



# Outline

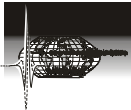
---

- Issue
- Formalism

①D - **Relative geomagnetic paleointensity**  
- Automatic picking of seismic phases

②D - Spatial distribution of seismic events  
- Analysis of mineral organizations of magmatic rocks

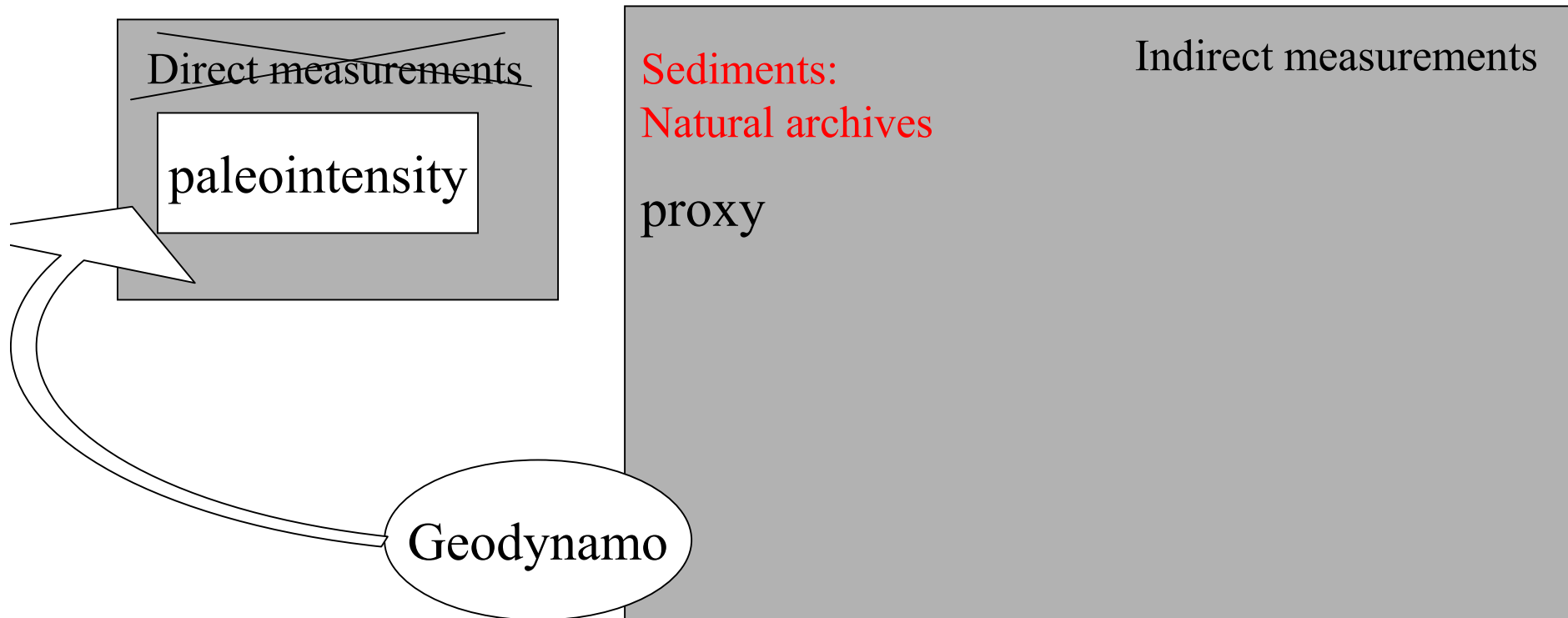
- Conclusion



# Wavelet and relative geomagnetic paleointensity

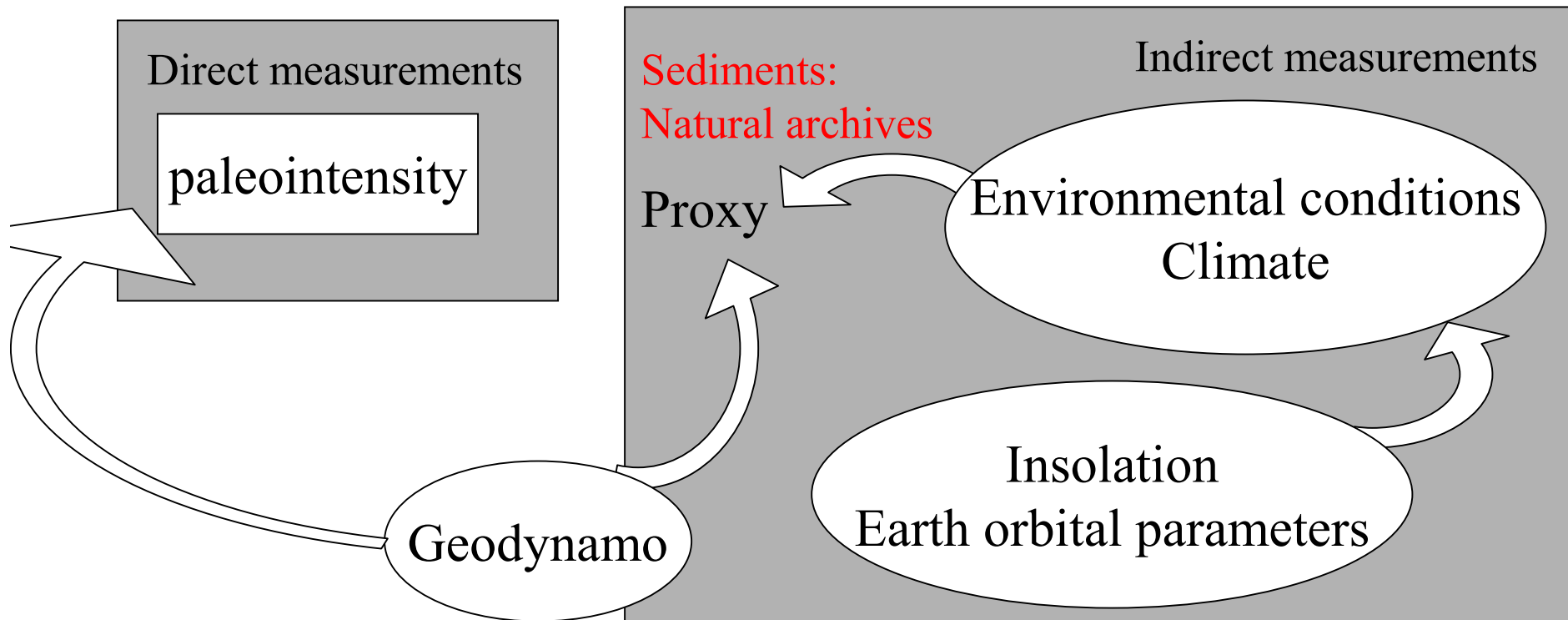
Y. Guyodo & J. Channell (U. of Florida); EPSL, **184**, 109-123, 2000.

