Spectroscopy and Remote Sensing for Assessment of Peatland degradation

Pedometrics 2017, Wageningen, NL

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The James Hutton Institute

Introduction

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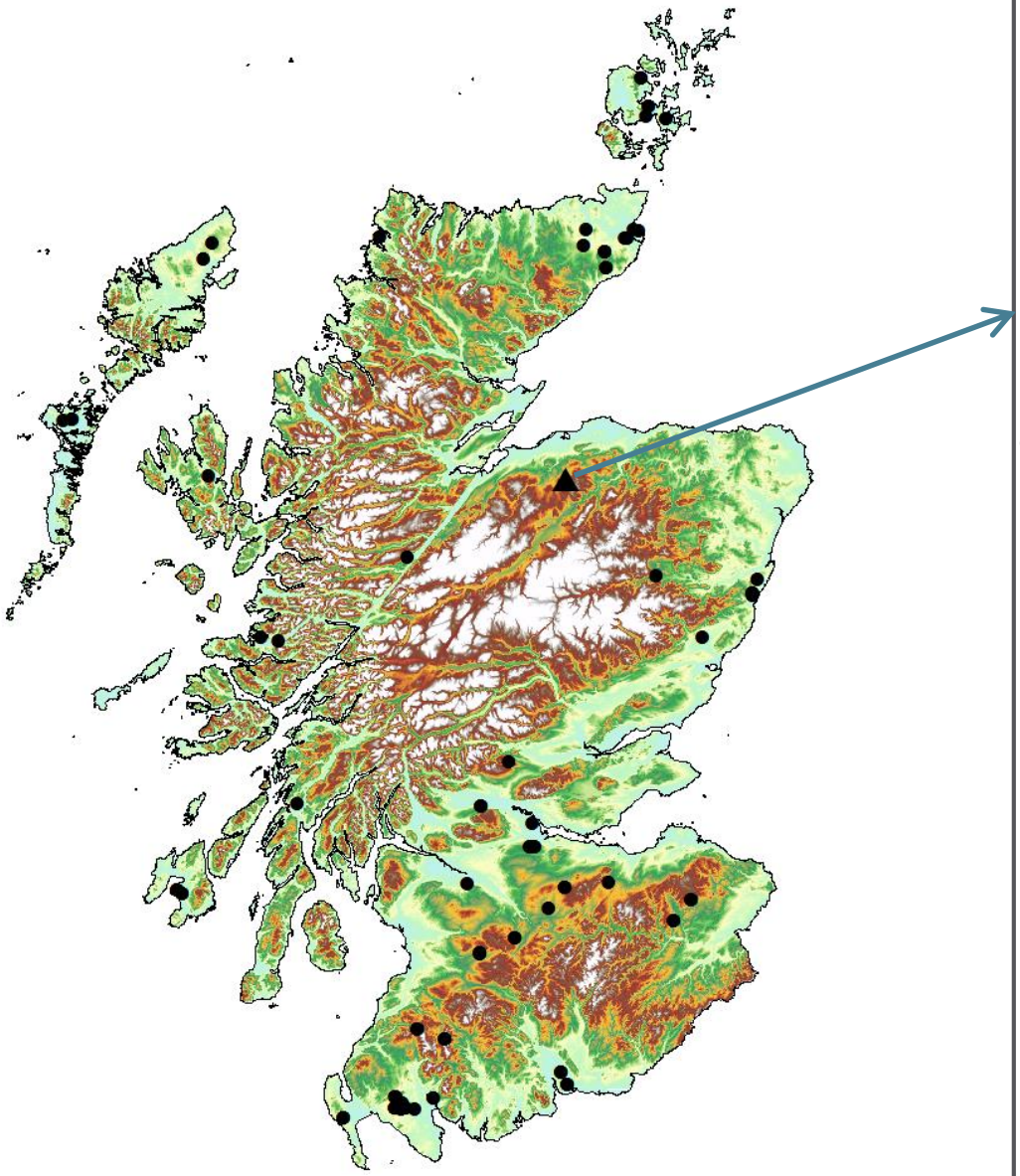
- Peatlands cover more than 20% of Scotland's land area -habitat mapping and assessment of their condition is a key issue both at Scottish and EU level
- These carbon-rich soils have a vital functional role and degraded peatlands are net emitters of carbon
- In order to return degraded peatlands to their naturally C sequestering state, restoration measures are often essential
- However often the location and extent of degradation is poorly defined
- Methods to provide rapid assessment of peatland degradation are required
- We are investigating the use of a combination of Fourier Transform Infrared (FTIR) spectroscopy and remote sensing (RS) for peatland assessment

Peat Survey data



RESTRICTED

SPC (MS) 157

SCOTTISH PEAT COMMITTEE

MOSS SURVEY GROUP

MOSS SURVEY REPORTS
No 15

DAVA MOSS
MORAYSHIRE

1955

PEAT SECTION
DEPARTMENT OF AGRICULTURE FOR SCOTLAND

Surveyor: A. TOMTER
P. R. WEBSTER

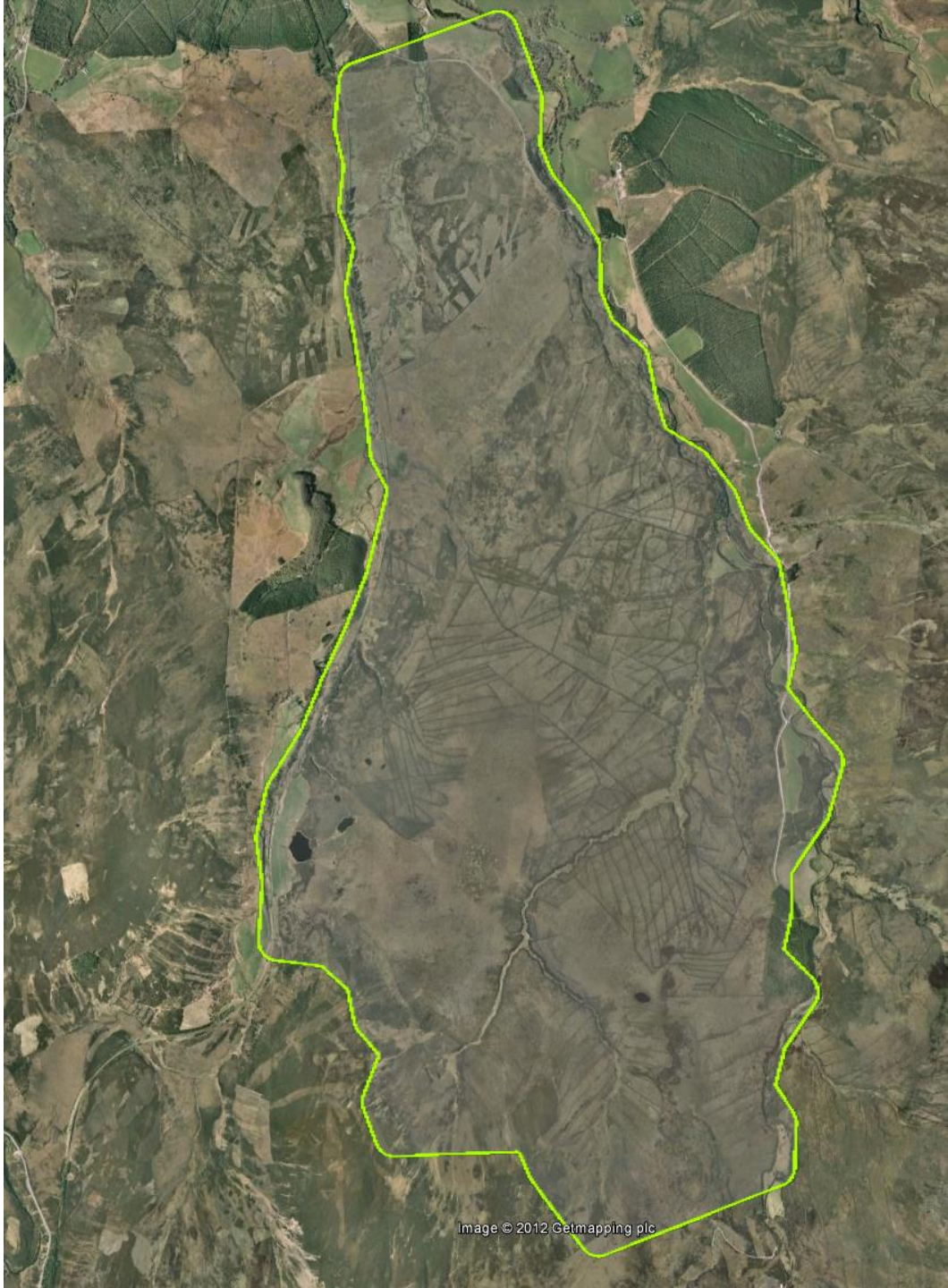
Botanist: P. C. JOWSEY, B.Sc.

