Use of Sen2-Agri system for spring- and summer-season (April – October 2016) crop classification in the region of Central Bohemia

Comparison of the L4A cropland mask and L4B crop-type map to Land Parcel Identification System (LPIS) farmer declarations and in-situ ground-data.

Presented by:
Dr. Neha Joshi
Gisat s.r.o., Prague
Tel: (+420) 774608100
E-mail: neha.joshi@gisat.cz
Web: www.gisat.cz
• Prague and Central Bohemia (22,733 km²)
• Main crop types:
  – Winter cereals (e.g. winter wheat, winter barley, winter rye etc.)
  – Spring cereals (e.g. spring barley, spring wheat etc.)
  – Winter rapeseed
  – Fodder crops (e.g. alfalfa, clover etc.)
  – Sugar beet
  – Maize
• Earth Observation (EO) data:
  – 96 scenes from Landsat-8 and 112 scenes from Sentinel-2

• Training data:
  – Visual interpretation of the satellite imagery over 283 Land Parcel Identification System (LPIS) polygons
  – CORINE land cover database from 2012 over 1585 non-agricultural areas

• Validation data:
  – Crop mask generated using the LPIS polygons
  – In-situ data collected at 91 polygon locations, and farmer crop declarations at 684 polygon locations.
• Crop Mask
  – 36% of the study area is arable land
  – “Land” status - average of 9 images and maximum of 21 images per pixel
  – An overall accuracy of 89% (kappa coefficient 0.77)

Confusion matrix (number of pixels)

<table>
<thead>
<tr>
<th>Classification (L4A product)</th>
<th>Non-agriculture</th>
<th>Agriculture</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-agriculture</td>
<td>127,861,082</td>
<td>17,320,191</td>
<td>145,181,273</td>
</tr>
<tr>
<td>Agriculture</td>
<td>6,956,622</td>
<td>75,219,885</td>
<td>82,176,507</td>
</tr>
<tr>
<td>Total</td>
<td>134,817,704</td>
<td>92,540,076</td>
<td>227,357,780</td>
</tr>
</tbody>
</table>

Accuracy assessment

<table>
<thead>
<tr>
<th>Class</th>
<th>Commission</th>
<th>Omission</th>
<th>Producer’s Accuracy</th>
<th>User’s Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-agriculture</td>
<td>11.93%</td>
<td>5.16%</td>
<td>94.84%</td>
<td>88.07%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>8.47%</td>
<td>18.72%</td>
<td>81.28%</td>
<td>91.53%</td>
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</tbody>
</table>
Crop-type Map

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter cereals</td>
<td>382044</td>
<td>46.1</td>
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<tr>
<td>Winter rapeseed</td>
<td>177022</td>
<td>21.4</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>97468</td>
<td>11.8</td>
</tr>
<tr>
<td>Maize</td>
<td>79101</td>
<td>9.5</td>
</tr>
<tr>
<td>Other crops</td>
<td>56584</td>
<td>6.8</td>
</tr>
<tr>
<td>Spring cereals</td>
<td>27117</td>
<td>3.3</td>
</tr>
<tr>
<td>Fodder crops</td>
<td>9507</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>828843</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Crop-type Map

Pixel-based validation

Confusion matrix (number of pixels)

<table>
<thead>
<tr>
<th>Classification (L4B product)</th>
<th>Winter cereals</th>
<th>Spring cereals</th>
<th>Winter rapeseed</th>
<th>Fodder crops</th>
<th>Sugar beet</th>
<th>Maize</th>
<th>Other crops</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter cereals</td>
<td>371364</td>
<td>3823</td>
<td>12350</td>
<td>89</td>
<td>7858</td>
<td>1296</td>
<td>1873</td>
<td>398653</td>
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<tr>
<td>Spring cereals</td>
<td>98222</td>
<td>58939</td>
<td>19985</td>
<td>551</td>
<td>13864</td>
<td>3925</td>
<td>42325</td>
<td>237811</td>
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<tr>
<td>Winter rapeseed</td>
<td>12425</td>
<td>2266</td>
<td>264104</td>
<td>48</td>
<td>1819</td>
<td>287</td>
<td>1092</td>
<td>282041</td>
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<tr>
<td>Fodder crops</td>
<td>46351</td>
<td>1713</td>
<td>30412</td>
<td>9987</td>
<td>22725</td>
<td>8995</td>
<td>4796</td>
<td>124979</td>
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<tr>
<td>Sugar beet</td>
<td>8694</td>
<td>1216</td>
<td>4525</td>
<td>218</td>
<td>273137</td>
<td>10849</td>
<td>2834</td>
<td>301473</td>
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<tr>
<td>Maize</td>
<td>2597</td>
<td>519</td>
<td>1746</td>
<td>4588</td>
<td>62594</td>
<td>112339</td>
<td>6276</td>
<td>190659</td>
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<tr>
<td>Other crops</td>
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<td>7692</td>
<td>7413</td>
<td>1342</td>
<td>40935</td>
<td>21774</td>
<td>75365</td>
<td>166156</td>
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<tr>
<td>Total</td>
<td>551288</td>
<td>76168</td>
<td>340535</td>
<td>16823</td>
<td>422932</td>
<td>159465</td>
<td>134561</td>
<td>1701772</td>
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</table>

