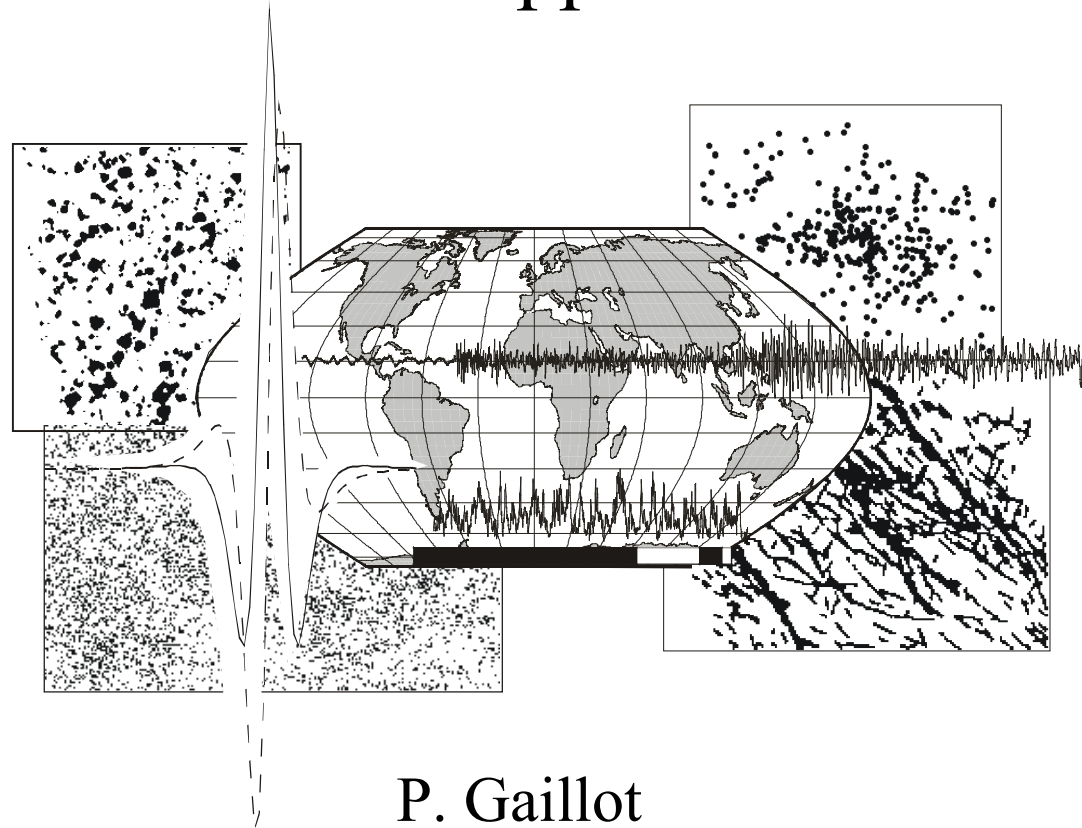
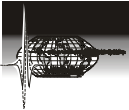


Ondelettes continues en Sciences de la Terre

- Méthodes et applications -

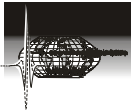


P. Gaillot



Plan

- Problématique
- Formalisme
- ① - Paléointensité relative du champ magnétique terrestre
- Pointés automatiques de phases sismiques
- ② - Analyse de la distribution spatiale des séismes
- Analyse d'organisations minérales des roches magmatiques
- Conclusions et perspectives

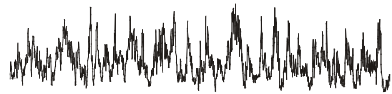


Problématique

Signaux Géophysiques - géologiques

Comportement non-stationnaire
Caractéristiques multi-échelles
singularités

- Mesures indirectes (analogues)



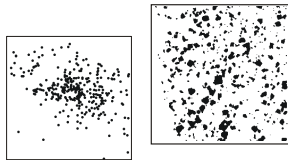
Paléo-champ magnétique

- Parasites - bruits

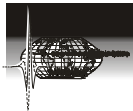


Sismogrammes

- Quantification intégrative



Distributions spatiales

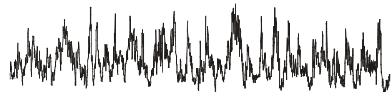


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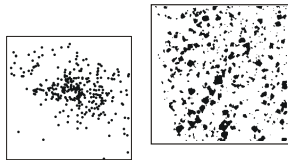
Paléochamp magnétique

- Parasites - bruits

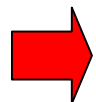


Sismogrammes

- Quantification intégrative

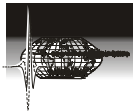


Distributions spatiales

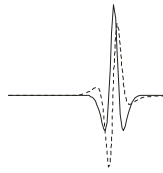


OBJECTIF:

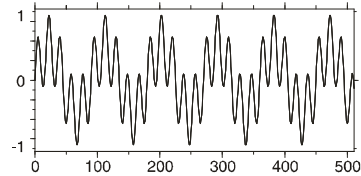
Extraire l'information pertinente
description et quantification fiable