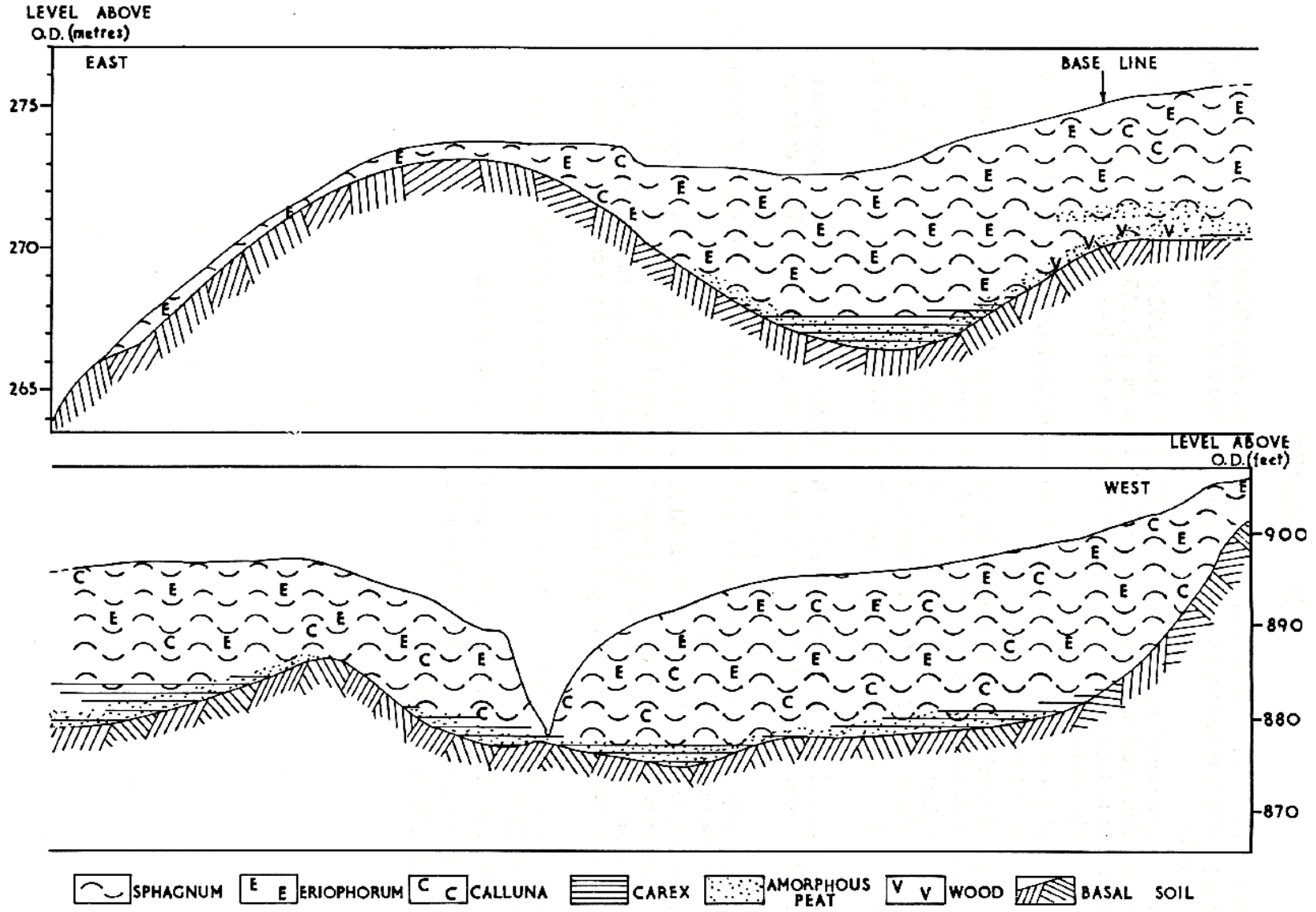
Study Area - Dava Bog

Dava Bog is a raised basin bog

- domes growing to 10m or more in height
- growing dome being ‘fed’ by rainwater
- waterlogged, acidic and lacking in nutrients

✓ First survey in 1913
✓ More detailed survey in 1955
✓ Re-sampled in 2012-15





HORIZONTAL SCALE 1:5280 VERTICAL SCALE GROSSLY EXAGGERATED.

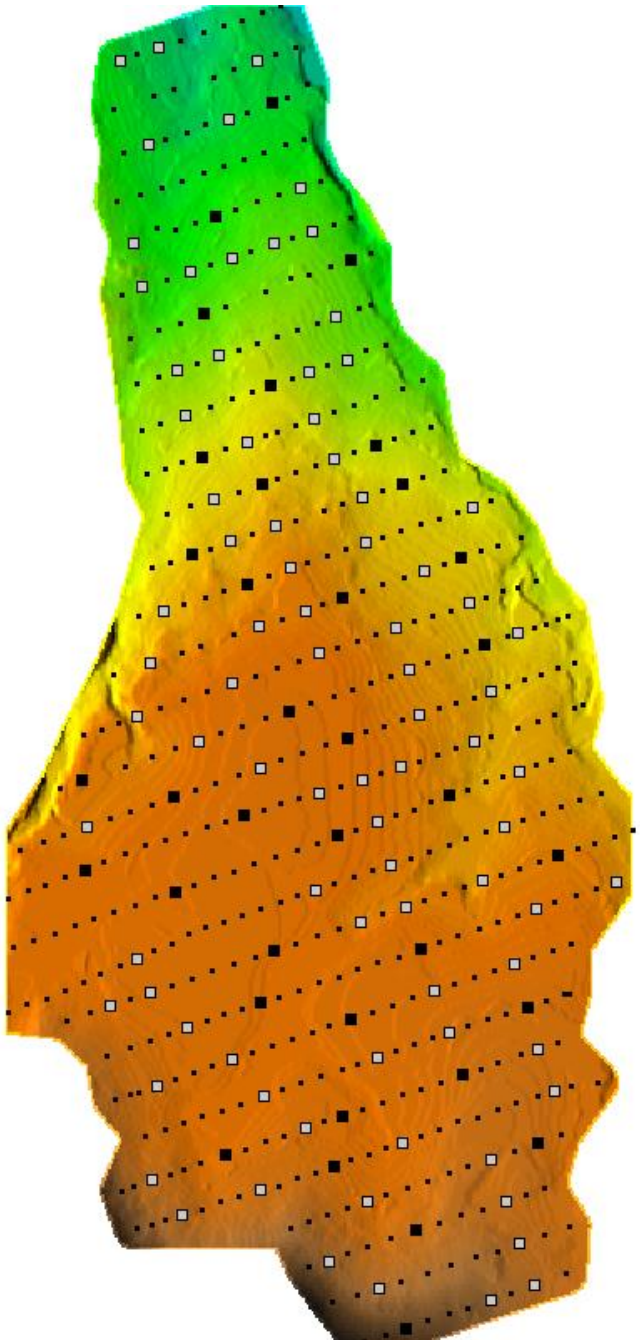
FIGURE 26. SECTION OF THE PEAT ON LINE 22

