Sen4CAP system and visualization tool
Objective, overview, architecture, data flow

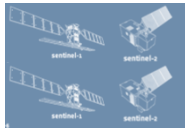
S.Bontemps, UCLouvain – Belgium
Sen4CAP hands-on training, 22-23 January 2020

sen4cap
common agricultural policy

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

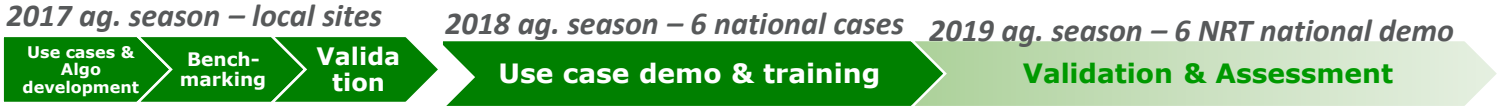
CAP monitoring approach – Technology meets Policy

sen4cap
common agricultural policy



Sen4CAP Objectives

- **Provide evidence** how Sentinel derived information can support the modernization and simplification of the CAP **in the post 2020 timeframe**
- Provide **validated algorithms**, **products**, **workflows** and **best practices** for agriculture monitoring relevant for the management of the CAP



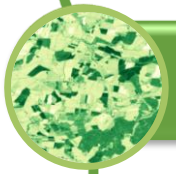
User Requirements in terms of IACS use cases

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

Use Cases
w/ Paying Agencies

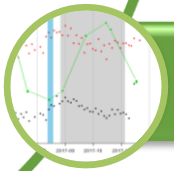
Use Cases: Sentinels to support payment decisions

Crop type mapping



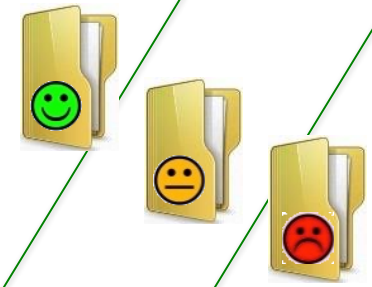
Growing vegetation indicators

Grassland mowing detection



Agricultural practices monitoring (EFA)

Use Cases
w/ Paying Agencies

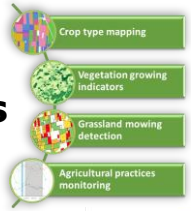


Use case
Crop diversification
Permanent grassland identification
EFA-Land lying fallo
EFA-Catch crops
EFA-Nitrogen-fixi
Interactive visu
Land abandor
LPIS update
Claimless system

From prototyping to NRT national demonstrations

Design and prototyping
2017 agri season – local sites

Use cases selection



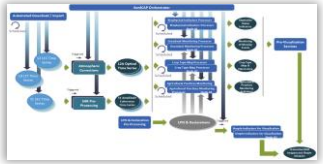
Products Specifications

Benchmarked Methods

Algo & System design

Prototype products

Validation



Demonstration and validation
2018 & 2019 agri seasons – national NRT

Use cases demonstration

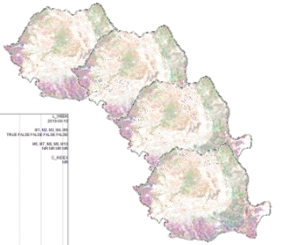
National scale

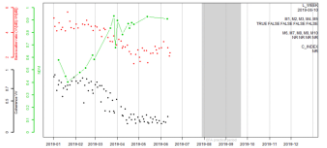
Continuous monitoring

Validation & Fitness-to-use assessment

Capacity building and training

System qualification





2018-2019 Sen4CAP national demonstration for 6+1 Paying Agencies running on distinct DIAS VMs along the agricultural season

