Can Small Changes in Soil Moisture Provide Enhanced Detection of Buried Landmines? – Early Results

Introduction

This research investigates the possibility that small changes in soil moisture over an extended time, can provide enhanced subsurface microwave imagery. Ultimately, the technique could lead to development of better detection and classification of buried landmines.

Methodology

- Develop a model describing the effect of the soil moisture changes on the permittivity of soil, verifying theory with realistic scenarios.
- Exploit this effect to enhance Synthetic Aperture Radar (SAR) images.

Simplified Model

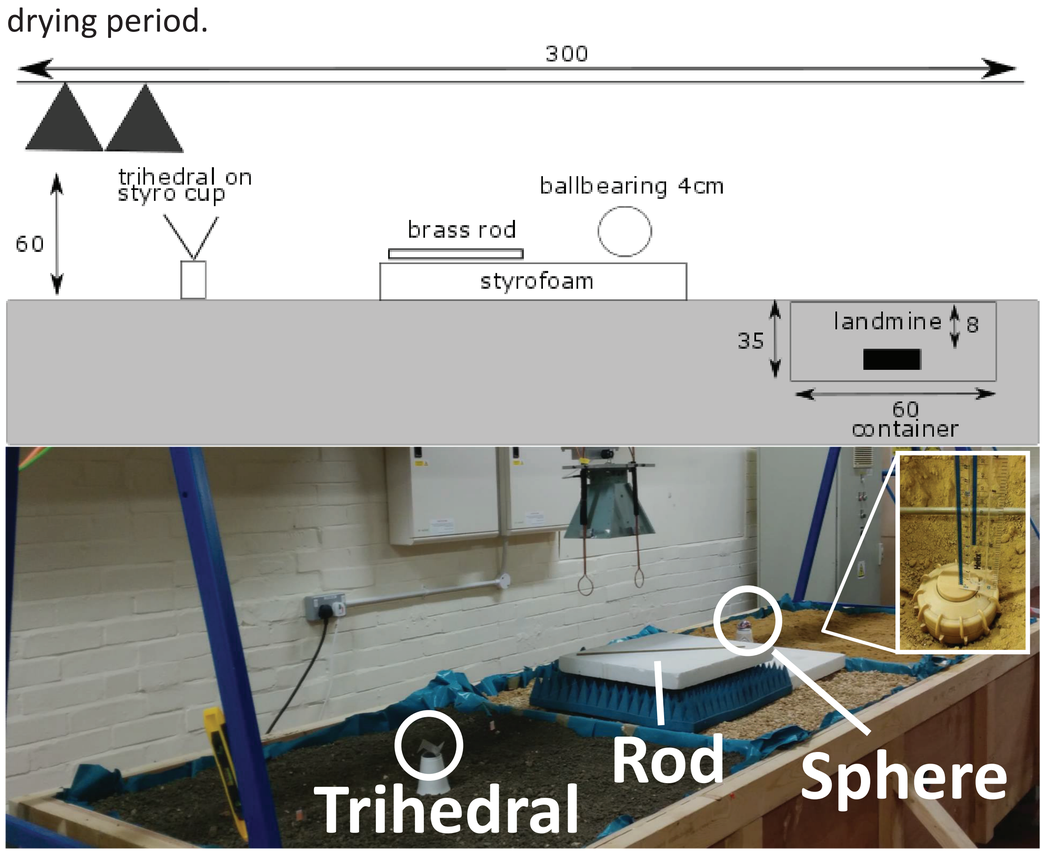
When an electromagnetic wave enters the soil its effective bandwidth B_e is changed by

$$B_e = f\sqrt{\Delta\epsilon},$$

where $\sqrt{\Delta\epsilon}$ is the variation in refractive index over time and ϵ is the effective complex dielectric constant of the soil and f is the true microwave frequency.

Laboratory Experiment

An anti-personnel landmine was buried in the sand lane of our Ground Penetrating Radar (GPR) test facility. The initial moisture level of the sand was measured to be 3% by weight. The sand moisture level was raised to 10% by the addition of deionized water. A GPR with 0.4-4.8 GHz bandwidth made repeated radar scans of the calibration targets and buried landmine acquiring data in 30 minute intervals over a 6 day drying period.



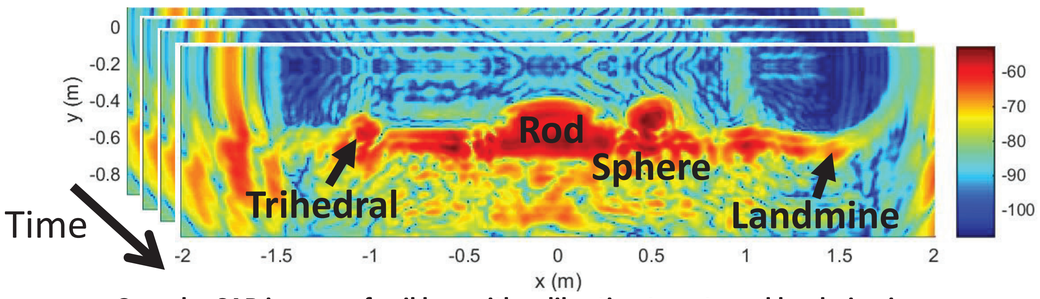
Side view sketch and photograph of experimental set up. The antenna head scans across the soil bays. A trihedral, a brass rod and a sphere are present as calibration targets. The TS50 landmine, with a diameter of 9 cm, is buried in the last bay at 8 cm depth in sand in a container 35cm deep and 60cm in diameter.