Peat Survey data (1955)

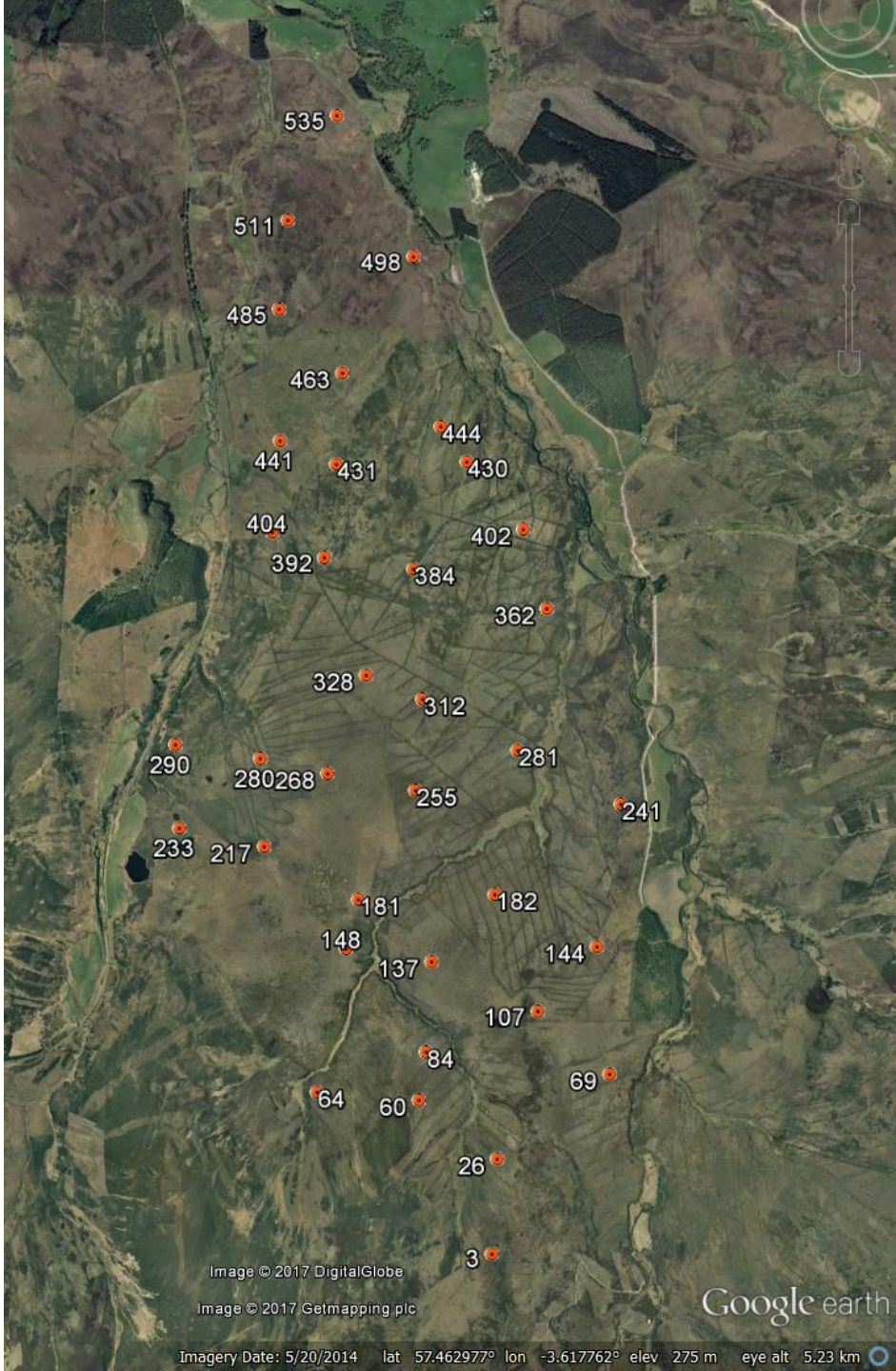
- 530 bore holes (BH) with measured depth
- 125 BH with site and profile description:

  Humification, Surface Firmness, Vegetation Survey
- 36 BH with sample data:

  Moisture content, Bulk Density, Ashes
- 12 BH with detailed chemical analysis (e.g. Carbon)

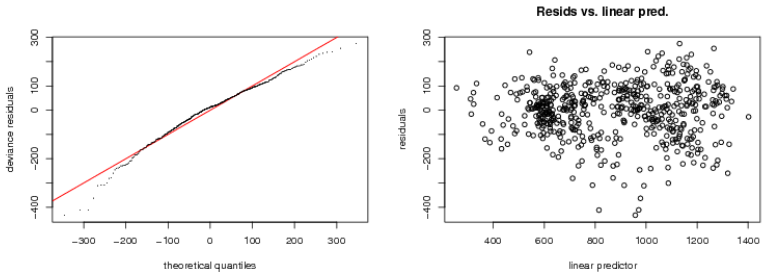


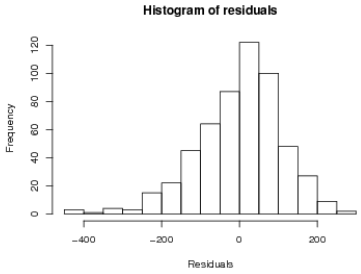
Re-sampling sites 2012-2015

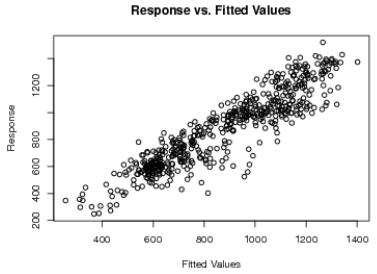


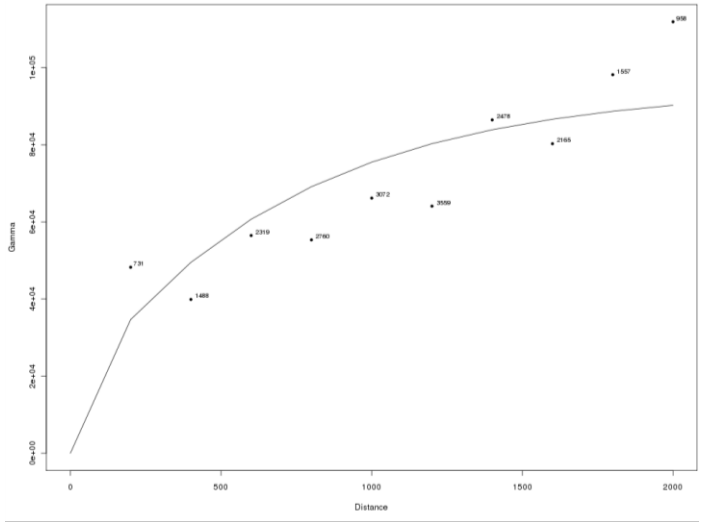
Interpolation

- Use of Generalized Additive Models and Classification Trees
- Covariates:
  - Remote sensing
  - Elevation
  - Depth
  - Soil properties
  - 3D coordinates smoother
- 3D kriging

