MAPPING INTRA-FIELD VARIABILITY OF SOIL HORIZONS USING GROUND PENETRATING RADAR

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Introduction

- Soil horizon thickness affects soil function including root development and can contribute to yield variability.
- Recent advancements in ground penetrating radar (GPR) technology showed promise in characterizing soil profile variability used to classify soils (Adamchuk et al. 2015).
- Doolittle and Collins (1995) has documented several applications of the GPR to map the thickness of soil horizons with antennas > 500 MHz in hard pans, dense till, permafrost soils in the United States.

Objective

To evaluate the efficiency of GPR to map soil horizon thickness in two potato fields in New Brunswick, Canada.

Materials & methods

Experimental sites

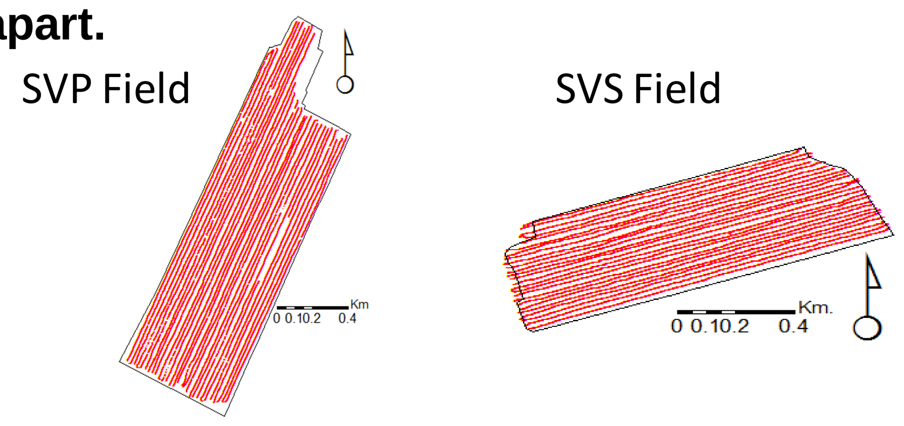
- Two commercial fields of 12 ha in NB, Canada:
  - SVP field in St-André (Madawaska county);
  - SVS field in Centreville (Carleton county).
- Rolling topography, shallow bedrock, silty loam texture.

GPR data collection

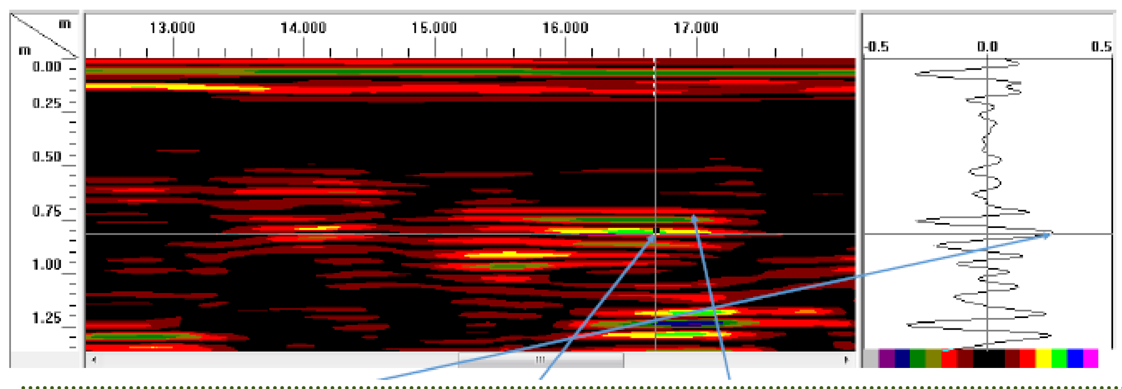
- Data acquisition February 2016.
- GSSI model SIR-3000; 400 MHz antenna, 30 scan sec^{-1}.
- DGPS (precision < 1 m).



- Data density: 20 416 points ha^{-1} :
  - Data were collected on parallel transects approximately 10-m apart.

