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Large-scale multi-configuration electromagnetic induction: a promising tool to improve hydrological models

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Large-scale multi-configuration electromagnetic induction (EMI) use different coil configurations, i.e. coil offsets and coil orientations, to sense coil specific depth volumes. The obtained apparent electrical conductivity (ECa) maps can be related to some soil properties such as clay content, soil water content, and pore water conductivity, which are important characteristics that influence hydrological processes. Here, we use large-scale EMI measurements to investigate changes in soil texture that drive the available water supply causing crop development patterns that were observed in leaf area index (LAI) maps obtained from RapidEye satellite images taken after a drought period. The 20 ha test site is situated within the Ellebach catchment (Germany) and consists of a sand-and-gravel dominated upper terrace (UT) and a loamy lower terrace (LT). The large-scale multi-configuration EMI measurements were calibrated using electrical resistivity tomography (ERT) measurements at selected transects and soil samples were taken at representative locations where changes in the electrical conductivity were observed and therefore changing soil properties were expected. By analyzing all the data, the observed LAI patterns could be attributed to buried paleo-river channel systems that contained a higher silt and clay content and provided a higher water holding capacity than the surrounding coarser material. Moreover, the measured EMI data showed highest correlation with LAI for the deepest sensing coil offset (up to 1.9 m), which indicates that the deeper subsoil is responsible for root water uptake especially under drought conditions. To obtain a layered subsurface electrical conductivity model that shows the subsurface structures more clearly, a novel EMI inversion scheme was applied to the field data. The obtained electrical conductivity distributions were validated with soil probes and ERT transects that confirmed the inverted lateral and vertical large-scale electrical conductivity model. These results show that multi-configuration EMI data provide detailed subsurface information up to several meters depth that can be used to improve hydrological process understanding.