PROSOIL

The evaluation of forthcoming satellites for mapping topsoil organic carbon in croplands
OBJECTIVES

To develop methods to produce up-to-date soil property data through multivariate calibration (MVC) of the signal from the new generation of satellites.

1. Develop MVC models that are applicable for large areas using a continental scale and harmonized SSL

2. Propose a standardized procedure for the processing of RS imagery through MVC based on laboratory SSL.
   a) Validate the derived soil products.
   b) Evaluate the effects of degraded satellite signals on the prediction accuracy
The objective is to test whether the LUCAS can be used to estimate SOC without a need for additional chemical analysis.
A routine chemometrics approach

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1. Classification of the LUCAS samples collected in croplands
2. Classification of local libraries according to the LUCAS classes
A routine chemometrics approach

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1. Classification of the LUCAS samples collected in croplands
2. Classification of local libraries according to the LUCAS classes
3. Calibration of PLSR models for each LUCAS class detected in the first step
4. Estimation of SOC content applying the LUCAS calibration models of a specific soil class
## SOC estimation

<table>
<thead>
<tr>
<th>Validation Dataset</th>
<th>RMSE</th>
<th>RPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam belt</td>
<td>1.2</td>
<td>1.41</td>
</tr>
<tr>
<td>Wallonia</td>
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</tr>
<tr>
<td>Luxembourg</td>
<td>5.1</td>
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<tr>
<td>Demmin</td>
<td>5.3</td>
<td>2.72</td>
</tr>
<tr>
<td>All</td>
<td>4.2</td>
<td>2.63</td>
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</table>

**Estimation of soil organic carbon in arable soil in Belgium and Luxembourg with the LUCAS topsoil database**

*European Journal of Soil Science, 2018*

doi: 10.1111/eps.12553
Bottom-up method

1. LUCAS Topsoil database
2. Local spectral library
3. Lab. soil spectra
4. RS image
5. Spectra at sampling points
6. Bare soil fields
7. MVR
8. SOC predicted
9. SOC maps
Bottom-up method

- LUCAS
- Local Spectral library
- SOC
- Clay
- Sand
- CaCO3
- N
- P
- ...

At sampling points

Maps
- Variable 1
- Variable 2
- Variable 3
Airborne - APEX Validation

Traditional Approach vs. Bottom-Up Approach

<table>
<thead>
<tr>
<th>Location</th>
<th>Traditional Approach</th>
<th>Bottom-Up Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RMSE g·kg⁻¹</td>
<td>RPD</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>4.9</td>
<td>1.7</td>
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<tr>
<td>Loam belt</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>3.6</td>
<td>2.1</td>
</tr>
</tbody>
</table>

**TRADITIONAL**

**BOTTOM-UP**

*Soil Organic Carbon Estimation in Croplands by Hyperspectral Remote APEX Data Using the LUCAS Topsoil Database*

Fabio Castaldi 1,*, Sabine Chabrillat 2, Arwyn Jones 3, Kristin Veys 4, Bari Bomans 4 and Bas van Wesenbeeck 1,*.
Airborne data

HySpex
SR: 4 m
408 bands
418 – 2498 nm

EnMap simulations

EnMap imager
- Spectral range from 420 nm to 2450 nm (VNIR-SWIR)
- **high spectral resolution** of 6.5 nm (VNIR) and 10 nm (SWIR); ~ 240 bands
- 30 m spatial resolution

EeteS processing scheme
EnMap simulations
HySpex and Simulated EnMap

The HySpex and simulated EnMap data in Demmin site were used to assess the uncertainty of the SOC maps retrieved by the bottom-up approach.

- Uncertainty due to the choice of the calibration dataset
- Uncertainty due to the prediction model
- Uncertainty due to the georeferencing error

![Diagram of the uncertainty assessment process]

1. **U_Dataset**: RS data → Estimated SOC
2. **U_Model**: Random forest model
3. **U_Georef.**: Bare Soil pixels → SOC maps → Validation

1000 times validation
Simulated EnMap

SOC maps

HySpex

EnMap

Uncertainty (variance)

Validation
(71 points/10 fields)

\( RPD: 1.7 \)

\( RPD: 0.6 \)
### Sentinel-2 images

<table>
<thead>
<tr>
<th>Study area</th>
<th>Acquisition date</th>
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<tbody>
<tr>
<td>Luxembourg</td>
<td>2016/05/08</td>
</tr>
<tr>
<td>Demmin</td>
<td>2017/08/30</td>
</tr>
<tr>
<td>Loam belt belt</td>
<td>2017/08/29</td>
</tr>
</tbody>
</table>

- **Level-1C**
  - **Sen2cor**
  - **Level-2A**
    - 10 m
    - 9 bands

B2 (490 nm), B3 (560 nm), B4 (665 nm), B5 (705 nm), B6 (740 nm), B7 (783 nm), B8 (842 nm), B11 (1610 nm) and B12 (2190 nm).
We compared the Sentinel-2 prediction accuracy with that obtained by hyperspectral airborne data in the same study area:

- Multispectral S2, hyper airborne, resampled S2
- We investigated the importance of spectral and spatial resolution
- SNR, VIP and spatial variability (infield, regional)
Evaluating the capability of the Sentinel 2 data for soil organic carbon prediction in croplands.

(Under review - ISPRS Journal of Photogrammetry and Remote Sensing)
REALISATION OF OBJECTIVES

• Reproducible approach to estimate SOC in arable soils with a satisfactory level of accuracy with only the spectra of soil samples and without the need for further laboratory analyses, using LUCAS

• We developed the bottom-up approach that allows transferring soil information from a continental library to remote sensing data, bypassing the issues related to spectral transfer.

• We validated the soil products

• We evaluated the effects of degraded satellite signals on SOC prediction accuracy (Airborne/Sentinel-2/EnMAP)
Thank you