New imaging technologies for monitoring the Common Agricultural Policy
European Court of Auditors – Luxembourg – 9-10 September 2019

SEN4CAP
Sentinels for CAP monitoring approach

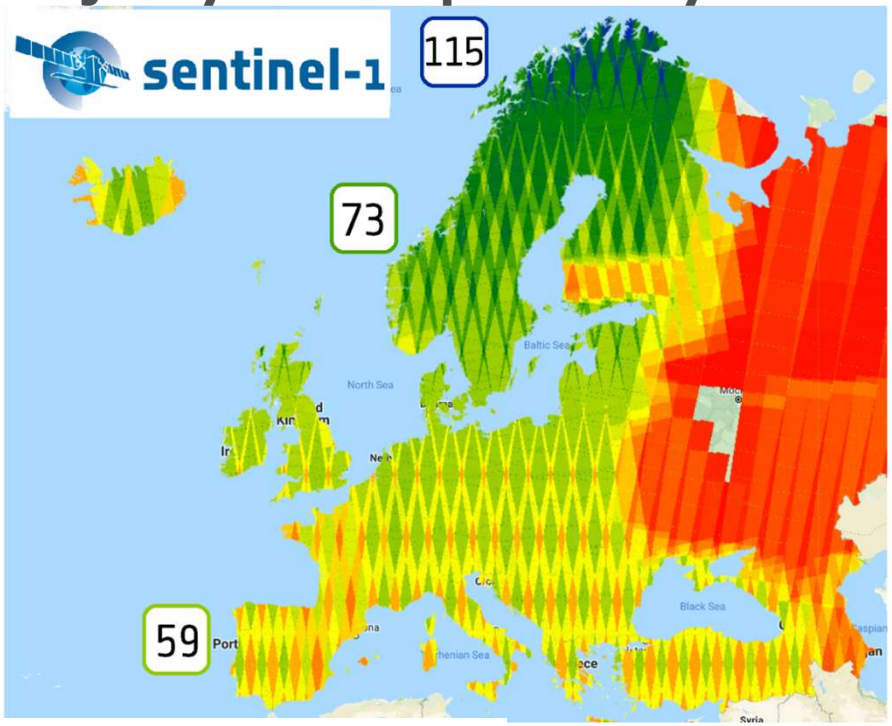
Defourny P., Bontemps S., Bajec K., Cara C., de Vendictis L., Kucera L., Malcorps P., Milcinski G., Nicola L., Rossi L., Sciarretta C., Slacikova J., Tutunaru F., Udroiu C., Zavagli M., Koetz B.

sen4cap
common agricultural policy

UCL Université catholique de Louvain
CS ROMANIA
e-geos AN ASI / TELESPAZIO COMPANY
SINERGISE
gisat

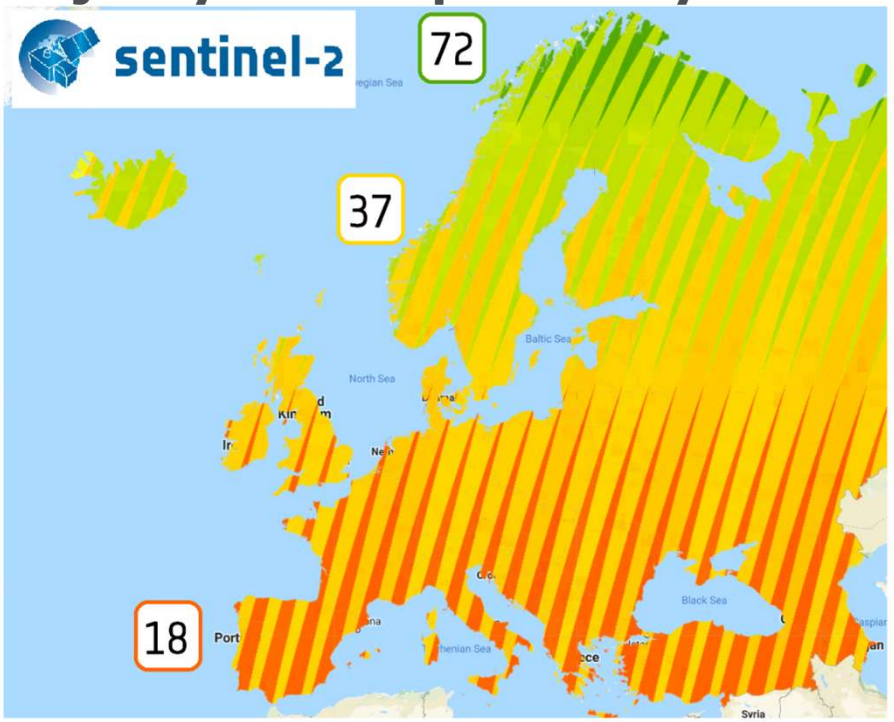
Sentinels high revisit to monitor Agricultural Dynamics

Majority of Europe >2 day revisit



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

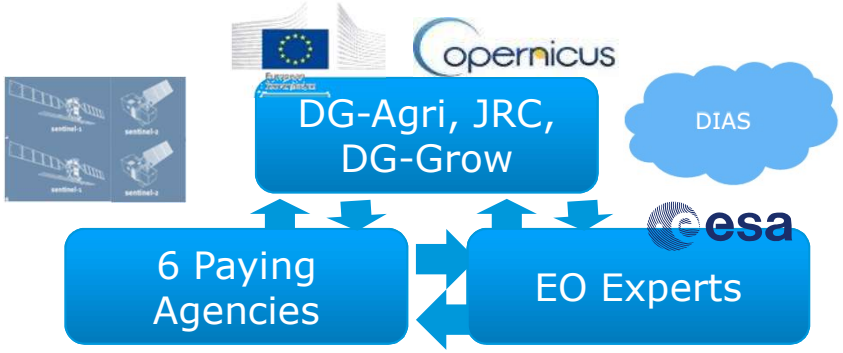
Majority of Europe >3 day revisit



S-2A & -2B (July-Sept 2018)

CAP monitoring approach – Technology meets Policy

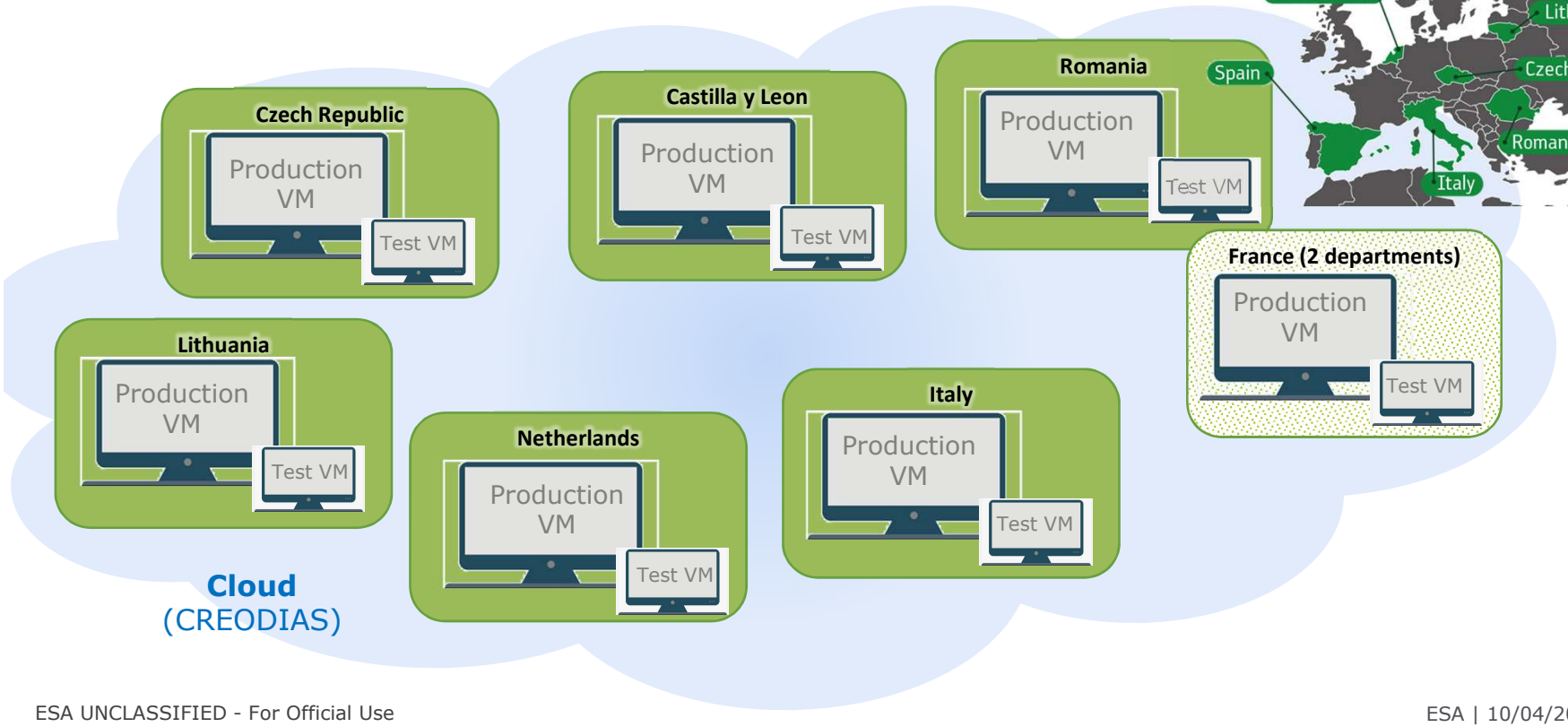
sen4cap
common agricultural policy



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

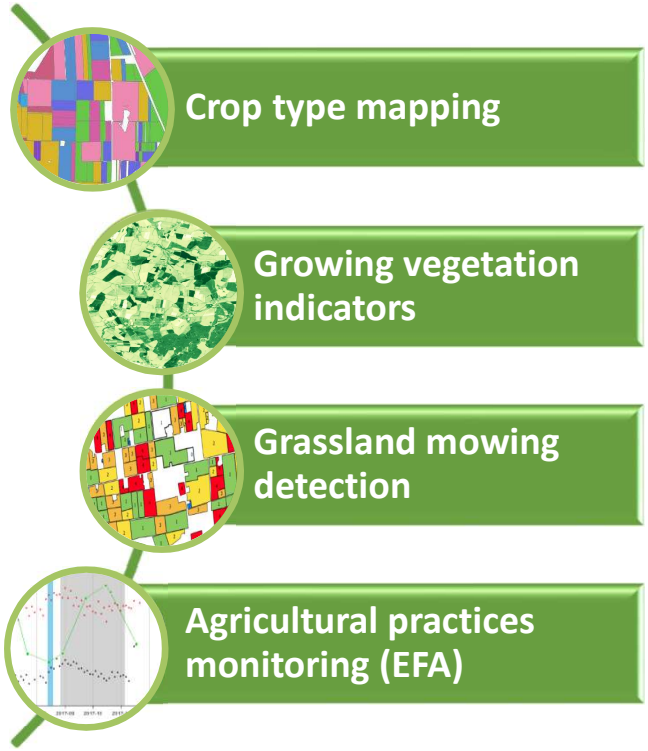


User Requirements in terms of IACS use cases

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

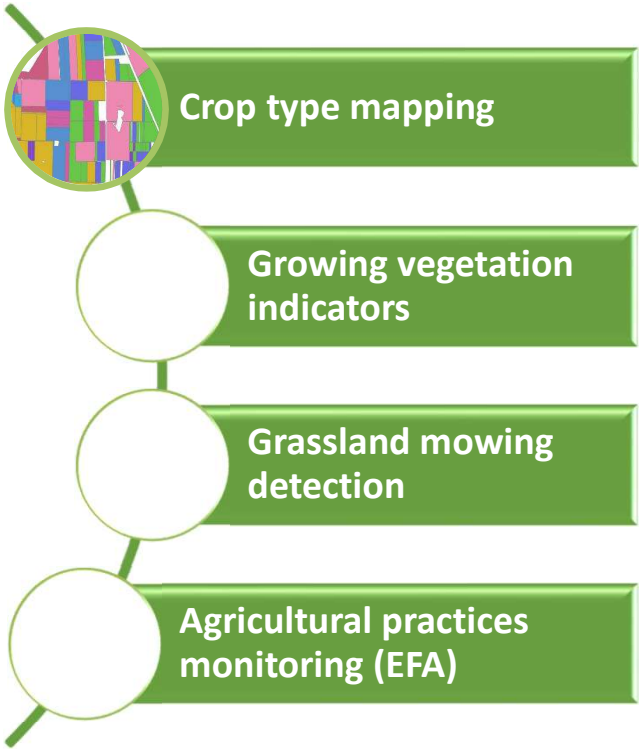
Use Cases: Sentinels to support payment decisions



