Grassland mowing detection from Sentinel-1 and Sentinel-2

Concept and method
Permanent grassland monitoring use case

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common agricultural policy

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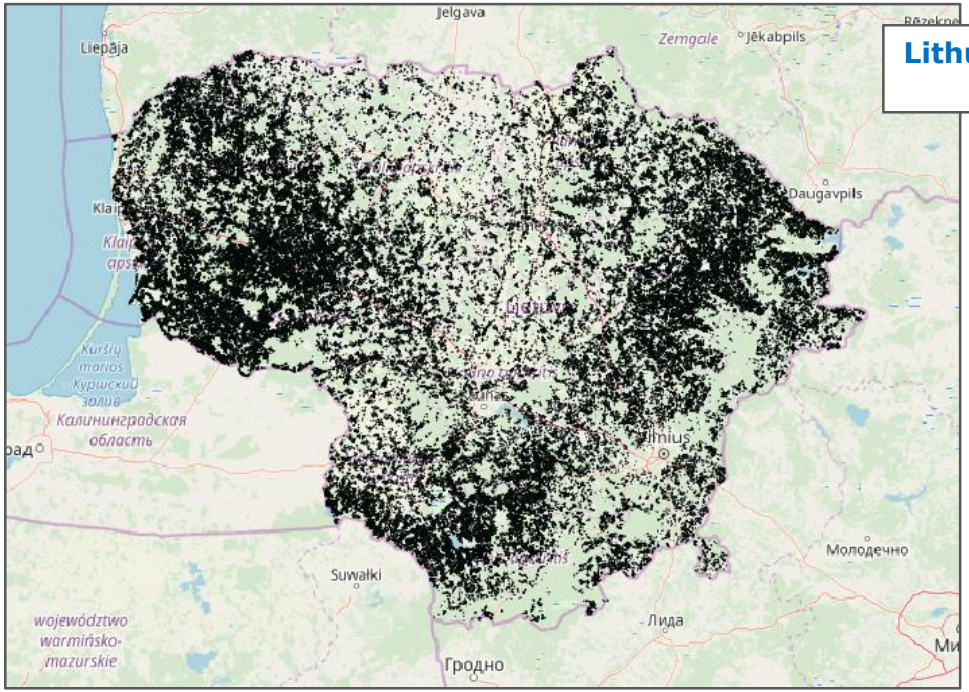
Content overview

- **PRODUCT AND METHOD**
  - Concept
  - Technical Specifications
  - Workflow of the processing chain
  - S1 and S2 algorithm principles and parameters
  - Overview of the product
- **USE CASE**
- **VALIDATION**
  - Accuracy assessment approach
  - 2019 preliminary accuracy assessment and comparison wrt 2018 results
- **LESSONS LEARNED AND NEXT STEPS**

Concept

- Grassland mowing product consists in the **detection of mowing events** occurred on **permanent grassland parcels** during a reference period, based on **temporal series of Sentinel-1 and Sentinel-2** satellite data



Lithuania Grassland Parcels (2019)

Specifications for Grassland Mowing product

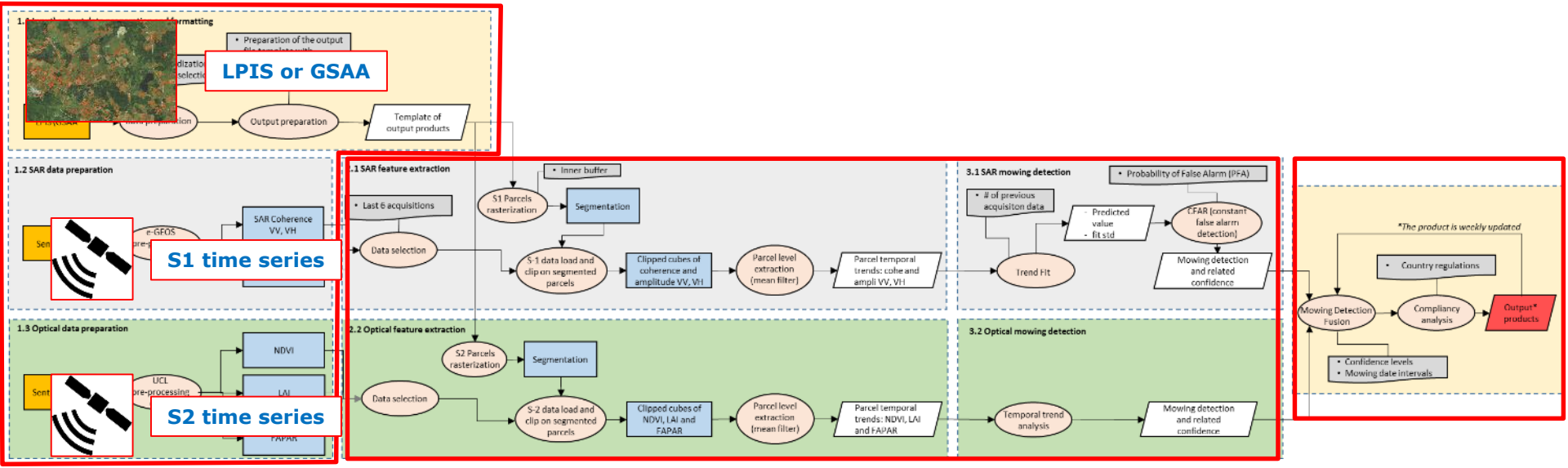
Properties	Product specification
Spatial coverage	Country
Monitoring period	**April – October** (depending on user requirements)
Temporal frequency	**Monthly\Bi-weekly** (first delivery is planned as soon as the declarations are available)
Delivery time	**72 hours after** the acquisition of the **last image** of the month\2 weeks
Spatial resolution	Parcel-level
Legend	GSAA grassland crop type
Quality flags	Confidence level for each detection
Format	SHP and .csv
Projection	UTM-WGS84
Metadata	.txt file
Products distribution	FTP; visualization tool

Workflow of processing chain

Input data

S2 and S1 Detection algorithm

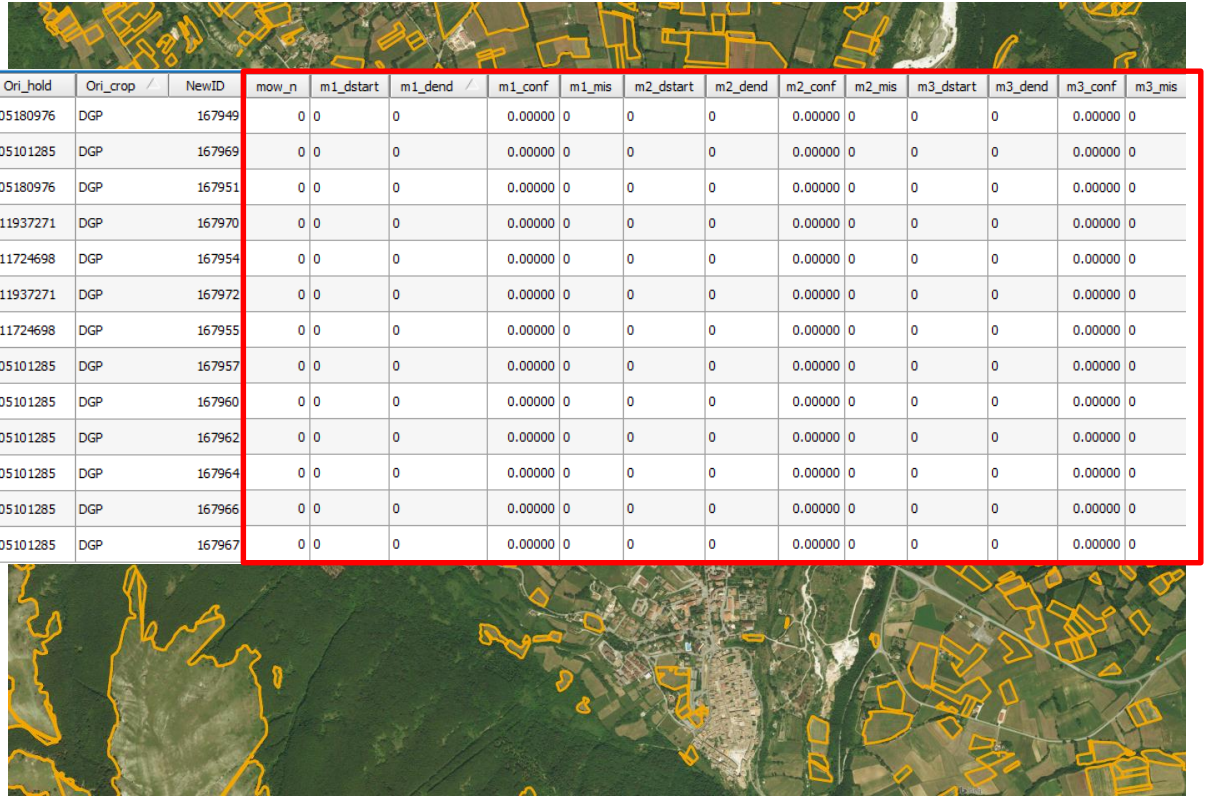
Detection fusion and compliancy assessment



Input data – GSAA grassland parcels

Geo-spatial aid application (GSAA)

- Unique Parcel identifier generation
- Quality flags (geometry and S2/S1 pixels)
- Filtering of grassland parcels
- Preparation of the schema (attribute) of the output product

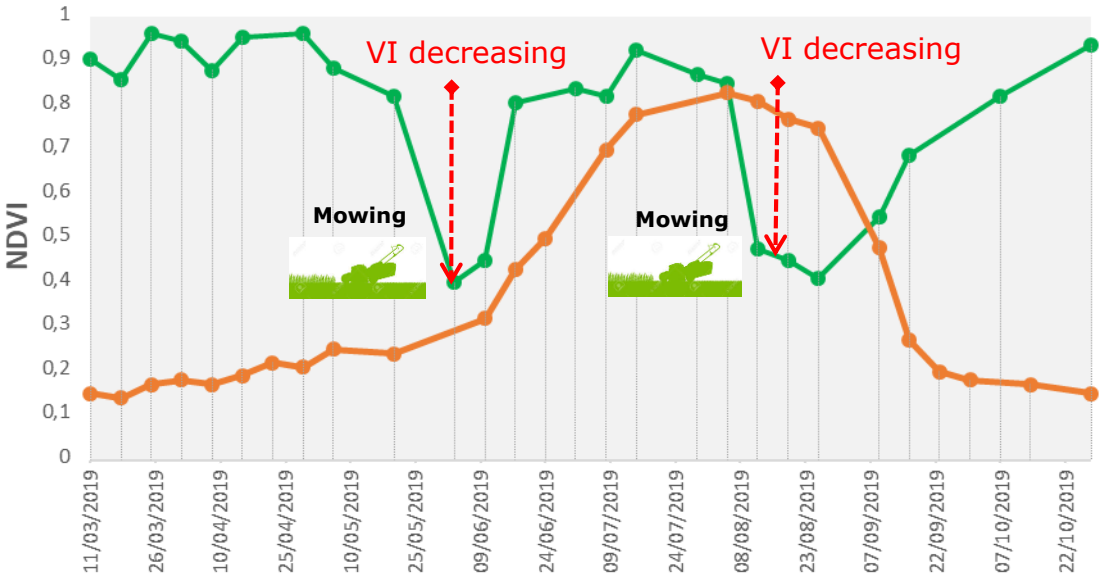


Ori_id	Ori_hold	Ori_crop	NewID	mow_n	m1_dstart	m1_dend	m1_conf	m1_mis	m2_dstart	m2_dend	m2_conf	m2_mis	m3_dstart	m3_dend	m3_conf	m3_mis
1005180976-075463-4481-2	1005180976	DGP	167949	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1005101285-113378-3362-1	1005101285	DGP	167969	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1005180976-074464-9101-1	1005180976	DGP	167951	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1011937271-054524-9085-1	1011937271	DGP	167970	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1011724698-190618-6905-1	1011724698	DGP	167954	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1011937271-048523-2522-1	1011937271	DGP	167972	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1011724698-190617-7057-2	1011724698	DGP	167955	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1005101285-115382-0937-1	1005101285	DGP	167957	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1005101285-115382-0937-2	1005101285	DGP	167960	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1005101285-115382-0937-3	1005101285	DGP	167962	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1005101285-114381-9383-2	1005101285	DGP	167964	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1005101285-115381-4634-1	1005101285	DGP	167966	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0
1005101285-115380-0761-1	1005101285	DGP	167967	0	0	0	0.00000	0	0	0	0.00000	0	0	0	0.00000	0

Input data – S2 Vegetation Status Indicators time series

S2 Time Series

- **NDVI** - Normalized Difference Vegetation Index
- **LAI** - Leaf Area Index
- **FAPAR** - Fraction of Absorbed Photosynthetically Active Radiation

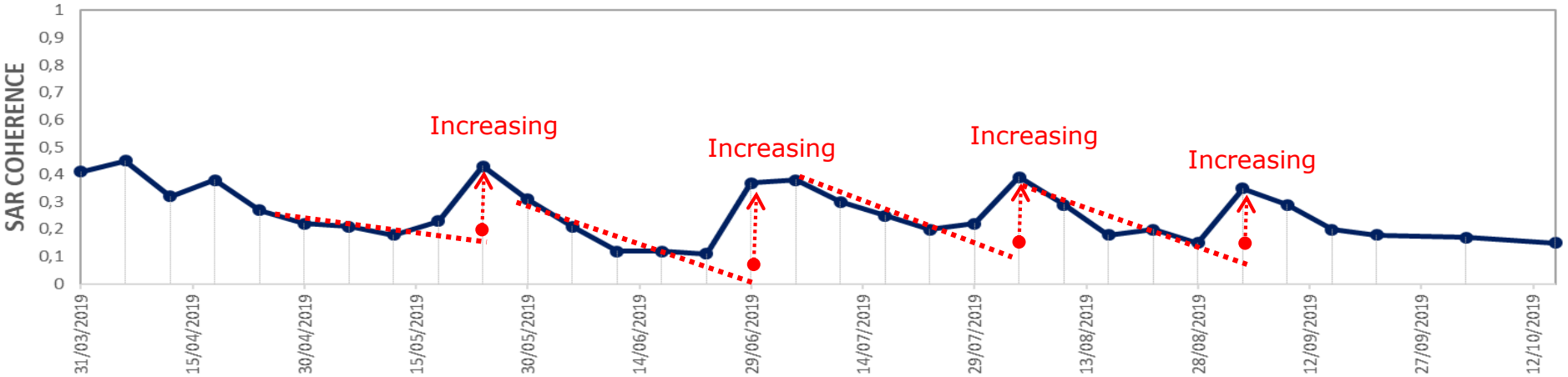


Input data – Sentinel-1 Indicators time series

S1 Time Series

- **COHERENCE**

Coherence is the fixed relationship between waves in a beam of electromagnetic (EM) radiation. Two wave trains of EM radiation are coherent when they are in phase. **High coherence implies that the scene is steady, low coherence indicates changes between the two acquisition dates.**



