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In Magnetotelluric (MT) data processing, poor signal-to-noise ratio usually biases the impedance tensor Z elements estimates. Strong electromagnetic (EM) noise may thus render the MT method impracticable in industrial areas. Noise due to periodic sources (i.e. power line harmonics) is easily removed by analog filtering in the field; but non-periodic EM noise (see e.g. Szarka, 1988, for an exhaustive list) should be handled more accurately in MT data processing. Time-domain processing of MT data has demonstrated that in time domain signals can be better than in frequency domain discriminated from the noise (Spagnolini, 1990). When, as is generally the case, the noise sources are fixed in space, noise shows strong directional properties, regardless of whether the source is uni-polar or bi-polar in nature. It may be possible to identify the main noise sources of the area with a net of MT sites. In this case, we take into consideration impulsive noise, like spikes and steps of random amplitudes and time positions. The first derivative of the signal transforms steps into one-lobe spikes, thus avoiding a differentiated approach to the two kinds.

Given the noisy field signal:

$\mathbf{S}_n(t) = \mathbf{S}(t) + \mathbf{N}(t)$ (bold indicates vector), noise correlation on orthogonal (telluric or magnetic) horizontal channels identifies one or more main directions in the noise $\mathbf{N}(t)$. Taking advantage of its directional properties, directional filtering of the most likely noise sources estimated from the data allows the selective cancelation of the artificial impulsive sources as well (Directional Noise Canceling: DNC). A time-domain fully automatic technique is presented that first identifies the most likely noise signals and then, using directional noise character, angularly locates the source and cancels only the artificial signal. A mean square time domain prediction approach is used as a raw estimate of the signal (i.e.

$\hat{\mathbf{S}}(t) \approx \mathbf{S}(t)$). The prediction mismatch is uncorrelated with the data and may be modeled as a white Gaussian distribution, while noise have a different 2D statistical distribution. The prediction error $\mathbf{S}_n(t) - \hat{\mathbf{S}}(t)$ is the combination of prediction mismatch and noise, the signal as well as the noise is estimated using the conditional mean (2D Bayes' estimation):

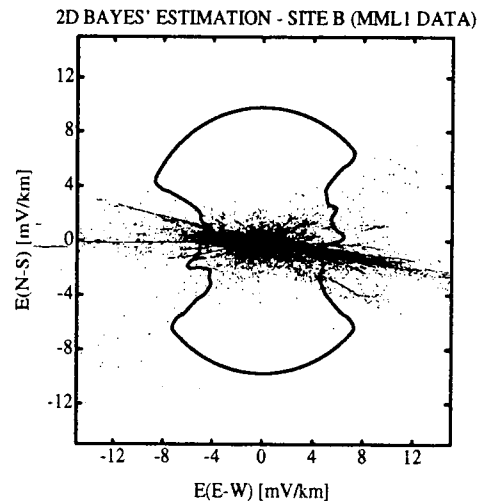


Fig.1 Prediction error shows strong directional properties due to noise (dots in the hodogram) while the DNC separates signal from noise (threshold: solid line).

$$N(t) \equiv E[N(t)/S(t) - \hat{S}(t)]. \quad (1)$$

The DNC takes advantage of the directional properties (polarization) of noise for the evaluation of (1). Fig.1 shows a histogram (hodogram) of prediction error (dots) and the non-linearity given by the conditional mean estimate (1) (only the expanded threshold is shown for clarity's sake). The dots along the E-W in Fig.1 represent the noise directions mainly due to a combination of different noise sources (it is very likely that allineated dots represent spatially fixed noise sources while sparse dots are due to other sources).

DNC was applied to MT data collected from six (not simultaneous) sites in the Central Alps (Northern Italy, Sondrio province). Mainly telluric but also magnetic signals were strongly contaminated by artificial noise of an impulsive nature. Thus field data were unuseful to estimate Z tensor elements and apparent resistivities by use of standard frequency domain methods (Sims et al., 1971), even after a careful visual choice of the time series (Fig.2). Removal of directional noise together with the use of the time-domain Z tensor estimation technique (Spagnolini, 1990) allowed a dramatic improvement of estimates quality, as shown in Fig.2 where apparent resistivities computed by time domain approach respectively before and after DNC are reported.