## Reconstruction of relative geomagnetic paleointensity



# Reconstruction of relative geomagnetic paleointensity

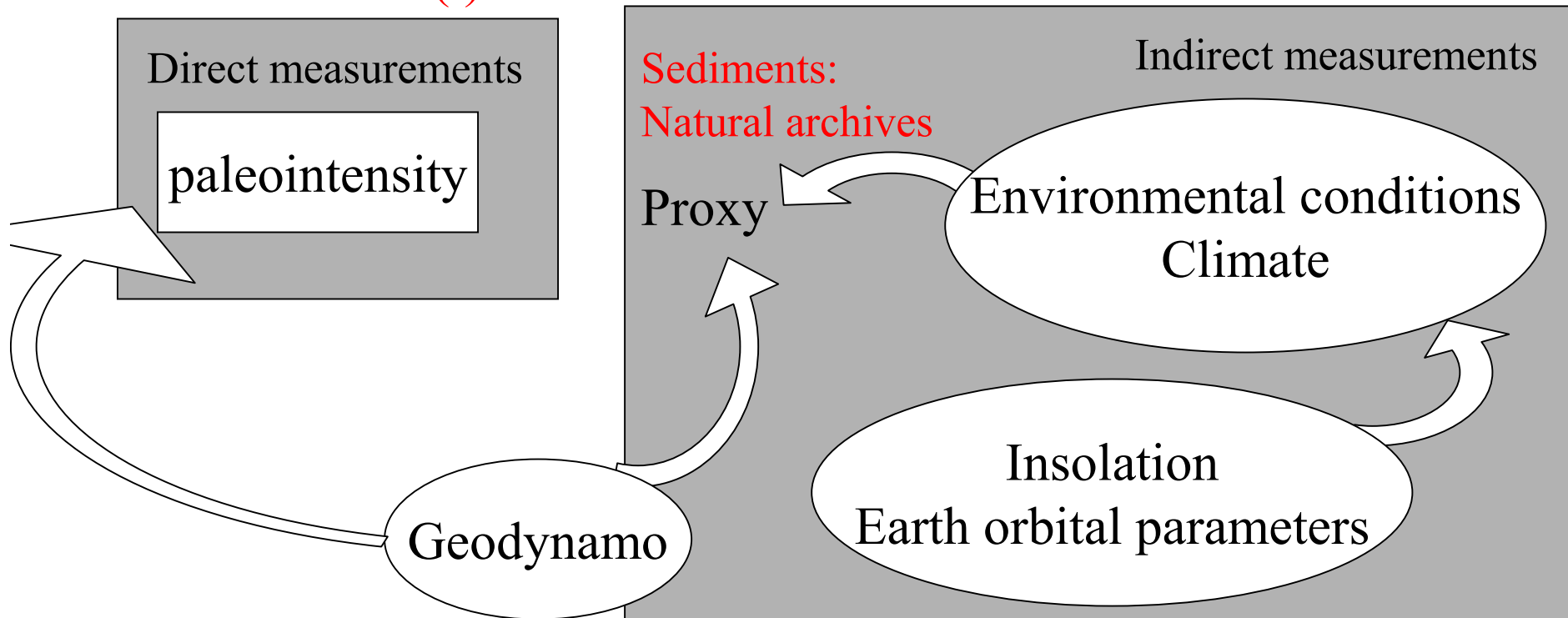
$$P(z) = f ( \mathbf{I}(t), \text{mineralogy, sedimentation rate, ...} )$$