Workflow of processing chain

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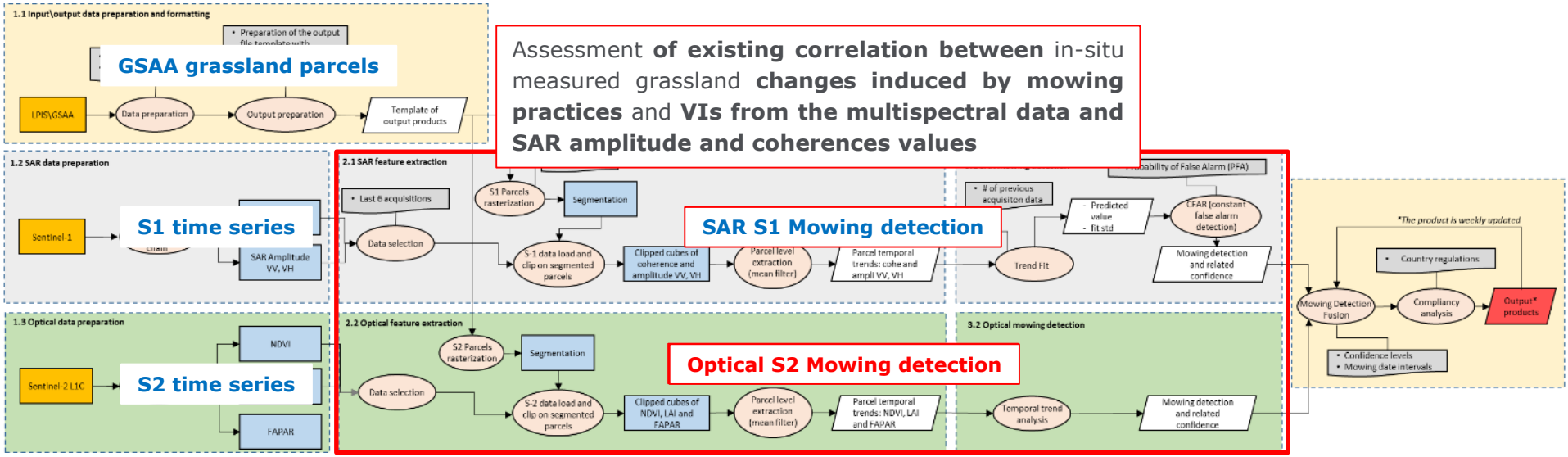
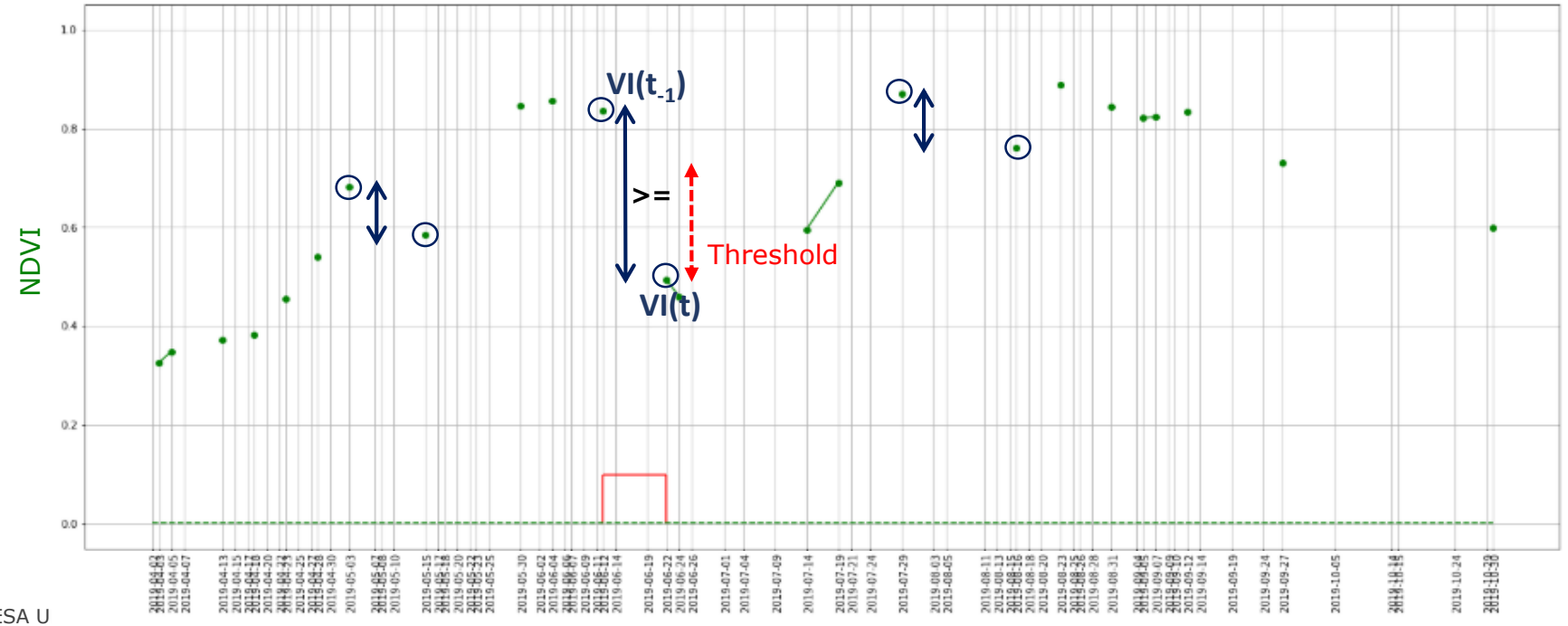
S2 and S1 Detection algorithm

Detection fusion and compliancy assessment



S2 algorithm

- S-2 data series are used to calculate **trends of indices related to the biomass** (for example NDVI) and to detect the **decreasing of these trends to identify a mowing event**.



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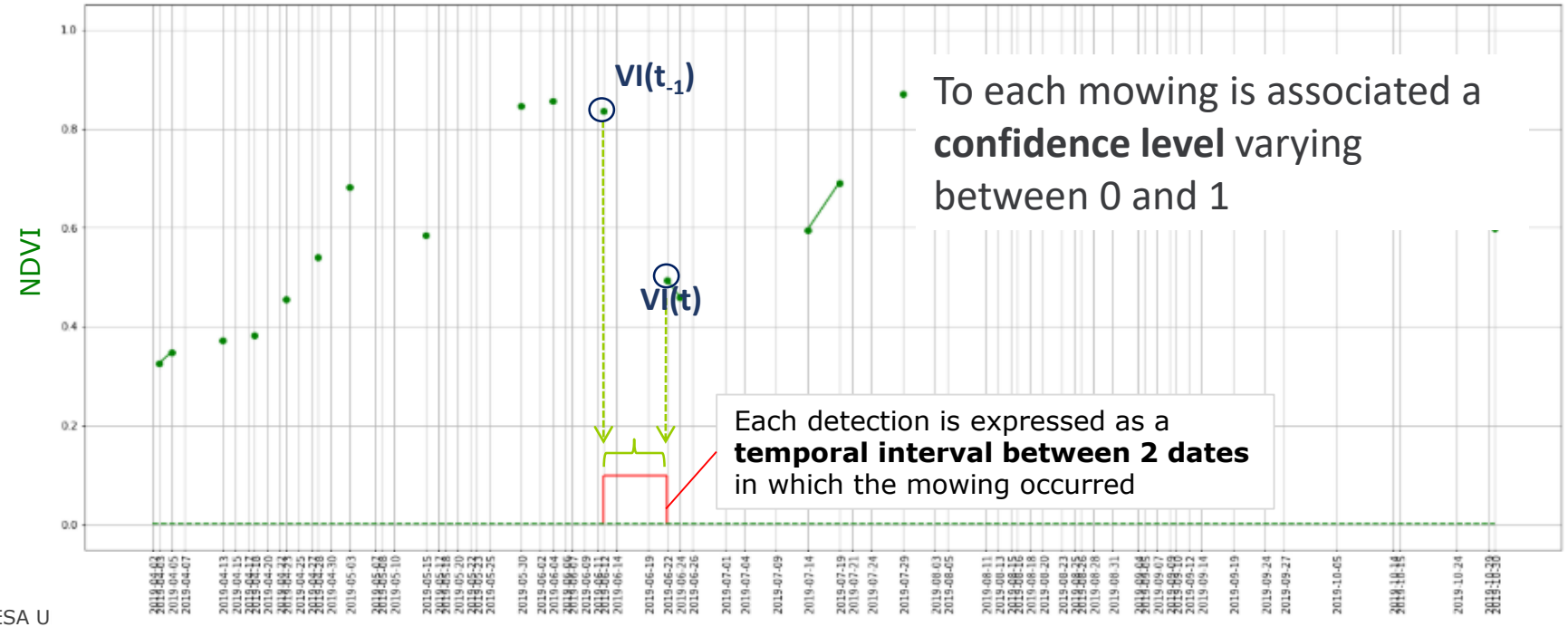

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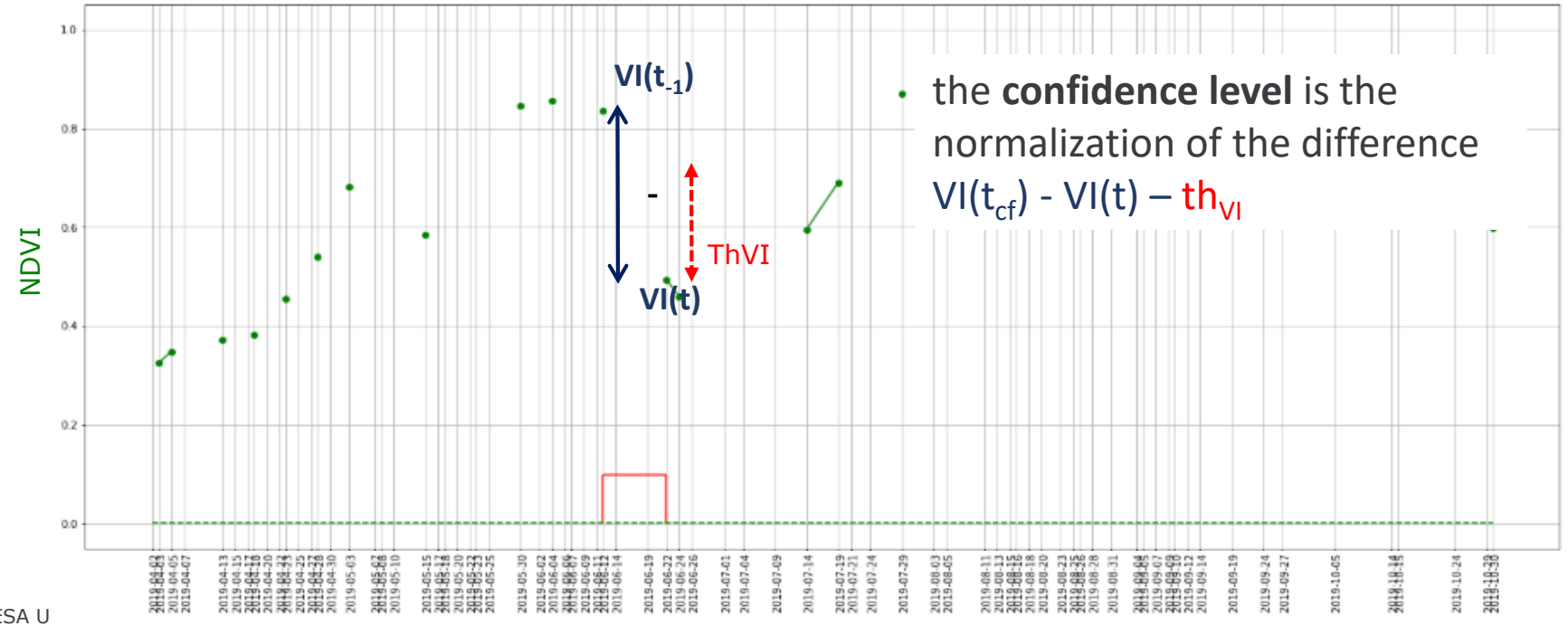