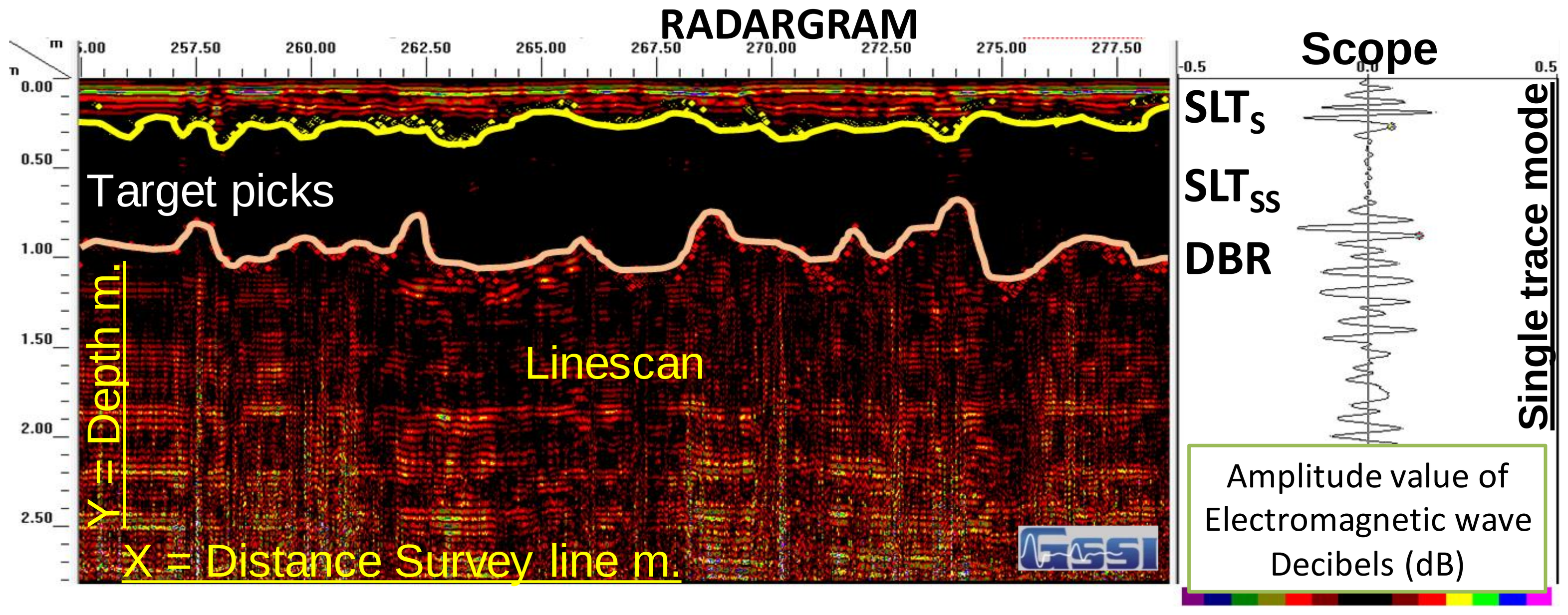


- The dielectric contrast of the GPR was adjusted using the maximum depth penetration of the VERIS P4000®.
- A field-specific GPR calibration was completed using the signal of a metallic plate installed at a depth of 0.75 m in the soil.