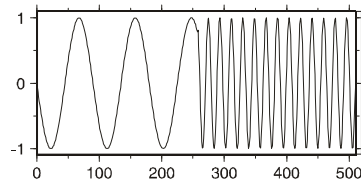
Limites des représentations classiques



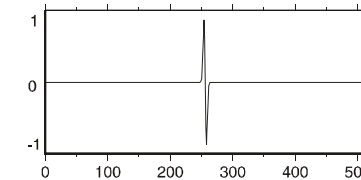
Stationnaire



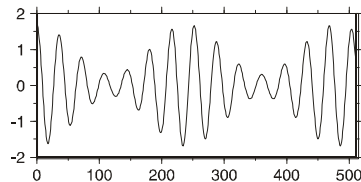
Changement de fréquence



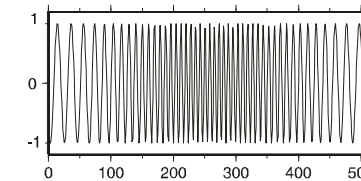
Changement temporel



Modulation d'amplitude

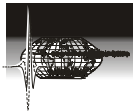


Modulation de fréquence

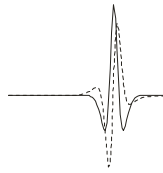


espace

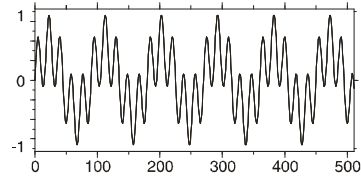
Propriétés statistiques évoluent dans l'espace



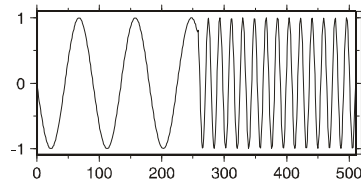
Limites des représentations classiques



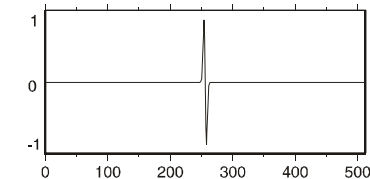
Stationnaire



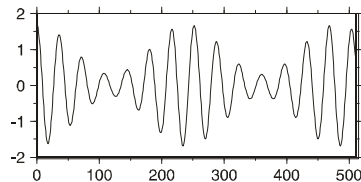
Changement de fréquence



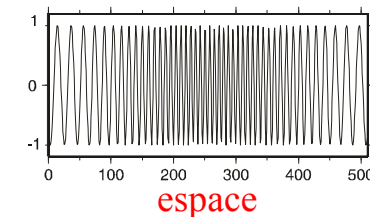
Changement temporel



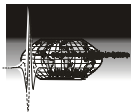
Modulation d'amplitude



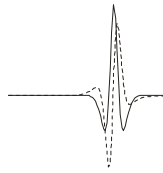
Modulation de fréquence



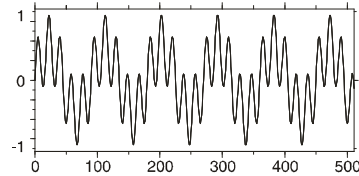
Evènement catastrophique ayant des effets à long terme



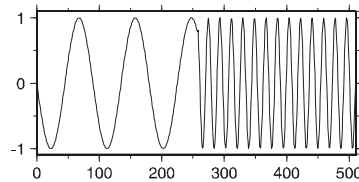
Limites des représentations classiques



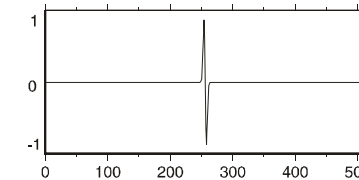
Stationnaire



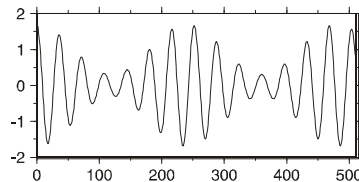
Changement de fréquence



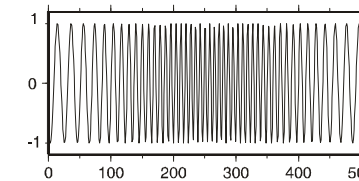
Changement temporel



Modulation d'amplitude

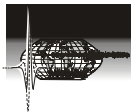


Modulation de fréquence

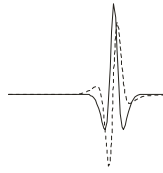


espace

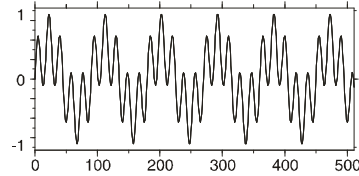
Événement catastrophique n'ayant pas d'effet à long terme



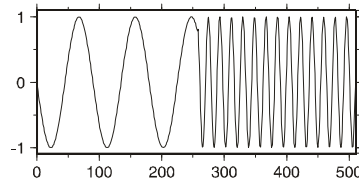
Limites des représentations classiques



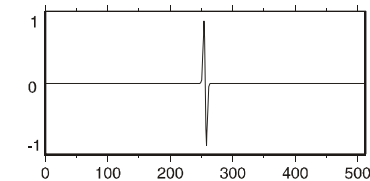
Stationnaire



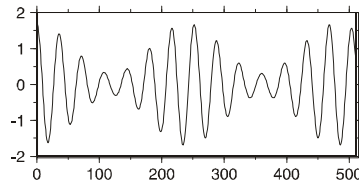
Changement de fréquence



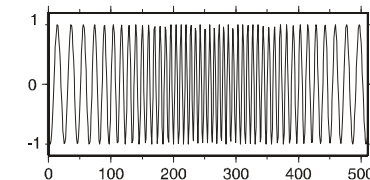
Changement temporel



Modulation d'amplitude

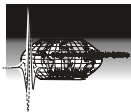


Modulation de fréquence

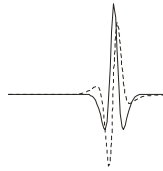


espace

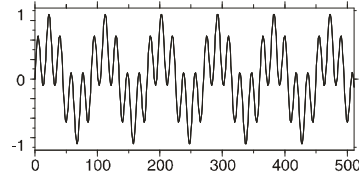
Interactions non-linéaires entre différentes échelles
Interférences entre fréquences voisines



