Sen4CAP project achievements

Bontemps S., Defourny P., Bajec K., Cara C., de Vendictis L., Kucera L., Malcorps P., Milcinski G., Nicola L., Sciarretta C., Slacikova J., Tutunaru F., Udroiu C., Zavagli M, Koetz B.

in close collaboration with partners from our 7 pilot countries (Czech Republic, France, Italy, Lithunia, Netherlands, Romania and Spain)

sen4cap
common agricultural policy

UCL Université catholique de Louvain

CS ROMANIA

e-geos AN ASI / TELESPAZIO COMPANY

SINERGISE

gisat

European Space Agency

Uptake of Copernicus within the CAP 2020

1st June: Modernizing and simplifying the Common Agricultural Policy

CAP monitoring approach – Technology meets Policy

Sentinel-1
- 2+ day revisit
- No cloud impact
- very dense time series

Sentinel-2
- 3+ day revisit
- 10-m resolution
- per-parcel monitoring
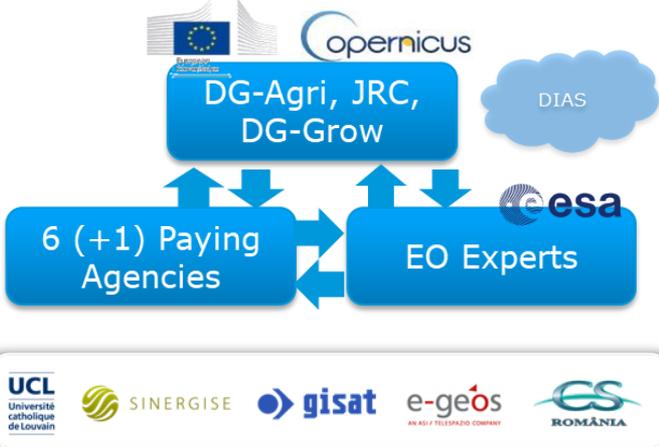
sen4cap — common agricultural policy   **Objectives**

- o **Provide evidence** how Sentinel derived information can support the modernization and simplification of the CAP **in the post 2020 timeframe**
- o Provide **validated algorithms**, **products**, **workflows** and **best practices** for agriculture monitoring relevant for the management of the CAP
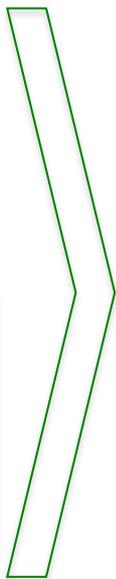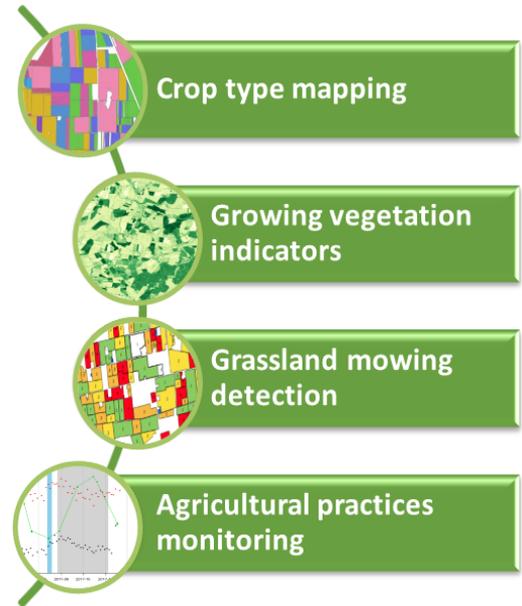
Sen4CAP – Use case and user-driven approach

1st User Workshop, Brussels, July 2017

Direct Payment Committee, Brussels, March 2018

Use case

| Crop diversification |
| Permanent grassland identification |
| EFA-Land lying fallow |
| EFA-Catch crops |
| EFA-Nitrogen-fixing crops |
| Interactive visualization |
| … keeping in mind much more |

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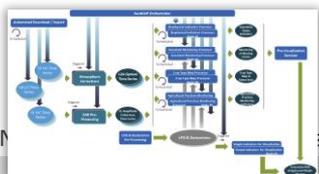- Agricultural practices monitoring

# Sen4CAP – A project of 3 years in 2 phases

Design and prototyping
2017 – local sites

Demonstration and validation
2018 & 2019 – national NRT

- Use cases selection
- Products Specifications
- Benchmarked Methods
- Prototype products
- Validation
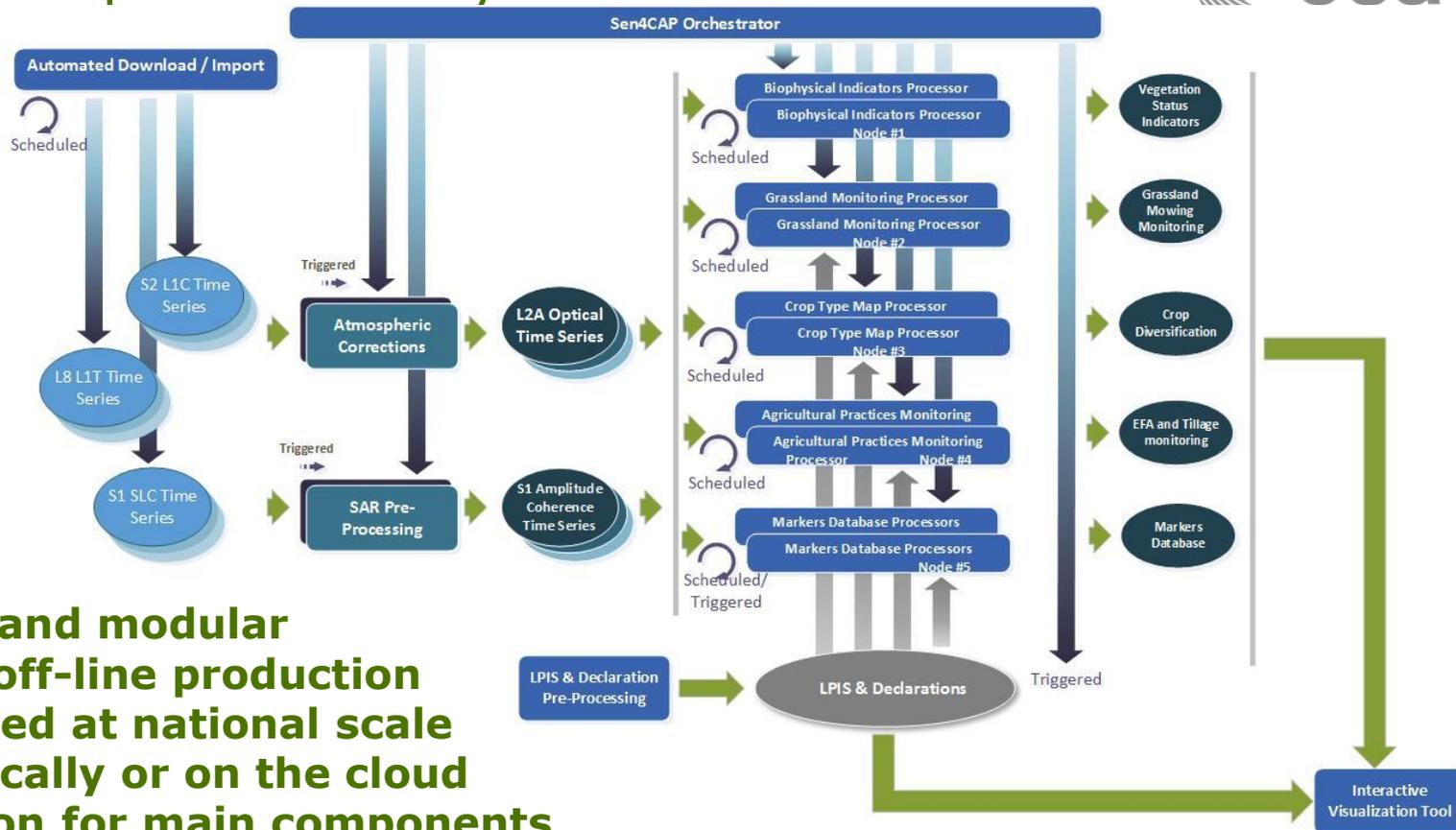- Tools design & implementation

- Use cases demonstration
- National scale
- Continuous monitoring
- Validation & Fitness-to-use assessment
- Capacity building and training
- System qualification
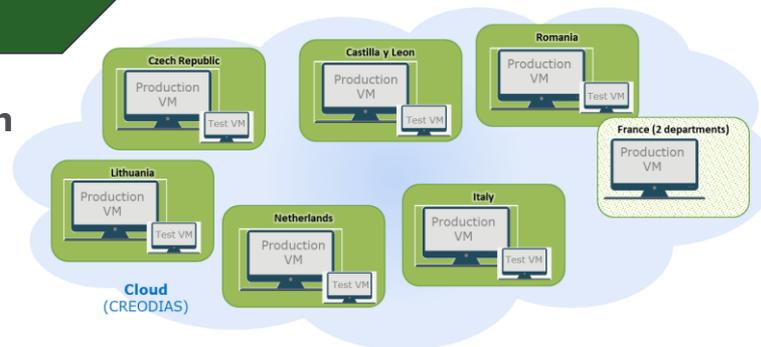
Sen4CAP – An open-source system

