Using GPR for determining soil horizons on different types of agricultural fields

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Introduction

The application of geophysical methods is rapidly gaining interest in agricultural studies worldwide (Novakova et al., 2013). The non-invasive nature of the ground penetrating radar (GPR) method coupled with its ability to provide continuous results across the field has shown the method to be successful for determining the presence, geometry and spatial extend of main soil horizons for the purpose of classifying soils (Jol, 2009 and references therein). While traditional soil studies give information on specific points in the field by using a gauge auger or by digging soil profiles, GPR provides continuous imaging of the subsurface without disturbing the soil (Novakova et al., 2013). In surveys related to optimizing the usage of irrigation systems in precision agriculture, the moisture tracking probes need to be installed in the most representative point of the agricultural field. We therefore tested the GPR method on different field types and compared the results with soil profiles.

Figure 1: Measurement with a GPR cart and 500 MHz antenna on an empty field (left) and in an orchard (right).

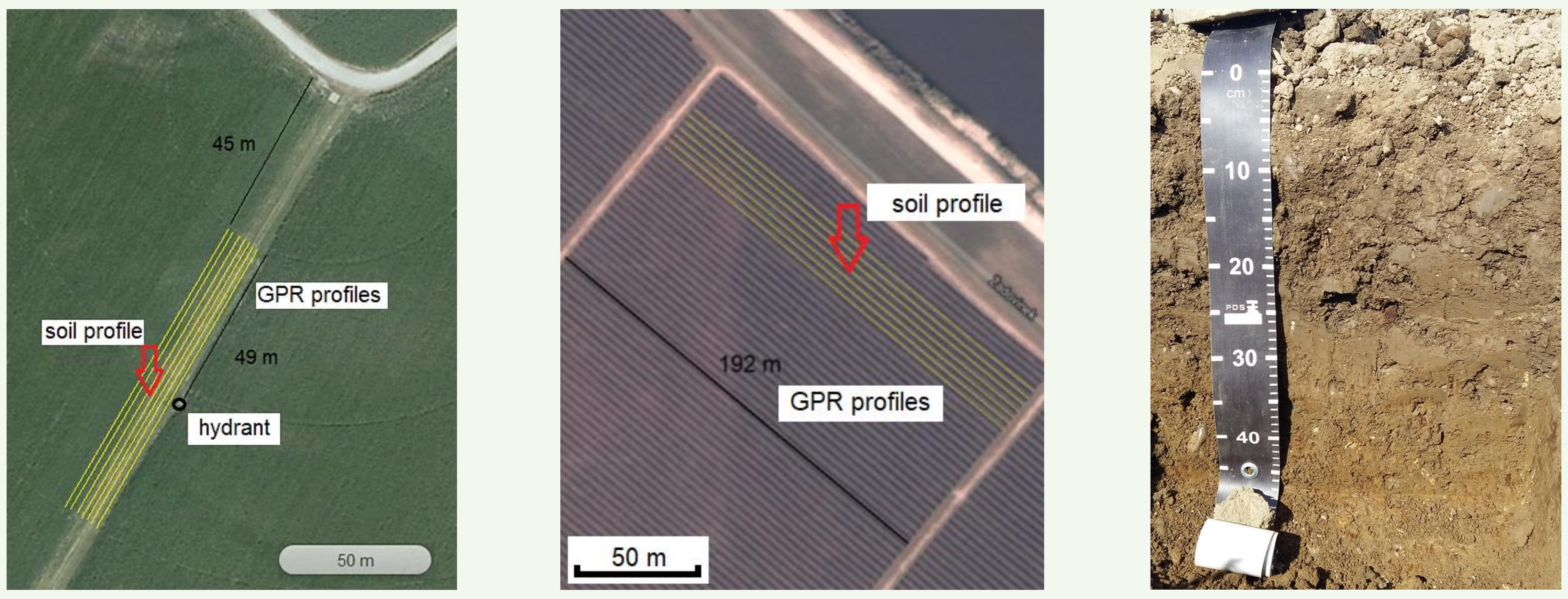


Figure 2: GPR profiles (yellow lines) recorded around the area of soil profiling (red arrow) on an empty field (left) and in an orchard (middle). Soil profile from the empty field is on the right.

