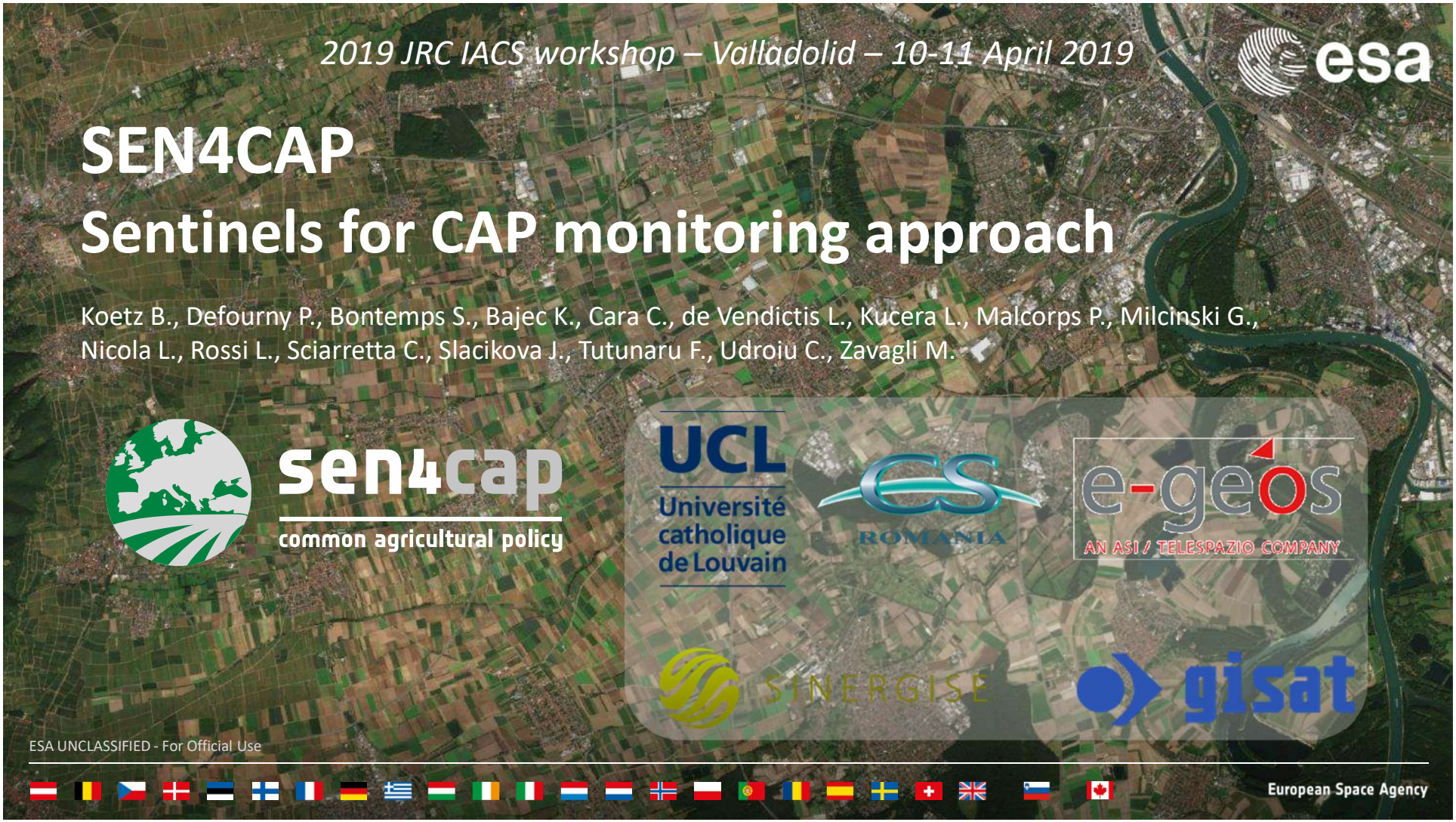
2019 JRC IACS workshop – Valladolid – 10-11 April 2019
esa
SEN4CAP
Sentinels for CAP monitoring approach
Koetz B., Defourny P., Bontemps S., Bajec K., Cara C., de Vendictis L., Kucera L., Malcorps P., Milcinski G., Nicola L., Rossi L., Sciarretta C., Slacikova J., Tutunaru F., Udroiu C., Zavagli M.
sen4cap
common agricultural policy
UCL
Université catholique de Louvain
CS ROMANIA
e-geos
AN ASI / TELESPAZIO COMPANY
SINERGISE
gisat
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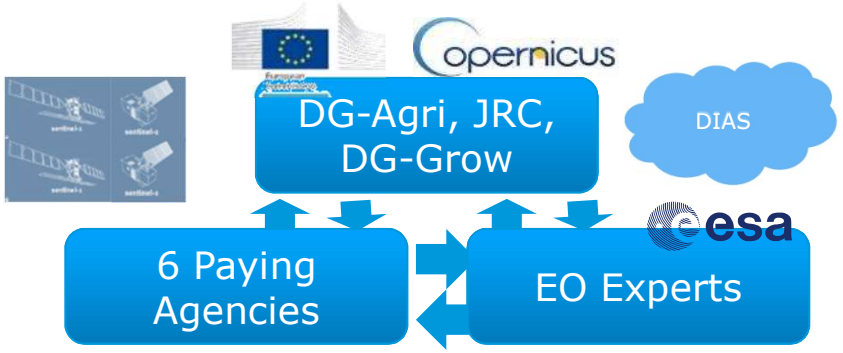
European Space Agency

CAP monitoring approach – Technology meets Policy

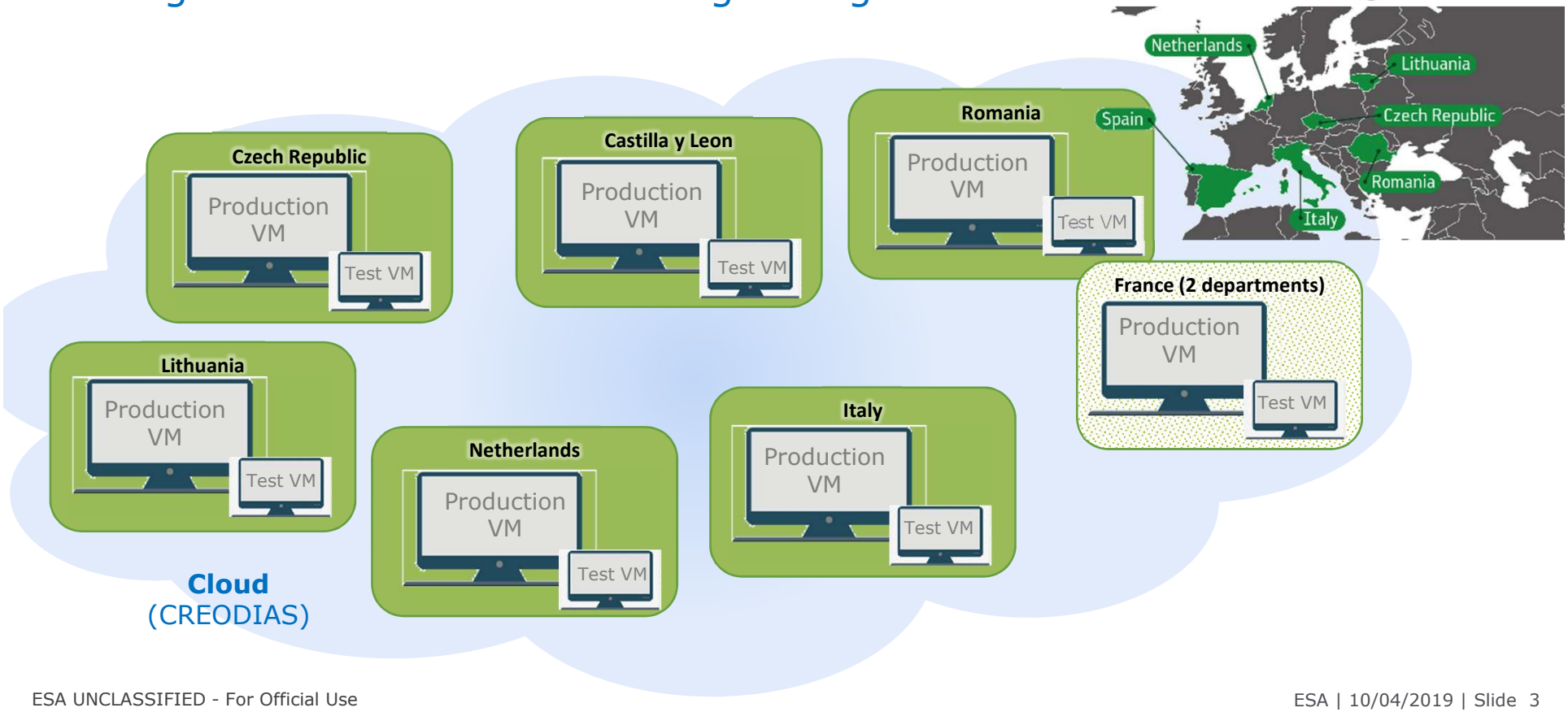
sen4cap
common agricultural policy



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 just started for 6+1 Paying Agencies running on distinct DIAS VMs along the agricultural season

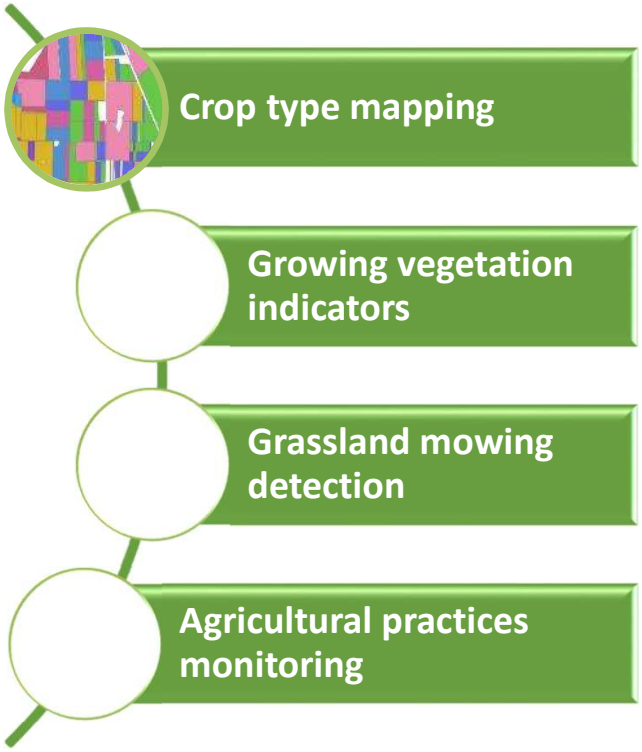


User Requirements in terms of IACS use cases

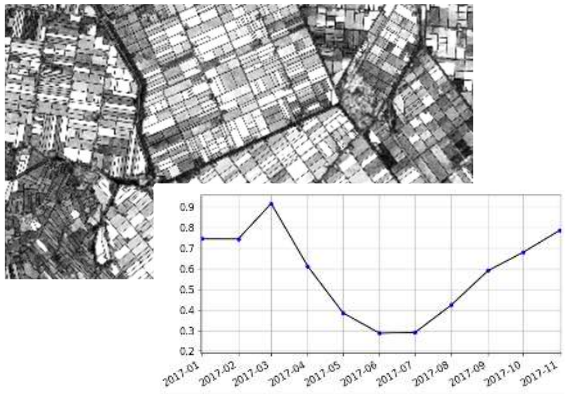
Use cases
Crop diversification
Permanent grassland monitoring
EFA-Land lying fallow
EFA-Catch crops
EFA-Nitrogen-fixing crops
Land abandonment
Interactive visualization
LPIS update
Claimless system

Use Cases
w/ Paying Agencies

Sentinel-derived indicators and markers – crop type

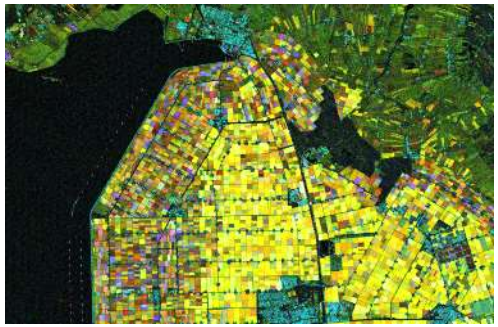


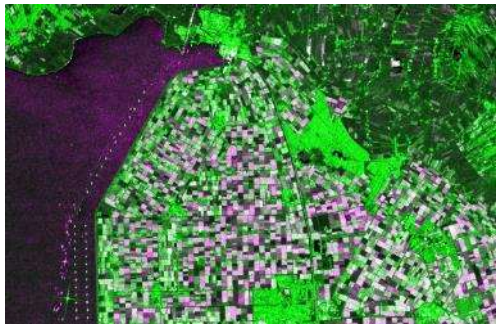
S2 time series data (May – Sep), CZE



Monthly coherence over a Winter Wheat field (Netherlands)

