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Smart software and **THEM Geophysics Inc.**

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Who am I? Why am I talking?

- I have a Ph.D. in Engineering Mathematics and am a UofT graduate. I work as a freelance consultant and speaker.

- I have worked for several years with THEM Geophysics on various projects ranging from numerical analysis (F.E.M.) to signal processing.

What I'll do today...

History (where we come from)

- Our software
- Our algorithms (some math)
- Our numerically modelling

Results! Examples of how our work is improving!

The future!

I'll try to stay brief!

A brief history

Early processing (1998 and before)

SIMn baseline correction,
Wavelet-based denoising...

New version of
THEM's software

Split
team

November 1999 revision (DLL)

Late 1999/early 2000
numerical modelling

Soudan (2000)

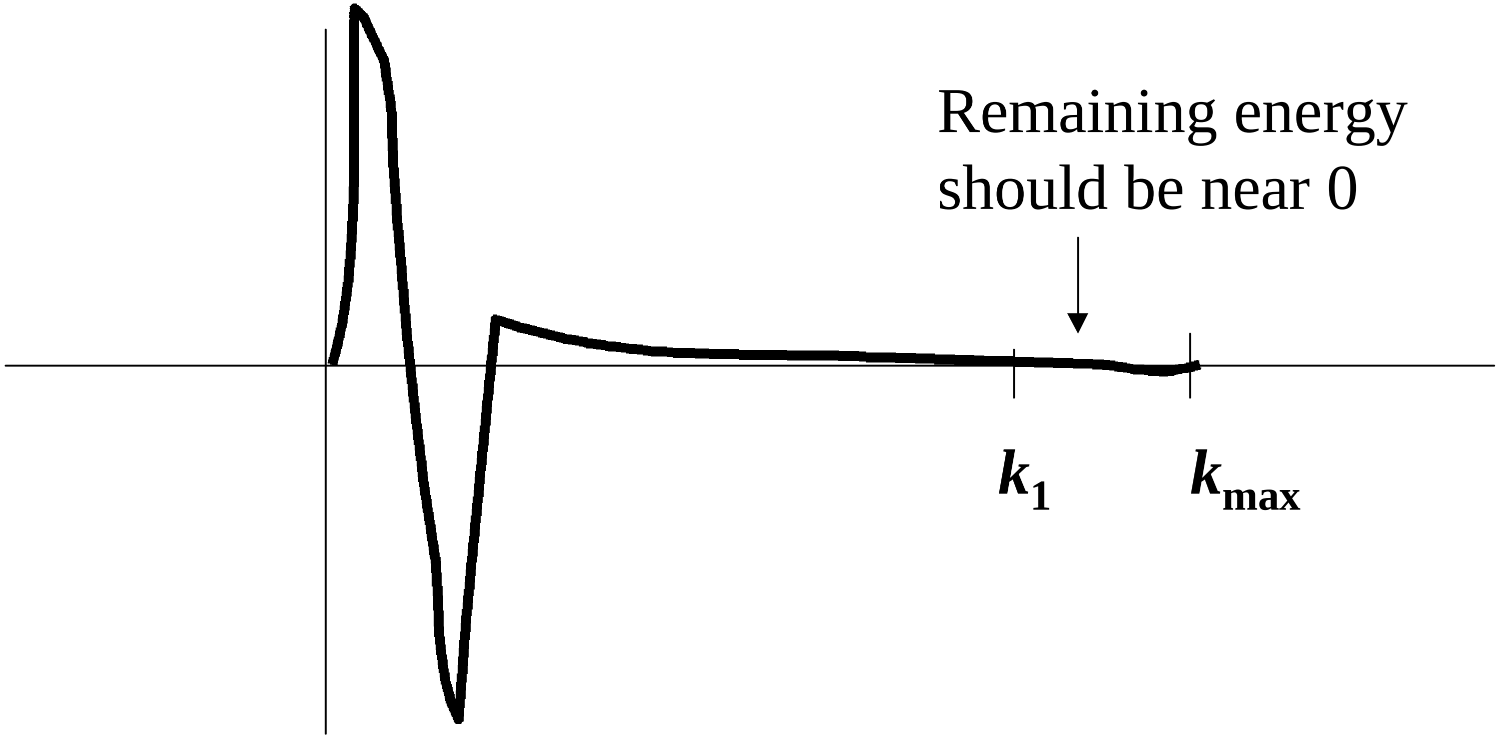
Toronto 2001 meeting?