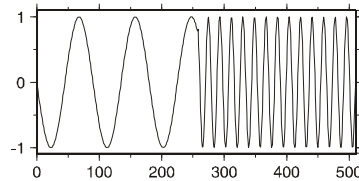
Limites des représentations classiques



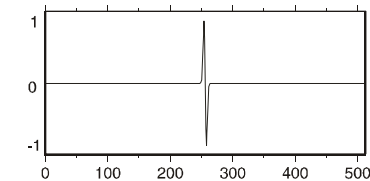
Stationnaire



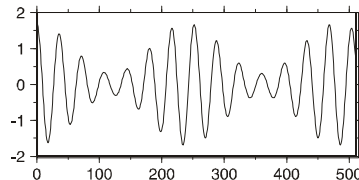
Changement de fréquence



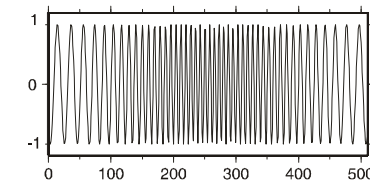
Changement temporel



Modulation d'amplitude

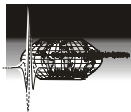


Modulation de fréquence

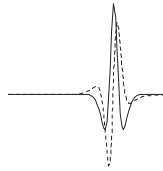


espace

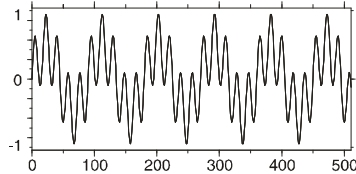
Systemes instables avec évolution temporelles des fréquences fondamentales



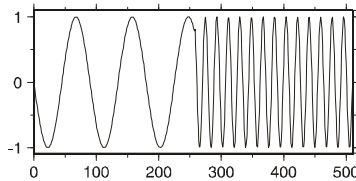
Limites des représentations classiques



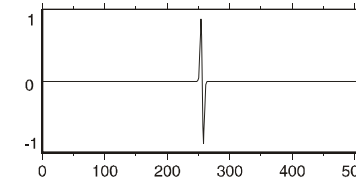
Stationnaire



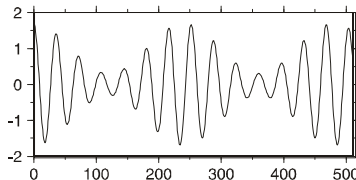
Changement de fréquence



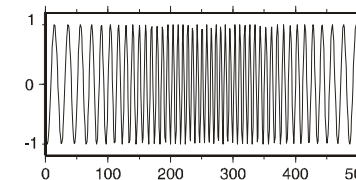
Changement temporel



Modulation d'amplitude



Modulation de fréquence



espace

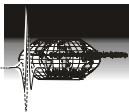
Evènement catastrophique ayant des effets à long terme

Evènement catastrophique n'ayant pas d'effet à long terme

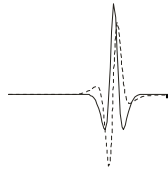
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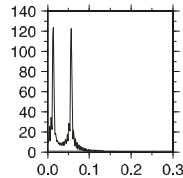
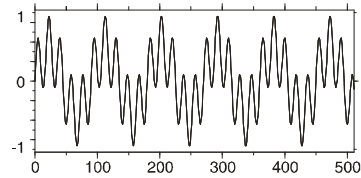
Systemes instables avec évolution temporelles des fréquences fondamentales



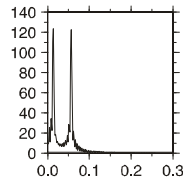
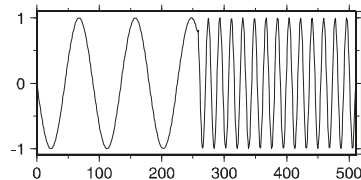
Limites des représentations classiques



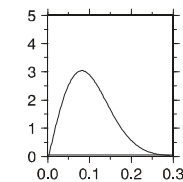
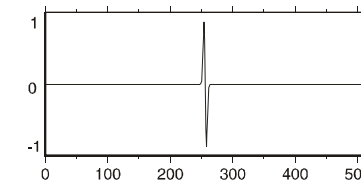
Stationnaire



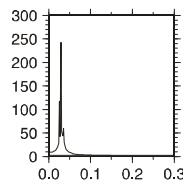
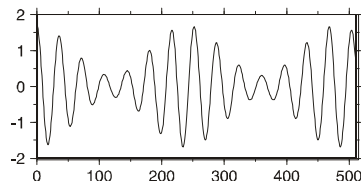
Changement de fréquence



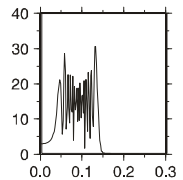
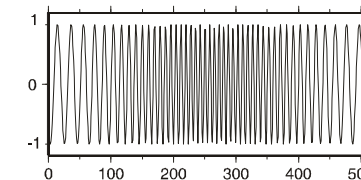
Changement temporel