References

- Sims, W.E., Bostick, F.X., Jr., and Smith, H.W., 1971, The estimation of the magnetotelluric impedance tensor elements from measured data: *Geophysics*, **36**, 938-942.
- Spagnolini, U. 1990, Adaptive MT time-domain processing, 60th S.E.G. Meeting, San Francisco, Expanded Abstract, 501-503.
- Szarka, L. 1988, Geophysical aspect of man-made electromagnetic noise in the earth- A Review, *Survey in Geophysics* **9**, 287-318.

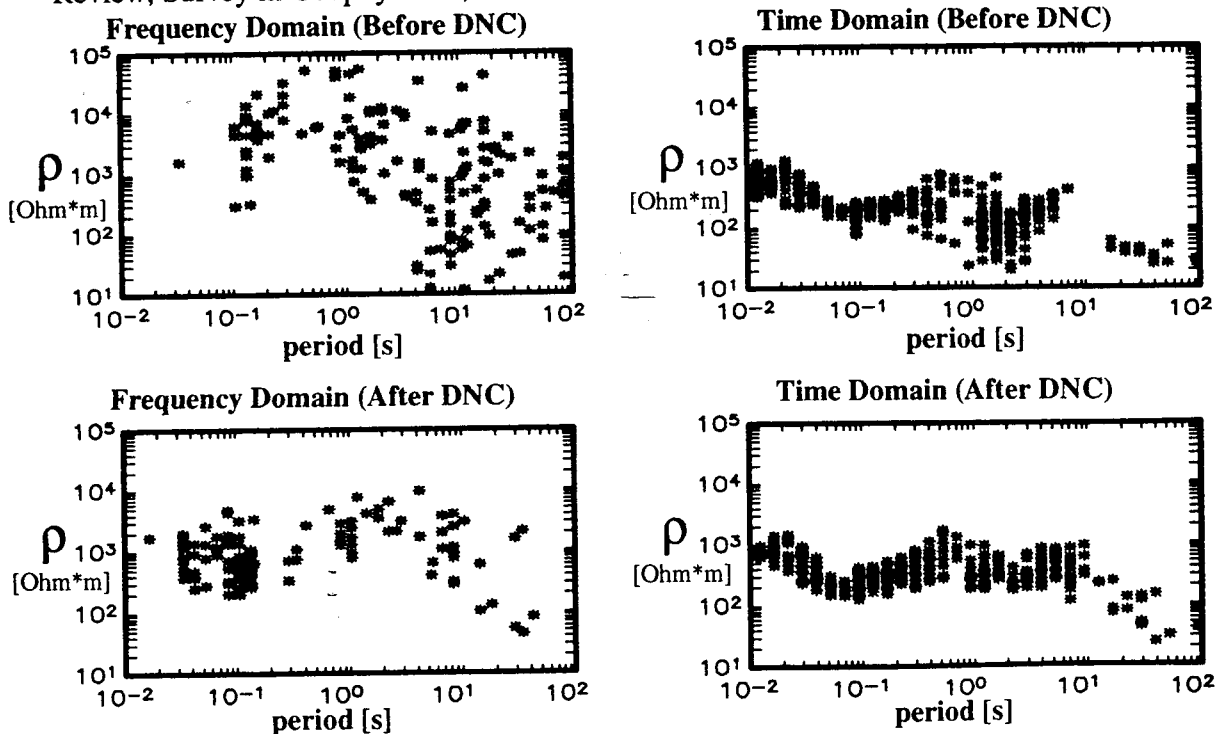


Fig.2 Apparent resistivities obtained using frequency domain technique (left) (Sims et al., 1971) and time domain technique (right) (Spagnolini, 1990) of the data shown in Fig.1. The improvement of DNC is more evident in frequency domain as time domain technique by itself is less sensitive to noise.