IMPROVING SPECTRAL TECHNIQUES TO DETERMINE SOIL ORGANIC CARBON BY ACCOUNTING FOR SOIL MOISTURE EFFECTS

Marco Nocita
Antoine Stevens
Bas van Wesemael

Presentation outline

• Background
  • Predicting soil organic carbon (SOC) using soil spectroscopy
  • Soil moisture and spectral reflectance
  • Research objectives
• Methodology
  • Study area
  • Soil analyses
  • Spectral measurements and data pre-processing
  • Soil moisture and SOC prediction models
• Results and discussion
  • Soil moisture effect on spectral reflectance
  • SOC predictions per moisture levels
  • Soil moisture prediction model
  • SOC modeling based on moisture content prediction
• Conclusions and follow-up

Background

Soil spectroscopy to predict SOC

accurate in the laboratory

less precise for field and airborne applications

Field spectroscopy

Why should we be concerned about soil moisture?

Hyperspectral remote sensing

Background

Viscarra Rossel et al. (2006)

accurate in the laboratory

less precise for field and airborne applications

Luxembourg

111 samples (0-5 cm), 37 fields
4 soil textures
SOC content range: 9-50 g C kg⁻¹
soil types: Cambisols, Luvisols, Arenosols, and Calciisols

Lobell et Asner, 2002

Questions:
Can we quantify the effect of soil moisture on SOC predictions based on VNIR spectroscopy?
Can we build a tool to predict SOC for soils with no a-priori data on their moisture content?
Soil analyses

- Soil samples: air dried, smashed and sieved (<2mm)
- SOC: dry-combustion with a VARIOMAX C/N analyser
- Moisture content: oven-dried at 105 °C during 24 h

...and spectral measurements

- ASD Fieldspec-Pro radiometer (350-2500 nm)
- Contact probe specific for soils (2-cm-diameter)
- Samples artificially wetted until reaching 5, 10,15, 20, and 25% MC

Soil moisture and SOC prediction models

- Dataset was divided in training (2/3) and test set (1/3)
- SOC prediction: Partial least square regression (PLSR)
  - leave one-out cross-validation of the training set (CV) to choose the latent factors (max=10)
  - Independent validation of the test set
- Moisture content: Normalized soil moisture index (NMSI) (Haubrock et al., 2008)
  - NSMI= \[ \frac{R(1800) – R(2119)}{R(1800) + R(2119)} \]^{-1}
  - Linear regression between GSM and NSMI

SOC content (g C kg^{-1})

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<td>35.75</td>
<td>50.22</td>
<td>19.51</td>
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</table>

Effect of increasing soil moisture on mean spectral reflectance

Principal components scores by soil type
SOC predictions by moisture content levels

Moisture content predicted vs. observed based on NSMI

SOC predicted vs. observed after NSMI application

Belgium Loam-Belt

- 30 soil cores (1m depth)
- 110 soil samples (10 cm)
- 330 soil spectra (3 times at different soil moisture)
- SOC range: 0.3 to 14 g C kg⁻¹
- Moisture content ranges (gravimetric):
  - 1st scan: ~15 : 35 %
  - 2nd scan: ~2 : 17%
  - 3rd scan: ~1 : 6%
- MC predictions: 10% of soil samples (random selection)

First application: profiling in a field (central Belgium)

- 30 soil cores (1m depth)
- 110 soil samples (10 cm)
- 330 soil spectra (3 times at different soil moisture)
- SOC range: 0.3 to 14 g C kg⁻¹
- Moisture content ranges (gravimetric):
  - 1st scan: ~15 : 35 %
  - 2nd scan: ~2 : 17%
  - 3rd scan: ~1 : 6%
- MC predictions: 10% of soil samples
Soil moisture is an important factor in soil spectroscopy
- Strong influence on spectral reflectance from dry to 15% moisture content
- Accuracy decrease when dry model is applied to moist soils
- Constant error for SOC predictions at different moisture levels
- NSMI easy and fast tool to develop moisture content classified predictions
- No accuracy decrease of SOC prediction after NSMI classification

Follow-up
Test of NSMI application under uncontrolled soil moisture conditions
1. Other profiling soil spectroscopy
2. Hyperspectral remote sensing

Thanks for your attention
marco.nocita@uclouvain.be