

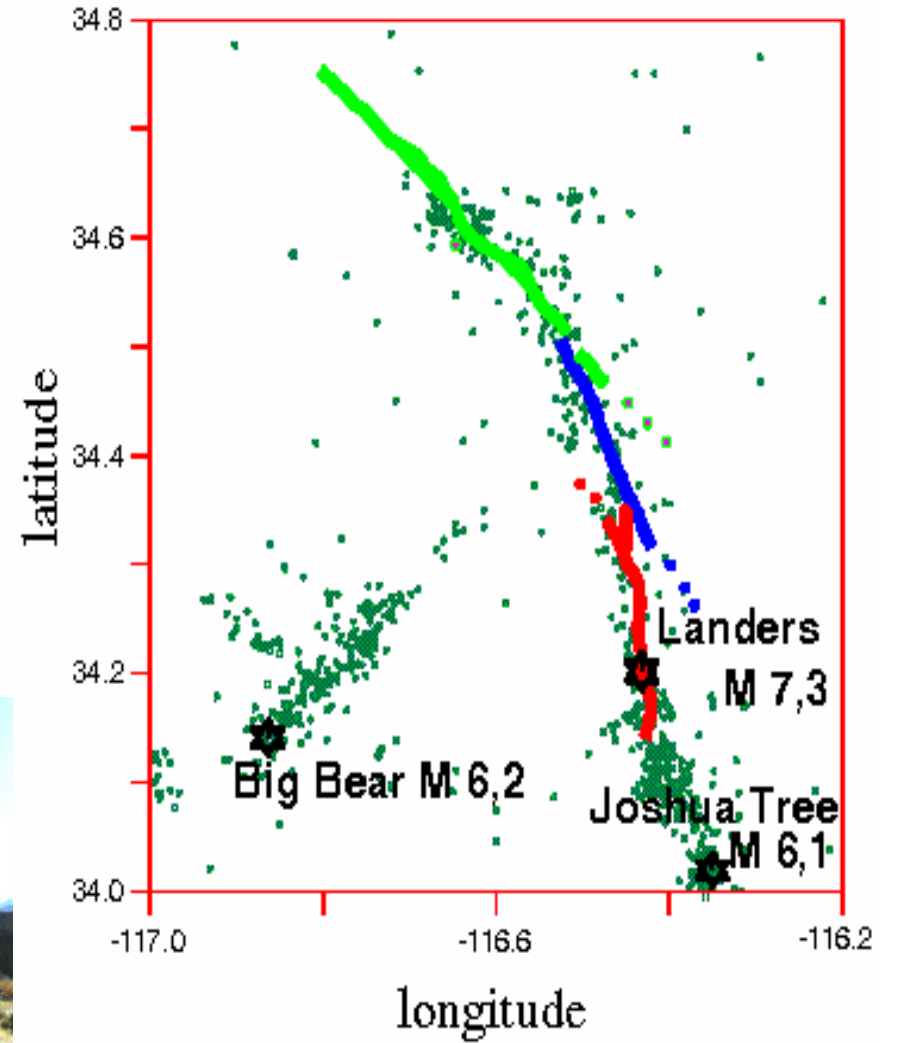
V Source étendue

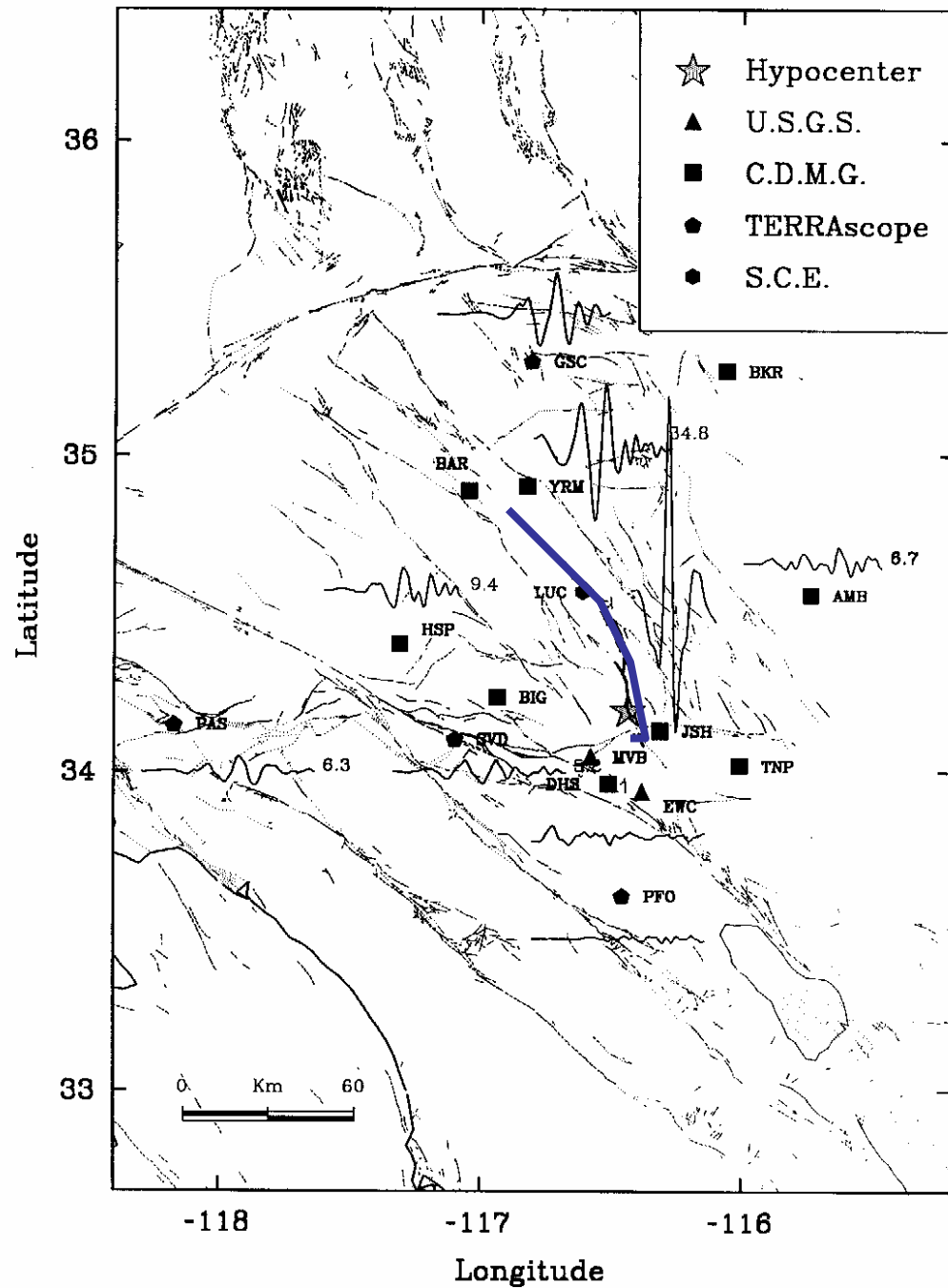
Les observables...

-trace de surface (parfois..)

-géodésie-déformation..

-sismogrammes, accélérogrammes...



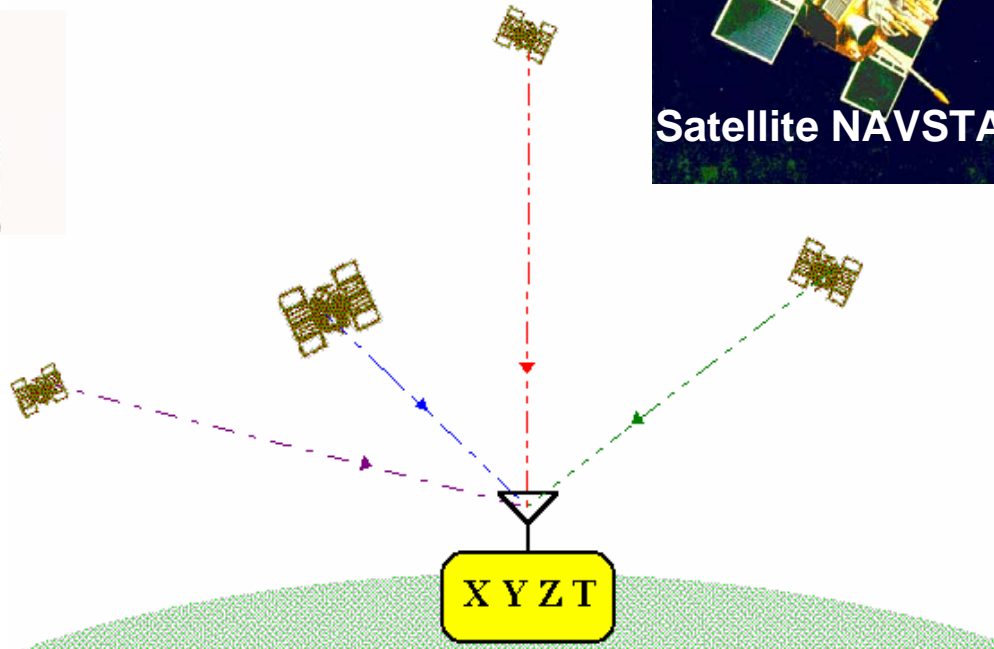
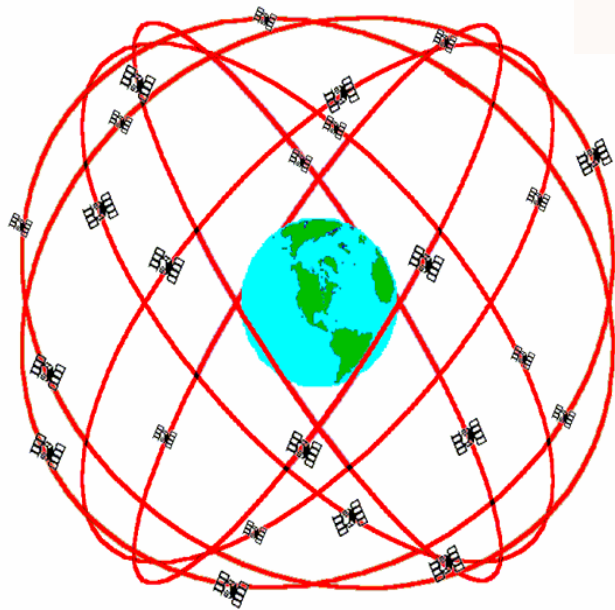
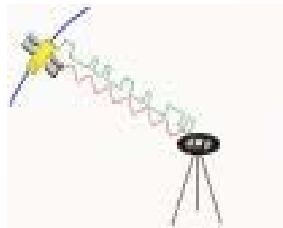


