



Journée thématique SFT; Paris, 26 mars 2007
Problèmes inverses de champs :
apports et limitations de la TIR

Analyse thermographique des champs de sources en fatigue des matériaux

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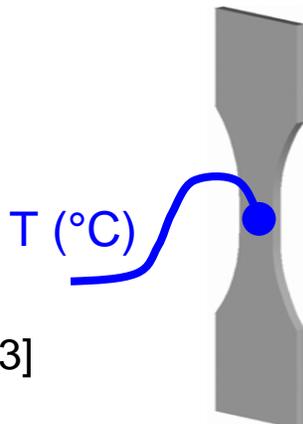
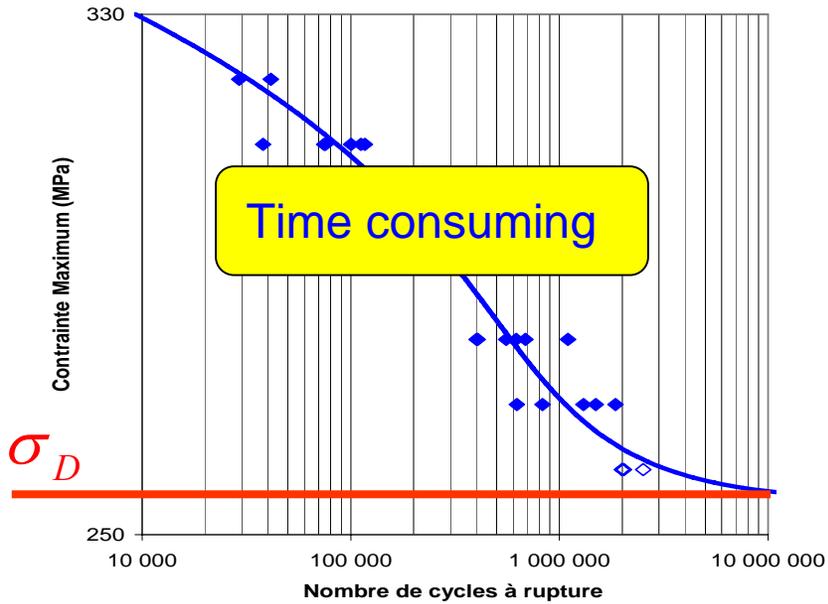


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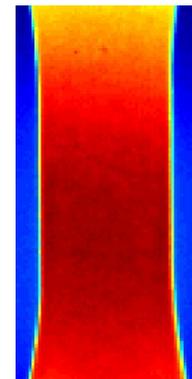


Introduction

S-N (Wohler) curve

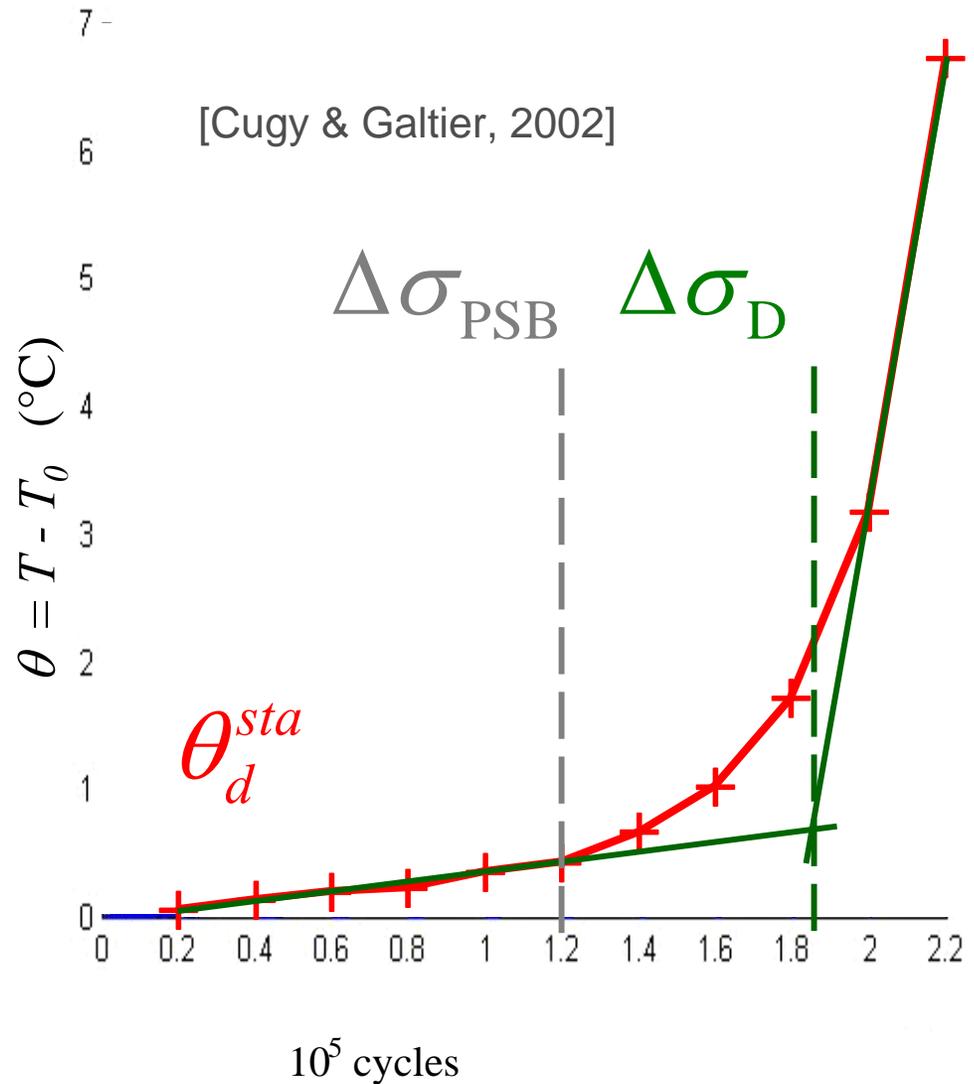
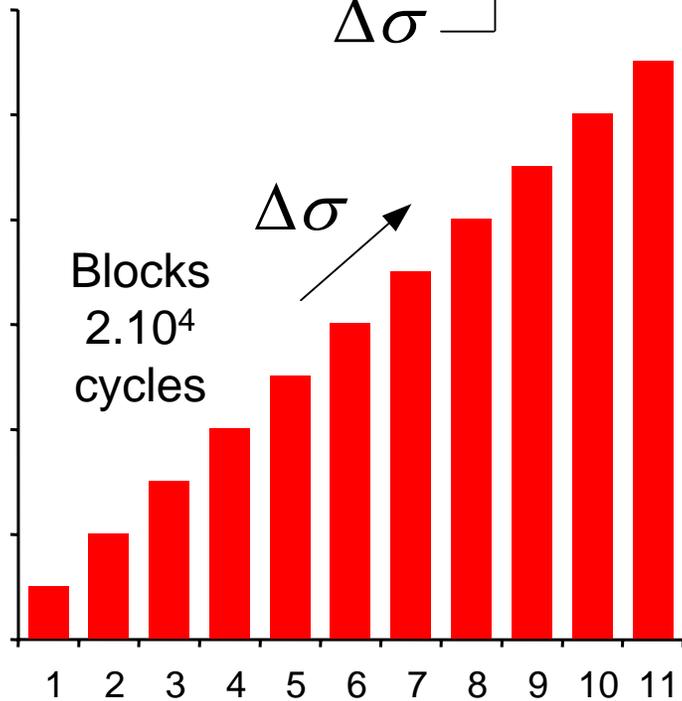
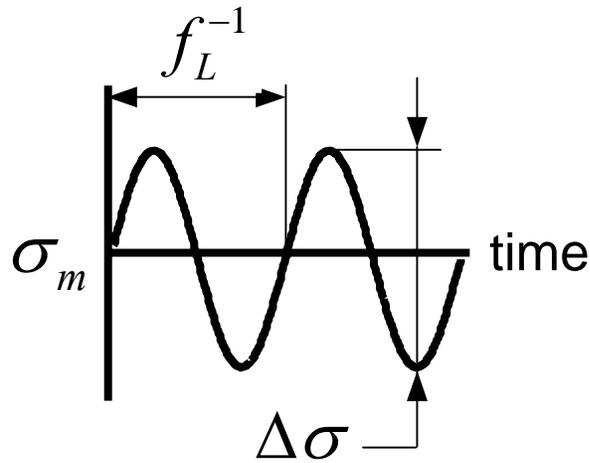


