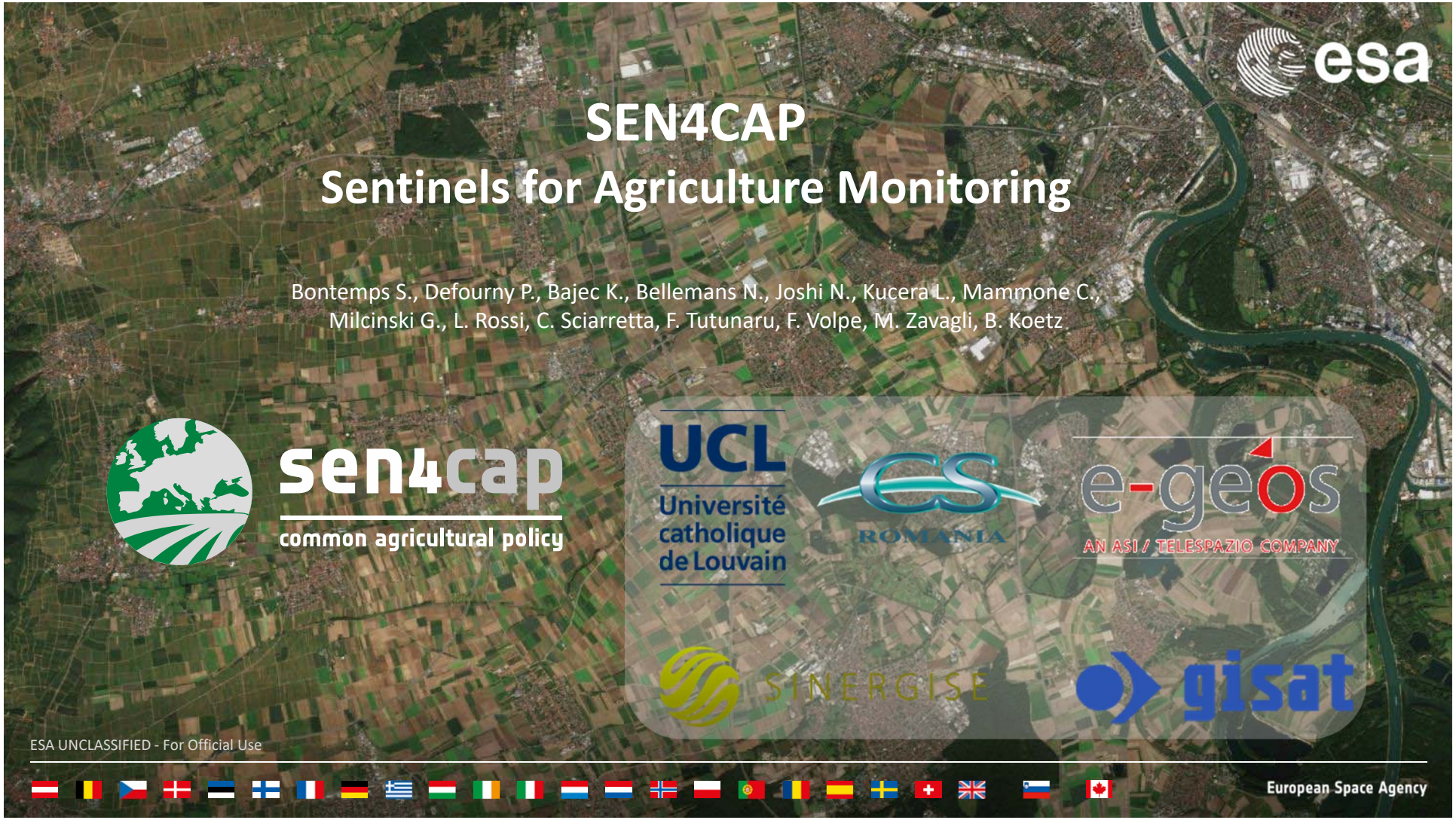
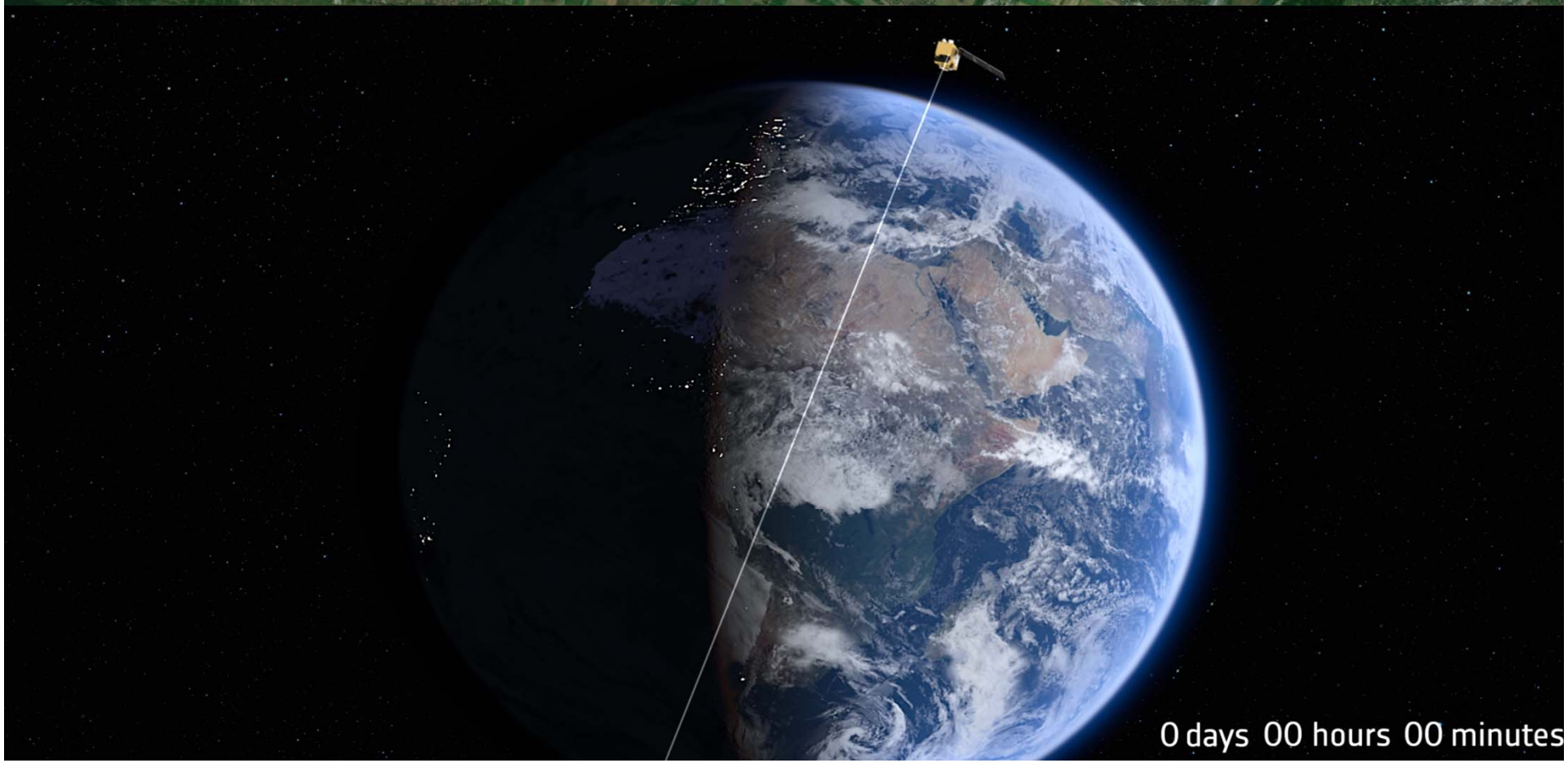
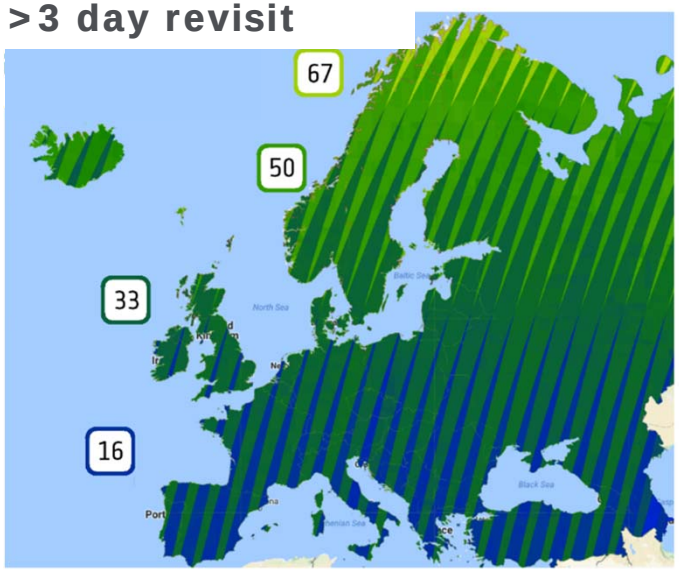

esa
SEN4CAP
Sentinels for Agriculture Monitoring
Bontemps S., Defourny P., Bajec K., Bellemans N., Joshi N., Kucera L., Mammone C.,
Milcinski G., L. Rossi, C. Sciarretta, F. Tutunaru, F. Volpe, M. Zavagli, B. Koetz
sen4cap
common agricultural policy
UCL
Université
catholique
de Louvain
CS
ROMANIA
e-geos
AN ASI / TELESPAZIO COMPANY
SINERGISE
gisat
ESA UNCLASSIFIED - For Official Use
European Space Agency

# Sentinels Looking after Agriculture



# Sentinel-2: key revisit and spatial resolution

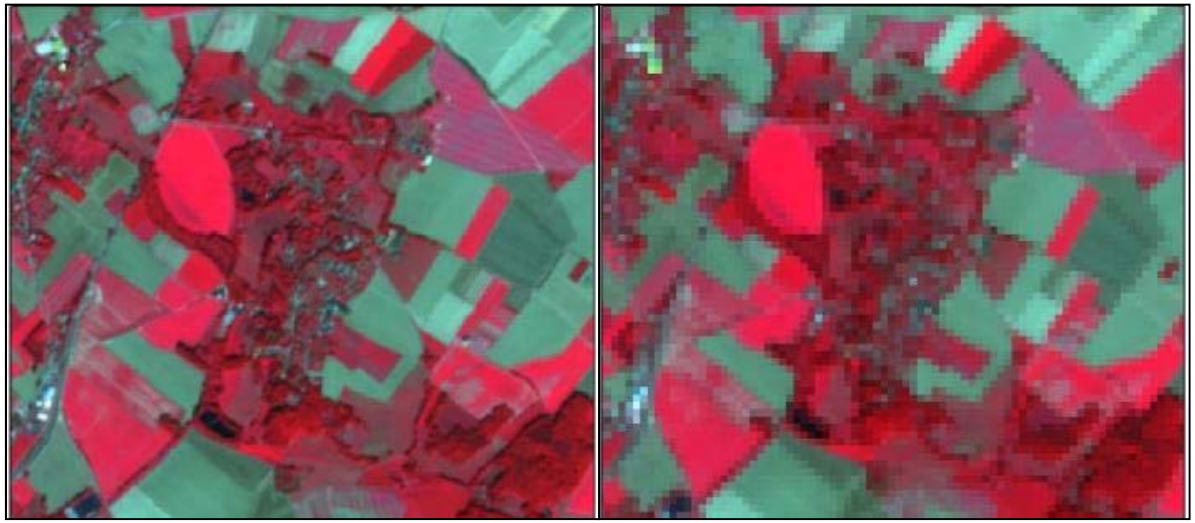
**Majority of Europe**
**>3 day revisit**




