Webinar CbM Outreach on Data analyses

Date: 19th November 2021

Agenda

09:30 - 09:35 Welcome

09:35 - 10:20 Translating practice to signal behaviour (Rafal Zielinski, JRC)

10:20 - 10:40 RESTful data access - refresh and updates (Guido Lemoine, JRC)

10:40 - 11:25 Signals and Signal Processing - Part I (Daniele Borio, JRC)

11:25 - 11:40 Break

11:40 - 11:55 Signal and Signal Processing - Part II (Daniele Borio, JRC)

11:55 - 12:25 Mowing Marker Detection (Daniele Borio, JRC)

12:25 - 13:00 Q&A, discussion (Rafal Zielinski, JRC)

Outreach: translating practice to signal behaviour

CbM Outreach 2021

Webinar, 19/11/2021

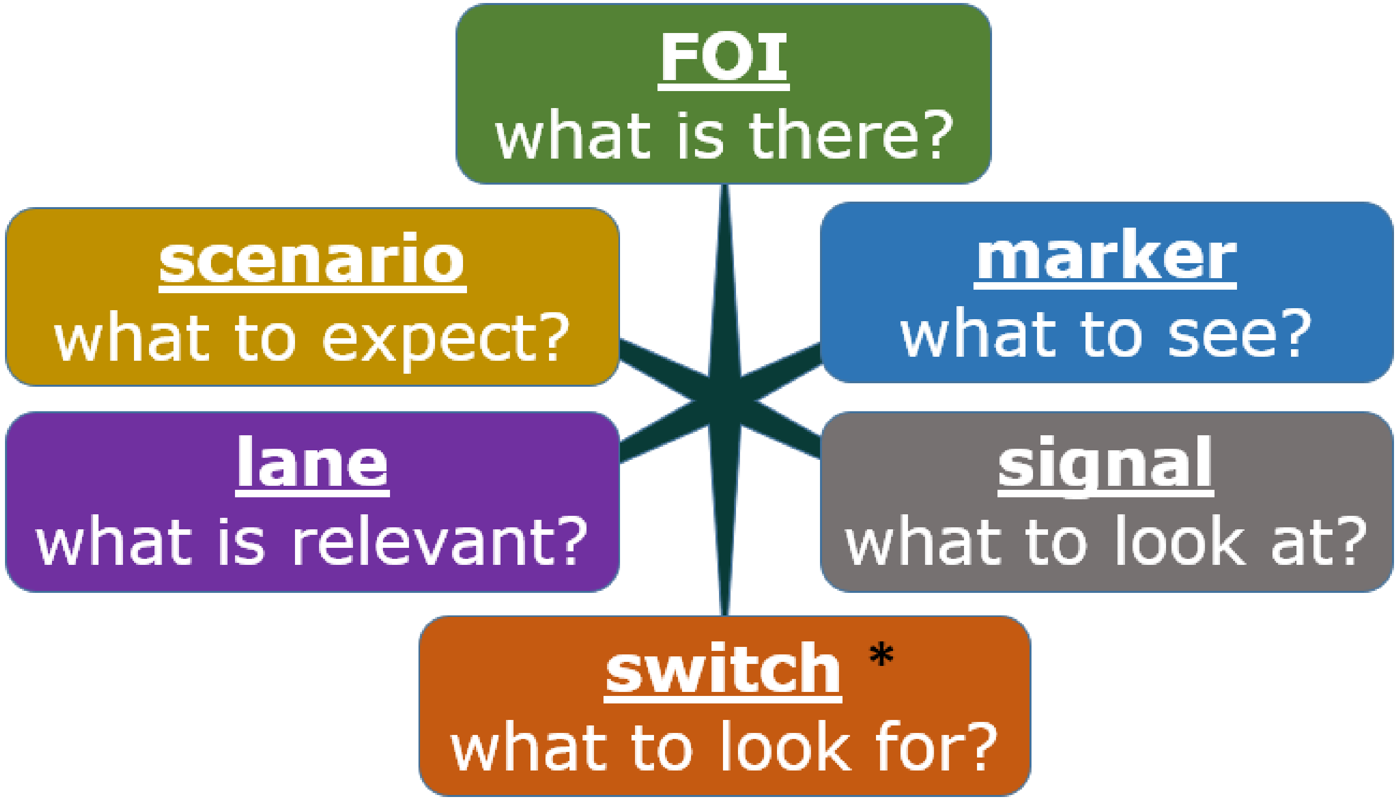
Agenda

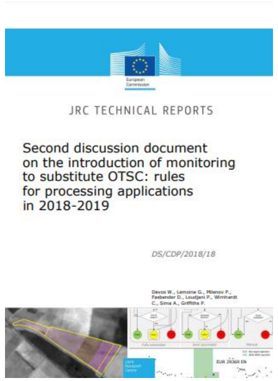
09:30 - 09:35	Welcome
09:35 - 10:20	**Translating practice to signal behaviour**
10:20 - 10:40	RESTful data access - refresh and updates
10:40 – 11:25	Signals and Signal Processing - Part I
11:25 - 11:40	Break
11:40 - 11:55	Signal and Signal Processing - Part II
11:55 - 12:25	Mowing Marker Detection
12:25- 13:00	Q&A, discussion

Outline

- An overview of scenarios collected in outreach
- Practices (mowing related)
- Ground truth derived signal behaviour for mowing practices
- Conclusion

Base concepts of CbM





* enactment of the ***lane rules***

updated documentation in preparation

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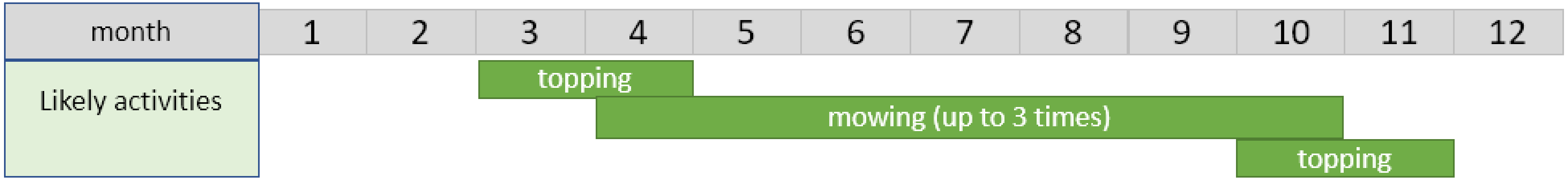
What is scenario?

- Scenario describes the sequence of stages (LC manifestations), that can be expected from the farmer's choice to use his land over a given timespan.

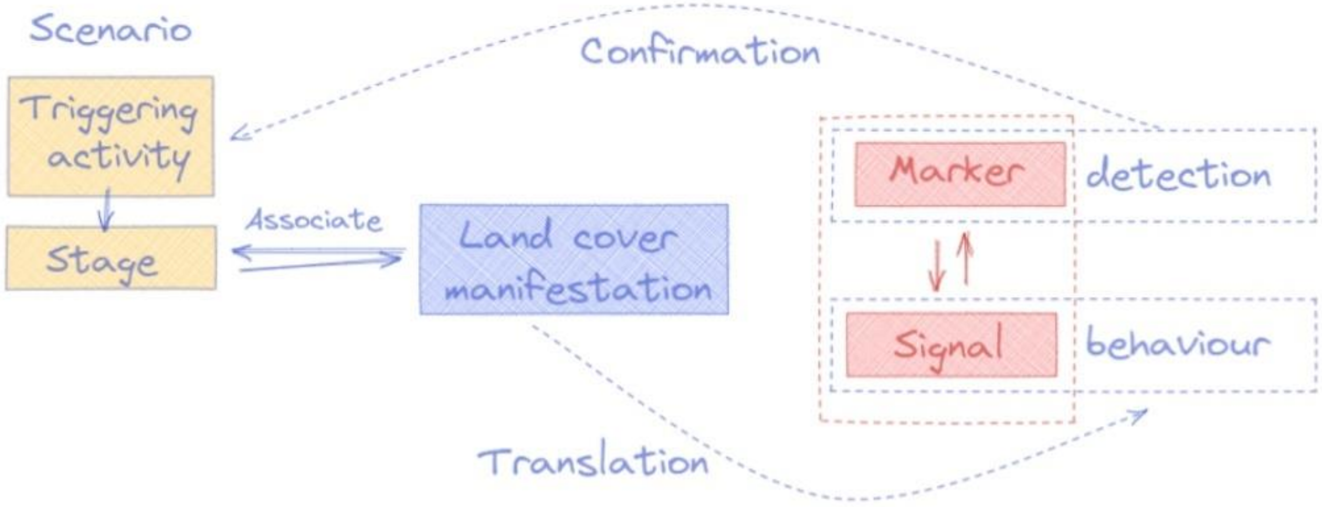


An example for permanent grassland

Function of scenario in CbM

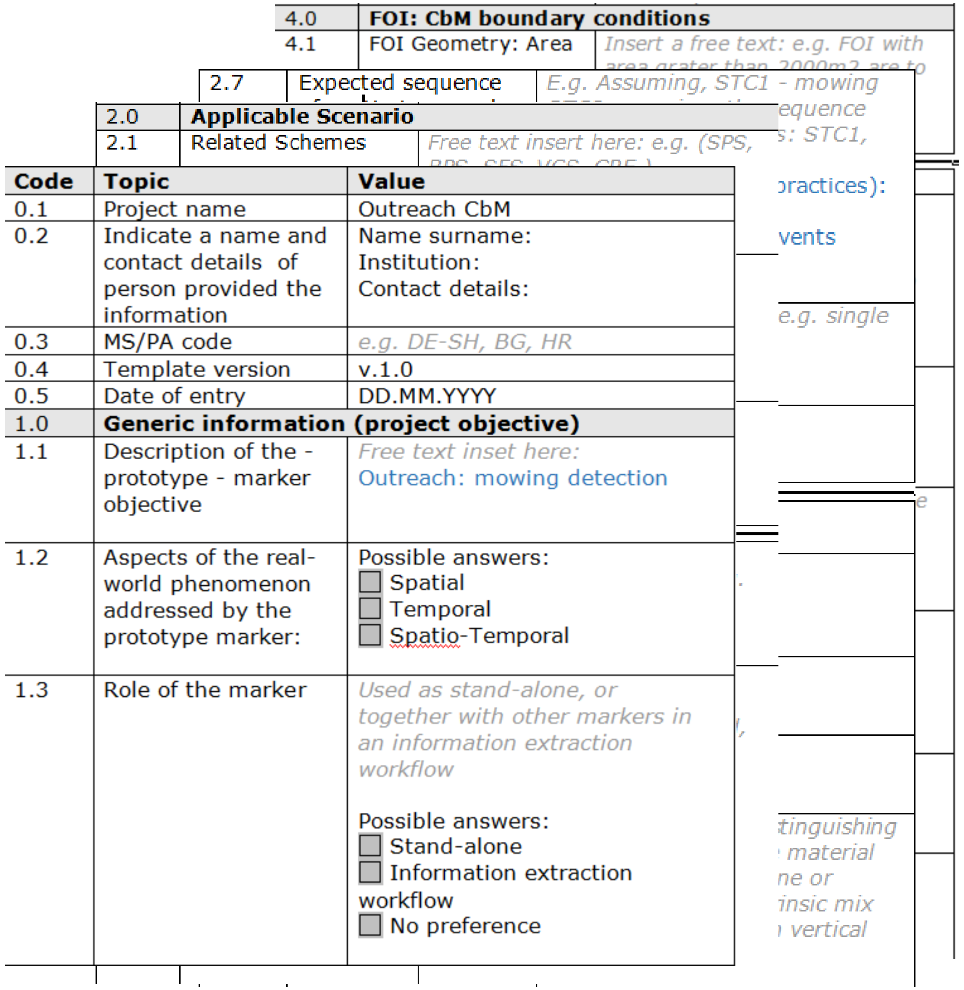
- The scenario brings the **local business logic** into the process by **integrating image based analyses** with the available **local know-how** on crop phenology and/or the **agricultural practices**.

- **Markers detect specific signal behaviour**, related to particular bio-physical manifestation of the FOI. Scenario places that manifestation (state or change of state) in the context of the intended use and local farm practices. By doing so, an observed land cover-related manifestation can reliably be attributed to a particular activity



Scenario-related template

- Eligibility criteria (scheme, periods of application, crop type, etc)
- Practices, type, number of actives, potential sequence of stages and corresponding time frame
- Condition of LC manifestation (Pre-condition, Mid-condition , End-condition)
- FOI: CbM boundary conditions, FOI generic information (type, shape, linage) verification method and pre-selection conditions
- Data collected from 13 MS



Code	Topic	Value
0.1	Project name	Outreach CbM
0.2	Indicate a name and contact details of person provided the information	Name surname: Institution: Contact details:
0.3	MS/PA code	*e.g. DE-SH, BG, HR*
0.4	Template version	v.1.0
0.5	Date of entry	DD.MM.YYYY
1.0	**Generic information (project objective)**	
1.1	Description of the - prototype - marker objective	*Free text inset here:* Outreach: mowing detection
1.2	Aspects of the real-world phenomenon addressed by the prototype marker:	Possible answers: ☐ Spatial ☐ Temporal ☐ Spatio-Temporal
1.3	Role of the marker	*Used as stand-alone, or together with other markers in an information extraction workflow* Possible answers: ☐ Stand-alone ☐ Information extraction workflow ☐ No preference

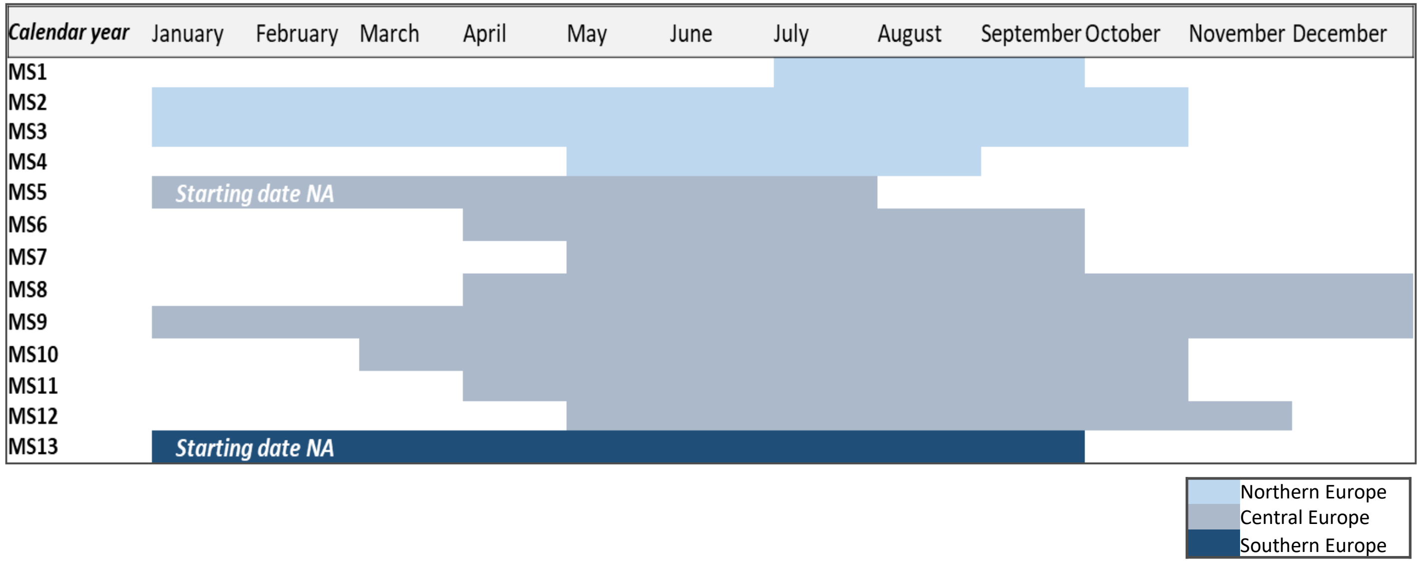
Scenarios: payment schemes

- Reported schemes for mowing: 9/13 BPS, 4 SAPS
- 5 MS are considering mowing activity detection to be used in support of other schemes: ANC,NATURA, National scheme: GLAS
- For 12 MS (BPS), during the observation period must occur:
  - at least one mowing or grazing (10 MS)
  - at least one mowing (2 MS)
- Note: mowing is a general but includes 3 distinct activities: mowing (hay, silage) and topping

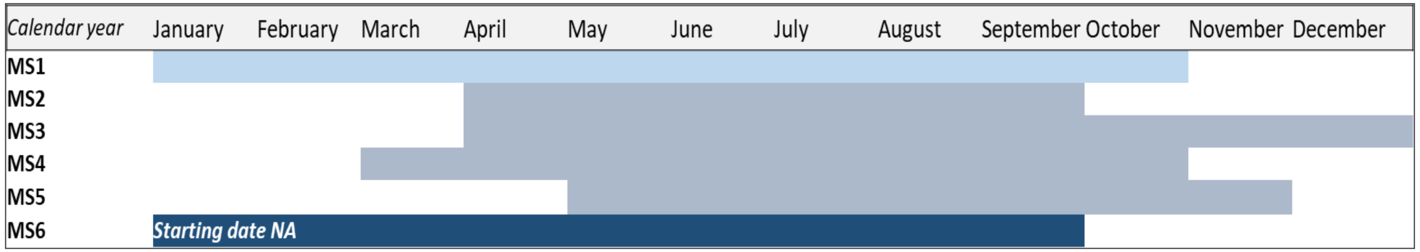
Scenarios: eligibility criteria

- Required activity should take place in a given period
- Permanent grasslands (11/13 MS)
  - April – September*
- Temporal grasslands (6/13 MS):
  - March –September*
- *Some MS declared a full calendar year frame.
- Specific conditions (3/13 MS) for particular grasslands types, i.e. karst pastures)

Eligibility criteria observation periods for permanent grasslands



Eligibility criteria observation periods for temporal grasslands



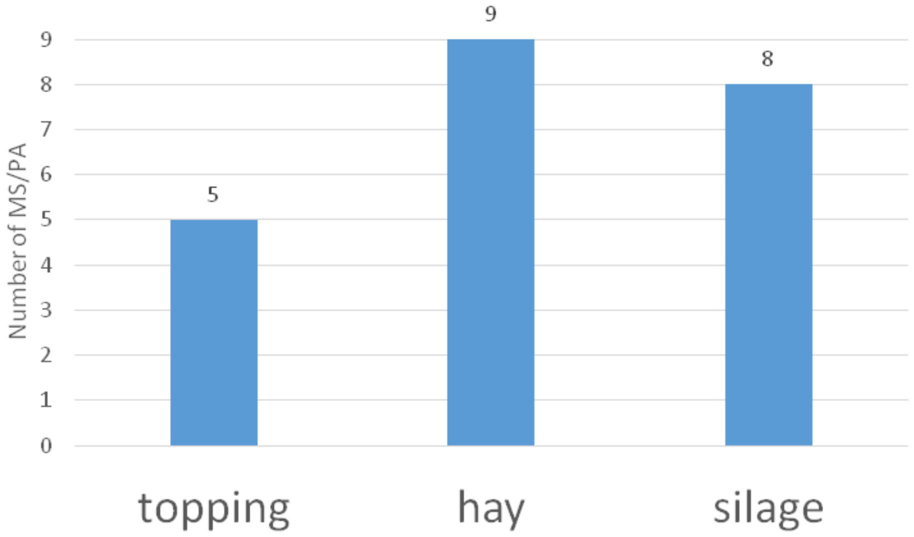
Scenarios: Practices (1/2)

- Practices - “agricultural activities” as applied by local farmers

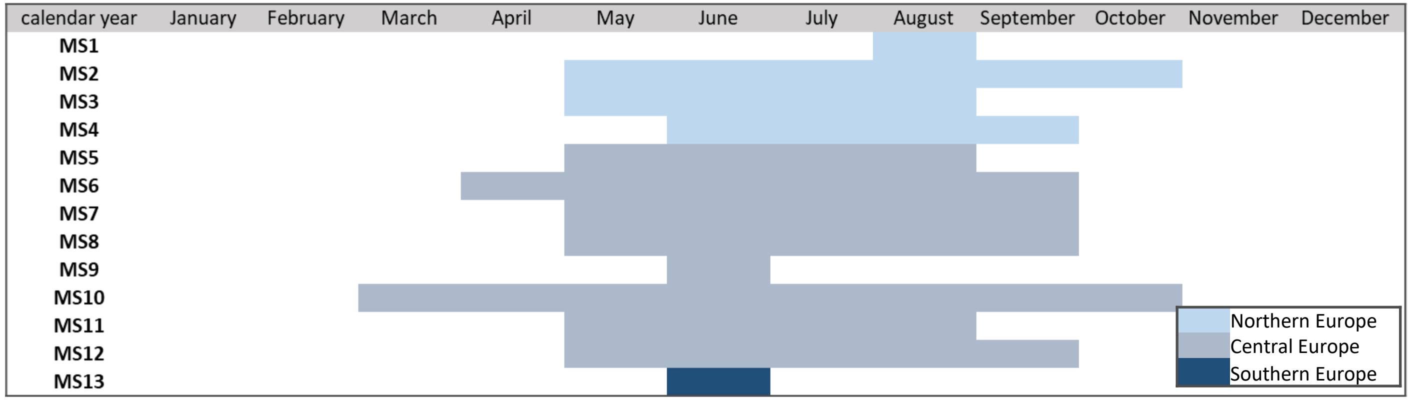
- Practices specified by MS/PA for the scenario
  - 9 MS/PA mowing grass for hay
  - 8 MS/PA mowing grass for silage
  - 5 MS/PA topping

- Mowing is expected in May-August

Reported practices



Period when mowing is may happen for permanent grasslands



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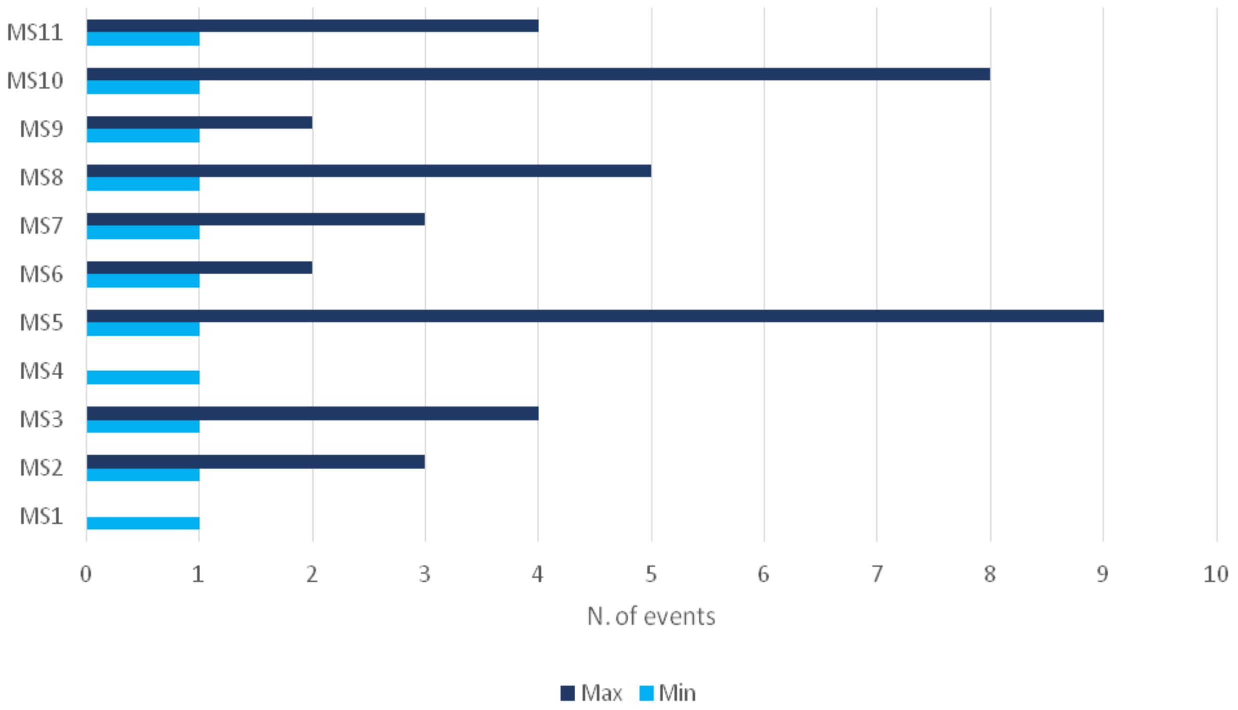
Scenarios: Practices (2/2)

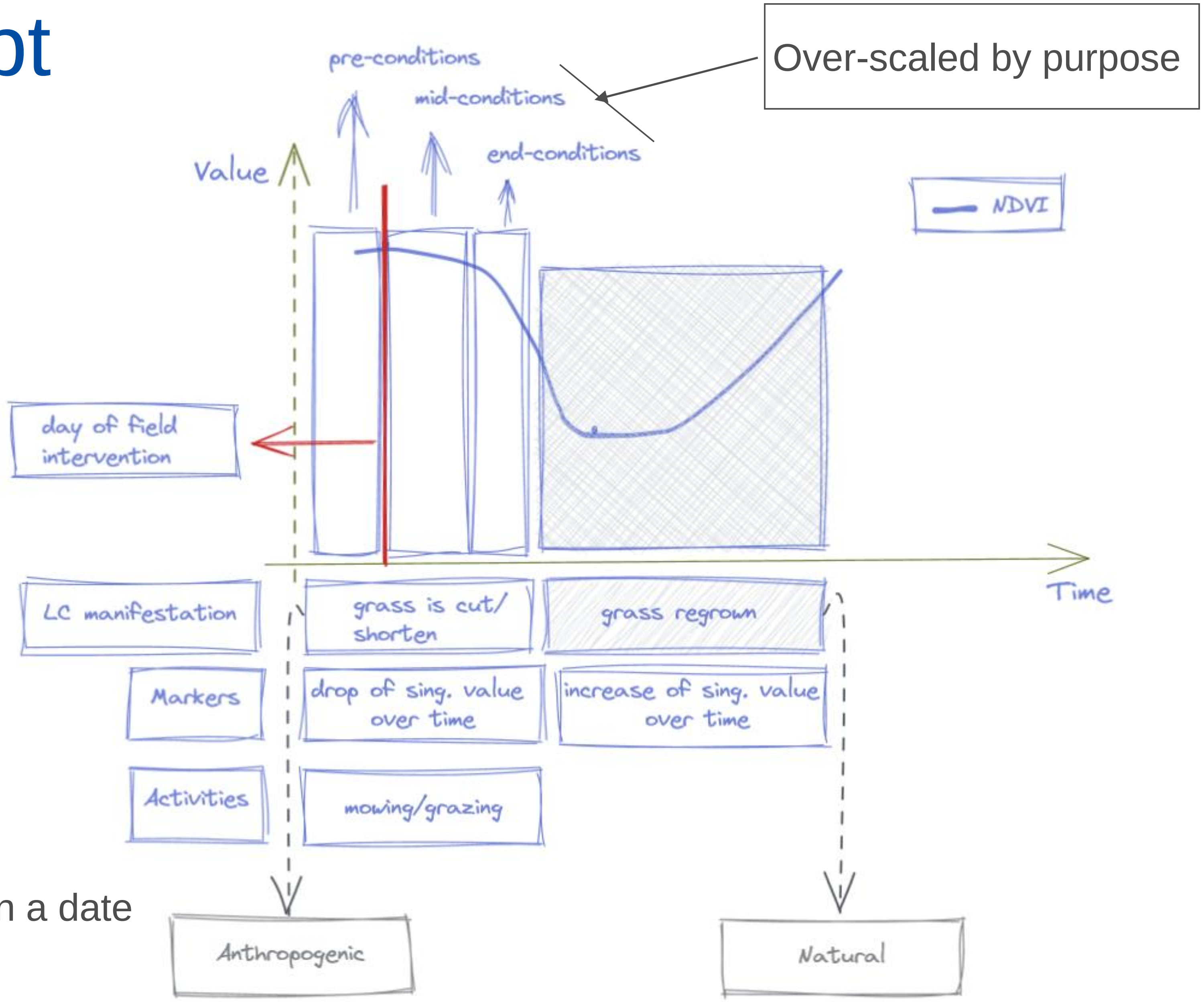
- 11 MS/PA reported the expected number of activities during the season on permanent grasslands
- From 1 to 9 activities (mowing and grazing) may take place depending on local conditions

Number of possible activities on permanent grassland



Back to the concept

- Activities
  - On the ground framers’ actions
- LC manifestation
  - Observable Land Cover
- Signal
  - i.e. S1/2 band or derivative
- Marker
  - Indicate state or change of state on a date



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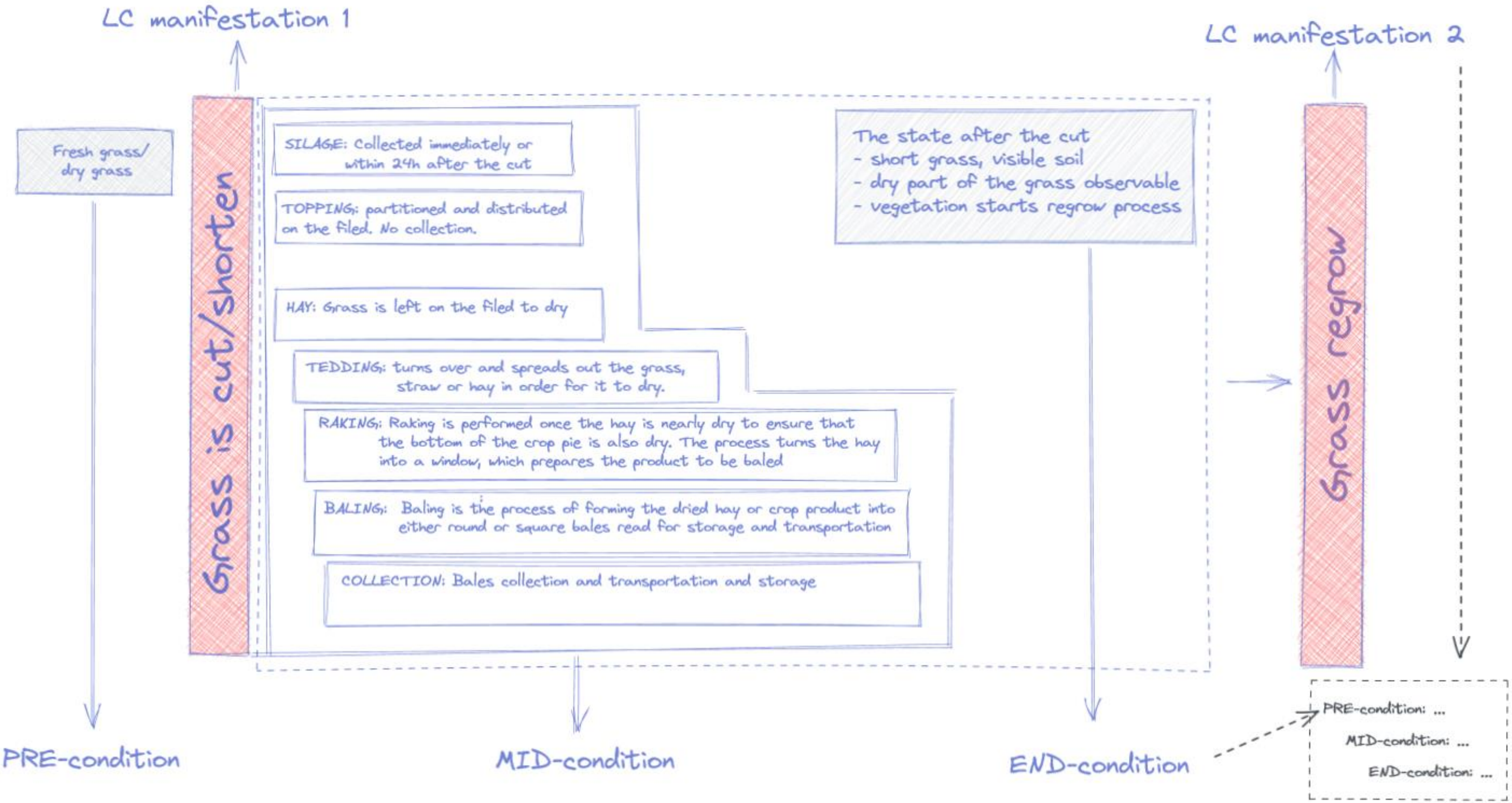
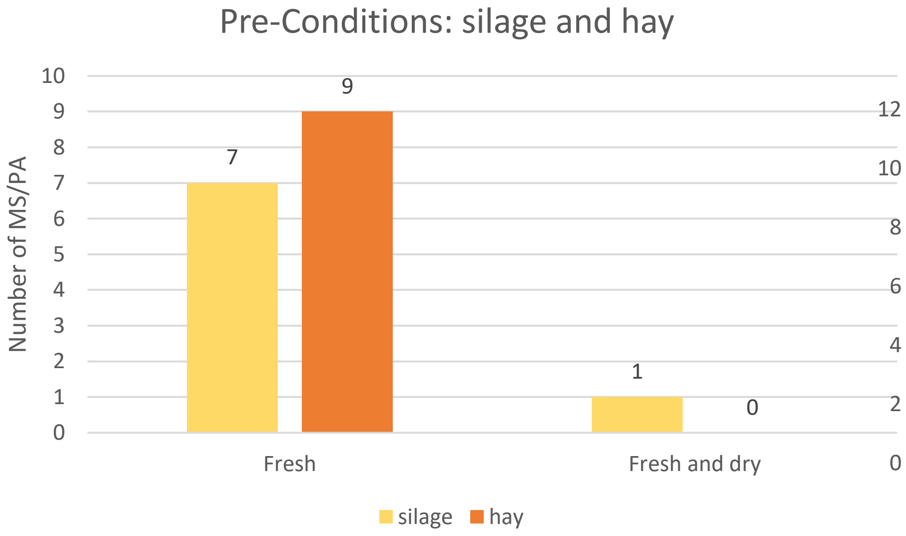
LC manifestations for mowing activity

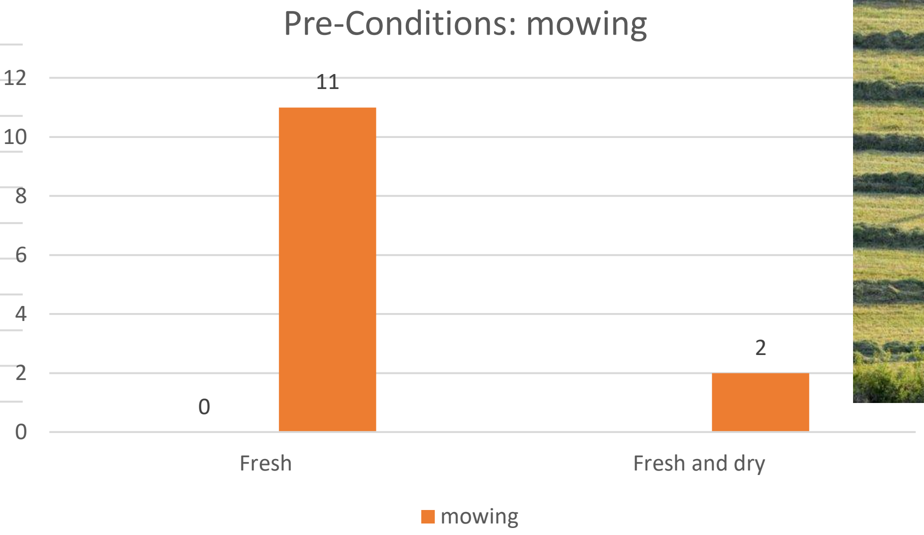


Scenarios: Pre-Conditions

- The grass is mostly mowed as fresh (11/13 MS). In 2 cases the grass can be cut also dry.
  - **Hay: cut as fresh** in all of MS/PA (9 out of 9 MS/PA)
  - **Silage: mostly cut as fresh** (7 out of 8 MS/PA). In one MS/PA the grass is cut fresh and dry conditions (South of Europe).