[Galtier, 1993]
[Curti, 1986]



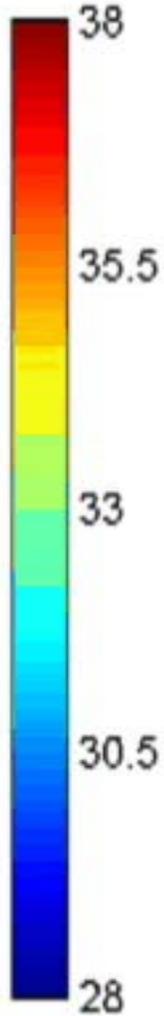
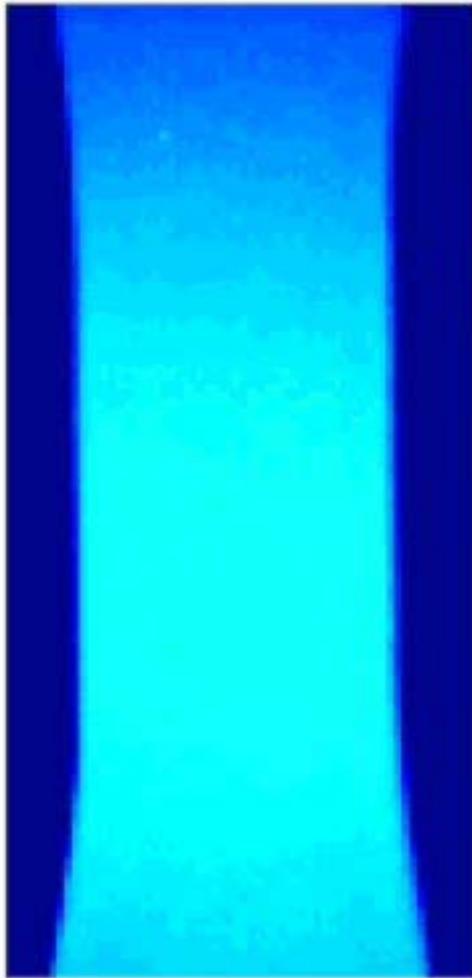
Méthode rapide pour estimer la limite de fatigue

[Luong, 1998], [Risitano, 2000],
[Krapez, 1999] etc

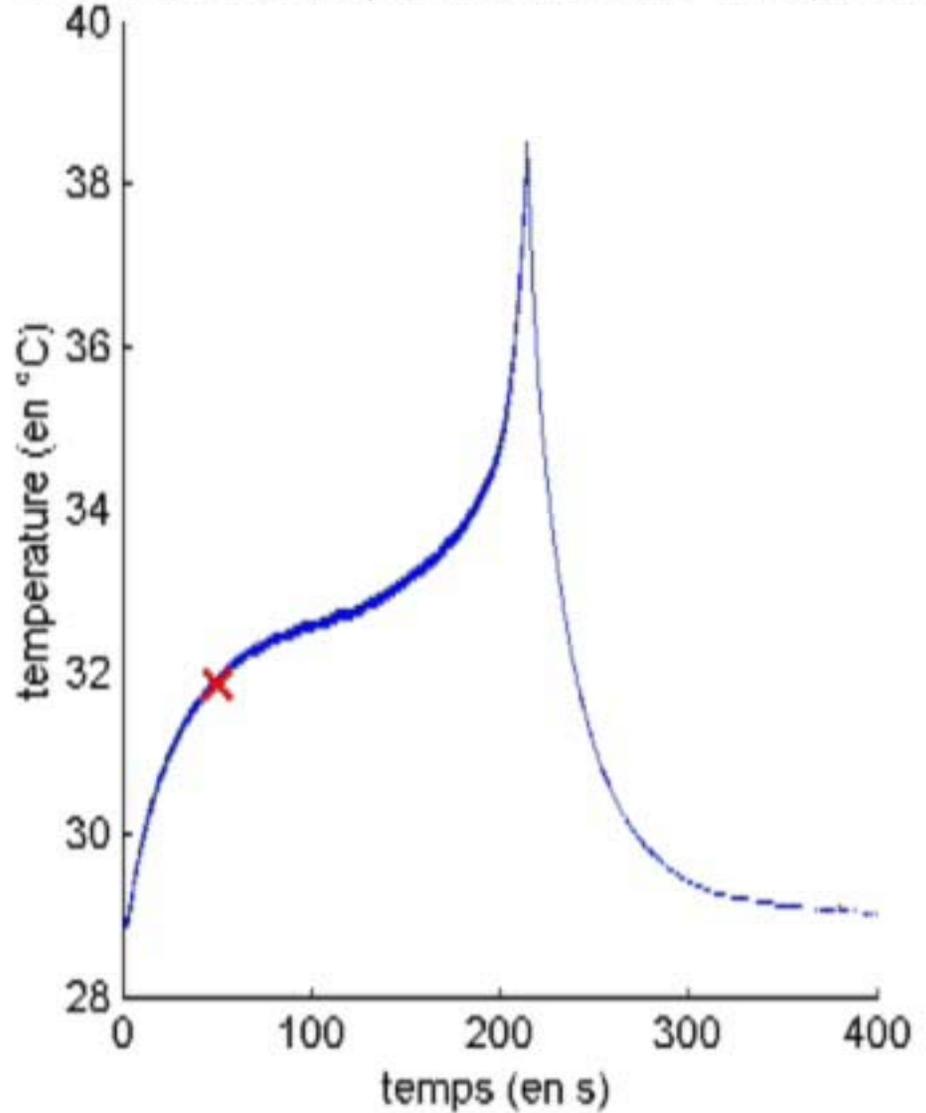


Diffusion de la chaleur : un mécanisme régularisant

Image n° 1000 (en °C)



