Inter-Disciplinary Underground Science and Technology

Very first observation data from a giant loop antenna at the LSBB

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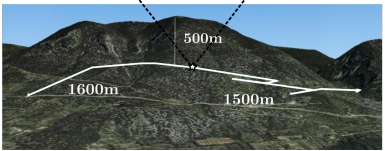
A giant loop antenna : Vestale loop

- LTS SQUID magnetometer
- 520 meter underground
- Shielding environment

SQUID magnetometer

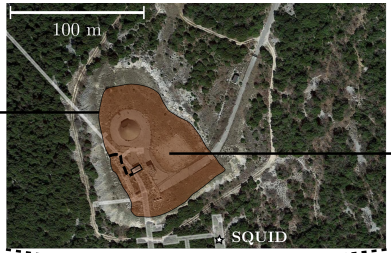


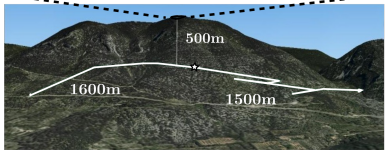
A giant loop antenna : Vestale loop

- Magnetic excitation source (2010)
- Mountain effect on the magnetic transfer

→ Create a large sensor for a long-term environmental observations

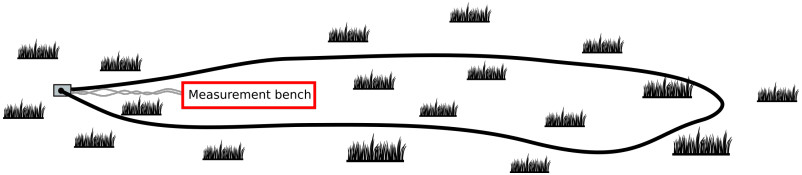
11-wire copper cable
1.5mm² cross-section





My PhD work

→ Build a standalone measurement device



2 kinds of measurement

- Active mode
- Passive mode

Specification

- Reuse existing system
- Evolving system
- Reliable
- Automated
- Remote control

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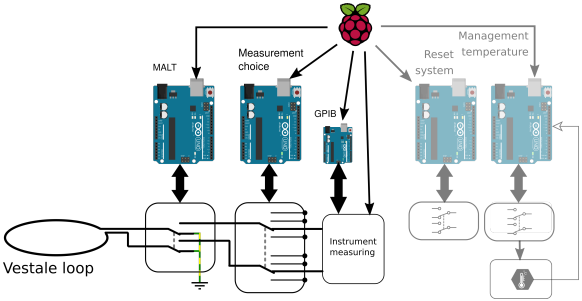
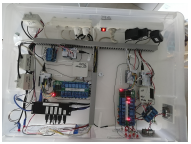
A original measurement bench





- Low-cost & open-source strategy
- Means on the precision instrument

→ Arduino – Raspberry PI – Python architecture

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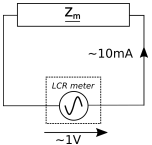
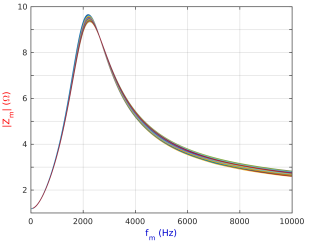
Active measurement principle

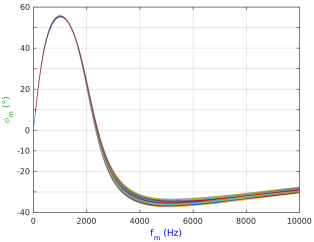


$$\underline{Z_m}(f_m) = \frac{U_m}{\underline{I_m}} = \left|\underline{Z_m}\right| e^{j\phi_m}$$

- 1 measured frequency → 1 impedance
- LCRmeter E4980A Keysight Technologies ©

Typical measurement @ 15/10/21 → 18/11/21

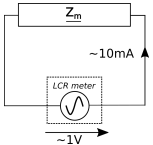




Long monitoring setup

- 20 Hz – 10 kHz range frequency sweep
- 1 sweep / 6 hours
- Continuously repeated sweeps

Active measurement principle



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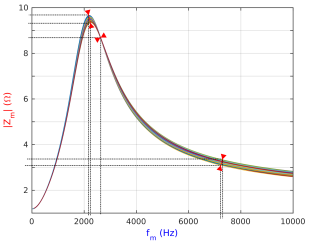