# Reconstruction of relative geomagnetic paleointensity

$$P(z) = f(I(t), \text{mineralogy, sedimentation rate, ...})$$

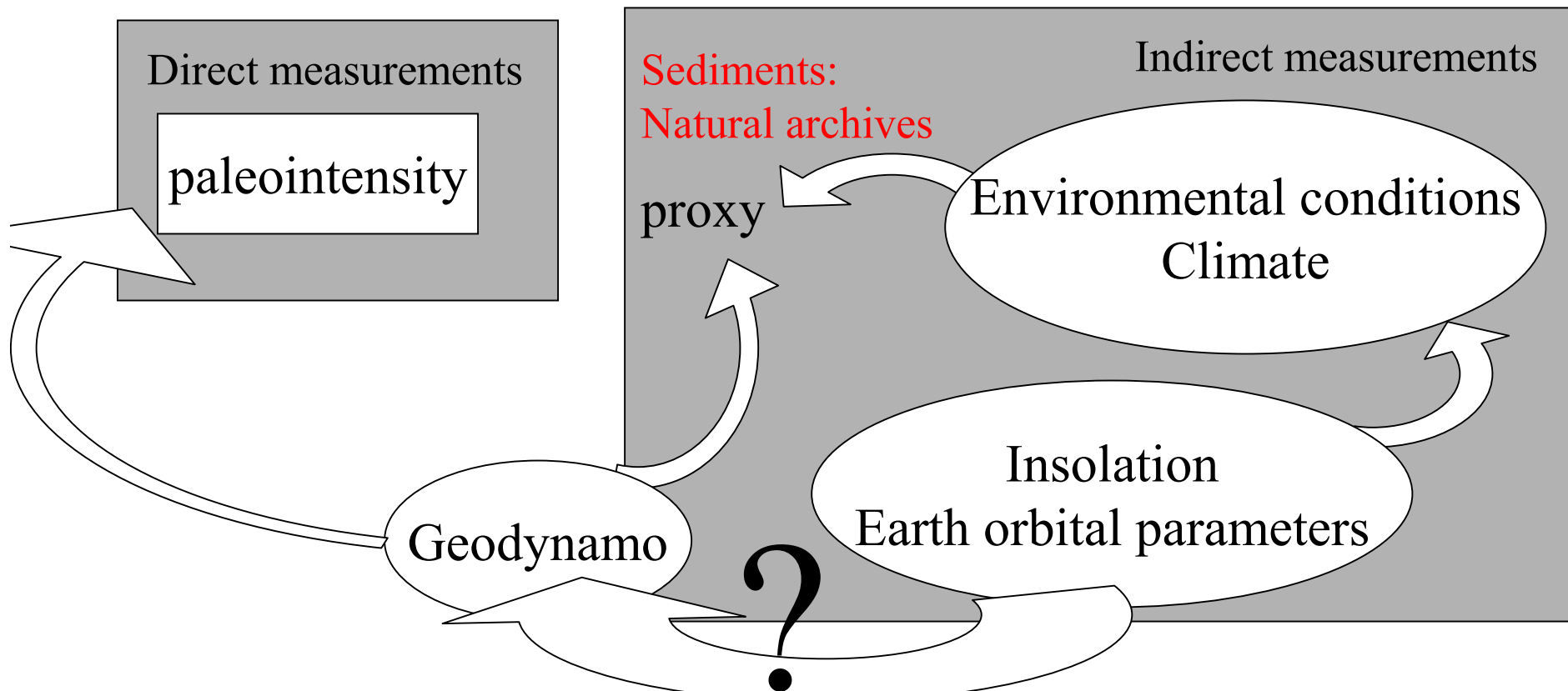
→  $I(t)$



Calibration in time ( $\delta^{18}\text{O}$ ) - Normalization

# Reconstruction of relative geomagnetic paleointensity

## Orbital forcing of the geomagnetic field

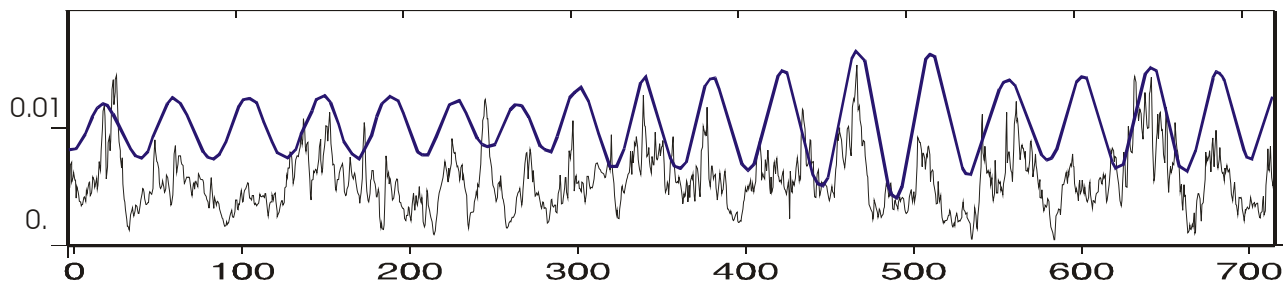


Channell et al., 1998

# Orbital forcing of the geomagnetic field ?

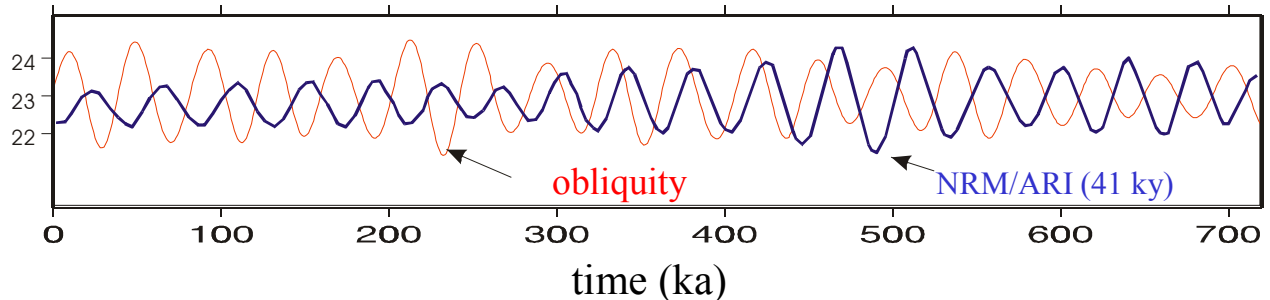
ODP 983

NRM/IRM

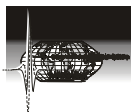


NRM/IRM

Obliquity

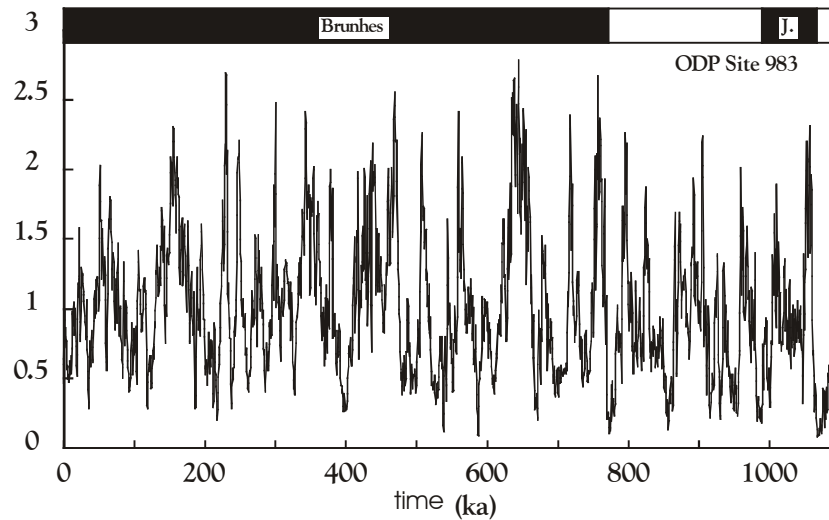
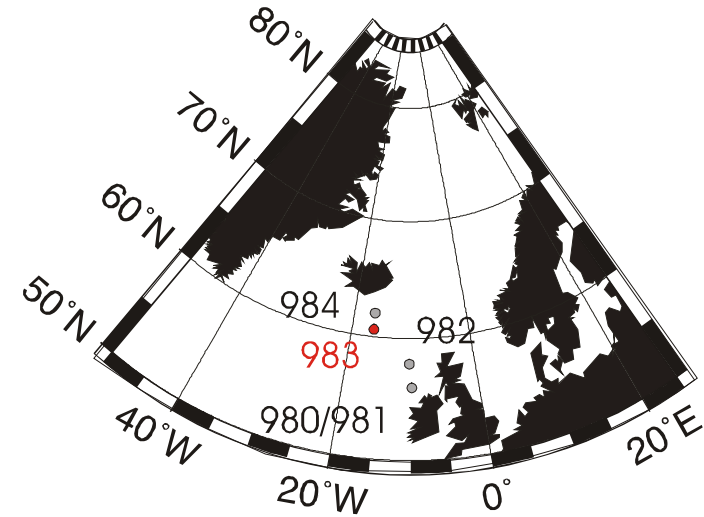


Channell and al. (1998)



# ODP Site 983

Arctic - N Atlantic border  
Ocean - atmosphere exchanges  
Climatic variability

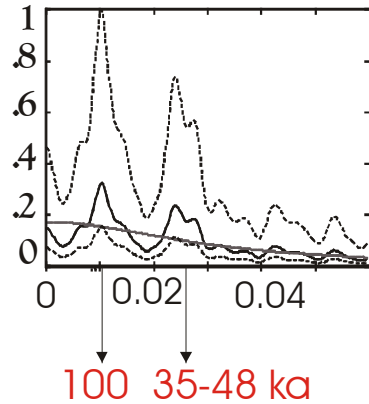


High resolution (12.3 cm/ka)  
High density of tie point  
NRM, ARM, IRM, k → **NRM/IRM**

