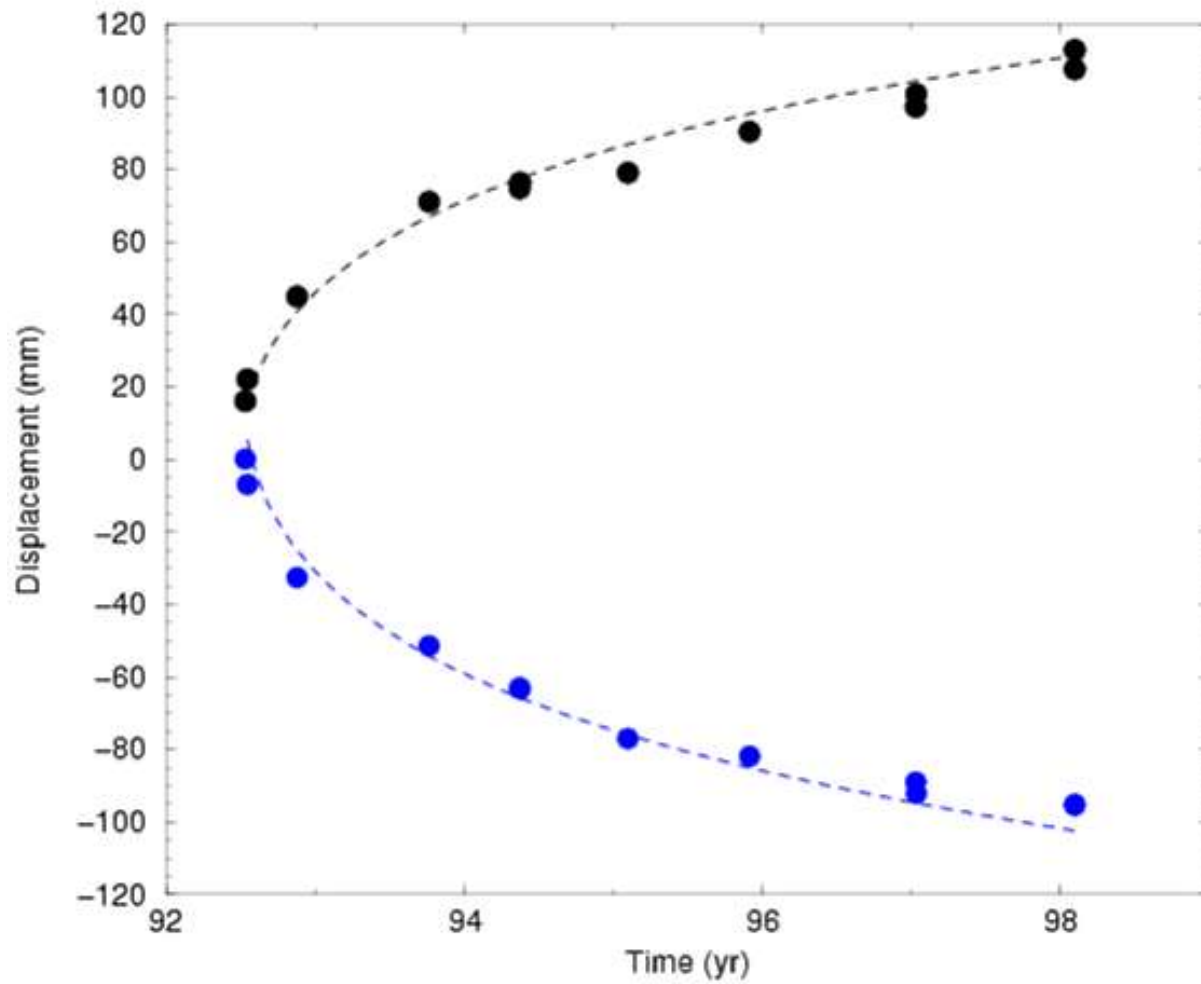
Oldd/Sanh



