Webinar on DIAS for CbM Outreach - Session 3 - repetition

Date: Friday, 30th September 2021

Agenda

09:30 - 09:45 Welcome and short introduction into the JRC-CbM frontend (Guido Lemoine, JRC)

09:45 - 10:15 Frontend data access: Direct DB + RESTful access (hands on) (Konstantinos Anastasakis, JRC)

10:15 - 10:45 Basic data use: selection and visualization (hands on) (Csaba Wirnhardt, JRC)

10:45 - 11:00 Break

11:00 - 11:30 Data interpretation for marker analysis (hands on) (Guido Lemoine, JRC)

11:30 - 12:30 Thematic use cases: FOI, ML and mowing (hands on) (Gilbert Voican, Pavel Milenov, Guido Lemoine, Daniele Borio, JRC)

12:30 - 12:45 Q&A, next steps and discussion (Guido Lemoine, JRC)

CbM on DIAS: the jrc-cbm frontend

On-line training for Outreach, 30 September 2021

JRC D5 – GTCAP Team

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09:30 - 09:45	Welcome and short introduction into the jrc-cbm frontend
09:45 - 10:15	**Frontend data access**: Direct DB + RESTful access (hands on)
10:15 - 10:45	**Basic data use**: selection and visualization (hands-on)
10:45 - 11:00	Break
11:00 - 11:30	**Data interpretation for marker analysis** (hands on)
11:30 - 12:30	**Thematic use cases**: FOI, ML and mowing (hands on)
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Welcome

- An introduction to the jrc-cbm **frontend** implementation on DIAS.
- An (adapted) repetition of the July 22 webinar. Integrates actual Outlook data.
- Please use the chat for questions during the sessions. Audio & Video during Q&A.
- Remember to switch off video (save bandwidth) and mute audio, when not speaking.
- We do **NOT** record this webinar. All materials will be made available.

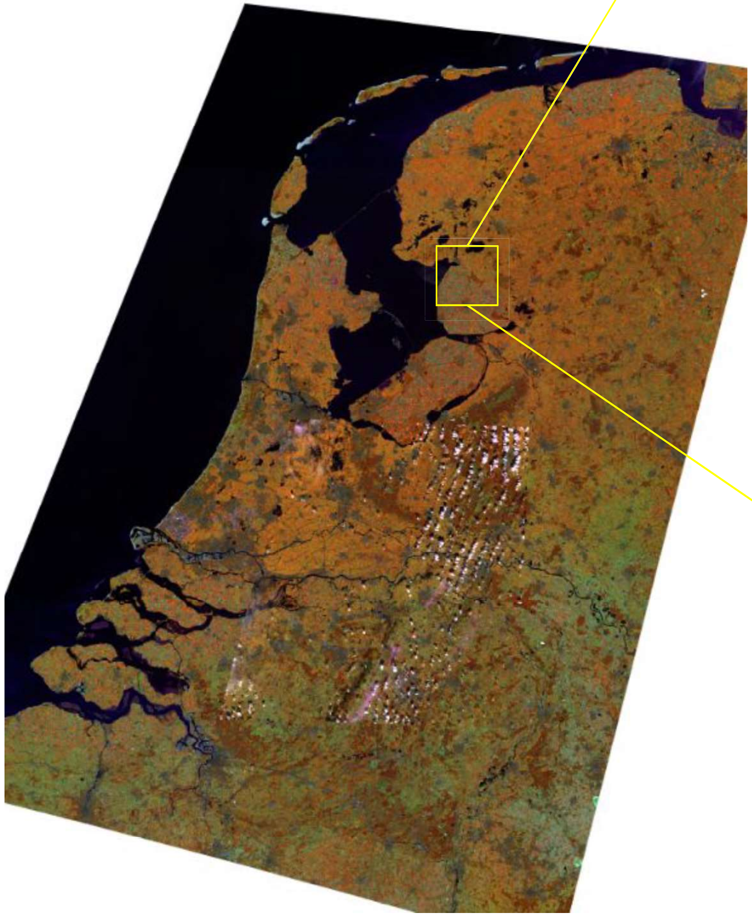
Audience

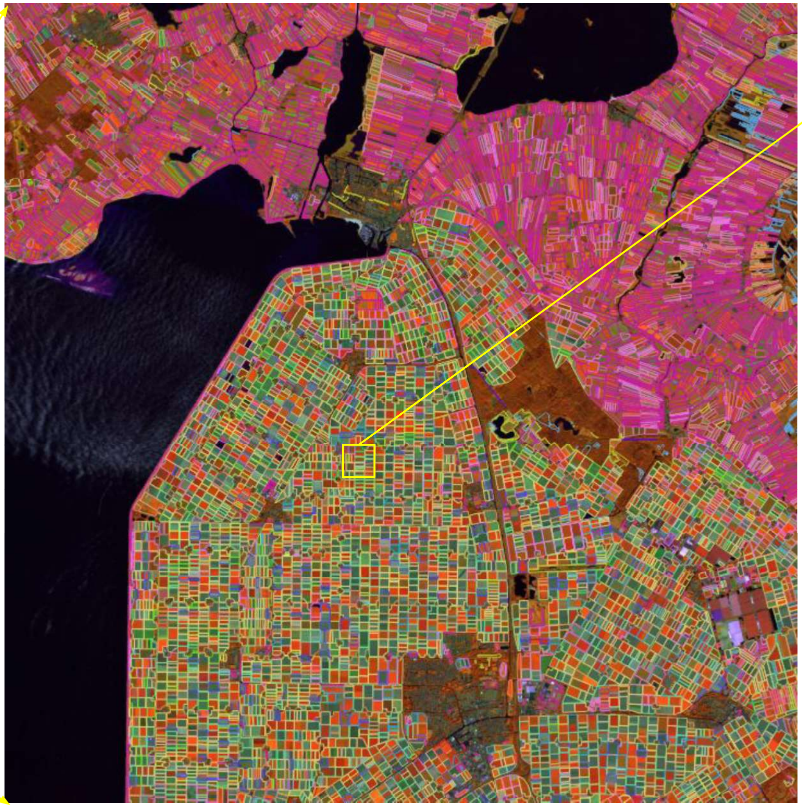
- For data analysts and users at the Paying Agency:
  - Data retrieval from DIAS backend
  - For analysis and marker development
  - “Traffic light” management decisions
  - Reporting
  - Links to schemes and agricultural practice
  - Issues, caveats to be aware of

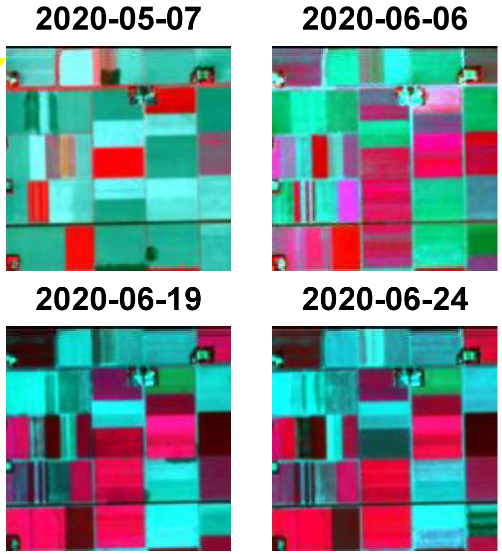
Context

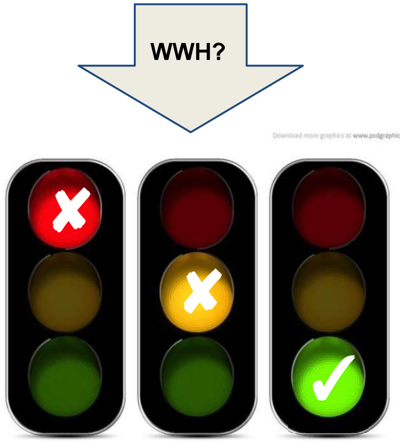
- Checks by Monitoring introduces **continuous use of Sentinel data streams** for 100% of the Member State territory.
- Copernicus DIAS advantages:
  - Access to a **consistent, complete** Sentinel data archive (push, not pull)
  - Provision of on-demand standard CARD processing
  - Access to compute resources that can (temporarily) scale to needs
  - Based on **open industry standards**, core open source modules
- Facilitates the needs for **TAILORED** automated processing.
- Provides access to standard “data reductions” (time series, image extracts)

m Sentinel-2 @ DIAS
p Sentinel-1 @ DIAS









n-m, n-p*2 spatial time series
for Sentinel-1, -2 CARD
for b bands (b=14 (S2), 2 (S1))
x 100 for whole EU

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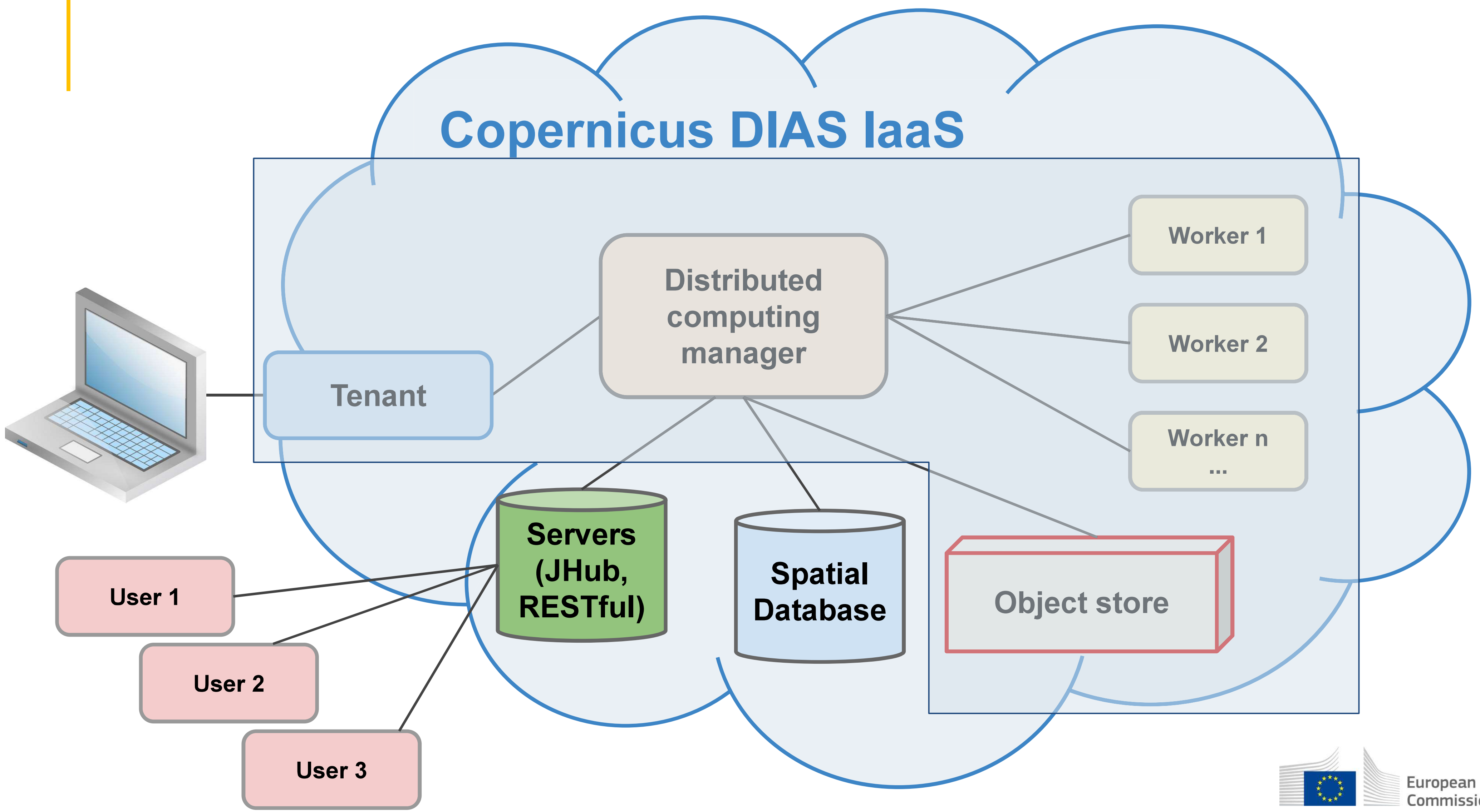
Backend take home messages

- The backend is the core jrc-cbm component for server-side requirements
- The backend does the processing heavy-lifting to provide consistent access to CARD data and their parcel reductions
- Backend operation requires expertise in cloud compute, Big Data Analytics
- Backend functionalities and performance focuses on common needs
- Backend development may be impacted by Copernicus programme decisions (e.g. ARD production) and adoption of novel approaches (k8s, dask, GPU)
- Backend server components provide access to the data via standard APIs
- The frontend “**consumes**” the backend data to support typical PA functions.



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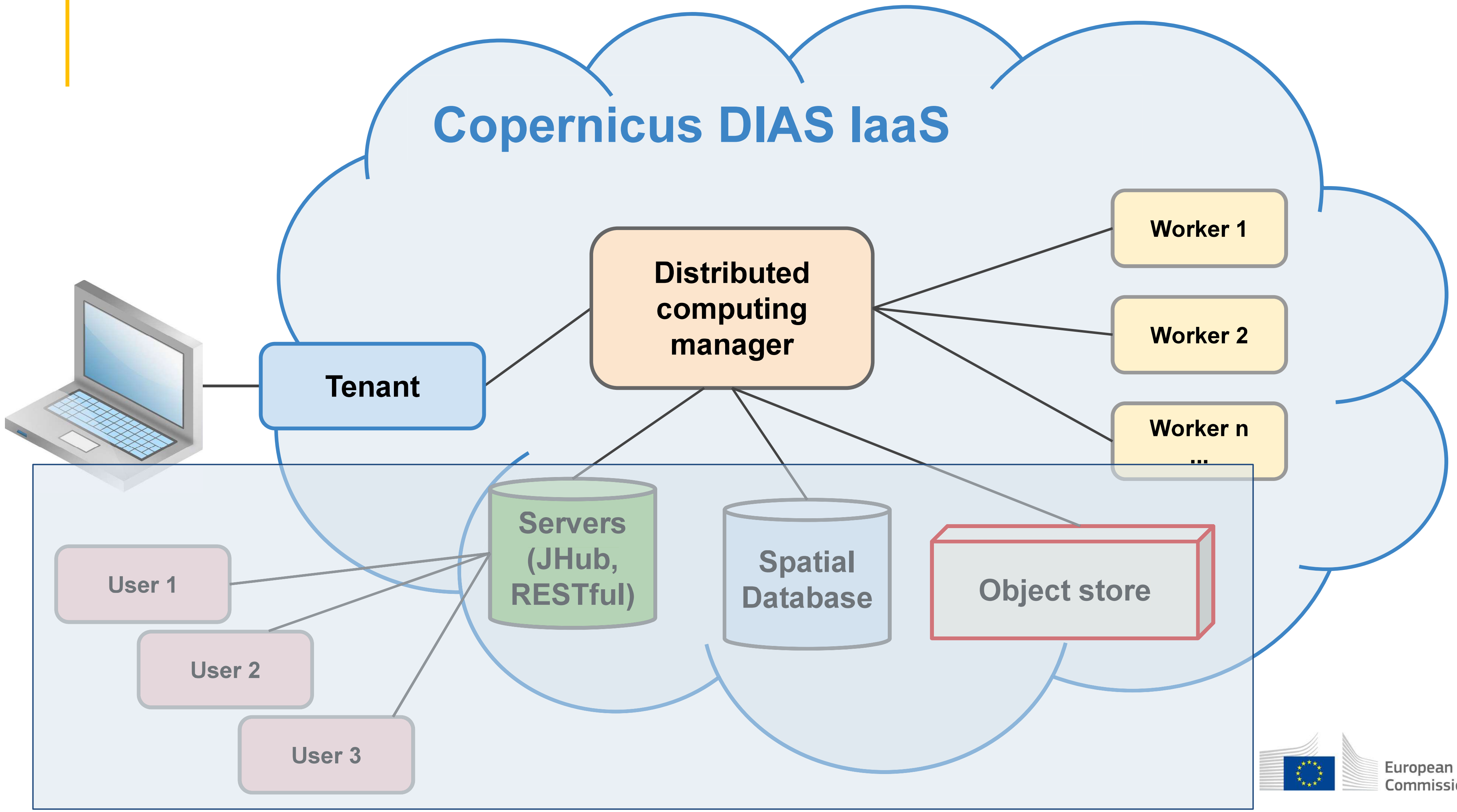
Copernicus DIAS IaaS
Distributed computing manager
Worker 1
Worker 2
Worker n
...
Tenant
Servers (JHub, RESTful)
Spatial Database
Object store
User 1
User 2
User 3

Technical choices

- jrc-cbm is designed on a cloud centric basis (but can also run stand-alone)
- all programming in **python**, mostly as **syntactic glue**
- using mature modules
- **PostgreSQL/Postgis** for (spatial) data management on **backend**.
- Linux (Ubuntu) bash scripting for orchestration, parsing, conversion (gdal)
- The backend server components provide the "**end-points**" to retrieve data.
- Frontend users do not require (extensive) backend expertise
- All maintained and documented on github.com/ec-jrc/cbm
- Licensed under BSD Clause 3 (facilitates maximum re-use)

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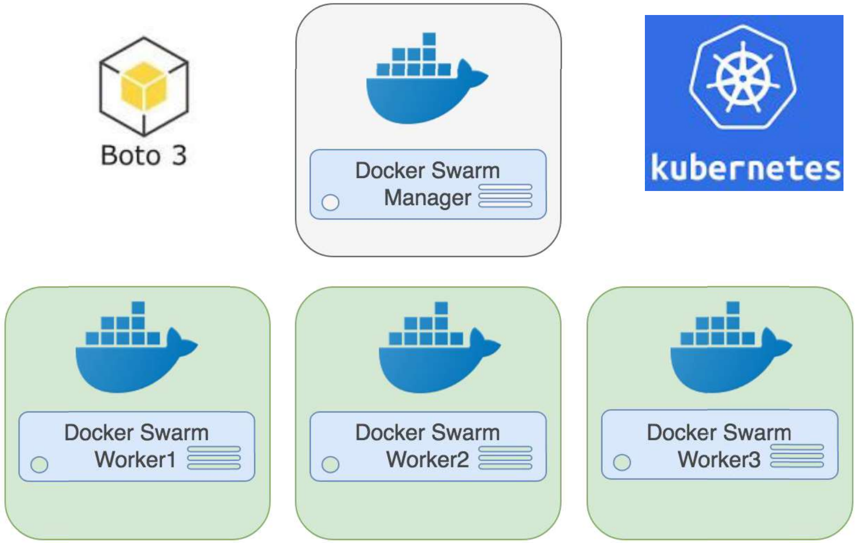
Open Source software components used



CbM on DIAS: Frontend data access

On-line training for Outreach, 30 September 2021

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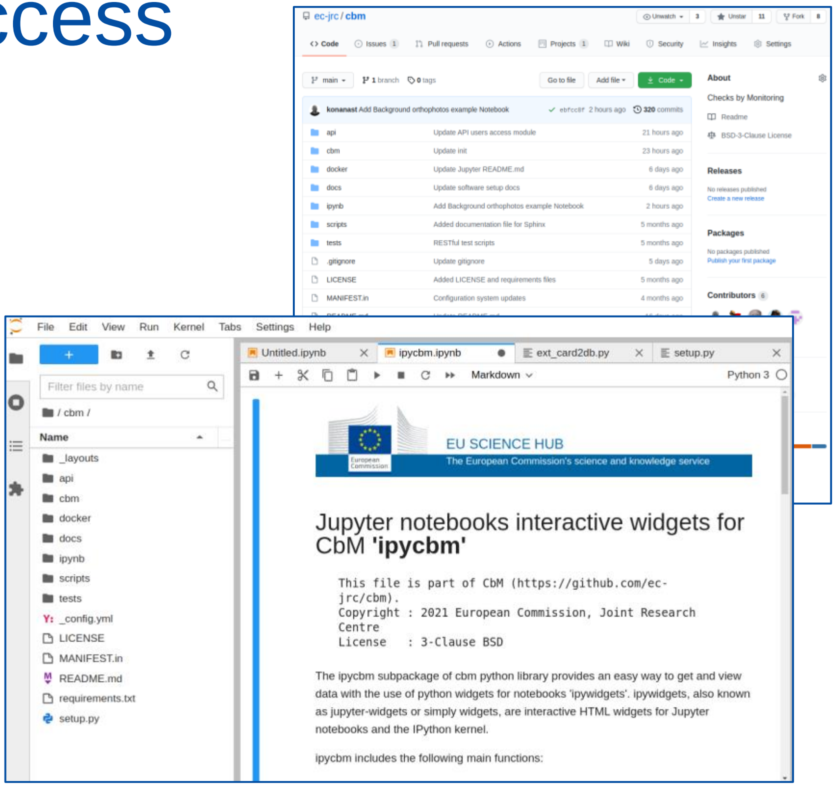
CbM Frontend data access

- **Data Access**
  - **RESTful API**
  - **Data Exports**
- **Jupyter Notebooks**
- **Examples**
- **CbM git repository**
- **Links**



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CbM data access

RESTful API

RESTful API Requirements:

- RESTful account from JRC
- Basic programing knowledge*

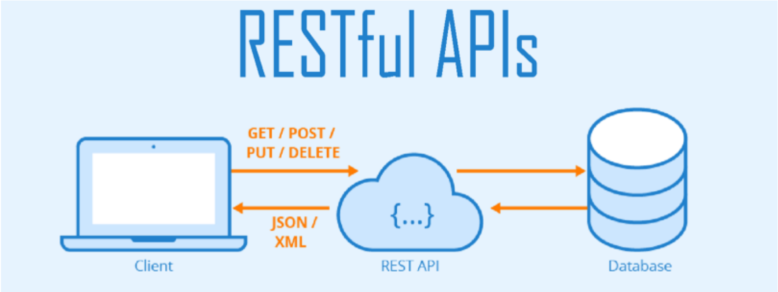
➢ **JRC does not provide direct database access**

Data Exports

Alternative data access Requirements:

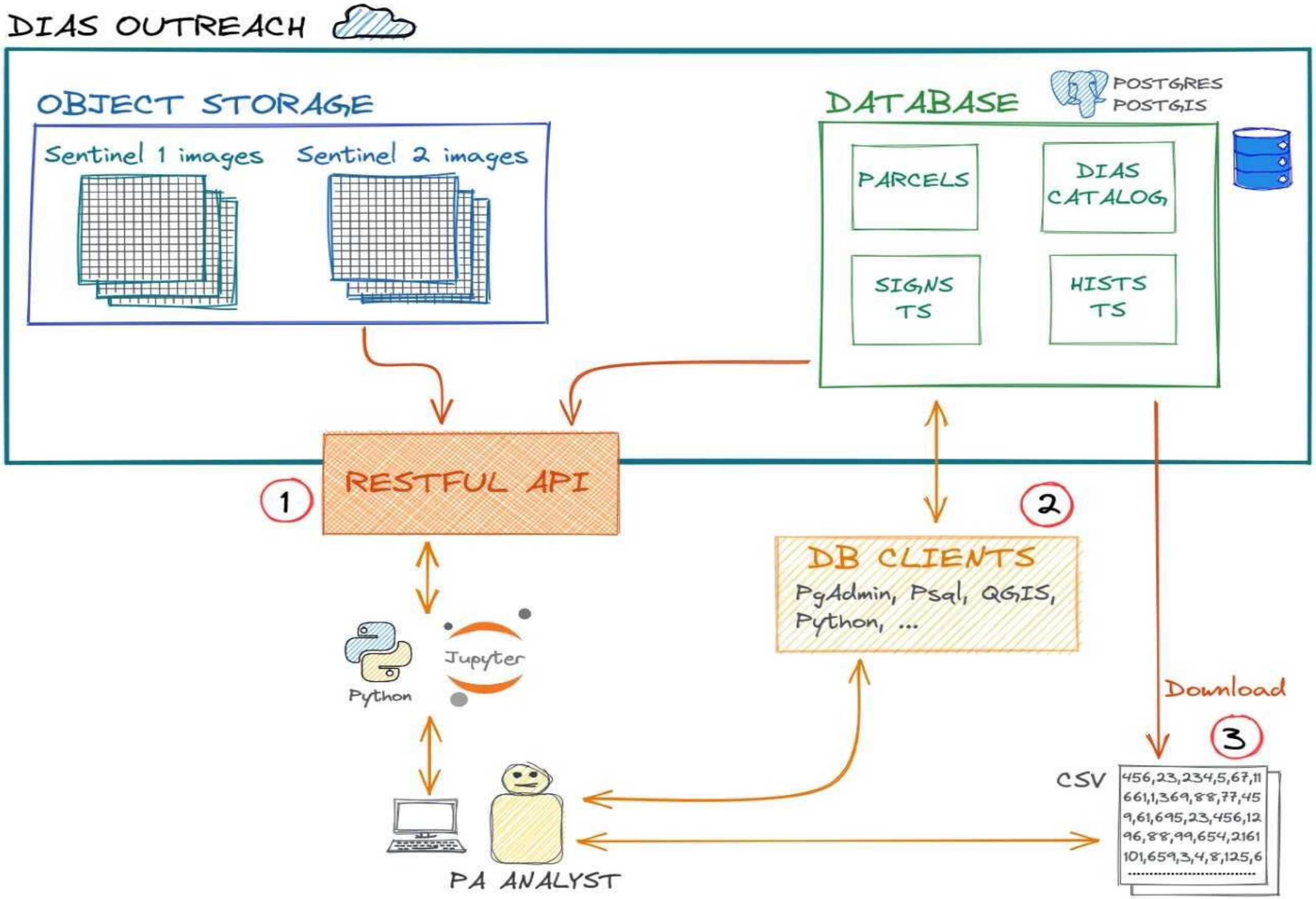
- Extracted data from JRC database
- A Postgres database server with PostGIS
- Good backend server management skills
- Good programing skills

RESTful APIs



Advantages:

- Provides predefined simplified functionalities to extract data based on a controlled set of parameters
- Ensures performance and security by preventing poorly designed resource-intensive queries and by adding other functionalities.
- Facilitates access to basic users with limited technical knowledge
- Simplifies the back-end management



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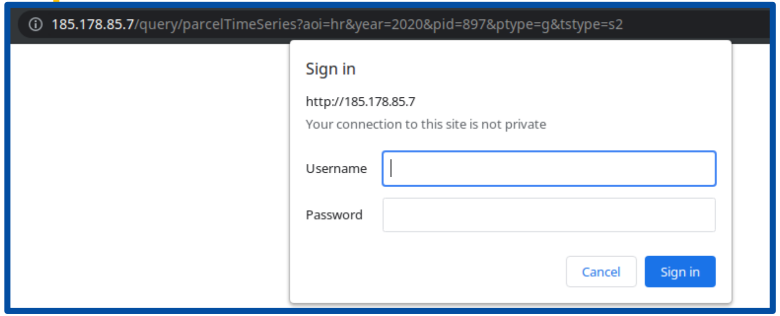
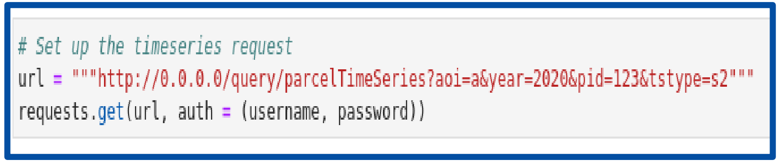
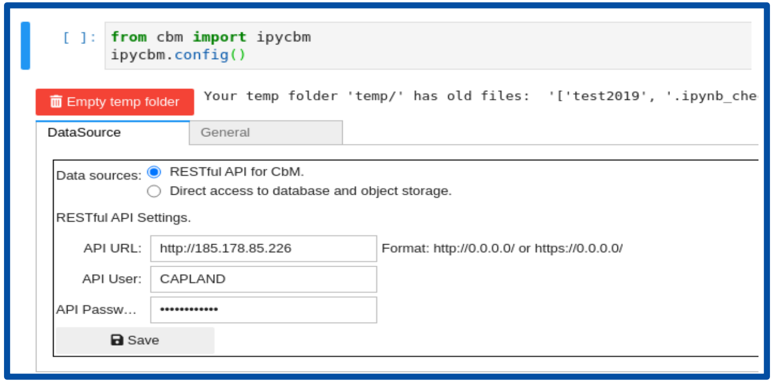
RESTful API data view methods



- **From the web browser**



- **Use of non Interactive scripts**



- **Interactively GUI within Jupyter Notebooks**

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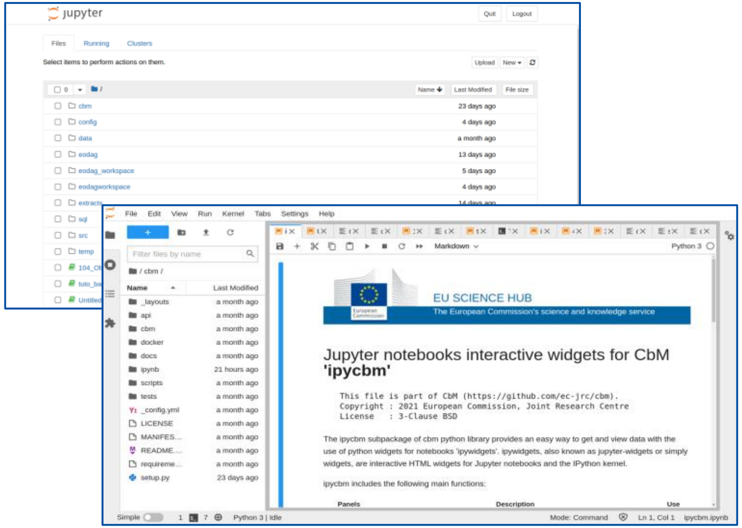
Jupyter Notebooks

https://jupyter.org/try



Jupyter Notebooks are documents that contain live code, equations, visualizations and narrative text.