Problems that have been solved?

- The new DSP library funded and developped for **THEM**, first released as a DLL in November 1999 has yet to be fully integrated in THEM’s systems. By using a DLL, we can easily upgrade the processing and fall back when needed.
- Among a few things, this *new* version fixed many problems in the baseline correction (SIMn algorithm) reported by **CGI**.

How does our baseline works?

The SIMn model first assumes that we can reliably divide the signal of each impulse in two *zones*.



SIMn postulates

1. The baseline should be continuous from one frame to the other;

2. The total mass from 0 à k_1 should be zero;

3. The remaining energy from k_1 to k_{max} should be as small as possible.

Lagrange equations...

Mathematically, we are solving for a polynomial of degree n (noted p) over each frame where y_0 is the value of the baseline at the end of the previous frame and where the actualsignal is noted s.

$$L(a_0,\ldots,a_n,\lambda_0,\lambda_1)=\sum_{k=k_1}^{k_{\max}}(p(k)-s_k)^2-\lambda_0 l_0-\lambda_1 l_1$$

where

$$l_0(a_0,\ldots,a_n)=p(0)-y_0$$

and

$$l_1(a_0,\ldots,a_n)=\sum_{k=0}^{k_1}p(k)-\sum_{k=0}^{k_1}s_k\ .$$

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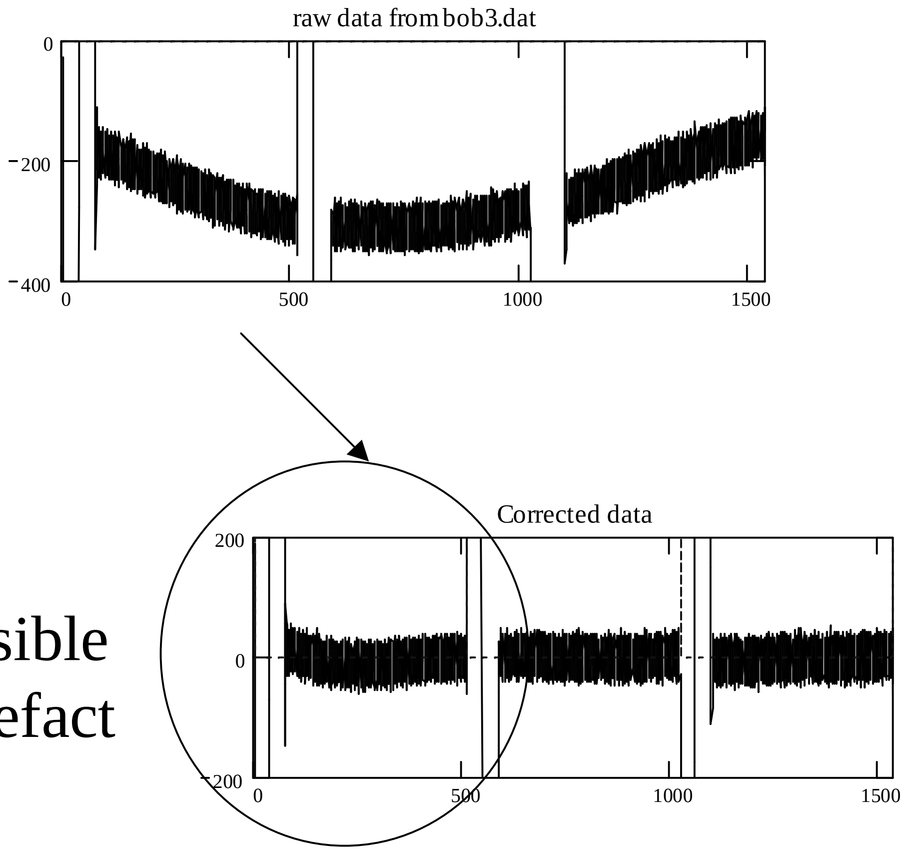
The new baseline in action!