Version 2.0 delivered on 8 Feb. 2021

- ❖ **Automated and modular**
- ❖ **For NRT or off-line production**
- ❖ **Demonstrated at national scale**
- ❖ **Operated locally or on the cloud**
- ❖ **Dockerization for main components**

Producing large dataset of markers from S1 & S2
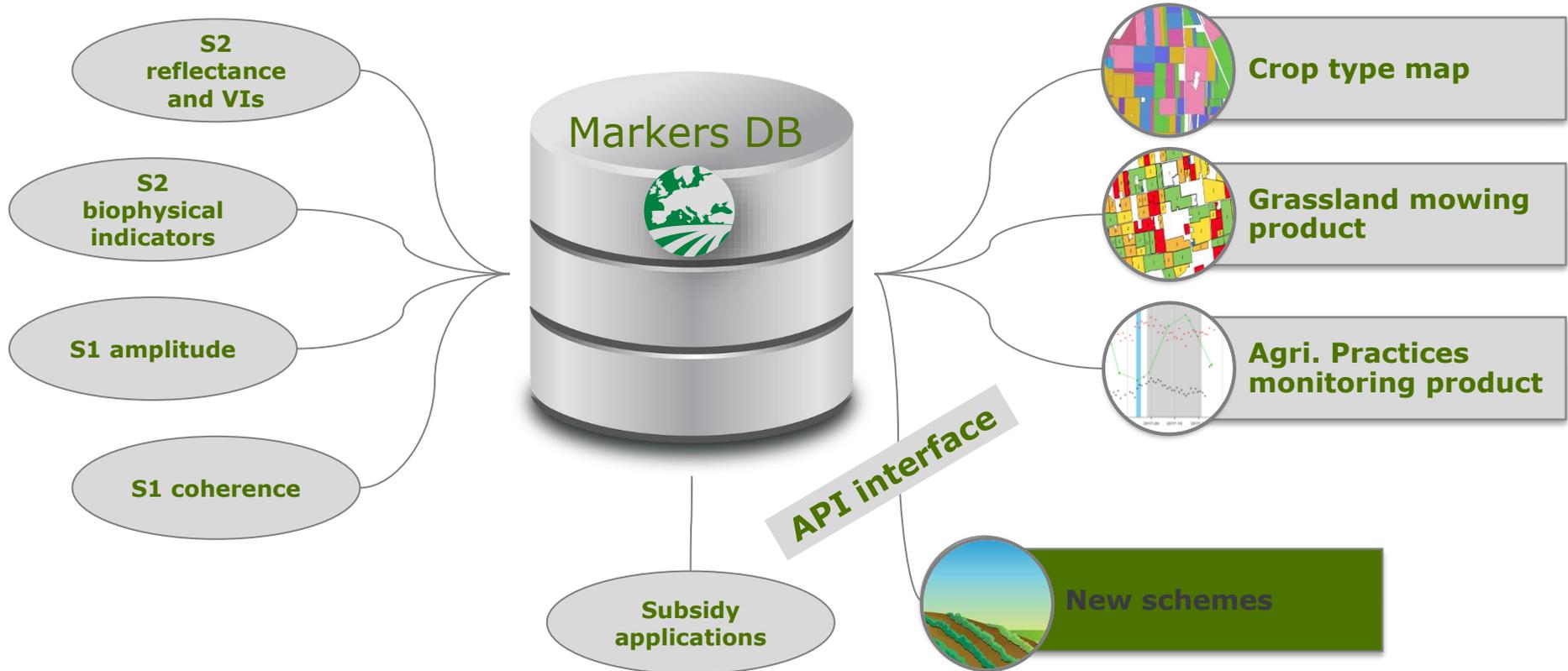## Markers stored in a database for each LPIS/GSAA parcel along the season

22 markers every 10 days
+ 3 markers at each S2 cloud-free observation

20 markers every week + 4 markers at
each acquisition + S1 temporal features

European Space Agency

Markers and products assessed through selected use cases but available for many other applications

S2 reflectance and VIs

S2 biophysical indicators

S1 amplitude

S1 coherence

Subsidy applications

Markers DB

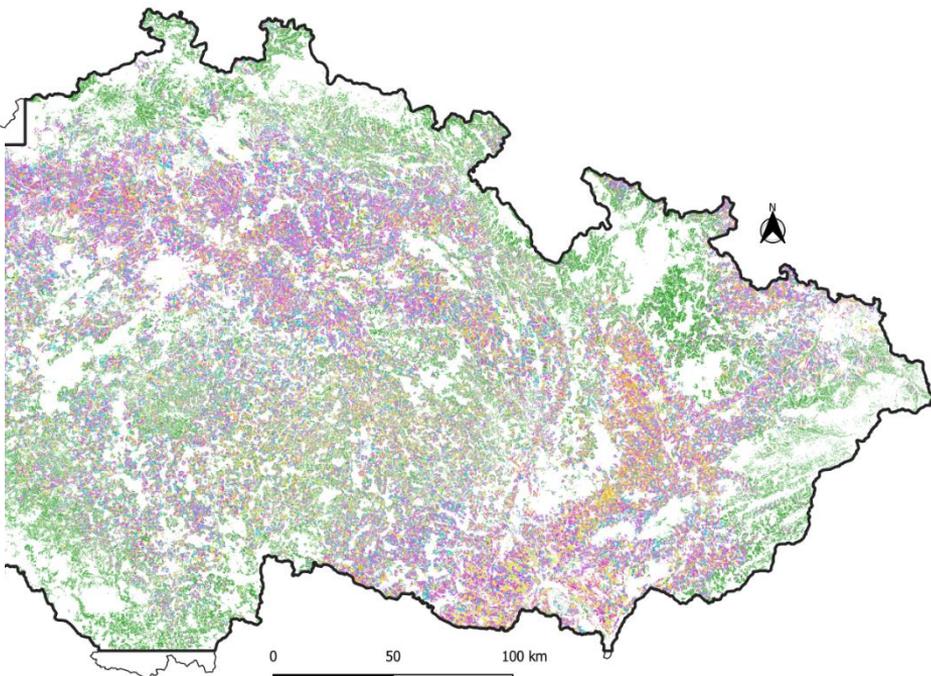API interface

Crop type map

Grassland mowing product
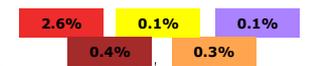
Agri. Practices monitoring product

New schemes

National crop type map over Czechia
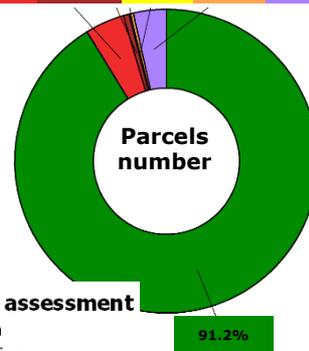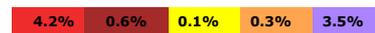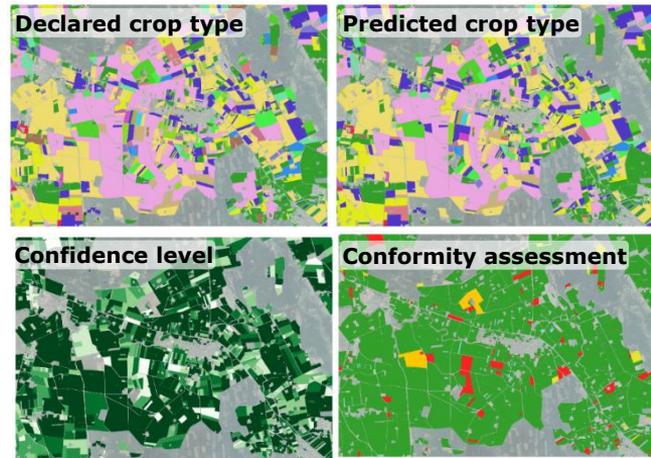## 2020, Mar-Aug, > 60 crop types

Crop types

- 🟩 Grassland
- 🟨 Winter wheat
- 🟪 Winter rapeseed
- 🟦 Maize
- 🟦 Spring barley
- 🟪 Winter barley
- 🟪 Lucerne
- 🟥 Clover
- 🟩 Sugar beet
- 🟦 Oat
- 🟨 Pea
- 🟪 Winter triticale
- 🟥 Poppy
- 🟨 Winter rye