Why Jupyter Notebooks:

- Open-source
- Exploratory Data Analysis (EDA)
- Easy Caching In Built-In Cell
- Language Independent
- Data Visualisation
- Live Interactions With Code
- Documenting code samples
- Extensible

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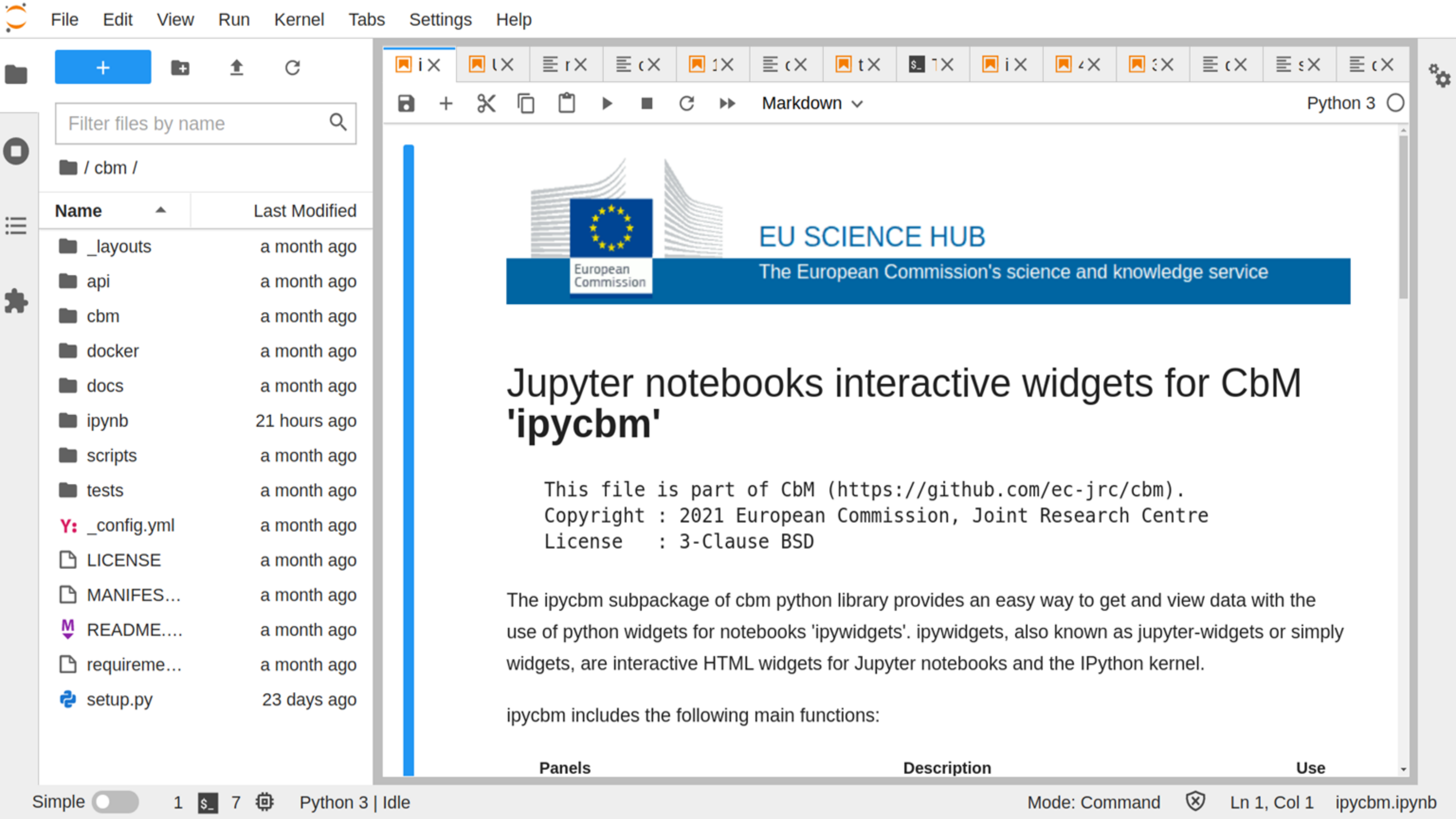

File Edit View Run Kernel Tabs Settings Help
Filter files by name
/ cbm /
Name
Last Modified
_layouts a month ago
api a month ago
cbm a month ago
docker a month ago
docs a month ago
ipynb 21 hours ago
scripts a month ago
tests a month ago
_config.yml a month ago
LICENSE a month ago
MANIFES... a month ago
README.... a month ago
requireme... a month ago
setup.py 23 days ago
Markdown
Python 3
European Commission
EU SCIENCE HUB
The European Commission's science and knowledge service
Jupyter notebooks interactive widgets for CbM 'ipycbm'
This file is part of CbM (https://github.com/ec-jrc/cbm).
Copyright : 2021 European Commission, Joint Research Centre
License : 3-Clause BSD
The ipycbm subpackage of cbm python library provides an easy way to get and view data with the use of python widgets for notebooks 'ipywidgets'. ipywidgets, also known as jupyter-widgets or simply widgets, are interactive HTML widgets for Jupyter notebooks and the IPython kernel.
ipycbm includes the following main functions:
Panels
Description
Use
Simple
1
7
Python 3 | Idle
Mode: Command
Ln 1, Col 1
ipycbm.ipynb

RESTful Access with Notebooks

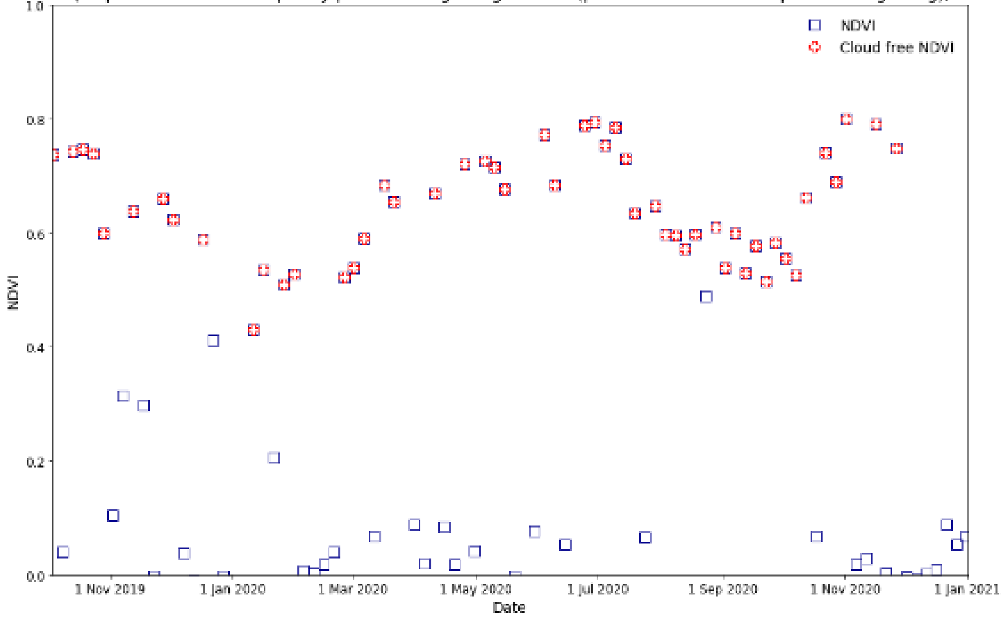
[ ]:
```
# install cbm python package
!pip install cbm
```

[6]:
```
import cbm
```

[ ]:
```
cbm.set_api_account("http://185.178.85.7/", "YOUR_Username", "YOUR_Password")
```

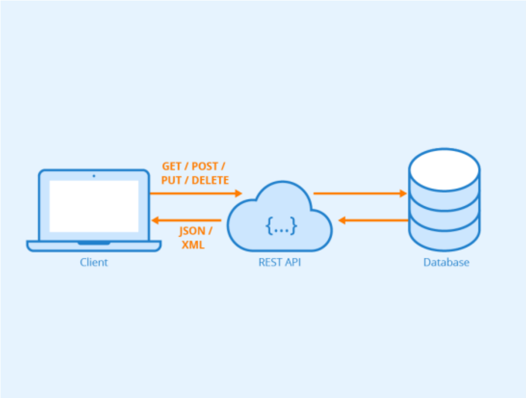
[2]:
```
cbm.show.time_series.ndvi('ms', '2020', '12345')
```

Parcel 05480-52-1-1 (crop: Permanent or temporary pastures for grazing animals (pastures and mountain pasture for grazing), area: 3325.40 sqm)



RESTful queries

- Parcel information
  - **parcelByLocation, parcelByID**
- Parcel signatures time series
  - **parcelTimeSeries**
- Parcel sentinel images
  - **chipByLocation, rawChipByLocation**
- Parcel orthophotos
  - **backgroundByLocation, backgroundByParcelId**
- Parcel peers
  - **parcelPeers**



RESTful API requests structure

Fixed part

Dynamic part

mandatory

optional

https://cap.users.creodias.eu/query/parcelPeers?aoi=MS&year=2020&pid=123&distance=1000&max=10

protocol

host name

path

parameters

RESTful - Parcel information

- parcelByLocation
  cap.users.creodias.eu/query/parcelByLocation?aoi=AA&year=2020&lon=6.32&lat=52.34
- parcelByID
  cap.users.creodias.eu/query/parcelById?aoi=AA&year=2020&pid=123&withGeometry=True

	Parameters	Type	Description
mandatory	**aoi**	String 2 - 5 characters	Area of Interest
	year	4 digits int	The target year
	• **lon/ lat**	Float	Longitude and latitude in decimal degrees
	• **pid**	String	ID of the parcel that has to be retrieved
optional	*withGeometry=True*	True or False (default)	Adds the geometry
	ptype	g,m,n. etc.	parcels dedicated to different analyses

RESTful USE

Get parcel information:

cap.users.creodias.eu/query/parcelById?aoi=ms&year=2020&pid=1234&withGeometry=True

Not secure | 185.178.85.7/query/parcelById?aoi=hr&year=2020&pid=324&ptype=g&withGeometry=True

{"ogc_fid": [324], "cropname": ["karst pasture"], "cropcode": [1702.0], "srid": [3765], "geom": ["{\"type\":\"MultiPolygon\",\"crs\":{\"type\":\"name\",\"properties\":{\"name\":\"EPSG:3765\"}},\"coordinates\":[[[[421224.59,4882801.222],[421202.728,4882773.123],[421167.328,4882813.117],[421130.577,4882854.192],[421129.045,4882873.401],[421139.485,4882880.788],[421146.95,4882879.834],[421150.539,4882878.055],[421159.507,4882869.963],[421185.558,4882839.787],[421224.59,4882801.222]]]]}"], "area": [3770.727024015728], "clon": [15.515777062644197], "clat": [44.08121398033482]}

Browser

Notebook

[2]:
```python
import cbm
cbm.get.parcel_info.by_pid('nld', 2019, 575541, True)
```

[2]:

```
{'ogc_fid': [575541],
 'cropname': ['Grasland, blijvend'],
 'cropcode': [265],
 'srid': [28992],
 'geom': ['{"type":"MultiPolygon","crs":{"type":"name","properties":{"name":"EPSG:28992"}},"coordinates":[[[[96576.009,417328.430199999],[96574.206300002,417366.527],[96572.206999998,417375.69],[96571.040800002,417391.0174],[96571.374000002,417396.6818],[96575.705699999,417414.175],[96578.3713,417432.334600002],[96688.661499999,417434.667],[96689.6611,417427.5031],[96690.993900001,417375.523400001],[96692.9932,417375.523400001],[96691.827,417434.167199999],[96695.159000002,417435.5],[96758.301,417435.9998],[96795.286499999,417436.832800001],[96800.2846,417436.499600001],[96803.616599999,417433.834],[96803.9498,417421.6721],[96804.9494,417376.189800002],[96806.282200001,417369.525800001],[96805.4492,417363.694699999],[96805.949,417336.372099999],[96804.283,417333.04],[96803.350099999,417333.450100001],[96782.7914,417332.207],[96738.1422,417331.374],[96589.866799999,417328.5418],[96576.009,417328.430199999]]]]}'],
 'area': [23898.22330816267],
 'clon': [4.542926127180021],
 'clat': [51.74211190705306]}
```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RESTful - Parcel Time Series

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

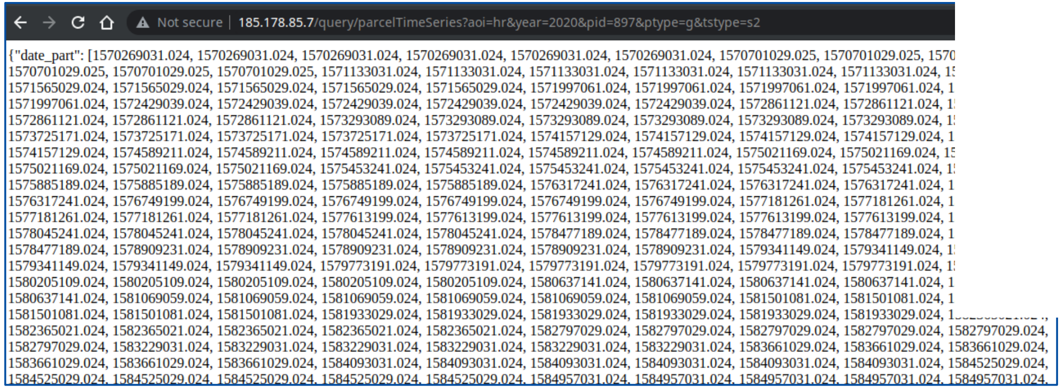
	Parameters	Type	Description
mandatory	**aoi**	String 2 - 5 characters	Area of Interest
	year	4 digits int	The year
	pid	String	Any geographical coordinate inside the respective territories
optional	tstype	s2(default), c6, bs	time series type
	band	B4, B8, SC or VV, VH	a selected band
	ptype	g,m,n. etc.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



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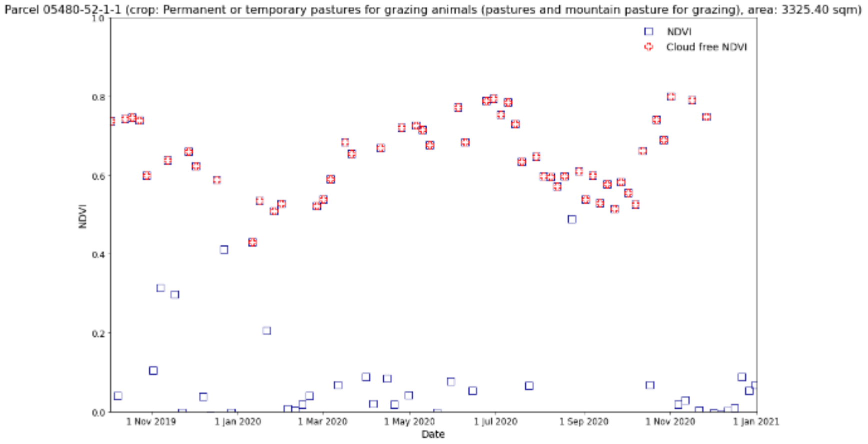
Notebook

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



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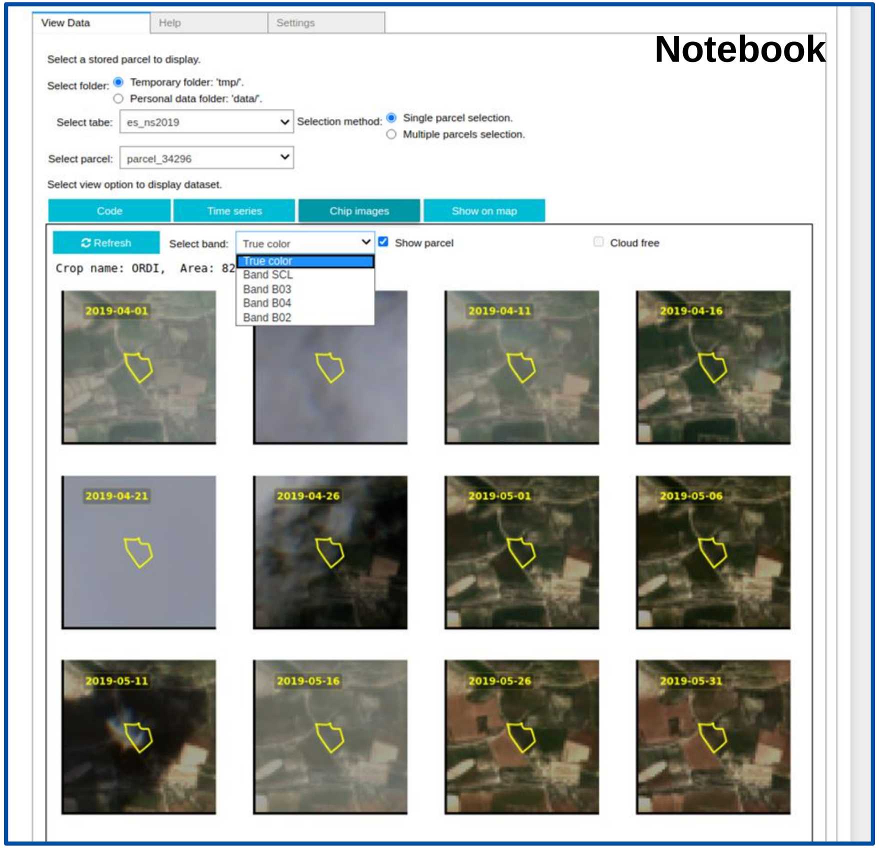
RESTful - Parcel Sentinel images

- rawChipByLocation

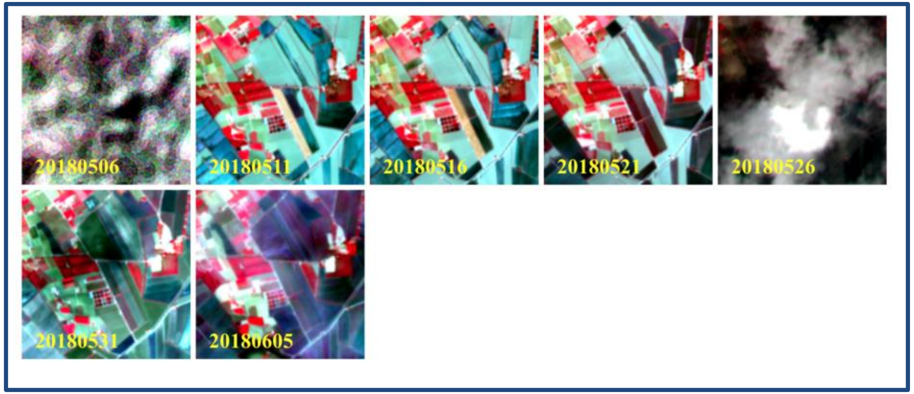
  `cap.users.creodias.eu/query/rawChipByLocation?lon=1.23&lat=1.23&start_date=2019-06-01&end_date=2019-06-30&band=B04&chipsize=2560`

Parameters	Format	Description
lon, lat	a string representing a float number	Any geographical coordinate where Level-2A Sentinel-2 is available
start_date, end_date	YYYY-mm-dd	Time window for which Level-2A Sentinel-2 is available (after 27 March 2018)
band	Bn1	Sentinel-2 band name. One of [‘B02’, ‘B03’, ‘B04’, ‘B08’] (10 m bands) or [‘B05’, ‘B06’, ‘B07’, ‘B8A’, ‘B11’, ‘B12’, ‘SCL’] (20 m bands).
chipsize	string	Defaults to ‘1280’. Cannot be larger than ‘5120’
plevel	string	‘LEVEL2A’ (default), ‘LEVEL1C’. Use LEVEL1C where LEVEL2A is not avaiable

RESTful - Parcel Sentinel images



Browser



RESTful - Parcel orthophotos

- backgroundByLocation
  cap.users.creodias.eu/query/backgroundByLocation?lon=1.32&lat=1.34&chipsize=512&extend=256.0
- backgroundByParcelID
  cap.users.creodias.eu/query/backgroundByParcelID?aoi=MS&year=2020&pid=1234&chipsize=512&extend=256.0

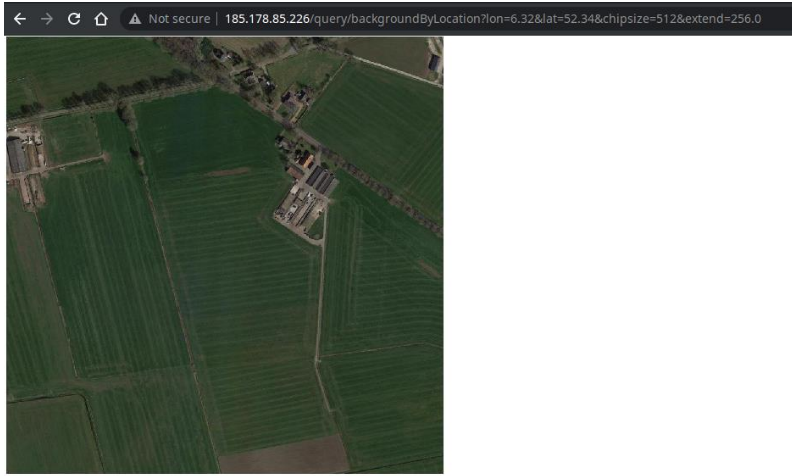
Parameters	Format	Description
lon, lat	a string representing a float number	Any geographical coordinate
chipsize	integer	The size of the chip image
extend	float	the effective resolution of the chip is extend/chipsize
tms	string	Google (default), Bing or MS orthophotos
ptype	g,m,n. etc.	parcels dedicated to different analyses

RESTful USE

Get parcel’s orthophotos

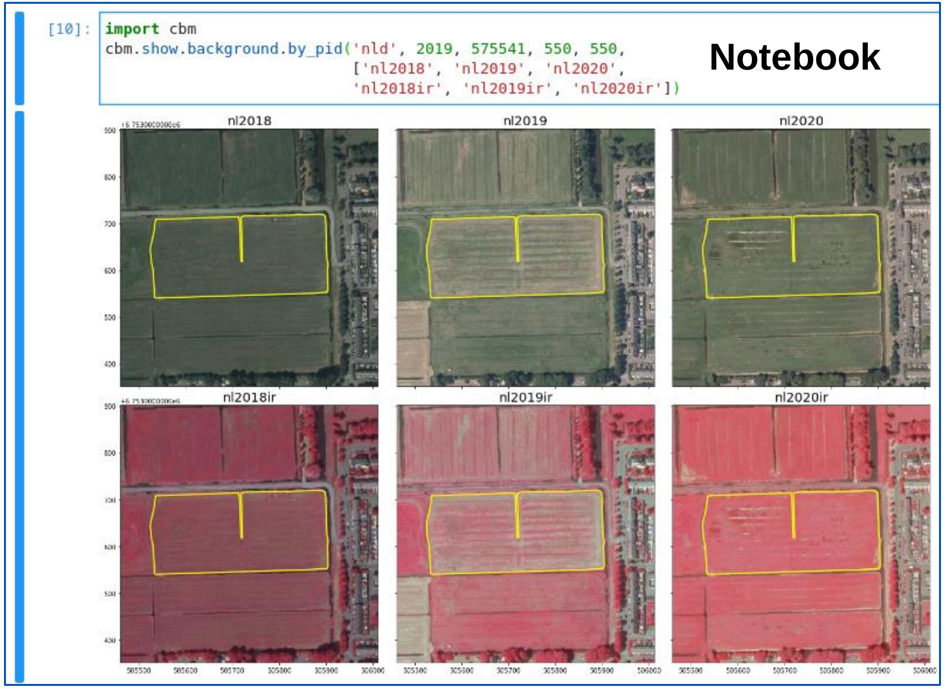
cap.users.creodias.eu/query/backgroundByLocation?lon=6.32&lat=52.34&chipsize=512&extend=256.0

Browser

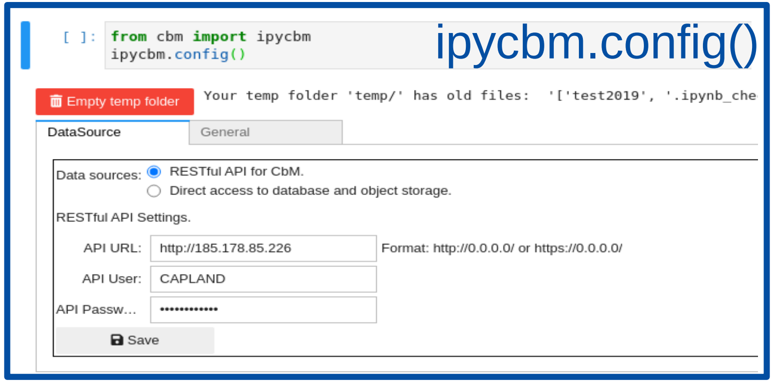


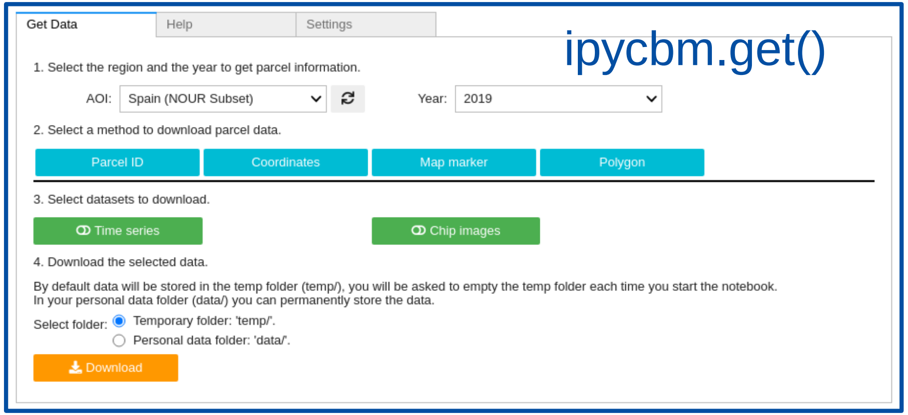
dump/62_74_7_192E6_32N52_34_512_256_0_Google/google.tif

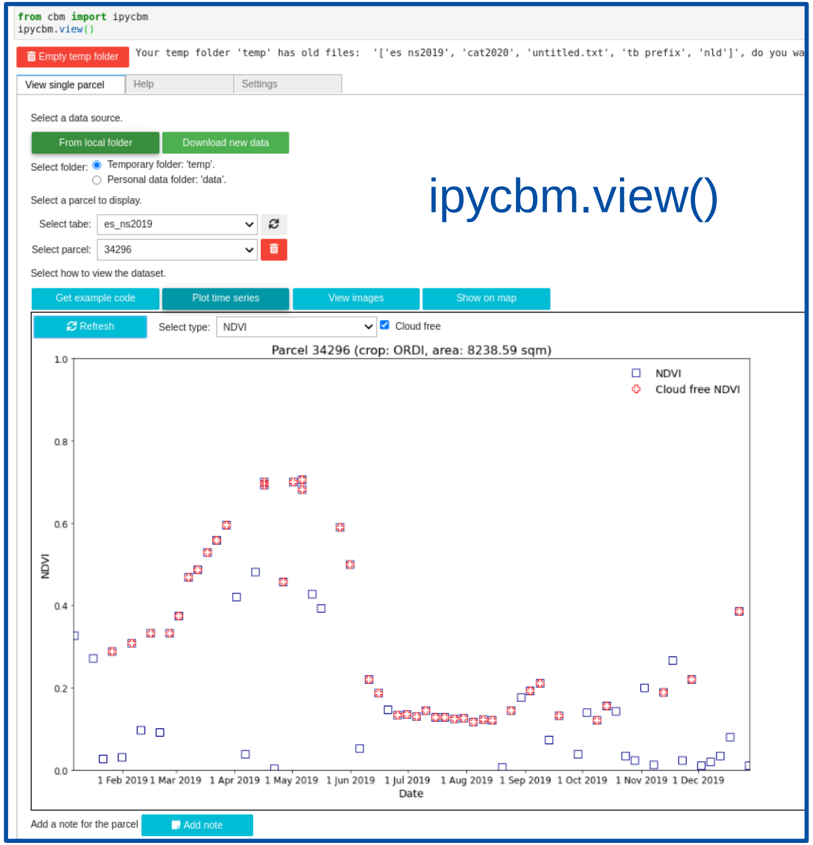
Notebook



cbm.ipycbm Examples







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CbM git repository

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

- api
- cbm
- docker
- docs
- ipynb
- scripts
- tests

- 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 scripts for signatures extraction and calendar generation

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

Links to get started

- ➔ **CbM repository: https://github.com/ec-jrc/cbm**
- ➔ CbM Documentation: https://jrc-cbm.readthedocs.io
- ➔ CbM Python library: https://pypi.org/project/cbm
- ➔ CbM docker images: https://hub.docker.com/u/gtcap

Other technical information:

- Creating pull requests with an interactive way:
  - docs.github.com/en/github/collaborating-with-issues-and-pull-requests/creating-a-pull-request
- Using git guide non interactively:
  - http://rogerdudler.github.io/git-guide
- Google Python Style Guide:
  - https://google.github.io/styleguide/pyguide.html
- Markdown (.md) and reStructuredText (.rst) guides:
  - https://www.markdownguide.org, https://docutils.sourceforge.io/rst.html
- Jupyter Notebooks:
  - https://jupyter-notebook.readthedocs.io/
  - Jupyter Notebook CheatSheet: Jupyter_Notebook_CheatSheet_Edureka.pdf
- Get started with python:
  - https://python101.pythonlibrary.org/
  - https://www.programiz.com/python-programming/first-program
  - https://realpython.com/tutorials/data-viz https://python-graph-gallery.com
  - https://realpython.com/tutorials/machine-learning

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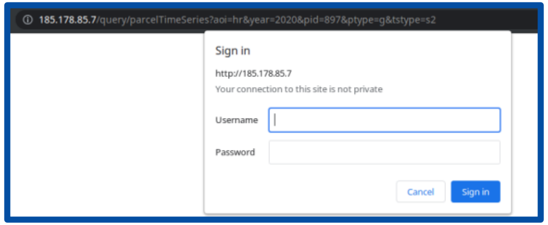
RESTful API Access



Please submit name of one person responsible for data access via restful service. The account will be created for this profile.

Submission should me made via email to Rafał and Kostas:

rafal.zielinski@ec.europa.eu &

konstantinos.anastasakis@ext.ec.europa.eu

European Commission

Q&A

guido.lemoine@ec.europa.eu
pavel.milenov@ext.ec.europa.eu
csaba.wirnhardt@ec.europa.eu
daniele.borio@ec.europa.eu
ferdinando.urbano@ec.europa.eu
gilbert-madalin.voican@ec.europa.eu
konstantinos.anastasakis@ext.ec.europa.eu

Image chip extract processing

The „calendar view” use case

Parcel time series processing from RESTful

Csaba Wirnhardt

DIAS frontend webinar, 30th September 2021

CbM context

CbM main workflow:

- **Batch extract** of signatures for all parcels
- **Automated processing** of large volumes

But:

- Consulting **individual cases (parcels)** is important for:
  - Marker development (parametrisation)
  - Checking yellow cases detected by the automated procedure
  - Annual CbM Quality Assessment (used operationally by some MS)

Main characteristics of chip extract processing

- Standalone - necessary python libraries: requests, geopandas, rasterio, matplotlib, osgeo, rasterstats, etc
- Based on these 3 RESTful services:
  - **rawChipByLocation** (https://jrc-cbm.readthedocs.io/en/latest/api_imgs.html)
  - **rawChipsBatch** and **rawS1ChipsBatch** (https://jrc-cbm.readthedocs.io/en/latest/api_post.html)
- Source code in cbm Git repository (https://github.com/ec-jrc/cbm/tree/main/scripts/calendar_view_gui)
- Documentation in cbm Git repository (https://github.com/ec-jrc/cbm/blob/main/docs/uc_calendar.md)
- Not a professional software – proof of concept

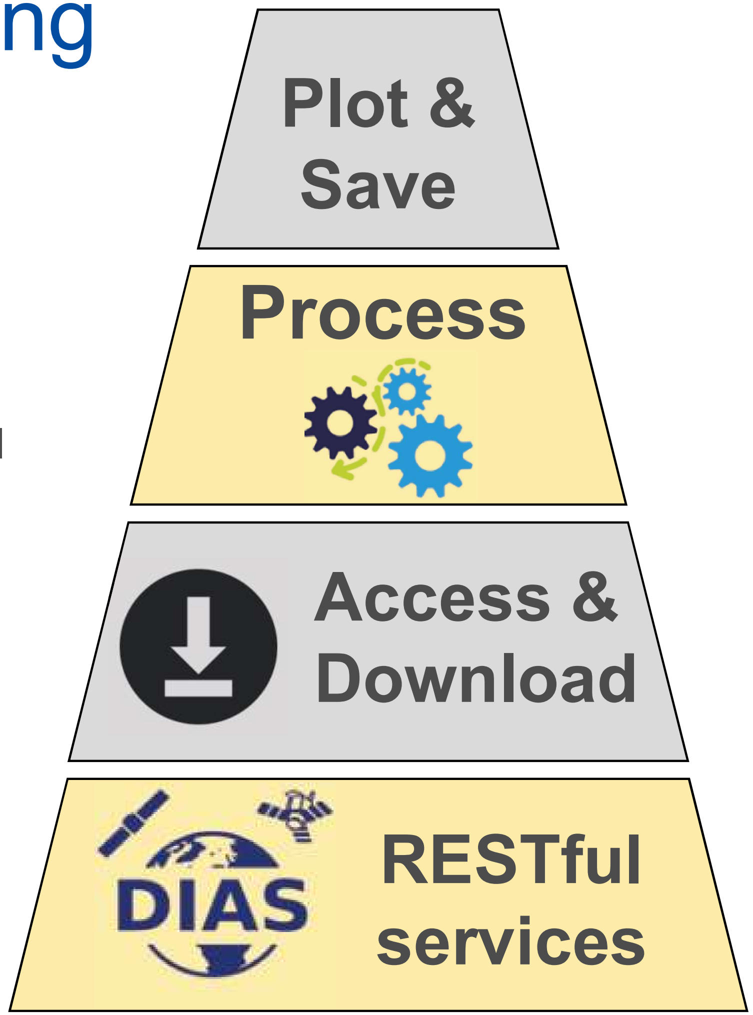
Python Libraries for chip processing

Python libraries for **searching**, **downloading** and **processing** Sentinel-1 and Sentinel-2 data

Download_utils.py → Access RESTful services and download ***full resolution*** Sentinel image subsets (imagettes/chips)

Batch_utils.py → Batch processing of imagettes related to a single parcel

graph_utils.py & plot_utils.py → Generation and display of final outputs (NDVI, calendar view….)



