Passive acoustic emission in soils: a new way to apprehend soil structure and monitor its dynamics?

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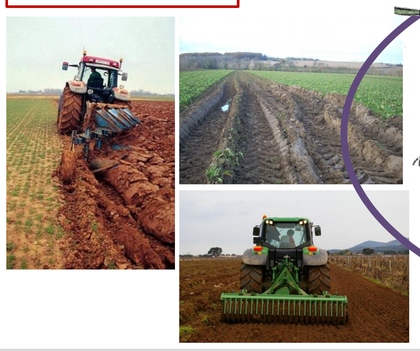
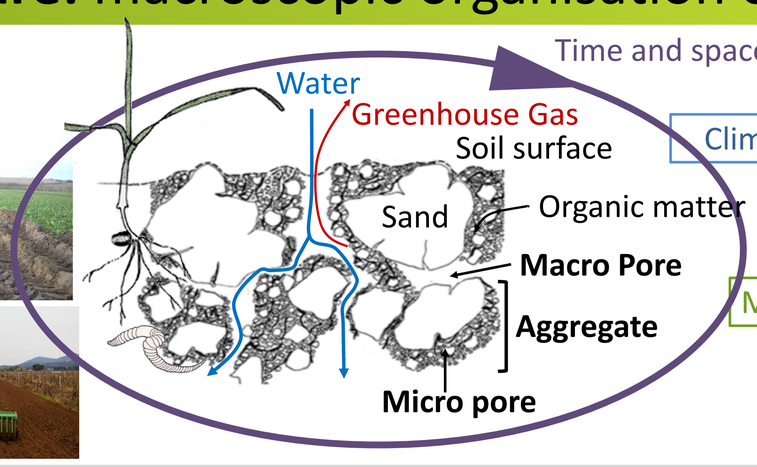
1. Soil structure: macroscopic organisation of soil aggregates and pores *(Dexter, 1988)*

Field practices





Climate

Macro-organisms

Control water and gas flows and storage in soils:

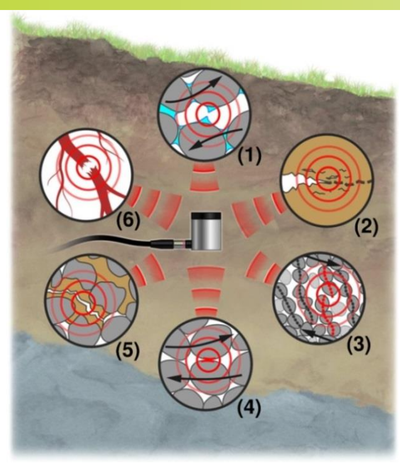
- Control physical and chemical environment for soil organisms
- Example: soil structure impacts on N^2O emissions by soils *(Rabot et al., 2015)*

➢ **Soil structure dynamics description and modelling = challenge in soil science**

Which tools to monitor soil structure dynamics?

2. Acoustic Emissions (EA)

- **Characteristics of measured AE:**
  - ➢ Passive AE: signal spontaneously produced by the material
  - ➢ *In-situ* and dynamic monitoring
  - ➢ Method sensible to movements (physical and biological)
- **Applications:**
  - ➢ AE used in civil engineering to study damages occurrence in infrastructures (bridges , etc.)
  - ➢ Ground movements and avalanche monitoring
  - ➢ AE not used in soil science → **methodological innovation**



AE source mechanisms in soils

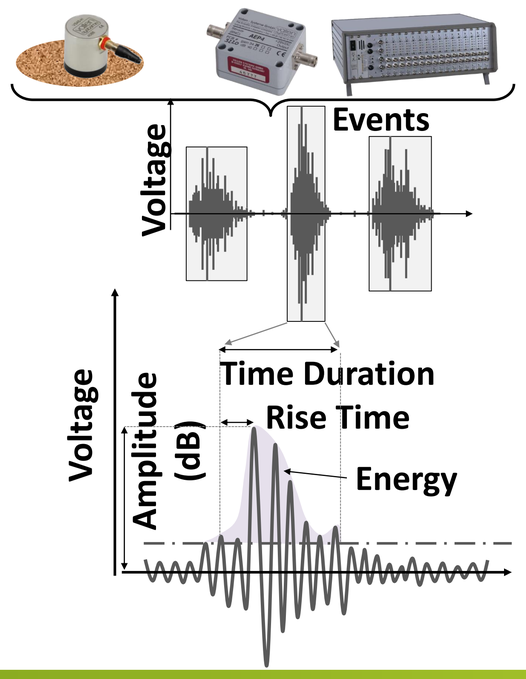
1. Liquid bridge rupture
2. Crack development
3. Release of force chains
4. Grain friction
5. Grain cementation fracture
6. Rupture of soil fibres

(Michlmayr, et al., 2012)