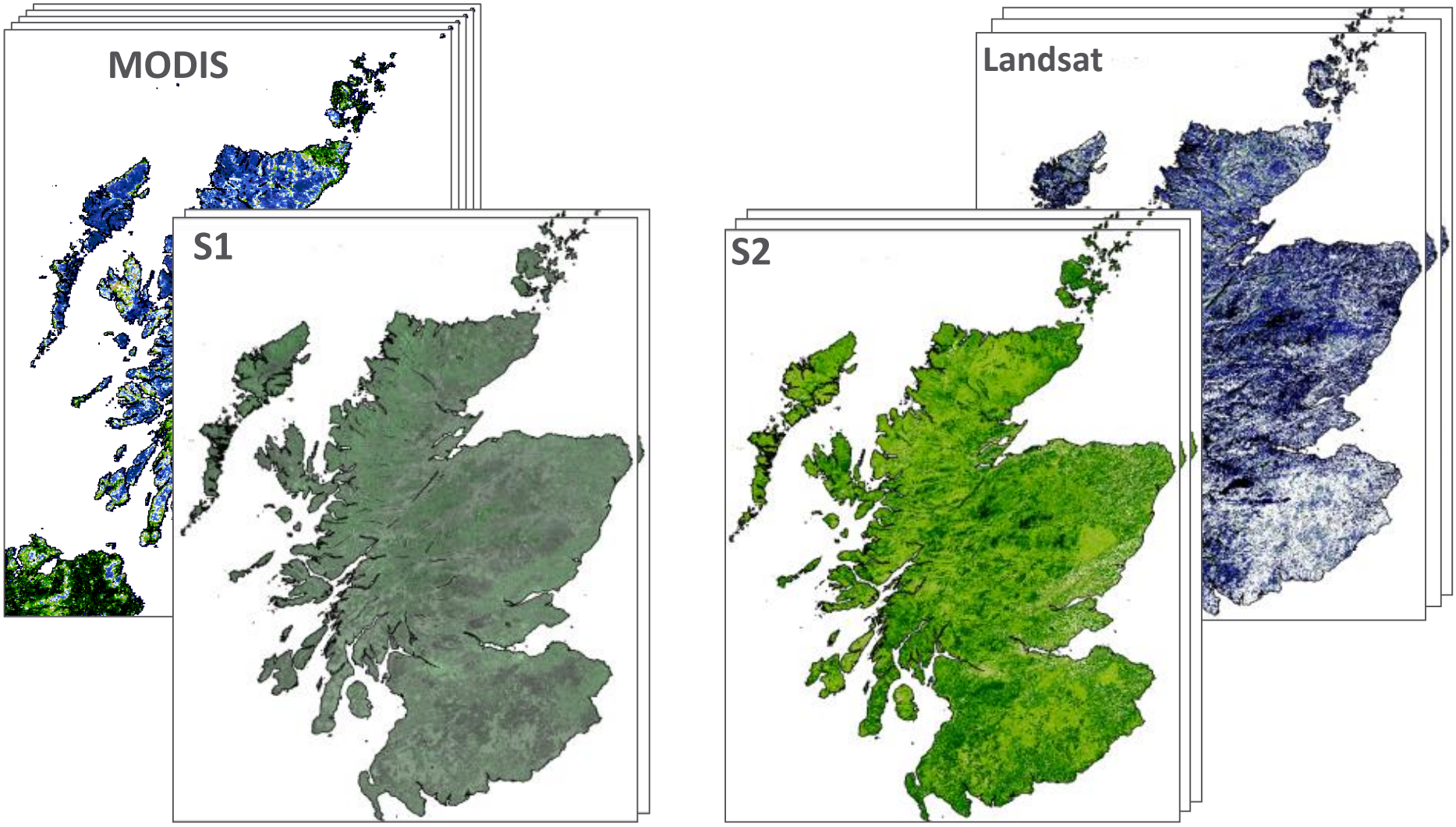






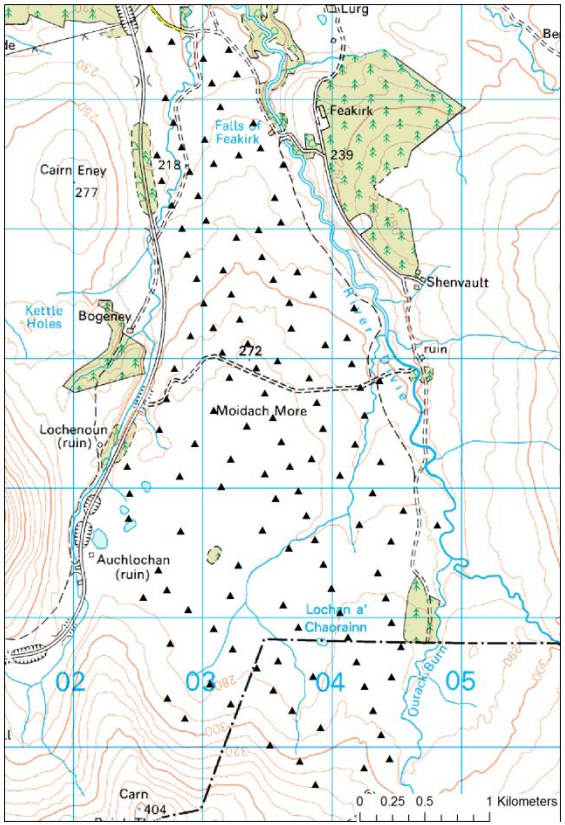


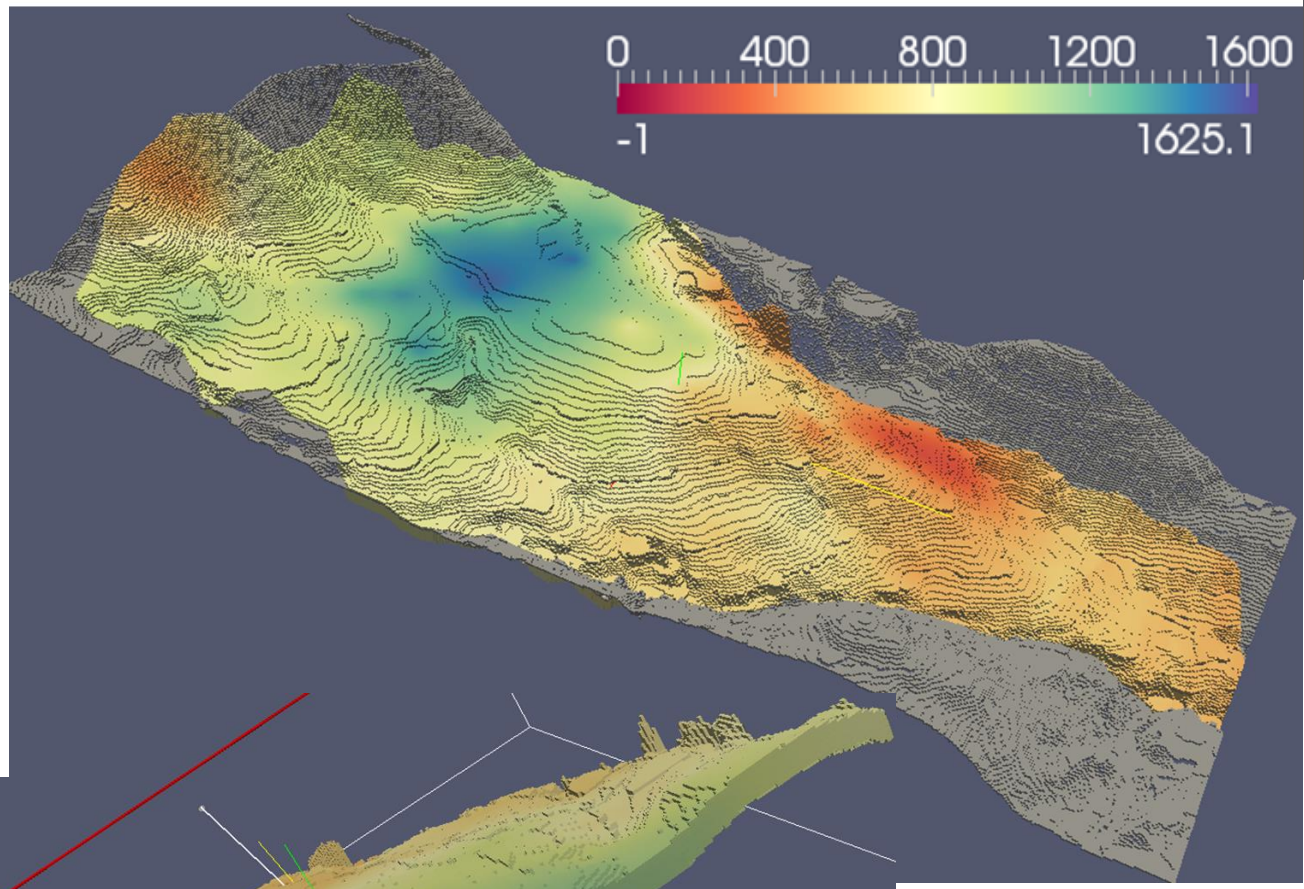
Considered RS covariates

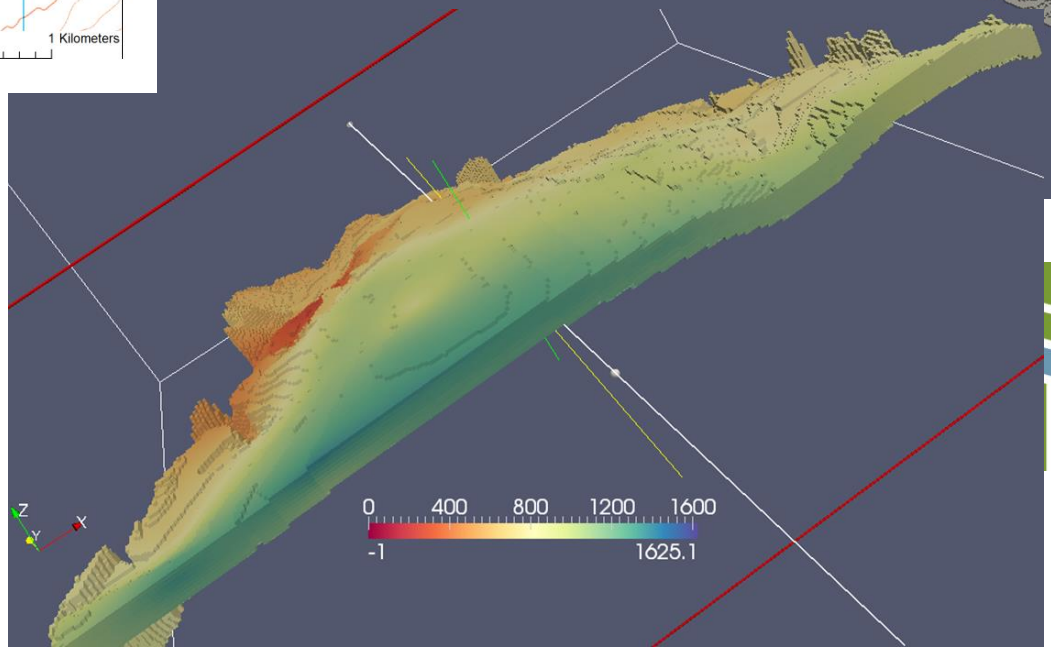


- MODIS: optical 500m resolution, daily overpass
- Landsat: optical 30m resolution, ca bi-monthly overpass
- Sentinel 1: radar, 10 m resolution, 6 days overpass