Additional libraries for more specialized functions

A Typical Processing Loop

Modular libraries able to accommodate different needs

For each parcel:

1) Get list of images covering the parcel (in a specific date range)

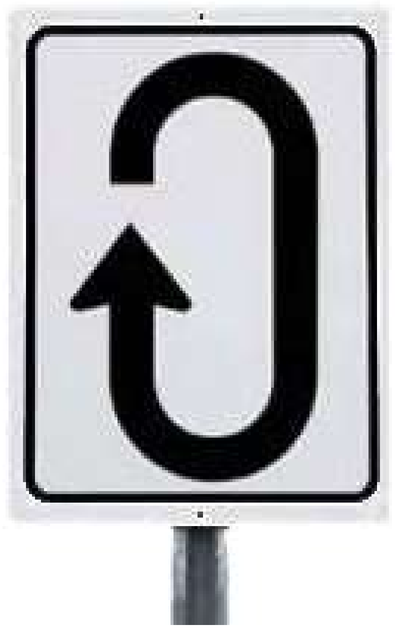
2) Download all SCL imagettes
   or use SCL histogram from outreach database with RESTful

3) Filter list of imagettes to download (cloud information)(S2 only)

4) Download imagettes from different bands
(e.g. S2: B04/Red, B08/NIR, B11/SWIR; S1: backscatter, coherence)

5) Processing: imagettes LUT stretch, NDVI/BSI calculation

6) Plotting and saving outputs



the code is general and can be easily adapted to work on geotiff downloaded from other sources

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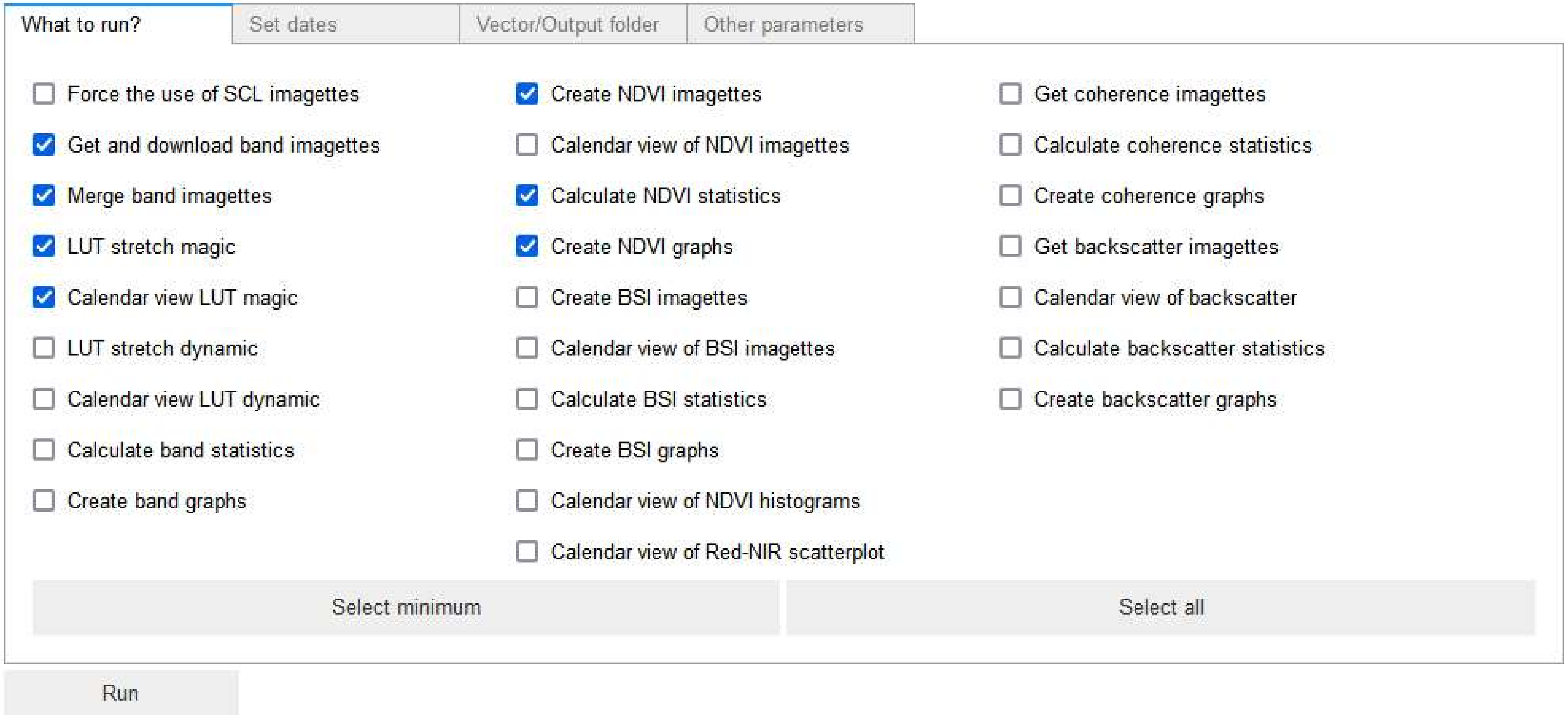
Chip extract processing GUI

Run calendar view script



https://github.com/ec-jrc/cbm/blob/main/scripts/calendar_view_gui/calendar_view_gui.ipynb

Live demo

Output folder structure

\ownCloud\GTCAP\Outreach_2021\MS_direcory\NL\mowing_c

Név	Kit.	Méret
[..]		<DIR>
[20_Grassland permanent]		<DIR>
[20_Grassland permanent_merged]		<DIR>
[20_Grassland permanent_merged_lut_magic]		<DIR>
[20_Grassland permanent_merged_ndvi]		<DIR>
[ndvi]		<DIR>
[ndvi_graphs]		<DIR>
[ndvi_graphs_fixed_date_range]		<DIR>
[overview_jpg_half_weekly]		<DIR>
run_params_2021_07_21_09_09_19	json	1 371
log	txt	895
lut	txt	2 431

Live demo – minimum output

\GTCAP\Outreach_2021\MS_direcory\NL\mowing_detection\cl

Név	Kit.	Méret
[..]		<DIR>
[1_Grassland permanent]		<DIR>
[1_Grassland permanent_merged]		<DIR>
[1_Grassland permanent_merged_lut_magic]		<DIR>
[1_Grassland permanent_merged_ndvi]		<DIR>
[1_Grassland permanent_s1_bs]		<DIR>
[1_Grassland permanent_s1_bs_rescale]		<DIR>
[1_Grassland permanent_s1_bs_rescale_lut]		<DIR>
[1_Grassland permanent_s1_coh6]		<DIR>
[ndvi]		<DIR>
[ndvi_graphs]		<DIR>
[ndvi_graphs_fixed_date_range]		<DIR>
[overview_jpg_half_weekly]		<DIR>
[overview_jpg_half_weekly_ndvi]		<DIR>
[s1_bs]		<DIR>
[s1_bs_calendar_view]		<DIR>
[s1_bs_graphs_together]		<DIR>
[s1_coh6]		<DIR>
[s1_coh6_graphs_together]		<DIR>
run_params_2021_07_06_11_58_40	json	1 361
log	txt	2 164
lut	txt	5 977

Live demo – reduced output

Live demo – full output

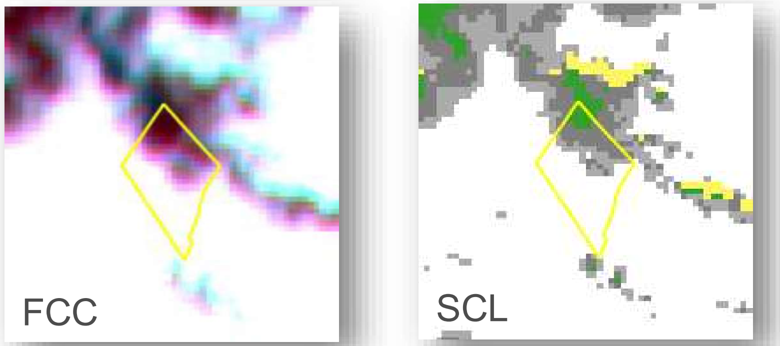
c:\Users\Csaba\ownCloud\GTCAP\agri_audit_support\fr\chips2019_new*.*

Név	Kit.	Méret
[..]		<DIR>
[640064_Soft winter wheat]		<DIR>
[640064_Soft winter wheat_merged]		<DIR>
[640064_Soft winter wheat_merged_bare_soil_index]		<DIR>
[640064_Soft winter wheat_merged_lut_dynamic]		<DIR>
[640064_Soft winter wheat_merged_lut_magic]		<DIR>
[640064_Soft winter wheat_merged_ndvi]		<DIR>
[640064_Soft winter wheat_s1_bs]		<DIR>
[640064_Soft winter wheat_s1_bs_rescale]		<DIR>
[640064_Soft winter wheat_s1_bs_rescale_lut]		<DIR>
[640064_Soft winter wheat_s1_coh6]		<DIR>
[band_graphs]		<DIR>
[band_stats]		<DIR>
[bare_soil_index]		<DIR>
[bare_soil_index_graphs]		<DIR>
[ndvi]		<DIR>
[ndvi_graphs]		<DIR>
[ndvi_graphs_fixed_date_range]		<DIR>
[overview_hist_half_weekly]		<DIR>
[overview_jpg_half_weekly]		<DIR>
[overview_jpg_half_weekly_bare_soil_index]		<DIR>
[overview_jpg_half_weekly_dyn]		<DIR>
[overview_jpg_half_weekly_ndvi]		<DIR>
[overview_scatter_half_weekly_fixed_scale_cumulative]		<DIR>
[s1_bs]		<DIR>
[s1_bs_calendar_view]		<DIR>
[s1_bs_graphs_together]		<DIR>
[s1_coh6]		<DIR>
[s1_coh6_graphs_together]		<DIR>
log	txt	2 993
lut	txt	9 074
run_params_2021_07_17_15_20_26	json	1 332

Use of Sentinel-2 Level 2A Scene Classification Layer for cloud screening

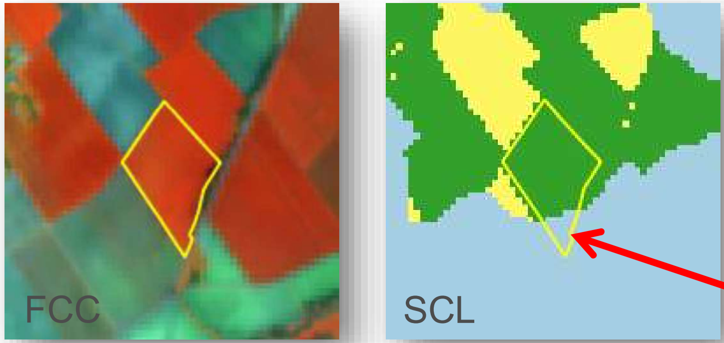
Correct detection of clouds

2019-06-12

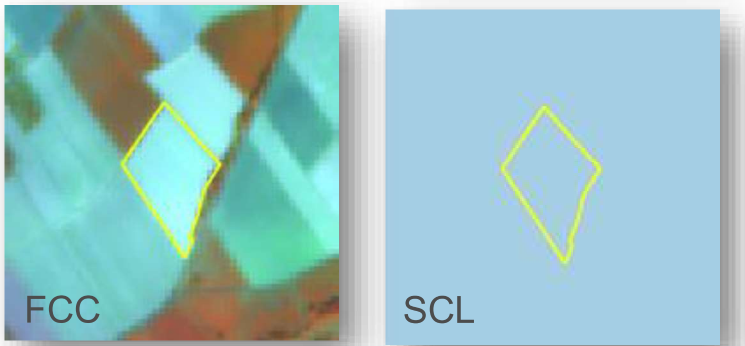


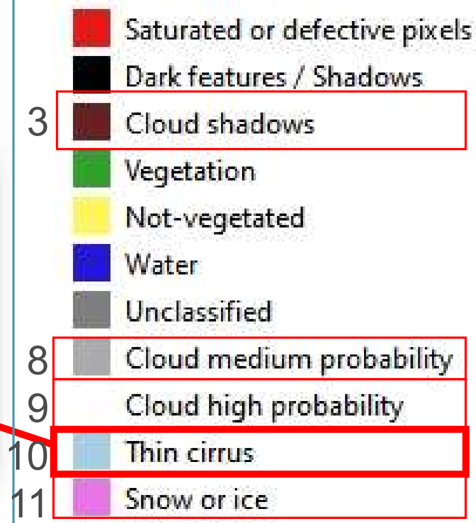
False detection of clouds

2019-04-06



2019-08-01





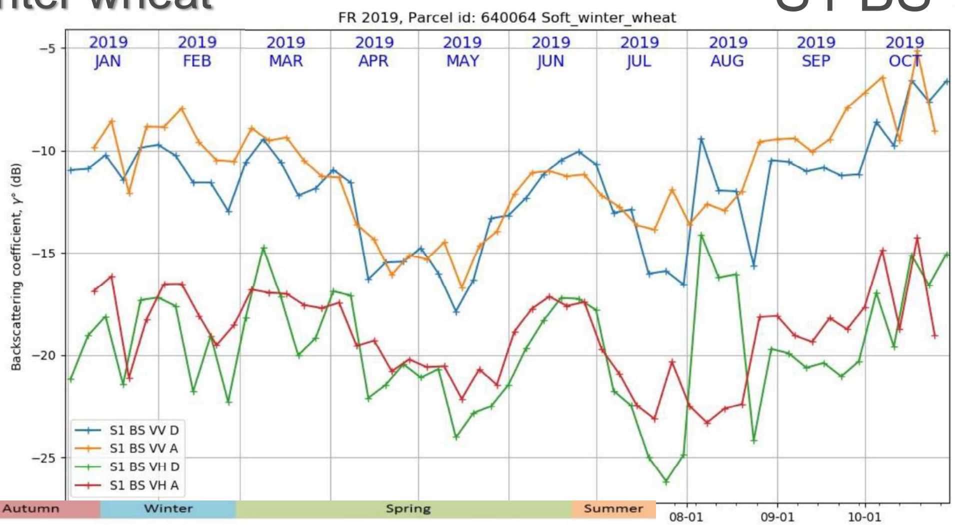
cloud_categories = [3,8,9,10,11]

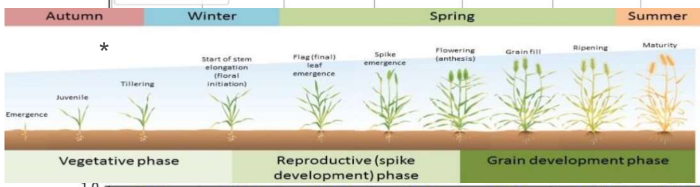
SCL cloud mask is good, but „thin cirrus" is problematic:

- Our approach: start extracting time series without dates where cirrus is detected → if too many dates left out include dates with cirrus

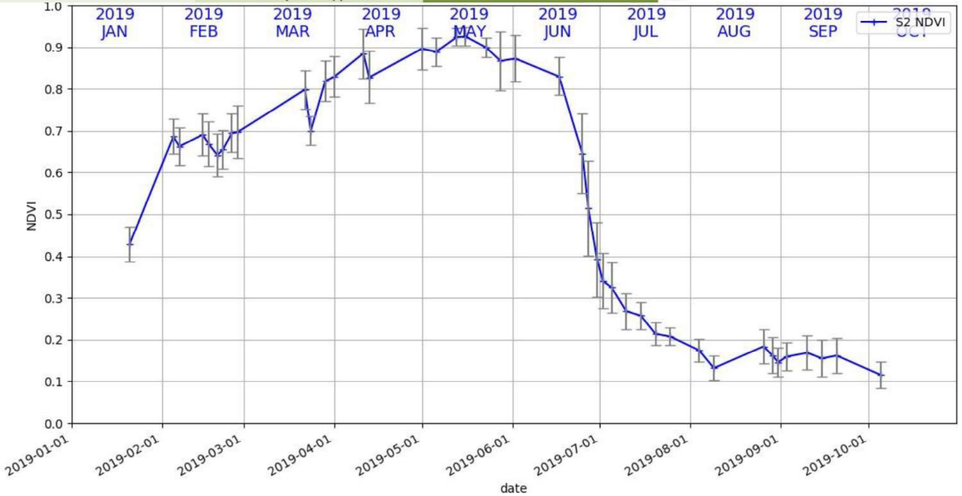
Winter wheat

S1 BS

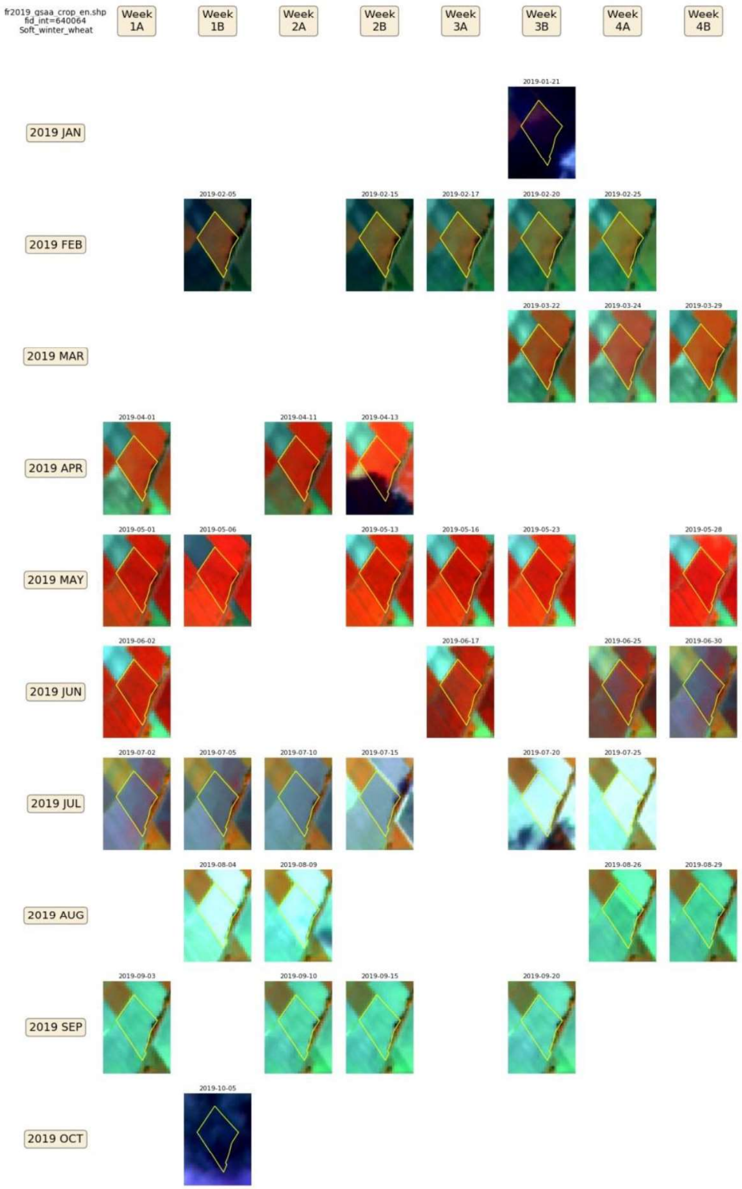




S2 NDVI



*Phenology stages graphics source: https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-papers/2018/08/wheat-phenology-and-the-drivers-for-yield-in-the-high-rainfall-zone



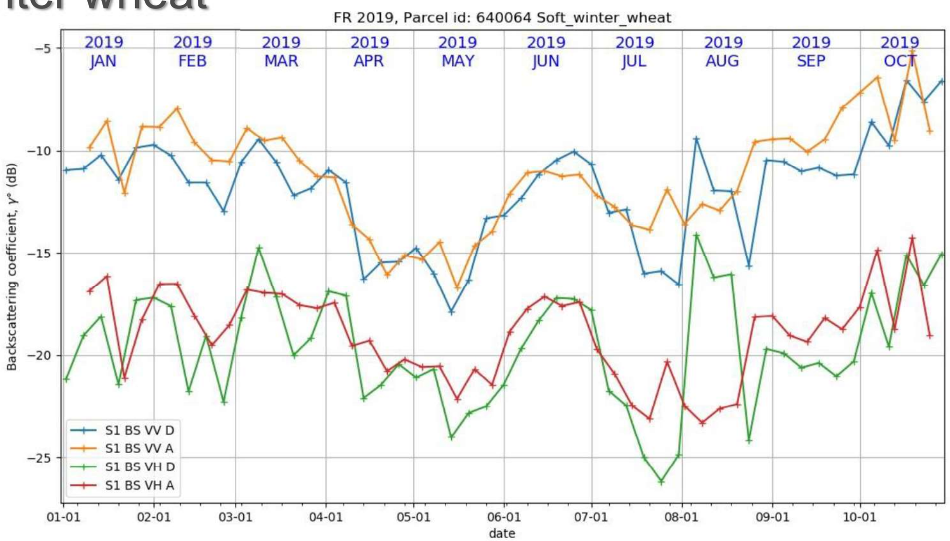
Calendar view

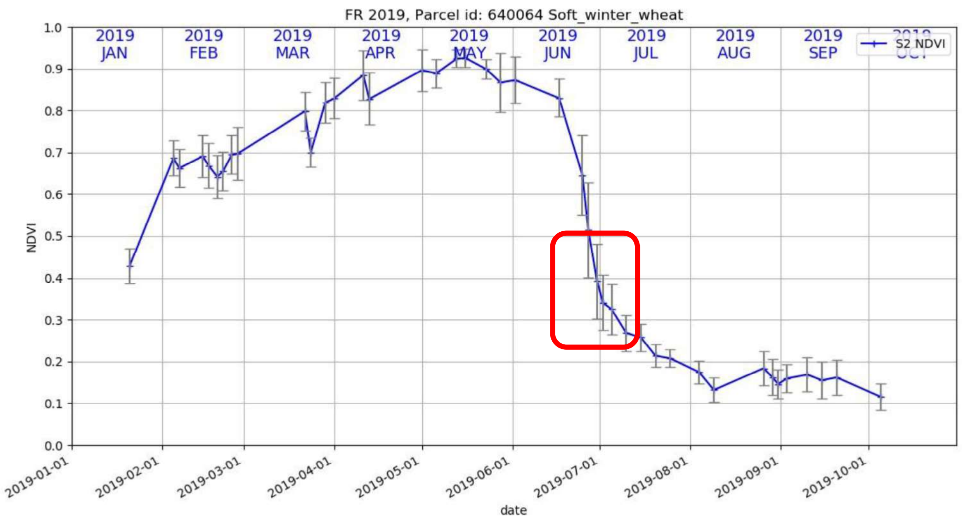
S2 False Colour Composite (FCC) 8,11,4 RGB LUT stretched (generic)