Czech Republic
Production VM
Test VM

Castilla y Leon
Production VM
Test VM

Romania
Production VM
Test VM

France (2 departments)
Production VM
Test VM

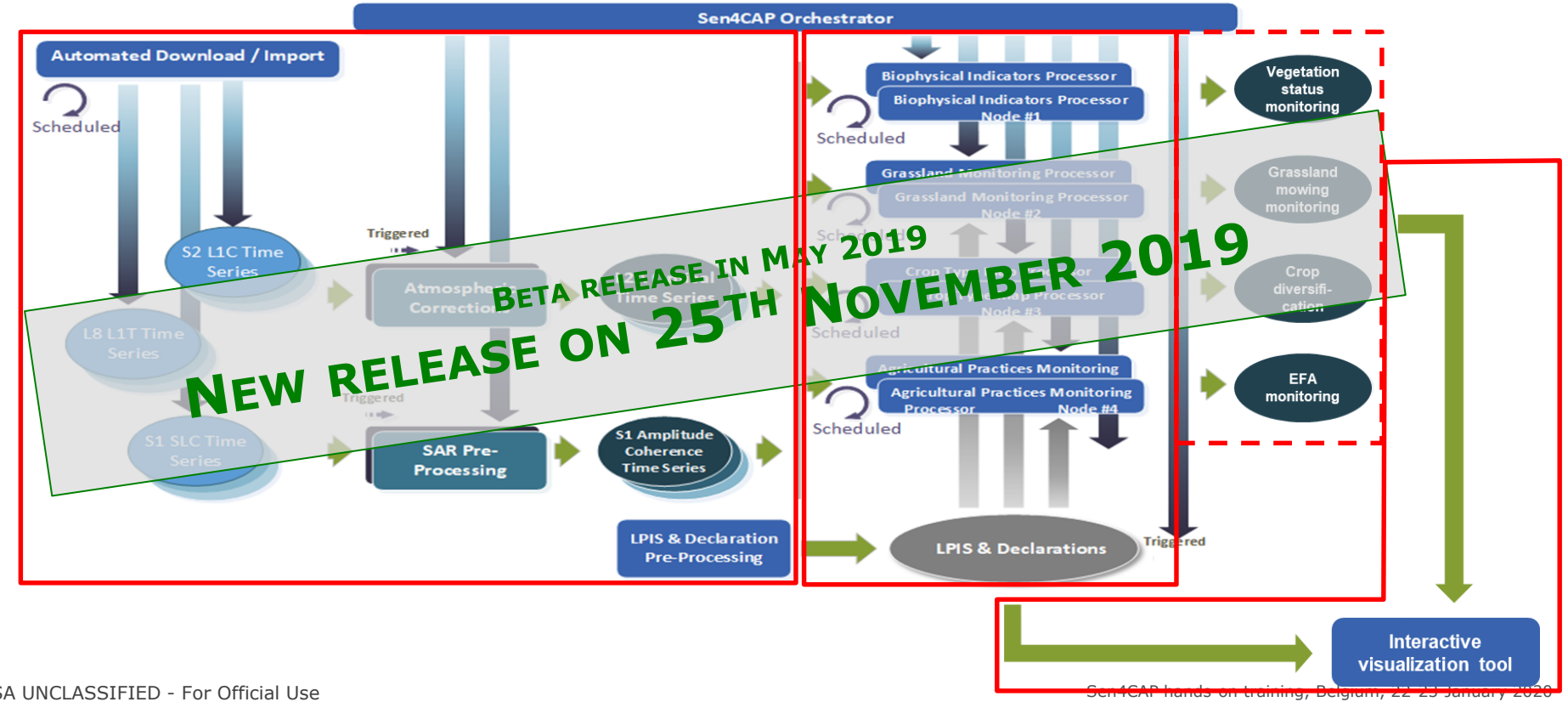
Lithuania
Production VM
Test VM

Netherlands
Production VM
Test VM

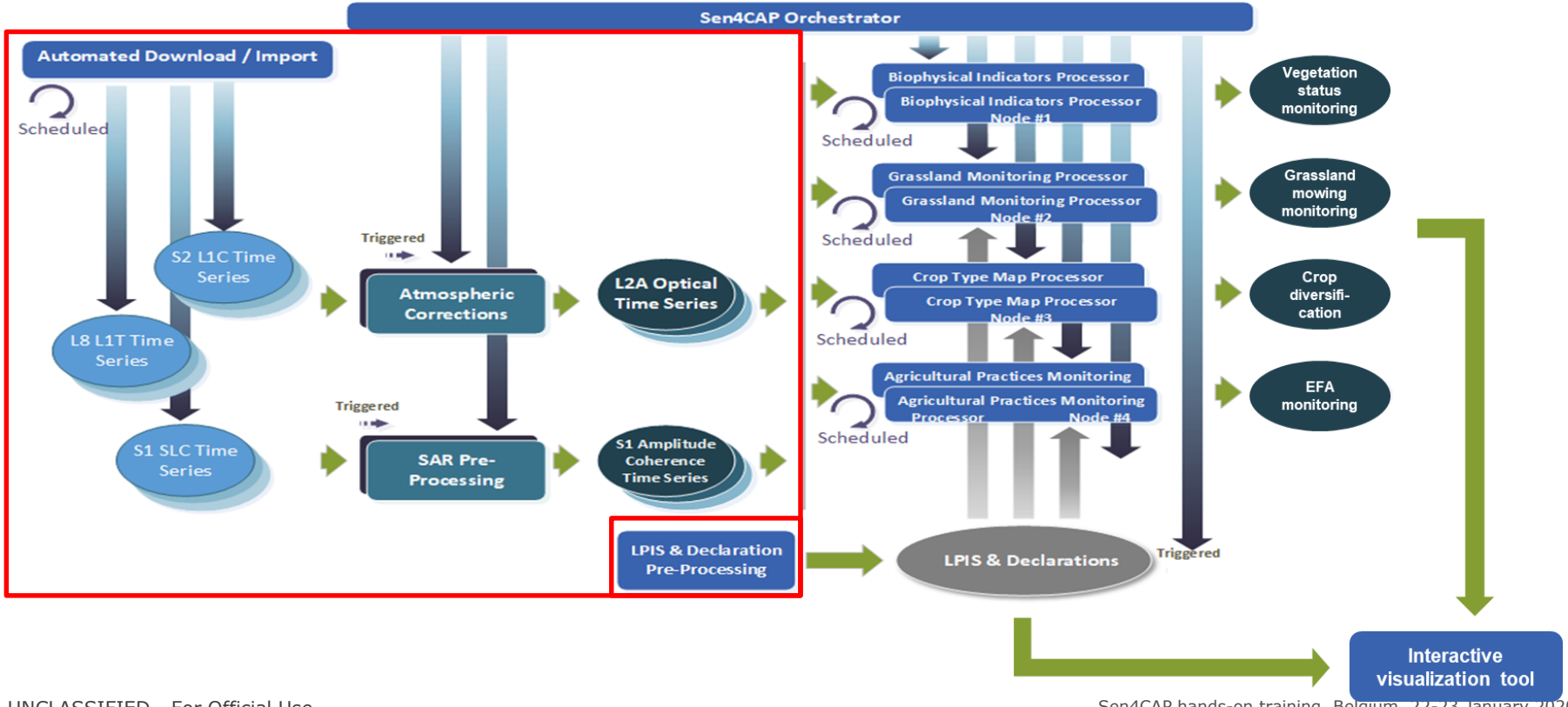
Italy
Production VM
Test VM

Cloud
(CREODIAS)

Sen4CAP system (v1.0)

