SEN4CAP
Sentinels for CAP monitoring approach

Sentinels high revisit to monitor Agricultural Dynamics

Majority of Europe >2 day revisit

Majority of Europe >3 day revisit

S-1A & -1B (July-Sept 2018)

S-2A & -2B (July-Sept 2018)
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.
2019 Sen4CAP processing ongoing for 6+1 Paying Agencies running on distinct DIAS VMs along the agricultural season.
User Requirements in terms of IACS use cases

<table>
<thead>
<tr>
<th>Use cases</th>
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<tbody>
<tr>
<td>Crop diversification</td>
</tr>
<tr>
<td>Permanent grassland monitoring</td>
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<tr>
<td>EFA-Land lying fallow</td>
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<tr>
<td>EFA-Catch crops</td>
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<td>EFA-Nitrogen-fixing crops</td>
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<td>Land abandonment</td>
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<tr>
<td>Interactive visualization</td>
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<tr>
<td>LPIS update</td>
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<td>Claimless system</td>
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Use Cases w/ Paying Agencies
Use Cases: Sentinels to support payment decisions

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

Use Cases w/ Paying Agencies

- Crop diversification
- Permanent grassland identification
- EFA-Land lying fallow
- EFA-Catch crops
- EFA-Nitrogen-fixing crops
- Interactive visualization
- Land abandonment
- LPIS update
- Claimless system
Sentinel-derived indicators and markers

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

S2 time series data (May – Sep), CZE

S1 composite of temporal features, NL

Monthly coherence over a Winter Wheat field (Netherlands)
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 (min. field size: 3 10-m pixels)
22 object-based metrics every 10 days

Sentinel-1 using LPIS (min. field size: 1 20 m pixel)
16 weekly object-based metrics + temporal features
Sen4CAP system - crop type identification

**System initialization**

### Setting parameters

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Sen4CAP system - crop type identification

**Before the start of the monitoring period**

System initialization

**Monitoring period**

Automatic EO data download and processing

EO data providers

S1

S2

SO

May-June

EoS

LPIS / GSAA

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Sen4CAP system - crop type identification

Before the start of the monitoring period

System initialization

EO data providers

S2

S1

Automatic EO data download and processing

May-June

SoS

EoS
Sen4CAP system - crop type identification

Before the start of the monitoring period

System initialization

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EO data providers

S1

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LPIS / GSAA
Sen4CAP system - crop type identification

**Before the start of the monitoring period**

**System initialization**

**Monitoring period**

**Automatic EO data download and processing**

**EO data providers**
- S2
- S1

**LPIS / GSAA**

**SoS**
- May-June
- ...
Sen4CAP system - crop type identification

System initialization

Before the start of the monitoring period

Automatic EO data download and processing

EO data providers

S1

S2

EO data providers

LPIS / GSAA

May-June

...  ...  ...

EoS

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Sen4CAP system - crop type identification

System initialization

Automatic EO data download and processing

Before the start of the monitoring period

Monitoring period

May-June

EO data providers

S2

S1

LPIS / GSAA

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Sen4CAP system - crop type identification

Before the start of the monitoring period

System initialization

EO data providers

S1

S2

Automatic EO data download and processing

EO data providers

LPIS / GSAA

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Sen4CAP system - crop type identification

System initialization

Automatic EO data download and processing

Before the start of the monitoring period

EO data providers

S2

S1

LPIS / GSAA
2018: National crop type mapping over 6 countries
Example – Romania (100+ crop types)
2018: National crop type mapping over 6 countries
Example over Romania

Assessing the crop type declared by the farmer at the parcel-level
- Declaration = EO prediction 1 or EO prediction 2 -> **CONFORM**
- Declaration ≠ EO prediction 1 and EO prediction 2 -> **NOT CONFORM**

« Classif_r » field
- **cl_co**: classified and conform
- **cl_noco**: classified and not conform
- **nocl_lc**: not classified because not monitorable land cover class
- **nocl_minS2pix**: not classified because not covered by at least 3 S2 pixels
- **nocl_noS1pix**: not classified because not covered by at least 1 S1 pixel
- **nocl_other**: not classified for other reason (duplicates, overlapping parcels, etc.)