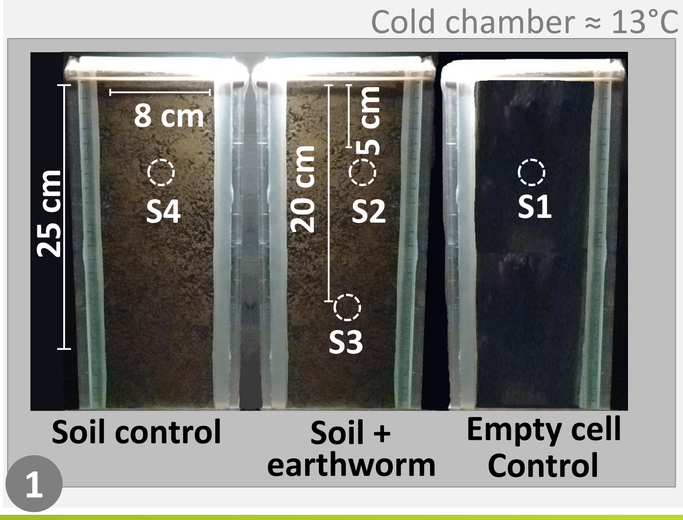
Can AE monitoring in soils characterize the dynamics of soil structure?

3. Materials & Methods: three lab experiments

AE sensor + Acquisition system

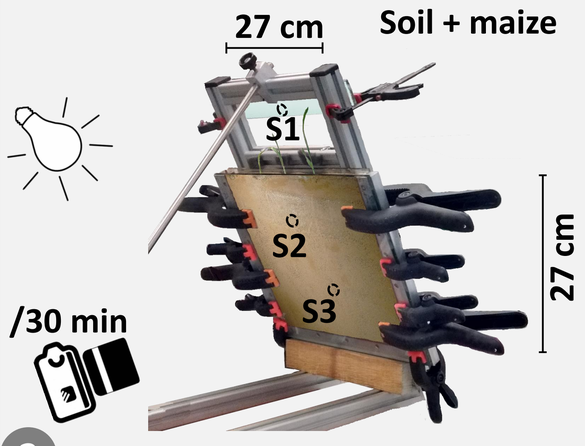


Uetliberg soil: 11% clay, 50% loam, 39% sand
≈ 34% water content, bulk density = 1.1 $g.cm^{-3}$
Earthworm: *Octolasium cyaneum* (endogeic)
Glass cells: 0.8 cm thick
Cold chamber ≈ 13°C



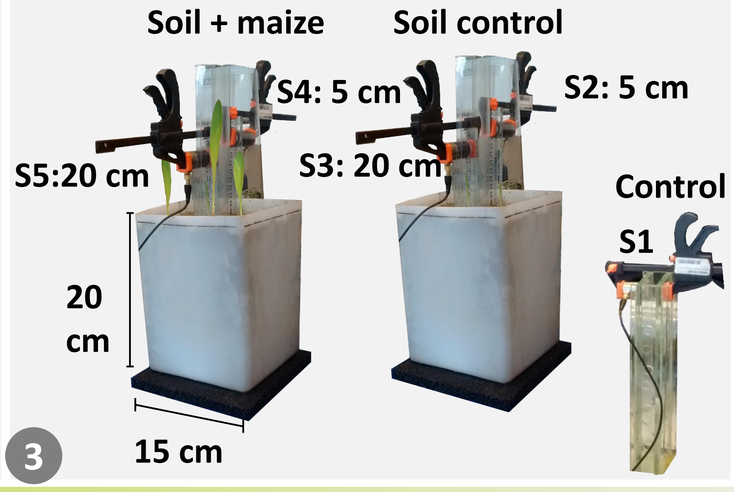
1

Winzlerboden soil: 9% clay, 9% loam, 82% sand
≈ 30% water content
bulk density = 1.4 $g.cm^{-3}$
Glass cell: 1.2 cm thick



