Drowned Dunes: Integrating 3D GPR and core data to reconstruct a late Holocene buried dune environment.

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During the last two decades, ground-penetrating radar (GPR) methods, have grown in popularity for acquiring high-resolution images of the stratigraphy, internal structure and wider context of geomorphology, as well as the reconstruction and evolution of buried landscapes. GPR offers centimetre-scale resolution of the subsurface, allowing 3D visualization of abrupt changes in palaeo-environments. Although often complemented by core data, GPR interpretations can also be extended beyond regions of ground-truth control. However, for all these advantages, GPR data interpretation can be non-intuitive and ambiguous, with the technique seldom giving images that immediately resemble the expected subsurface geometry. Interpretation can be made yet more onerous when handling the large 3D data volumes that are commonly available with modern GPR technology.

In this paper, we outline the development of a semi-automated GPR feature-extraction tool, based on the image processing techniques ‘Edge Detection’ and ‘Thresholding’. Developed initially for medical image analysis, we investigate them as a means of assisting the analysis of GPR data for subsurface geomorphic features. Given that GPR reflectivity can be related to changes in lithology and/or pore fluids, the structure and extent of subsurface depositional environments can be efficiently estimated using these algorithms. When benchmarked against representative core control, the 3D architecture of the palaeo-landscape can be reconstructed from the GPR dataset.

We present a 500 MHz GPR dataset collected over a buried Holocene coastal dune system in Llanbedr, Gwynedd, North Wales, which has since been reclaimed for use as an airfield. Core data, with maximum depth 2 m, suggest rapid vertical changes from sand to silty-organic units, and GPR profiles suggest that similar lateral complexity is likely across the dataset. By applying thresholding methods to top-down depth slices, the environment is effectively characterised. Furthermore, automatic extraction of the local reflection power with depth yields a strong correlation with the vertical variation of organic content. Similar analyses away from core control could, therefore, deliver a powerful proxy for parameters derived from invasive core logging.