- Sentinel 2: optical 10-30m resolution, 6-12 days overpass

Moisture content







From points to x,y, depth maps

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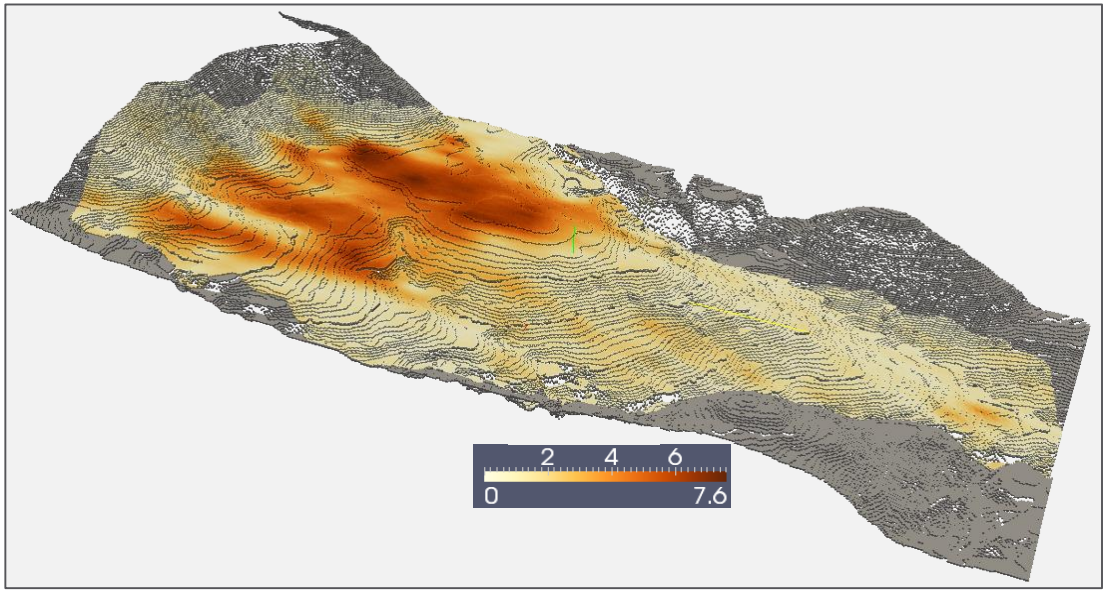
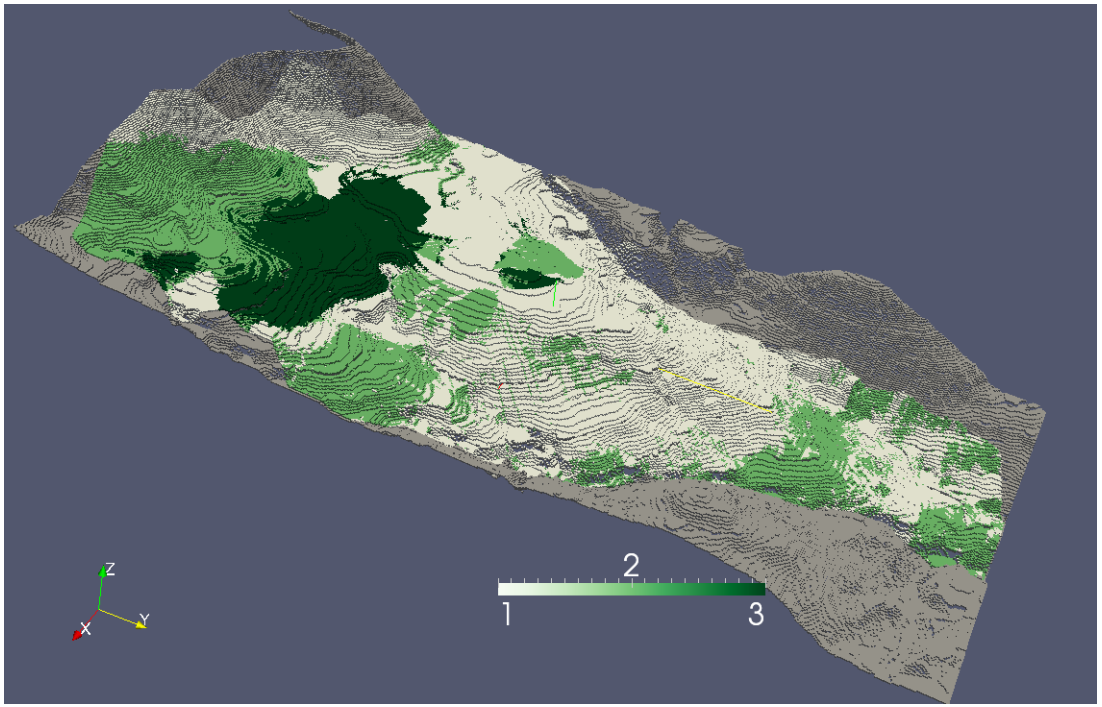
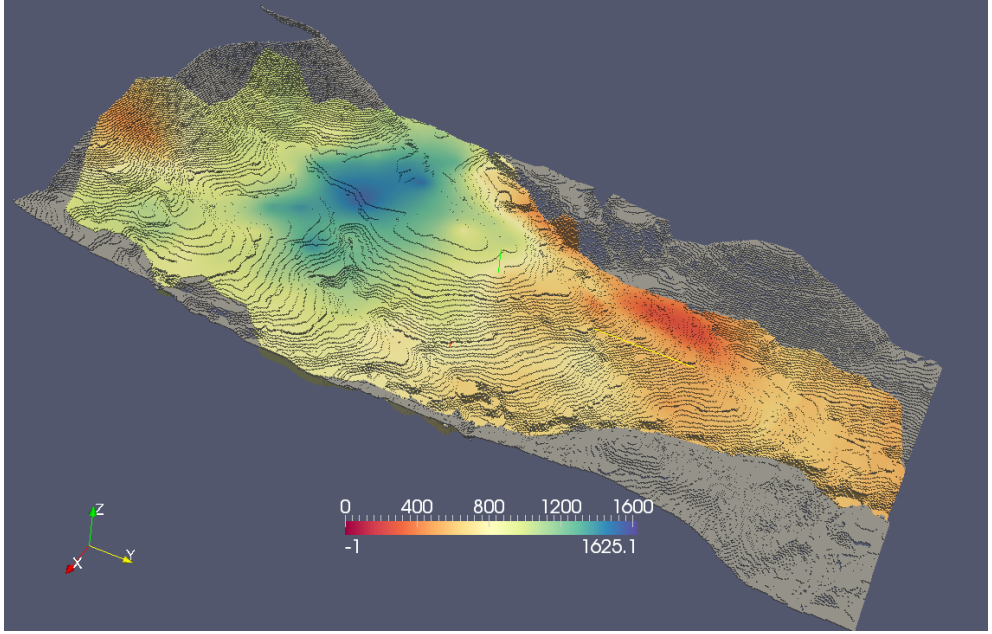
Poggio, Gimona, Aalders, Hough at Eurosoil 2012