✓ **420 S2 markers + 610 S1 markers**

✓ **95,9% parcels / 99,5% area assessed**

✓ **90.3% overall accuracy**

ESA UNCLAS

Declared crop type

Predicted crop type

Confidence level

Conformity assessment

Parcels number

4.2% 0.6% 0.1% 0.3% 3.5%

91.2%

Parcels area

2.6% 0.1% 0.1%
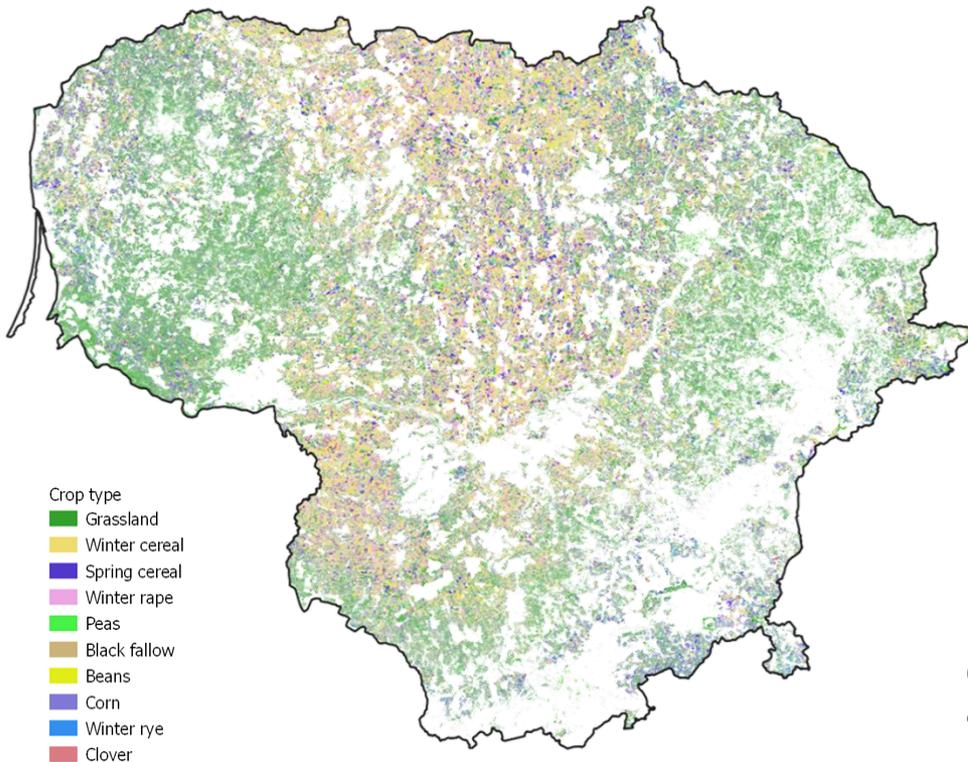0.4% 0.3%

96.5%
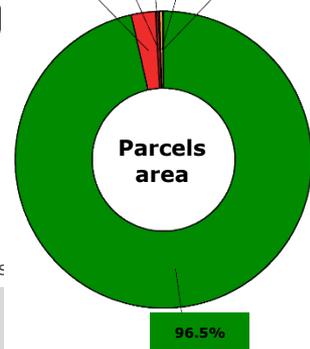
Parcel conformity assessment
- 🟩 Classified and conform
- 🟥 Classified and not conform
- 🟧 Not classified - geometry problem
- 🟨 Not classified - not monitored land cover
- 🟪 Not classified - < 3 S2 pixels
- 🟦 Not classified - no S1 pixel
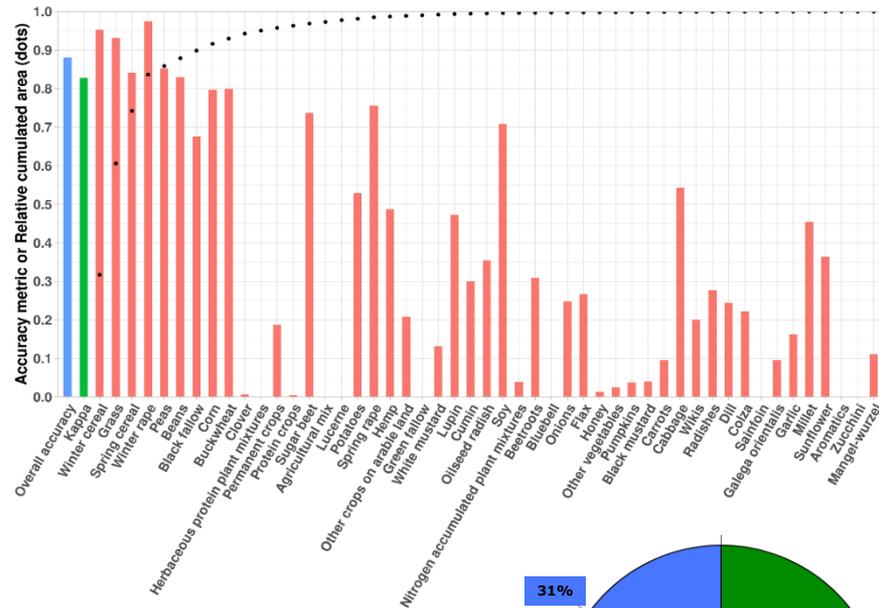- ⬜ Not classified - other

AP Final User Works

National crop type map over Lithuania
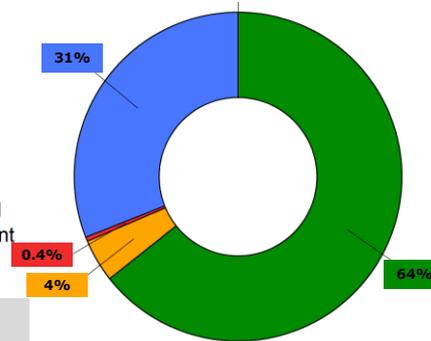## Jan-Jul, > 100 crop types

OA = 88% (2019 and 2020)
Good performance for the 9 main crops (≈92% area)
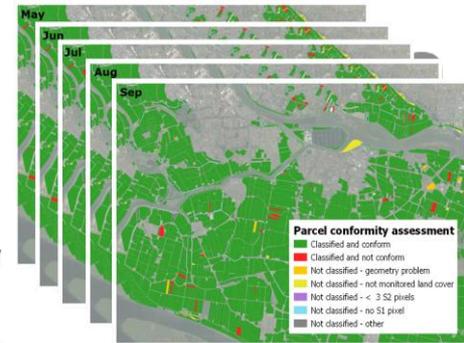
Crop diversification assessment (holding level)

High accuracy achieved from May/June

Early classification to supporting claimless system
NIVA use case tested in Lithuania

- Using applications from last year - 2019
- Map on 1st April and 1st May 2020 using data from 1st January
- 2 legends:
    - 4 main classes:
        - Annual crop
        - Grassland
        - Permanent crop
        - Fallow
    - 6 main classes: 4+
        - Other natural areas
        - Greenhouse and nursery

1st May 2020 map, OA = 84.58%
(best results for Arable land / Grassland)

Other natural areas
Annual crop
Permanent crop
Grassland
Fallow land
Greenhouse and nursery

European Space Agency
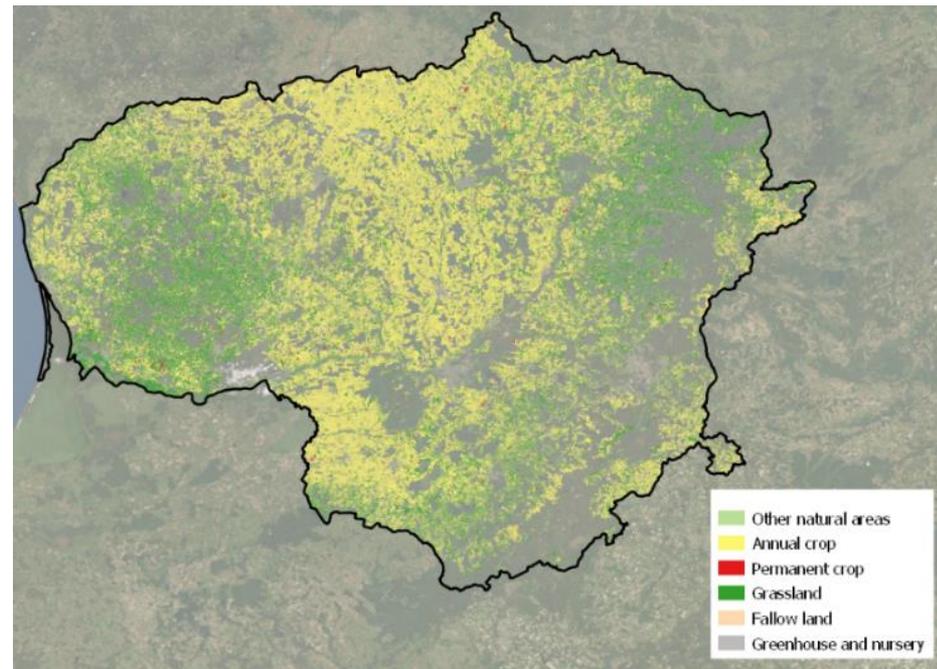
Mowing detection over all grassland parcels based on S1 and S2 time series