Grande variabilité du mouvement du sol

GPS



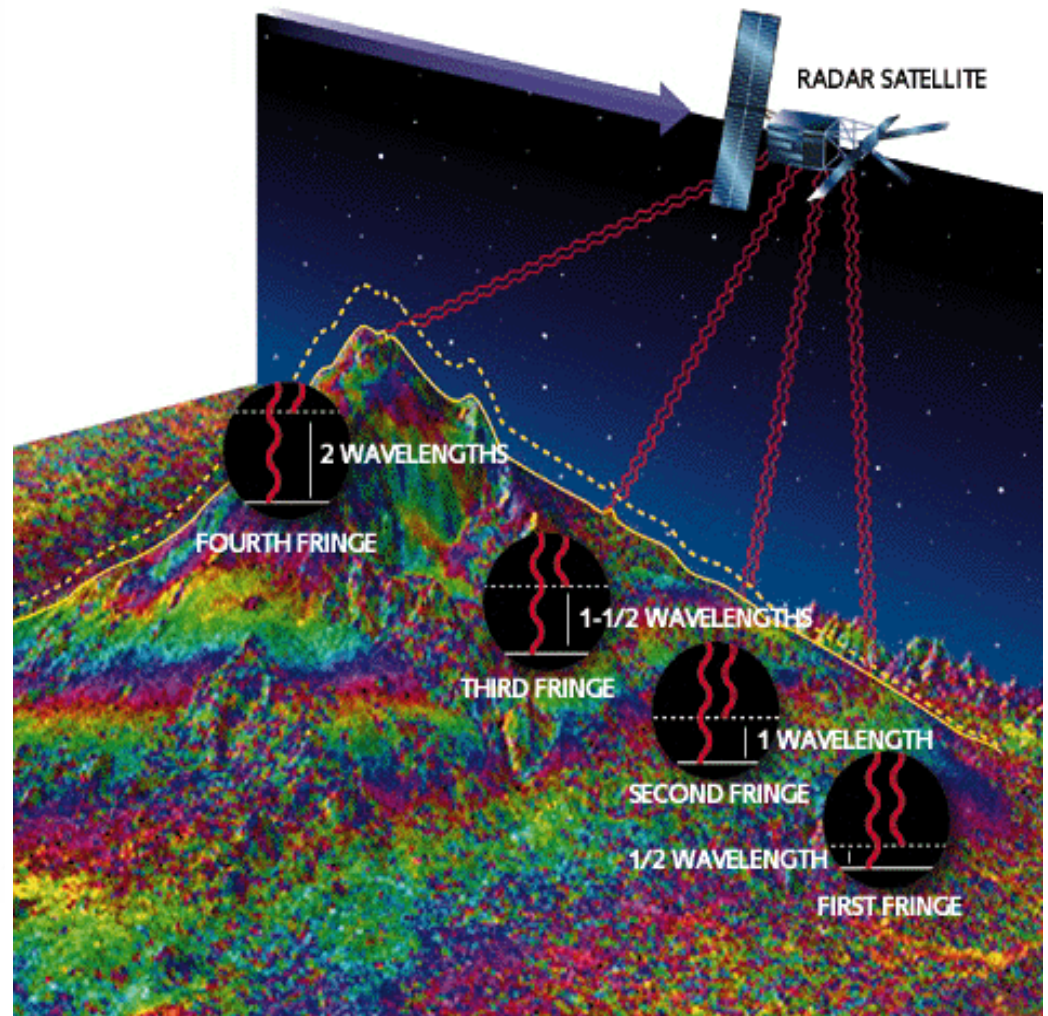
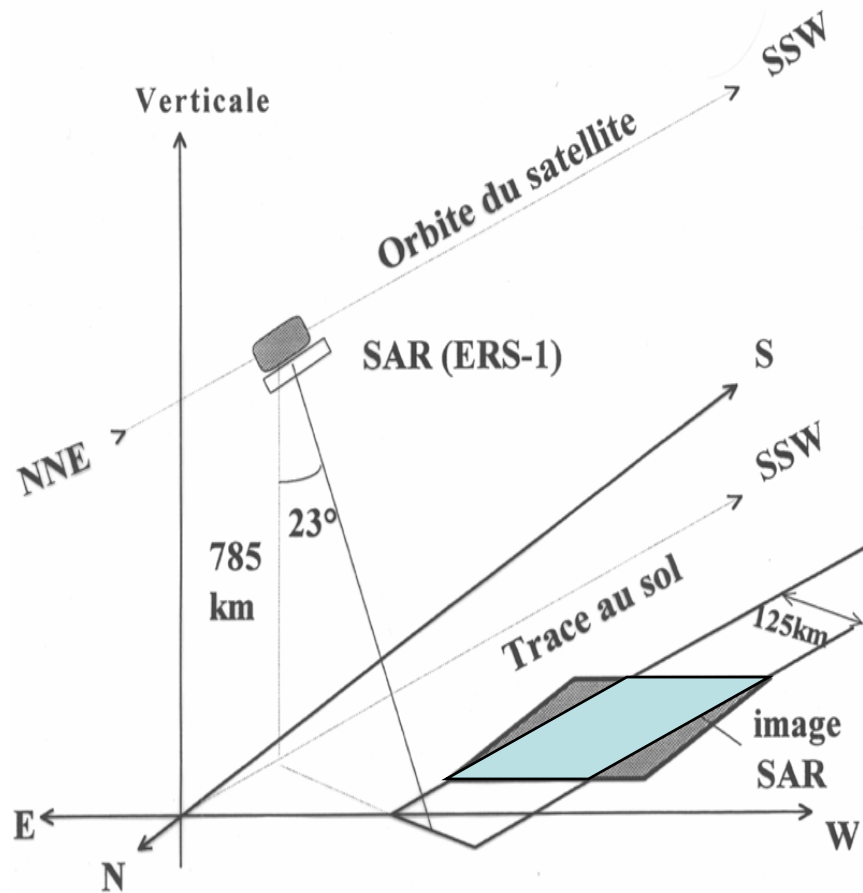
Constellation de satellites
altitude : 20200 km