Evolution de la température au centre de l'éprouvette



Objectifs

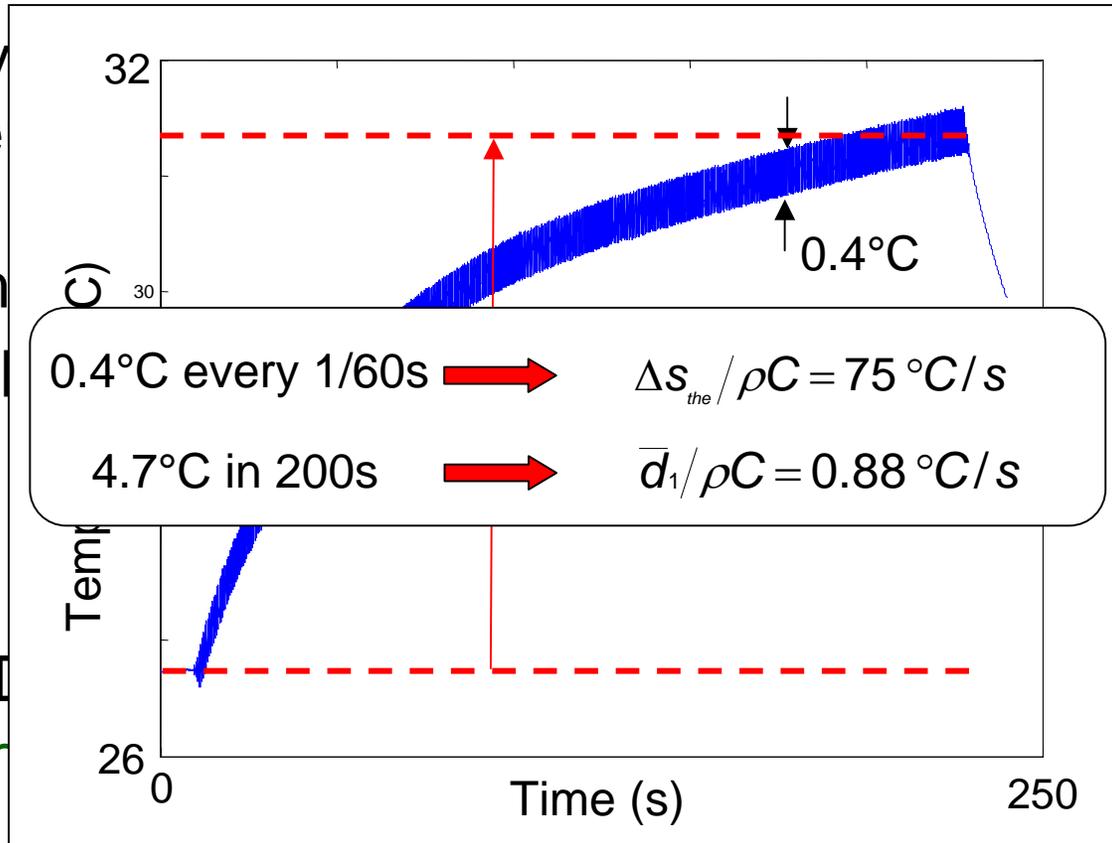


Doctorat : T. Boulanger, B. Berthel

➤ Analyse
chale

➤ Estim
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➤ IRT+[
[Berth



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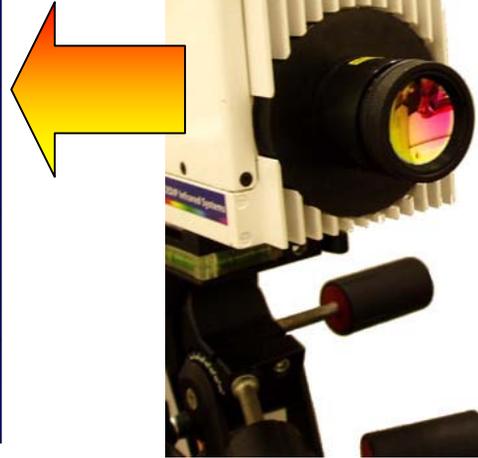
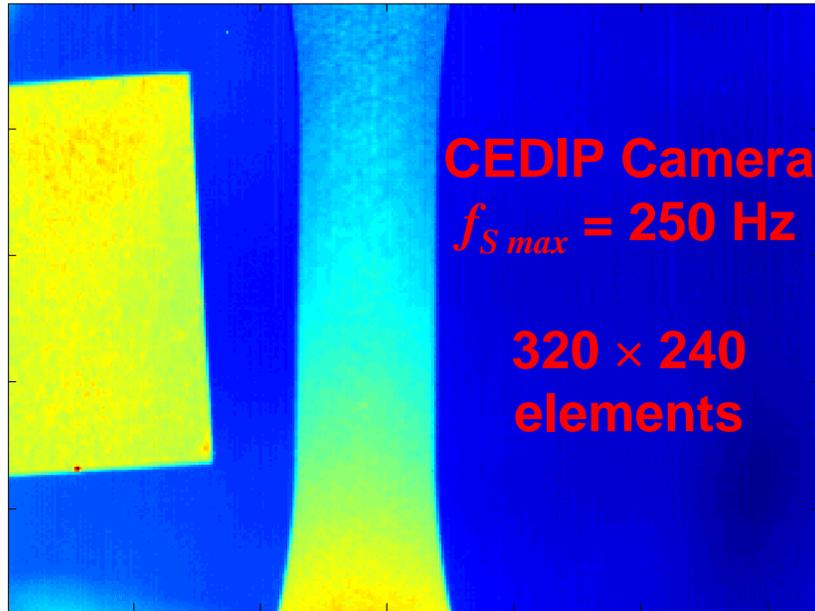
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➤ Modélisation des cinétiques de fatigue :
comportement des matériaux et des structures