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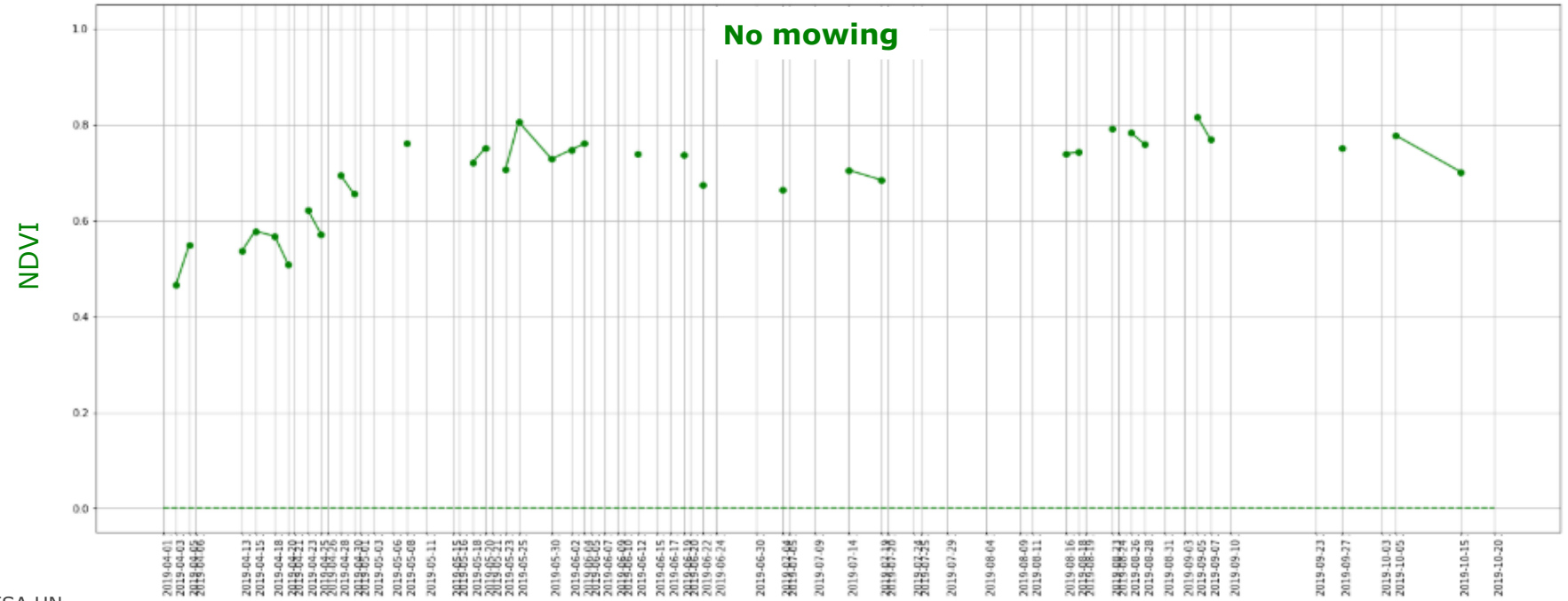
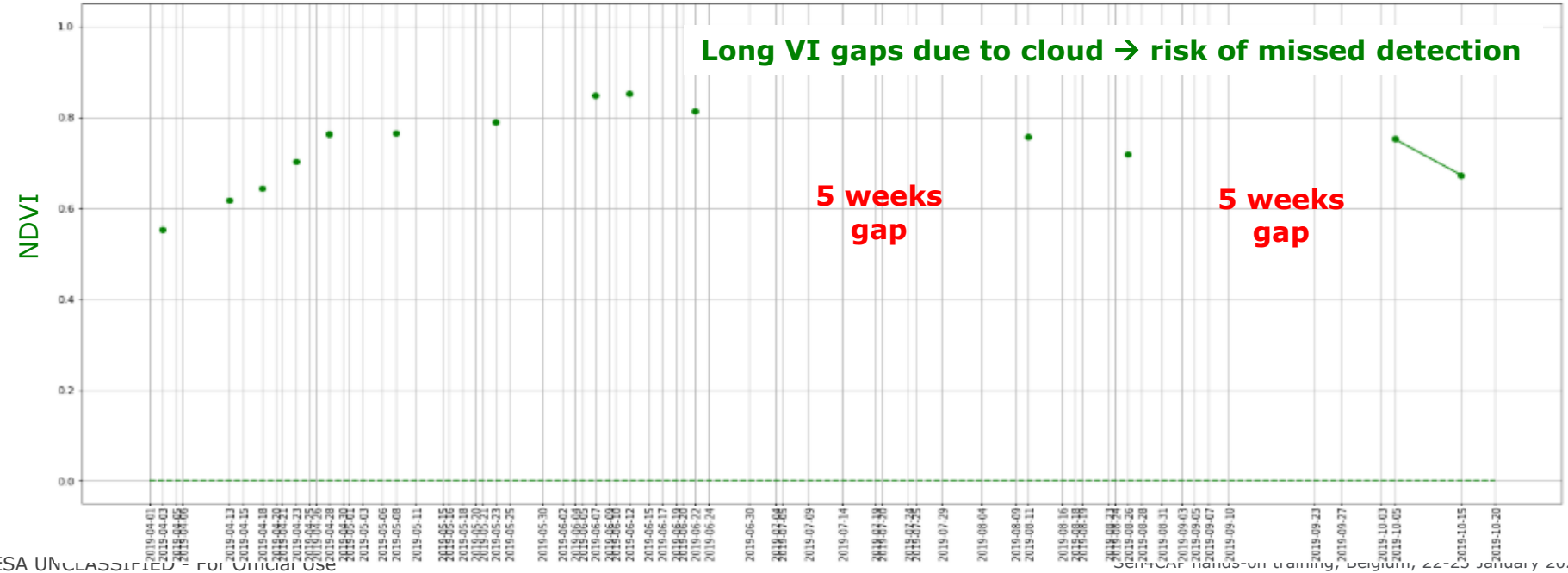


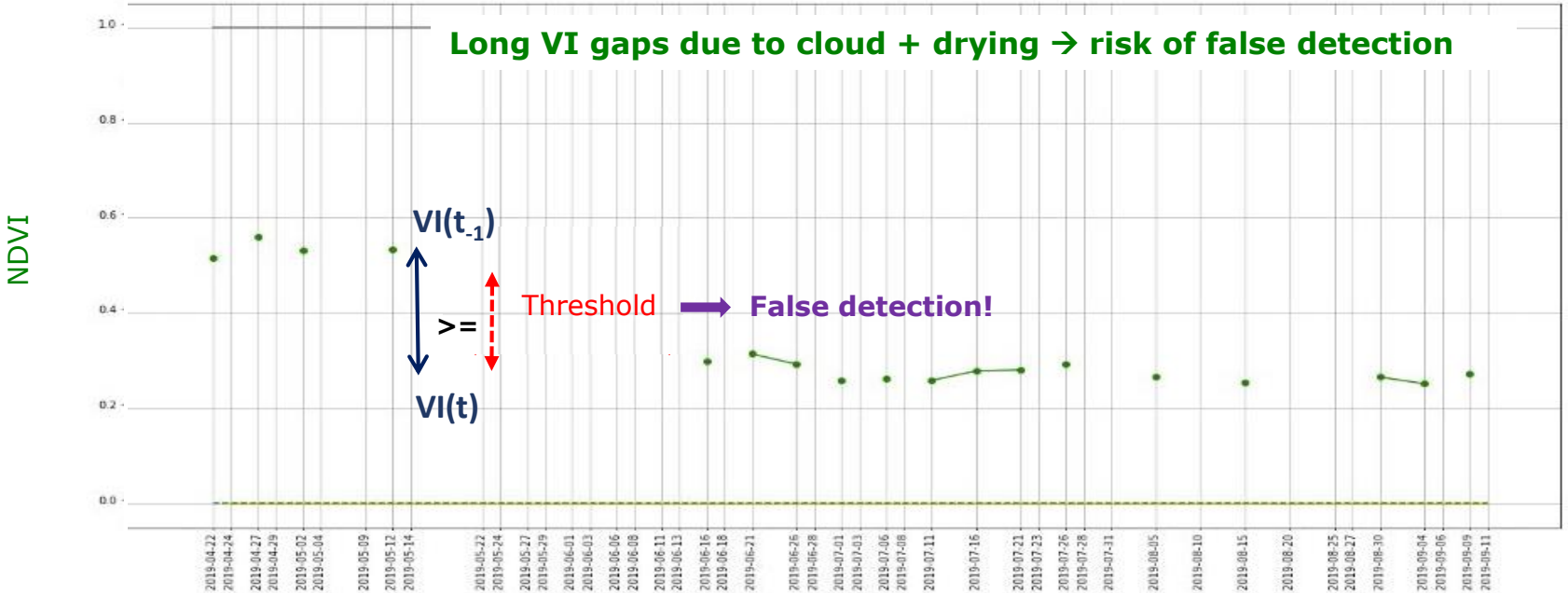
S2 algorithm

- Depending on the European regional area:
  - the **number of valid cloud free values and the annual trend of each of them varies strongly** depending on latitude, and therefore on country



S2 algorithm

- Depending on the European regional area:
  - **decreasing of NDVI could occur due to grass drying out** before and during Summer, but it has a **slower dynamic** with respect to mowing events



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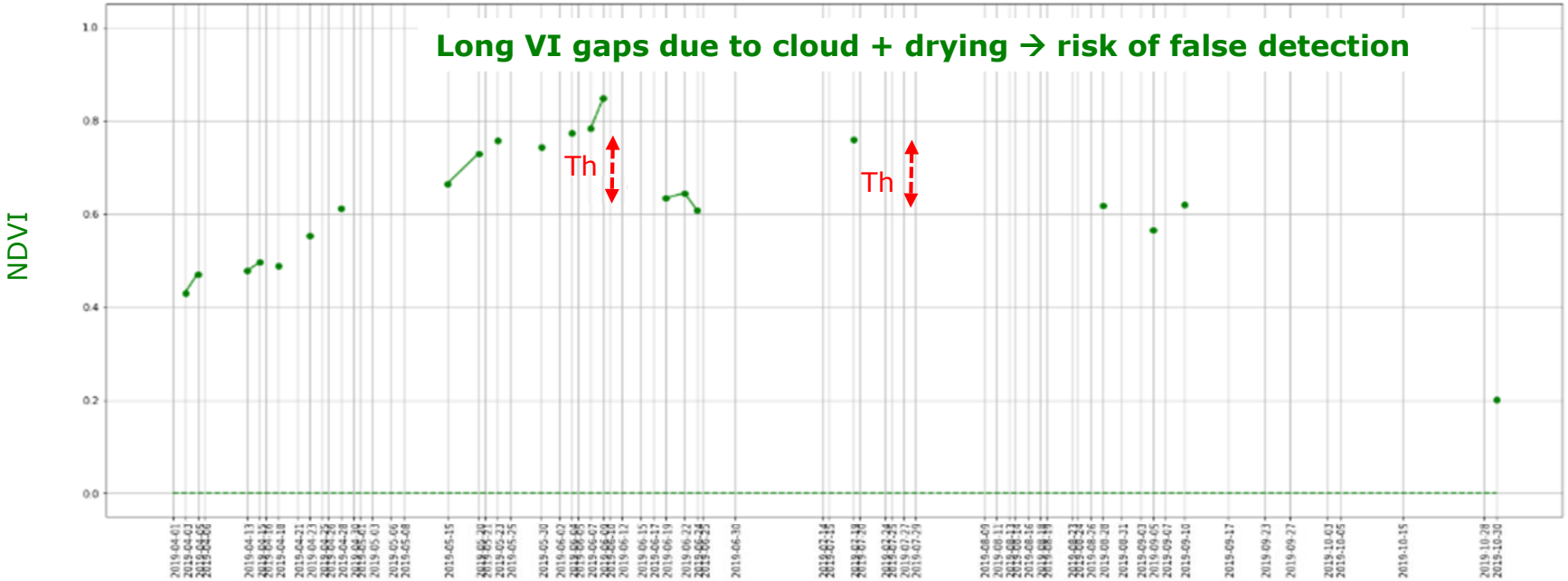

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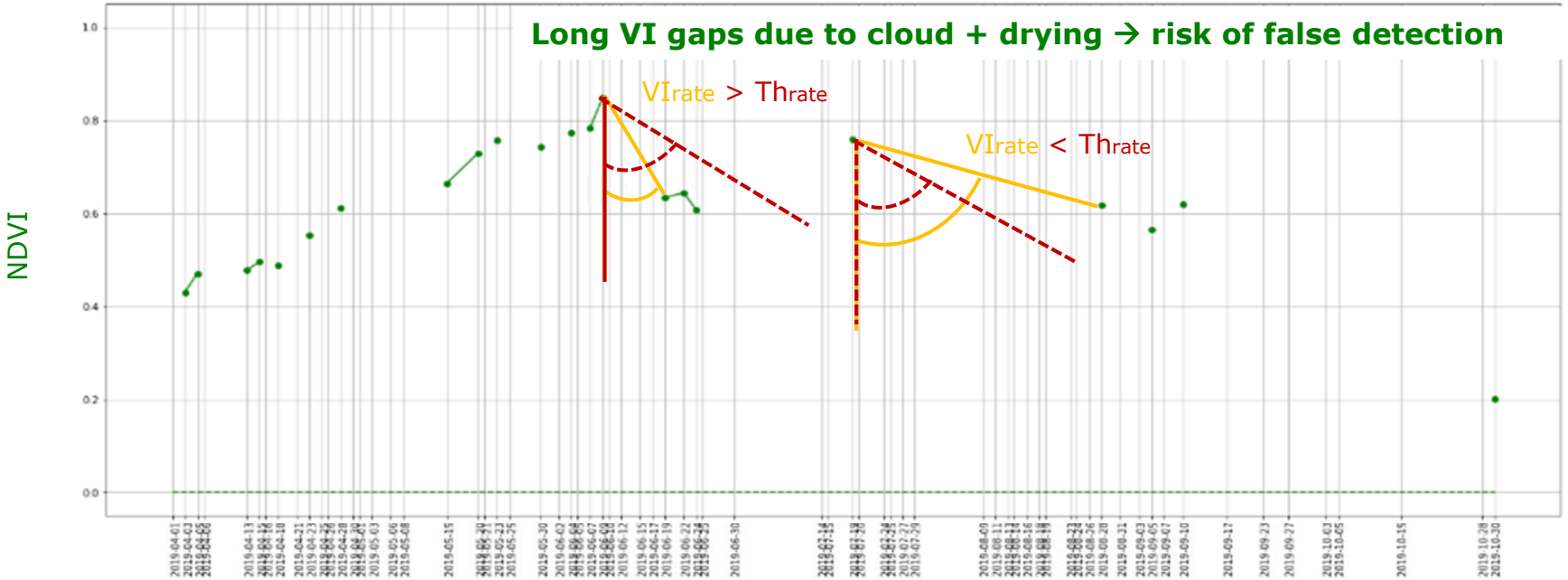

Workflow of processing chain

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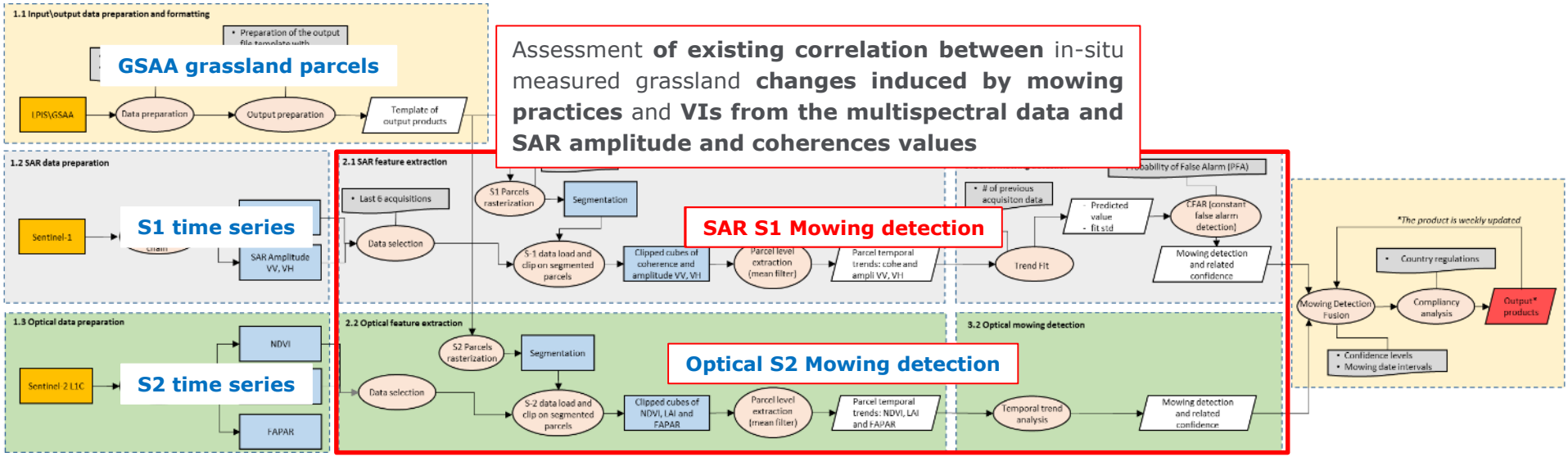