**S-2A & -2B (July-Sept 2017)**

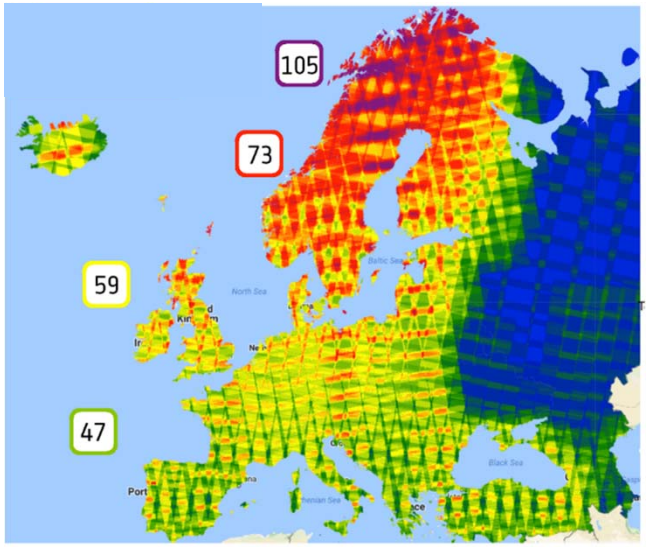
**S2 10 meters**

**L8 30 meters**

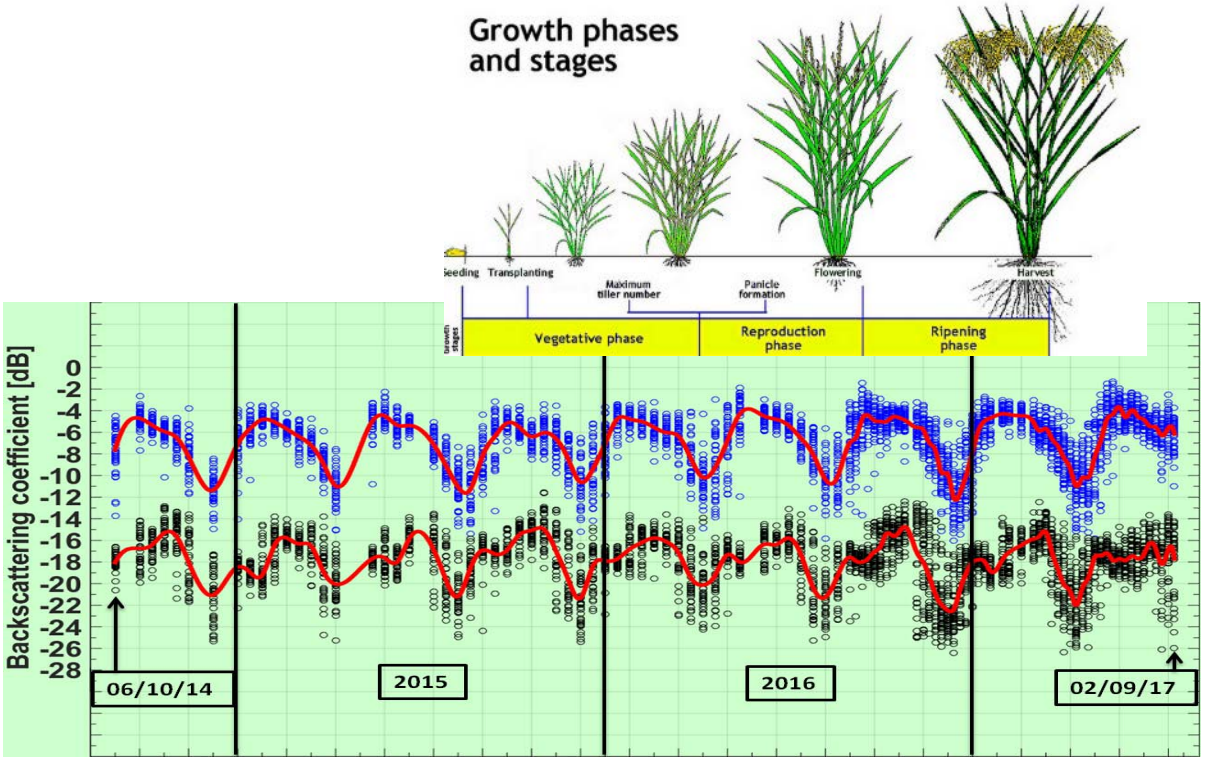


# Sentinel-1: Dense time series for crop stages monitoring

**Majority of Europe**
**>2 day revisit**




**S-1A & -1B (July-Sept 2017)**



# Uptake of Copernicus within the CAP 2020


ESA UNC

1th of July: Modernizing and simplifying the Common Agricultural Policy

# European Collaboration – Technology meets Policy

sen4cap

common agricultural policy

**Commissioner Phil Hogan, DG-Agri** (25th of May, Press release):
"This new **satellite technology** will significantly **reduce the number of field inspections**, removing the climate of fear, which causes significant stress for farmers.
It will also benefit public administrations, by **reducing the costs of administering controls** and checks. It is thus a win-win for farmers and administrators."

# Sen4CAP: R&D for Common Agricultural Policy

EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR AGRICULTURE AND RURAL DEVELOPMENT
DIRECTORATE-GENERAL FOR INTERNAL MARKET, INDUSTRY, ENTREPRENEURSHIP AND SMEs

Directorate D. Direct support
Space policy, Copernicus and Defence
Directors

Brussels,
D(SBL) Ares(2016) 7630856

**Subject:** **Cooperation between the European Commission and the European Space Agency (ESA) on the follow-up of the CzechAgri study**

Dear Mr Aschbacher,

Both ESA and the European Commission have an interest in promoting and supporting the development of Earth Observation (EO) use and related capacity in Agriculture.

We have taken great interest in the results of the CzechAgri study that was jointly initiated in December 2015 by ESA, DG JRC and SZIF (Czech Paying Agency) and successfully implemented thanks to ESA funding and a technical steering involving DG AGRI.

Following these promising results, it would be extremely useful to further explore –in close cooperation with the European Commission– the capabilities of the Copernicus Sentinels in view of the current works on the modernisation and simplification of the CAP and the opportunities of EO from space for supporting the Integrated Administration and Control System (IACS). As you may know, technical solutions to improve and to make the IACS more cost efficient are high on the political agenda. A promising way forward is offered by the important potential of Sentinel/Copernicus for administration and control purposes, i.e. in a broader perspective than the current on-the-spot controls using remote sensing. Indeed, the ambition for the next programming period is greater, we also want the IACS to be a key tool in the delivery of enhanced environmental services and public goods.

With this letter, we acknowledge and welcome ESA's readiness to continue this effort by conducting two or three follow-up pilot studies to the CzechAgri project in preparation of the CAP 2020 reform together with the main stakeholders (DG AGRI, DG GROW and DG JRC) and the national Paying Agencies.

Mr. Josef Aschbacher
Director of Earth Observation Programmes
European Space Agency
Via Galileo Galilei
Casella postale 64
00044 Frascati - Italy

Commission européenne/European Commission, 1049 Bruxelles/Brussel, BELGIQUE/BELGIË - Tel. +32 22991111

- **Sen4CAP Implementation:**
  - Responding to the request from DG-AGRI & DG-GROW
  - Collaboration with DG-AGRI, DG-GROW, DG-JRC and national Paying Agencies
- **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

