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Comparison of geophysical pedotransfer functions using laboratory measurements

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Small-scale variations of soil parameters such as water and clay content are of interest in agriculture and soil science. With geophysical methods it is possible to map variations of this scale easily and fast, but the measured geophysical parameters have to be converted into the soil parameters of interest, using geophysical pedotransfer functions (GPTFs). To test the suitability of different GPTFs linking electrical conductivity and permittivity to water content laboratory measurements under controlled conditions have been conducted. 23 large soil samples of different soil types have been taken in the field and dried at room temperature to achieve the lowest possible water content. Each sample was then filled into a plastic cylinder of 75 cm height and 23 cm diameter. This cylinder is equipped with two plate electrodes at bottom and top, respectively, for current injection and two ring electrodes in the middle to measure the potential difference. This array measures the electrical conductivity of the soil sample. To measure the permittivity, a 1.6 GHz GPR antenna was placed on top of the sample and the reflections originating from the bottom plate were recorded. Using the measured traveltime and the known travelpath the velocity and thus the permittivity of the soil could be determined. In successive steps, each sample was progressively saturated with a constant amount of rainwater (2-3 vol%) until full saturation, then measurements of electrical conductivity and permittivity were repeated. The water content was controlled by weighting of added water and the whole sample and small subsamples were taken and dried in the oven to yield the exact water content.
Applications of different empirical and constitutive models show that the relatively simple empirical and volumetric mixing models give accurate results in the prediction of the water content from these geophysical parameters. The more complicated effective medium models had only slightly better RMS errors.
We can observe a linear relationship between electrical conductivity and permittivity that can be used to determine the GPR velocity distribution from an inverted geoelectric profile in situ. These results are confimed by a comparison with additional field velocity measurements showing good agreement.

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