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Testing how geophysics can reduce the uncertainty of groundwater model predictions

Nikolaj Kruse Christensen (1,2), Steen Christensen (2), and Ty Ferre (3)

(1) Corresponding author; (phda.nikolaj.kruse@geo.au.dk), (2) Department of Geoscience, Aarhus University, Aarhus, Denmark, (3) Department of Hydrology and Water Resources, University of Arizona, USA.

Geophysical data are increasingly used to construct groundwater models. Such data are collected at lower cost and much higher density than the traditionally used geological, hydraulic, and hydrological data. The geophysical data are often inverted independently and used together with geological data to build the conceptual model and define the parameterization of the groundwater model. The groundwater model is then calibrated against hydrological measurements only. This sequential inversion approach process is relatively straightforward; however it fails to extract all of the relevant information contained in the data. Previous researchers have shown examples for which joint or coupled hydrogeophysical inversion leads to improved use of geophysical and hydrological data. However, to date there are no clear guidelines for when sequential, joint, or coupled inversion should be used. We present a modeling platform that can be used to examine the conditions that support the use of each inversion approach for efficient and effective use of all data to constrain hydrologic models.

We have developed a synthetic "test-bench environment" to test the advantages and limitations of alternative hydrogeophysical inversion approaches. The environment consists of multiple high resolution realizations of synthetic hydrogeological and geophysical systems (called true systems). The two types of true systems can be used together with corresponding forward codes to generate hydrological and geophysical data sets, respectively. There is also complete flexibility in the choice of relationships between hydraulic and geophysical properties. Noise can be added to the synthetic hydrologic and geophysical data sets and these exhaustive data sets can be down sampled to represent realistic data sets of varying measurement density and coverage. Finally, these synthetic data sets can be interpreted using any hydrogeophysical inversion scheme and the resulting predictions can be compared with predictions from the 'true' model. The modular nature of this platform allows for investigations of the role of inversion approach, data density, data quality, and uncertainty in petrophysical relationships on the accuracy of hydrologic predictions.

We will demonstrate the "test-bench" by using a hydrogeological system with a buried valley eroded into an impermeable low-resistivity substratum; the buried valley is filled with and covered by layered glaciofluvial and glacial deposits. The hydrological data consist of 35 hydraulic head measurements and one river discharge measurement, while the geophysical data consist of 77 TEM soundings. The data are inverted sequentially and jointly. Through this example, we highlight the value of joint hydrogeophysical inversion and the importance of uncertainty in the petrophysical relationship.