# Sen4CAP – Expertise, Technology & Collaboration

Paying Agencies & Farmers

Steering Committee

DG-Agri, JRC, DG-Grow

EO Experts

UCL Université catholique de Louvain · e-geos · gisat · SINERGISE

Open Source

sen4cap common agricultural policy

**Cloud Technology** (DIAS)

Continuous Monitoring

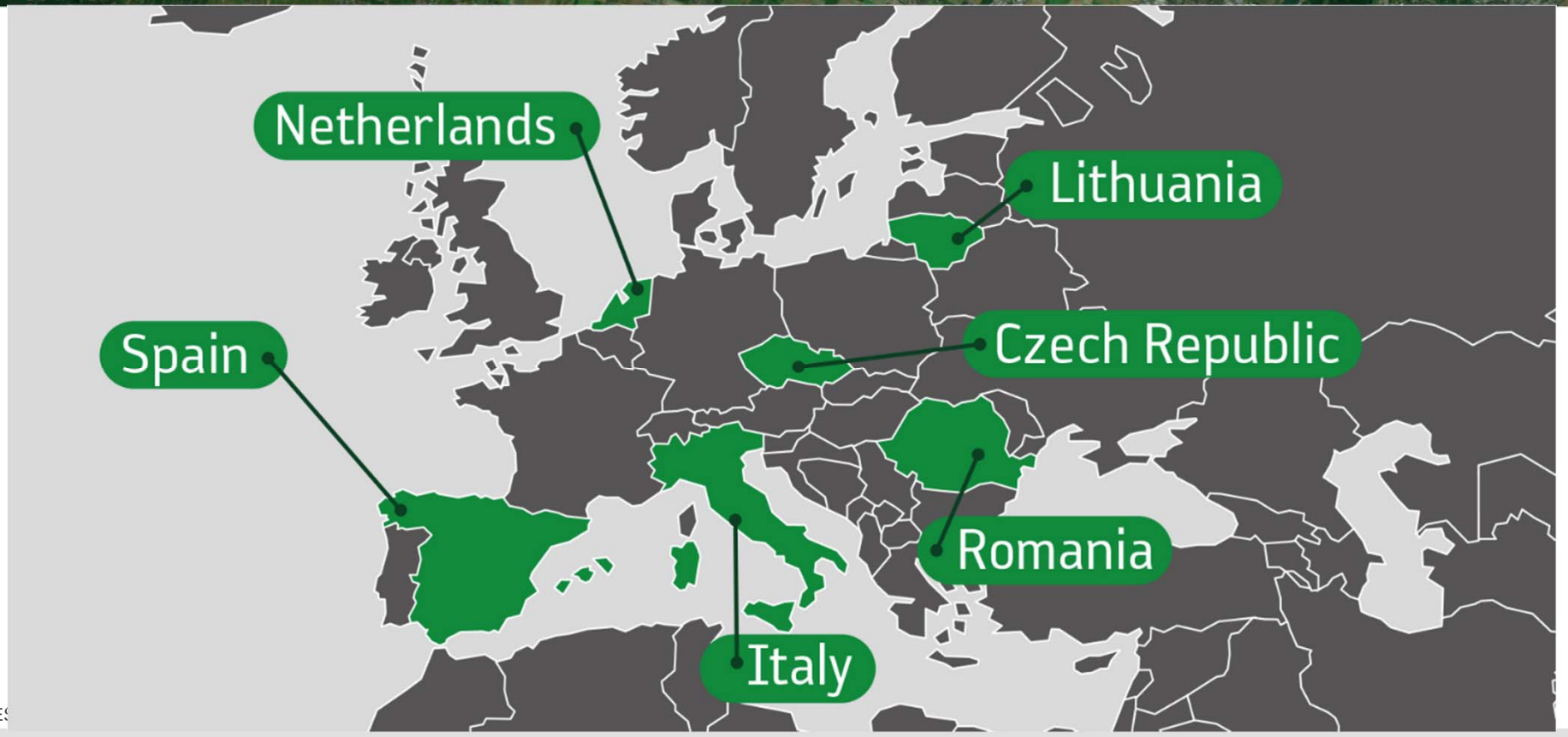
Validated Performance

National Demonstration

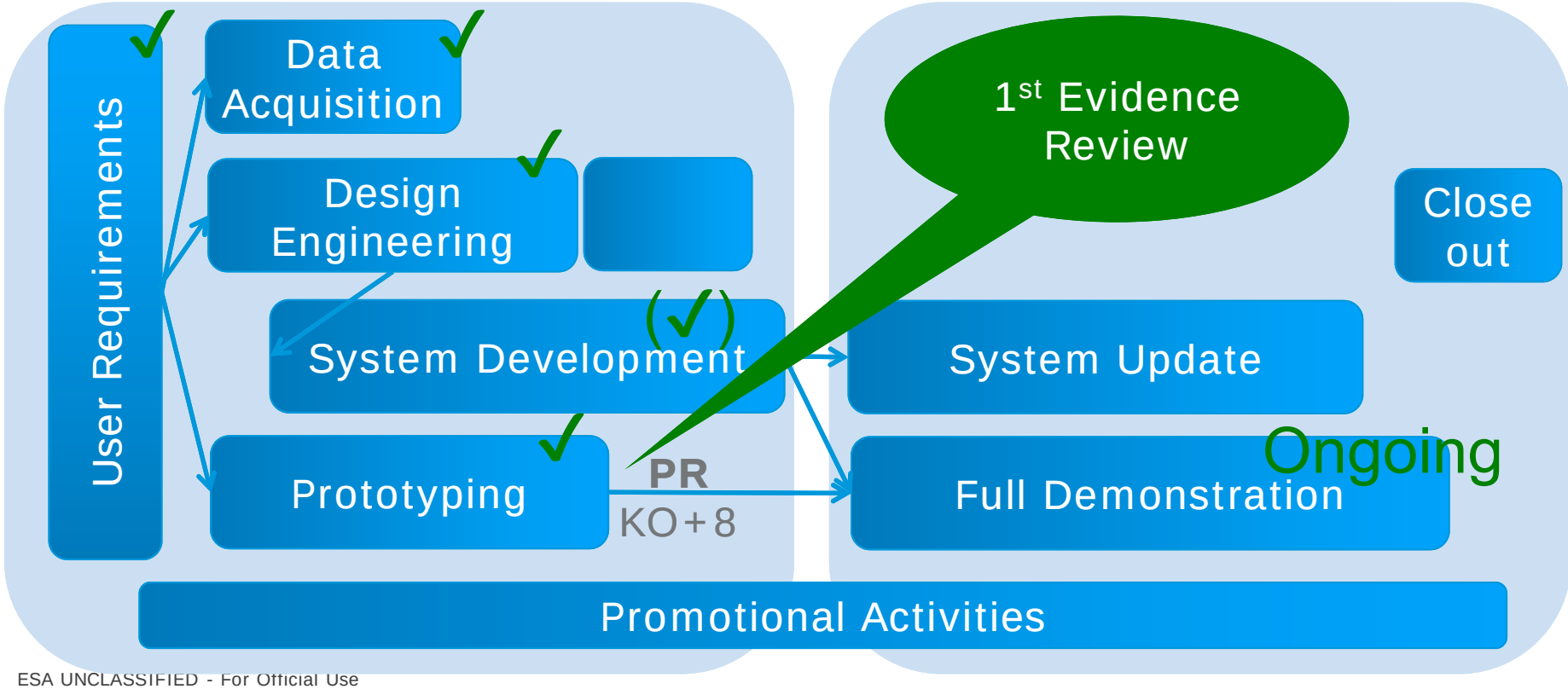
Innovative Practices

**CAP2020 Reform**

# Sen4CAP Pilot Countries – EU Agricultural Landscape



# Sen4CAP – Time Planning & Status



# User Requirements and Engagement

1. Analysis existing **recommendations** coming from the **CzechAgri pilot study** and the different **PA workshops** from the last months
2. Design of a **questionnaire** dedicated to the PAs formally involved in the project + **interview** of these PAs
3. Organize a **User Requirement Workshop** in which the user requirements were discussed actively with all bodies involved

Czech Agri Pilot Study


Panta Rhei
EUROPEAN AGRICULTURE PAYING AGENCIES PLATFORM

Sen4CAP 1st User Workshop, July 2017, Brussels

# User Requirements in terms of IACS use cases

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

Prototyping – Development & Testing at EU level

**Use Cases** w/ Paying Agencies

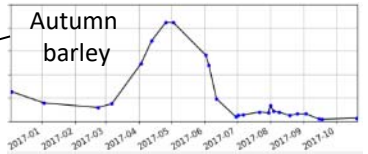
Sen4CAP - Sentinels for Common Agricultural Policy

User Requirement Document

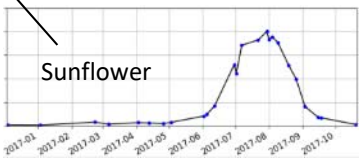
sen4cap common agricultural policy

# Identify Sentinel-based markers for CAP Monitoring

- Crop type mapping
- Vegetation growing indicator
- Grassland mowing detection
- Agricultural practices monitoring




Crop type information & vegetation growing indicators




Number of detected mowing events

Physical markers to monitor EFA agricultural practices

# Prototyping - Developing & Testing at EU level

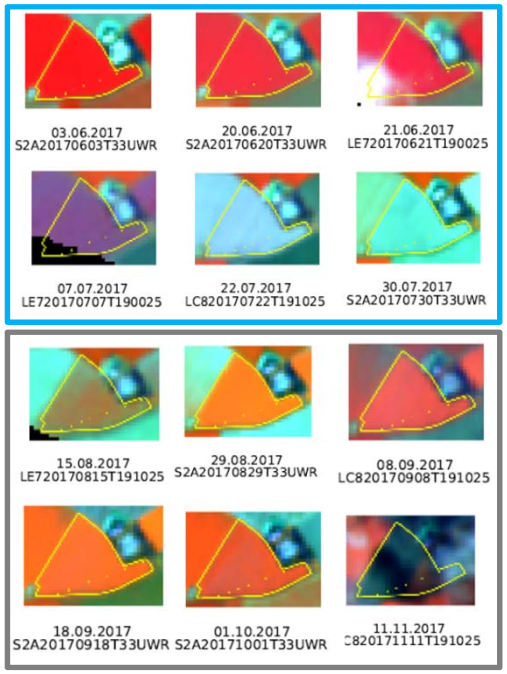
- **2 “national” coverage (NLD + CyL) + 10.000 km² test sites**
- **In-situ data sets shared by Paying Agencies**
  - LPIS/GSAA datasets, subsidy applications, physical inspections, CwRS
- **Sampling heterogeneous EU agricultural landscape:**
  - LPIS types: Cadastral (IT, ES), Physical Block (NL, LI, RO), Farmers Block (CZ)
  - Field sizes: Minimum: RO & IT 72-85% < 1ha, Maximum: CZ 66% > 1ha
  - Landscape & climate: wide geographical range

➔ **Algorithm Development, Benchmarking & 1st Validation**

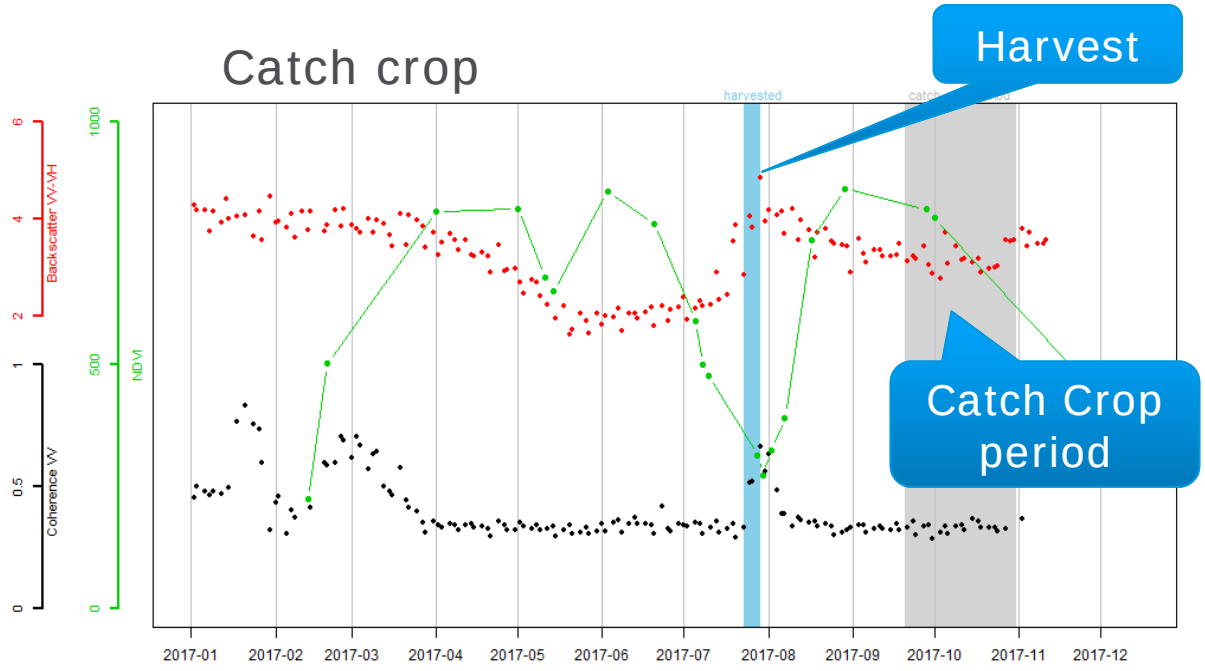
# Monitoring of Agri. Practices for EFA compliancy
## Czech Republic

