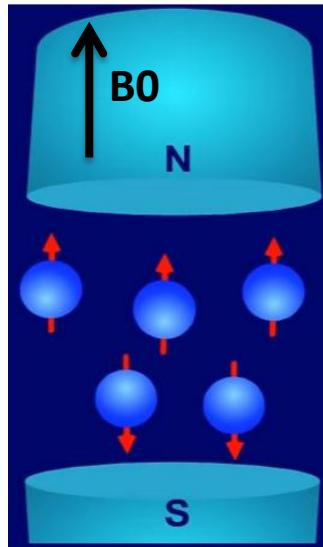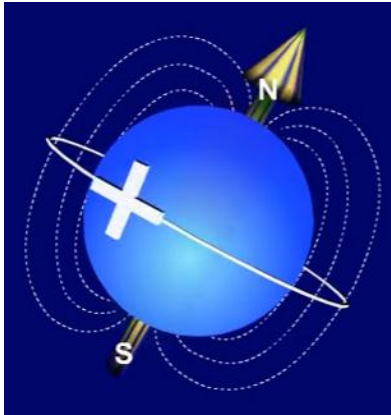# Surface Nuclear Magnetic Resonance (SNMR)

Objectives /possibilities

- Estimate water content in the subsurface
- Depth and thickness of aquifers
- Distinguish free water from bound water
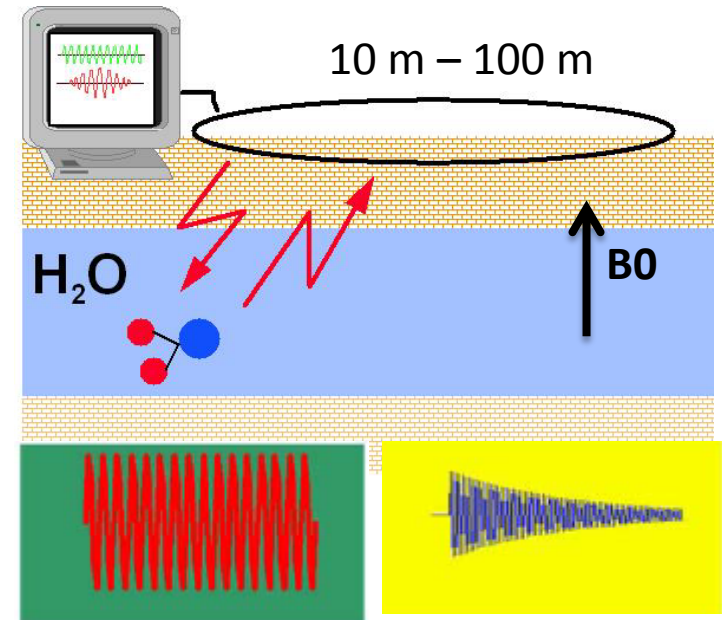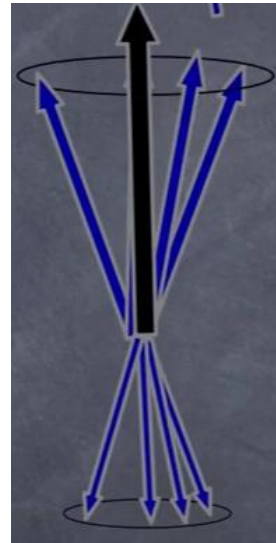- Estimate hydraulic properties (porosity / hydraulic conductivity)