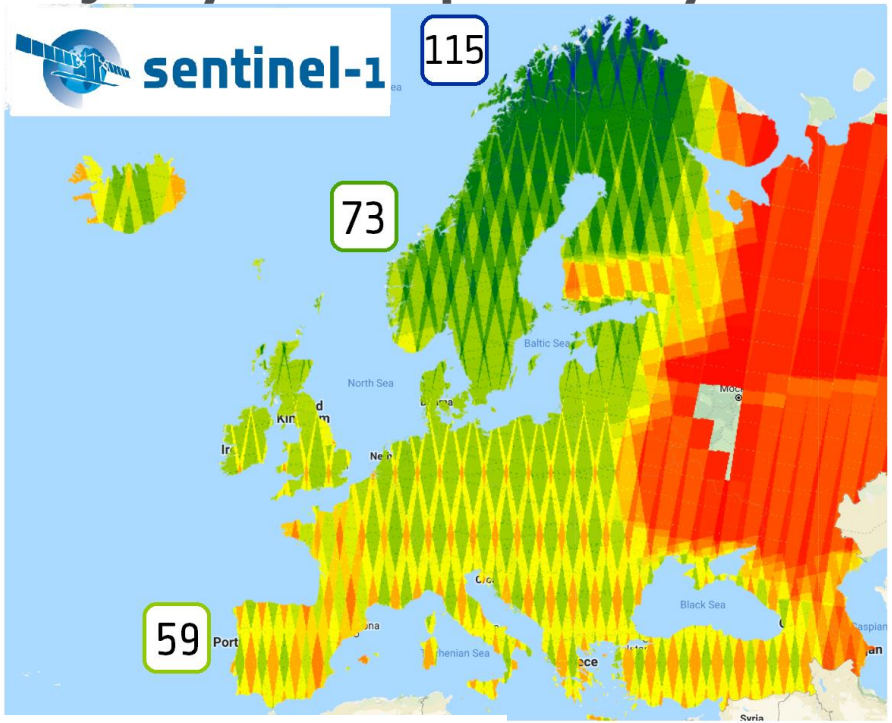


Sen4CAP system



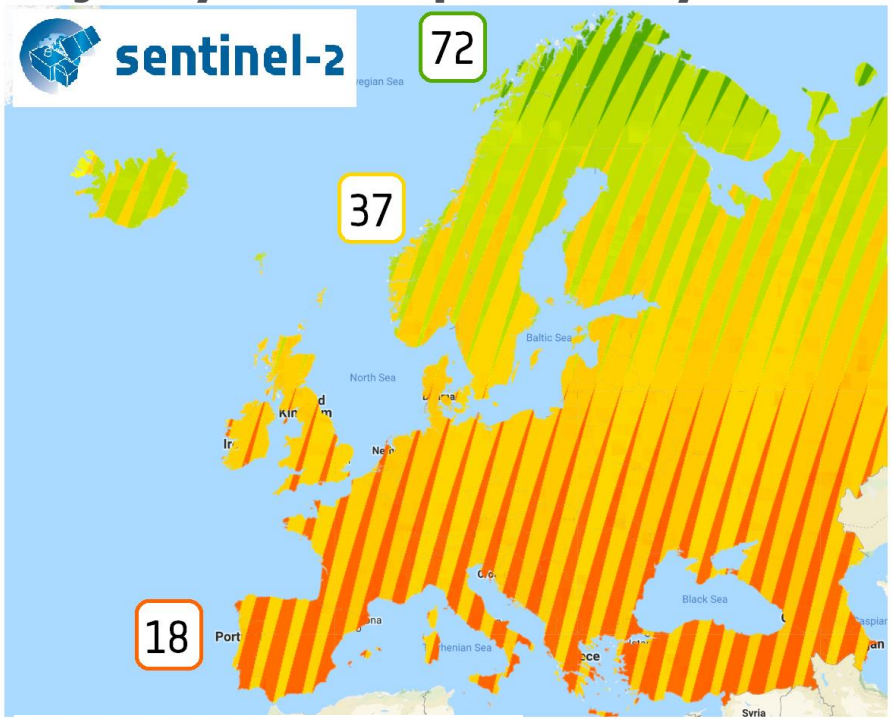
Input EO time series

Majority of Europe >2 day revisit



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

Majority of Europe >3 day revisit



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

Sentinel-2 pre-processing

- Correcting single-date Level-1C products from the effects of the atmosphere that reduce the quality of the images

Table 1: Sentinel-2 product types

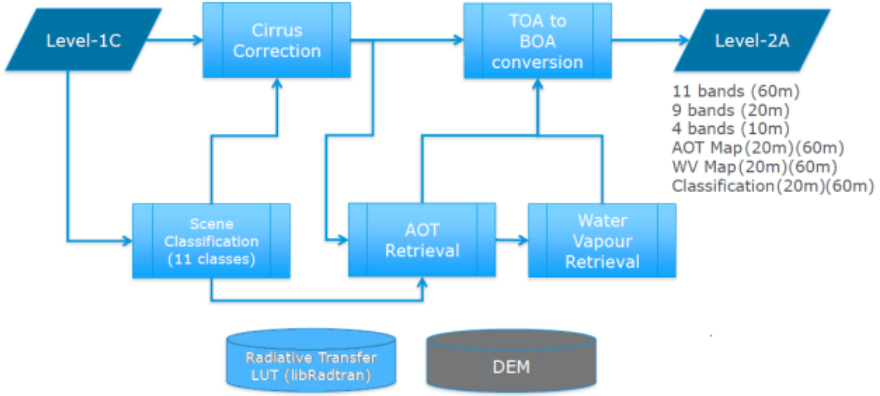
Name	High-level Description	Production & Distribution	Data Volume
Level-1C	Top-of-atmosphere reflectances in cartographic geometry	Systematic generation and on-line distribution	600 MB (each 100x100 km2)
Level-2A	Bottom-of-atmosphere reflectance in cartographic geometry	Systematic generation and on-line distribution and generation on user side (using Sentinel-2 Toolbox)	800 MB (each 100x100 km2)

- Level-2A products are systematically generated at the ground segment over Europe since March 2018 using Sen2COR processor

https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi/product-types/level-2a

Sen2COR Workflow

- Starting from Top-Of-Atmosphere (TOA) Level-1C products
  1) Cloud detection and scene classification
  2) Retrieval of Aerosol Optical Thickness
  3) Retrieval of Water Vapour
  4) TOA to Bottom-of-Atmosphere (BOA) conversion
- Options: cirrus correction, terrain correction, adjacency correction and empirical BRDF-corrections



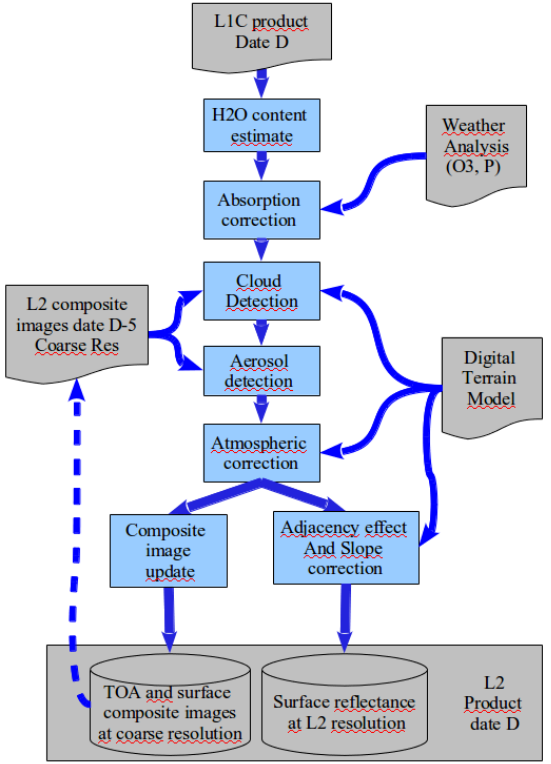
+ L2A images systematically produced by ESA over Europe

