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SOIL SCIENCE

Integrating proximal gamma ray spectrometry and apparent electrical conductivity to monitor SOC content at field-scale

De Ros A.[a] , Piccoli I.[b] , Sartori L.[a] , Dal Ferro N.[b] , Morari F.[b]
[a]Department of Land, Environment, Agriculture and Forestry University of Padova
[b]Department of Agronomy, Food, Natural resources, Animals and Environment, University of Padova

Corresponding author: angelica.deros@phd.unipd.it

DAFNAE
Dipartimento di Agronomia Animali Alimenti Risorse naturali e Ambiente
TESAF Department of Land, Environment, Agriculture and Forestry
800 ANNI 1222·2022
UNIVERSITÀ DEGLI STUDI DI PADOVA

INTRODUCTION

In the framework of «Carbon farming» initiative, new ways are being sought for effective monitoring, reporting and verification (MRV) of soil organic carbon (SOC) sequestration. Remote and proximal sensing have been identified as effective tools to provide regular and systematic observations on soil properties variations with particular attention to SOC.

AIM

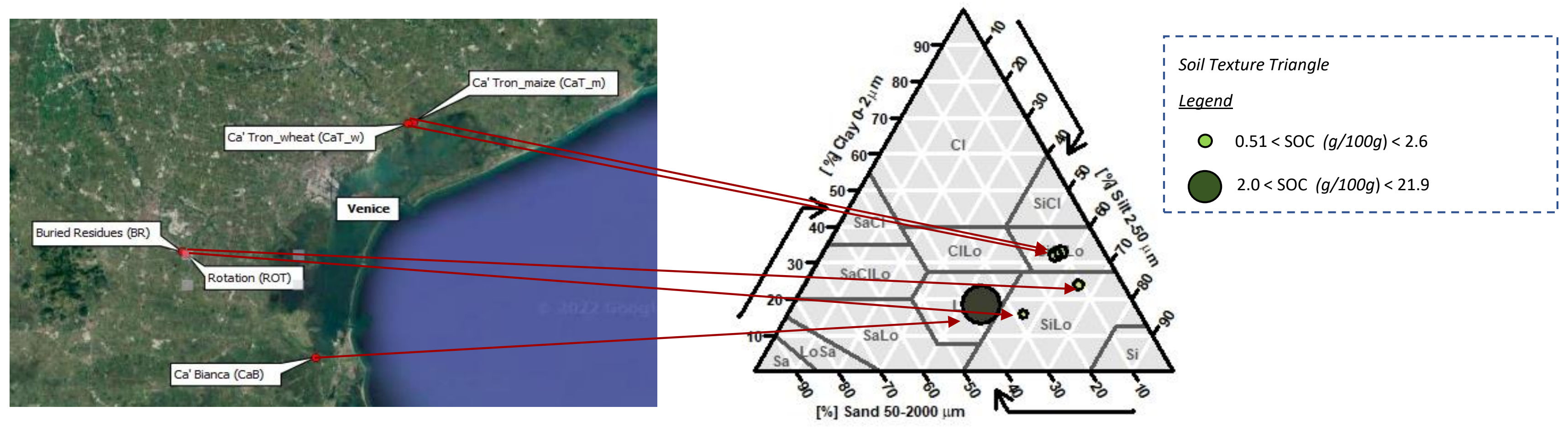
Evaluate the combination of two proximal sensors to predict soil properties with particular attention to SOC content.

→ Electromagnetic Conductivity meter
→ Gamma-ray detector

MATERIAL and METHODS

Field surveys were conducted in 2019 on five agricultural areas in northeastern Italy, Veneto region.