- Catch crops, based on S1&2 time series – 5 markers tracing crop activities

Harvest – Visual check




Winter Catch Crop – Visual check

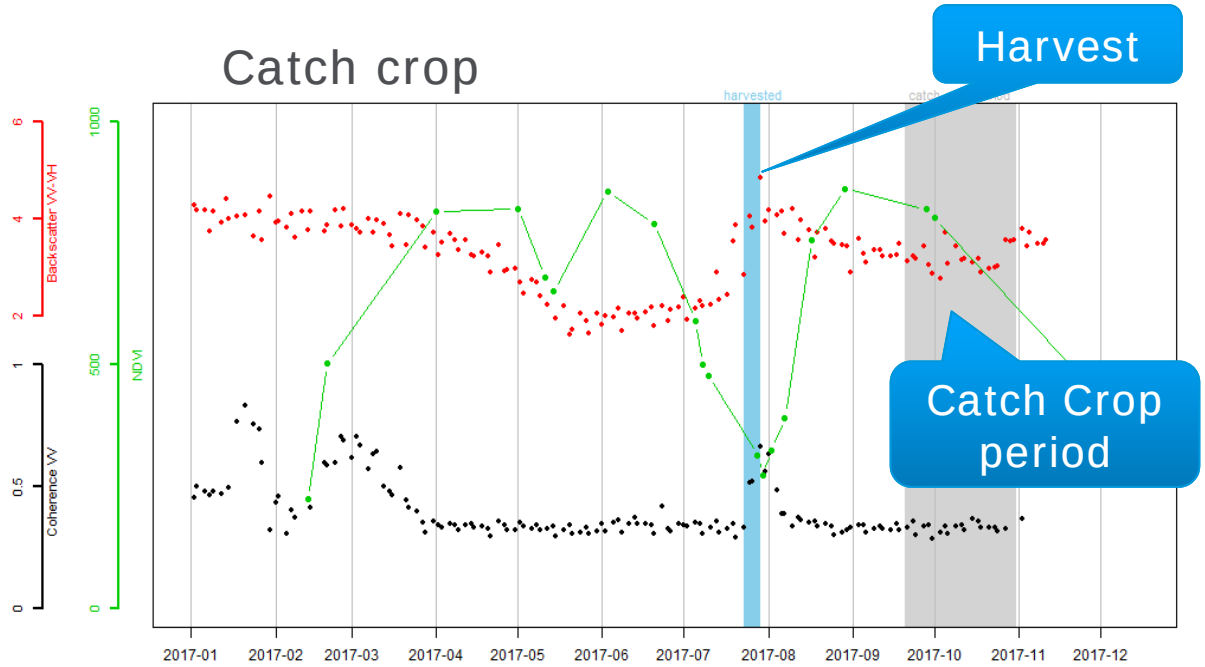


# Monitoring of Agri. Practices for EFA compliancy
## Czech Republic

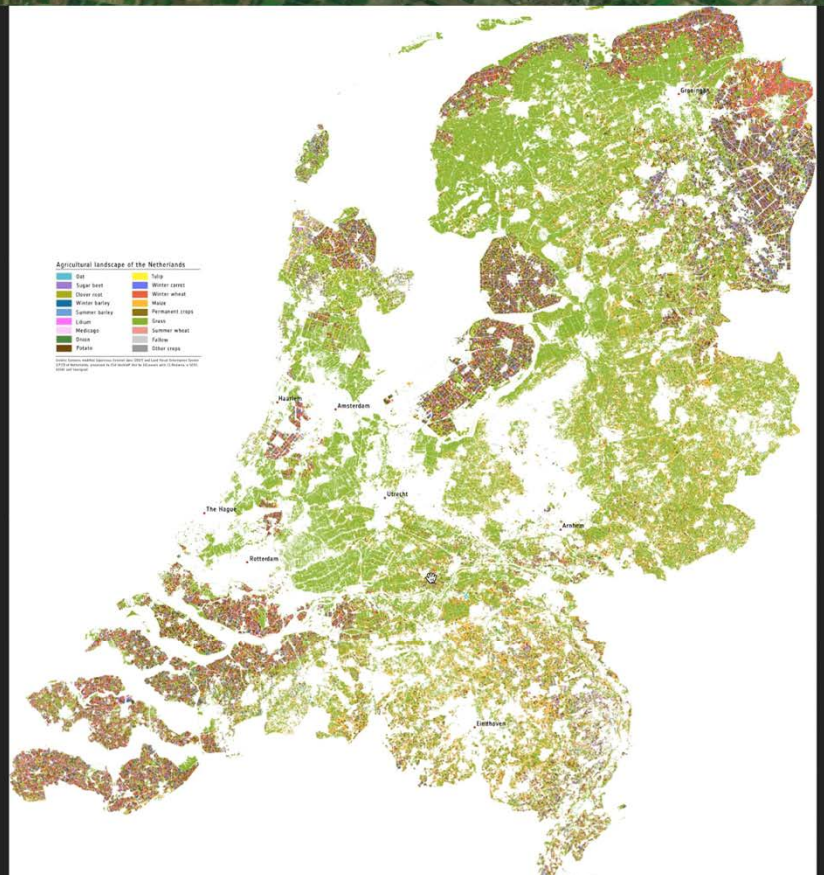
- Catch crops, based on S1&2 time series – 5 markers tracing crop activities

**Output:** (per parcel)

- Harvest detection
- Harvest week
- Catch crop detection
- Confidence level for compliancy



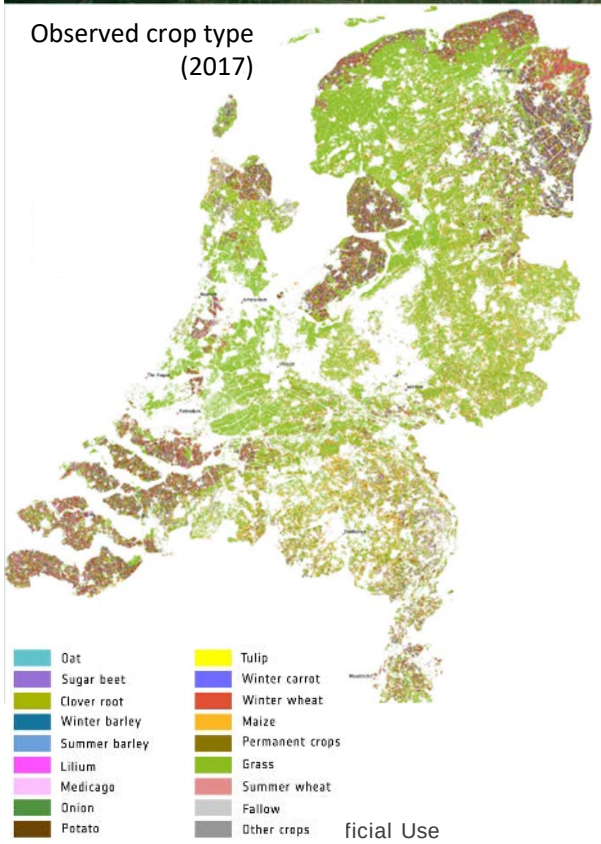
# National dynamic crop mapping at field scale

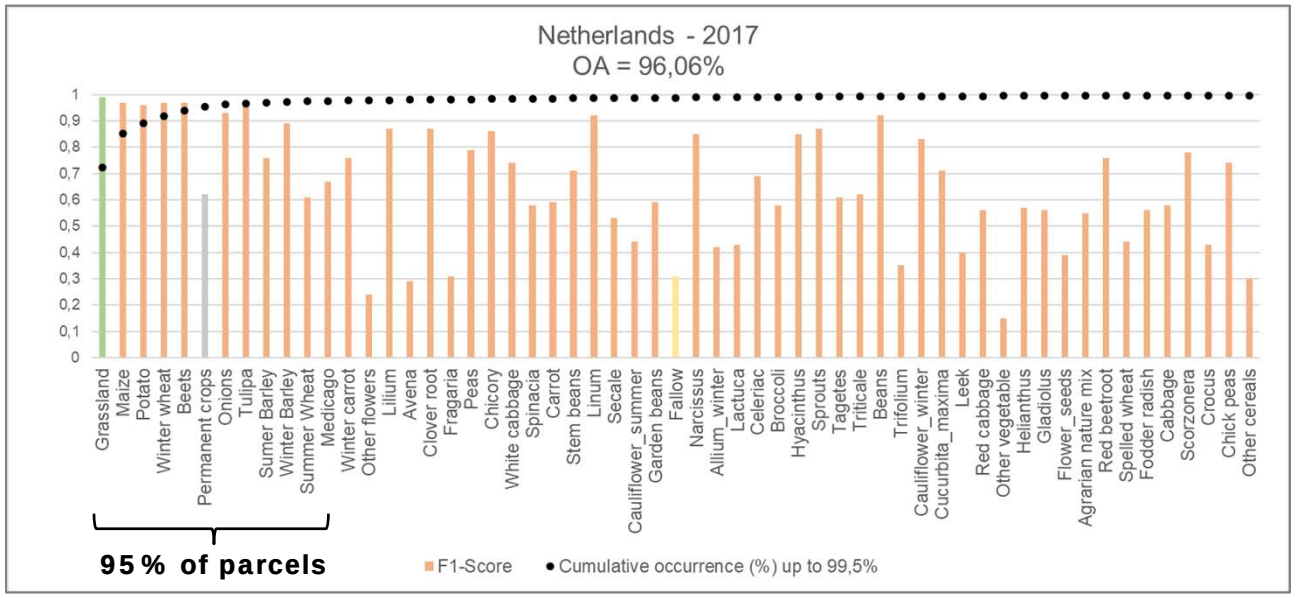



**Full Resolution Visualization Online:**
http://www.esa.int/spaceinimages/Images/2018/05/Crop_map

# Crop type mapping for crop diversification monitoring
## Netherlands

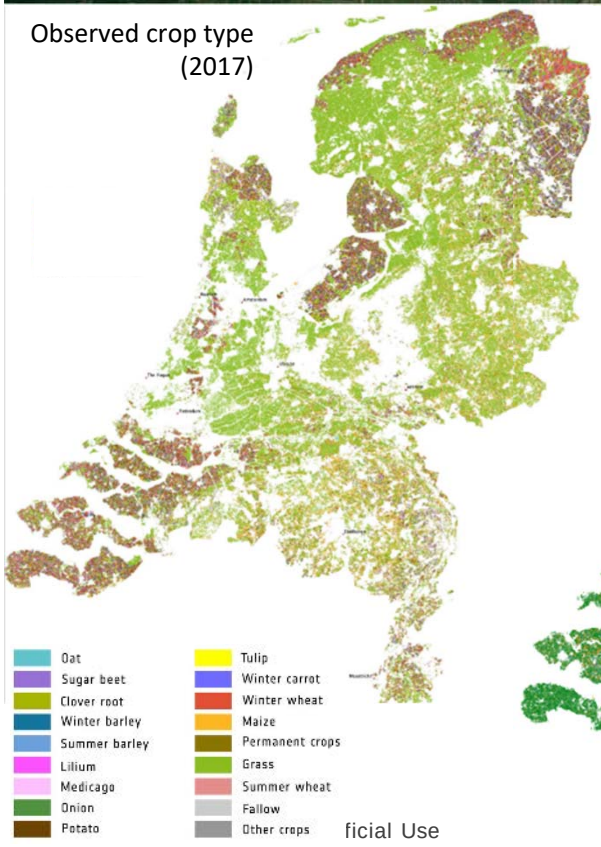
Observed crop type (2017)