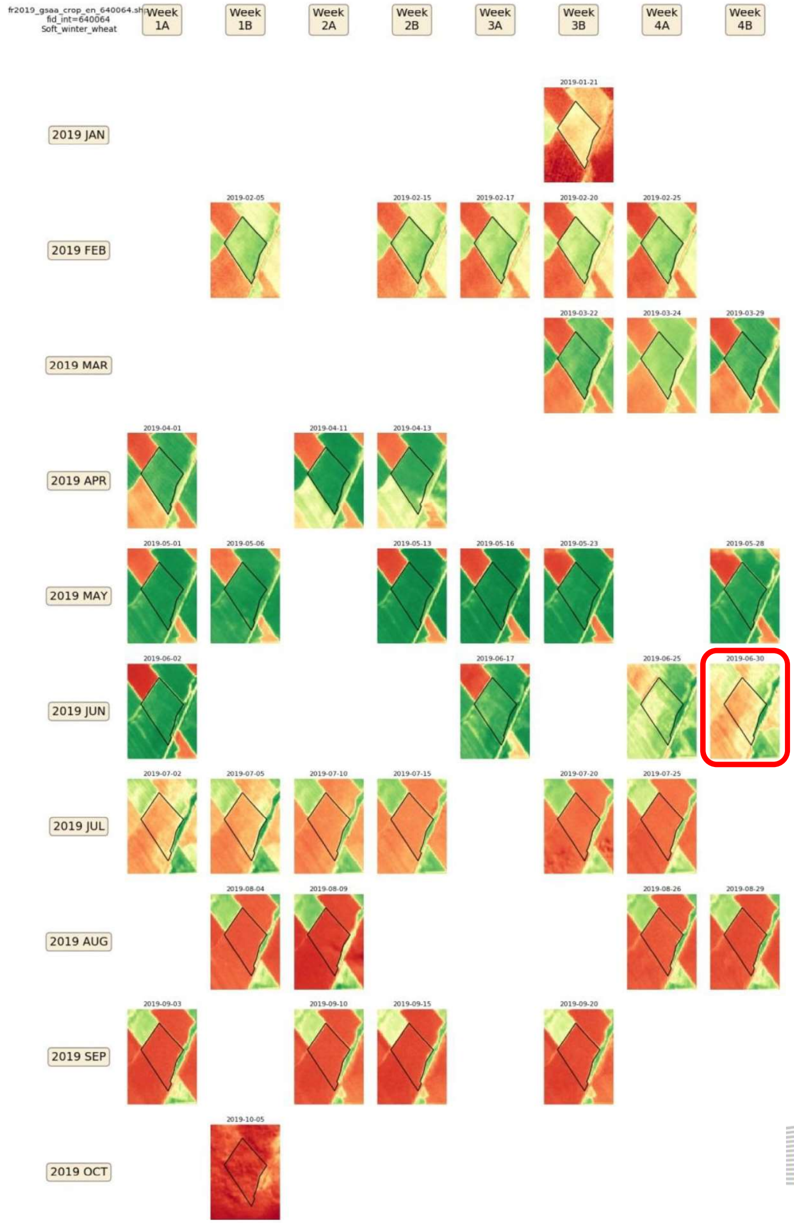
red = B08
green = B11
blue = B04

rmin = 1200
rmax = 5700
gmin = 800
gmax = 4100
bmin = 150
bmax = 2800

Winter wheat

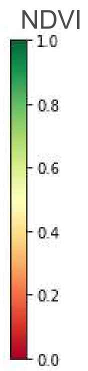




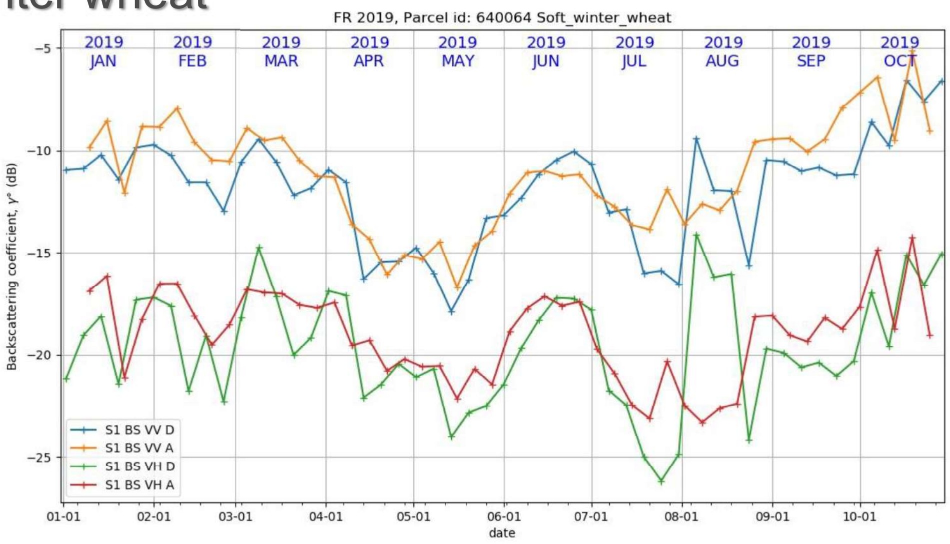


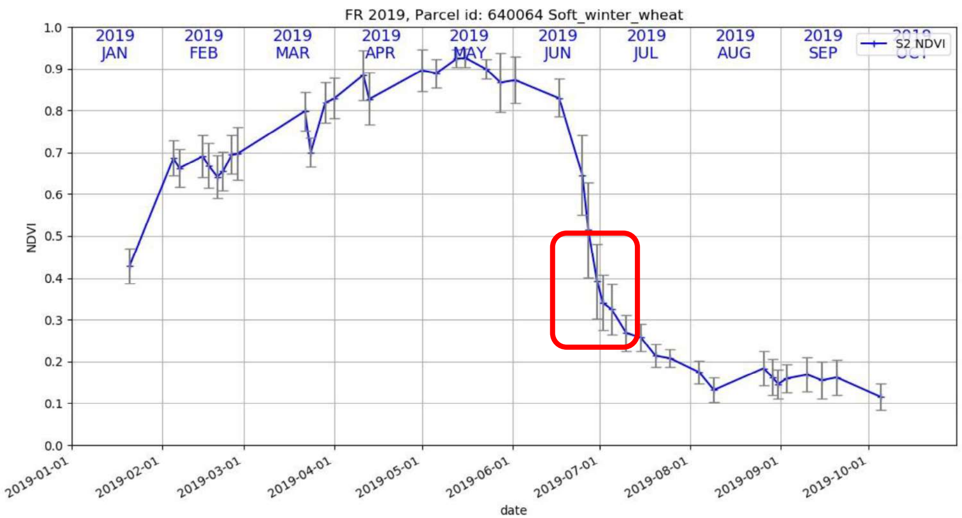
Calendar view

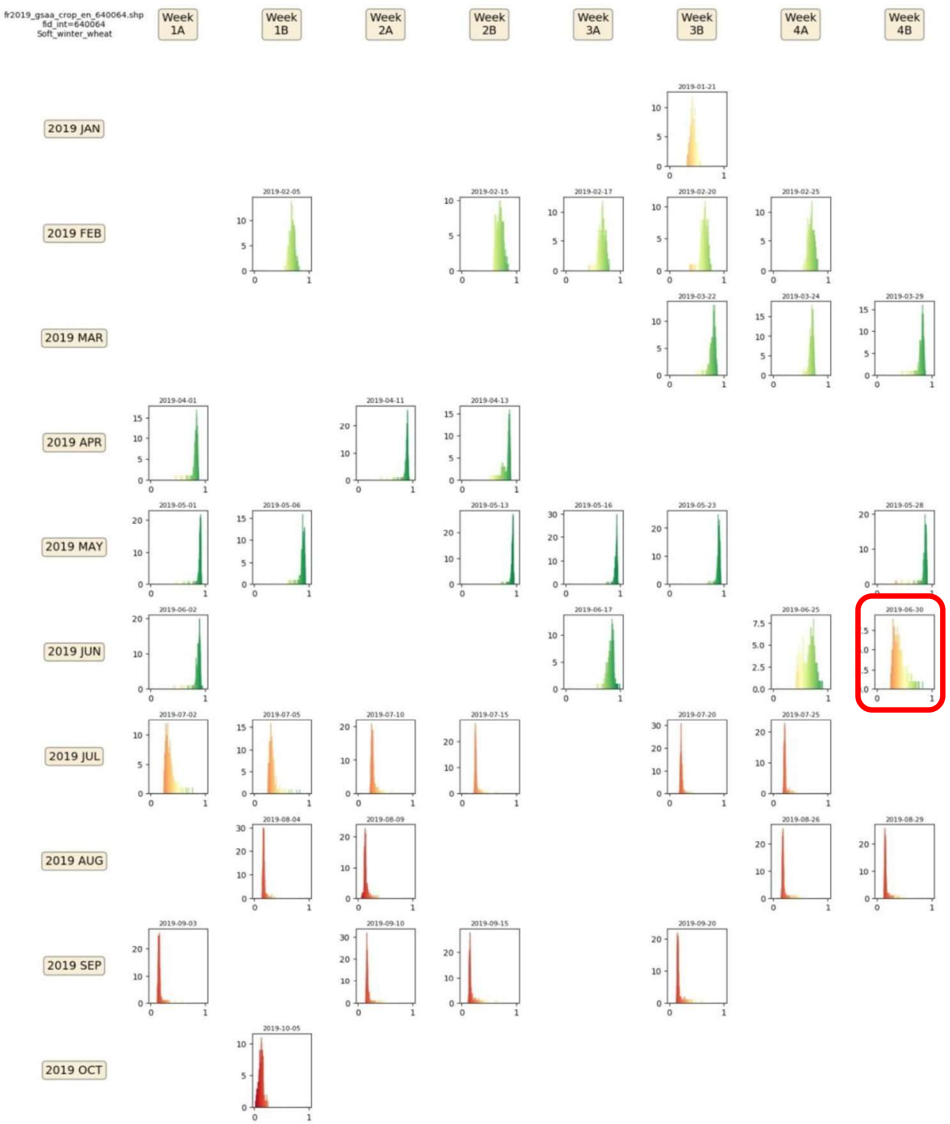
S2 NDVI



Winter wheat



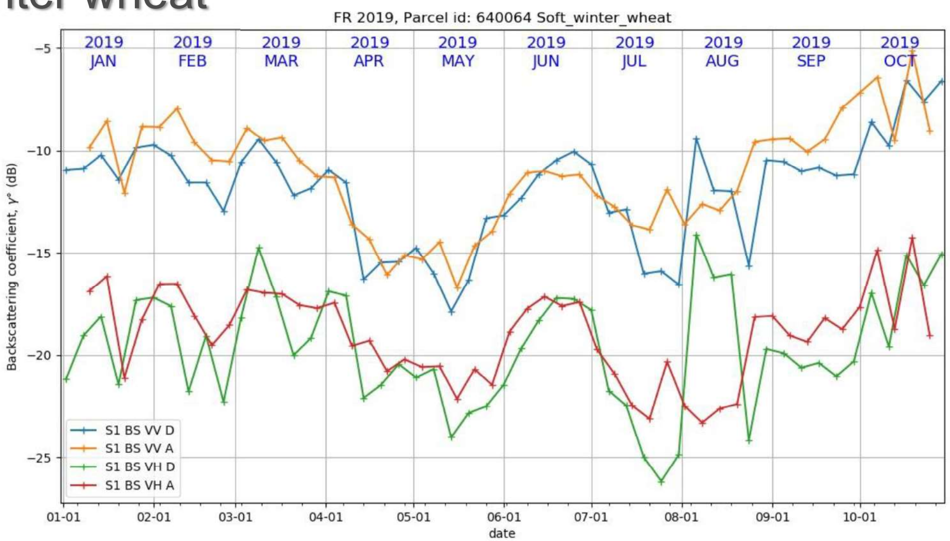


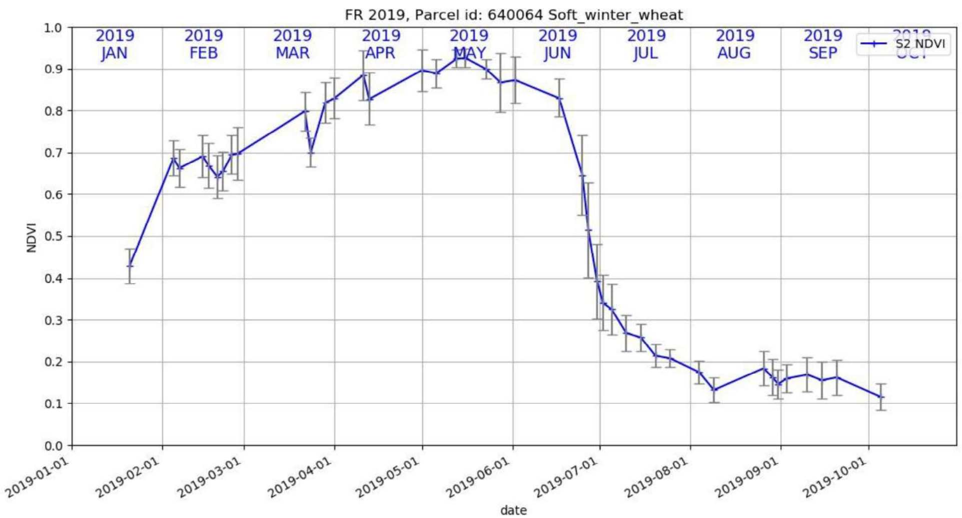


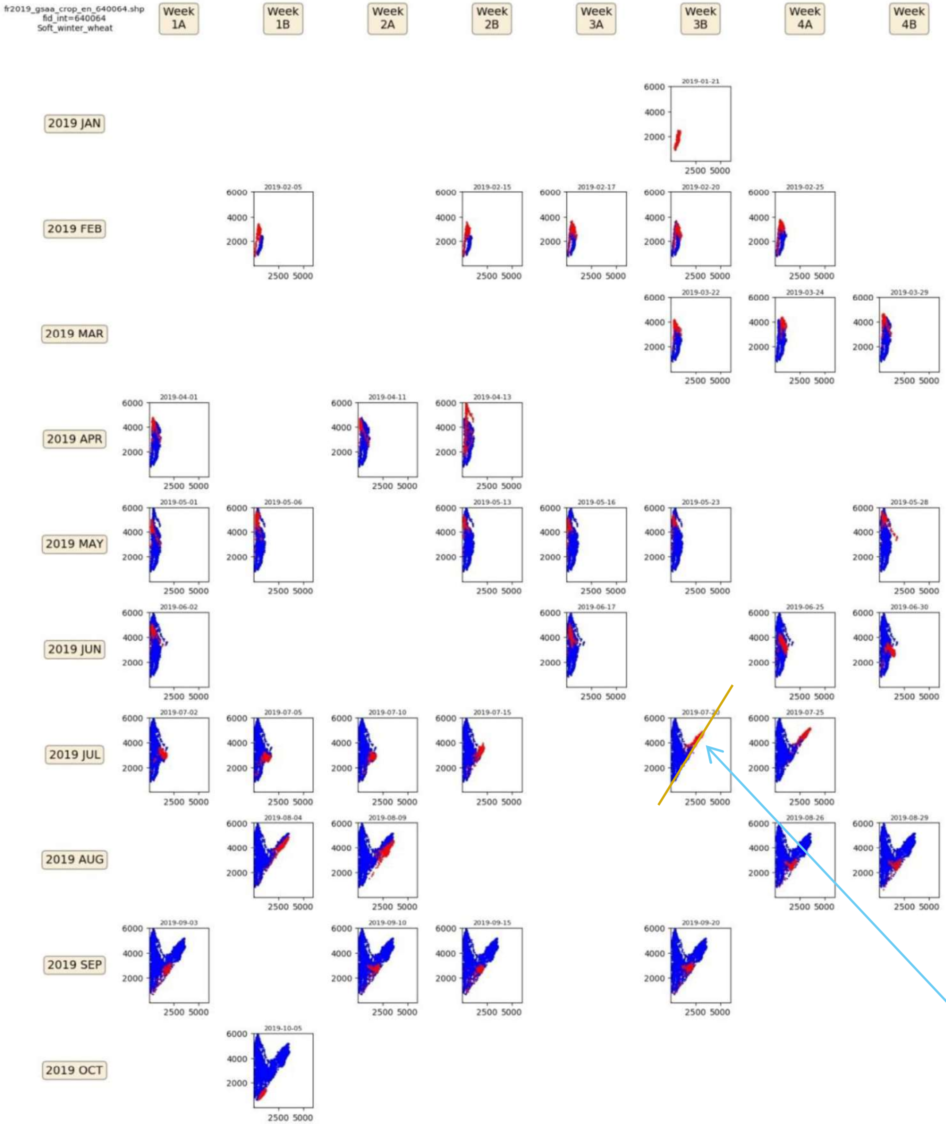
Calendar view

Histogram of S2 NDVI within the parcel

Winter wheat







Calendar view

Cumulative scatter plot of Red (horizontal axis) and NIR (vertical axis) bands within the parcel

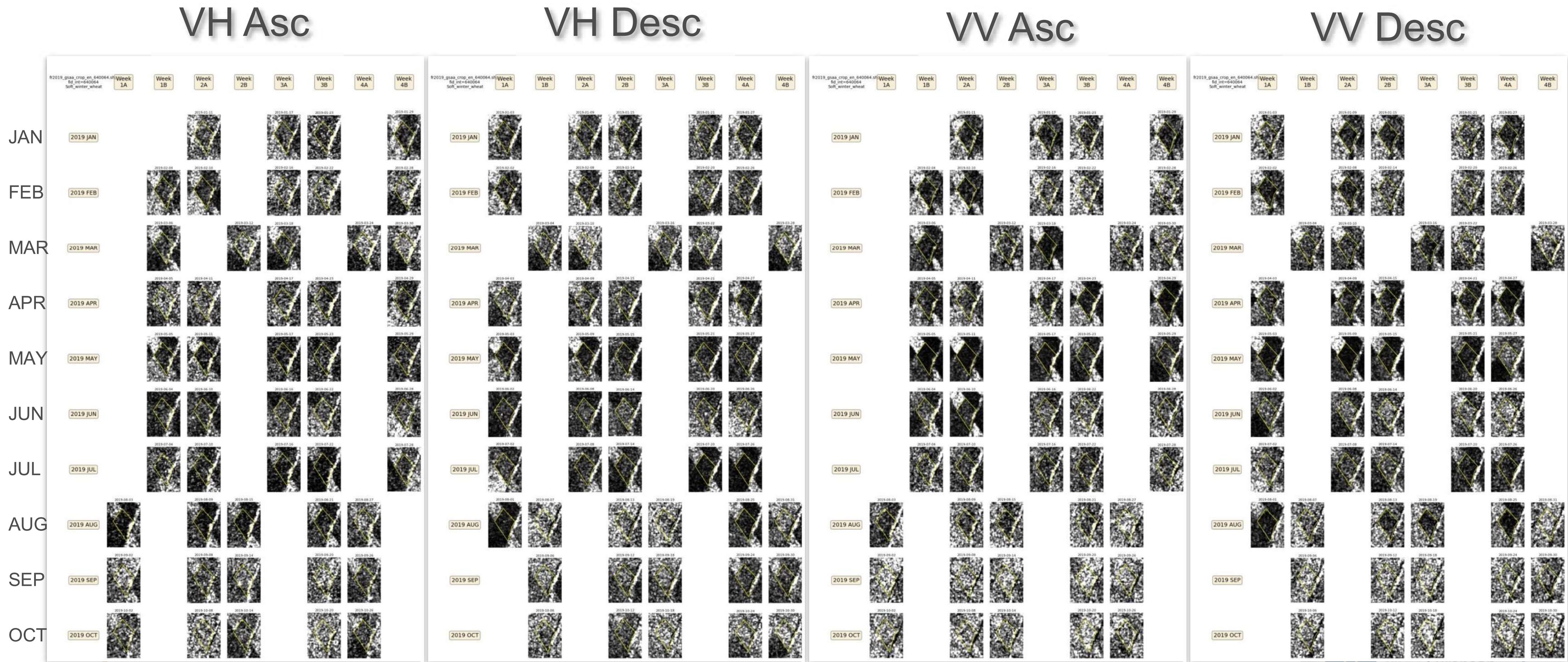
Red dots: scatter plot of current date

Blue dots: scatter plot of all previous dates

Soil line

Calendar view of S1 backscatter imagettes

Winter wheat



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Fixed vs. dynamic LUT stretch

Sentinel-2 Level 2A data (in theory) represent Bottom of Atmosphere (BoA) reflectance

Applying fixed generic LUT (left image) for the whole season gives visually comparable representation

Applying dynamic LUT (right image) based on histogram calculated for the extent of the imagettes could give more contrast, but less comparable representation throughout the season

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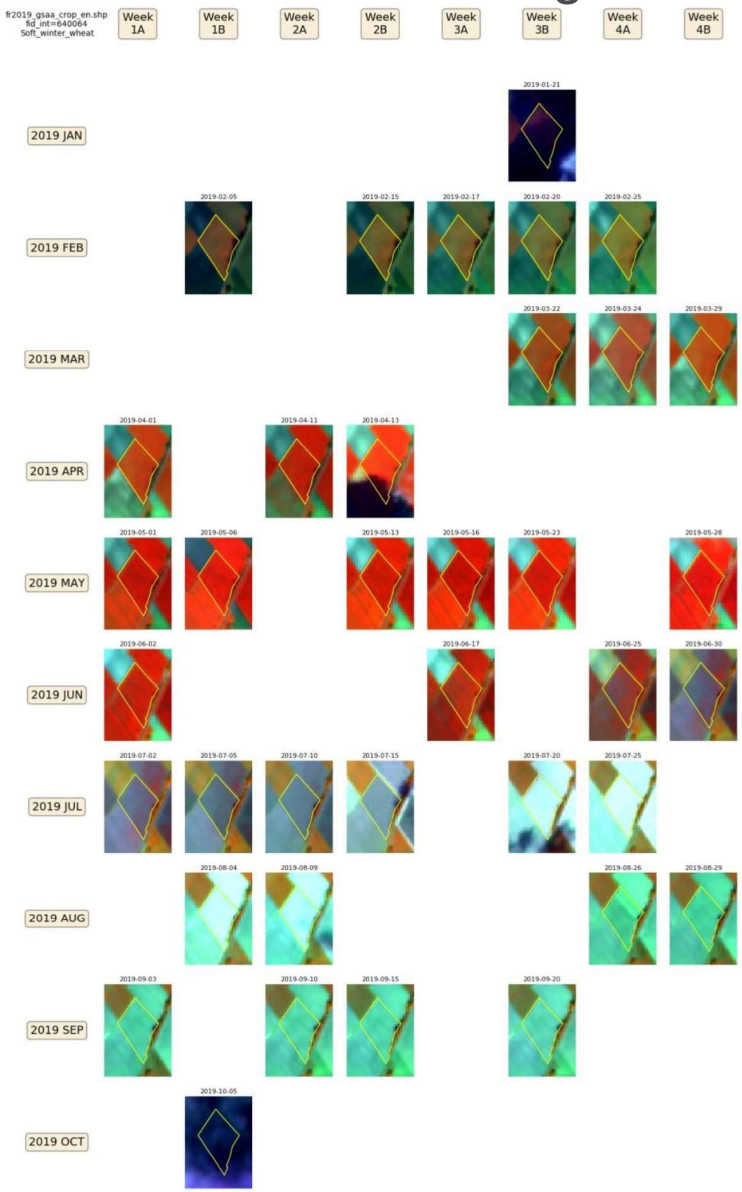
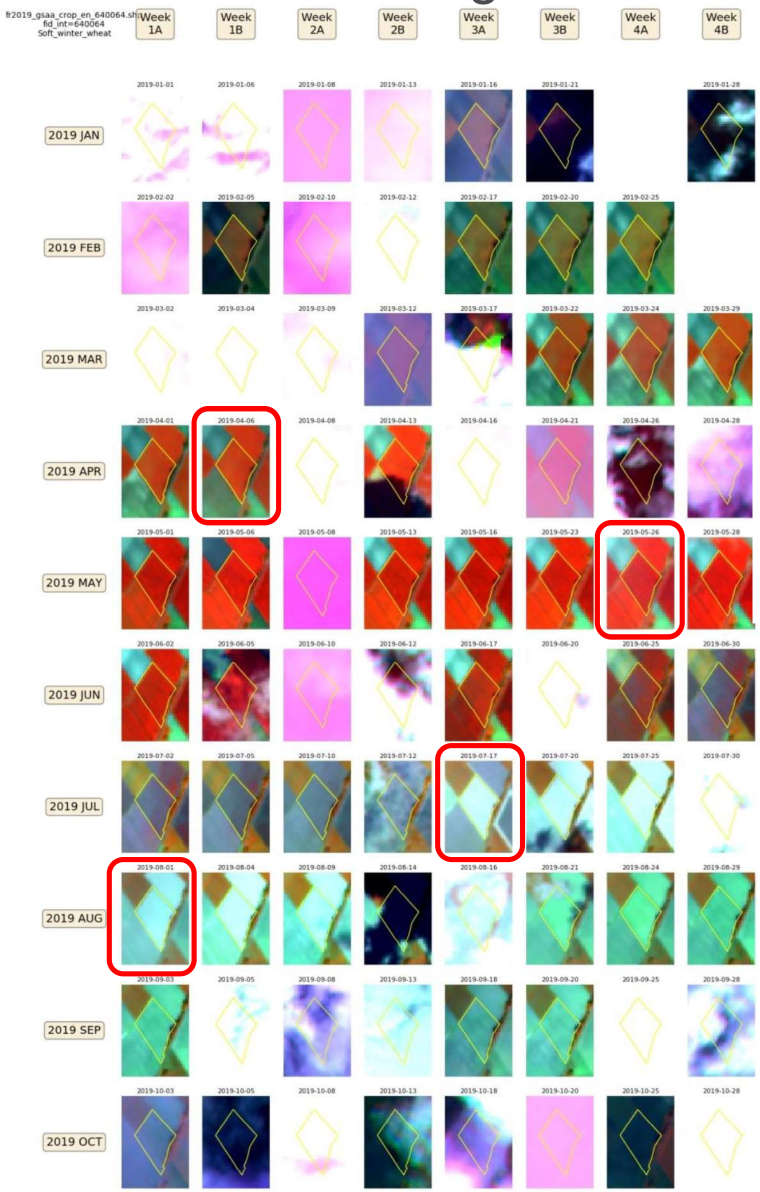
The importance of cloud filtering

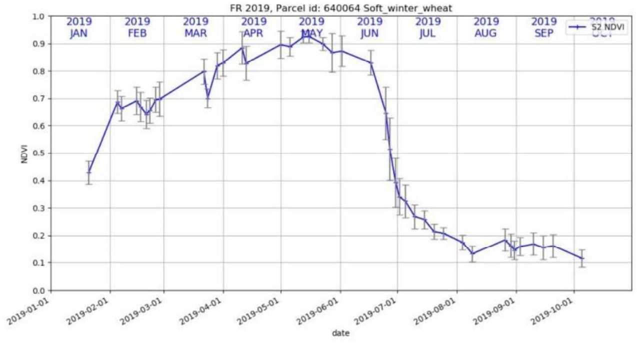
Cloudfree images



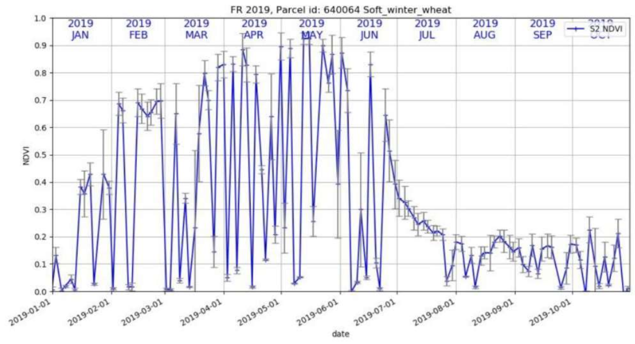
All images



NDVI for cloudfree images



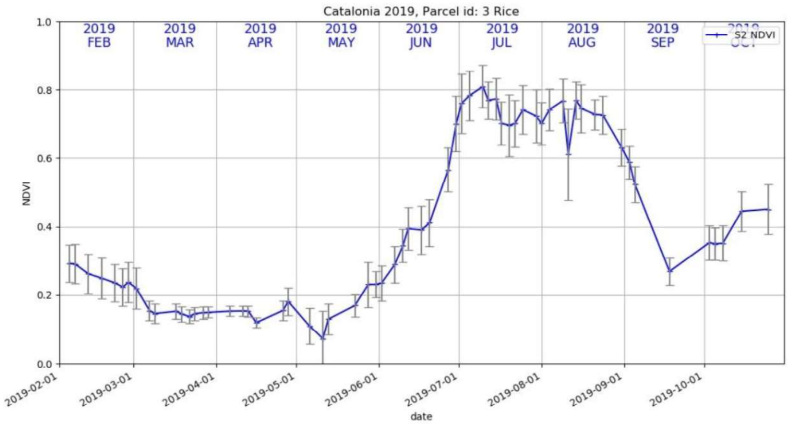
NDVI for all images



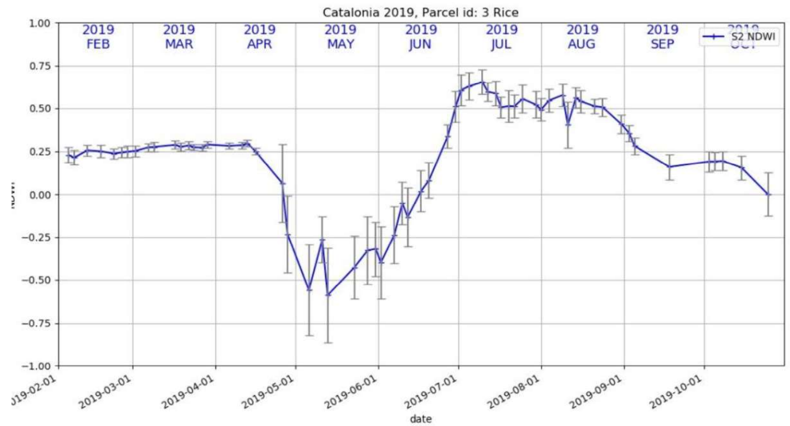
FOI ordinal number = 0003
G1/T3 inspection
reference period: Feb – Oct 2019

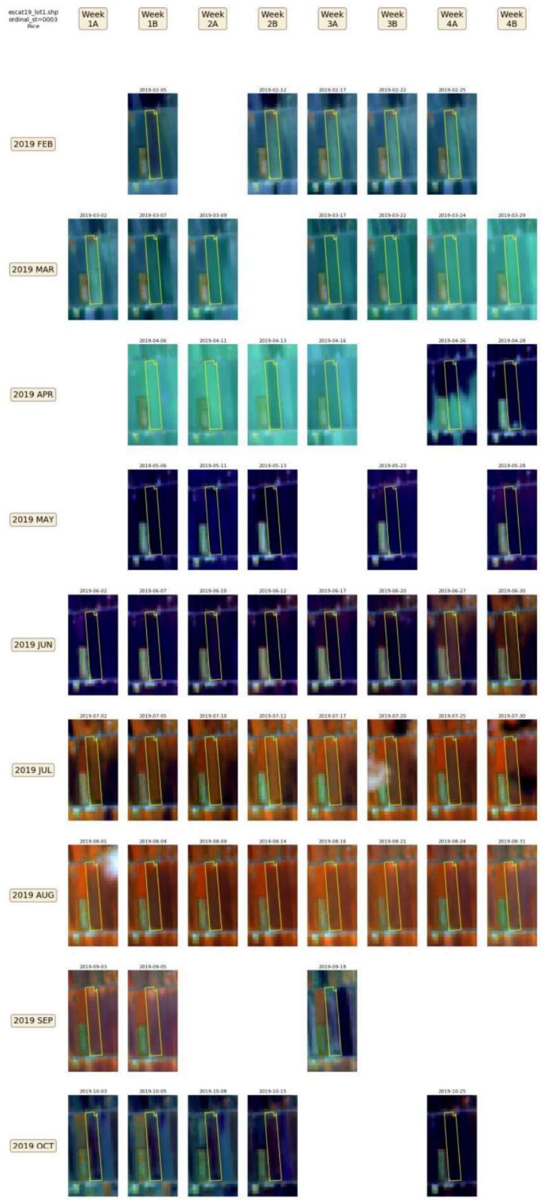
False color composite B8 B11 B4

NDVI time series



NDWI time series





Combined use of **NDVI** and **NDWI** temporal profiles for rice fields monitoring

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

$$NDWI = \frac{SWIR - Red}{SWIR + Red}$$

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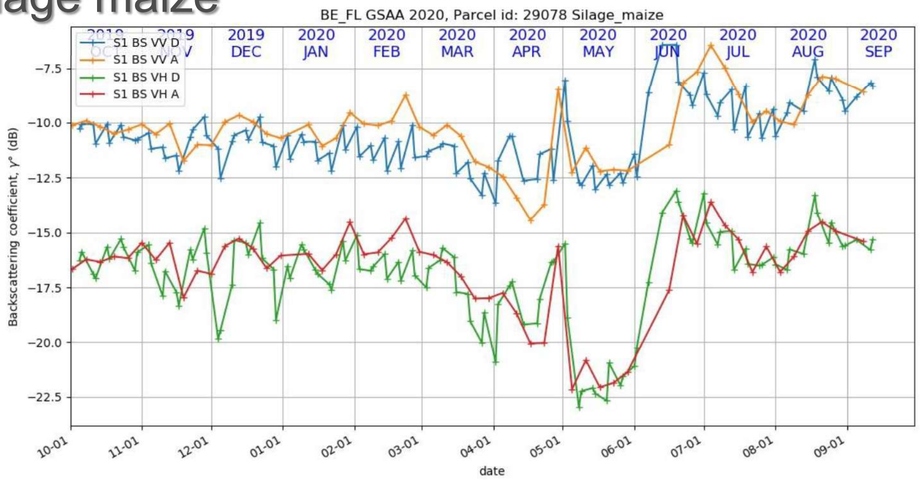
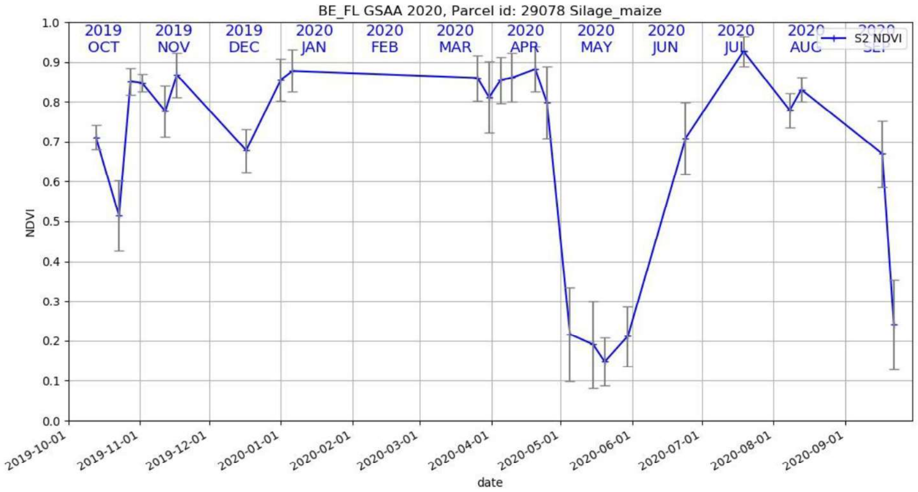
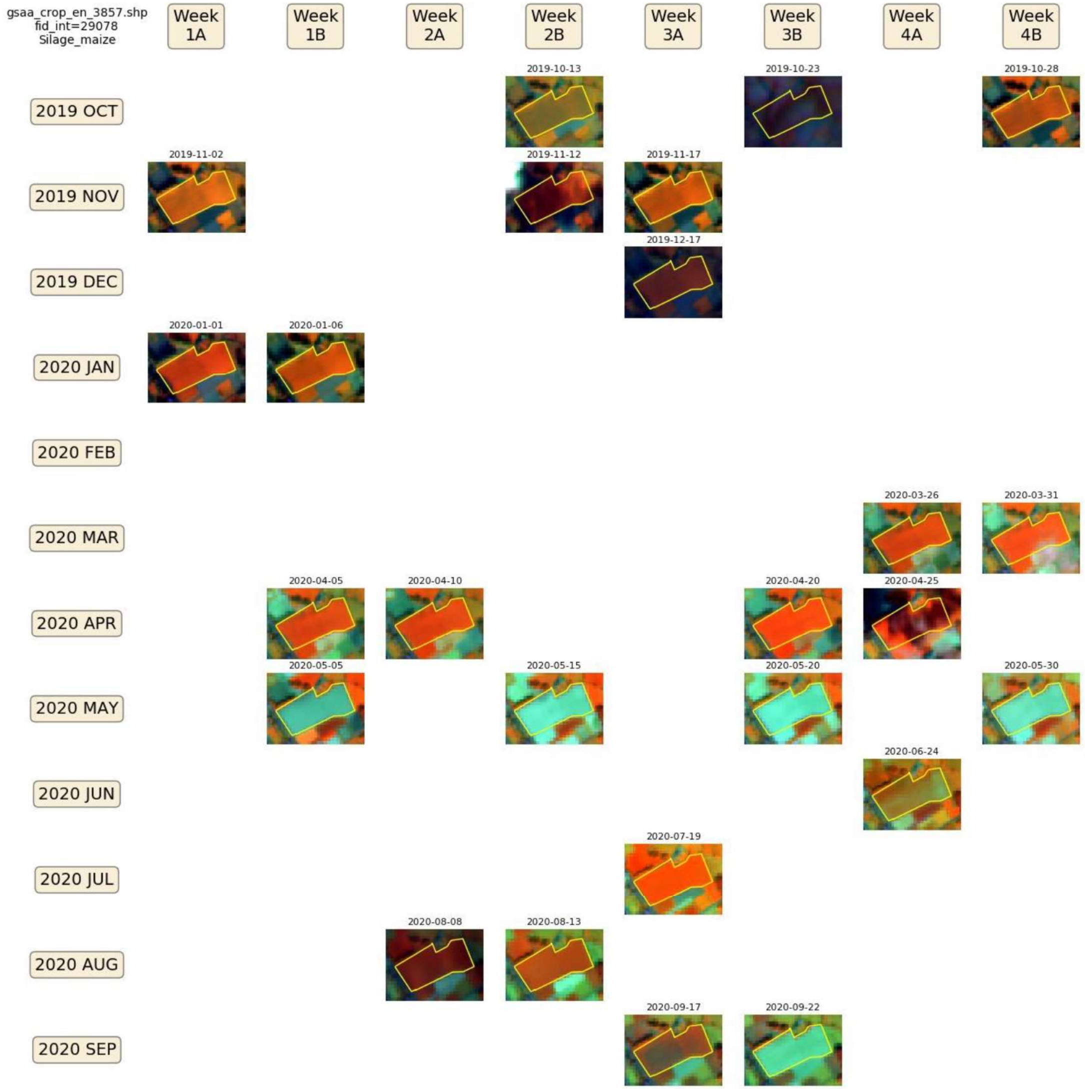
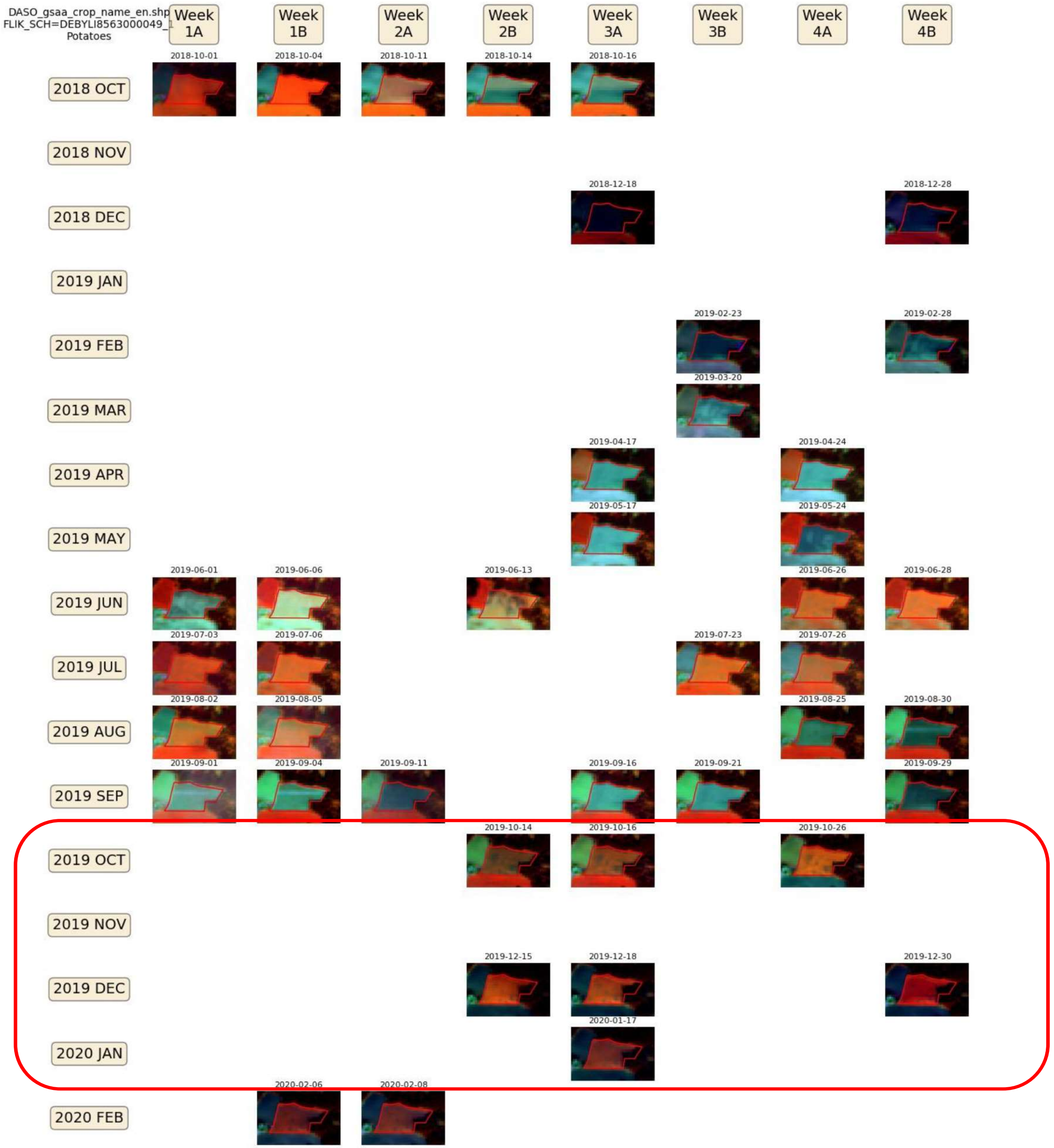
Nice alignement of S1 and S2 signatures