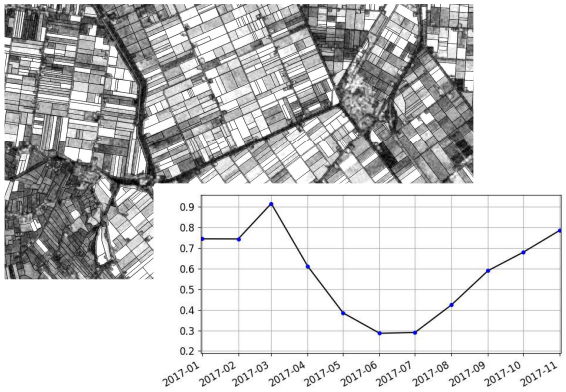
Use Cases
w/ Paying Agencies

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

Sentinel-derived indicators and markers

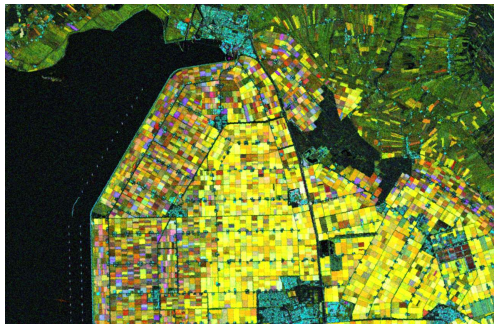


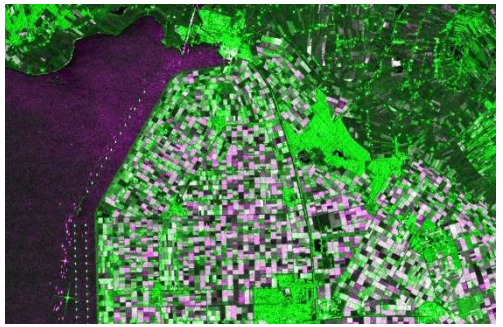
S2 time series data (May – Sep), CZE



Monthly coherence over a Winter Wheat field (Netherlands)

S1 composite of temporal features, NL

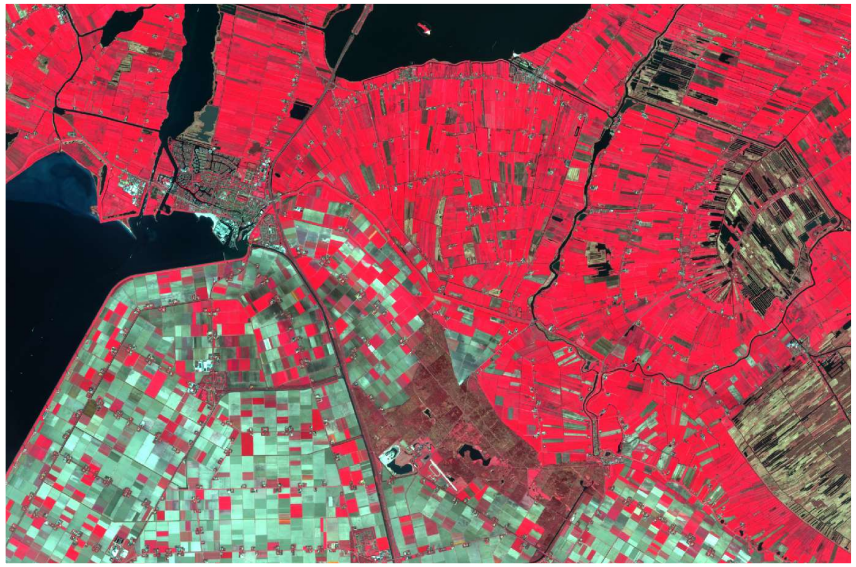




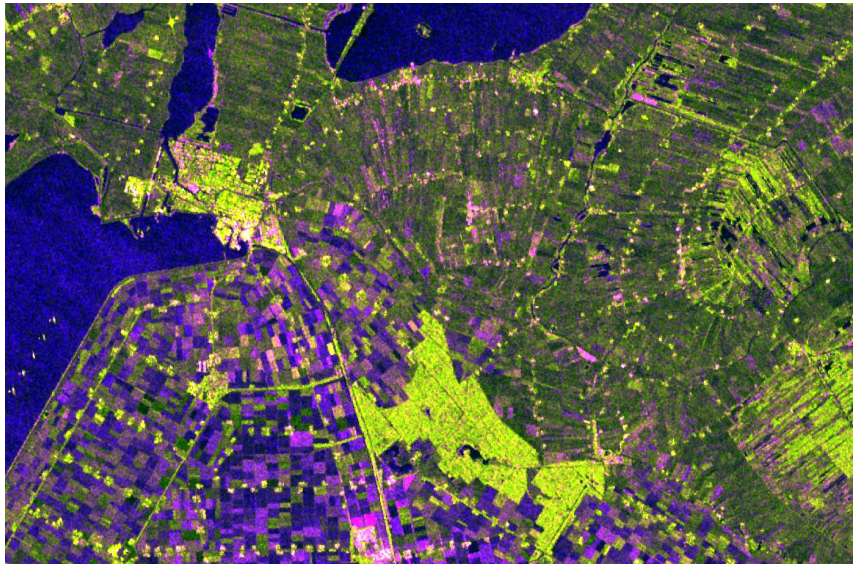
Large dataset from Sentinel-1 & 2 for a national coverage

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

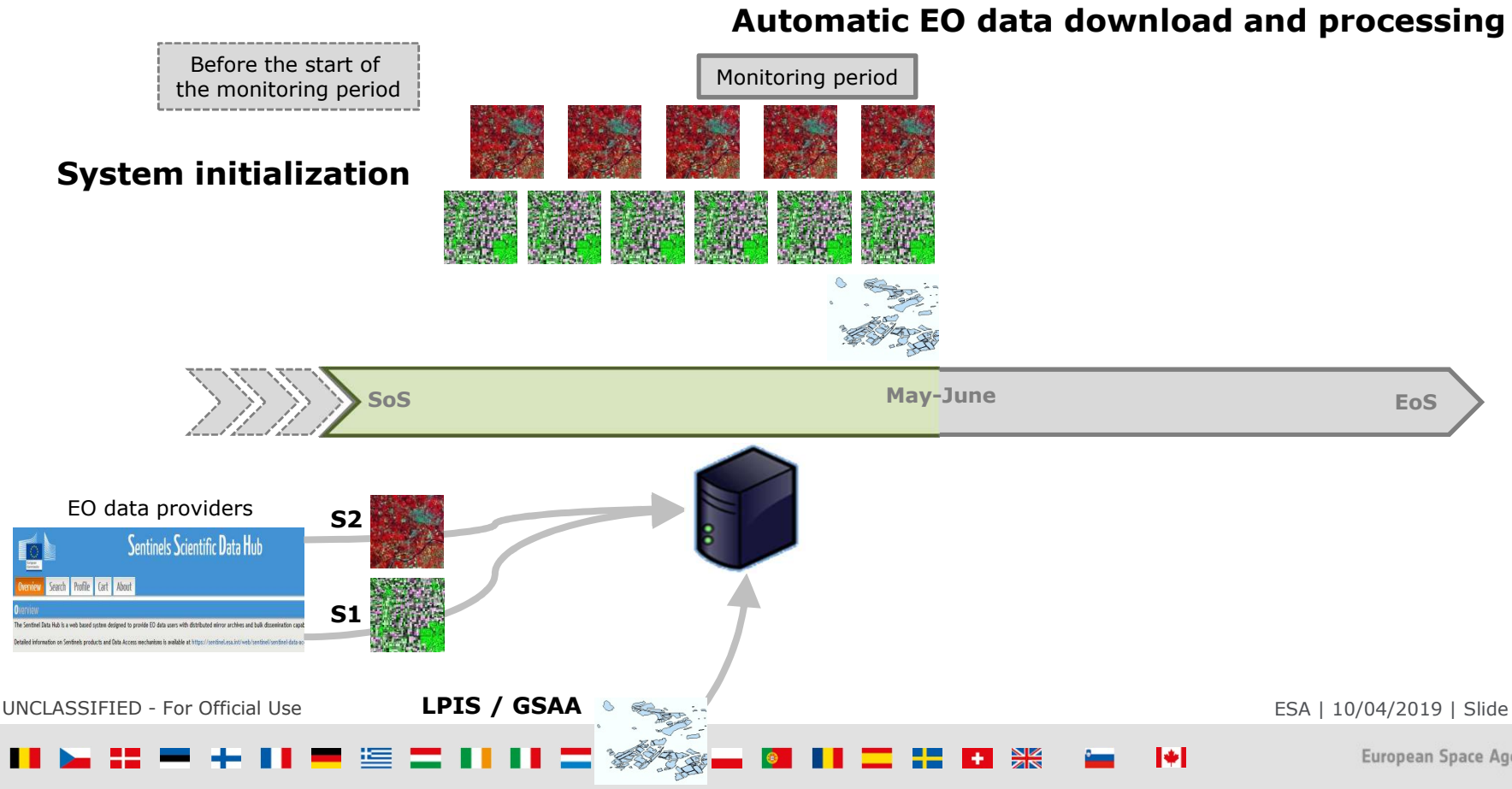
Before the start of the monitoring period

Monitoring period

SoS

Setting parameters	
Area of Interest	Shapefile to be uploaded
Monitoring period	Start and end dates to be defined
S1 and S2	To be selected

Sen4CAP system - crop type identification



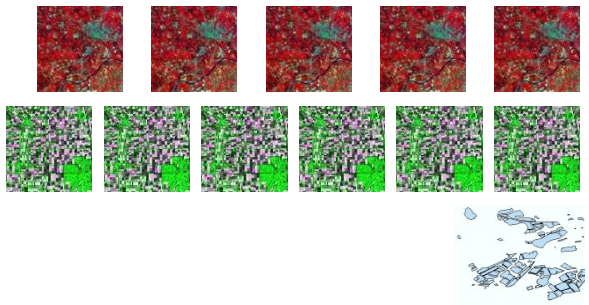
Sen4CAP system - crop type identification

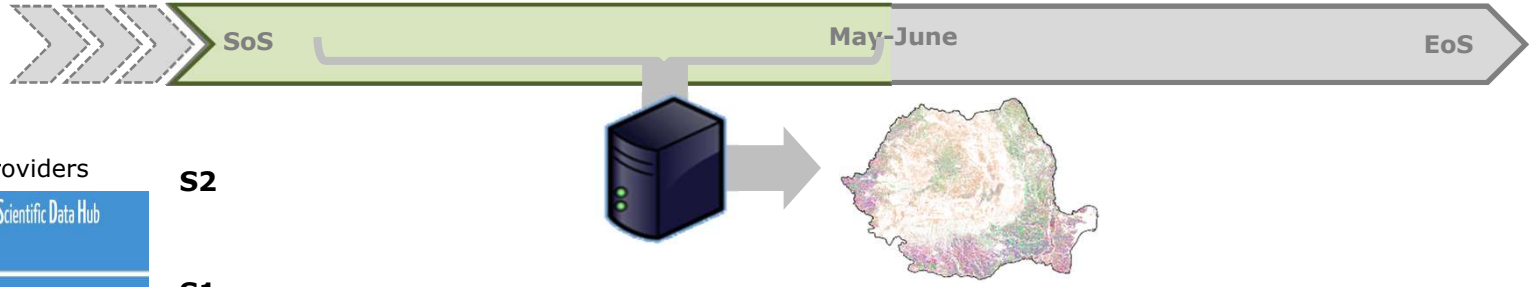
Automatic EO data download and processing