Basic principles : flipping the magnetic moment of hydogens atoms from the H20 molecule and measure the precession magnetic field.
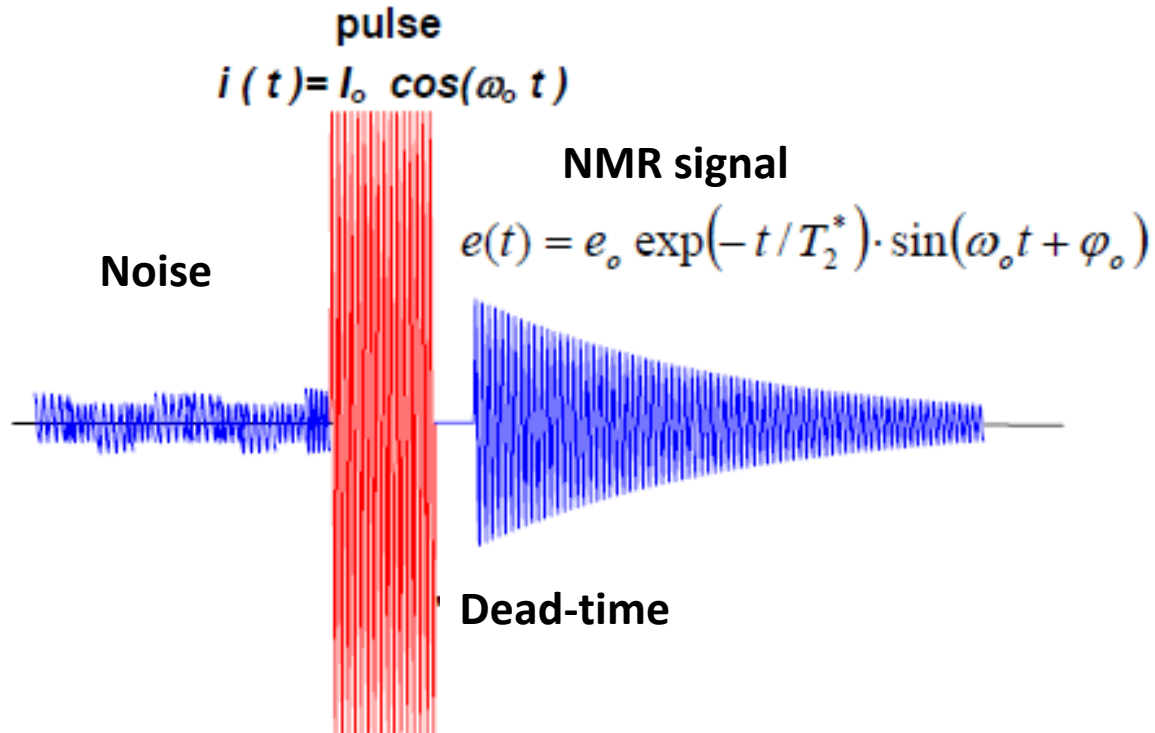
Spin => magnetic moment

Magnetization vector

Static magnetic field

10 m – 100 m

H_2O

$B0$

$$f_0 = \gamma B_0$$
Larmor frequency

Surface Nuclear Magnetic Resonance (SNMR)

NMR signal

pulse

$i(t) = I_o \cos(\omega_o t)$

NMR signal

Noise

$e(t) = e_o \exp\left(-t / T_2^*\right) \cdot \sin(\omega_o t + \varphi_o)$

Dead-time

E_0 ⟶ **Water content**
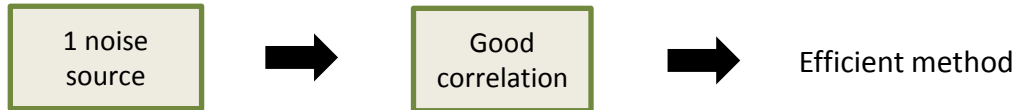
T^*_2 ⟶ **Hydraulic properties**

Surface Nuclear Magnetic Resonance (SNMR)

Anthropic and natural EM noise mask the NMR signal

Measured signal

$$p(k) = \mathrm{NMR}(k) + h_p(k) + \mathrm{spikes}_p(k) + N_p(k)$$

Uncorrelated noise
- *Electronics*
- *????*

NMR signal

Harmonic components (LHT)