Silage maize

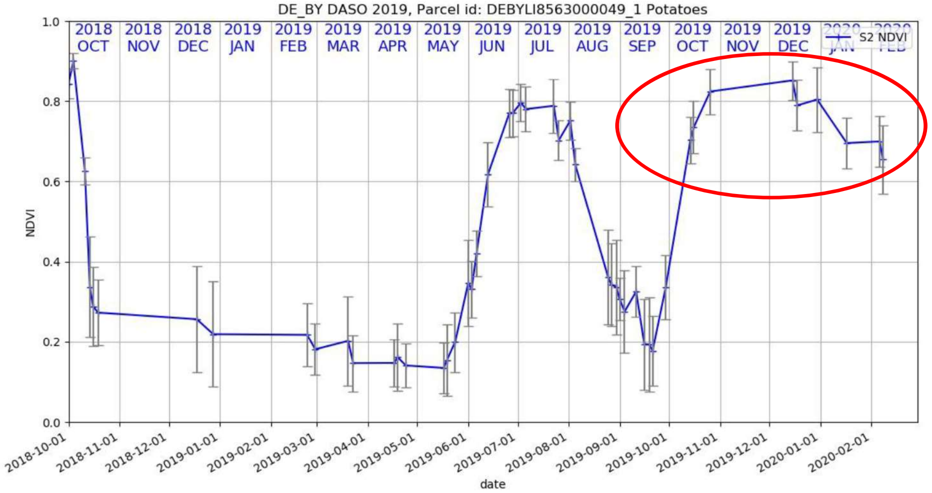








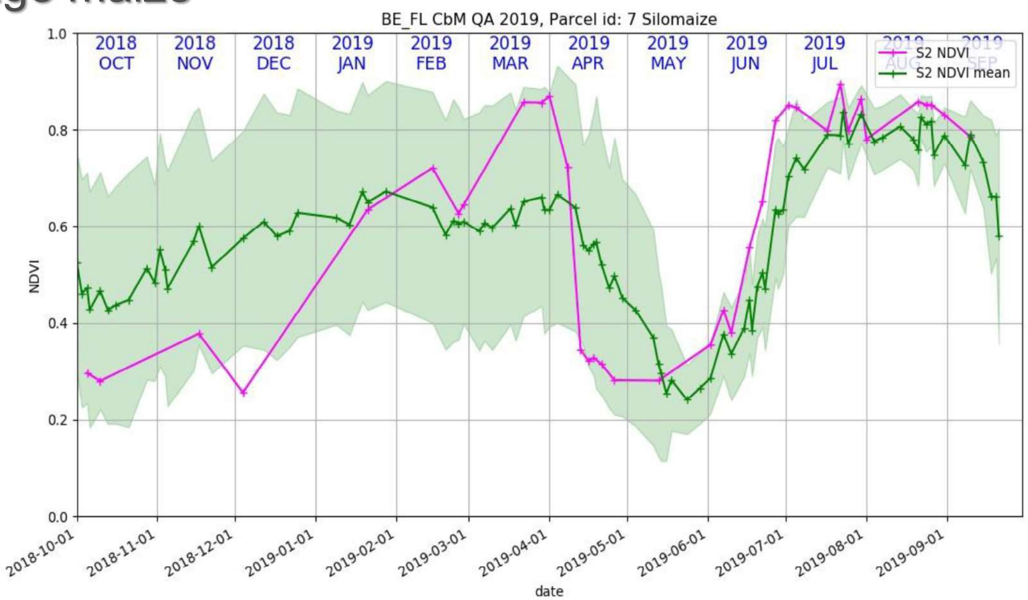
Winter green cover

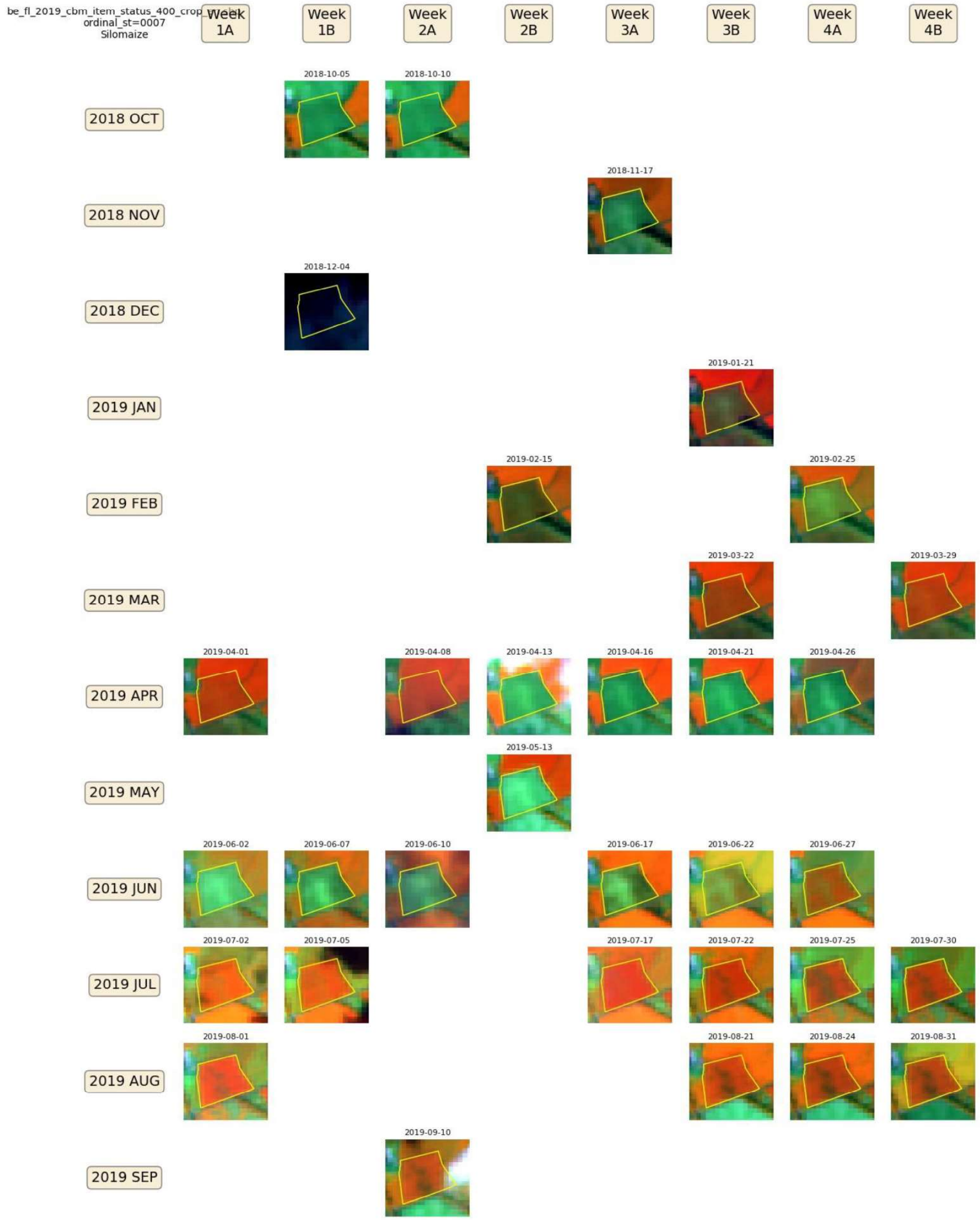


- Nov-Dec 2019 confirmed

Use of mean crop profiles

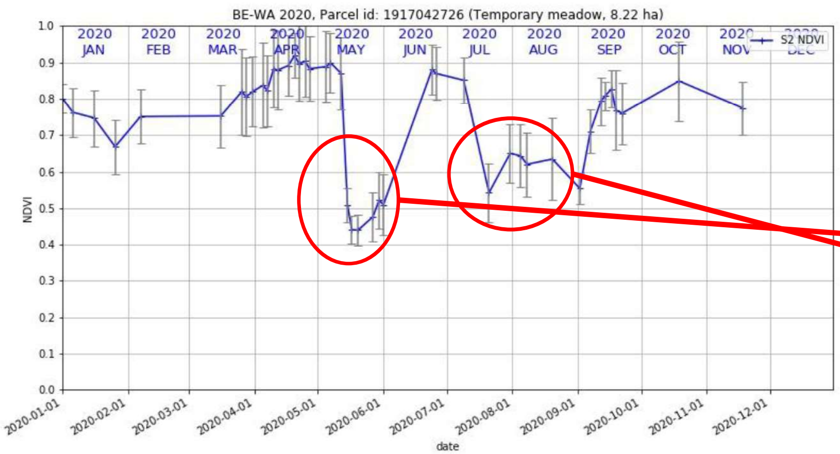
Silage maize

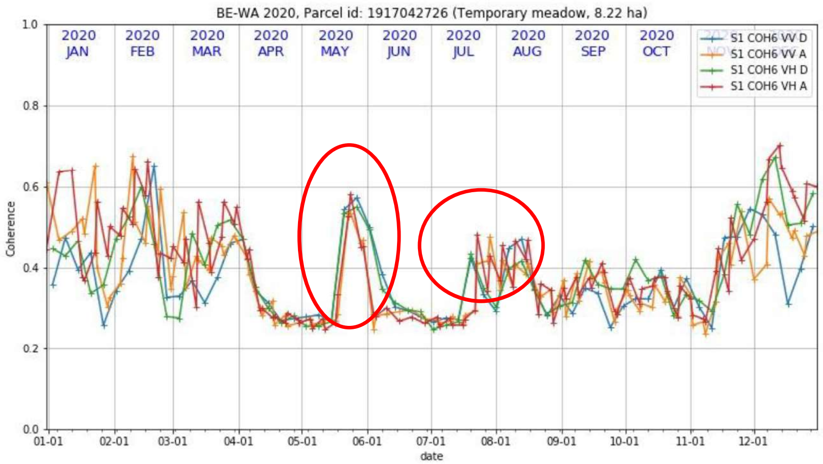


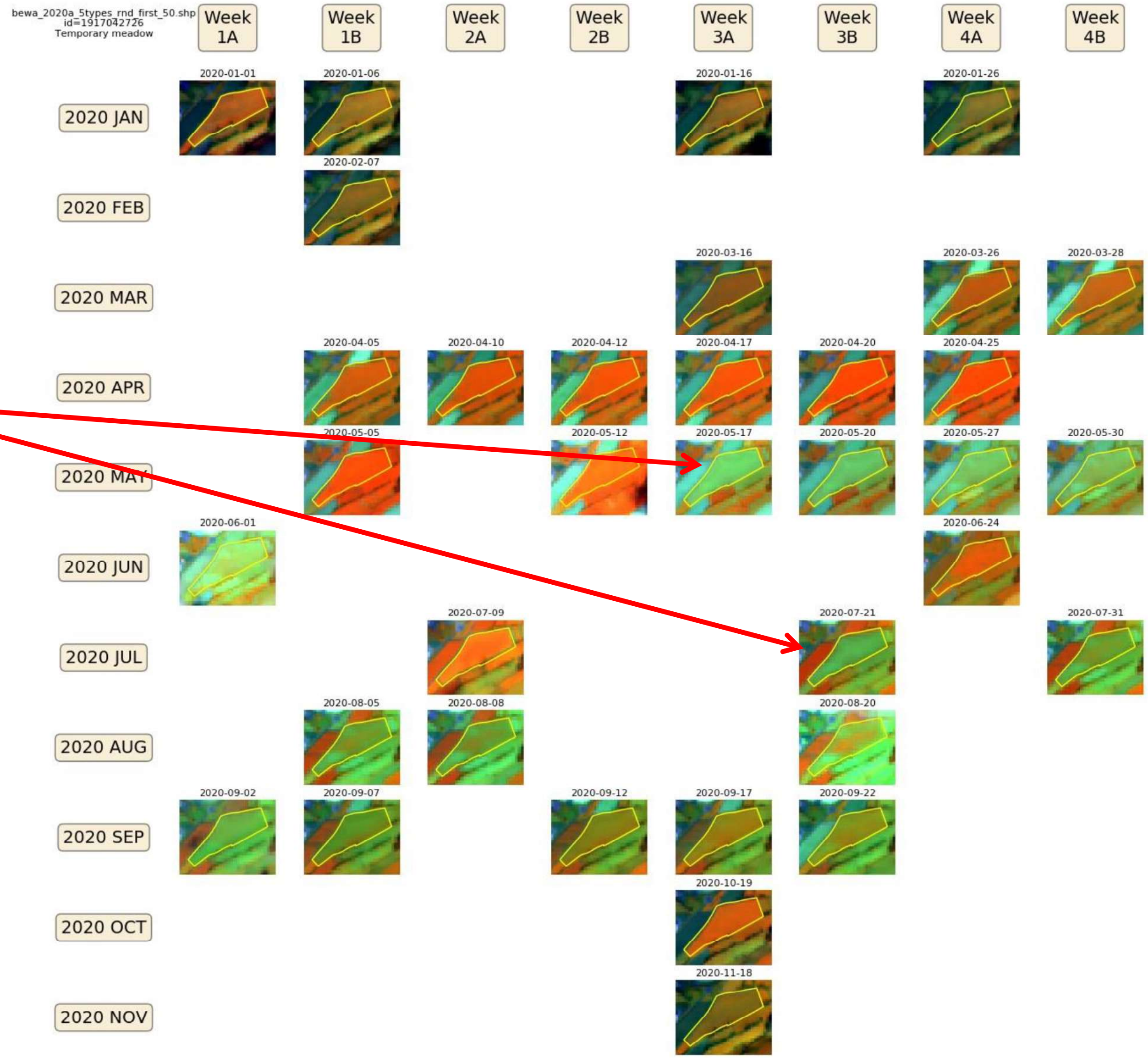


- Green line and green strip: mean profile and standard deviation of silage maize parcels from declared GSAA in the country (could be restricted to neighbouring parcels)
- Purple: profile of current parcel

Managed grassland with mowing events expected







Mowing events in May and July

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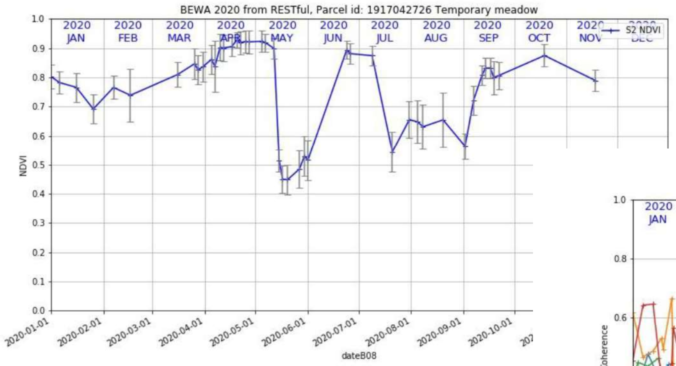
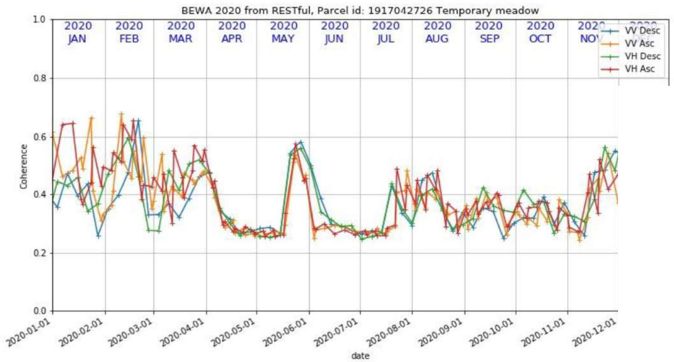
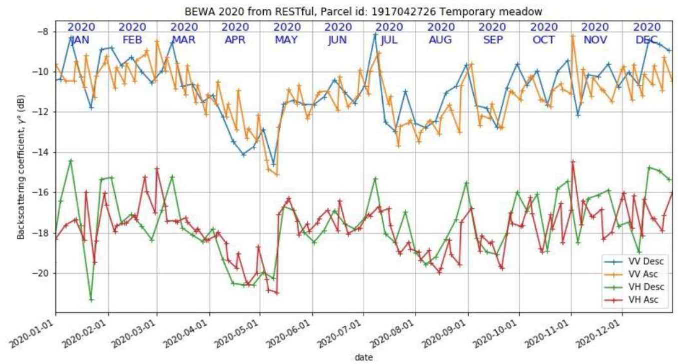
Parcel and time series information from RESTful api

- parcelById - http://185.178.85.7/query/parcelById?aoi=bewa&year=2020&pid=1917042726&withGeometry=True
- parcelTimeSeries - http://185.178.85.7/query/parcelTimeSeries?aoi=bewa&year=2020&pid=1917042726&tstype=s2&scl=True&ref=True
- Source code in cbm Git repository (https://github.com/ec-jrc/cbm/tree/main/ipynb/get_and_display_graphs_from_restful)



- Example of 50 random parcels





Live demo

Conclusion

Use image chip extract processing:

- to check an individual parcel (eg. CbM QA) and elaborate observations
- to refine knowledge to define markers and then perform automatic processing of large amount of FOIs (without visualising them ...)
- to publish parcels' findings revealed by automatic processing

European Commission

Thank you

csaba.wirnhardt@ec.europa.eu

CbM on DIAS: the jrc-cbm frontend

On-line training for Outreach, 30 September 2021

JRC D5 – GTCAP Team

Agenda

09:30 - 09:45	Welcome and short introduction into the jrc-cbm frontend
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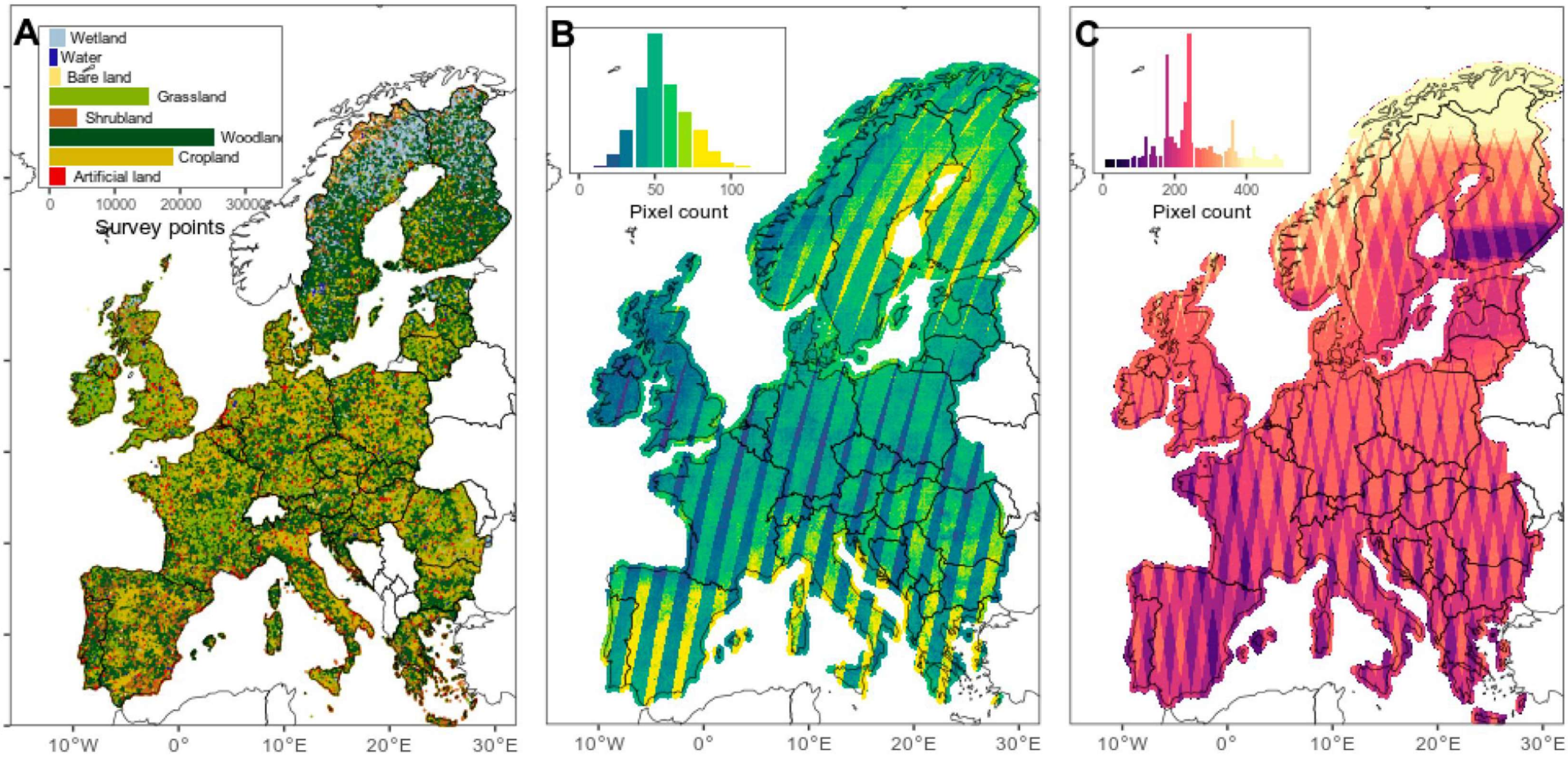
Interpretation basics

- Agricultural practices lead to geometric or radiometric change at the surface
- Sentinel-1 and -2 detect the change in the (parcel averaged) time series
- And/or a change in the spatial variation within the parcel
- S1: measures in C-band ($\lambda \sim 5.5$ cm) and 2 polarizations (VV and VH)
- S2: measures in 10 spectral bands (4x VIS, 4x NIR, 2x SWIR)
- Nominally acquires every 6 (S1) and 5 days (S2)
- Overlapping orbits leads to more frequent S1 (than 6 days repeat)
- Cloud cover means less frequent S2 (than 5 days repeat)
- Actual acquisition frequency depends on latitude and prevailing weather



Venter, Z.S.; Sydenham, M.A.K. Continental-Scale Land Cover Mapping at 10 m Resolution Over Europe (ELC10). *Remote Sens.* **2021**, *13*, 2301.
https://doi.org/10.3390/rs13122301

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Data interpretation for marker analysis

- Frontend APIs provide access to extracted time series and chip sets
- Time series provide temporal dynamics, some spatial variation within parcel
- Statistics: mean, stdev, count, min, max, p25, p50, p75 (see FOI use case)
- S2 bands: [B02, B03, B04, B08], [B05, B11], S1 bands: [VV, VH]
- S2: meaningful (only) for cloud screened data: SCL histograms
- S1: we mix (overlapping) descending and ascending orbits, no systematic correction (yet) for terrain height variation (DEM!)
- Some signal variation is due to other than agri-practice (e.g. snow, frost, rain)

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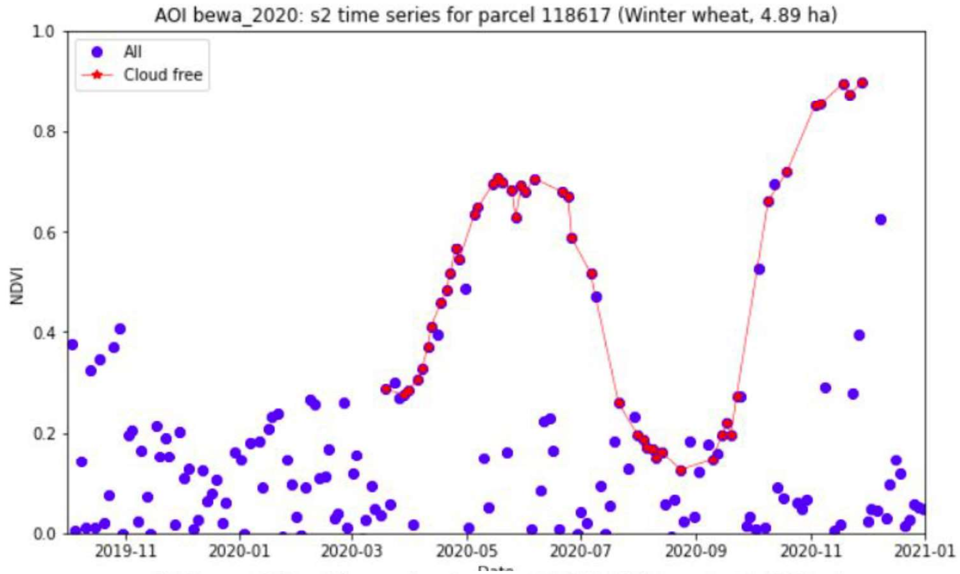
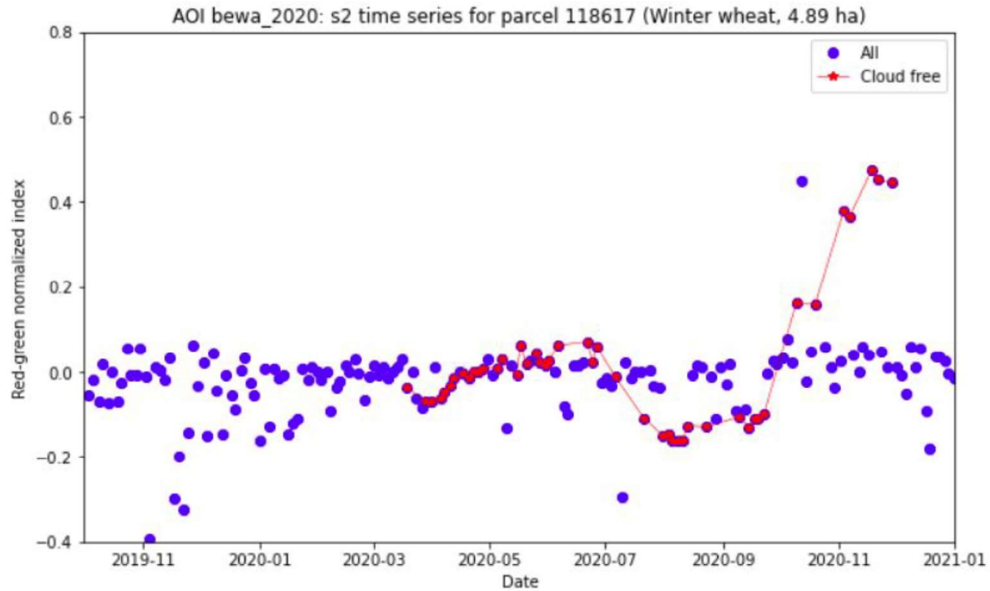
Interpretation basics

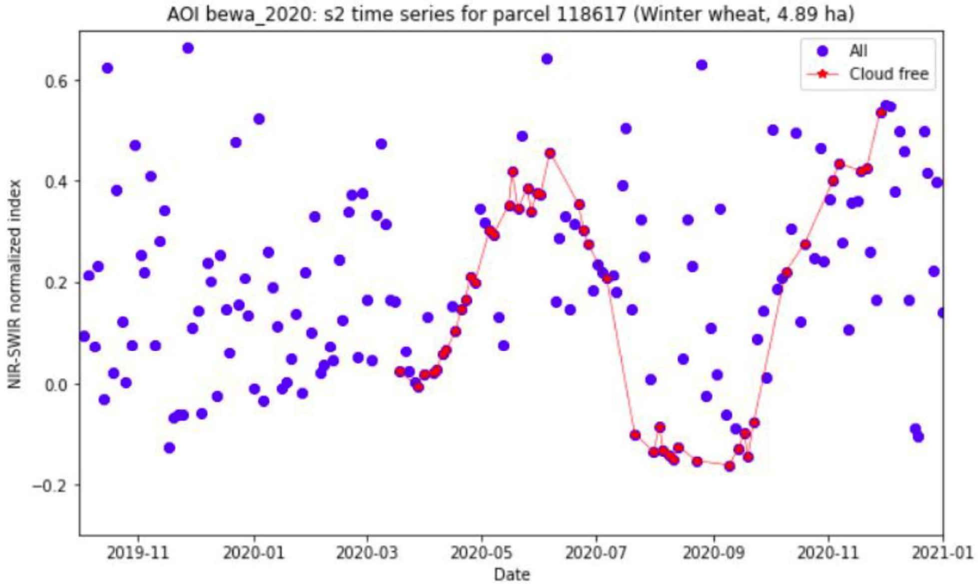
- Interpretation is based on understanding the physics behind signal detection!
- Both sensor characteristics and radiometric interactions with the “target”
- Translated into practical rules on expected detectability.