Before the start of the monitoring period

System initialization

Monitoring period





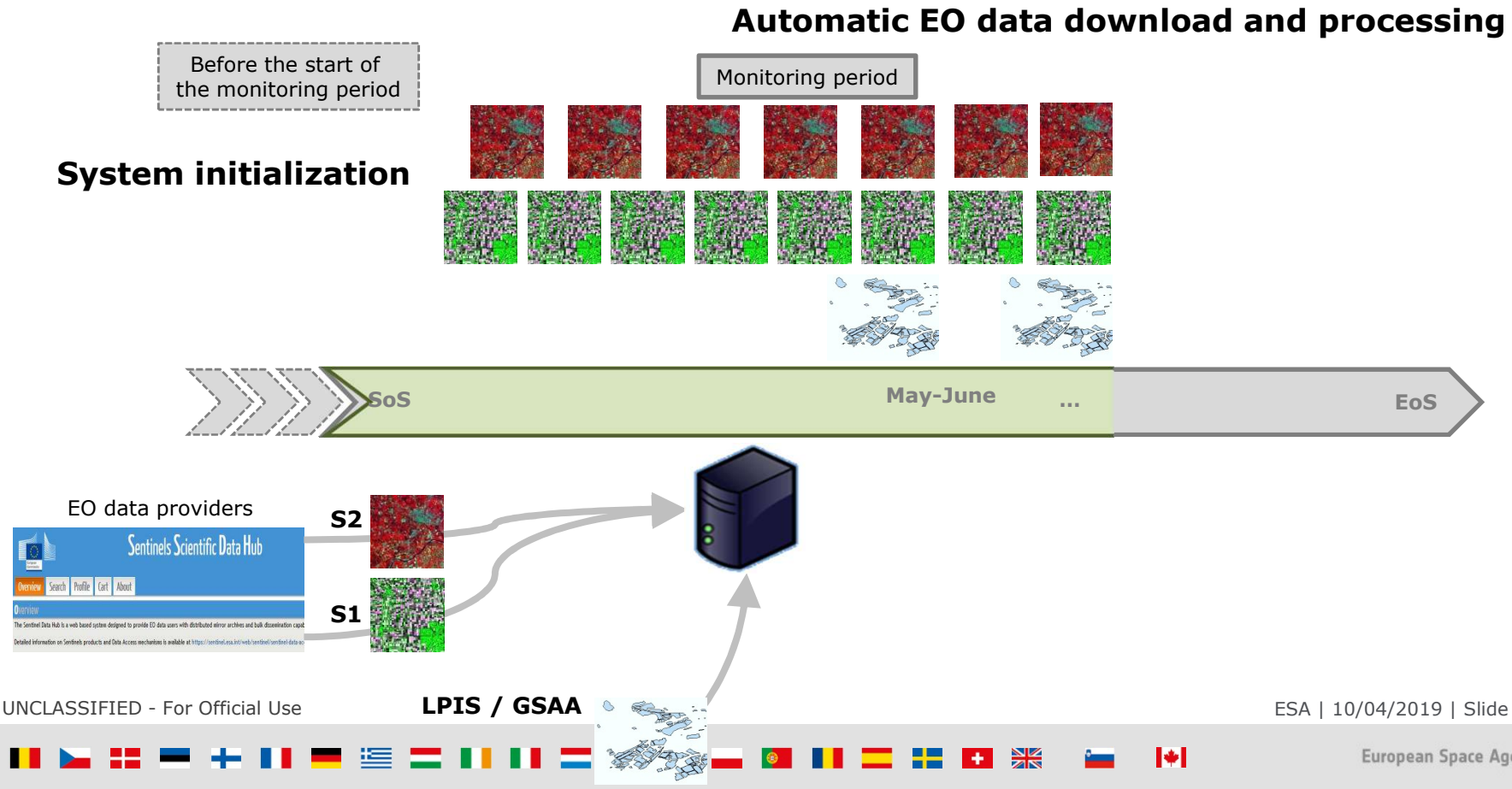
EO data providers

S2

S1

LPIS / GSAA

Sen4CAP system - crop type identification



Sen4CAP system - crop type identification

Automatic EO data download and processing

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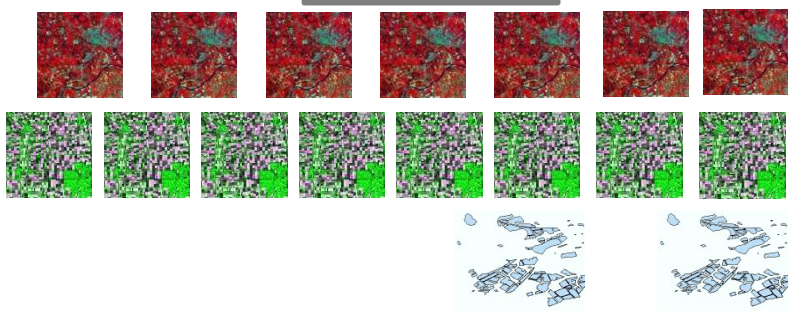
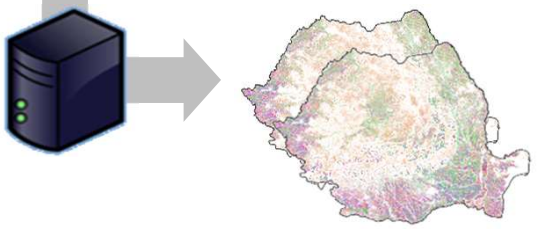
Monitoring period





EO data providers

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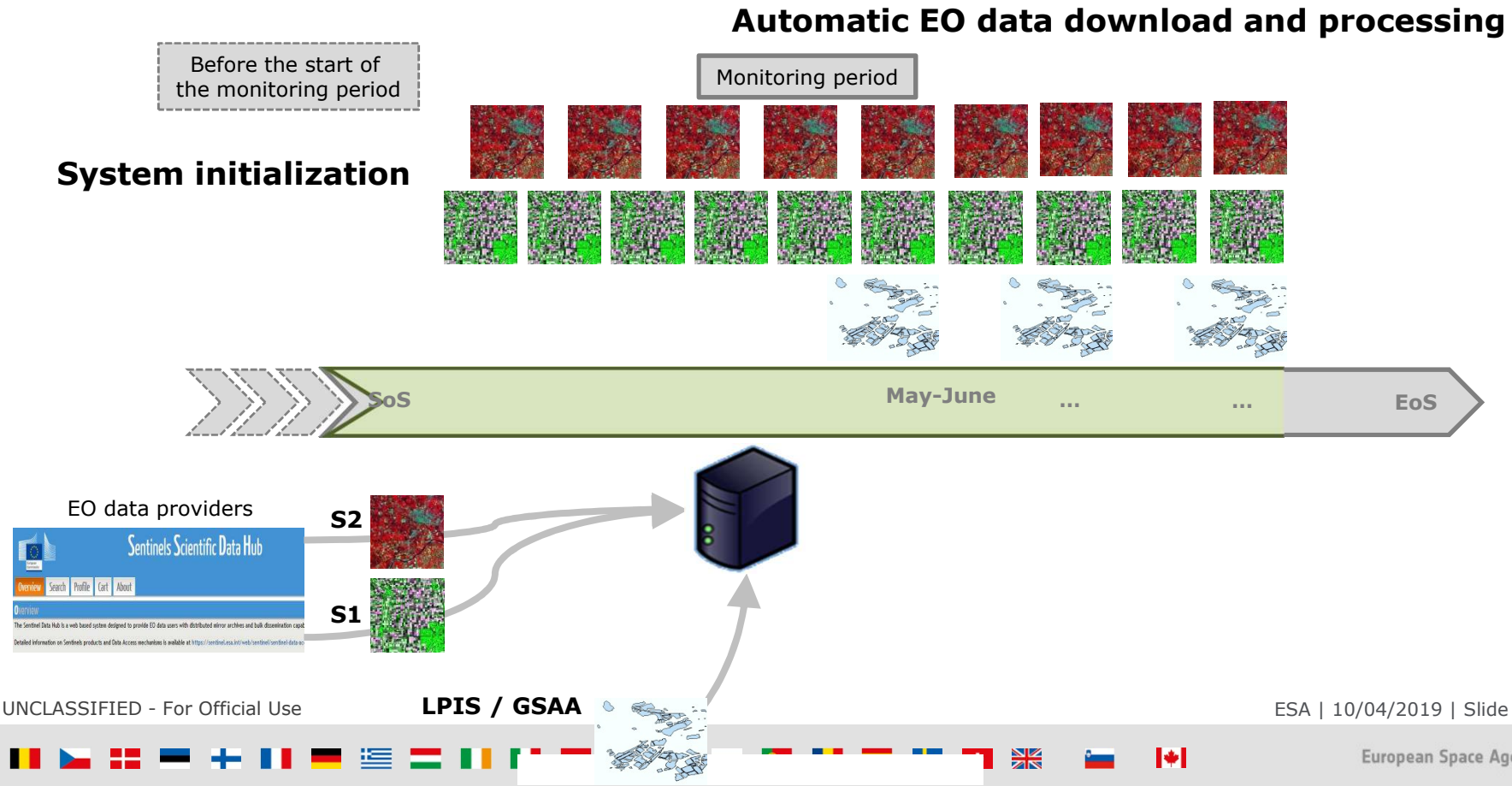
Sen4CAP system - crop type identification



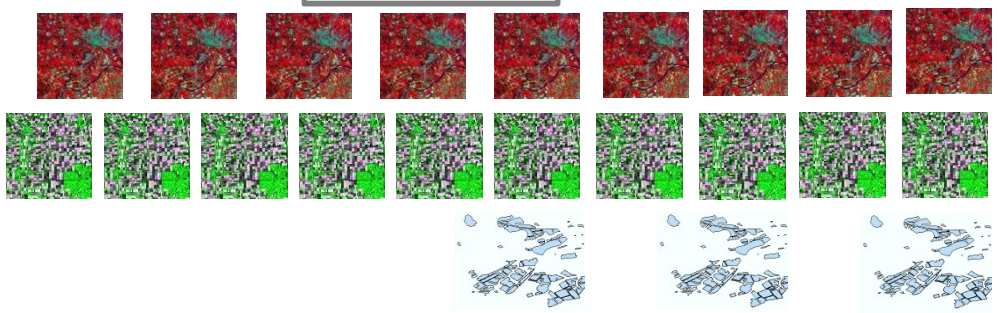
Sen4CAP system - crop type identification