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</table>
2018: National crop type mapping over 6 countries
Romania (100+ crop types)

Declared crop type
Predicted crop type

Confidence index
Conformity assessment

Crop type
- Alfa-alfa
- Autumn barley
- Autumn common wheat
- Autumn rape
- Bean peas
- Corn
- Fresh vegetables
- Sunflower
- Permanent crop
- Grassland
2018: National crop type mapping over 6 countries
Example over Romania (100+ crop types) from S1 & S2

Parcel assessment
- Classified and conform
- Classified and not conform
- Not classified - not monitorable
- Not classified - < 3 S2pix
- Not classified - no S1pix
- Not classified - undefined

Area

# parcels

- Classified and conform: 51.72%
- Classified and not conform: 10.05%
- Not classified: 10.96%
- Not classified - undefined: 38.22%
- Not classified - < 3 S2pix: 7.19%
- Not classified - no S1pix: 81.85%
2018: National crop type mapping over 6 countries
Romania (100+ crop types) from S2 only (lower constraint on field size)
Synthesis of preliminary performances of crop type identification in different EU agricultural landscapes for 2018

- **16 millions of parcels assessed** for 600 000 sq.km²
- **Overall accuracies from 71 % to 95 %** (all > 70 %, 3 countries > 80%)
  ⇒ **Possible improvements identified** (refined crop type list, better selection the calibration dataset, exclusion of poorly defined classes, stratification, ...)

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

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<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>
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<td>71,16%</td>
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</table>

* Not to be considered because of parcel duplicate
From crop type mapping to crop diversification
Combining 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 compliancy of the holding with regard to the crop diversification rules

**Following the « worst case scenario » approach**
(presented by JRC – MARS conference, Nov 2018)

**When we don’t know:**
- Assume the worst scenario
- Check if it has an impact
From crop type mapping to crop diversification
Combining 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 compliance analysis at holding level

**EXAMPLE OF OUTCOMES FROM TRAINING & DISCUSSION WITH PAs**

1) Parcels classified as **not conform** when « we don’t know anything about »
   -> implementation of the use of the predicted crop type with high confidence

2) Additional **rule** from the crop diversification regulation regarding permanent grassland, crop under water, etc. .../...
Sentinels indicators and markers – veg. indicators

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

Crop type information & growing vegetation indicators

- NDVI
- FAPAR
- LAI
- fCOVER

Autumn barley
Sunflower

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Sentinels indicators and markers – grassland mowing

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

**S2 vegetation indices (NDVI, LAI, FAPAR) decrease**

**S1 coherence increase**
Mowing detection by VIs decrease wrt expected model

Detection of **VIs decrease with respect to the expected model** of unmowed grassland for that area.

Each detection is expressed as a temporal interval between 2 dates in which the mowing occurred.
S2 mowing detection in a Mediterranean context

Sudden drop of veg. indicators to separate from grass drying out
Detection of sudden increase of 6-day coherences through change detection in the coherence temporal profile.

S1 mowing detection by sudden coherence increase.
Grassland mowing detection – detection attributes

- Grassland mowing product contains, for each parcel, information about **number and temporal intervals of mowing events** detected.

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- 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 (Si, S2 or both)
  - Compliancy level
2018 Grassland mowing events detection
Sentinels indicators and markers – ag. practices (EFA)

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

Harvest
Catch Crop period
Winter Catch Crop – Visual check
Harvest – Visual check
### Sentinels markers for ag. practices (EFA monitoring)

**10 markers related to vegetation state or vegetation change on a parcel**

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<td>High values of NDVI</td>
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<tr>
<td><strong>M2</strong> M2: Loss of vegetation</td>
<td>Break in NDVI (decrease)</td>
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<tr>
<td><strong>M3</strong> Loss of vegetation</td>
<td>Break in backscatter ratio (increase)</td>
</tr>
<tr>
<td><strong>M4</strong> Low/no vegetation</td>
<td>High values of backscatter ratio</td>
</tr>
<tr>
<td><strong>M5</strong> Low/no vegetation (stable conditions)</td>
<td>Break in VV Coherence (increase) or high values of VV Coherence</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MARKERS FOR DECLARED PRACTICES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M6</strong> Presence of vegetation</td>
<td>High values of NDVI</td>
</tr>
<tr>
<td><strong>M7</strong> Growth of vegetation</td>
<td>Break in NDVI (increase)</td>
</tr>
<tr>
<td><strong>M8</strong> No loss of vegetation</td>
<td>No break in NDVI (decrease)</td>
</tr>
<tr>
<td><strong>M9</strong> No loss of vegetation</td>
<td>No increase of the backscatter ratio</td>
</tr>
<tr>
<td><strong>M10</strong> Presence of vegetation (dynamic conditions)</td>
<td>No Break in VV Coherence (increase) and no high values of VV Coherence</td>
</tr>
</tbody>
</table>
### Agricultural Practices Monitoring
Detection of harvest date for the main crop - LTU