Modulation d'amplitude



Modulation de fréquence

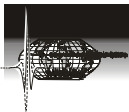


espace

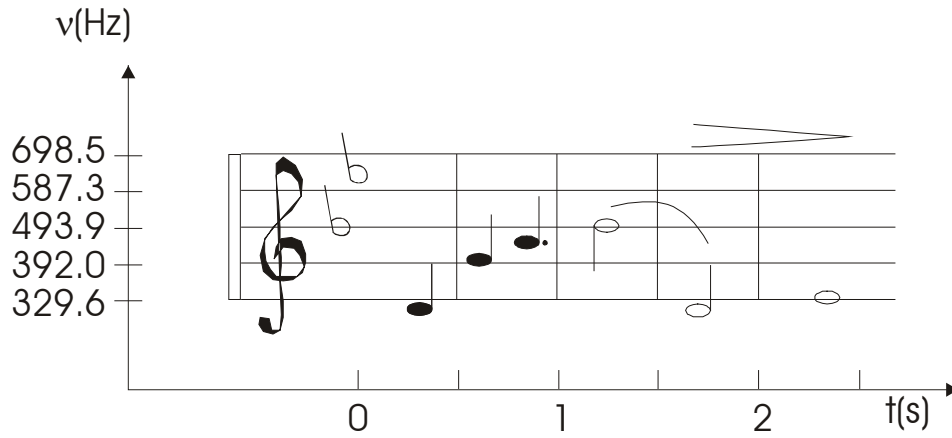
fréquence

représentations | Temps
Fréquence

**NOUVELLE
REPRESENTATION ...**



Nouvelle représentation

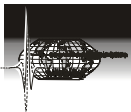


2 paramètres : temps - fréquence

Début, fin, durée \longrightarrow Localisation

Fréquence \longrightarrow Multi-échelle

Dynamique

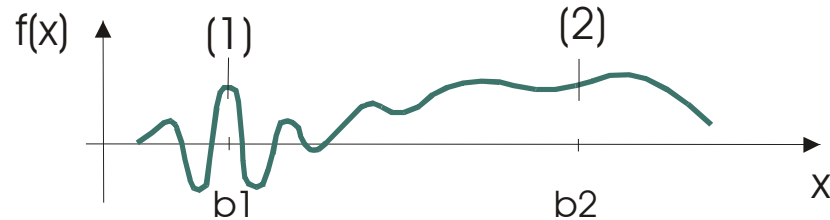


Transformée en ondelettes continues

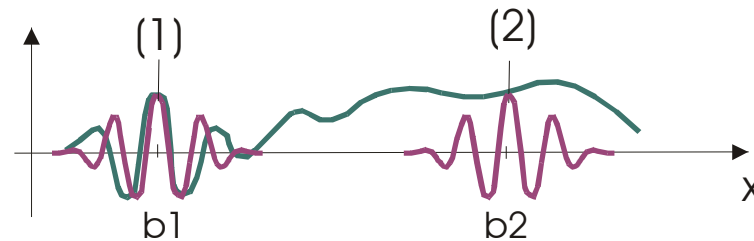
$$C(a, b) = \Psi(a, b) \otimes f(x)$$

a: facteur d'échelle

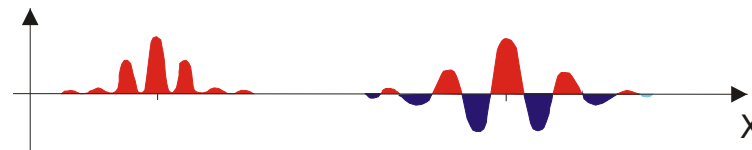
b: paramètre de translation



① Multiplication de l'ondelette centrée en b avec f

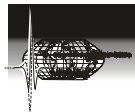
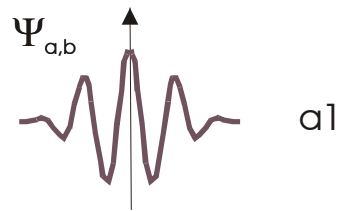


② Calcul du signal "Produit"

