External abstract No.

USING GROUND PENETRATING RADAR TO MAP PEAT CONDITION AT A LANDSCAPE SCALE

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SUMMARY

Physical properties, such as depth, bulk density and humification are closely linked to many of the ecosystem services provided by peatlands. Beneath the surface these properties can be highly spatially variable. This variation can be difficult to map using traditional manual measurements, often leading to unreliable estimates of ecosystem services such as carbon storage.

Ground Penetrating Radar (GPR) is a geophysical technique which can map the peatland subsurface (Holden et al, 2002; Sass et al, 2010 and Comas et al, 2005a). This project investigates how GPR can be used to map properties such as bulk density, humification and depth at landscape scales. The GPR is towed using a low ground pressure tracked vehicle, allowing for surveys to be carried out in otherwise inaccessible areas. Ultimately these data will be used to generate carbon inventories and maps of peatland condition which can be used to inform peatland wind farm developments and restoration projects.

KEYWORDS: Carbon inventory, humification, bulk density, surveying, ground penetrating radar.

INTRODUCTION

In the United Kingdom and in many other peatland rich nations of the world there is increasing need for accurate surveying of the physical properties of peatlands. The traditional methods currently employed, such as coring and probing, require considerable man power, time and give limited spatial resolution. A methodology which allows peatland physical properties to be surveyed at a landscape scale with a finer resolution could greatly improve the management of individual peatlands. This data could be used for many purposes, such as informing the construction of windfarms on peatlands, developing restoration plans and improving the datasets used in international policy such as Landuse Landuse Change and Forestry (LULUCF) in the Kyoto Protocol.

GPR is a geophysical technique, which has shown considerable promise for surveying the subsurface features of peatlands. Several studies have investigated the use of GPR to map peat depth and subsurface geomorphology (Rosa *et al*, 2009 and Comas *et al*, 2005b) and recently new techniques have emerged to detect free phase gases within the peat body (Comas *et al*, 2005b, Comas *et al*, 2007 and Parsekian *et al*, 2010). However, the potential for using

GPR to map peatland physical properties has not yet been fully investigated. This project aims to investigate the ways in which GPR can be used to map bulk density, humification and depth at landscape scales. Following this, the datasets will be used to develop mapping of peatland ecosystem services such as carbon storage.

As the GPR is moved across a peatland, several pulses of electromagnetic energy are emitted from the GPR unit. This process polarises electrons within the peatland subsurface, the energy stored during polarisation is known as the dielectric permittivity (ε). The GPR is able to produce images of the peatland subsurface by detecting the change in ε as each pulse travels through the peat profile (Neal, 2004). The electromagnetic properties of soils are strongly related to moisture content and density (Reynolds, 1997), therefore changes in ε recorded within a GPR trace could be correlated with peatland properties, such as moisture content, bulk density and humification degree. Ketteridge (2008) identified that the patternation of GPR reflectors was related to the level of humification of a peatland, which supports our hypothesis. However, Ketterige *et al* (2008) used qualitative analysis, but in our study we investigate whether these relationships can be used quantitatively to model change in peatland physical properties over a large spatial area.

MATERIALS AND METHODS

Site

A test survey was carried out on a 25 hectare area of Keasdon Moor, a blanket peatland in the Forest of Bowland, Lancashire, England and Malham Tarn a raised bog within the Yorkshire Dales National Park, England.

Survey Setup

100 MHz and 250 MHz shielded antennae were mounted on a specially adapted sled and towed behind a low ground pressure tracked vehicle. A Real Time Kinematic (RTK) differential GPS was used to accurately log the position of each GPR trace.

GPR Survey

Over 8km of GPR data was gathered across a grid using both the 100 and 250MHz antennas. The grid was spaced at 50 m, 25 m and 12.5 m intervals, allowing for the spatial variability in peatland physical properties to be analysed.

Peat Depths and Coring

At points along the grid over 160 peat depths were manually recorded, with three replicates at each point and seven full profile cores were extracted using a Russian corer. Each core was analysed for bulk density, humification degree (von Post scale) and Loss on Ignition (LOI) at regular intervals throughout the profile.