+ These images should be available on DIAS

- Problematic cloud detection

Pre-processing with MAJA as an alternative

- CNES/CESBIO and DLR joined their efforts to develop MAJA (MACCS-ATCOR Joint Algorithm)
- Same main steps
- Specificity: use of multi-temporal methods, which is key for cloud detection
- Assumption: surface reflectances are stable over short periods of time in the absence of cloud while the presence of a cloud or a cloud shadow introduces a quick variation of the reflectance



+ Better cloud detection -> more usable dataset

- Time and ressource consuming

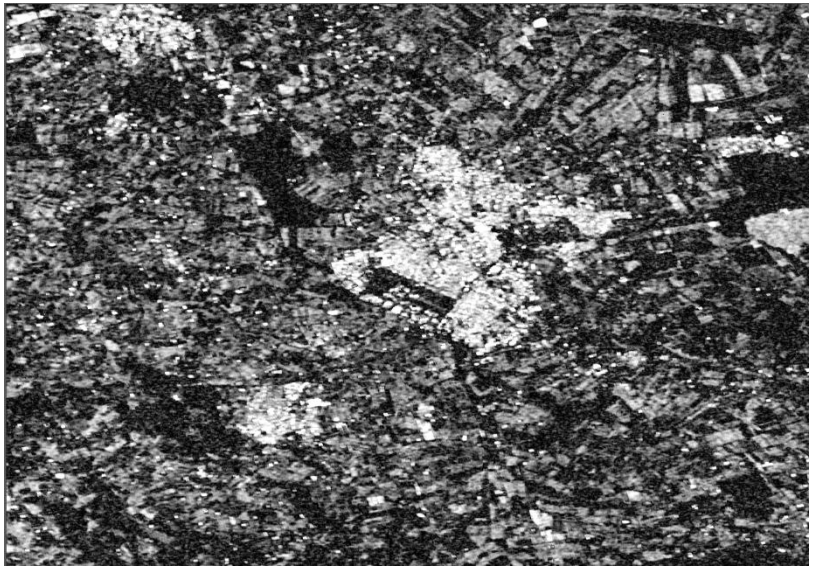
Sentinel-2 pre-processing

- Temporal resampling, with gap filling (every 10-day)
- Objective: produce a reflectance image time series which is gap-filled with respect to missing data (clouds, cloud shadows, saturated pixels) and temporally sampled on a regular grid
- Makes use of validity mask from L2A products (clouds, cloud shadows, saturated pixels)

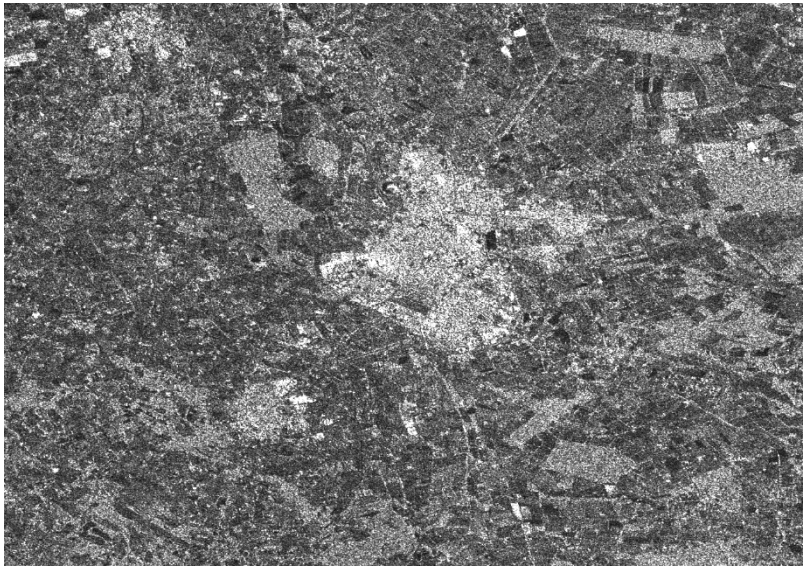
S-2 time series data from May to Sept 2018, N-W of Prague

Sentinel-1 pre-processing

- Generation of **coherence** and **amplitude** products, from Sentinel-1 Interferometric Wide images