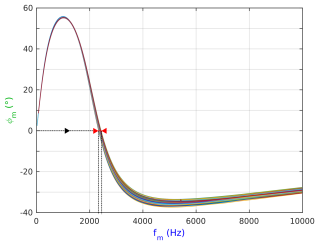

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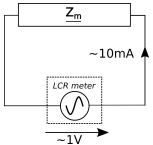

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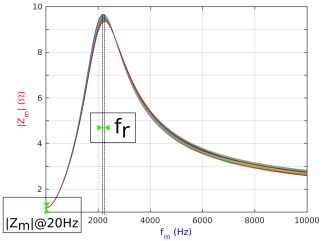
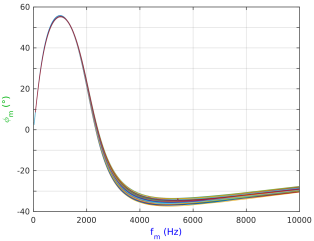




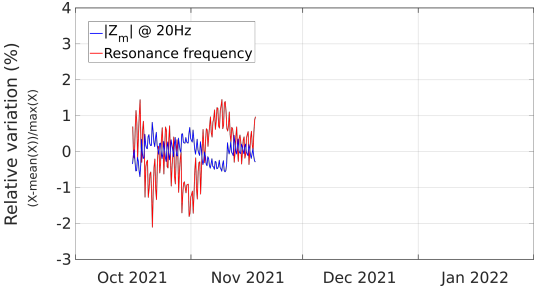
Long monitoring setup

- 20 Hz – 10 kHz range frequency sweep
- 1 sweep / 6 hours
- Continuously repeated sweeps

Proof at the environment sensitibility

→ MiniStale mock-up
→ Metric scale
→ Prototyping

In Avignon lab



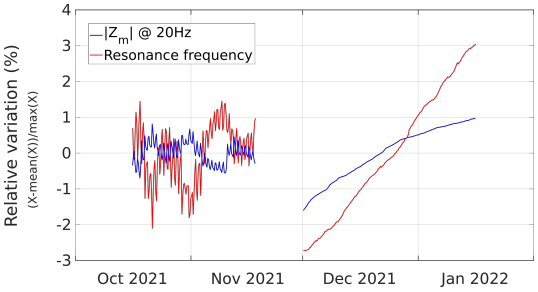
– Daily oscillations !

Proof at the environment sensitibility

→ MiniStale mock-up
→ Metric scale
→ Prototyping

In Avignon lab

In GAS gallerie



– Daily oscillations !

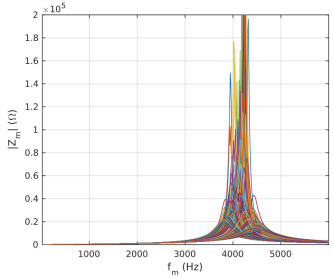
– Slow variations !

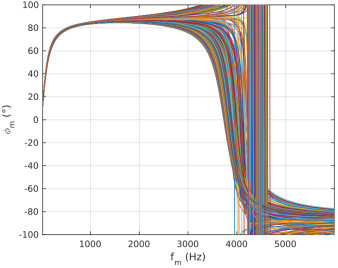
→ Surrounding environment sensibility
→ Many possible dynamics of the sensitivity

→ Same experimental conditions

Giant loop measurement

Typical measurement @ 16/02/21 → 11/05/21

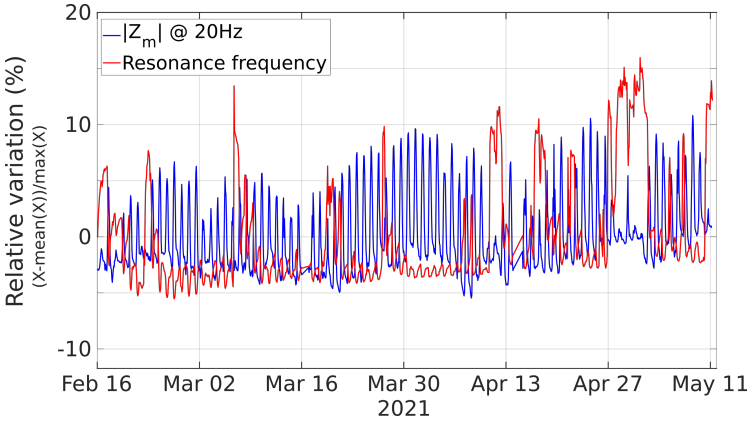




Long monitoring setup

- 20 Hz – 6 kHz range frequency sweep
- 1 sweep / 11/2 hours
- Continuously repeated sweeps