Relative geomagnetic paleointensity

# Spectral analysis

## 1) Power spectrum

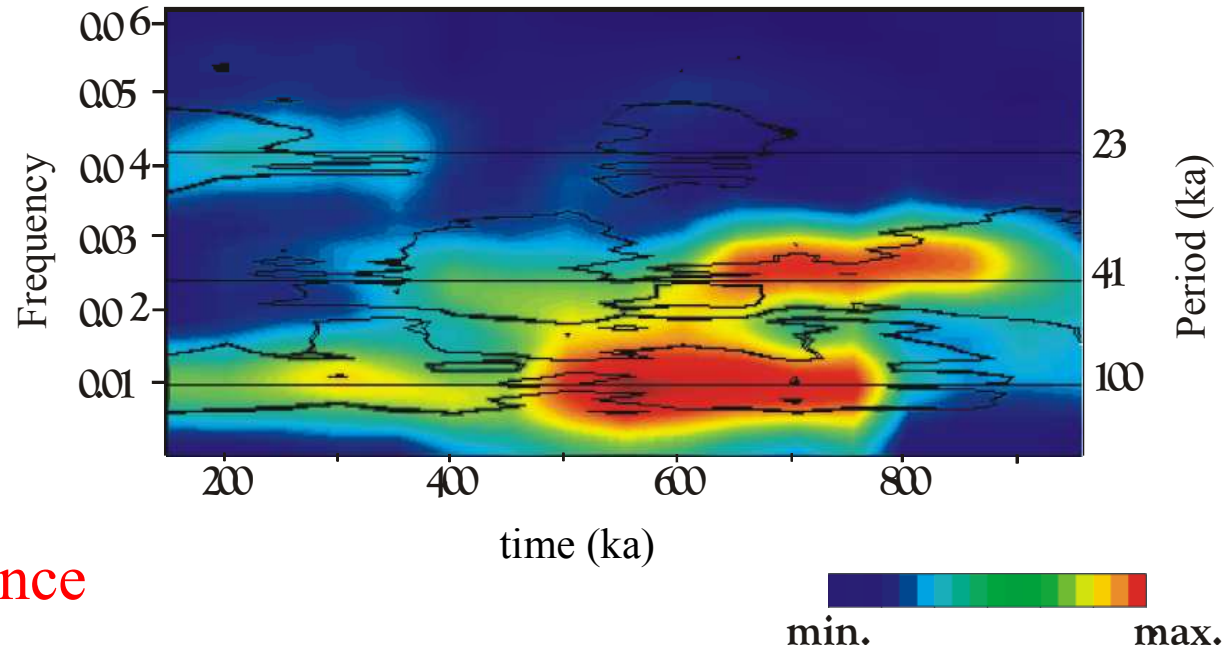


Non stationary  
Temporal dependence

## 2) Evolutionary power spectrum

Window = 300 ka

Step = 50 ka



Relative geomagnetic paleointensity

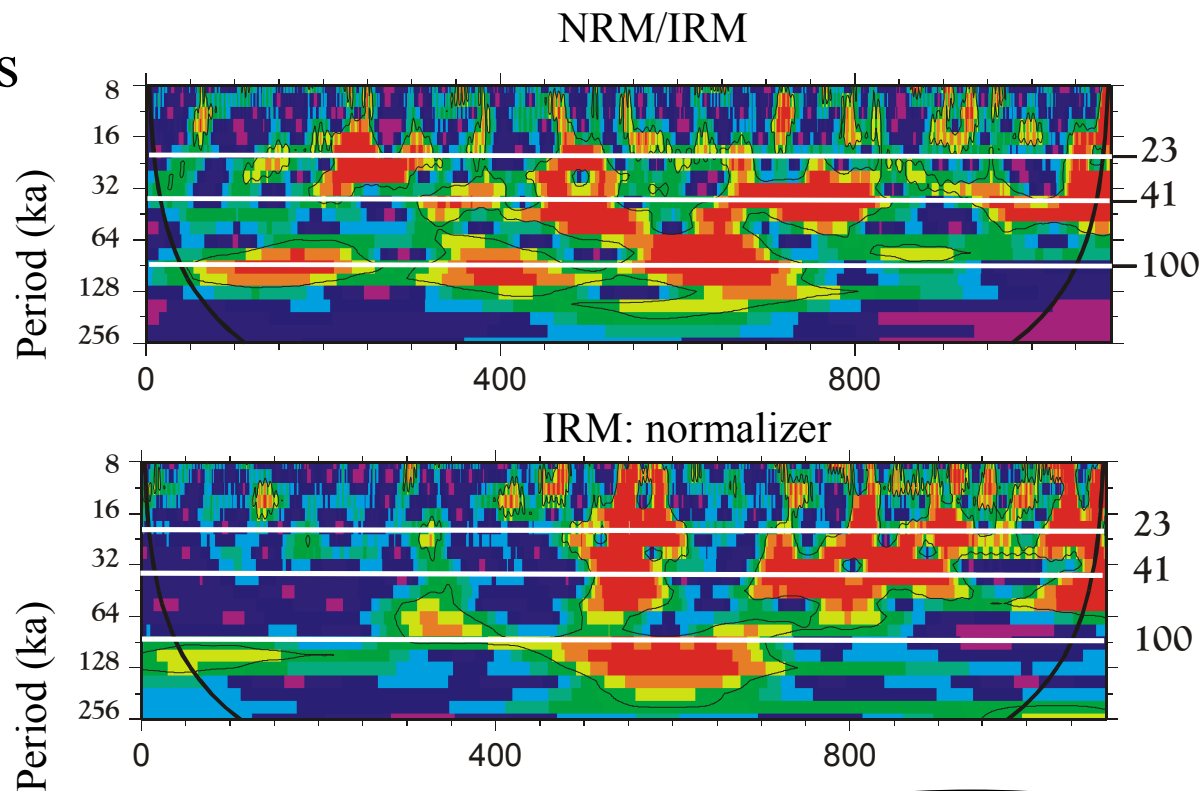


# Normalisation reliability

## 3) Wavelet analysis

Significant power in frequencies corresponding to orbital parameters

Lithologic component of NRM not completely removed by the normalization with IRM



Orbital parameters

Environmental cond.

$$\text{NRM}(t)/\text{IRM}(t) = f(I(t), \text{lithology})$$

Relative geomagnetic paleointensity

# Estimation of lithological effect

## 4) Cross Wavelet spectrum

Local correlation

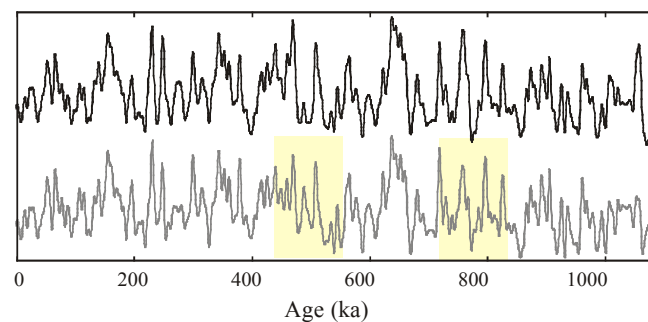
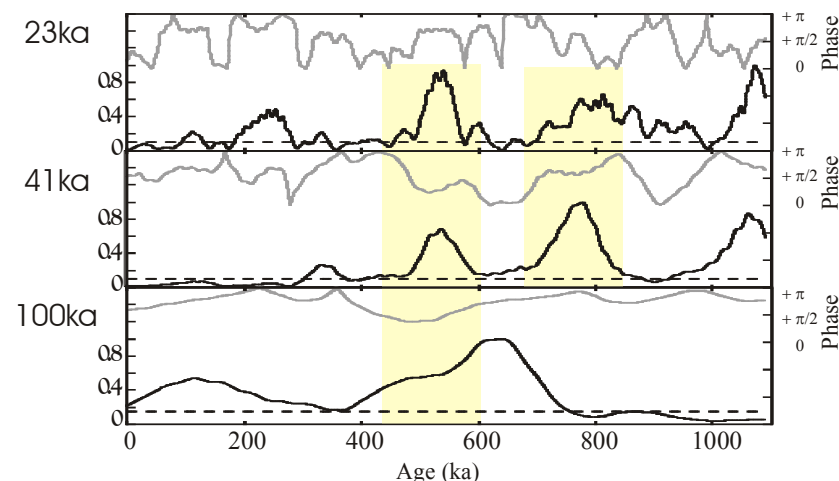
NRM/IRM - IRM

Proxy - normalizer

Incomplete normalization

Quantify the dual dependency of the NRM, on the IRM and ARM/k (time dependent)

The lithologically-controlled overprint characteristics features their usefulness for correlation to other paleomagnetic records



Relative geomagnetic paleointensity



# Results and conclusion

---

## Time-frequency representation

define intervals where orbital frequencies are present

investigate the stability of the covariance function (proxy - normalizer)

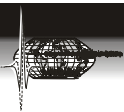
detect a secondary lithologic overprint ← incomplete normalization

## Orbital forcing ?

other records

good quality

various climatic context





# Outline

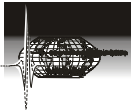
---

- Issue
- Formalism

①D - Relative geomagnetic paleointensity  
- Automatic picking of seismic phases

②D - Spatial distribution of seismic events  
- Analysis of mineral organizations of magmatic rocks

- Conclusion



# Wavelets and seismological observatory

ReNaSS (French seismic survey)