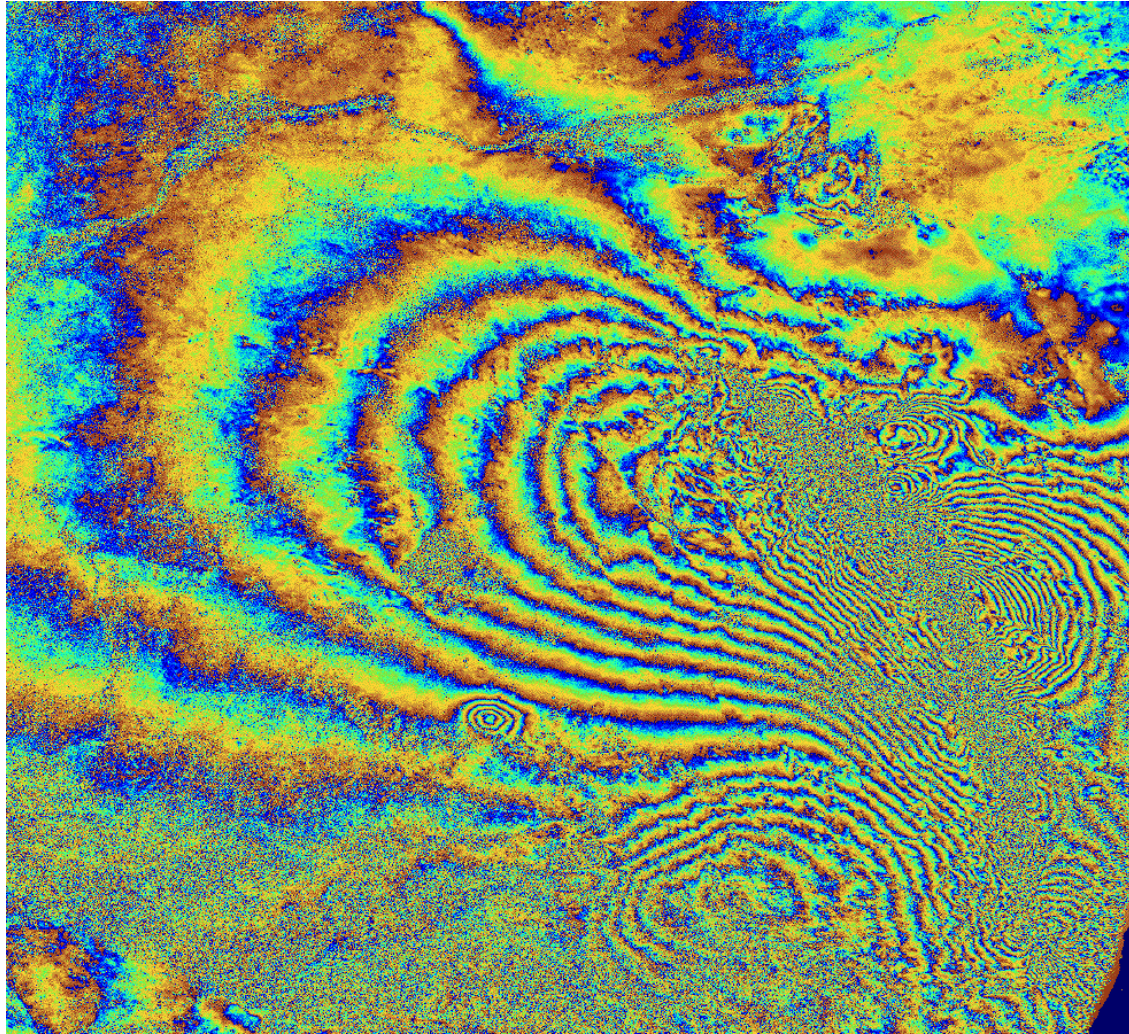


Antennes :
Précision < 1 cm

Interférométrie RADAR

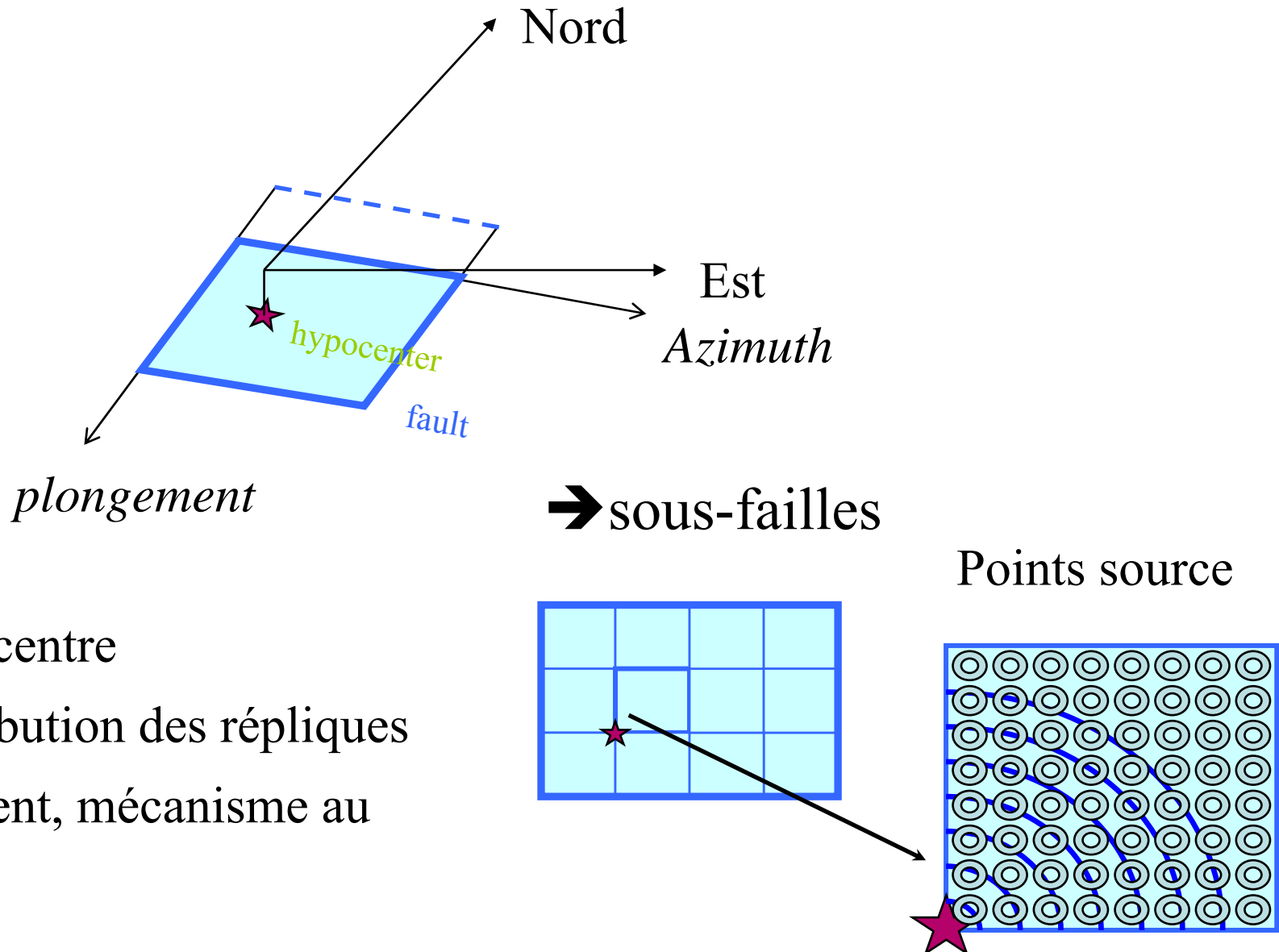
$$\Delta\phi = \frac{4\pi\Delta d}{\lambda} [2\pi]$$





120km x 120 km

Discrétisation de la faille

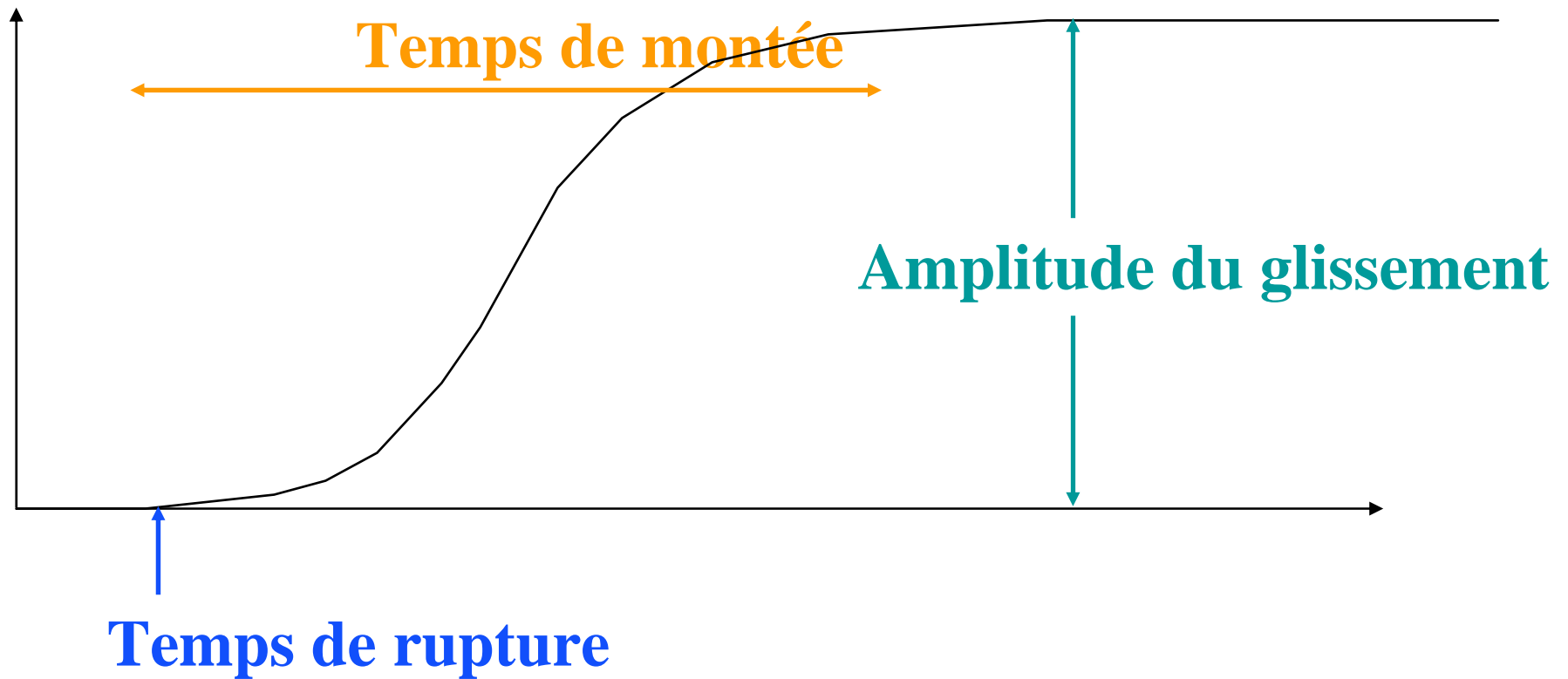


Hypocentre

Distribution des répliques

Moment, mécanisme au
foyer

Description du glissement sur chaque point de la faille



Formulation directe

À la station i pour la fréquence ω

$$u_i(\omega) = \sum_{k=1}^N (A_k) S(\tau_k, \omega) \exp(-i\omega t_k) G_{k,i}(\omega)$$

Somme sur
les sous-
failles k

amplitude

Temps de
montée

Temps de
rupture

Déplacement
à la station i
du à la sous-
faille k

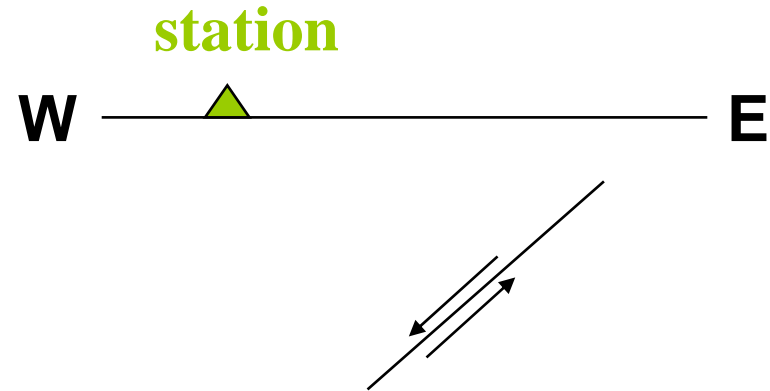
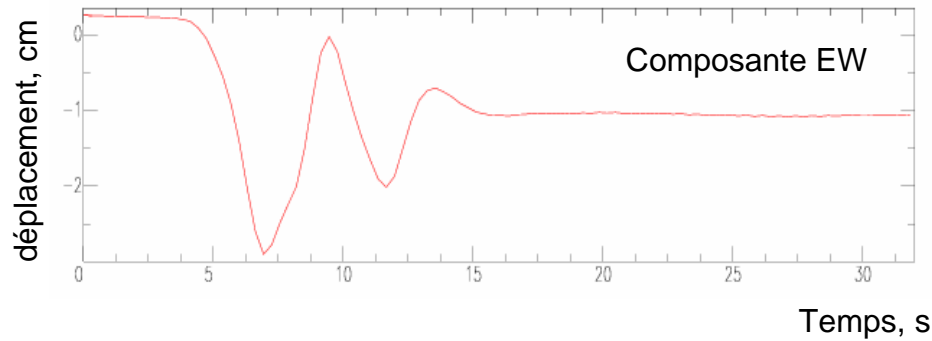
Modèle de Terre

Calcul de la
réponse élastique
à une dislocation

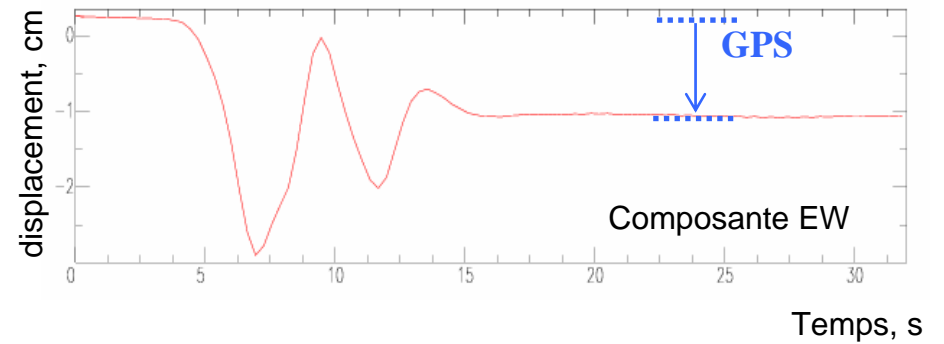
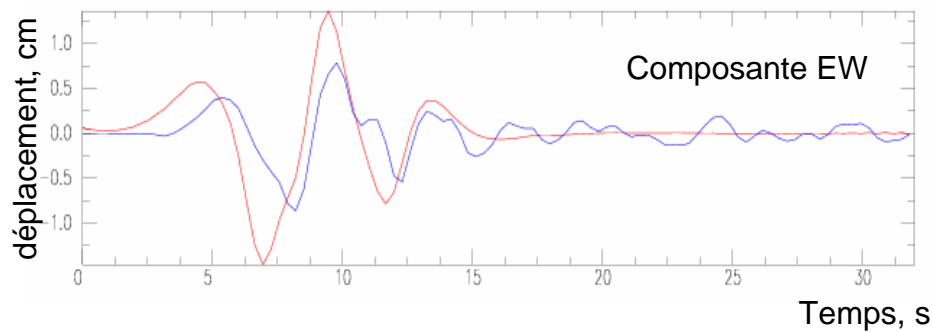
	Vp km s ⁻¹	Vs km s ⁻¹	Density kg cm ⁻³	Qp	Qs
0	4,1	2,3	2,5	300	300
2	5,5	3,2	2,8	500	500
4					
26					
	6,8	3,9	3,1	500	500
32					
	8,2	4,7	3,2	500	500

