Prediction of soil bulk density in agricultural soils using mid-infrared spectroscopy
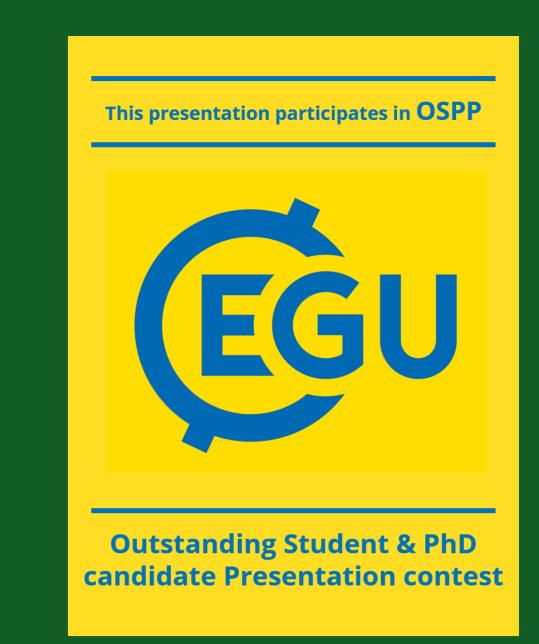
Longnan Shi[a,b], Sharon O'Rourke[b], Felipe Bachion de Santana[a], Karen Daly[a]

[a]Environment Soils and Land Use Department, Teagasc, Johnstown Castle,Wexford, Ireland.
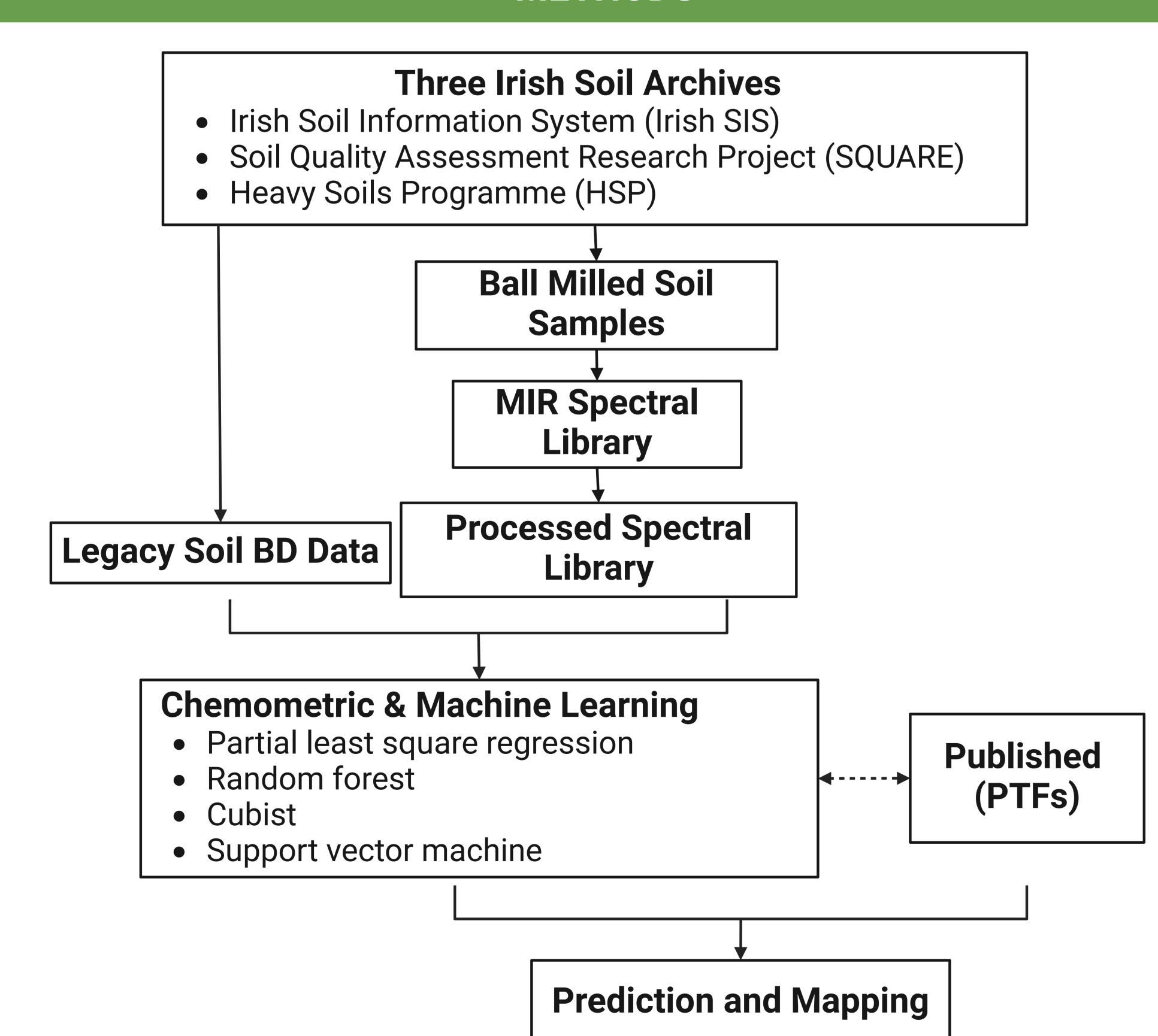[b]School of Biosystems and Food Engineering, University College Dublin, Belfield, Dublin 4.