Automatic EO data download and processing

Before the start of the monitoring period

System initialization

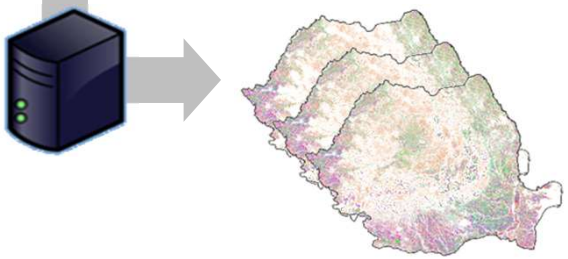
Monitoring period



EO data providers

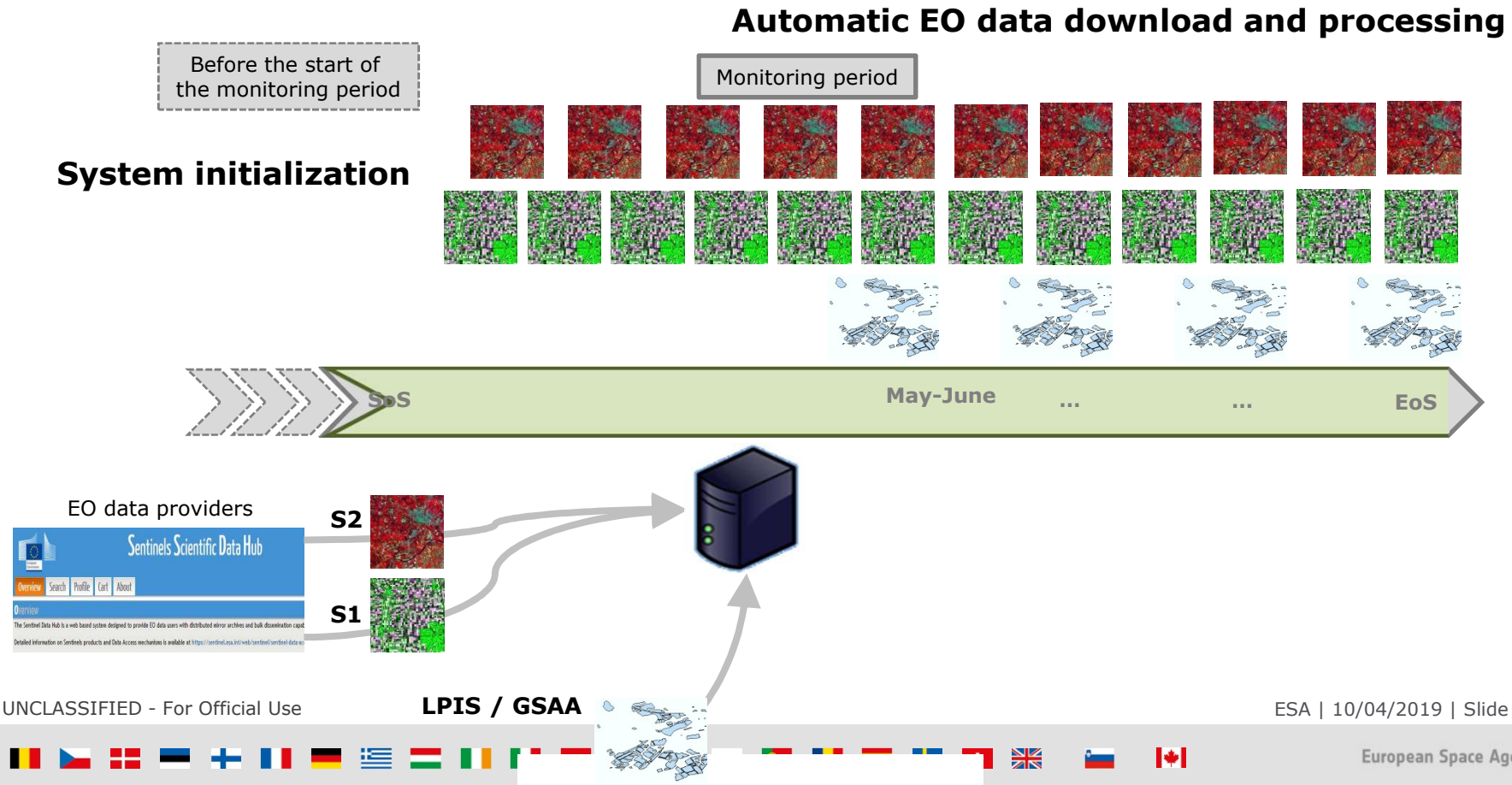
S2

S1



LPIS / GSAA

Sen4CAP system - crop type identification



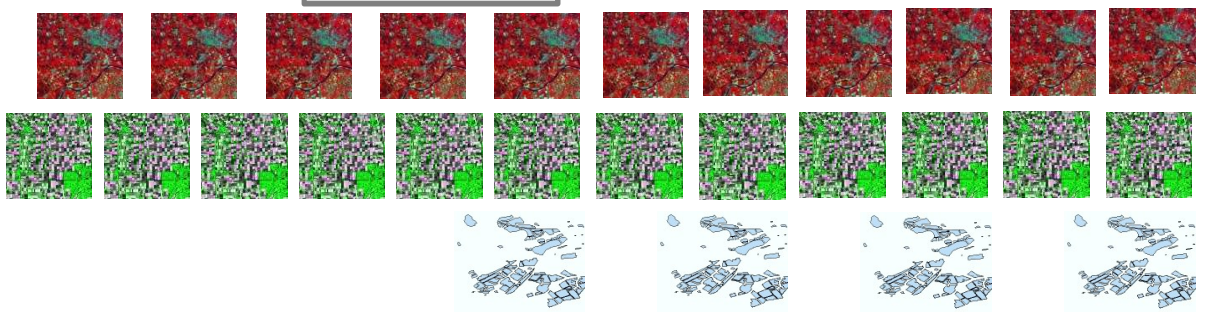
Sen4CAP system - crop type identification

Automatic EO data download and processing

Before the start of the monitoring period

System initialization

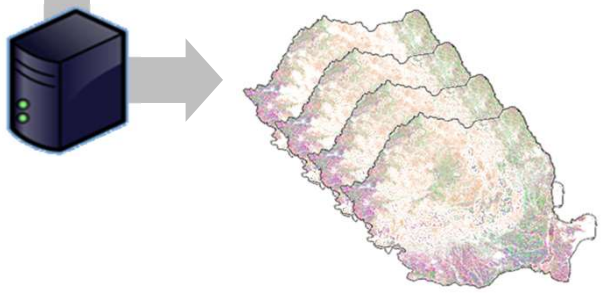
Monitoring period



EO data providers

S2

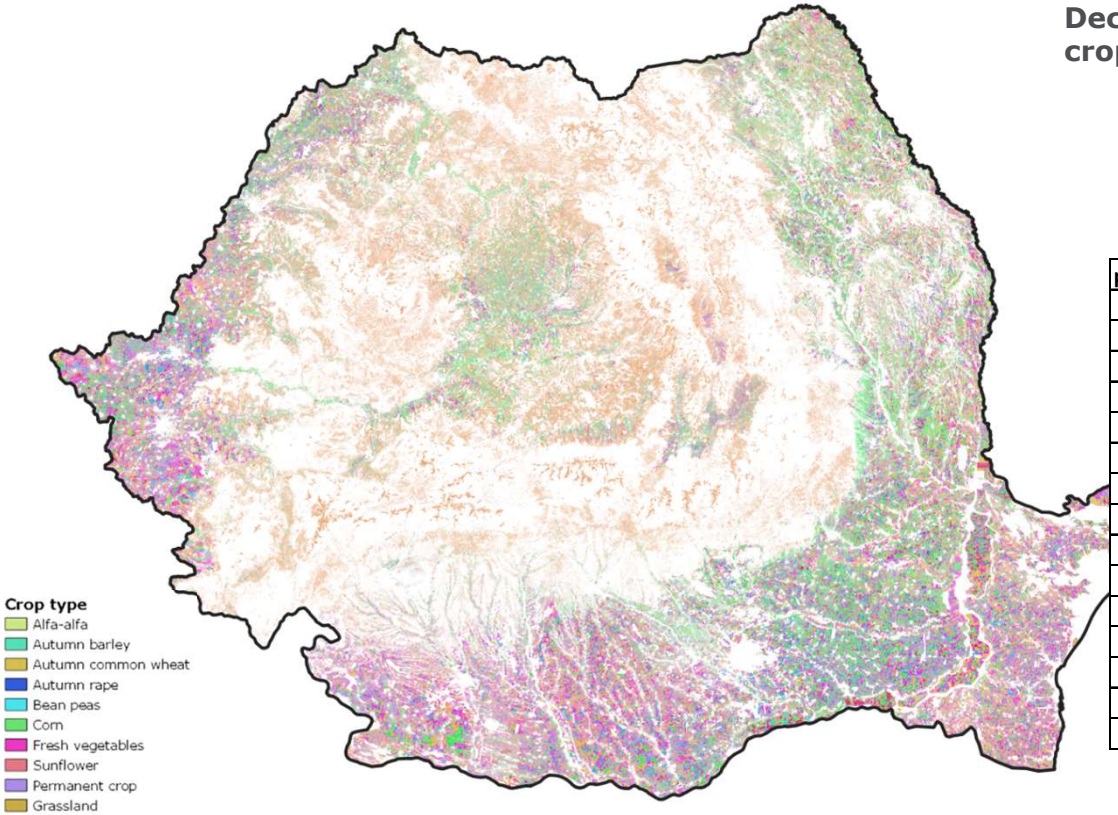
S1



LPIS / GSAA

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

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**

Assessment at the parcel level

« 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.)

parcel_id	crop_code	CT_decl	CT_pred_1	CT_conf_1	CT_pred_2	CT_conf_2	Classif_r
158568	101	8	8	0,941	31	0,011	cl_co
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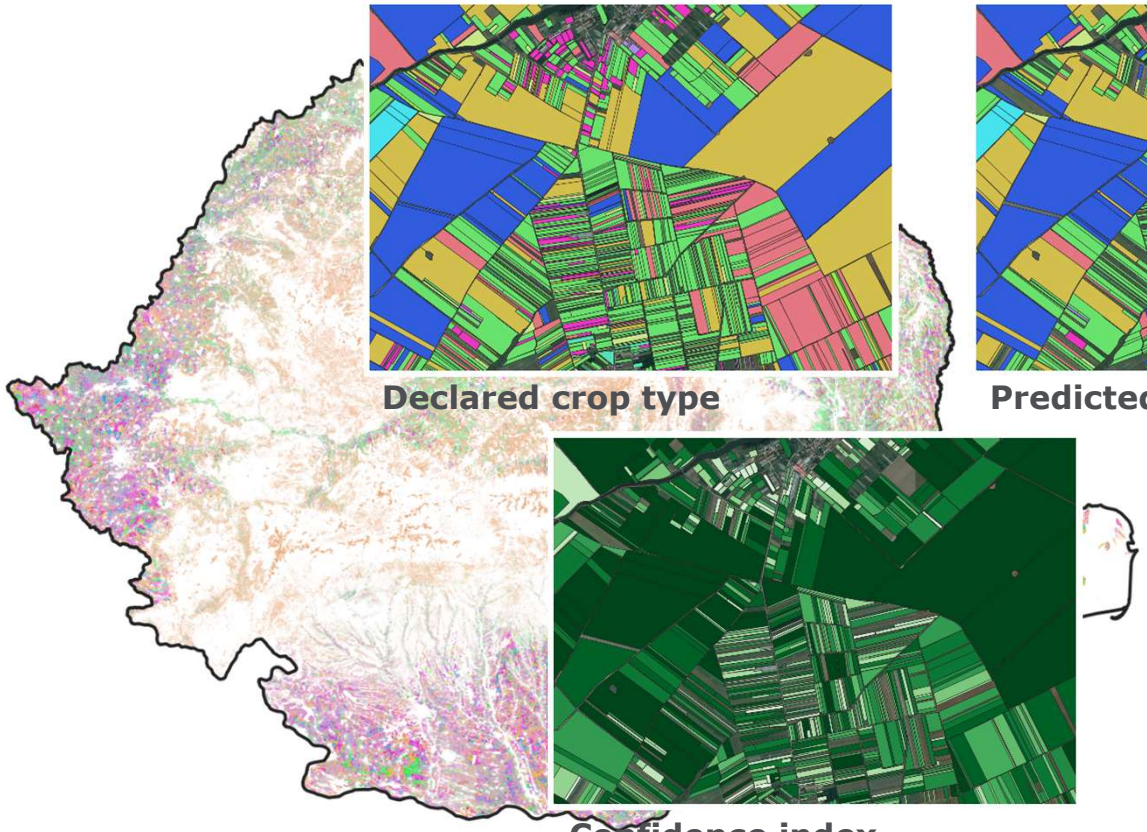
2018: National crop type mapping over 6 countries

Romania (100+ crop types)