Coherence 20180512 - 20180518

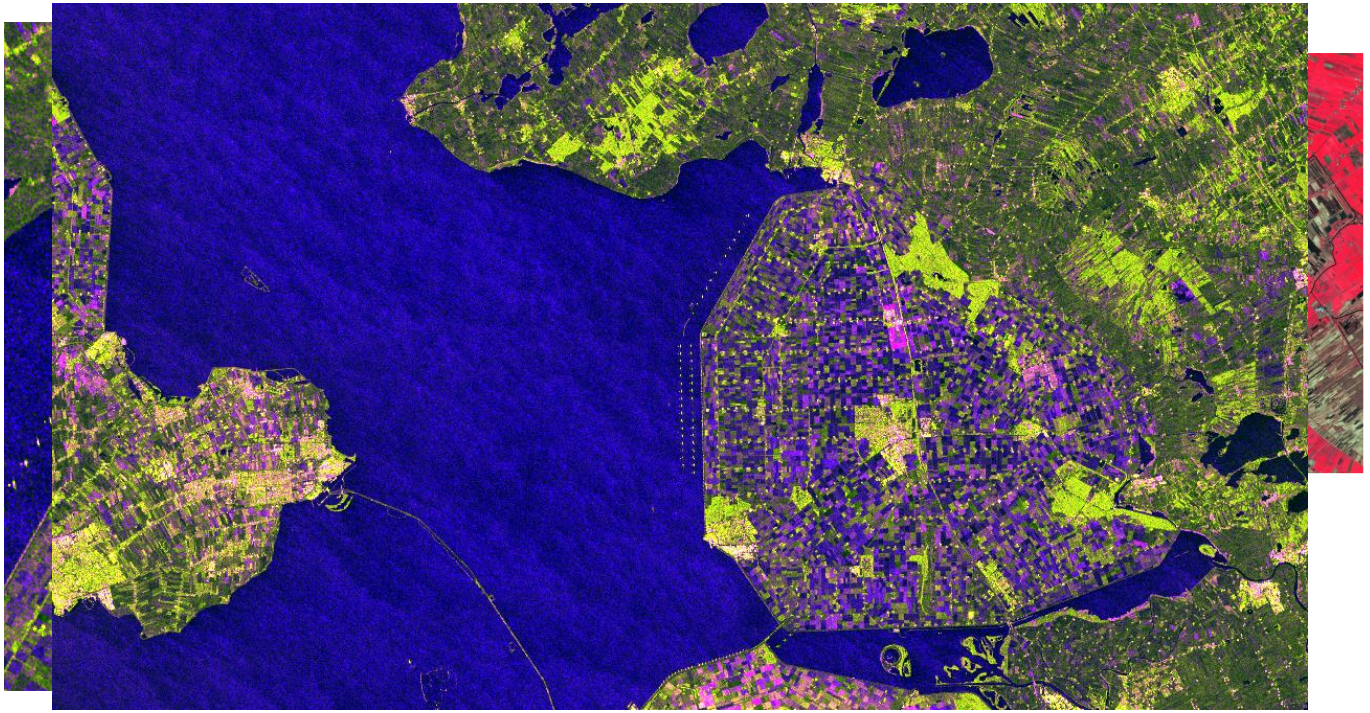


Amplitude 20180518

Nordhorn (NLD)

Sentinel-1 time series

Sentinel-1 backscatter and coherence time series in VV and VH polarization (weekly mosaics)



SAR coherence and amplitude

- SAR Coherence

The coherence, which assume values in the range [0.0, 1.0], gives an **estimation of changes in the scene taking into account variation of the phase of the backscattered radar signal:** high coherence (close to 1.0) implies that the scene is steady (e.g. urban areas, bare soil, rocks and so on), low coherence indicates changes between the two acquisition dates.

The coherence is calculated from a couple of SAR images acquired from the same orbit (in order to have significant coherence values the images must be acquired with similar sight of view). The high revisit time of Sentinel-1 mission allows to calculate **short term coherence** from couples of images acquired one **6 days** from the other.

- SAR backscattering (after calibration, sigma nought $\sigma 0$)

The **SAR backscattering** is a measure of the outgoing radar signal that the target redirects directly back towards the radar antenna. It is a measure of the reflective strength of a target. The normalised measure of the radar return from a distributed target is called the backscatter coefficient, or **sigma nought** (σ_0), and is defined as per unit area on the ground. In general, due to the high dynamic of the SAR backscatter coefficient, **the amplitude** = sqrt(σ_0) is preferred for visualization purposes.

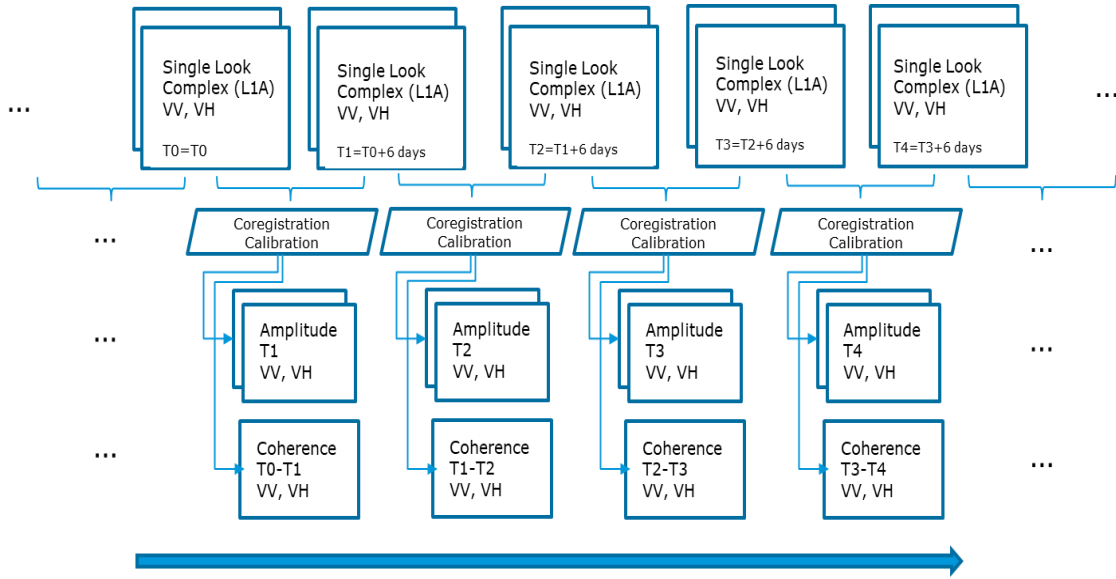
Definitions of SAR terms can be found in https://earth.esa.int/handbooks/asar/CNTR5-2.html

