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Use of large-scale multi-configuration EMI measurements to characterize heterogeneous subsurface structures and their impact on crop productivity

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Soil subsurface structures can play a key role in crop performance, especially during water stress periods. Geophysical techniques like electromagnetic induction EMI have been shown to be able of providing information about dominant shallow subsurface features. However, previous work with EMI has typically not reached beyond the field scale. The objective of this study is to use large-scale multi-configuration EMI to characterize patterns of soil structural organization (layering and texture) and the associated impact on crop vegetation at the km2 scale. For this, we carried out an intensive measurement campaign and collected high spatial resolution multi-configuration EMI data on an agricultural area of approx. 1 km2 (102 ha) near Selhausen (North Rhine-Westphalia, Germany) with a maximum depth of investigation of around 2.5 m. We measured using two EMI instruments simultaneously with a total of nine coil configurations. The instruments were placed inside polyethylene sleds that were pulled by an all-terrain-vehicle along parallel lines with a spacing of 2 to 2.5 m. The driving speed was between 5 and 7 km h-1 and we used a 0.2 Hz sampling frequency to obtain an in-line resolution of approximately 0.3 m. The survey area consists of almost 50 different fields managed in different way. The EMI measurements were collected between April and December 2016 within a few days after the harvest of each field. After data acquisition, EMI data were automatically filtered, temperature corrected, and interpolated onto a common grid. The resulting EMI maps allowed us to identify three main areas with different subsurface heterogeneities. The differences between these areas are likely related to the late quaternary geological history (Pleistocene and Holocene) of the area that resulted in spatially variable soil texture and layering, which has a strong impact on spatio-temporal soil water content variability. The high resolution surveys also allowed us to identify small scale geomorphological structures as well as anthropogenic activities such as soil management and drainage networks carried out in the last 150 years. To identify areas with similar subsurface structures with high spatial resolution, we applied multiband image classification using the nine coil configurations as bands of a single image. We compared both supervised and unsupervised classification and obtained promising preliminary results showing a good degree of conformity between EMI supervised classification maps and observed patterns in plant productivity.