Plan

- Introduction
- Dispositif expérimental
- Traitement d'images
- Quelques résultats

Dispositif, matériau, éprouvette

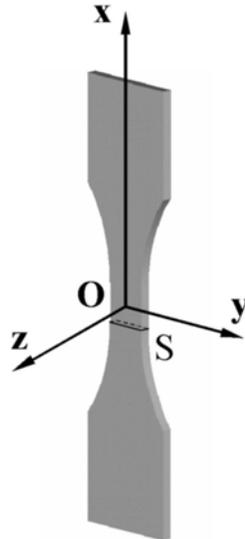


Arcelor Steel
Dual Phase 600

$$R_{p0.02} = 360 \text{ MPa}$$

$$\Delta\sigma_D^0 = 464 \text{ MPa}$$

$$\Delta\sigma_D^{-1} = 526 \text{ MPa}$$

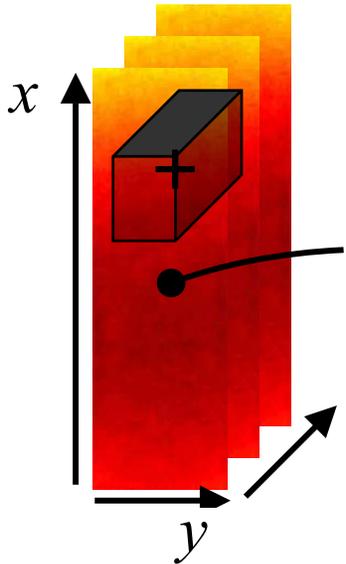


Testing machine MTS 25kN

$$f_{Lmax} = 50 \text{ Hz}$$

Traitement d'image: une approche « directe »

$$\rho C \left(\frac{\partial \bar{\theta}}{\partial t} + \frac{\bar{\theta}}{\tau_{th}} - \frac{k}{\rho C} \left(\frac{\partial^2 \bar{\theta}}{\partial x^2} + \frac{\partial^2 \bar{\theta}}{\partial y^2} \right) \right) = \bar{d}_1 + \bar{s}_{the}$$



Linear PDE
+
Linear boundary conditions



$$\theta = \theta_d + \theta_{the}$$

In phase with the loading

$$w_{the} = \int_{cycle} s_{the} d\tau = 0$$

Slow evolution of mean dissipation

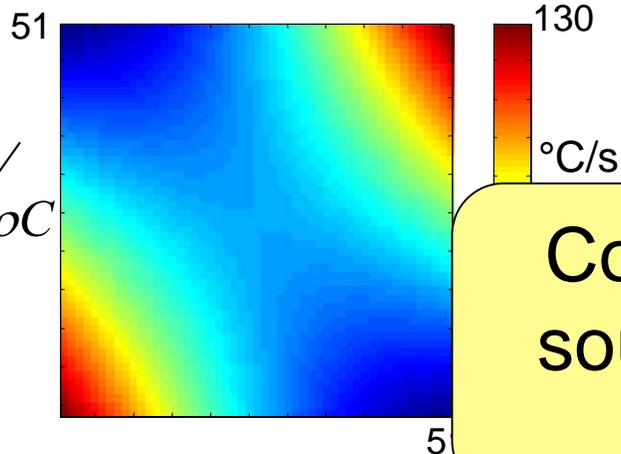
$$\int_{cycle} f_L d_1 d\tau = \bar{d}_1$$

$$\theta_{app}(x,y,t) = \underbrace{p_1(x,y) \cos(2\pi f_L t) + p_2(x,y) \sin(2\pi f_L t)}_{\text{periodic response}} + \underbrace{p_3(x,y) t + p_4(x,y)}_{\text{drift}}$$