Simulation directe

synthétiques [0 ; 1,5] Hz



Données sismiques ([0,1 ; 1,5] Hz) et géodésiques (f # 0 Hz)



Inversion linéaire : divers problèmes d'imagerie

Problème direct (simulation)

$$s = G.m$$

m: modèle de départ dont on déduit

s: observables

Problème inverse:

s est donné
trouver m

Exemple de solutions: moindres carrés pondérés

$$m' = m_0 + (G^t C_d^{-1} G + C_{m_0}^{-1})^{-1} G^t C_d^{-1} (d - G m_0)$$

Lissage a priori de la solution

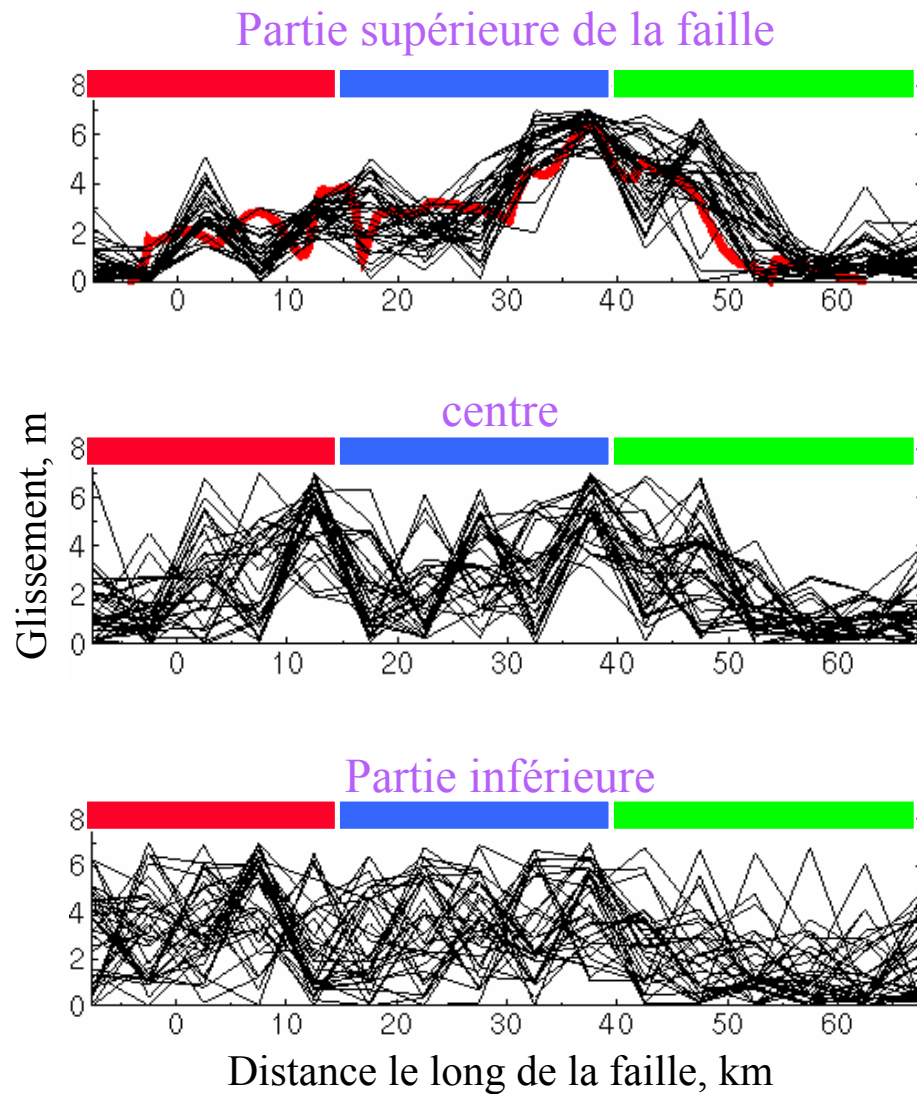
$$C_{m_0}(i, j) = \sigma_i \sigma_j e^{-\left(\frac{d^2(i, j)}{2l^2}\right)}$$

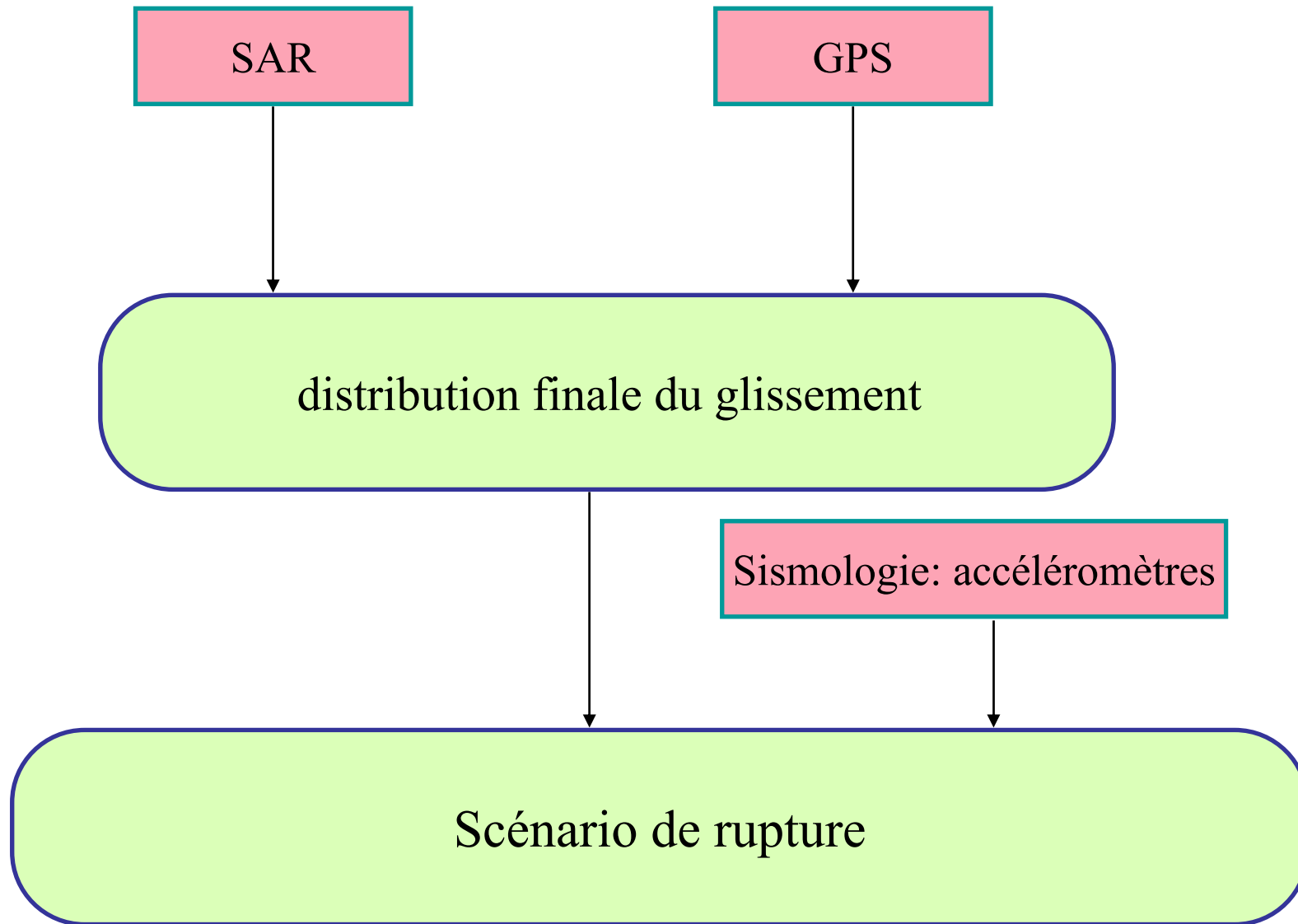
Résolution: mesure la qualité

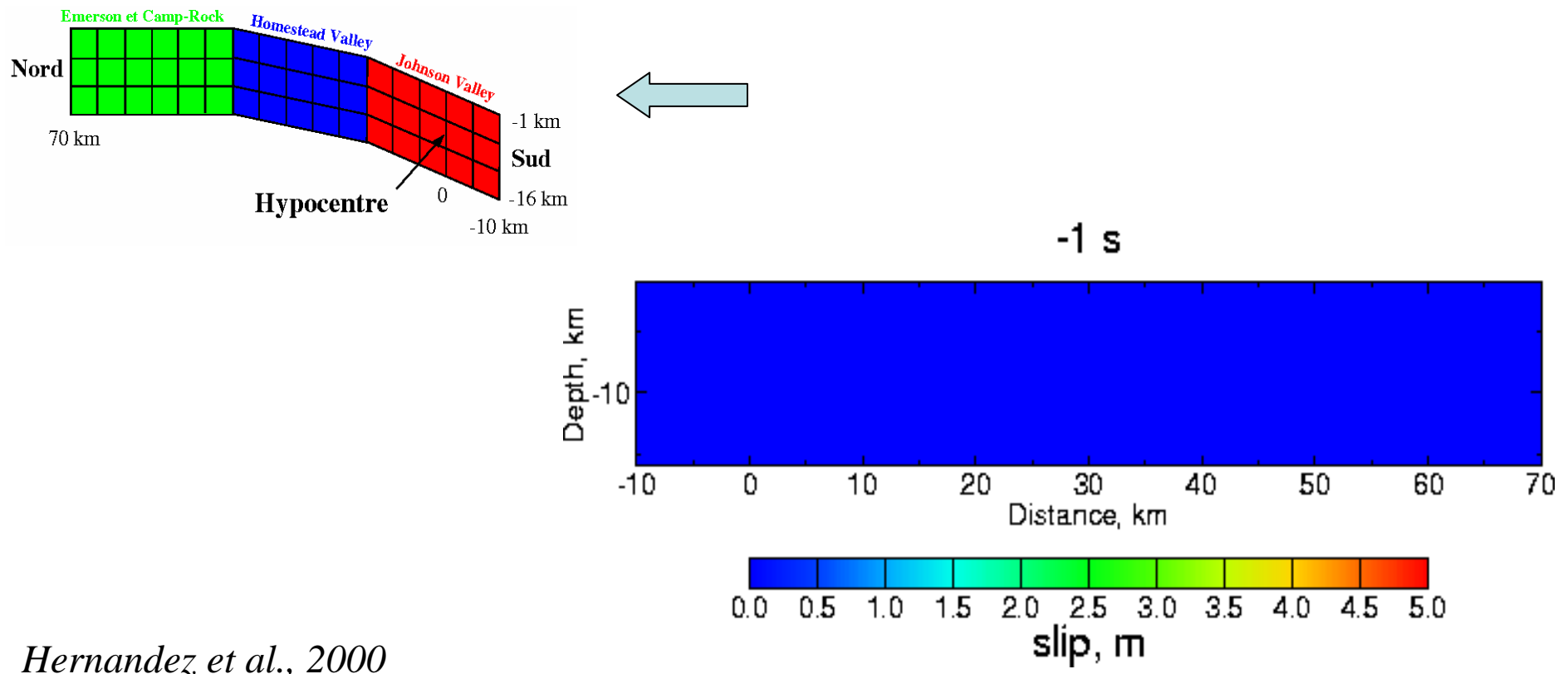
$$R = (G^t C_d^{-1} G + C_{m_0}^{-1})^{-1} G^t C_d^{-1} G$$

+ algorithme génétique, Monte-Carlo,.....