S1 algorithm

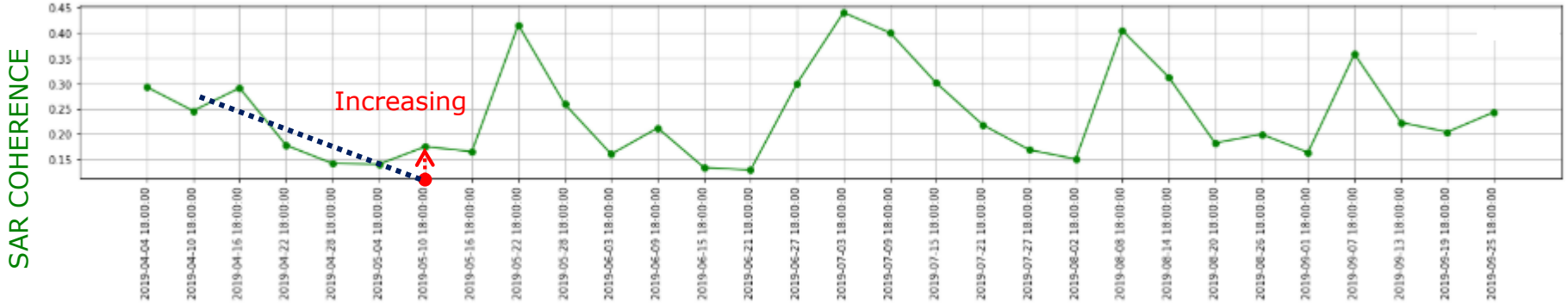
The mowing detection based on SAR data is based on the following principles:

- **high grass makes low the measured coherence**, because incoherent

- **coherence based on both images after the mowing is expected higher because corresponding to two scenes with low level of the grass** and therefore with a component of the backscatter coming from the soil which should be more coherent of the grass leafs.

S1 algorithm

On the base of these principles, the main **mechanism used to detect a mowing is to identify sudden increasing of the coherences through change detection in the coherences temporal trends**.



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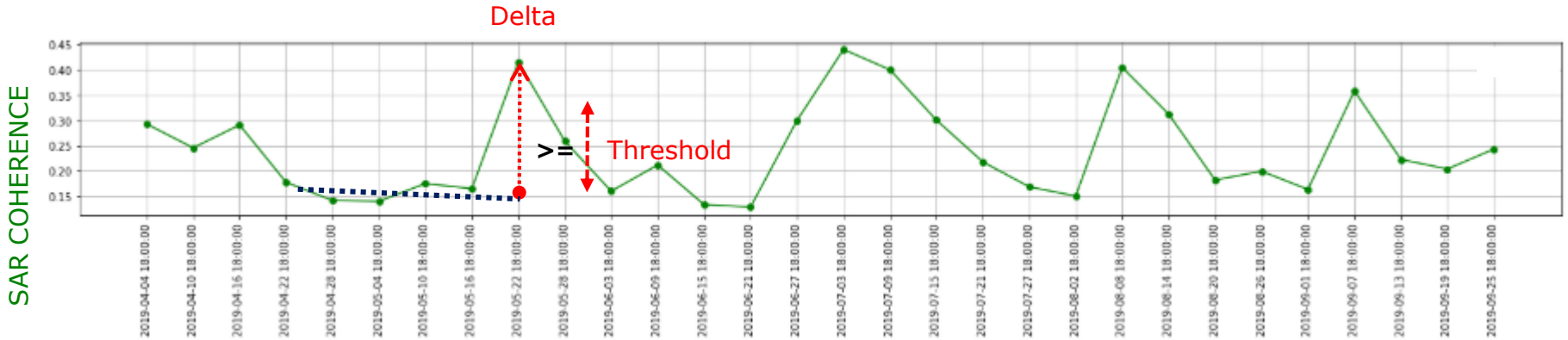

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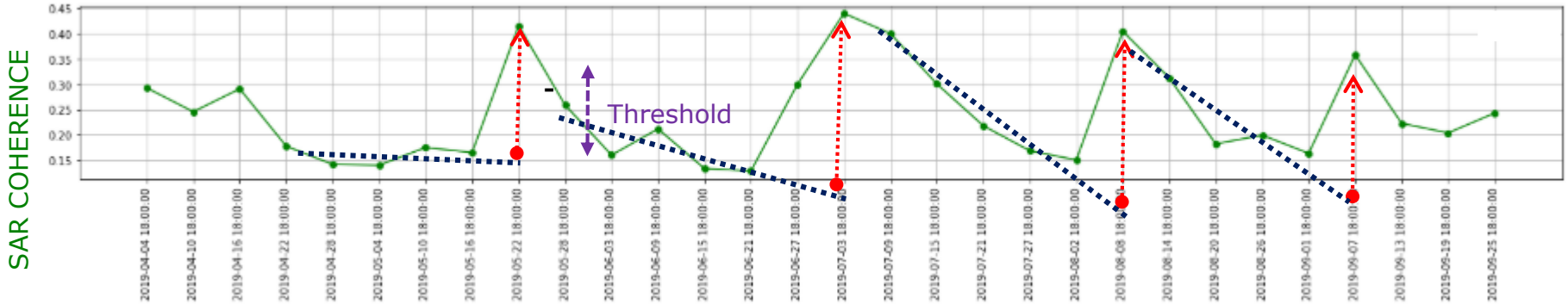

The **Confidence level** is the normalization of the difference **$Cohe(t=T_0\text{-}T_{-1})$ - $Cohe\_fit(t=T_{-1}\text{-}T_{-5})$ - th_{COHE}**, where

- $Cohe(t=T_0\text{-}T_{-1})$ is the coherence between the current S1 acquisition and the previous one,
- $Cohe\_fit(t=T_{-1}\text{-}T_{-5})$) is the coherence between the previous S1 acquisition and the one before and
- th_{COHE} is the threshold

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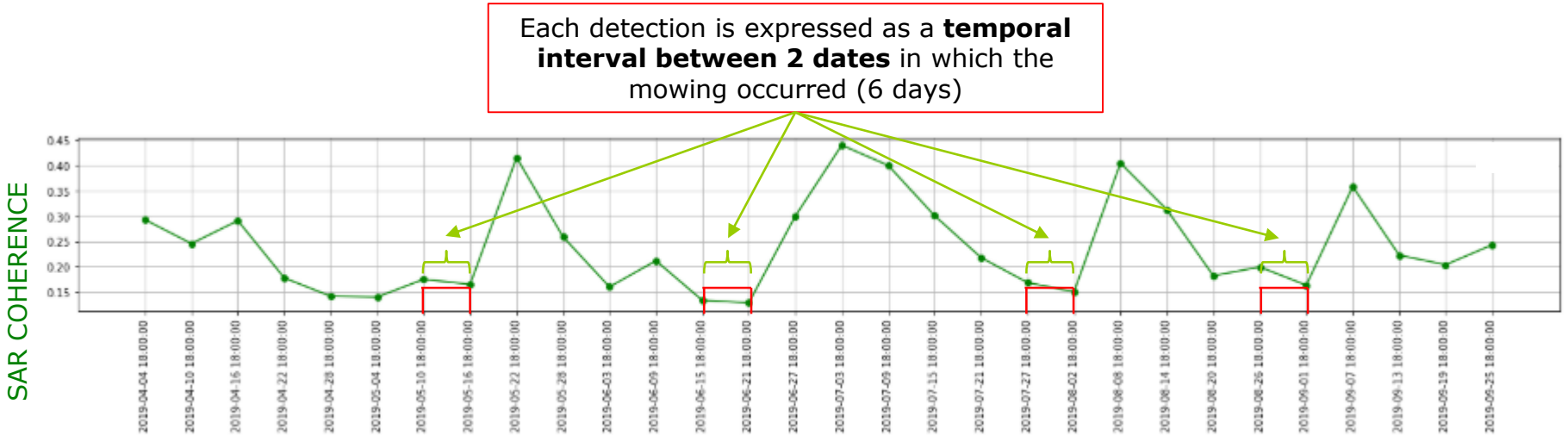

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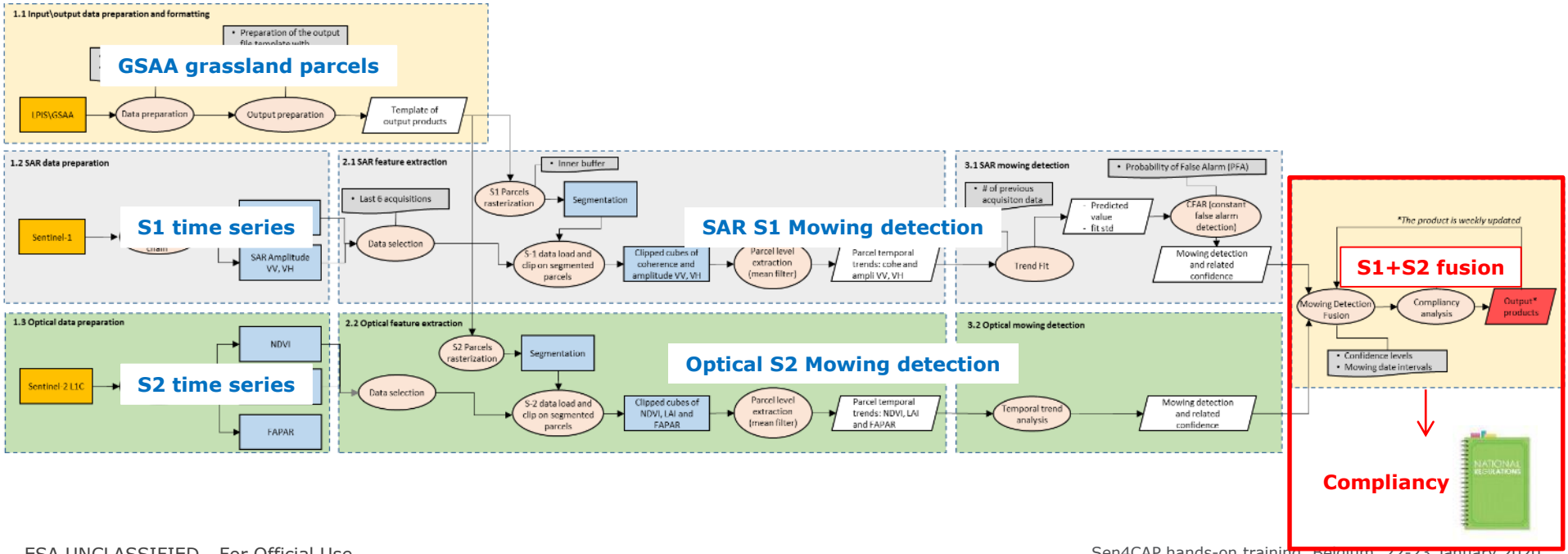

S1 and S2 detection fusion

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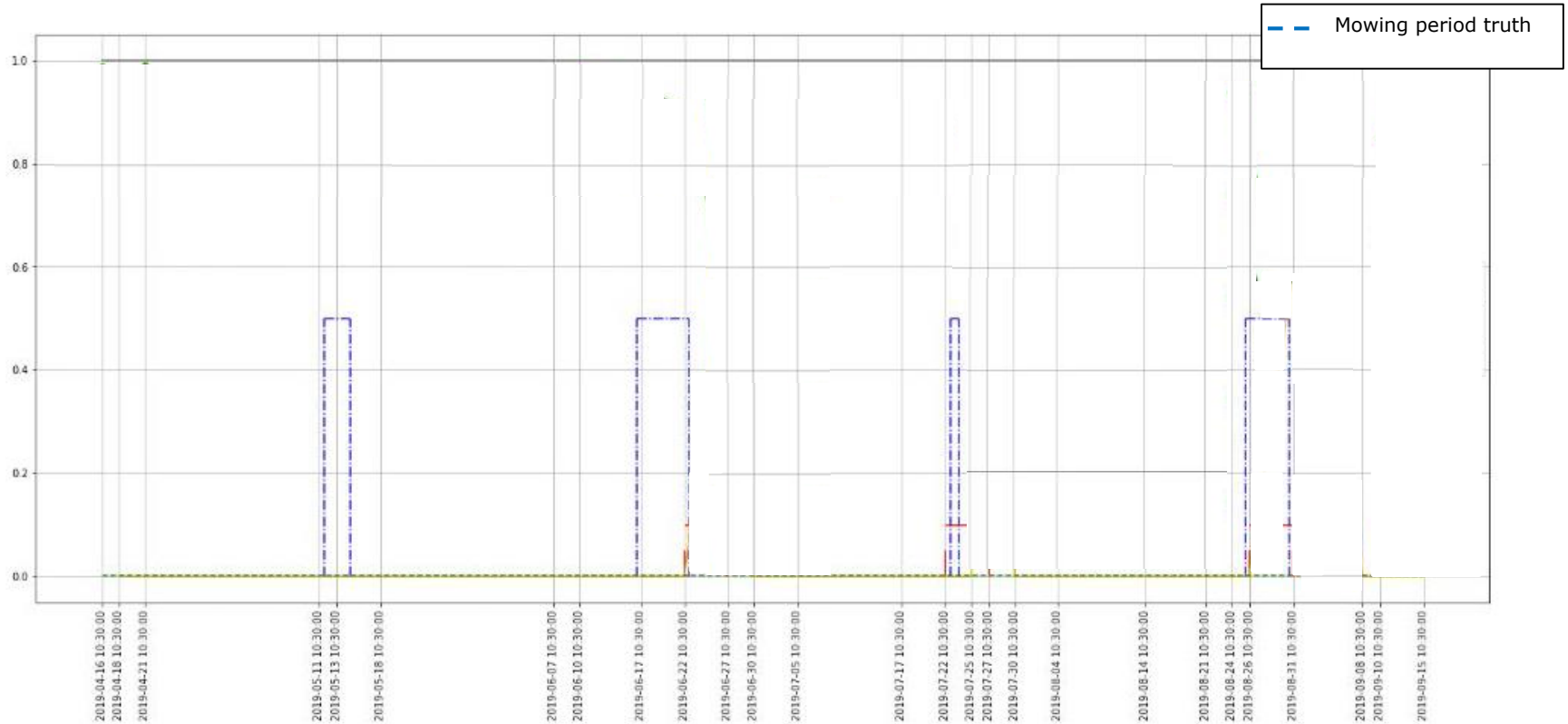