S1 composite of temporal features, NDLS





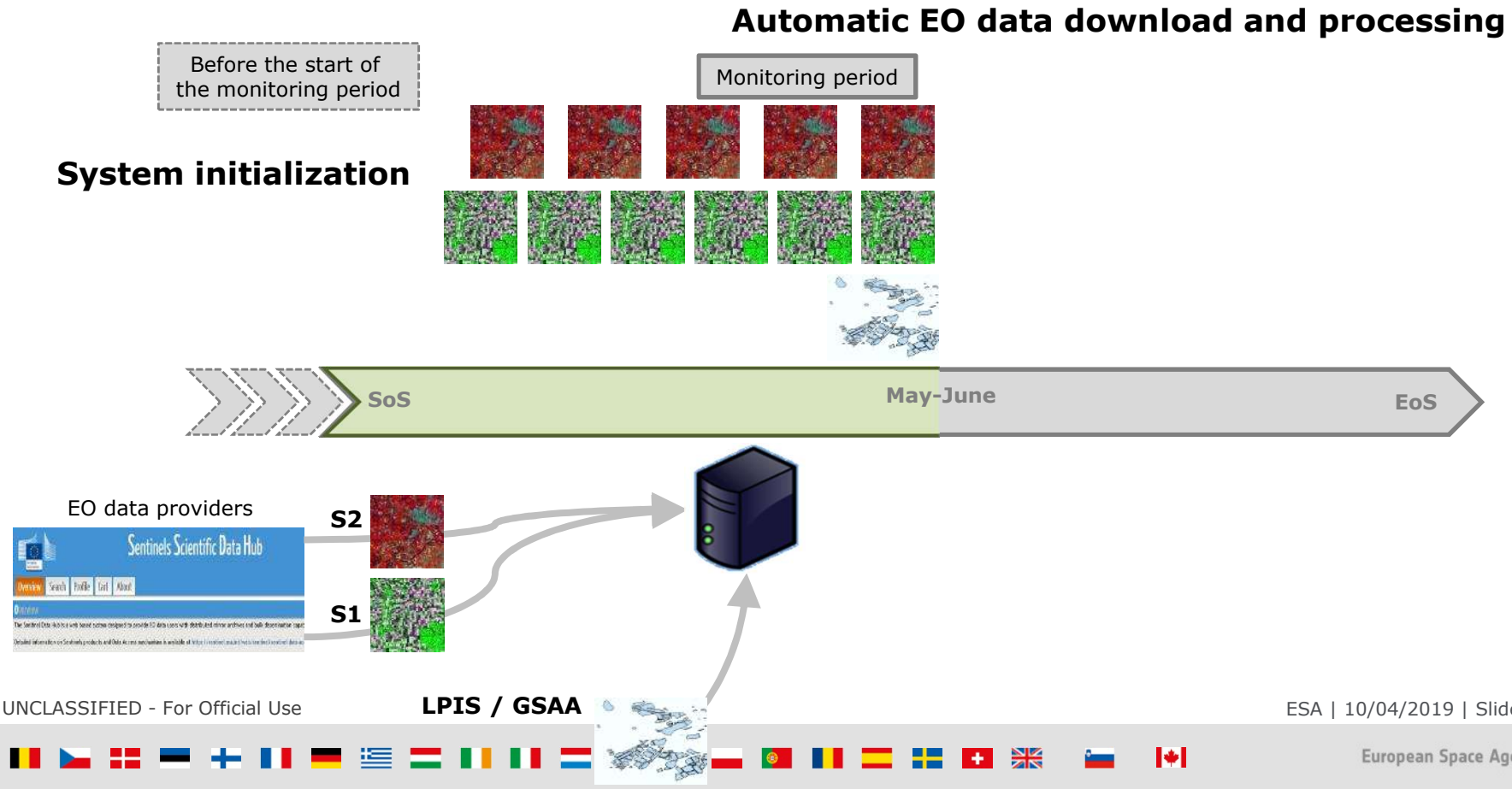
Large dataset from Sentinel-1 & 2 for a national coverage

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 pixel)
5 weekly object-based metrics + temporal features

Sen4CAP system - crop type identification



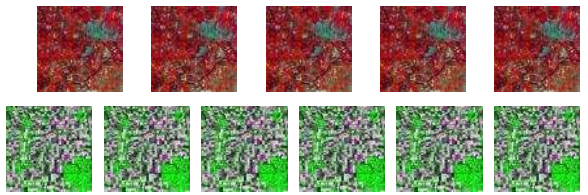
Sen4CAP system - crop type identification

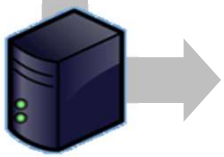
Automatic EO data download and processing

Before the start of the monitoring period

System initialization

Monitoring period



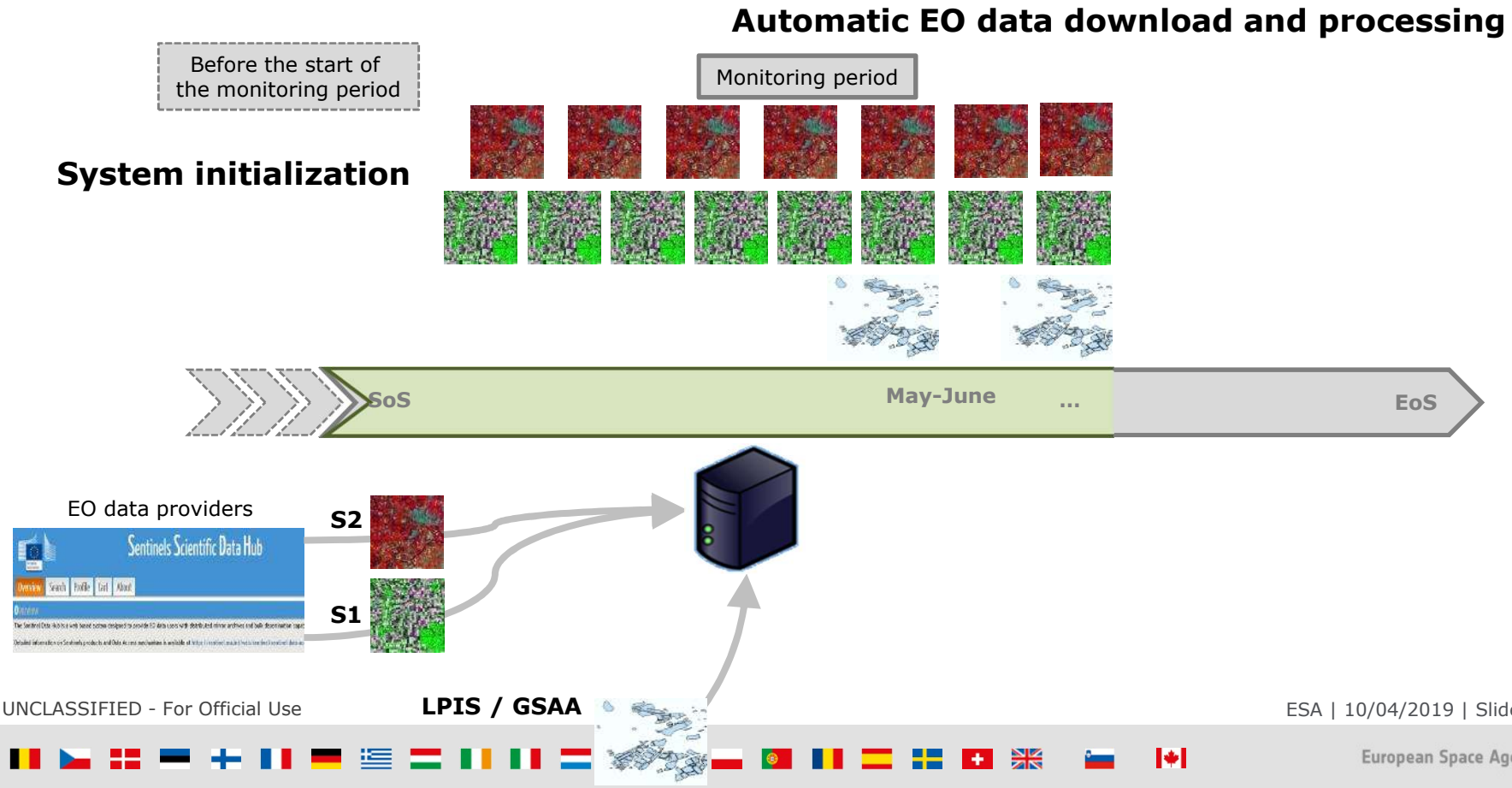


EO data providers

S2

S1

Sen4CAP system - crop type identification



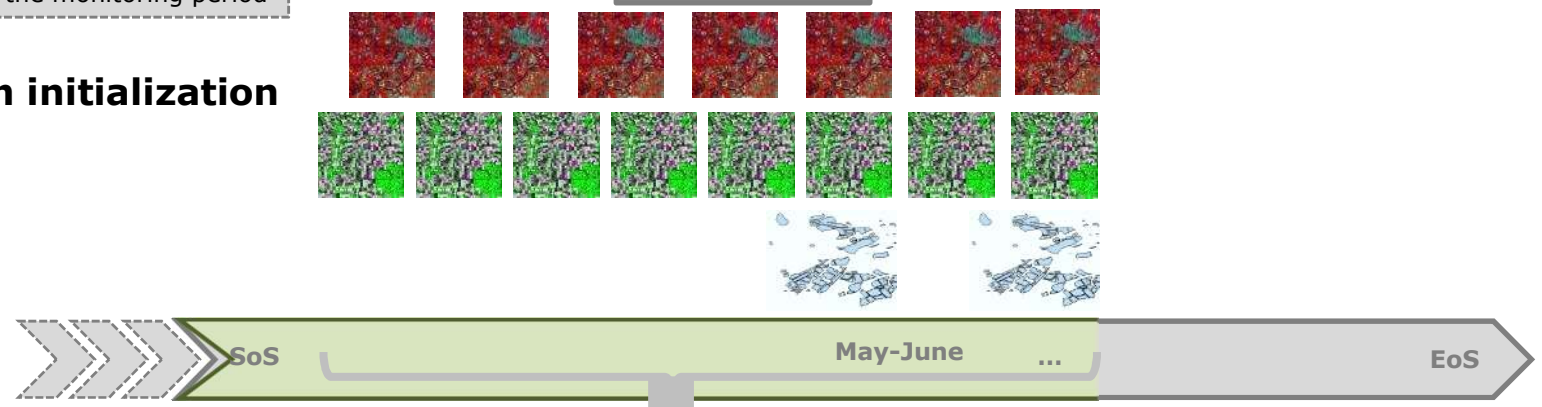
Sen4CAP system - crop type identification

