Geophysical Research Abstracts
Vol. 15, EGU2013-10590, 2013
EGU General Assembly 2013

On the effect of non stationary (synthetic) sources in the magnetotelluric method

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A new, non stationary scheme for the statistical magnetotelluric (MT) transfer function estimation is used to assess the effects of non stationary noise in MT data processing. The scheme uses Empirical Mode Decomposition (EMD) to process spectral data and is referred to as Empirical-mode-decomposition-based Magneto-Telluric processing (EMT).

We compare EMT with BIRRP by Chave and Thomson [2004], a traditional and efficient processing code based on the Fourier Transform. Two tests are performed, first, synthetic, non stationary data is constructed from two non stationary sources to demonstrates the inability of a Fourier based method to deal with non stationary sources. Then, secondly, these sources are used as a noise source. The non stationary noise is added only to the electric fields and leaves the magnetic and remote channels completely unaffected. Therefore, we can show that the computation of the spectra via Fourier Transform fails, because uncorrelated stationary noise in the spectra should be cleaned by the remote referencing technique, which is applied in the test. Since any uncorrelated (random) non stationary noise acts as any random stationary noise and does not affect the measurements other than decreasing the confidence in the results (larger error bars), this test shows that the mere fact that the added noise is non stationary affects the estimated results by a Fourier Transform based method or even makes it impossible to extract reasonable transfer functions, whereas the EMT algorithm is able to deal with the non stationarity and allows a more precise estimation to a lower signal-to-noise ratio.

In summary, we show that non stationary sources can heavily impact on traditional MT processing routines which rely on the Fourier Transform but that this effect can be diminished by relying on a purely non stationary analysis. The non stationary source is specifically designed to disturb the Fourier Transform and to break its assumptions, however the results provide an insight in how bad real non stationary noise can affect MT measurements and encourage to verify these findings on a real world problem with data that is suspected to contain, in particular, non stationary noise, e.g. data that is acquired close to train lines, mining shafts and elevators or electric fences.