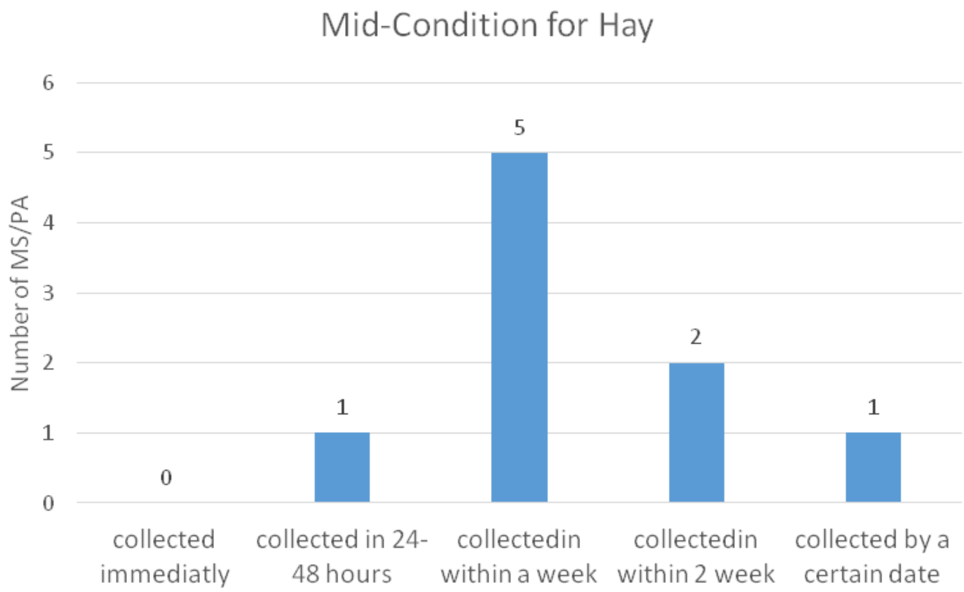
source: agriland.ie





Scenarios: Mid-Conditions:

- In case of **hay** (described by 9 MS/PA): collection in **2-14 days**
- In case of **silage** (described by 8 MS/PA): the grass is **immediately collected after cut or within 48 hours**



source: farm-equipment.c

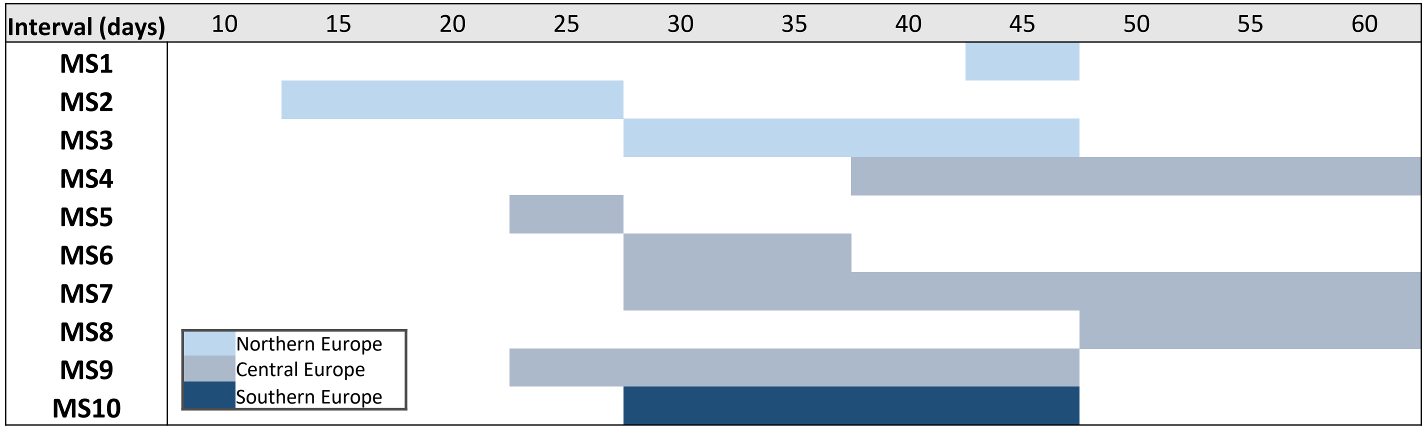
source: rossfilippini.files.wordpress.com

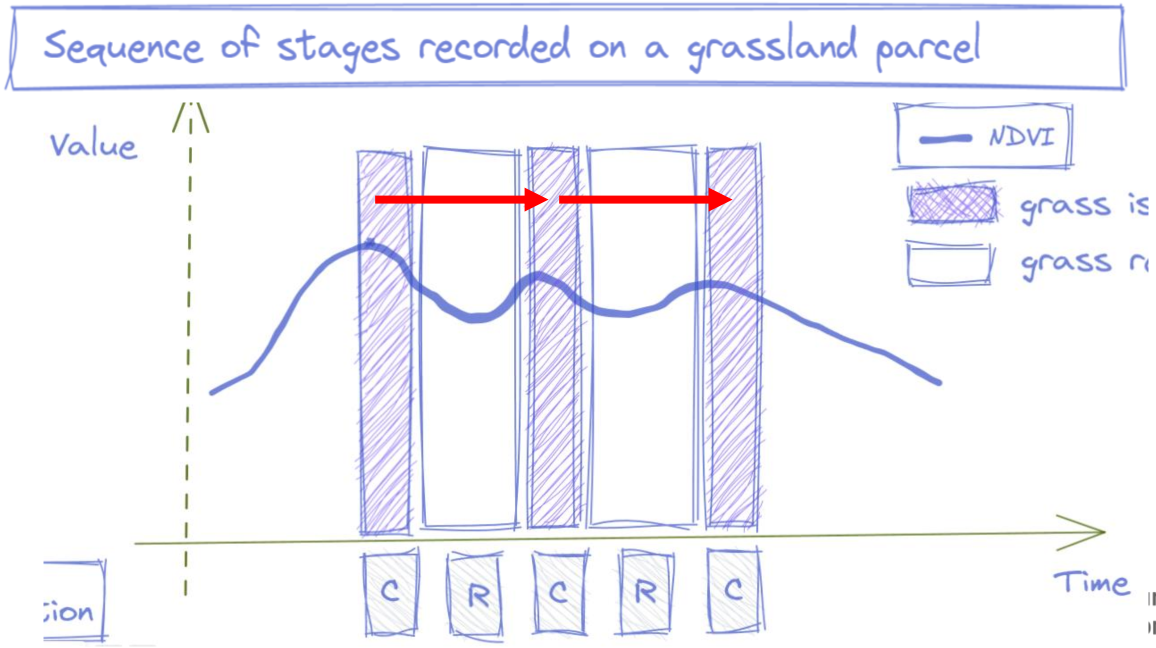
Scenarios: Post-Condition

3 MSs have not provided data

- **Re-occurring** periods are quite different and closely linked with the **local practices** and **environment conditions**

- The intervals between two consecutive activities last between 15-60 days (**average about 30 days**)

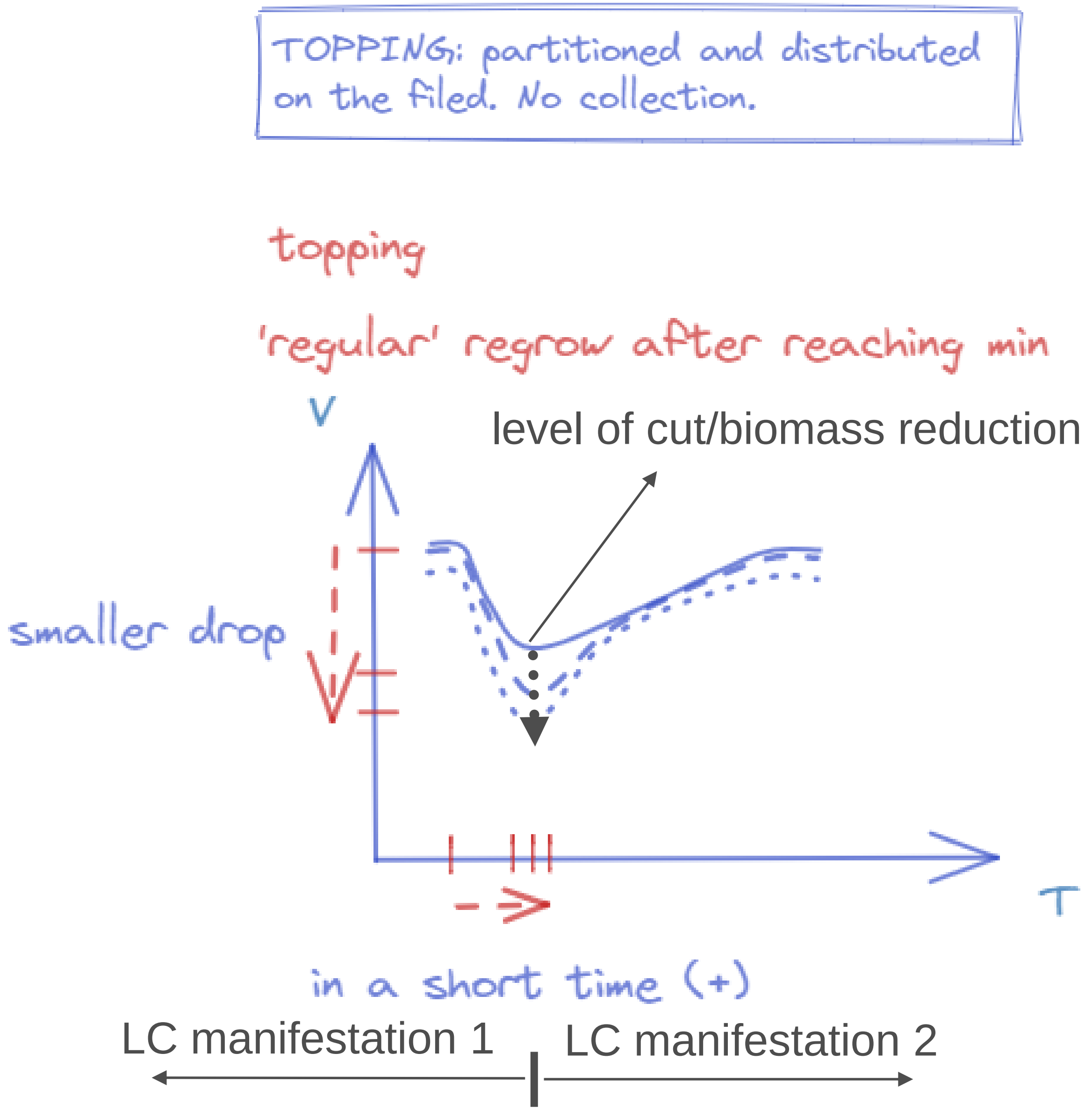




Mowing - topping

- Event: grass is cut/shorten
- Pre-condition:
  - Fresh grass normal height at full development
  - Dense/close vegetation cover
- Mid-condition:
  - Presence of dry/dead vegetation, mixed with a fresh vegetation underneath, both covering soil
- End-condition:
  - Short grass, visible soil, and residuals partitioned and evenly distributed, not covering entirely the gr (changing from fresh – dry- fertilizer)

Temporal change is abrupt



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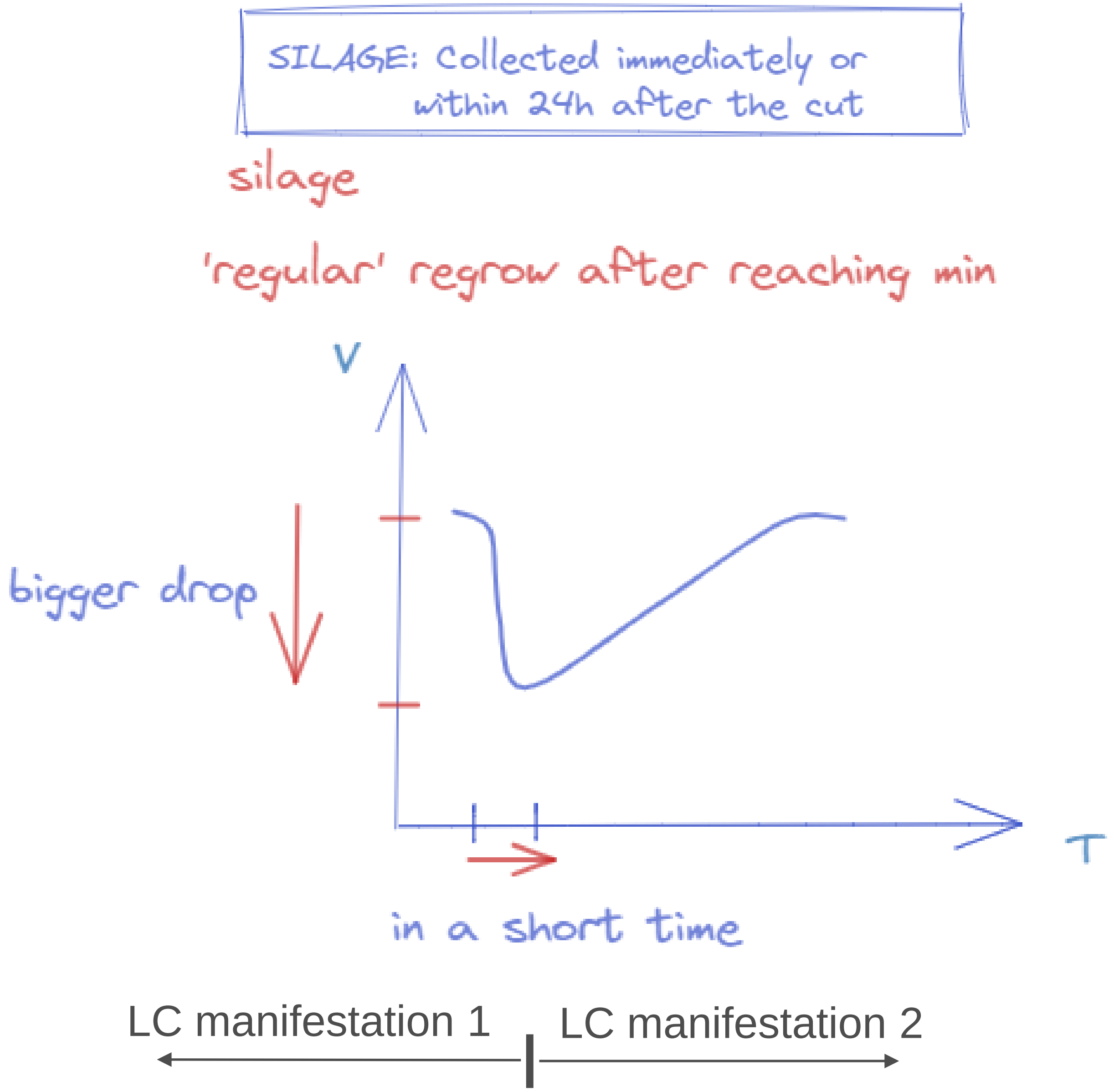
Mowing - silage

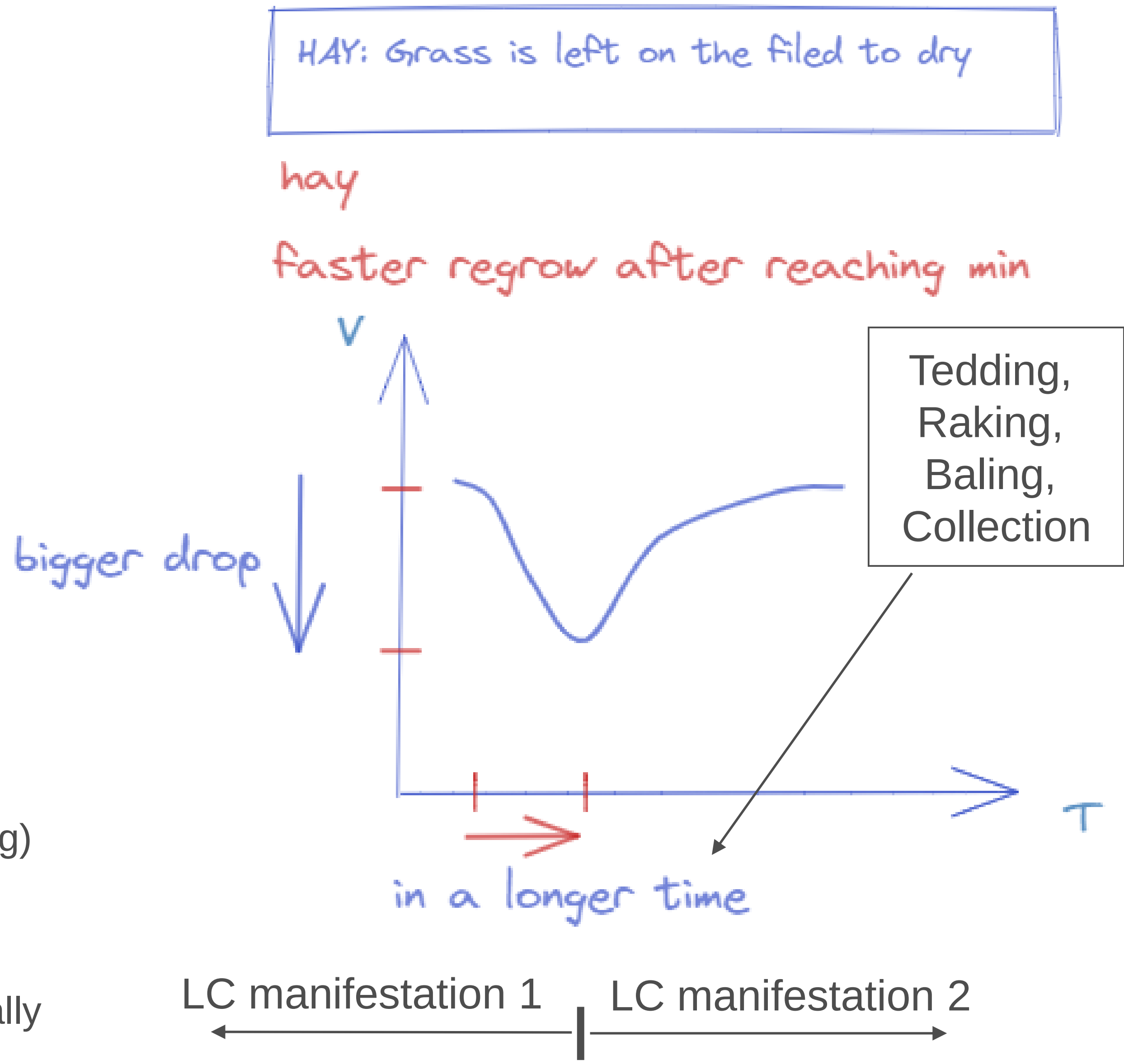
- Event: grass is cut/shorten
- Pre-condition:
  - Fresh grass normal height at full development
  - Dense/close vegetation cover
- Mid-condition:
  - Absence of cut grass (immediate, collection up24h)
  - Open soil
- End-condition:
  - Short grass, visible soil, and potentially dry matter.
  - Open vegetation cover



considering S1/S2 revisit time

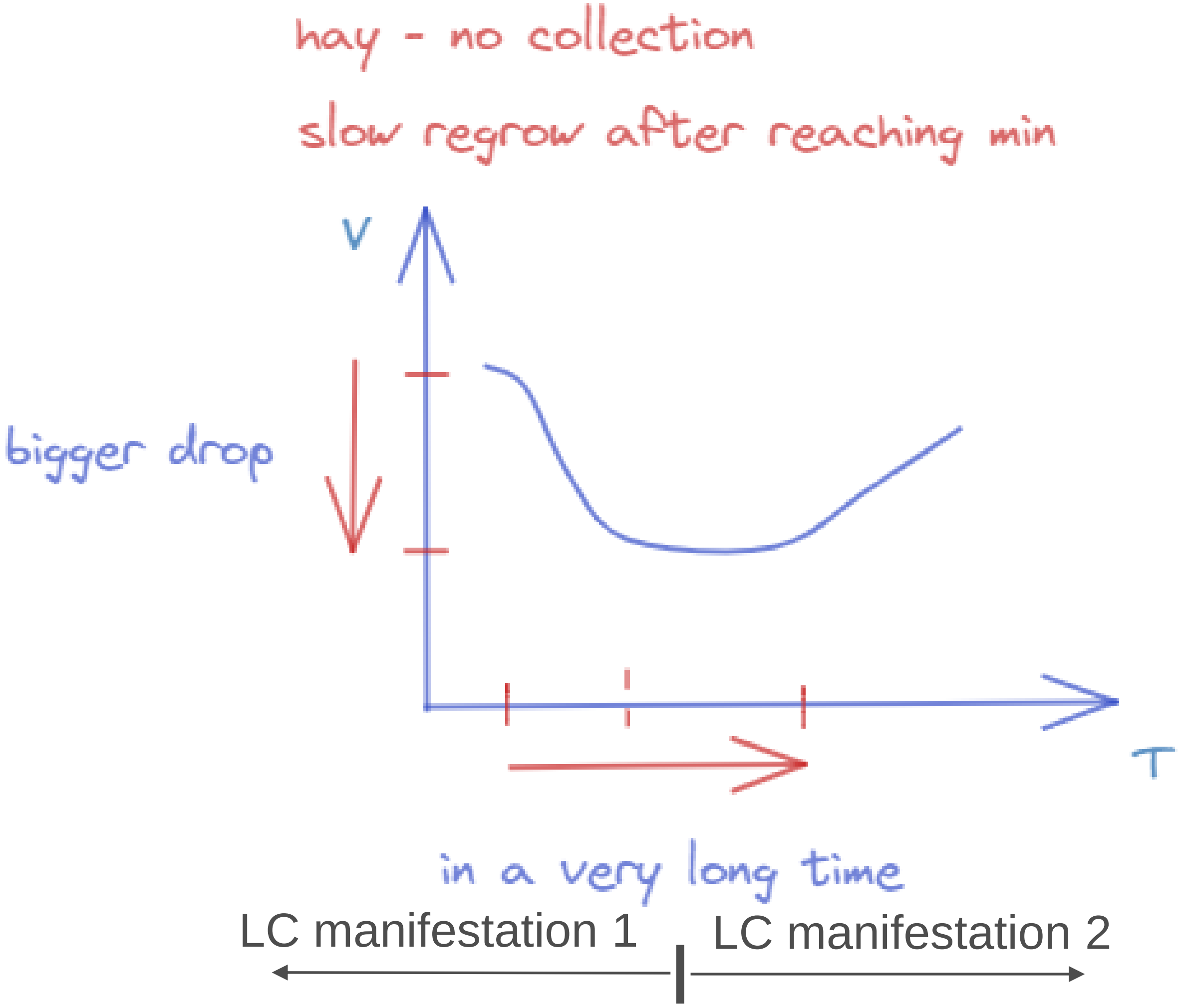
Mowing - hay

- Event: grass is cut/shorten
- Pre-condition:
  - Fresh grass normal height at full development
  - Dense/close vegetation cover
- Mid-condition:
  - Presence of dry/dead vegetation covering the crop for (i.e. 7-14) days
  - Potential changing appearance due to mechanical operations with grass left to dry (tedding, raking, baling)
- End-condition:
  - Followed by very short grass, visible soil, and potentially dry matter
  - Open vegetation cover



Mowing hay without collection

- Event: grass is cut/shorten
- Pre-condition:
  - Fresh grass normal height at full development
  - Dense/close vegetation cover
- Mid-condition:
  - Presence of dry/dead vegetation covering the soil
  - Lack of changing appearance due to mechanical operations with grass left to dry
- End-condition:
  - Decomposition of cut grass residuals
  - Followed by overgrown of grass
  - Open vegetation cover



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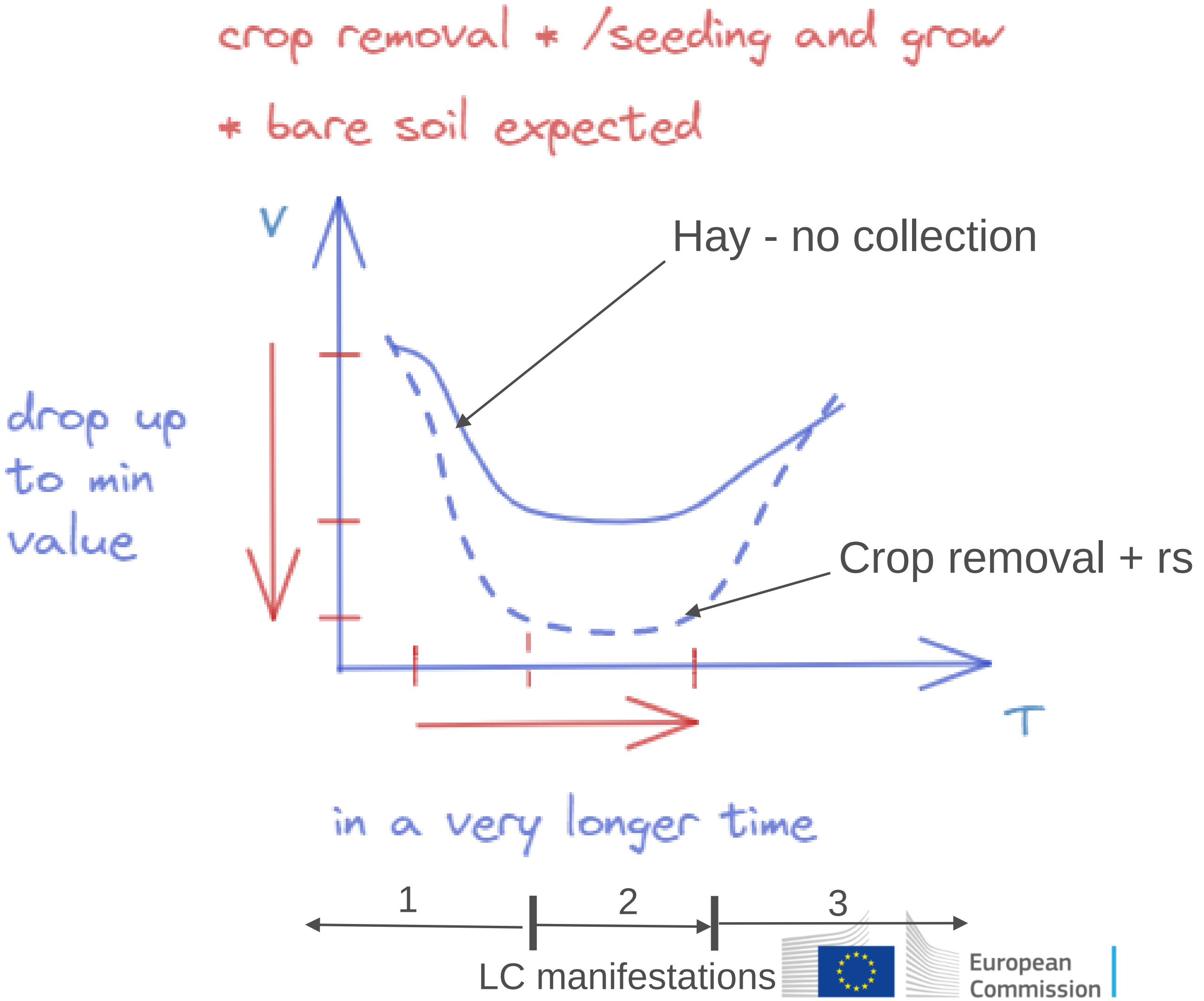
Grassland – crop removal + re-seeding

- Event: grass/crop removal
- Pre-condition:
  - Fresh grass normal height at full development
  - Dense/close vegetation cover
- Mid-condition:
  - Full crop cover removed
- End-condition:
  - No vegetation, bare soil persistently observable



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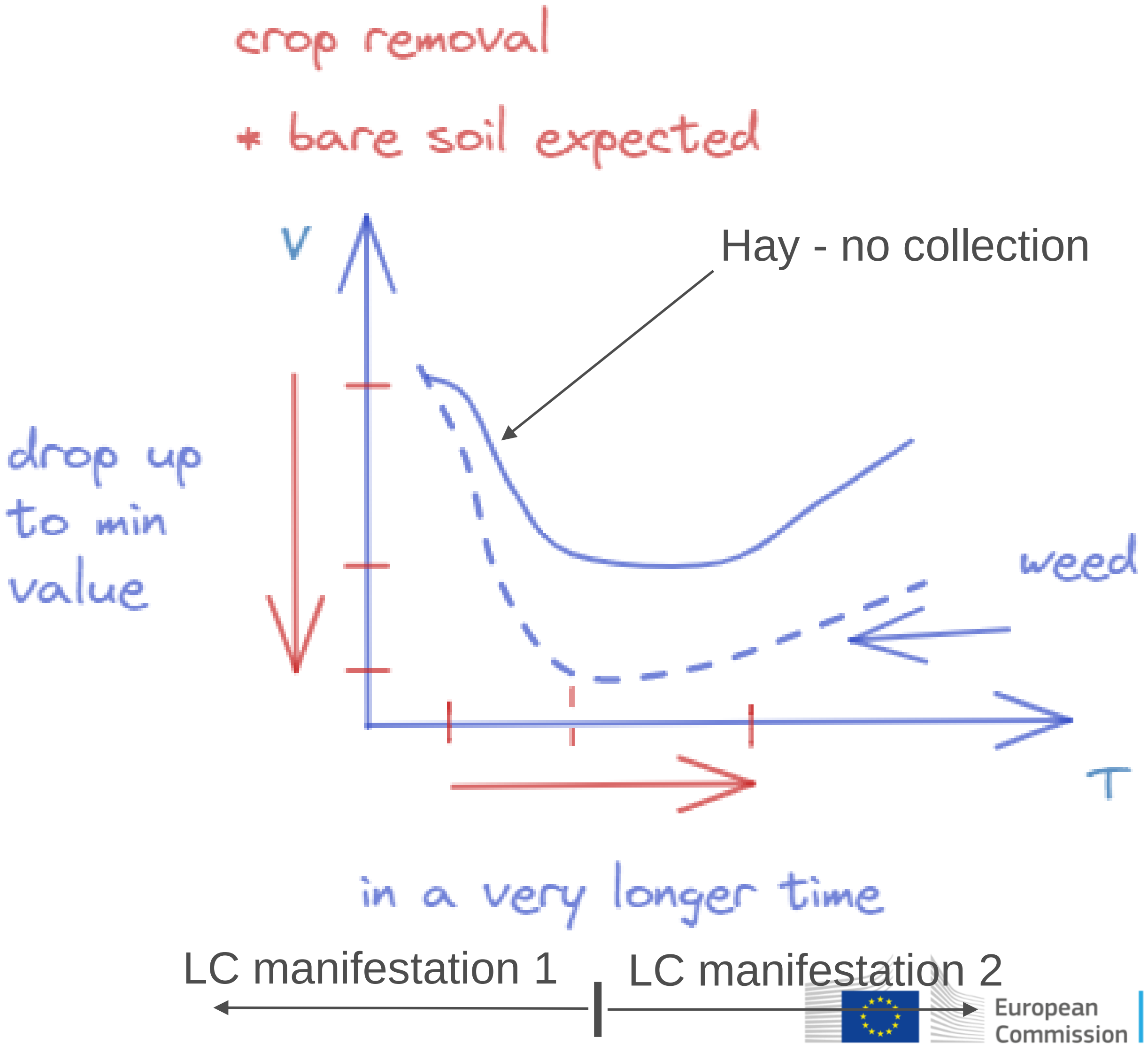
Grassland – crop removal

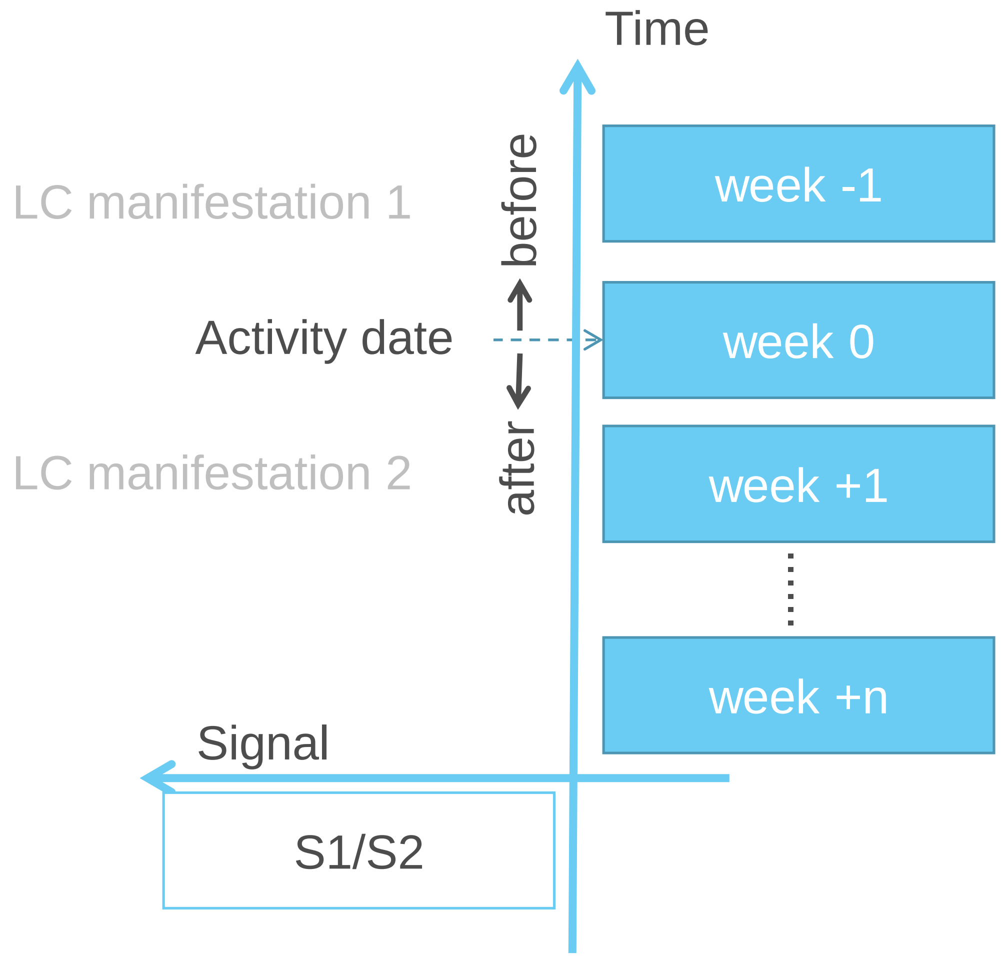
- Event: grass/crop removal
- Pre-condition:
  - Fresh grass normal height at full development
  - Dense/close vegetation cover
- Mid-condition:
  - Full crop covered removed
- End-condition:
  - Bare soil persistently observable