- *Electrics fences*
- *Thunder*

Harmonic filtering

Despiking

Stacking

Adaptive reference noise cancellation

Transfer function **FT1**

N1

Ref1

Primary

| 1 noise source | → | Good correlation | → | Efficient method |
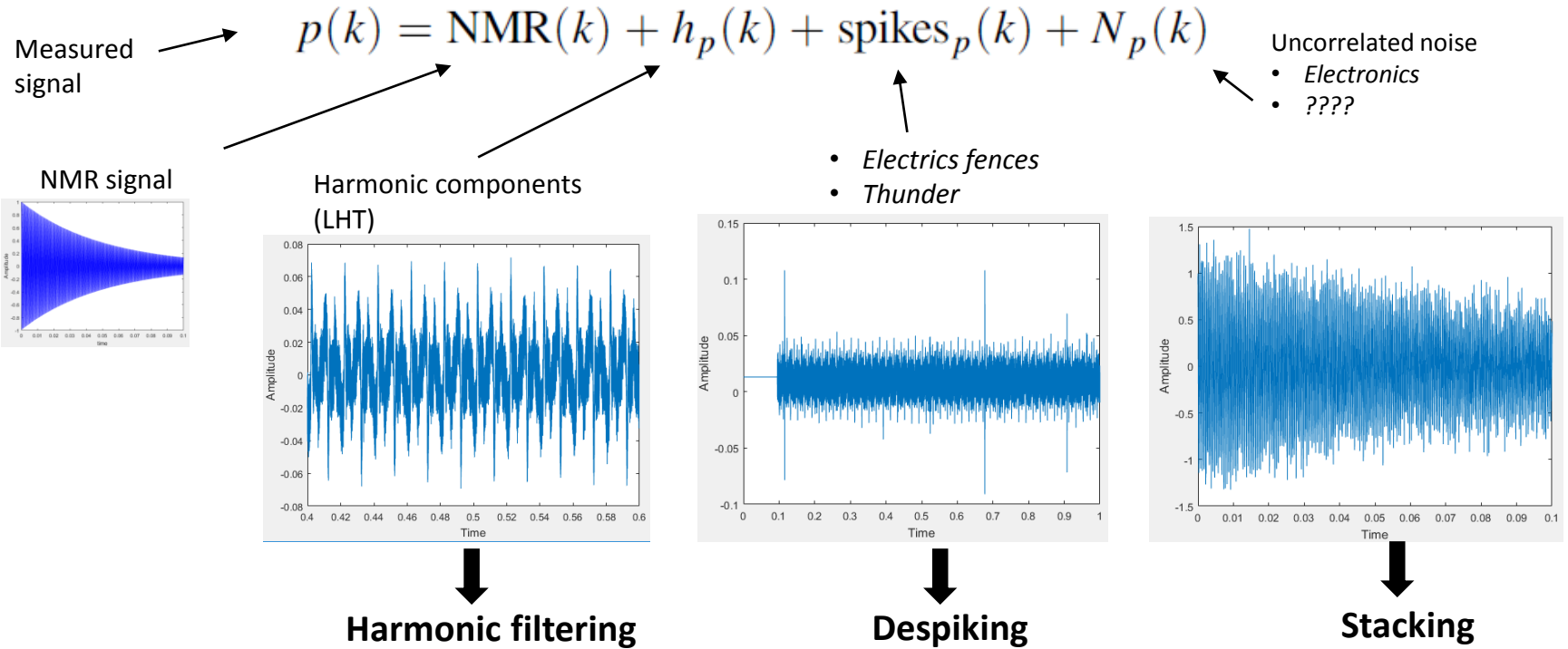
Processing SNMR signals

Adaptive reference noise cancellation

Transfer function **FT1**

FT3

Ref3

Primary

Ref1

FT2

Ref2

1 noise source	➡ Good correlation	➡ Efficient method
Multiple noise source	➡ Correlation decreases	➡ Efficiency decreases
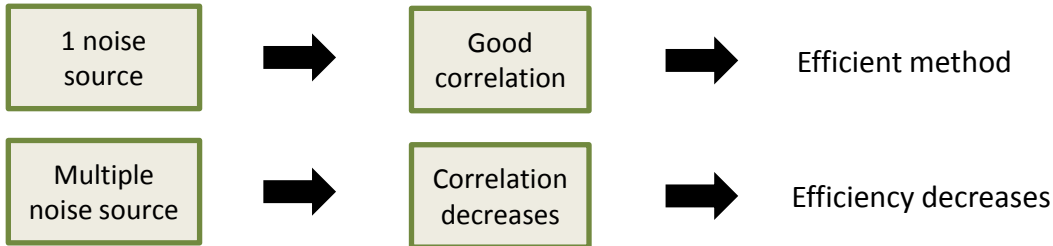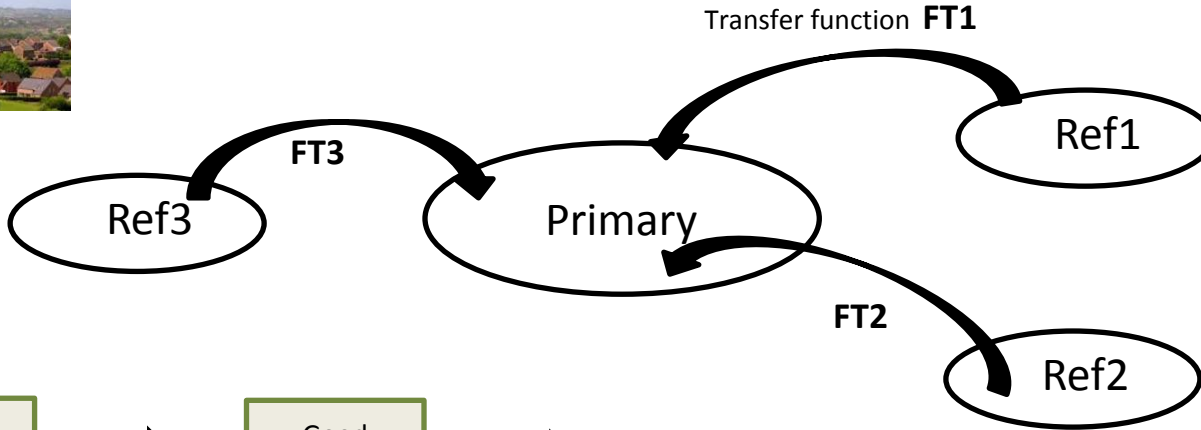
Adapt to multiple noise sources context

