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Efficient mapping of agricultural soils using a novel electromagnetic measurement system

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“Despite all our accomplishments, we owe our existence to a six-inch layer of topsoil and the fact that it rains.” – Paul Harvey. Despite the fact, that a farmers most precious good is the soil that he or she cultivates, in most cases actually very little is known about the soils that are being farmed. Agricultural soils are under constant threat through erosion, depletion, pollution and other degrading processes, in particular when considering intensive industrial scale farming. The capability of soils to retain water and soil moisture is of vital importance for their agricultural potential. Detailed knowledge of the physical properties of soils, their types and texture, water content and the depth of the agricultural layer would be of great importance for resource-efficient tillage with sub-area dependent variable depth, and the targeted intelligent application of fertilizers or irrigation.

Precision farming, which has seen increasing popularity in the USA as well as Australia, is still in its infancy in Europe. Traditional near-surface geophysical prospection systems for agricultural soil mapping have either been based on earth resistance measurements using electrode-disks that require soil contact, with inherent issues, or electromagnetic induction (EMI) measurements conducted with EMI devices mounted in non-metallic sledges towed several metres behind survey vehicles across the fields.

Every farmer passes over the fields several times during each growing season, working the soil and treating the crops. Therefore a novel user-friendly measurement system, the “Topsoil Mapper” (TSM) has been developed, which enables the farmer to simultaneously acquire soil conductivity information and derived soil parameters while anyway passing over the fields using different agricultural implements. The measurement principle of the TSM is electromagnetic induction using a multi-coil array to acquire conductivity information along a vertical profile down to approximately 1.1 m depth. Instead of being towed several metres behind the tractor, as common with traditional EMI systems used in precision farming, the novel device is conveniently mounted on the front hitch of a tractor and operated from a terminal in the driver’s cabin. A major improvement compared with existing EMI systems is the system’s capability to cope with the induced noise from the tractor, through integration of a mechanical shielding mechanism into the sensor housing. Any remaining vehicle induced high-frequency electromagnetic noise is filtered out on-the-fly by the data acquisition software, logging the data and positioning information on a ruggedized small computer. The main purpose of this system is to permit the land owner or farmer the efficient mapping of the electrical soil conductivity across agricultural fields on the scale of the entire acreage. The main objective of the measurements is to obtain detailed information on the long wavelength variability of soil structure, while eliminating short wavelength variations.

The calculation of the depth of the agricultural layer, or topsoil thickness, has been implemented by inverting the cumulative response function for all coil configurations. The resulting inverted models of the soil conductivity display the vertical distribution of agriculturally relevant soil parameters and improve the chances to identify different subsoil features.

By providing this information on the shallow subsurface in real-time, while passing across the field, permits the agriculturist to variably adjust for instance tillage depth or to control other agricultural implements and machines based to the derived information, rendering the soil cultivation both ecologically as well as economically more efficient. We present the TSM system as well as derived data examples.