12 seismic events / day

7 days / week

1 seismic alarm / week

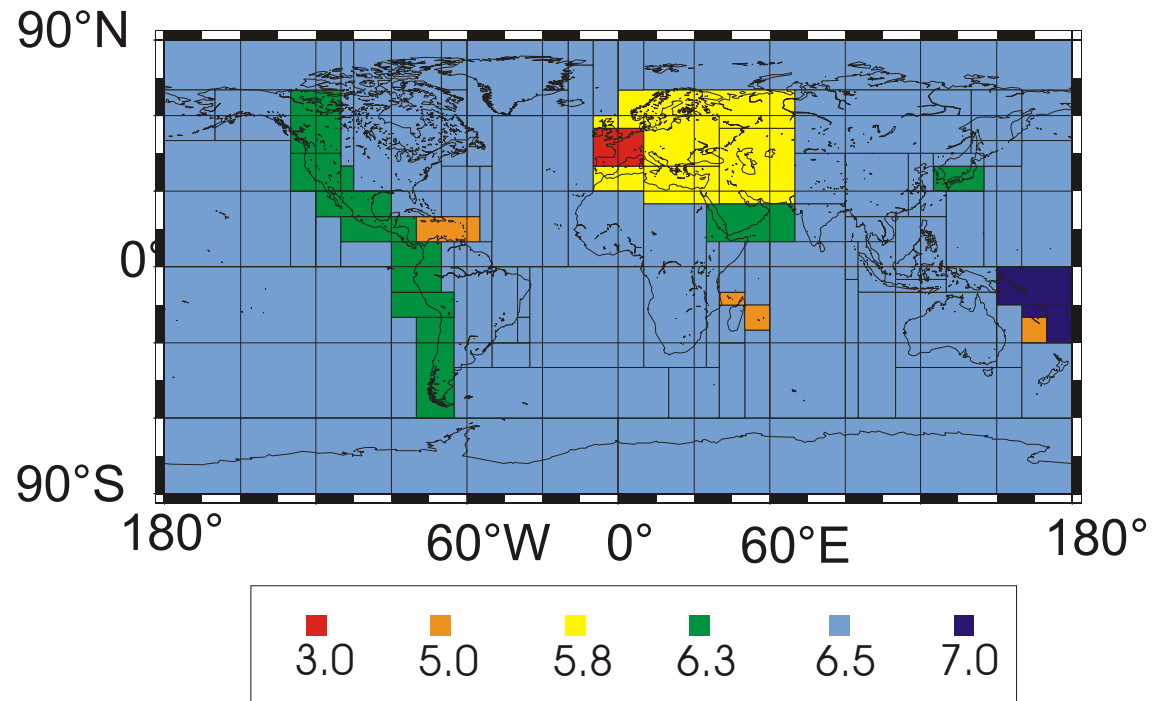
Automation

24h / day

7 days / week



Seismic alarm



Automatic seismic phase picking



# Requirements

---

Detect arrival time of seismic phases

Reject noise

Distinguish local from teleseismic events

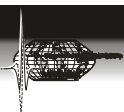
Give accurate and reliable picks

## Expected accuracy

Local event (Pg, Pn) < 0.5 s

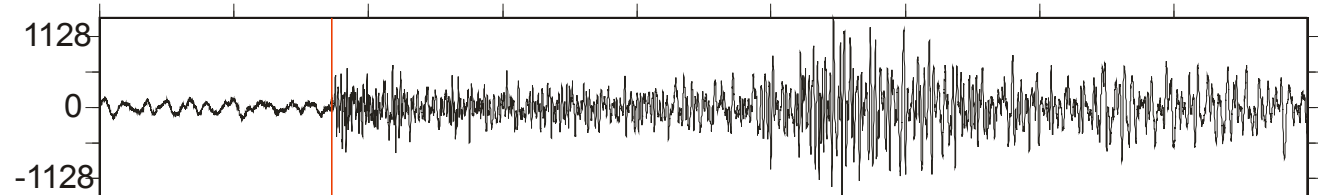
Local event (Sg) < 1.0 s