- S1: measures in C-band (λ ~ 5.5 cm) and 2 polarizations (VV and VH)
- S2: measures in 10 spectral bands (4x VIS, 4x NIR, 2x SWIR)
- S1: sensitive to **geometry** and **water content** of the **soil-canopy** (γ^0, c6)
- S2: sensitive to **reflectance properties** of **soil-canopy**
- Remote sensing 101

Signature basics







Sentinel-2

- Sensitive to reflectance contrast of soil & canopy
- Sensitive to reflectance difference in canopy stages
- Surprisingly little added information in extra bands
- Clouds break temporal consistency

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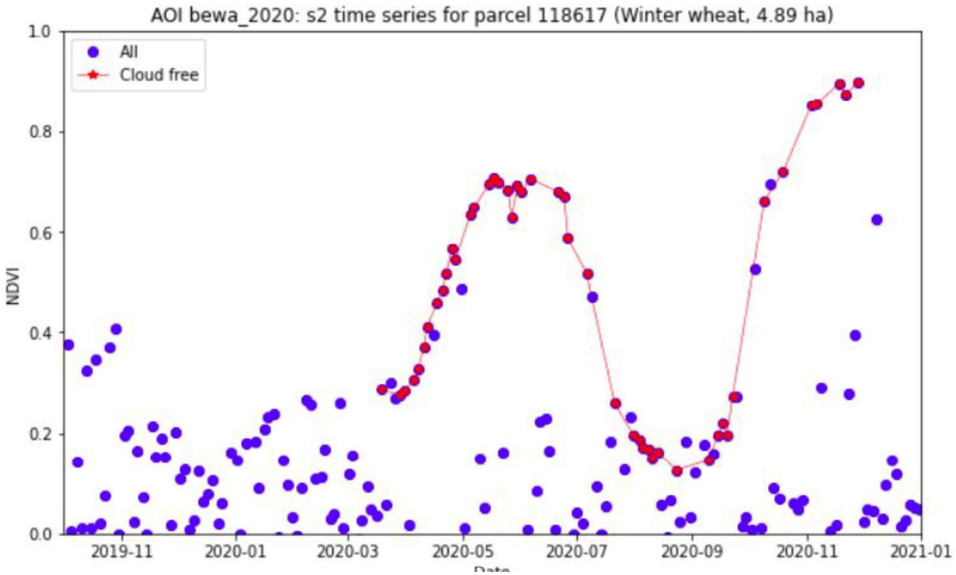
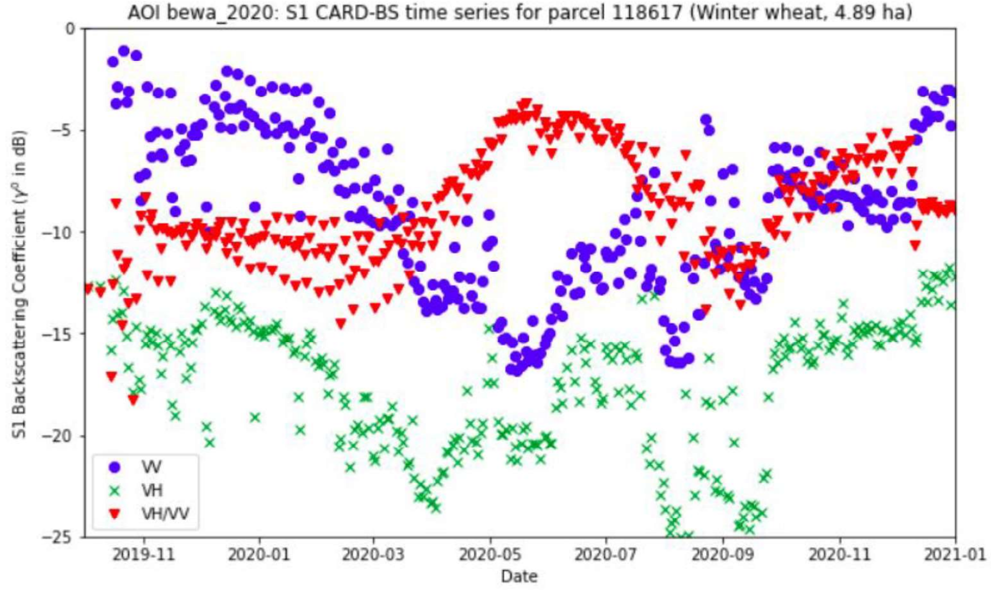
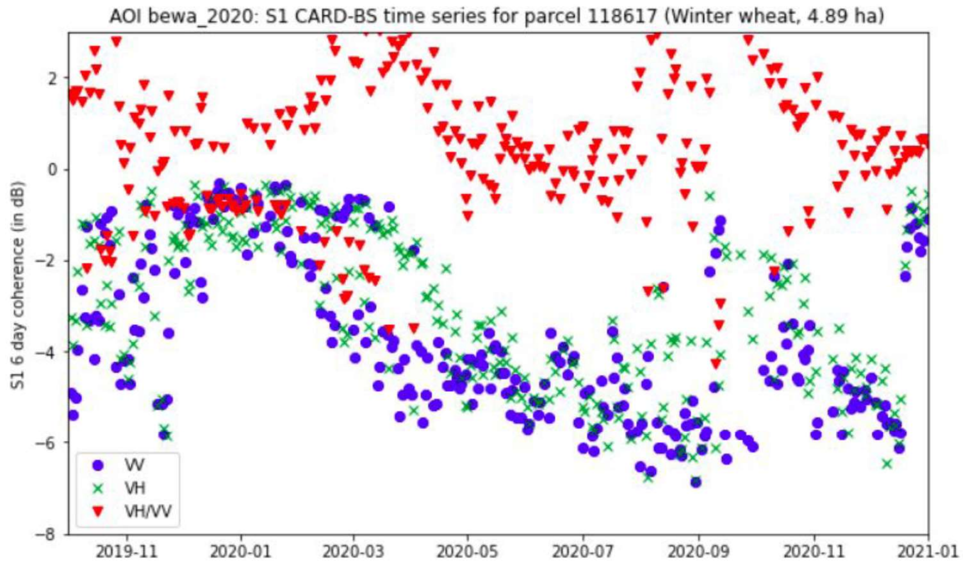
Signature basics







Sentinel-1 CARD-BS

- Sensitive to backscatter contrast of soil & canopy
- Sensitive to structural difference in canopy stages
- Parallel with S2 vegetation cover (e.g. VH/VV)
- Temporal consistency

Sentinel-1 CARD-COH6

- Sensitive to stability of scatters
- Sensitive to stable bare soil vs. canopies
- Sensitive to change in bare soil conditions

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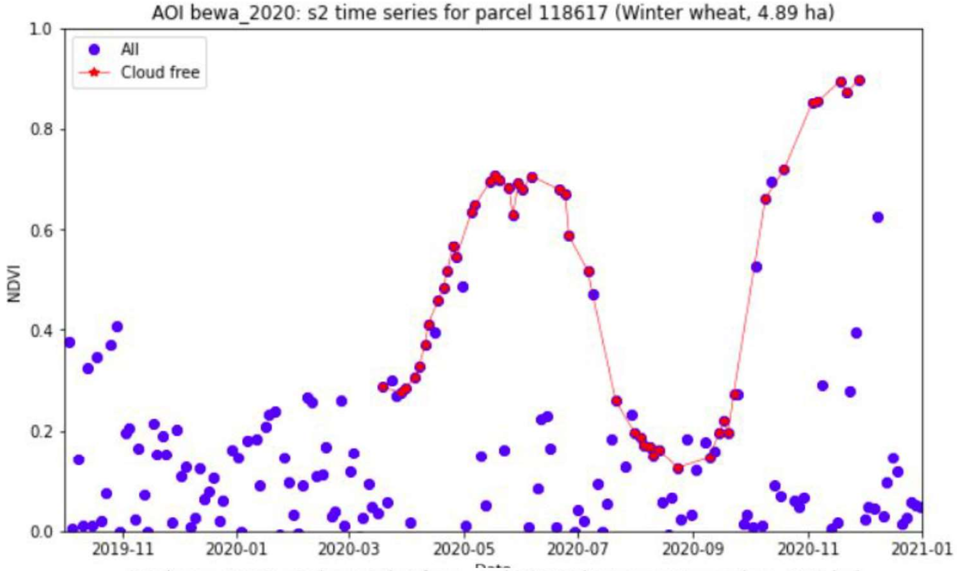
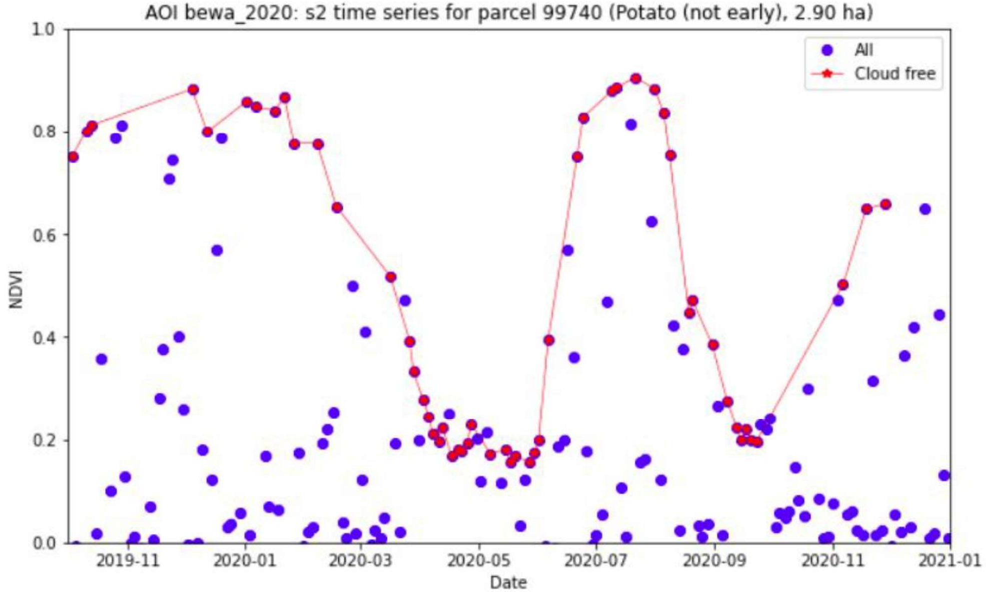
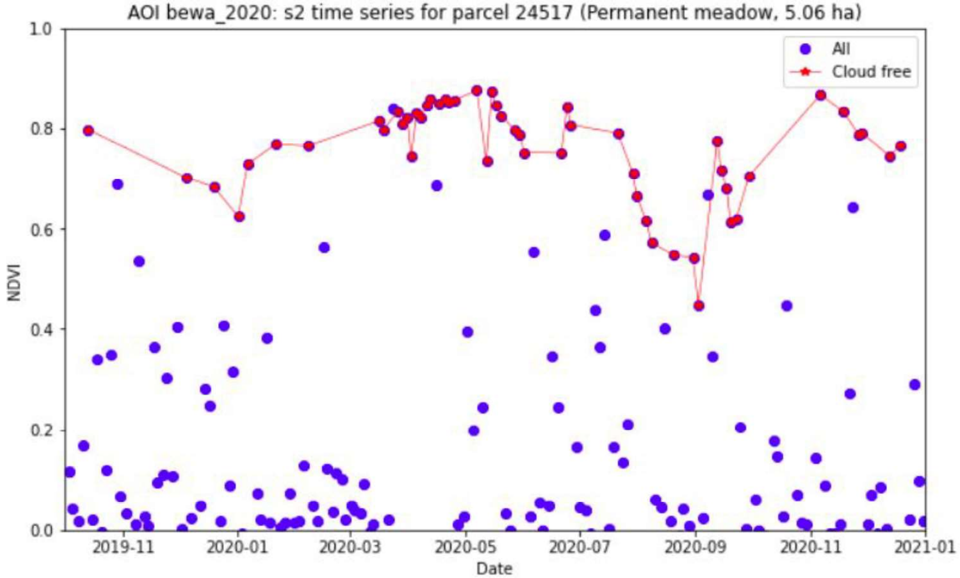
Signature basics







Sentinel-2

- Sensitive to timing of seasonal phenology
- Sensitive to vegetation removal
- Cloud cover may cause “events” to be missed

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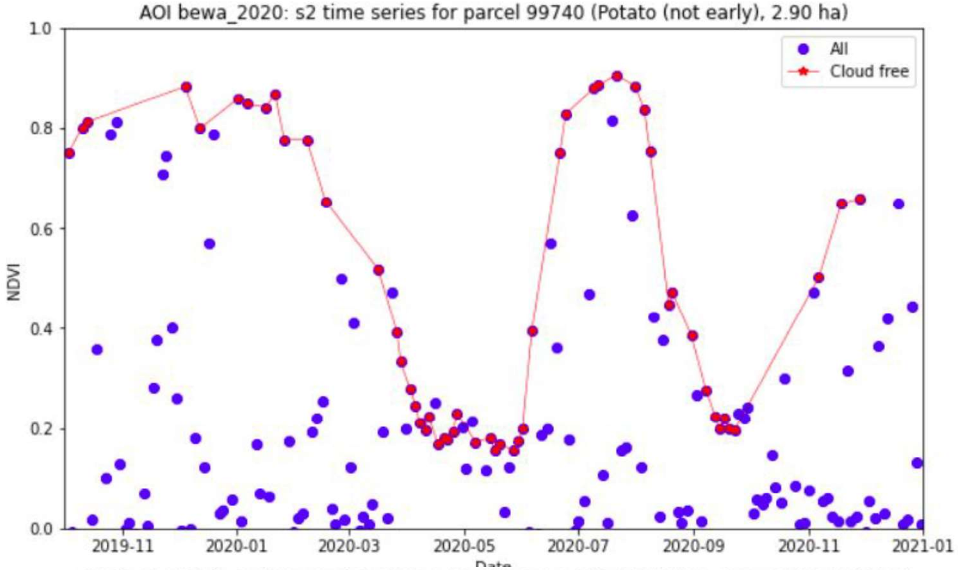
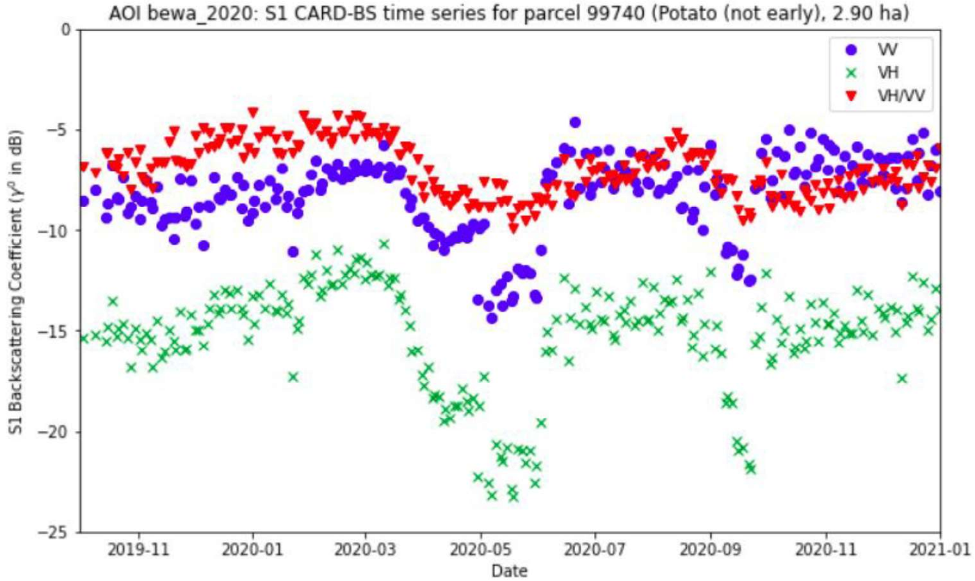
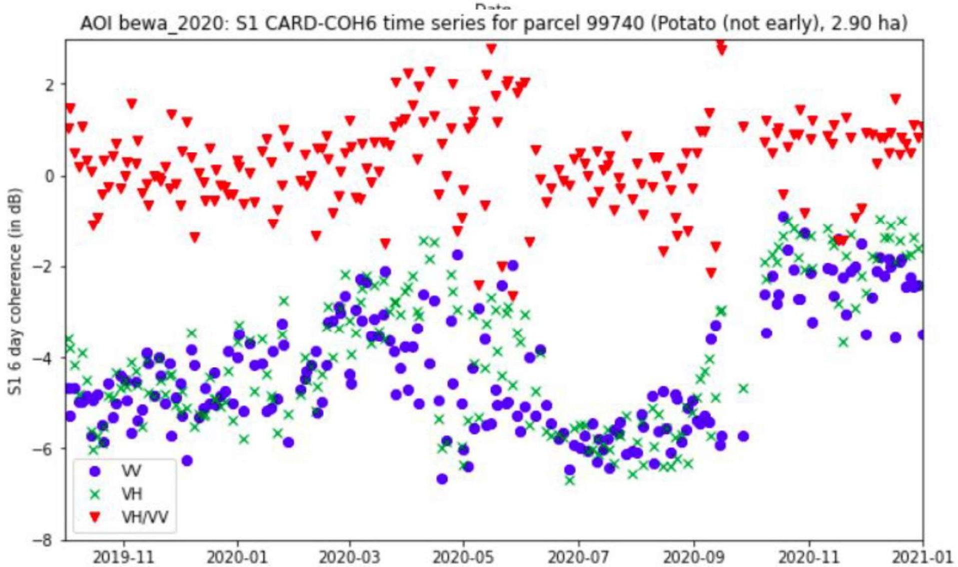
Signature basics







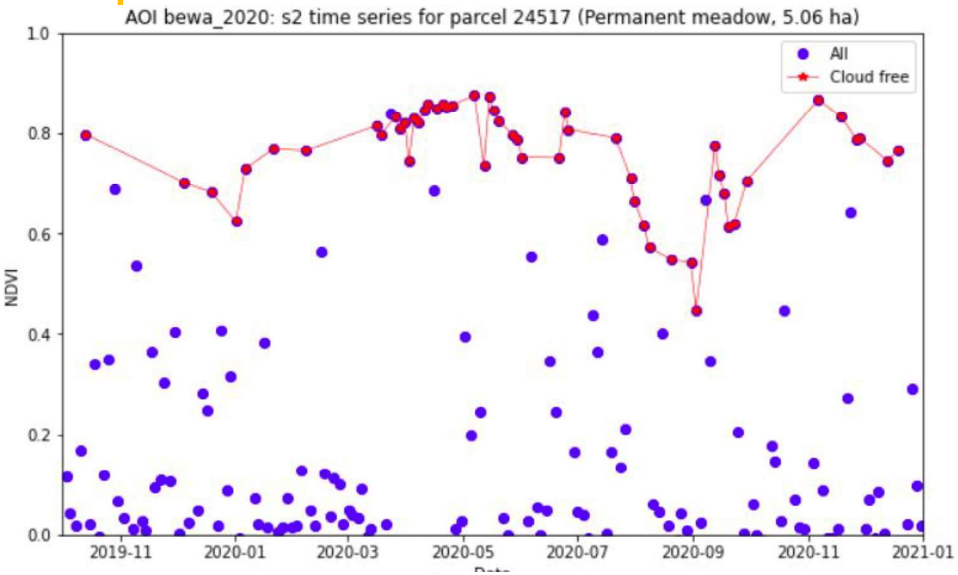
Sentinel-1 CARD-BS

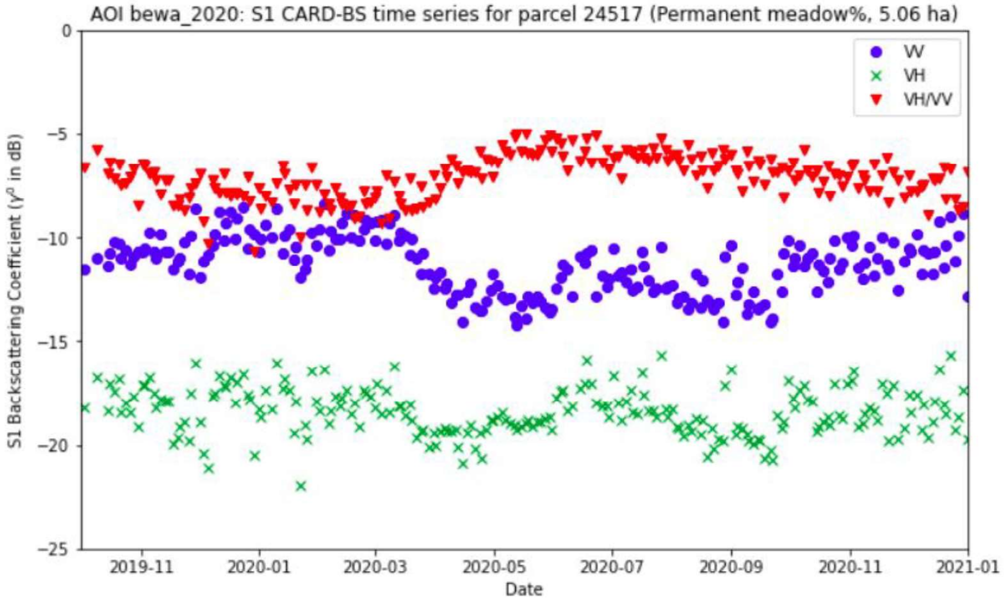
- Sensitive to vegetation removal and emergence
- Sensitive to soil surface preparation
- Revisit matches agricultural practice dynamics (!)

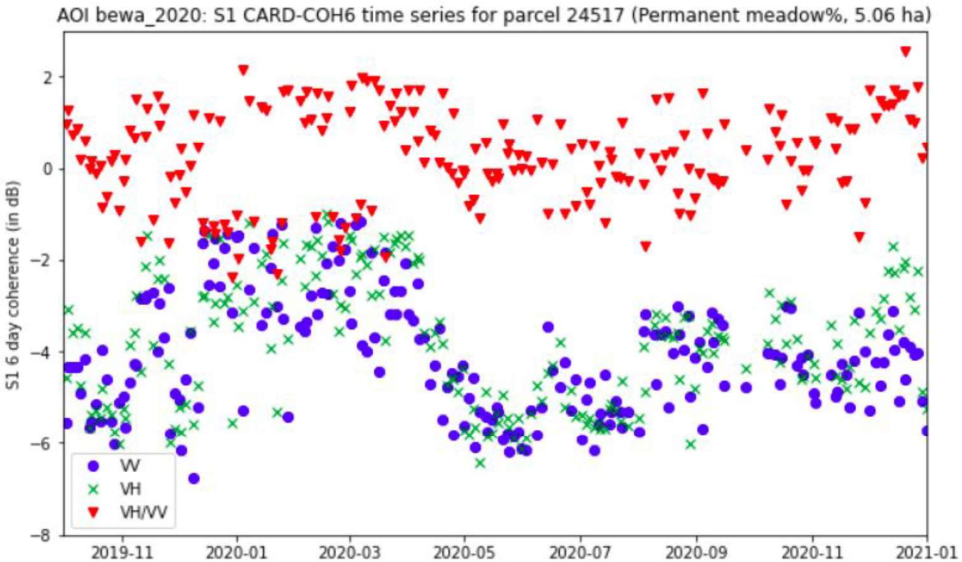
Sentinel-1 CARD-COH6

- Sensitive to stable bare soil vs. canopies
- Sensitive to change in bare soil conditions

Signature basics







Sentinel-1 CARD-BS

- Flat signature for grassland
- Sparse vegetation leads to higher soil backscatter

Sentinel-1 CARD-COH6

- Sensitive to grass regrowth phase
- Sensitive to grass removal
- Less risk to miss “events”

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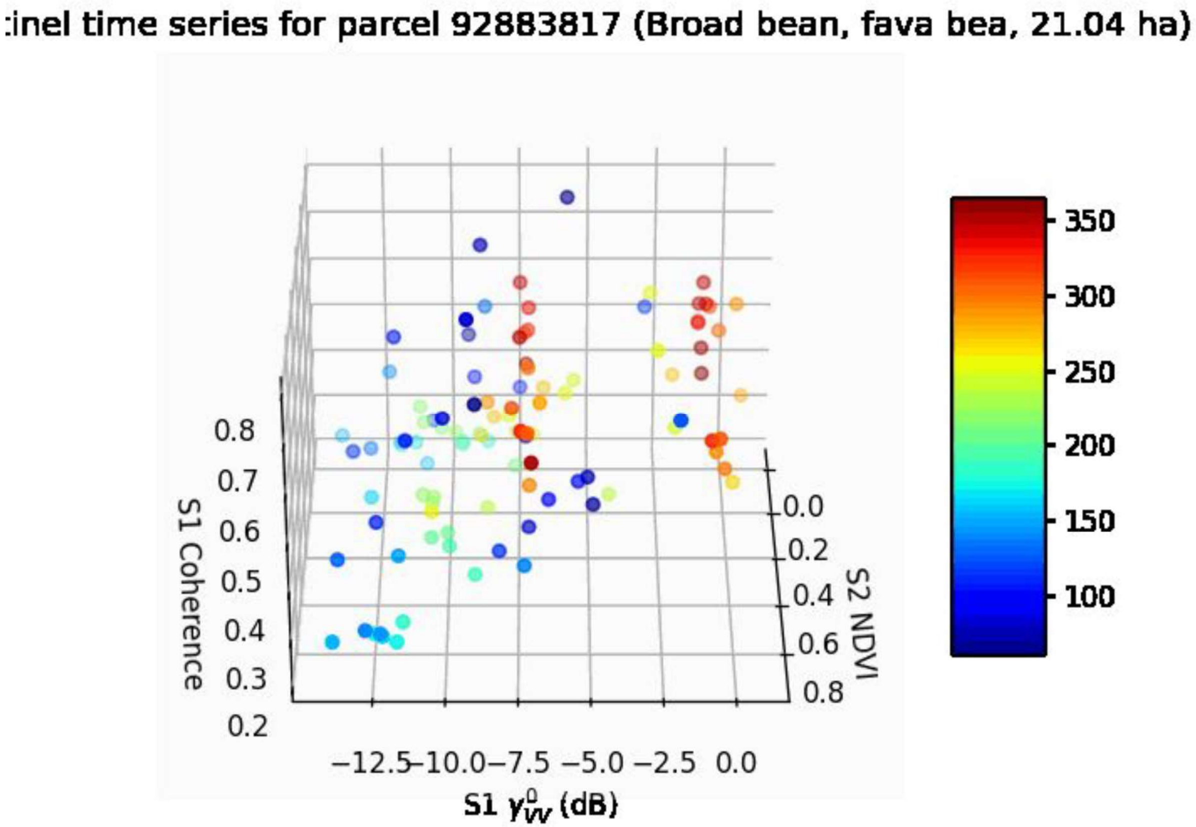

“How does your FOI perform [with regards to heterogeneity] in it's temporal trajectory in hybrid HR Sentinel radiometric feature space?”

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Sentinel ARD issues

- S-2: adjacent granules with 10% overlap, may be projected in straddling UTM
- This leads to data duplication, esp. for S-2 L2A (to be resolved in extract)
- S-2A and S-2B till suffer from systematic pixel shift (esp. older data)
- We do not calculate indices at parcel level, but from band means

- S1 CARD-BS/COH-6 has one or more empty lines between frames
- S1 CARD-BS is not yet “terrain flattened” (work in progress)

- Parcels with only NODATA are dropped, partial NODATA is not dropped

DIAS Tools for FOI analysis

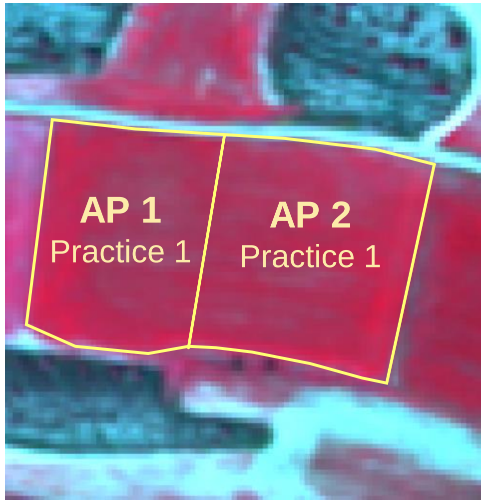
FOI Group – GTCAP Team

DIAS Front-end webinar, 30th September 2021

Feature of interest (FOI) - principles

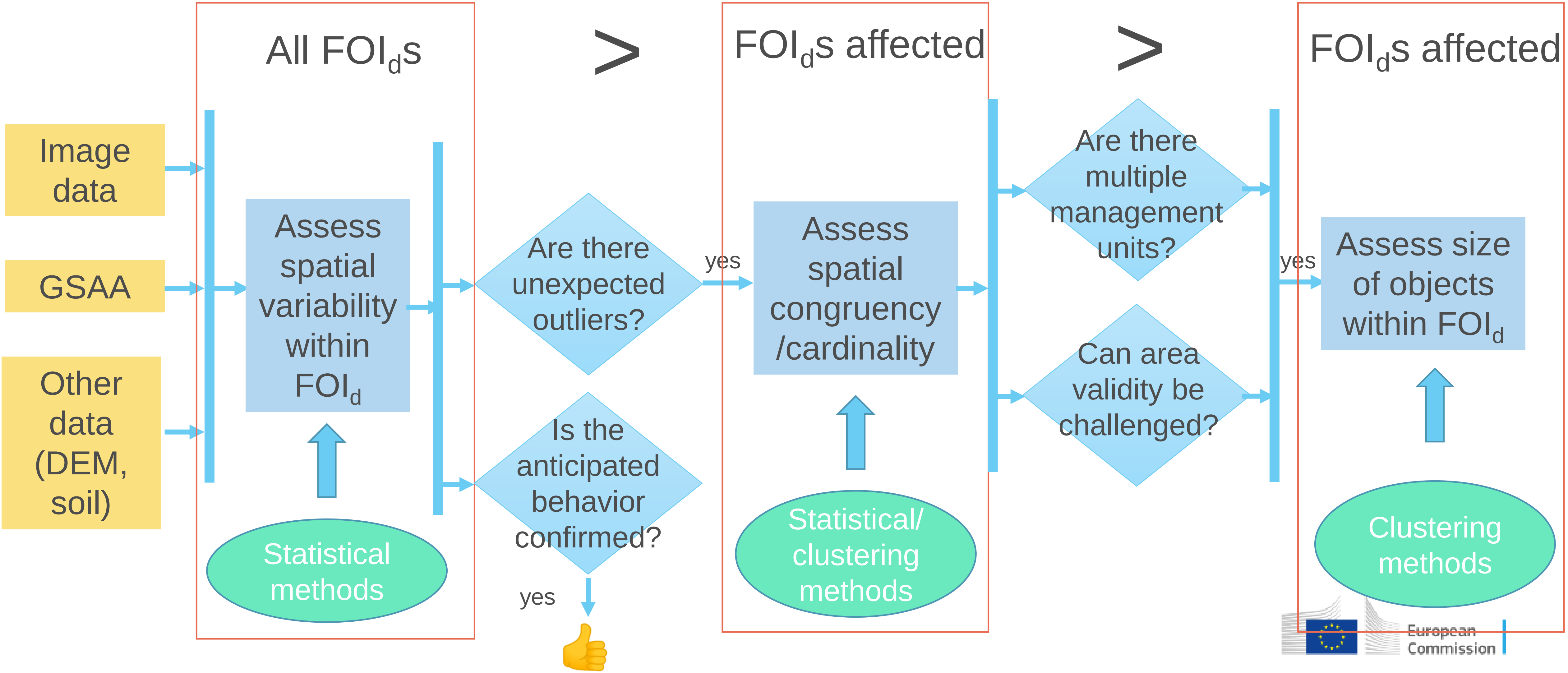
- It is the **physical surface of the earth**, where the specified practice is performed
  - Single unit of agricultural management
  - Has initially assumed perimeter from GSAA/LPIS
    - Acting as digital representation of the FOI (FOI_D)
    - Being the “spatial object” CbM operates with
- GSAA **perimeter compared with captured one** from Sentinels
- FOI >< GSAA AP can have **many-to-many** relationships
  - Key validity check in CbM

In GSAA



In CbM

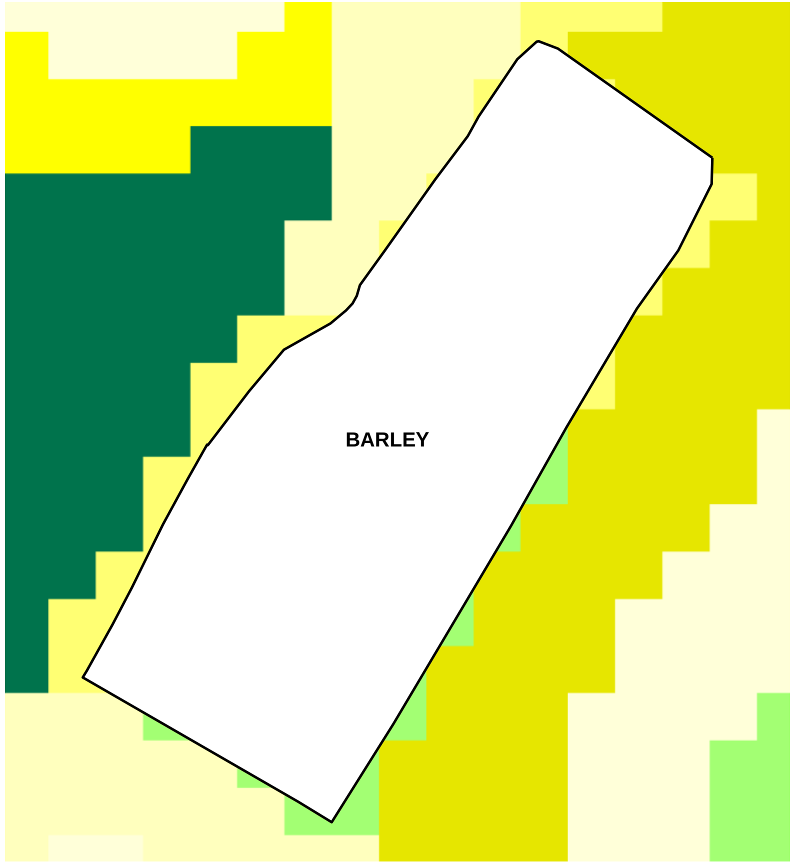
FOI generic workflow – the reductive approach



