Sen4CAP – Supporting the CAP reform using Sentinel-1 and -2 for agriculture monitoring

Sen4CAP Objectives

- **Provide evidence** how Sentinel derived information can support the modernization and simplification of the CAP **in the post 2020 timeframe**
- Provide **validated algorithms, products, workflows** and **best practices** for agriculture monitoring relevant for the management of the CAP
Users requirements in terms of use cases

Use cases

- Crop diversification
- Permanent grassland monitoring
- EFA-Land lying fallow
- EFA-Catch crops
- EFA-Nitrogen-fixing crops
- Land abandonment
- Interactive visualization
- LPIS update
- Claimless system

Use Cases w/ Paying Agencies
Sentinel-derived indicators and markers

- Crop type mapping
- Growing vegetation indicators
- Grassland mowing detection
- Agricultural practices monitoring

S2 time series data (May – Sep), CZE

S1 composite of temporal features, NDLS

Monthly coherence over a Winter Wheat field (Netherlands)
Very large dataset from Sentinel-1 & 2 for a national coverage

Sen4CAP system to process full time series on the cloud for 6 Paying Agencies

Sentinel-2 using LPIS/GSAA (min 3 10-m pixels)
22 object-based metrics every 10 days

Sentinel-1 using LPIS (min 1 20-m pixel)
10 object-based metrics every 10 days + temporal features
2018: National crop type mapping over 6 countries
Example – Romania (100+ crop types)
2018: National crop type mapping over 6 countries
Romania (100+ crop types)
Synthesis of preliminary performances of crop type in different EU agricultural landscapes for 2018

- **16 millions of parcels assessed** for 600,000 km²
- **Overall accuracies from 71% to 95%** (all > 70 %, 3 countries > 80%)
  
  => Improvements foreseen by refining crop type list, selecting better the calibration dataset, excluding poorly defined classes, using stratification,...

- **Limited impact of parcel size and shape** on the assessed areas (0,3 % to 8 %)

<table>
<thead>
<tr>
<th>Country</th>
<th>Area Of Interest</th>
<th>EO input</th>
<th>Total area (km²)</th>
<th>Total parcels (nr)</th>
<th>Parcels not assessed (%)</th>
<th>Parcels not assessed because of the size (%)</th>
<th>Overall Accuracy</th>
</tr>
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<tbody>
<tr>
<td>NLD</td>
<td>100 % country</td>
<td>S2 + S1</td>
<td>42508</td>
<td>802217</td>
<td>17,27% 4,49%</td>
<td>9,25% 1,03%</td>
<td>94,95%</td>
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<td>CZE</td>
<td>100 % country</td>
<td>S2 + S1</td>
<td>78873</td>
<td>593787</td>
<td>14,11% 1,71%</td>
<td>8,40% 0,30%</td>
<td>82,75%</td>
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<tr>
<td>LTU</td>
<td>100 % country</td>
<td>S2 + S1</td>
<td>64897</td>
<td>1153796</td>
<td>19,63% 3,17%</td>
<td>16,16% 1,46%</td>
<td>78,74%</td>
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<td>ITA</td>
<td>100 % of the AOI (5 Regions)</td>
<td>S2 + S1</td>
<td>67270</td>
<td>8527409</td>
<td>78,60% 36,12%</td>
<td>33,94% 15,49%*</td>
<td>72,37%</td>
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<tr>
<td>ESP</td>
<td>100 % of the AOI (Castilla Y Leon)</td>
<td>S2 + S1</td>
<td>94226</td>
<td>3540880</td>
<td>35,71% 28,62%</td>
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<td>81,83%</td>
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<td>ROU</td>
<td>100 % country</td>
<td>S2 + S1</td>
<td>238369</td>
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<td>38,22% 10,96%</td>
<td>35,77% 8,34%</td>
<td>71,16%</td>
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Sentinels indicators and markers – veg. indicators

- Crop type mapping
- Growing vegetation indicators
- Grassland mowing detection
- Agricultural practices monitoring

4 indicators

- NDVI
- FAPAR
- LAI
- fCOVER

Crop type information & growing vegetation indicators
Sentinels indicators and markers – grassland mowing