Workflow

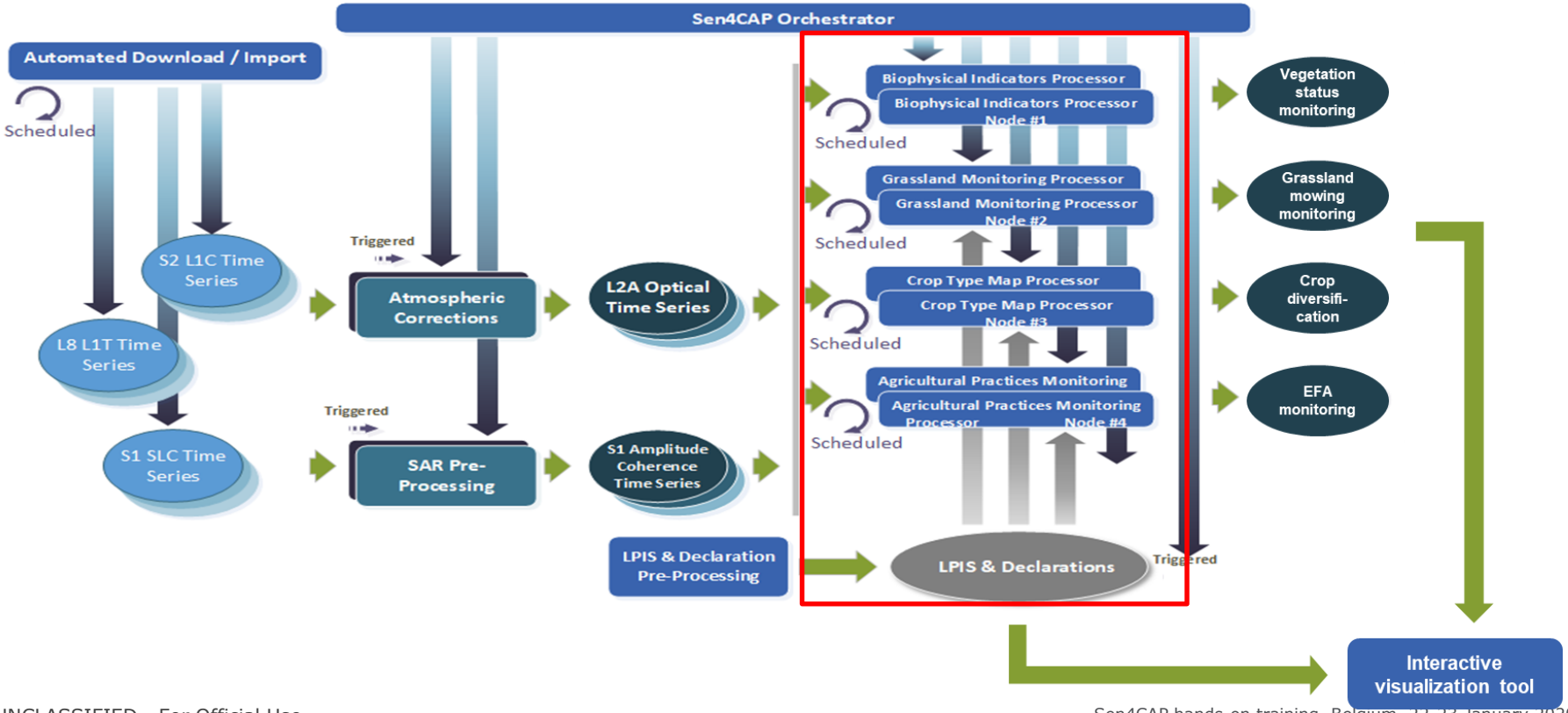
SAR preprocessing

The scheme shows how the acquisition of new S1 data at the times T0, T1, T2, … drives the preprocessing workflow

- The acquisition of a new S1 data and its availability **triggers** the calculation of the SAR amplitude and coherences.
- S-1 data at time T_n leads to the generation of VV and VH amplitudes relative to the T_n and to the VV and VH coherences relative to the time interval $[T_{n-1}, T_n]$
- A coregistration step guarantees the quality of the **coherence extraction** from consecutive (6 days) SAR data of the same orbit and the **precise alignment** of the coherence and amplitude stacks.

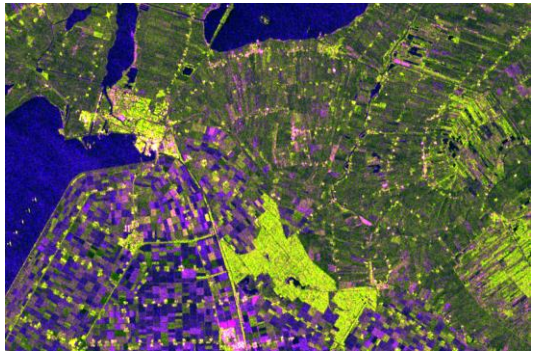


Sen4CAP system



Large dataset of markers from S1 & S2 for a national coverage

Sen4CAP system to process in near-real time full time series locally or on the cloud

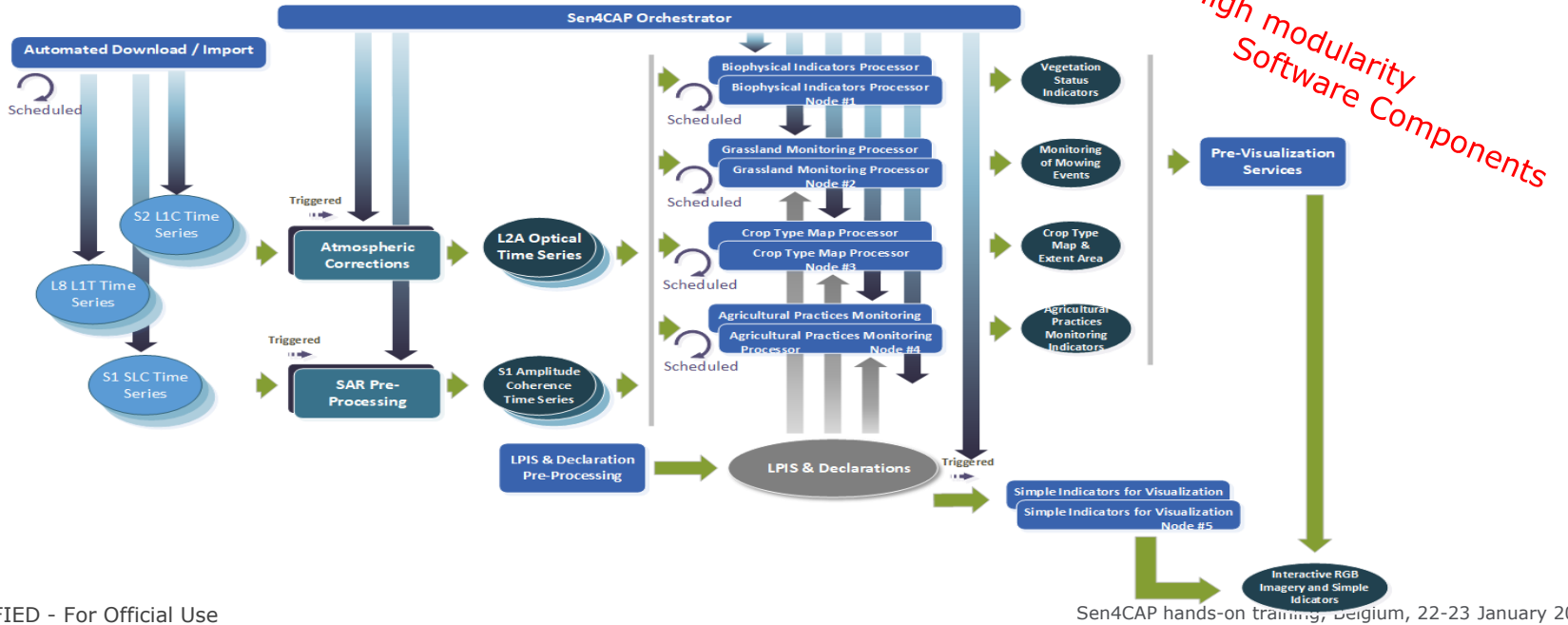


Metrics / markers stored for each LPIS/GSAA parcel

- Crop type mapping
- Growing vegetation indicators
- Grassland mowing detection
- Agricultural practices monitoring

Sen4CAP open source system

A system designed to run in an automated near real time and in off line mode to generate markers and products at the parcel-level along the season as Sentinel-1 and Sentinel-2 images are ingested => **Orchestrator concept**



Sen4CAP is free and open source
Based on open source existing software

Under GNU-GPL License

Based on **Orfeo ToolBox** framework

Cluster-ready architecture for distributed processing

Integration of **SNAP** tools and processing chains

Operational system required : **CentOS7** (GNU/LINUX)

PostgreSQL and **PostGIS** implementation

Sen4CAP system : simple parametrization and subsidy application upload

Before the monitoring period | Monitoring period

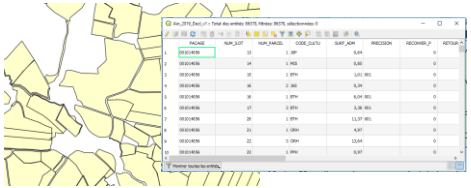
System initialization

Start of the season → End of the season...

