Accurate processing and inversion as the ultimate QC of AEM data

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ABSTRACT

The task of QC AEM data is common to many organizations and professional profiles. From Geological Surveys, to contractors, from hydrogeologists, to geophysicists and exploration geologists. It is however no trivial problem, attacked often from different angles, depending on background, expertise, goals. The thrust of this paper is to show that there is no better (no other) way of QC AEM data than to work not just in the data space, but also in the model space (i.e., the 3D distribution of electrical resistivity of the subsurface). One of the terms most often cited in QC data is that of *precision*. Despite the fact that sometimes this term is misused, precision is defined as the degree to which a given instrument, *under unchanged conditions*, is capable of repeating to the measure of a given physical property. Hence, often the approach for testing it, is that of flying the same line twice, and show how repeatable the reading in the Rx (Volts, or Teslas/s) are. However what often fails to be recognized, and perhaps even communicated to the end users, is that it is very rare that a given piece of ground is measured twice by an AEM system *under unchanged conditions.* Most often than not, system height and frame attitude change. At times, also the Tx current varies. If the conditions change, the instrument must not necessarily repeat the same reading; e.g., flying closer to the ground gives higher signal, especially at early times/high frequencies , even over the same piece of ground. The readings in the Rx are the convolution of ground response and system transfer response (STF). In re-flights, what needs to be repeatable –hence precise- is the ground component part of the readings. The only way to assess precision is therefore to invert the data, uncoupling, from the measured signal, system STF and ground response. Another concept, rarely directly used in QC, but sometimes hinted at, and sometimes confused with precision, is that of *accuracy*. The latter is the measurement of closeness of measurement of a quantity to its actual (true) value. It should be evident that precision (repeatability) is not that useful per se, if the measured value we can repeat to a satisfying degree is not accurate (i.e., it is repeatedly far from the true value). An AEM system is well *calibrated*, if it is accurate. It is obvious that also in order to assess the accuracy (calibration) of an AEM system in rendering the actual distribution of the electrical resistivity, we need to work in the model space. The first approach is to invert the AEM data and compare the outcome with a relevant resistivity reference model (obtained from DC/borehole data, other EM data). The second is to forward model the reference resistivity model with the STF of the particular system in the condition of acquisition, and compare it with the actual observations of the system over it. For different reasons, the first approach tends to be the most tempting. It must however be stressed that an inversion output is the end result of a series of steps. From survey design, to data acquisition, pre-processing, post-processing, data integration (another issue that only makes sense contemplating the model space), and inversion, they all contribute to the output. Inaccurate processing and inversion can jeopardize the recovered models, and in turn also the ultimate assessment on AEM data precision and accuracy. If a problem of inaccuracy/poor calibration of an AEM system has been detected, it is again through inversions that, in some cases, the accuracy/calibration of that dataset might be improved. We will present examples that illustrate all the aspects mentioned above.

Key words: Accuracy, calibration, AEM, modelling, inversion, processing, data integration