Automatic EO data download and processing

Before the start of the monitoring period

System initialization

Monitoring period



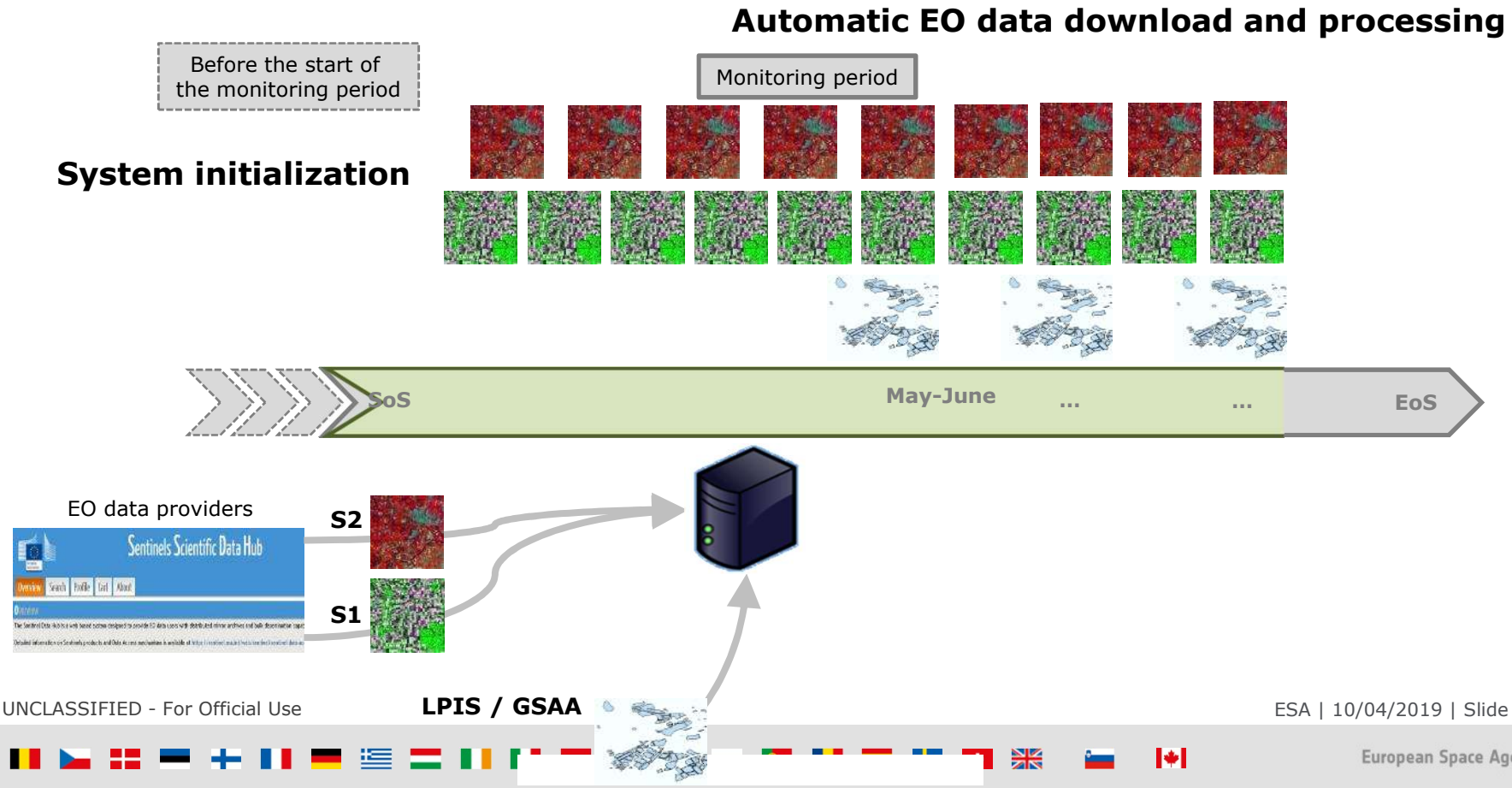
EO data providers

S2

S1

LPIS / GSAA

Sen4CAP system - crop type identification



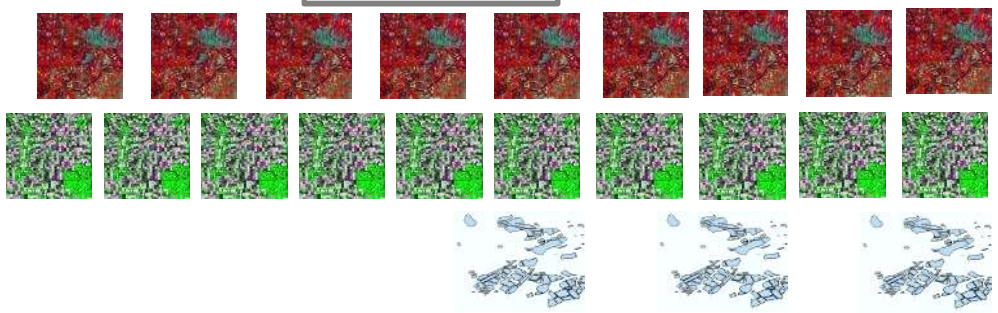
Sen4CAP system - crop type identification

Automatic EO data download and processing

Before the start of the monitoring period

System initialization

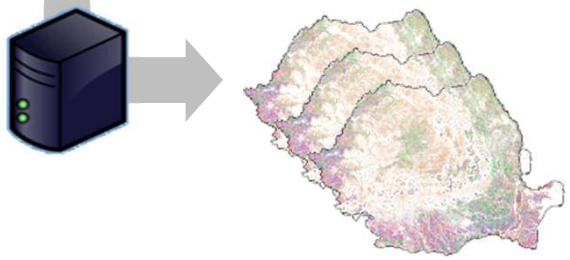
Monitoring period



EO data providers

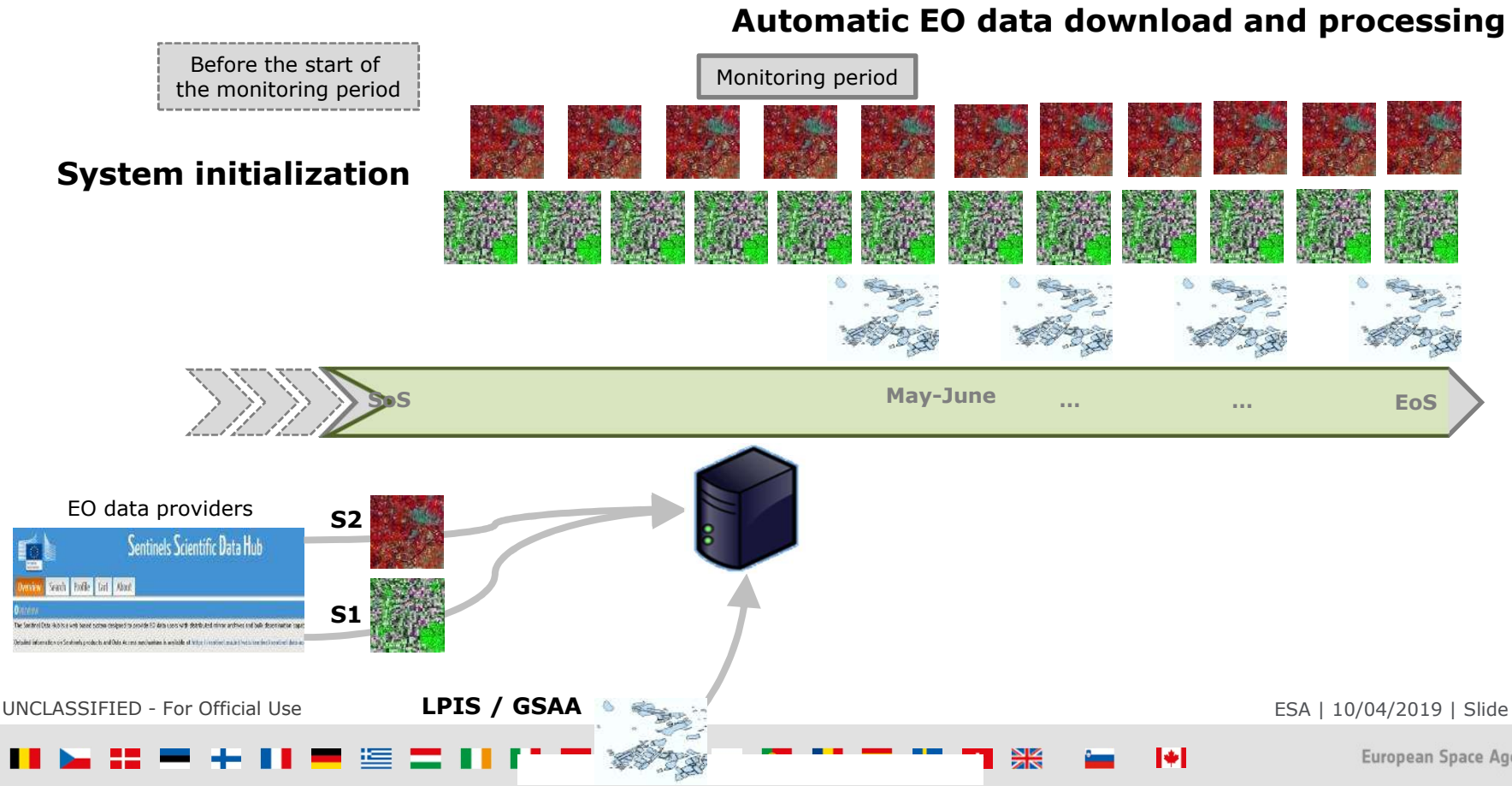
S2

S1



LPIS / GSAA

Sen4CAP system - crop type identification



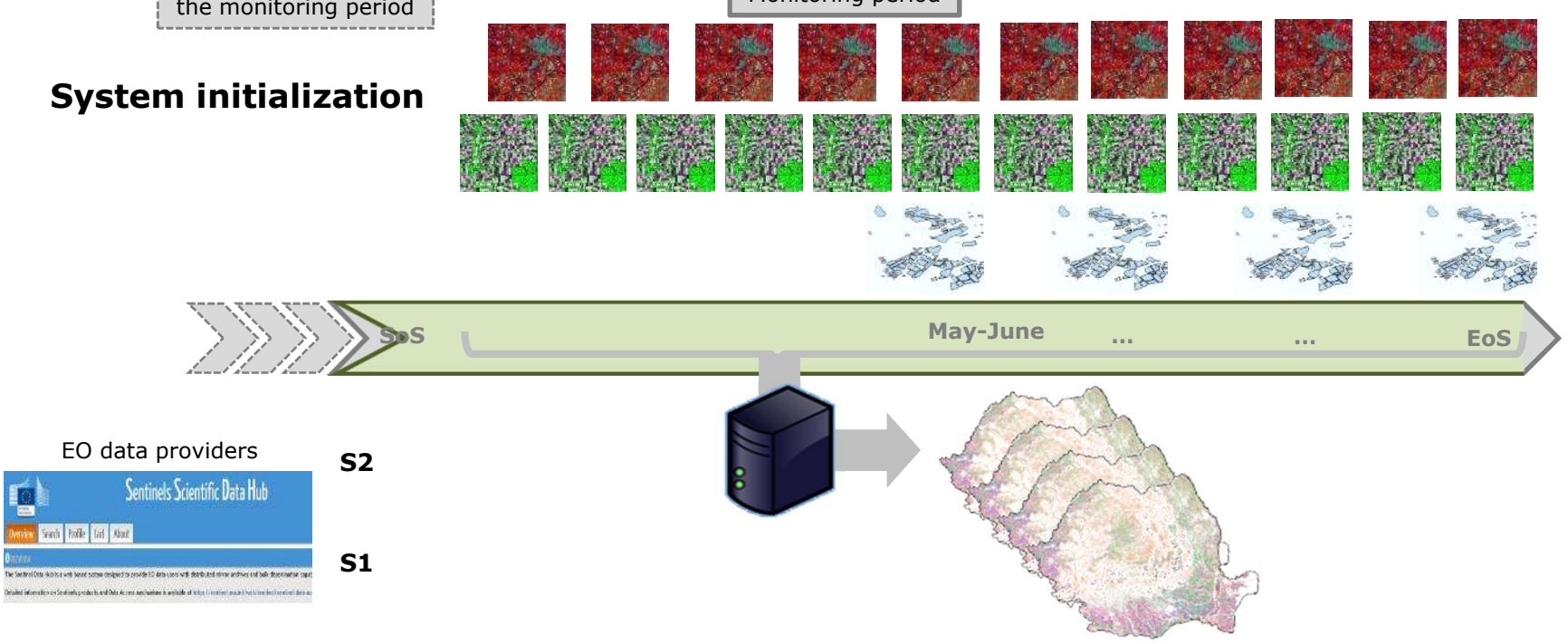
Sen4CAP system - crop type identification