Crop type mapping

Growing vegetation indicators

Grassland mowing detection

Agricultural practices monitoring

Mowing detection based on the detection of **S2 Vegetation Indices** (NDVI, LAI and FAPAR) decrease and **S1 coherence** increase
S2 mowing detection by VIs decrease w.r.t expected model for unmowned grass

Each detection is expressed as a temporal interval between 2 dates in which the mowing occurred
S1 mowing detection by sudden increase of 6-day coherences
Grassland mowing detection

Thematic content

- Parcel identifier
- Grassland Crop type
- Number of mowing events (maximum 4)
- For each mowing event (up to 4):
  - Temporal interval in which the mowing event occurred (t_start and t_end)
  - Confidence level in terms of probability of right mowing (conf)
  - Satellite mission data used for detection of mowing (S1, S2 or both)
  - Complaincy level

<table>
<thead>
<tr>
<th>Parcel id</th>
<th>Crop code</th>
<th>n1</th>
<th>m1_start</th>
<th>m1_end</th>
<th>n1_conf</th>
<th>m1_res</th>
<th>m2_start</th>
<th>m2_end</th>
<th>n2_conf</th>
<th>m2_res</th>
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Sentinels indicators and markers – Agricultural practices (EFA)

Crop type mapping
Growing vegetation indicators
Grassland mowing detection
Agricultural practices monitoring

RULE: Winter Catch Crop must be sown before 20 Sept. and must not be harvested before 31 Oct. During this period, crop coverage must not be mechanically or chemically removed or limited in growth.

Crop type mapping
Growing vegetation indicators
Grassland mowing detection
Agricultural practices monitoring

Harvest – Visual check
Winter Catch Crop – Visual check
Catch Crop period
10 markers related to vegetation state or vegetation change on a parcel

**MARKERS FOR HARVEST**

<table>
<thead>
<tr>
<th>M1</th>
<th>M1: Presence of vegetation in the main vegetation season (pre-requisite)</th>
<th>High values of NDVI</th>
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</thead>
<tbody>
<tr>
<td>M2</td>
<td>M2: Loss of vegetation</td>
<td>Break in NDVI (decrease)</td>
</tr>
<tr>
<td>M3</td>
<td>Loss of vegetation</td>
<td>Break in backscatter ratio (increase)</td>
</tr>
<tr>
<td>M4</td>
<td>Low/no vegetation</td>
<td>High values of backscatter ratio</td>
</tr>
<tr>
<td>M5</td>
<td>Low/no vegetation (stable conditions)</td>
<td>Break in VV Coherence (increase) or high values of VV Coherence</td>
</tr>
</tbody>
</table>

**MARKERS FOR DECLARED PRACTICES**

<table>
<thead>
<tr>
<th>M6</th>
<th>Presence of vegetation</th>
<th>High values of NDVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>M7</td>
<td>Growth of vegetation</td>
<td>Break in NDVI (increase)</td>
</tr>
<tr>
<td>M8</td>
<td>No loss of vegetation</td>
<td>No break in NDVI (decrease)</td>
</tr>
<tr>
<td>M9</td>
<td>No loss of vegetation</td>
<td>No increase of the backscatter ratio</td>
</tr>
<tr>
<td>M10</td>
<td>Presence of vegetation (dynamic conditions)</td>
<td>No Break in VV Coherence (increase) and no high values of VV Coherence</td>
</tr>
</tbody>
</table>
Use Cases
Sentinels to support payment decisions

Use case
Crop diversification
Permanent grassland identification
EFA-Land lying fallow
EFA-Catch crops
EFA-Nitrogen-fixing crops
Interactive visualization
Land abandonment
LPIS update
Claimless system

Crop type mapping
Vegetation growing indicators
Grassland mowing detection
Agricultural practices monitoring

Use Cases
w/ Paying Agencies
From CT mapping to crop diversification assessments at parcel- and holding-level

**Parcel-level**
Assess if the crop type declared by the farmer is confirmed by the satellite signal

**Holding-level**
Assess the compliance of the holding with regard to the crop diversification rules
Crop diversification monitoring at national scale