$p_i(x,y)$, $i=1,\dots,4$, are 2nd order polynomials of x and y

Contrôle de validité du traitement : méthode

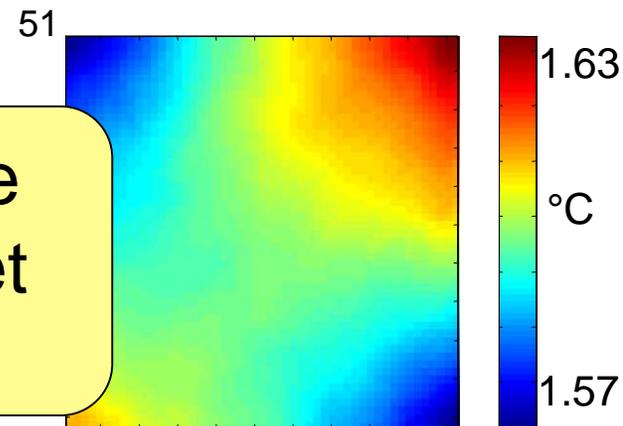
3D distribution of sources



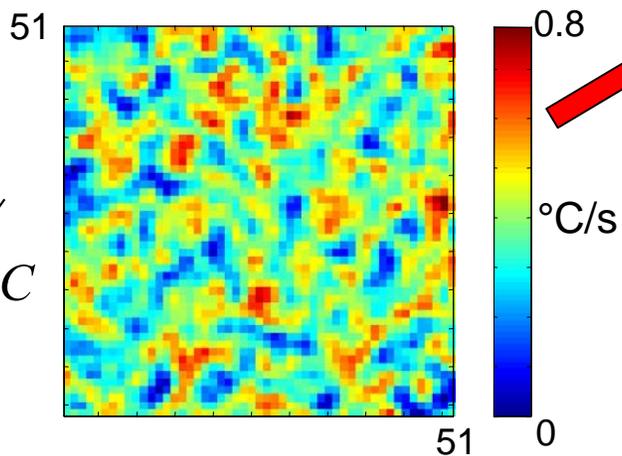
$$\frac{\Delta s_{the}}{\rho C}$$

Thermal simulations

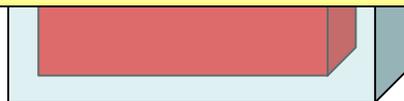
3D Temperature fields



Comparaison entre sources données et reconstruites



$$\frac{\bar{d}_1}{\rho C}$$



In the domain

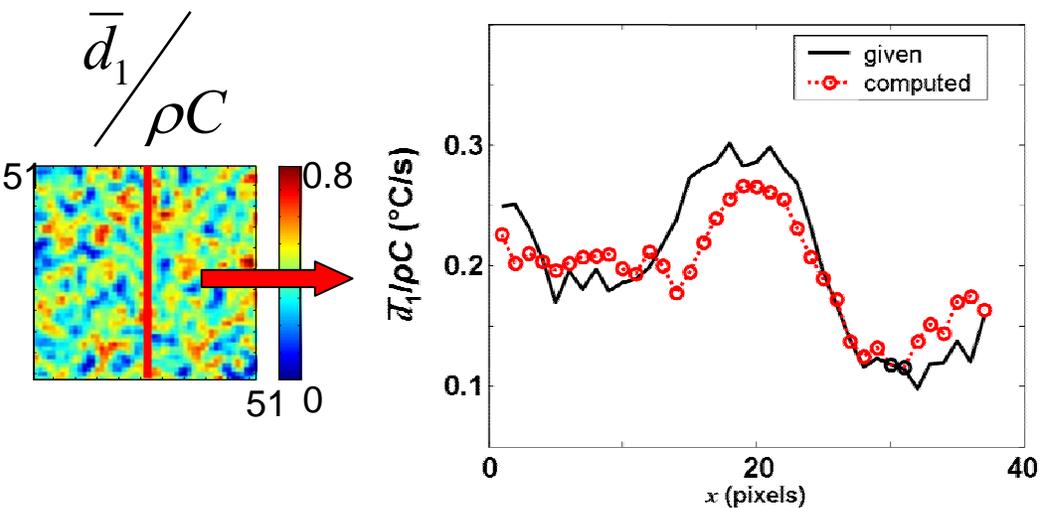
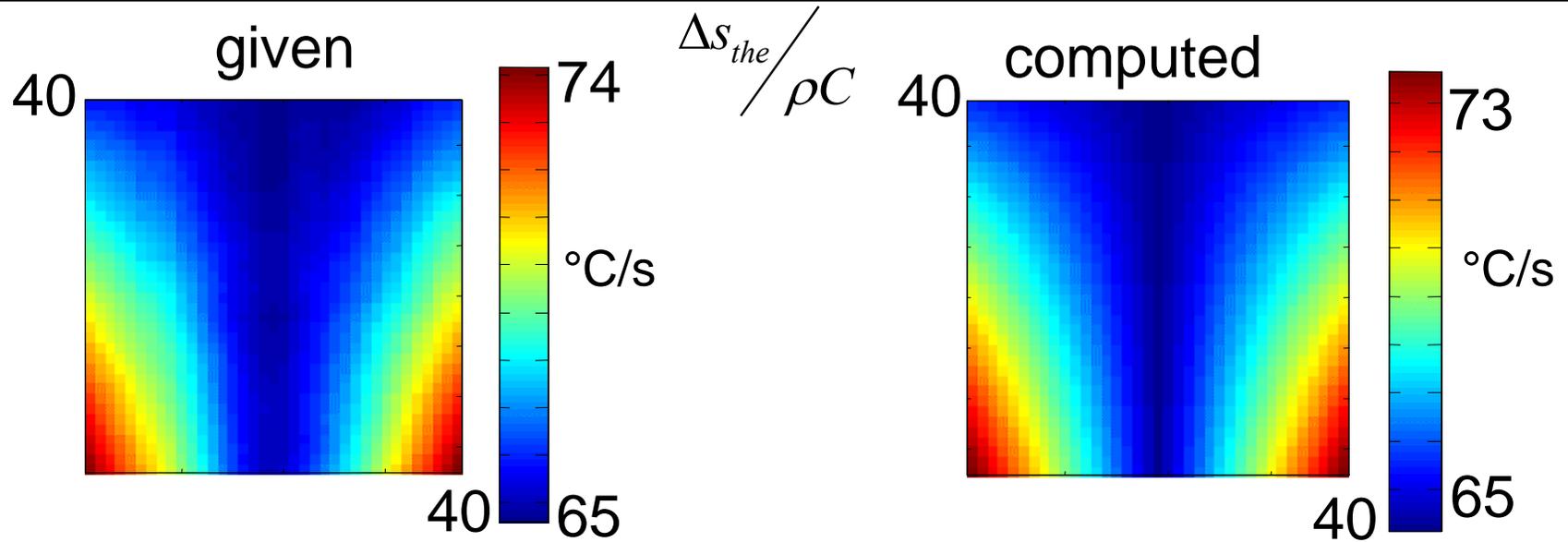
$$\rho C \frac{\partial \theta}{\partial t} - k \Delta \theta = d_1 + s_{the}$$

Boundary conditions

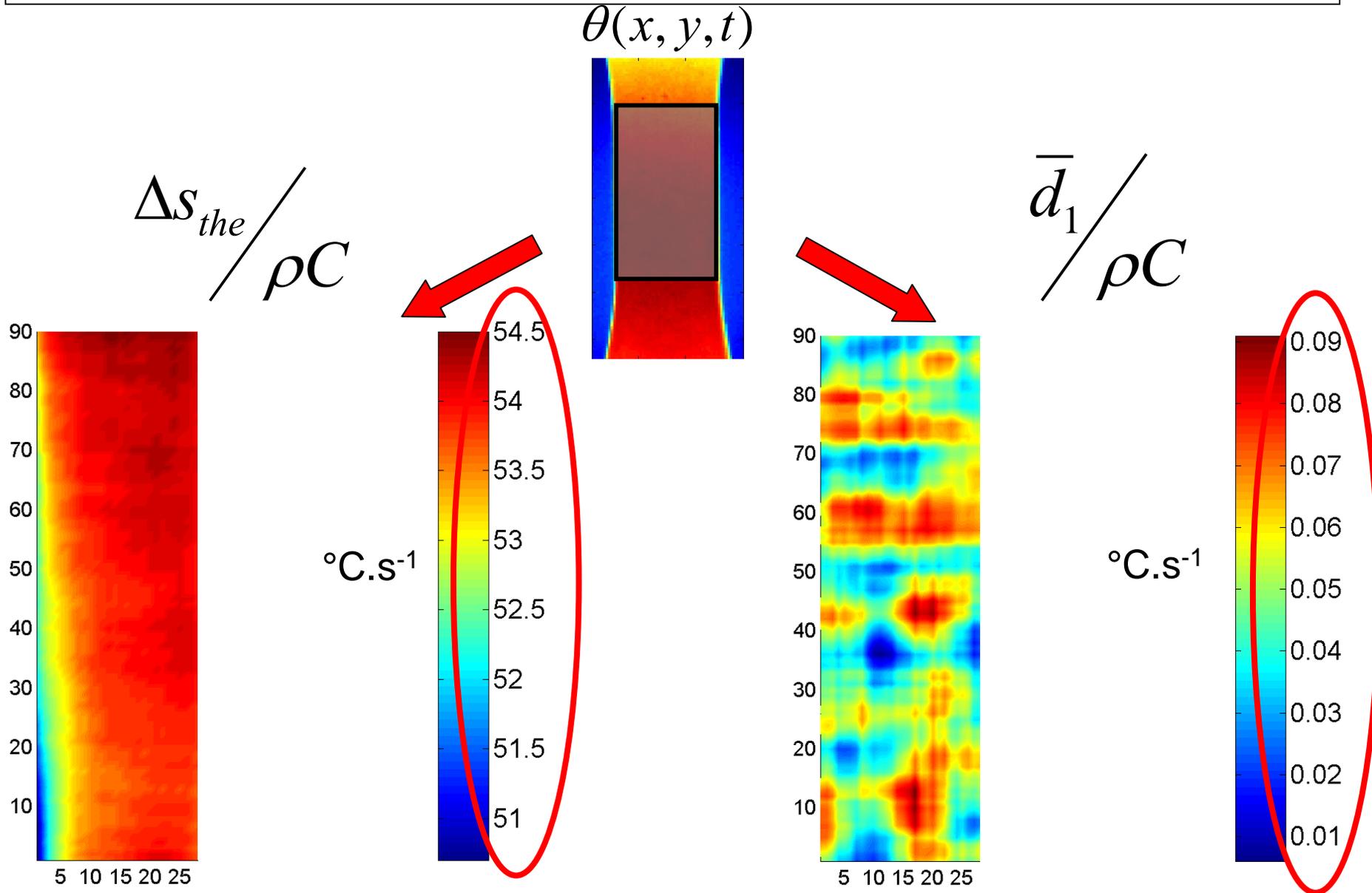
$$\frac{\partial \theta}{\partial x} \pm \lambda \theta = 0$$