Automatic EO data download and processing

Before the start of the monitoring period

Monitoring period

System initialization



EO data providers

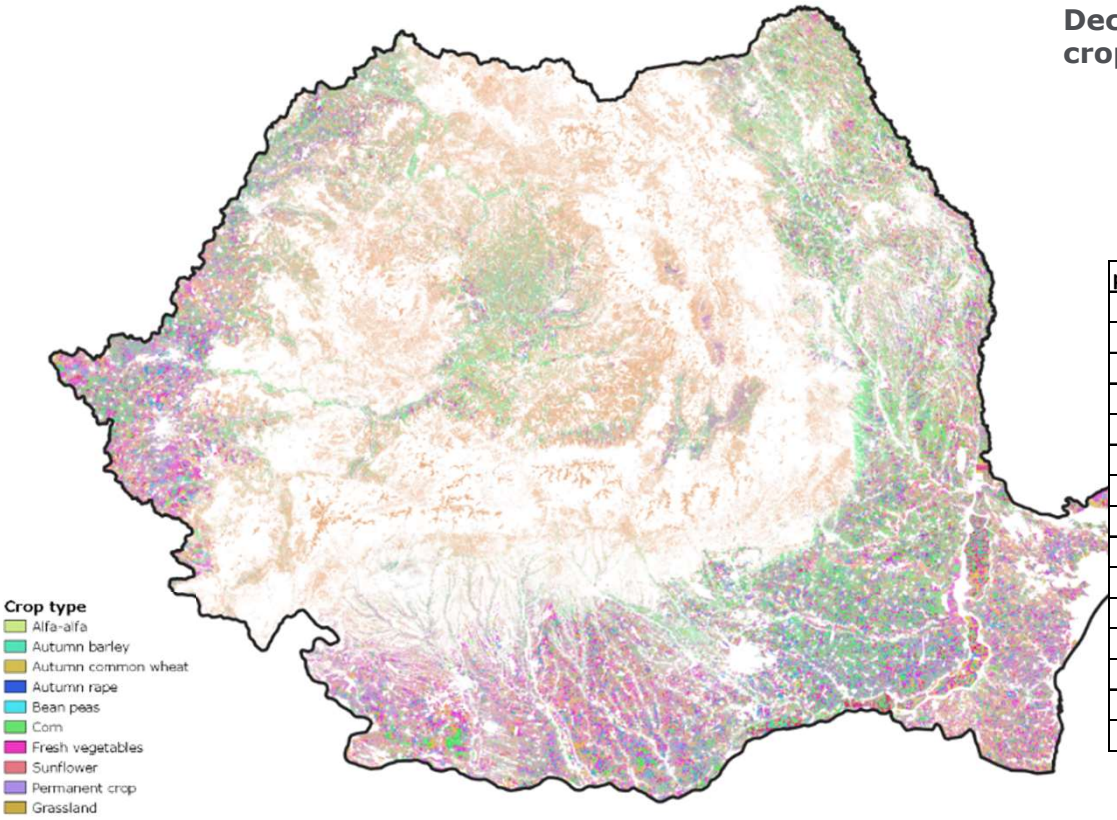
S2

S1

LPIS / GSAA

2018: National crop type mapping over 6 countries

Example – Romania (100+ crop types)



Declared crop type

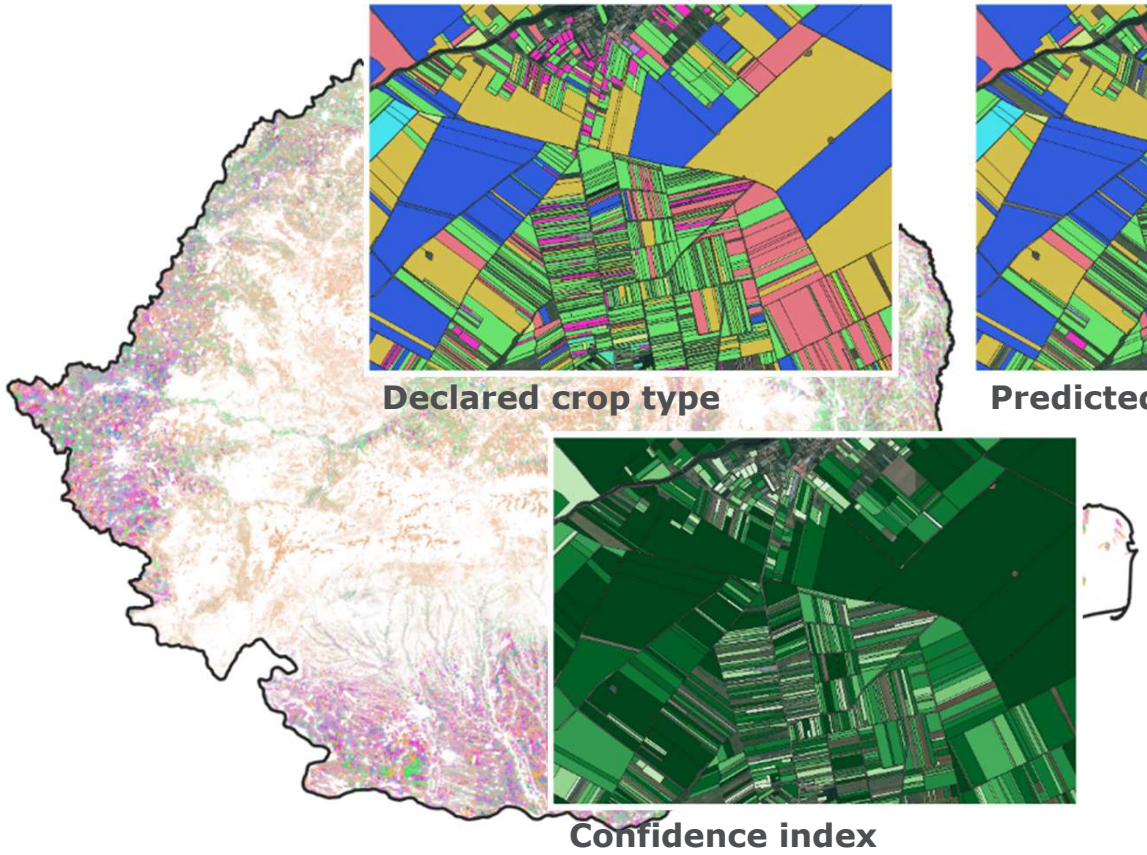
1st prediction and confidence level

2nd prediction and confidence level

parcel_id	crop_code	CT_decl	CT_pred_1	CT_conf_1	CT_pred_2	CT_conf_2
158568	101	8	8	0,941	31	0,011
158583	2037	126	126	0,868	8	0,073
158598	131	31	31	0,247	137	0,21
158613	450	0	0	0	0	0
158628	9748	2	3000	0,398	2	0,339
158643	978	49	3000	0,532	2	0,2
158658	974	2	2	0,415	3000	0,326
158673	978	49	31	0,315	137	0,154
158688	106	7	7	0,944	8	0,027
158703	607	3000	3000	0,889	200	0,022
158718	101	8	12	0,616	8	0,124
158733	202	12	12	0,861	3000	0,067
158748	202	0	0	0	0	0
158763	606	3000	3000	0,846	200	0,028
158778	607	3000	3000	0,798	2000	0,074

2018: National crop type mapping over 6 countries

Romania (100+ crop types)