Example of non-uniform vegetation cover

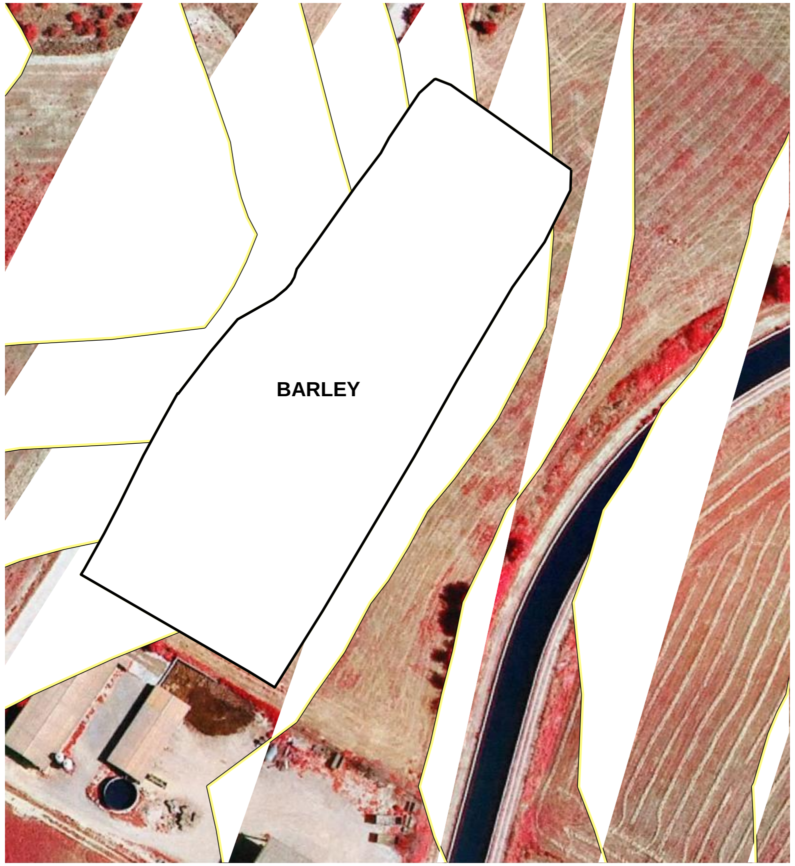
VHR imagery 2019

Thematic raster file



Calcaric Leptic Regosols

Orthophoto 2020

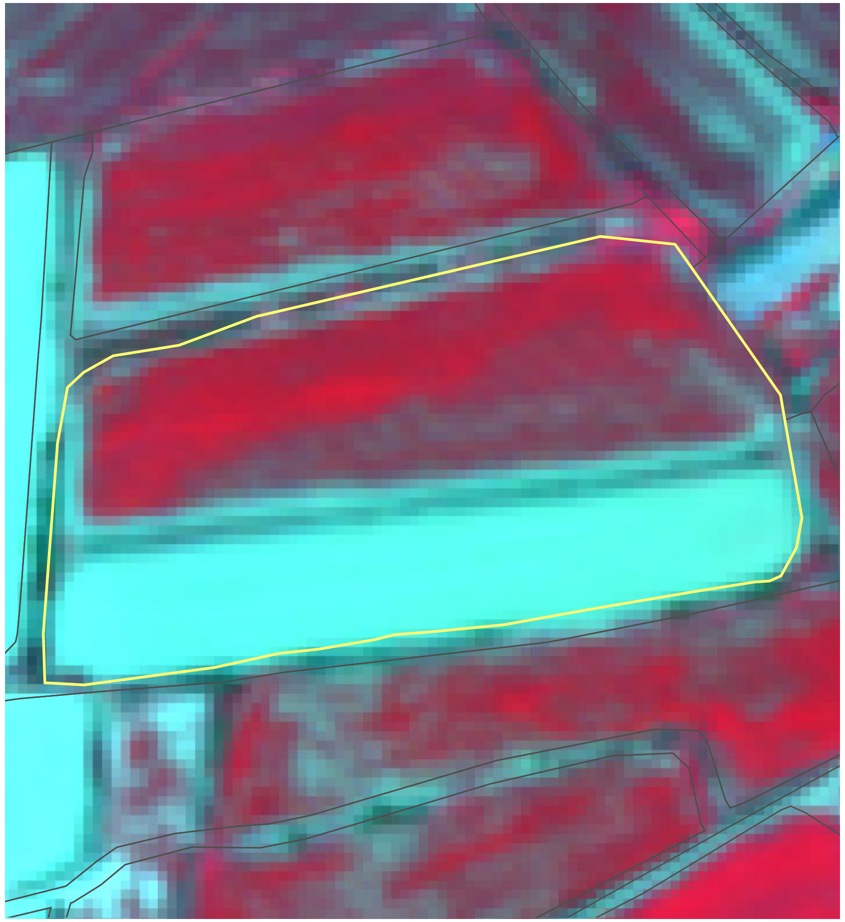


Mean slope: 8.2 %

Interpretation of results should be done <u>always in local context</u>

Example: Two management units in FOI

VHR imagery 2019



Thematic raster file

Orthophoto 2020

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Relevant python libraries and references

- FOI assessment notebook (applicable also outside CbM workflow)
- Statistical and IQR analysis (on signatures)
- Image segmentation (on preselected outliers)

References:

FOI progress report:

https://marswiki.jrc.ec.europa.eu/wikicap/images/7/75/JRC123711_foi_assessment_final22.pdf

FOI assessment notebook:

from https://github.com/ec-jrc/cbm

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CbM on DIAS: the jrc-cbm frontend

On-line training for Outreach, 30 September 2021

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Thematic use cases: FOI

- Heterogeneity will be captured in the histogram of band values
- summarized in the extracted parcel statistics (min, max, p25, p50, p75)
- IQR (p75 - p25) relative to median (p50) provides skewness indicator
- std (or std/mean) may be result of random noise
- Simple thresholding suits the reduction concept
- Other criteria for significance: high heterogeneity in relevant time sequence, class of the parcel (e.g. grassland in mowing season)
- Escalate to local image segmentation to quantify parcel subdivisions
- Notebook using OpenCV

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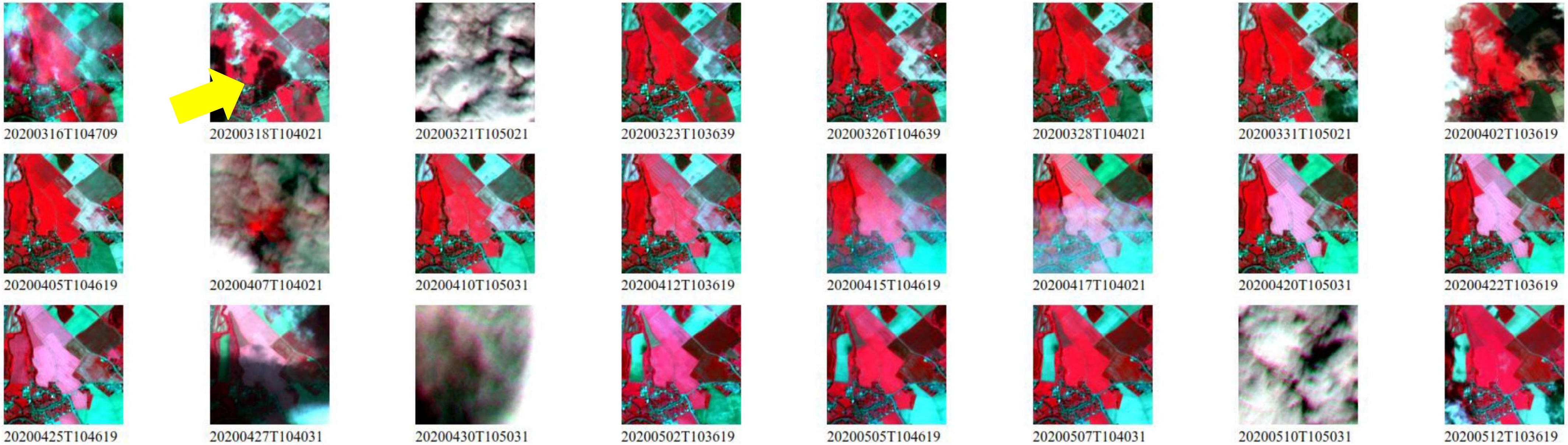
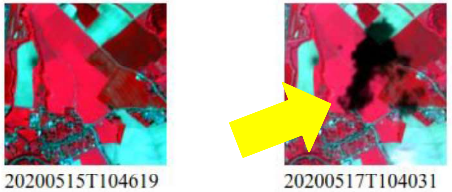
Clouds and sen2cor: the heterogeneity curse






```
df[df['pid'] == 111817] #.sort_values(['high'], ascending=False)
```

	Unnamed: 0	pid	obstime	mean	std	p25	p50	p75	count	high
97316	114329	111817	2020-03-18 10:40:21.024	2988.3926	1436.7032	1535.00	2633.0	4384.75	1228.0	1.082321
97317	114331	111817	2020-05-17 10:40:31.024	3503.7158	1958.9343	1305.75	3885.5	5445.50	1228.0	1.065436

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Thematic use cases: Machine Learning

- jrc-cbm started off with ML in 2018 to show Sentinel data relevance
- dug out as Outreach thematic use case (barely changed)
- **core idea**: S1 time series provide consistent time series for ML (S2 doesn't)
- Since S1 time series mark practices, ML should separate (core) practices
- Try out in "crop marker" context: can ML identify **outliers**?
- ML requires **data preparation**, training the **model**, analyzing the **inference**
- We use a Deep Neural Network (DNN) in tensorflow/tflearn
- A single notebook in 5 "easy steps". Code and docs in github.com/ec-jrc/cbm
- Hands on runs in Google Colab (provides access to GPU acceleration)

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JRC TECHNICAL REPORTS

Technical guidance on the decision to go for substitution of OTSC by monitoring

DS/CDP/2018/17

Devos W., Lemoine G., Milenov P., Fasbender D.

European Commission

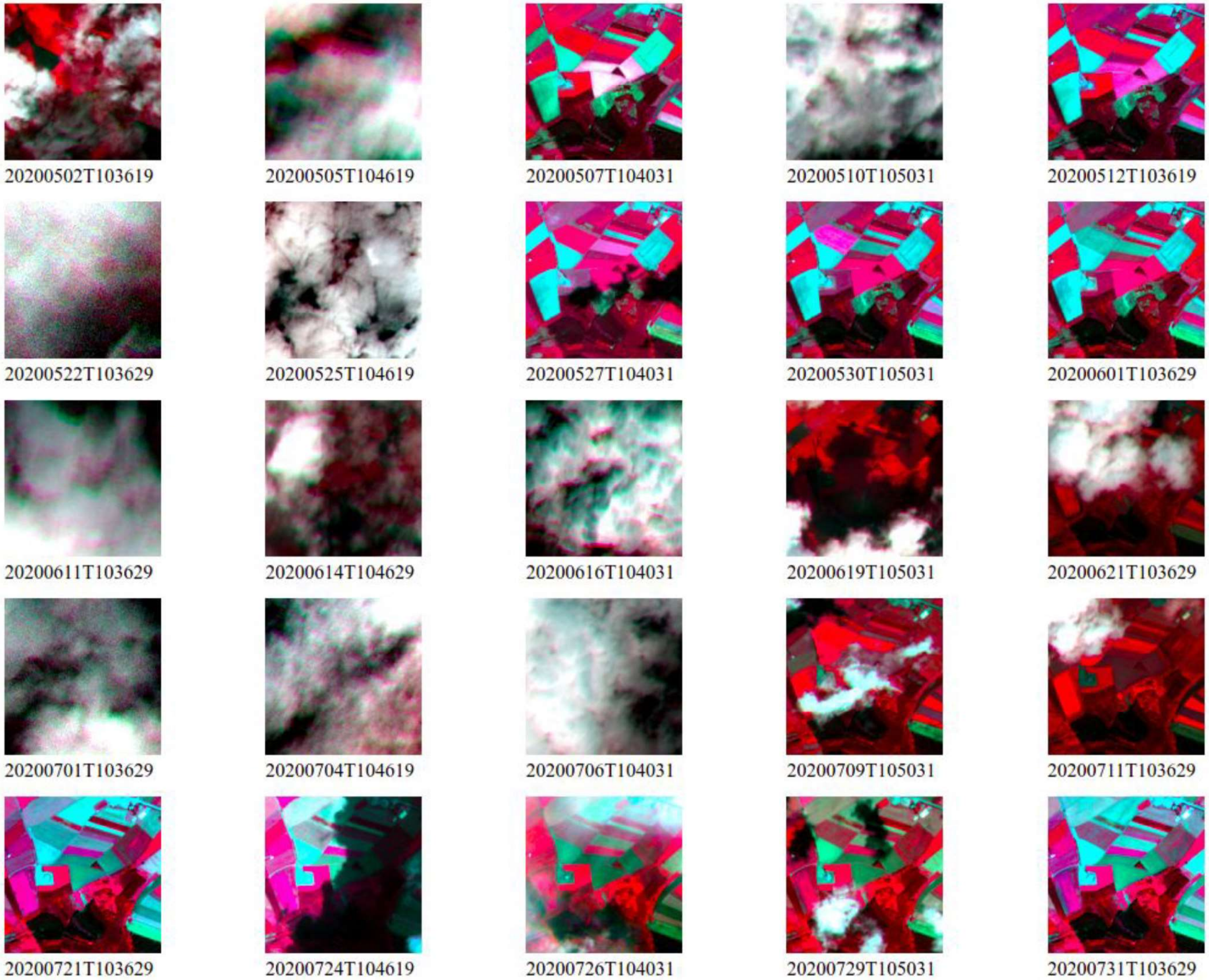
ML-s1_sigs.ipynb - Colab × BEWA - Google Drive ×

drive.google.com/drive/folders/182jFaUjnCmblPQdudt0sw3HU0ljFw8Fv

bewa_2020_tfrecords_cropselect_classes.csv

Open with

	klass	run0	run1	run2	run3	majclass	majcount
1	0	0	-1	0	0	0	3
2	0	0	-1	0	0	0	3
3	0	0	0	-1	0	0	3
4	0	0	0	-1	0	0	3
5	0	0	0	-1	0	0	3
6	0	-1	0	0	0	0	3
7	0	0	-1	0	0	0	3
8	0	-1	0	0	0	0	3
9	0	-1	0	0	0	0	3
10	0	0	-1	0	0	0	3
11	0	-1	0	0	0	0	3
12	0	0	0	0	-1	0	3
13	0	0	0	0	-1	0	3
15	0	0	0	0	-1	0	3
16	0	0	-1	0	0	0	3



	id	klass	run0	run1	run2	run3	majclass	majcount
2399	2778	0	-1	9	9	9	9	3
22771	26656	0	9	-1	9	9	9	3
27498	32041	0	-1	9	9	9	9	3
28333	33043	0	9	9	-1	9	9	3
58191	68258	0	9	9	-1	9	9	3
	76072	0	9	9	9	-1	9	3

6

Outlier review with S2 chips

temporary meadow found as oil seed rape (4.1 ha)

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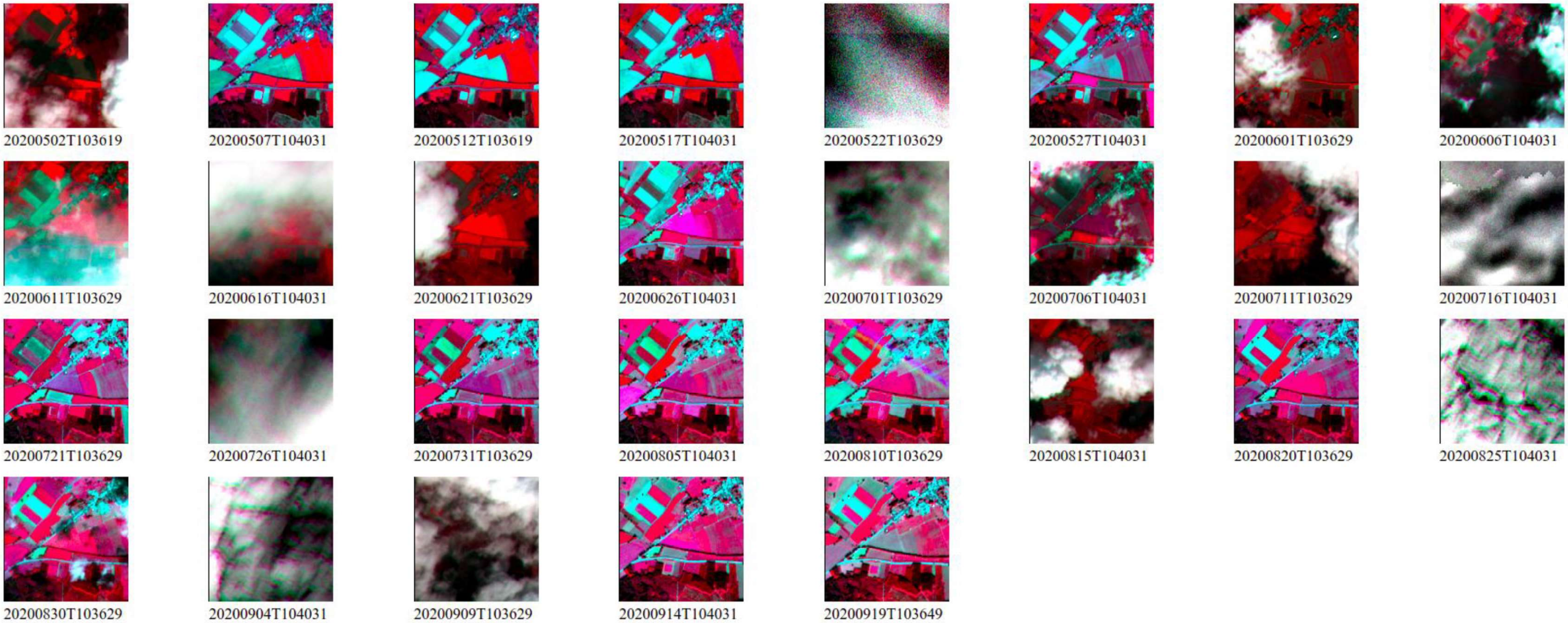

	id	klass	run0	run1	run2	run3	majclass	majcount
35252	41106	0	-1	1	1	1	1	3
35532	41427	0	1	1	-1	1	1	3
[illegible]	41663	0	1	-1	1	1	1	3
38288	44702	0	1	1	1	-1	1	3
41102	48073	0	1	1	1	-1	1	3
41493	48520	0	1	1	1	-1	1	3

64

Outlier review with S2 chips

permanent meadow (etc.) found as maize (7.1 ha)

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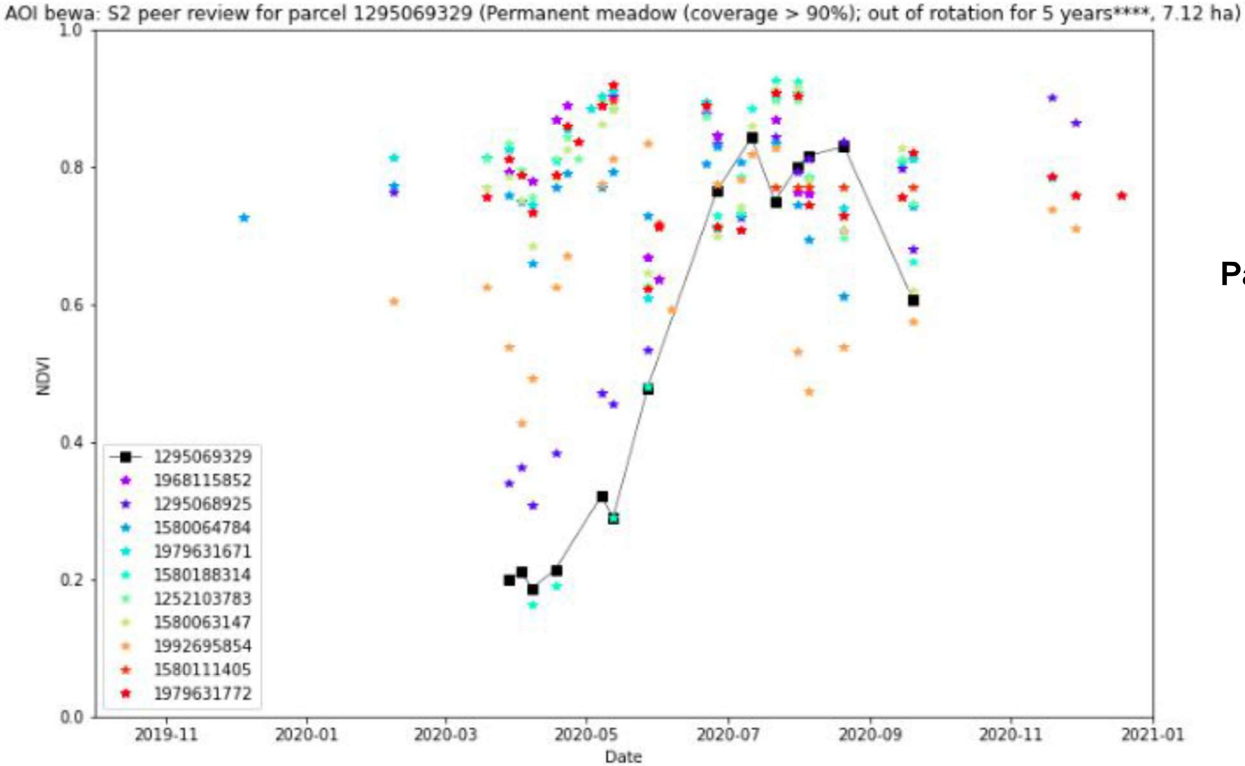


Parcel Peer Review

- Compare outlier parcel against neighbors
- 10 nearest within 500 m
- Compare relevant marker
- Apply phenological logic

Mowing Time Series Analysis

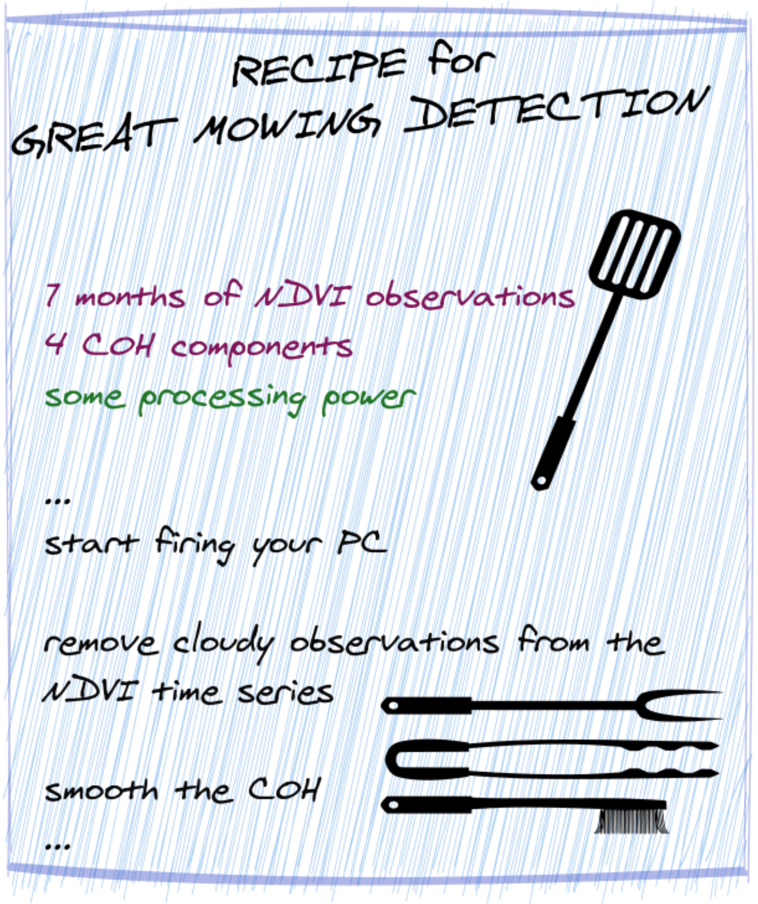
On-line training for Outreach, 30 Sep 2021

JRC D5 – GTCAP Team

Introduction

Goal: introduce basic principles/operations for **mowing detection** using Sentinel 1/2 time series

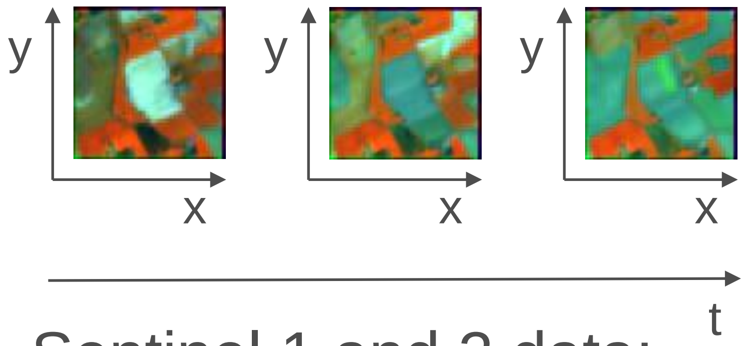
This is **not the only way** to perform **mowing detection**: several approaches from the literature
- general concepts
- proof-of-concept level
- reusable components



- **Concrete example** based on **outreach data** (dataset from the 2018 Dutch population)
- Some **simplifications** (not all the details will be discussed)

Summarizing the Spatial Dimension

So far:

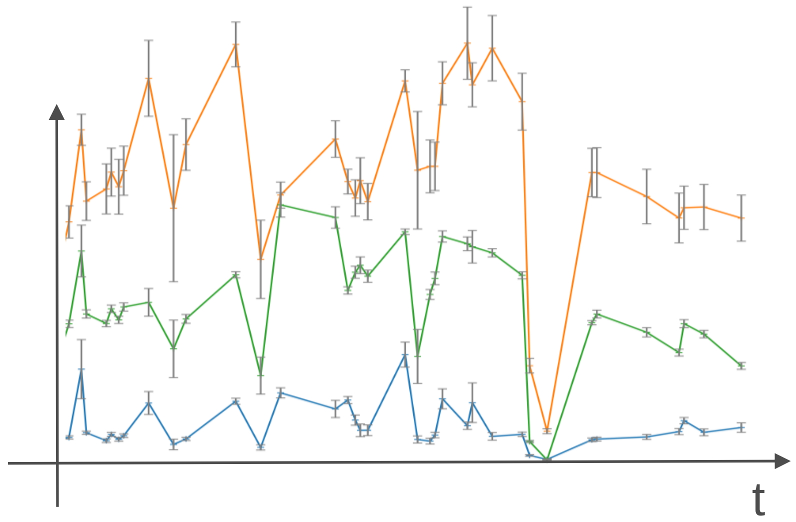


Sentinel 1 and 2 data: function of both **space** and **time**

After performing FOI analysis, heterogenity check,...

Effectively summarizing the spatial dimension

Time Series



Summary fuctions:

mean

$$\frac{1}{N_{x,y}}\sum_{x,y}(\cdot)$$

$$MEDIAN(\cdot)$$

mean, after applying a buffer

compromize between **efficiency** and **robustness**

Time Series: input of the processing

+ additional statistics

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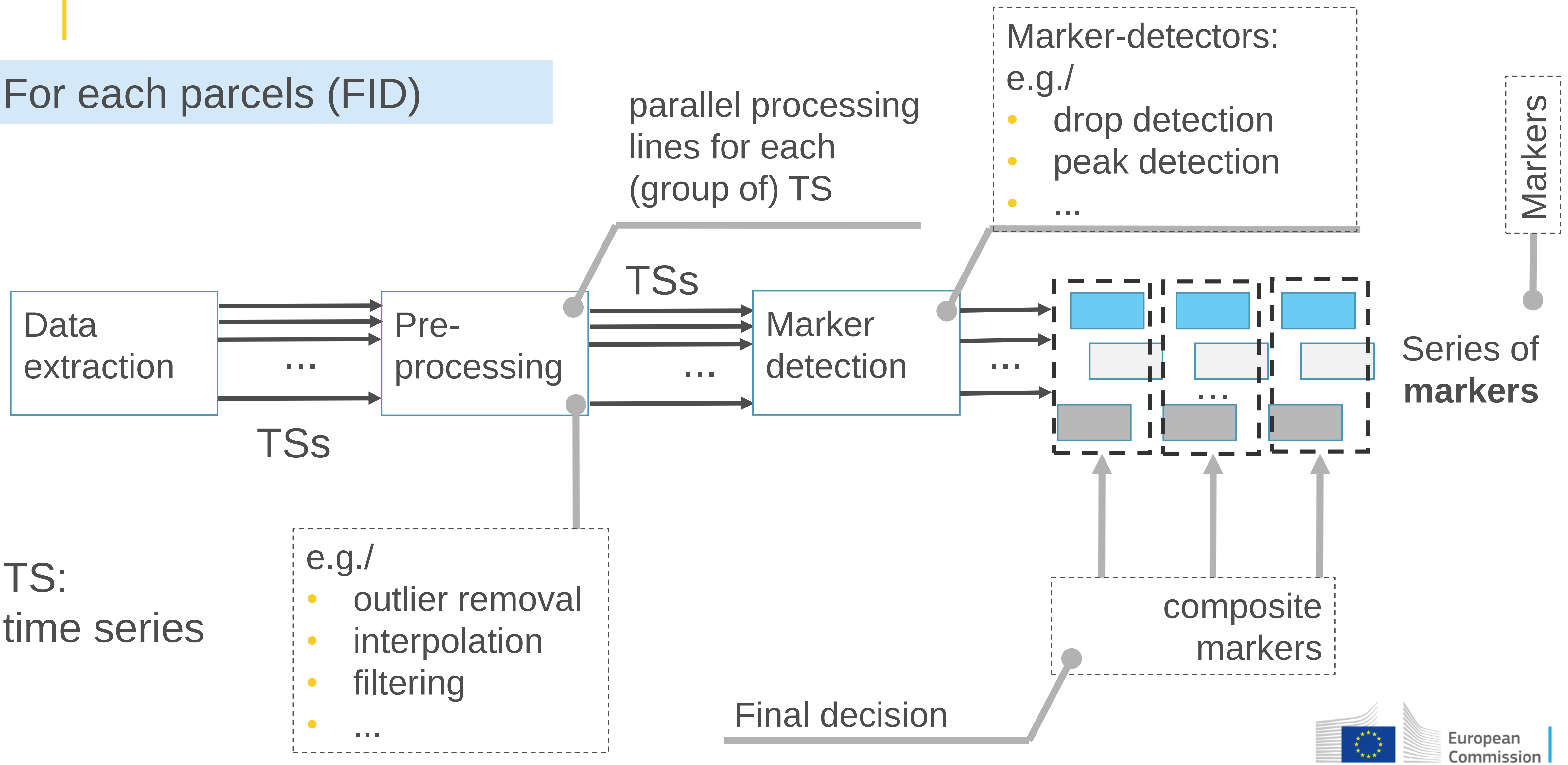
Overall Processing Chain

For each parcels (FID)



TS:
time series

Main Python Libraries

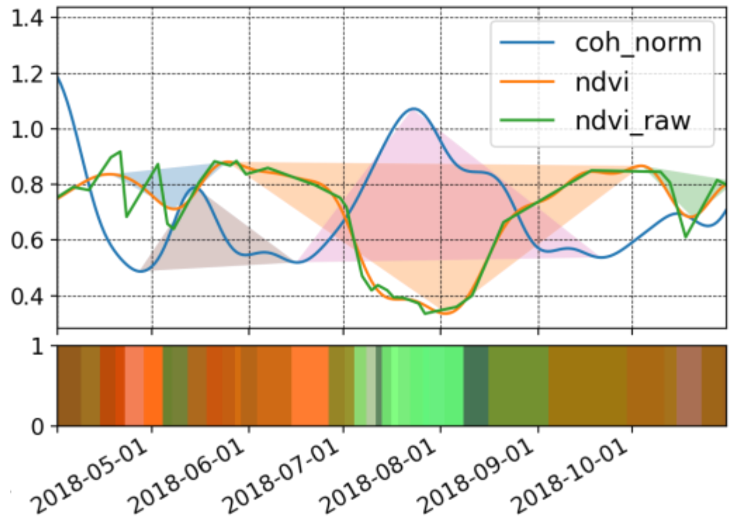
pandas — time series and data frame manipulation

