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Enhancing signal-to-noise ratio of magnetotelluric responses by directional filtering

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The magnetotelluric (MT) method generally suffers from a low signal-to-noise ratio (S/N), particularly in some frequency bands, due to the presence of a variety of sources for natural and cultural noise. A significant contribution to noise in the data is caused by localised cultural sources such as mining areas, electric fences and television transmitters. Accordingly, S/N can be improved by filtering and subsequently rejecting signals arriving at the recording station from the direction of these sources.

Usually MT data is Fourier transformed and estimates of the electric impedance are made in the frequency domain. But the Fourier transformation (FT) method has low sensitivity to non-stationary signals (variable over the recording time) and is not able to determine the arrival time of a signal. This can be overcome by either dividing the record into shorter segments of time, performing the FT for each of the subsets and subsequently investigate the results for each of the subsets, or by continuous wavelet transform (CWT) analysis of the recorded signal. Here the CWT analysis is used for processing the data as it provides an evolutive (time-varying) spectral estimate of chosen frequencies for the recorded data set. Among the different wavelet forms for CWT analysis the Morlet wavelet was found to be most effective in processing MT data. The arrival of a signal can therefore be found from an increase in the measured spectra.

A typical MT station setup comprises two dipoles measuring the horizontal electric field (E) in orthogonal directions and two magnetometers measuring the horizontal magnetic field (H) in orthogonal directions. We pick the arrival times in the recorded H-field dataset and compare the signal strength of both records for each picked time. As the magnetic field in measured in orthogonal directions, the direction of a signal can be found (in multiples of 180 deg) as phi = atan (c2/c1) with c1, c2 denoting the strength of the H-field in north-south and east-west respectively and phi, the angle clockwise from north. In this way we obtain a directional distribution of the recorded signals. By directional segregation of the signals according to their noise level a group of signals with enhanced S/N can be extracted. This group can then be used for further conventional MT processing.