Declared crop type

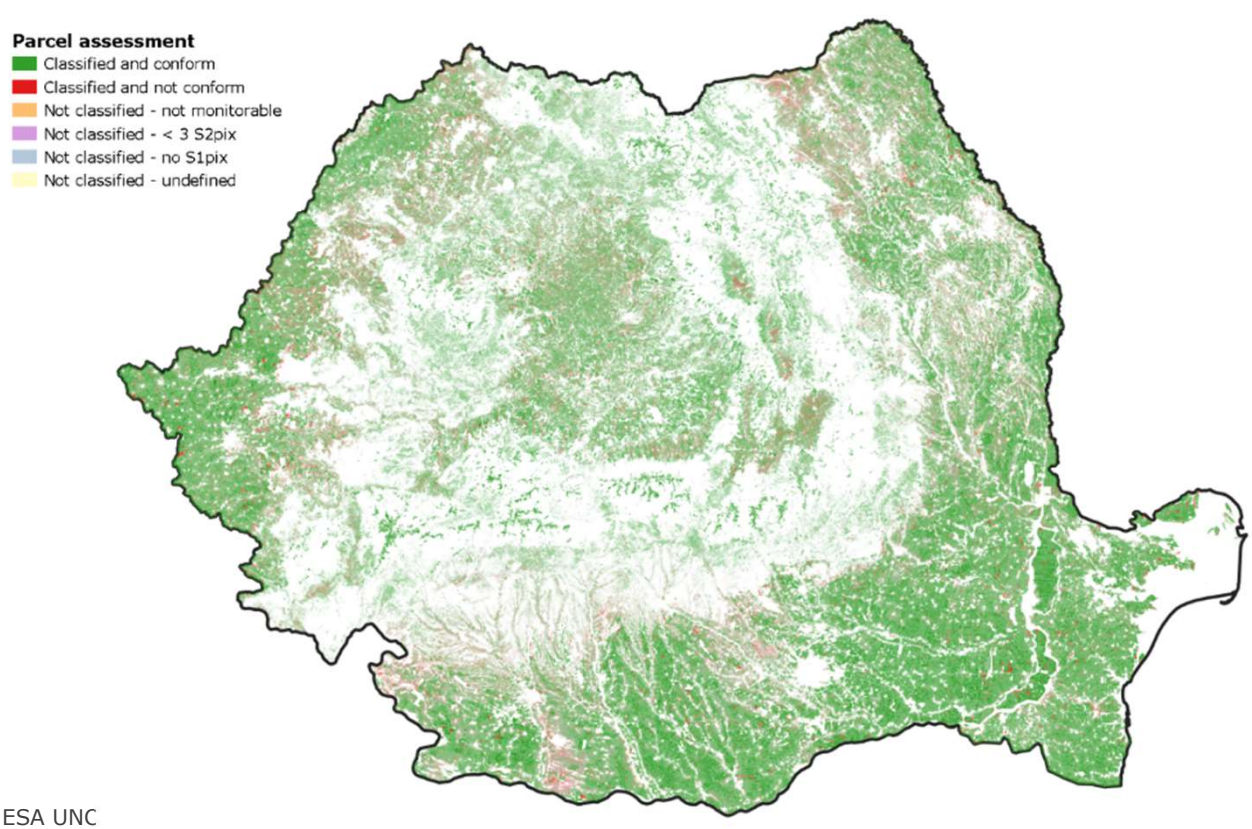
Predicted crop type

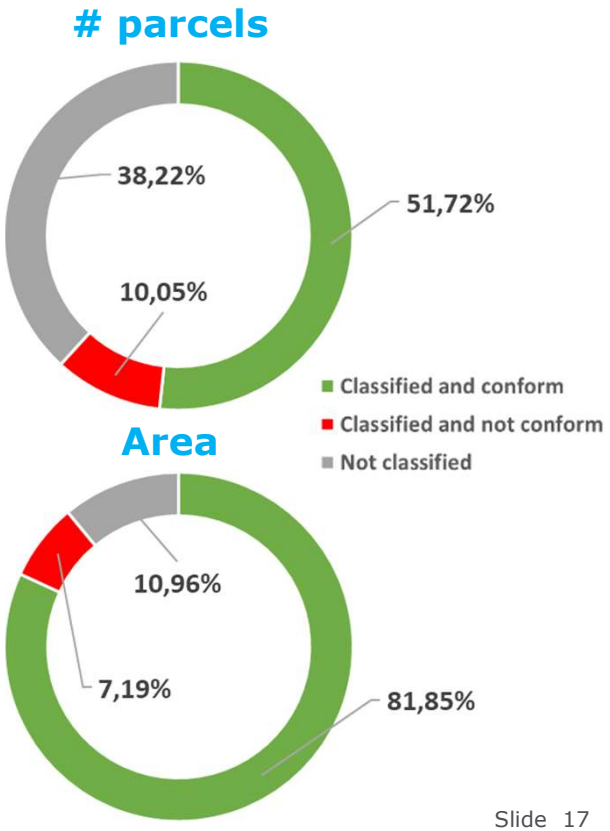
Confidence index

Conformity assessment

2018: National crop type mapping over 6 countries

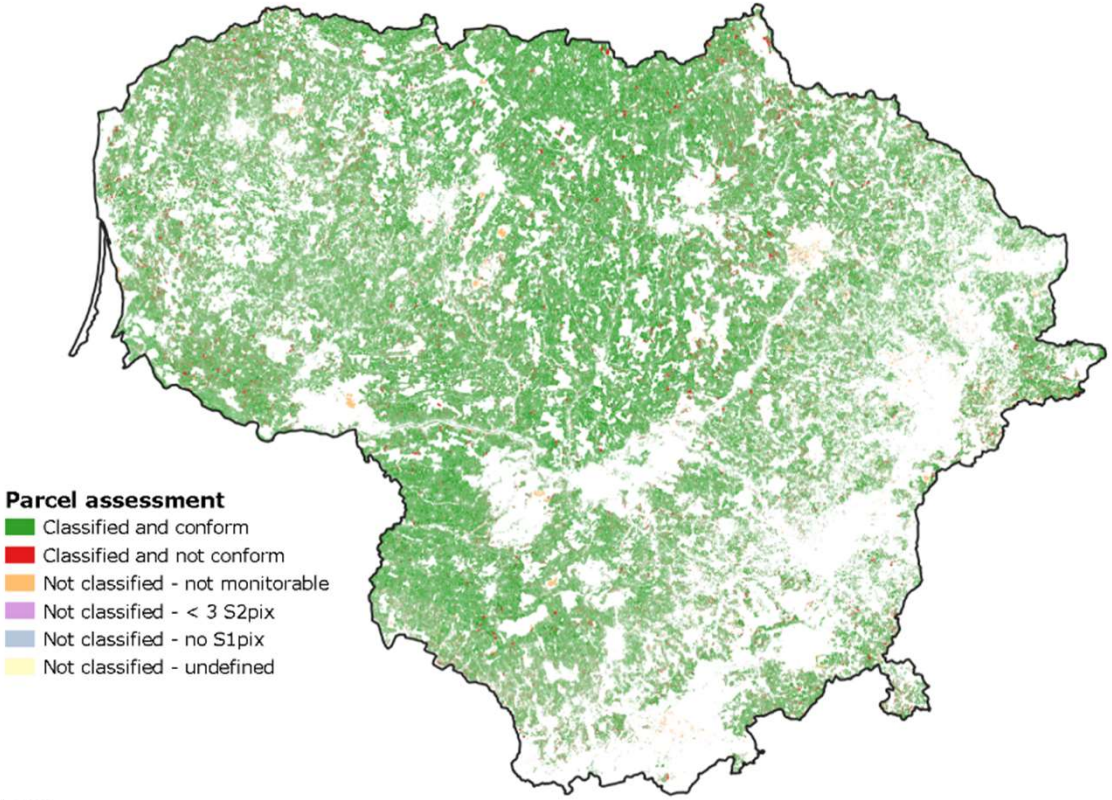
Example over Romania



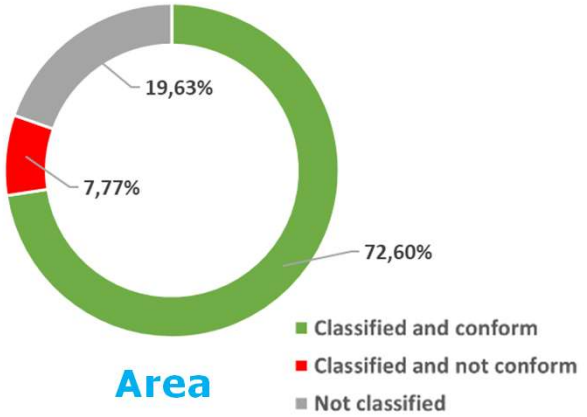


2018: National crop type mapping over 6 countries

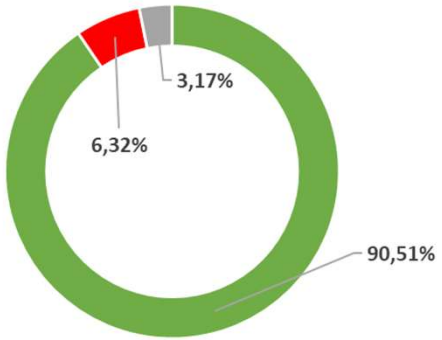
Lithuania (80+ crop types)



 # parcels



Area



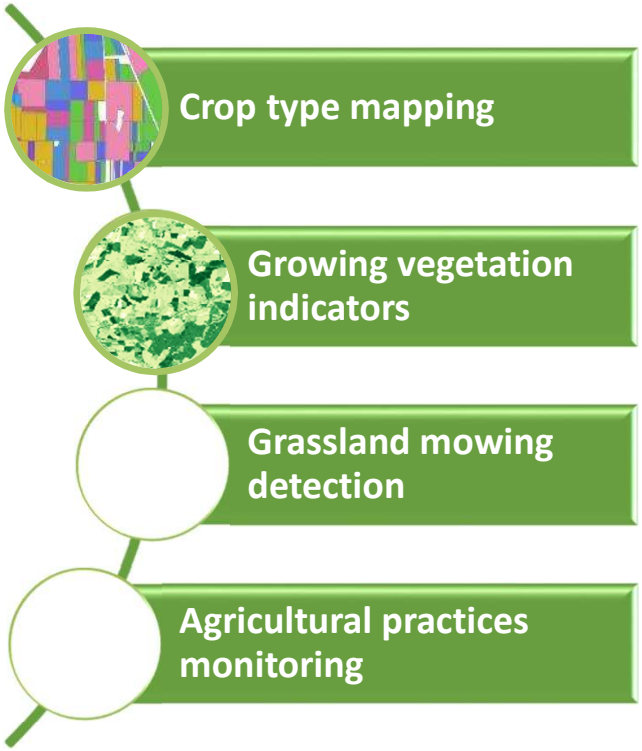
Synthesis of preliminary performances of crop type identification in different EU agricultural landscapes for 2018

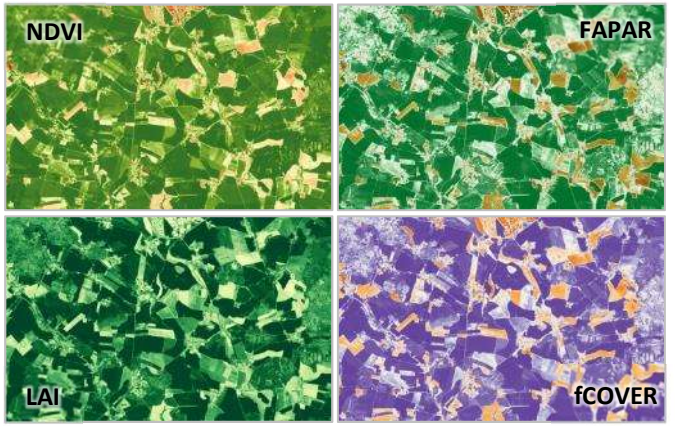
- **16 millions of parcels assessed** for 600 000 sq.km²
- **Overall accuracies from 71 % to 95 %** (all > 70 %, 3 countries > 80%)
  - ⇒ **Possible improvements identified** (refined crop type list, better selection the calibration dataset, exclusion of poorly defined classes, stratification,...
- **Limited impact of parcel size and shape** on the assessed areas (0,3 % to 8 %)

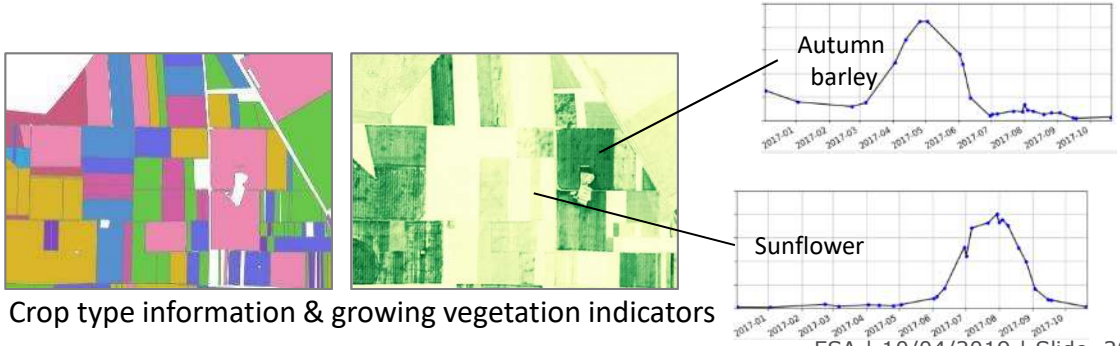
Country	Area Of Interest	EO input	Total area (km²)	Total parcels (nr)	Parcels not assessed (%)		Parcels not assessed because of the size (%)		Overall Accuracy
					Nr	Area	Nr	Area	
NLD	100 % country	S2 + S1	42508	802217	17,27%	4,49%	9,25%	**1,03%**	**94,95%**
CZE	100 % country	S2 + S1	78873	593787	14,11%	1,71%	8,40%	**0,30%**	**82,75%**
LTU	100 % country	S2 + S1	64897	1153796	19,63%	3,17%	16,16%	**1,46%**	**78,74%**
ITA	100 % of the AOI (5 Regions)	S2 + S1	67270	8527409	78,60%	36,12%	33,94%	*15,49%**	**72,37%**
ESP	100 % of the AOI (Castilla Y Leon)	S2 + S1	94226	3540880	35,71%	28,62%	34,60%	*27,78%**	**81,83%**
ROU	100 % country	S2 + S1	238369	6127057	38,22%	10,96%	35,77%	**8,34%**	**71,16%**

* Not to be considered because of parcel duplicate

Sentinels indicators and markers – veg. indicators





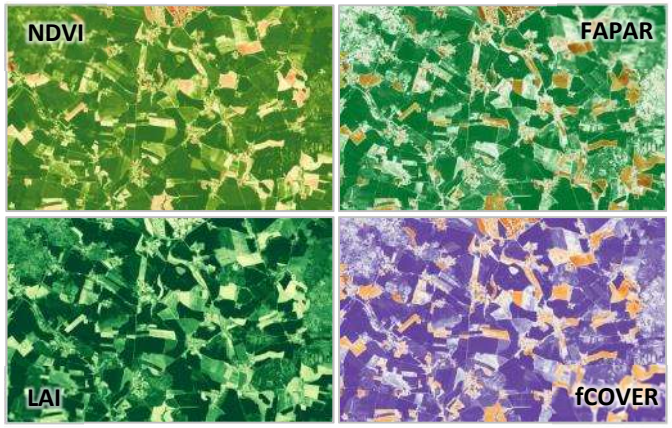


Crop type information & growing vegetation indicators

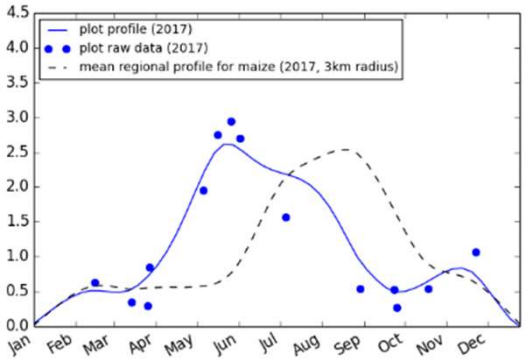
Sentinel-based vegetation indicators as auxiliary data

Czech Republic

4 indicators

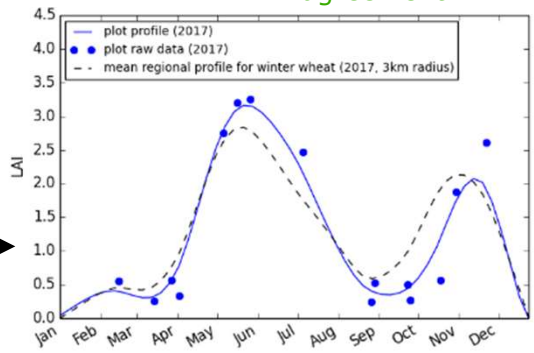


Czech Republic



High confidence in disagreement

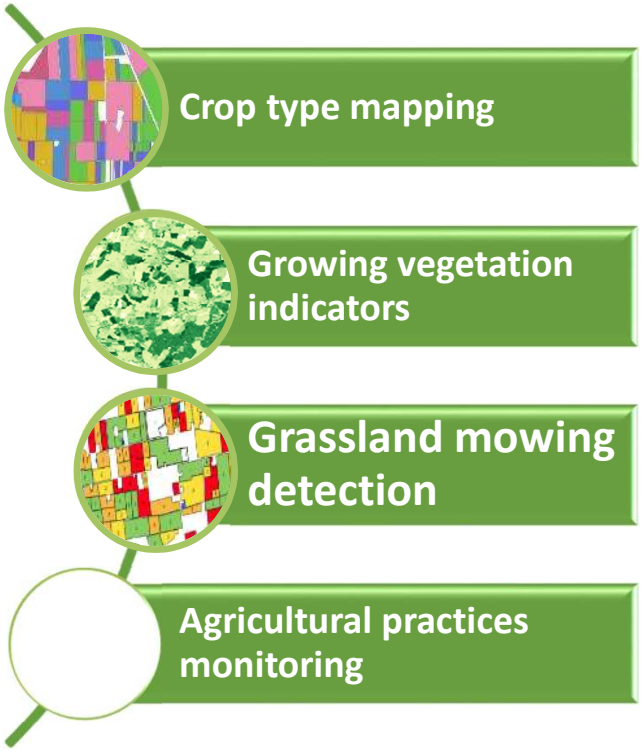
High confidence in agreement

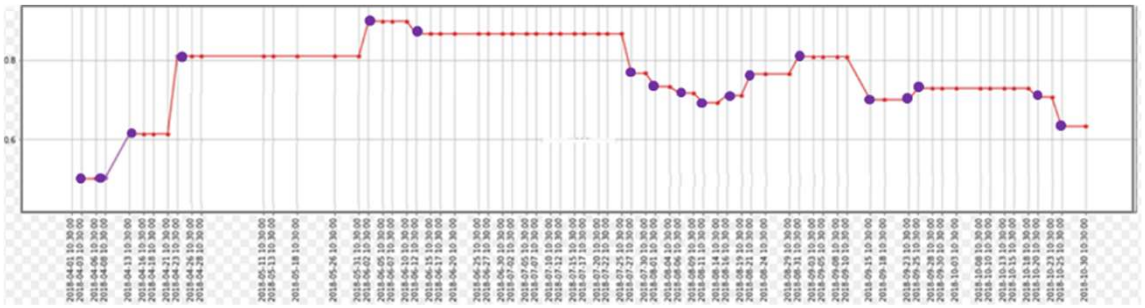


ID	NKOP_DPB	AREA	CONF_IDX	CT_DECL	CT_PRED_1	CT_CONF_1	C_INDIC
5482		23275	0	Maize	Winter rapeseed	0,56	**Disagreement confirmed**
6581		18086	1	Winter Wheat	Grassland	0,25	**Agreement confirmed**