+ bruit "réel"

Contrôle de validité du traitement : résultats



Résultats expérimentaux

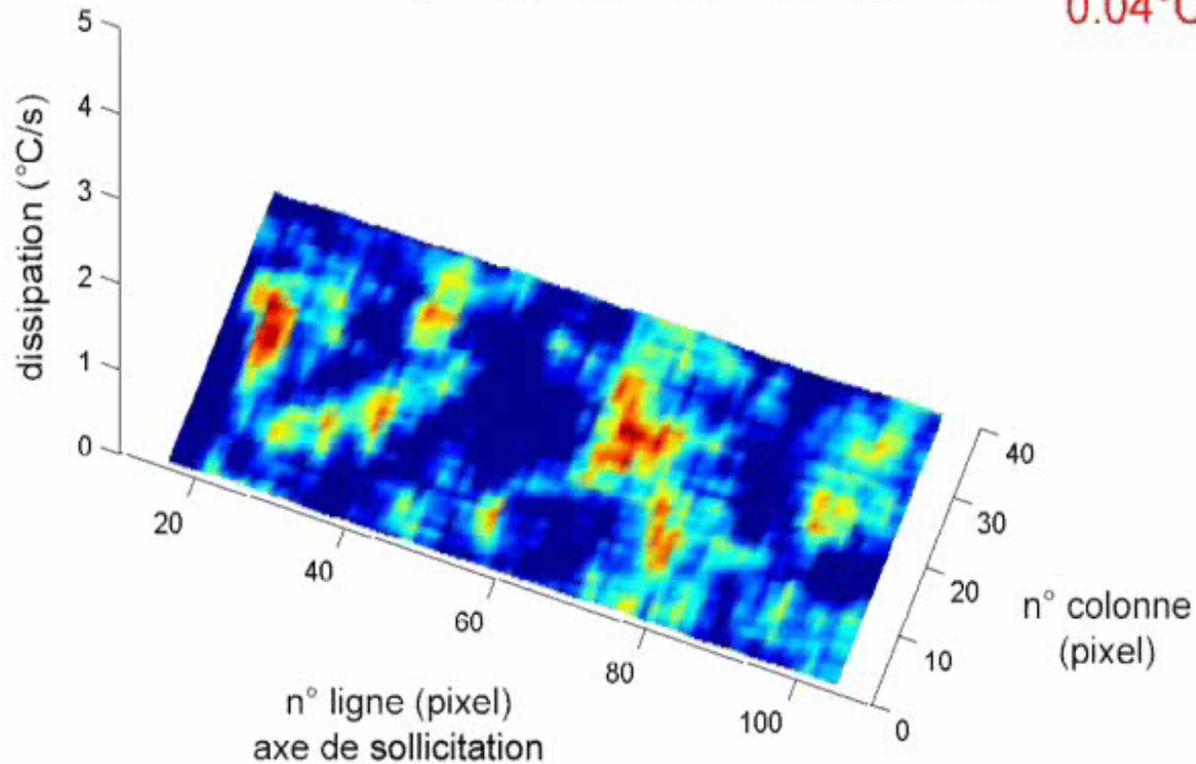
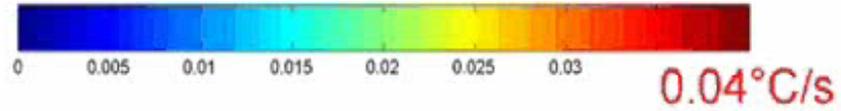


Champs de dissipation (fatigue par blocs, $R_\sigma = -1$)