Declared crop type

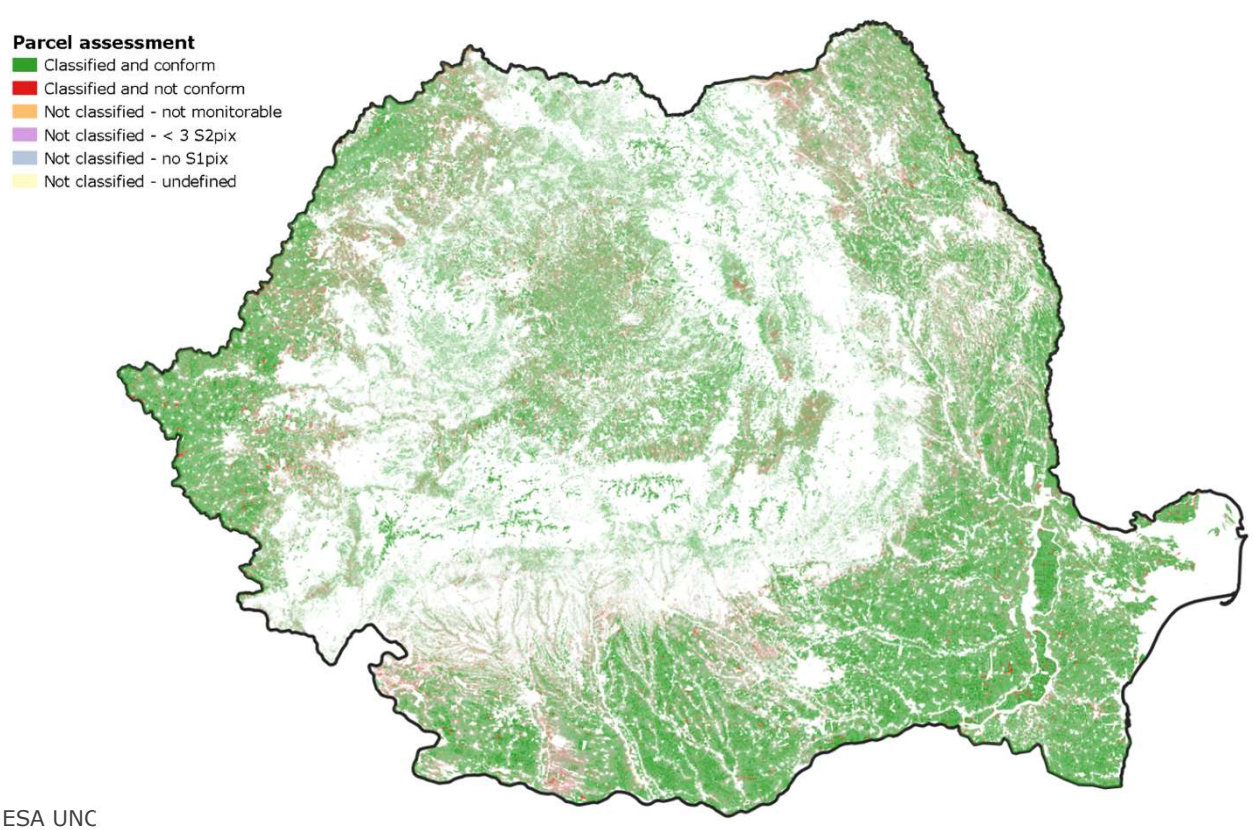
Predicted crop type

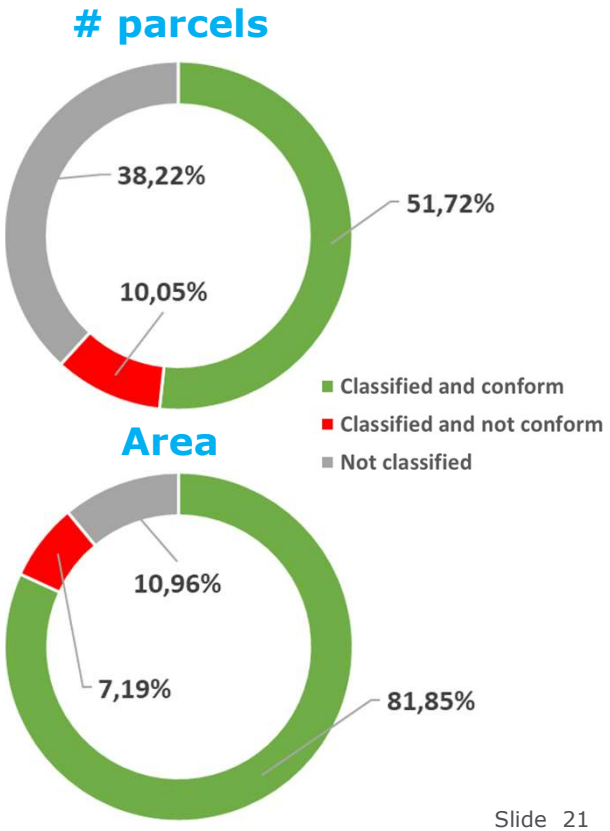
Confidence index

Conformity assessment

2018: National crop type mapping over 6 countries

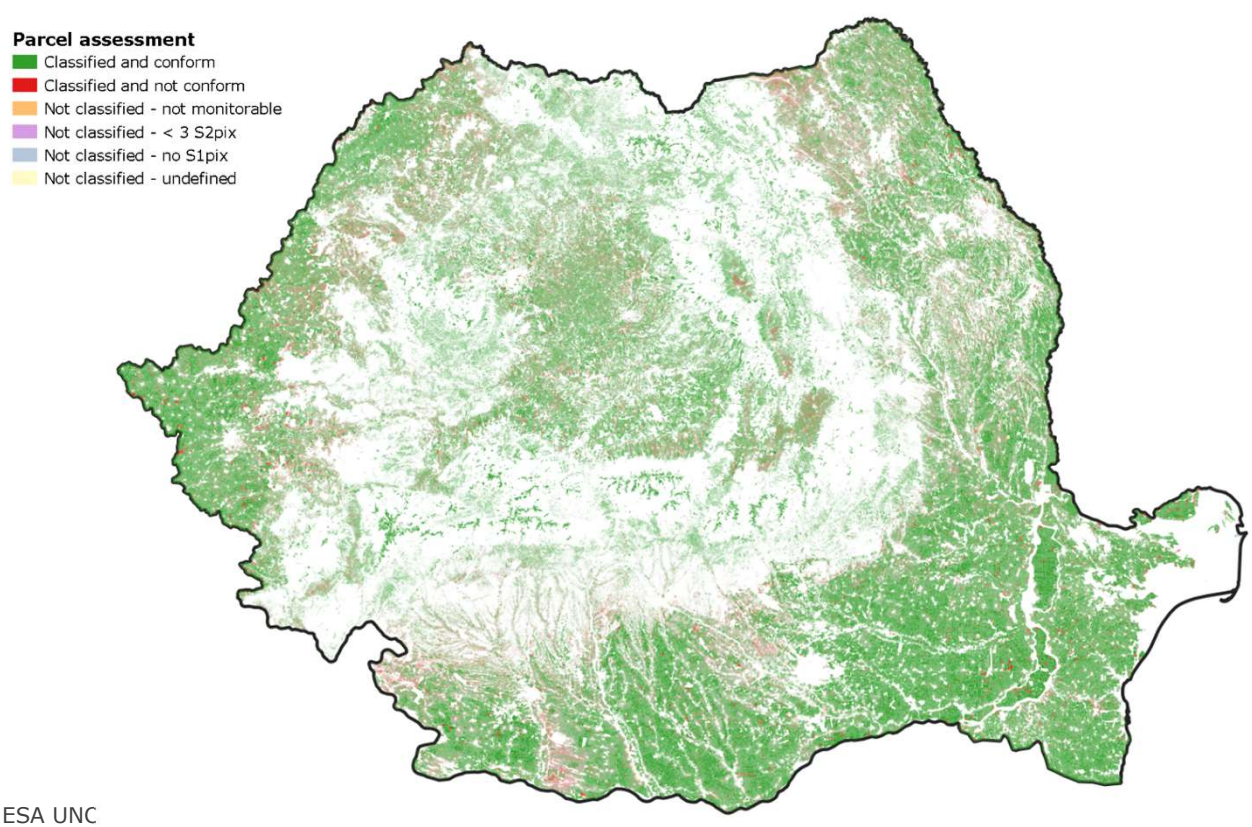
Example over Romania (100+ crop types) from S1 & S2

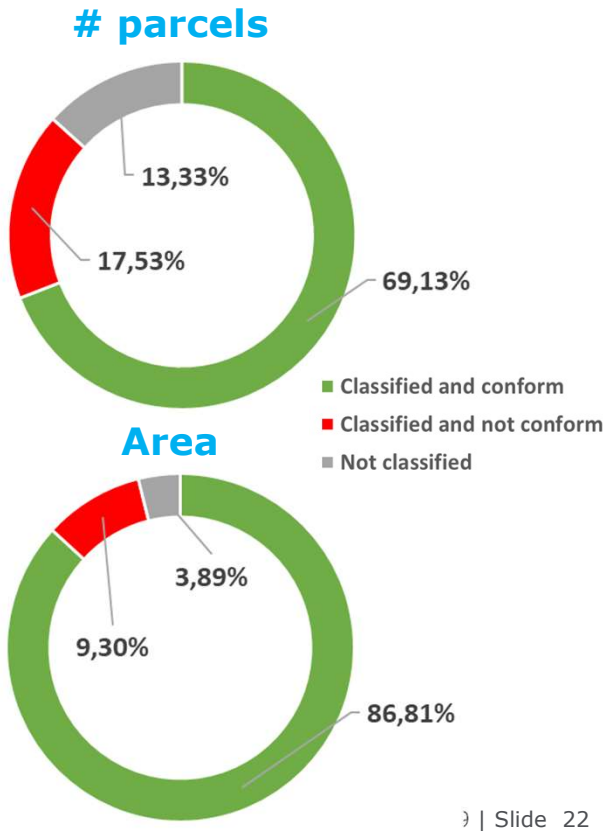




2018: National crop type mapping over 6 countries

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 %)

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

From crop type mapping to crop diversification
Combining assessments at parcel- and holding-level

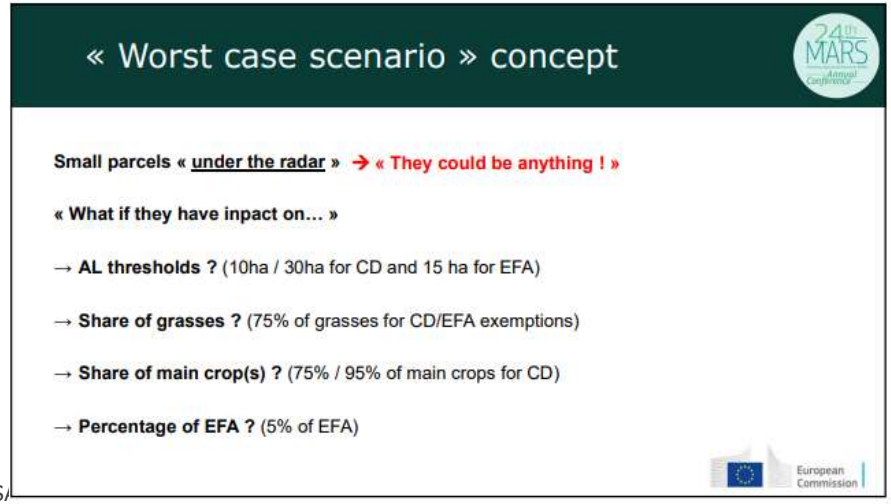
Parcel-level

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

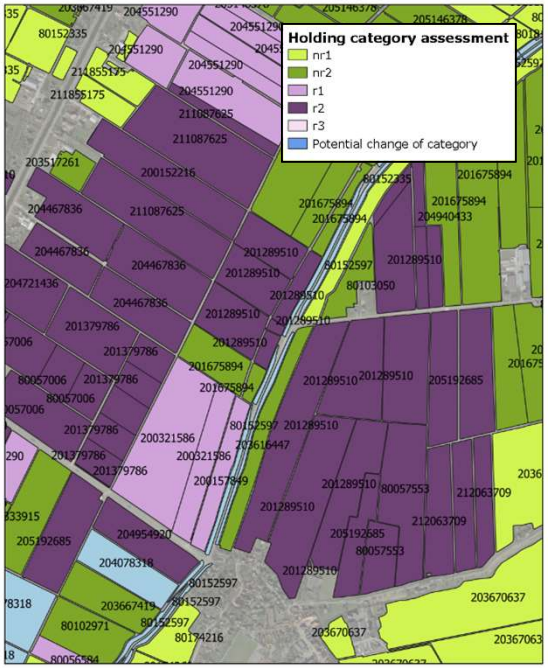
Combining assessments at parcel- and holding-level

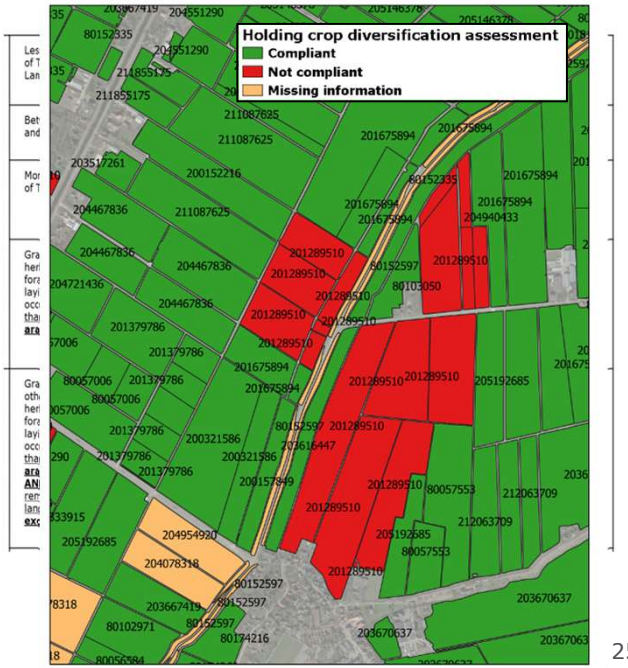
Parcel-level

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

Holding-level

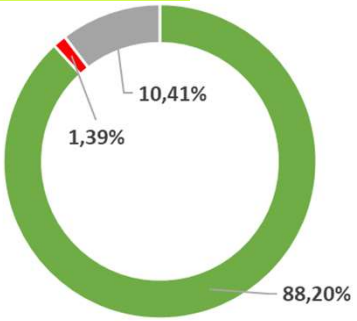
Assess the compliancy of the holding with regard to the crop diversification rules



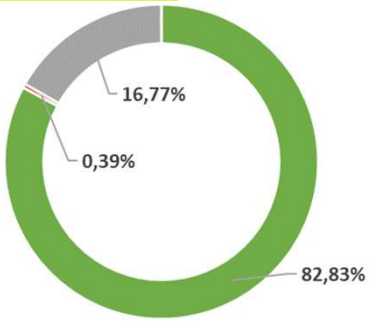


Crop diversification compliance analysis at holding level

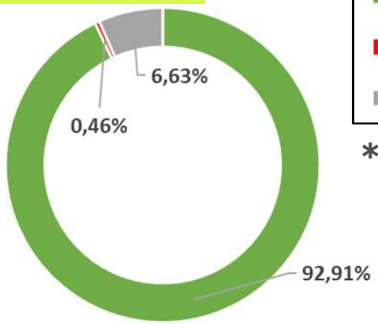
CZECH REPUBLIC



CASTILLA Y LEON



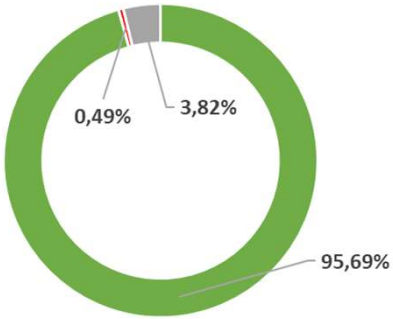
ITALY



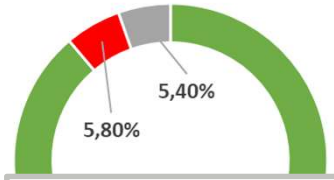
Compliant
Not compliant
Missing information