S2 vegetation indices decrease + S1 coherence increase
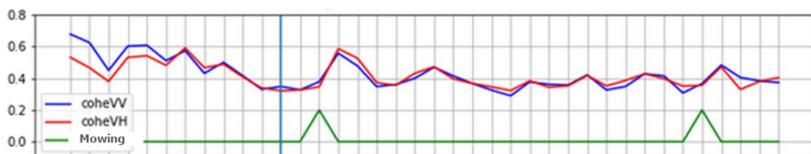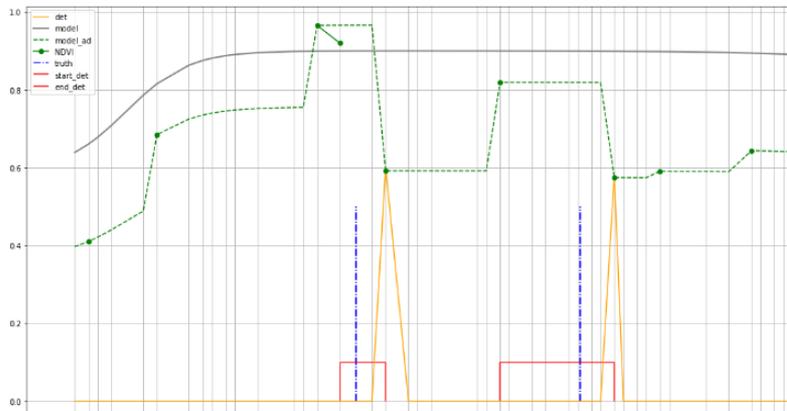
- ✓ Number of mowing events (0 to 4)
- ✓ For each mowing event:
  - o Temporal interval in which the mowing event occurred
  - o Confidence level
  - o Satellite mission used for detection (S1, S2 or both)
  - o Compliancy level

Mowing detection example on Castilla y Leon

Parcel n° 55367

Legend:
- NDVI (S2) trend
- Mowing period truth
- Mowing period detected

Dates shown: 28/04/2019, 01/05/2019, 11/06/2019, 18/06/2019, 15/07/2019, 18/07/2019, 22/08/2019, 27/08/2019
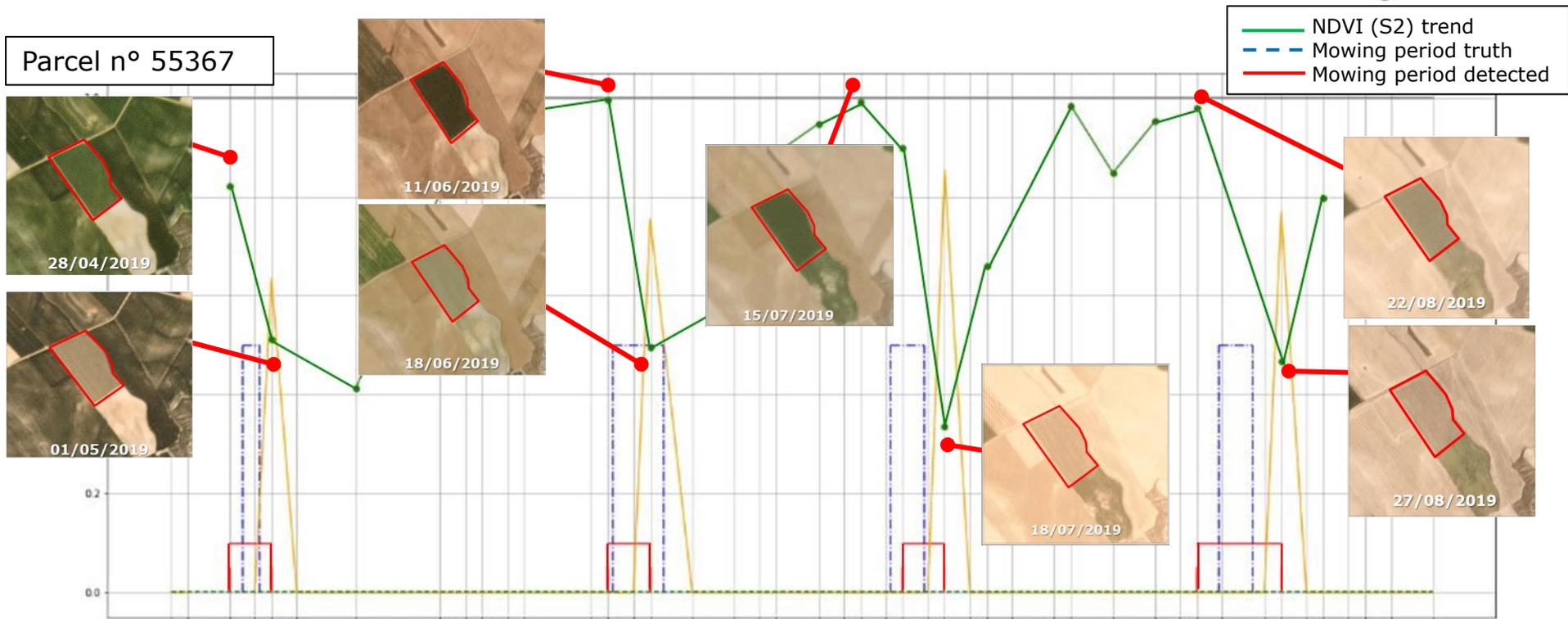
Algorithm improvement from 2018 to 2019
Much higher precision
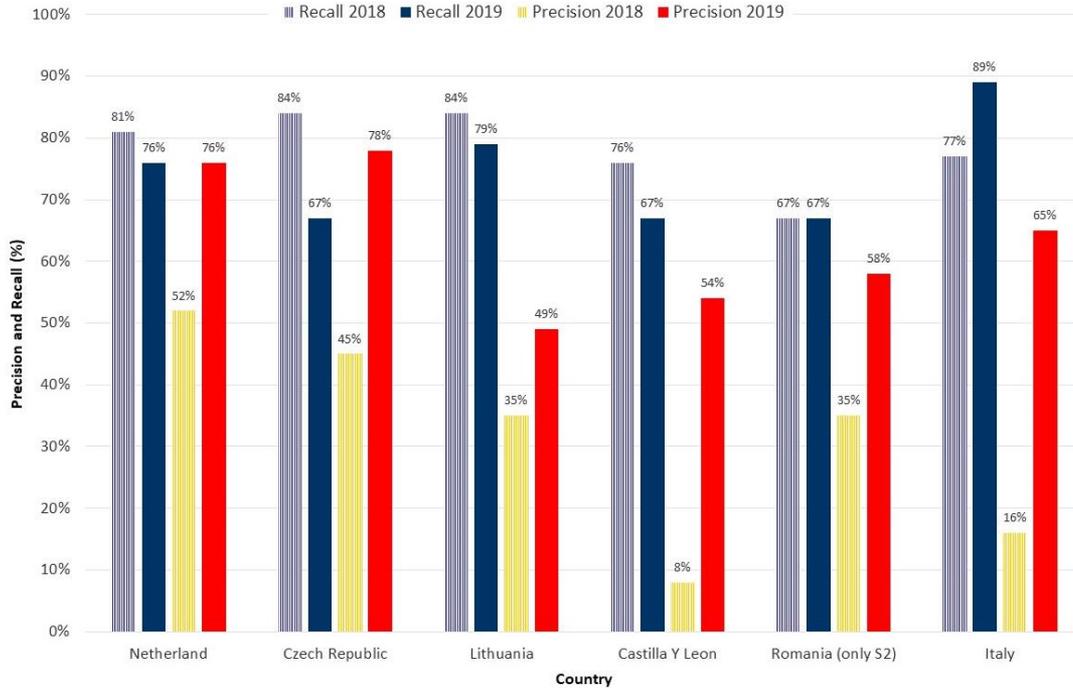
Still impacts of
- grassland drying
- grazing
- partial mowing

Agricultural practices monitoring: 10 markers related to vegetation state or vegetation change on a parcel

MARKERS FOR HARVEST		
M1	**M1: Presence of vegetation in the main vegetation season** (pre-requisite)	High values of NDVI
M2	**M2: Loss of vegetation**	Break in NDVI (decrease)
M3	**Loss of vegetation**	Break in backscatter ratio (increase)
M4	**Low/no vegetation**	High values of backscatter ratio
M5	**Low/no vegetation (stable conditions)**	Break in VV Coherence (increase) or high values of VV Coherence
MARKERS FOR DECLARED PRATICES		
M6	**Presence of vegetation**	High values of NDVI
M7	**Growth of vegetation**	Break in NDVI (increase)
M8	**No loss of vegetation**	No break in NDVI (decrease)
M9	**No loss of vegetation**	No increase of the backscatter ratio
M10	**Presence of vegetation (dynamic conditions)**	No Break in VV Coherence (increase) and no high values of VV Coherence

European Space Agency

Environmental Focus Area agricultural practices
Harvest and catch crop monitoring

