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Using GPR early-time amplitude analysis to monitor variations in soil water content at a clay-rich agricultural site in response to irrigation

Jonathan Algeo (1), Remke Van Dam (2), and Lee Slater (1)

(1) Rutgers-Newark University, Newark, New Jersey, United States, (2) Queensland University of Technology, Brisbane, QLD, Australia

Geophysical methods are increasingly used to analyze spatial variation in soil water content (SWC). Electrical resistivity (ER), ground-penetrating radar (GPR), and time-domain reflectometry (TDR) have all been applied to this problem. However, TDR is limited in terms of its ability to provide good spatial coverage over large areas, ER can be very time consuming depending on the survey, and GPR direct wave and reflection methods are ineffective in clay-rich environments. We employed a relatively new GPR methodology, early-time amplitude analysis, during an infiltration experiment conducted in a clay-rich agricultural field. The research took place at the Samford Ecological Research Facility, Queensland, Australia, with the goal of monitoring changes in SWC in response to irrigation. We hypothesize that early-time analysis can be used to detect and monitor infiltration in clay-rich soils where direct wave and reflection GPR fails, thus opening new avenues of hydrogeophysical research in the increasingly important field of water resource management. Initial field work showed that traditional methods of using GPR reflection surveys and ground wave velocity analysis were ineffective due to the excessive signal attenuation caused by the clay-rich soil at the site. GPR and TDR datasets were collected over a 20 meter by 15 meter section of the field. GPR datasets were collected once daily, at 10 am, and TDR measurements were collected once daily at 11 am from Thursday, August 28th, 2014 until Monday, September 1st, 2014. A sprinkler irrigation was carried out on the evening of Thursday, August 28th. The results suggest that the early-time GPR method is capable of monitoring the resulting changes in SWC due to infiltration in clayey soils despite the failure of reflection and ground wave velocity analysis. The early time GPR results are consistent with moisture content estimates from TDR and gravimetric analysis of soil cores taken in the field.