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Close range aerial sensing of soils for improved remote sensing products RAPAS

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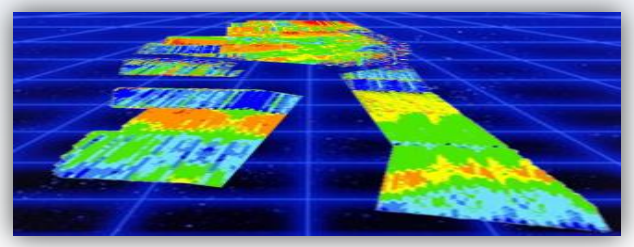
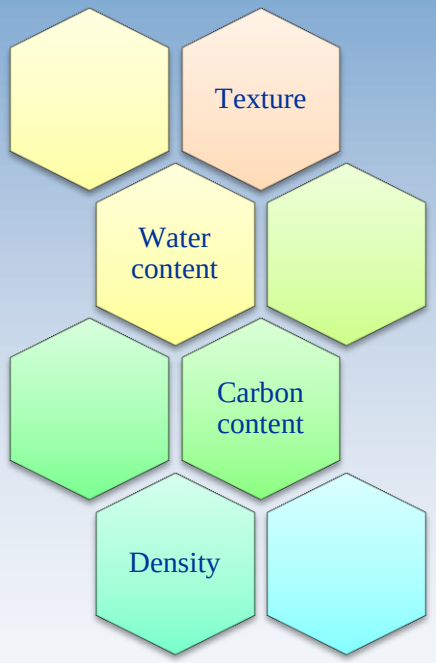
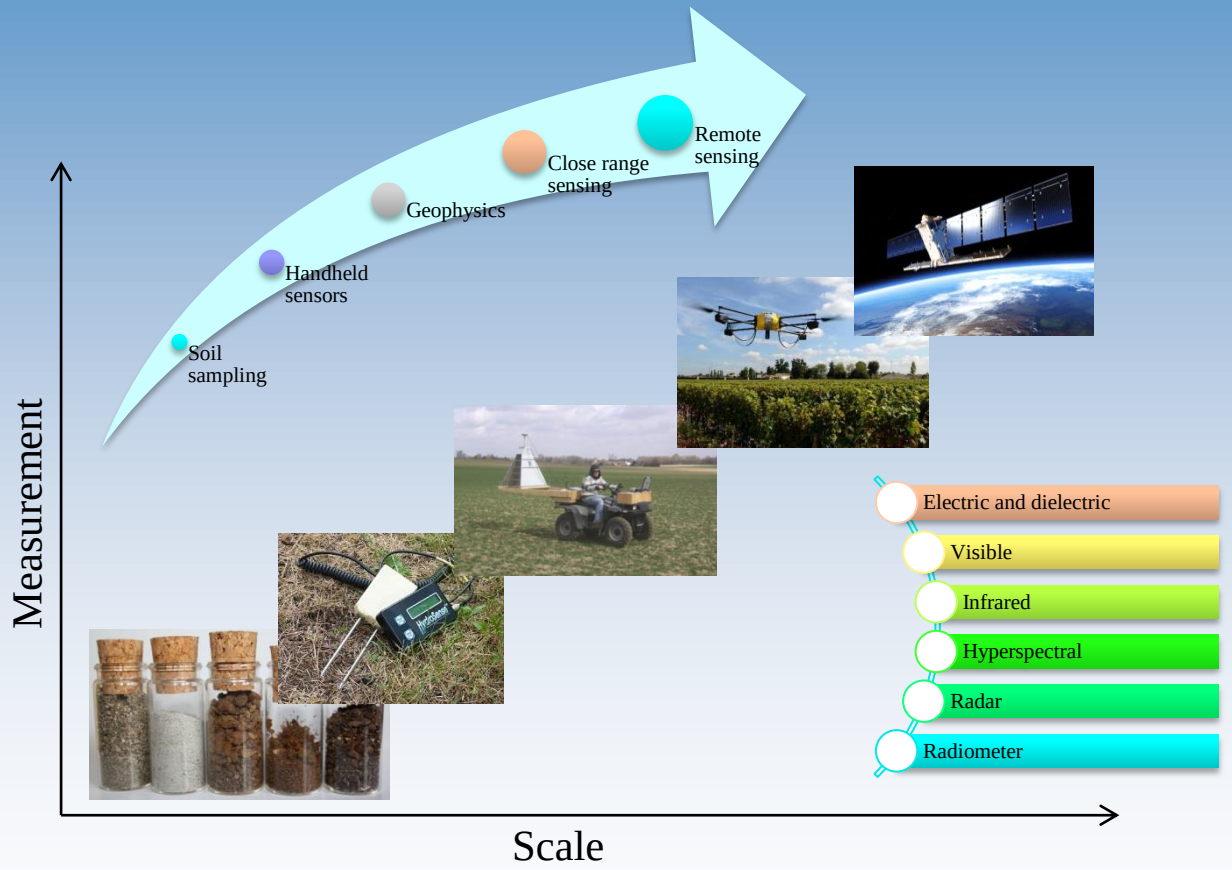


CSL

Introduction

Knowledge of soil properties and dynamics is essential for optimal and sustainable management of soil and water resources in a growing demographic context





Soil governs: infiltration and runoff, evaporation, climate feedbacks, plant growth (food & energy), contamination of groundwater, etc.