Adapting to multiple noise sources context

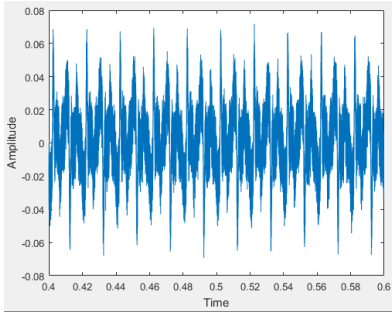## Model-based harmonic filtering – 2 power line
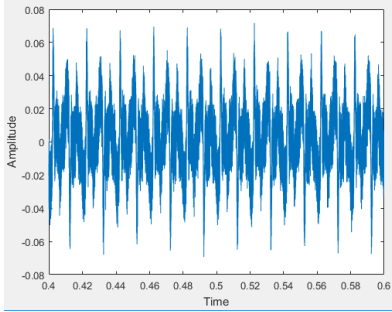
$$h_p(k) = \sum_m A_m \cos\left(\frac{\omega_0}{f_s} km + \varphi_m\right)$$

Parameters determination
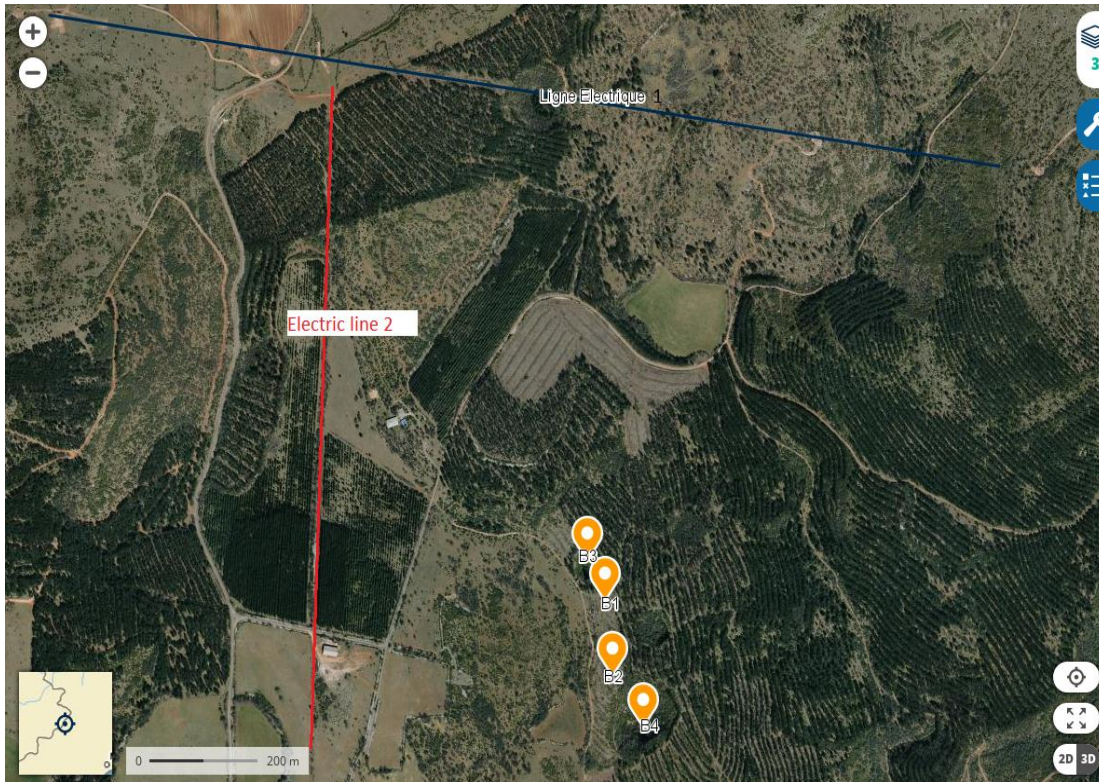
Subtraction

Adapting to multiple noise sources context

Model-based harmonic filtering – 2 power line

$$h_p(k) = \sum_m A_m \, \cos\left(\frac{\omega_0}{f_s} km + \varphi_m\right)$$

Parameters determination

↓

Subtraction

Ligne Electrique 1

Electric line 2

B3
B1
B2
B4

0   200 m

Adapting to multiple noise sources context

Model-based harmonic filtering

$$h_p(k) = \sum_m A_m \cos\left(\frac{\omega_0}{f_s} km + \varphi_m\right)$$

Electric line 2

Single-Sided Amplitude Spectrum of X(t)

Adapting to multiple noise sources context

Model-based harmonic filtering

$$h_p(k) = \sum_m A_m \, \cos\left(\frac{\omega_0}{f_s} km + \varphi_m\right)$$

Single-Sided Amplitude Spectrum of X(t)