Peat depth

Vegetation cover





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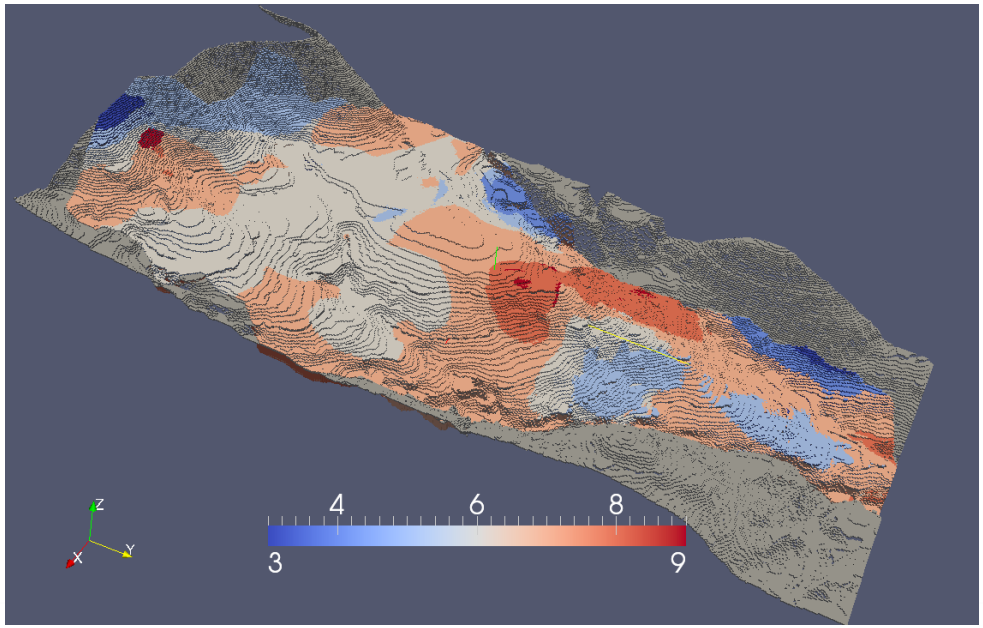
Moisture content

Humification

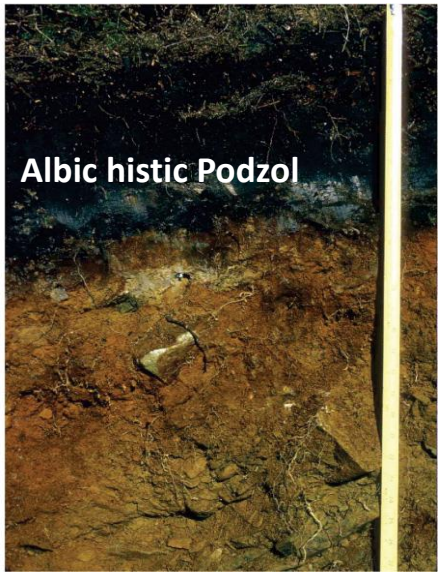


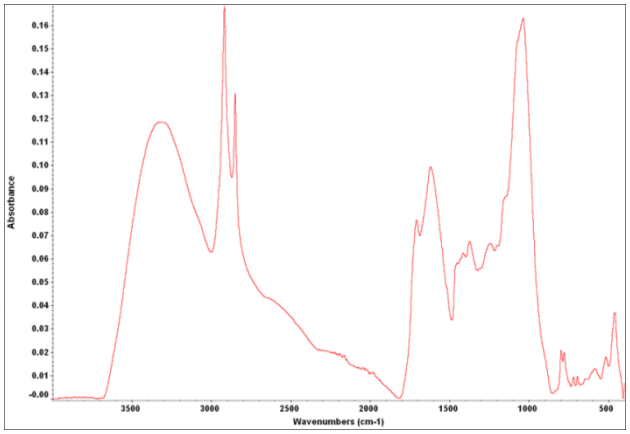
FTIR Spectra of Soil Samples

- An FTIR (Fourier Transform Infrared) spectrum in the mid infrared (MIR) region of a soil sample, produced when infrared radiation is absorbed by a soil sample, gives the overall chemical profile of the soil

- Absorption bands in the IR spectrum (4000 to 400 cm^{-1}) relate to fundamental vibrations of the functional groups present in the sample

- Interpretation of FTIR spectra can therefore provide an insight into the chemical composition of the soil