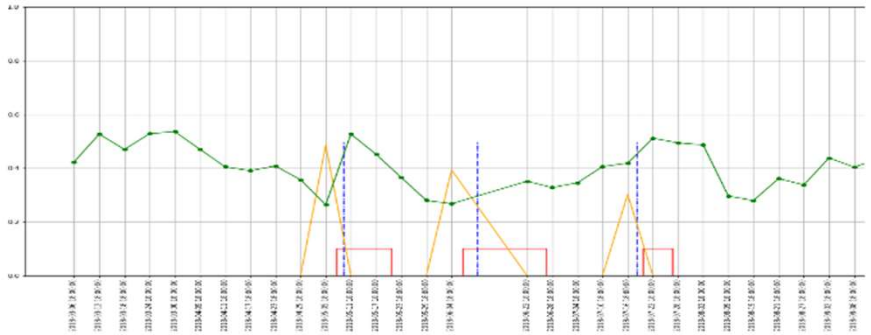
Support by RMSE values between mean local profile and parcel profile

Sentinels indicators and markers – grassland mowing



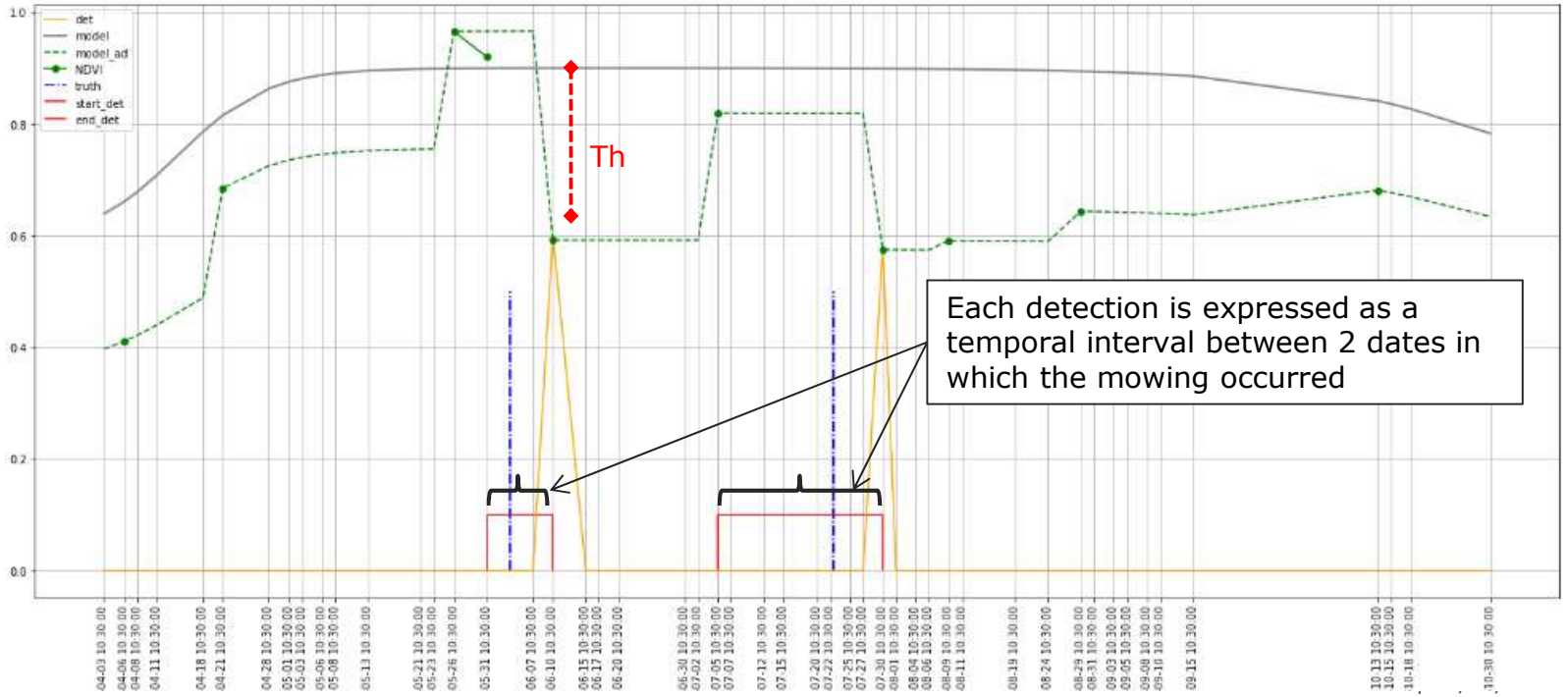


Mowing detection based on the detection of **S2 Vegetation Indices decrease** and **S1 coherence increase**



S2 mowing detection by VIs decrease wrt expected model

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



Grassland mowing detection – detection attributes

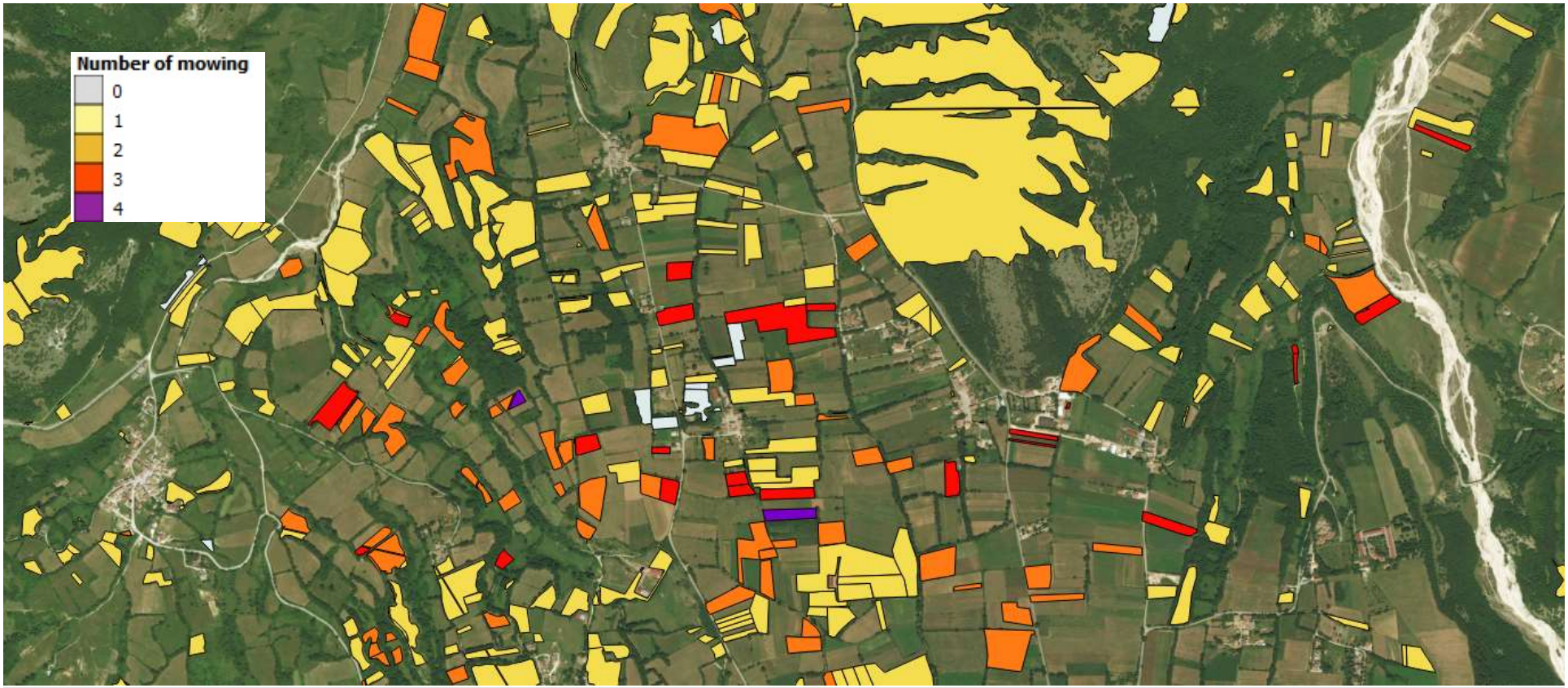
- Grassland mowing product contains, for each parcel, information about **number and temporal intervals of mowing events** detected

parcel_id	crop_code	mow_n	m1_dstart	m1_dend	m1_conf	m1_mis	m2_dstart	m2_dend	m2_conf	m2_mis	m3_dstart	m3_dend	m3_conf	m3_mis	m4_dstart	m4_dend	m4_conf	m4_mis	compl
31.0000002869728.001	265	3	2018-05-08 00:0...	2018-05-21 00:0...	0.554000...	S2	2018-07-12...	2018-07-20 ...	0.55300...	S2	2018-08-24...	2018-09-18 ...	0.518...	S2	0				
31.0000002869729.001	265	3	2018-05-08 00:0...	2018-05-21 00:0...	0.522000...	S2	2018-07-07...	2018-07-12 ...	0.50200...	S2	2018-08-24...	2018-09-13 ...	0.517...	S2	0				
31.0000002869730.001	265	3	2018-05-08 00:0...	2018-05-21 00:0...	0.519000...	S2	2018-07-07...	2018-07-12 ...	0.50700...	S2	2018-08-24...	2018-09-13 ...	0.517...	S2	0				
31.0000002811919.002	265	3	2018-05-08 00:0...	2018-05-11 00:0...	0.777000...	S2	2018-05-21...	2018-06-20 ...	0.71200...	S2	2018-08-06...	2018-08-26 ...	0.712...	S2	0				
31.0000002869731.001	265	1	2018-09-08 18:0...	2018-09-14 18:0...	0.486000...	S1	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002811948.002	265	1	2018-08-09 18:0...	2018-08-15 18:0...	0.448000...	S1	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002869732.001	265	0	0	0	0.000000...	0	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002812236.002	265	3	2018-05-03 00:0...	2018-05-06 00:0...	0.632000...	S2	2018-06-07...	2018-06-27 ...	0.74700...	S2	2018-08-14...	2018-09-13 ...	0.641...	S2	0				
31.0000002869733.001	265	0	0	0	0.000000...	0	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002869734.001	265	1	2018-09-08 18:0...	2018-09-14 18:0...	0.422000...	S1	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002869735.001	265	0	0	0	0.000000...	0	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002869736.001	265	0	0	0	0.000000...	0	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002813128.002	336	0	0	0	0.000000...	0	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002869737.001	265	0	0	0	0.000000...	0	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002826797.002	265	4	2018-04-21 00:0...	2018-05-06 00:0...	0.536000...	S2	2018-05-26...	2018-06-07 ...	0.62500...	S2	2018-07-02...	2018-07-12 ...	0.609...	S2	2018-08-				
31.0000002869738.001	331	1	2018-08-09 18:0...	2018-08-15 18:0...	0.171000...	S1	0	0	0.00000...	0	0	0	0.000...	0	0				
31.0000002826801.002	265	3	2018-05-26 00:0...	2018-06-07 00:0...	0.560000...	S2	2018-07-12...	2018-07-15 ...	0.53100...	S2	2018-08-21...	2018-09-13 ...	0.616...	S2	0				
31.0000002869739.001	331	0	0	0	0.000000...	0	0	0	0.00000...	0	0	0	0.000...	0	0				