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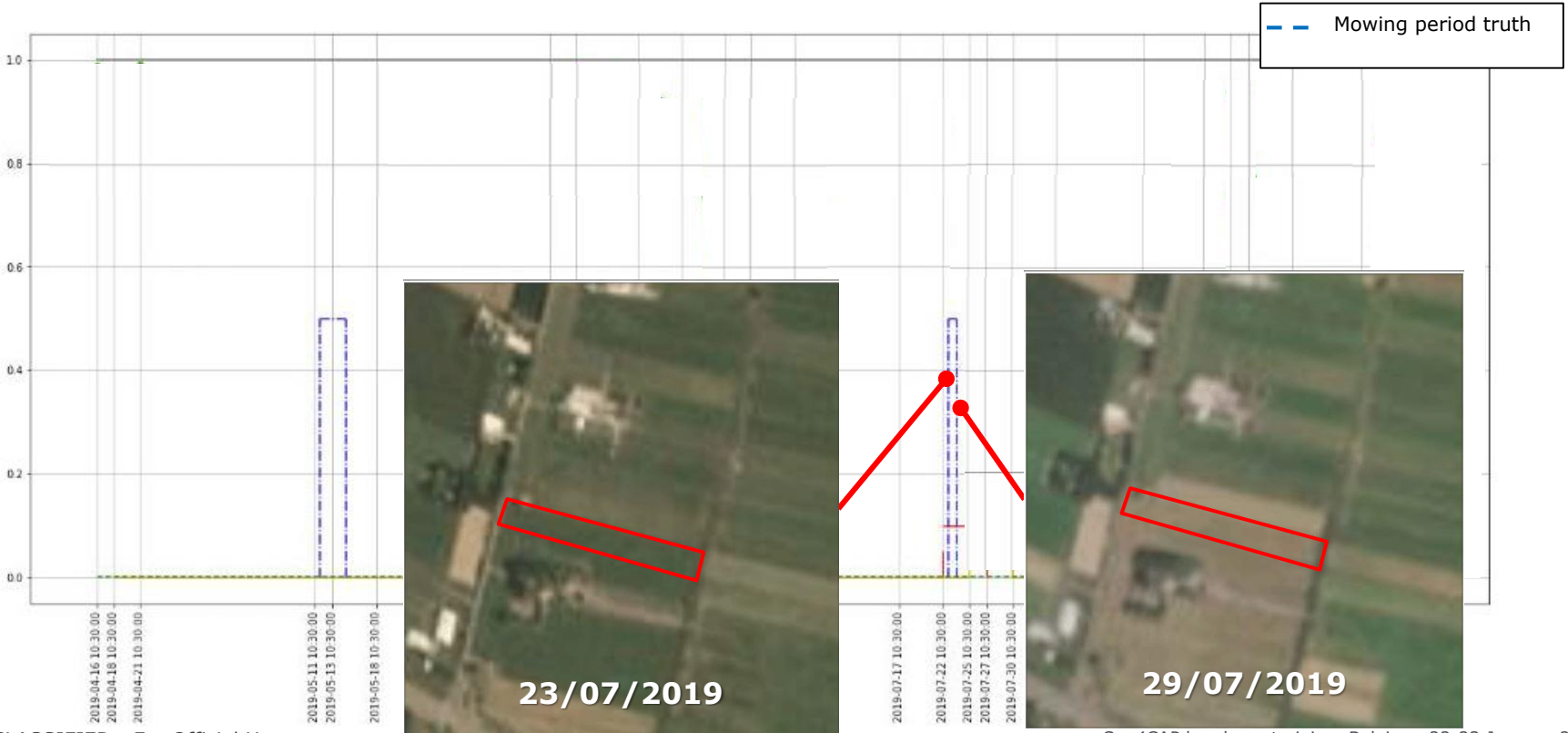

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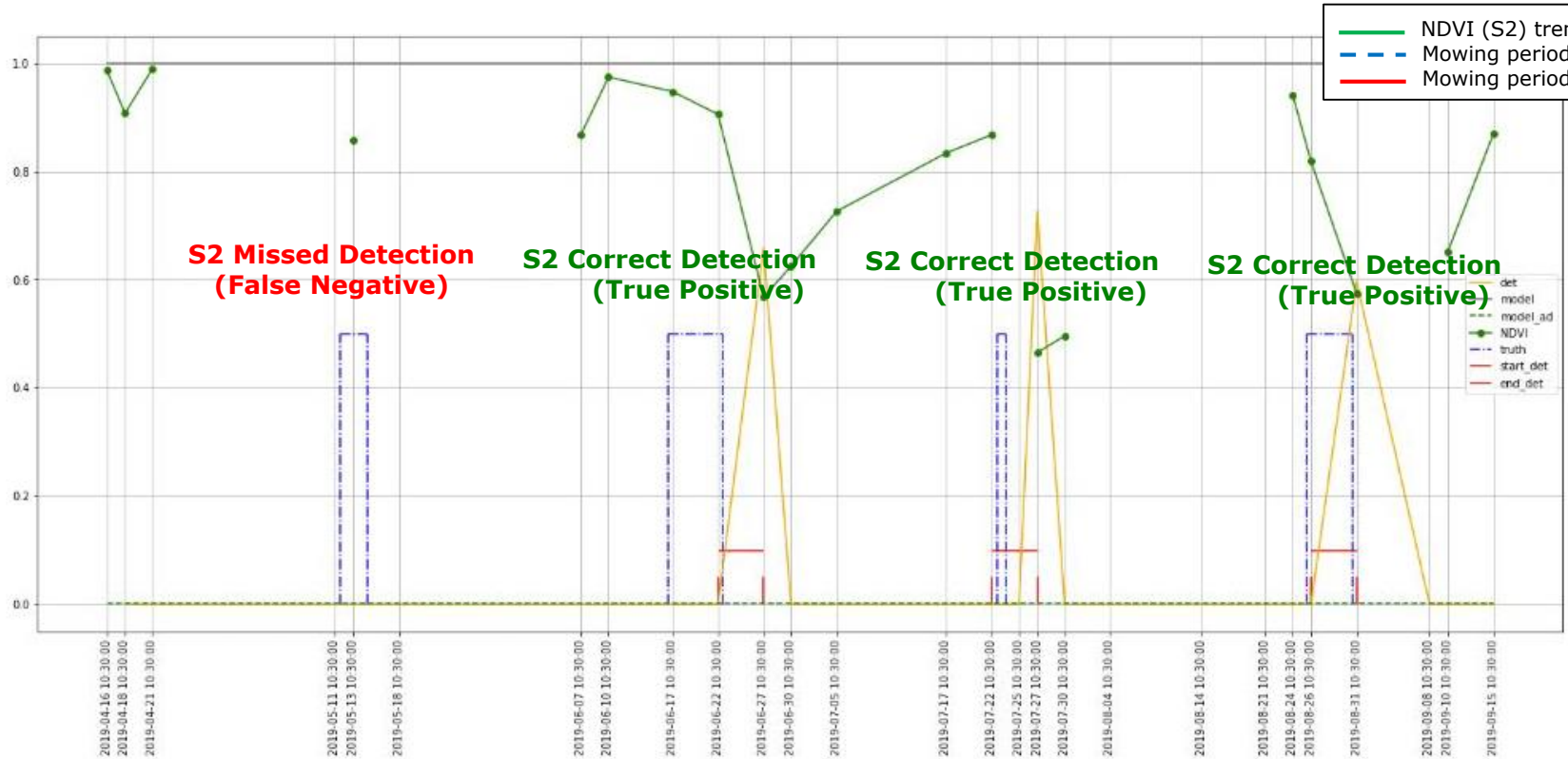
S2 detection



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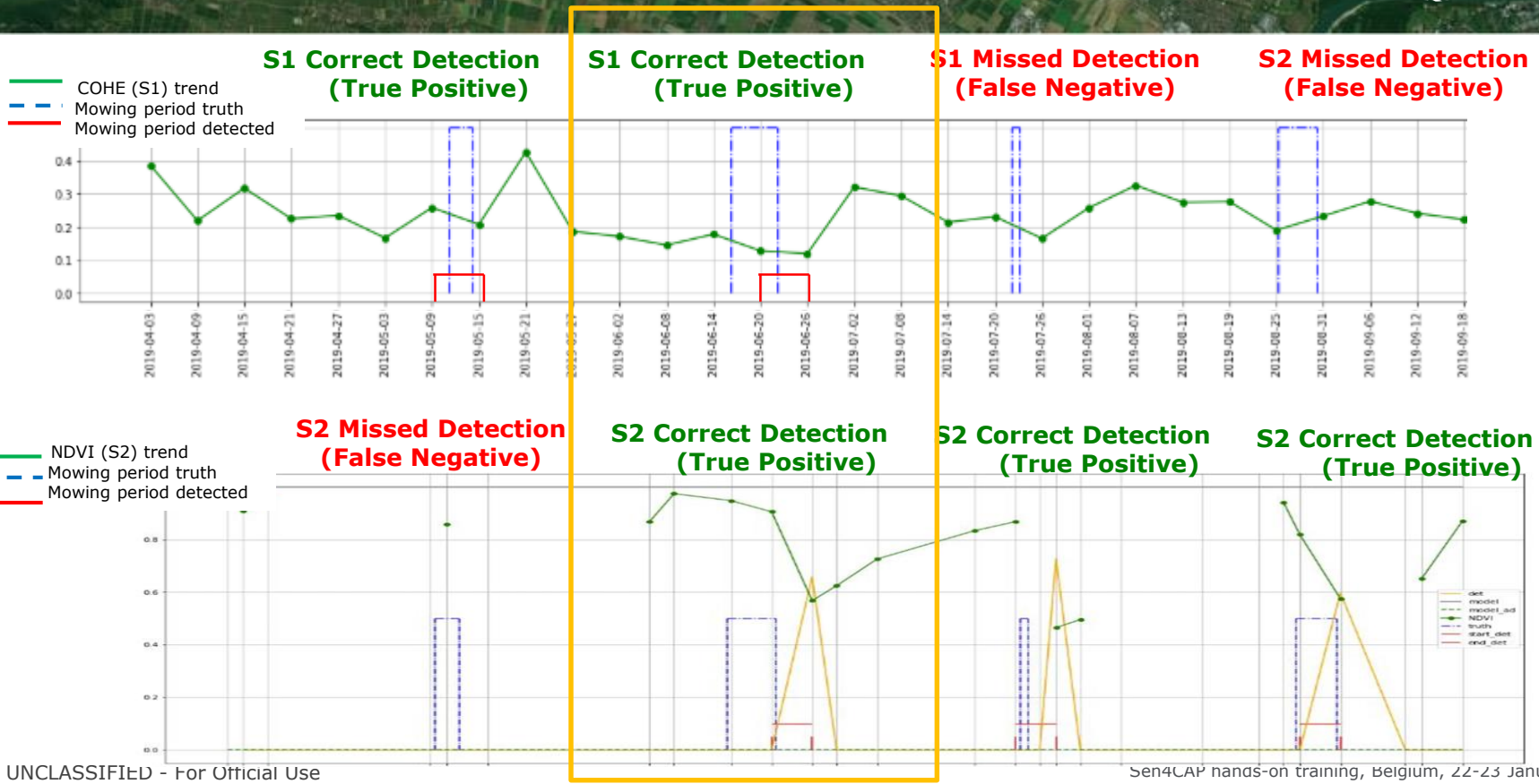

S1 and S2 detection fusion

- **For each new S1 or S2** (related VI) image, a new detection processing is performed and the **results are fused** with the previous ones, according to the following methodology:
  - **Maximum 4 mowing event**
  - By default, giving to **S2 a confidence** level (within (0.5, 1)) **always higher than S1** (0, 0.5);
  - For each parcel, a **new detection is included if**:
    - its confidence is in the **top 4 most confidence** detections
    - it **has a temporal distance higher than 30 days** with respect to the most confident detections

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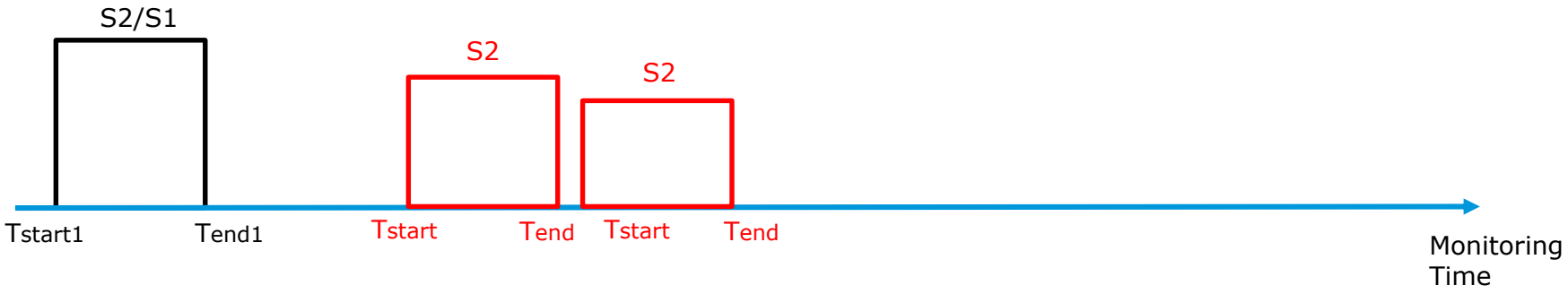

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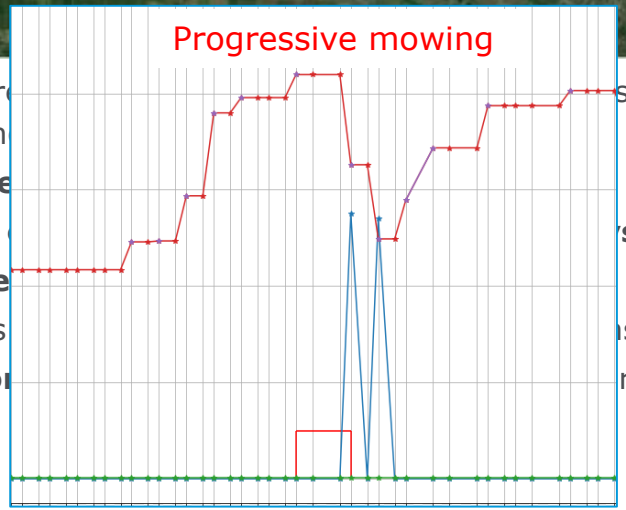