E.g. Netherlands 2019 (parcel with winter wheat, 2.5 ha)
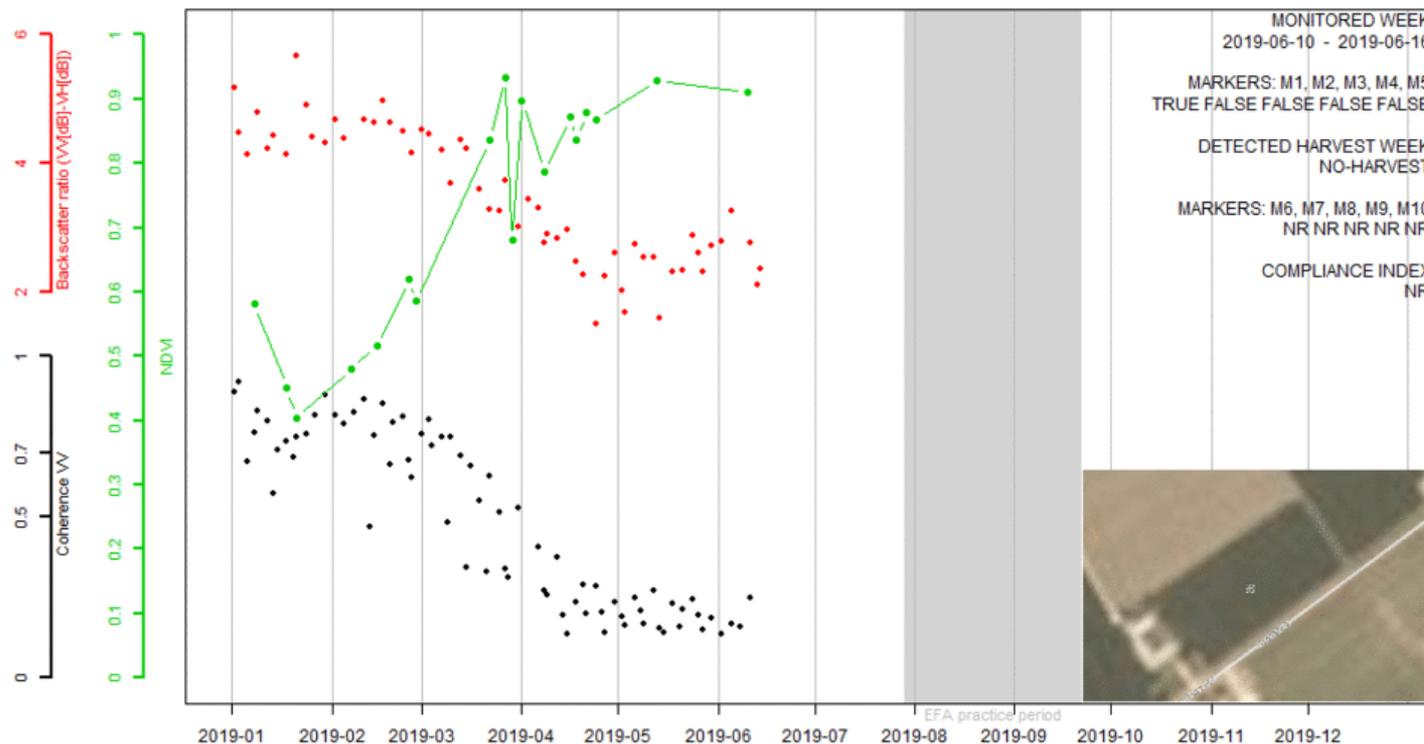
Evolution of harvest detection in 2019

Evolution of the percentage of the harvested parcels (confirmed harvest week) in 2019
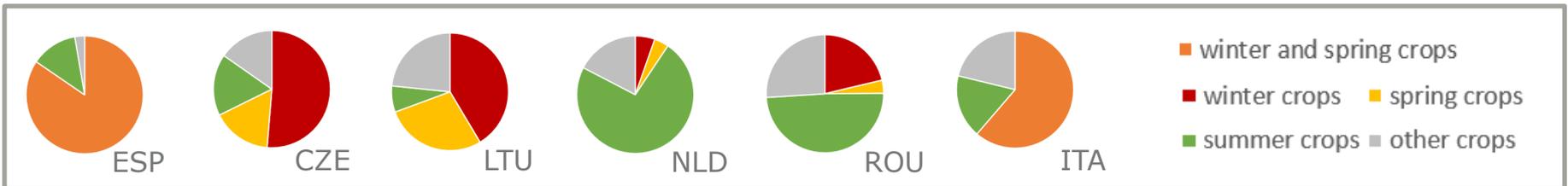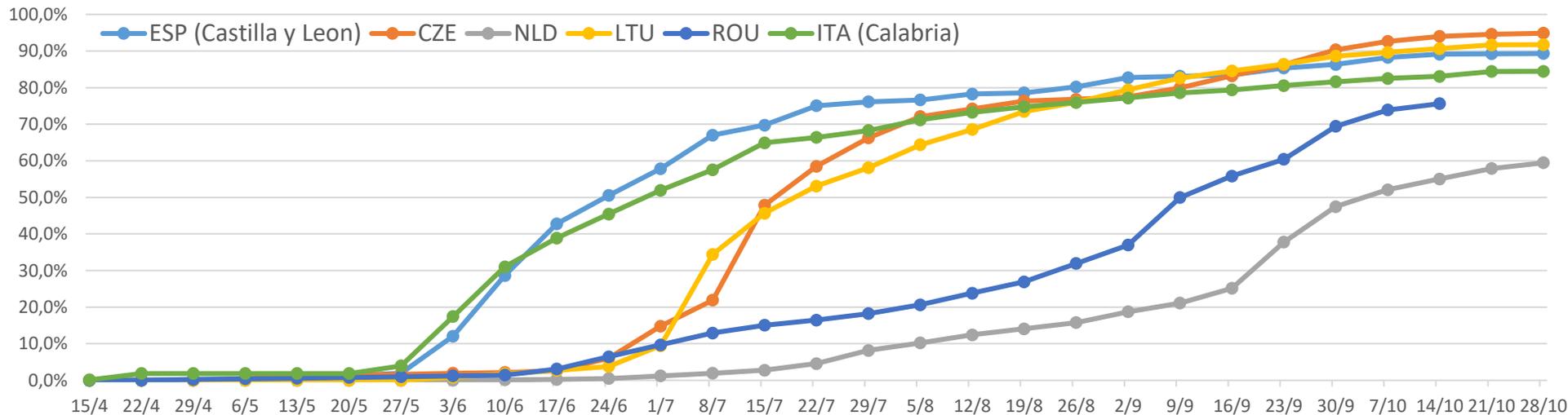
Detection of tillage applied after the harvest of the main crop, using „harvest" markers

- Based on NDVI, backscatter ratio and coherence VV

  (1) NDVI should remain low throughout this process

  (2) The backscatter ratio should remain high/increasing throughout this process

  (3) Coherence should increase during/after harvest, decrease after ploughing/tilling and finally increase again to a stable condition

id: 49432, orig_id = 1011868272-044514-3448-1,   practice: 2020-09-01 - 2020-10-15,   harvest: 2020-08-03 - 2020-08-09
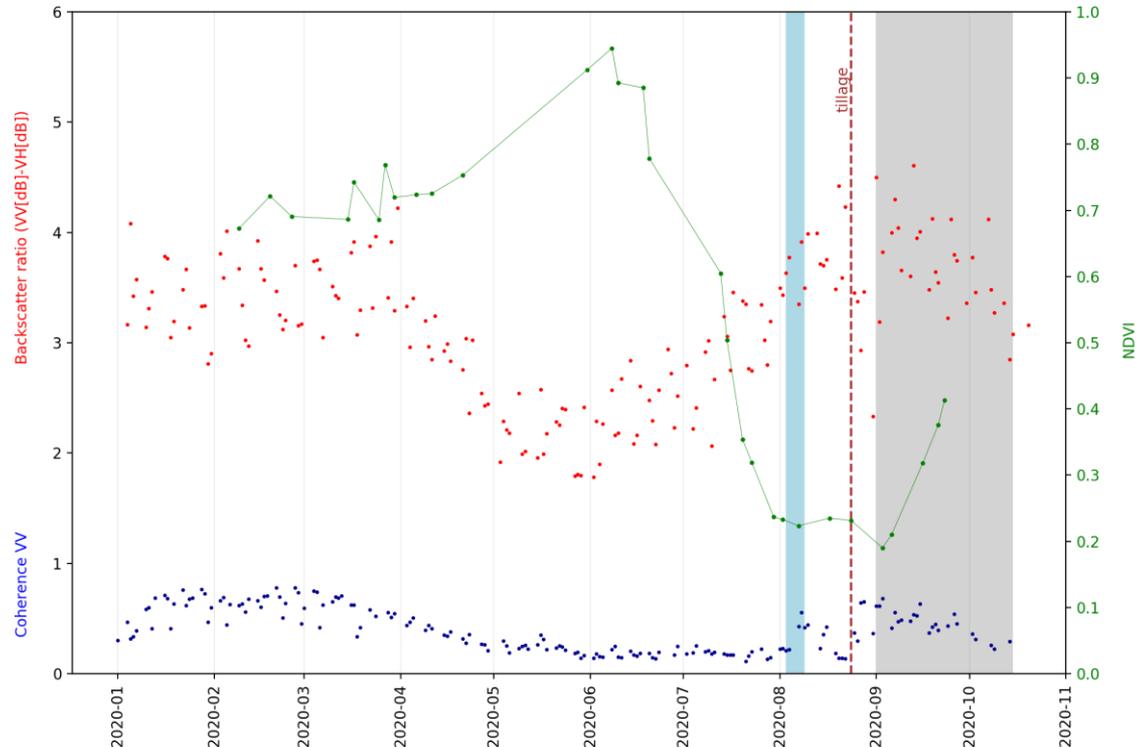
Sen4CAP: from an ESA project to a toolbox