The same as previous, only LC man. 2 is different



Ground truth data vs signal behaviour

- Random selection of small subsets of available ground truth datasets from 3 MSs
- Activities dates were extracted
- The S1 and S2 observations shortly before and after activities were extracted and organised in a weekly pattern (given by the date of an activity)
- Variability and Mean-Variance analyses (only selected results shown below)



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Ground truth data vs signal behaviour

- Dataset: 3 subsets with 25 FOIs/parcels of permanent grasslands

IE dataset	
Frequency of observation:	weekly
Time stamp:	week of the year
Number of activities:	Yes*

* *Including: crop, phenological stage, activities: silage, hay, topping, zero grazing, grazing, harvest crop*

50+/year

CZ dataset	
Frequency of observation:	≥ 2 times in a season
Time stamp:	a data range, start and finish
Number of activities:	Yes**

*** Including: mowing and grazing*

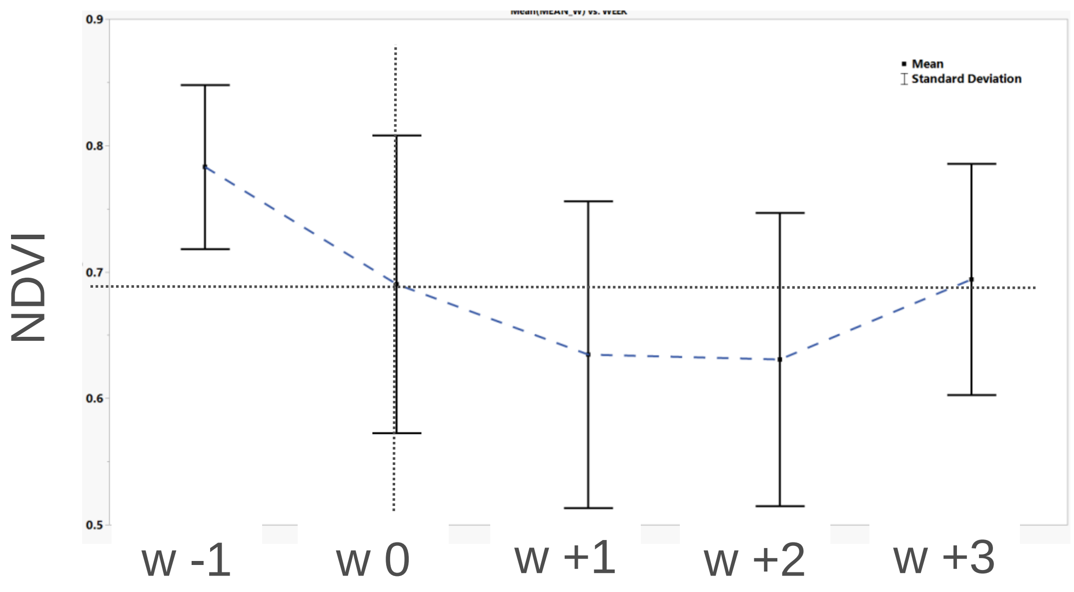
2/year

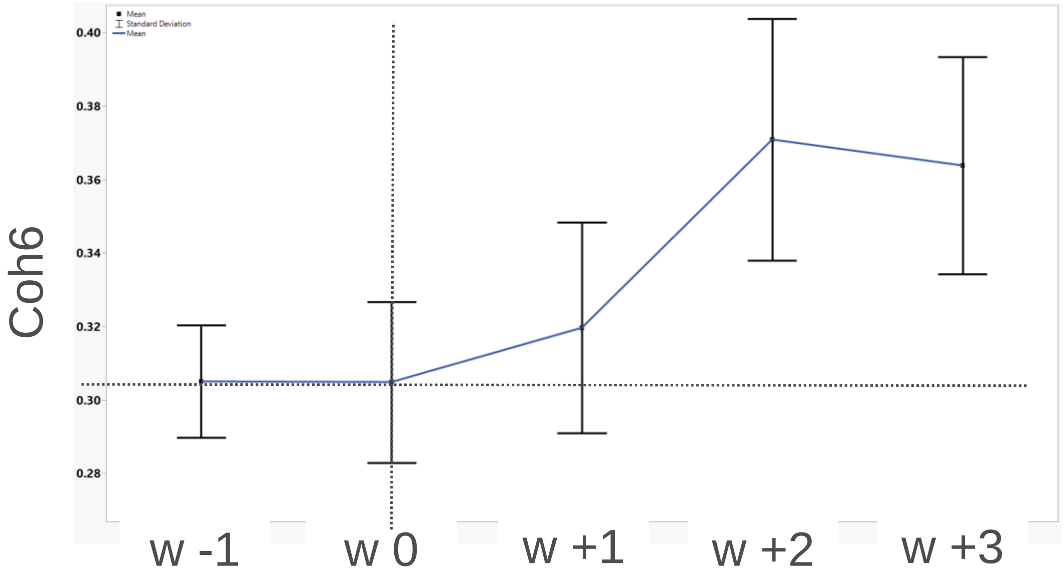
LV dataset	
Frequency of observation:	once a season***
Time stamp:	date of a visit
Number of activities:	Yes**

****geo-tagged photos available*

1/year

Change of LC manifestation in Coh6 and NDVI





CZ (ndvi): mowing

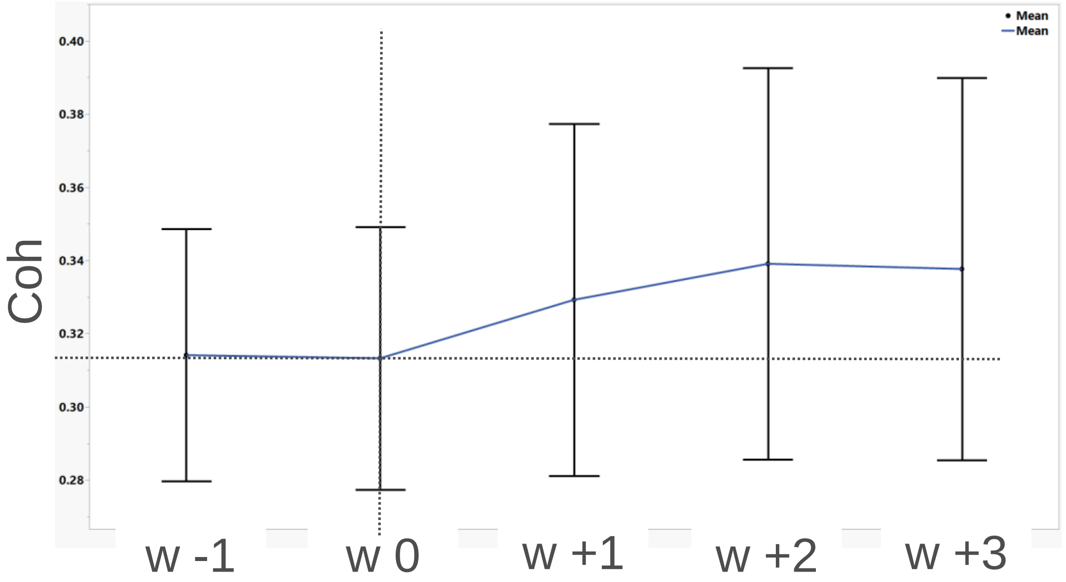
- NDVI indicating the amount of green chlorophyll containing biomass, after cut decrees thus lower values after the activities are recorded.
- after activity NDVI value drops for next 2 weeks then starts increasing, due to noticeable sings of re-grown (depends of the practice and mid-condition, CZ no specific data)

CZ (coh6): mowing

- before activity Coh6 value is nearly at the same level as in a week of activity (only one week before activity considered)
- Removal of vegetation cause increase soil participation thus increase the coherence value.
- after activity Coh6 value increases for next 2 weeks then starts decreasing together with sighs of vegetation regwon

Change of LC manifestation in coherence

No valid data! Just clouds



*1 Stdev values 68%

IE (ndvi): mowing
- Often May-July with a single cloud free acquisition per month
- Not enough valid data S2, only **15%** observations in comparison to Coh.

IE (coh6): mowing

- **Similar signal behavior observed**
- before activity Coh6 value is nearly at the same level as in a week of activity
- after activity Coh6 value increase for next 2 weeks then starts decrees with the vegetation regrown. In the presence of vegetation, temporal decorrelation decreases the measured coherence.

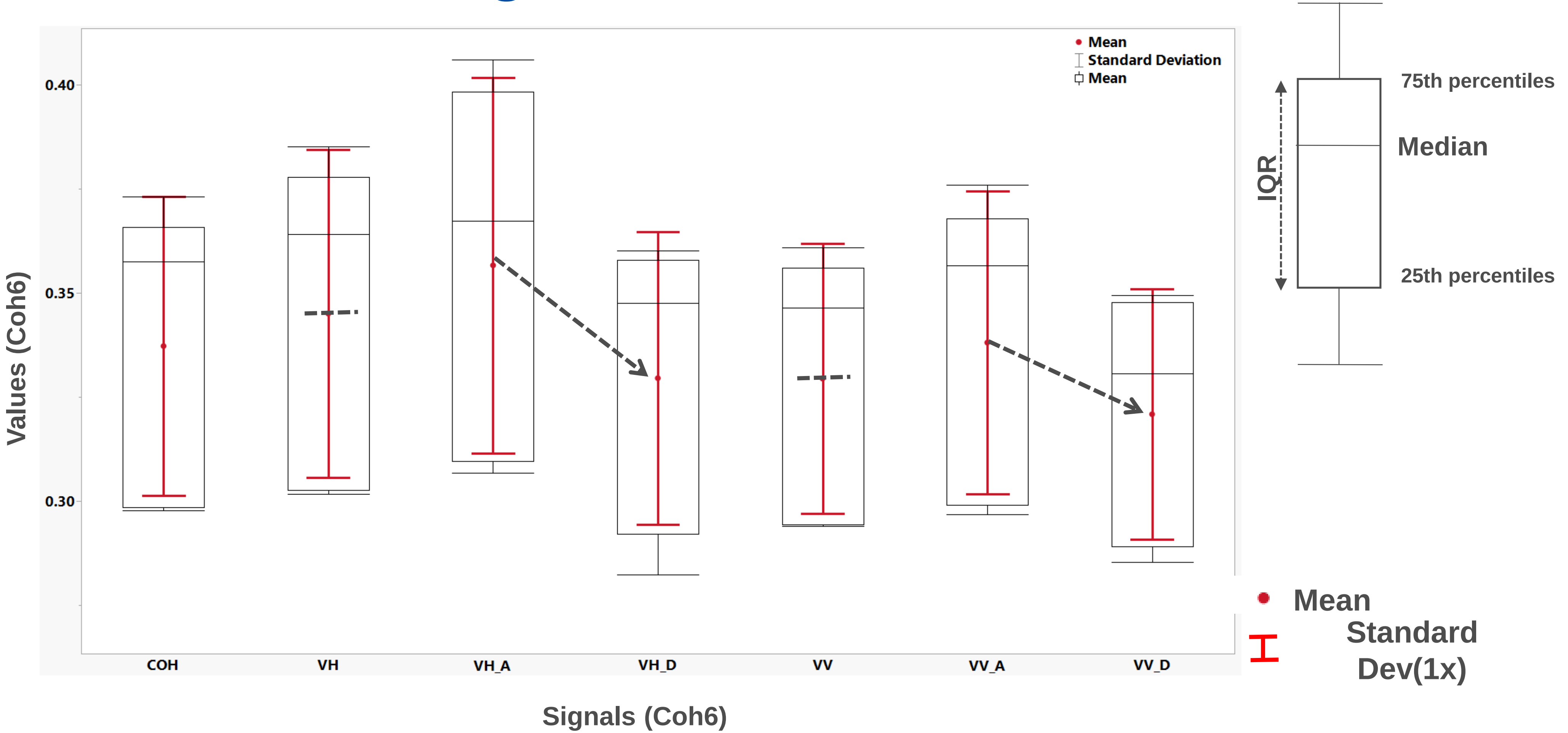
Read me: Voormansik, et al. 2020, Tamm, et al. 2016

Coherence based signals

IE (Coh6, all weeks)

Polarisation: VH>VV
Orbit: _A>_D

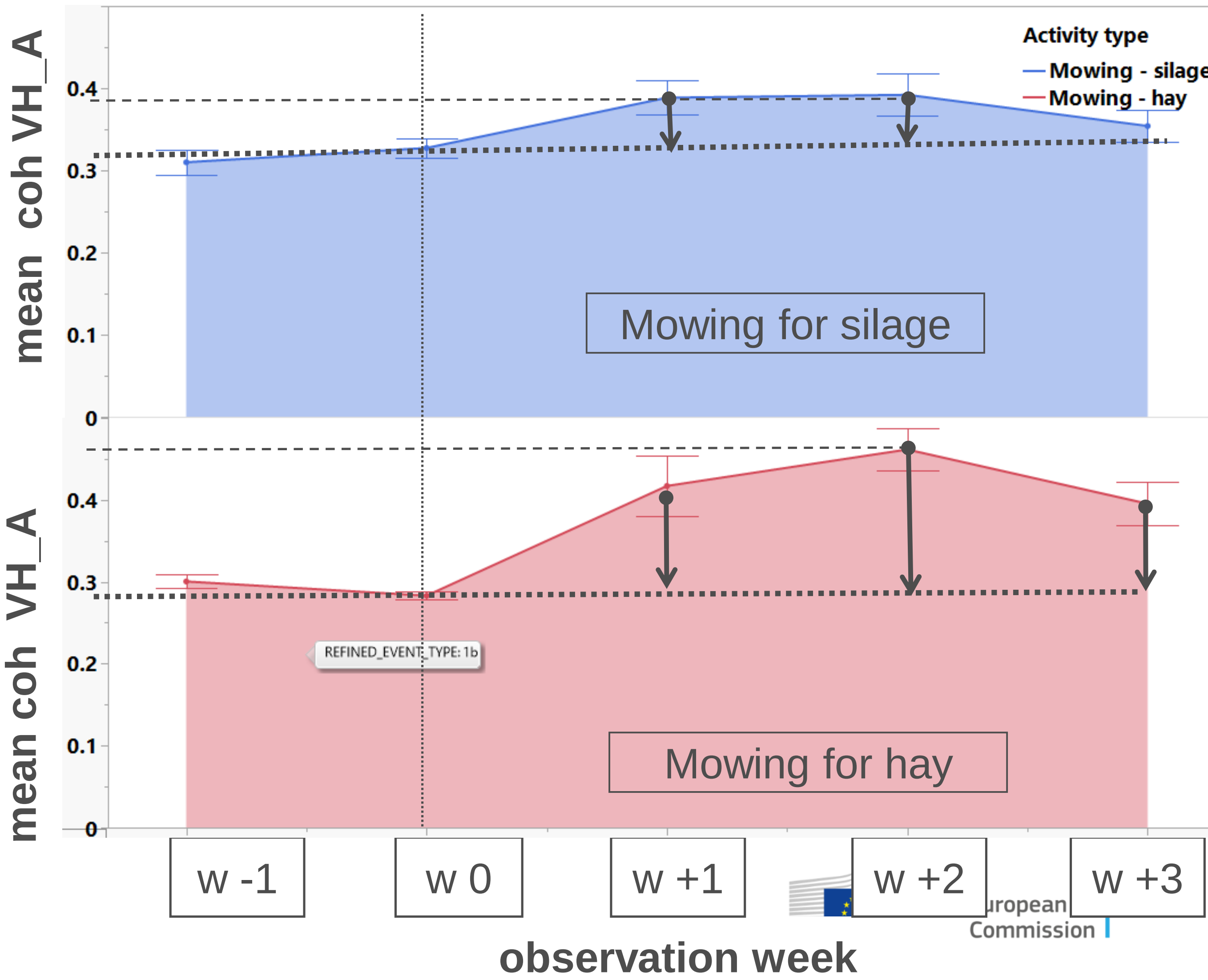
Signals: VH_A and VV_D hold most of variability



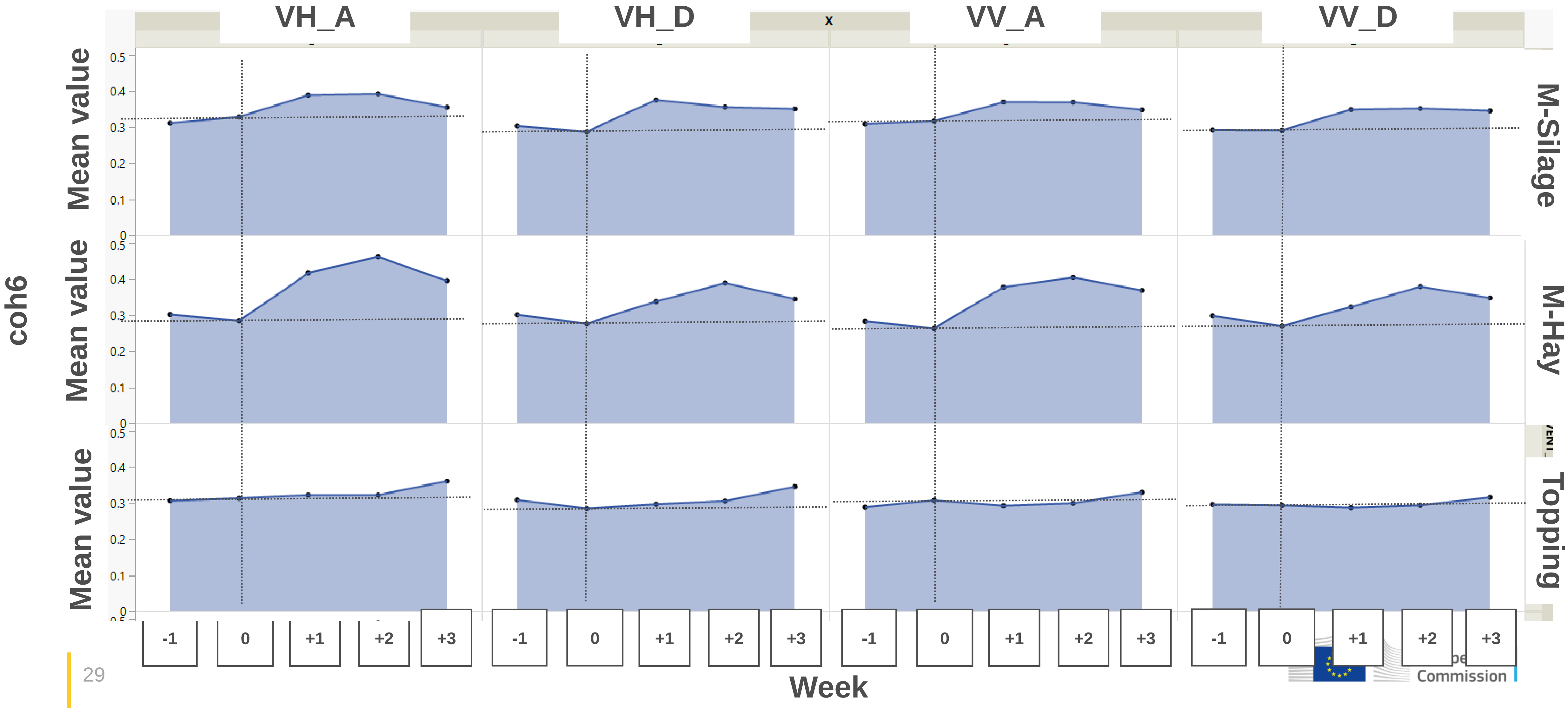
The difference between VV and VH maybe caused by discrepancies in scattering due to vegetation structure and soil roughness.

Mowing types in signal behaviour (1/2)

- **IE (coh6 VH_A, mowing types)**
- Practices mowing (hay, silage)
- Significant difference Coh (VH_A) value increase after the activity recorded
- ΔVH_A(hay) twice bigger than ΔVH_A(silage) for consecutive weeks after activity
- Important for developing mowing detection algorithms based on S1



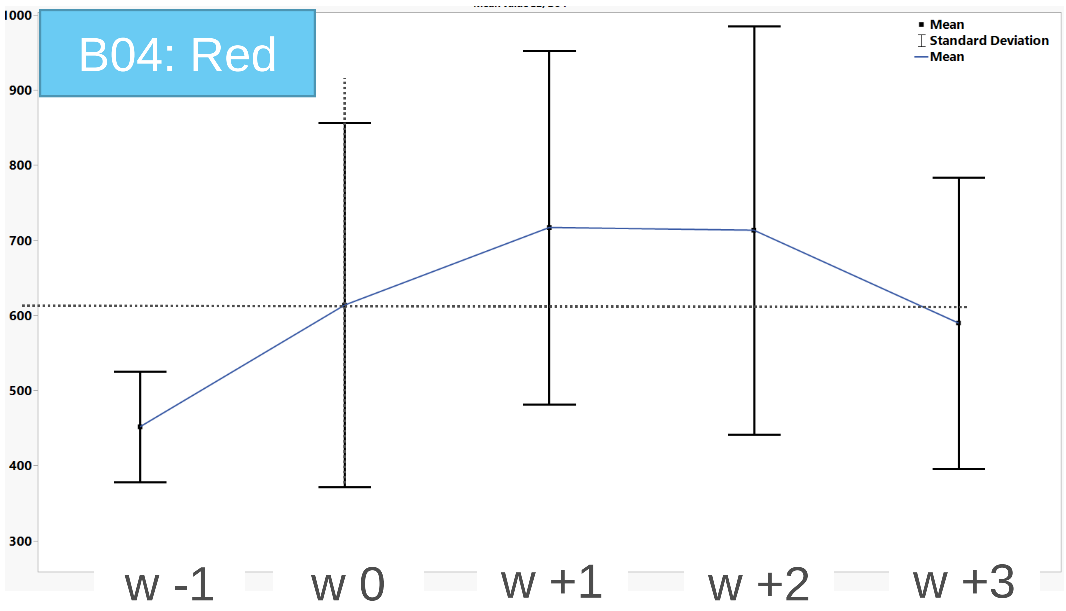
Mowing types in signal behaviour (2/2)

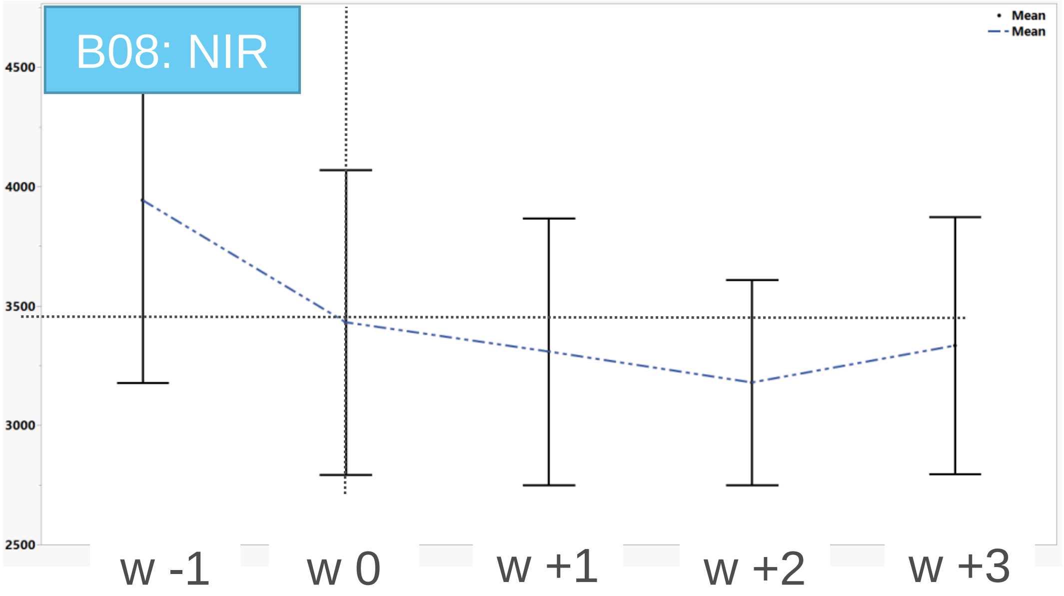


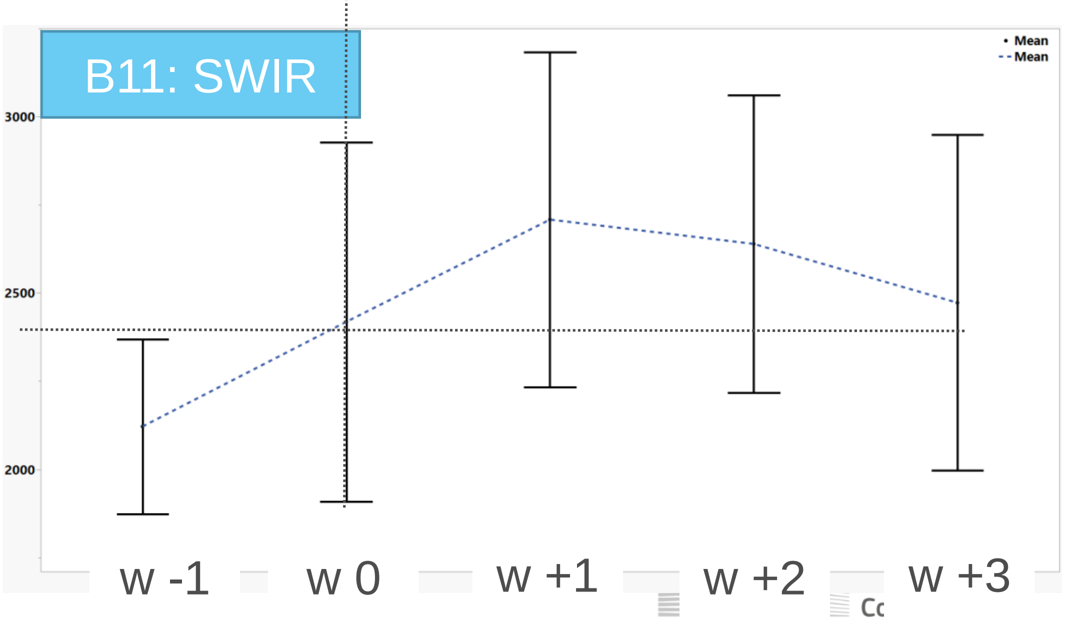
Example of LC manifestation in S2 bands

Mowing (CZ), Spectral bands S2 (4,8,11)

- Similar analyses can be done for any band or signal derivative
- important when considering inclusion of ‘a new’ signal in processing





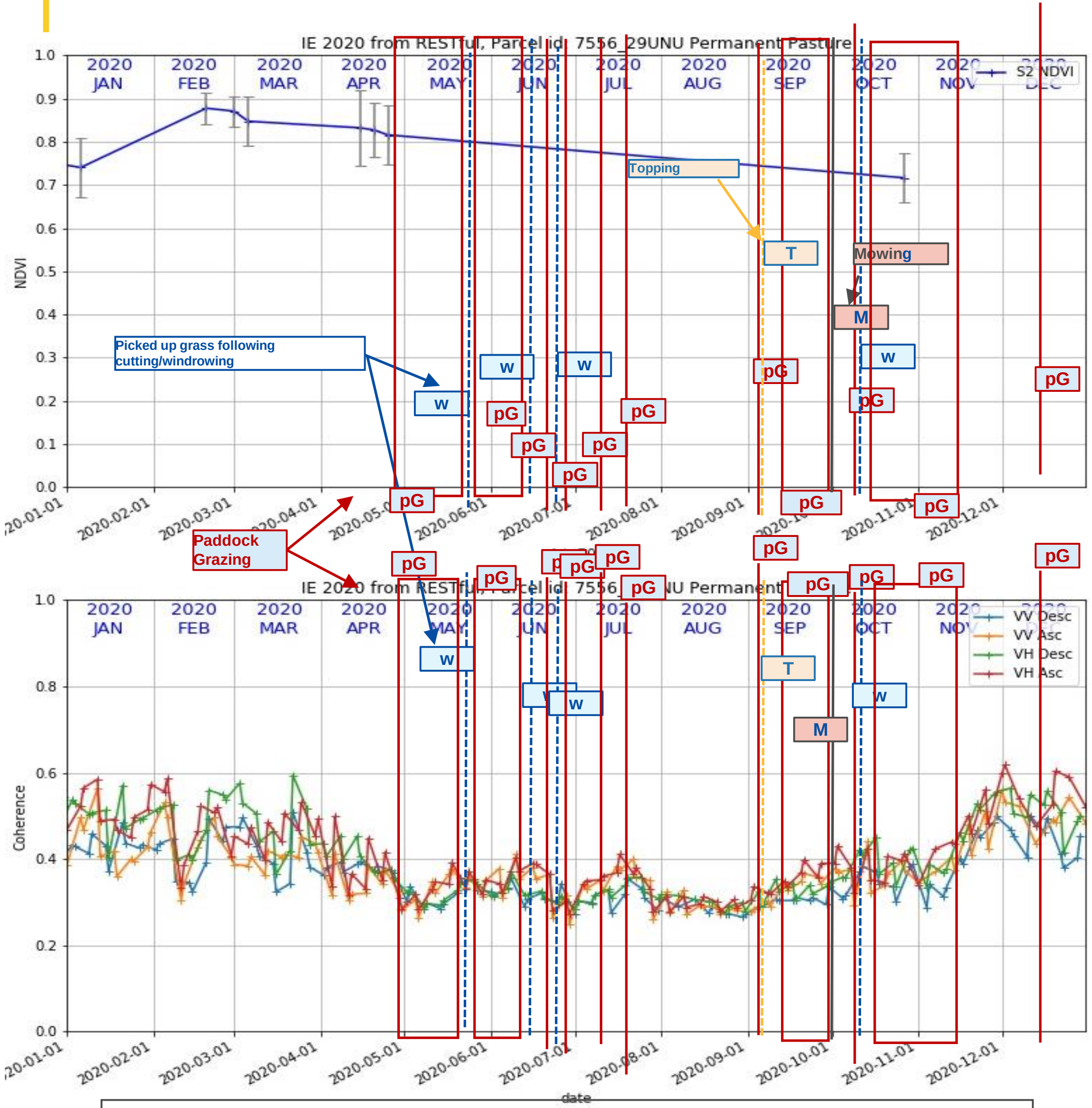


Read more: Bekkema and Eleveld, 2018

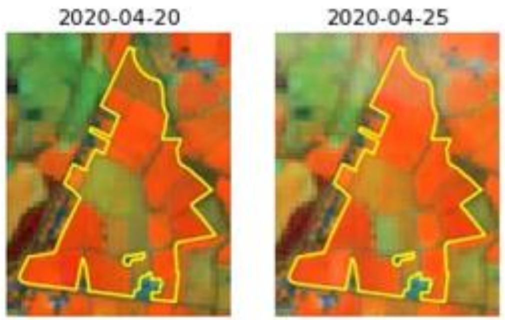
Ground truth data

- Many protocols/data sources of ground data collection
  - Dedicated **field surveys**
  - Geo-tagged **photos** /aerial orthophoto, aerial oblique imagery
  - **Control data** (RFV, OTSC)
- Knowledge of the activity date is a crucial element of signal data analyses
  - **frequency of observations** in a season (best: weekly; more the better depends on duration of the phenomena observed)
  - **type of information recorded** (best: crop, crop phonological status, activities observed and date; at least: date of observed activity)
  - **spatial coverage data collection** (flexible according to survey plan or fixed distribution of existing control data)
  - **number of parcel observed** (cost of new survey vs reuse of existing information)

The correctness of FOI crucial for analyses



Excellent data set – weekly observations



Parcel area = **32 ha**

Single FOI

- Number of activities reported = 20+
- Multiple AP in a single FOI (not homogeneous)
- S1/2 statistics extracted – no problem
- Possibly detected makers would not be valid
- Need for FOI validation procedure

Final observations

- Good understanding of practices is the key element of developments
- Conditions (pre, mid, end) help to translate practices to signal behaviour
- Ground observation are important for both: understanding the signal behaviour and quality control of the outcome
- For any future data collection surveys – important careful planning, no click and deliver, the result will be available after a season
- Fit for purpose ground observation. Detailed data recorded give more possibilities for data analyses
- The ‘smartest’ analytical approaches will not give a proper results if your FOIs are not correct.