Visible
artefact

It used to be
that the baseline
would require
several frames
to work properly.
The new processing (1999)
reduces these artefacts
dramatically.

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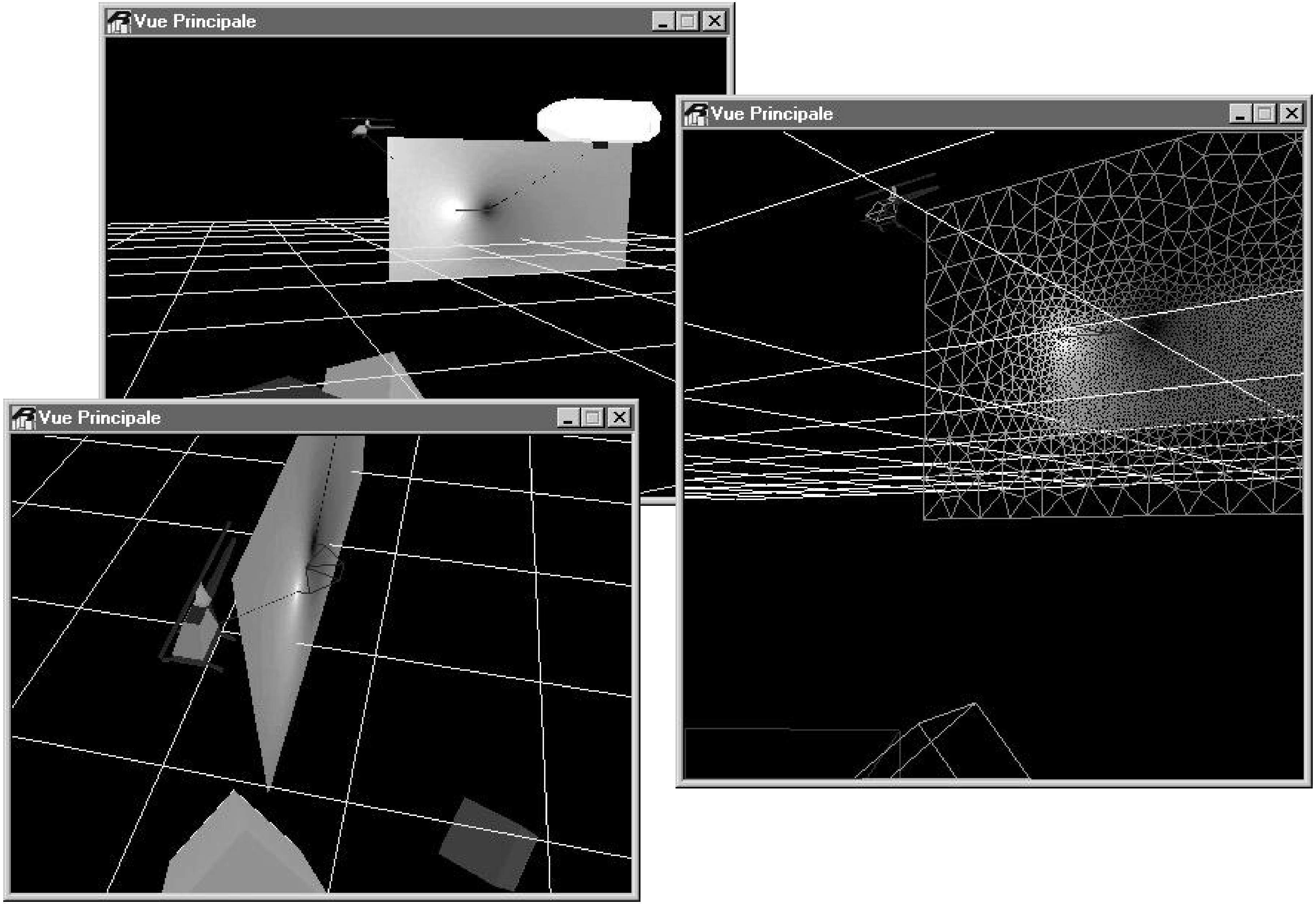
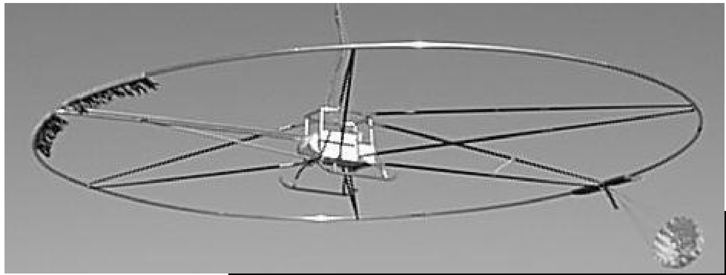
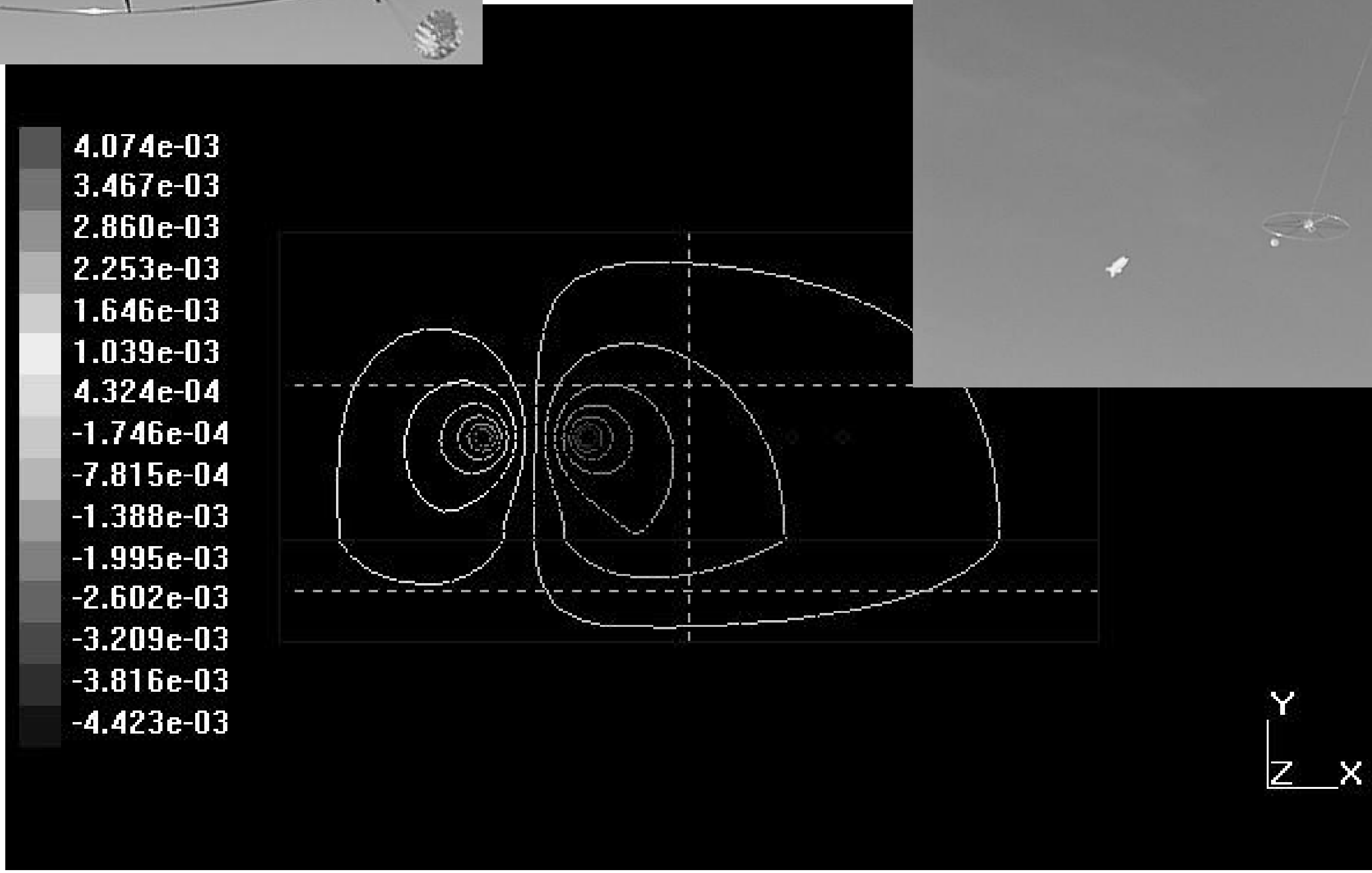