Design and prototyping	Demonstration and validation	User uptake and system evolution
2017 – local sites	*2018 & 2019 – national NRT*	*2020, 2021 …*

Design and prototyping

- Use cases selection
- Products Specifications
- Benchmarked Methods
- Algo & System design
- Prototype products
- Validation
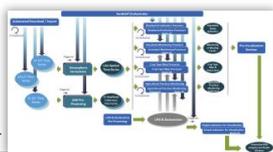
Demonstration and validation

- Use cases demonstration
- National scale
- Continuous monitoring
- Validation & Fitness-to-use assessment
- Capacity building and training
- System qualification

User uptake and system evolution
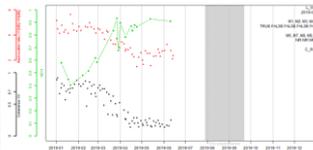
- 330 downloads and 20+ Paying Agencies testing the system on CREODIAS
- Training with 44 participants from 20 different countries
- Webinars every month
- Support to users
- System evolution

2020 uptake by Sen4CAP Pilot Countries

Spain (Castilla y Leon)

Sen4CAP **run in their own premises by the Paying Agency**

Netherlands – Italy

Sen4CAP **operated by the Paying Agencies on CREODIAS** with our support
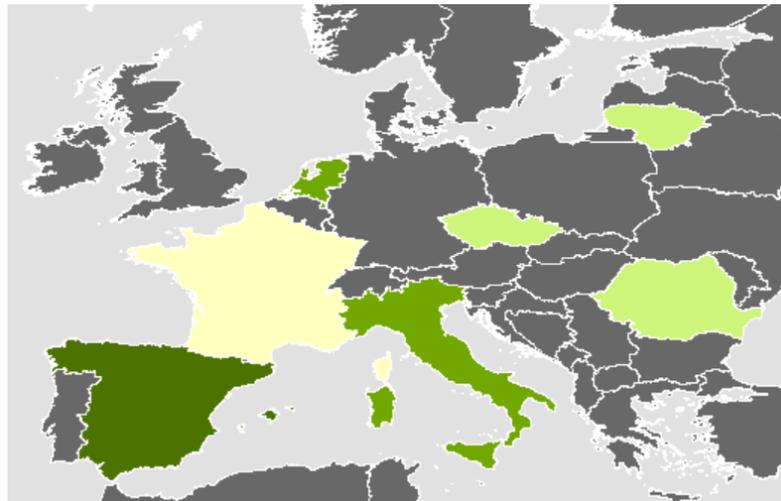
Czech Republic – Lithuania – Romania

Sen4CAP **operated by the consortium**

Better understanding of the **Sentinel added-value** for their future system

France

Linking with NIVA

Italy: Sen4CAP running on 6 sites

- Pre-processing
- Crop type mapping
- Grassland mowing detection

Vercelli

Udine, Pordenone

Viterbo, Macerata, Perugia, Ancona

Foggia, Campobasso, Benevento, Chieti

Bari, Matera, Cosenza, Crotone

Caltanissetta

European Space Agency

Czech Republic: Sen4CAP activities supporting the move to the check by monitoring

E.g. L4A validation

3. L4A CROP DIVERSIFICATION – VALIDATION RESULTS

- FALSE POSITIVE AND FALSE NEGATIVE VALUES (CROP DIVERSIFICATION COMPLIANCE ASSESSMENT)

SZIF
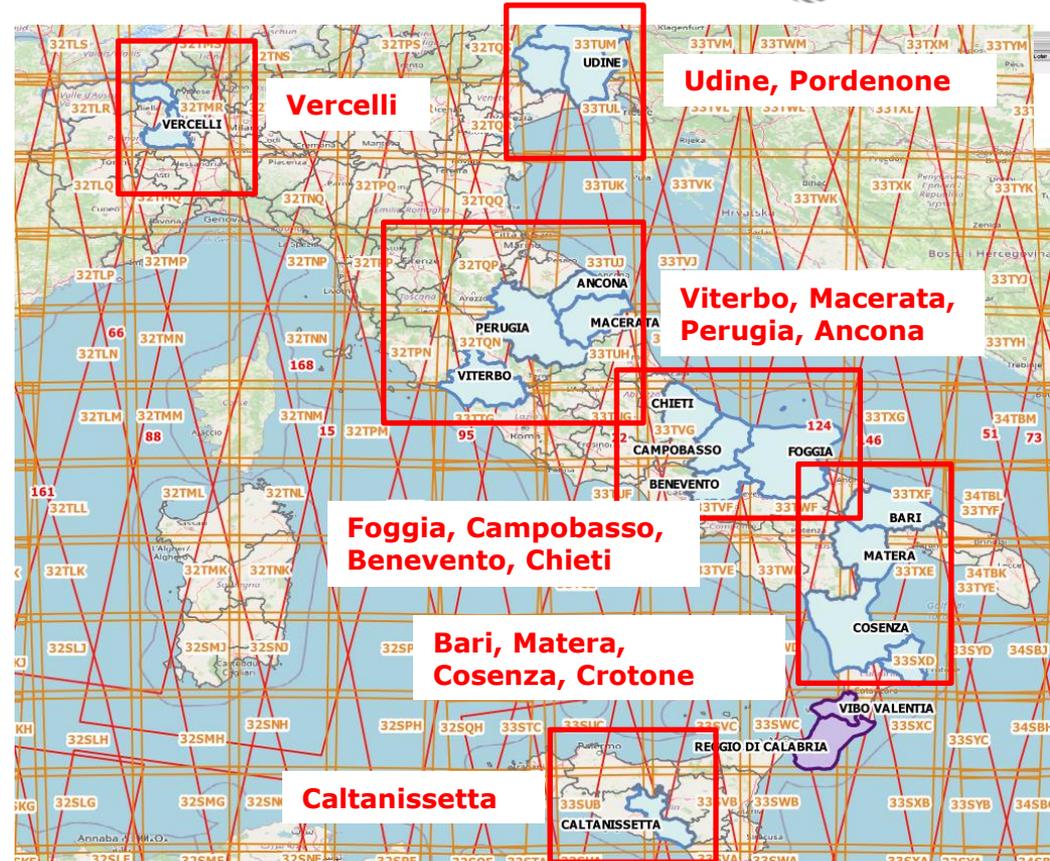Státní zemědělský intervenční fond

Crop diversification assessment Sen4CAP L4A (amount of farmers)	Crop diversification assessment classical OTSC (amount of farmers)					
	YES	% value	NO	% value	Extemption	% value
Compliant	389	82,2 %	1	0,2 %	1	0,2 %
Missing_info	65	13,7 %	3	0,6 %	2	0,4 %
Not_compliant	3	0,6 %	1	0,2 %	0	0 %
Not_required	5	1,1 %	0	0 %	3	0,6 %

Note.: Due to the rounding, the sum up valued does not equal to 100 %.

❑ **FALSE POSITIVE (false red) value: α = 1.7 %**
❑ **FALSE NEGATIVE (false green) value: β = 0.4 %**
❑ **Very satisfactory results;**

3. L4A – SUMMARY OF VALIDATION

SZIF
Státní zemědělský intervenční fond

➤ **Very satisfactory results for both products** (crop classification, crop diversification);

➤ **Applicable for the operational use;**

➤ **High valuable for determining national rules on CbM** (including specific use-cases);

➤ **High valuable as an input for functional and technical specifications for the tailored (CZ) solution;**

➤ **Minor recommendations provided to the Sen4CAP team based on the validation outcomes;**