Electrical parameters monitoring of the Giant loop



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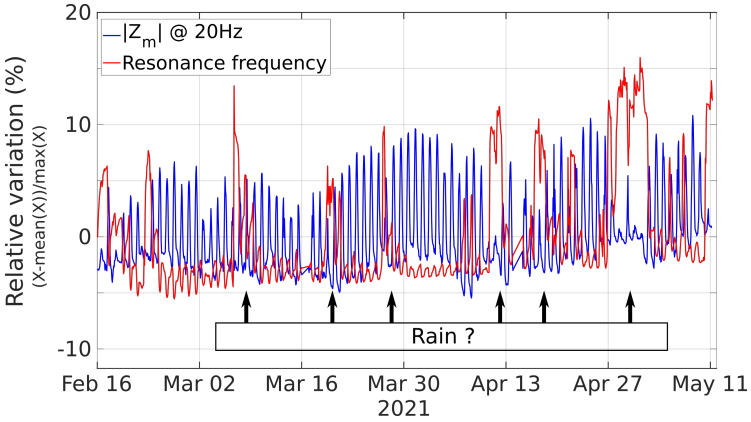

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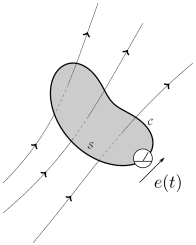
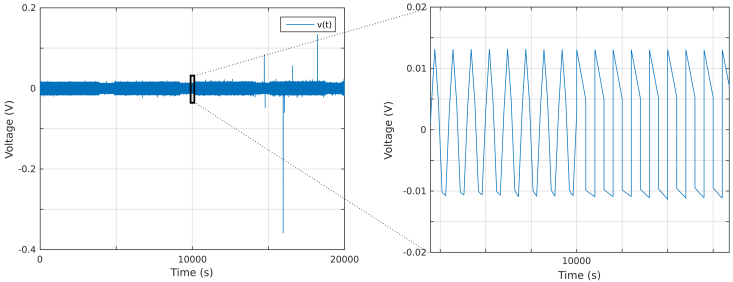
Passive measurement principle



$$e(t) = -N\frac{d\Phi(t)}{dt}$$

- Digital MultiMeter DAQ6510 Keithley ©
- 5 MSamples

03/06/22 from 14h55' → 20h28'
Sampling : 250 Hz



– 50Hz power line frequency & Aliasing phenomena

→ Passive mode is working
→ Improve maturity status

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Conclusion & Perspectives

- Large factory generating data (active and passive mode works)
- Environment sensitivity
- Experimental site sharing

Perspectives

Adapt experimental protocol
Sampling, frequency sweep, calibre...

⇓

Find the best adapted sensitive marker
quality factor, $\left|\underline{Z_m}\right|$ *@*$20\,Hz$*, zero phase...*

⇓

Correlation

- Hydrogeologic data
- Gravimeters data
- SQUID data
- Weather data
- Atmospheric EM data

Thank you for your attention

Any questions ?

LSBB Laboratoire Souterrain à Bas Bruit
Low Noise Inter-Disciplinary Underground Science & Technology

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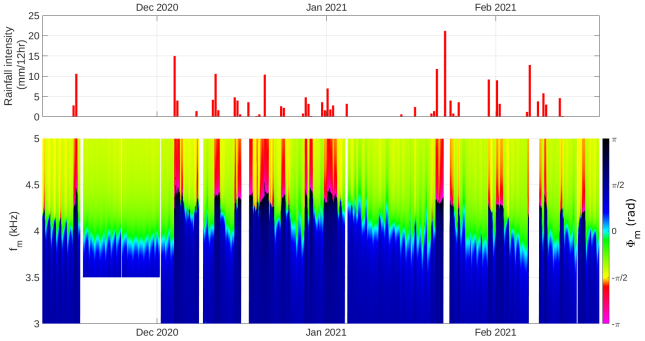
Environnement Méditerranéen et Modélisation des Agro-Hydrosystèmes

First correlation with rain data



3 months monitoring

- Daily oscillations
- Slow variation
- Ponctual event

Electrokinetic model

- Installation intrinsics parameters,
  - L_0 : self-inductance
  - R_0 : Cable electrical resistance
  - C_0 : Capacitance (ground contact, insulator,...)
- Environment coupling
  - R_e **: energy dissipation**.