Project objective

To integrate ground-penetrating radar (GPR) and hyperspectral spectrometer (HS) on a close range remotely piloted aircraft system (RPAS) for improving digital soil sensing capabilities

Setup of the close range sensing platform

- WP1: GPR instrument design and control
- WP2: Spectrometer instrument design and control

Data acquisition and data processing

- WP3: Full-wave GPR data inversion
- WP4: Spectrometer data processing

Data fusion

- WP5: Joint radar and hyperspectral data interpretation and fusion

Comparison with spaceborne remote sensing

- WP6: Upscaling of soil moisture using Sentinel-1 radar products

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Full-wave inverse modeling for soil characterization

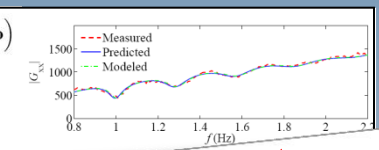
Accurate electromagnetic modeling (Lambot *et al.*, IEEE TGRS 2004 ; 2014)

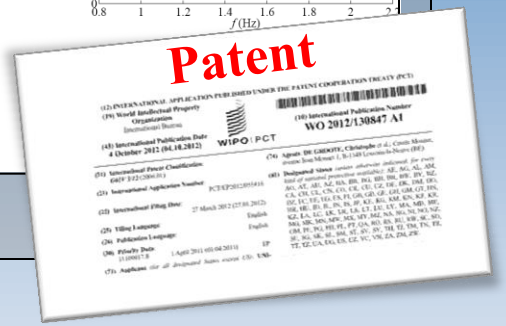
- 3-D layered medium
- Efficient antenna model
- Antenna-medium interactions

$$S = \frac{b}{a} = T_0 + \begin{bmatrix} T_{s,1} & T_{s,2} & \cdots & T_{s,N} \end{bmatrix} \left((\mathbf{A}^H \mathbf{A})^{-1} \mathbf{A}^H \mathbf{b} \right)$$

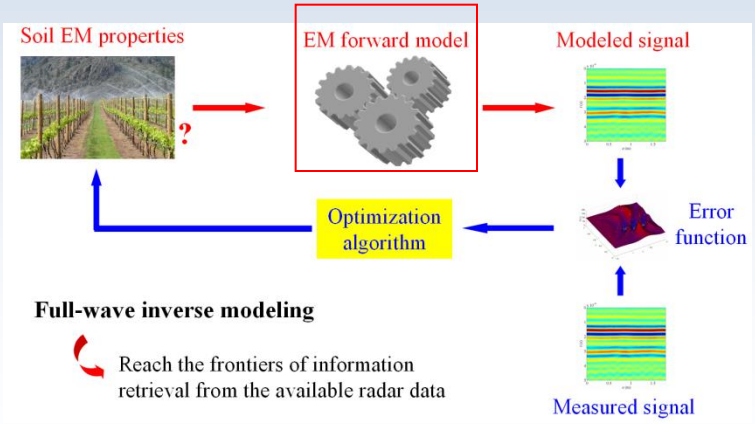
$$\mathbf{A} = \begin{bmatrix} R_{s,1}G^0_{11} & R_{s,2}G^0_{12} & \cdots & R_{s,N}G^0_{1N} \\ R_{s,1}G^0_{21} & R_{s,2}G^0_{22} & \cdots & R_{s,N}G^0_{2N} \\ \vdots & \vdots & & \vdots \\ R_{s,1}G^0_{N1} & R_{s,2}G^0_{N2} & \cdots & R_{s,N}G^0_{NN} \end{bmatrix} - \mathbf{I}_N$$

$$\mathbf{b} = - \begin{bmatrix} T_{i,1}G_{11} & T_{i,2}G_{12} & \cdots & T_{i,N}G_{1N} \\ T_{i,1}G_{21} & T_{i,2}G_{22} & \cdots & T_{i,N}G_{2N} \\ \vdots & \vdots & & \vdots \\ T_{i,1}G_{N1} & T_{i,2}G_{N2} & \cdots & T_{i,N}G_{NN} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix}$$