WITH THE PERMISSION OF SZIF

European Space Agency

In 2020, wide user uptake

- 330 downloads of the Sen4CAP system since November 2019
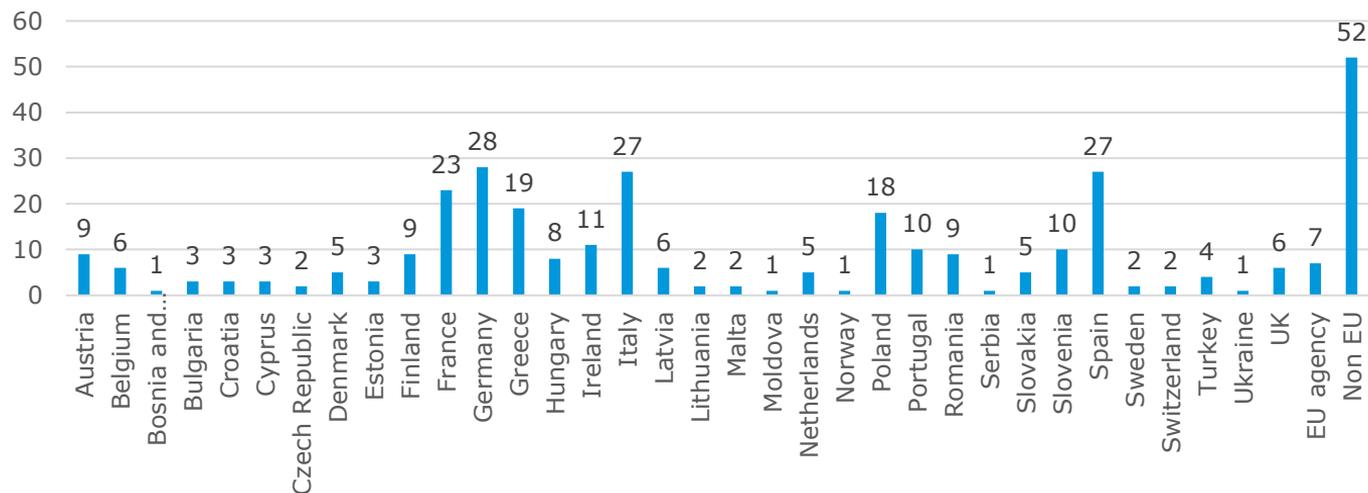
- 20+ Paying Agencies testing Virtual Machines on CREODIAS granted by the project to discover Sen4CAP and assess its fitness-to-use

- DIAS offering Sen4CAP as a service

https://creodias.eu/-/sen4cap

Sen4CAP Fir

European Space Agency
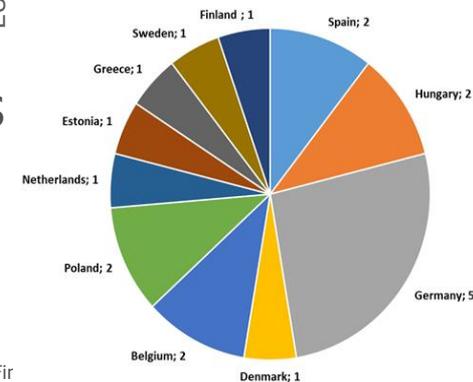
Sen4CAP uptake by external users
E.g. with Denmark: maize harvest analysis - 2019

- 1 Sentinel-2 tile

- Using L4C S1 and S2
  « harvest » markers

Listen to the 5th webinar recording
http://esa-sen4cap.org/content/presentations

	Sen4CAP			Producer´s accuracy
	Harvest	No harvest	Total	
Road side observations Harvest	158	55	213	**74%**
No harvest	0	10	10	**100%**
Total	158	65	223	
User´s accuracy	**100%**	**15%**		

➢ Maize harvest can be predicted with high user´s and producer´s accuracies at the end of the season

➢ Lower accuracy for "non harvest"

➢ Promising results to be confirmed over larger area

SOURCE: DANISH PAYING AGENCY PRESENTATION FROM THE 5TH SEN4CAP WEBINAR

Capacity building & User support (1/2)

Physical & online hands-on training

> Belgium (Jan. 2020): 44 participants from 20 different countries

> Methodologies + hands-on

> Online training in Apr. 2020
> 100 + participants, 2 repeated sessions

> All resources available online

http://esa-sen4cap.org/content/resources

Home   About ⌄   Data & Tools ⌄   Resources ⌄   News   Fo

Technical documents

Presentation

Data

Videos

Resources

The following Sen4CAP project related documents can be downloaded from this site:
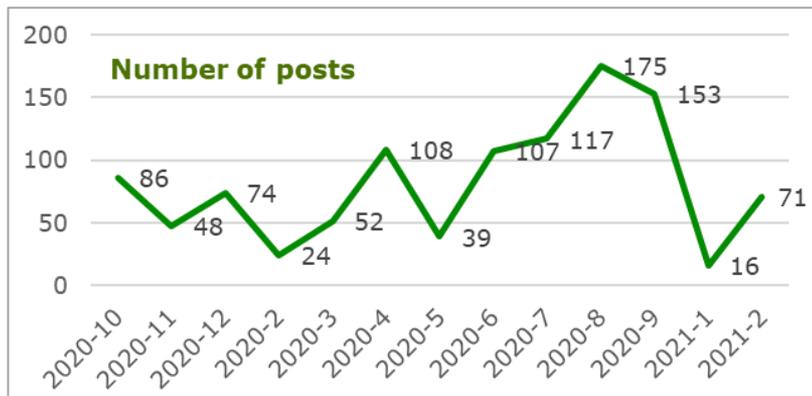
- **Presentations** given at conferences or Sen4CAP trainings
- **Technical documents** to support the use of the Sen4CAP system and products
- **Data** - sample data for an easier start of using Sen4CAP system

Capacity building & User support (2/2)

Online forum

https://forum.esa-sen4cap.org/

➢ 90 active users

Individualized support

Frequently Asked Question webpage

Regular webinars and Q&A sessions

➢ 60 to 150 participants each time

➢ External presenters

Integration of new DEM for Northern countries
System evolution based on users' request

- Sentinel-1 and Sentinel-2 pre-processing based on SRTM – up to 60°N

- Modules updated to be compatible with alternative DEMs*:
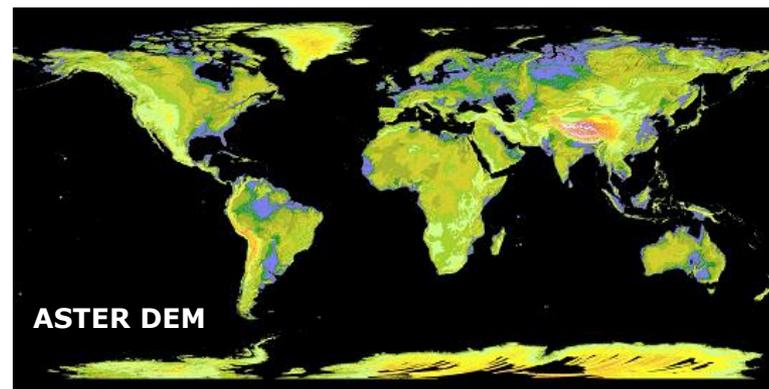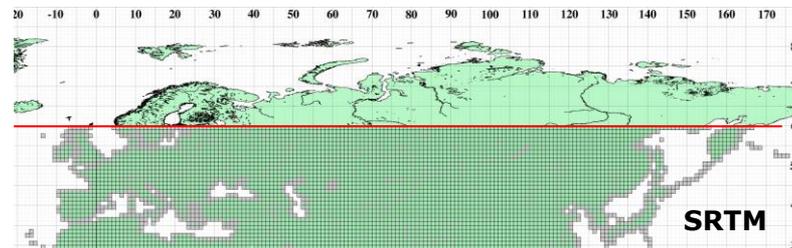
  - Copernicus EU DEM
    - Coverage: EEA39 region
    - 1000km x 1000km tiles, EPSG:3035
    - 10m spatial resolution

  - Aster DEM v3
    - Coverage: 83°S - 83°N
    - 1°x1° tiles, EPSG:4326
    - 30m spatial resolution

* EU DEM is available only for Sentinel-2 pre-processing

SRTM

ASTER DEM

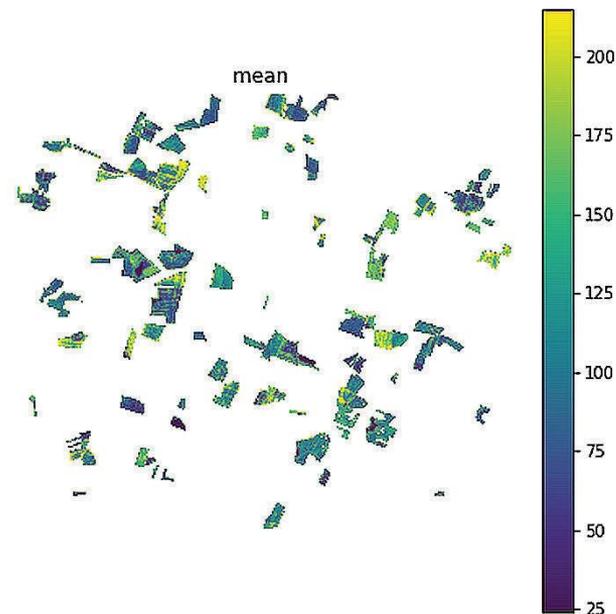# Building links between Sen4CAP and NIVA projects

- Sen4CAP in NIVA in different use cases

E.g. using Sen4CAP markers and products for agri-environmental indicators – done by NIVA French partners (ASP, IGN, CESBIO, DYNAFOR, LBAE)