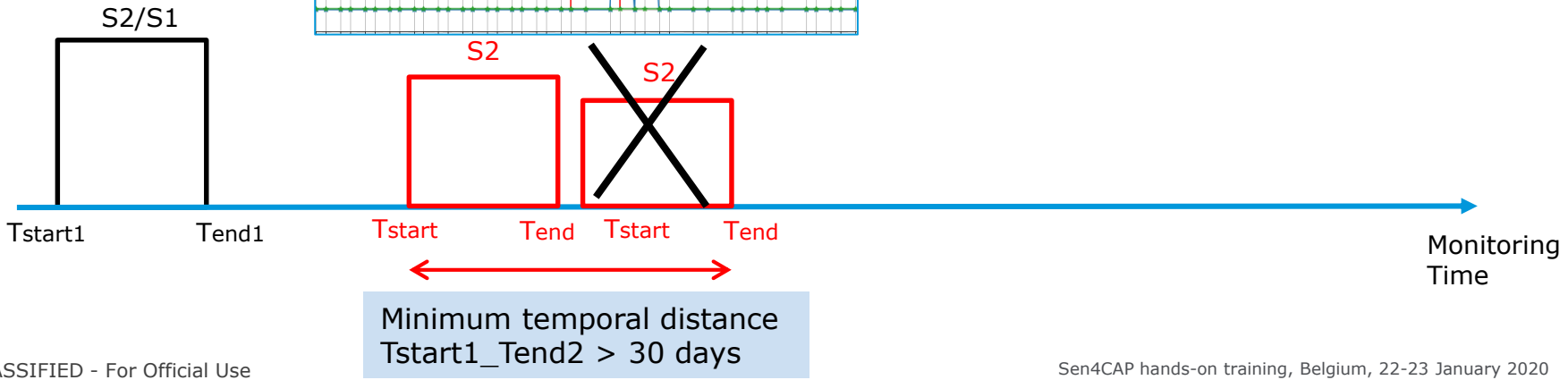

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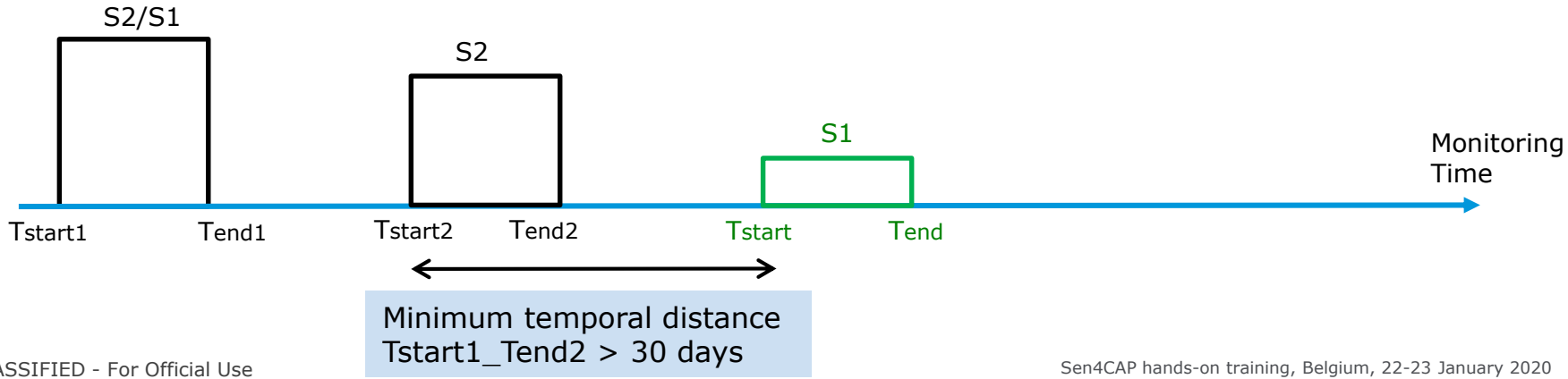

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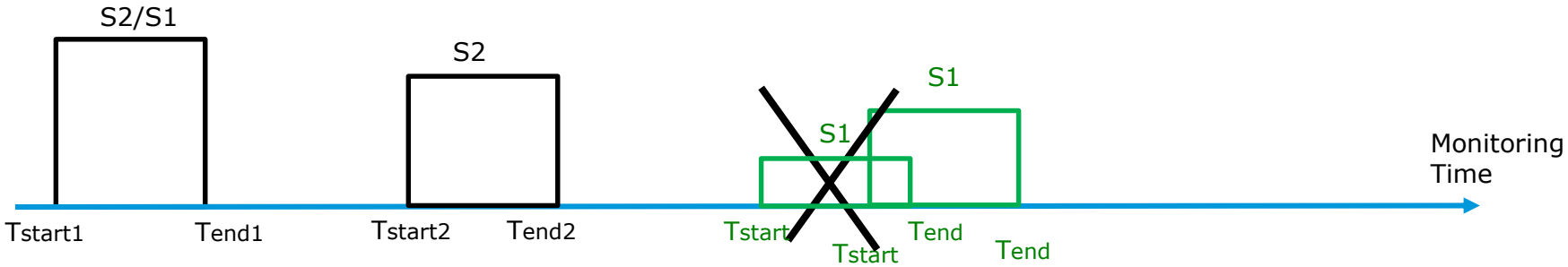

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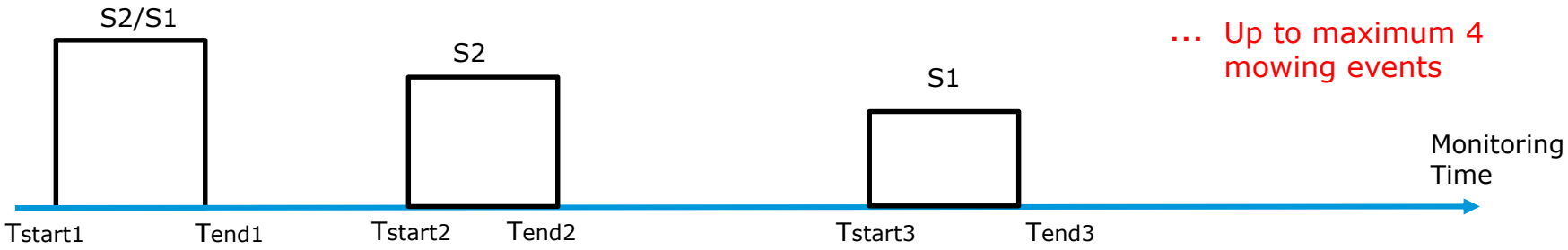
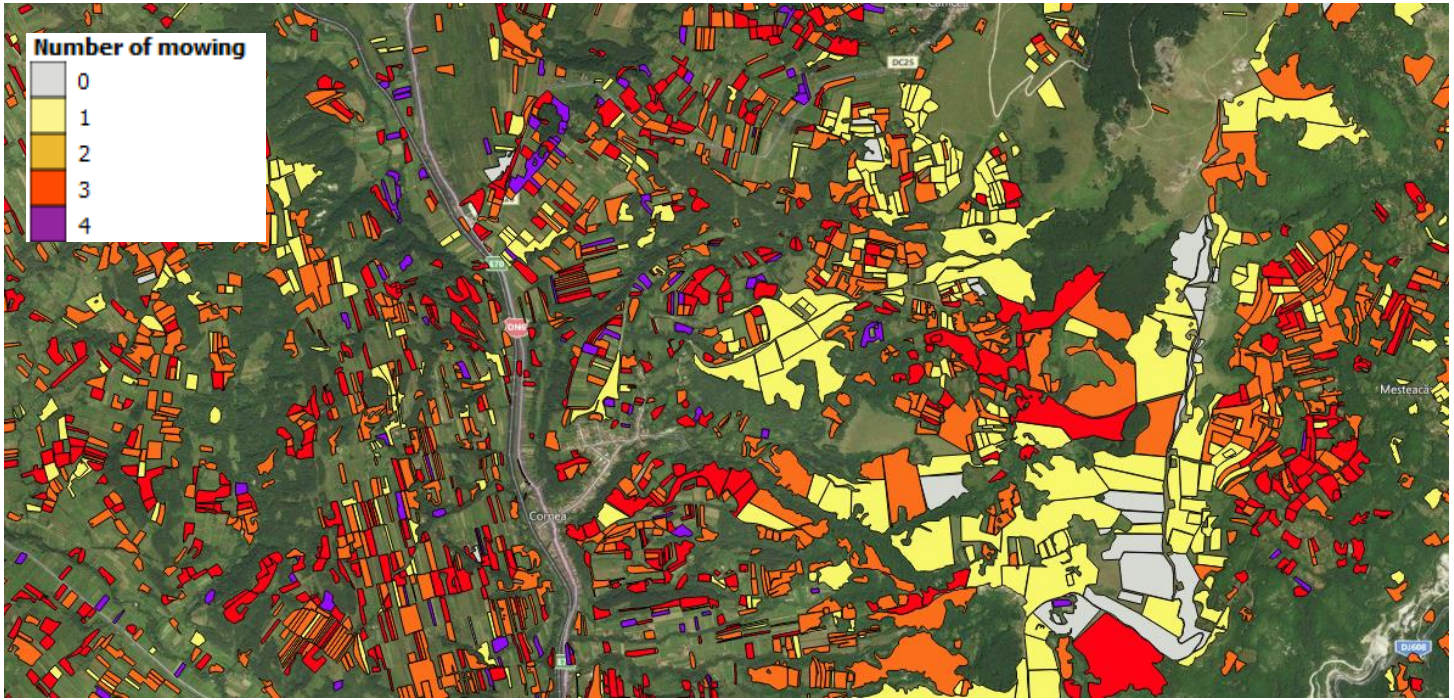


Product overview - Specifications

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



Product overview - Attributes

NewID	Ori_id	Ori_hold	ori_crop	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
635744	1005335922-156416-4101-1	1005335922	DGP	1	2019-08-16...	2019-08-18...	0,76500	S2	0	0	0,00000	0	0	0	0,00000	0	0	0	0,00000	0	2
168109	1005335948-155415-7315-1	1005335948	DGP	3	2019-05-20...	2019-05-26...	0,14300	S1	2019-07-27 ...	2019-08-02 ...	0,49500	S1	2019-09...	2019-09-...	0,76000	S2	0	0	0,00000	0	1
635895	1005336962-153414-7624-2	1005336962	DGP	2	2019-06-12...	2019-06-19...	0,83500	S2/S1	2019-07-19 ...	2019-08-16 ...	0,82900	S2/S1	0	0	0,00000	0	0	0	0,00000	0	1
635897	1005336962-153415-6959-1	1005336962	DGP	1	2019-06-12...	2019-06-19...	0,87600	S2/S1	0	0	0,00000	0	0	0	0,00000	0	0	0	0,00000	0	1
635899	1005336962-155412-3423-1	1005336962	DGP	1	2019-07-08...	2019-07-14...	0,35800	S1	0	0	0,00000	0	0	0	0,00000	0	0	0	0,00000	0	1
635900	1005336962-155412-3423-2	1005336962	DGP	0	0	0	0,00000	0	0	0	0,00000	0	0	0	0,00000	0	0	0	0,00000	0	2
635901	1005336962-155412-3423-3	1005336962	DGP	4	2019-05-03...	2019-05-08...	0,51000	S2	2019-06-07 ...	2019-06-12 ...	0,51800	S2	2019-07...	2019-07-...	0,50000	S1	2019-08-0...	2019-08...	0,47100	S1	1
635903	1005336962-156413-5535-1	1005336962	DGP	2	2019-06-12...	2019-06-19...	0,87600	S2/S1	2019-07-19 ...	2019-07-29 ...	0,85800	S2/S1	0	0	0,00000	0	0	0	0,00000	0	1
636233	1005338544-156416-8405-2	1005338544	DGP	2	2019-06-22...	2019-06-24...	0,75500	S2	2019-08-06 ...	2019-08-12 ...	0,22300	S1	0	0	0,00000	0	0	0	0,00000	0	1
636234	1005338544-157415-0181-1	1005338544	DGP	2	2019-06-24...	2019-07-09...	0,76000	S2/S1	2019-08-16 ...	2019-08-18 ...	0,50200	S2	0	0	0,00000	0	0	0	0,00000	0	1
636463	1005339881-152415-0562-3	1005339881	DGP	1	2019-07-27...	2019-08-02...	0,22600	S1	0	0	0,00000	0	0	0	0,00000	0	0	0	0,00000	0	1

Unique parcel identifier

Original info (id, holding, crop name)

N° of mowing events (max 4)

Compliancy level

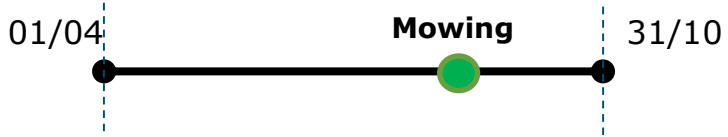
For each mowing event (up to 4):

- Temporal interval in which the mowing event occurred (t_start and t_end)
- Confidence level
- Satellite mission (S1, S2 or both)

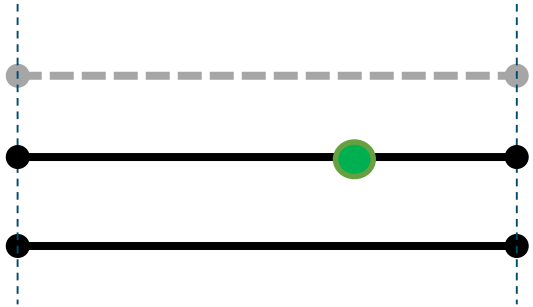
Use Cases – Minimum Activity

Objective: to verify, according to the national regulations, the mowing events during the mandatory periods

Mandatory period for grassland crop X → At least 1 mowing between 1st April and 31st October