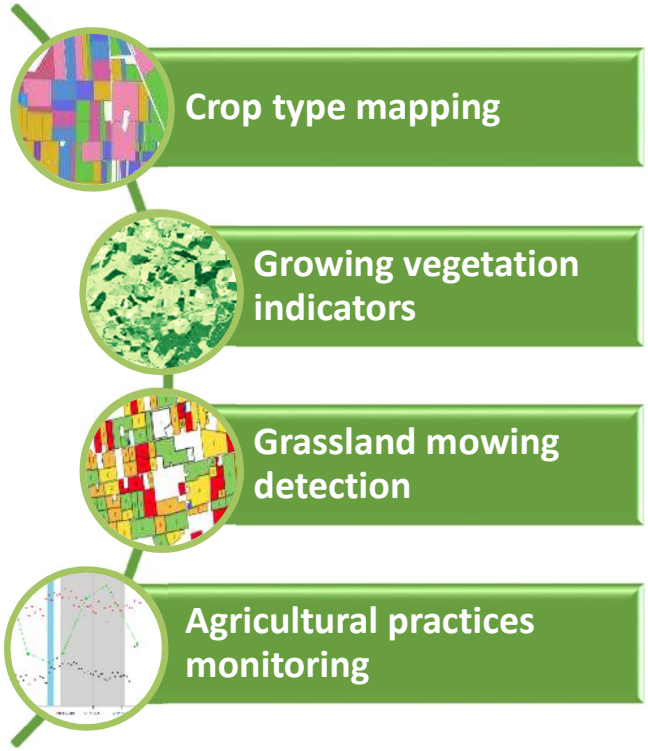
Product info for each parcel

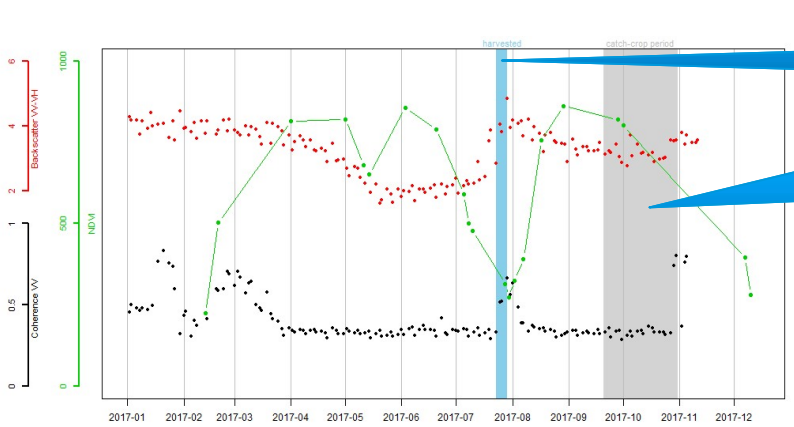
- ✓ Parcel identifier
- ✓ Grassland Crop type
- ✓ Number of mowing events (maximum 4)
- ✓ For each mowing event (up to 4):
  - Temporal interval in which the mowing event occurred (t_start and t_end)
  - Confidence level in terms of probability of right mowing (conf)
  - Satellite mission data used for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

2018 Grassland mowing events detection



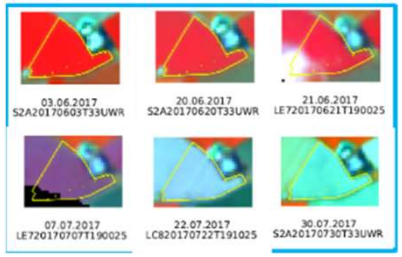
Sentinels indicators and markers – ag. practices (EFA)





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

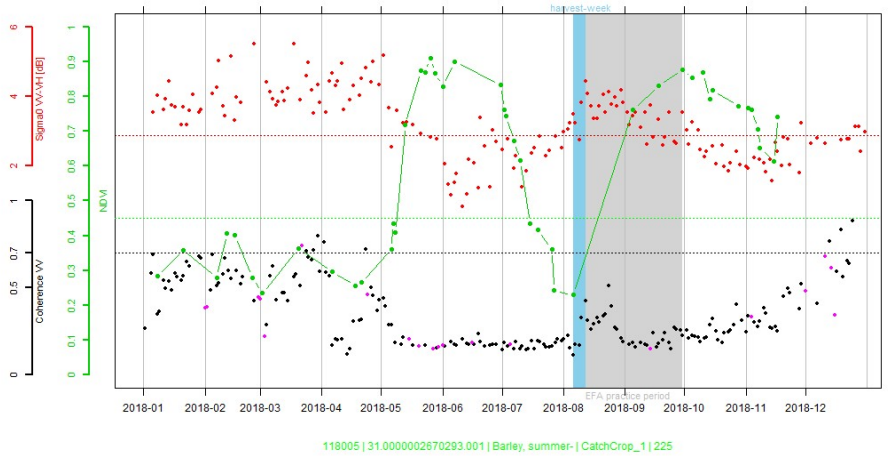
MARKERS FOR HARVEST		
M1	**M1: Presence of vegetation in the main vegetation season** (pre-requisite)	High values of NDVI
M2	**M2: Loss of vegetation**	Break in NDVI (decrease)
M3	**Loss of vegetation**	Break in backscatter ratio (increase)
M4	**Low/no vegetation**	High values of backscatter ratio
M5	**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

Agricultural Practices Monitoring
Detection of catch crop - NLD

ORIG_ID	FIELD_ID	COUNTRY	YEAR	MAIN_CROP	VEG_START	H_START	H_END	PRACTICE	P_TYPE	P_START	P_END
1003XXX-XXXX-XXX	118005	NL	2018	236	2018-05-01	2018-05-15	2018-10-15	CatchCrop	CatchCrop_1	2018-08-06	2018-09-30

M1	M2	M3	M4	M5	H_WEEK	M6	M7	M8	M9	M10	C_INDEX
TRUE	TRUE	TRUE	TRUE	TRUE	32	TRUE	TRUE	TRUE	TRUE	TRUE	STRONG

W_GAPS	S1PIX	H_W_START	H_W_END
0	225	2018-08-06	2018-08-12



Farmer interview:

Declared crop	Sow crop	Harvest crop	Sow catch-crop
Barley, summer-	17.4.2018	27.7.2018	20.8.2018

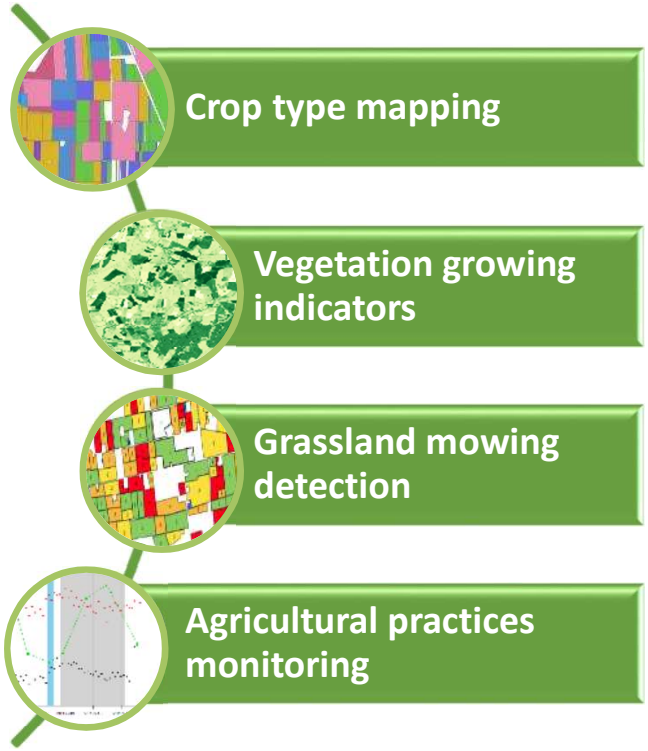
Synthesis of preliminary performances for ag. practices in different EU agricultural landscapes for 2018

All parcels in 6 countries having at least 1 S1 and 3 S2 pixels:

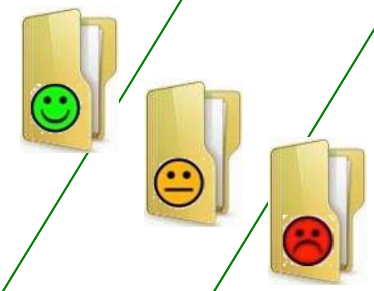
- **Harvest detection for 4 472 852 parcels**
- **EFA practices monitored : catch crops (4 PAs)**
  fallow land (4 PAs)
  nitrogen fixing crops (5 PAs)
- **EFA practices : 994 388 parcels assessed**
  With different degree of compliancy based on diverse national rules and nbr of markers
- **Validation:**
  - Farmer interviews
  - Planet data visual interpretation

AGRICULTURAL PRACTICES SUMMARY			
COUNTRY	NUMBER OF HARVEST/CLEARANCE PARCELS PROCESSED	EFA PRACTICES	NUMBER OF EFA PARCELS PROCESSED
Czechia	148 342	Catch crops (2), Fallow land, Nitrogen fixing crops	26 282
Spain	1 208 102	Fallow land, Nitrogen fixing crops	464 443
Lithuania	437 039	Catch crops (2), Fallow land (2), Nitrogen fixing crops	44 734
Netherlands	157 317	Catch crops (3)	46 971
Romania	2 063 990	Catch crops, Nitrogen fixing crops	127 163
Italy	458 062	Fallow land, Nitrogen fixing crops	284 795

Use Cases: Sentinels to support payment decisions



Use Cases
w/ Paying Agencies



Use case
Crop diversification
Permanent grassland identification
EFA-Land lying fallo
EFA-Catch crops
EFA-Nitrogen-fixi
Interactive visu
Land abandor
LPIS update
Claimless system

From crop type mapping to crop diversification

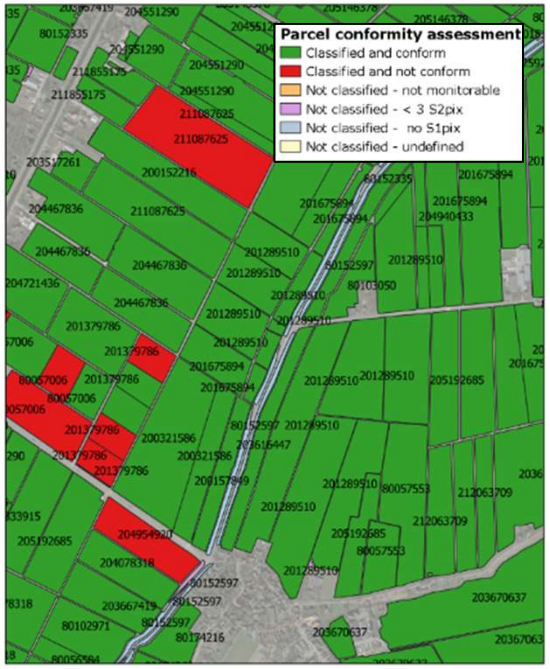
Combining assessments at parcel- and holding-level

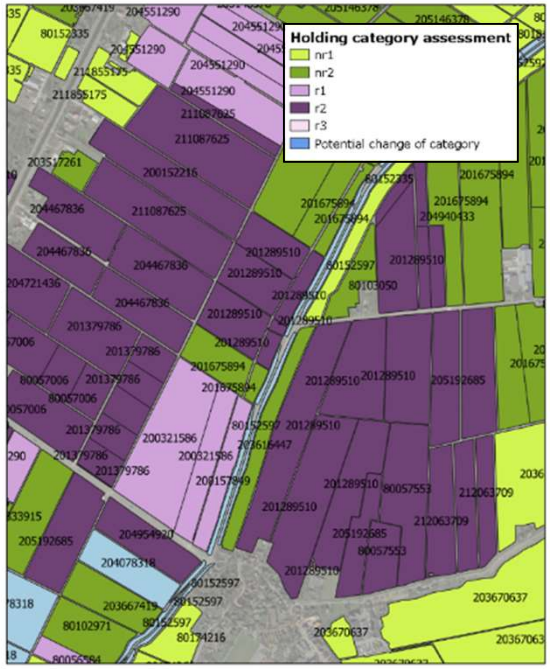
Parcel-level

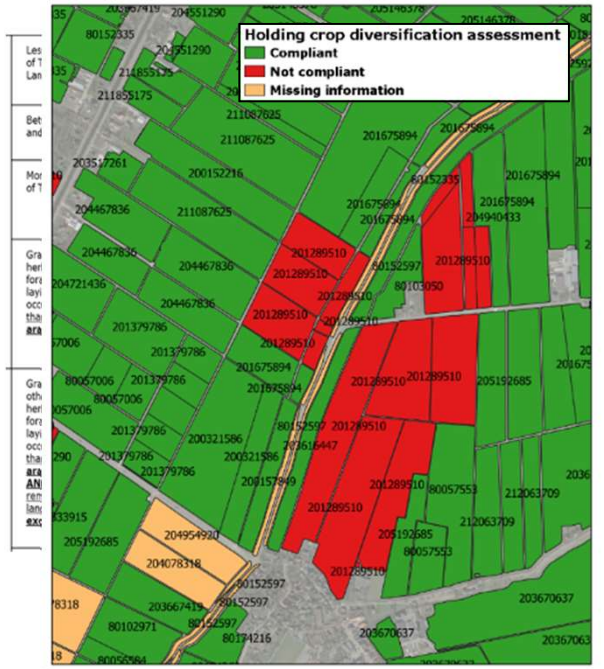
Assess if the crop type declared by the farmer is confirmed by the satellite signal

Holding-level

Assess the compliancy of the holding with regard to the crop diversification rules