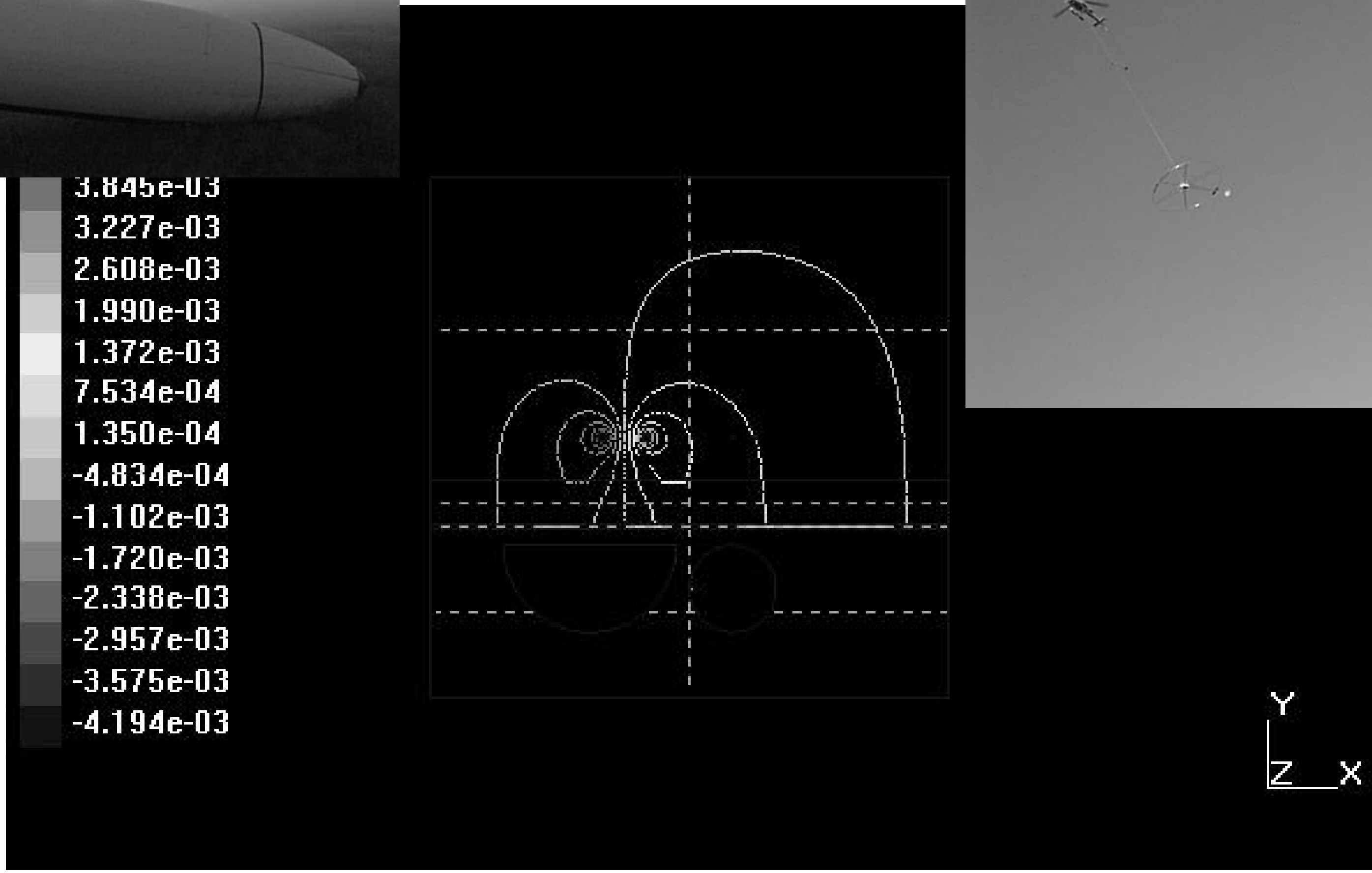
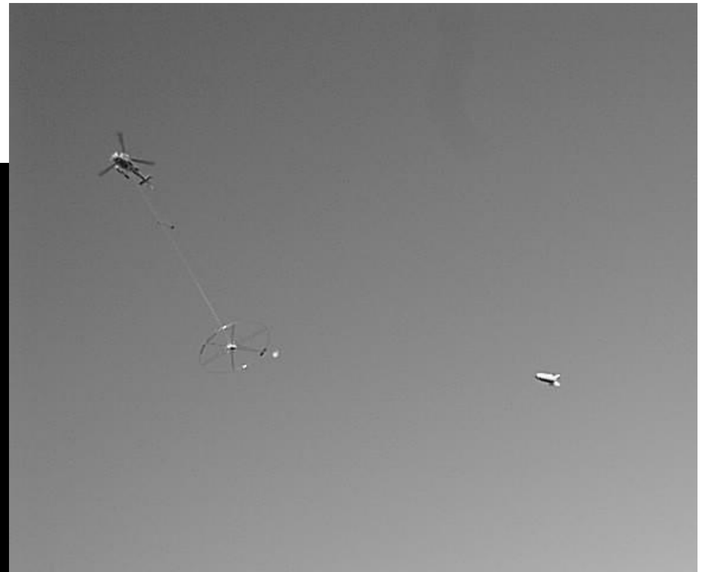