2

≈ 18% water content
bulk density = 1.2 $g.cm^{-3}$
Soil column: 15 x 15 x 20 cm



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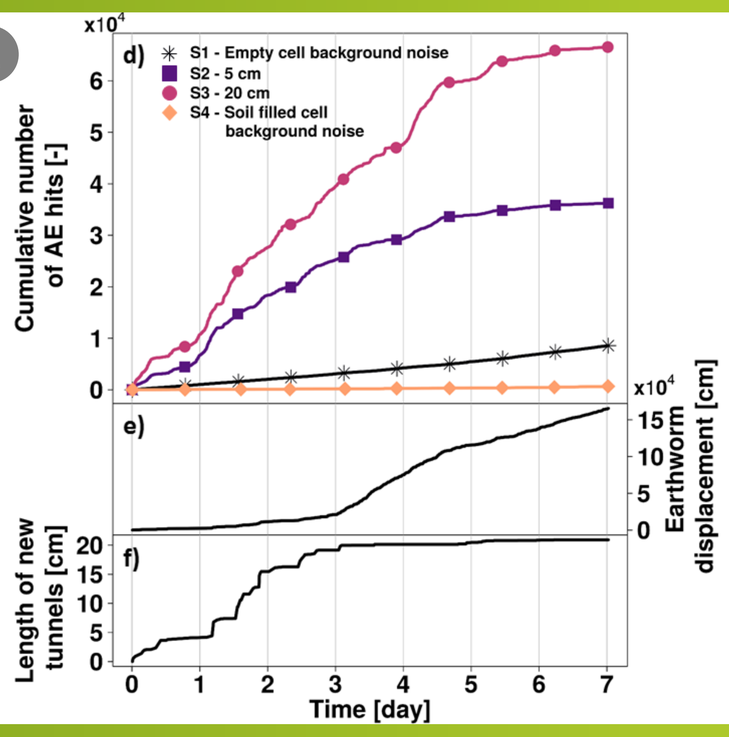
4. Results

1



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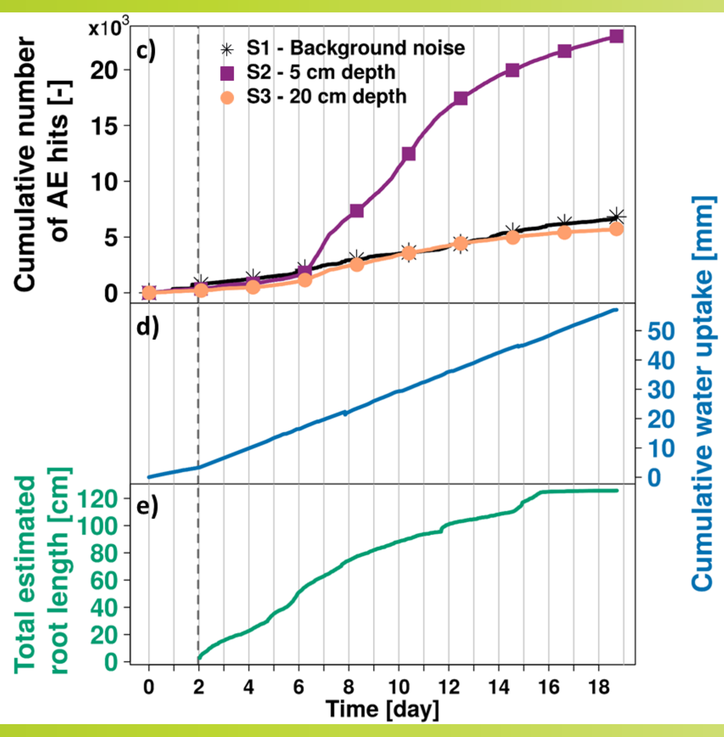

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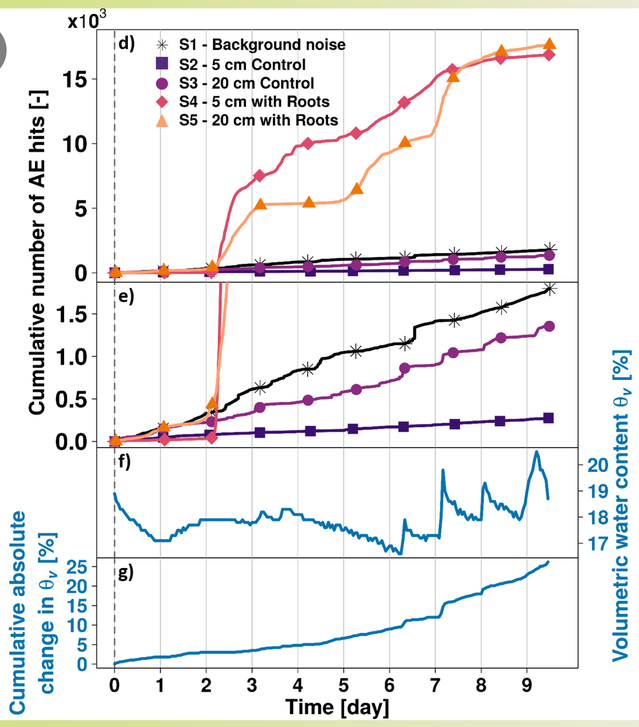

5. Conclusions and perspectives

Promising results

- ➢ AE signals correlate with earthworm burrow lengths and with root growth.
- ➢ AE from the soil columns: several orders of magnitude larger than AE emanating from bare soil under similar conditions.

AE monitoring

- ➢ **A window into largely unobservable biomechanical processes important for soil structure formation**
- ➢ **Insight into root development and earthworm ecology**

Results still exploratory: the method requires further development and refinement.

References. **Lacoste, M., Ruiz, S., Or., D. Listening to earthworms burrowing and roots growing - acoustic signatures of soil biological activity.** ***Scientific Report (minor revisions)***

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