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Imaging of Ultra-Wideband Georadar Data

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We present a methodology for georadar acquisition and processing that returns superior images of the subsurface for low cost. Georadar data were acquired in March 2011 in the anti-blast tunnel within the Inter-Disciplinary Underground Science \& Technology Laboratory at the Laboratoire Souterrain a Bas Bruit (LSBB, http://lsbb.oca.eu), Rustrel, France. The georadar data from LSBB were acquired with an exponentially tapered slot antenna (ETSA) of the Vivaldi type. The ETSA is connected to an Agilent vector network analyzer and it operates between 150 MHz to 2 GHz with a noise floor of -120 dB. One of the most interesting technical aspects of the recordings is the use of both a conventional bistatic recording geometry (the source / receiver offset is about 65 cm) and what we will call a monostatic recording geometry where the emitting antenna is also the receiving antenna. The monostatic (reflection) data and bistatic (transmission) data are recorded complex numbers and each recorded number is a stack of monochromatic wave measurements.

This system is reported to have a number of outstanding attributes including long depth of resolution due to it's wide bandwidth. Compared to other systems it has a greater dynamic range plus low distortion, and this is achieved with low-noise, low-loss cables and shielding with ultra-wideband absorbers. The resulting monostatic georadargrams are a true, zero-offset recording geometry, and so zero-offset migration (imaging that is based on the exploding reflector concept) returns a high accuracy image for low cost.

To restore reflection attenuation due to the low Q factor associated with georadar, we apply nonstationary, Gabor-domain deconvolution. We find that amplitude attenuation is restored and phase distortion is corrected. The improved accuracy of our methodology is established first through direct comparison of our Gabor-deconvolved data with conventional, stationary deconvolution where we find that the nonstationary result is superior. Then, using a bistatic data set for an imaging comparison, we show that ZOM (Zero-Offset Migration) applied to the bistatic data introduces spurious reflection imagery in the upper 50 cm, but that PSDM (Pre-Stack Depth Migration) of the bistatic data returns an image that is similar to ZOM of the monostatic data. The bistatic data were acquired coincident with the monostatic acquisition and have a source / receiver offset of 65 cm. Thus, imaging accuracy associated with PSDM is achieved using ZOM at 1/100 the computational cost.

In the deeper section of our dataset, we find that the ZOM image using the monostatic data returns a significantly improved image than PSDM of the bistatic data. This is unexpected, but perhaps the difference is a phenomenon that is due to out-of-plane reflections and that 2D PSDM is rightly defocussing out-of-plane energy. We feel that subsequent 3D data acquisition could resolve this difference.