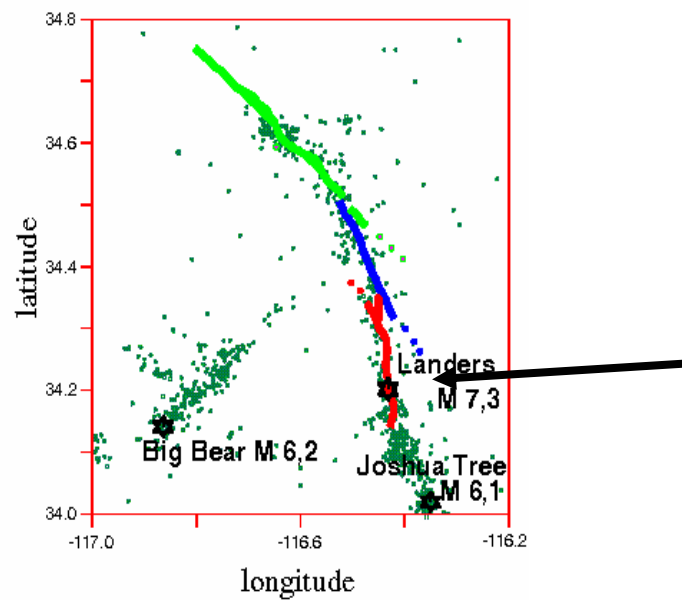
Algorithme génétique:



