Extraction of complex delay from diffusive electromagnetic data in frequency domain

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We report a new method of decomposing the diffusive electromagnetic data in frequency domain for geophysical exploration into a pseudo-impulse response, which is essentially an impulse sequence. Each of the impulses is related to complex delay corresponded to the particular ray path of EM signal propagation from the ground surface to the reflectors and back, and its amplitude carries the information on reflection and transmission coefficients at layer interfaces and also attenuation all along the path. Whereas such a decomposition was proposed by Levy et al (1982), it has not been developed further to extract full information on each impulse as complex delay.

Our approach is based mainly on the introduction of two factors; (1) time scale conversion of data to account for the dispersion of diffusive field (velocity is proportional to the square root of frequency) and thereby (2) autoregressive model (Hasada et al, 2000) can be used for impulse (wave element) decomposition with high resolution.

We have applied this new approach for synthetic and CSAMT data. The original apparent resistivity data is re-sampled with a uniform spacing in square root of frequency, the reflectivity on the surface are calculated, and the wave-element decomposition proposed by Hasada et al (2000) is employed. The decompositions into the pseudo-impulse are made successfully. In the case of CSAMT data acquired at Tono Geoscience Center and around (Ogata et al, 1998), the decomposition is made to (a) one wave arrival from the source to the receiver via air, (b) two reflected waves from the depth, and (c) such diffuse one that is supposed to be near field component.

The new method appears sound as demonstrated by the data analysis above. The complex delay from the subsurface reflectors can be decomposed, and the depth and the impedance change at each reflector can be evaluated. Higher resolution analysis in time domain is made by acquiring the observation data with higher S/N by EM-ACROSS (Nakajima et al, 2004) combined with the newly introduced method of data analysis in this work.