Teleseismic event < 1.0 s

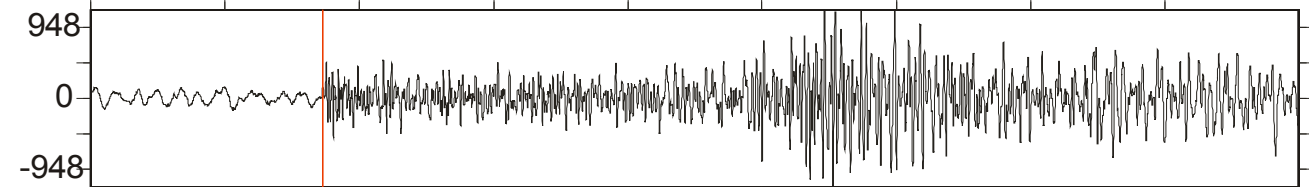


# STA/LTA Algorithm

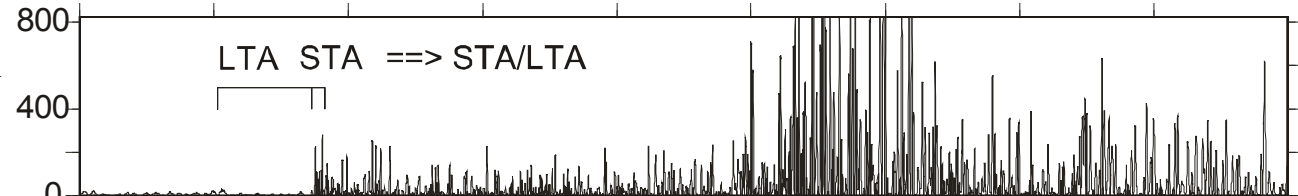
Original seismogram



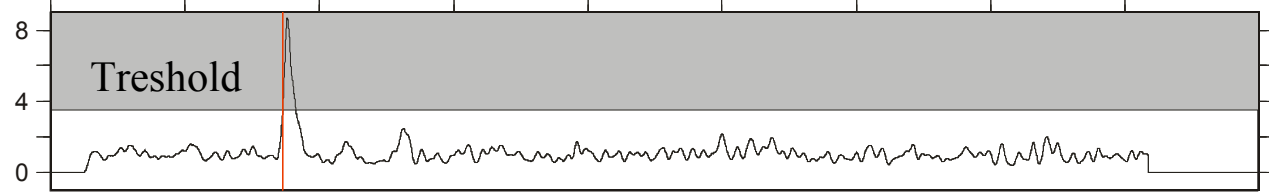
Filtered seismogram



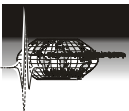
Characteristic function



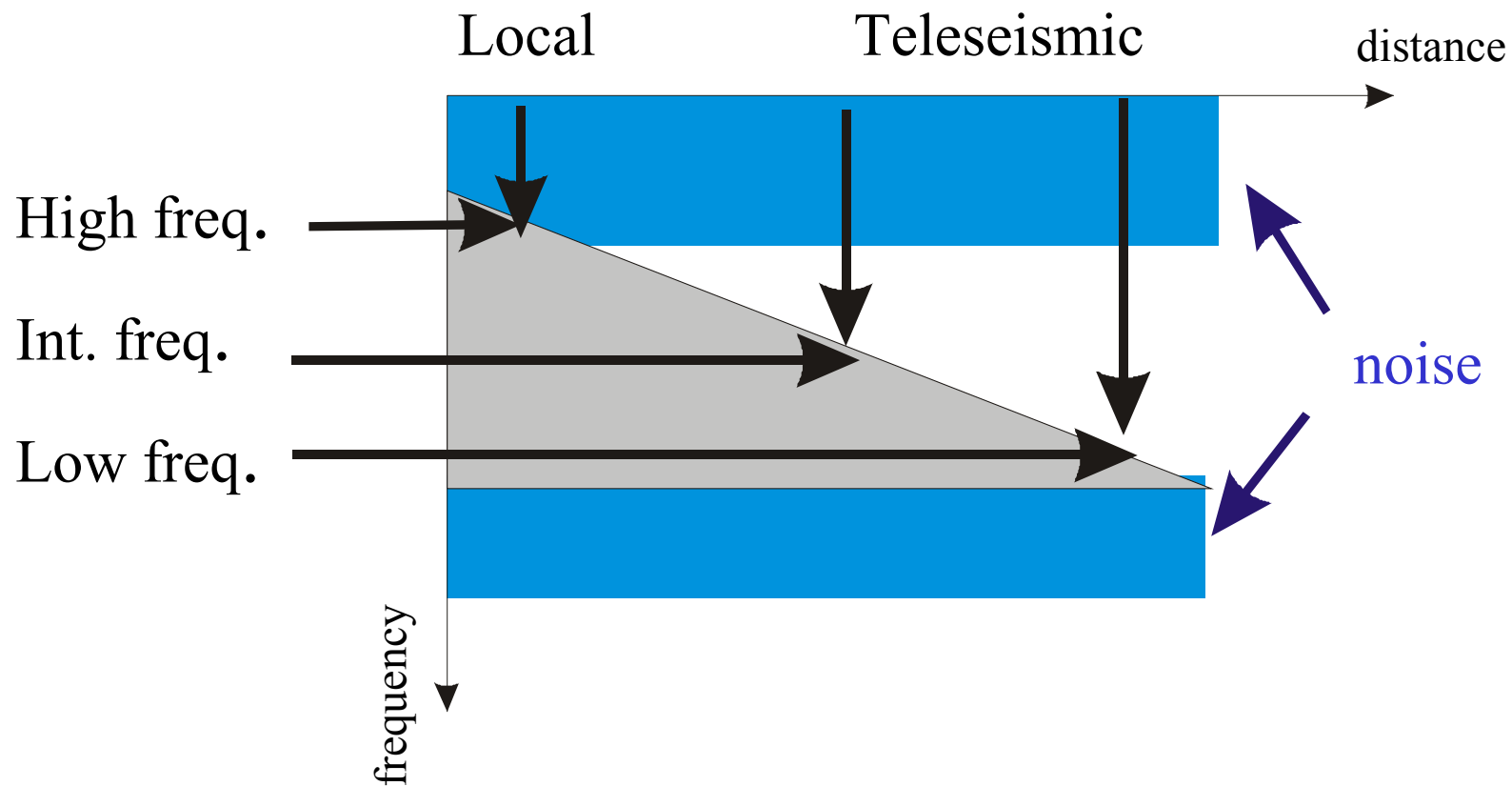
STA/LTA ratio



time (s)



# Physics

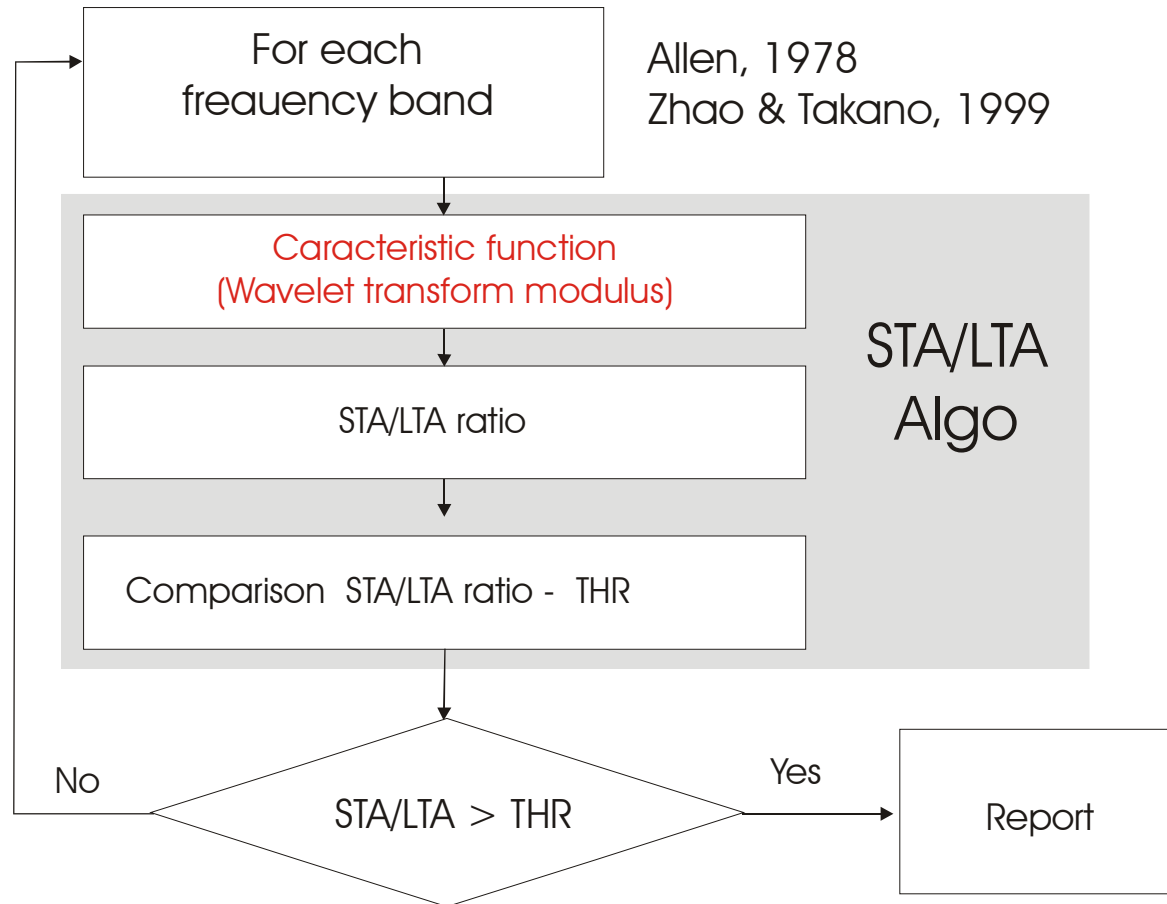


Allen, 1978

Zhao & Takano, 1999

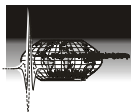
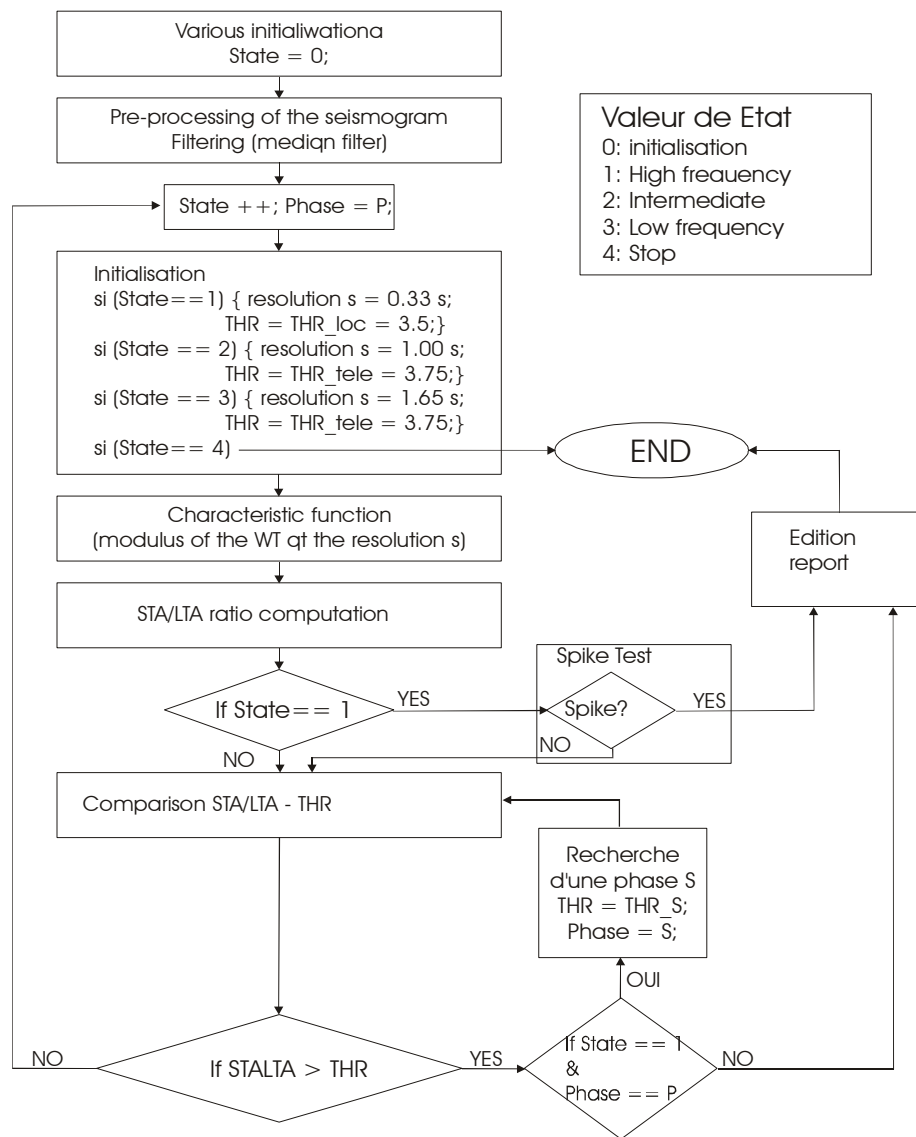