GeoPandas — handling of parcel geometries

NumPy — numerical computing, array and matrix operations

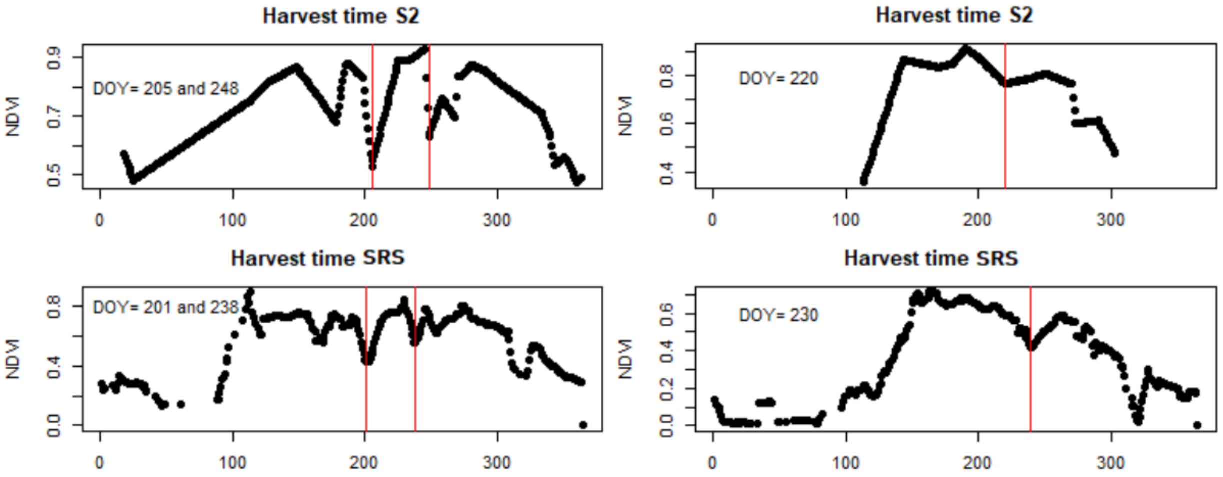
SciPy — signal processing and statistical operations

matplotlib — data visualization

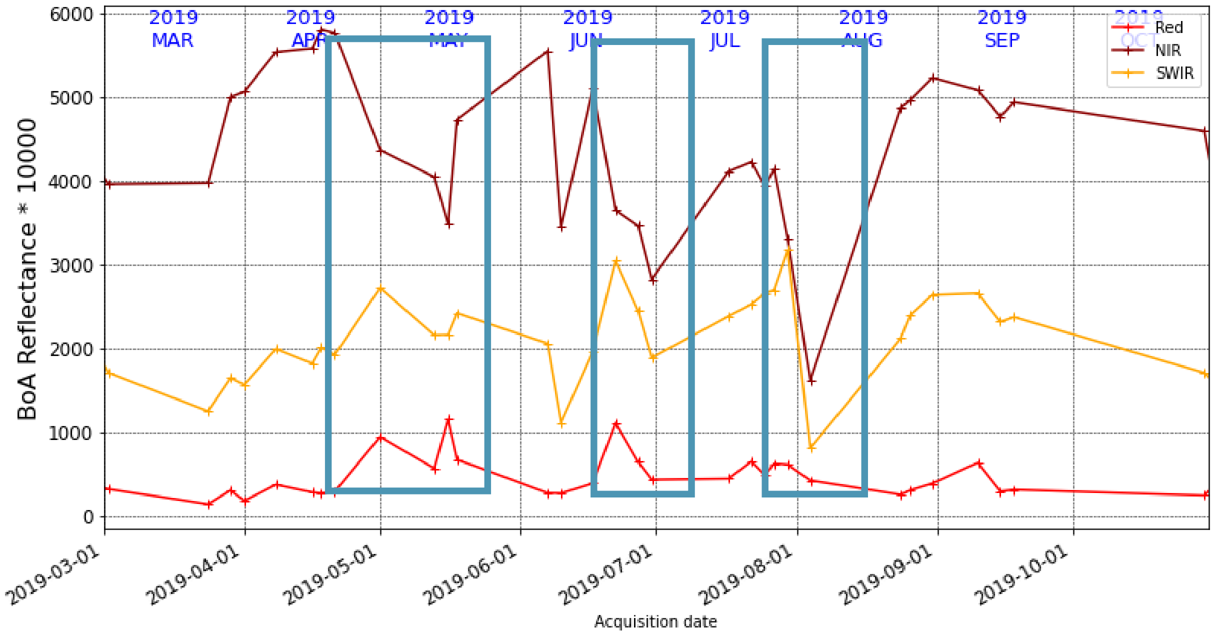


Mowing: Signal Selections - S2

- Mowing implies a **significat reduction of biomass**:
- direct impact on NDVI:
  expected significant drop
  'max-min-max'/'growth-cut-regrowth' **pattern**



NDVI examples from *L. Stendardi et al.* "Exploiting Time Series of Sentinel-1 and Sentinel-2 Imagery to Detect Meadow Phenology in Mountain Regions" *Remote Sensing 2019*



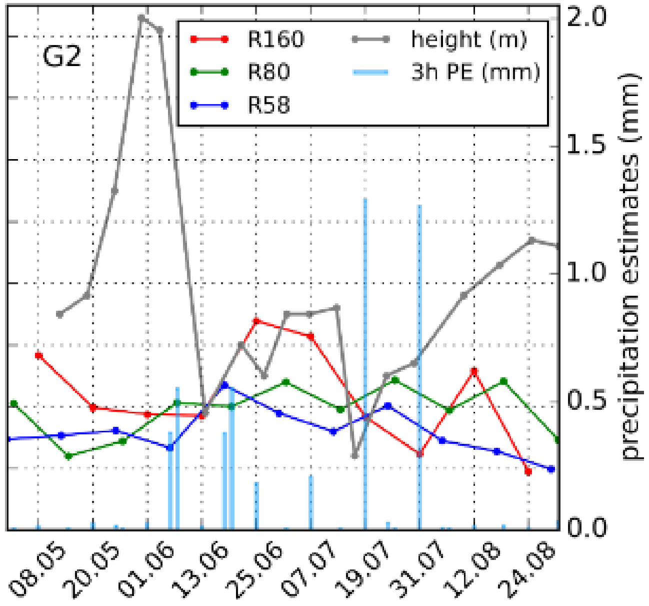
mowing events 'visible' in other S2 signals, including individual band components

only basic markers idenfied as a drop are considered here

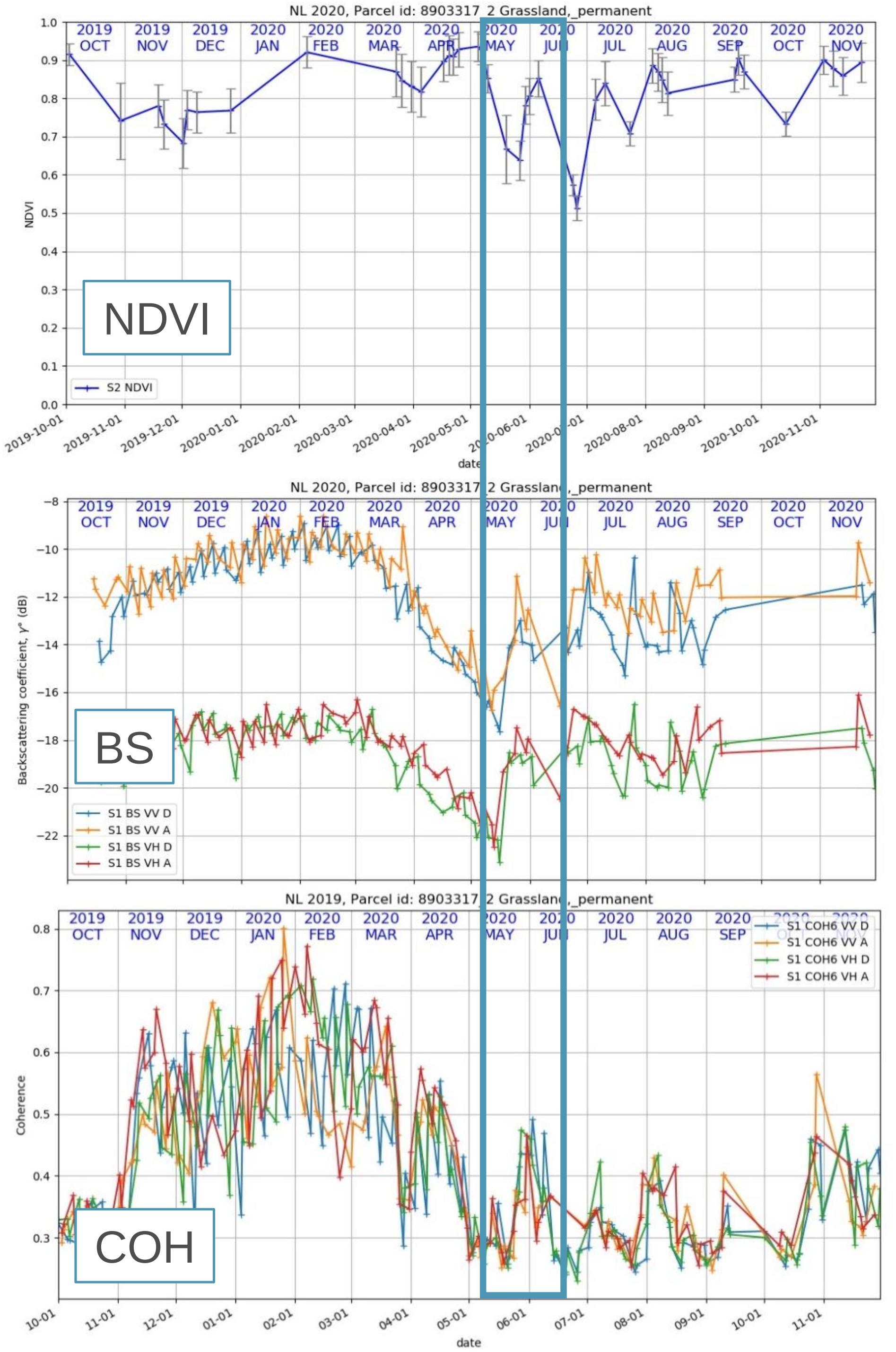
Mowing: Signal Selection and Behaviour - S1

Sentinel-1 Back-scattering and Coherence (COH) can **reveal mowing events**

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



coherence example from Tamm et al. “Relating Sentinel-1 Interferometric Coherence to Mowing Events on Grasslands” Remote Sensing, 2016



For this training: focus on NDVI and COH

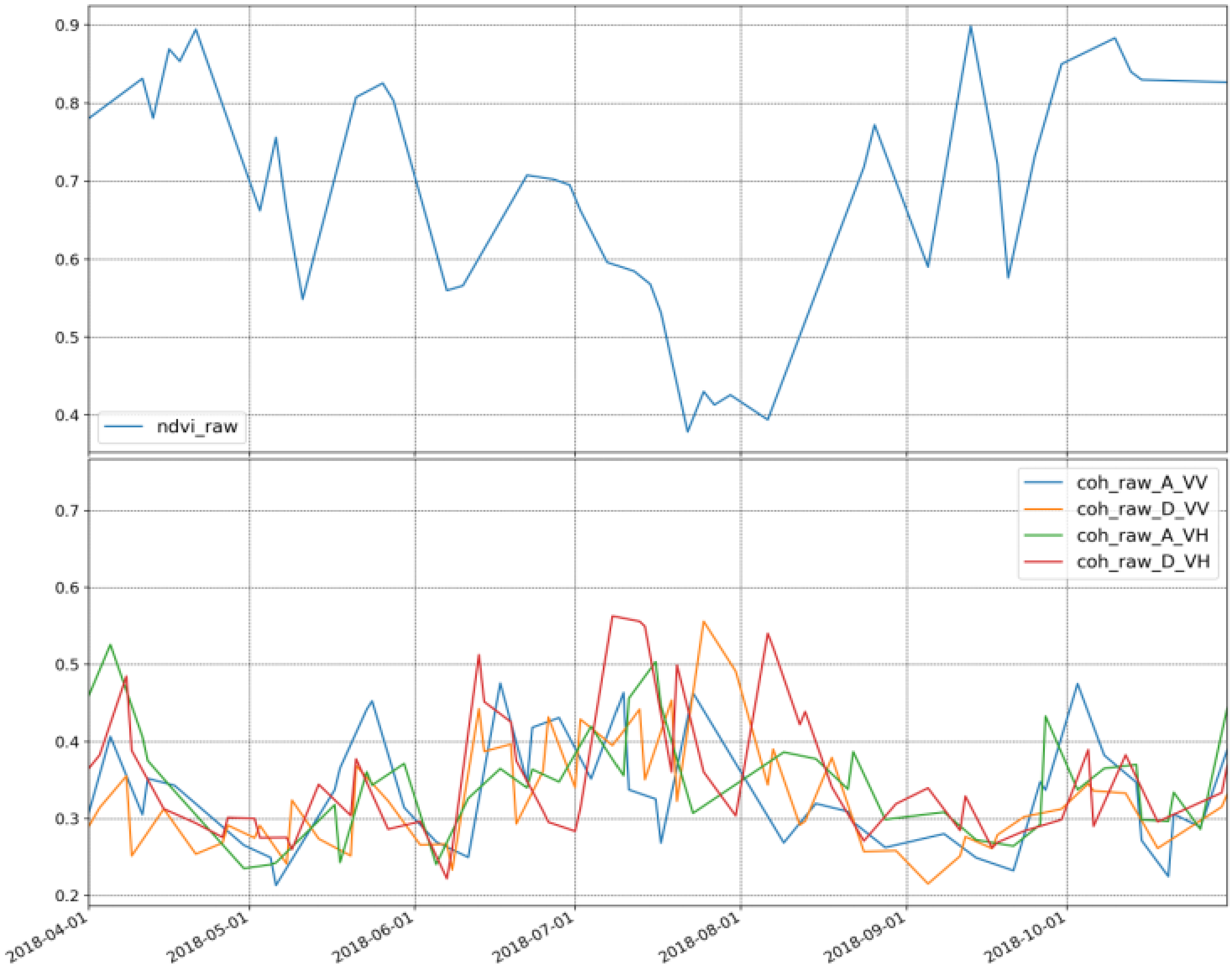
Input Time Series

NDVI: search for **drops**

- **Irregular sampling** and **missing data**
- **Presence of outliers** despite filtering based on SCL layer

COH: search for **peaks**

- **Four components** determined by **signal polarization** and **orbit direction** (ascending/descending)
- Which **(combination of) component(s)** should be used?
- **Regular sampling**, but not uniform if **several orbits** are combined
- **Noisy** time series: search for peaks could be difficult



Different sampling instants

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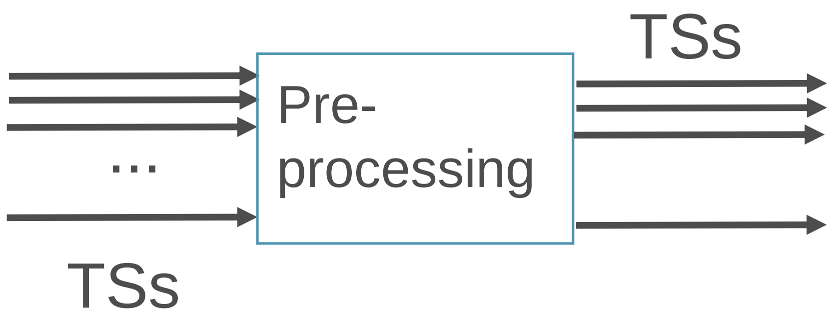
Time Series Pre-processing



Several operations possible

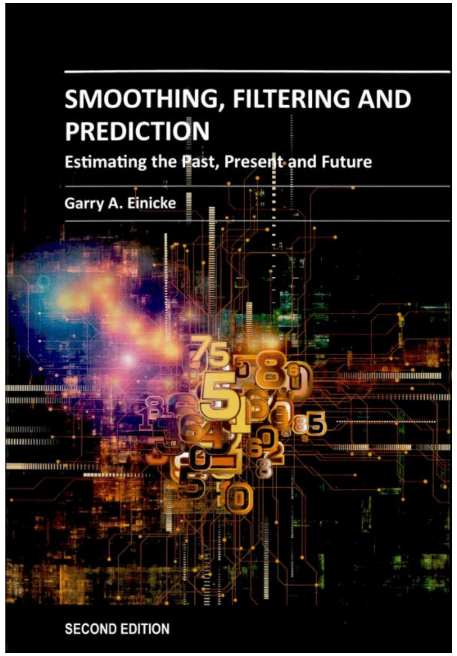
outlier removal:

for example based on the SCL, on the B02 component, several other methods

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

- **filtering** and **smoothing*:**
  - reduce the impact of noise and other (high frequency) phenomena not corresponding for example to mowing

- **time series combining**:
  computation of vegetation indexes from single band data, combining COH components, ...



*these words have specific meanings in the **signal processing** literature and must not be confused with their common use in remote sensing

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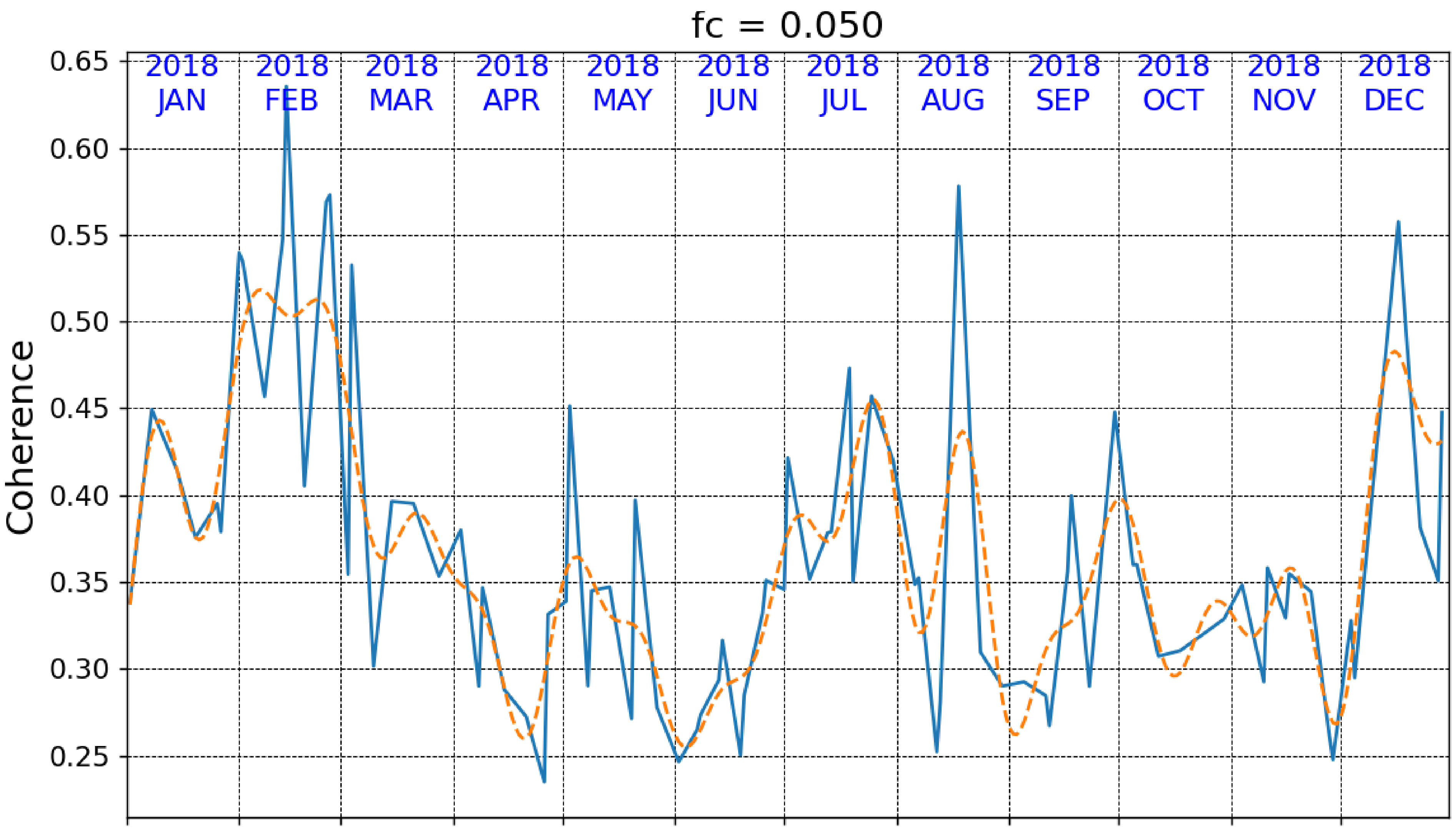
Impact of Smoothing



FilterDemo-Freq demo based on jupyter notebook

Butterworth filters “maximally flat in band”

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Coherence: Dealing with four Components

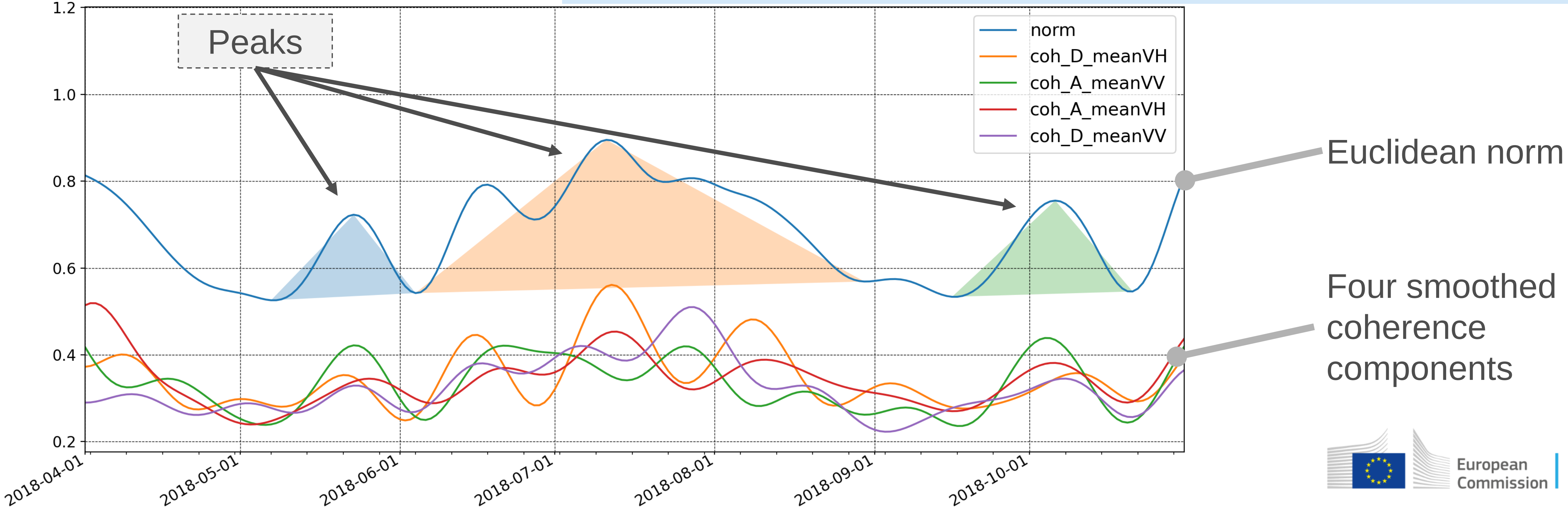
From the literature: no evidence that one of the components carries more information than the others

Symmetry between components

Euclidean norm: a possible candidate

Need for a summary function:

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



Marker Detection (I/II)

At this point: two smooth TS → **NDVI** and **COH norm**

Marker: drop → NDVI

Marker: peak → COH norm

Search for a peak: equivalent to **searching for a drop** on the TS multiplied by -1

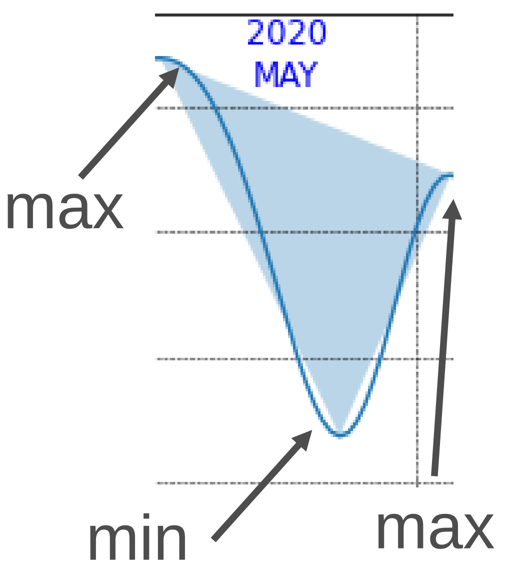
A drop is a **max-min-max pattern**

Basic approach: seach for **maxima** and **minima** of the TS

Simple functions based on **SciPy**

scipy.signal.argrelmax

`scipy.signal.argrelmax(data, axis=0, order=1, mode='clip')`

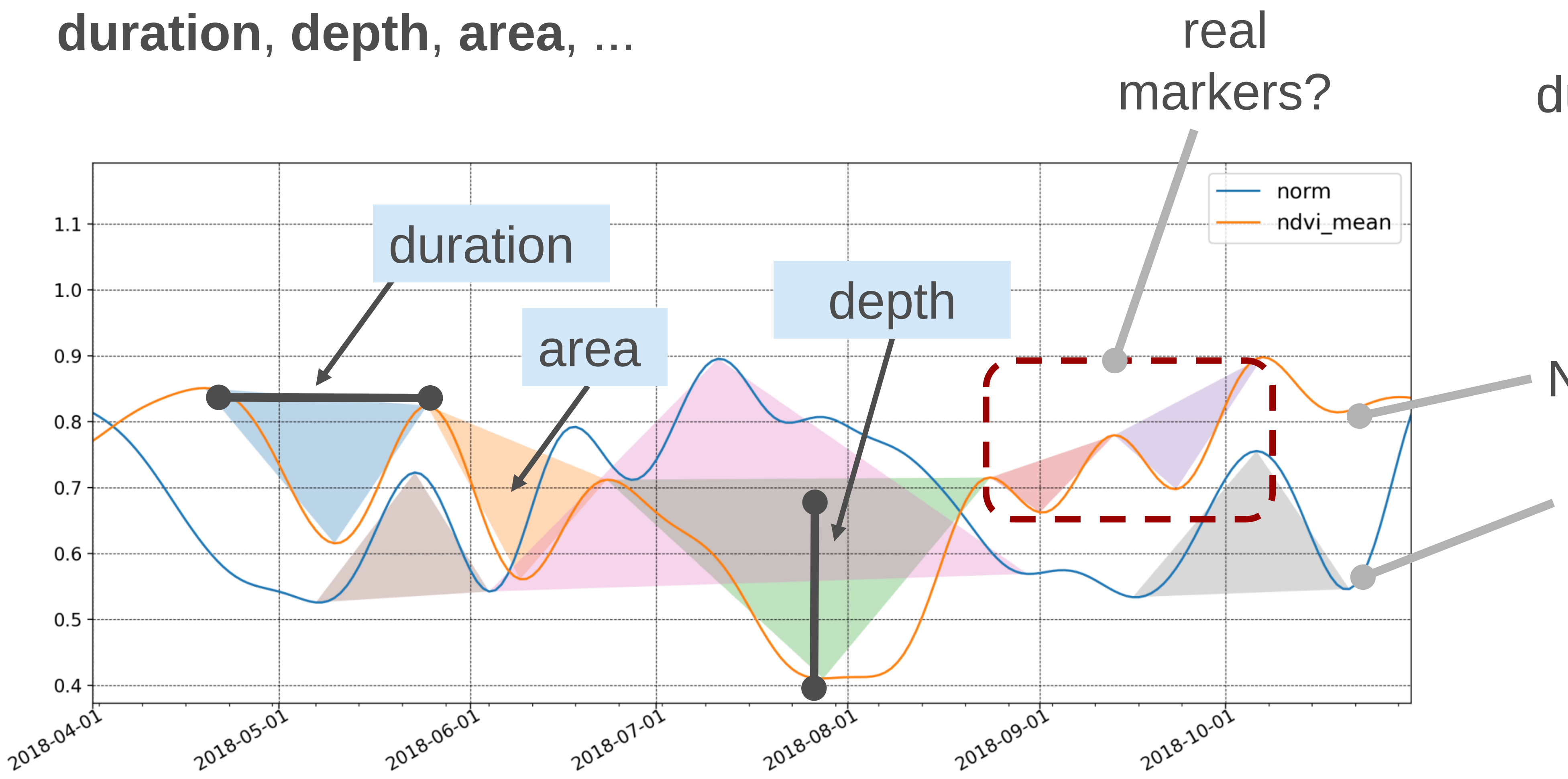


Few functions to deal with maxima and minima

- marker_utils.py
  - get_maxima
  - get_minima
  - argrelmax
  - get_first_maxima_before
  - get_first_maxima_after
  - get_first_minima_before
  - get_first_minima_after
  - get_extrema_features
  - find_closest_date
  - aggregate_extrema
  - aggregate_extrema_angle
  - filter_events_based_on_angle

Marker Detection (II/II)

Each drop (peak) has properties:
duration, **depth**, **area**, ...



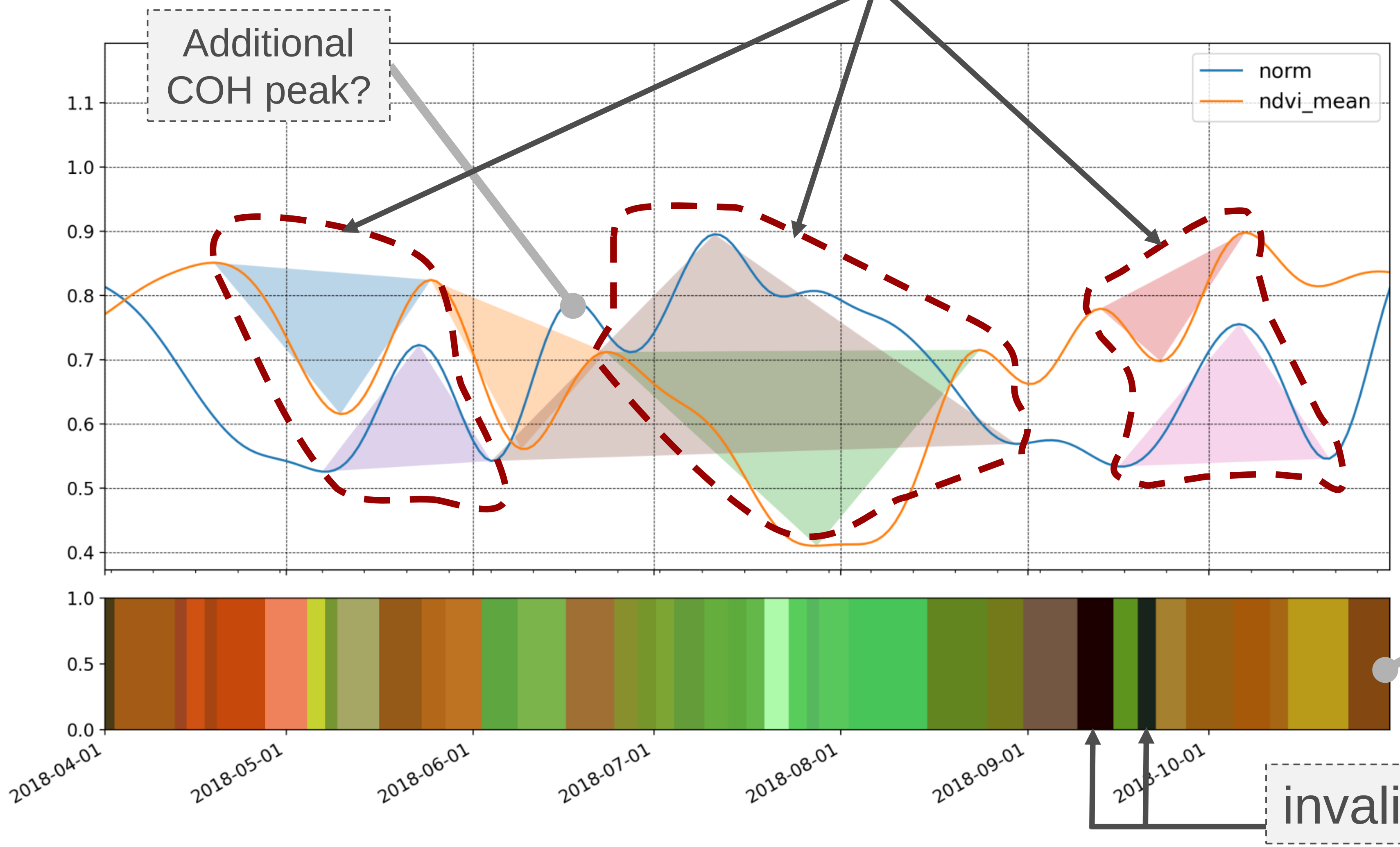
Filter markers with respect to these **parameters**

Thesholds on duration, depth and areas

Thesholds to be selected according to the **local conditions**

Composite Markers

Markers are found on both NDVI and COH



Composite markers built from **simple markers** observed on **single time series**

Concept of **co-occurrence**

Composite markers: more reliable decisions

False color composite with average B08,B11 and B04 components (see previous presentations)

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Conclusions and Next Steps

- Presentation of general principles for marker detection on time series with focus on mowing
  - pre-processing (filtering/smoothing, computation of derived time series)
  - simple marker detection based on TS extrema
  - composite markers

- The process can be fully automated with **two levels of outputs**:
  - **marker level** (list of markers detected)
  - **parcel level** (e.g. list of parcels for which at least one marker was found)

- Additional elements to consider include
  - better handling of data gaps and outliers
  - parameter tuning
  - processing on individual bands (only mentioned)

We are only scratching the surface

Q&A

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CbM on DIAS: the jrc-cbm frontend

On-line training for Outreach, 30 September 2021

JRC D5 – GTCAP Team

Next steps

- Time series stored in Outreach MS specific schema
- CARD-BS, CARD-COH6 complete and extracted.
- Secure RESTful access to sigs, hists, parcels.
- MS accounts can be used to test frontend code
- JRC to tailor to the thematic domains (mowing, grazing, catch crops, etc.)
- JRC can organise bilateral technical sessions for data analysis
- MS with DIAS instances can expand their samples (inside the AOI)
- Decisions on CAP 2022+ and Copernicus DIAS are key drivers for future
- We will continue to add to jrc-cbm components at github.com/ec-jrc/cbm

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Q&A

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