***At holding level**

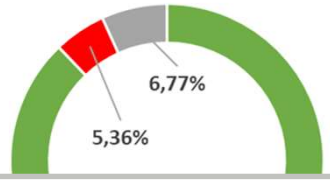
LITHUANIA



NETHERLANDS



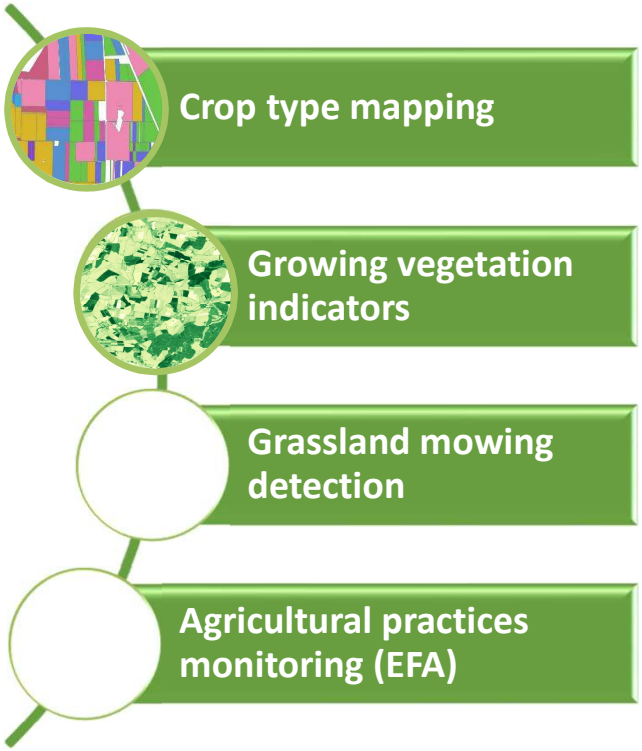
ROMANIA

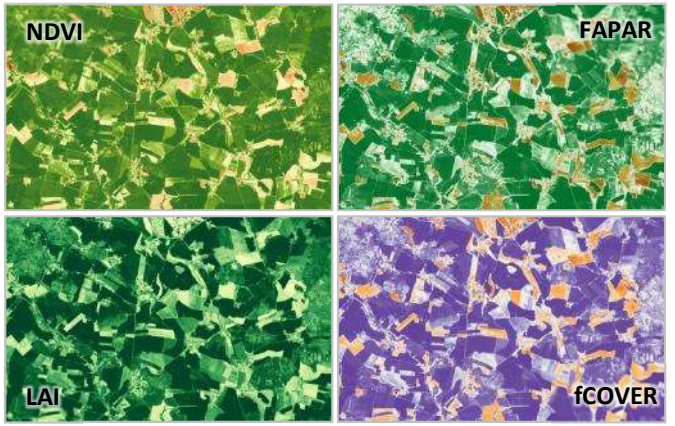


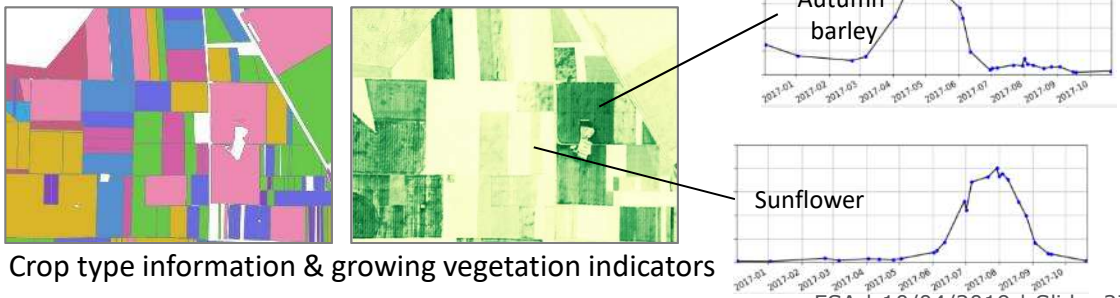
EXAMPLE OF OUTCOMES FROM TRAINING & DISCUSSION WITH PAs

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. …/…

Sentinels indicators and markers – veg. indicators

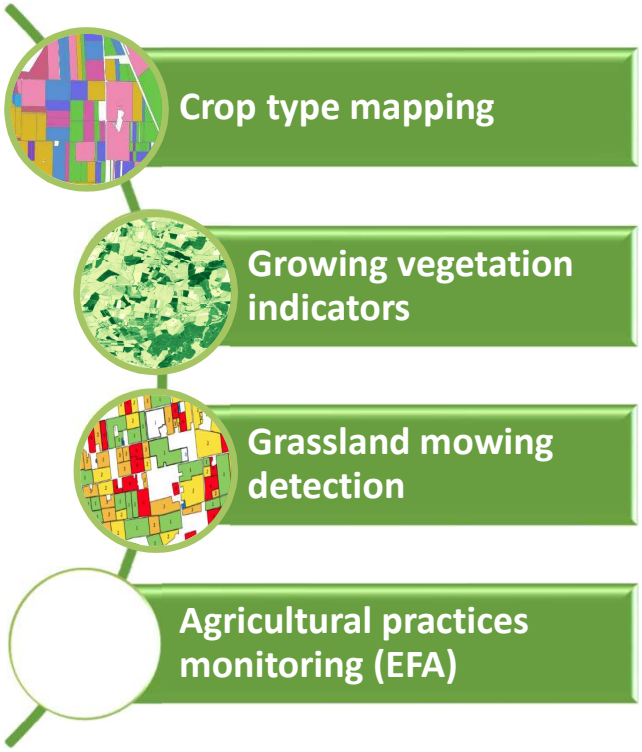




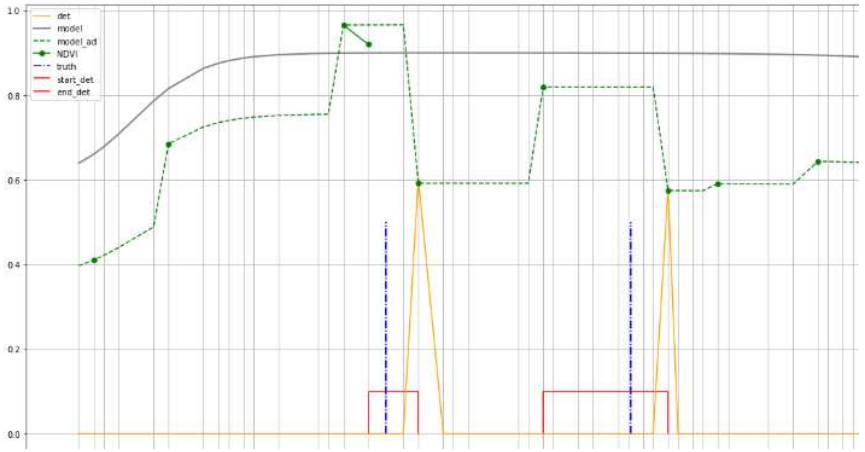


Crop type information & growing vegetation indicators

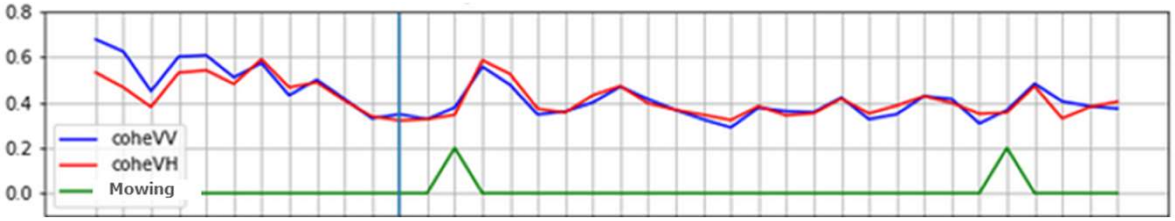
Sentinels indicators and markers – grassland mowing