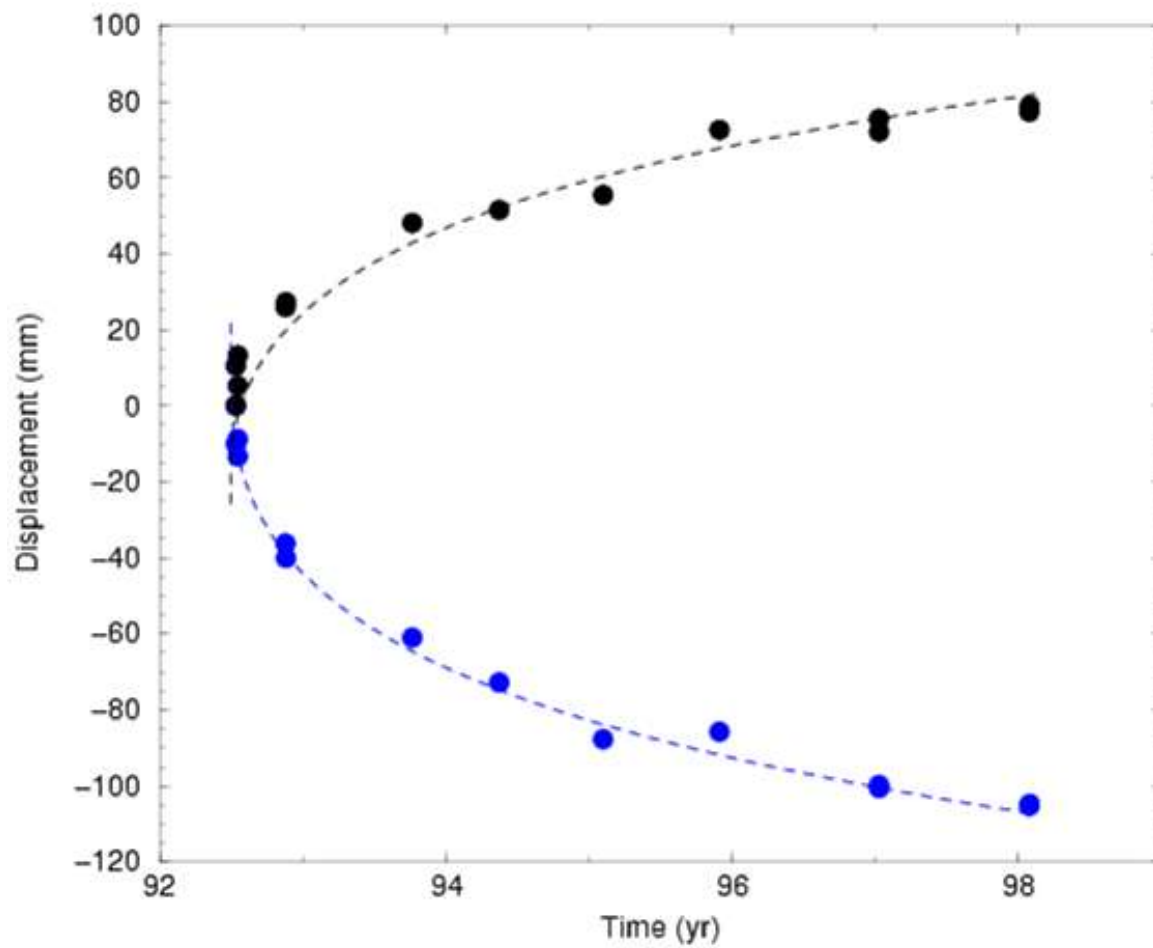
Law4/Sanh



