Electromagnetic Interferometry by Multidimensional Deconvolution: Acquisition Aspects

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The electromagnetic fields recorded in a Controlled Source Electromagnetics (CSEM) experiment in a marine environment are strongly affected by the water depth and the position of the source in the water. This dependence of the water depth makes a quantitative interpretation of the data with respect to subsurface structures difficult. Interferometry by multidimensional deconvolution (MDD) can overcome this issue, because it allows to retrieve a reflection response which contains only information from the subsurface. By applying interferometry by MDD, the structure above the receivers is replaced with a homogeneous halfspace consisting of the same material parameters as the first layer below the receivers. In other words, all reflections from above the receivers are eliminated. Furthermore the direct field is erased too and the sources are redatumed to the receiver positions.

Interferometry by MDD consists of two steps. First the recorded fields need to be decomposed in upwards and downwards decaying fields. This was first done by Amundsen *et al.* (2006) in CSEM. In our research an algorithm provided by Slob (2009) is used. This decomposition requires in 3D recordings of all four horizontal EM field components. The decomposed fields can be related to each other through a reflection response $\hat{\mathbf{R}}_0^+$:

$$\hat{\mathbf{P}}^- = \hat{\mathbf{R}}_0^+ \hat{\mathbf{P}}^+. \qquad (1)$$

Equation 1 uses matrix notation introduced by Berkhout (1982). Each column of the matrices $\hat{\mathbf{P}}^-$ and $\hat{\mathbf{P}}^+$, containing the upwards and downwards decaying fields, consists of various receiver positions but a fixed source position and vice versa for the rows. The circumflex denotes space-frequency domain and the superscripts $^-$ and $^+$ indicate upwards and downwards direction respectively. The subscript $_0$ stands for the absence of any reflections from above the receiver level in the reflection response.

In the second step, the reflection response $\hat{\mathbf{R}}_0^+$ is retrieved with a least-squares inversion of equation 1:

$$\hat{\mathbf{R}}_\mathbf{0}^+ = \hat{\mathbf{P}}^- \left(\hat{\mathbf{P}}^+\right)^\dagger \left[\hat{\mathbf{P}}^+ \left(\hat{\mathbf{P}}^+\right)^\dagger + \varepsilon^2 \mathbf{I}\right]^{-1}. \qquad (2)$$

The superscript † denotes complex-conjugation and transposition and $\mathbf{I}$ is the identity matrix. The stabilization parameter ε prevents the inversion from being unstable. Compared to classical seismic interferometry carried out by Cross-Correlation (CC), interferometry by MDD is not a trace to trace process, but requires an array of receivers. The advantages of MDD include elimination of the source signature, improved radiation characteristics of the retrieved source and relaxation of the assumption of a lossless medium. On the other hand, MDD is more expensive and the matrix inversion involved may be unstable. A general overview of interferometry by MDD can be found in Wapenaar *et al.* (2008).

In this paper we investigate acquisition aspects such as receiver and source spacing, source aperture and noise levels for different thicknesses of the water layer using synthetic datasets.

References

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