- Rotation (ROT) - - - > Calcaric CM; Silty-Loam; low SOC (0.51 < SOC < 1.27)
- Buried Residues (BR) - - - > Calcaric CM; Silty-Loam; low SOC (0.73 < SOC < 1.073)
- Ca’ Tron maize plot (CaT_m) - - - > Gleyic CL; Silty-Clay-Loam; 1.04 < SOC < 2.60
- Ca’ Tron wheat plot (CaT_w) - - - > Gleyic CL; Silty-Clay-Loam; 1.19 < SOC < 2.56
- Ca’ Bianca (CaB) - - - > Sapric-Thionic HS; Loam; high SOC content (1.34 < SOC < 21.90)



SOIL ANALYSIS

- Bulk Density (g/cm^3)
- Soil texture (g/100g)
- SOC content (g/100g)

VWC

Soil Volumetric Water content (VWC%)
recorded by TDR (Time Domain Reflectometer, FieldScout TDR 350, Spectrum Technologies Inc

SOCstock (t/ha) = SOC (g/100g) × BD (g/cm^3) × depth (30cm)
wc (%) = VWC (%) / BD (g/cm^3)

Soil moisture correction
*Total Count correct = TC *(1 + 1.11wc)*
*^{232}Th or ^{238}U or ^{40}K correct = ^{232}Th or ^{238}U or ^{40}K *(1+1.11wc)*

- Spatial analysis - - - > Ordinary Kriging
- Multivariate data analysis - - - > PCA
- Spearman’s rank correlation
- Multiple Linear Regression (LM)