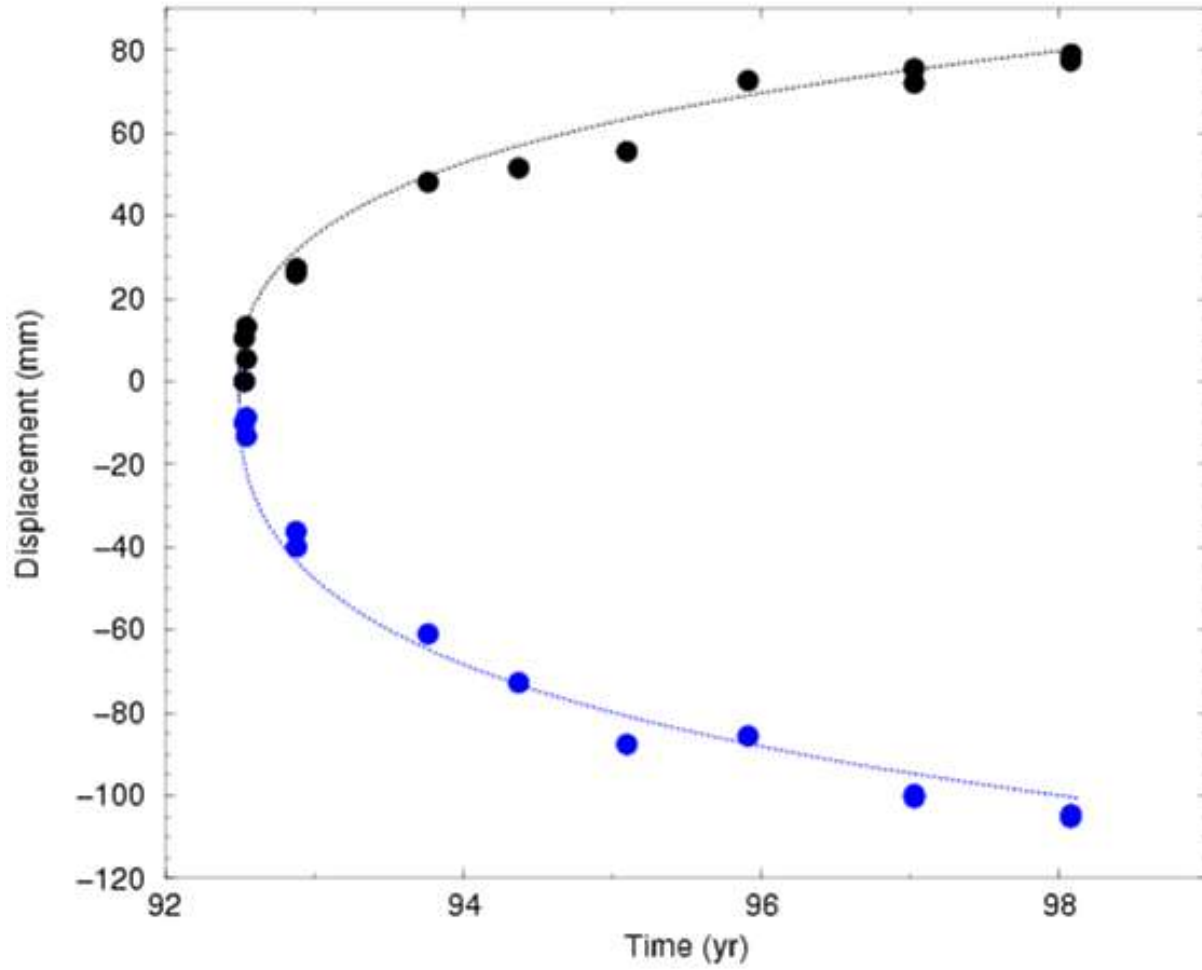
Law3/Sanh