Sen4CAP system : main parameters settings

Area of Interest	Shapefile to be uploaded
Monitoring period	Start and end dates to be defined
S1+S2 / S1+S2+L8	L8 to be selected

Subsidy application

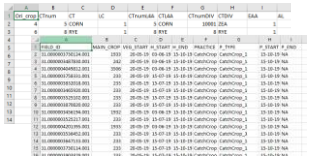


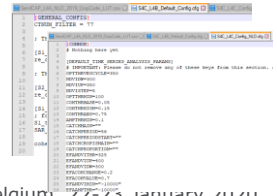
Upload data

Sen4CAP system : data from PA

Subsidy application (shp)	Subsidy application layer (shapefile)
Tables and config files (csv)	L4A crop code LUT L4B config file L4C config file + agri practices tables

Tables and config files





2 operating modes

Automated mode through the web graphical user interface (GUI)

a) Based on the Orchestrator with by-default parameterization, automatic data download and processing until the end of the season, on-time delivery => **operational scenarios**
b) Processor execution on user request, with by-default parameterization

Manual mode: to run processor independently, with custom parameters

a) Through the GUI, with the *Custom job* approach
b) In command line through a linux terminal

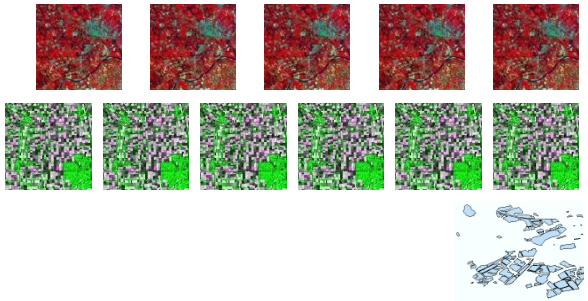
Sen4CAP system - crop type identification

Automatic EO data download and processing

Before the start of the monitoring period

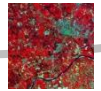
Monitoring period

System initialization



EO data providers

S2



S1

LPIS / GSAA

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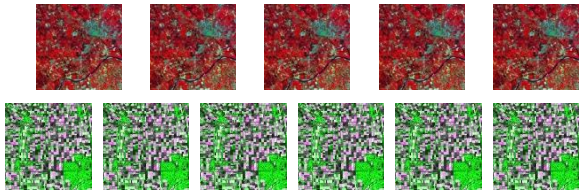
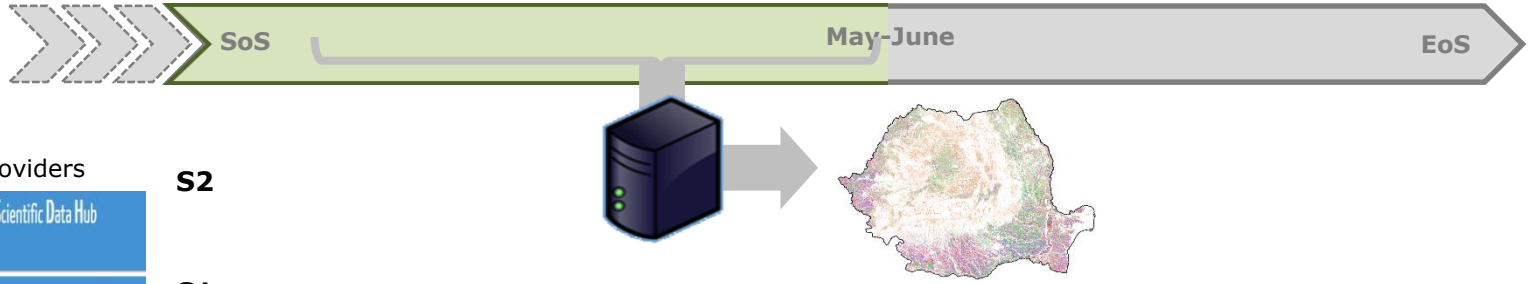
Automatic EO data download and processing

Before the start of the monitoring period

Monitoring period



System initialization



EO data providers

S2

S1

LPIS / GSAA

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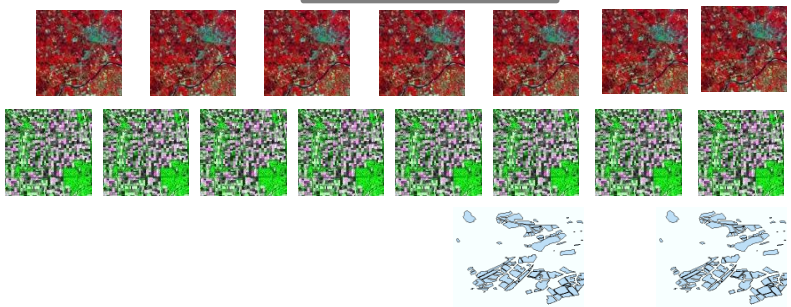
Before the start of the monitoring period

System initialization

Monitoring period



EO data providers

S2

S1

LPIS / GSAA

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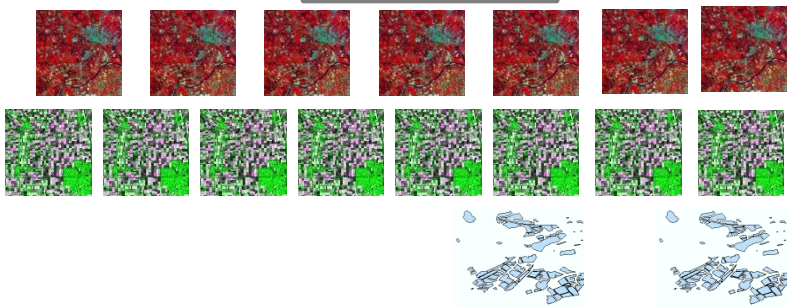
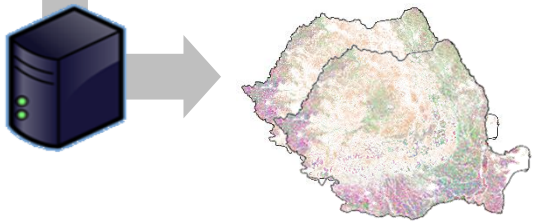
Before the start of the monitoring period