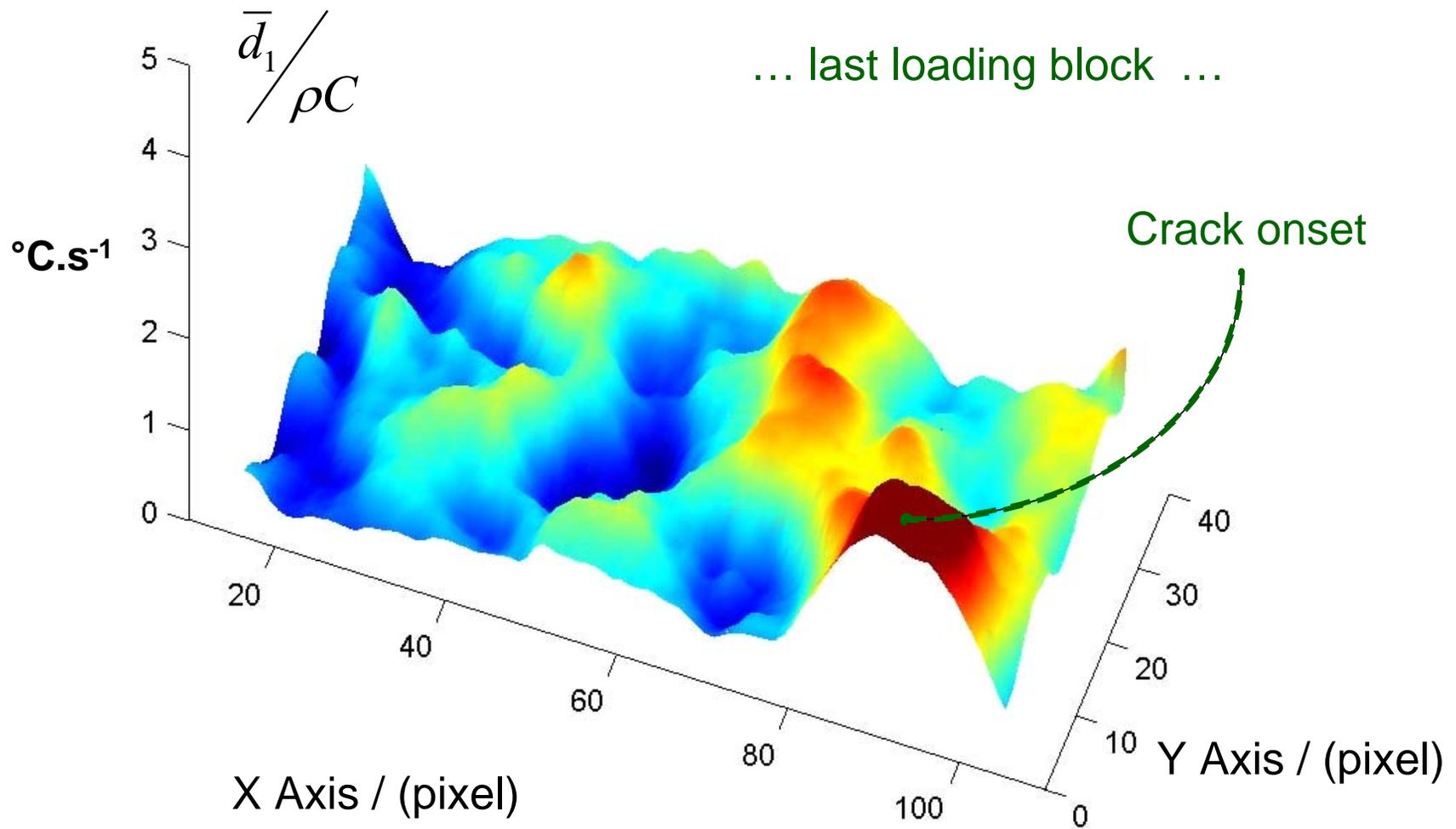
Amplitude de contrainte $\Delta\sigma/2$	133 MPa
Rapport de charge	$R_\sigma = 0$

Dimension de la partie utile (h* ℓ)	10x9x2.5mm ³	Nombre de cycles par blocs	20000
Fréquence de sollicitation F _s	50 Hz	Fréquence d'acquisition F _a	19 Hz
Temps du bloc	400s	Résolution spatiale	0.196 mm/pixel
Lieu de fissuration	Pixel 96x6	ligne limite de la zone utile	35 à 86