Thank you

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CbM on DIAS: Refresher & data access

Online training for Outreach, 19 November 2021

JRC D5 – GTCAP Team

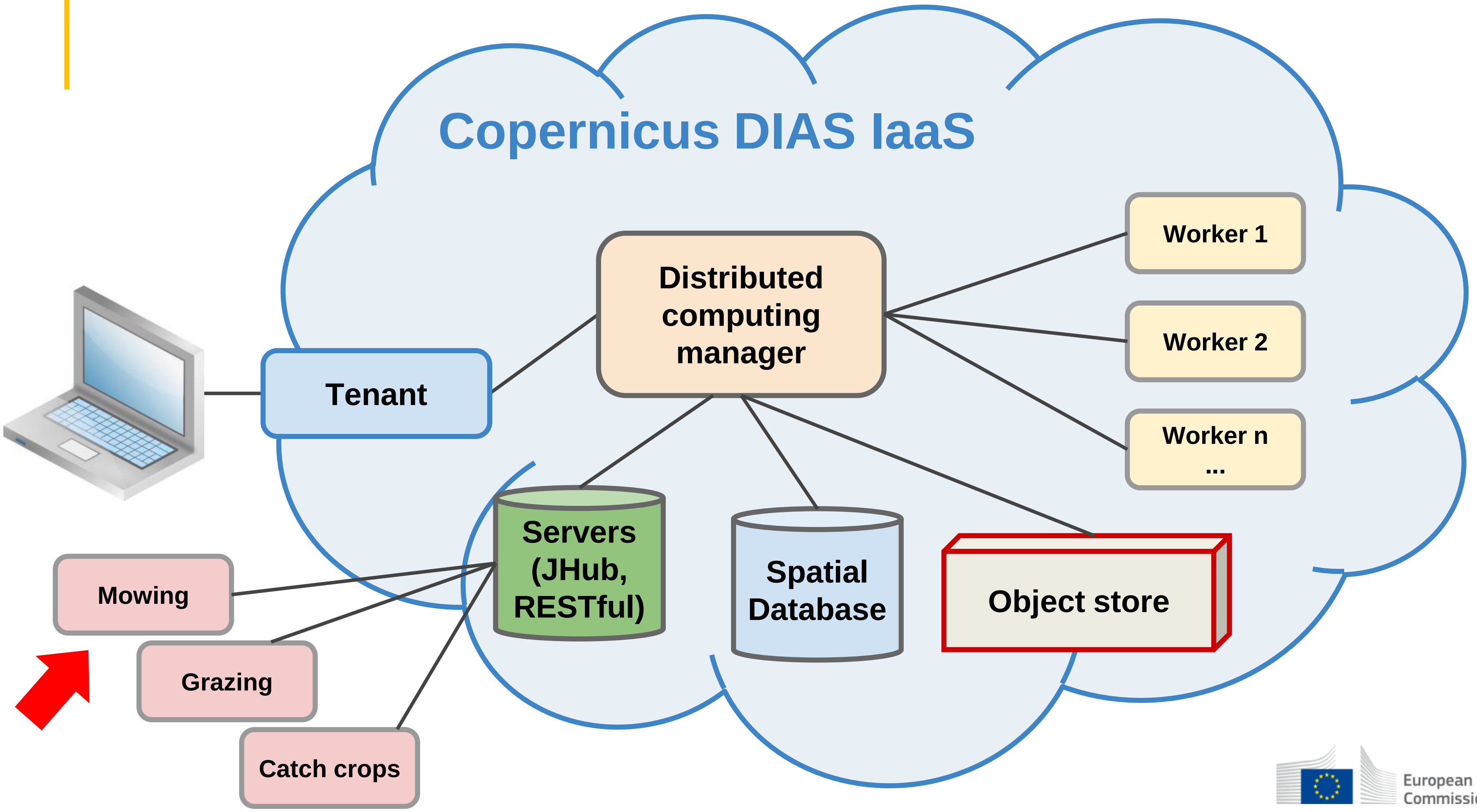
Agenda

09:30 - 09:35	**Welcome**
09:35 - 10:20	**Translating practice to signal behaviour**
10:20 - 10:40	**RESTful data access - refresh and updates**
10:40 – 11:25	**Signals and Signal Processing - Part I**
11:25 - 11:40	**Break**
11:40 - 11:55	**Signal and Signal Processing - Part II**
11:55 - 12:25	**Mowing Marker Detection**
12:25- 13:00	**Q&A, discussion**

Outreach

- **Outreach** is a capacity demonstrator which:
    - Groups CbM processing needs for Sentinel data on a single platform
    - Deploys back-end components to provide analysis ready data
    - Handles all intrinsic DIAS processing details on a JRC managed instance
    - For selected thematic CbM application contexts
    - Jointly designed with participating Member State PAs

- Back-end and front-end modules were explained in previous Webinars
- Today is about plugging **frontend data** pipelines into **analysis workflow**
- Applied to grassland mowing scenarios



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Refresher

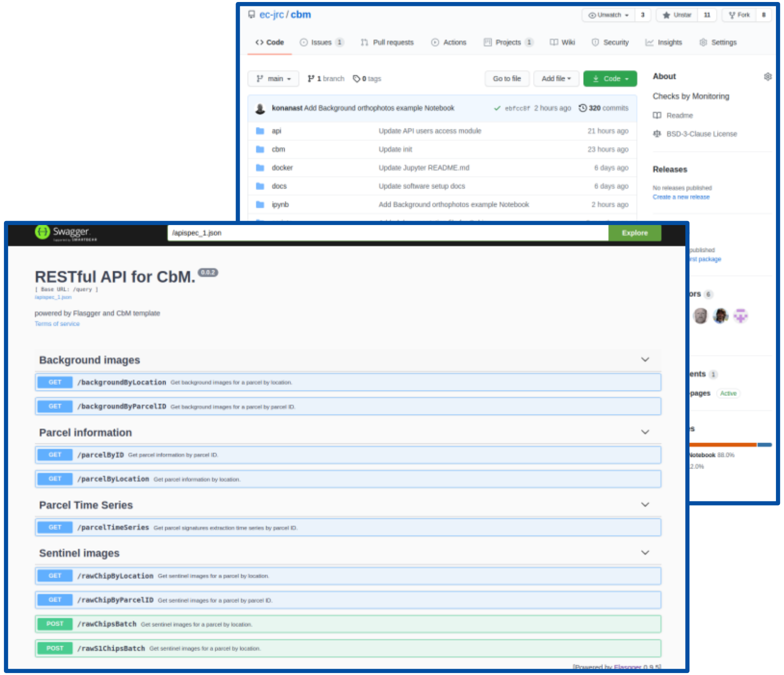
- The backend integrates access to the **Sentinel data archive**
- Provides functionality and processing power to generate **Analysis Ready Data**
- Runs parcel extraction as a key **reduction** stage in CbM.
- Fit for purpose for **full territory**, operational needs
- Best place to integrate and scale up **common data processing patterns**

- The frontend **consumes** the backend data to support typical PA functions
- Through the use of standard protocols in particular **RESTful**
- Supports best-in-class interactive and machine analysis, reporting
- Focus on parcel reductions, but extendable to direct image access
- Following the “reduction first, escalate for specific cases” CbM paradigm

- All Outreach participants have exclusive access to their CbM data sets

CbM Frontend data access

- **Data Access**
- **RESTful API updates**
- **Most common mistakes**
- **Usage statistics**



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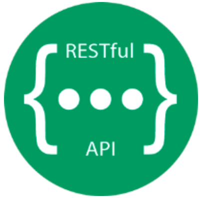
CbM data access

RESTful API



RESTful API Requirements:

- RESTful account from JRC
- Basic programing knowledge*

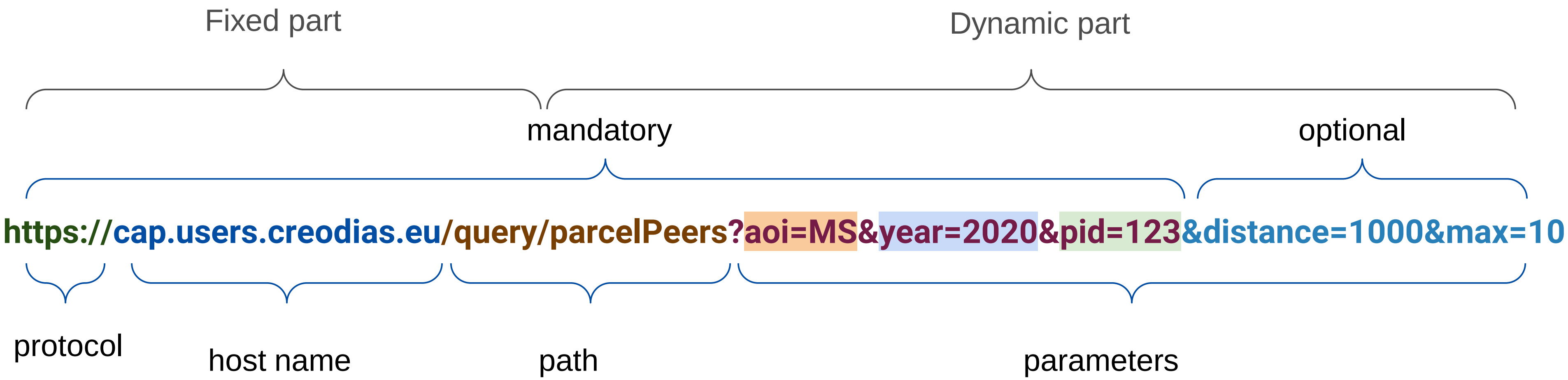
➢ **JRC does not provide direct database access**

Data Exports

Alternative data access Requirements:

- Extracted data from JRC database
- A Postgres database server with PostGIS
- Good backend server management skills
- Good programing skills

RESTful API requests structure



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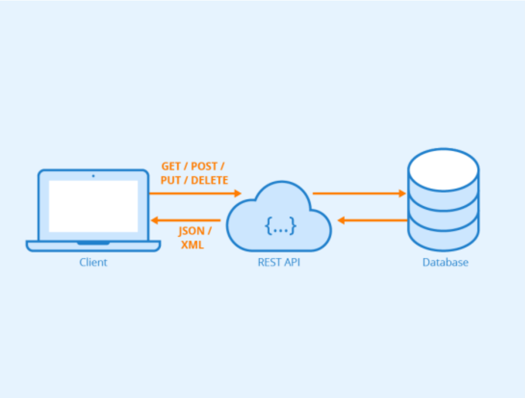
RESTful queries



- Parcel information
  - **parcelByLocation, parcelByPID**
- Parcel signatures time series
  - **parcelTimeSeries**
- Parcel sentinel images
  - **chipByLocation, rawChipByLocation**
- Parcel orthophotos
  - **backgroundByLocation, backgroundByPID**
- Parcels lists
  - **parcelPeers, parcelsByPolygon**

RESTful - Parcel Time Series

- parcelTimeSeries
  cap.users.creodias.eu/query/parcelTimeSeries?aoi=AA&year=2020&pid=123&tstype=s2

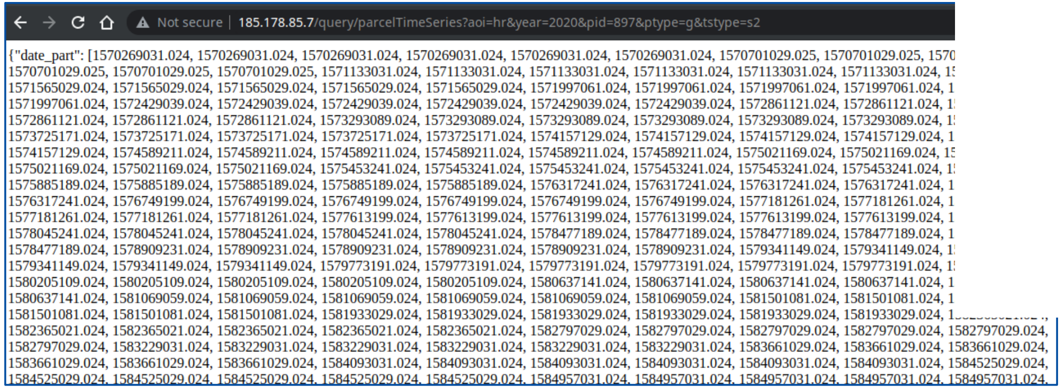
	Parameters	Type	Description
mandatory	**aoi**	String 2 - 5 characters	Area of Interest
	year	4 digits int	The year
	pid	String	Any geographical coordinate inside the respective territories
optional	tstype	s2(default), c6, bs	time series type
	band	B4, B8, SC or VV, VH	a selected band
	ptype	g,m,n. etc.	parcels dedicated to different analyses

RESTful - Parcel Time Series examples

Get parcel Time series:

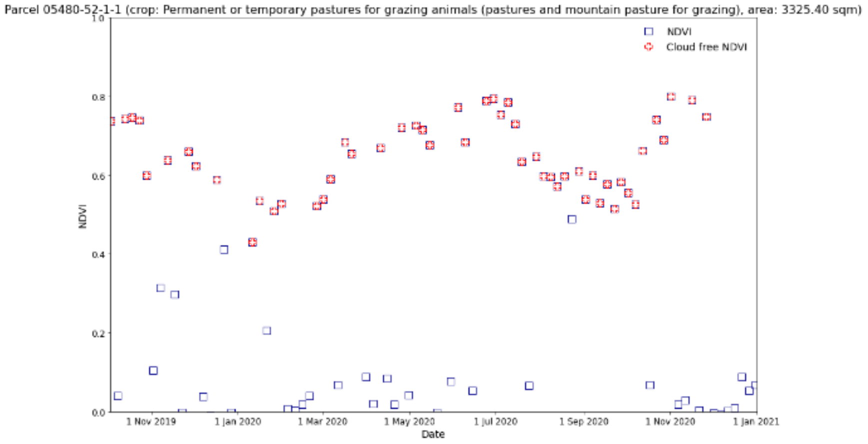
cap.users.creodias.eu/query/parcelTimeSeries?aoi=ms&year=2020&pid=1234&tstype=s2

Browser



Notebook

```
[2]: cbm.show.time_series.ndvi('ms', '2020', '12345')
```



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RESTful API updates

- Available data: information of the data that is available for the user in json format:
  - https://cap.users.creodias.eu/query/info
- Swagger/Flasgger an easy to use interface to get started with RESTful requests:
  - https://cap.users.creodias.eu/apidocs/
- parcelsByPolygon: returns a list of parcel within a given polygon
  - cap.users.creodias.eu/query/parcelsByPolygon?aoi=AA&year=2020&polygon=[polygon_coordinates]
- Fix sentinel images requests for selected parcel ID or location
  - https://cap.users.creodias.eu/query/rawChipByParcelID?aoi=MS&year=2020&pid=1234&start_date=2020-01-01&end_date=2020-01-30&band=B04&chipsize=920
  - https://cap.users.creodias.eu/query/rawChipByLocation?lon=5.123&lat=55.123&start_date=2020-01-01&end_date=2020-01-30&band=SCL&chipsize=920

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RESTful API available data

- https://cap.users.creodias.eu/query/info


```
{
    "server": {
        "title": "RESTful API for CbM.",
        "host": "https://cap.users.creodias.eu",
        "description": "Main development server for CbM",
        "license": "3-Clause BSD"
    },
    "aois": {
        "befl": {
            "dataset_types": [
                "c",
                "m"
            ],
            "years": [
                "2019",
                "2020"
            ],
            "ts_data": [
                "s2",
                "bs",
                "c6"
            ],
            "id_table_column": "parcel_id",
            "id_examples": [
                1261601602.0,
                1716403074.0,
                1698388659.0
            ],
            "request_examples": {
                "parcelById": "https://cap.users.creodias.eu/query/parcelById?aoi=befl&year=2020&pid=1698388659.0&ptype=c&withGeometry=True",
                "parcelTimeSeries_s2": "https://cap.users.creodias.eu/query/parcelTimeSeries?
aoi=befl&year=2020&pid=1698388659.0&ptype=c&tstype=s2&scl=True&ref=True",
                "parcelTimeSeries_bs": "https://cap.users.creodias.eu/query/parcelTimeSeries?aoi=befl&year=2020&pid=1698388659.0&ptype=c&tstype=bs",
                "parcelTimeSeries_c6": "https://cap.users.creodias.eu/query/parcelTimeSeries?aoi=befl&year=2020&pid=1698388659.0&ptype=c&tstype=c6",
                "backgroundByParcelId": "https://cap.users.creodias.eu/query/backgroundByParcelId?
aoi=befl&year=2020&pid=1698388659.0&ptype=c&chipsize=256&extend=512&iformat=png"
            }
        }
    }
}
```


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Swagger

Swagger Supported by SMARTBEAR

/apispec_1.json Explore

RESTful API for CbM. 0.0.2

[Base URL: /query]
/apispec_1.json

powered by Flasgger and CbM template

Terms of service

Background images

GET /backgroundByLocation Get background images for a parcel by location.

GET /backgroundByParcelID Get background images for a parcel by parcel ID.

Parcel information

GET /parcelByID Get parcel information by parcel ID.

GET /parcelByLocation Get parcel information by location.

Parcel Time Series

GET /parcelTimeSeries Get parcel signatures extraction time series by parcel ID.

Sentinel images

GET /rawChipByLocation Get sentinel images for a parcel by location.

GET /rawChipByParcelID Get sentinel images for a parcel by parcel ID.

POST /rawChipsBatch Get sentinel images for a parcel by location.

POST /rawS1ChipsBatch Get sentinel images for a parcel by location.

[Powered by Flasgger 0.9.5]

Swagger

Parcel Time Series

GET `/parcelTimeSeries` Get parcel signatures extraction time series by parcel ID.

Parameters Try it out

Name	Description
aoi * required *(query)*	Area of Interest (The member state or region code). aoi - Area of Interest (The member state or re
year * required *(query)*	The year of parcels dataset. year - The year of parcels dataset.
pid * required *(query)*	The parcel ID. pid - The parcel ID.
ptype *(query)*	Parcel type (use only in case there are separate parcel tables of the same year dedicated to different type of analyses or for different regions). ptype - Parcel type (use only in case there ar
tstype **string** *(query)*	s2:Sentinel-2 Level 2A, bs:S1 CARD Backscattering Coefficients, c6:S1 CARD 6-day Coherence, scl:Scene classification layer. *Available values* : s2, bs, c6, scl *Default value* : s2 s2
scl **string** *(query)*	Include scl in the s2 extraction, for use in cloud screening. *Available values* : True, False *Default value* : True True
ref **string** *(query)*	Include Sentinel image reference in time series. *Available values* : True, False *Default value* : False False

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Most common mistakes

- Wrong credentials - host
  - Use the credentials that are send to you, username format “ms_name” e.g.: **ie_john**

Your user account for the development outreach RESTful API server has the following credentials:
Username: ms_username
Password: PASSWORD
Host: https://cap.users.creodias.eu/

https

- Missing parameter
  - Some of the parameters are mandatory see:
    - **https://cap.users.creodias.eu/apidocs**
    - **Data_access_information.pdf**
    - **https://jrc-cbm.readthedocs.io**

- Wrong parameters data
  - To see the type of the parameter see:
    - **https://cap.users.creodias.eu/query/info**

Usage statistics

User activity (total 16):

- 3 - active users
- 5 - occasionally connected
- 8 - non active users

4 - downloaded the example files

Endpoint	Today	Last 7 days	Overall	Last requested
parcelTimeSeries_query	26 [2]	6,675 [12]	48,341	10 minutes ago
parcelById_query	9	4,268 [3]	14,494	27 minutes ago
rawChipByLocation_query	0	70 [1]	558	13 hours ago
rawS1ChipsBatch_query	0	0	240	1 week ago
rawChipsBatch_query	2	46	199	5 hours ago
backgroundByID_query	1	1	78	1 hour ago
download_files	0	19 [17]	53	21 hours ago
backgroundByLocation_query	0	1	43	3 weeks ago

CbM git repository https://github.com/ec-jrc/cbm

- Files to create a RESTful API for cbm with Flask
- cbm python package at Python Package Index (PyPI)
  - pypi.org/project/cbm Installable with: `pip install cbm`
- Docker images source files.
  - Available on Dockerhub: hub.docker.com/u/gtcap
- Documentation source files.
  - Can be viewed at: jrc-cbm.readthedocs.io
- Jupyter Notebook examples
- Python code packages for (scripts):
  - Signatures extraction
  - Calendar generation
  - Signal marker processing

Technical issues page on github https://github.com/ec-jrc/cbm/issues

Q&A

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Signals and Signal Processing
Part I

Outreach Training

JRC D5 – GTCAP Team

19 Nov 2021

Agenda

09:30 - 09:35	**Welcome**
09:35 - 10:20	**Translating practice to signal behaviour**
10:20 - 10:40	**RESTful data access - refresh and updates**
10:40 – 11:25	**Signals and Signal Processing - Part I**
11:25 - 11:40	**Break**
11:40 - 11:55	**Signal and Signal Processing - Part II**
11:55 - 12:25	**Mowing Marker Detection**
12:25- 13:00	**Q&A, discussion**

Outline

- Outreach data and signals
- Overall processing architecture
- Introduction to the signal and marker processing notebook
- Preliminary operations: SCL and cloud masking
- Index computation

Outreach Time Series (Recap.)

- Outreach database providing both S1 and S2 time series for a **specific parcel** through **RESTful API**
  See pervious training ("Parcel time series processing from RESTful" presentation)

- Data directly imported into a data frame (get_time_series.py, available at (https://github.com/ec-jrc/cbm/tree/main/ipynb/get_and_display_graphs_from_restful)

- Data aggregated at the parcel level: **spatial dimension summarized by statistics**

- Six Sentinel 2 bands: RGB (B02, B03, B04), Vegetation Red Edge (B05), NIR (B08) and SWIR (B11) + SCL Histogram

- Sentinel 1 backscattering (BS)

- Sentinel 1 coherence (COH)

Sentinel 2 Time Series (Recap.)

date

Summary statistics: mean, std, min, p25, p50 (median), p75 and max

date_part	band	count	mean	std	min	p25	p50	p75	max	hist	reference
1.50832e+09	B08	1501	4197.11	232.069	2932	4056	4240	4356	4600	{'8': 11, '10': 363}	S2B_MSIL2A_20171018T105029_N0213_R051_T3
1.50832e+09	B11	374	2358.32	88.5482	2153	2319.25	2359	2411.5	2706	{'8': 11, '10': 363}	S2B_MSIL2A_20171018T105029_N0213_R051_T3
1.5085e+09	B02	1496	287.156	45.5943	137	253	280	325	466	{'4': 374}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B02	1501	288.348	44.3535	135	254	281	327	422	{'2': 1, '4': 370, '7': 3}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B03	1501	664.264	81.3611	338	604	658	735	865	{'2': 1, '4': 370, '7': 3}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B03	1496	669.844	77.3804	346	607	666.5	739	858	{'4': 374}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B04	1501	323.527	76.6127	150	257	298	388	576	{'2': 1, '4': 370, '7': 3}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B04	1496	323.457	76.4696	151	258	298	390	571	{'4': 374}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B05	374	1158.14	118.699	913	1056.25	1159	1267.75	1418	{'4': 374}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B05	374	1127.14	152.37	472	1035	1124	1261.75	1377	{'2': 1, '4': 370, '7': 3}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B08	1496	4240.06	387.576	1782	4046	4332	4532	4964	{'4': 374}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B08	1501	4184.81	538.329	837	3974	4328	4540	4920	{'2': 1, '4': 370, '7': 3}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B11	374	2044.97	120.162	1485	1944	2090	2133.75	2253	{'4': 374}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.5085e+09	B11	374	2002.5	189.706	916	1908	2054	2130	2242	{'2': 1, '4': 370, '7': 3}	S2A_MSIL2A_20171020T104051_N0213_R008_T3
1.50936e+09	B02	1496	228.511	40.5748	113	198	225	256	386	{'4': 374}	S2A_MSIL2A_20171030T104151_N0213_R008_T3

Band ID

pixel count

SCL histogram: very important for **cloud masking**

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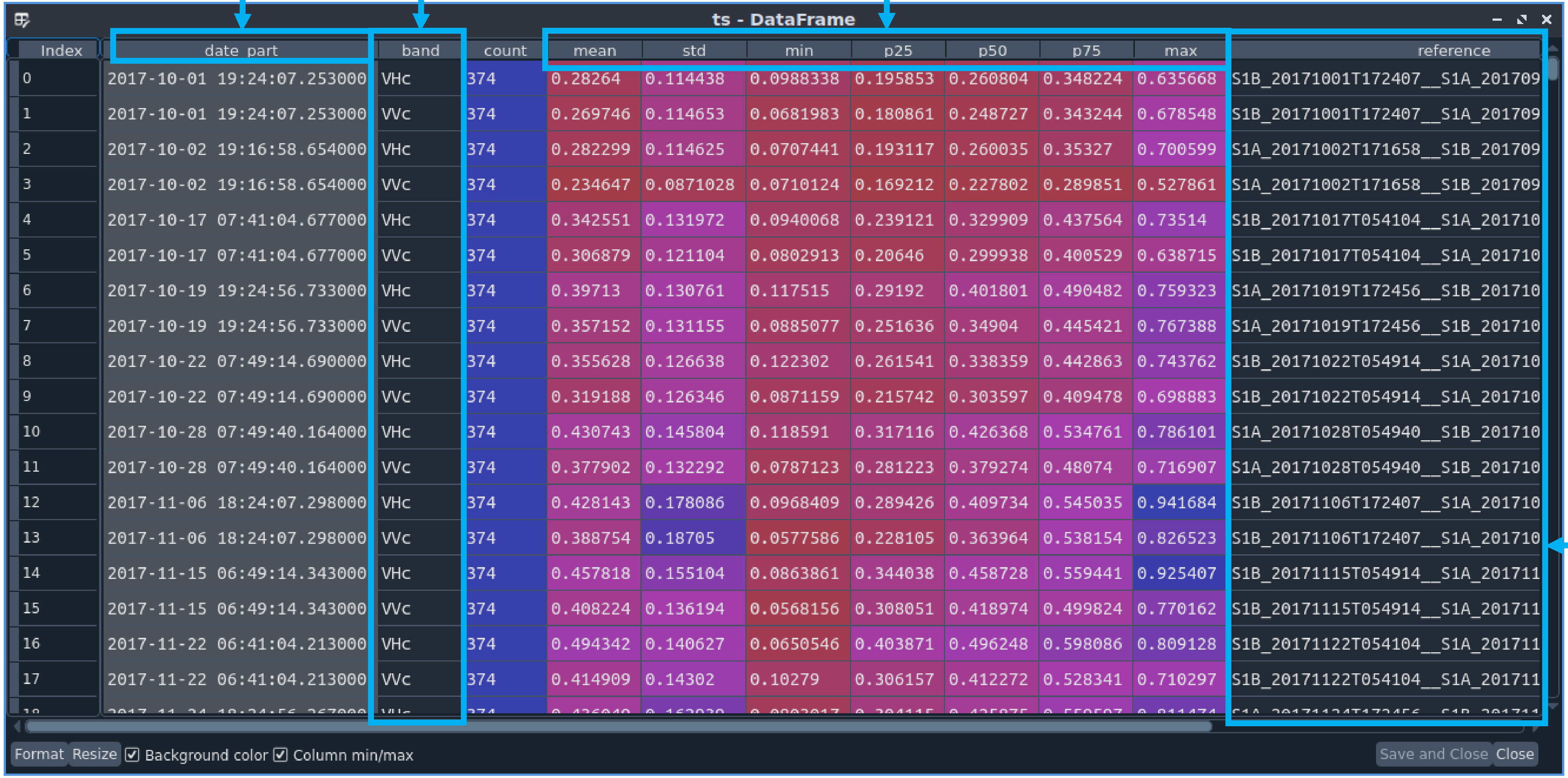
Sentinel 1 Time Series (Recap.)

date

polarization

Summary statistics: mean, std, min, p25, p50 (median), p75 and max

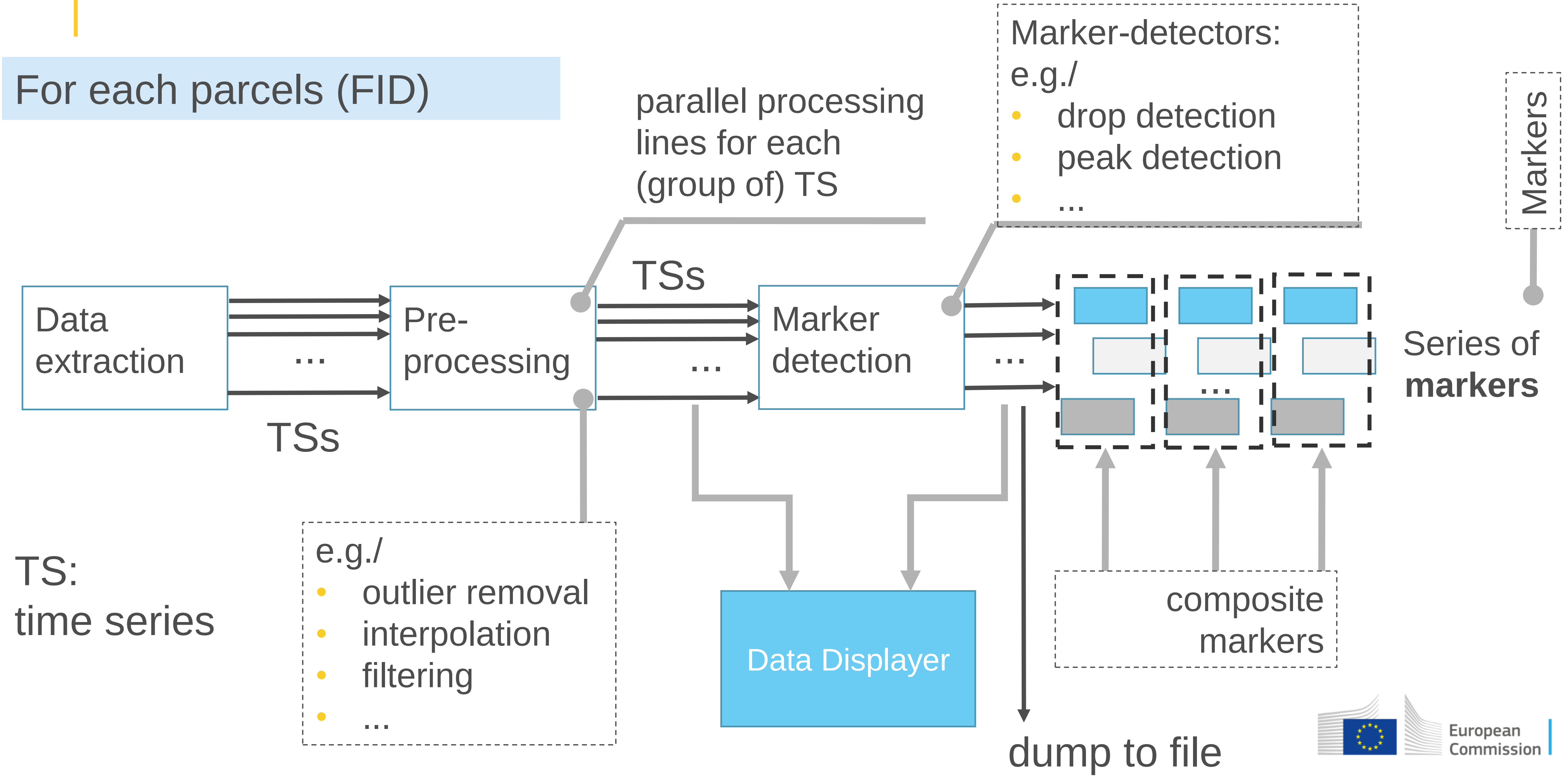


Index	date_part	band	count	mean	std	min	p25	p50	p75	max	reference
0	2017-10-01 19:24:07.253000	VHc	374	0.28264	0.114438	0.0988338	0.195853	0.260804	0.348224	0.635668	S1B_20171001T172407__S1A_201709
1	2017-10-01 19:24:07.253000	VVc	374	0.269746	0.114653	0.0681983	0.180861	0.248727	0.343244	0.678548	S1B_20171001T172407__S1A_201709
2	2017-10-02 19:16:58.654000	VHc	374	0.282299	0.114625	0.0707441	0.193117	0.260035	0.35327	0.700599	S1A_20171002T171658__S1B_201709
3	2017-10-02 19:16:58.654000	VVc	374	0.234647	0.0871028	0.0710124	0.169212	0.227802	0.289851	0.527861	S1A_20171002T171658__S1B_201709
4	2017-10-17 07:41:04.677000	VHc	374	0.342551	0.131972	0.0940068	0.239121	0.329909	0.437564	0.73514	S1B_20171017T054104__S1A_201710
5	2017-10-17 07:41:04.677000	VVc	374	0.306879	0.121104	0.0802913	0.20646	0.299938	0.400529	0.638715	S1B_20171017T054104__S1A_201710
6	2017-10-19 19:24:56.733000	VHc	374	0.39713	0.130761	0.117515	0.29192	0.401801	0.490482	0.759323	S1A_20171019T172456__S1B_201710
7	2017-10-19 19:24:56.733000	VVc	374	0.357152	0.131155	0.0885077	0.251636	0.34904	0.445421	0.767388	S1A_20171019T172456__S1B_201710
8	2017-10-22 07:49:14.690000	VHc	374	0.355628	0.126638	0.122302	0.261541	0.338359	0.442863	0.743762	S1B_20171022T054914__S1A_201710
9	2017-10-22 07:49:14.690000	VVc	374	0.319188	0.126346	0.0871159	0.215742	0.303597	0.409478	0.698883	S1B_20171022T054914__S1A_201710
10	2017-10-28 07:49:40.164000	VHc	374	0.430743	0.145804	0.118591	0.317116	0.426368	0.534761	0.786101	S1A_20171028T054940__S1B_201710
11	2017-10-28 07:49:40.164000	VVc	374	0.377902	0.132292	0.0787123	0.281223	0.379274	0.48074	0.716907	S1A_20171028T054940__S1B_201710
12	2017-11-06 18:24:07.298000	VHc	374	0.428143	0.178086	0.0968409	0.289426	0.409734	0.545035	0.941684	S1B_20171106T172407__S1A_201710
13	2017-11-06 18:24:07.298000	VVc	374	0.388754	0.18705	0.0577586	0.228105	0.363964	0.538154	0.826523	S1B_20171106T172407__S1A_201710
14	2017-11-15 06:49:14.343000	VHc	374	0.457818	0.155104	0.0863861	0.344038	0.458728	0.559441	0.925407	S1B_20171115T054914__S1A_201711
15	2017-11-15 06:49:14.343000	VVc	374	0.408224	0.136194	0.0568156	0.308051	0.418974	0.499824	0.770162	S1B_20171115T054914__S1A_201711
16	2017-11-22 06:41:04.213000	VHc	374	0.494342	0.140627	0.0650546	0.403871	0.496248	0.598086	0.809128	S1B_20171122T054104__S1A_201711
17	2017-11-22 06:41:04.213000	VVc	374	0.414909	0.14302	0.10279	0.306157	0.412272	0.528341	0.710297	S1B_20171122T054104__S1A_201711

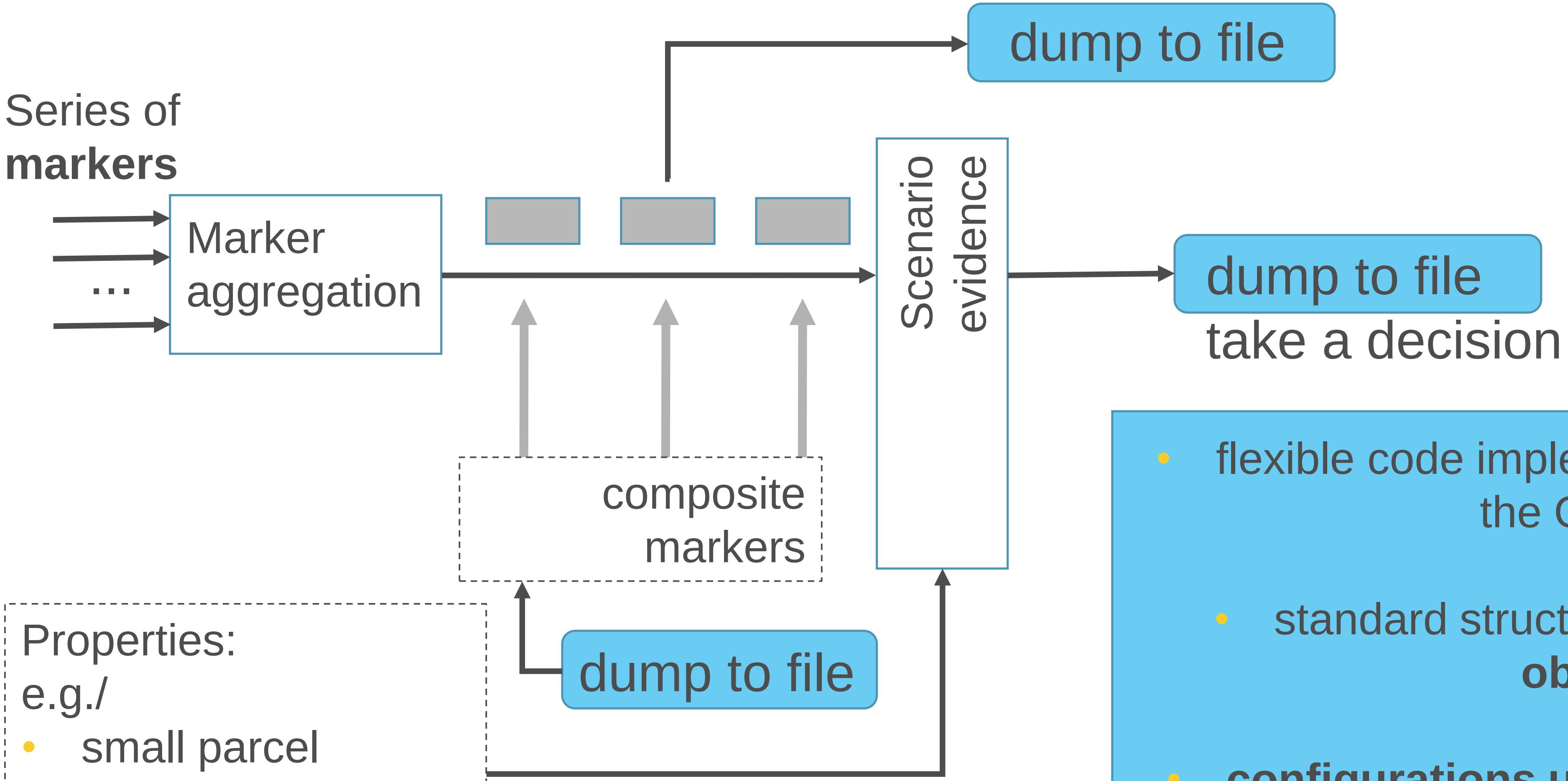
Similar data arrangement for COH and BS

Reference information

Overall Processing Chain (I/II)