RESULTS / DISCUSSION

Survey Setup

Results from the field survey clearly demonstrate that several kilometres of high quality GPR data can readily be gathered. Conditions on UK blanket peatlands can be highly variable, as a result we are currently reviewing the design of the survey set up, to ensure the best quality data will be the output at all times. An example of a topographically rectified GPR plot was produced (Fig. 1). In this data a natural cavity known as a peat pipe can be identified at trace number 100, demonstrating the ability of the GPR to map peatland physical features at a landscape scale.

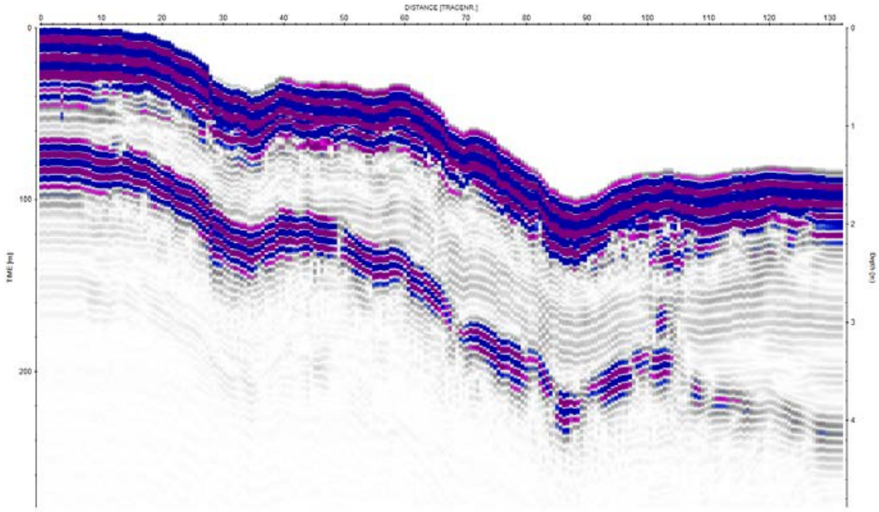

Figure 1. Example GPR profile where the bottom of the peat and a peat pipe can be identified. This was taken using a tracked vehicle and sled set up, which can map large areas of peatland in short time scales.

Peat Depth

Over 160 peat depths were manually probed to validate readings from the 100 Mhz GPR antennae, using the standard velocity of 0.035m/ns. This resulted in a positive correlation between GPR data and manual coring being generally in close agreement (Fig. 2). However, at depths of less than 150 cm the GPR is consistently identifying a mean depth 32 cm greater than manual measurements. Additionally, a number of GPR depths greater than 375 cm have manual measurements up to 200cm less.

Cores taken from Keasdon had a layer of soft clay at the bottom of a number of the shallow profiles and often had large amounts of birch starting at approximately 350 cm depth. It is likely that these factors have caused the disagreement between the two methodologies. Both GPR and manual probing are commonly thought to give accurate readings of peat depth. However, these results demonstrate that careful interpretation of depth data must be made, with consideration of site conditions, before the data can be used with any certainty (Fig. 3).

Peat Physical Properties

The profiles of individual cores are currently being analysed in detail to investigate if any quantitative relationship can be identified between bulk density, humification and GPR traces. If significant relationships are identified, this data will be used to estimate peat condition throughout the surveyed area.

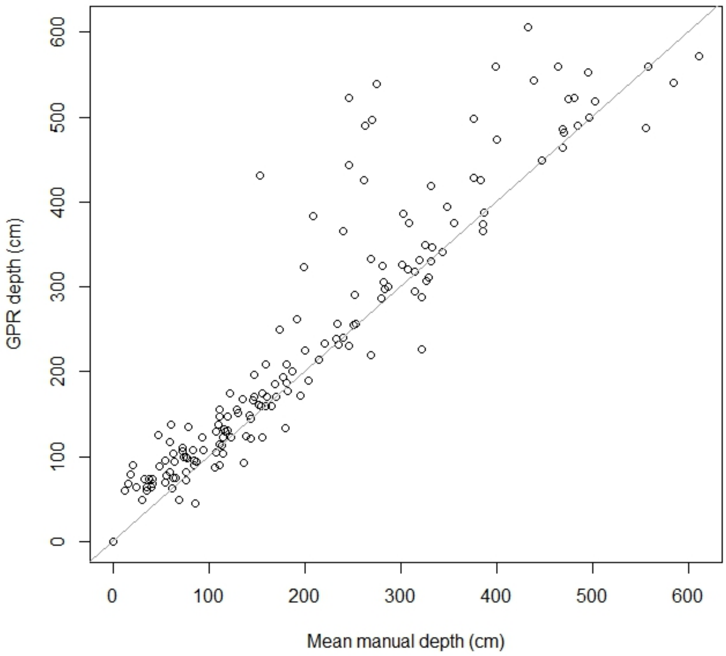

Figure 2. A comparison of manual and GPR depths taken at Keason, a blanket peatland in Lancashire UK