HIGHLIGHTS

- Soil BD predicted from MIR spectroscopy using SVM shows the best accuracy
- Soil organic matter related wavenumber bands are key drivers for predicting soil BD
- Soil BD MIR model had better accuracy than published traditional PTFs for Irish soil
- Soil BD Spectral model shows homogeneity of performance at different depth layers above 50 cm

INTRODUCTION

Soil bulk density (BD) is a key physical parameter in soil quality control and in the calculation from soil organic carbon (SOC) mass (g/kg) content to area stock (kg/ha). However, BD laboratory analysis is time-consuming, labour intensive and expensive, especially for a national-scale soil assessment.

METHODS

Three Irish Soil Archives
- Irish Soil Information System (Irish SIS)
- Soil Quality Assessment Research Project (SQUARE)
- Heavy Soils Programme (HSP)

Ball Milled Soil Samples

MIR Spectral Library

Processed Spectral Library

Legacy Soil BD Data

Chemometric & Machine Learning
- Partial least square regression
- Random forest
- Cubist
- Support vector machine

Published (PTFs)

Prediction and Mapping

RESULTS

Model	R²	RMSEP(g/cm³)	RPIQ
PLSR	0.79	0.136	3.34
Random Forest	0.80	0.132	3.60
Cubist	0.78	0.139	3.53
SVM	0.81	0.132	3.61