Compliancy Level

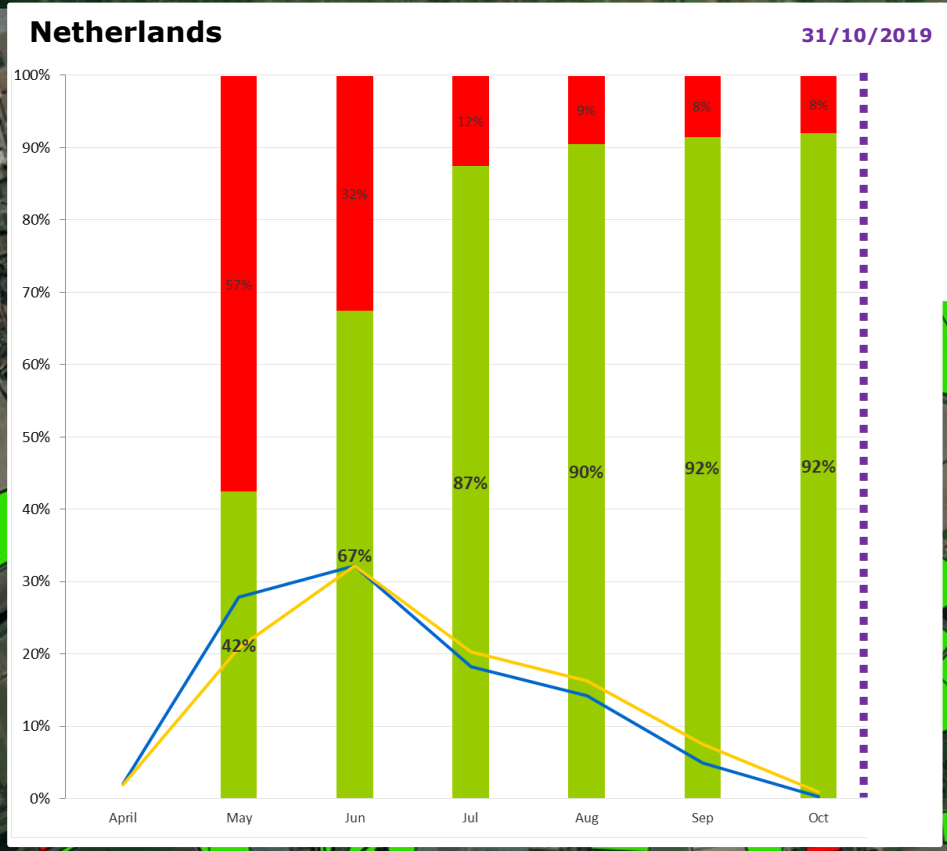


0: Not assessed

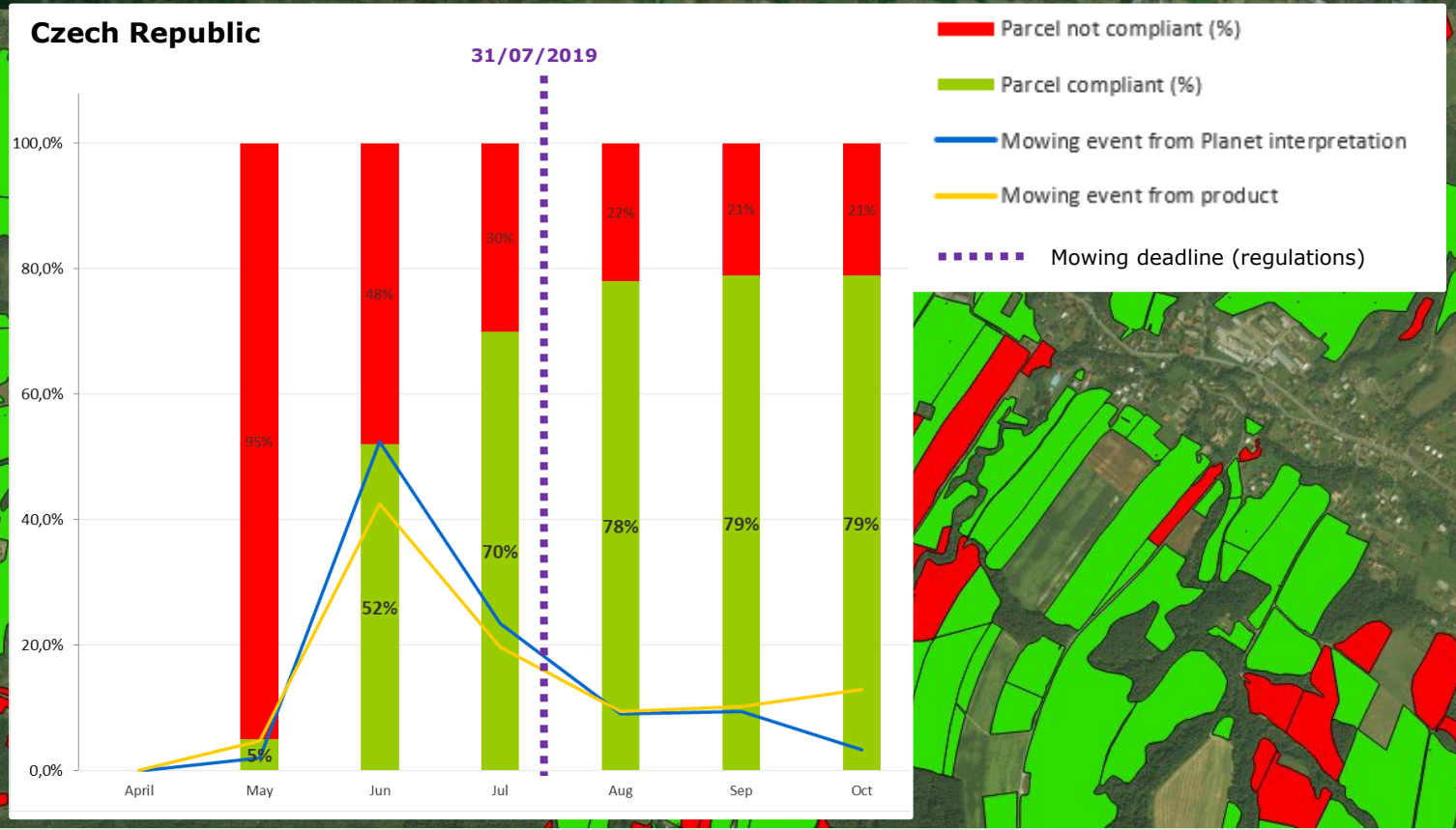
1: Assessed and compliant because a mowing occurred in the mandatory period

2: Assessed and not compliant because no mowing occurred in the mandatory period

Compliancy evolution during monitoring - NLD

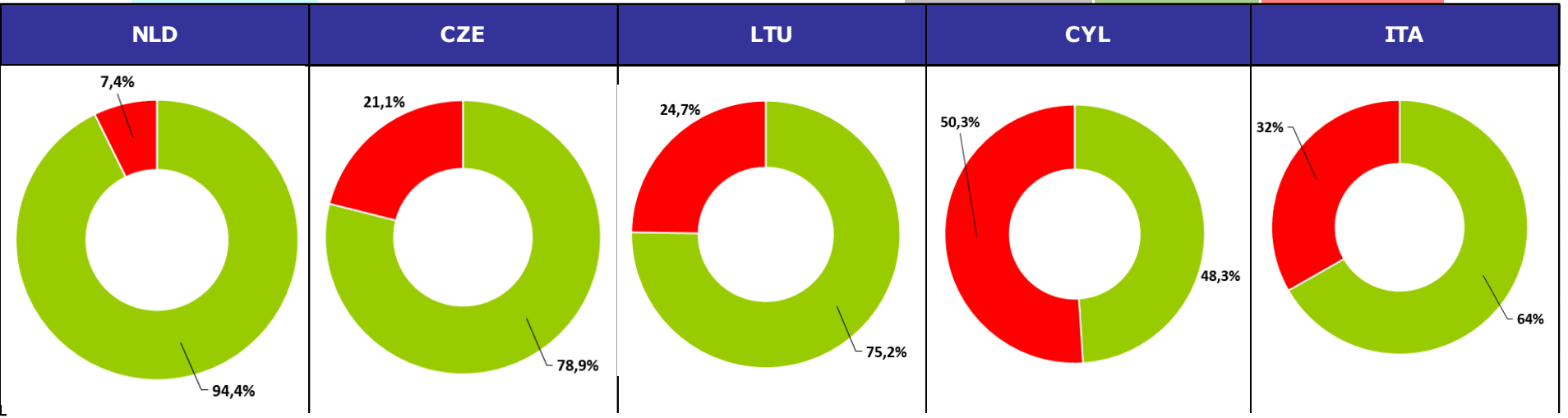


Compliancy evolution during monitoring - CZE



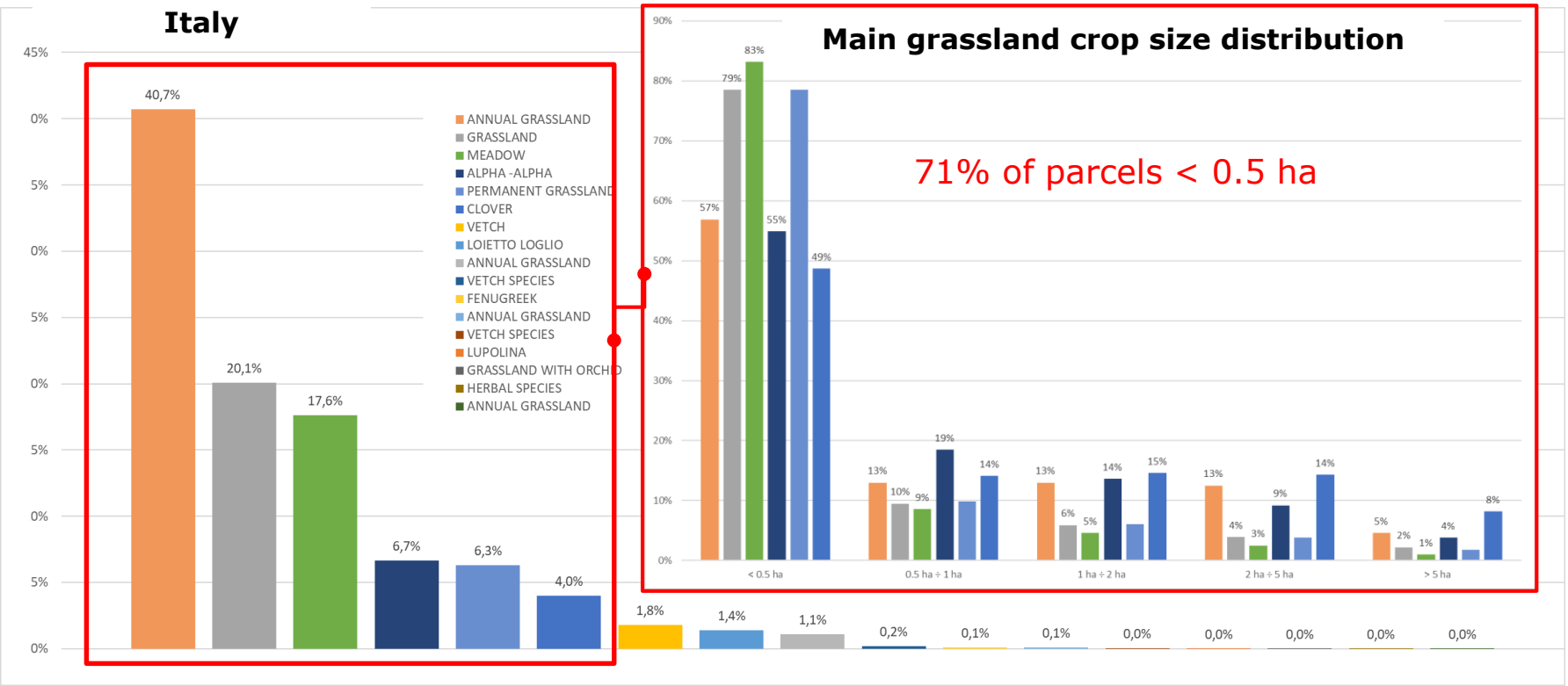
Grassland 2019 compliancy statistics at the end of the season

Country	Total parcels (n°)	Total area (ha)	Not processed (% n°)	Not processed (% ha)	Parcel mowed* (% n°)	Parcel not mowed* (% n°)

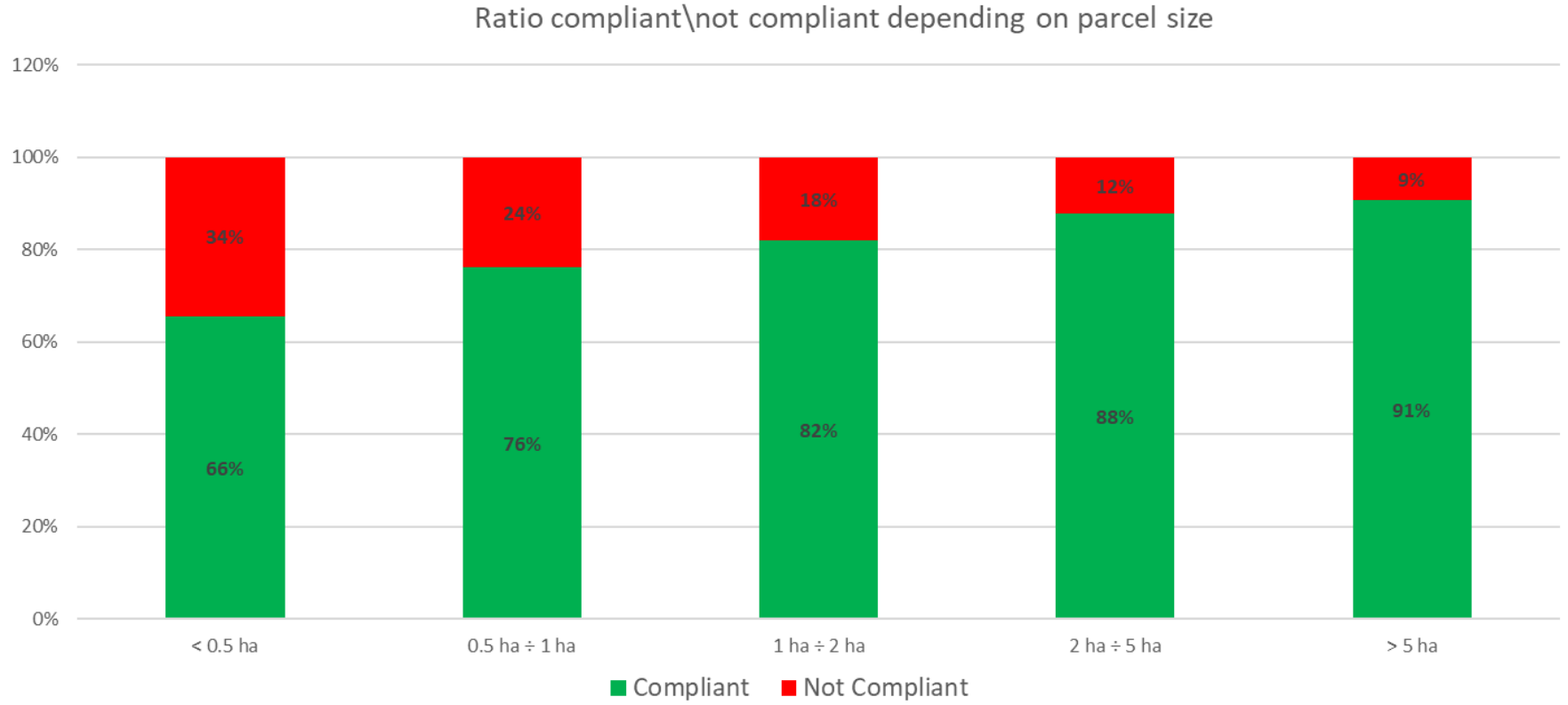


Product includes only mowing event (not grazing)

Grassland parcels characteristics - ITA



Impact of parcel size and grassland type
E.g. Italy



Accuracy assessment

Validation data source:

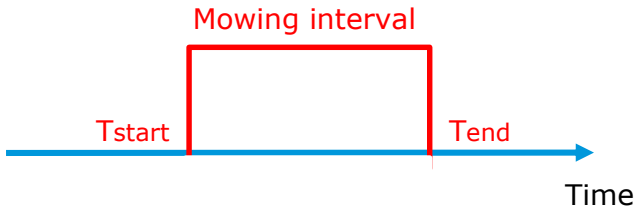
- 2018
  - Interview with farmers
  - Planet data
- 2019
  - Planet data

Planet Data: **7 June**

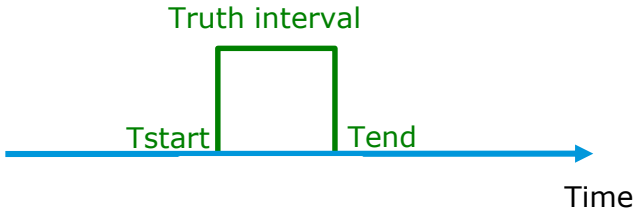
Planet Data: **15 June**

Validation – Accuracy assessment approach (1/2)

- Each **mowing detection** is expressed as a **temporal interval (T1-T2)**, in which the mowing probably occurred.