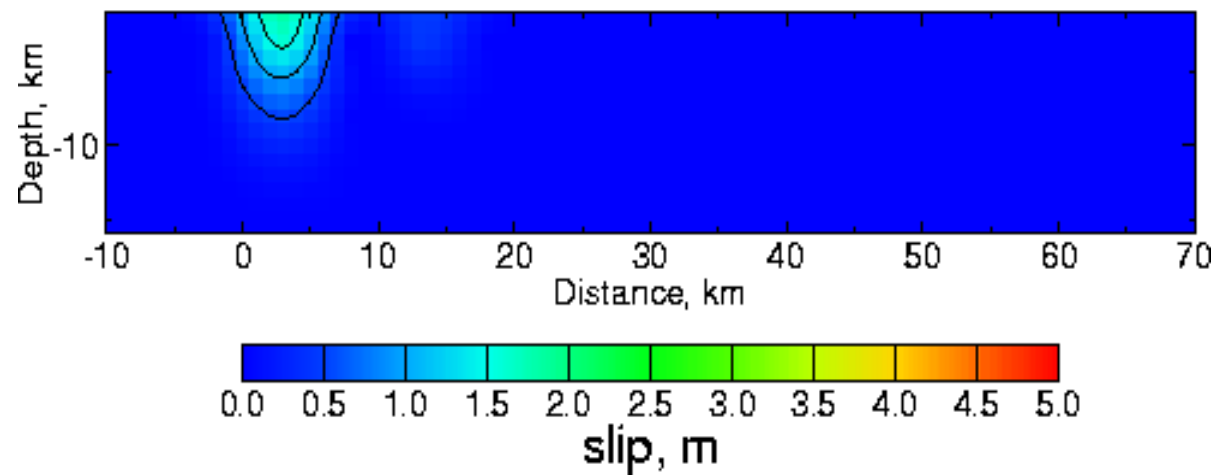


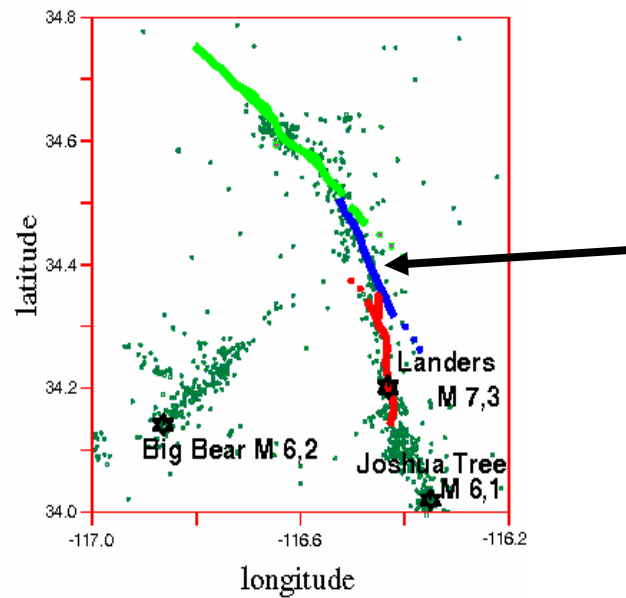


Hernandez et al., 2000

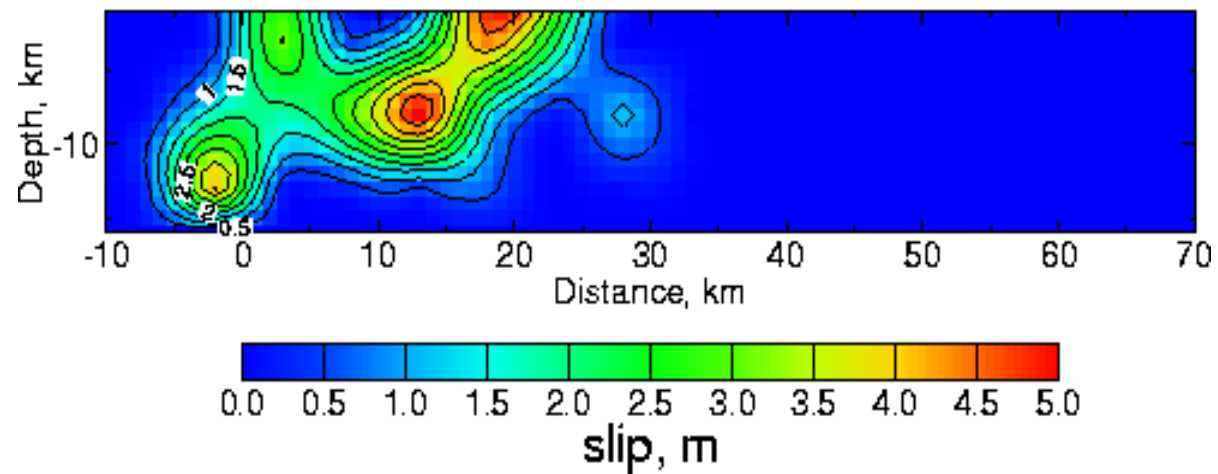


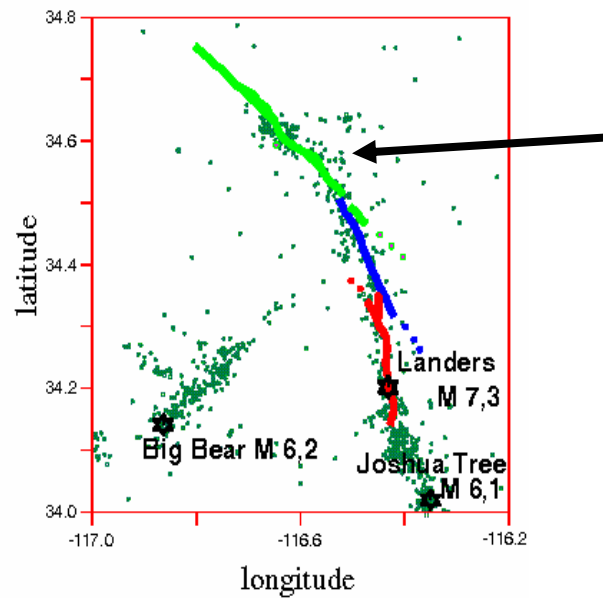
1 s



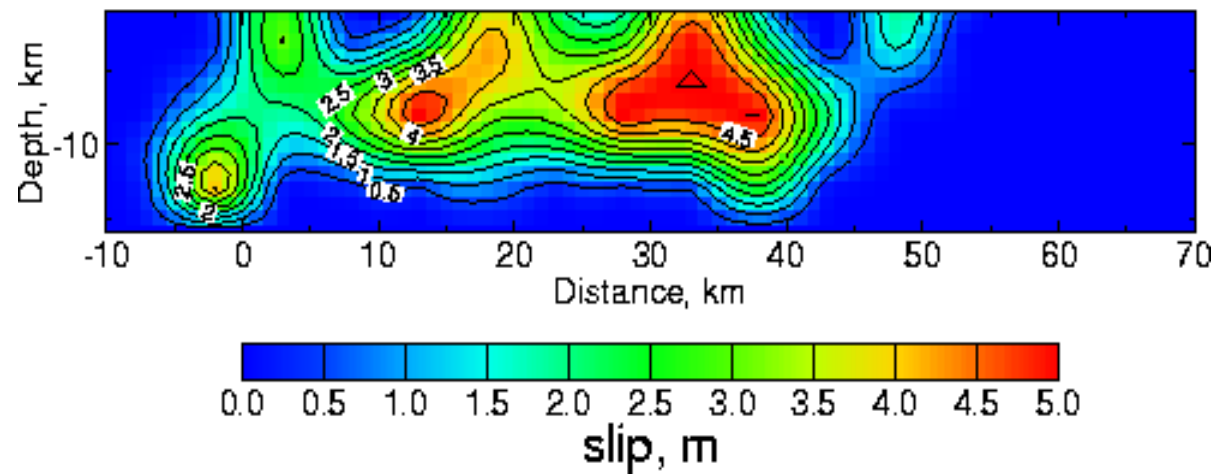


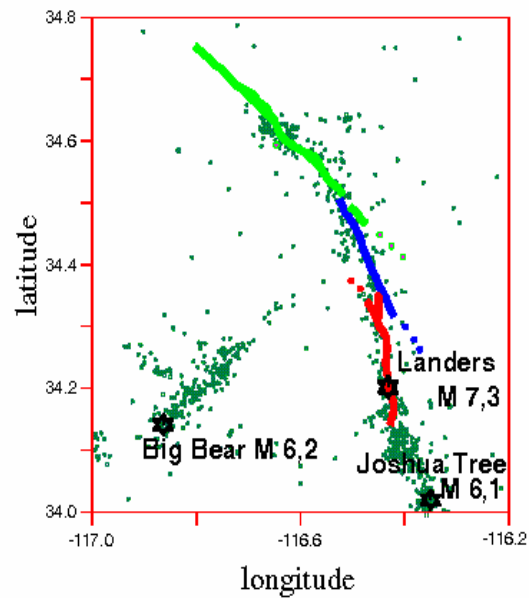
9 s



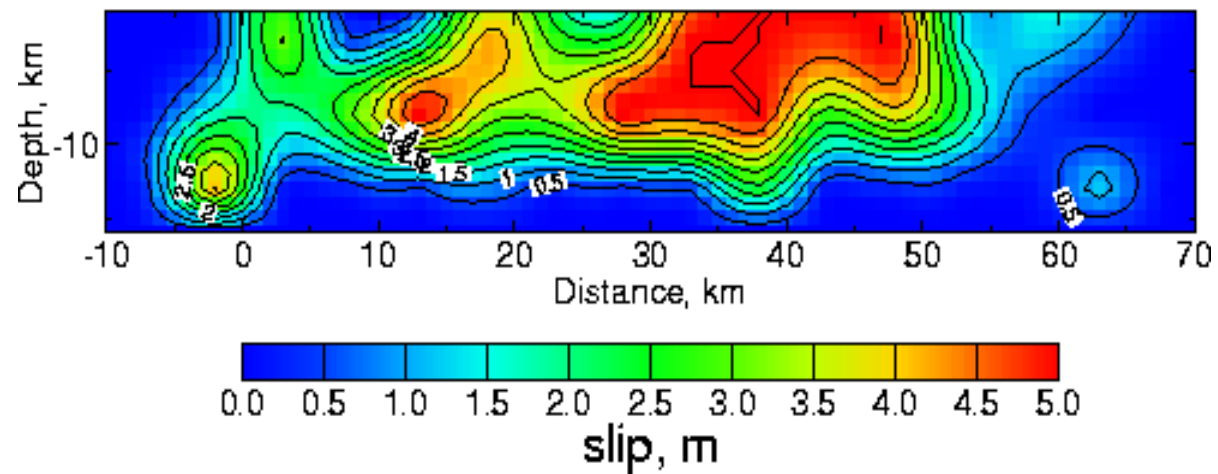


15 s

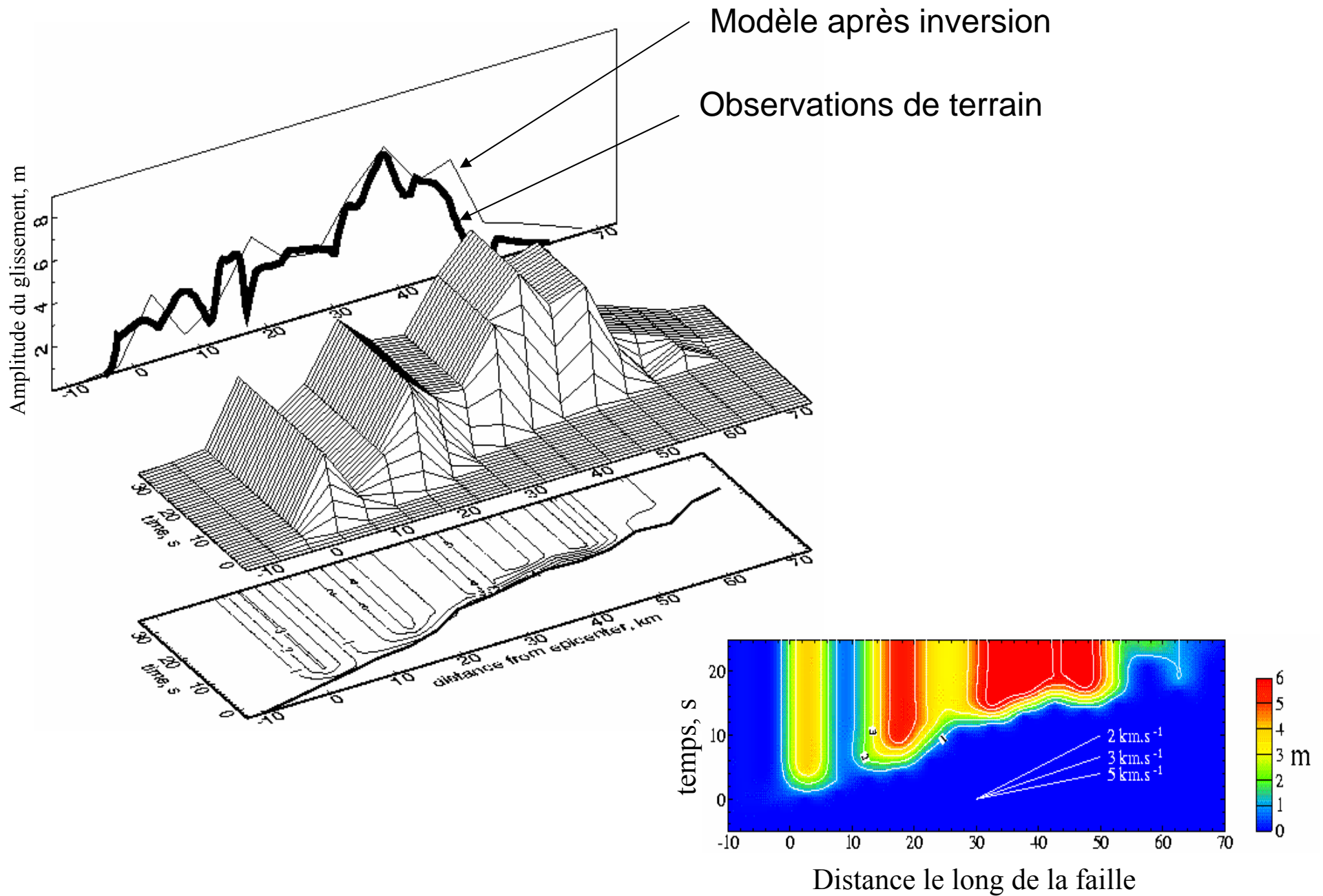




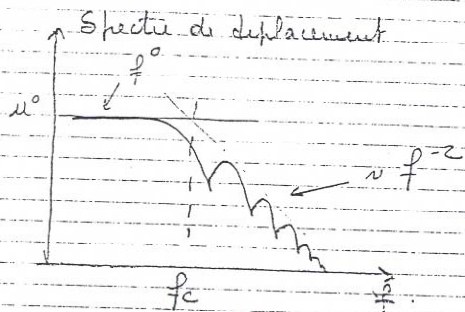
23 s



Vitesse de rupture à la surface



Comprendre les caractéristiques des signaux
observés : modèle cinématiques



- f_c varie inversement avec la magnitude
- signaux digitaux → u°, f_c
- f_c varie avec l'azimut / faille.
+ P et S
- ⇒ modèle simple faille étendue

modèle cinématique = déplacement imposé

Etude rayonnement champ lointain

Effet de directivité

Les effets de directivité sont provoqués par un effet Doppler des ondes qui se propagent

L'effet de directivité conduit à une augmentation de l'amplitude et de la fréquence du mouvement du sol dans la direction de la rupture sismique