Overall Processing Chain (II/II)

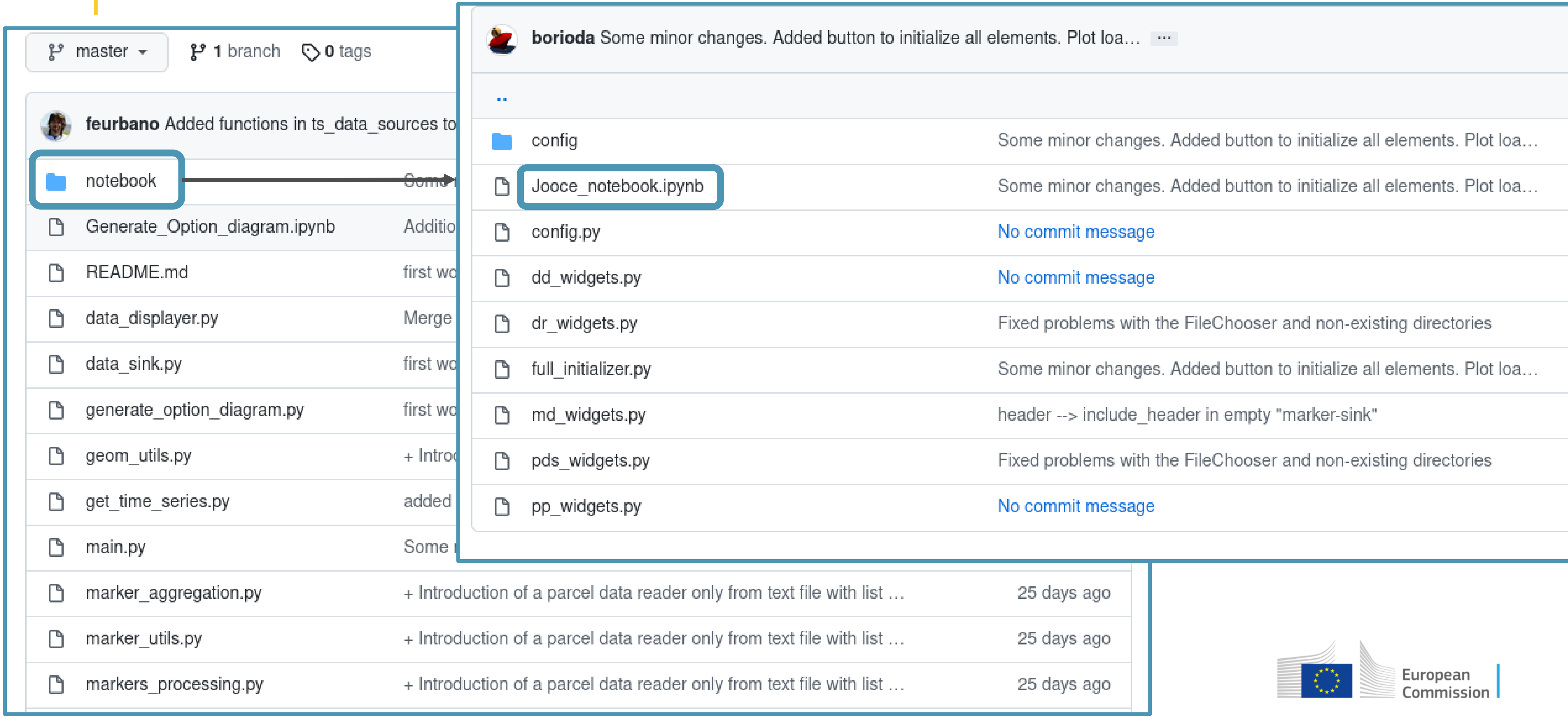


Properties:
e.g./
- small parcel
- low nb. S2 pixels
- NDVI data missing
- NDVI flat profile

- flexible code implemented using the OOP paradigm
- standard structures based on **object factories**
- **configurations using external option file**

Get the Code

https://github.com/ec-jrc/cbm/scripts/signal_marker_processing/



First Steps with the JRC Marker Processing Code

option file

simplified generation with a dedicated jupyter notebook

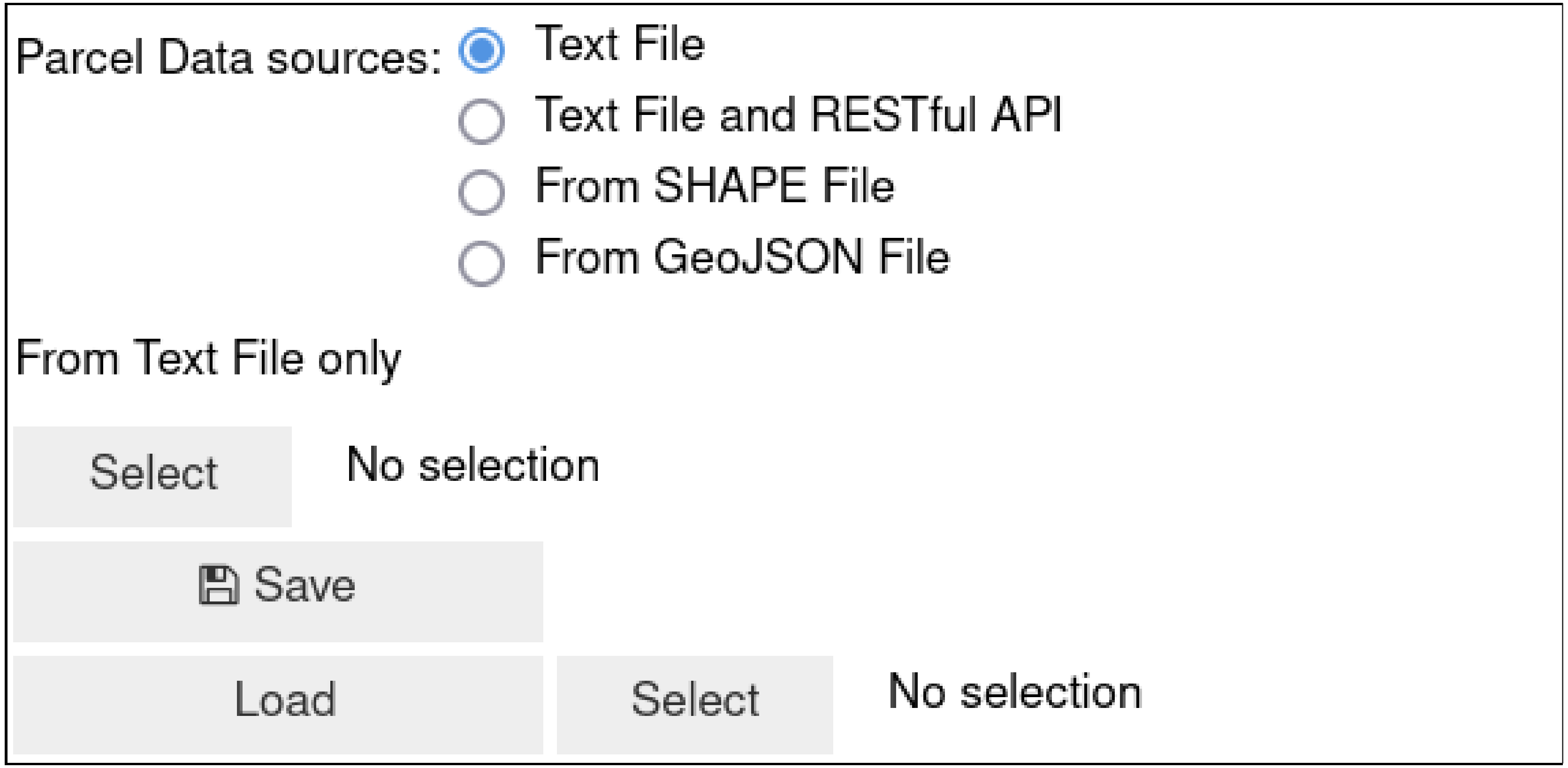
initialization of all code elements

main code
processing of the full parcel population

```
▼ root:
  ▶ parcelSource:
  ▶ dataReaders: [] 2 items
  ▶ pre-processors: [] 4 items
  ▶ marker-detectors: [] 4 items
  ▶ marker-aggregator: [] 3 items
  ▶ data-displayer:
  ▶ marker-sink: [] 2 items
  ▶ scenario-evidence:
```

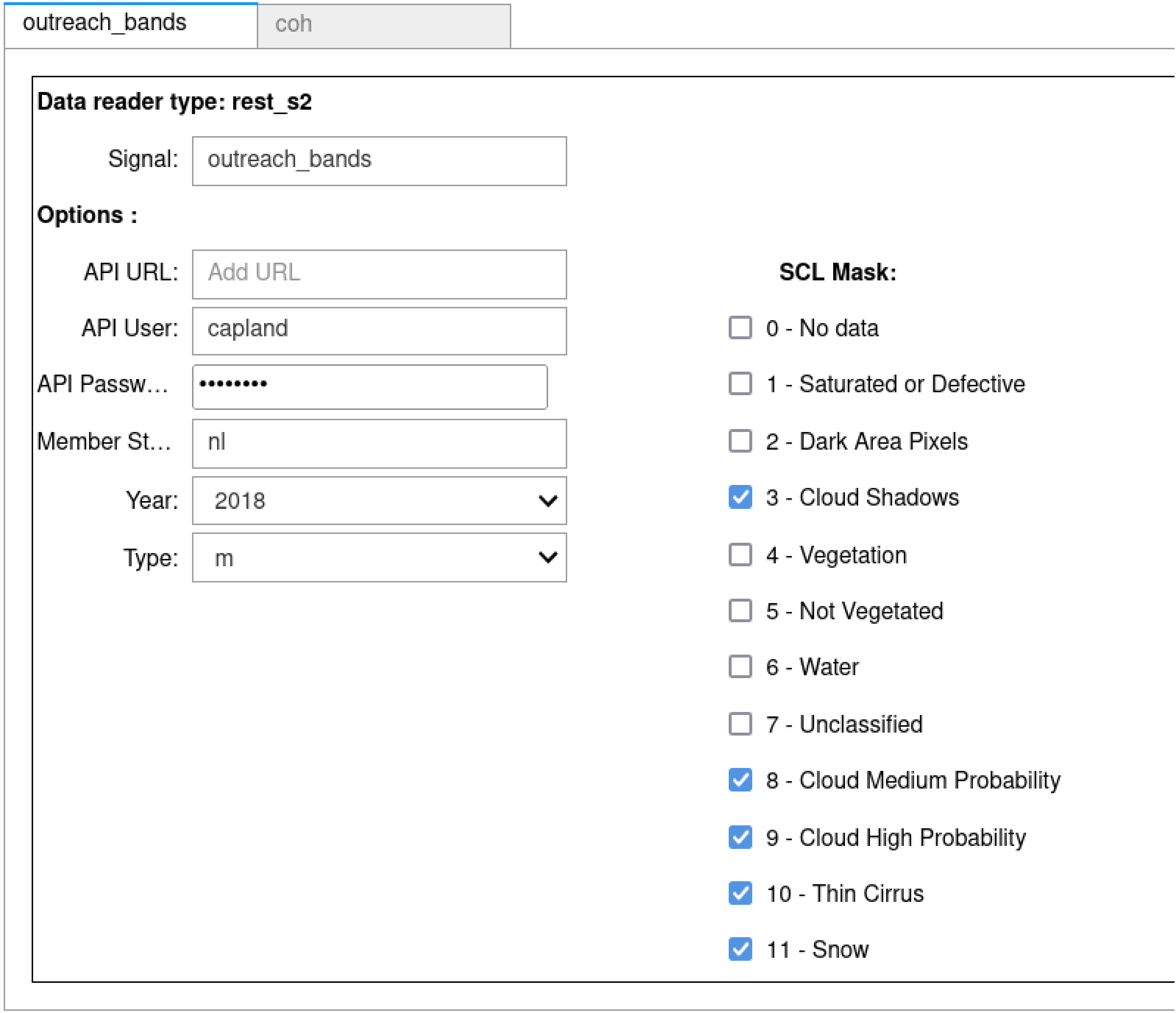
Step 1: Parcel Data Sources

- Select the list of parcels to process: several options available



Step 2: Time Series Sources

- Instruct the code on how **retrieve the time series** (S1 and S2) for the different parcels
- **Several options (including RestFul API)**
- Preliminary operations to **reshape** the retrieved data **(synchronous components)**



Output Signals and Components

components

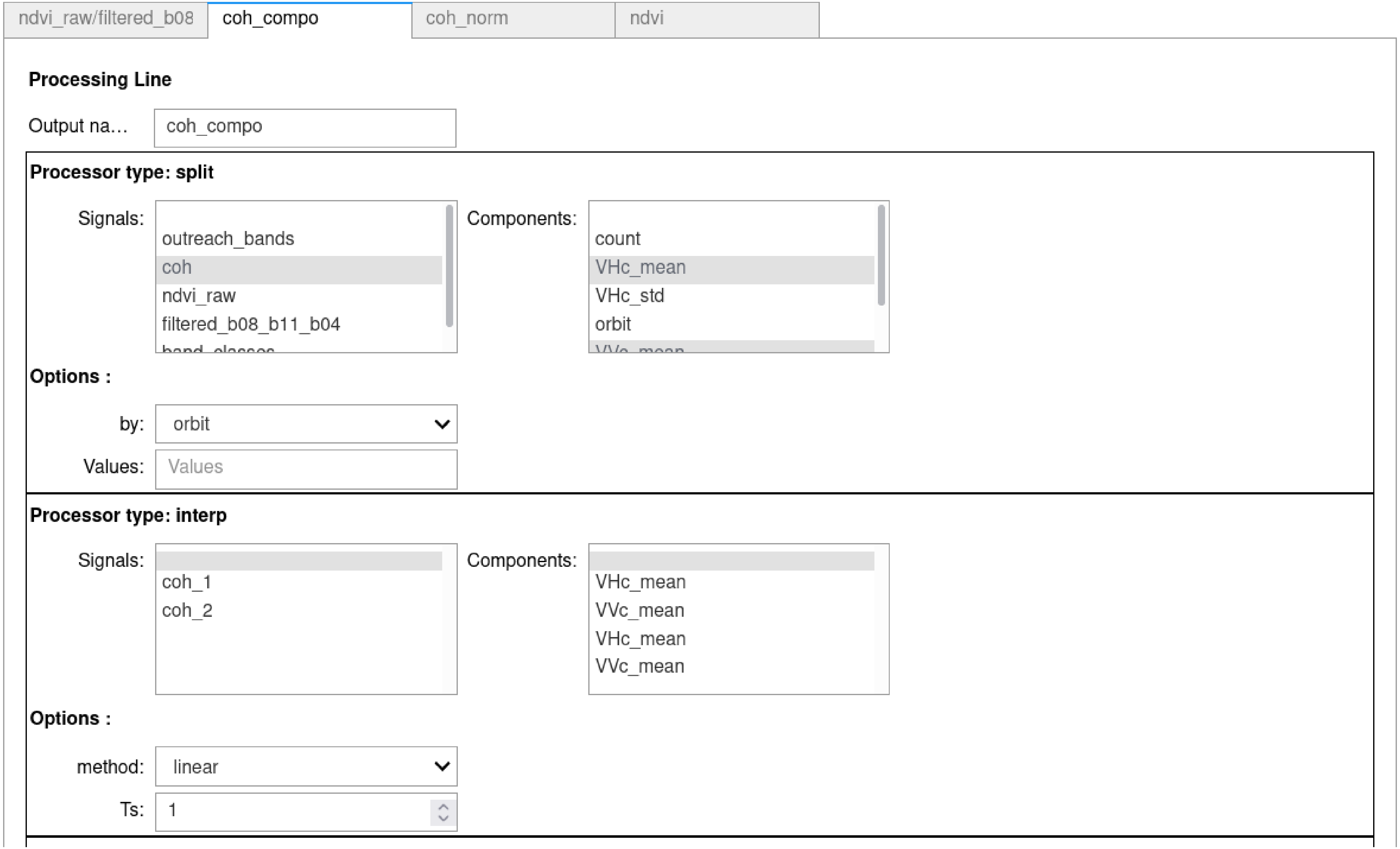
date!

outreach_bands - DataFrame

date part	302 mear	B02 std	cloud pct	303 mear	B03 std	304 mear	B04 std	305 mear	B05 std	308 mear	B08 std	311 mear	B11 std	tm numbe
2019-10-03 12:50:31.024000	1947.46	448.136	100	2067.36	391.736	1873.27	388.374	2431.73	384.98	4093.37	264.185	2685.23	241.641	31
2019-10-05 12:40:29.024000	8246.43	456.923	100	7820.83	431.755	7461.76	406.651	7508.54	434.509	7424.2	402.686	4897.25	383.413	31
2019-10-08 12:50:29.024000	6792.73	143.305	100	6821.37	143.425	6748.53	141.039	6808.16	148.578	6740.07	131.865	3545.14	178.569	31
2019-10-10 12:40:31.024000	1343.91	1394.56	15.2174	1600.17	1275.64	1449.67	1237.06	2066.3	1121.08	4103.01	1012.67	2956.64	781.535	31
2019-10-13 12:50:31.024000	343.842	48.2673	0	692.251	70.17	601.607	86.0658	1210.12	91.0568	2920.76	241.013	2398.05	165.123	31
2019-10-15 12:40:29.024000	8480.47	58.4238	100	8181.25	51.3594	7953.38	43.8425	8150.35	34.18	8096.02	50.5254	1969.8	16.1301	31
2019-10-18 12:50:39.024000	5857.2	131.55	100	5431.53	222.416	5230.79	334.936	5602.83	396.111	5140.35	157.204	1557.68	230.027	31
2019-10-20 12:40:51.024000	11911.3	74.774	100	11617.8	66.8158	11268.3	70.2642	11824.8	66.5597	11625.3	67.5196	3762.41	41.8086	31
2019-10-23 12:51:11.024000	1212.38	34.7258	100	1426.63	39.0673	1266.37	47.8843	1792.32	56.8394	3239.45	152.954	2229.12	84.8739	31
2019-10-25 12:40:29.024000	10600.4	773.644	100	9659.92	744.833	8875.15	737.395	9108.47	796.313	8313.73	716.553	5238.92	734.859	31
2019-10-28 11:50:49.024000	142.15	30.1965	96.7391	251.93	41.5468	214.315	31.1006	408.728	42.1762	1093.89	108.498	578.228	61.691	31
2019-10-30 11:41:51.024000	6002.97	175.381	100	5915.33	144.459	5679.52	108.183	5870.45	84.8652	6712.5	137.667	3558.98	41.6066	31
2019-11-02 11:52:11.024000	10596.5	120.756	100	9829.16	107.021	9338.89	114.464	9508.36	124.087	9250.37	107.165	2170.39	54.2452	31
2019-11-04 11:41:19.024000	363.187	78.9823	6.5217	294.08	63.6354	182.449	47.3816	252.598	48.9279	470.401	107.956	146.75	40.3872	31
2019-11-07 11:51:39.025000	6838.86	786.705	100	6513.02	758.943	6312.7	728.163	6358.27	678.625	6301.69	780.124	2842.7	643.454	31
2019-11-09 11:42:51.024000	5151.12	365.346	100	4464.55	350.202	4062.2	346.43	4080.51	344.092	3824.8	358.468	2201.05	258.937	31
2019-11-12 11:53:01.024000	6301.07	565.946	100	6238.35	562.44	6353.72	595.443	6604.45	581.406	6679.97	636.955	2413.95	192.478	31
2019-11-14 11:42:09.024000	7078.37	197.871	100	6668	217.276	6545.26	258.154	6579	300.326	6311.58	191.911	3106.01	262.358	31
2019-11-17 11:52:29.024000	3507.27	54.4407	100	3300.4	51.4857	3133.26	41.619	3556.62	48.7317	4419.34	69.406	2106.91	27.5119	31

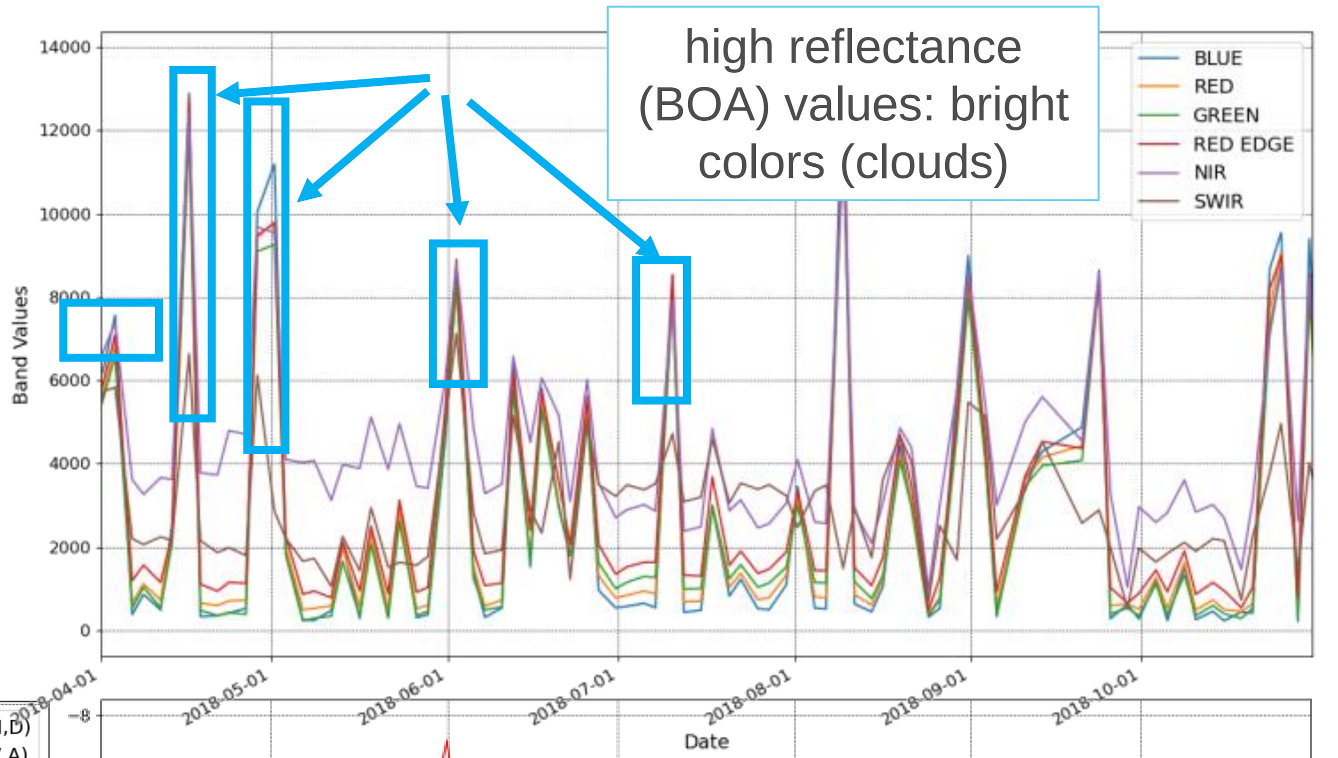
Format Resize ☑ Background color ☑ Column min/max Save and Close Close

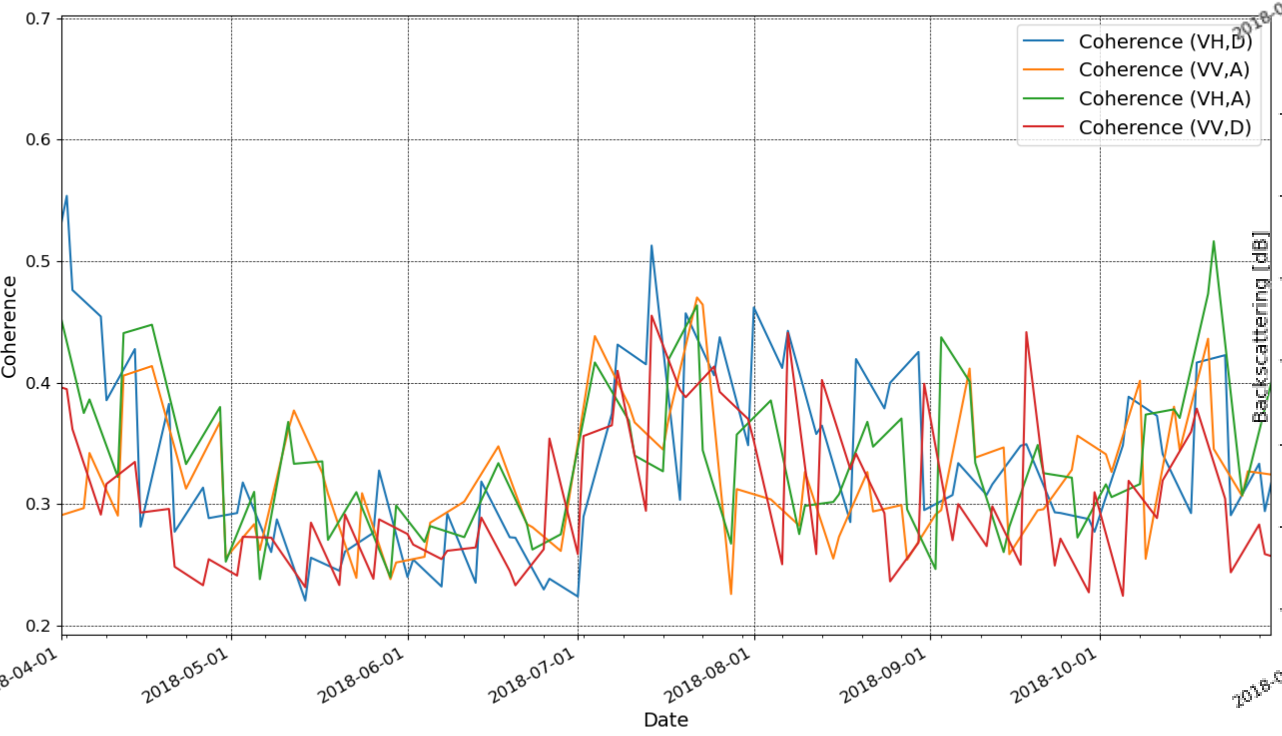
Time-Series Pre-processing

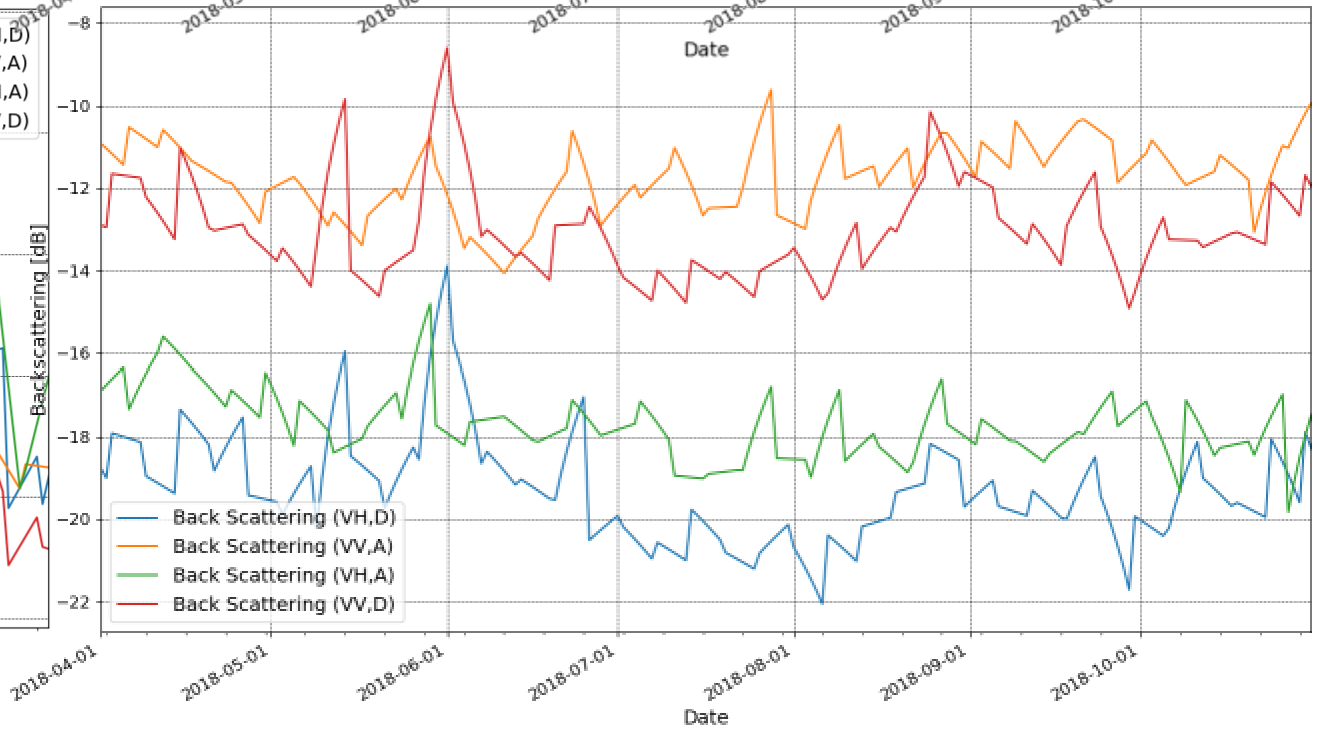


From Tables to Plots

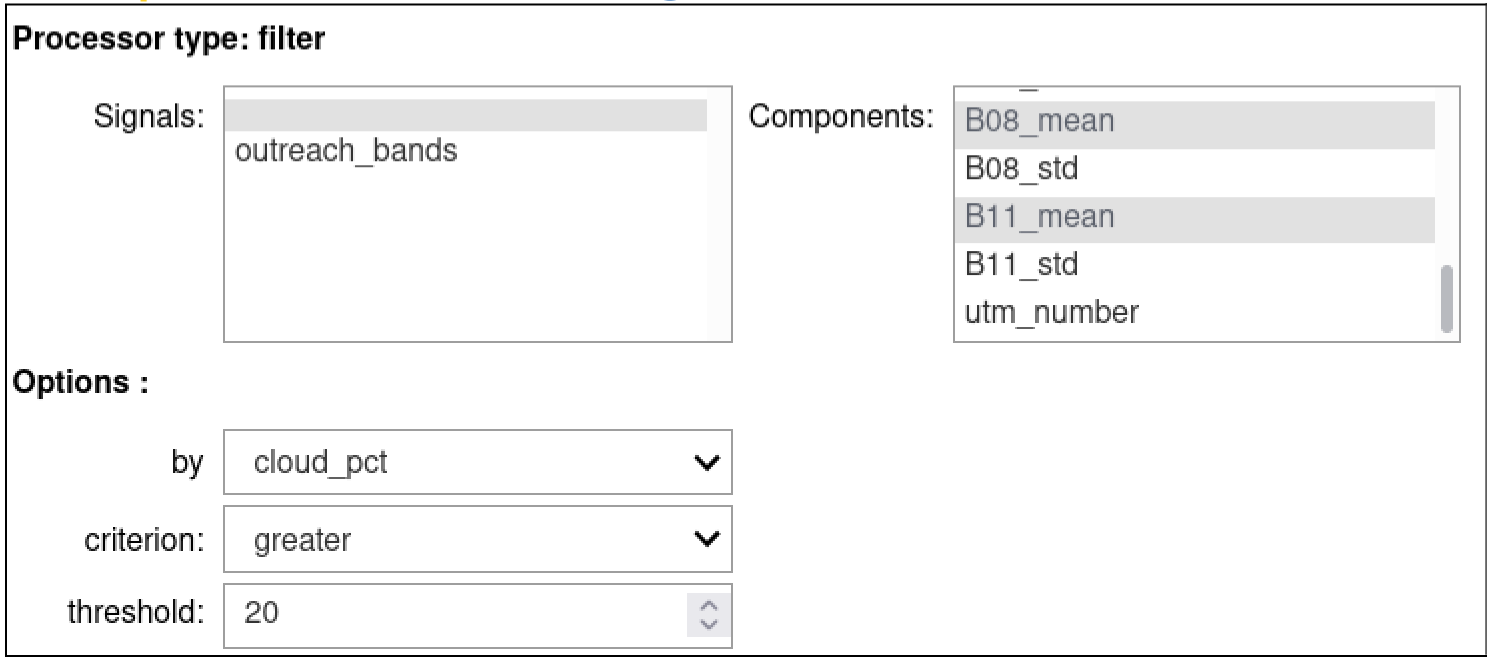
- S2 time series: highly correlated
- Cloud masking/filtering essential
- BS: low variations expected during mowing
- COH: noisy







SCL Histogram and Cloud Masking


Processor type: filter

Signals: outreach_bands

Components: B08_mean, B08_std, B11_mean, B11_std, utm_number

Options :

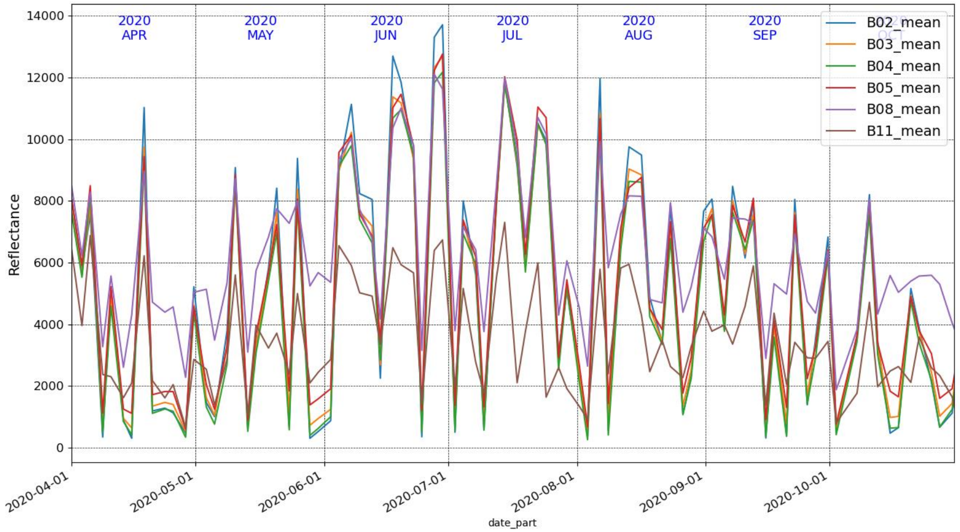
by: cloud_pct

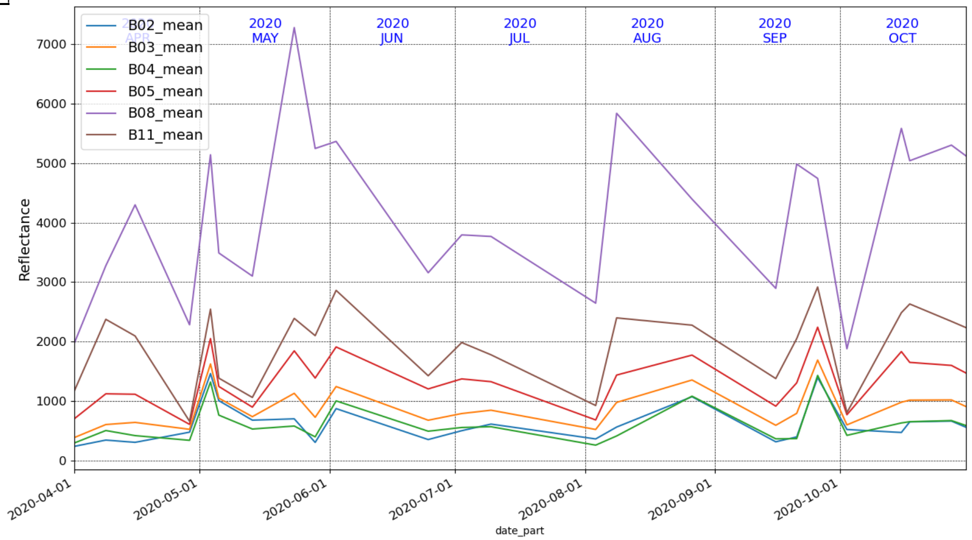
criterion: greater

threshold: 20

Possibility to remove cloudy observations based on a **cloud percentage** computed using the **SCL layer** and the categories selected when configuring the **restful S2 time series source**