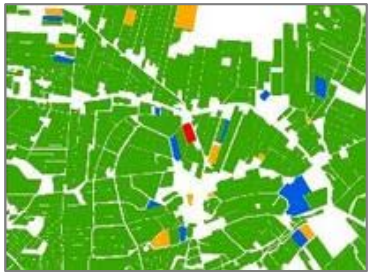



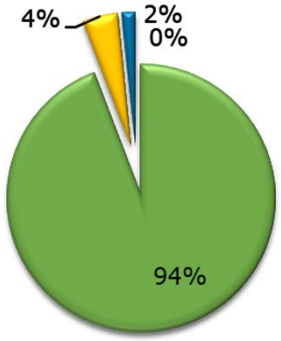
# Crop type mapping for crop diversification monitoring
## Netherlands

Observed crop type (2017)




Confidence indicator of agreement (2017)

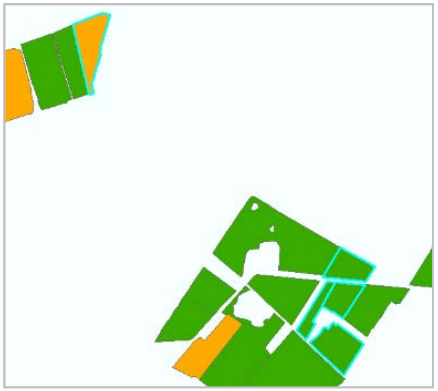





- High confidence in agreement
- Average confidence in agreement
- Weak confidence in agreement
- High confidence in disagreement

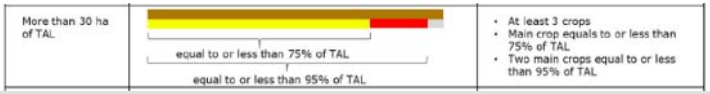
# Crop type mapping for crop diversification monitoring
Lithuania

## Crop type mapping for crop diversification monitoring - Lithuania



Compliance indicator of agreement at parcel-level

- High confidence in agreement
- Average confidence in agreement
- Weak confidence in agreement
- High confidence in disagreement




| VALDA | Area | Conformity | CT_decl | CT_pred_1 | Status | C_Indic |
|---|---|---|---|---|---|---|
| 100476xxxx | 15676 | 0 | Lupin | Beans | Assessed | Insufficient evidence |
| 100476xxxx | 15102 | 0 | Grassland & Meadows | Grassland & Meadows | Assessed | Compliant |
| 100476xxxx | 8927 | 1 | Grassland & Meadows | Grassland & Meadows | Assessed | Compliant |
| 100476xxxx | 10731 | 0 | Oats | Oats | Assessed | Compliant |
| 100476xxxx | 6177 | 1 | Spring barley | Spring barleay | Assessed | Compliant |

56,6 ha

4 crops

| | |
|---|---|
| Grassland & meadows | 42% |
| Lupin | 28% |
| Oats | 19% |
| Spring barleay | 11% |

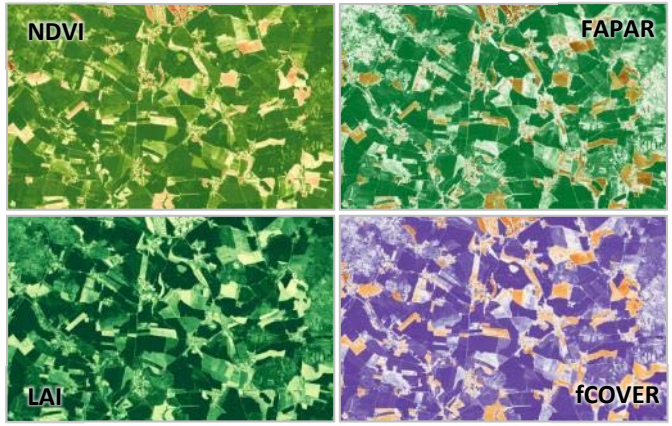
✓ Compliant at holding-level

Available information:

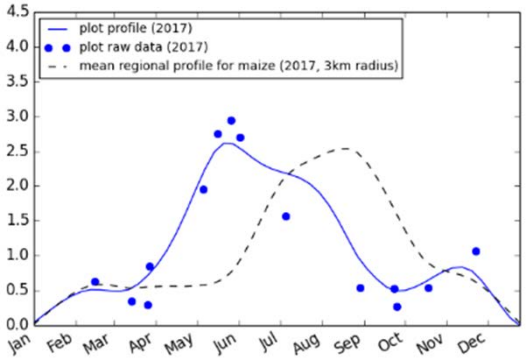
- ✓ Total area of arable land at the farm-level
- ✓ Number of crops at the farm-level
- ✓ Proportions of the main crops

# Sentinel-based vegetation indicator as auxiliary data
## Czech Republic

4 indicators

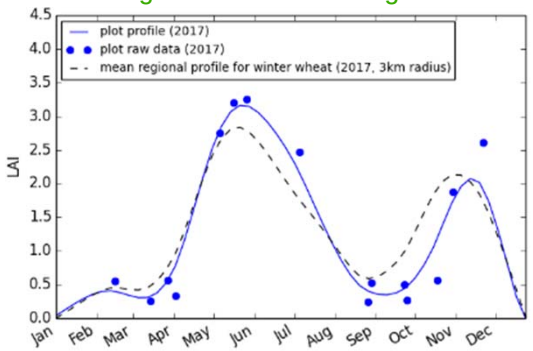



**Czech Republic**



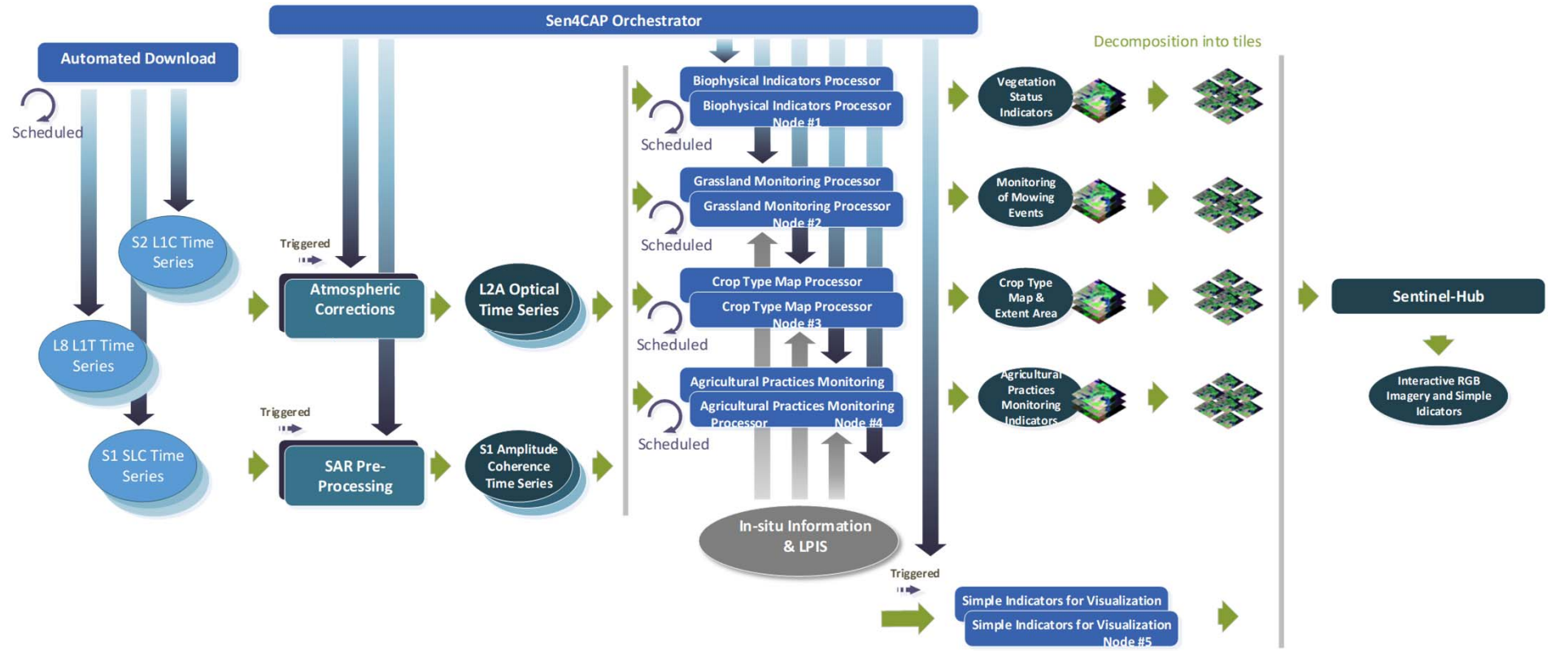

Low confidence in agreement

High confidence in agreement



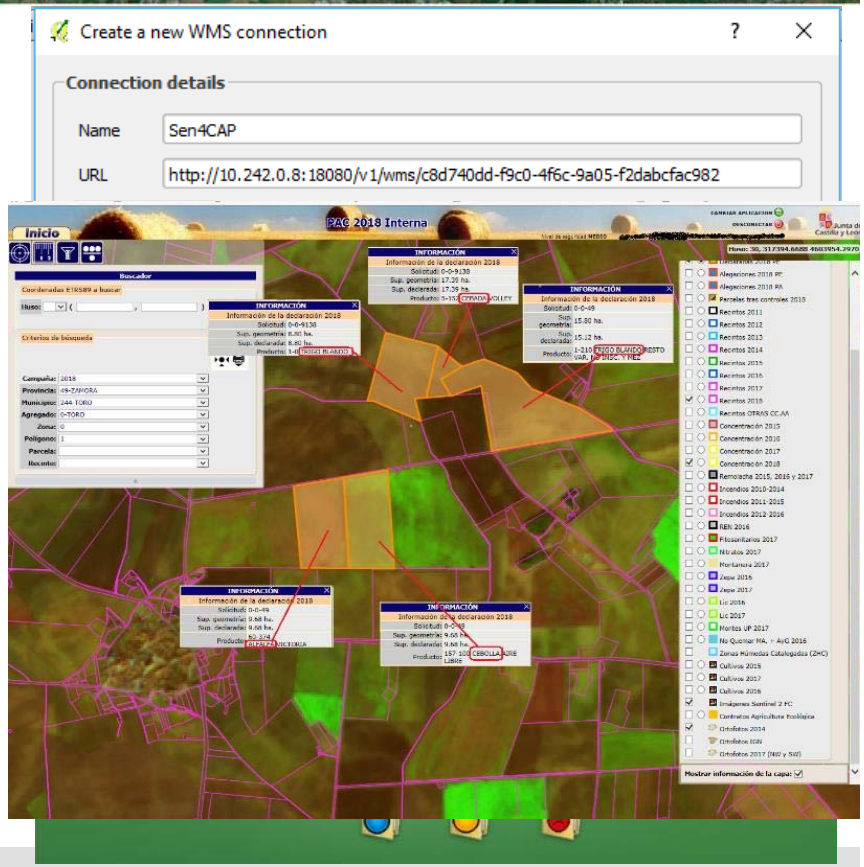

| ID | NKOP_DPB | AREA | CONF_IDX | CT_DECL | CT_PRED_1 | CT_CONF_1 | C_INDIC |
|---|---|---|---|---|---|---|---|
| 5482 | | 23275 | 0 | Maize | Winter rapeseed | 0,56 | Additional info required |
| 6581 | | 18086 | 1 | Winter Wheat | Grassland | 0,25 | Additional info required |