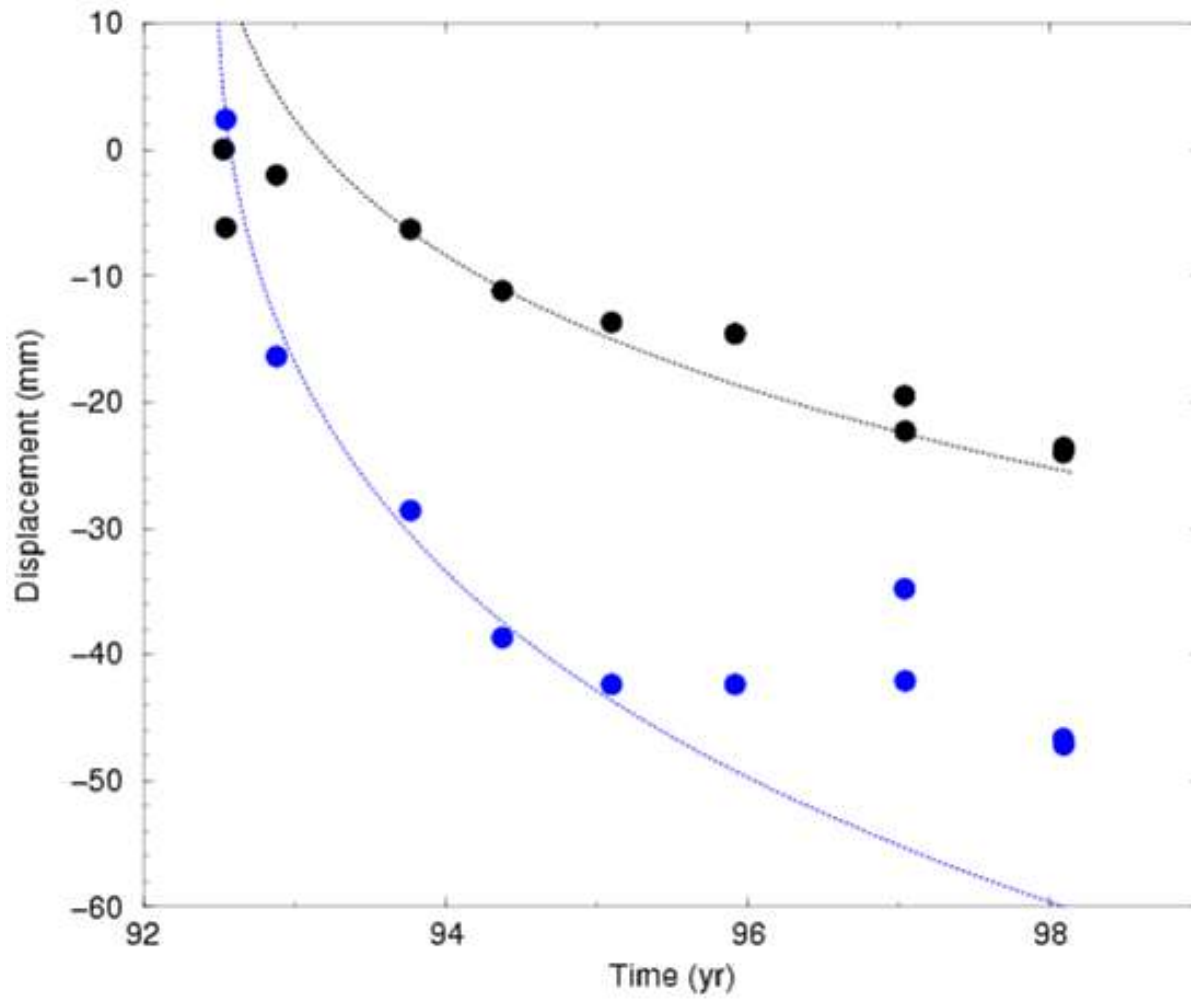
Law2/Sanh



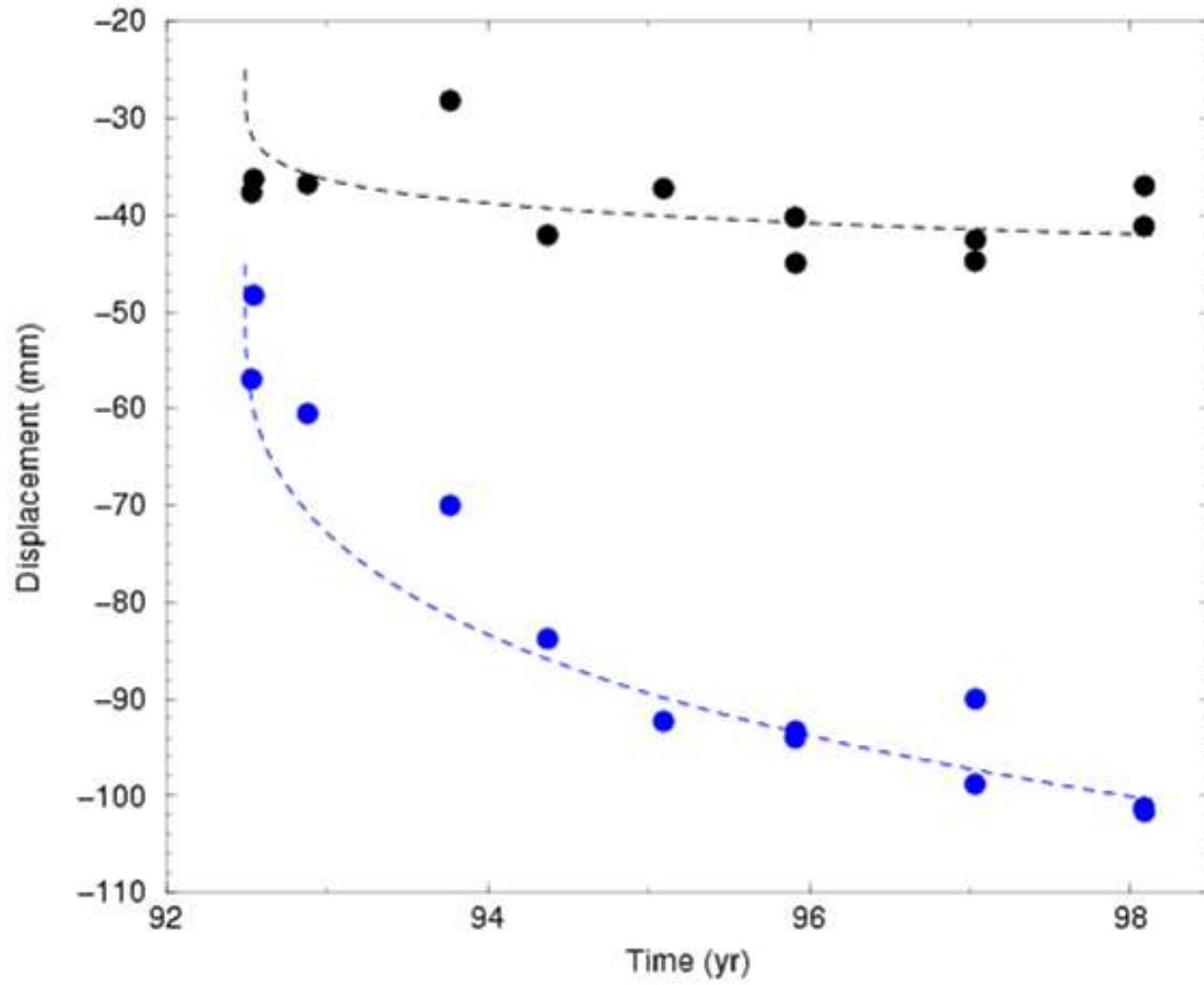
