EGU General Assembly 2020

EGU2020-16956
https://doi.org/10.5194/egusphere-egu2020-16956
EGU General Assembly 2020

Cumulative errors in the use of geophysically-derived salinity for the characterization of seawater intrusion in heterogeneous coastal aquifers

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Seawater intrusion is a natural phenomenon occurring in coastal aquifers, which is exacerbated by borehole abstraction, which may lead to contamination of water supplies. Borehole data are usually too scarce spatially to enable accurate identification and delineation of seawater intrusion. For that purpose, electrical resistivity tomography (ERT) and electromagnetic (EM) methods are proven and popular geophysical techniques because of their high spatial resolution and sensitivity to pore water salinity, which is particularly beneficial in heterogeneous aquifers characterised by complex saltwater intrusion patterns. Inverted resistivity models can be converted into pore water salt concentration through the application of so-called petrophysical relationships, and further interpreted to map seawater intrusion patterns or used as constraining dataset for groundwater models. However, the conversion procedure is prone to conceptual and computational errors including the application of the appropriate petrophysical relationship —considering heterogeneity or clay content—, and the numerical limitations in the inversion of the geophysical data. These errors are cumulated and transferred throughout all steps from geophysical acquisition to the hydrogeological model. In this work, using ERT geophysics as an example, we evaluate the magnitude and spatial distribution of relative errors and their imprint in the final recovered salinity section to be used for interpretation or model calibration. Results highlight the importance of applying the appropriate petrophysical relationship when delineating spatial salinity patterns from the resistivity model, along with the errors associated with the conceptual simplifications in heterogeneous systems on one hand, and with the geophysical inversion procedure on the other hand. These three sources of errors add-up and may lead to large inaccuracies in the estimated position and spreading of the seawater-freshwater mixing zone. They need to be accounted for when using geophysical model for mapping and modelling of saltwater intrusion. The analysis also provides practical insights for the integration of inverted geophysical data in early-warning seawater intrusion monitoring strategies, for improved estimations of freshwater resources and for the management of coastal aquifers.