S2 vegetation indices (NDVI, LAI, FAPAR) decrease

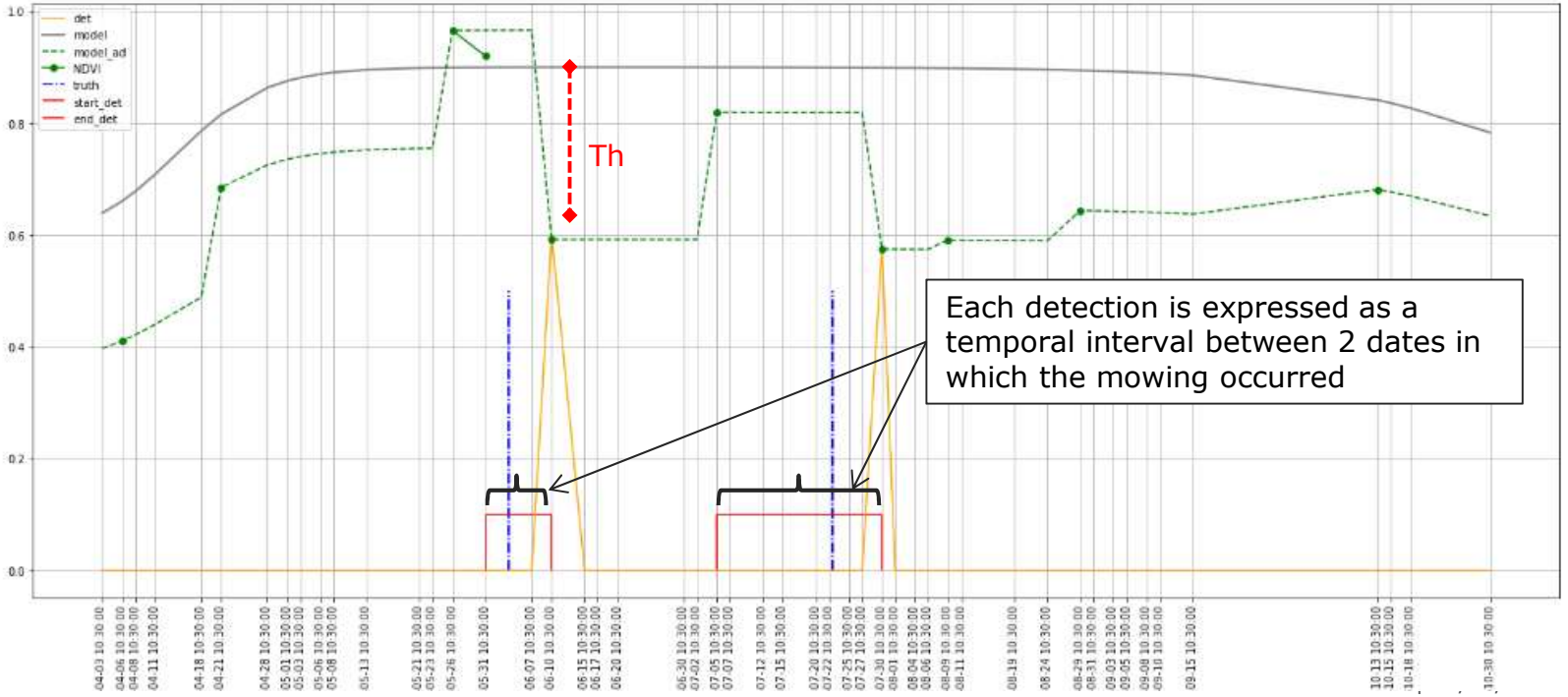


S1 coherence increase



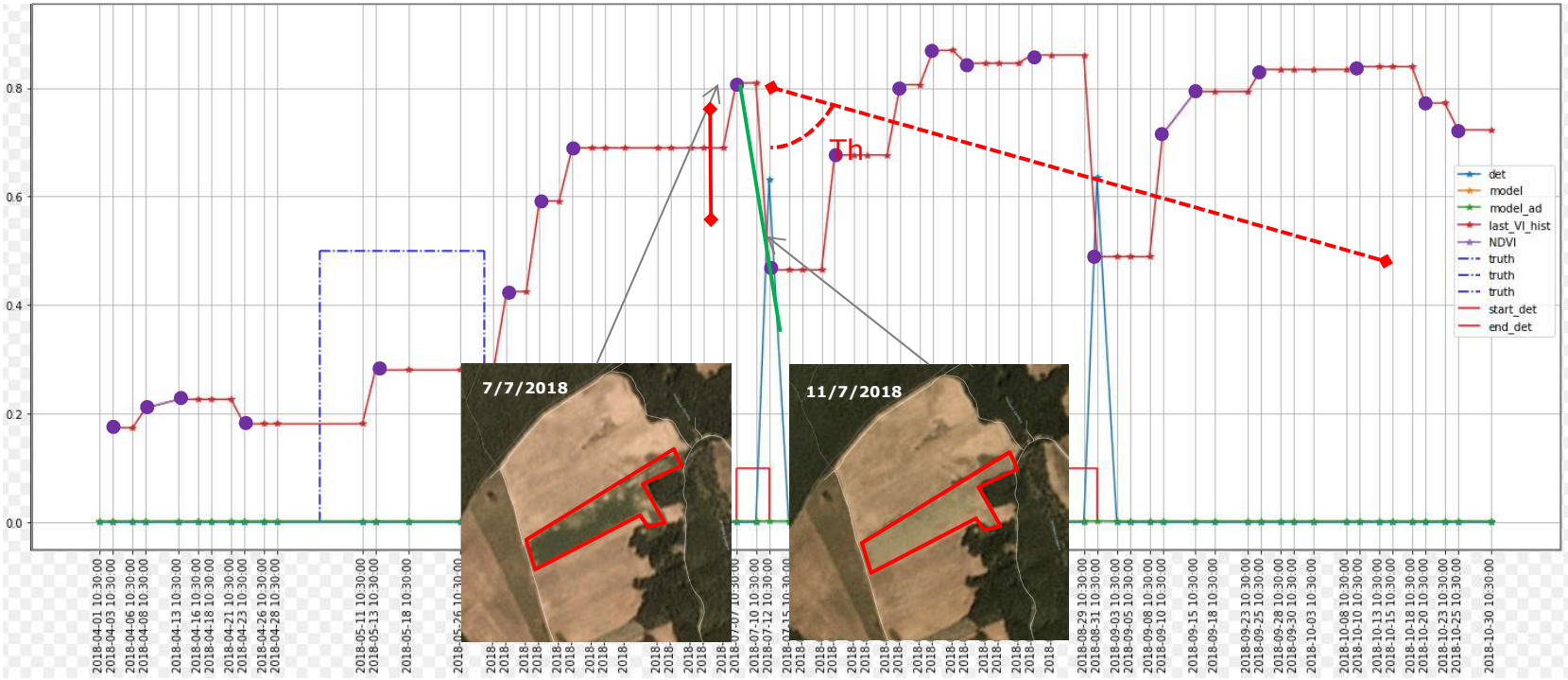
Mowing detection by VIs decrease wrt expected model

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



S2 mowing detection in a Mediterranean context

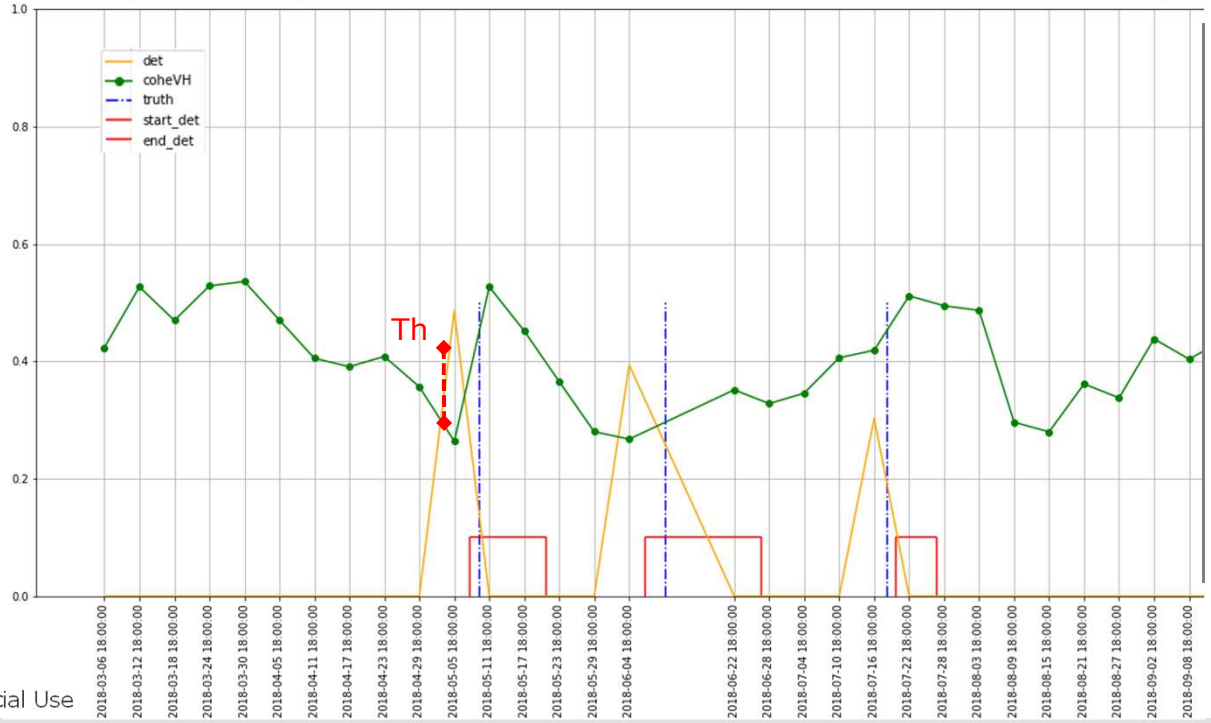
Sudden drop of veg. indicators to separate from **grass drying out**



S1 mowing detection by sudden coherence increase

Detection of sudden increase of 6-day coherences

through change detection in the coherence temporal profile



Grassland mowing detection – detection attributes

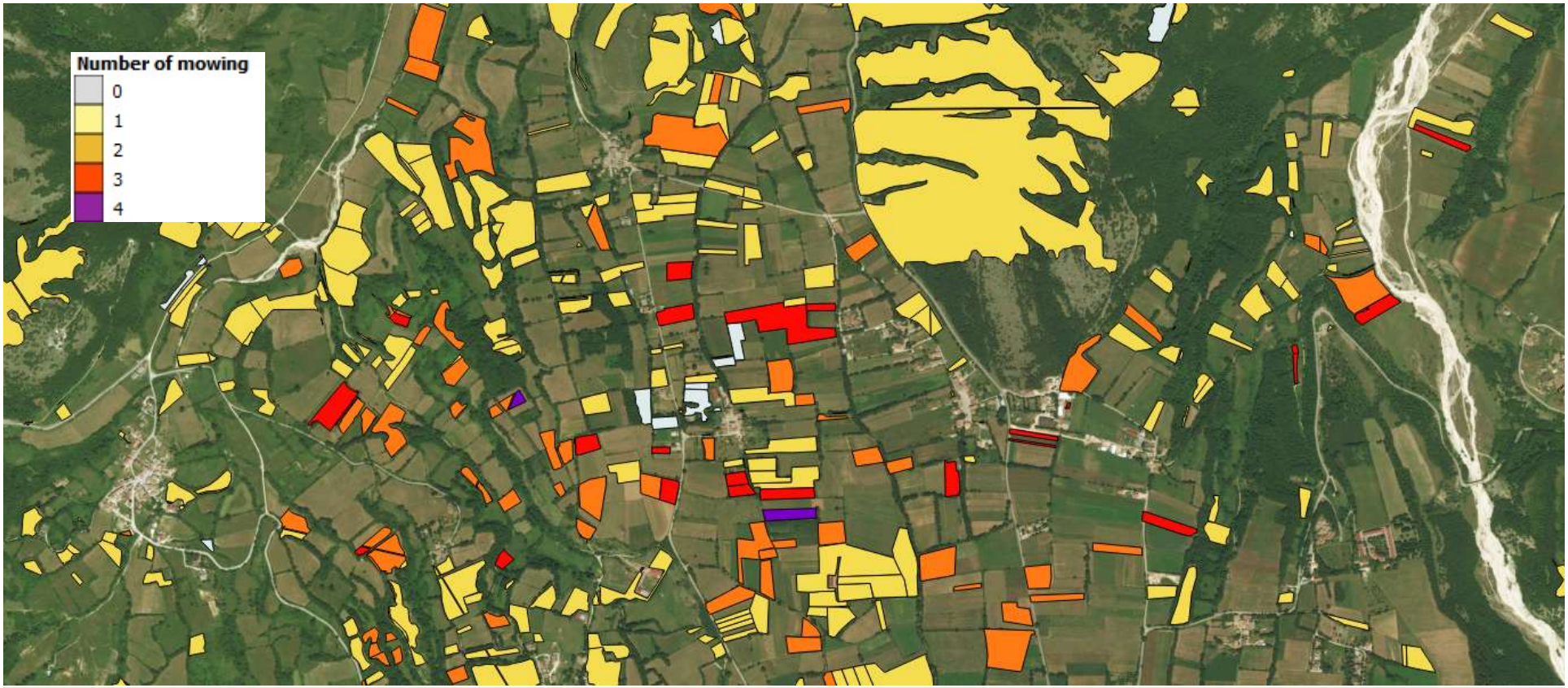
- Grassland mowing product contains, for each parcel, information about **number and temporal intervals of mowing events** detected

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				

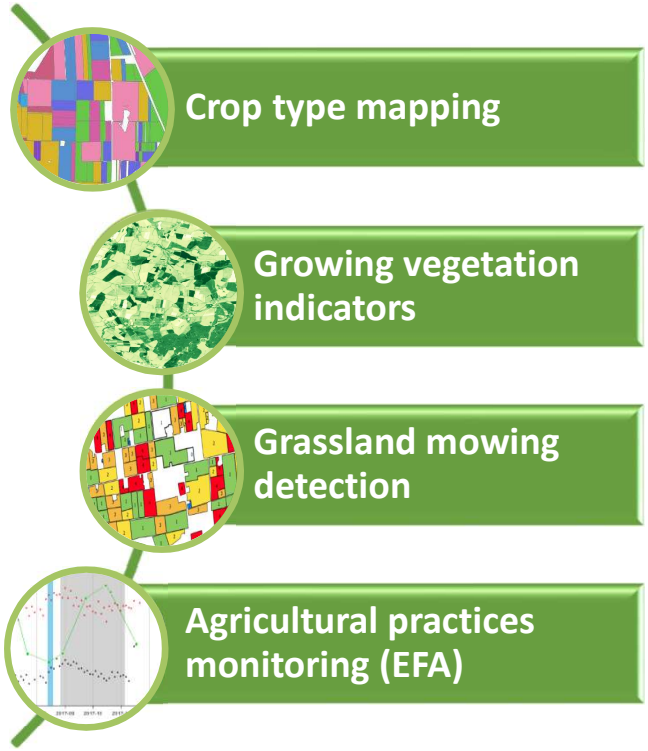
Product info for each parcel

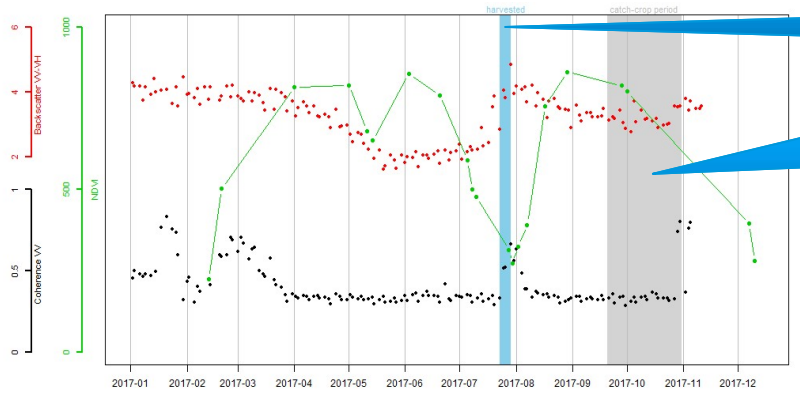
- ✓ Parcel identifier
- ✓ Grassland Crop type
- ✓ Number of mowing events (maximum 4)
- ✓ For each mowing event (up to 4):
  - Temporal interval in which the mowing event occurred (t_start and t_end)
  - Confidence level in terms of probability of right mowing (conf)
  - Satellite mission data used for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

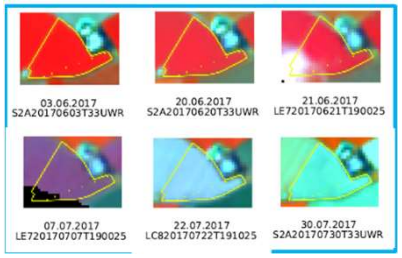
2018 Grassland mowing events detection



Sentinels indicators and markers – ag. practices (EFA)