Data Acquisition

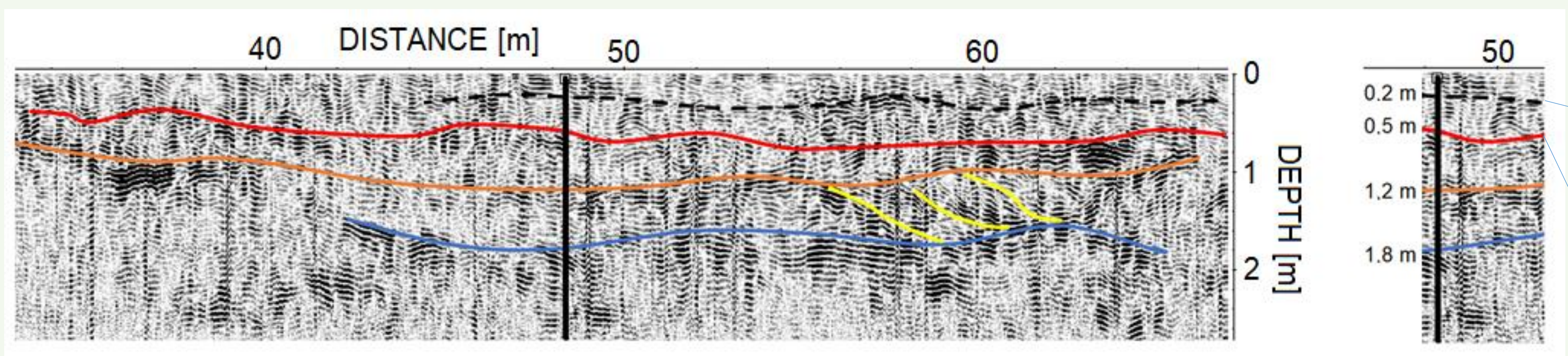
On two different agricultural fields, seven parallel GPR profiles with a fixed spacing were recorded using a 500 MHz antenna (Fig. 1). On the empty field, the profiles were 100 m long and 2 m apart, while in the orchard the profiles were 192 m long and 3.5 m apart. In both cases, the profiles were positioned around the area of soil profiling in order to directly compare the horizon thicknesses acquired with both methods (Fig. 2). Soil horizons were classified in the field and soil samples were collected for further analysis.

Results and Discussion

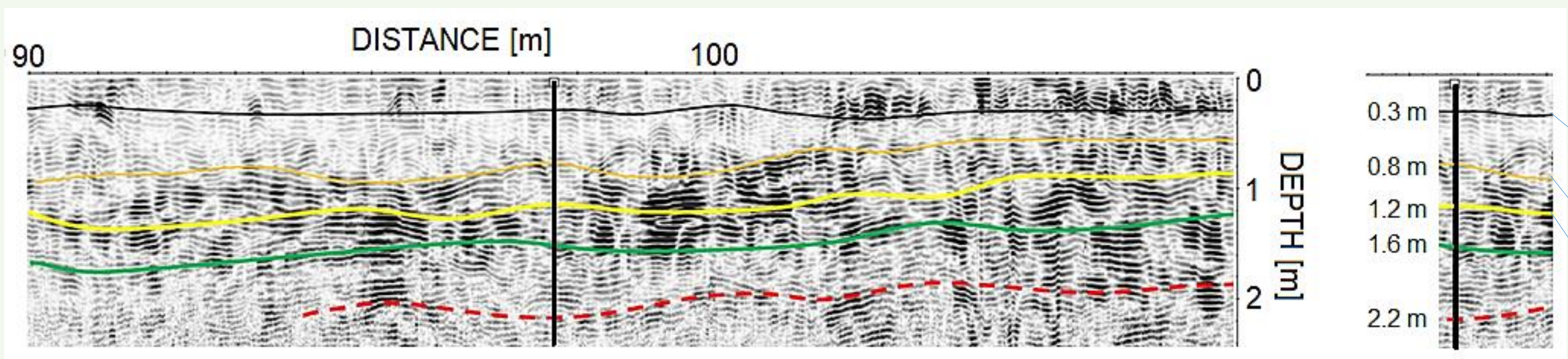
GPR transmits electromagnetic signals into the subsurface, which reflect back to the surface after reaching boundaries between materials with different electromagnetic properties. These boundaries produce stronger reflections in cases where consecutive soil horizons have highly contrasting physical and chemical properties (Daniels, 2004).

