Strategies for reservoir characterization and production monitoring using controlled source electromagnetic data

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Exploiting the fact that in a marine environment the source is continuously in action while towed behind a boat has improved CSEM capability as a direct resistor indicator. We have taken this synthetic source aperture concept one step further to show on numerically modeled data that uncertainties in source location and orientation are eliminated using a processing procedure called interferometry by multi-dimensional deconvolution. This procedure also eliminates the effects of the sea-surface. This procedure could work well for acquisition according to the present industry practice, under realistic uncertainties in receiver location and orientation, and realistic levels of noise. This is a data-driven procedure that requires properly recorded data. In case some data are not properly recorded due to receiver clipping, a hybrid model-driven data-driven approach must be used. We show some simple 2D examples to illustrate the concept of this procedure, including its drawbacks and advantages for characterization and monitoring purposes.

On-land monitoring is in principle easier to achieve than in a marine setting, but time-lapse changes in the near surface may be more severe leading to signal changes that are much stronger than those related to hydrocarbon production. Modeling results on the 3D SEG/EAGE Overthrust model have shown that the time-lapse acquisition can be tuned to give measurable differences that are caused by production under realistic levels of both multiplicative and additive time-lapse noise. If a well exists that can be used for measurements, an attractive option is to design a walk-away survey with measuring the vertical electric field component in the well. These strategies require an acquisition repeatability error of less than 1% and proper removal of coherent noise, such as MT noise from each data set. In case these criteria cannot be met, acquisition with sources and receivers at the surface can be performed at two frequencies, where in each data set the high-frequency data is subtracted from the low-frequency data containing information on the target. The time-lapse difference of these reduced data sets show the time-lapse changes in the reservoir better at higher levels of noise and repeatability errors. We show several numerical examples of these techniques including the limitations of these two concepts.