# Developed algorithm



**Improvements**  
Elimination of spikes  
S picking

# Detailed algorithm



# Parameters

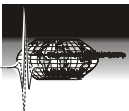
<i>Original data</i>	
Duration (s)	180.0
N data points	16384
Sampling rate (Hz)	91.02

<i>Analysis</i>	<i>Start (s)</i>	<i>End (s)</i>
Local	5.0	20.0
Teleseismic	150.0	150.0

	<i>Window (s)</i>
STA	0.055
LTA	5.5

	<i>Resolution (s)</i>
High frequency	0.33
Intermediate	1
Low frequency	1.65

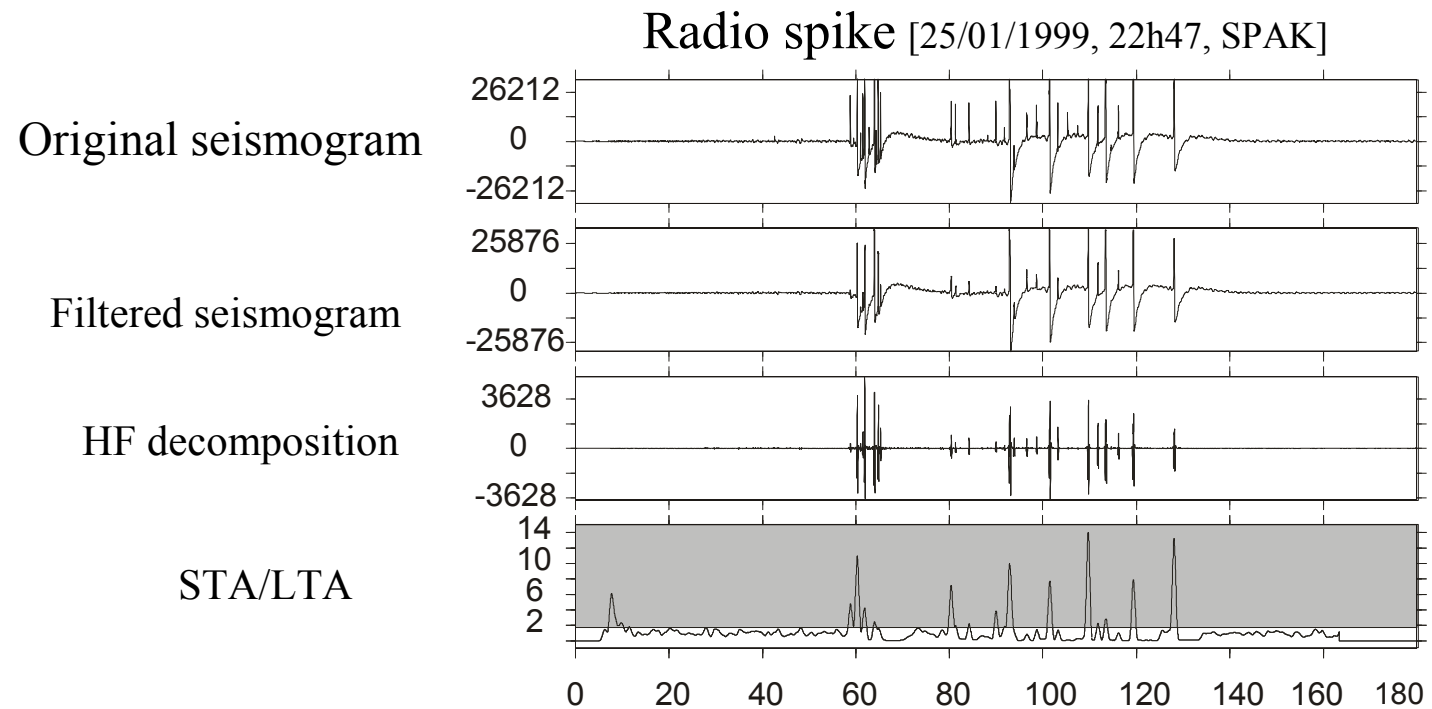
	<i>Threshold THR</i>
P_local: THR_loc	3.5
S_local: THR_S	2.8
P_teleseismic: THR_télé	3.75