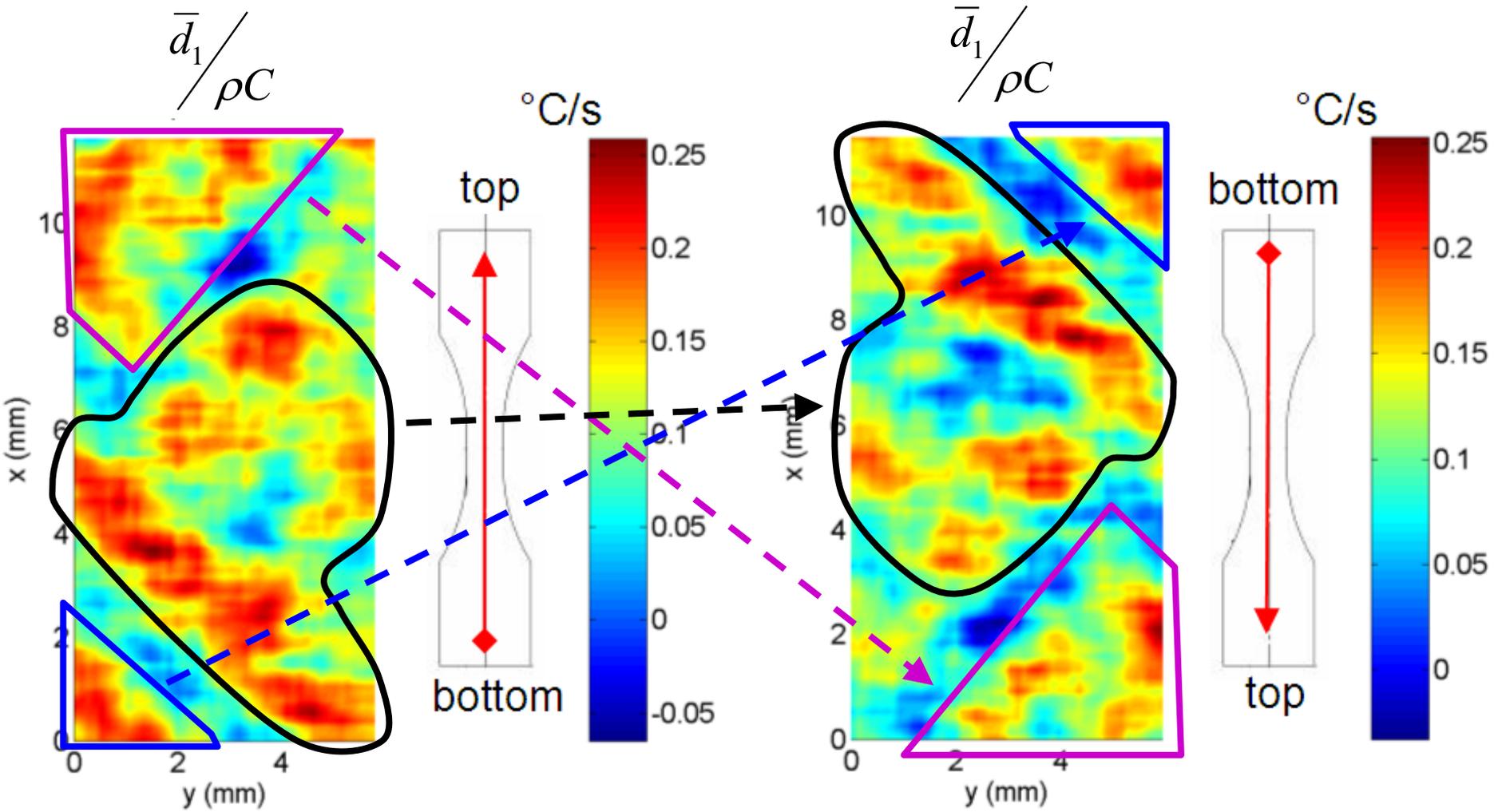
0 cycles 20000



Détection des zones potentielles de fissuration

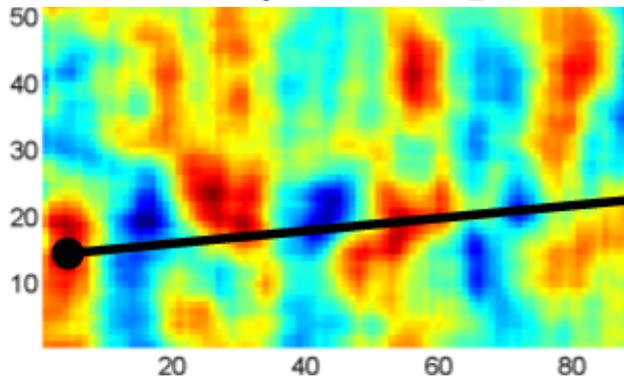


Champs de dissipation: un effet matériau

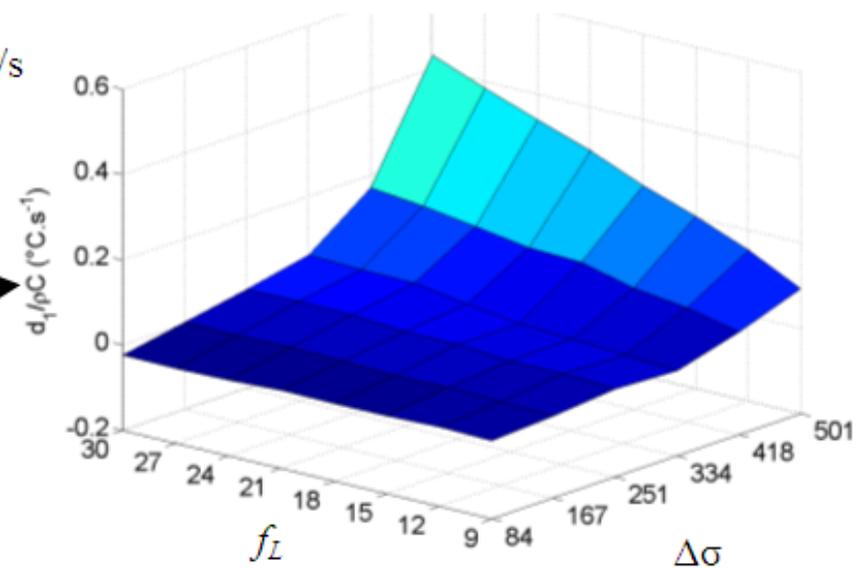
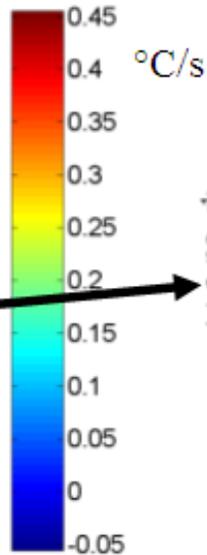


Propriétés des dissipations

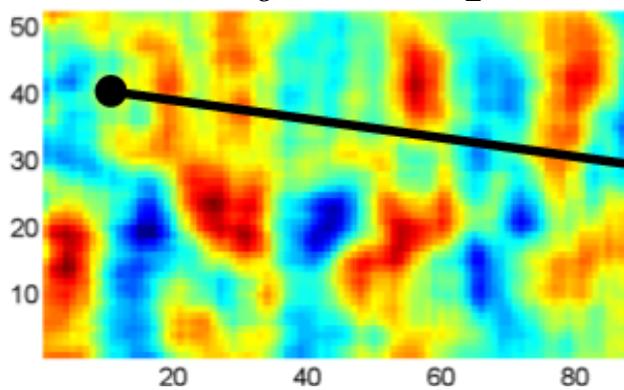
Dissipative sources at
 $\Delta\sigma=500\text{MPa}$, $R_\sigma=-1$ and $f_L=30\text{Hz}$



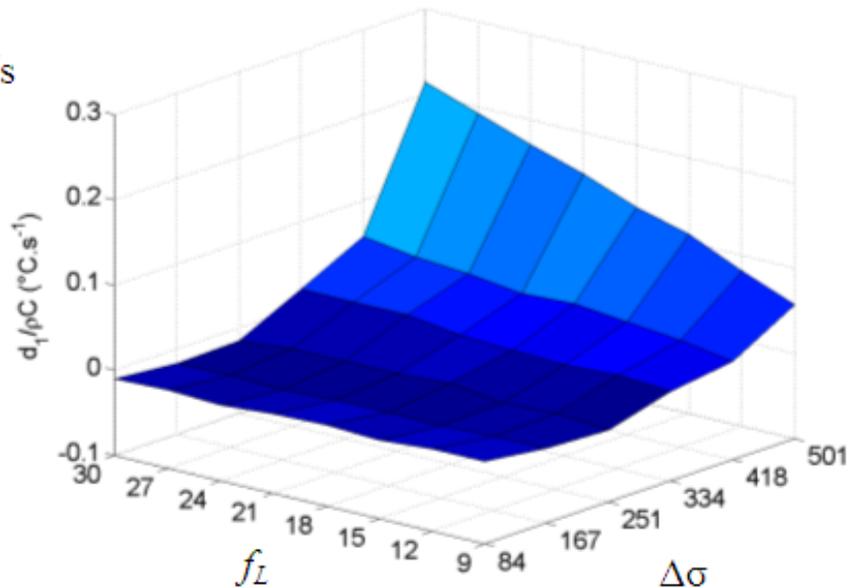
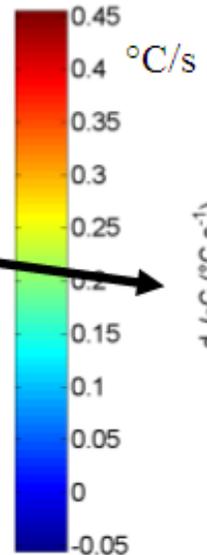
« high intensity » zone



Dissipative sources at
 $\Delta\sigma=500\text{MPa}$, $R_\sigma=-1$ and $f_L=30\text{Hz}$



« low intensity » zone



Conclusions / perspectives

- **Traitement d'images infrarouges**
champs de s_{the} , d_1 identifiés séparément ($|\Delta s_{the}| \gg d_1$)
- **CIG + TIR : mécanismes de fatigue**
CIG (analyse ε, σ , énergie de déformation) + TIR
bilan local d'énergie → variations d'énergie interne
[Berthel *et al.*, ICEM13]
- **Méthodes inverses** : vers de vrais problèmes 3D où
seules sont connues les conditions aux limites
ANR 06 – ANR 07 ... ANR 08 !?