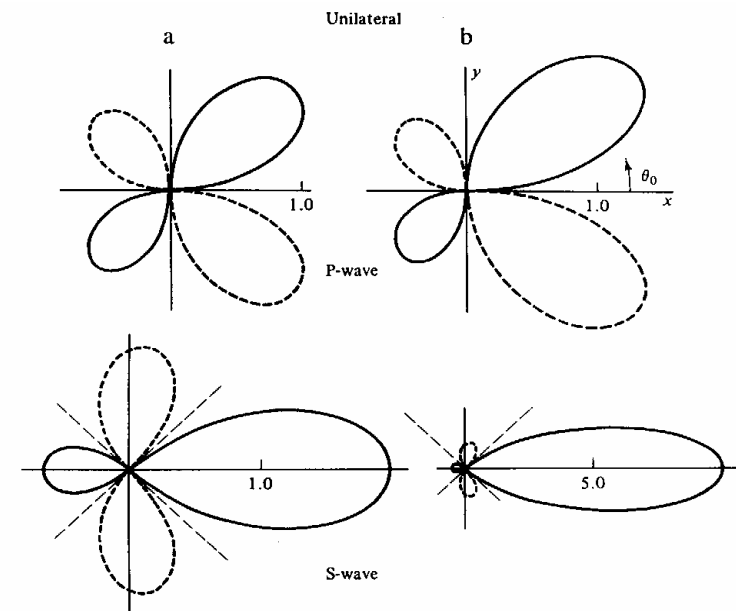
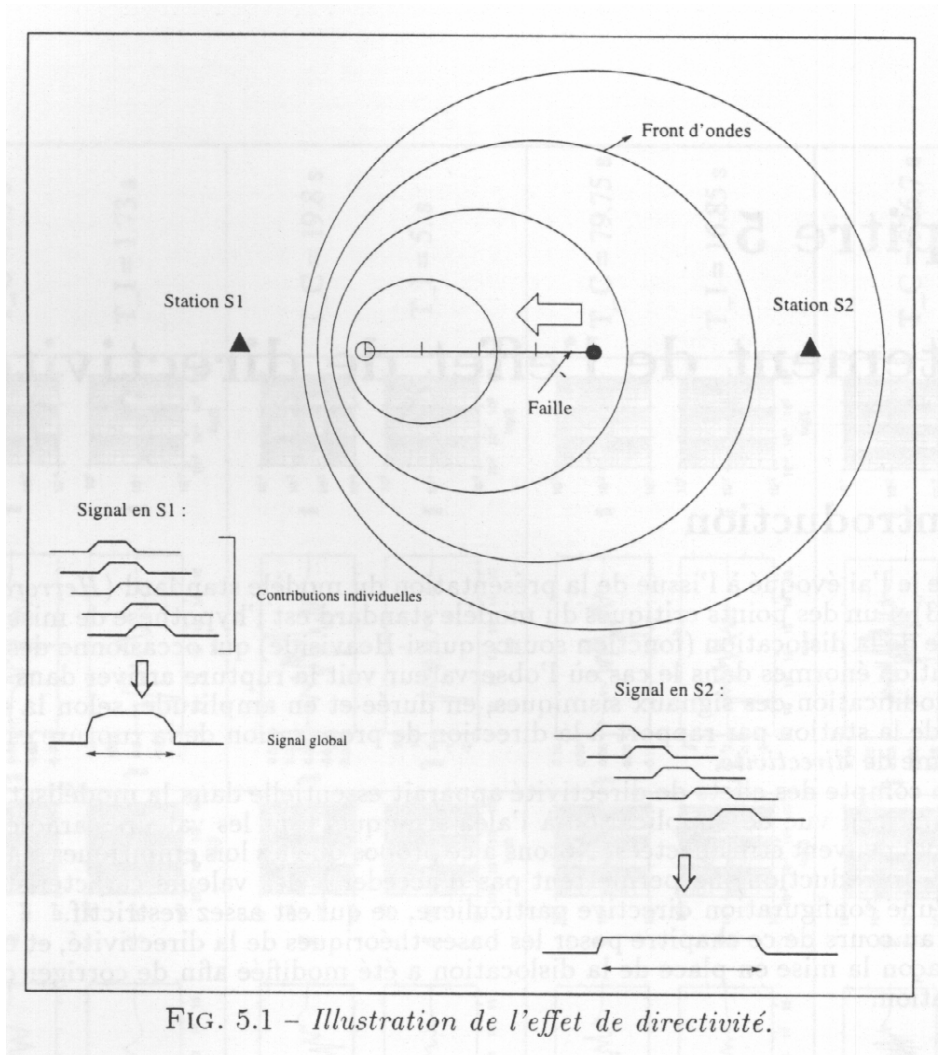
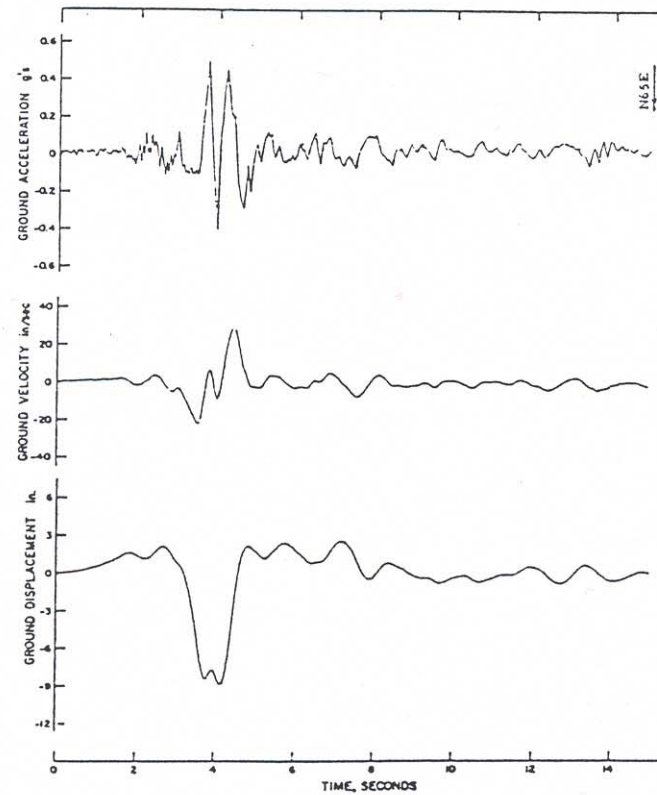
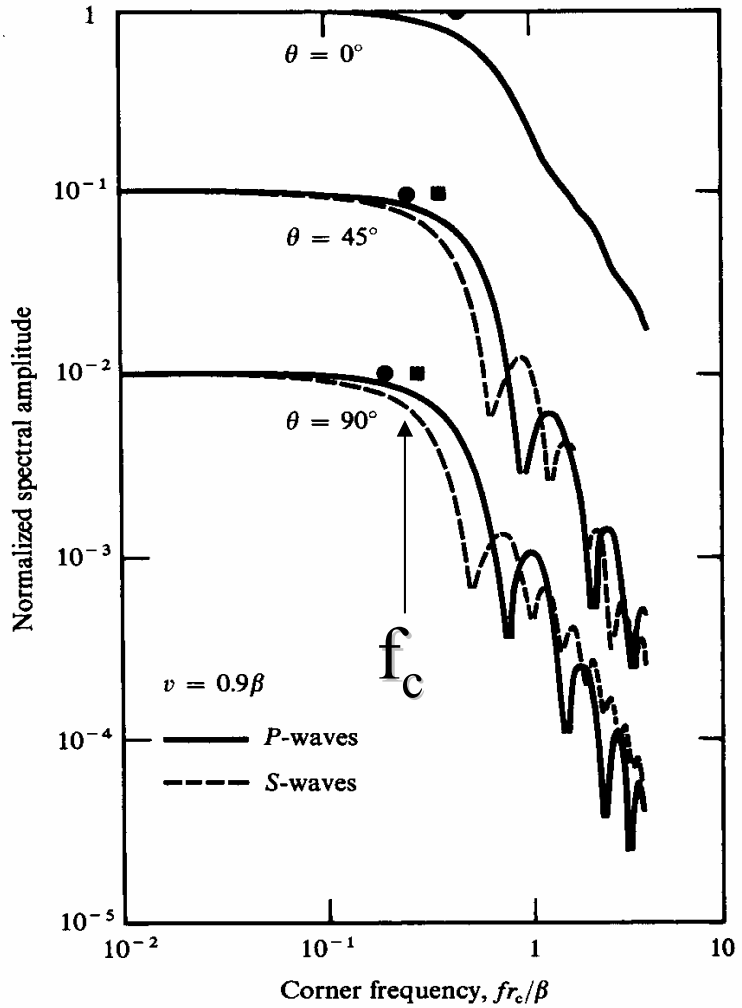


FIGURE 9.10 The variability of *P*- and *SH*-wave amplitude for a propagating fault (from left to right). For the column on the left $v_r/v_s = 0.5$, while for the column on the right $v_r/v_s = 0.9$. Note that the effects are amplified as rupture velocity approaches the propagation velocity. (From Kasahara, 1981.)

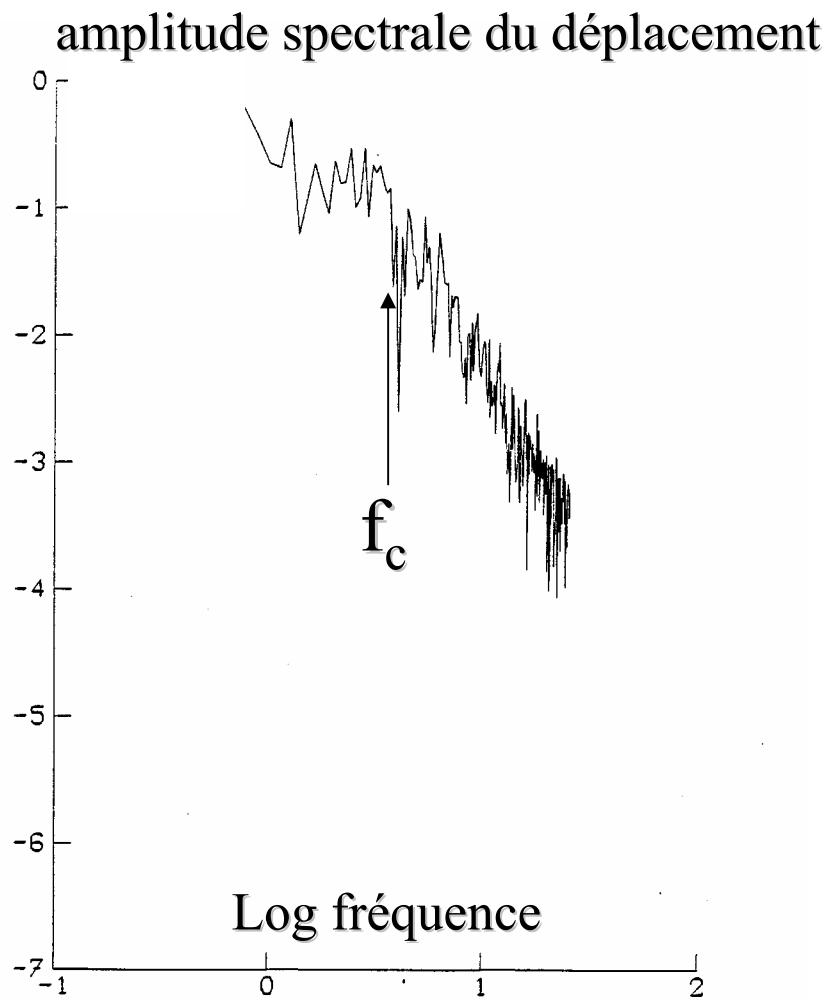
Transverse motion on the fault trace
during the 1966 Parkfield earthquake.



« ω^{-2} » décroissance haute fréquence au-delà de la fréquence de coin f_c

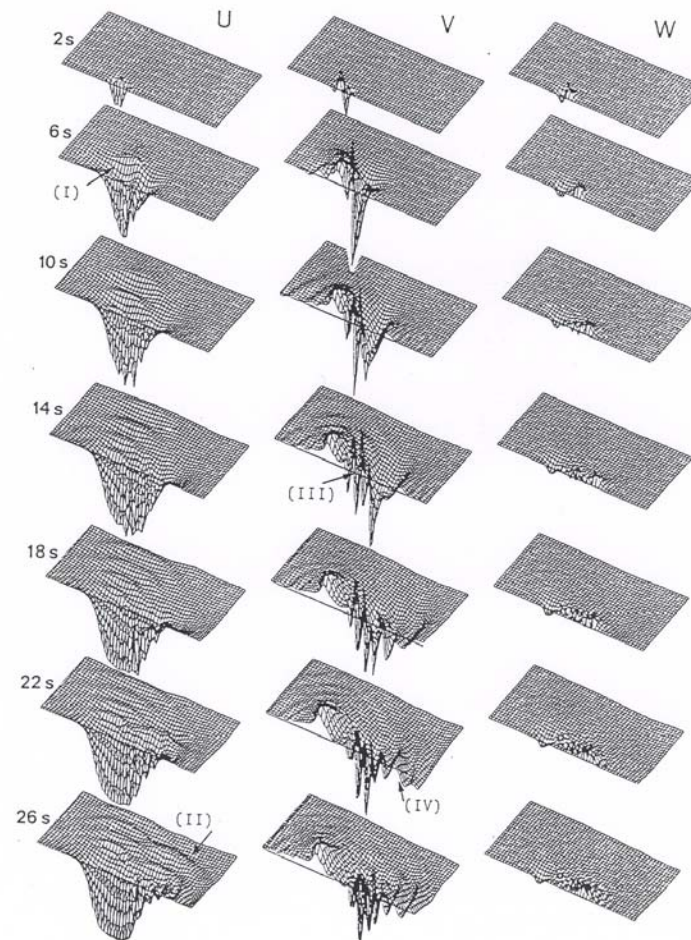
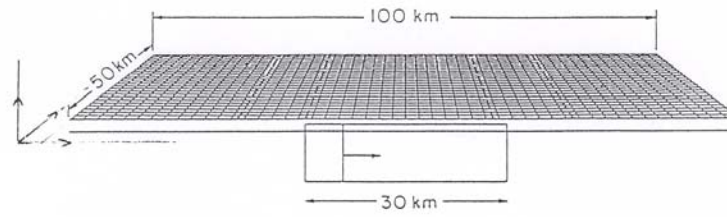


