Informing groundwater models with near-surface geophysical data - DTU Orbit (23/12/2018)

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Over the past decade geophysical methods have gained an increased popularity due to their ability to map hydrologic properties. Such data sets can provide valuable information to improve hydrologic models. Instead of using the measured geophysical and hydrologic data simultaneously in one inversion approach, many of the previous studies apply a Sequential Hydrogeophysical Inversion (SHI) in which inverted geophysical models provide information for hydrologic models. In order to fully exploit the information contained in geophysical datasets for hydrological purposes, a coupled hydrogeophysical inversion was introduced (CHI), in which a hydrologic model is part of the geophysical inversion. Current CHI-research has been focussing on the translation of simulated state variables of hydrologic models to geophysical model parameters. We refer to this methodology as CHI-S (State). In this thesis a new CHI-approach was developed, called CHI-P (Parameter), which applies coupling constraints between the geophysical and hydrologic model parameters. A CHI-P was used to estimate hydraulic conductivities and geological layer elevations for a synthetic groundwater model using Time-Domain Electromagnetic (TDEM) data and for a real-world groundwater model using geo-electric data. For the synthetic study, the CHI-P resulted in improved parameter estimates and a reduction in parameter uncertainty for both the hydrologic and the geophysical model, when compared with a SHI. For the realworld groundwater model, parameter uncertainty could not be reduced significantly, but the CHI-P resulted in more consistent parameter estimates between the groundwater model and the geophysical model. To our knowledge, CHI-P is the first CHI method that can be applied to inform large-scale groundwater models with near-surface geophysical data. In another study, we successfully applied a CHI-S to estimate parameter values of a saltwater intrusion model with TDEM data. Considering the small number of estimable parameters, data fit and parameter uncertainty, the salt water intrusion model provided an excellent interpretation of the geophysical data. The CHI-S yielded a geophysical model that could never be obtained with a separate geophysical inversion. Furthermore, we applied a CHI-S to evaluate the potential for time-lapse relative gravimetry (TL-RG) and magnetic resonance sounding (TL-MRS) to improve the estimation of aquifer properties during an aquifer pumping test. This was done, taking in account a number of practical issues that might limit the sensitivity of these techniques with respect to the estimated aquifer properties. For this purpose a virtual pumping test was used with synthetic observation data. In contrast to the prior assumptions, the conclusions suggest that both geophysical techniques have a potential to improve the estimation of aquifer properties. In the analyses, TL-MRS outperformed TL-RG data and parameter uncertainty could be reduced with ca. 30 % for most of the scenarios that were investigated.

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