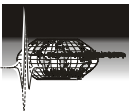
# Spikes elimination

$N > 4$

$\text{THR\_spike} = \max(\max(\text{STA}/\text{LTA}/25), 1.75)$

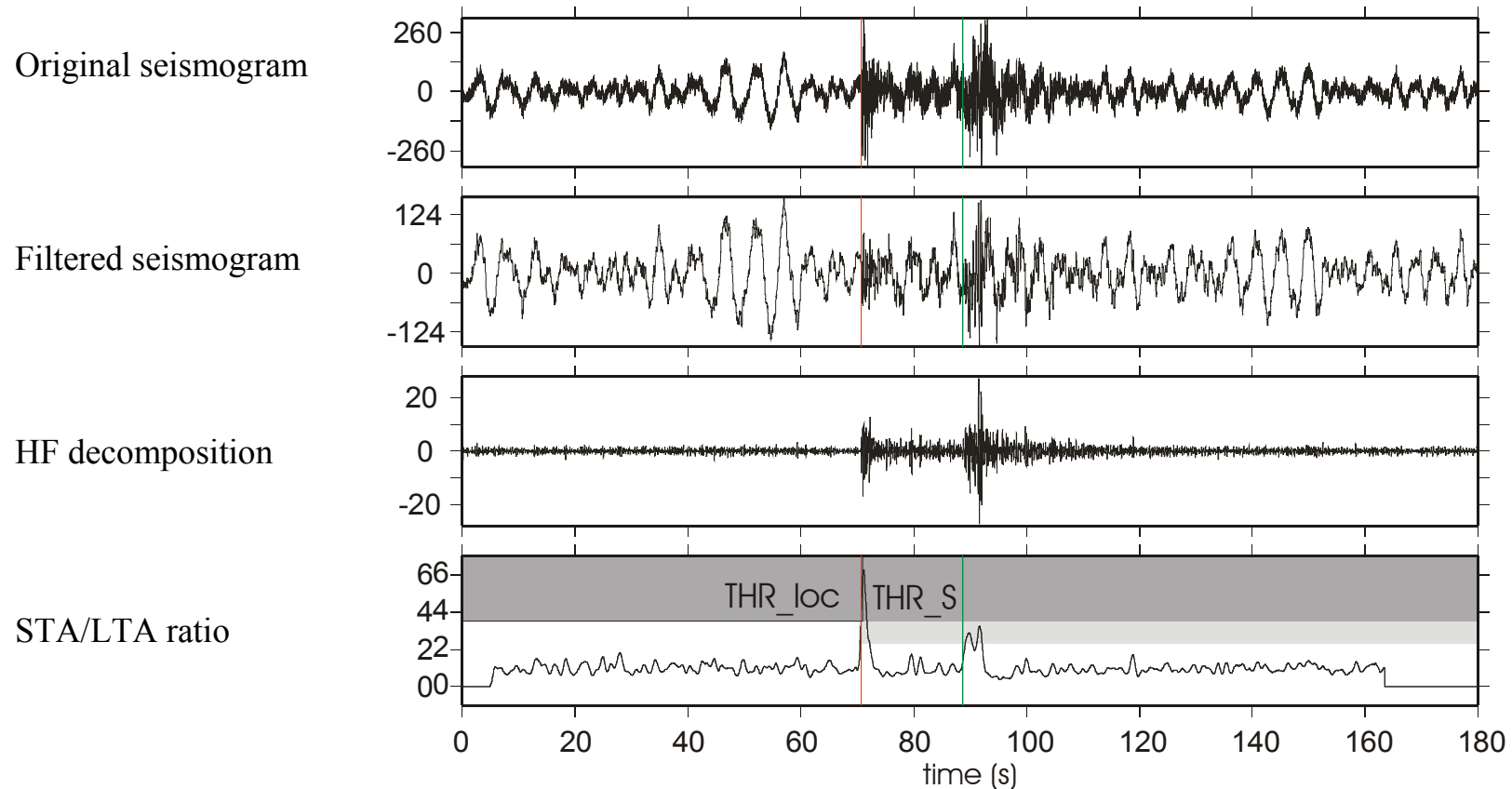


Rejected seismogram

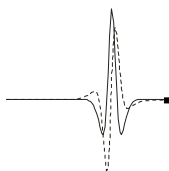


# S phase picking

Colmar [16/03/1999; 16h20; Ml=2.4]

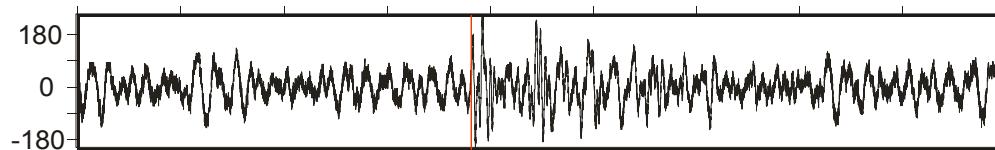


# Teleseismic event

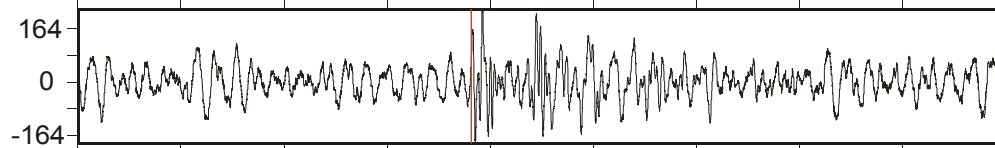


Loyauty island [02/04/1999; 20h16; Mb=4.7]

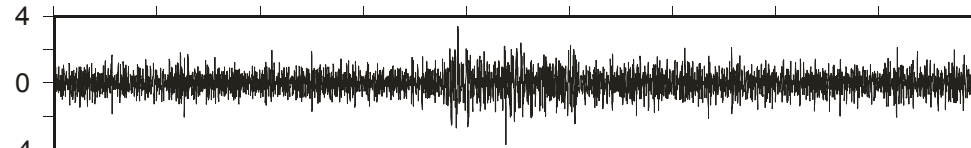
Original seismogram



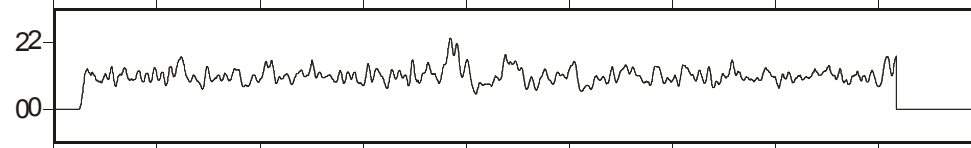
Filtered seismogram



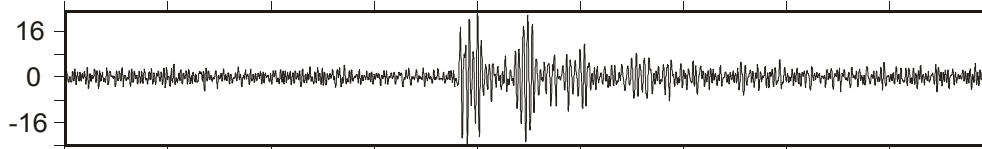
HF decomposition



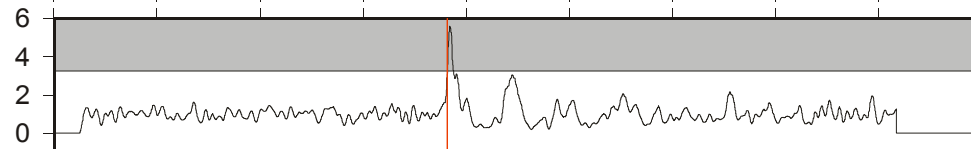
STA/LTA ratio



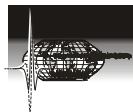
IF decomposition



STA/LTA ratio

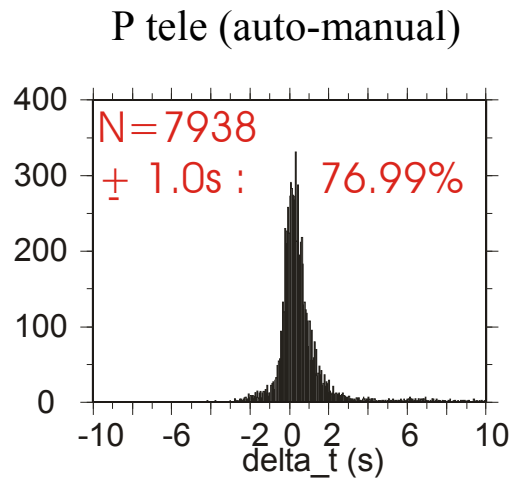
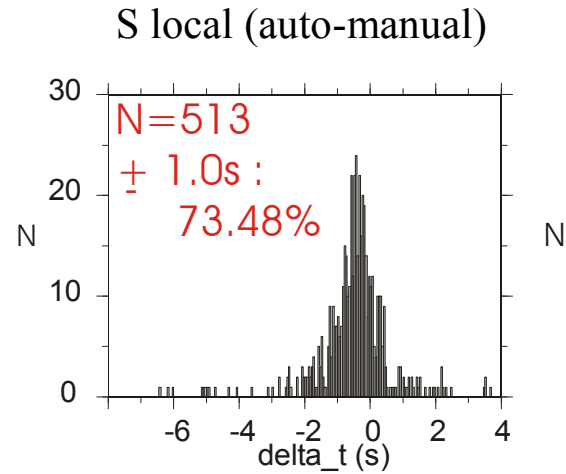
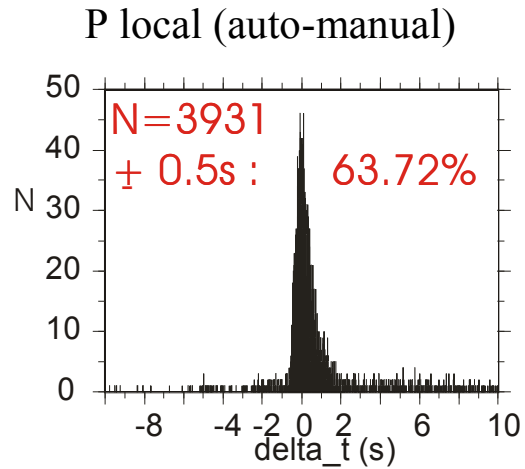


Time (s)



# Statistics

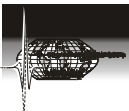
All seismic events [01/09/1998 - 31/12/1999]



## Results:

Success rate: 70%

Gendron et al., BSSA, 06/2000





# Results

---

Increase performance

React 24h/day, 7days/week

## Wavelets

Characterize a transitory signal

Good resolution in time and frequency at all scales

Rapid

## Algorithm

Competitive in time

Distinction local / teleseismic event

Reject uncertain picks

Suppress spike and noise effect

Picking of S phase

Run seismic alarm