# Design of Sen4CAP processing system



# Towards PA's uptake in their environment

- Integration of S1 & S2 images, EO products & markers in PA's environment
- WMS providing RGB imagery and simple indicators
  - Easily integrated in PAs environment
  - S1, S2 & L8 images
  - Vegetation Indicators (NDVI, LAI, Fcover, FAPAR)
  - Time filtering
  - Configurable visualization
  - Reprojection to local coordinate systems
  - Customizable by country

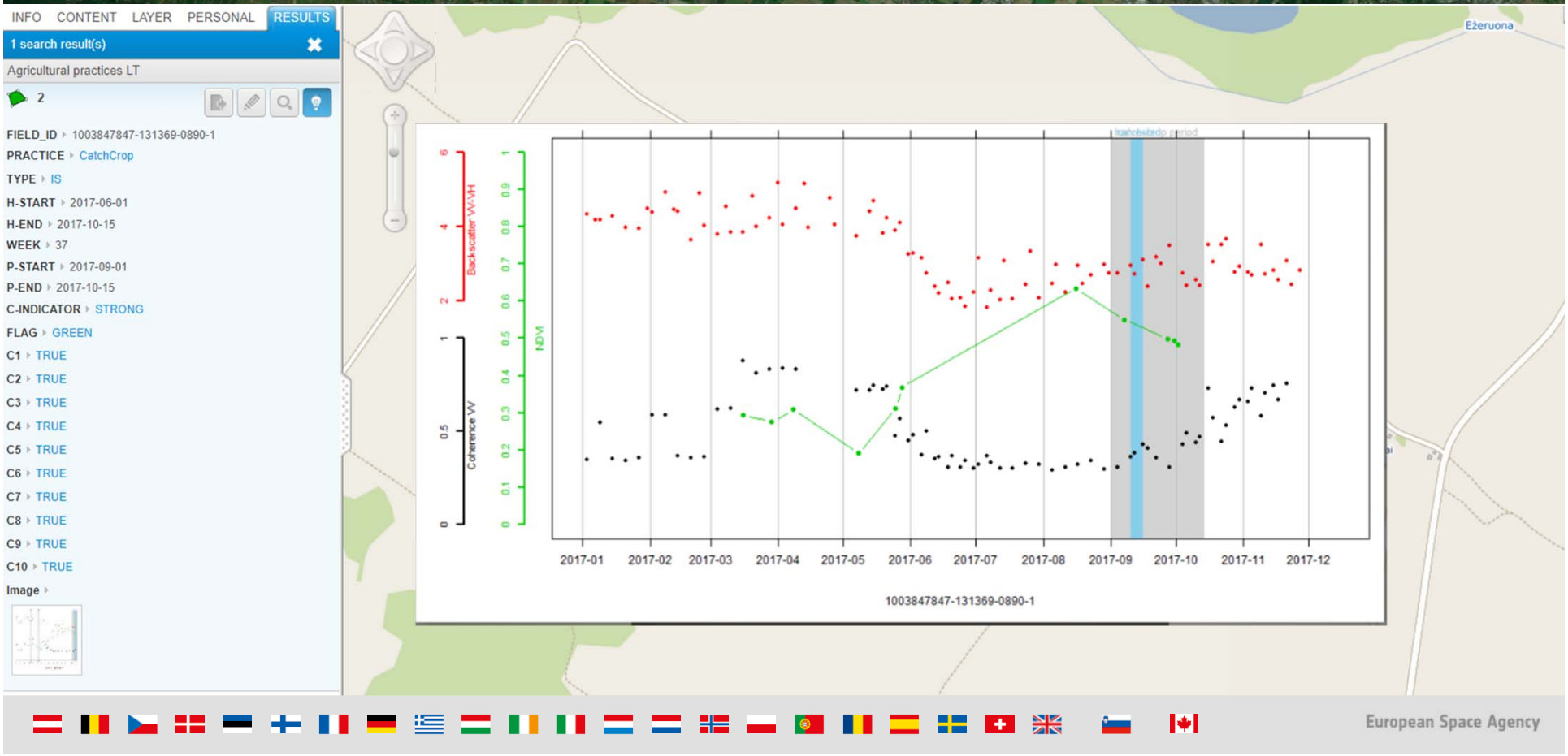


# Visualisation tool – Implementation by country





# Visualisation tool – view attributes of the parcel related to the selected layer



# Visualisation tool – viewing results at farm level for compliance assessments

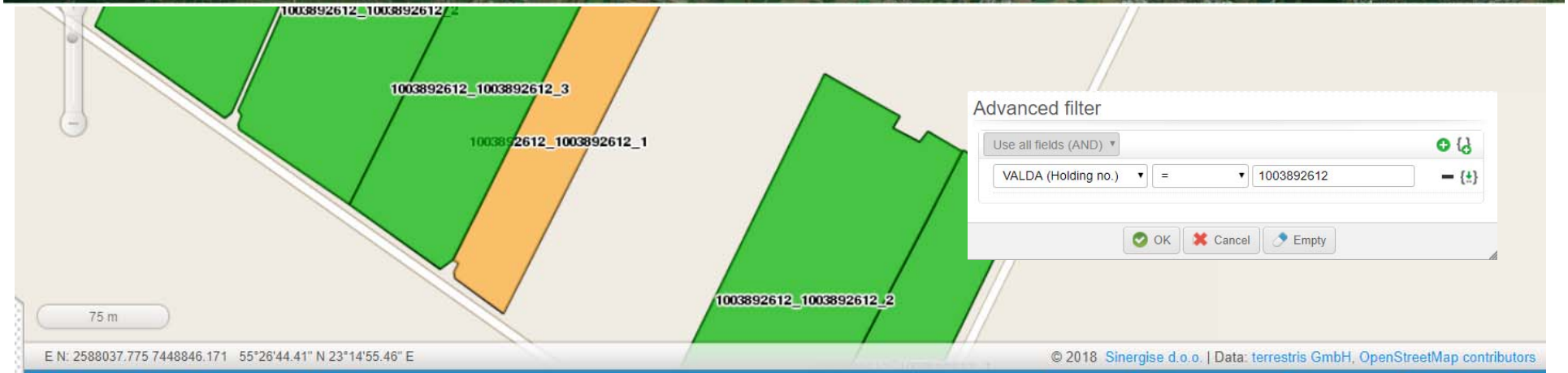
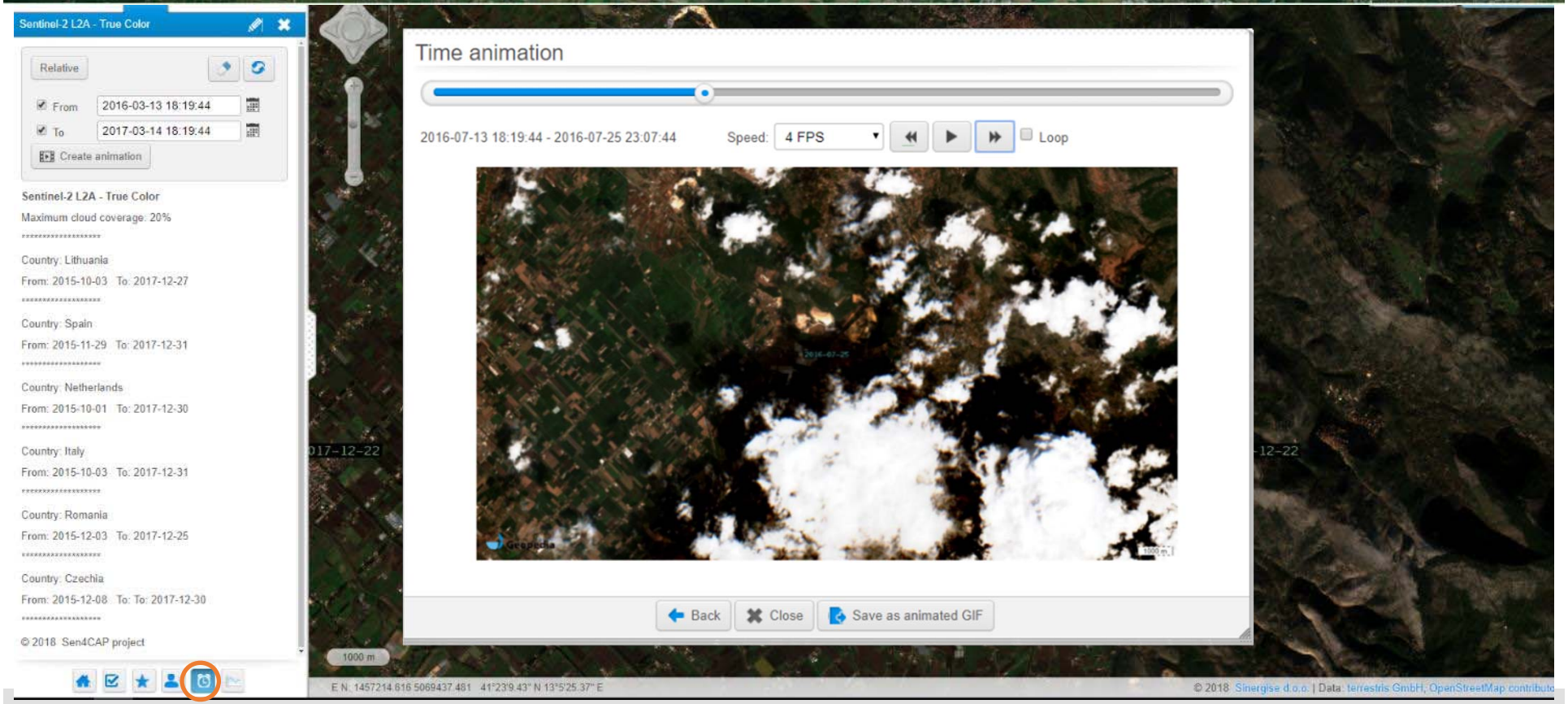