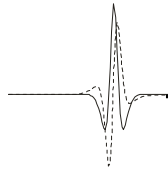


Fort $C(a, b)$

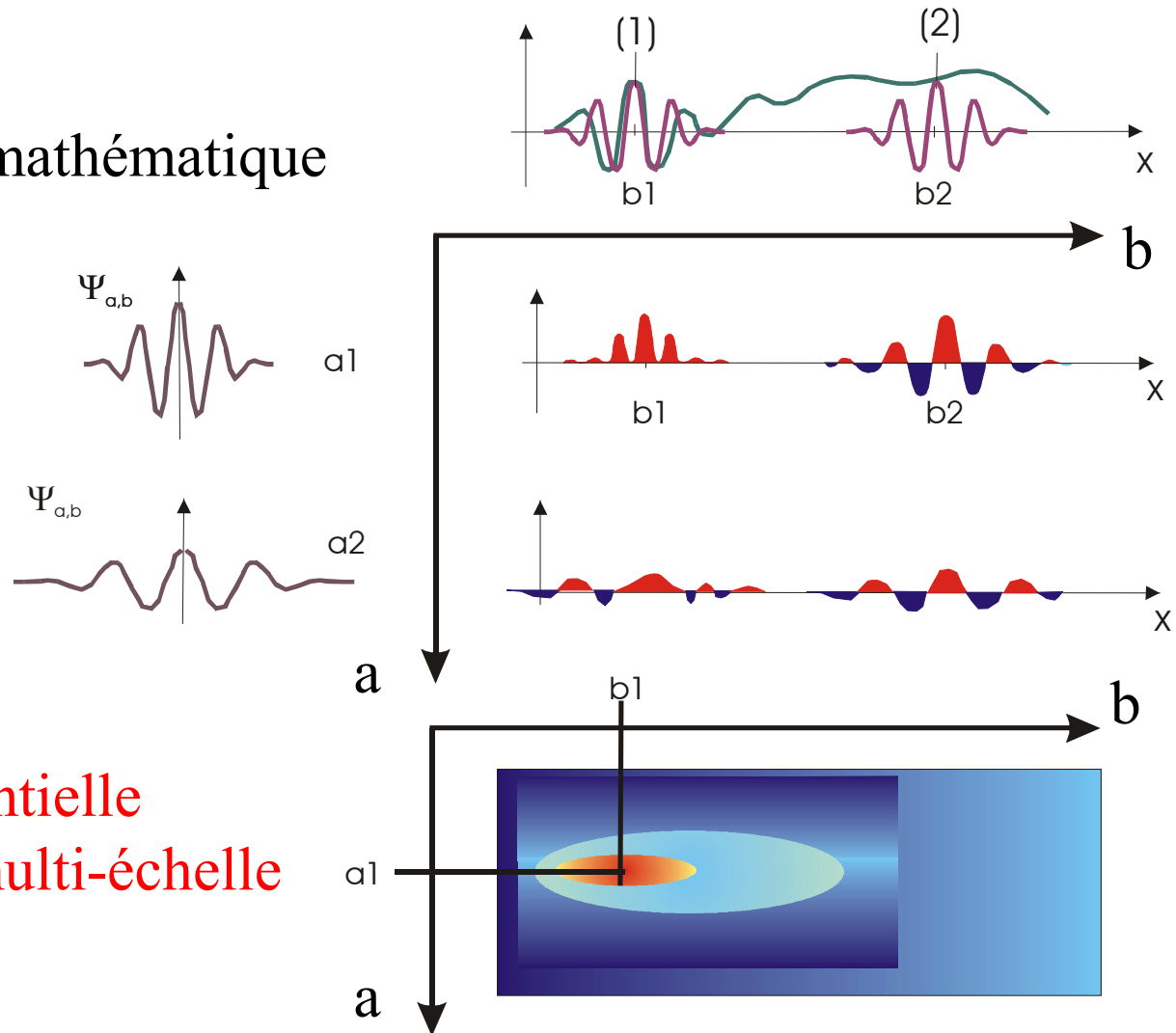
Faible $C(a, b)$



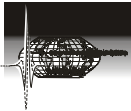
Transformée en ondelettes continues



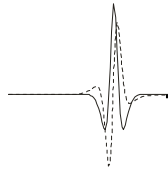
Microscope mathématique



- Evolution fréquentielle
- Comportement multi-échelle
- Singularités

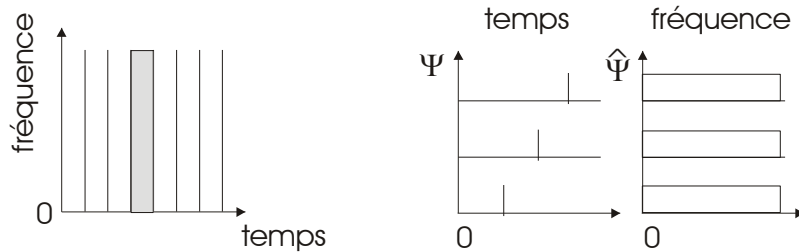


Fenêtres temps-fréquences



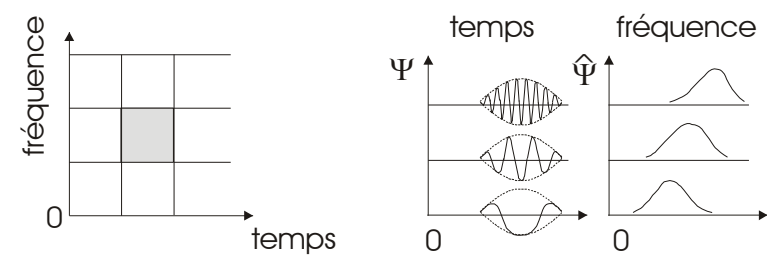
Temporelle

a Base standard



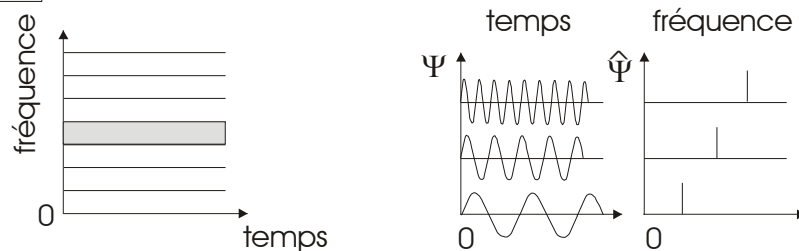
TF fenêtre glissante

c Base de Gabor



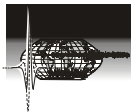
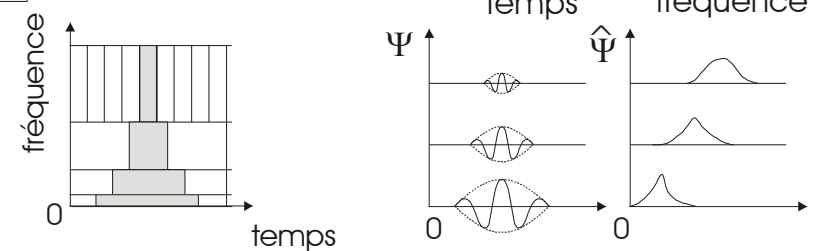
Fréquentielle (TF)