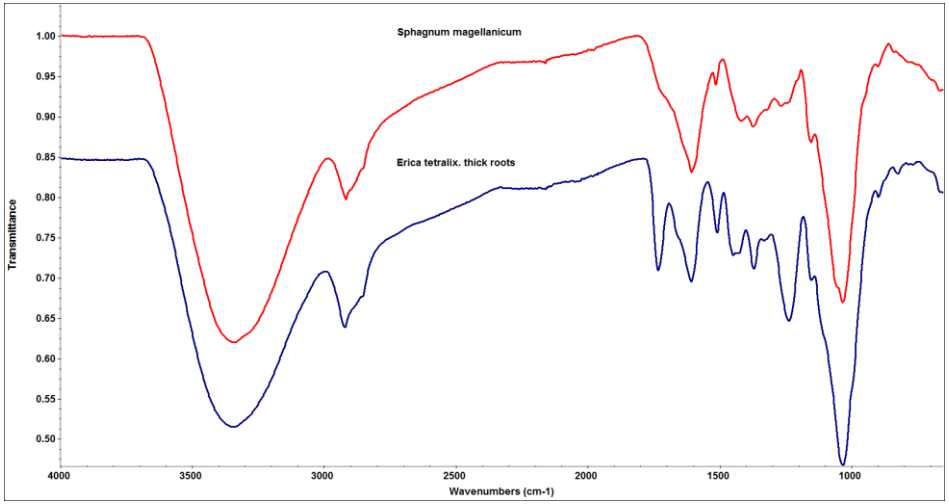




FTIR Spectra of Peat

- Peats represent accumulations of partly or completely decomposed plant residues formed under anaerobic conditions
- Their spectra are related to that of the un-decomposed vegetation, and peat spectra will differ according to plant population
- The peat spectra will also differ from the vegetation depending on the extent of decomposition

FTIR spectra of two types of un-decomposed vegetation



Functional Groups in the IR Spectrum of Peat

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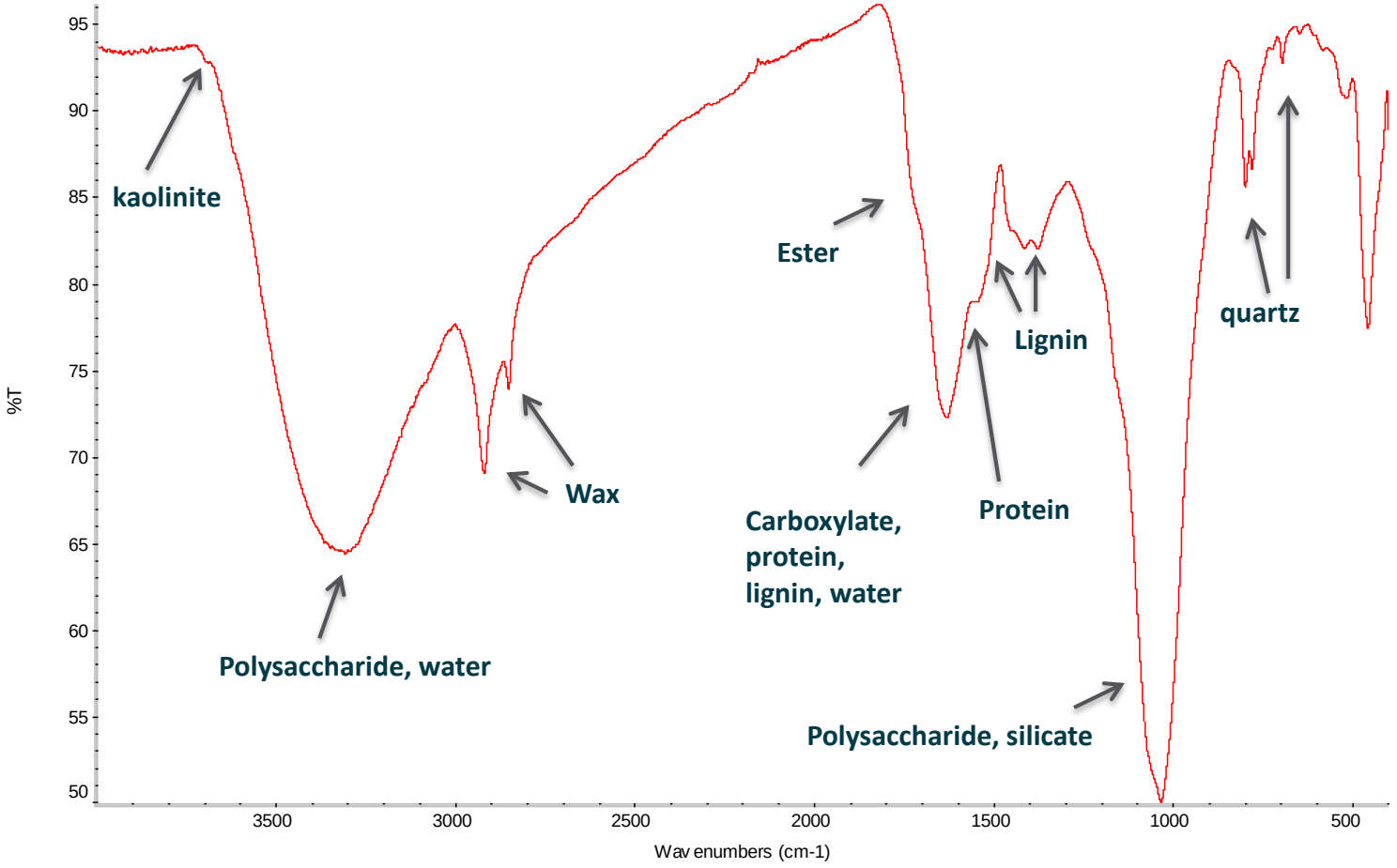
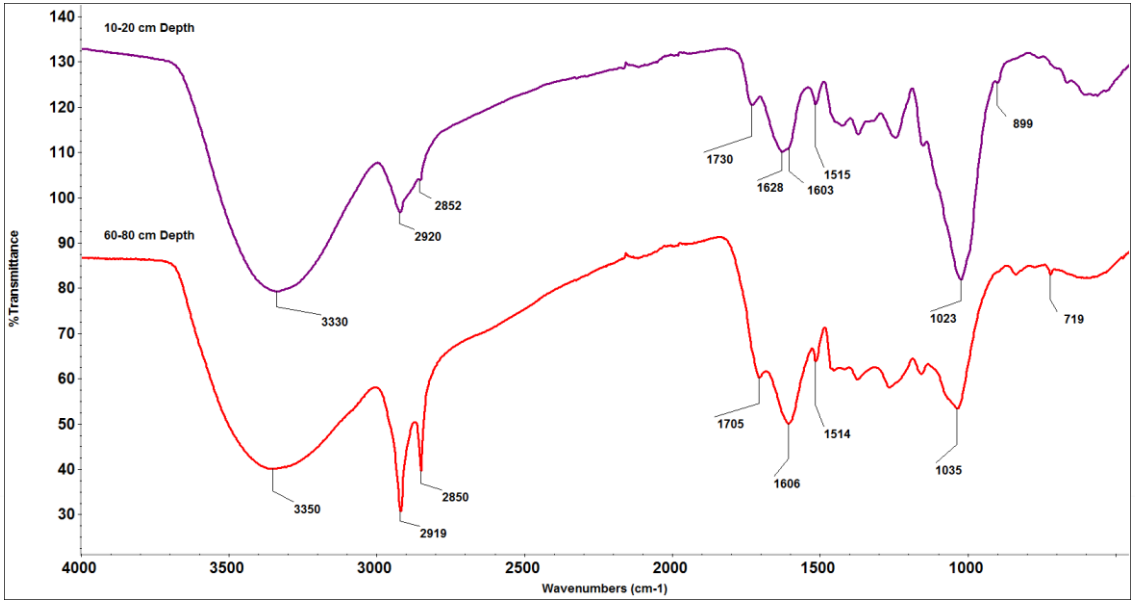