Summary

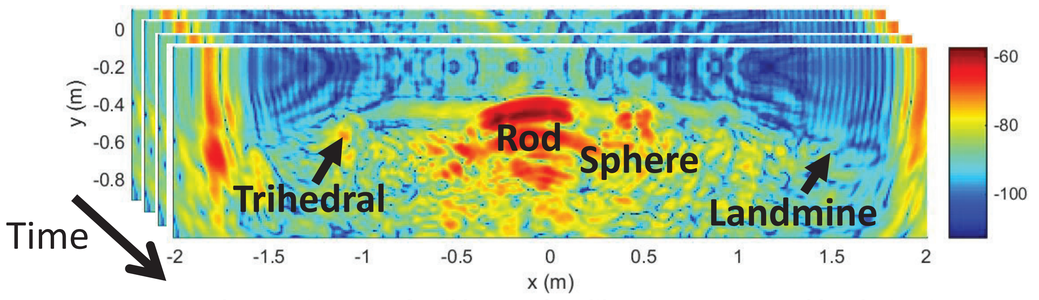
Range profile and SAR processing demonstrate that the buried landmine can be identified in drying sand. The next steps are to implement polarimetric calibration, extract and monitor the effective permittivity on pixels that comprise the target. Thus enabling higher resolution and quality imaging of land mines.

Results

Over 640 microwave scan datasets were acquired of the drying scene. These were processed to produce range profile and Synthetic Aperture Radar (SAR) image products.



Co-polar SAR images of soil bay with calibration targets and landmine in scene



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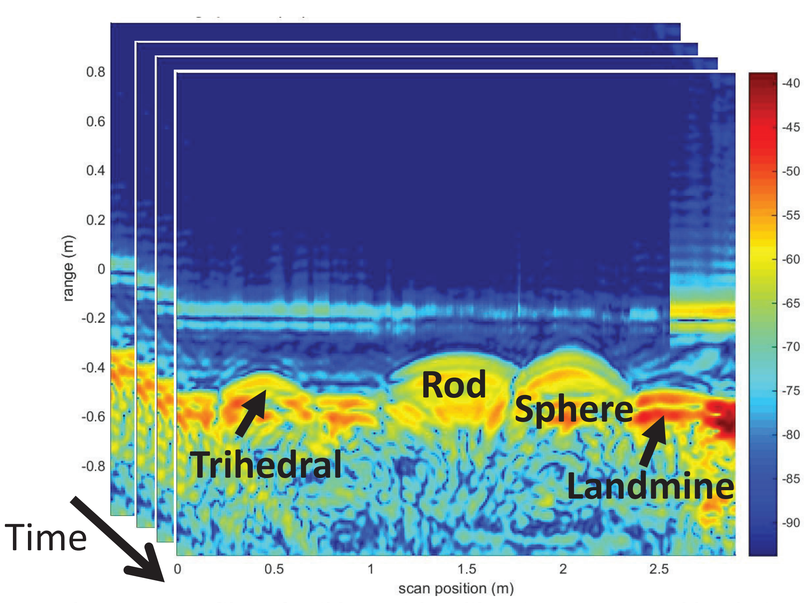
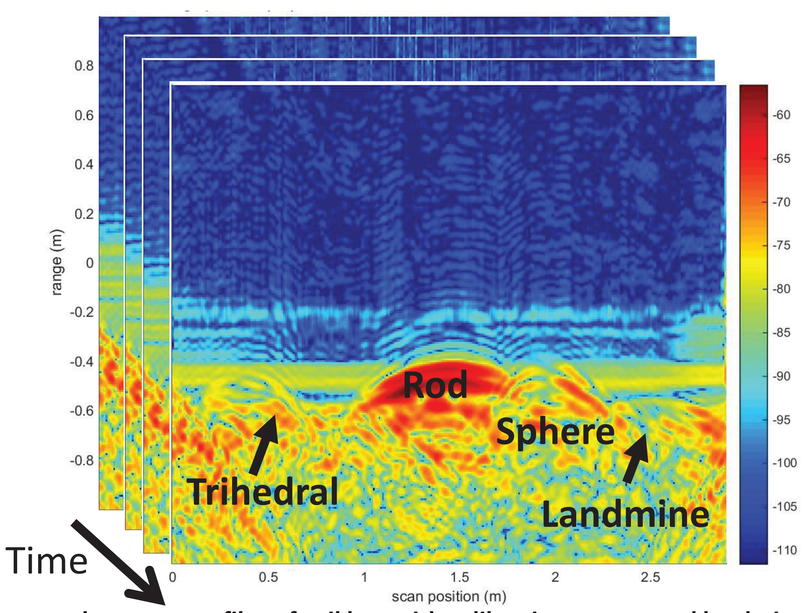


Co-polar range profiles of soil bay with calibration targets and landmine in scene



Cross-polar range profiles of soil bay with calibration targets and landmine in scene

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