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Combining X-ray and electrical resistivity tomography methods towards a new methodology of soil hydraulics properties assessment

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Developing a better understanding of soil hydraulic properties is of significant importance for such diverse fields as agriculture, soil and ecosystems management, civil engineering and geotechnics. Electrical Resistivity Tomography (ERT) and X-ray Computed Tomography (CT) are two state-of-the-art methodologies with great potential for applications in soil science. ERT allows time-lapse monitoring of solute transport. X-ray CT is sensitive to bulk density changes at high resolution.
We obtained the functional dependence of soil electrical resistivity and x-ray absorption on moisture content in a laboratory-controlled calibration experiment, therefore deriving the corresponding transfer functions. Experimental results were compared with existing models, such as Waxman-Smits and Bailly. The high degree of correlation (Pearson R > 0.85) and low misfit (%RMS < 12%) between measurements and model predictions confirmed the validity of these models, subsequently allowing us to formulate a new property relationship linking x-ray absorption and electrical conductivity. Furthermore, we conducted a column experiment, which takes advantage of the specific strength of both tomography methods. It aimed to assess the effect of long-term zero tillage (ZT) by monitoring a 0.05 M KCl solution infiltration in 4 undisturbed soil cores subjected to different management practices: Ploughed, 2, 7 and 12 years ZT. 7 and 12-year ZT soils exhibited a slow infiltration and a more expansive solution distribution. We correlated these results to structural parameters which indicate a lower total porosity, lower pore connectivity, increased bulk density and a significant ion binding effect.
This methodology opens the door for future assessments of soil hydraulic properties using X-ray CT and ERT in conjunction and may serve as reference for future calibration studies between electrical and structural properties of materials. Furthermore, this study brings new insights about the long-term effect of ZT by quantifying and directly linking structural and hydraulic soil properties.