$F_0 = 50.017$ Hz
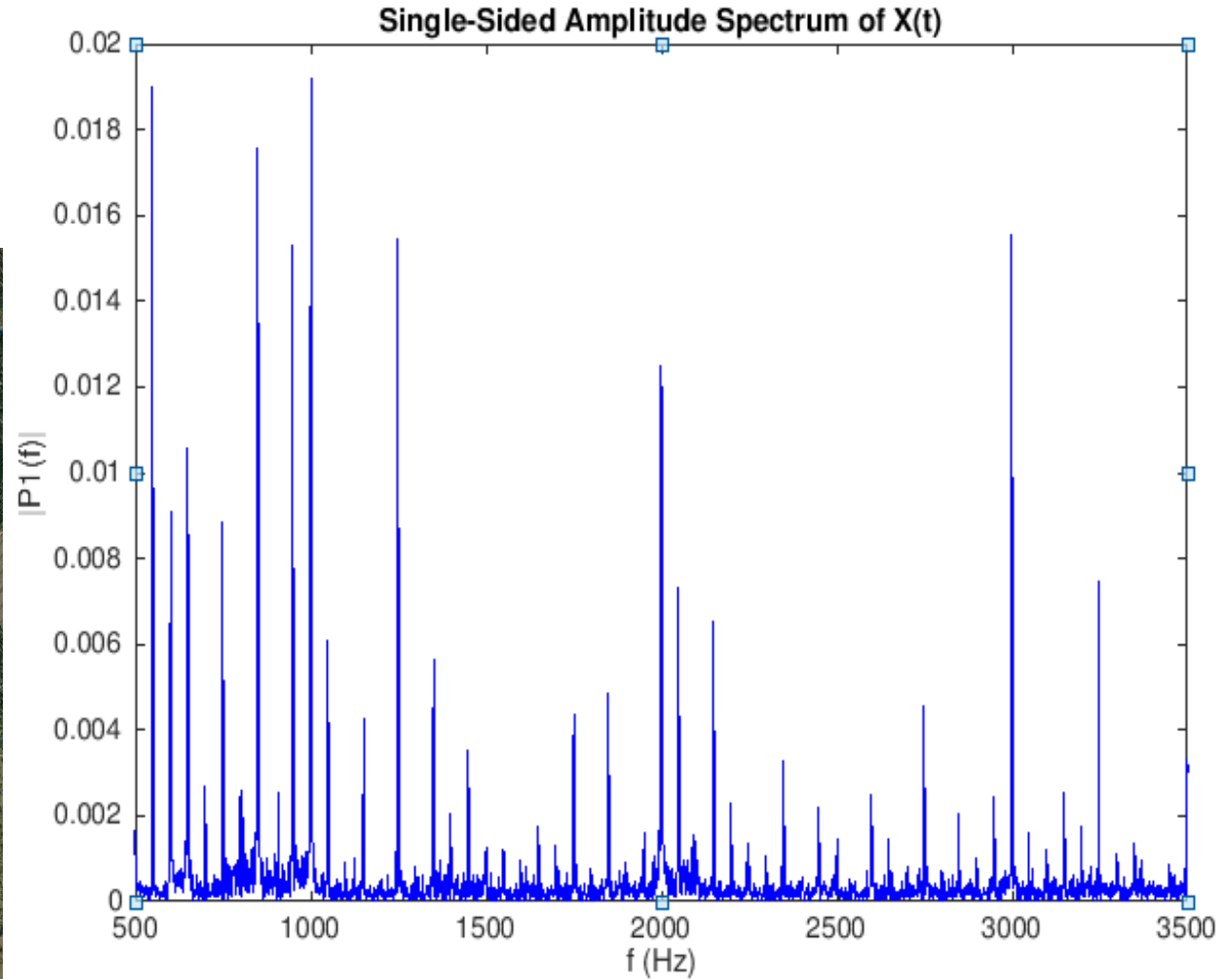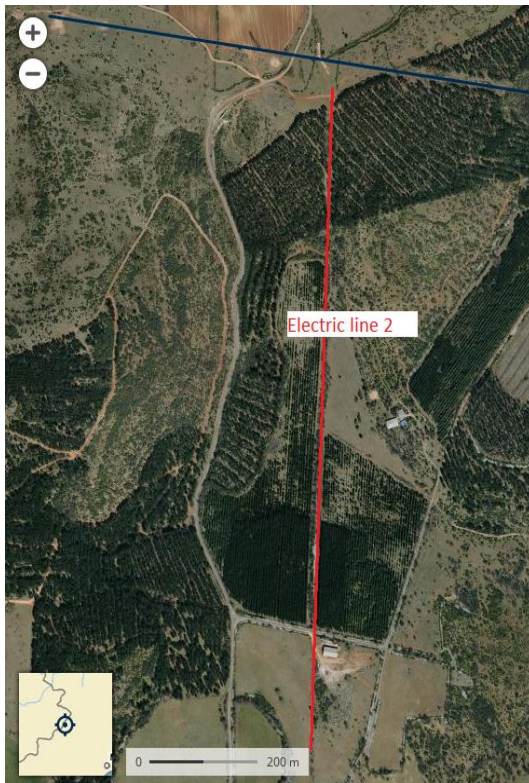