Table of records for layer: **Crop type map LT (Filtered)**

Refresh | Add selection set | Export layer | Filter

| VALDA (Holding no.) | KZS (Block no.) | LAUKO_NR (Field no.) | Area | Conformity | CT_decl | CT_pred_1 | CT_conf_1 | CT_pred_2 | CT_conf_2 | Status | C_Indic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1003892612 | 146452-5589 | 2 | 6,398 | 1.0 | MNŠ | MNŠ | 0.161 | DOB | 0.092 | Yes | Compliant |
| 1003892612 | 145452-6380 | 1 | 11,004 | 1.0 | MNŠ | MNŠ | 0.332 | DOB | 0.163 | Yes | Compliant |
| 1003892612 | 145451-5152 | 1 | 8,550 | 1.0 | NMI | AVI | 0.227 | KVV | 0.117 | Yes | Insufficient evidence |
| 1003892612 | 145451-5768 | 1 | 15,131 | 1.0 | KRŽ | KVŽ | 0.434 | KRŽ | 0.19 | Yes | Expert-judgement required |
| 1003892612 | 146452-0763 | 3 | 19,083 | 0.0 | MNŠ | MNŠ | 0.355 | DOB | 0.129 | Yes | Compliant |
| 1003892612 | 145452-8265 | 2 | 18,000 | 0.0 | MNŠ | MNŠ | 0.318 | DOB | 0.138 | Yes | Compliant |

# Visualisation tool – Time animation following crop dynamics



# Visualisation tool – products metadata

Product description

- Year
- Type of agricultural practice
- Regulation
- Interpretation of regulation
- Description of fields

Legends

Codelists with descriptions

INFO CONTENT LAYER PERSONAL

Crop type map LT

COUNTRY: LITHUANIA

YEAR: 2017

AGRICULTURE PRACTICE: CROP TYPE

REGULATION: The crop types declared by the farmers at the parcel level are checked using remote sensing data. Crop type detections are provided with confidence indices and compared with the declared crop to indicate compliancy or not.

INTERPRETATION OF REGULATION: The remote sensing check is performed on parcels declared as annual and permanent crops, grasslands and fallows. To some extent, the original legend of the GSAA files has been simplified but keeps, as a minimum, all the groups needed for the "crop diversification" scheme.

- NEWID: Unique ID of the parcel
- VALDA;KZS;LAUKO_NR: GSAA / LPIS unique ID of the parcel
- AREA: Area of the original parcel or block (m²)
- CONF_IDx: Conformity indicator of the parcel
- CT_DECL - Crop Type declared: the code of the crop type that was declared by the farmer in the GSAA application. It can be linked with the original GSAA crop code using the table LT_LUT_CropCode
- CT_PRED_1: 1st Crop Type predicted - the code of the crop type detected by remote sensing associated with the highest prediction confidence
- CT_CONF_1: Prediction confidence (%) associated with the 1st crop type detected
- CT_PRED_2: 2nd Crop Type predicted - the code of the crop type detected by remote sensing associated with the second highest prediction confidence
- CT_CONF_2: Predecition confidence (%) corresponding to the 2nd crop type detected
- STATUS: Binary value indicating if the parcel has been assessed or not by remote sensing
- C_INDIC: Indicator of the compliance between the declared and observed crop types

Legend

Crop type map LT

- Compliant
- Insufficient evidence
- Non-Compliant
- Expert-judgement required

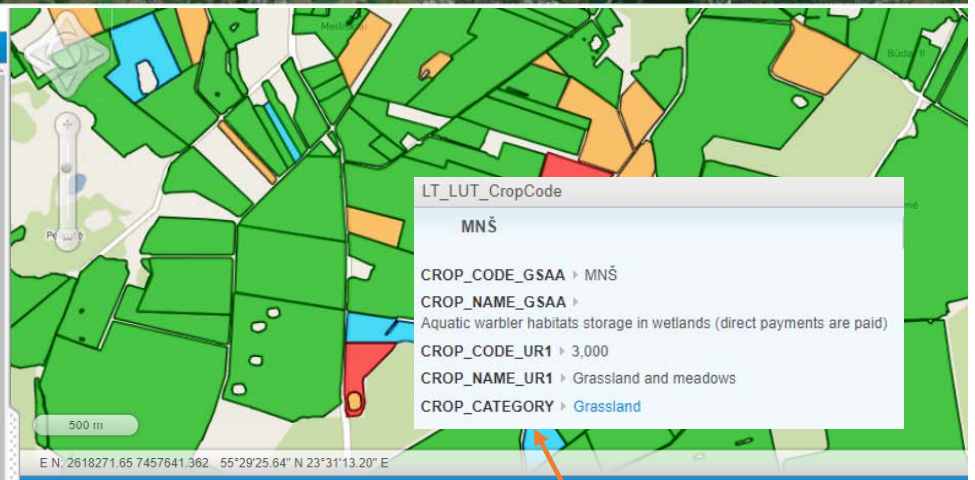



Table of records for layer: **Crop type map LT**

| VALDA (Holding no.) | KZS (Block no.) | LAUKO_NR (Field no.) | Area | Conformity | CT_decl | CT_pred_1 | CT_conf_1 |
|---|---|---|---|---|---|---|---|
| 1003930429 | 143603-1158 | 4 | 8,048 | 0.0 | MNŠ | MNŠ | 0.471 |
| 1003935506 | 149453-1989 | 2 | 12,504 | 1.0 | MNŠ | MNŠ | 0.107 |
| 1004028997 | 145451-1870 | 1 | 6,295 | 1.0 | PDJ | PDJ | 0.245 |
| 1004028997 | 144450-5980 | 1 | 5,769 | 1.0 | MIV | DAK | 0.085 |
| 1003930429 | 143603-1158 | 1 | 10,668 | 0.0 | MNŠ | MNŠ | 0.476 |
| 1004722421 | 131526-4915 | 2 | 47,716 | 0.0 | MNŠ | MNŠ | 0.471 |
| 1003935506 | 148453-4941 | 4 | 26,900 | 1.0 | MNŠ | MNŠ | 0.338 |

# From prototyping to national demonstration

## Prototypes for proof of concept

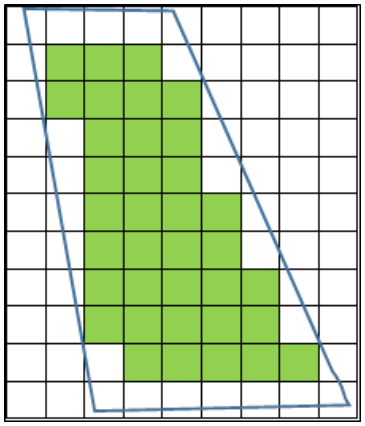
- ✓ 2016 & 2017
- ✓ 10.000 km² test site + national coverage (NLD and Castilla i Leòn)

## Full scale demonstration

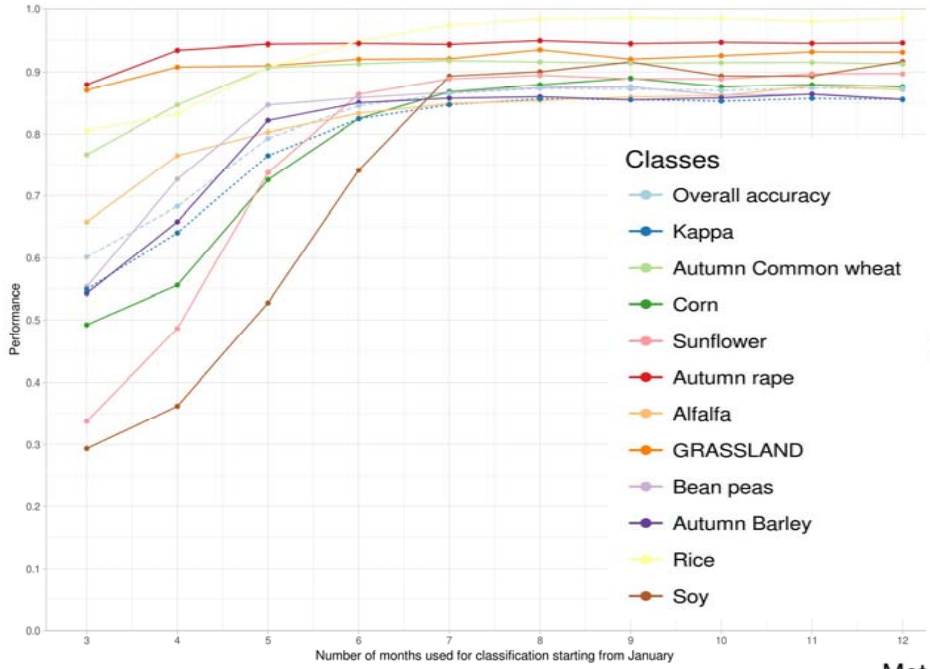
- ✓ 2018 & 2019
- ✓ National coverages for all six countries
- ✓ Near-real time processing (2019) and timely delivery
- ✓ Operational environment of pilot PAs
- ✓ Capacity building and training

# Methodological developments

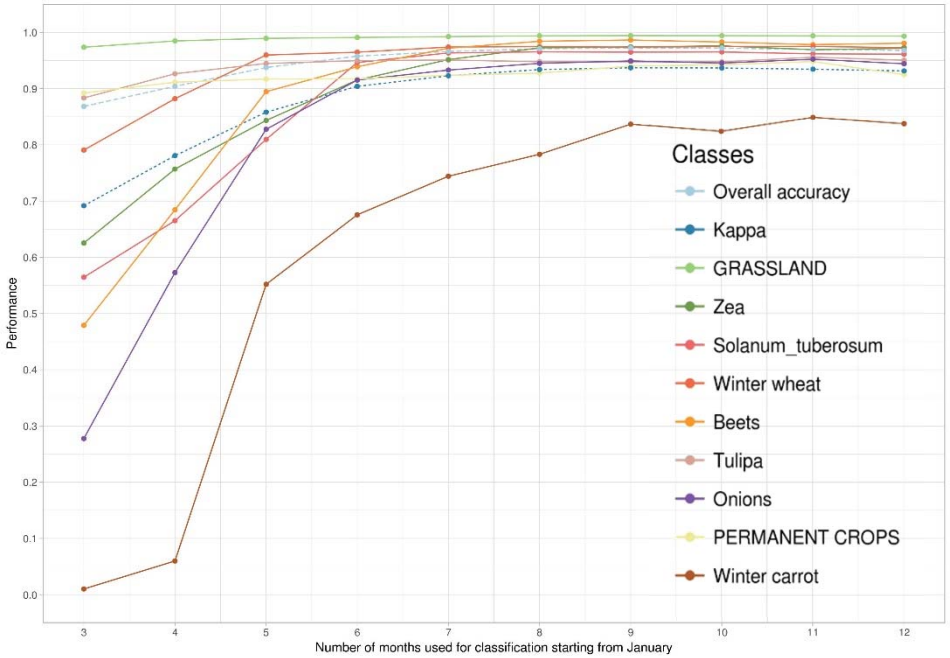
- Algorithms improvements and refinements based on PA's feedback
  - Crop type legend: are all the crop classes needed? How to merge? BPS vs crop diversification use cases
  - Better understanding and integration of EFA regulations
  - Better integration of S1 & S2 for grassland monitoring
- Selection of « monitorable » parcels
  - Prototyping: 0.5 – 1ha threshold; inner buffers
  - No more thresholds but considering only inner pixels
- Continuous monitoring



