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Robust estimation of magnetotelluric impedance functions based on a bounded-influence regression M-estimator and the Hilbert transform

D. Sutarno

Physics of Complex System Division

Faculty of Mathematics and Natural Sciences

Institut Teknologi Bandung

Accurate estimation of impedance functions is essential for the correct interpretation of magnetotelluric (MT) measurements. Noise is inevitably encountered when MT observations are conducted and, consequently, impedance estimates are usually based on least-squares (LS) regression. Least squares ultimately assumes simple Gaussian statistics. However, estimation procedure based on LS would not be statistically optimal, as outliers (abnormal data) are frequently superimposed on normal ambient MT noise field, which is approximately Gaussian. In this situation, the estimation can be seriously misleading and results in a distortion of the estimates.

This paper proposes a procedure for making unbiased robust estimates of MT impedance functions. The means for accomplishing this is based on the bounded-influence regression M-estimation and the Hilbert transform operating on minimum phase MT impedance functions. A bounded-influence robust estimator is here developed to simultaneously provide protection from the influence of outliers in both response and input variables. This new robust estimator combines a standard robust M-estimator with leverage weighting based on the statistics of the hat matrix, which is a standard statistical measure of unusual input. On those bases, outlier contamination is removed from the resulting regression estimates and the bias problem is solved. Using synthetic and real MT data, it is shown that the method can produce improved MT impedance functions even under conditions of severe noise contamination and in the absence of remote reference data.