Results show that the most prominent horizons can be defined in GPR profiles and correlate well with soil logs (Fig. 3), while the thinner horizons and those with subtle changes in soil properties cannot be differentiated. The most pronounced horizons can be traced both laterally and vertically, providing deeper and wider information on the subsurface conditions than soil profiles alone (Fig. 4).

GPR was thus proven useful for subsurface examinations needed for optimal positioning of soil moisture probes in the field. Its implementation could, therefore, be useful for irrigation optimization surveys to assure water sustainability and higher agricultural productivity in precision agriculture.



Depth	Horizon
0 – 15 cm	Ap
15 – 25 cm	A_2
25 – 35 cm	G_{O1B}
35 – 45 cm	G_{O2}



Depth	Horizon
0 – 12 cm	Ap
12 – 33 cm	A
33 – 48 cm	Bv
48 – 70 cm	I
70 – 110 cm	II
110 – 140+ cm	III

Figure 3: Sections of GPR profiles recorded next to the soil profiles (marked with black vertical line) with depths to GPR horizons and tables with data from soil profiles (above – empty field; below – orchard).

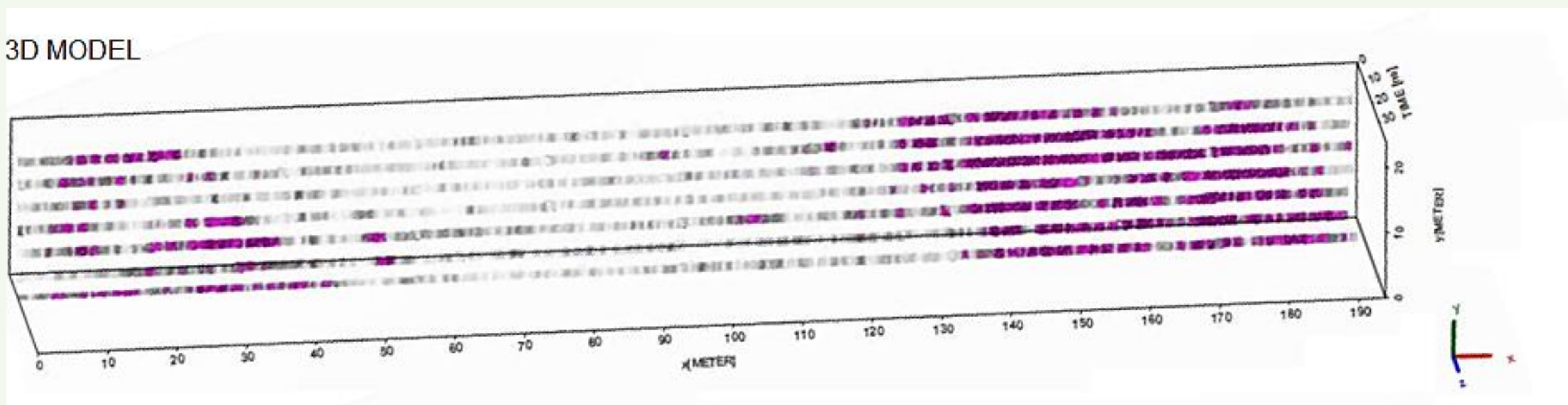


Figure 4: A horizontal slice at the depth of 0.6 m from a 3D model comprising all GPR profiles recorded in the orchard. The difference in the reflection strength shows areas with strong signal reflections at both ends of the model and a lack of reflections in the central part. This shows that subsurface conditions vary across the studied area.

References

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