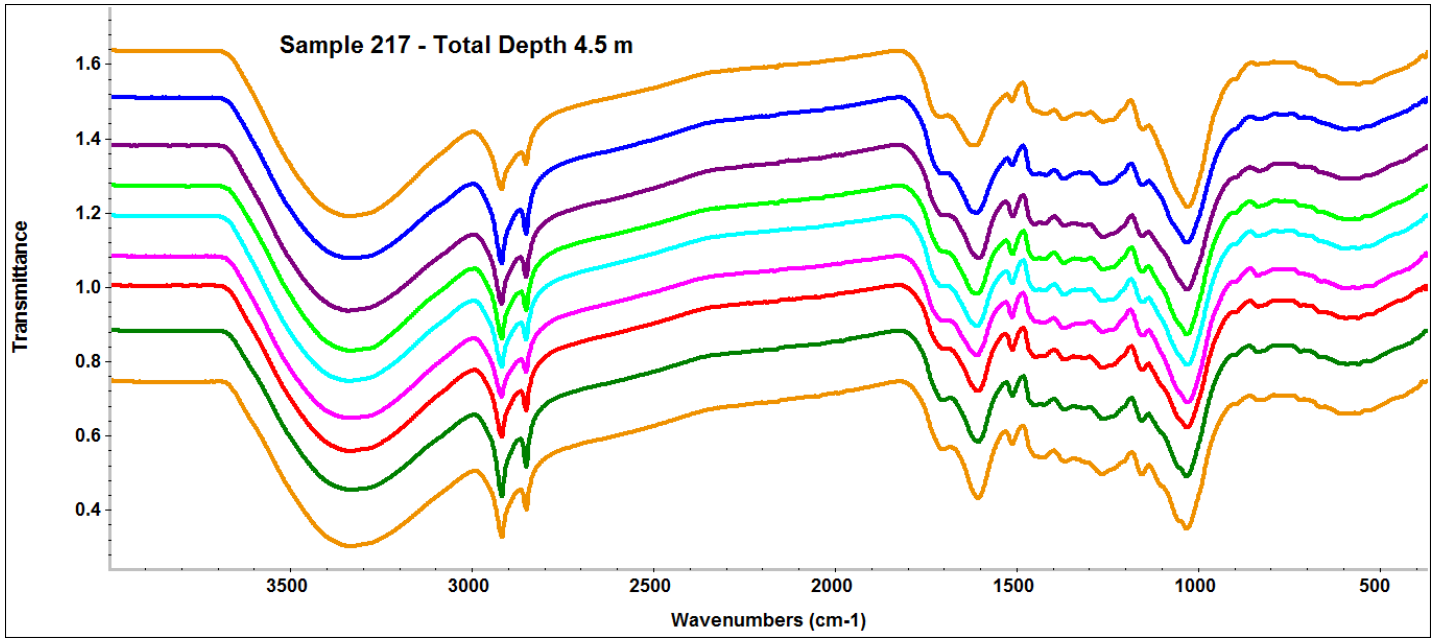
Changes in Chemical Characteristics of Peat

- Organic soils which are more decomposed (often deeper in the peat) are likely to have reduced polysaccharides (C-O 1100-900 cm^{-1})
- Although some ester may be present, there is likely to be predominantly carboxylic acid present (C=O ~1710 cm^{-1})
- The CH stretching region (3000 -2800 cm^{-1}) of these soils will also show evidence of long chain or waxy compounds with sharp distinct peaks at 2920 cm^{-1} and 2850 cm^{-1} which are derived from CH_2 stretching vibrations. In addition there is a small but sharp CH_2 "wagging" vibration which appears at 720 cm^{-1}



Changes in a Peat with Depth

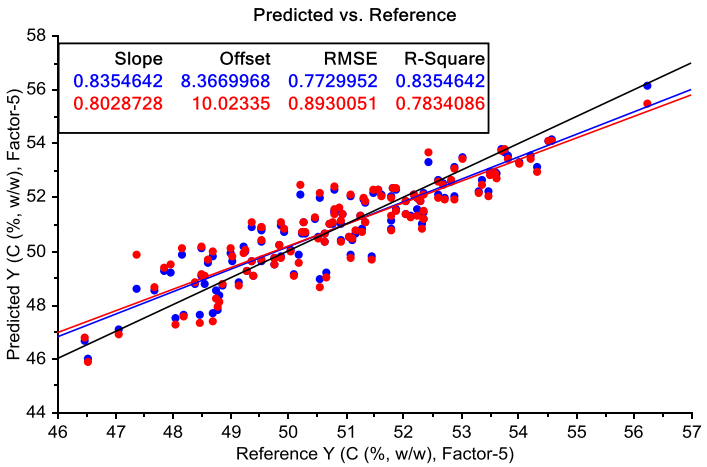
FTIR spectra of the Dava Bog

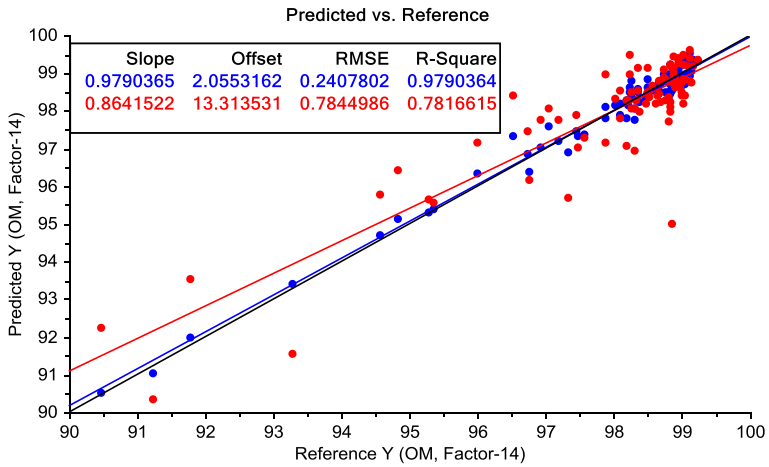


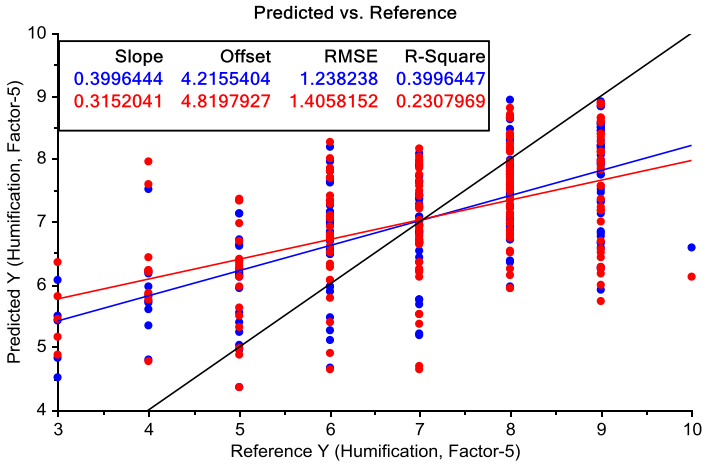
Increasing depth

- The spectra shown here illustrate IR spectra at 50 cm intervals to a depth of 4.5m
- There is a relative decrease in the intensity of the C-O absorption due to polysaccharide with depth, change from ester to acid C=O absorption and a slight increase in absorption due to CH_2
- However changes are relatively subtle, and not the marked changes with depth often seen in peats

FTIR predictions of peat properties







- Calibrations are being developed to predict peat properties for the Dava Bog from the FTIR spectra
- Results are shown here for % C, % OM and Von Post Scale of Humification

Future Work

- Development of further FTIR calibrations
- Prediction of soil properties by FTIR to provide additional ground-truthing for integration and fusion with the remote sensing data
- Exploration of the relationship between Von Post Scale and the FTIR spectra
- Can FTIR spectral features be used to develop a useful classification tool for assessing status of peat ?
- Application to other peatland sites

Acknowledgements

Special thanks go to Silvia Clinori for spectra collection.

This work was funded by the Rural & Environment Science & Analytical Services Division of the Scottish Government