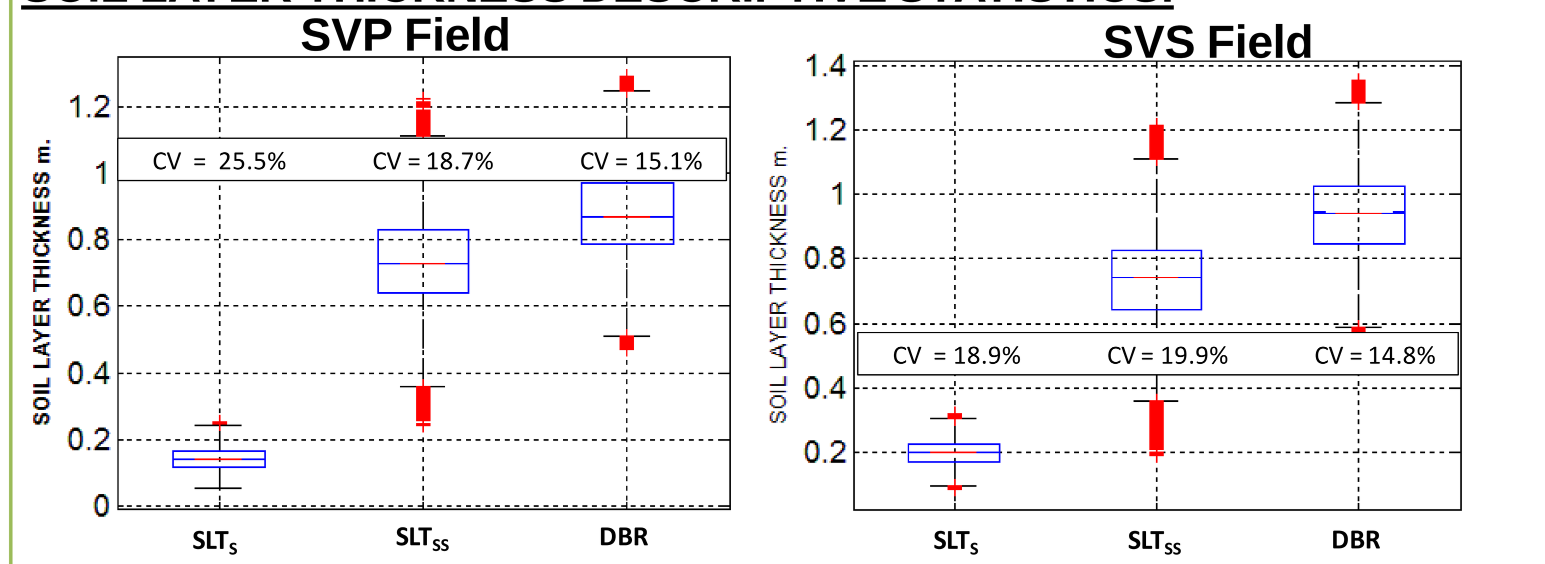



Results

In both fields, two soil layer thickness referred to (SLT_S) surface and (SLT_{SS}) subsurface limited by rock depth (DBR) showed contrasting relative amplitude of the GPR waveform (linescan).