Sample parcel from Ireland 2020

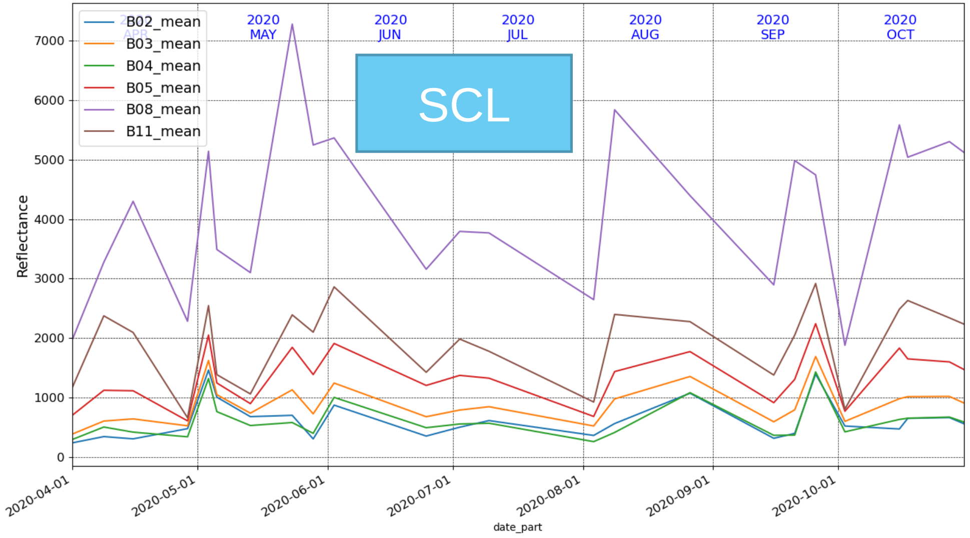


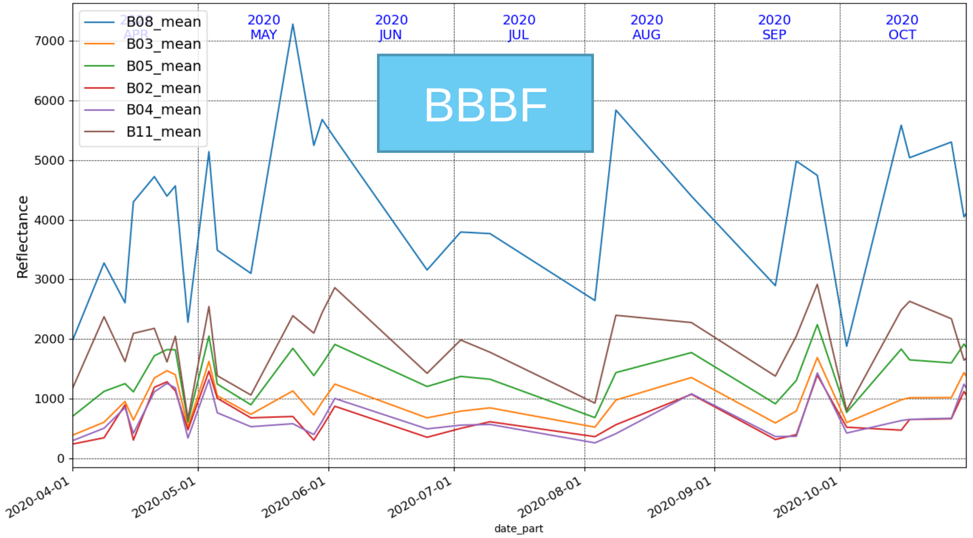


Blue Band Based Filtering

- SCL cloud masking **could be insufficient** (residual measurements corrupted by clouds, shadows and other artefacts)
- **Several approaches available** in the literature for further filtering observations:

can be easily implemented in the framework proposed



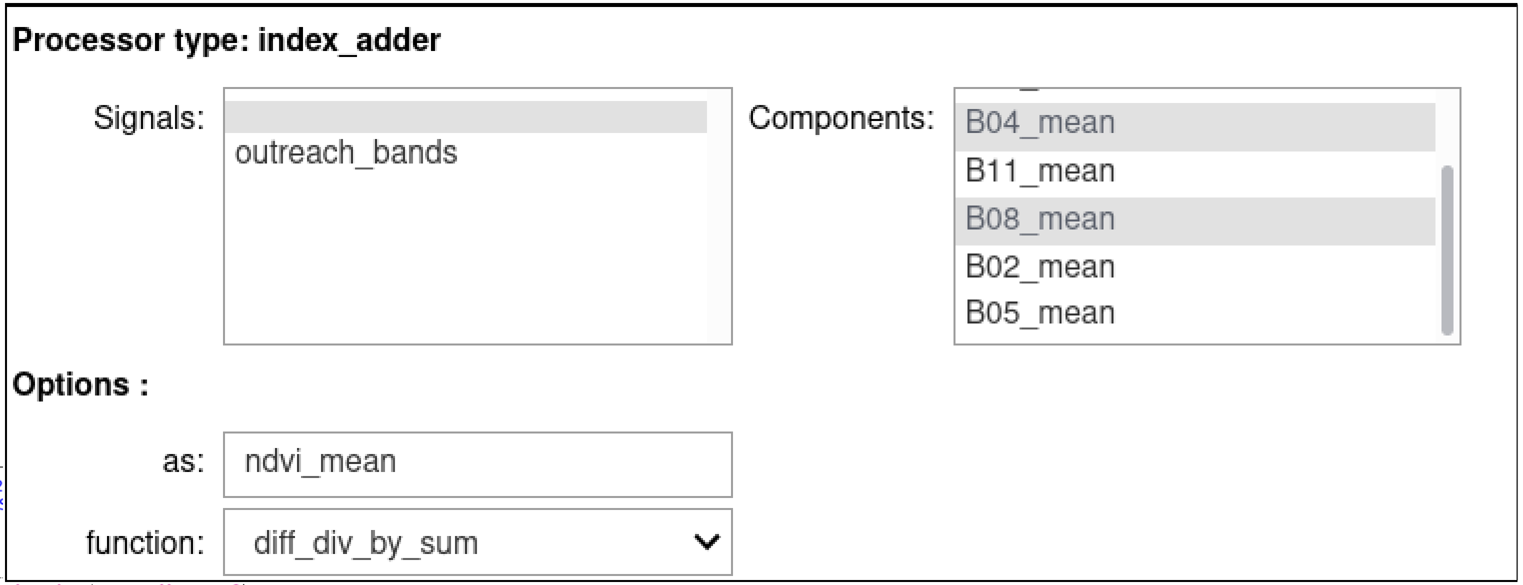


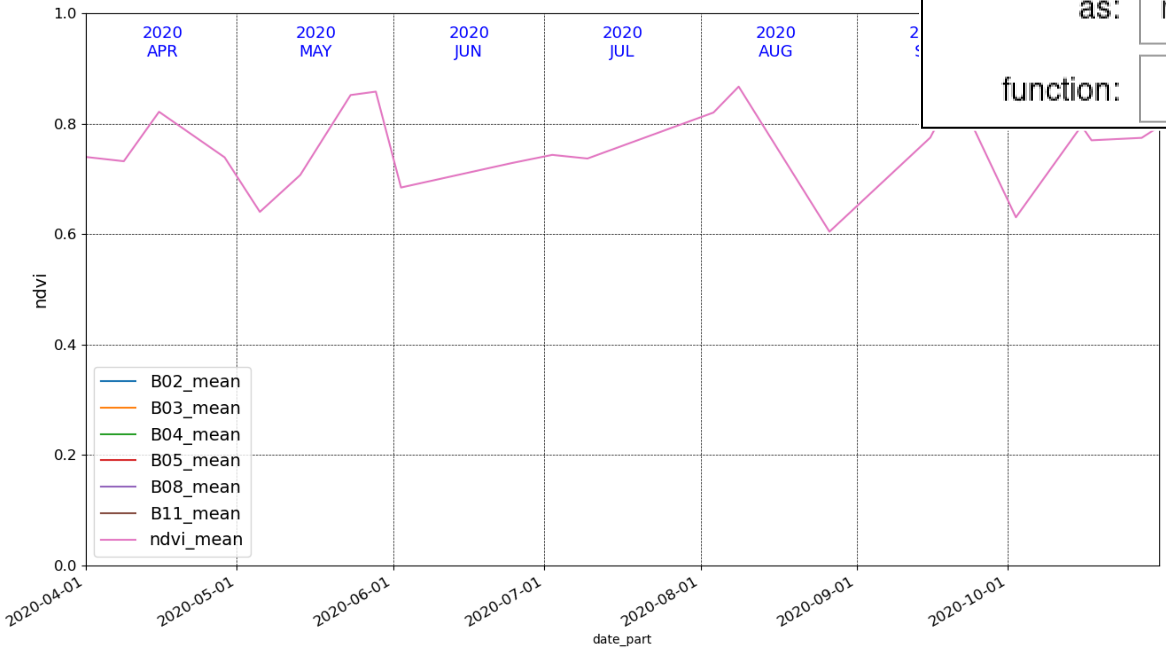
Blue Band Based Filtering: remove observations for which B02 > 1500

Kolecka et al. "**Regional Scale Mapping of Grassland Mowing Frequency with Sentinel-2 Time Series**", Remote Sensing 2018

Index Computation

Dedicated pre-processor for the computation of indexes from the individual band values





Pre-processors can be concatenated in a flexible way

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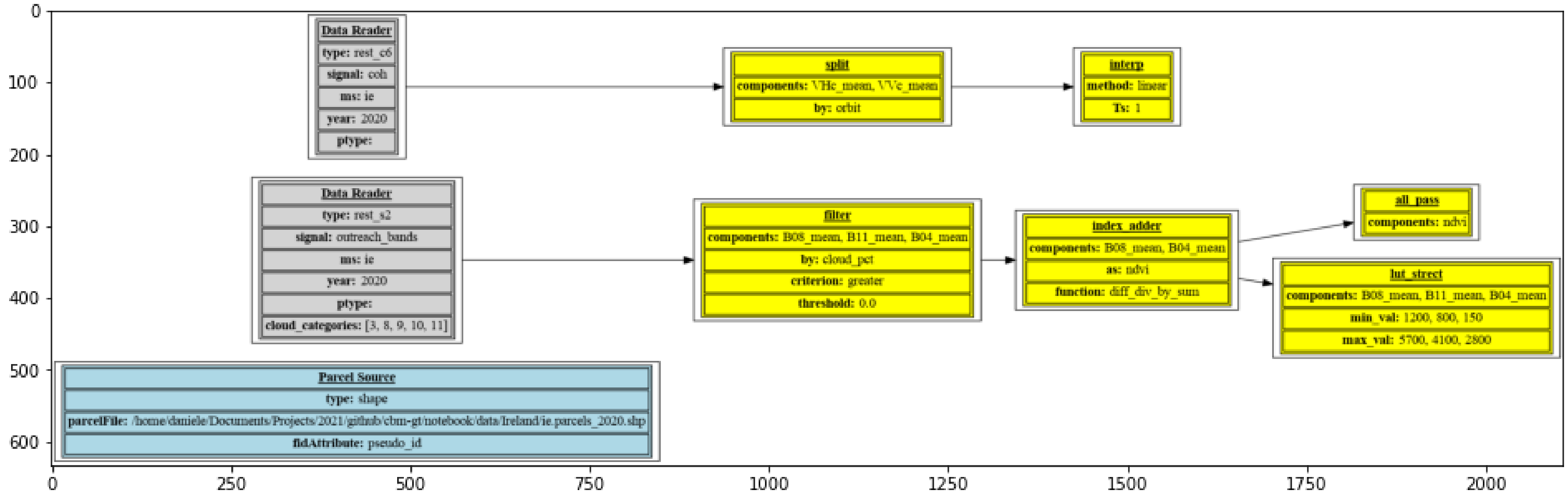
Summary

- Introduction to the general processing framework for time series and marker processing
- Preliminary operations on the time series before marker detection
- A few steps toward mowing detection

All the processing introduced: can be visualized as a **processing diagram**



Significant effort invested in **flexibility:**

allow MS to play with the configurations and determine the best **processing option** for their **local conditions**

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Q&A

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Signals and Signal Processing Part II

Outreach Training

JRC D5 – GTCAP Team

19 Nov 2021

Agenda

09:30 - 09:35	**Welcome**
09:35 - 10:20	**Translating practice to signal behaviour**
10:20 - 10:40	**RESTful data access - refresh and updates**
10:40 – 11:25	**Signals and Signal Processing - Part I**
11:25 - 11:40	**Break**
11:40 - 11:55	**Signal and Signal Processing - Part II**
11:55 - 12:25	**Mowing Marker Detection**
12:25- 13:00	**Q&A, discussion**

Outline

Final steps before marker detection

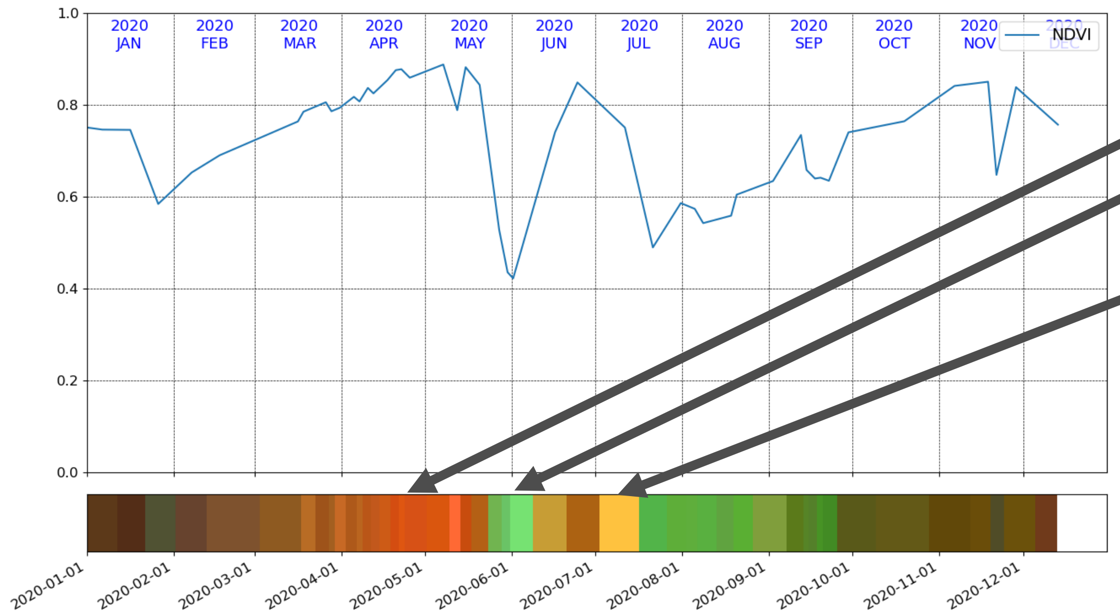
- NIR, SWIR and RED processing
- Signal resampling and interpolation
- Signal Smoothing
- Signal Combining

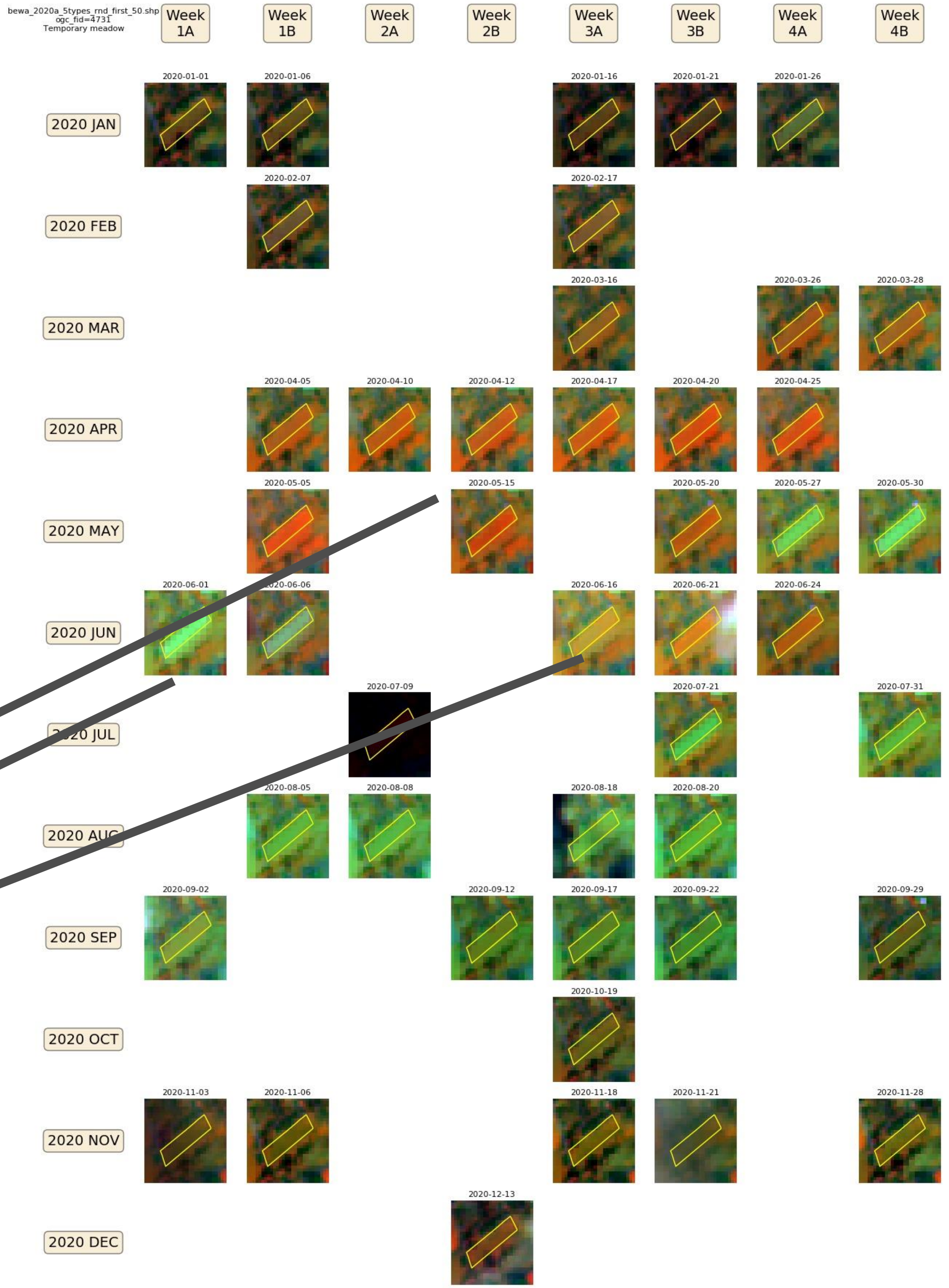
NIR, SWIR, RED False Color Composite

More information can be obtained (wrt to NDVI alone) by considering invidual bands

Compress the imagettes information in a **color bar**: **each point = “average” imagette color**

A **human interperter** can associate a **grassland state** to each color ⟶ potential for **classification approaches**





Magic LUT Stretching and Classification

False color composite of NIR, SWIR and RED: more details in pervious training on "Parcel time series processing from RESTful"

Stretching using an optimized LUT of these three band components

Same examples:

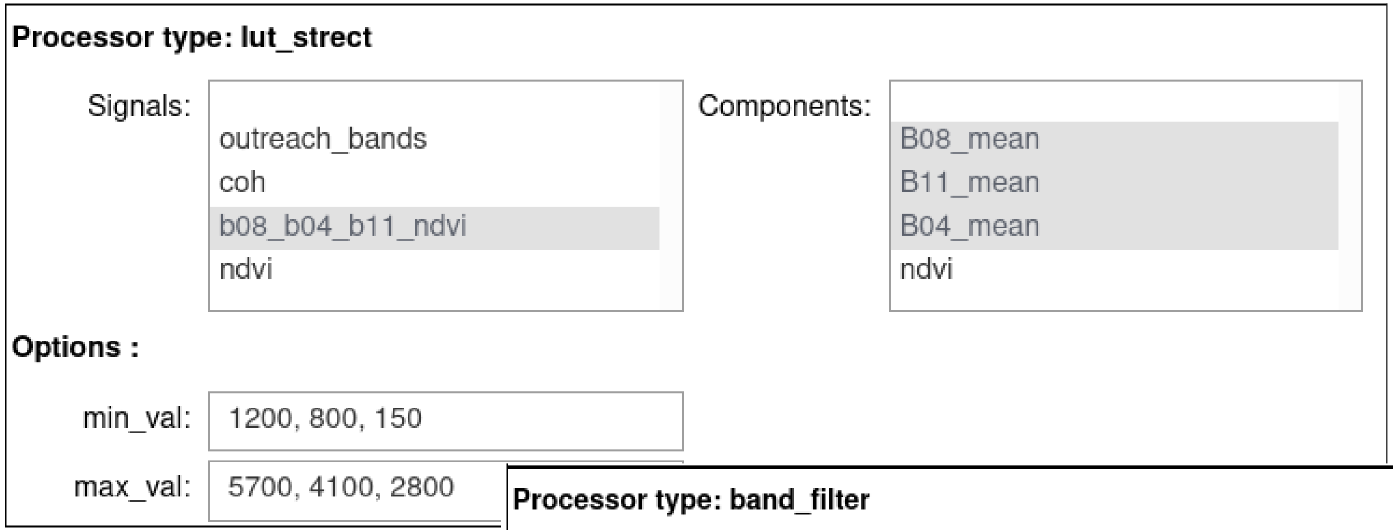
maintained/mowed/grazed

vegetated

shadowed invalid

Information from the NIR, SWIR, RED color band can be used to **further filter invalid observations** and to **confirm** for example that an **NDVI drop** corresponds to a real mowing event

In the Notebook

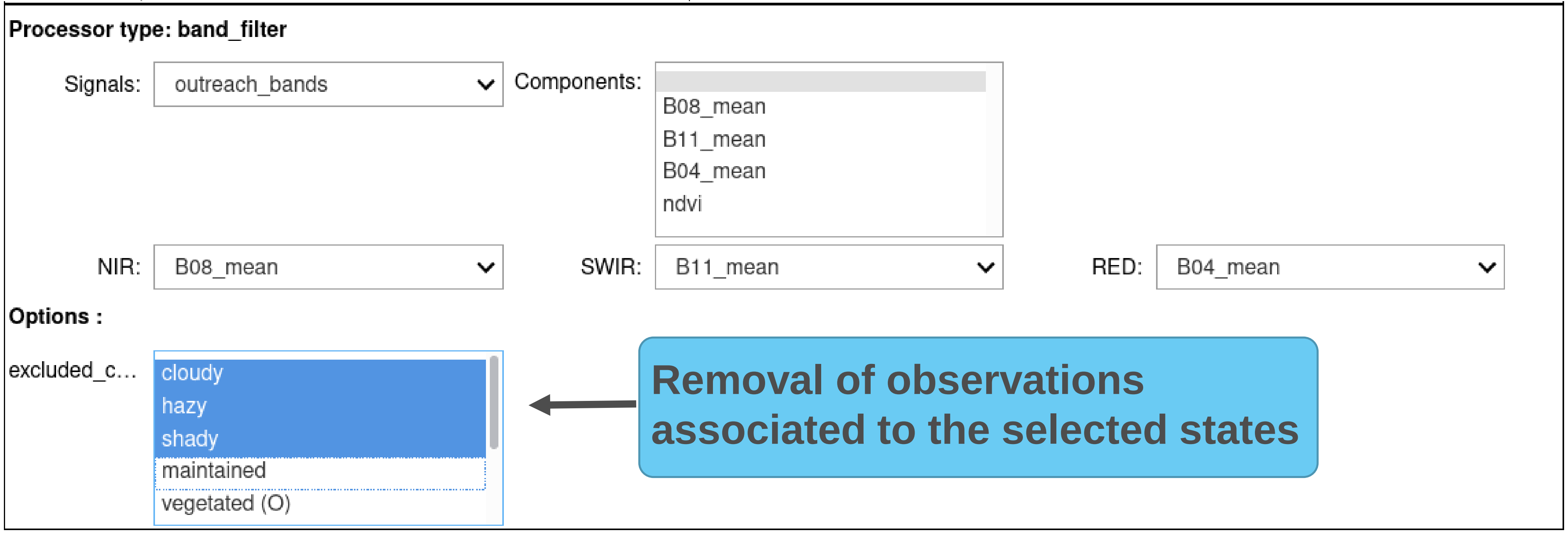


LUT-Stretching for the **individual components**

Possibility to **set the transformation**

More complex processing based on a **local classifier** (each color associated to a different state)

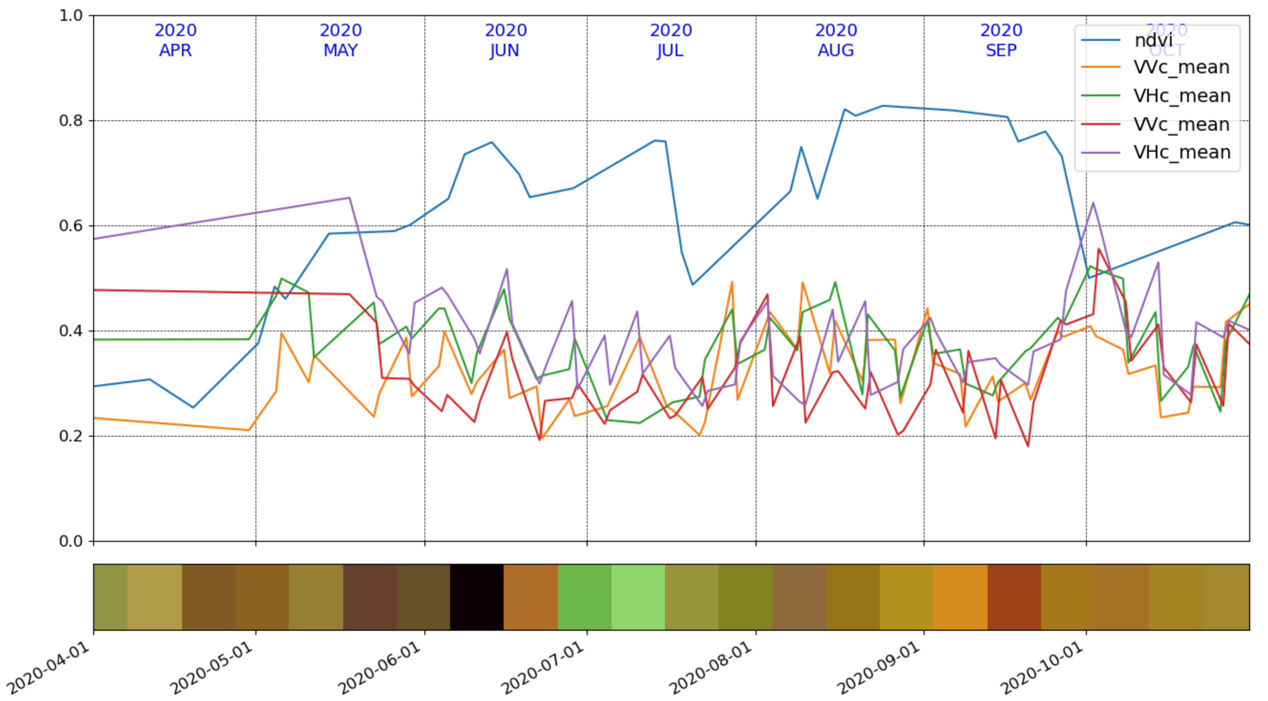
Training based on NL data

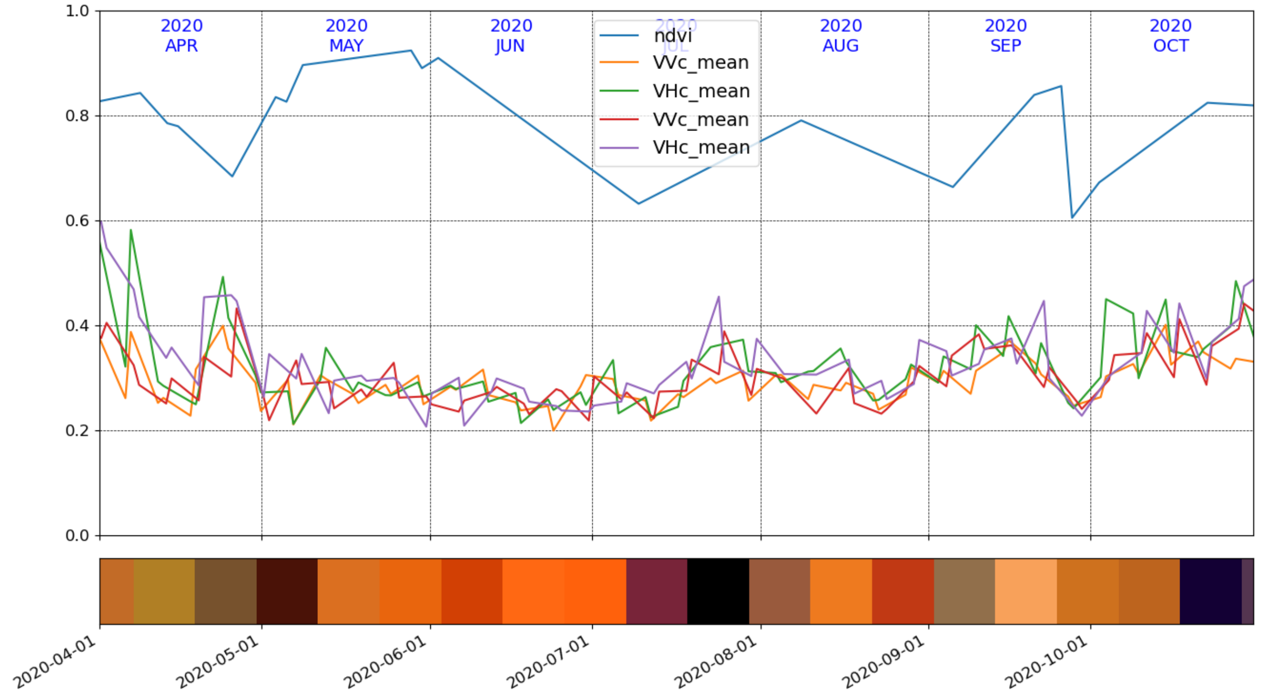


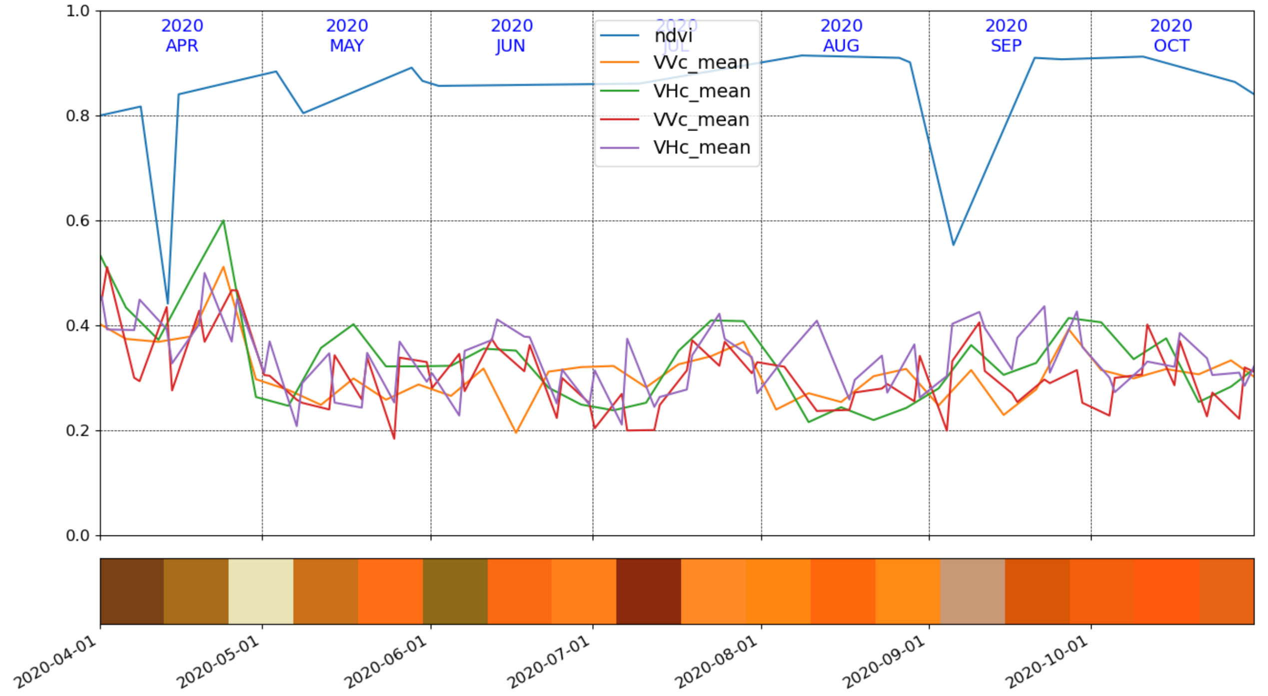
Putting all Together

NDVI, COH components and stretched NIR, SWIR and RED on the same plot

BS not considered for mowing detection

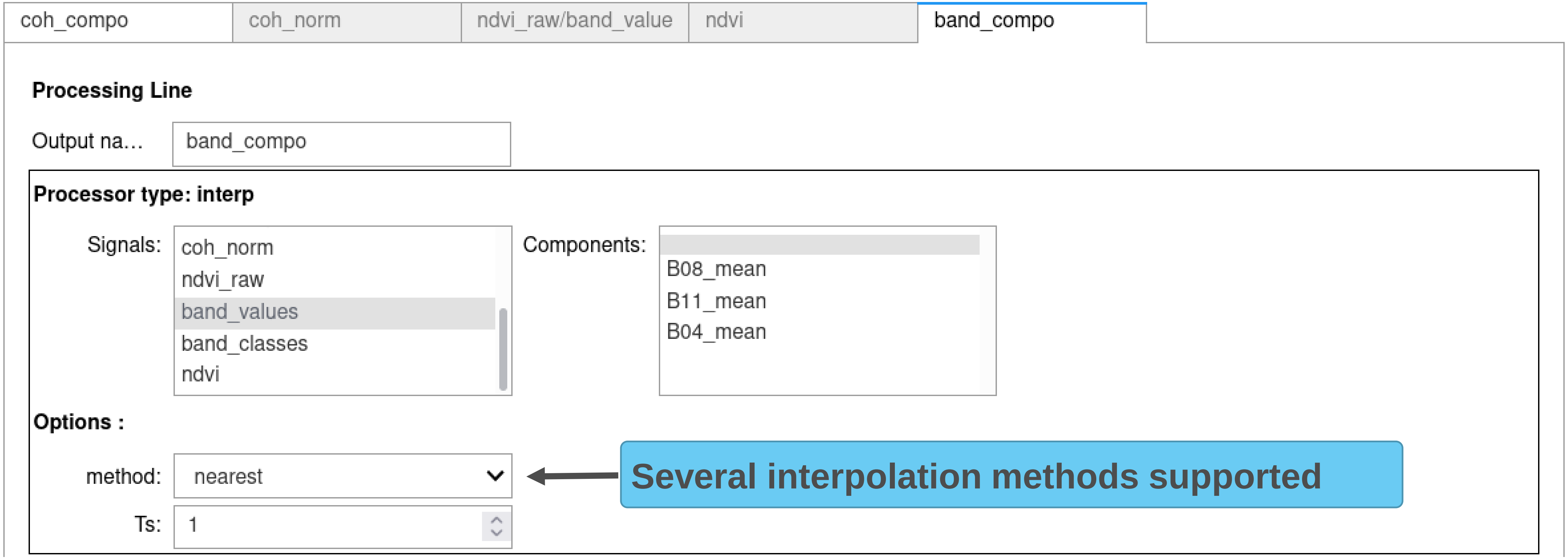






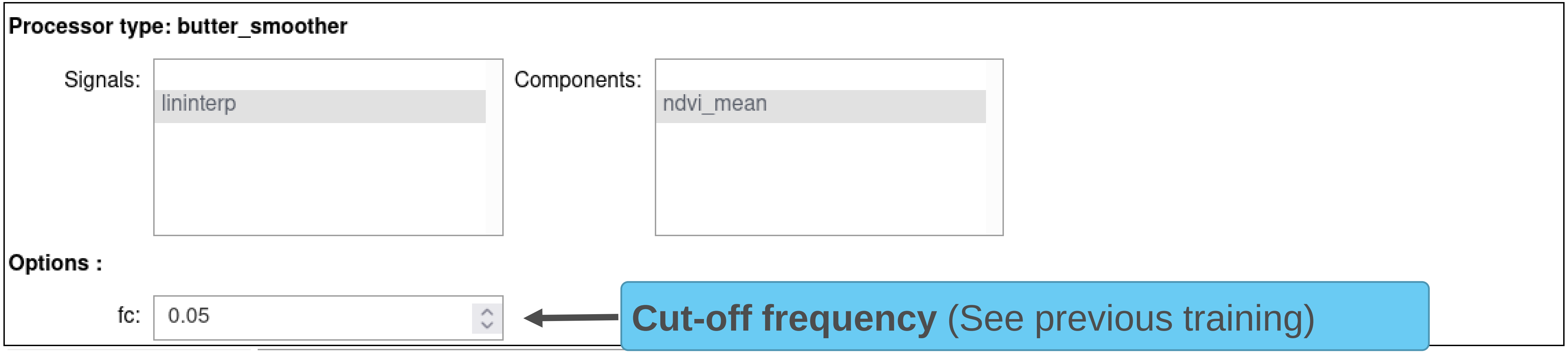
Resampling and Interpolation

- to obtain **uniformly sampled time series** which allow simplified operations
- to use a **common time scale** between time series