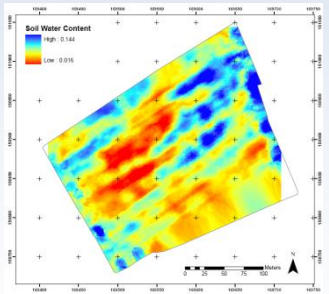




System design



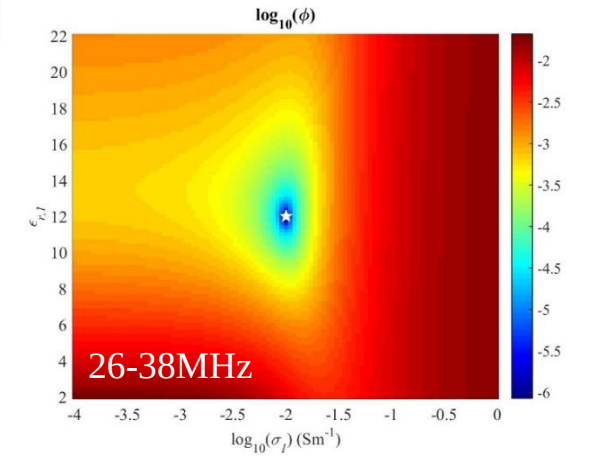
Product

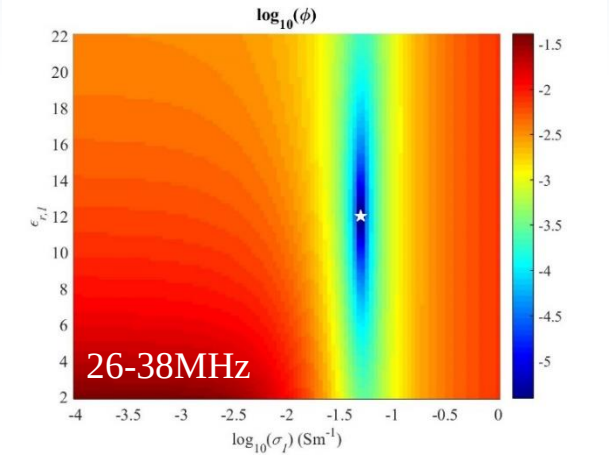


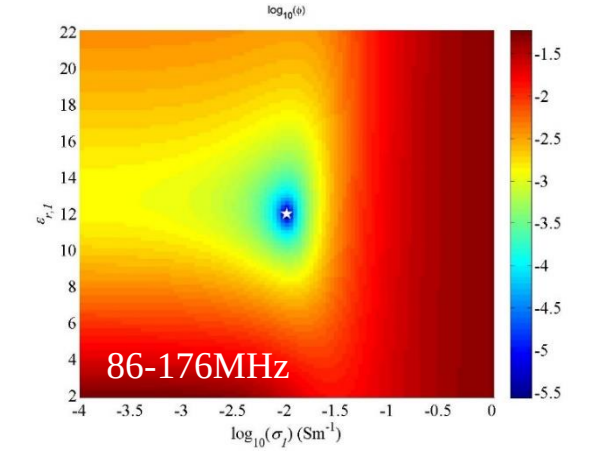
Signal inversion

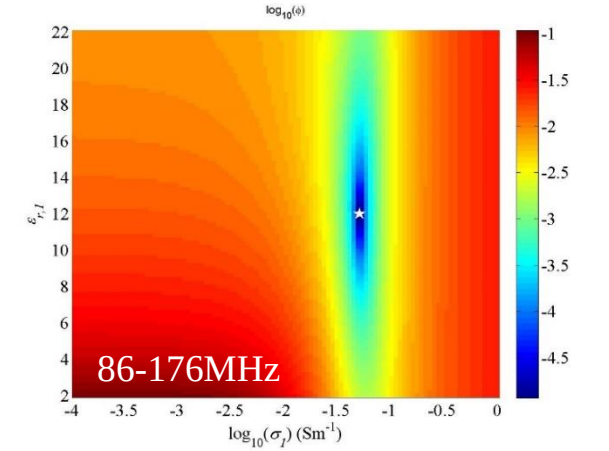
Numerical analyses for root zone characterization

- Information content (permittivity, conductivity)
- Sensitivity with respect to depth