Théorie



Données brutes d'un séisme local

$f_c \sim \beta/a \rightarrow$ longueur caractéristique



Effet de directivité : exemple du séisme de Landers

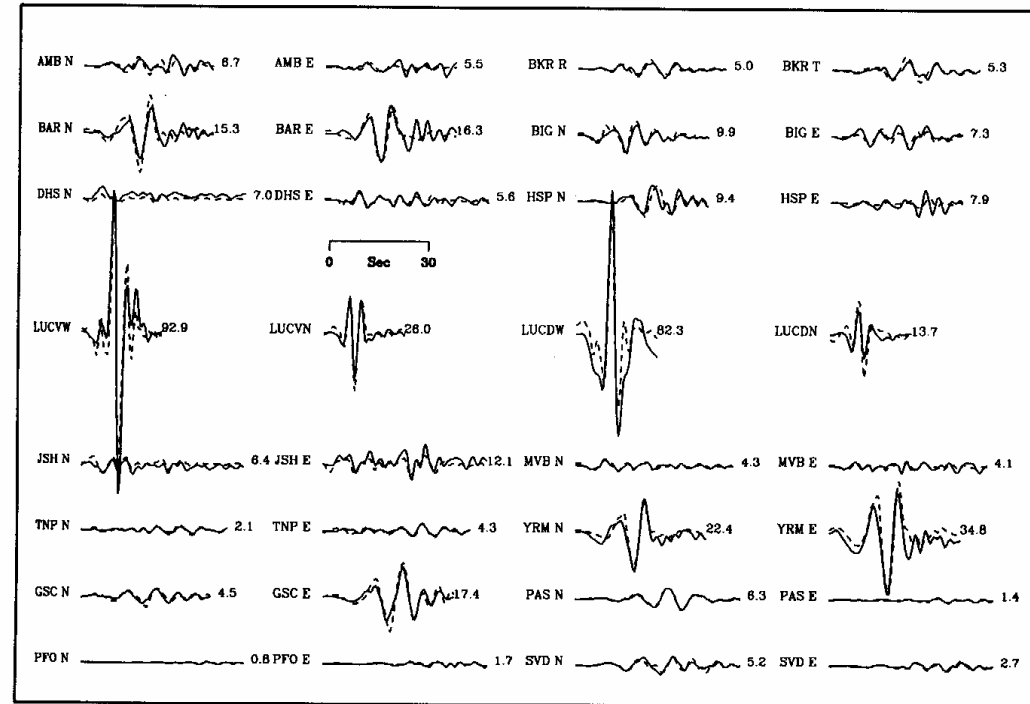
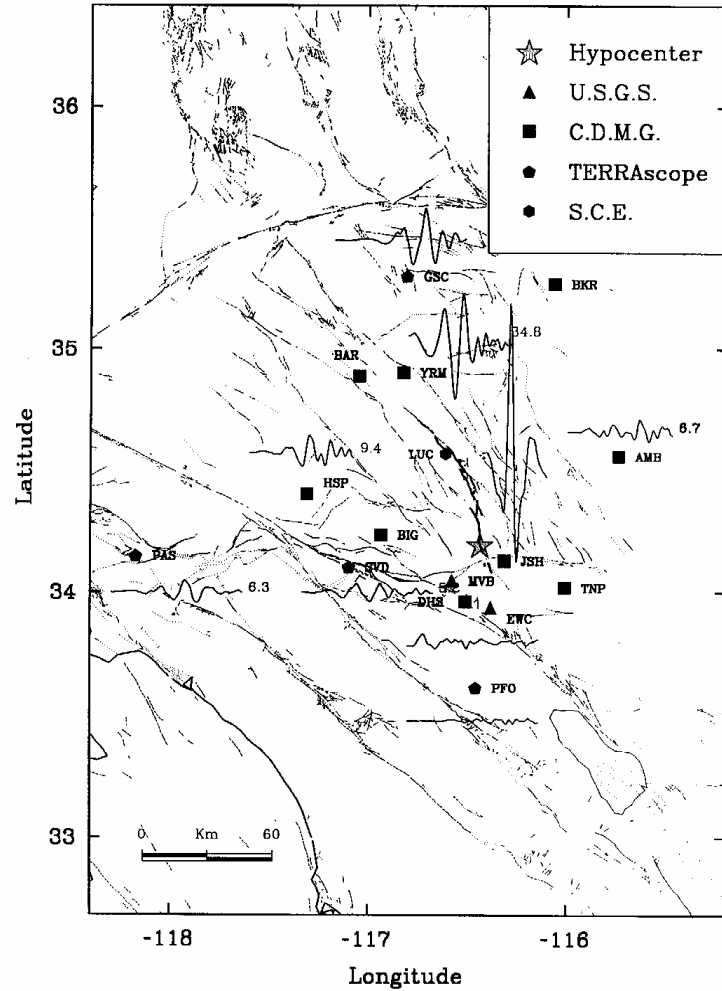
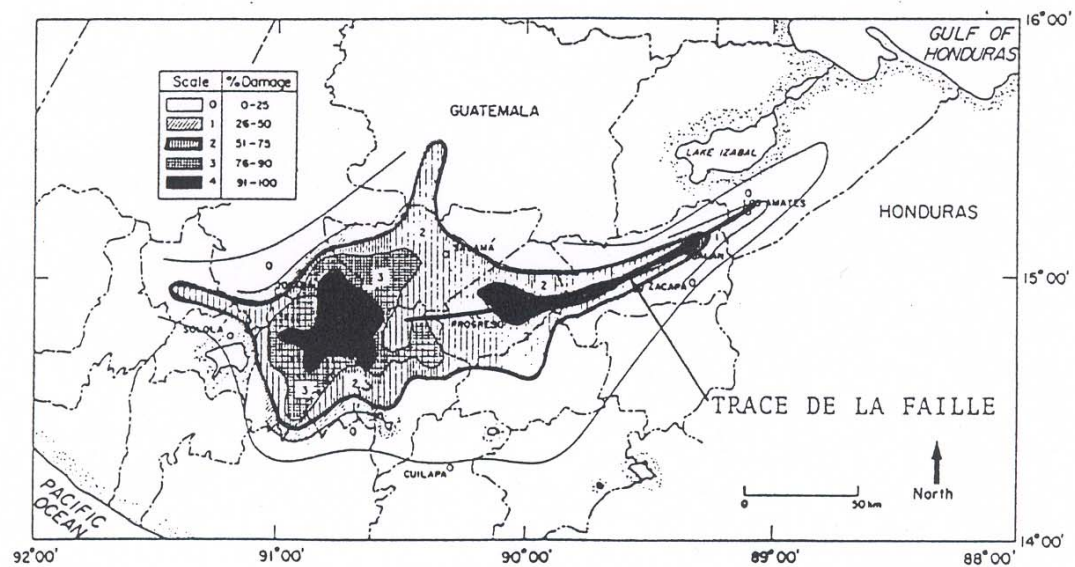
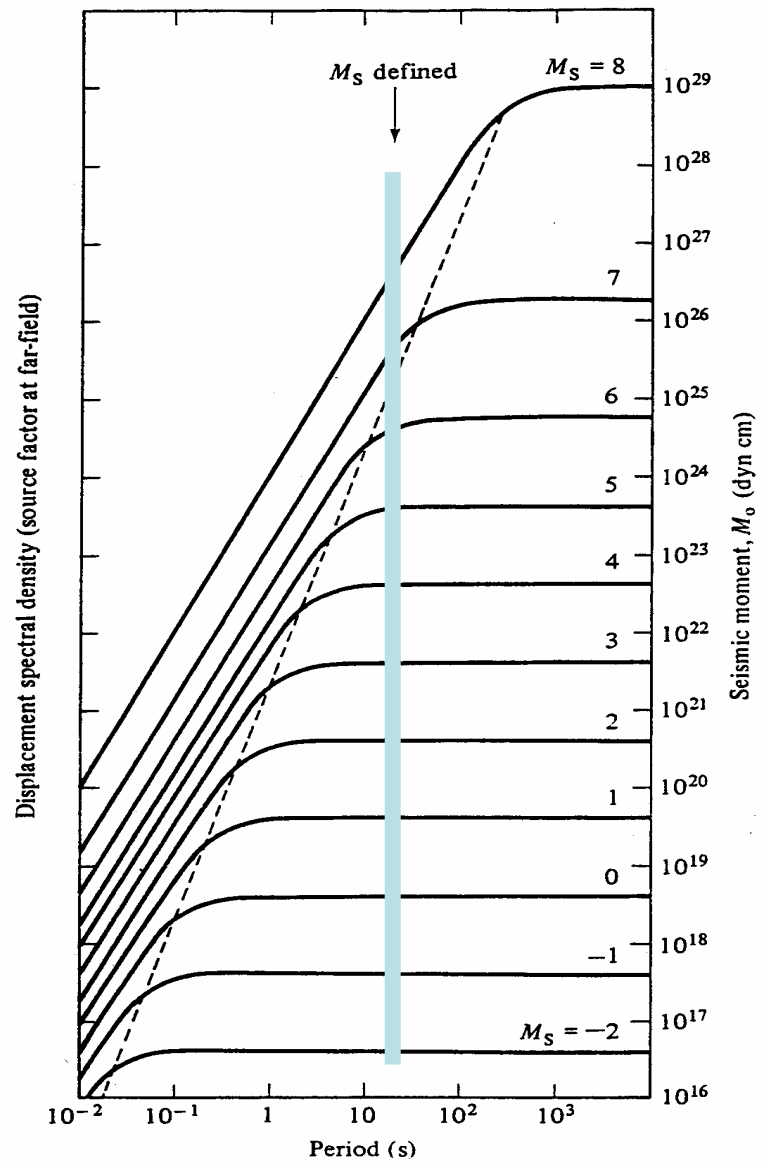


Figure 11. Strong-motion displacement observations (solid lines) and synthetics (dashed lines) for the strong-motion dislocation model. Observed amplitudes are given to the right of each trace in centimeter, and all have a common scale. For station LUC (Lucerne Valley), both velocity (LUCVW, LUCVN) and displacement (LUCDW, LUCDN) data and synthetics are presented, with the velocity amplitudes in cm/sec.

Damage map during the 1976 Guatemala earthquake.





Biais de la magnitude
'instrumentale'

Aki, 1967