# Continuous monitoring




**Romania**

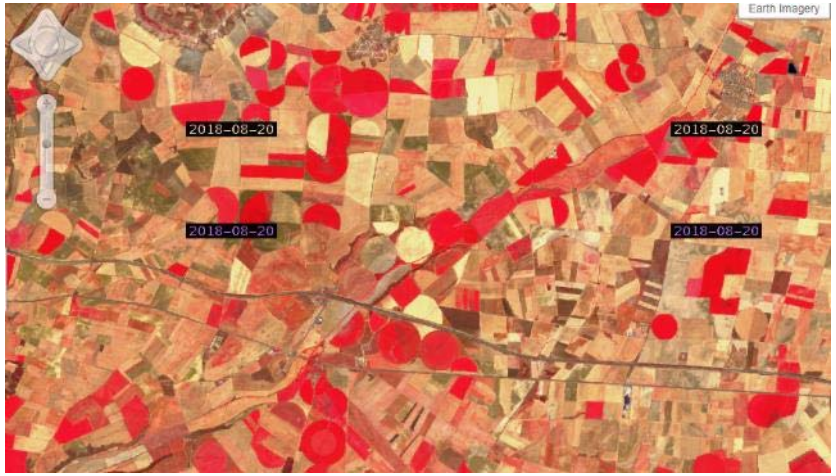



**Netherlands**

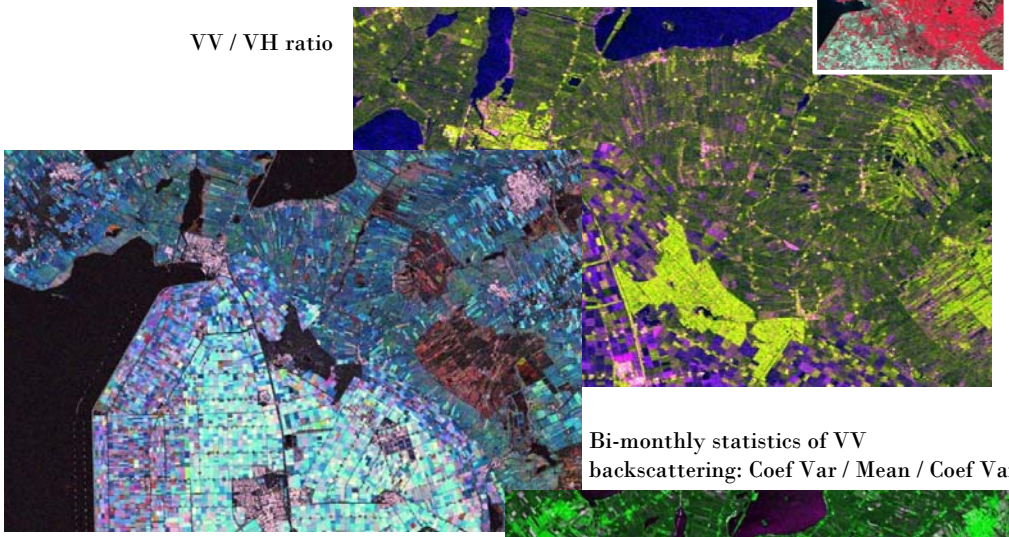
Metrics
F-score
Kappa
Overall accuracy

# EO data timely processing

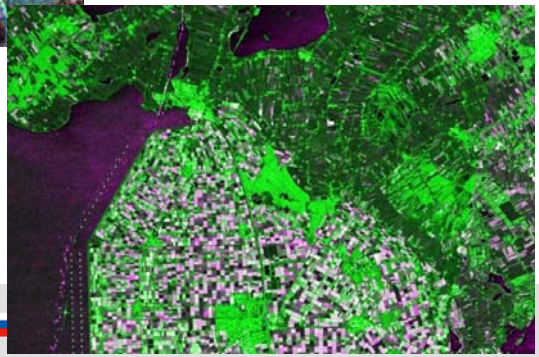
- S1 and S2 data, since the 1st January 2018 continuously processed




VV / VH ratio



Bi-monthly statistics of VV backscattering: Coef Var / Mean / Coef Var



Monthly average of VV coherence: April / March / February

# 2018 in situ data collection

- Subsidy applications for 2018


- On-The-Spot-Check (OTSC) data

- Farmers interview for grassland mowing and agri. practices
  - Interactions by e-mails
  - 250 to 500 fields surveyed by practice (grassland, crop harvest, catch crops, nitrogen fixing crops, fallow land)

| ID | Unique parcel ID | Area | MOWING 1 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mowing | | | | Extension (parcel area %) | Mowing practice | Additional information | | | | |
| | | | FROM | (+/- days) | TO | (+/- days) | | | Drying | Baling | Bales of hay on the parcel | Removal of bales | Other |
| 1 | XXXX | | | | | | | | | | | | |
| 1 | Comment | | | | | | | | | | | | |
| 2 | XXXX | | | | | | | | | | | | |
| 2 | Comment | | | | | | | | | | | | |

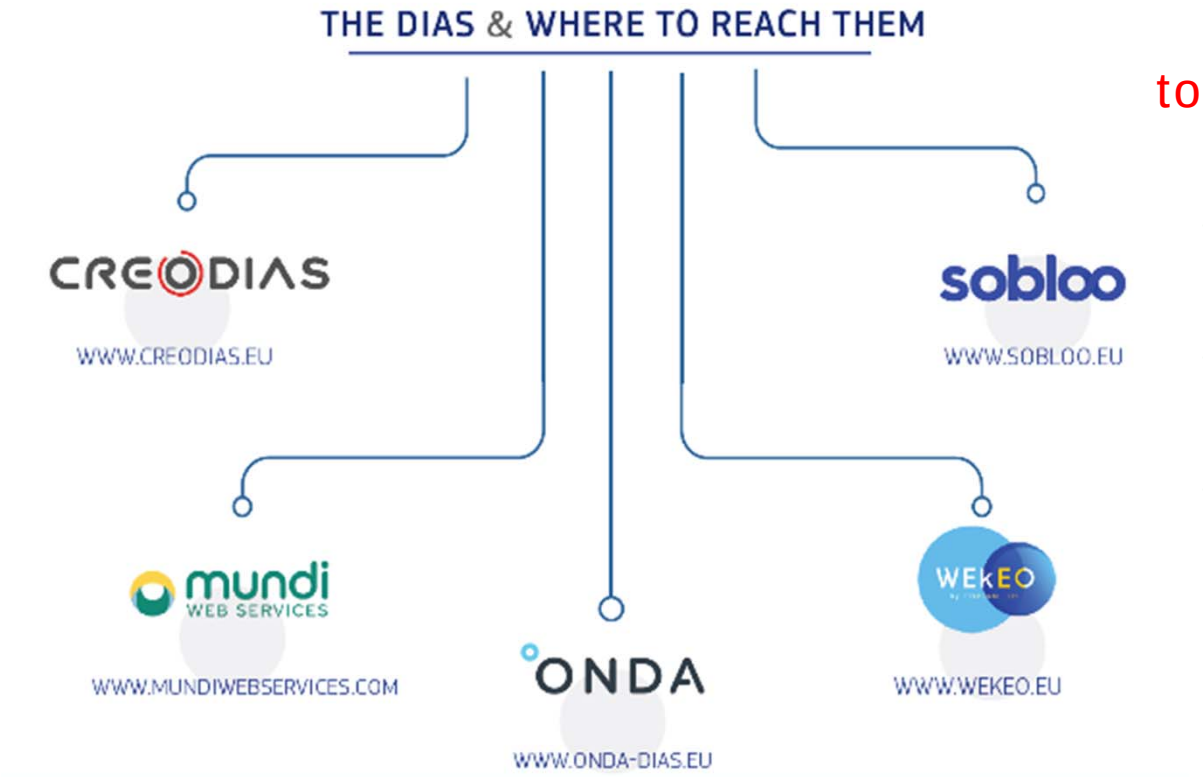
| ID | Unique parcel ID | Area | Main crop | EFA type | Seedbed preparation for main crop | | Sowing of main crop | | Harvest of main crop | | Handling of main crop residues | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | FROM | TO | FROM | TO | FROM | TO | FROM | TO |
| 1 | XXXX | | | | | | | | | | | |
| 1 | | | | Comment | | | | | | | | |
| 2 | XXXX | | | | | | | | | | | |
| 2 | | | | Comment | | | | | | | | |

# National Monitoring - Processing resources

| | Czech Republic | Italy |
|---|---|---|
| Input EO data (2016-2019) | 26 TB | 128 TB |
| Output L2 data (2016-2019) | 31 TB | 137 TB |
| Output L3 and L4 data (2016-2019) | 14 TB | 50 TB |
| Pre-processing resources (ongoing) | 16 cores, 90 GB | 48 cores, 230 GB |
| Products & distribution resources (ongoing) | 28 cores, 72 GB | 62 cores, 144 GB |

*Average LPIS database volume: 0.1-10 GB

# Embracing DIAS




Selection in progress
to be ready end of 2018 for
NRT processing in 2019

- Sen4CAP requirements definition
- RFI document to the 5 DIAS-es
- Test access

# Summary

- Sentinels benefits for CAP monitoring demonstrated with ***prototype*** products
  - For IACS use cases: crop diversification, permanent grassland and EFA
  - Under specific assumptions in terms of parcels size, parcels geometry, etc.
  - Several ways identified to increase relevance of Sentinels markers
- Moving to national demonstration, wall-to-wall coverage, timely delivery
  - Wall-to-wall coverage over 6 countries (1.2 Mkm²) with diverse cropping systems, LPIS, landscape, etc.
  - 2018 processing ongoing: in-situ and EO data (S1 + S2 pre-processing, markers)
  - Tacking national-scale methodological issues
  - Going to use cases
  - Moving to DIAS
  - Capacity building & training