Law1/Sanh



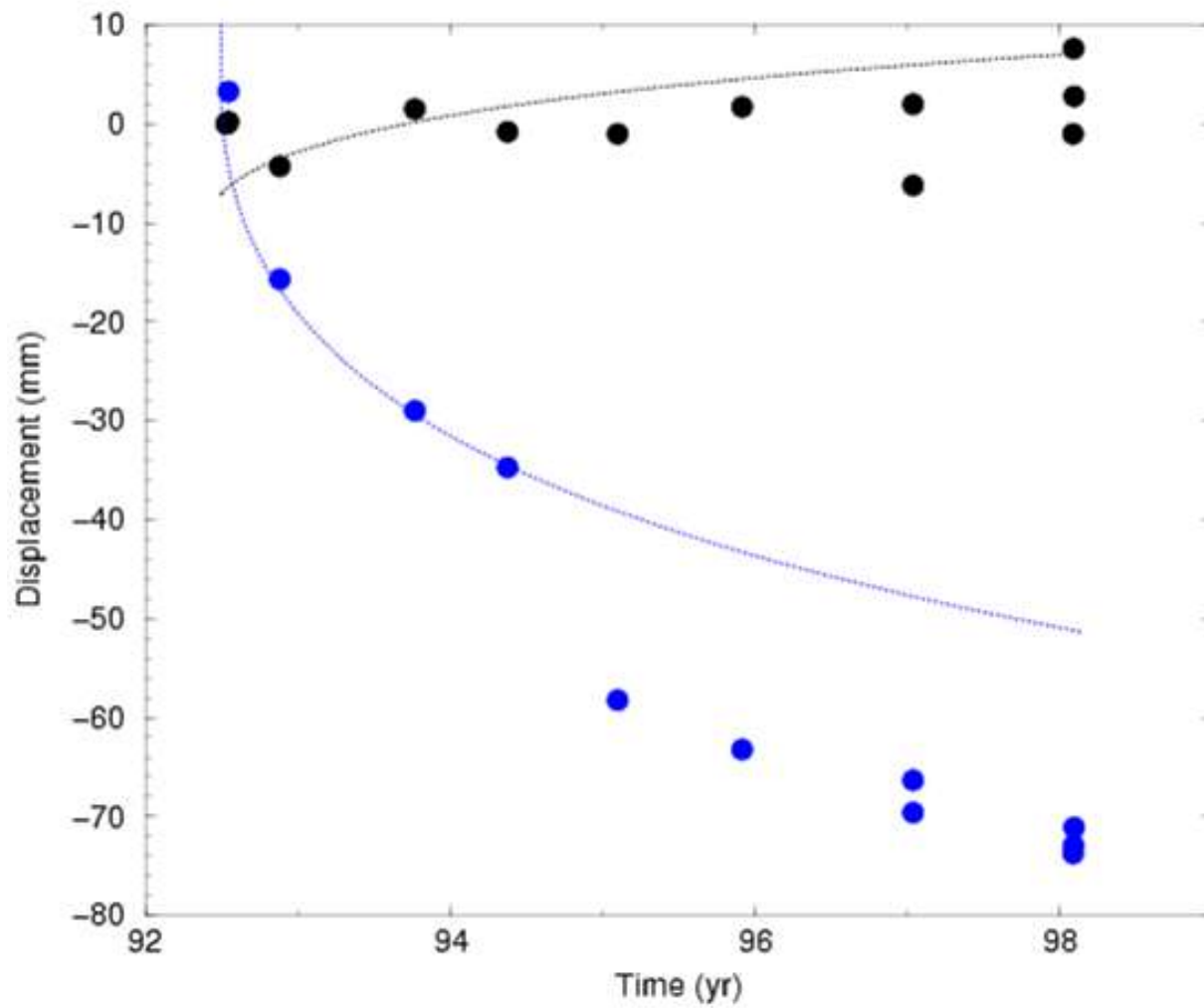
Lae4/Sanh



Lae3/Sanh



Lae2/Sanh



Lae1/Sanh