=> Extending the use of Sentinel data and Sen4CAP to the 2nd pillar
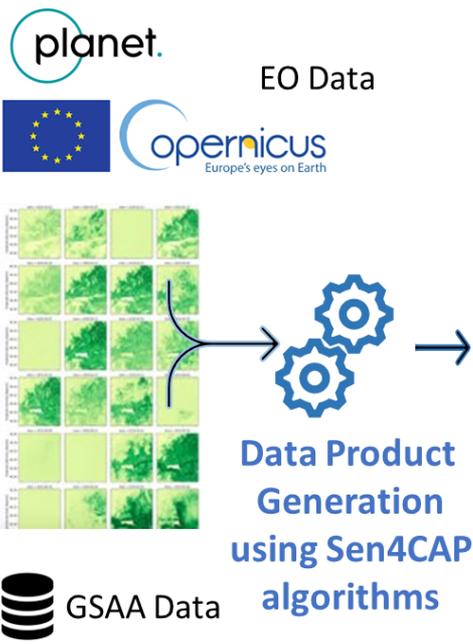
See presentation from France

Mapping of net CO_2 fluxes on wheat plots carried out with the TIER-3 method (SAFY-CO2 model) over southwestern France using Sentinel-2 and Venµs data.
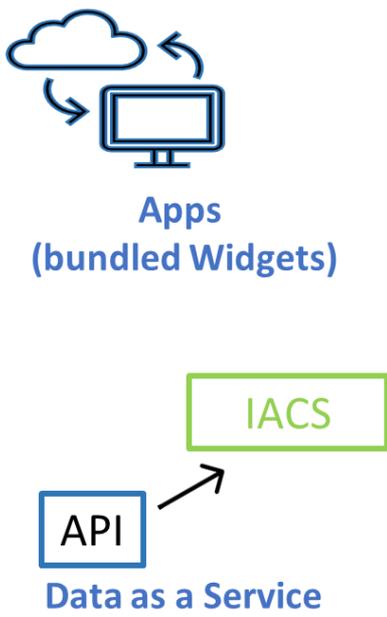
Source: CESBIO in Theia bulletin 13 (Sep 2020)

Sen4CAP as starting point in ESA EO-Widget project

EO-WIDGET Data Products	ID
Signal as a Service	EO-2.3
Vegetation Status Indicator	EO-3.1
Marker as a Service	EO-3.2
Cultivated Crop Type Product	EO-4.1
Grassland Mowing Product	EO-4.2
Harvest Detection Product	EO-4.3
Land Fallow Product	EO-4.4
Winter Catch Crop / Nitrogen Fixing Crop Map	EO-4.5
Intercropping Product	EO-4.6
Biodiversity Strips Map	EO-4.7

EO Data

Data Product Generation using Sen4CAP algorithms

GSAA Data

Apps (bundled Widgets)

IACS

API

Data as a Service

Sen4CAP in RACE initiative from EC and ESA

Rapid Action Coronavirus Earth observation dashboard platform

COVID19 impact on agricultural production
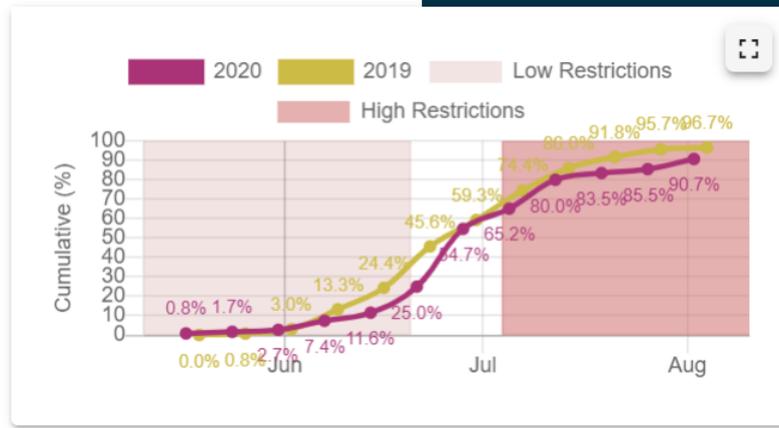### Verification of delay or disruption of winter cereals harvesting in Spain

National coverage, running on DIAS, weekly monitoring of "harvest" markers

**Harvest evolution over time + Comparison with 2019**

Lessons learned
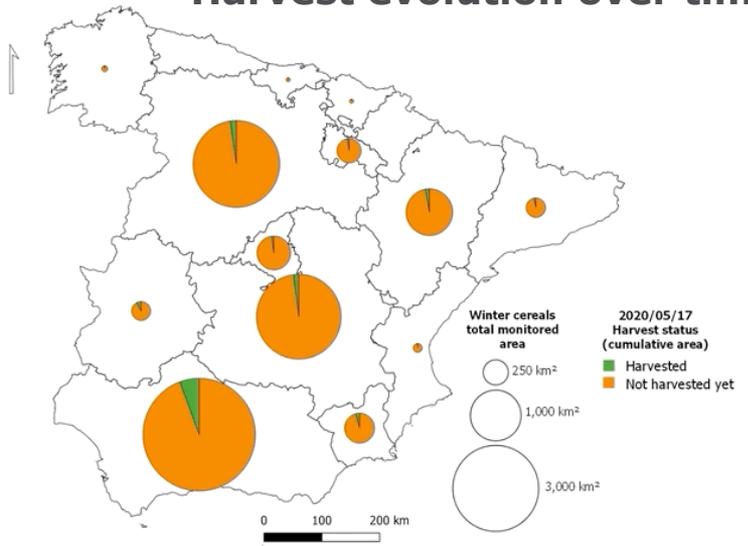
- Sen4CAP **open source system**, providing **markers** from Sentinel-1 and Sentinel-2 time series at the **parcel-level along the year**

  - ✓ Sentinel markers and EO **products usefulness assessed nation-wide** through selected use cases in 7 pilot countries (2018-2019-2020)

  - ✓ Near-real time or off-line production; running on the cloud or locally

- Sen4CAP as a **modular** system with a **markers database** open the floor for new applications supporting a more sustainable agriculture (building blocks for specific monitoring systems)

- Wide uptake of the Sen4CAP modules and system

  - ✓ 330 downloads and 20+ Paying Agencies testing the system

  - ✓ Strong effort in **capacity building to support this uptake** (training, forum, webinars, etc.)

  - ✓ System maintenance will be ensured in the **ESA Agricultural Virtual Lab**

  => Long-term <u>user support</u> and <u>tools maintenance</u> are key conditions to allow technologies transfer (uptake is a long process that needs multiple changes)

# Sen4CAP as a powerful tool supporting the process of moving towards the development of monitoring systems
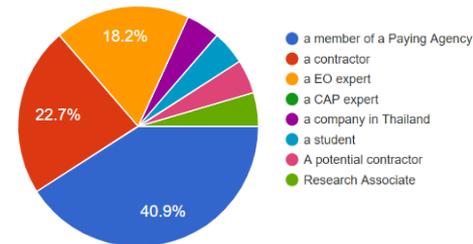
Did you already start testing some elements of the Sen4CAP system??

- Yes, the full system
- Yes, only some specific elements
- No

50% / 45.5%
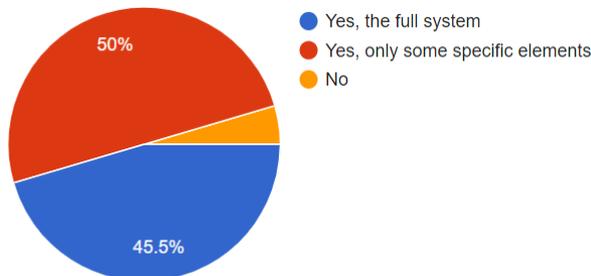
Do you consider to make use of some elements of the Sen4CAP system for your future monitoring system ?

- Yes
- Understanding the Sen4CAP approach was inspiring but I will not use it
- No

81.8% / 18.2%
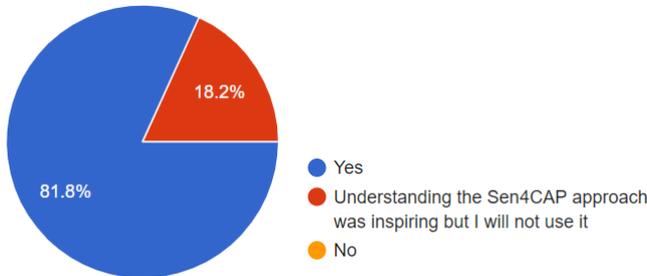
Did you already attend a Sen4CAP hands-on training, a Sen4CAP webinar or other event (training, Q&A session)?

- Yes
- No

95.5%
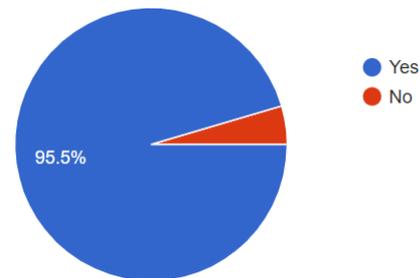
Sen4CAP contributing to the uptake and implementation of the new CAP paradigm through a collaborative approach, sharing knowlegde and learning lessons
Thank you to all of you and let's discuss how continuing this effort!

European Space Agency

**Thank you for your attention
and your contribution**

sen4cap
common agricultural policy