b Base de Fourier



Transformée en ondelettes

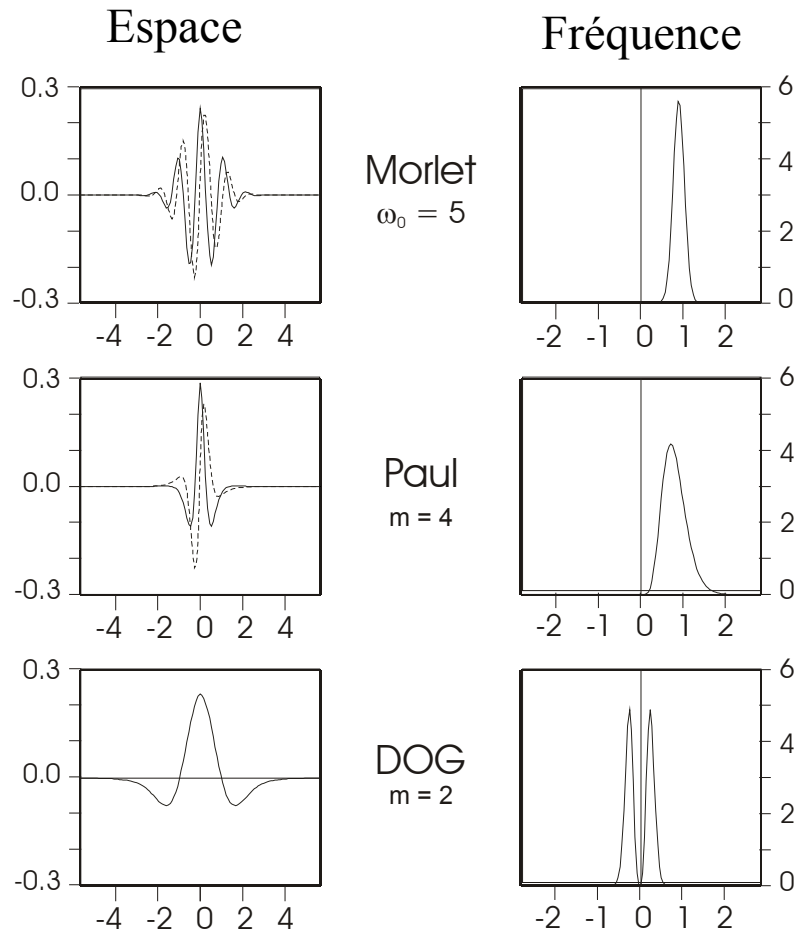
d Base d'ondelette



Fonction mère

Support compact
Moyenne nulle

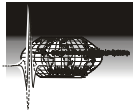
Domaine



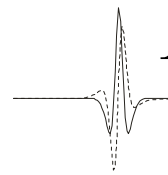
Applications
environnementales

Applications
sismologiques

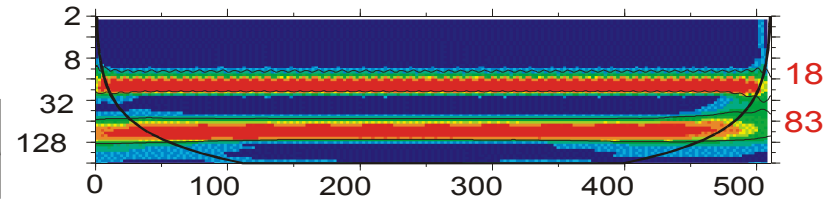
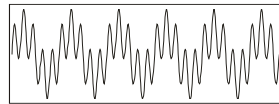
Applications
2D



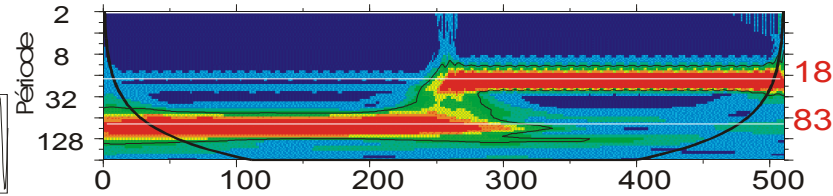
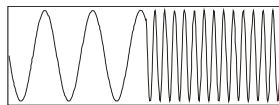
Illustration



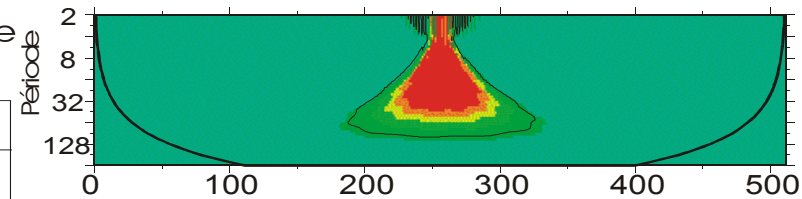
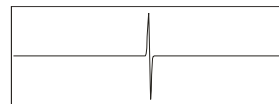
Stationnaire



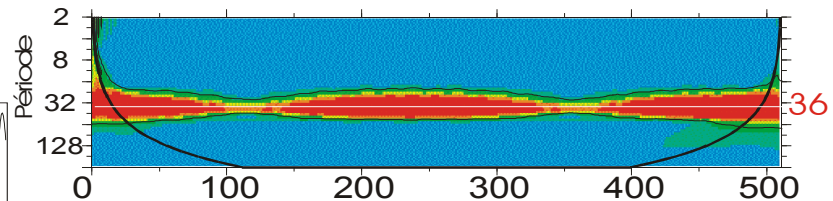
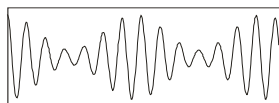
Variation de fréquence



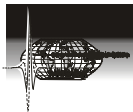
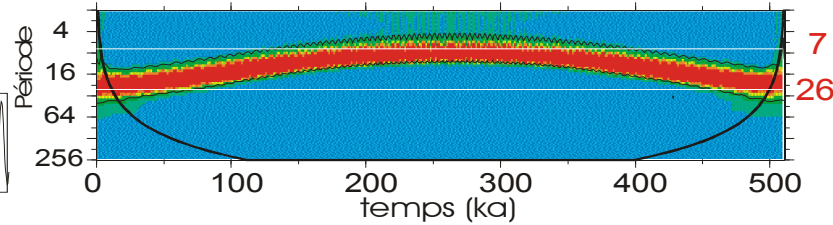
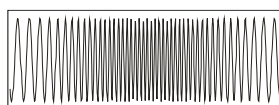
Variation brutale dans le temps