SVM

BD (g/cm³) = 0.23
SOM (%) = 26.9

BD (g/cm³) = 0.23
SOM (%) = 26.9

Lines
- Confidence Interval
- Ideal line
- Prediction Inverval
- Regression line

Points
- ○ calibration
- ● validation
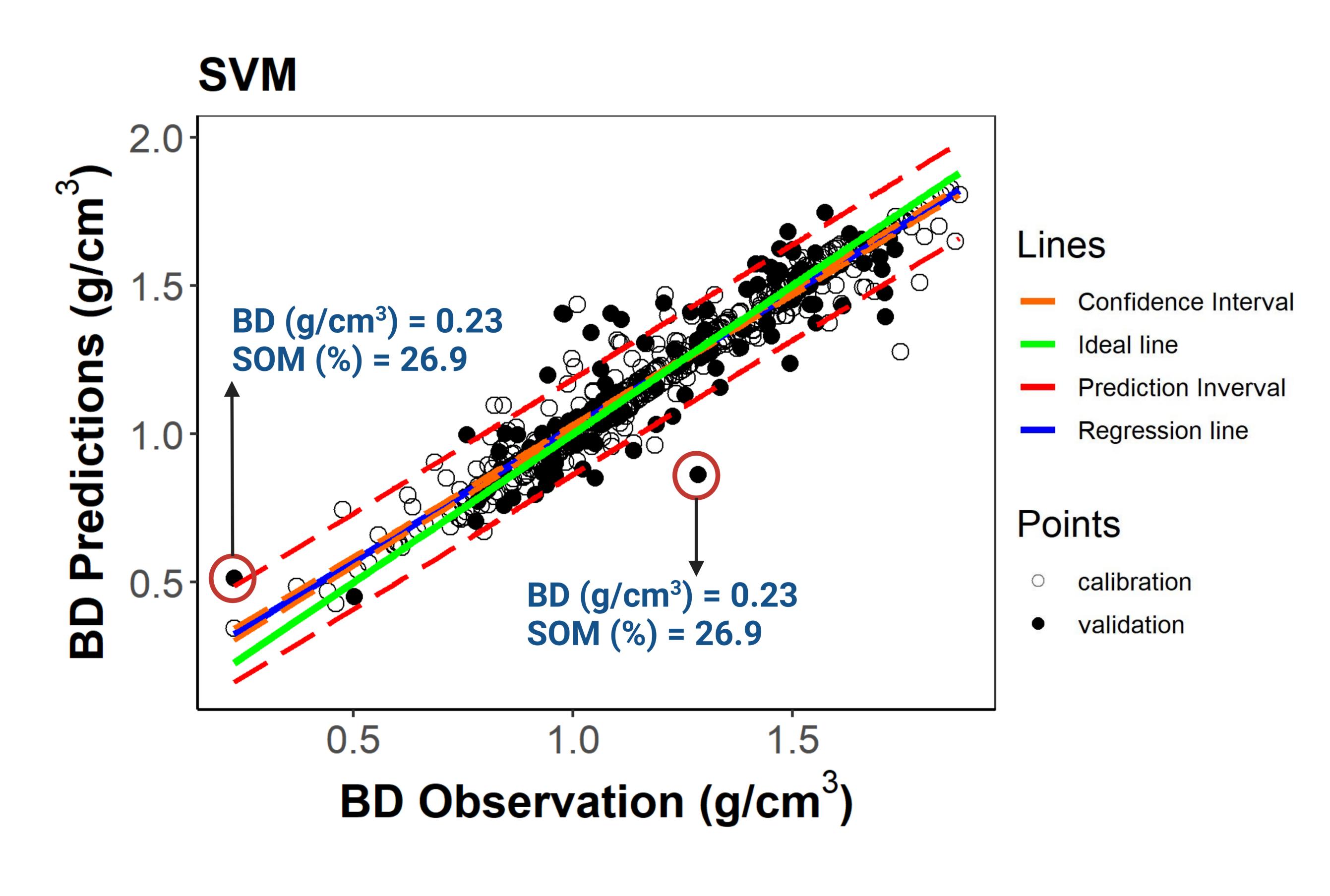
Fig 1. Predicted value of soil bulk density (BD) vs reference value

a) PLSR

clay minerals — 3610, 3710
alkyl and –CH2 — 2840, 2910
N = C = S — 2040
Organic matter (carboxylic acid, –COOH) — 1750, 1530, 1620, 1370
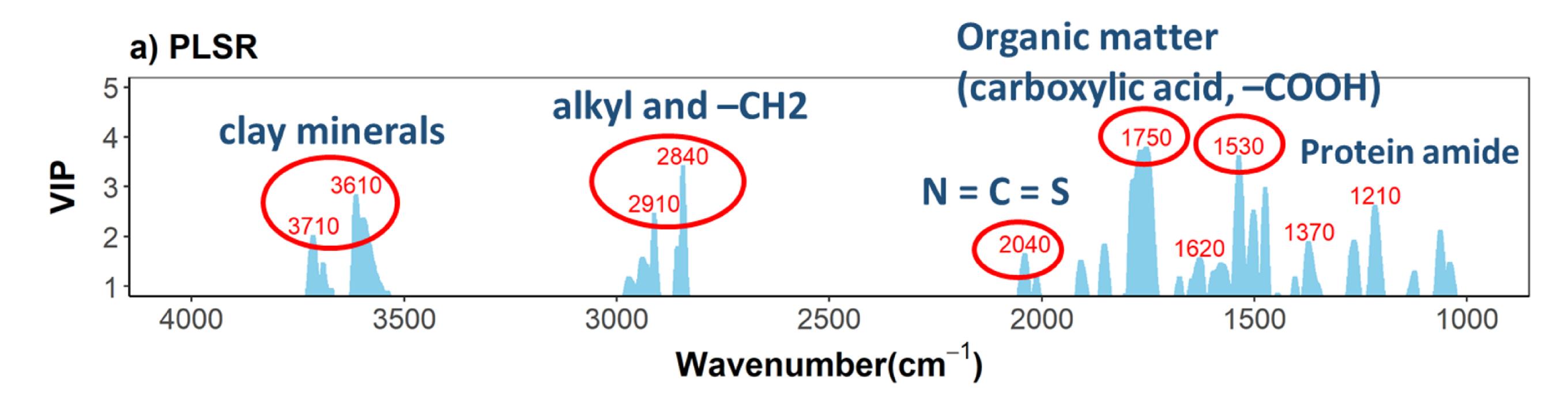Protein amide — 1210

