Non-Destructive Techniques for Mapping Agricultural Subsurface Drainage Systems

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Agricultural subsurface drainage systems are installed to transform poorly drained soils into productive cropland and to mitigate soil salinization. Globally, some of the most productive regions are a result of adopted artificial drainage practices. These drainage systems play a crucial role in modulating the water table, while also acting as a shortened pathway for the transport of nutrients, pesticides and pathogens to the surface water bodies. Despite the importance for planning eutrophication and pollution mitigation strategies and for the installation of a new drainage system, their location is often poorly documented or entirely unknown. The traditional methods of drainage mapping involve the use of tile probes and trenching equipment. Both these methods are time-consuming, labor-intensive and invasive, and thereby inherently carry a risk of damaging the drainage pipes. Non-destructive proximal and remote soil sensing techniques might provide an efficient alternative solution. Amongst the proximal sensing techniques, a frequency-domain ground penetrating radar (GPR) and a novel vector magnetic gradiometer (tMag) were tested at study sites in Denmark and a time-domain GPR was tested at study sites in Midwest USA. Amongst the remote sensing techniques, unmanned aerial vehicles (UAVs) equipped with visible, multispectral and thermal infrared (TIR) cameras were tested at study sites in both Denmark and the Midwest USA. While the GPR proved successful at study sites where the soil electrical conductivity was lower than 20 mS m^{-1}, the tMag instrument proved less useful for this purpose. The newly emerging and increasingly affordable UAVs equipped with different cameras showed considerable potential, amongst which the TIR imagery was mainly successful when the relative humidity was lower than 60%. As the GPR and UAV technologies vary in their mode of employment, time and/or cost of data acquisition, and the soil properties they measure, the complementary use of both techniques proved to be most optimal for efficient subsurface drainage mapping. While the UAV imagery can possibly map the drain lines across the entire agricultural site, the GPR acted as a validation technique to discriminate the signature of drain

lines in the UAV imagery from that of farm field operations and provided depth information of the drain lines that is an important piece of information for accurate hydrological modeling.

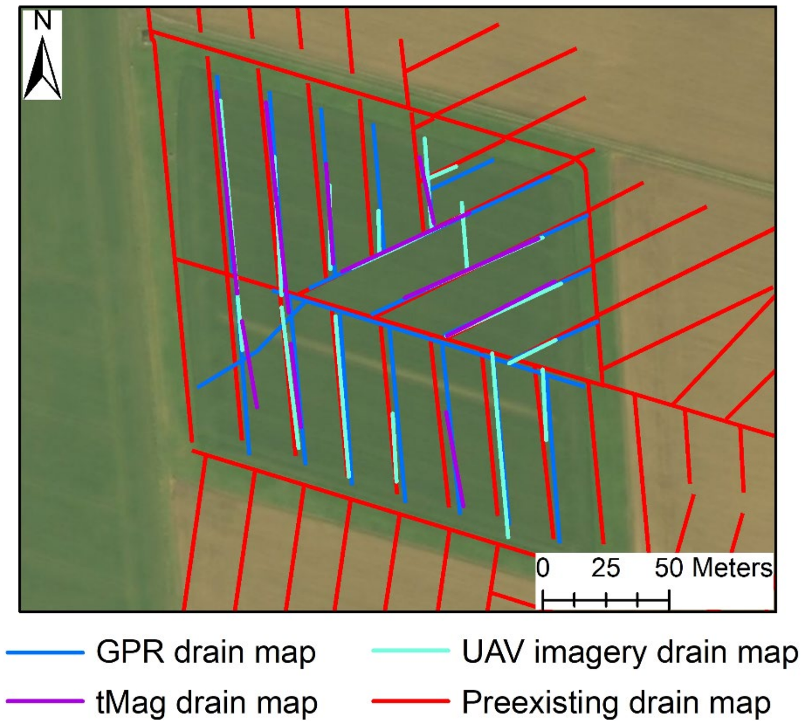

Figure: Drainage pipes mapped at a study site in Denmark using proximal (GPR, tMag) and remote (UAV imagery) sensing techniques.