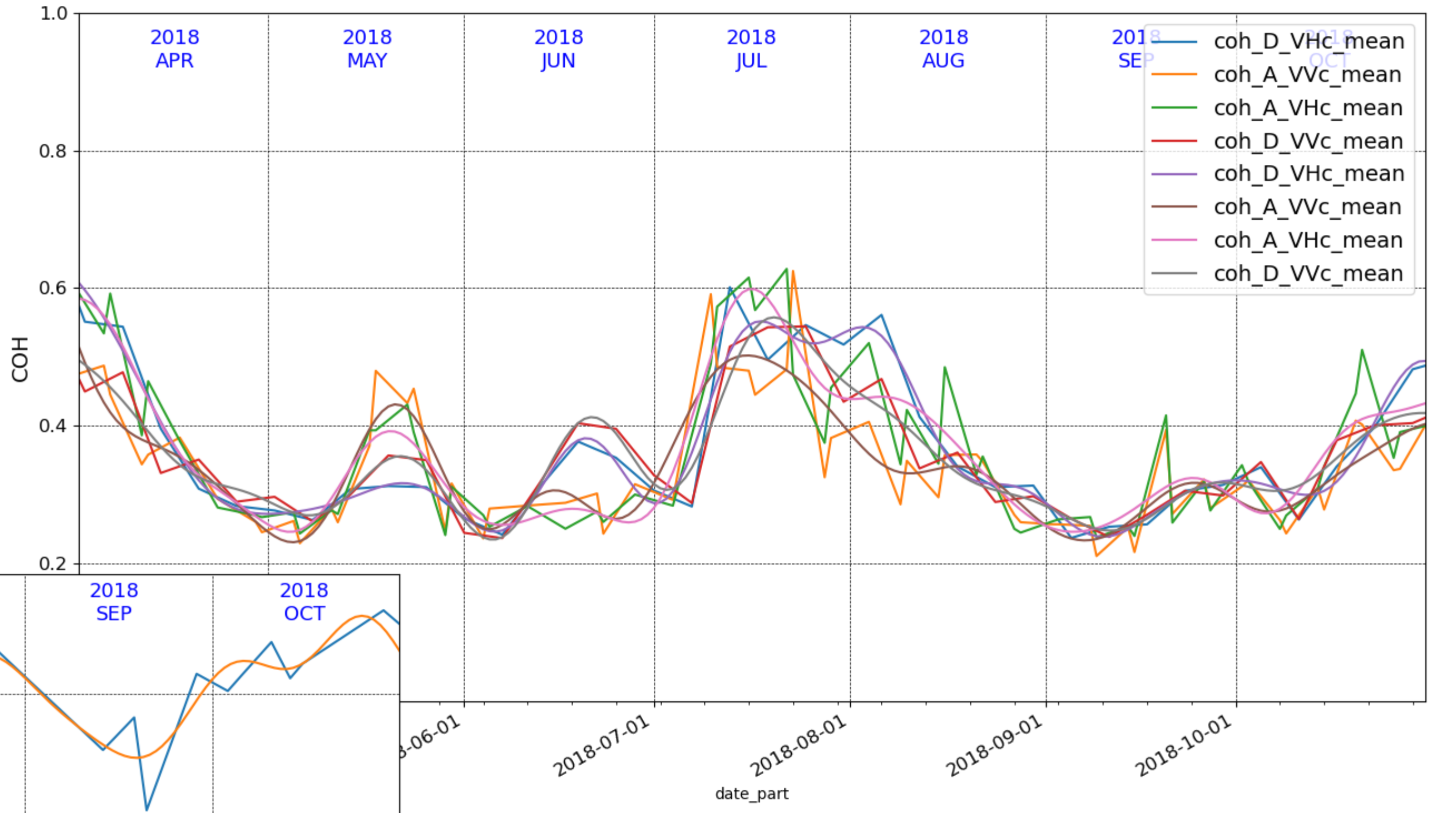


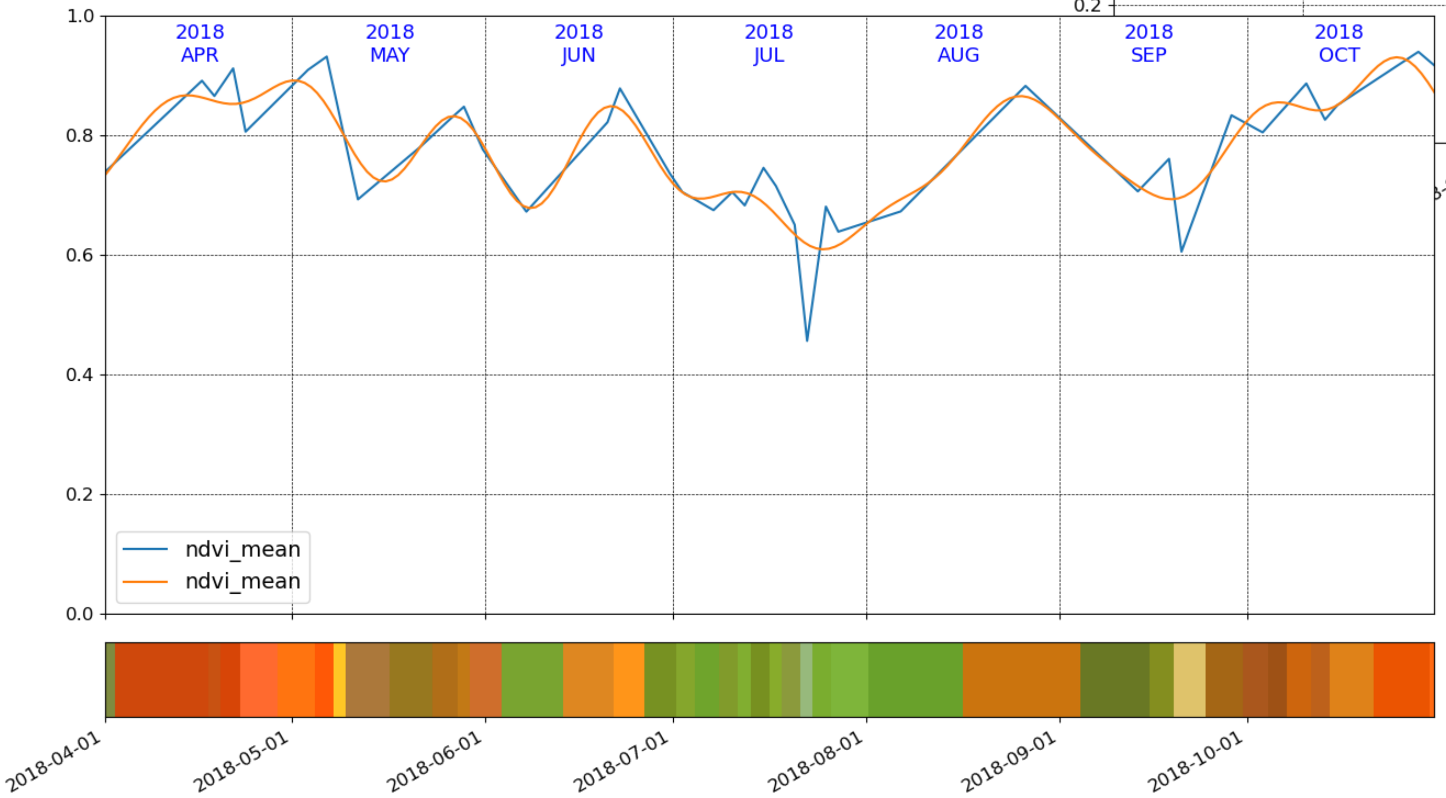
Smoothing

Reduce the impact of noise and other high-frequency phenomena not corresponding to mowing



Examples





From NL 2018m database

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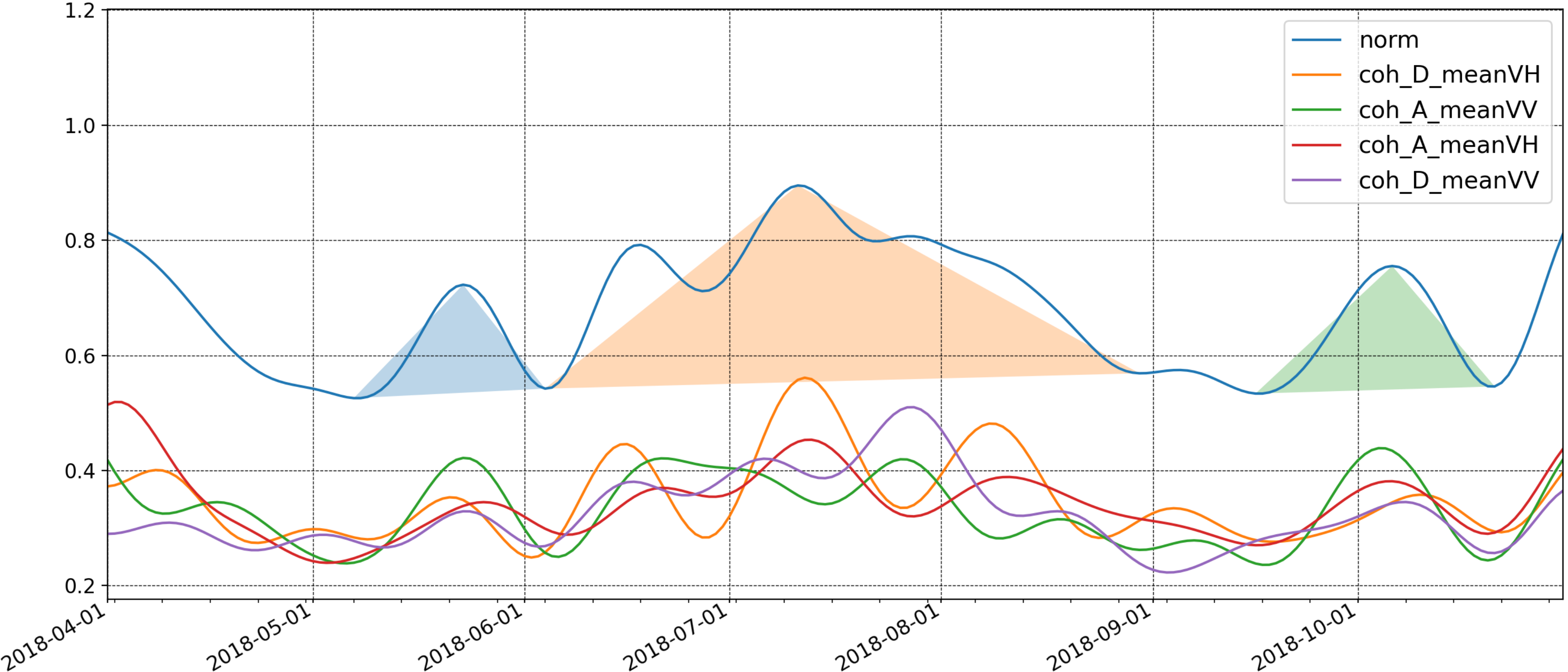
Signal Combining (I/II)

- **Several time series** may be used for **marker detection**

→ **effectively combine time series**

$$co_s[n] = \sqrt{\tilde{co}^2_{VH-A}[n] + \tilde{co}^2_{VH-D}[n] + \tilde{co}^2_{VV-A}[n] + \tilde{co}^2_{VV-D}[n]}$$

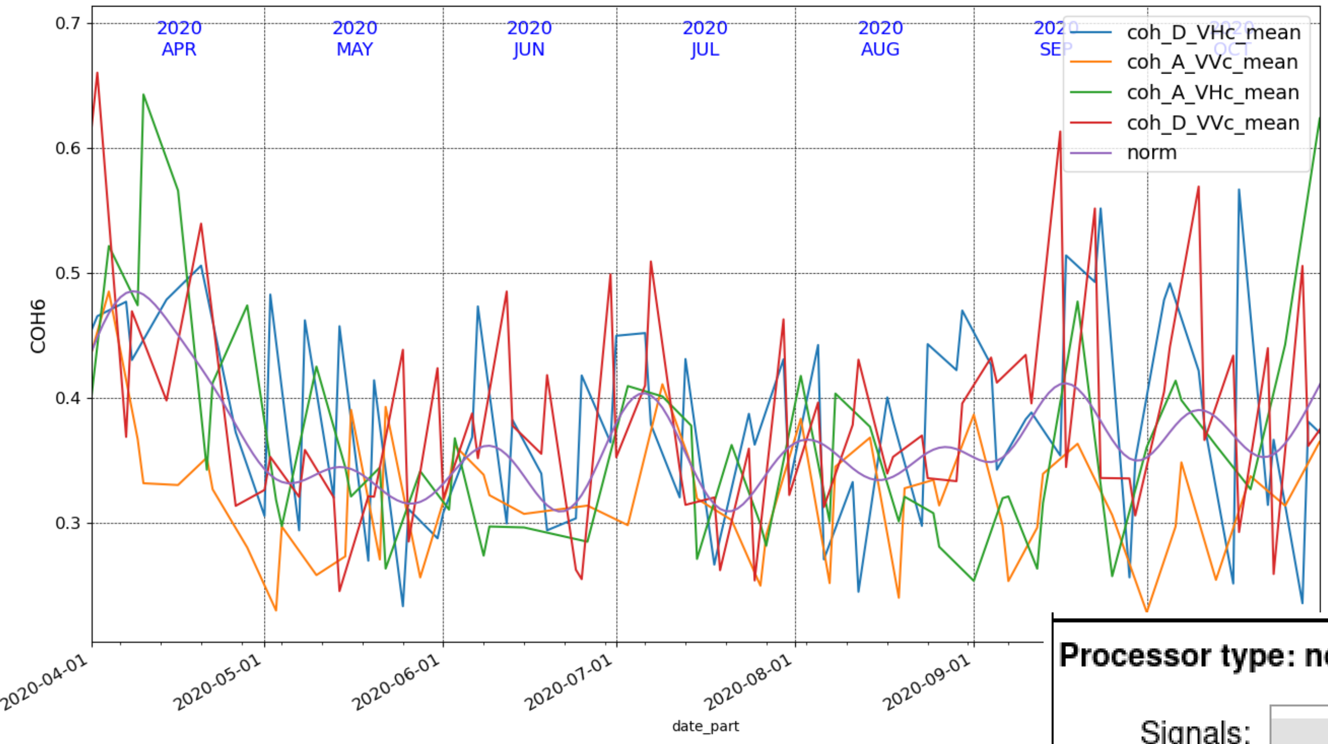


E.g./ combine the 4 coherence components (VV-D, VH-D, VV-A, VH-A)

Euclidean norm

Four smoothed coherence components

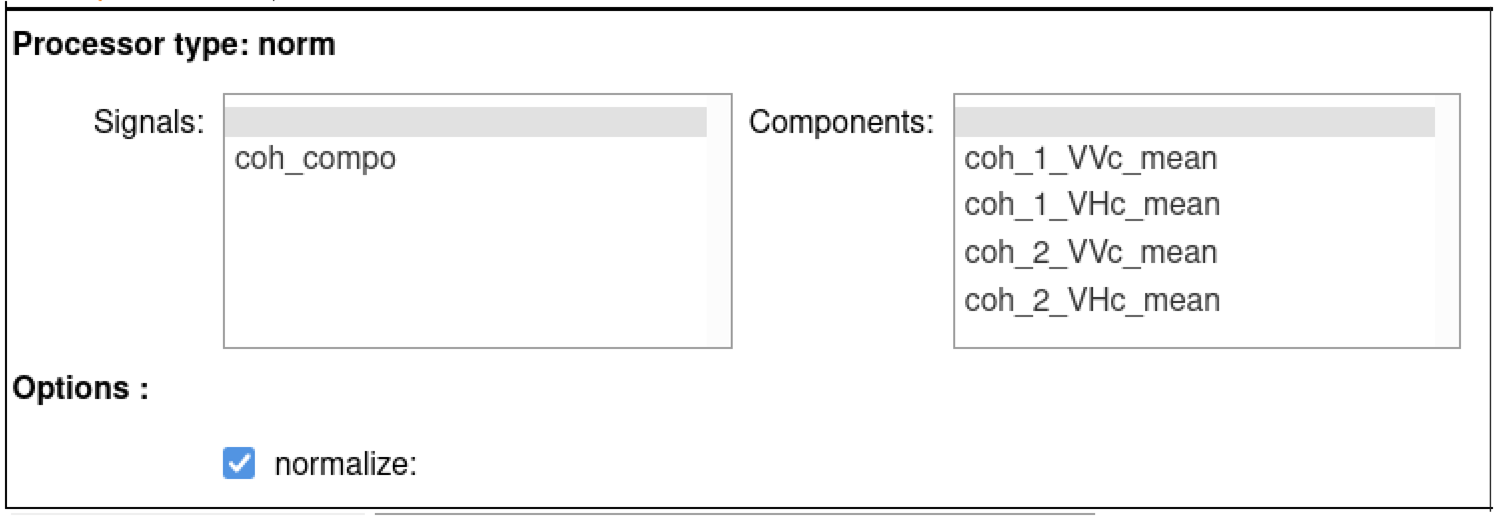
Signal Combining (II/II)



- Flexibility to include new combining strategies: **additional processors**

- **Norm normalization:** coherence assumes values between 0 and 1. Constraints on the processing to preserve this conditions

- Combining may be needed for other signals (BS, S2 signals bands, etc.)



Conclusions

- **Signal for mowing detection:** NDVI, individual bands (NIR, SWIR, RED), S1 coherence
- **Signal pre-processing:** important stage to reduce the impact of noise and artefacts
- **Operations:**
  - cloud masking/outlier removal
  - resampling/interpolation
  - smoothing (low-pass filtering)
- **Object oriented framework for data loading, signal processing and marker detection**

- Designed to be **flexible** and **easily extendable**
- **GUI in a Jupyter notebook**

... finally ready for actual Marker Detection

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... Use Predefined Configuration Files

- configuration files with predefined processing options available
  - → NDVI alone
  - → Coherence alone
  - → NDVI+Coherence
  - → ...

Simplified initialization through a single button

Initialize all elements

Initialize All

Q&A

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konstantinos.anastasakis@ext.ec.europa.eu

European Commission

Mowing Marker Detection

Outreach Training

JRC D5 – GTCAP Team

19 Nov 2021

Agenda

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12:25- 13:00	**Q&A, discussion**

Outline

- Peak and Drop detectors
- State verification using a (NIR, SWIR, RED)-classifier
- Comparison with reference data
- Performance and marker parametrization

Basic Principles: S2 signals

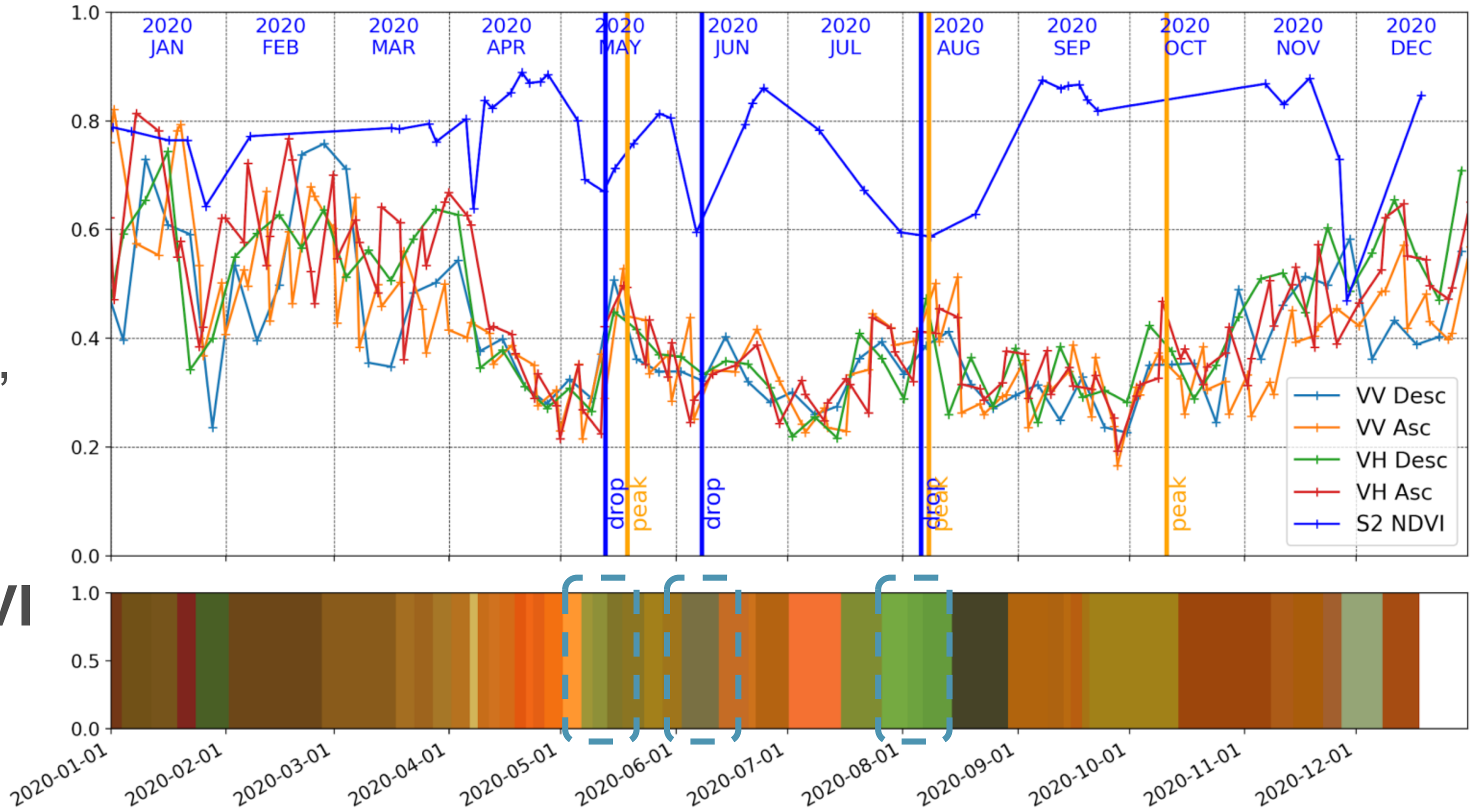
- Mowing implies a **significant reduction of biomass**:

- direct impact on NDVI: **expected significant drop** 'max-min-max'/'growth-cut-regrowth' **pattern**

→ **Detection of drops in the NDVI**

- NIR, SWIR and RED false color composite: **only greenish colors correspond to mowing states**

→ use a classifier to associate states to the NIR, SWIR, RED color composite and confirm NDVI based detection



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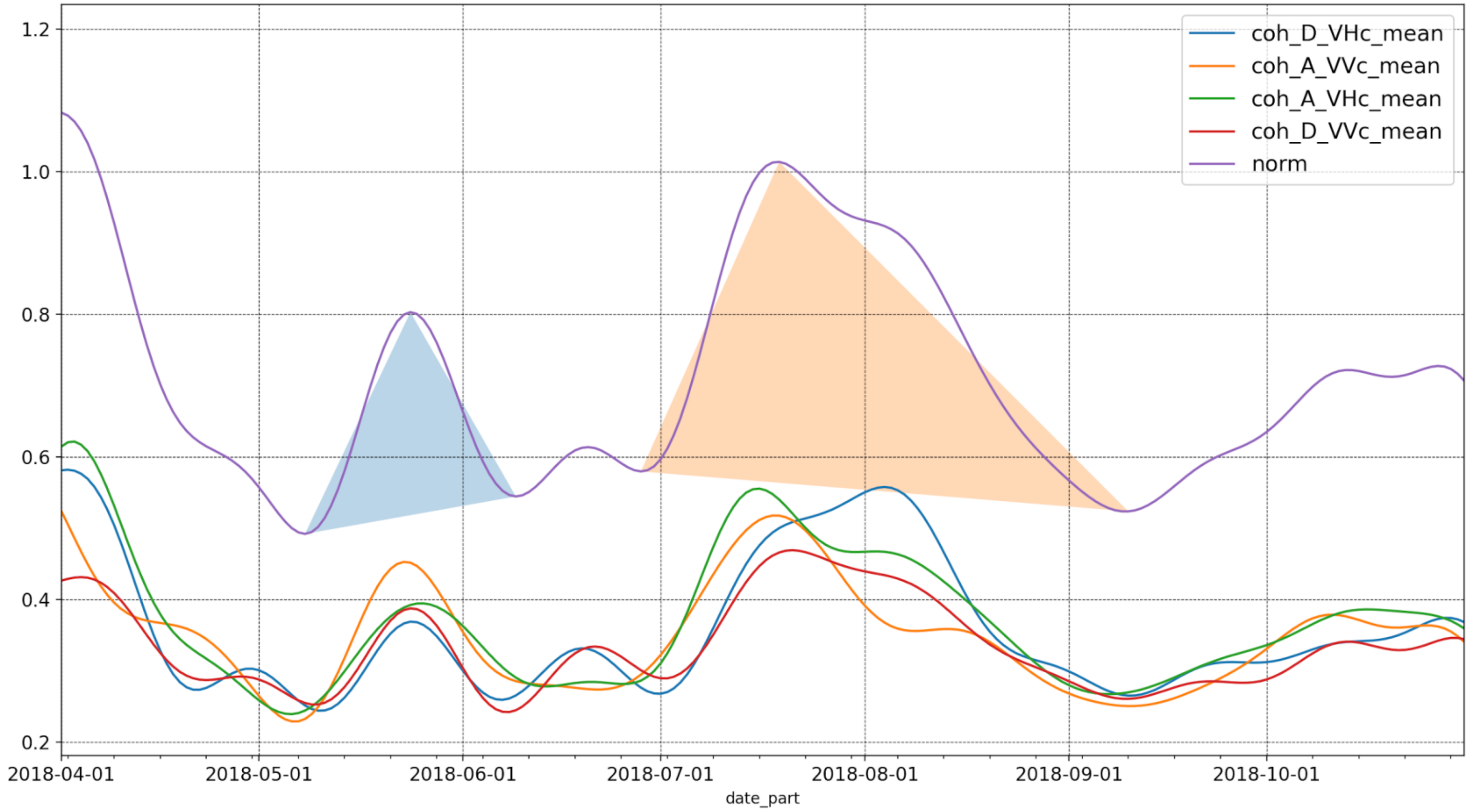
Basic Principles: S1 COH

Coherence should increase after a mowing event. Several approaches available in the literature (for instance Tamm et al. 2016)

Stable BS: not considered here

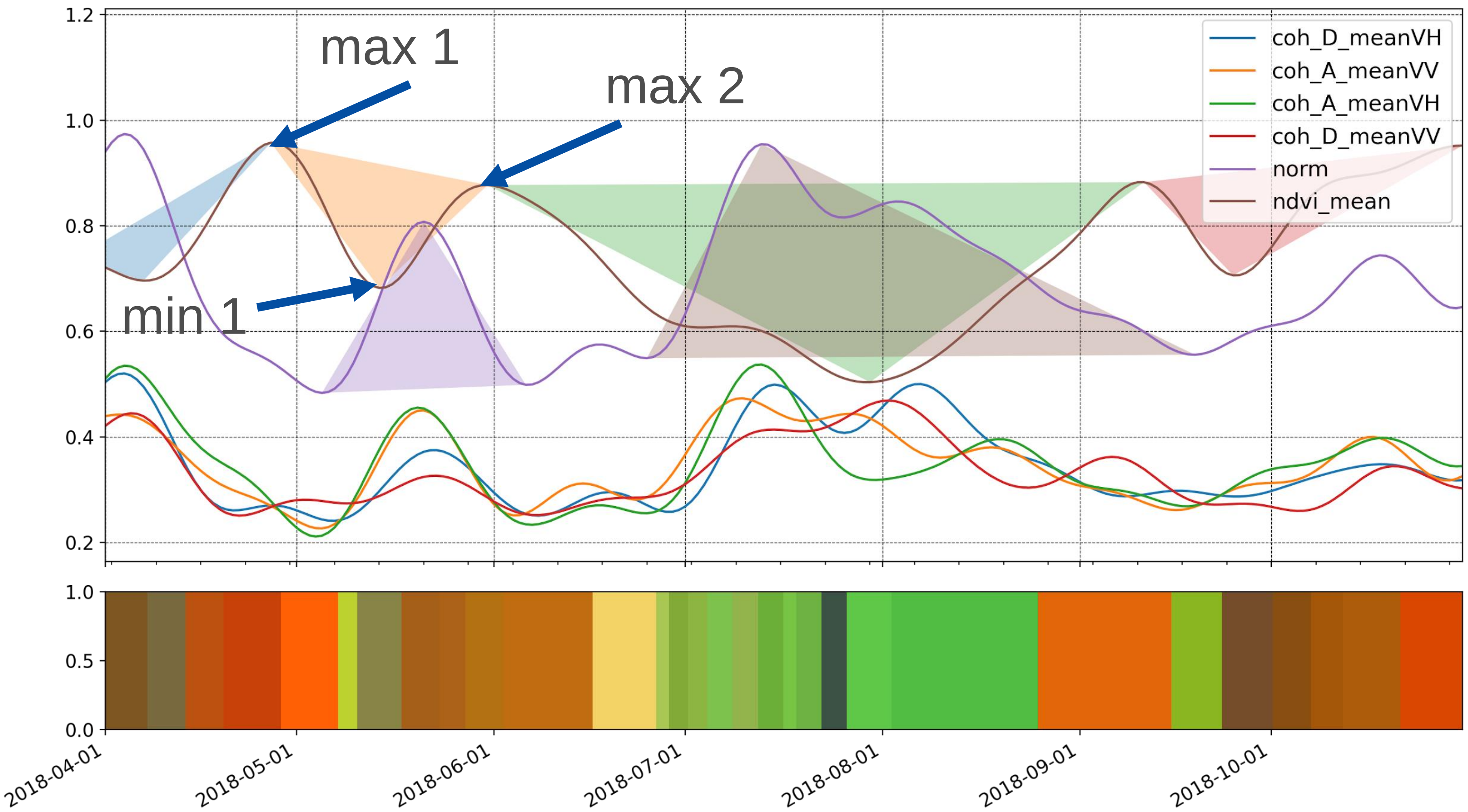
Detection of peaks in the COH norm



Process similar to the detection of drops in the NDVI: a peak becomes a drop is the original time series is multiplied by -1