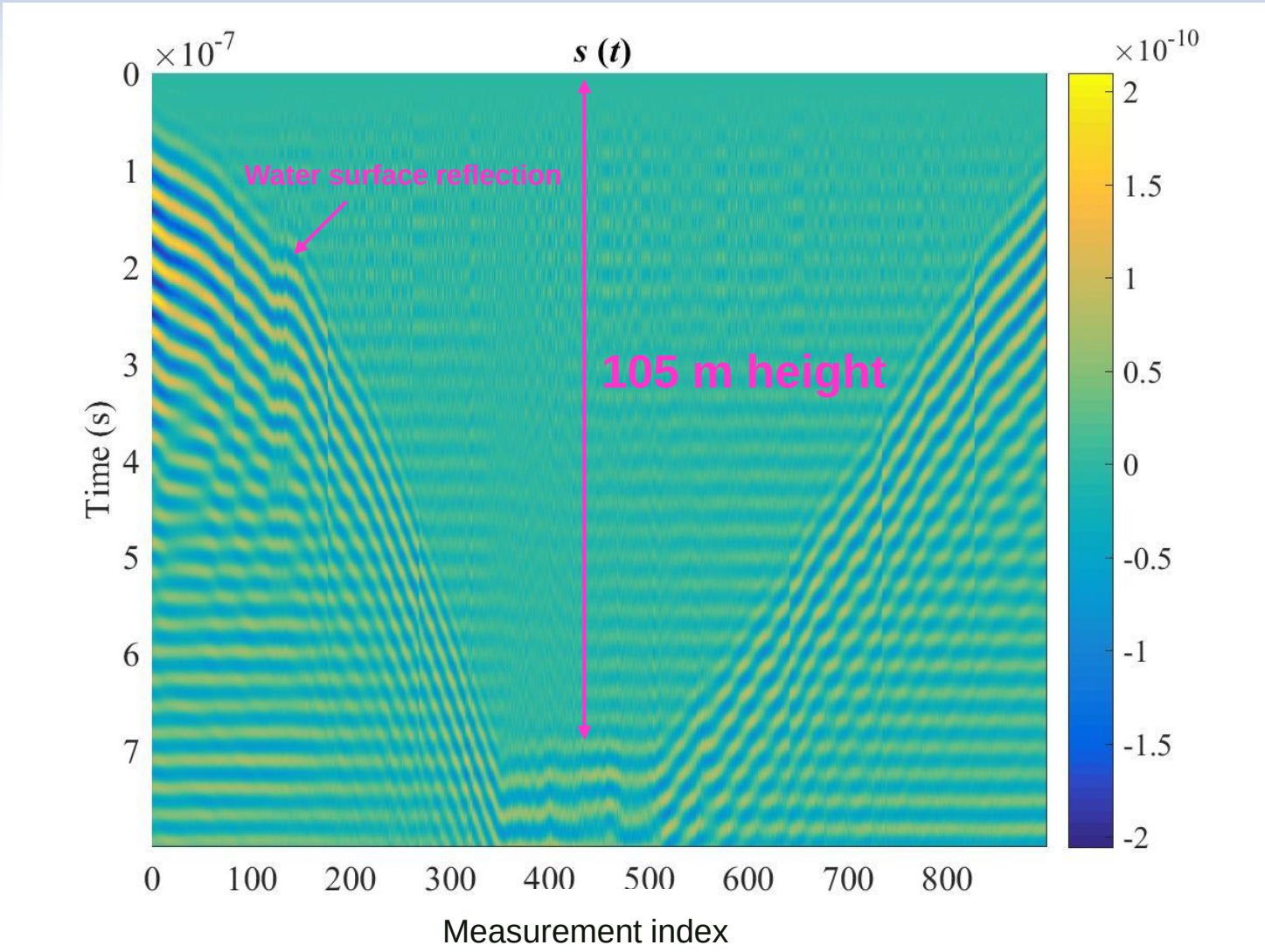






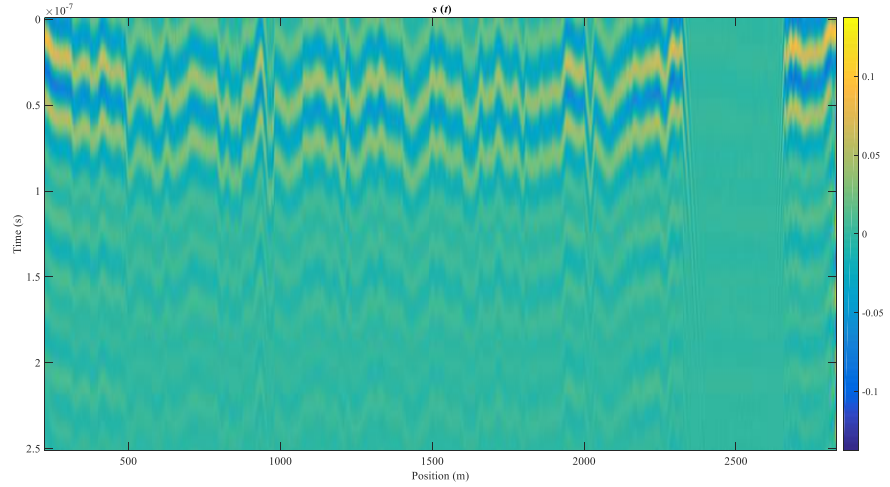
Radar antenna calibration over water

Measurements over water



Measurements over the soil

First root-zone moisture map coming soon



Thank you for your attention

http://sites.uclouvain.be/gprlouvain/rapas.html