

Technical Note: Estimating the noise associated with each GEOTEM/MEGATEM time window at each measurement location.

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Introduction

When running inversions on GEOTEM or MEGATEM data, the inversion programs frequently require a noise or standard deviation estimate to associate with each measurement. The noise estimate is used to determine how closely to fit the measured data. Small noise levels should indicate that the fitting program should try fitting the data more closely and large noise levels indicate that a close fit is not required.

We have developed two methods for estimating the noise for each time window at each location. The methods require the raw data (with noise) and the processed data after a “best effort” has been made to remove the noise. The black and red traces on Figure 1 are the raw data and the data after processing respectively. The high frequency noise has been removed, but small amounts of signal might also have been removed, for example at the peak of the anomaly near 2400 m.

The black trace at the bottom of the profile plot shows the power line monitor. This indicates that there is one or more large power lines at 1600 m. There is also a broad anomaly at 4400 m. The purple trace is the difference between the raw and processed data. The difference is large near the power line. There is an increase near the sharp anomaly at 2400 m. At this location, we feel that the difference actually contains a small signal component, indicating that the “noise removal” processing has removed some signal. However, having a component of signal in the difference trace is not a bad thing when it indicates that the data at the peak should not be fitted closely. Note that the raw and processed data on the flanks of the anomaly are close and the noise trace is small, so the data can be fitted closely.

The broad anomaly at 4400 m shows no apparent component of signal in the difference trace.

The two different methods use the noise from the difference trace to estimate the noise.

Noise envelope method.

The difference trace D and the Hilbert transform of the difference trace $\mathcal{H}(D)$ have been combined to give an estimate of the noise envelope N .

$$N = \sqrt{D^2 + (\mathcal{H}(D))^2}$$

This is shown as the dark blue trace on Figure 1. This envelope is a positive quantity. Essentially the amplitude of the noise is smaller than the envelope value. Locations where the envelope increases reflect where the noise is greater (around the power line), or the noise contains signal and the processed data should not be fitted as closely (at 2400 m). Note that the Noise envelope around 4400 m is comparable to other locations.

Standard deviation method

The standard deviation SD at sample j is calculated as

$$SD_j = \sqrt{\frac{1}{2M} \sum_{i=j-M}^{j+M} (D_i - \hat{D})^2},$$

where \hat{D} is the mean of the D_i over the range $[j-M, j+M]$. The standard deviation noise estimate calculated using a window of 31 points ($M=15$) is shown with the light blue trace. In this case 31 points corresponds to a width of nearly 500 m. Note that the light blue standard deviation trace is generally comparable to the noise envelope estimate, but smoother and smaller. The smoothness is a function of the window size. A smaller window size would give a less smooth appearance. The fact that the standard deviation is smaller is because 66 % of (Gaussian distributed) samples will be less than the standard deviation, so 33% must be above. The noise envelope is defined such that all difference values should lie below the envelope. In some cases, the difference trace lies outside the

noise envelope. This is because a small 5-point filter has been applied to the noise envelope.

Note that the results can be used in two ways. If the data errors are required at each measurement location, then the blue profiles of figure 1 can be provided in the database with the measurements. Alternatively, if all that is required is a representative error estimate for a line or the survey, then the profiles can be averaged on a line or survey basis.

Conclusion

It is possible to get an estimate of the noise associated with each GEOTEM or MEGATEM data measurement. The methods assumed that the information removed by the processing is an indication of the noise. There are two estimates available. The noise envelope estimate gives an upper bound on the noise. The standard deviation estimate gives a value SD and 66 % of the noise samples will be less than this value. In calculating the standard deviation, it is necessary to select a window width $(2M+1)$.

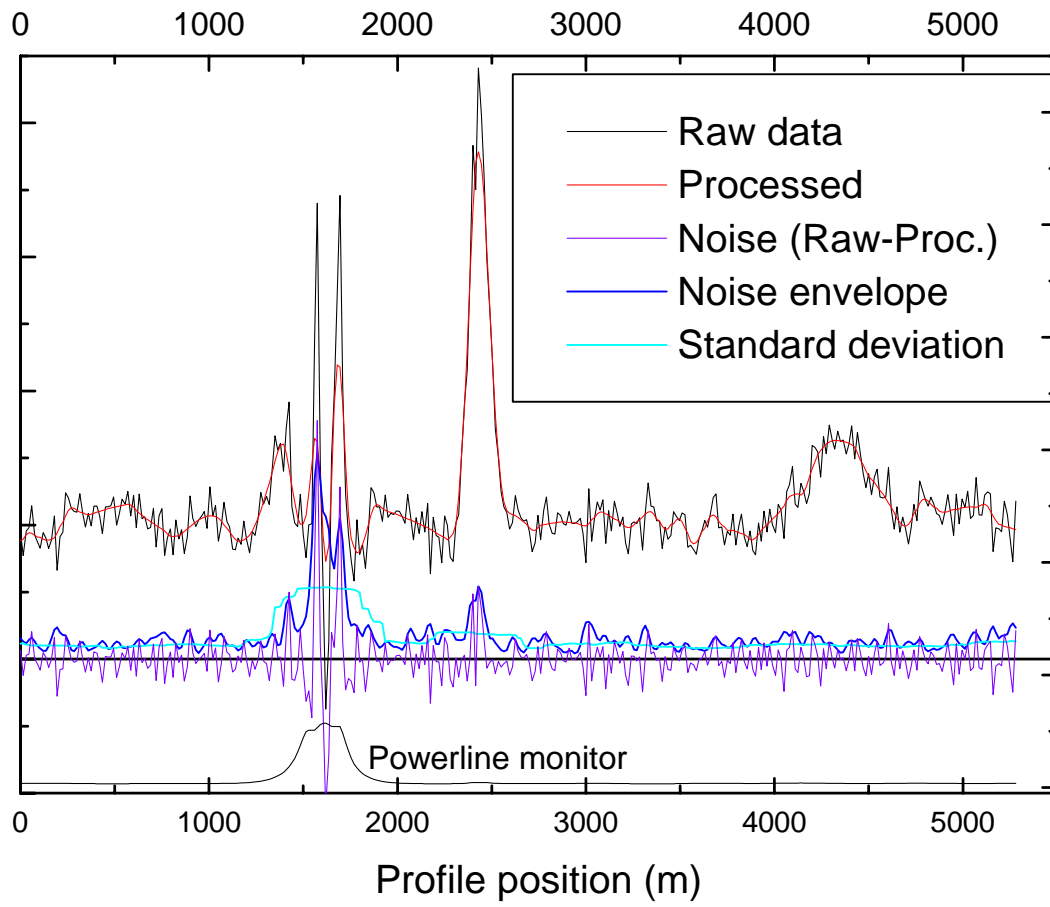


Figure 1