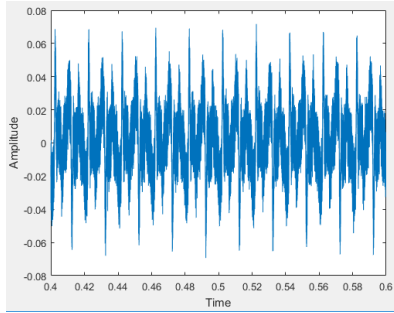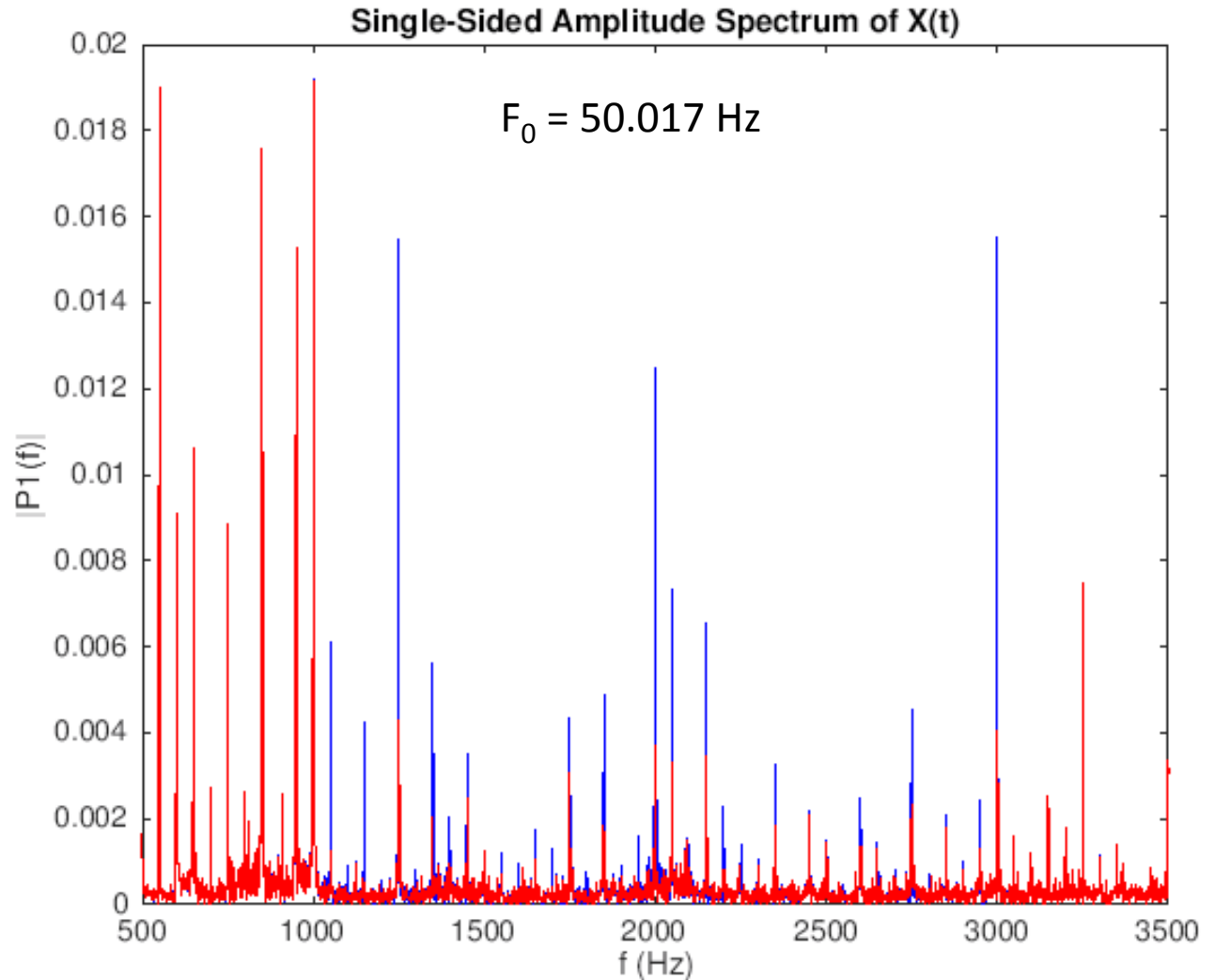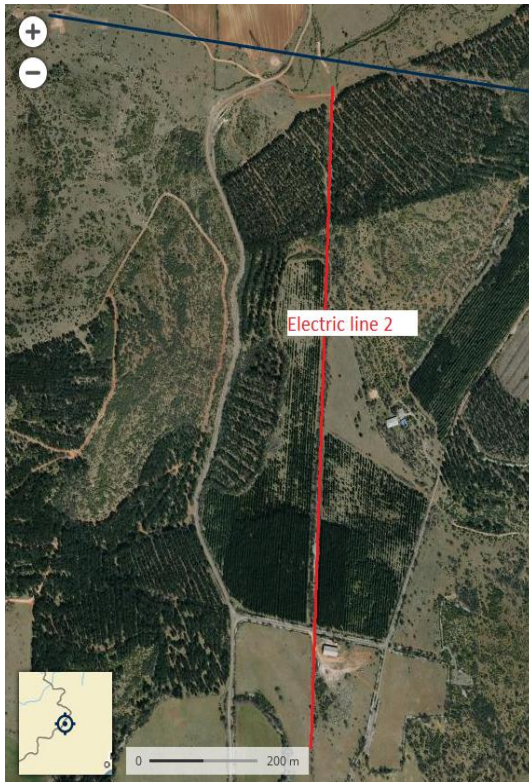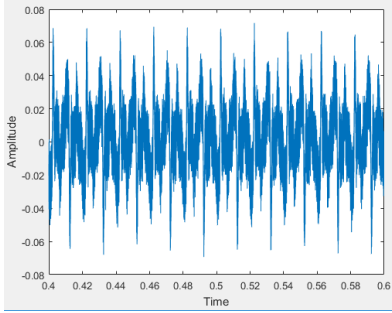
Adapting to multiple noise sources context