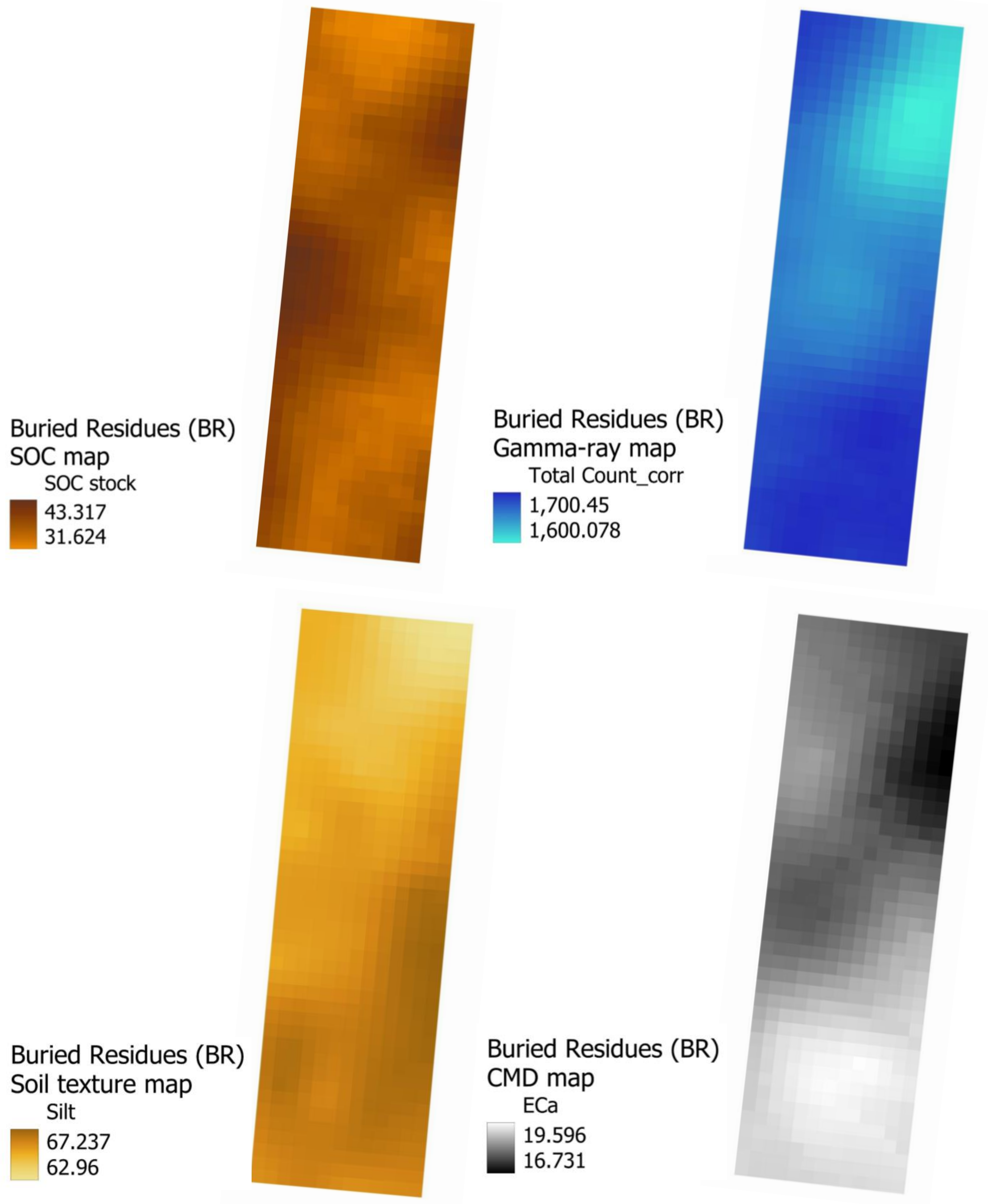
PROXIMAL SENSING

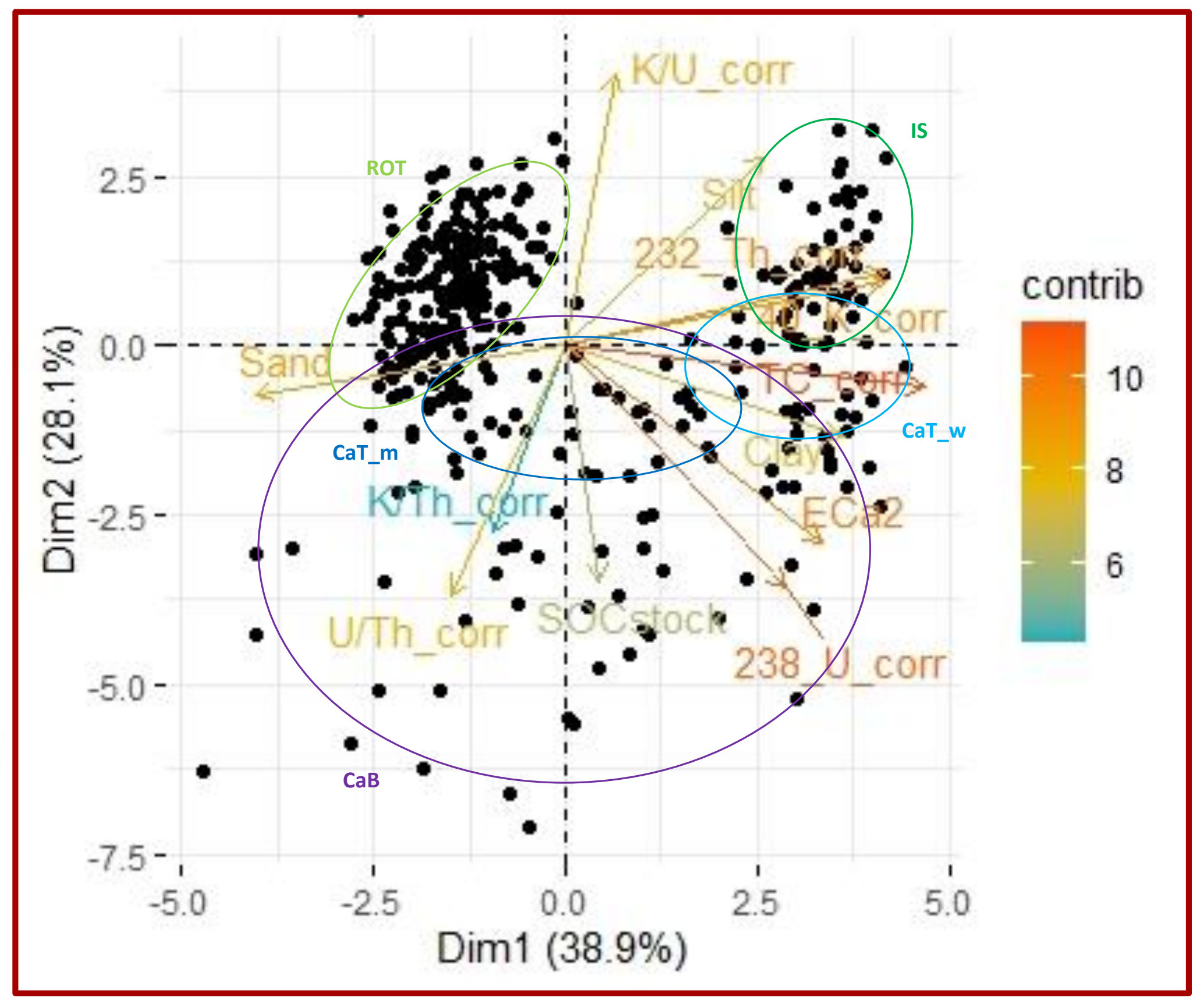
Soil apparent electrical conductivity (ECa)
recorded by CMD-Mini Explorer, GF Instrument