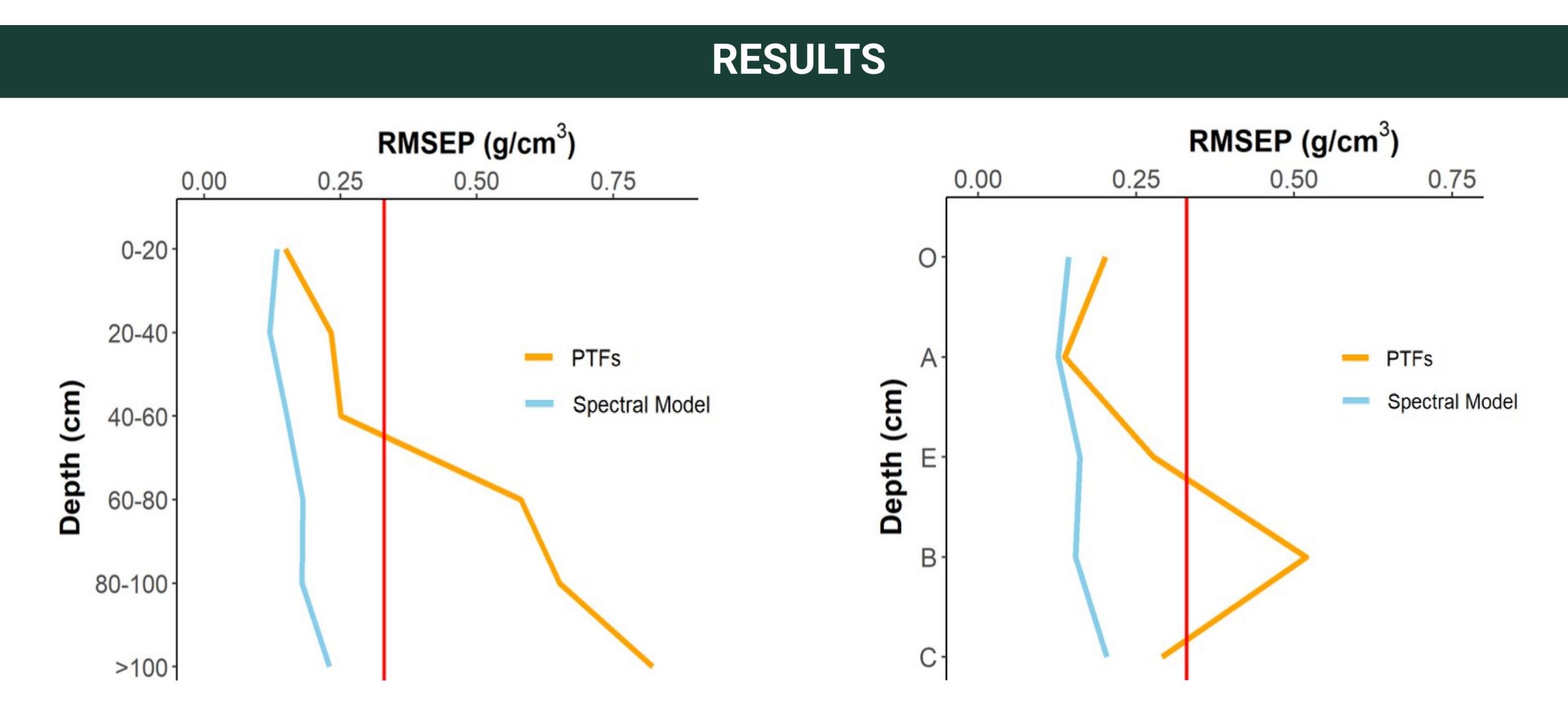Fig 2. Variable importance of PLSR

RESULTS

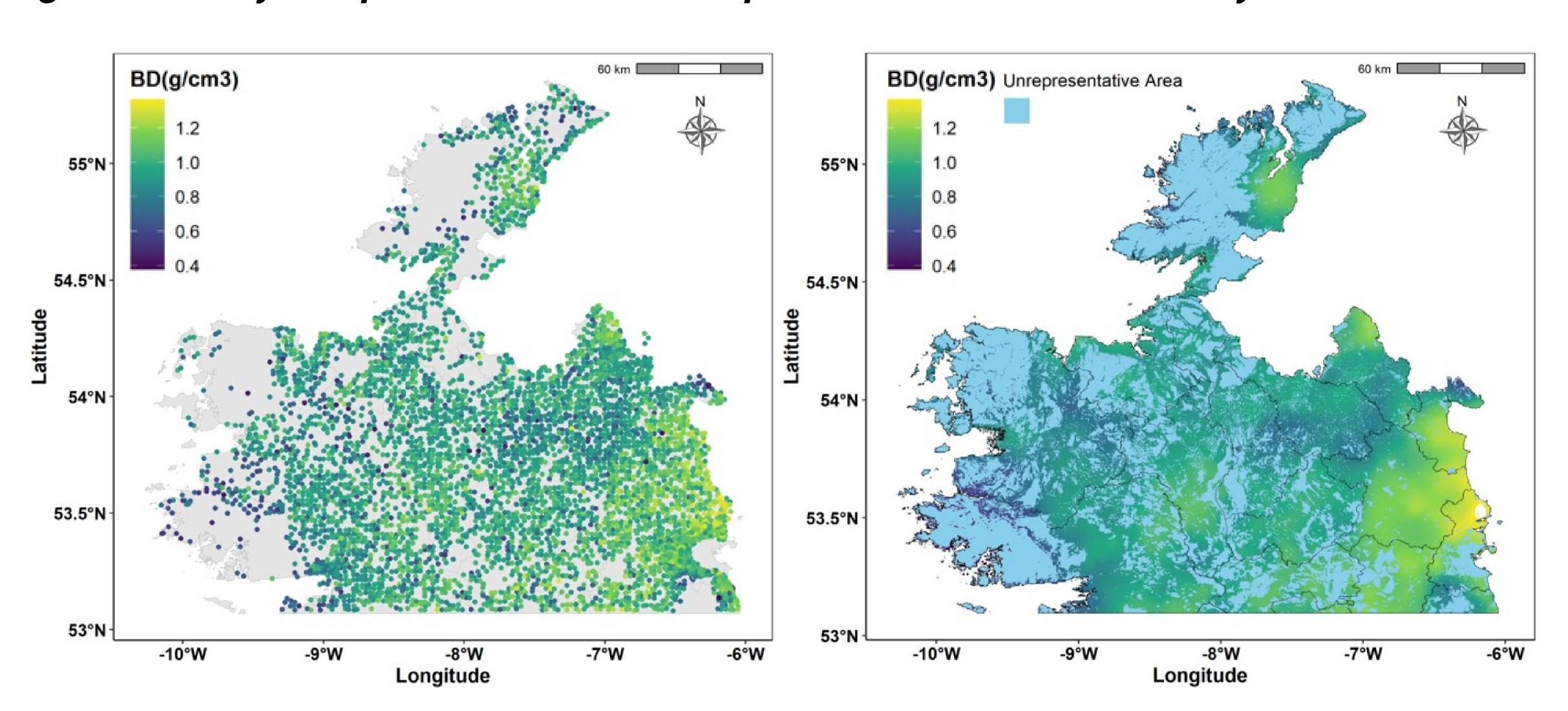Fig 3. Accuracy comparison of PTFs and Spectral model on different layers

Fig 4. Predicted Soil BD on TerraSoil A samples (5-20cm)

CONCLUSIONS

Compared to traditional PTFs, the spectral soil BD model shows several benefits, such as high accuracy and the homogeneity of performance on different depth layers above 50 cm. These characteristics can be noteworthy strengths of spectral modelling techniques when carrying out national soil surveys and large-scale carbon stock assessments

ACKNOWLEDGEMENTS