ENHANCING PORTABLE FIELD SPECTROSCOPY MEASUREMENT OF SOIL ORGANIC CARBON (SOC) IN BARE CROPLAND BY REDUCING THE DISTURBING EFFECT OF SOIL RELATIVE SHADOW

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ABSTRACT

1. INTRODUCTION

Soil Organic Carbon (SOC) stock has been the object of a growing literature these last decades due to their role in the conservation of **soil quality and in the global C** cycle which contributes to global environmental changes through CO_2 fluxes between soil and atmosphere [1].

Conventional sampling techniques are often too expensive and time consuming due to the high sampling density necessary to detect change in SOC stock which is slow and masked by its important spatial variability.
Conversely, **diffuse reflectance spectroscopic techniques**, and in particular Visible and Near Infra Red (VNIR) spectroscopy (350 nm to 2500 nm), allows rapid sampling and instantaneous determination of SOC values, at field and regional levels (in remote sensing mode). This technique provides in a cost effective way the large amount of spatial data required in soil monitoring or modeling studies like the monitoring of decline of soil organic matter in the topsoil.
However spectroscopy techniques present still **major constraints**. In particular, **spatial variation in surface soil properties** induce a variability not directly related to the studied property and reduce the accuracy of SOC prediction in the field. According to Atzberger (2000) [2], the **main disturbing factors** are soil water content, vegetation residues and surface roughness. The latter can be approximated by soil Relative Shadow (RS) (Cierniewski and Verbrugghe, 1997) [3] which is the percentage of shadowed soil area.

The **purpose of this study** is to identify and reduce the effect of soil RS on the SOC prediction. Figure 1 presents the effect of soil RS on laboratory soil reflectance spectra. Increasing RS decreases the reflectance.

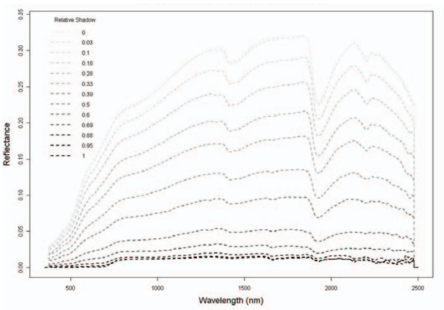

Figure 1: Reflectance spectra for 13 Relative Shadow levels.

2. METHODOLOGY

A field campaign was realized in Grand-Duchy of Luxembourg on an area with different soil types and a large variation in SOC content. **Ninety-nine soil plots** were investigated in 8 bare fields. For each plot, several **measurements** were done. **Reflectance** in the VIS-NIR range of the electro-magnetic spectrum (350 nm to 2500 nm) was measured with a FieldSpec Pro spectroradiometer (Analytical Spectral Device ASD) with a Full Width Half Maximum of 3 nm for the 350-1000 nm region and 10 nm for the 1000-2500 nm region. **Soil Relative Shadow (RS)** was measured with the image analysis software DEFINIENS DEVELOPPER (DEFINIENS Inc.) through the analysis of vertical digital photographs of soil. Observed RS values are included in the range 0.25 to 0.65. Finally **soil samples** were taken for further spectral analysis in laboratory among which **SOC** measurements with the method of dry combustion with a CN analyzer.

Then for each soil sample, an individual **correction factor "K"** was computed by comparing the RGB value of non-shadowed area with the mean RGB value of the whole soil digital photography in the visible range (1 "K" value per soil sample). The good correlation between K and RS ($R^2 = 0.74$) enabled **the prediction of K from RS: "**Kpredicted" or **"Kp"**. Another K with value for each wavelength (350 -2500 nm), "Kextrapolated" or **"Ke",** was computed from K and a reference K shape acquired from laboratory experiment. Then the ASD **reflectance was corrected** from soil relative shadow effect by applying these correction factors K, Kp and Ke. Finally, in order to check if the corrected reflectance enhanced the SOC prediction, **SOC prediction** was realized by means of a multivariate calibration technique (Partial Least Square Regression PLSR) with both raw **field ASD reflectance and reflectances corrected using K, Kp and Ke. Results** are presented in table 1. The performance of the prediction model was measured by the **Root Mean Square Error in Cross Validation** (RMSECV) and by the **Ratio of Performance to Deviation** (RPD, ratio between standard deviation and RMSECV). According to Chang et al., 2001, [4], a calibration model with a RPD>2 can predict accurately the property under study.

Treatment	RPD	RMSECV (gC/kg dry soil)
No treatment – raw reflectance	3.11	3.64
Reflectance corrected with K	3.40	3.33
Reflectance corrected with Kp	3.23	3.41
Reflectance corrected with Kextrapolated	3.61	3.05

Table 1: SOC prediction results with raw and corrected reflectance.

Table 1 suggests that all treatments improve significantly both RPD and RMSECV values. In particular, the reflectance correction with Ke enhances the SOC prediction by 20 percent.

3. CONCLUSION

Results show that it is possible to enhance the SOC prediction by correcting the effect of soil relative shadow on the spectra. Taking in account this disturbing factor could represent an important step forward in order to use spectral techniques in real case studies where soil conditions are not always optimal and cannot be controlled.

4. REFERENCES

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