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Geophysics-based soil mapping improves the simulation of crop productivity at the field scale and beyond.

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Detailed soil maps are vital in agroecosystem modelling and precision agriculture since the spatial distribution of soil characteristics is a key control for water and nutrient availability. Non-invasive geophysical methods, such as electromagnetic induction (EMI) measurements, combined with direct soil sampling can be used to produce detailed soil maps. Despite the increased availability of such geophysical data sets, it is still challenging to produce relevant soil maps from such data for multiple adjacent fields and beyond the field-scale from such data. Furthermore, the added value of such high-resolution soil information for the simulation of patterns in plant productivity has not been fully investigated yet. In this study, high-resolution multi-configuration EMI data was measured in 2016 on 51 adjacent agricultural fields (102 ha) near Selhausen (NRW, Germany). In this area, the subsurface structure is known to affect the productivity of multiple crop types during water stress periods. Each field was separately measured within a few days after harvest and six apparent electrical conductivity (ECa) maps with increasing depth of investigation (DOI) were obtained in all the 51 fields. Since a direct correlation between EMI measurement and a single soil property is often difficult to obtain, we used a supervised image classification method to classify each field. The result was a 1 m resolution map of the study area that identifies 18 soil units with similar ECa signature. In a next step, 100 ground truth locations were randomly selected and information on horizon type, depth and texture were collected until a maximum depth of 2 m to provide each EMI-derived soil unit with a typical soil profile. Statistical tests (two-tailed t-test) were used to verify that each unit had unique soil characteristics in comparison to other units. The proposed methodology was effective in producing a high resolution soil map in a large and complex study area that extends well beyond the field scale. The EMI-derived high-resolution soil map was used to simulate the effect of subsurface heterogeneity on crop productivity in the presence of water stress for the 2016 growing season. For this, we used an ensemble of AgroC model runs. AgroC is a one-dimensional agroecosystem model that couples SoilCO_2, RothC, and SUCROS subroutines to predict plant productivity with an hourly time resolution. The necessary hydraulic parameters were estimated from the available soil texture information using pedotransfer functions. Information on crop type, emergence dates, and harvest dates were obtained from field observations. The simulated leaf area index (LAI) obtained with AgroC showed clear correlation with LAI derived from six RapidEye satellite images. Furthermore, simulations using commonly available soil maps performed significantly worse than using the geophysics-based soil map in terms of model efficiency and RMSE. Overall, it was concluded that there is a considerable added value in geophysics-based soil mapping for agroecosystem modelling and precision agriculture.