- Inductor, air, soil and receptor (5132 elements)



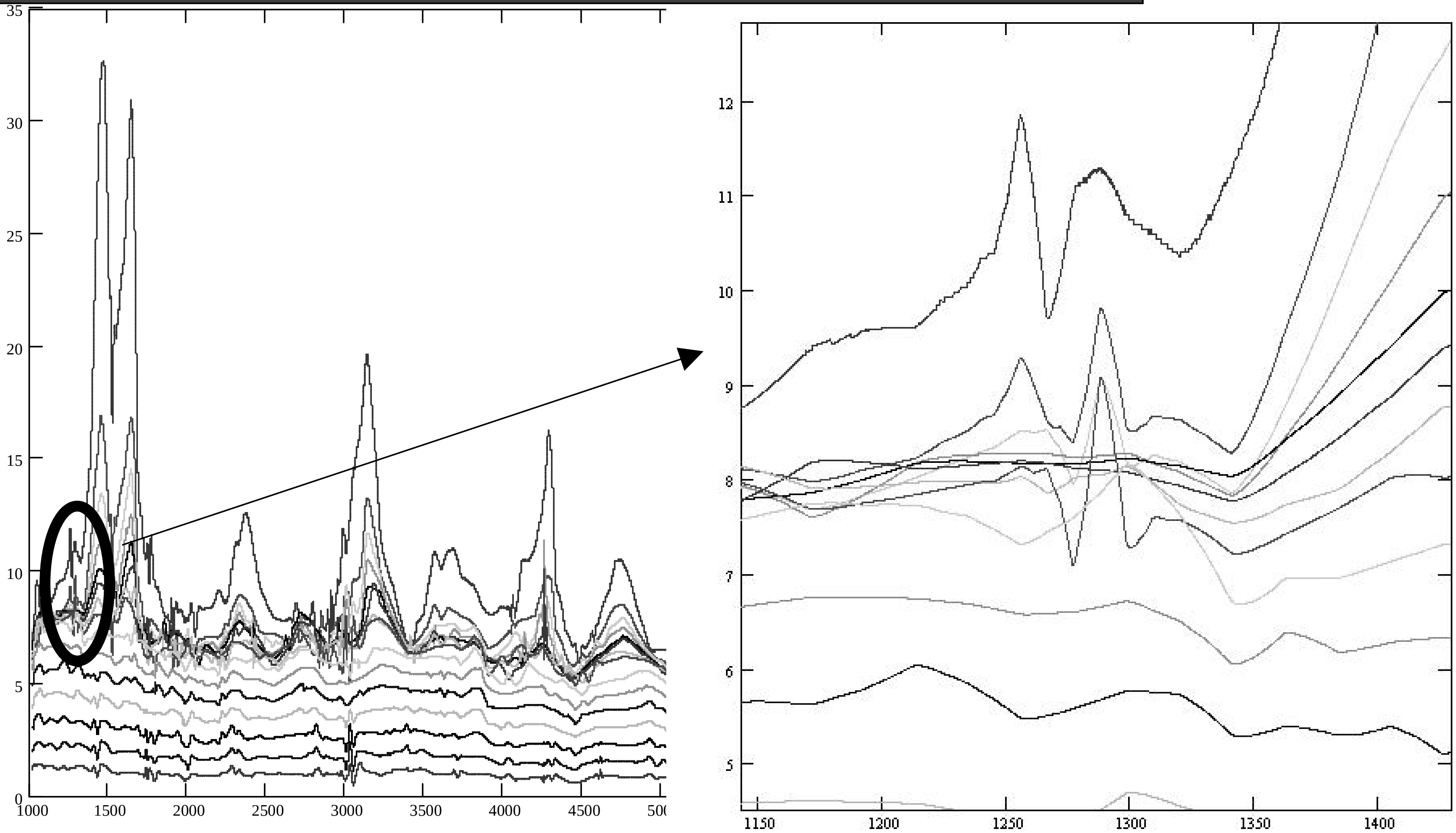


- Inductor, soil, highly conductive sheet, 2 conductive anomalies, receptor (214056 elements)

Feature extraction through wavelets

Most current denoising scheme either rely on modelling or lowpass/highpass filtering. Filtering is nice because it provides you with smooth curves if you want to… However, doing so will also kill some features that you may want to keep.

To properly select the features that might be interesting we use a time-frequency analysis called Wavelet Shrinkage. In effet, we do no discrimate against any range of frequency in particular (so we might keep a lot of very localized components if needed) but focus on keeping the most significant features, no matter what they are.



At lowsettings, it kills much of the apparent noise , while keeping some striking features.