Accuracy assessment

<table>
<thead>
<tr>
<th></th>
<th>Producer's Accuracy</th>
<th>User's Accuracy</th>
<th>F-Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter cereals</td>
<td>93%</td>
<td>67%</td>
<td>0.78</td>
</tr>
<tr>
<td>Spring cereals</td>
<td>25%</td>
<td>77%</td>
<td>0.38</td>
</tr>
<tr>
<td>Winter rapeseed</td>
<td>94%</td>
<td>78%</td>
<td>0.85</td>
</tr>
<tr>
<td>Fodder crops</td>
<td>8%</td>
<td>59%</td>
<td>0.14</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>91%</td>
<td>65%</td>
<td>0.75</td>
</tr>
<tr>
<td>Maize</td>
<td>59%</td>
<td>70%</td>
<td>0.64</td>
</tr>
<tr>
<td>Other crops</td>
<td>45%</td>
<td>56%</td>
<td>0.50</td>
</tr>
<tr>
<td>Kappa</td>
<td></td>
<td></td>
<td>0.61</td>
</tr>
<tr>
<td>Overall accuracy</td>
<td></td>
<td></td>
<td>68.0%</td>
</tr>
</tbody>
</table>
Crop-type Map

Polygon-based validation

### Confusion matrix (number of polygons)

<table>
<thead>
<tr>
<th>Classification (L4B product)</th>
<th>Winter cereals</th>
<th>Spring cereals</th>
<th>Winter rapeseed</th>
<th>Fodder crops</th>
<th>Sugar beet</th>
<th>Maize</th>
<th>Other crops</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter cereals</td>
<td>139</td>
<td>42</td>
<td>2</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>206</td>
</tr>
<tr>
<td>Spring cereals</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>Winter rapeseed</td>
<td>0</td>
<td>4</td>
<td>106</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>122</td>
</tr>
<tr>
<td>Fodder crops</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>15</td>
<td>99</td>
<td>27</td>
<td>21</td>
<td>166</td>
</tr>
<tr>
<td>Maize</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>63</td>
<td>10</td>
<td>79</td>
</tr>
<tr>
<td>Other crops</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>43</td>
<td>64</td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
<td>92</td>
<td>108</td>
<td>53</td>
<td>102</td>
<td>94</td>
<td>80</td>
<td>669</td>
</tr>
</tbody>
</table>

### Accuracy assessment

<table>
<thead>
<tr>
<th>Classification</th>
<th>Producer's Accuracy</th>
<th>User's Accuracy</th>
<th>F-Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter cereals</td>
<td>99.0%</td>
<td>67.0%</td>
<td>.80</td>
</tr>
<tr>
<td>Spring cereals</td>
<td>27.0%</td>
<td>93.0%</td>
<td>.42</td>
</tr>
<tr>
<td>Winter rapeseed</td>
<td>98.0%</td>
<td>87.0%</td>
<td>.92</td>
</tr>
<tr>
<td>Fodder crops</td>
<td>8.0%</td>
<td>80.0%</td>
<td>.14</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>97.0%</td>
<td>60.0%</td>
<td>.74</td>
</tr>
<tr>
<td>Maize</td>
<td>67.0%</td>
<td>80.0%</td>
<td>.73</td>
</tr>
<tr>
<td>Other crops</td>
<td>54.0%</td>
<td>67.0%</td>
<td>.60</td>
</tr>
<tr>
<td>Kappa</td>
<td></td>
<td></td>
<td>0.66</td>
</tr>
<tr>
<td>Overall accuracy</td>
<td></td>
<td></td>
<td>72.0%</td>
</tr>
</tbody>
</table>
• The study has been supported by the Czech State Agricultural Intervention Fund (Czech Paying Agency)

• The agency is interested in operational crop monitoring service based on Sentinel imagery

• The intended use is expected within various decision making processes in the frame of Integrated Administration and Control System (IACS) of the EU’s Common Agricultural Policy (including the LPIS update, administration and control mechanisms)

• The generated products served as the demonstrator of the capabilities of the Copernicus Sentinels for EO based agriculture monitoring

• The products have not been directly used by the agency
• **Did you have the opportunity to operate the Sen2Agri system?**
  – Yes, we use the GUI of the Sen2Agri system

• **What is your experience**
  – Positive:
    (1) Well designed and delivers as promises.
    (2) Commendable support from the development staff.
  – Negative:
    (1) The GUI is too inflexible
    (2) The system is too demanding on computing resources and hence too slow.

• **What are your recommendations for the future for the system?**
  (1) Improve the user guide and a ‘trouble shooting’ section
  (2) Improve system performance
Feedback provided by the Paying agency:

- Sentinel data brings great potential in the agriculture, in both the public and private sector
- The frequency of data acquisitions and possibilities for time series analyses are enormous.
- However, the further actions have to be taken at the EU and national level to reach the real added value of the use of Sentinel data. The actions have to be taken cross wide - in respect of methodology, administrative, organizational and IT aspects.