Sensing Soil Physical Properties
Physical soil properties

Soil physical properties measured in 2012 and 2015 to:
- Provide quantitative data for agronomic assessment and crop planning
- Assess any differences in soil properties due to the project methodology

This was done by:
- Sampling by Universidad Politécnica de Madrid
- Scanning with the Agribox by Medusa
  - Gammaspectrometer
  - GPR: radar

Furthermore we performed field tests with:
- A decompactador to test the effect of improved soil structure in Illana
- Other projects and Spanish partners to test the methodology in agro-forestry, orchards and vineyards
Actual Bulk Density - RhoC

Density over 15 cm

ρ

Radioactive source

Sediment

Medusa sensor

Slide n° 3
Actual Bulk Density - RhoC
Soil structure test - Descompactador
# Soil structure test - Descompactador

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>soil bulk density (g/cm³)</td>
<td>1.54</td>
<td>1.32</td>
<td>1.55</td>
<td>1.41</td>
<td>1.70</td>
<td>1.60</td>
</tr>
<tr>
<td>soil rooting depth (cm)</td>
<td>10</td>
<td>32</td>
<td>14</td>
<td>57</td>
<td>64</td>
<td>22</td>
</tr>
</tbody>
</table>

![Graphs showing average penetrometer profile per area in 2014 and 2015](image_url)
Physical soil properties - Agribox
Agribox

Medusa
Soil composition

Data integration unit

GPS

Fieldbook
Data logging and viewing

Ground Penetrating Radar
Impermeable layers
Agribox - Benefits

- System powered by the car engine
- Build-up time 5 minutes per field
- Flexible and robust
- Fast (4-6 hectare/hour)
- High data density, resulting in field covering data
- Much detail; enables precision farming and analysis of within field and between field analysis of soil variation
- Map of raw data visible during sensing:
  - Enhances communication between owner and operator
  - Improves the understanding of the geology and soil of the field.
Gammaspectrometer

Measures natural background radiation as radionuclide concentrations (Bq/kg)
- Potassium (bulk) ($^{40}$K)
- Uranium ($^{238}$U)
- Thorium ($^{232}$Th)
- Caesium ($^{137}$Cs)

Measurement depth is average over 30 cm

Determine fingerprint of minerals:
- Provenance dependent (origin of parent material)
- Concentration of $^{40}$K,$^{238}$U,$^{232}$Th in clay and sand are different
- $^{40}$K, $^{238}$U, $^{232}$Th proxy for soil texture

Application: **Soil composition**
Geology of Spain
Gammaspectrometer

Soil sensing

Clay content measurement

Clay content map

Falces

North East group

Sand fraction [%] lab

40K concentration (Bq/kg)
Ground Penetrating Radar (GPR)

Maps of compacted layers/soil depth

Change in soil texture
Understanding soil

Measurements

Interpretation of the soil based on pits

GPR

Open data

Mapping

Comprehensive maps of the soil

Lab analysis

<table>
<thead>
<tr>
<th>Finca</th>
<th>arcilla</th>
<th>Mat. Org.</th>
<th>Etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Promedio</td>
<td>promedio</td>
<td>...</td>
</tr>
<tr>
<td>2</td>
<td>promedio</td>
<td>Promedio</td>
<td>...</td>
</tr>
</tbody>
</table>
Example Falces - Navarra
### Look-up table soil properties

<table>
<thead>
<tr>
<th>region</th>
<th>Navarra</th>
<th>Navarra</th>
<th>Navarra</th>
</tr>
</thead>
<tbody>
<tr>
<td>area</td>
<td>Falces</td>
<td>Falces</td>
<td>Falces</td>
</tr>
<tr>
<td>farmer</td>
<td>Jesus Aranda Torres</td>
<td>Placido Tainta Ausejo</td>
<td>Jesus Aranda Torres</td>
</tr>
<tr>
<td>years organic 2012</td>
<td>20</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>field</td>
<td>81</td>
<td>82</td>
<td>85</td>
</tr>
<tr>
<td>slope</td>
<td>Level</td>
<td>Level</td>
<td>Flat</td>
</tr>
<tr>
<td>max slope</td>
<td>Steep</td>
<td>Moderately steep</td>
<td>Steep</td>
</tr>
<tr>
<td>geology</td>
<td>limestone with marls</td>
<td>limestone with marls</td>
<td>limestone with marls</td>
</tr>
<tr>
<td>texture</td>
<td>25-35 % clay</td>
<td>25-30 % clay</td>
<td>25-35 % clay</td>
</tr>
<tr>
<td>texture variation</td>
<td>more clayey uphill; freshly eroded sediments?</td>
<td>more clayey uphill</td>
<td>more clayey uphill; freshly eroded sediments?</td>
</tr>
<tr>
<td>changes in texture</td>
<td>no major differences</td>
<td>no major differences</td>
<td>no major differences</td>
</tr>
<tr>
<td>differences structure topsoil</td>
<td>rel. denser topsoil; patterns comparable</td>
<td>differences perhaps related to compaction</td>
<td>topsoil/ subsoil patterns are the same</td>
</tr>
<tr>
<td>differences structure subsoil</td>
<td>in NW part of the field geologic layer at 120-80 cm</td>
<td>middle of the fields has accumulated soil</td>
<td>some geologic layers visible</td>
</tr>
<tr>
<td>compaction</td>
<td>perhaps</td>
<td>little</td>
<td>little</td>
</tr>
<tr>
<td>compaction increased</td>
<td>-</td>
<td>probably not</td>
<td>-</td>
</tr>
</tbody>
</table>
Conclusions

We developed and tested a measurement setup for effective and fast mapping of agricultural fields in Spain:

- Mobile platform with Gammaspectrometer, GPR
- Point measurements of actual soil bulk density
- Soil texture at high spatial resolution
- Information about compaction/soil depth
- Integrate various data sources to a conceptual map of understanding of the soil

We learned that the geophysical variation maps already prove to be valuable as a means of communication between farmers, agronomists and other project partners.

- The maps quantify the knowledge of the farmer
- They stimulate thoughts and discussions about the soil, its possibilities and hazards with respect to growing specific crops
- During the measurements and while discussing results we found that the variation in soil properties is already useful information.

We would like to explore this methodology for irrigated lands, vineyards, orchards, more high value crops: Outlook
Outlook - Vineyards

- Variety allocation
- Crop growth
- Irrigation regime
- Pruning regime
- Selection of grape quality
Outlook - Agroforestry

- Variety allocation
- Crop growth
Outlook - Agroforestry

Field testing – Comparable soils
Outlook - Orchards

- Variety allocation
- Crop growth
Muchas Gracias!