Anisotropic 2D modelling of induced polarization data

J. Kenkel, R. Martin, A. Kemna, University of Bonn, Germany

Research over the last decade has shown the potential of electrical impedance measurements to characterize soils and rocks with respect to pore-fluid chemistry and saturation, mineral surface properties, texture, and hydraulic permeability – the latter being attributes which become accessible with the recent findings. Commonly, electrical impedance data recorded at the field scale are processed using techniques based on isotropic subsurface properties. However, it was previously shown for DC conductivity that ignoring anisotropy may yield misleading inversions, resulting also in false hydrological interpretations. We study the effects of anisotropic complex electrical conductivity, with a particular emphasis on the polarization properties described by its imaginary component (or its phase). In our case, the anisotropic complex electrical conductivity is expressed by three independent components of a diagonal tensor corresponding to the x, y and z directions, respectively. An example-driven sensitivity analysis with respect to the anisotropic complex conductivity is carried out. Hereby, the influence of changes in the anisotropic complex conductivity in a defined region of the subsurface on the recorded complex electrical impedance data is examined for different measurement configurations and subsurface models. The study is carried out with an extended version of the isotropic finite-element forward modelling code by Kemna (2000), which now supports anisotropy in the computation of impedance data and corresponding sensitivities. Our results show different sensitivity distributions for all components of the anisotropic complex conductivity. These distributions each show zones of large absolute sensitivities that are located in distinct regions of the subsurface. If employed in an inversion algorithm for anisotropic complex conductivity, this individuality is expected to lead to an improved reconstruction of subsurface structures, if anisotropy is present.

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