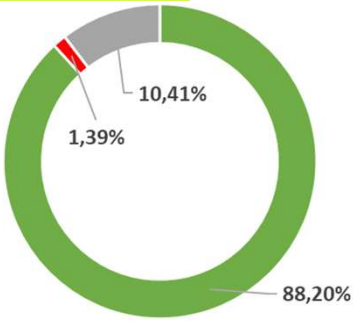




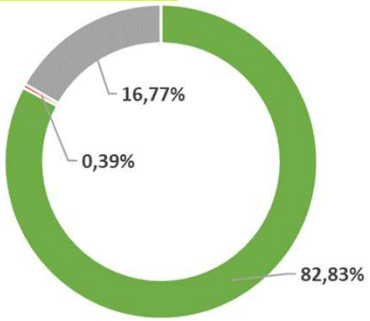


Crop diversification compliance analysis at holding level

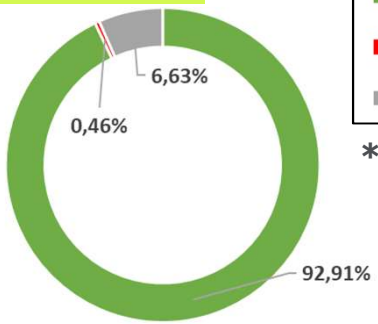
CZECH REPUBLIC



CASTILLA Y LEON



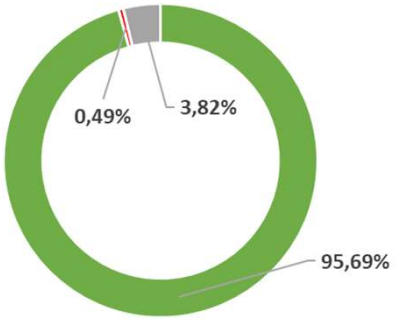
ITALY



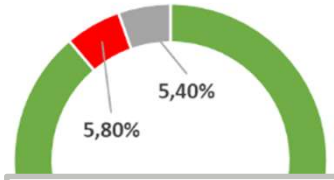
- Compliant
- Not compliant
- Missing information

***At holding level**

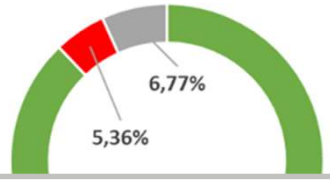
LITHUANIA



NETHERLANDS



ROMANIA



EXAMPLE OF OUTCOMES FROM TRAINING & DISCUSSION WITH PAs

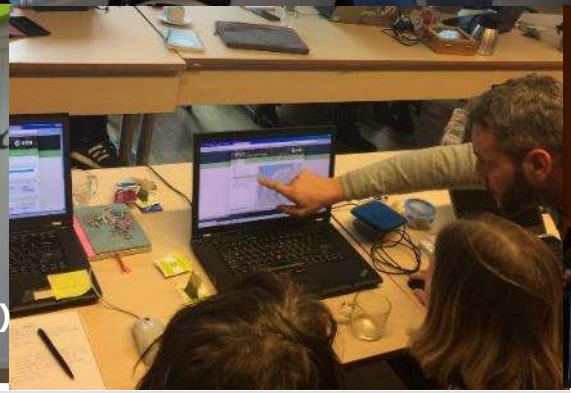
1) Parcels classified as **not conform** when « we don't know anything about »
   -> implementation of the use of the **predicted crop type** with high confidence
2) Additional **rule** from the crop diversification regulation regarding permanent grassland, crop under water, etc. …/…

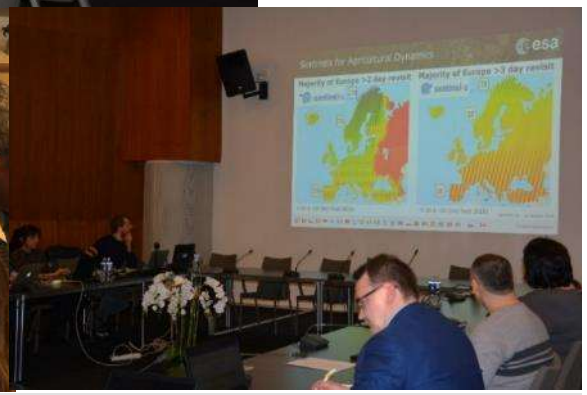
2-day trainings in each 6 PAs premisses (Feb.- Apr.19)

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





Lessons learned from 2018 demonstrations

Paying Agencies feedback

Better understanding by PAs of Sen4CAP markers, products and methods

Further validation needed for the 2018 outputs

Identification of necessary improvements prioritized for 2019

Main recommendations for 2019

National adaptation required – fine-tuning the regulation implementation

On-the-job training of PAs for local sites on Virtual Machines running on DIAS

Continuous support for customization and adaptation

Dedicated in-situ data required for validation – building confidence

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

Farmers interviews conducted by

PAs for grassland mowing and

EFA practices

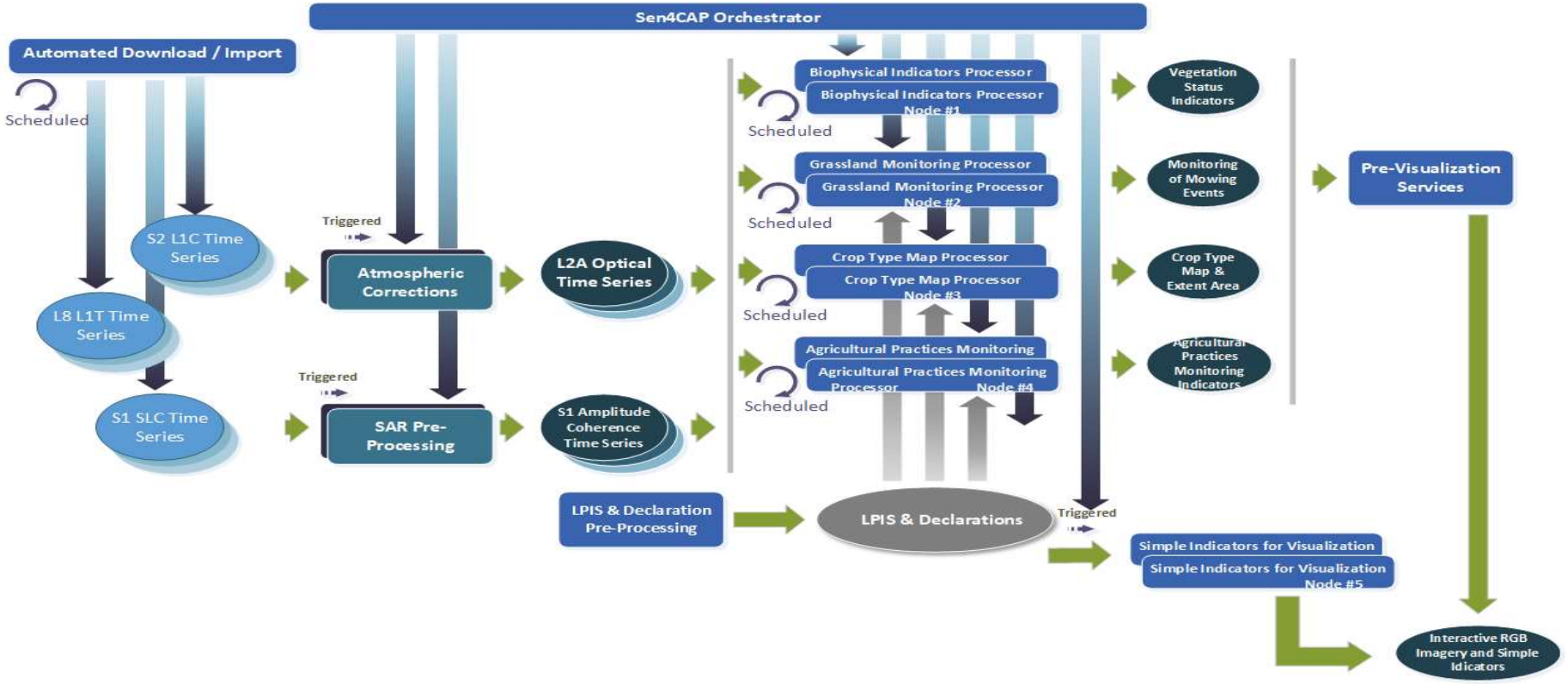
ID	Unique parcel ID	Area	MOWING 1										
			Mowing				Extension (parcel area %)	Mowing practice	Additional information				
			FROM	(+/- days)	TO	(+/- days)			Drying	Baling	Bales of hay on the parcel	Removal of bales	Other
1	XXXX												
1	Comment												
2	XXXX												
2	Comment												

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								

- Access granted to Planet data

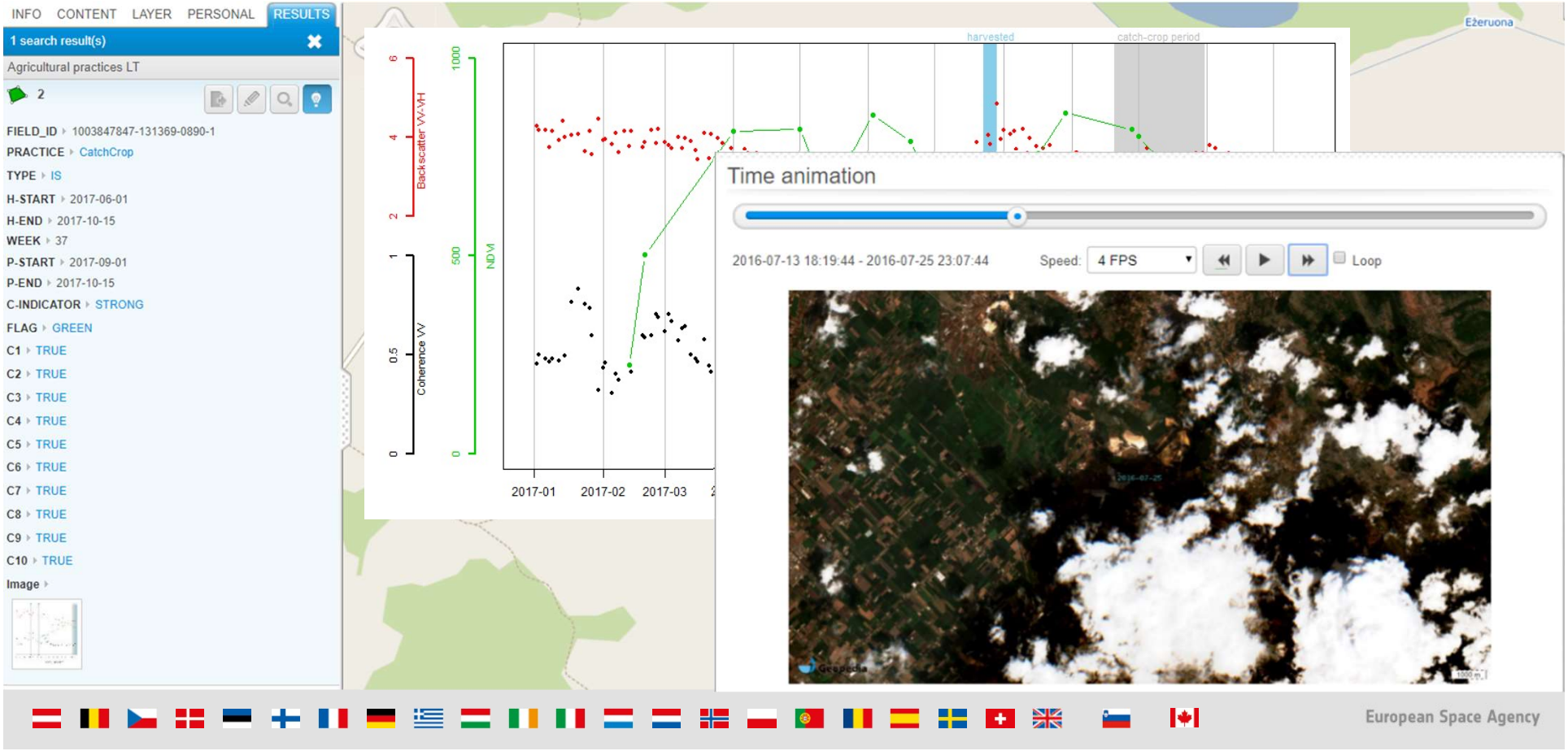
7 May 2018 **9 May 2018**

Sen4CAP System overview – open source code



Visualisation tool to access all products at the parcel-level

As a web application or as WMS in QGIS



European Space Agency

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** (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**
- ○ Key emphasis on product **validation and markers/products use** by PAs
- ○ **Open source system** for uptake and customization by all PAs

sen4cap
common agricultural policy

http://esa-sen4cap.org

SEN4CAP BETA RELEASE MAY 2019


Thank you for your attention
and your contribution
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