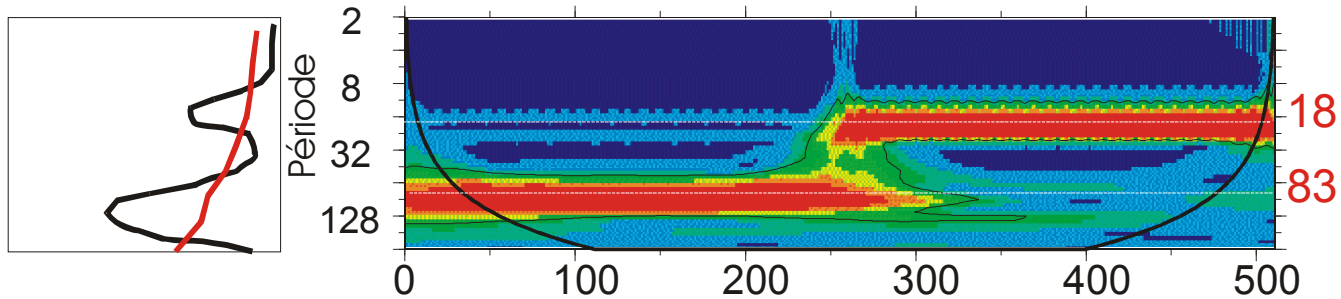
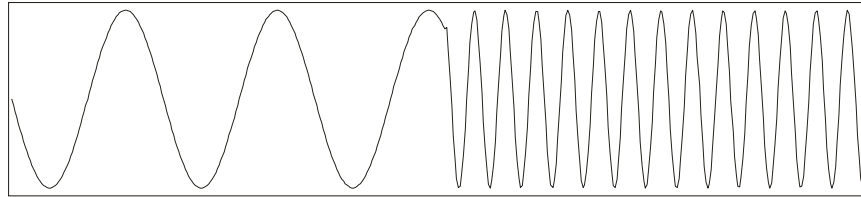
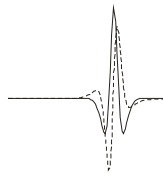
Modulation d'amplitude



Modulation de fréquence



Test statistique de confiance

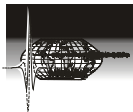


Spectre du bruit de fond
x niveau de confiance (χ^2)

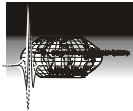
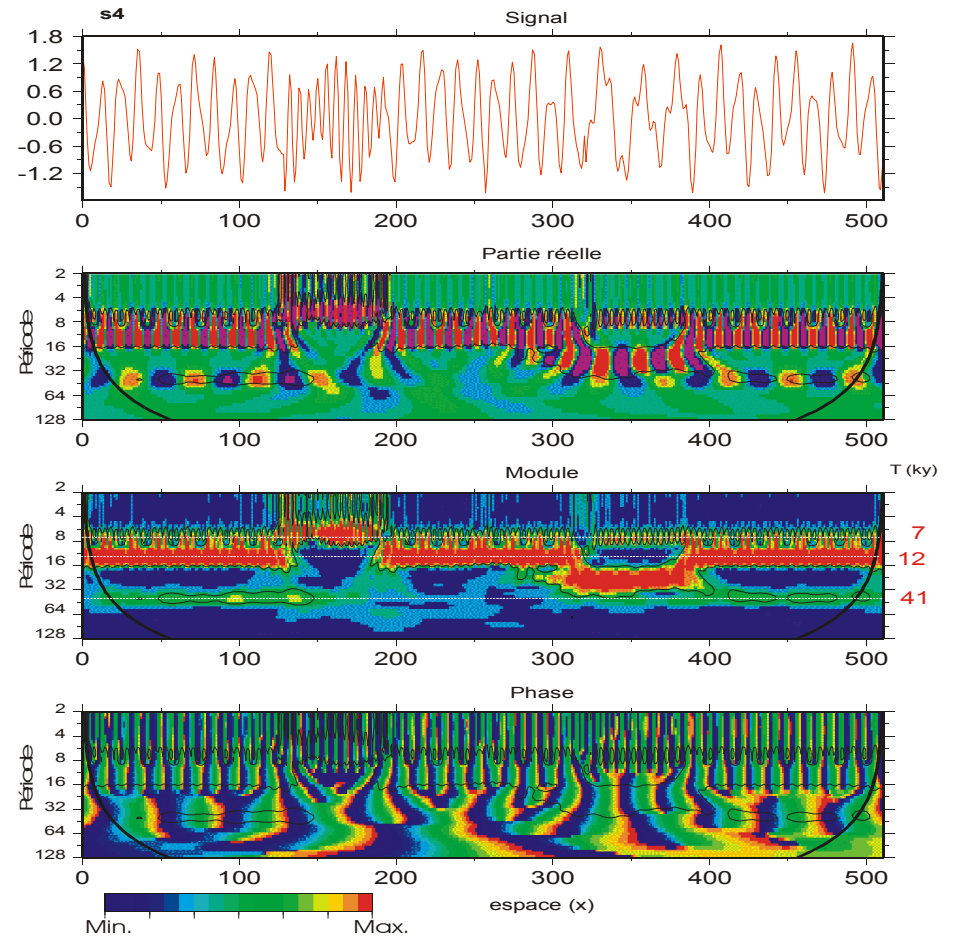
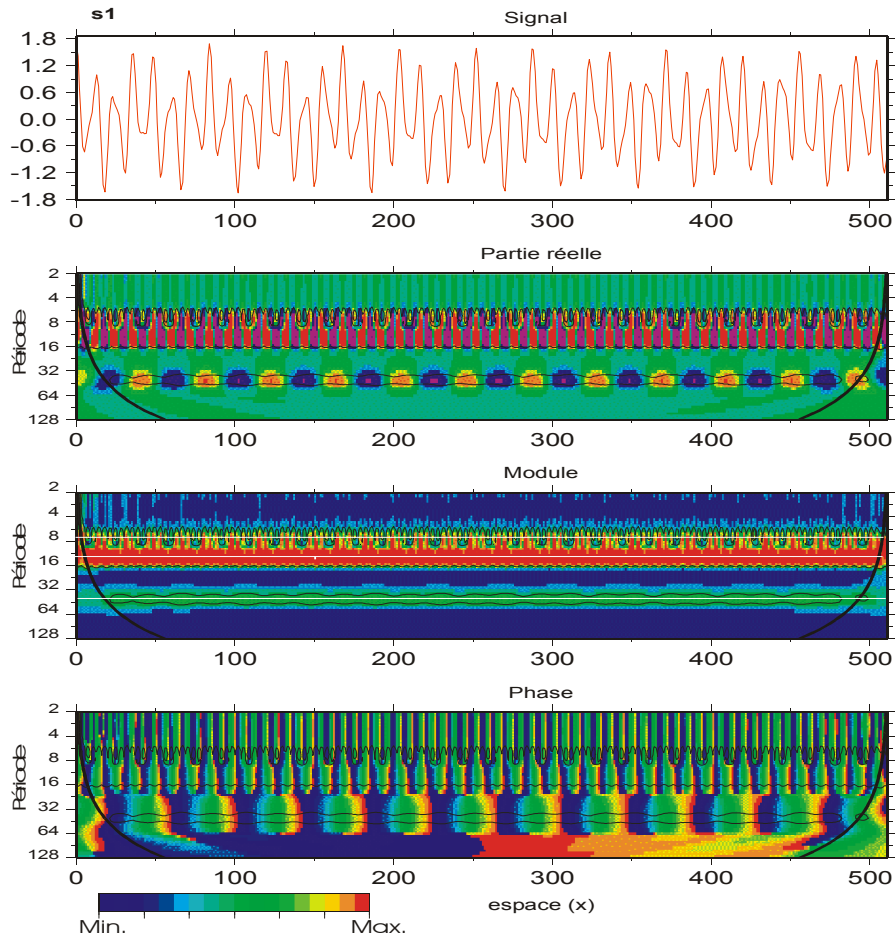
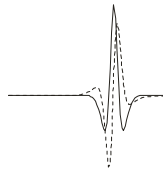


