PROBABILISTIC INVERSION FOR GEOLOGICAL FEATURES DIRECTLY FROM AIRBORNE EM DATA

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Collection of electromagnetic (EM) data (from airborne systems, boats, towed instruments on the surface) has found widespread use, as it allows efficient imaging of large areas of subsurface variations in resistivity, that has a variety of uses as for example for ground water management, contamination analysis, permafrost imaging, and mineral exploration. Traditionally the analysis of such EM data has been done in a sequential order: First EM data have been inverted to resistivity volumes, which have then been analyzed by geologists, hydrologists or petro-physicists, depending on the use case. This leads to a workflow in which it is practically impossible to account for uncertainty, not least because analysis is typically performed on a single optimal model (both the output from the geophysical analysis, and the subsequent geological analysis). Further, most all available geophysical inversion methods used to convert EM data into resistivity volumes, make implicit assumptions about the subsurface variability (such as simplicity/smoothing). In practice this means that the produced resistivity volumes may by construction be inconsistent with the actual subsurface geology.

Recently probabilistic inversion methods have become available that allow taking into account geological information, directly in the inversion, as prior information. This means that the outcome of the inversion will by construction be consistent with known assumed geological variability. And, the outcome can be direct estimates of geological features, such as: what is the probability of locating a potential ground water reservoir? To fully utilize such a probabilistic framework, the main challenge is to quantity geological information, by construction of an algorithm that can generate realizations of an assumed statistical model representing geological structures and associated uncertainty.

Using airborne EM data from the southwestern Sweden, we will demonstrate how to implement such a probabilistic approach to directly quantify the probability of locating a specific gravel layer of interest. We will do this in a two-step process: The first involves quantifying prior information to describe a probabilistic conceptual geological model, that represent expected layers, and their potential thicknesses. Then we describe a probabilistic link between geological properties and the associated resistivity distribution. This represents a joint prior conceptual geological and resistivity model. Once this has been established, we apply a probabilistic inversion that allow quantifying the posterior probability of any feature that is described in the prior model. Here the main focus is the existence of a relatively thin gravel layer, that has potential to contain easy to produce drinking water.

We present a novel framework, and the methods needed to implement the framework, that allow quantifying jointly, and unbiased, geological and geophysical information into one model, from which decision makers can directly get answers, consistent with the available information.