Model-based harmonic filtering

Two fundamental frequencies

Single-Sided Amplitude Spectrum of X(t)

F_{01} = 49.995 Hz

F_{02} = 50.007 Hz
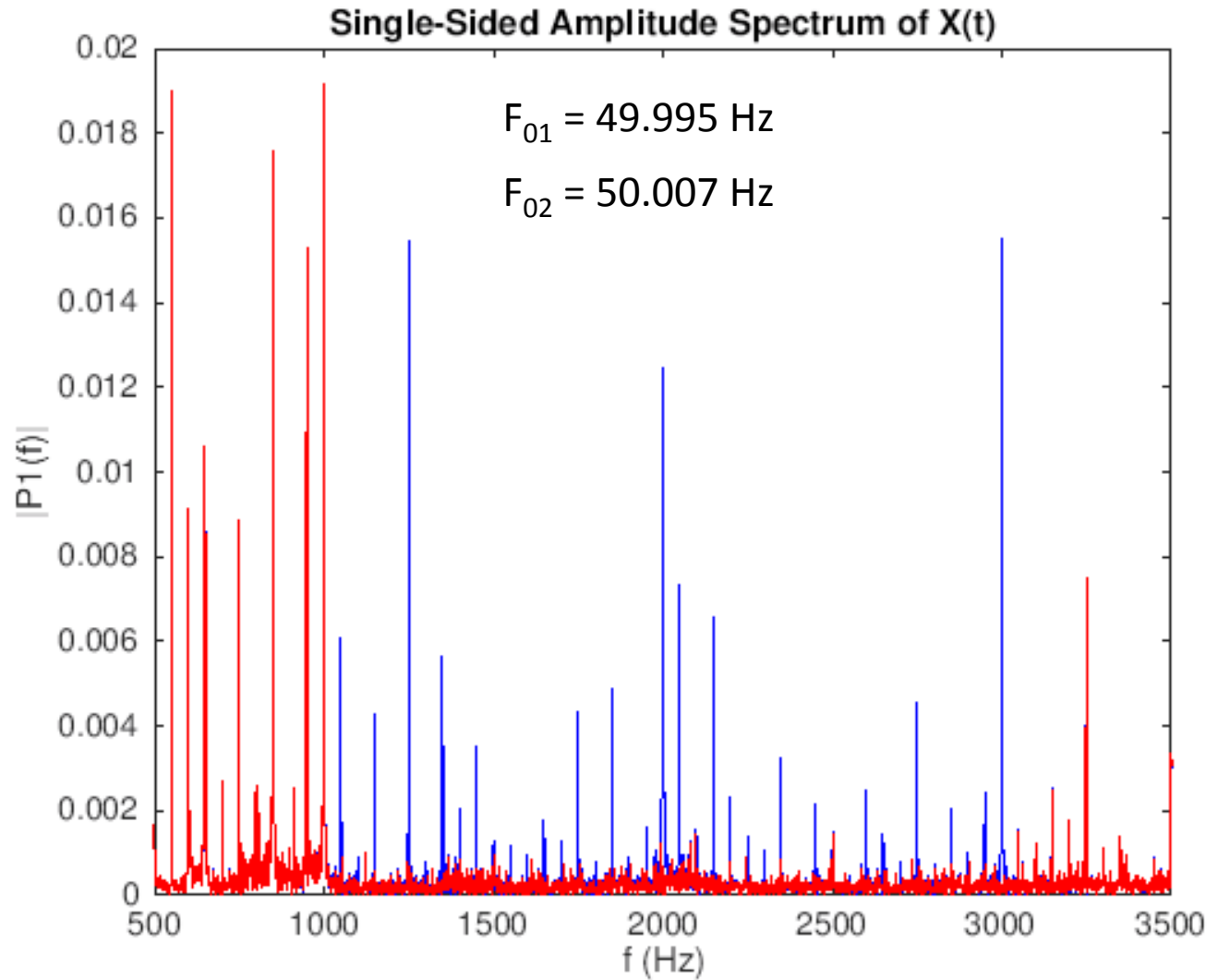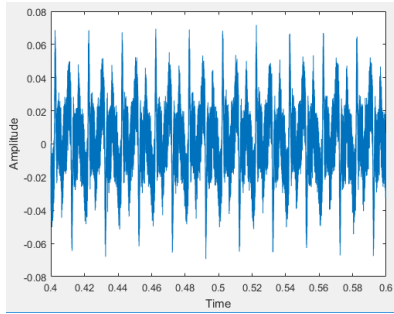
Thank you

Thomas Kremer – Frédéric Nguyen

Niveau d'eau

Crépines

argile

craie

sable

argile

NUMIS inversion

depth [m]

0,0

-10,0

-20,0

-30,0

-40,0

-50,0

-60,0

-70,0

-80,0

-90,0

-100,0

0,0   6,4   12,8   19,2   25,6   32,0

water content (%)

T1*: 100   >600 ms