Spectre local

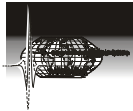
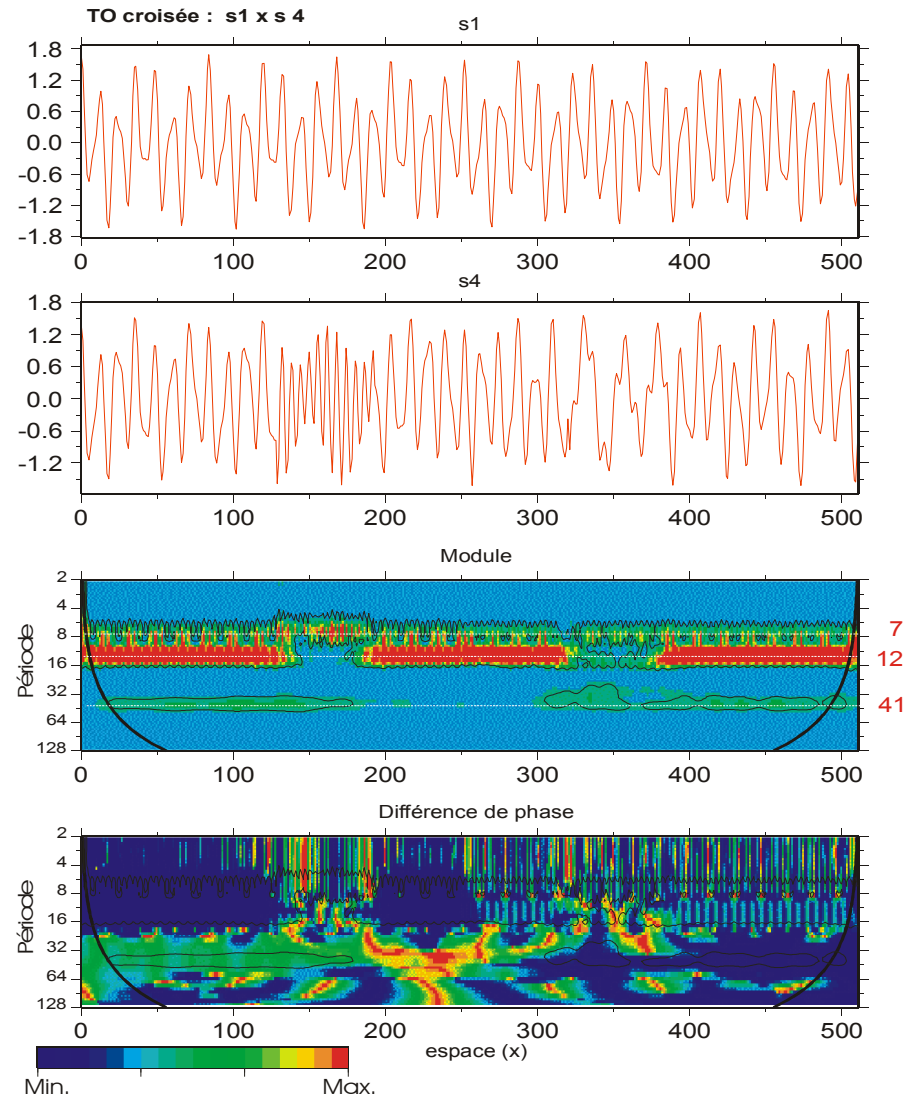
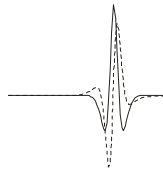
Torrence and Compo, 1998



Interactions entre signaux



Spectre croisé



Résumé

Ondelettes

locale et multi-échelles
aucune hypothèse

Représentation "espace-échelle"

dynamique
comportement multi-échelles

Processus