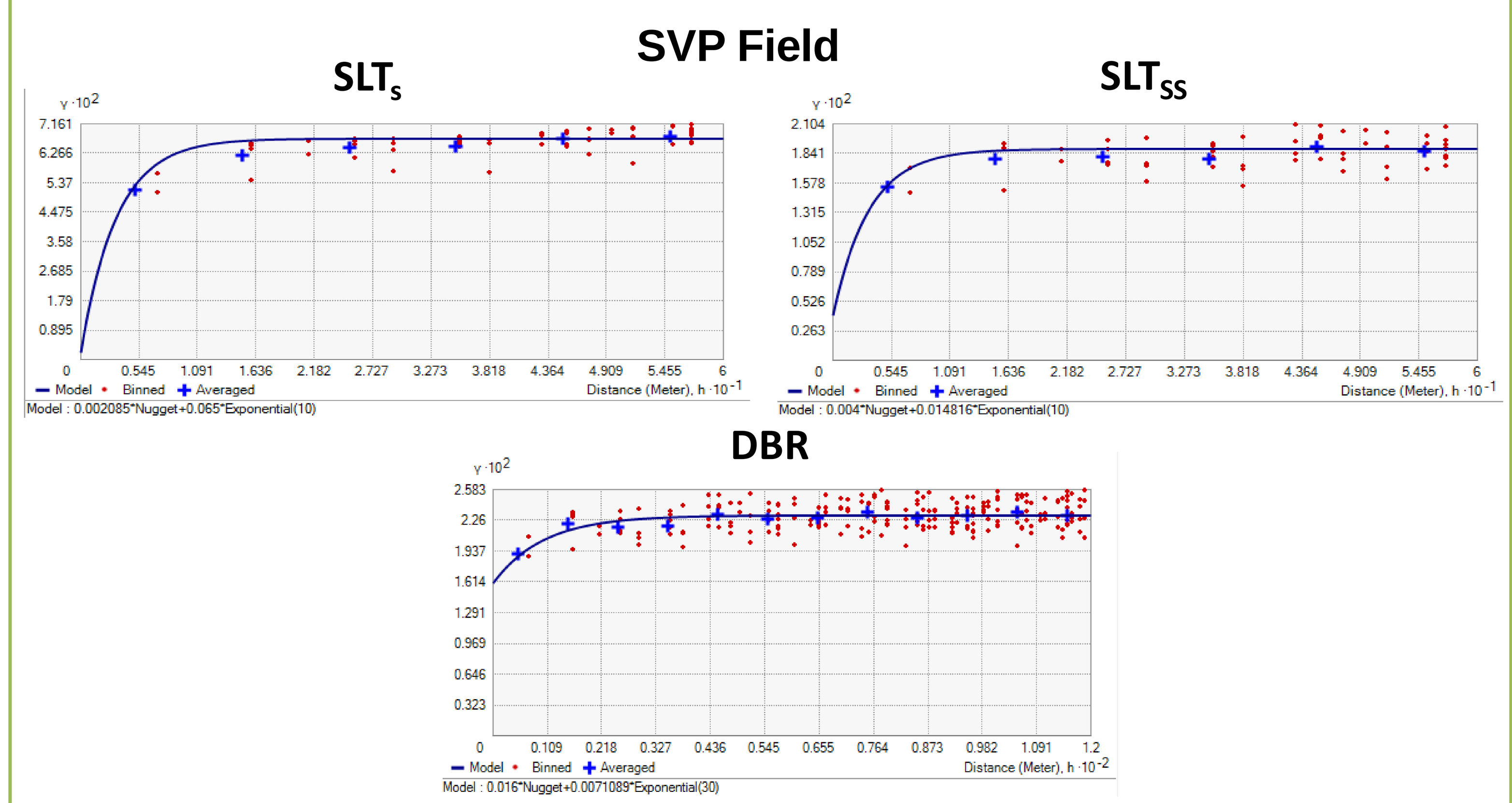


SOIL LAYER THICKNESS DESCRIPTIVE STATISTICS:



SVP field: SLT_s → 0.05 to 0.25 m, SLT_{ss} → 0.24 to 1.22 m and DBR → 0.47 to 1.28
SVS field: SLT_s → 0.08 to 0.31 m, SLT_{ss} → 0.18 to 1.21 m and DBR → 0.49 to 1.35

SEMIVARIOGRAM PARAMETERS:

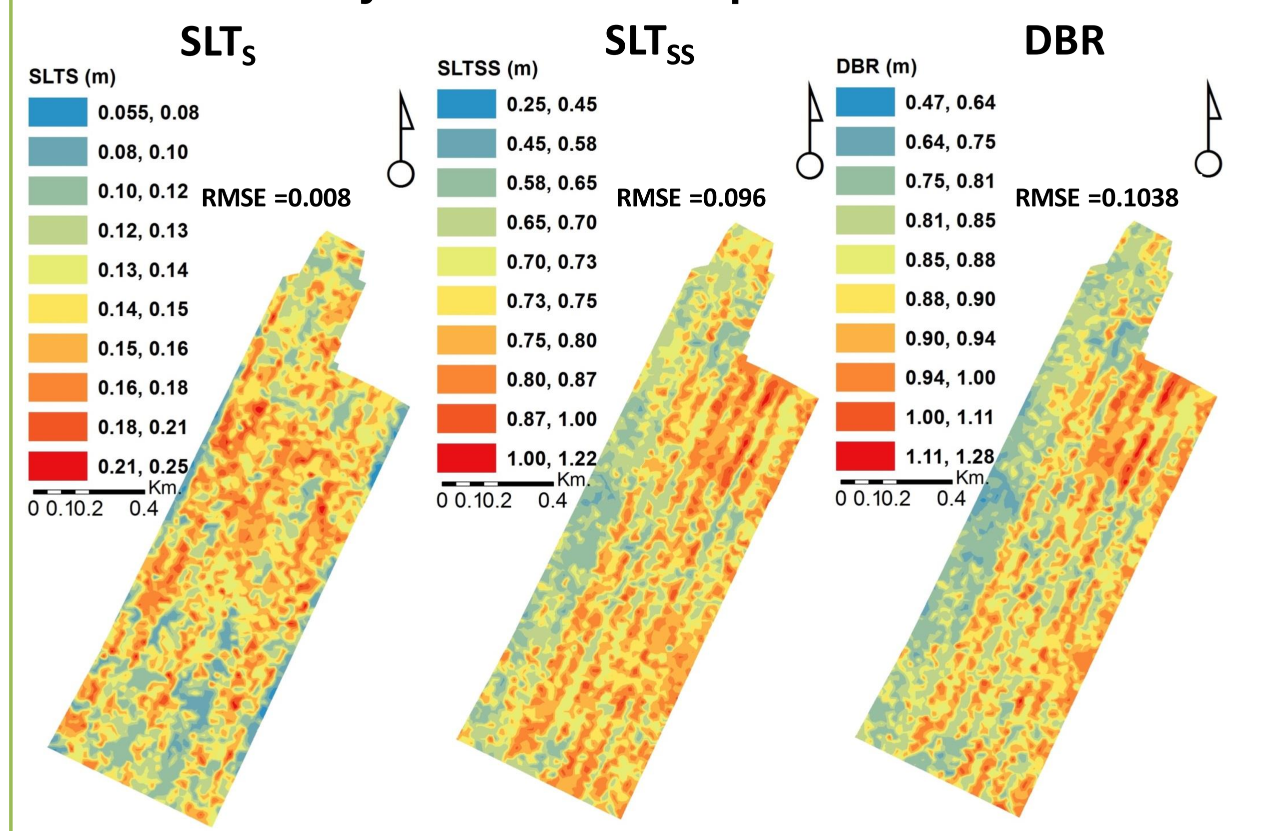


		Nugget ratio, %	Spatial class	Range	Model	Cross validation R^2
SVP Field	SLT_S	3	S	10	Exp.	0.95
	SLT_{SS}	29	M	10	Exp.	0.51
	DBR	14	S	30	Exp.	0.39
SVS Field	SLT_S	35	M	6	Exp.	0.72
	SLT_{SS}	23	S	10	Exp.	0.74
	DBR	19	S	10	Exp.	0.75

- Strong (S) to moderate (M) spatial structure (≤ 75%) for soil layer thickness (Cambardella et al. 1994).
- The ranges show that the grid sampling strategy used to characterize the spatial variability of sites was appropriate.

KRIGING MAPS:

Soil layer thickness maps for SVP field



PEARSON CORRELATION COEFFICIENTS BETWEEN GPR AND TOTAL TUBER YIELDS

	SVP			SVS		
	SLT_S	SLT_{SS}	DBR	SLT_S	SLT_{SS}	DBR
YIELD 2013	0.00	0.20*	0.22**	n.a.	n.a.	n.a.
YIELD 2014	0.25**	0.01	-0.05	0.20*	-0.12	-0.09

*, ** = significant at 0.05, 0.01, respectively; n.a.: non available.

- SLT_S, SLT_{SS}, and DBR presented significant positive correlations (at 0.05, 0.01) with the total tuber yields.
- In 2013, the depth of the DBR derived from GPR data were positively and significantly correlated with the total tuber yields in SVP Field.
- In 2014, the depth of the SLTs derived from GPR data were positively and significantly correlated with the total tuber yields.

Conclusions

The RMSE and cross-validation parameters clearly indicate that GPR was efficient in quantifying soil layer thickness.

In 2013, increased values of the DBR were significantly correlated with increased total tuber yield at SVP Field.

In 2014, increased values of the SLTs were significantly correlated with increased total tuber yield at both sites.

References

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