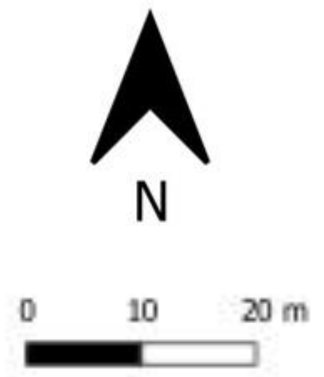
Soil gamma-ray emissions (Total Count, ^{232}Th, ^{238}U , ^{40}K) isotopes recorded by MS-2000 Agri detector, Medusa Radiometrics

RESULTS

MINERAL SOILS



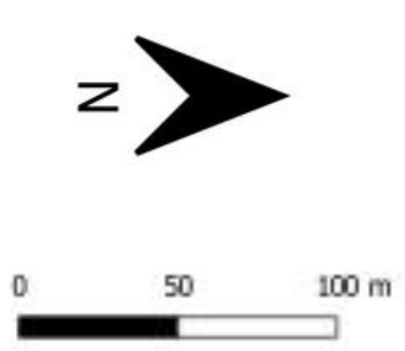


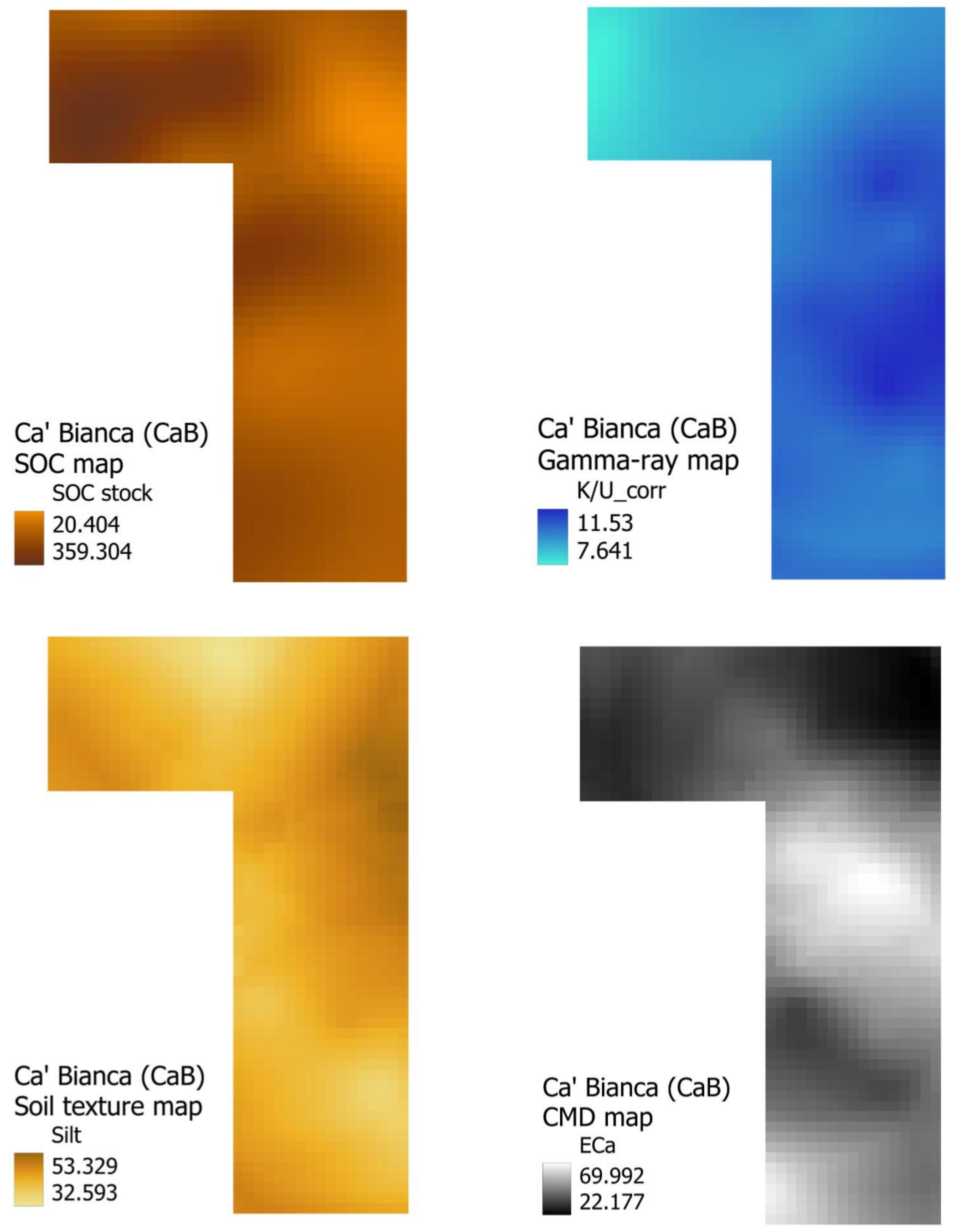


MINERAL SOILS	SOC_stock	Sand	Silt	Clay
Total Count_corr		- 0.543 **	0.541 **	0.544 **
40_K_corr		- 0.270 *	0.249 *	0.294 *
232_Th_corr		- 0.520 **	0.552 **	0.389 **
238_U_corr				
K/U_corr				
K/Th_corr			- 0.267 *	
U/Th_corr		0.325 **	- 0.378 **	
ECa	- 0.353 **	- 0.434 **	0.425 **	0.425 **

Sperman’s correlation matrix results for mineral soils.

PEAT SOILS





PEAT SOILS	SOC_stock	Sand	Silt	Clay
Total Count_corr		- 0.771 **	0.503 **	0.633 **
40_K_corr	- 0.448 *	- 0.775 **	0.555 **	0.715 **
232_Th_corr		- 0.541 **	0.340 **	0.459 **
238_U_corr		- 0.608 **	0.428 **	0.440 *
K/U_corr	- 0.543 **	0.391 *	0.382 **	0.528 **
K/Th_corr	0.142 *			
U/Th_corr				
ECa			0.378 *	

Sperman’s correlation matrix results for peat soils.

CONCLUSION

1. Gamma-ray spectra discriminate between different types of soils.
2. Significant correlations between gamma-ray spectra and soil texture components were always observed, both in case of mineral and peat soils.
3. Gamma-ray were predictors of SOC stock variability in peat soils, which contrasts with results obtained in mineral soils.
4. K/U radionuclides ratio was more effective than the single ones in monitoring SOC stocks at field scale.
5. ECa was a significant predictor for both SOC stocks and soil texture in mineral soils.
6. According to Sperman’s correlation matrices, the relationship between SOC and both gamma-ray radionuclides and ECa depends on soil texture components.