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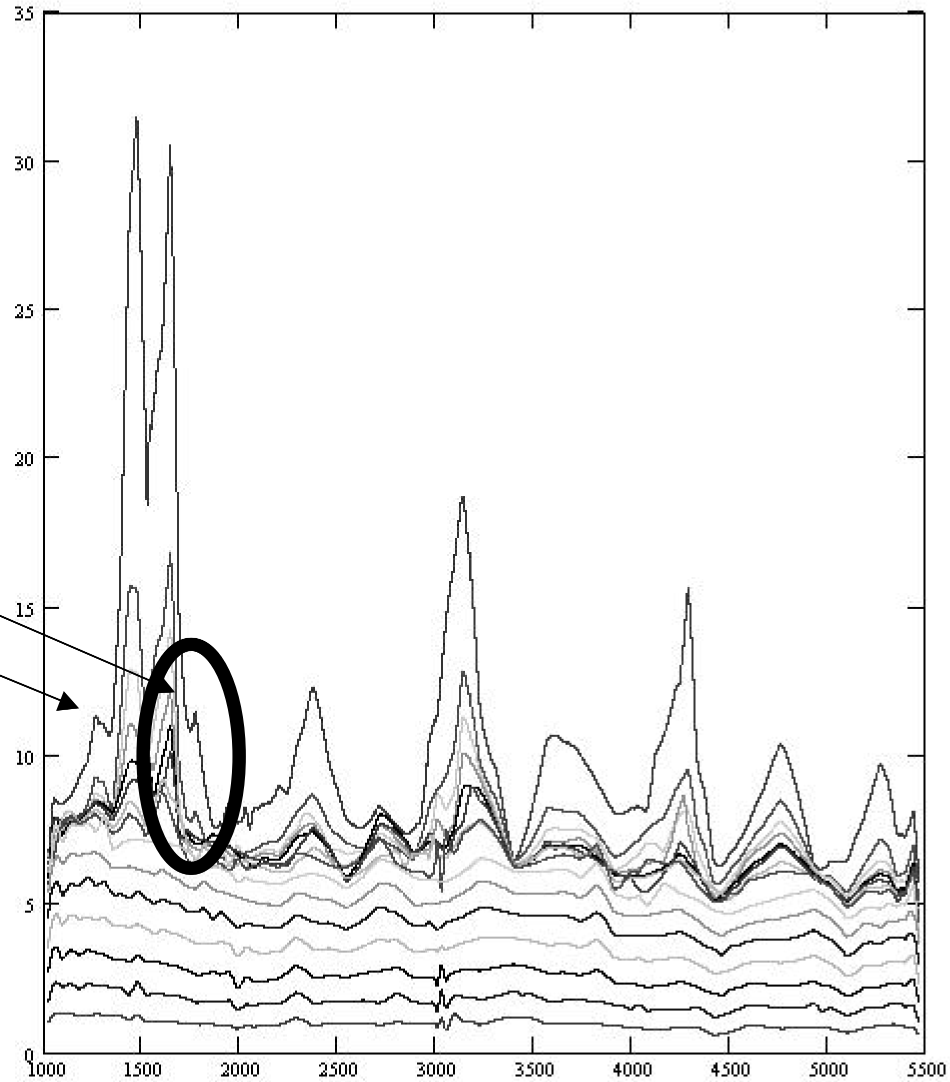
At higher settings
we have a very clean
signal but we keep
dominant features that
might have been lost
with most denoising
scheme.



To resume: we can
provide simple plots
but still keep as much
information as possible!

The future

- Deconvolution (at least compensate for the morphology of the impulse)
- Better wavelet processing (less aliasing)
- Achieve scientific results with unicoil
- B field estimation through spline modelling
- MAG compensation
- stereoscopic acquisition
- better X-Z processing
- Even more accurate baseline

Simplification through convolution

While more research is needed, it is already a fact that deconvolving the frames using a simple input function (a cosine adapted to the impulse length), reduce a great deal the entropy… (3 complex numbers model more than 90% of the energy in the signal)