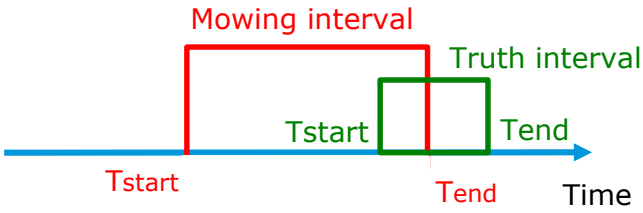


- The **truth mowing** dates are temporal interval too, at minimum of 1 day.



Validation – Accuracy assessment approach (2/2)

Intersection → **True Positive (TP)**

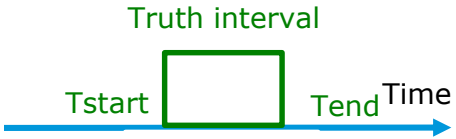


2 accuracy indexes:

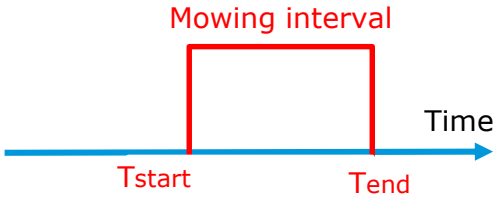
Recall: TP/(TP+FN)
Precision: TP/(TP+FP)

No Intersection with a Truth

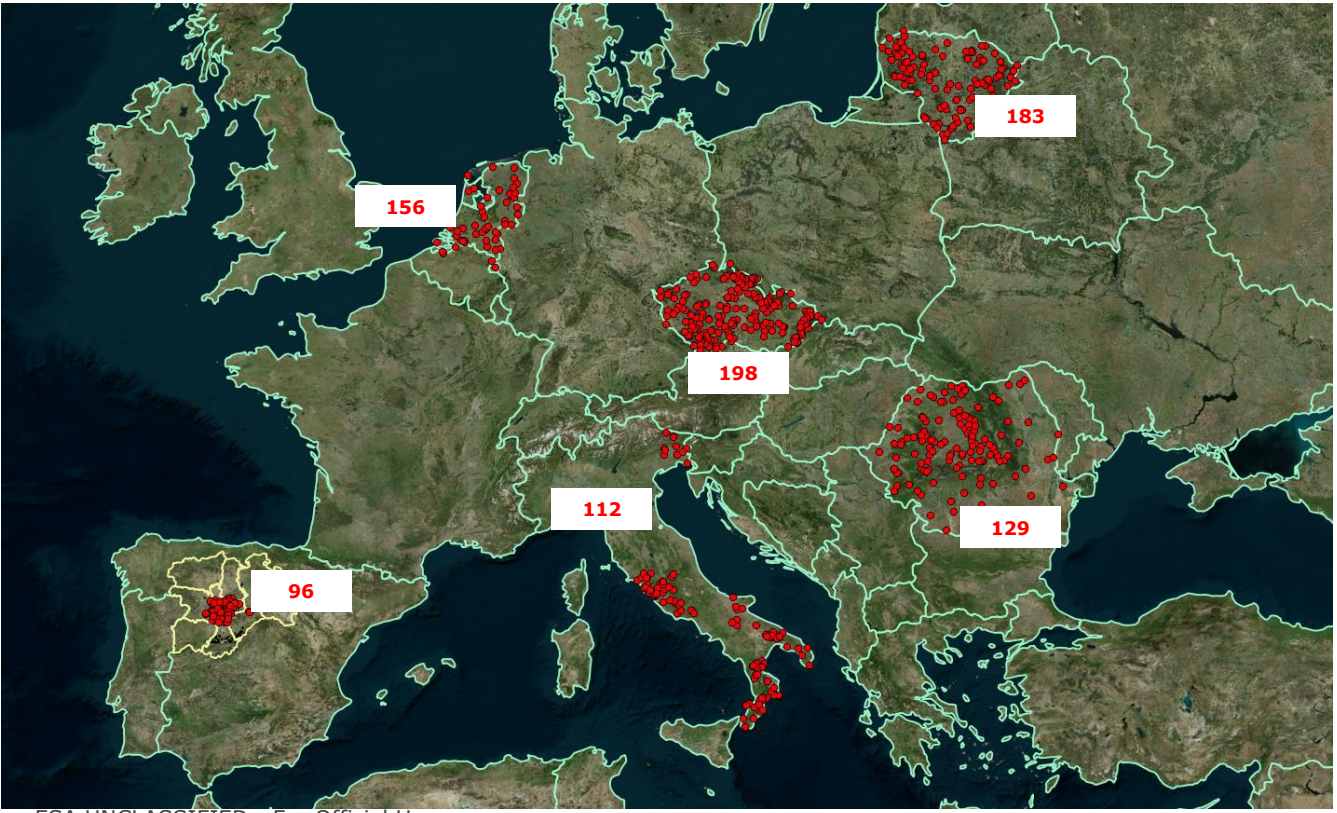
False Negative (FN)



False Positive (FP)



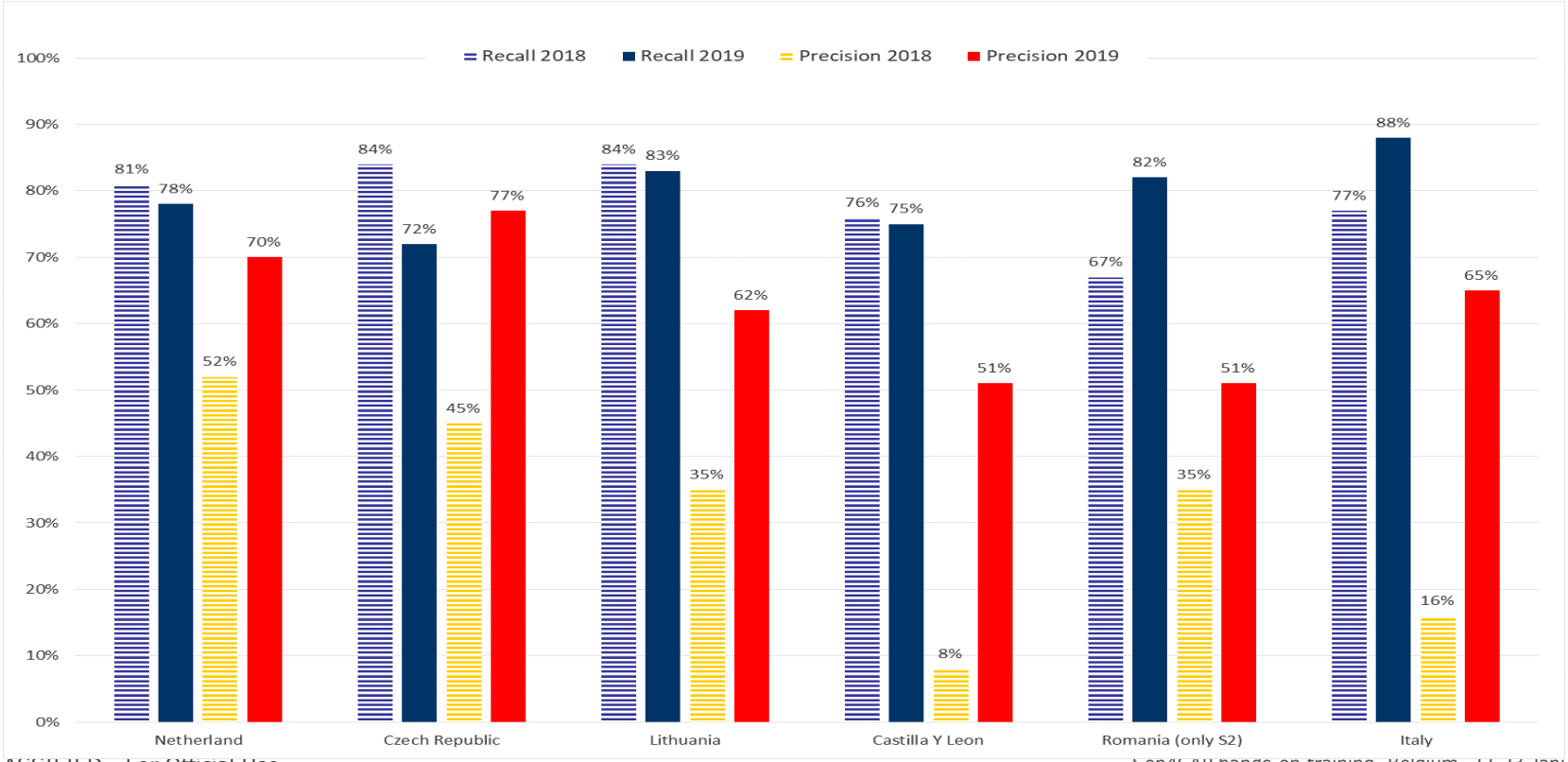
Truth dataset preparation based on Planet data



Truth selection criteria

- **Number of parcels** of preliminar dataset: 100÷200
- **Crop type selection** representative of country distribution
- **5 classes of parcel size for each crop type** (<0.5 ha, 0.5÷1 ha, 1÷2 ha, 2÷5 ha, >5 ha)
- **Random** selection

Preliminary accuracy assessment



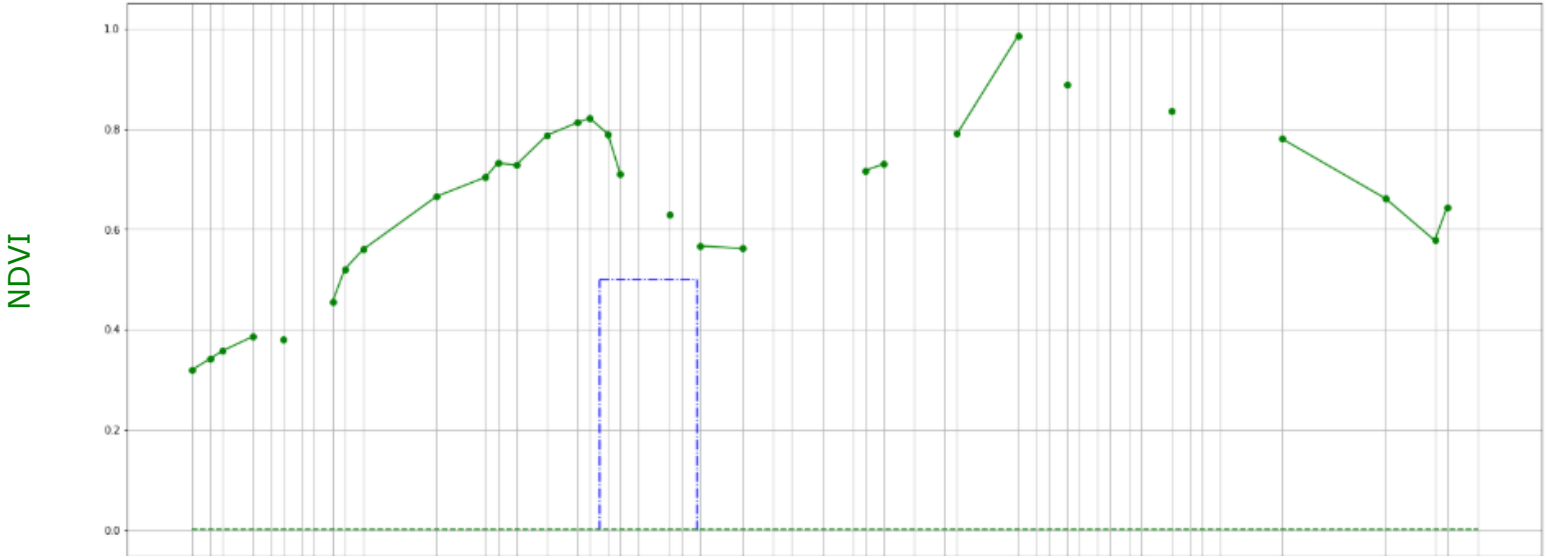
Lessons learned

- Algorithm improvements aimed to reduce the false positive cases
  - Finer **thresholds calibration** for each country
  - Implementation of **control mechanisms** to detect and exclude detections due to some **anomalous NDVI values** (e.g. due to clouds not well masked)

- Known **limitations**, independent from current algorithm implementation (parcel based)
  - **NDVI profile gaps** due to cloud persistence
  - Accuracy of **cloud mask**
  - **Grazing** detection

Next steps (algorithm)

- Use of **weather data** to remove the false detection due to **drying** → reduce False Positive
- **Detection of partial mowing**
- **Progressive mowing** → reducing missed mowing (False Negative)



Next steps (Use case)

- Additional use cases:
  - **Resting period** → verify the absence of mowing according to national regulations
  - **Agri-envinroment climate measure** → verify the compliancy for grassland parcels according to the AECM regulations


Thank you for your attention
and your contribution
Any questions?
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