



Advancements in Drone-Borne Ground-Penetrating Radar for Precision Soil Mapping and the Introduction of gprSense

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Recent advancements in drone-borne ground-penetrating radar (GPR) have significantly enhanced our ability to map soil moisture and electrical conductivity with high precision, offering vital insights for precision agriculture and environmental monitoring. This body of work, encompassing three pivotal studies, demonstrates the innovative use of drone-borne GPR for soil characterization at varying depths and scales. These advancements are grounded in the use of full-wave modeling and inversion based on the radar equation introduced by Lambot et al. (2004, 2014).

The first study showcases a lightweight, drone-borne GPR system for high-resolution soil moisture mapping (Wu et al., 2019). The second study explores low-frequency GPR for soil electrical conductivity mapping (Wu and Lambot, 2022), emphasizing the increased sensitivity to conductivity over permittivity. The third study investigates the impact of radar incident angle on soil permittivity measurements (Wu and Lambot, 2022), highlighting the need for precision in radar methodologies.

Complementing these studies is the introduction of gprSense (<https://www.gprsense.com/>), a groundbreaking GPR software solution developed under the EU agROBOfood MIRAGE project. gprSense, designed for both advanced and basic users, revolutionizes soil moisture measurement with automated, real-time data processing. Its intuitive user interface makes advanced radar data processing accessible to non-experts, such as farmers, facilitating widespread adoption in precision agriculture. Initially implemented on an irrigation robot, gprSense represents a major leap towards automated, precision irrigation, and non-destructive soil testing.

These studies and the development of gprSense collectively illustrate the vast potential of drone-borne GPR in digital soil mapping. They demonstrate technical innovations and pave the way for practical applications in managing soil and water resources effectively. Moreover, this technology holds significant promise in improving remote sensing data products. By providing high-resolution ground truths, GPR can be instrumental in calibrating and refining satellite remote sensing, thereby enhancing the accuracy and reliability of remote sensing data across various applications. Current projects are exploring this synergy, marking a critical step forward in integrated Earth observation and agricultural management.

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