<table>
<thead>
<tr>
<th>ORIG_ID</th>
<th>FIELD_ID</th>
<th>COUNTRY</th>
<th>YEAR</th>
<th>MAIN_CROP</th>
<th>VEG_START</th>
<th>H_START</th>
<th>H_END</th>
<th>PRACTICE</th>
<th>P_TYPE</th>
<th>P_START</th>
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<tbody>
<tr>
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<td>TRUE</td>
<td>TRUE</td>
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<td>M6</td>
<td>M7</td>
<td>M8</td>
<td>M9</td>
<td>M10</td>
<td>C_INDEX</td>
</tr>
<tr>
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<td>TRUE</td>
<td>TRUE</td>
<td>TRUE</td>
<td>TRUE</td>
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<table>
<thead>
<tr>
<th>W_GAPS</th>
<th>S1PIX</th>
<th>H_W_START</th>
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<tr>
<td>0</td>
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<td>2018-07-16</td>
<td>2018-07-22</td>
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**Winter wheat**
Agricultural Practices Monitoring
Catch Crop: Netherlands 2018

- National regulations:
  - **Catch Crop as Main Crop**: must be growing in the field between **15 May** and **15 July**.
  - **Catch Crop after Main Crop**:
    - Earliest sowing date: July 15
    - Categories 1 & 2: shall be growing in the field for **8 weeks**. Ultimate date of sowing catch crop is **15th of October**.
    - Category 3: **Sowing of grass in (under) the main crop**. Shall be growing in the field for **8 weeks**. Ultimate date of harvest of main crop is **15th of October**.

<table>
<thead>
<tr>
<th>ORIG_ID</th>
<th>SEQ_ID</th>
<th>COUNTRY</th>
<th>YEAR</th>
<th>MAIN_CROP</th>
<th>VEG_START</th>
<th>H_START</th>
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<th>PRACTICE</th>
<th>P_TYPE</th>
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### Agricultural Practices Monitoring

#### Detection of catch crop - NLD

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#### M1 - M10 & C_INDEX

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<tr>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
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<th>M8</th>
<th>M9</th>
<th>M10</th>
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#### W_GAPS & S1PIX

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<td>2018-08-12</td>
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### Farmer interview:

Declared crop: Sow crop, Harvest crop, Sow catch-crop

Working hand-to-hand with Paying Agencies
Specific effort to get validation data

Farmers interviews conducted by PAs for grassland mowing and EFA practices

- Access granted to Planet data

<table>
<thead>
<tr>
<th>ID</th>
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<th>Area</th>
<th>Mowing</th>
<th>MOWING 1</th>
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<tbody>
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<td>FROM</td>
<td>TO</td>
</tr>
<tr>
<td>1</td>
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<tr>
<td>2</td>
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<table>
<thead>
<tr>
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<th>EFA type</th>
<th>Seedbed preparation for main crop</th>
<th>Sowing of main crop</th>
<th>Harvest of main crop</th>
<th>Handling of main crop residues</th>
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<td>FROM TO</td>
<td>FROM TO</td>
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<tr>
<td>2</td>
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</tbody>
</table>

7 May 2018
9 May 2018
2-day trainings in each 6 PAs premises (Feb.- Apr.19)

Training at AGEA (Rome, ITALY)
19-20/03/2019

Training at NMA (Vilnius, LITHUANIA)
06-07/03/2019

Training at NVWA (Zwolle, THE NETHERLANDS)
11-12/03/2019 © Wilmer Woudwijk
Visualisation tool to access all products at the parcel-level
As a web application or as WMS in QGIS
Sen4CAP: an collaborative effort to prepare for CAP2020

- CAP monitoring evidence provided based Sentinels **prototype** products
- **2018 national demonstration** with wall-to-wall coverage
  - 6 countries 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**
  - Key emphasis on product **validation and markers/products use** by PAs
  - **Open source system** for uptake and customization by all PAs

[http://esa-sen4cap.org](http://esa-sen4cap.org)
Thank you for your attention and your contribution.