Markers as Triangles

Conventional representation:



for NDVI: mowing date **most likely** between max1 and min1

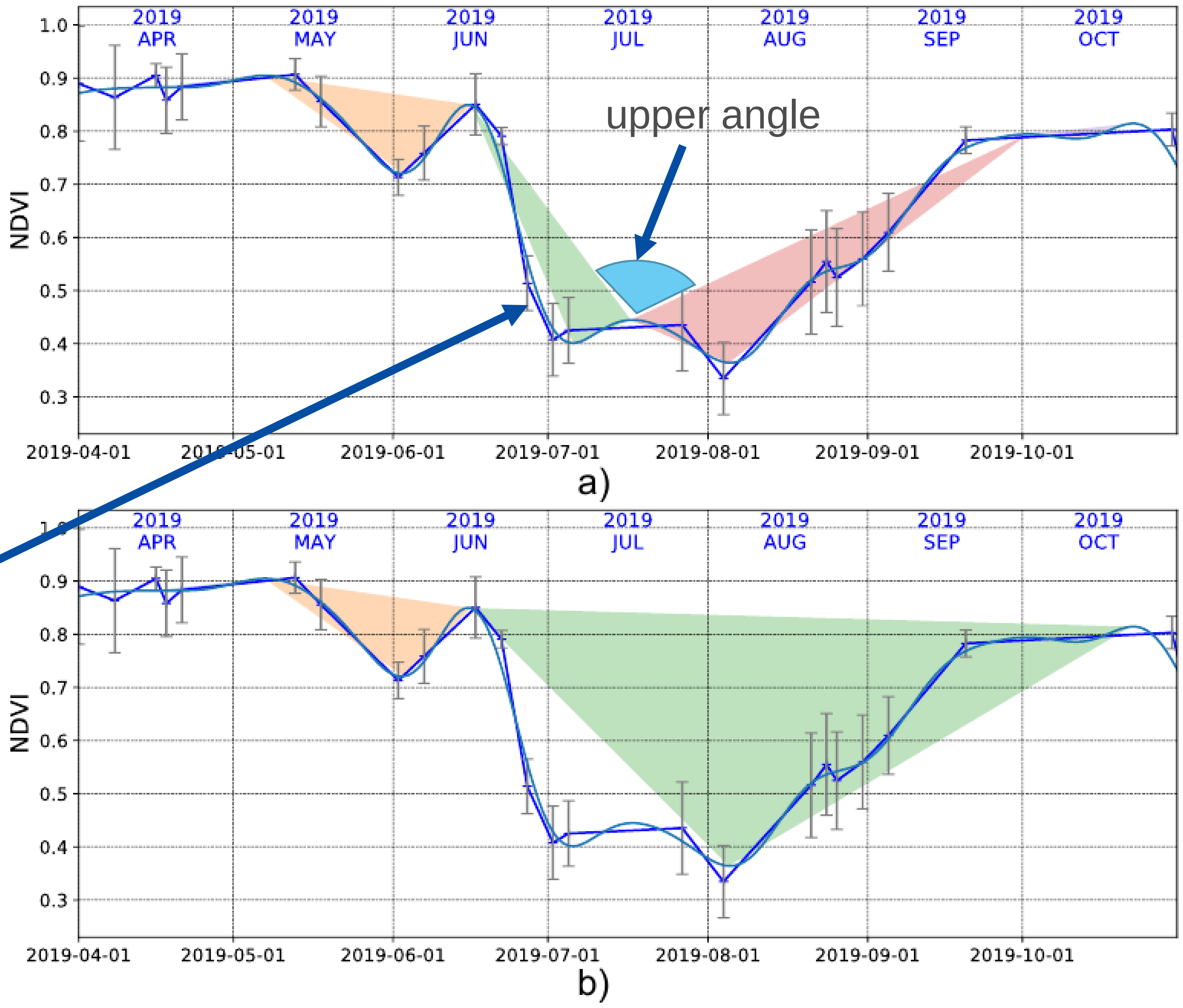
regrowth phase: between min1 and max2

a new mowing activity cannot occur if the regrowth phase is not completed

similar considerations for COH

Triangle Aggregation

- Peak and drops detected by identifying local **maxima** and **minima** in the smoothed NDVI and COH curves
- There could be ambiguous situations: one or two markers?
- Possibility to aggregate “triangles”
- Aggregation criterion: angle between the two triangles



Drop and Peak Detectors

drop-detector

Processor type: drop-detector

Signals:
- band_values
- band_classes
- ndvi
- band_compo
- coh_smooth

Start date: 04 / 01 / 2018

Stop date: 10 / 31 / 2018

Options :

min_duration: 7

min_drop: 0.1

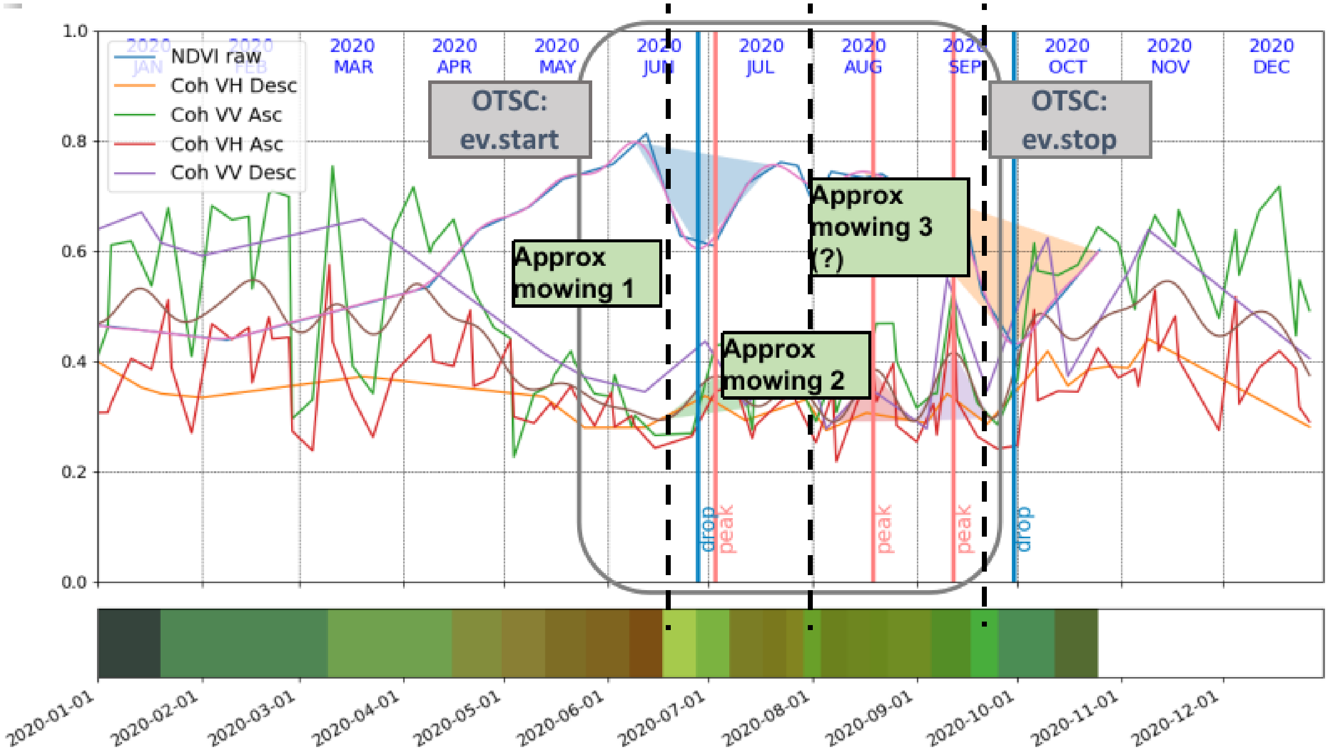
filter_by_angle: ☐

aggregate: 2

Comparison with Reference Data

- Very flexible framework for marker detection: to **be tuned to local conditions**
- **One solution will work for a MS and fails for another**

Comparison with reference data: to determine the **best solution** for a specific scenario/MS



- **Performance evaluation:** could be challenging due to **uncertanties** in the **reference data**
- **E.g./** Did the event really occur?
- **Uncertanities in the dates** of the event (reference data) and markers (automatic detection)

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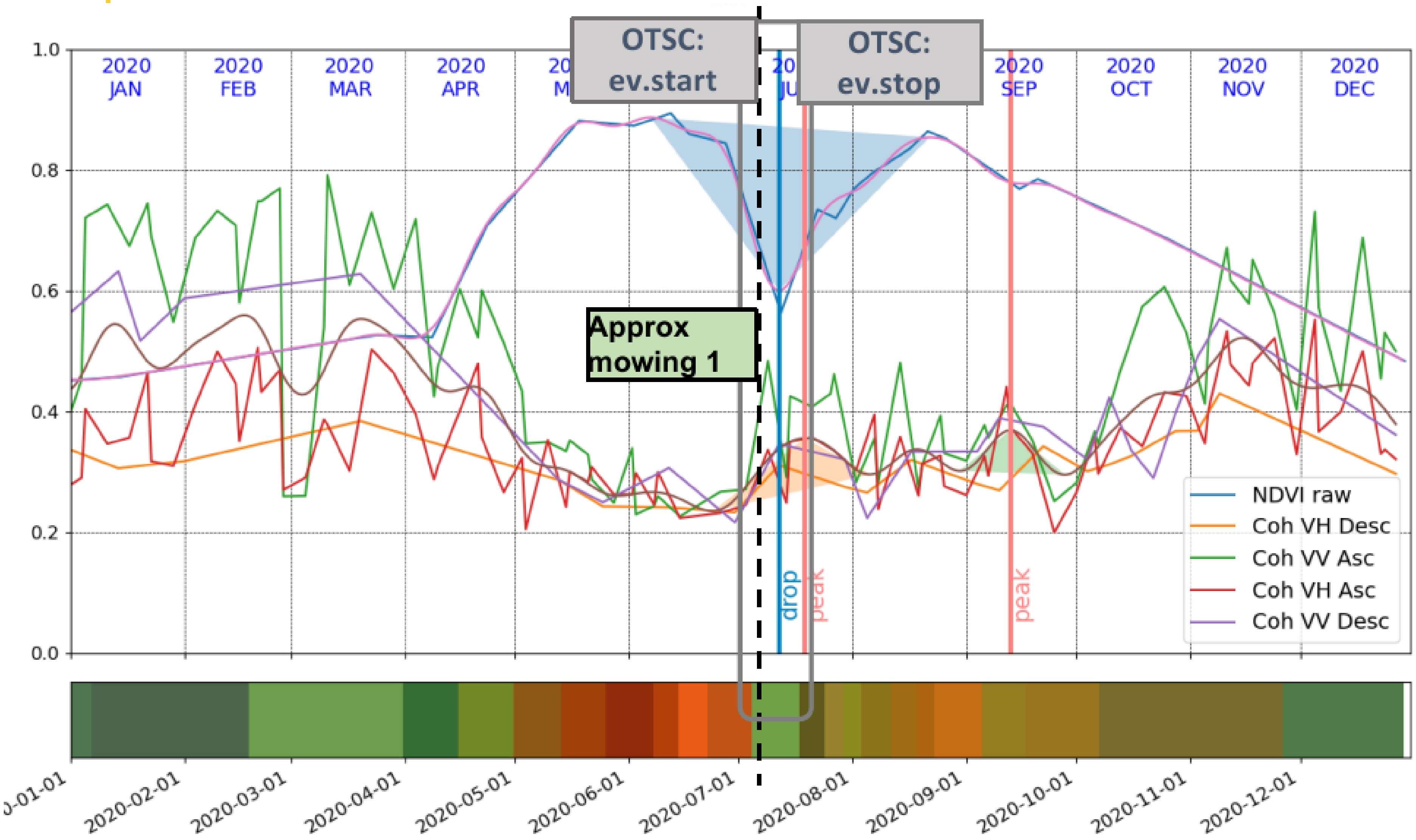
Some Examples: CZ 2020



- NDVI drop markers effective in reveling the mowing activity
- Moderate numbers of NDVI data gaps
- COH: can have oscillations leading to false alarms

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Some Statistics: CZ

- Results obtained without proper marker parametrization
- No marker combining implemented
- Only 25 parcels considered for the analysis

Detection probabilities determined by **requiring a match** between the **dates** of **reference event** and the **marker dates**

NDVI

Missed Detection	Detection
38.46 %	61.54 %

COH

Missed Detection	Detection
14.29 %	85.71 %

Relaxed problem

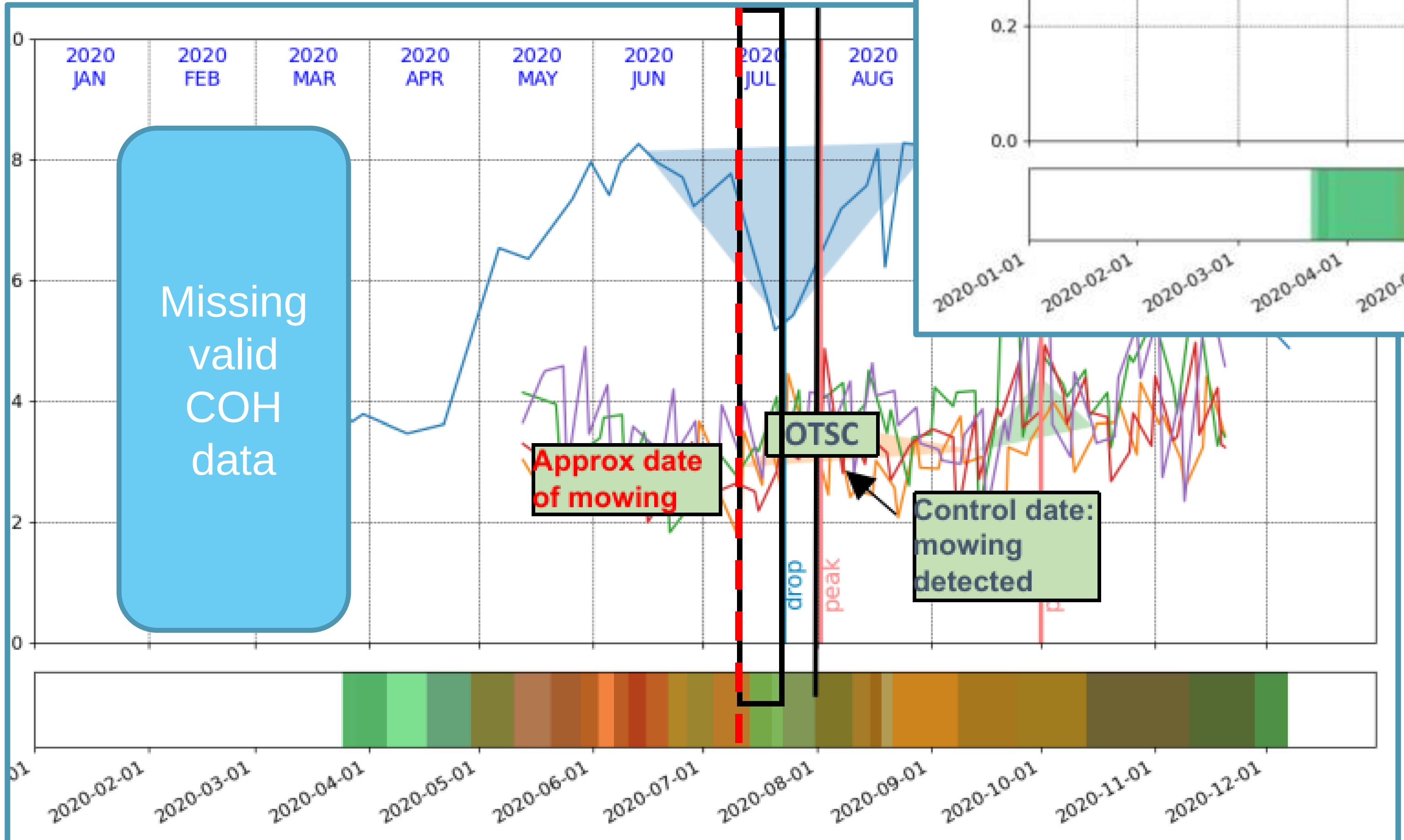
Probability that at least one mowing event is correctly identified in a parcel during the season

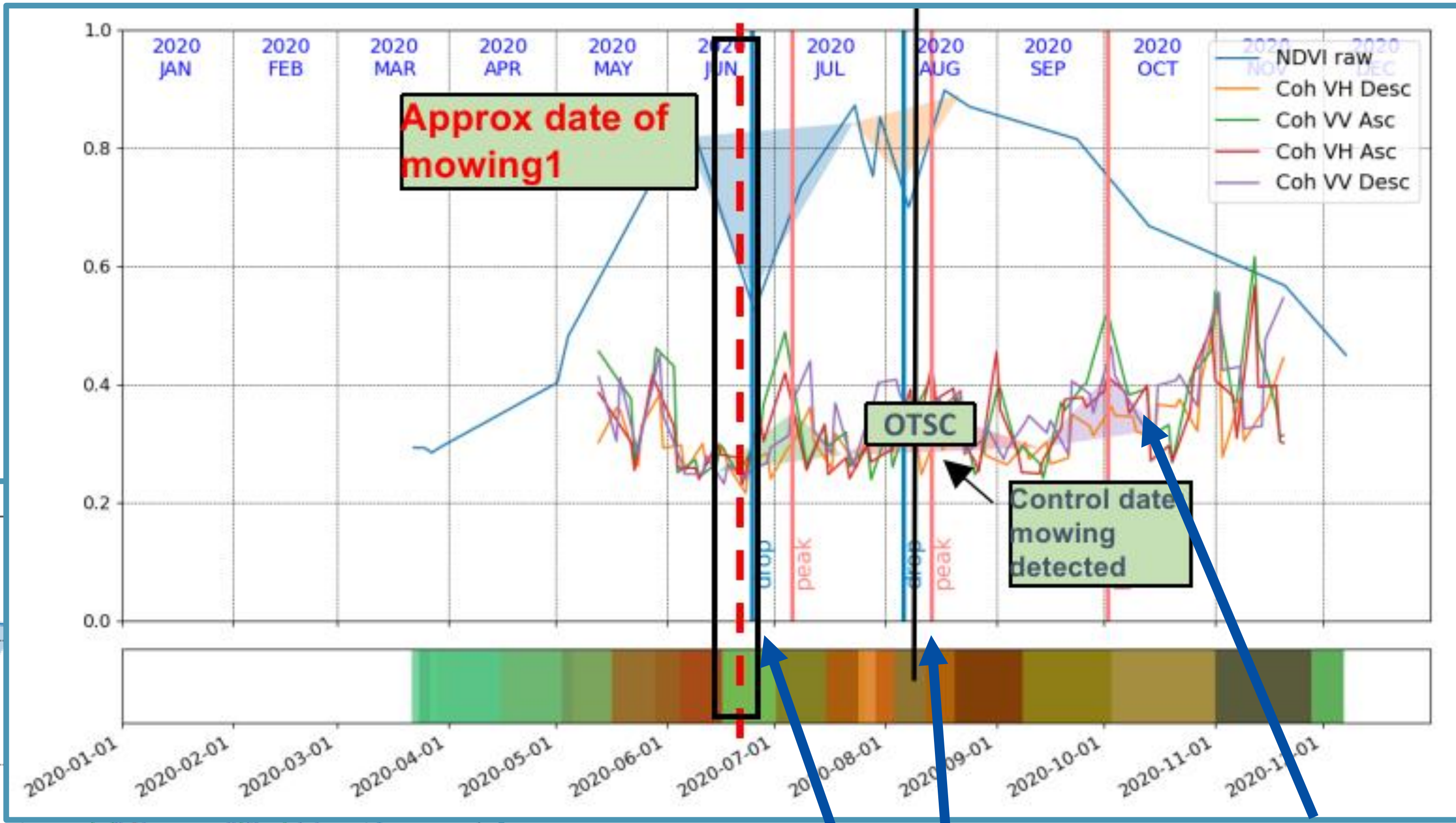
NDVI

Missed Detection	Detection
5%	95%

Small parcels (0.08ha), end-of-season events, ...

A Second Example: LV





Both activities correctly detected by both NDVI and COH

COH False alarm

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Some Statistics: LV

- Sentinel 1 Extra Wide Swath Mode (EW) early and late in the year constrains the COH-based analysis

- Usage of COH to be carefully evaluated for the specific cases (parcel size and shape)

- Further investigations needed to determine root causes for low COH detection rates

date matching: hard requirement

uncertanities in the event/marker dates can lead to very conservative detection results

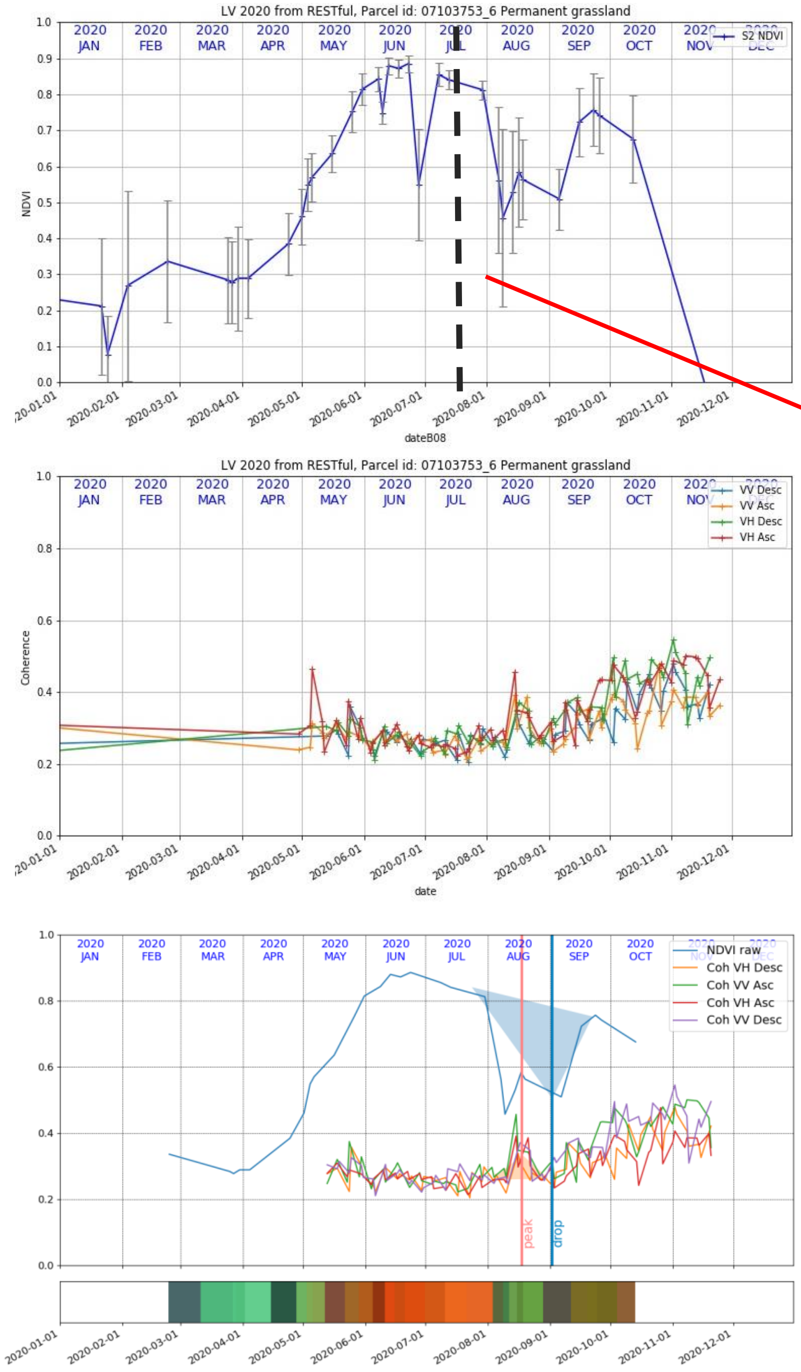
NDVI

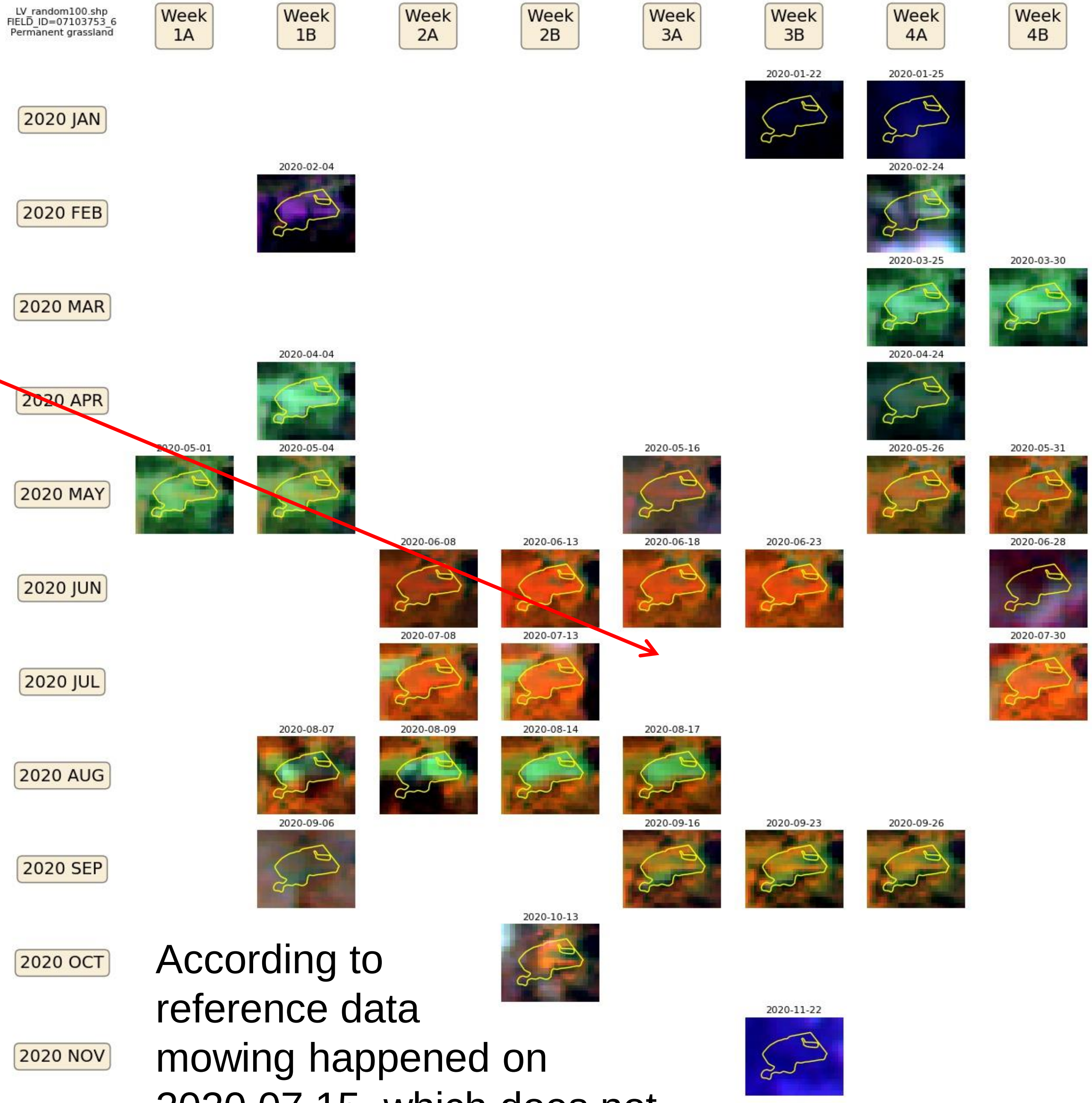
Missed Detection	Detection
16%	84 %

COH

Missed Detection	Detection
64%	26 %

Date uncertainties: an example

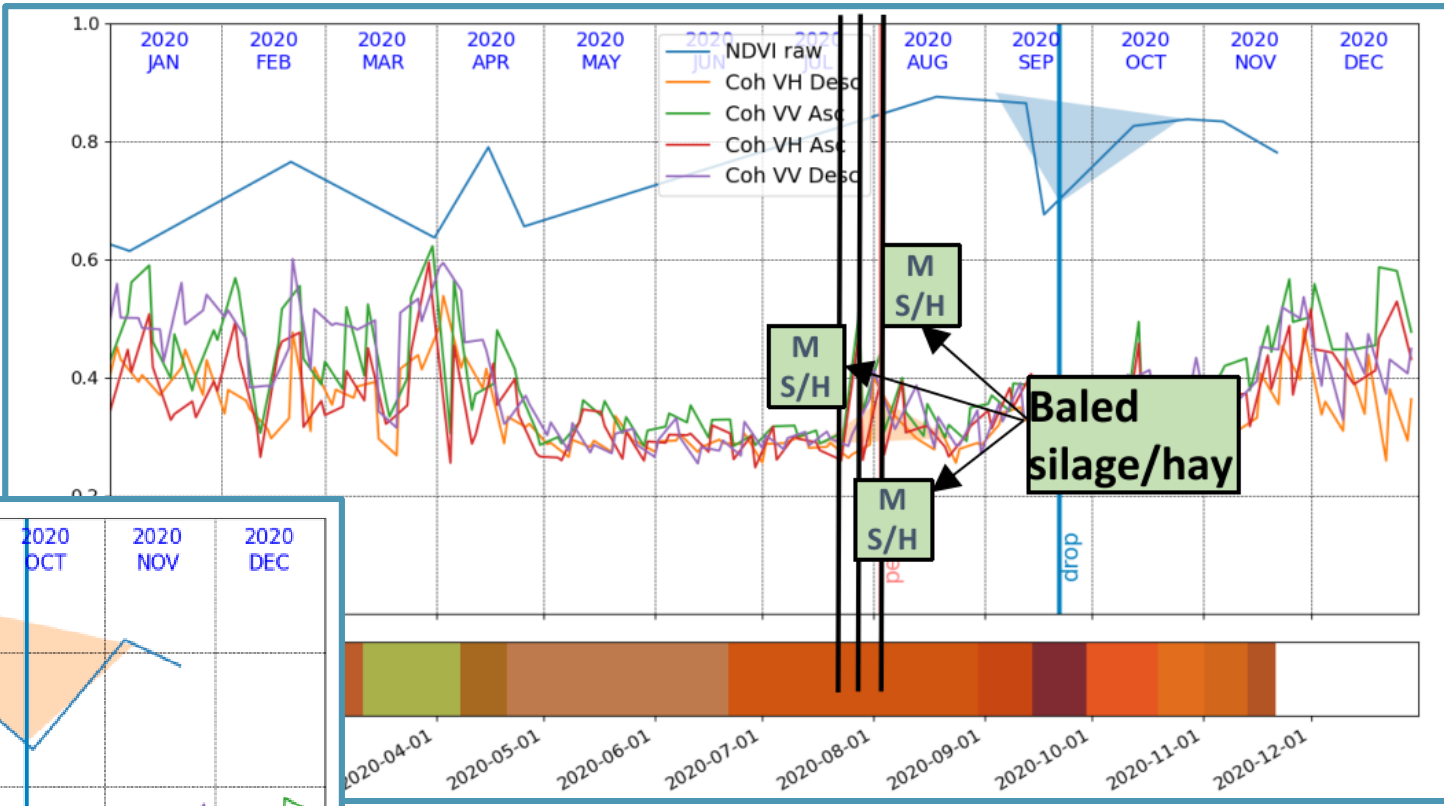




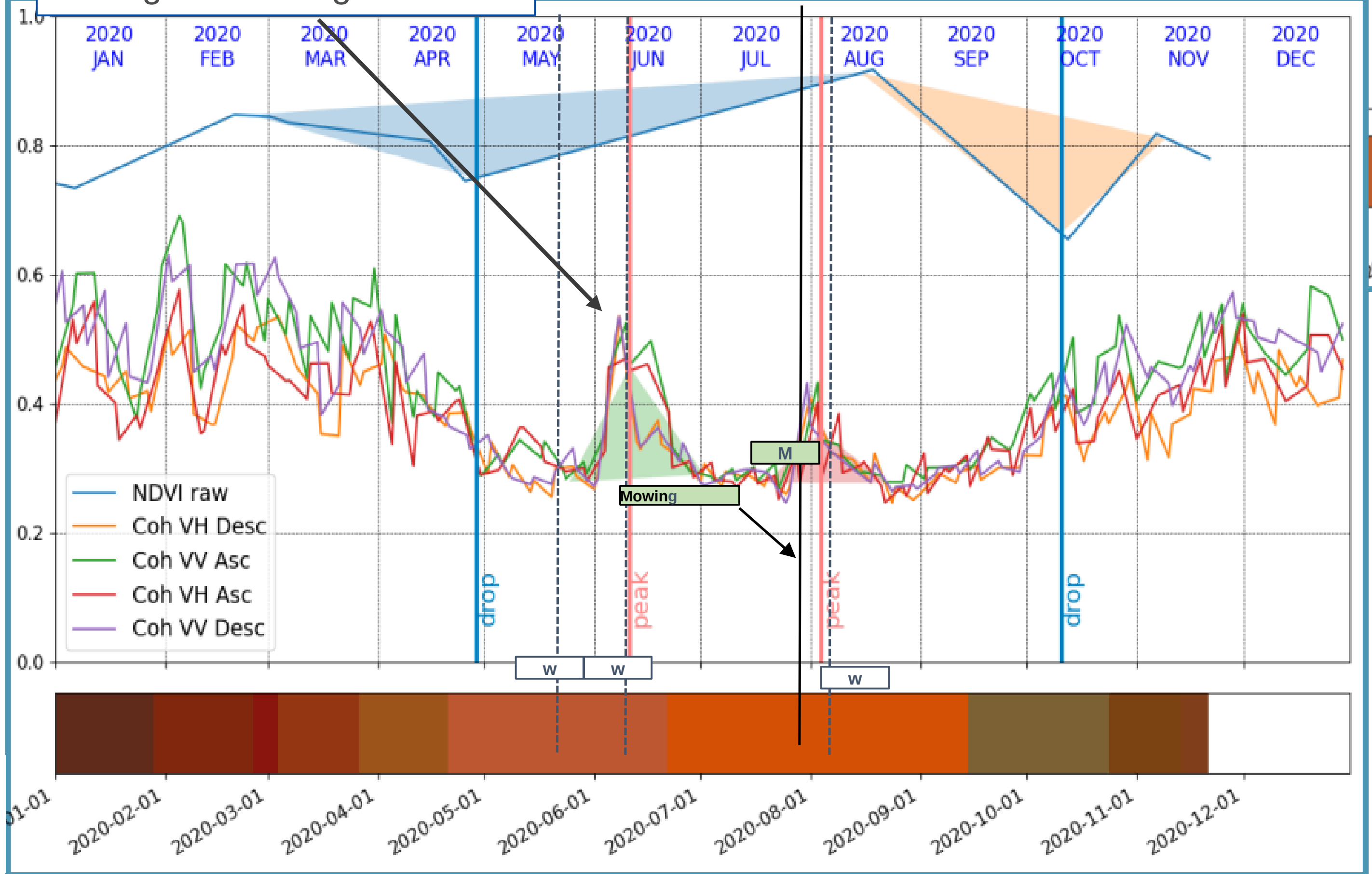
According to reference data mowing happened on 2020.07.15, which does not seem plausible

A Last Example: IE

- NDVI hardly available



Picked up grass following cutting/windrowing



- COH and drop detection: effective results under several cases

- Critical importance of the selection of the signals for marker detection

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Outreach: Next Phase

- Need for carefull signal selections according to local conditions
- Pre-determined parameters must be fine tuned to specific local conditions (min/max event durations, drop/increase in NDVI/COH)
- Additional parameters could be defined and introduced
- Full potential of the tool: calibration/validation effort required
- **Performance analysis: to be assessed with respect to the actual problem:**

  1) Was mowing performed at least once in the season?
  2) How many mowing activities were performed?
  3) What are the mowing dates?

Outreach: Next Phase

- Call for MS interested and willing to participate in this next phase
- Require closer and active involvement from MS
- MS will need to test parameter settings in their context and find the configuration that work best for their specific case.

jupyter

Python framework and Jupyter notebooks for mowing and marker detection

Code available at:
https://github.com/ec-jrc/cbm/

European Commission

Q&A

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guido.lemoine@ec.europa.eu
konstantinos.anastasakis@ext.ec.europa.eu