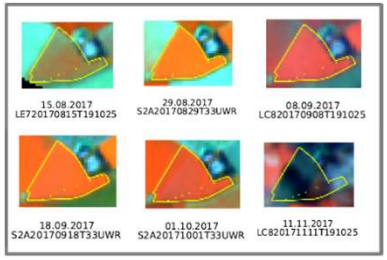






Winter Catch Crop – Visual check

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

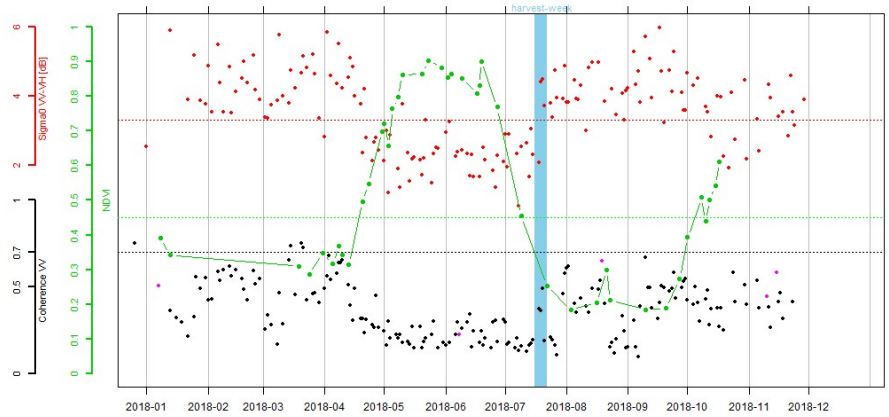
Agricultural Practices Monitoring
Detection of harvest date for the main crop - LTU

ORIG_ID	FIELD_ID	COUNTRY	YEAR	MAIN_CROP	VEG_START	H_START	H_END	PRACTICE	P_TYPE	P_START	P_END
1003XXX-XXXX-XXX	65	LTU	2018	KVŽ	2018-04-02	2018-06-01	2018-12-15	NA	NA	NA	NA

M1	M2	M3	M4	M5	H_WEEK	M6	M7	M8	M9	M10	C_INDEX
TRUE	TRUE	TRUE	TRUE	TRUE	29	NA	NA	NA	NA	NA	NA

W_GAPS	S1PIX	H_W_START	H_W_END
0	16	2018-07-16	2018-07-22

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**.

vegetation period

ORIG_ID	SEQ_ID	COUNTRY	YEAR	MAIN_CROP	VEG_START	H_START	H_END	PRACTICE	P_TYPE	P_START	P_END
31.0000002555170.001	676	NL	2018	233	2018-05-01	2018-07-15	2018-10-15	CatchCrop	CatchCrop_1	2018-10-15	NA
31.0000002624927.001	5752	NL	2018	799	2018-05-01	2018-05-15	2018-10-15	CatchCrop	CatchCropIsMain	2018-05-15	2018-07-15

harvest period

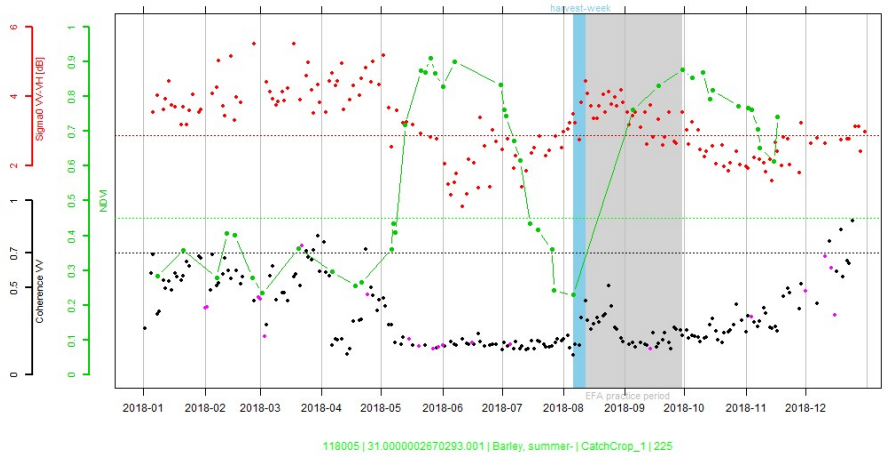
practice period

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

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

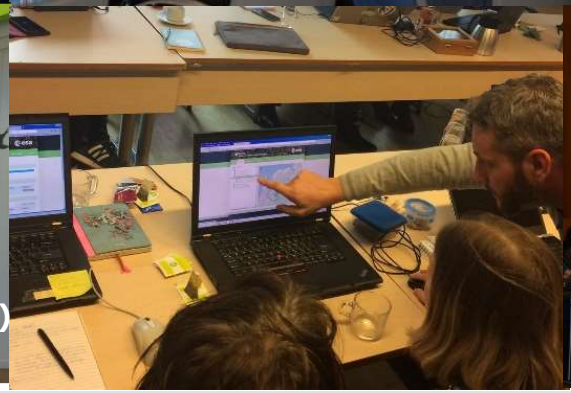
7 May 2018 **9 May 2018**

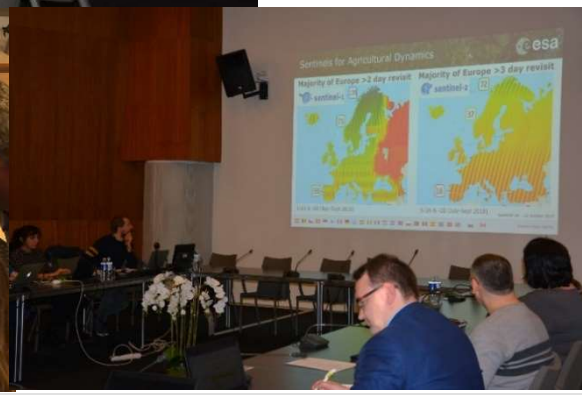
2-day trainings in each 6 PAs premisses (Feb.- Apr.19)

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

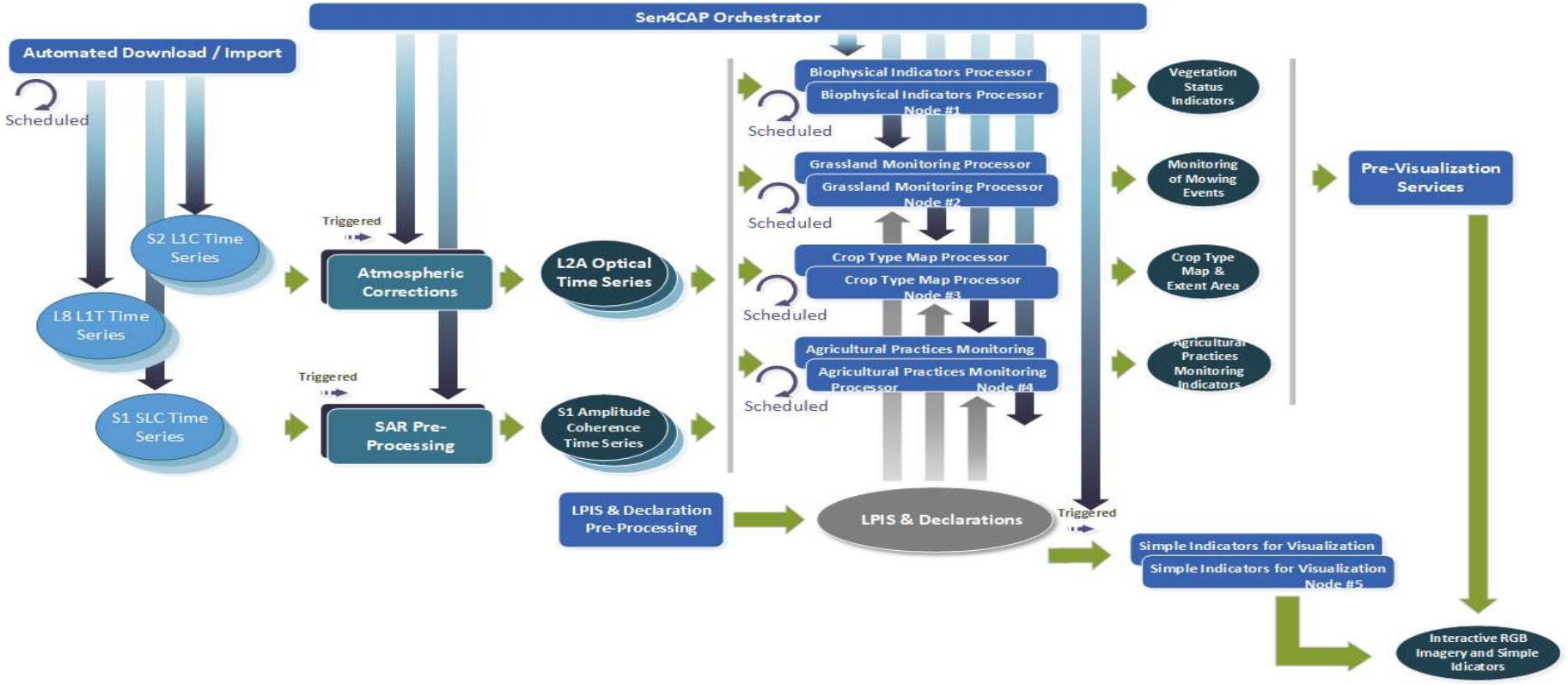
Training at NMA (Vilnius, LITHUANIA)
06-07/03/2019

Training at NVWA (Zwolle, THE NETHERLANDS)
11-12/03/2019 © Wilmer Woudwijk



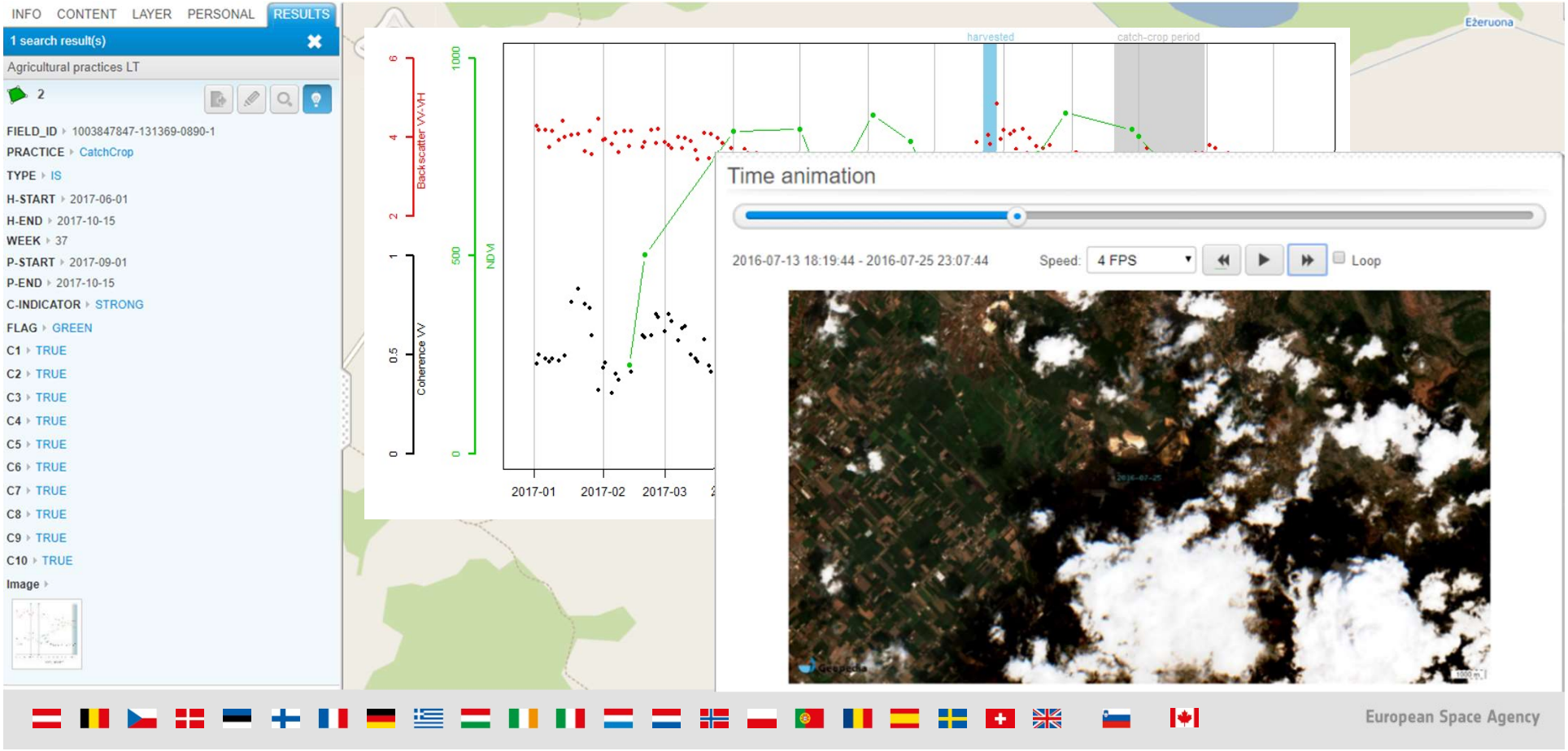


Sen4CAP System overview – open source code



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** 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
sen4cap
common agricultural policy