CZECH REPUBLIC
- 10.41%
- 88.20%
- 1.39%

CASTILLA Y LEON
- 16.77%
- 82.83%
- 0.39%

ITALY
- 6.63%
- 92.91%
- 0.46%

LITHUANIA
- 3.82%
- 95.69%
- 0.49%

NETHERLANDS
- 5.40%
- 88.81%
- 5.80%

ROMANIA
- 6.77%
- 87.88%
- 5.36%

*At holding level
### Farmer interview:

- **Declared crop**
  - Sow crop
  - Harvest crop
  - Sow catch-crop

- **Barley, summer**
  - Sow: 17.4.2018
  - Harvest: 27.7.2018
  - Sow catch-crop: 20.8.2018
Agricultural Practices Monitoring
Detection of fallow land - LTU

<table>
<thead>
<tr>
<th>ORIG_ID</th>
<th>FIELD_ID</th>
<th>COUNTRY</th>
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<th>VEG_START</th>
<th>H_START</th>
<th>H_END</th>
<th>PRACTICE</th>
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<table>
<thead>
<tr>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>H_WEEK</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>M9</th>
<th>M10</th>
<th>C_INDEX</th>
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<tbody>
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<td>TRUE</td>
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<td>TRUE</td>
<td>H_WEEK</td>
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<table>
<thead>
<tr>
<th>W_GAPS</th>
<th>S1PIX</th>
<th>H_W_START</th>
<th>H_W_END</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>22</td>
<td>2018-09-03</td>
<td>2018-09-09</td>
</tr>
</tbody>
</table>

Green fallow
2-day trainings of 6 PAs in their premisses (Feb. - Apr. 19)

- Training at AGEA (Rome, ITALY)
  19-20/03/2019
  Better understanding of products & methods
- Training at NVWA (Zwolle, THE NETHERLANDS)
  11-12/03/2019 © Wilmer Woudwijk
  Plan for 2019
- Training at NMA (Vilnius, LITHUANIA)
  06-07/03/2019
  Prioritization of improvements
  Further validation of 2018 products
  Validation data collection
  Request for more capacity building
2019 Sen4CAP processing just started for 6+1 Paying Agencies

Running on distinct DIAS VMs along the agricultural season:

- **Czech Republic**
  - Production VM
  - Test VM

- **Castilla y Leon**
  - Production VM
  - Test VM

- **Romania**
  - Production VM
  - Test VM

- **Lithuania**
  - Production VM
  - Test VM

- **Netherlands**
  - Production VM
  - Test VM

- **Italy**
  - Production VM
  - Test VM

- **France (2 departments)**
  - Production VM
  - Test VM

Cloud (CREODIAS)
Sen4CAP System overview – open source code
Visualisation tool to access all products at the parcel-level
Scientific challenges for CAP ... ... and much more

- Crop diversification < crop type mapping
  - General CT mapping nicely done by most users
  - Small parcels? Marginal crops? Permanent crops? Fallows?

- Permanent grassland monitoring < mowing detection
  - Link with land use intensity and more sustainable agriculture

- EFA < agriculture practices monitoring
  - EFA will evolve in the CAP 2020, but agriculture practices will remain
  - Exploit the huge density of S1 time series

2 posters in sessions A3.02 and A3.17
Sen4CAP: a collaborative effort to prepare for CAP2020

✓ CAP monitoring evidence provided based Sentinels **prototype** products
✓ **2018 national demonstration** with wall-to-wall coverage
  - 6 **countries** (1.2 Mkm²) with diverse cropping systems, LPIS, landscapes, etc.
  - good to very good performances but still to be improved by specific fine tuning
  - critical importance to work hand-to-hand with Paying Agencies
✓ **Sen4CAP training completed for 6 Paying Agencies** at their premises and VMs available to each for testing
✓ **Operational cloud computing on DIAS for 2019 national demonstration**
  o Key emphasis on product **validation and markers/products use** by PAs
  o **Open source system** for uptake and customization by all PAs

*Sen4CAP BETA RELEASE MAY 2019*

http://esa-sen4cap.org
Thank you for your attention
and your contribution