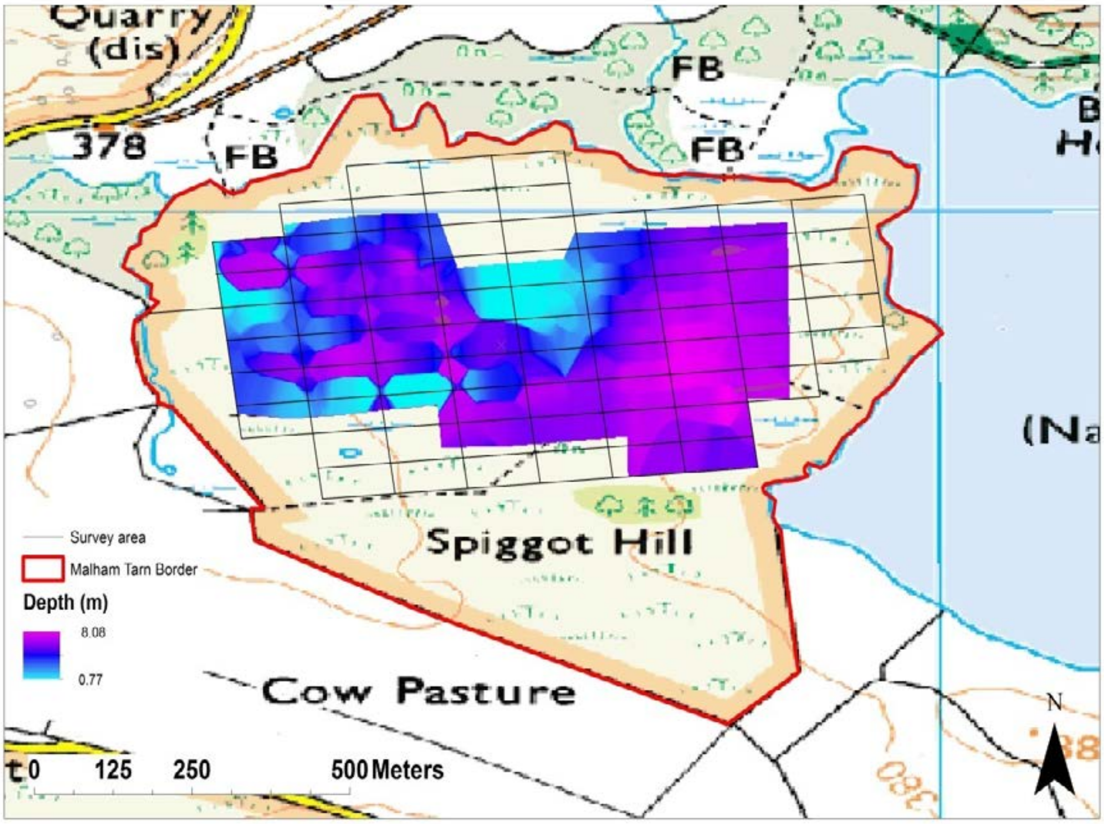

Figure 3. Peat depth mapping at Malham Tarn Moss, Yorkshire, UK. The GPR can be used to map depths of greater than 8m in ombrotrophic and minerotrophic peatlands.

CONCLUSIONS

Using a specially adapted tracked vehicle set up, large quantities of high quality GPR data can be gathered rapidly on difficult, hummucky, sloping peatland terrain. Although much of this research is currently ongoing, there is great potential for GPR to be used to map peatland physical properties at a landscape scale. Datasets such as this could be used in many contexts, for example more accurately quantifying peatland carbon stocks, or more effectively targeting restoration projects. If you are interested in following the outcomes of this project, or would like to enquire about a GPR survey please contact Lauren Parry using the contact details provided above.

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