Improvement in MRS parameter estimation – a closer step toward hydrogeological interpretations

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We present results of a new inversion scheme which greatly improves the estimation of Magnetic Resonance Sounding (MRS) model parameters. During the last few decades, electrical and electromagnetic methods have been widely used for groundwater investigations, yet they suffer from some inherent limitations; e.g. equivalent layer sequences. Furthermore, the water content information is only empirically correlated to the resistivity of the formation. MRS is a non-invasive geophysical technique which directly quantifies the water content distribution from surface measurements. The resistivity information of the subsurface is obtained from a complementary geophysical method like the TEM or DC resistivity methods. The conventional step-wise inversion of MRS data assumes the resulting resistivity structure to be the true one and considers a constant MRS kernel through the inversion. We show that this assumption may introduce an error to the forward modeling and consequently result in erroneous parameter estimations in the inversion process. In other words, the MRS data contain resistivity information which helps update the MRS forward response during inversion and leads to more reliable and robust estimation of aquifer characteristics. A joint and laterally constrained inversion scheme of the MRS and TEM data is presented. We prove the need for sufficient deep and correct resistivity information and discuss the advantage of TEM for the joint inversion compared to DC resistivity. A fast and numerically efficient MRS forward routine makes it possible to invert the MRS and TEM data sets simultaneously along profiles. Moreover, by application of lateral constraints on the model parameters, laterally smooth 2D model sections can be obtained. The simultaneous inversion for resistivity and MRS parameters leads to a more reliable and robust estimation of all parameters, and we show that the MRS data diminish the range of equivalent resistivity models. As a consequence, a more reliable estimation of hydraulic parameters of the aquifer can be achieved. The approach is examined through a synthetic example and a field example from Denmark in which the results of step-wise, joint and joint-LCI inversions of MRS data are compared. The field results agree well the information from the existing boreholes at the site, and a clear correlation between the relaxation time T_2^* and the grain size distribution of a sandy aquifer is observed (figure 1).

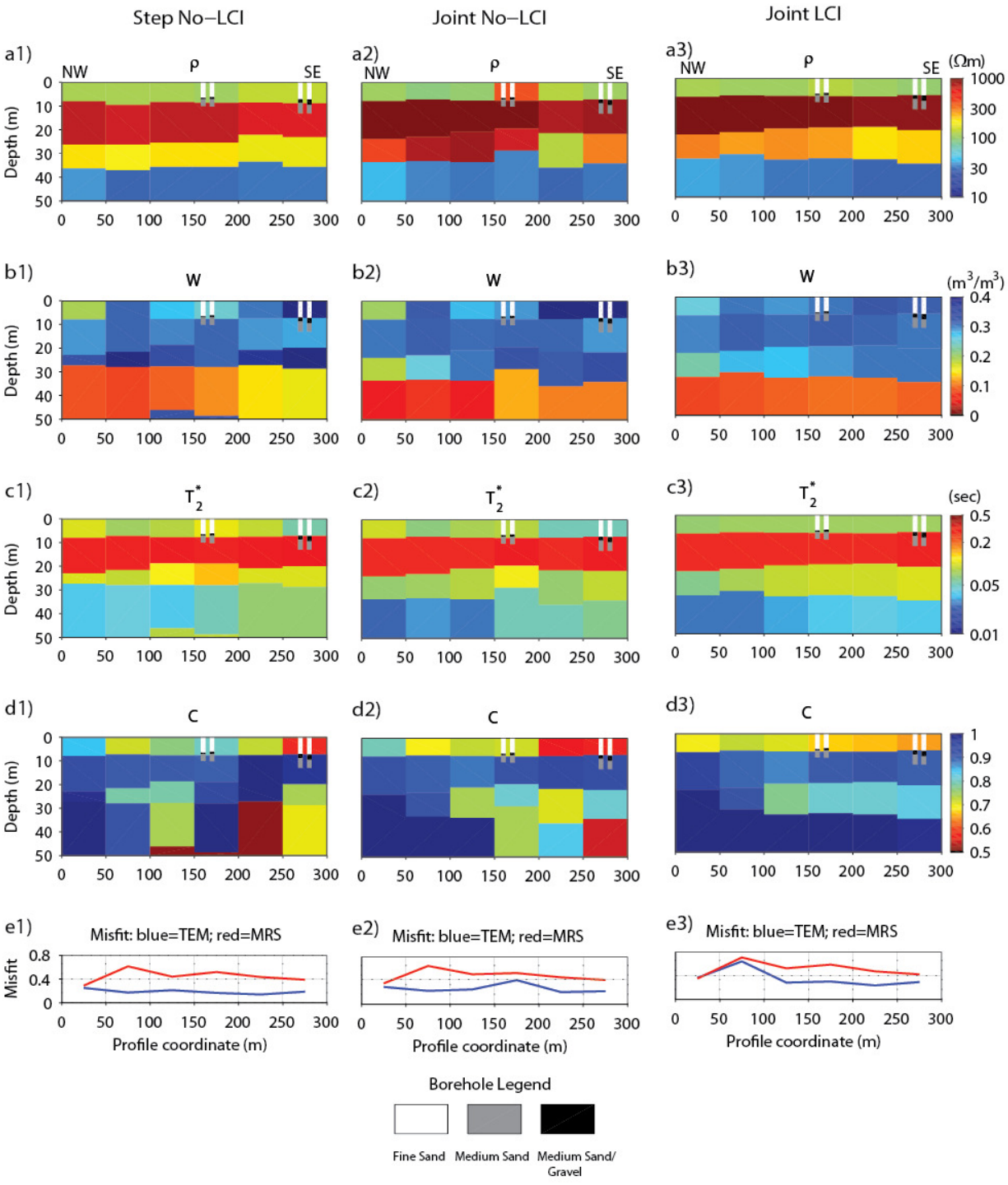

Figure 1. Inversion results. Left: the step-wise; middle: the joint (no LCI); right: the joint-LCI approach.