System initialization

Monitoring period





EO data providers

S2

S1

LPIS / GSAA

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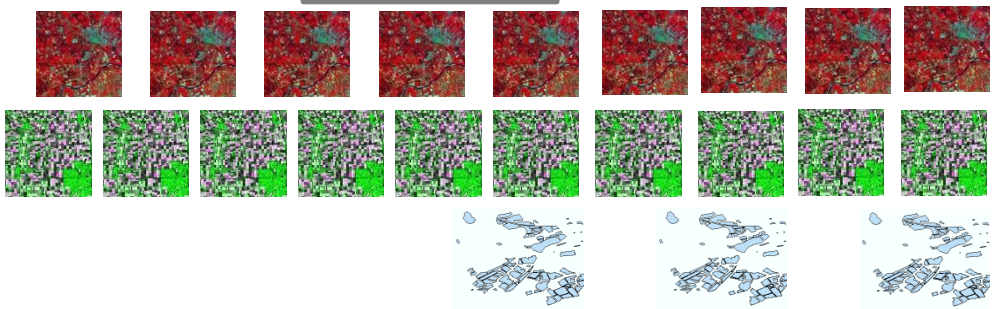
System initialization

Monitoring period



EO data providers

S2

S1

LPIS / GSAA

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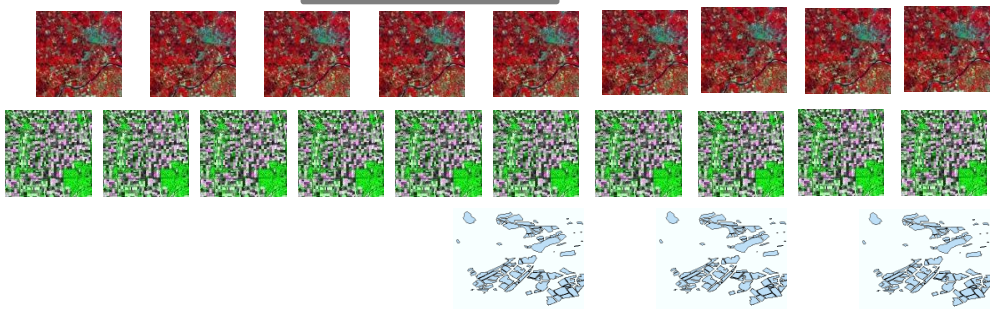
System initialization

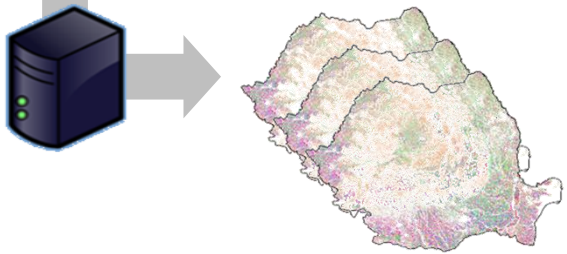
Monitoring period



EO data providers

S2

S1



LPIS / GSAA

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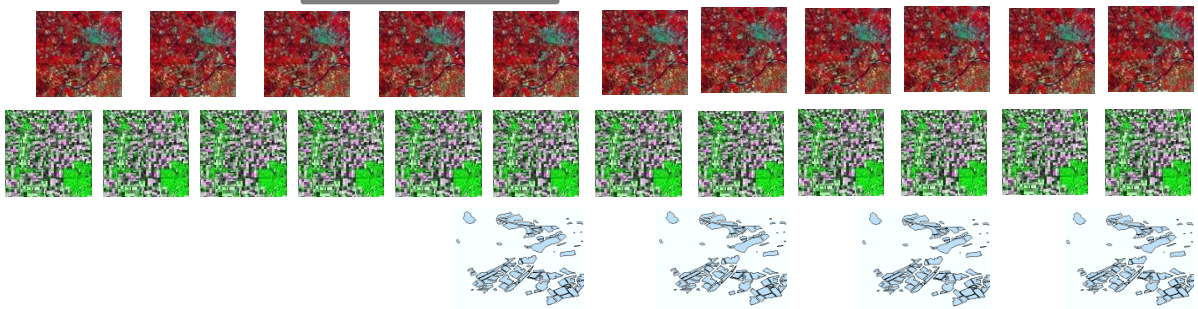

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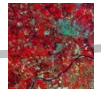

S1

LPIS / GSAA

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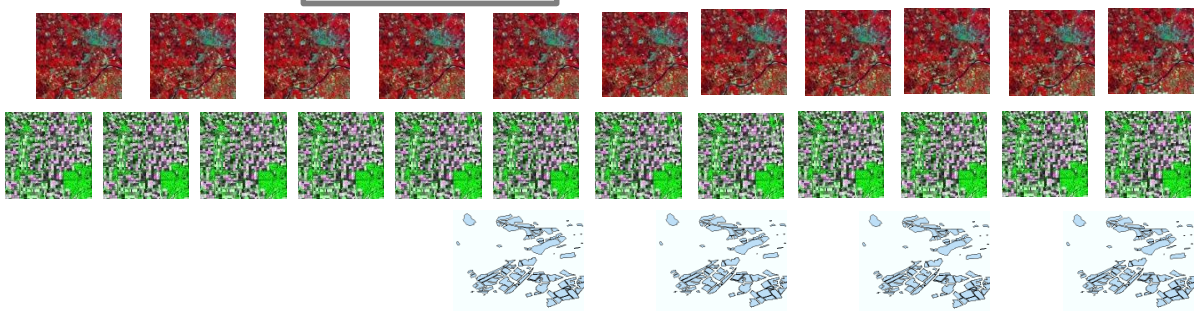
System initialization

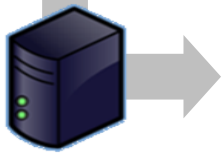
Monitoring period

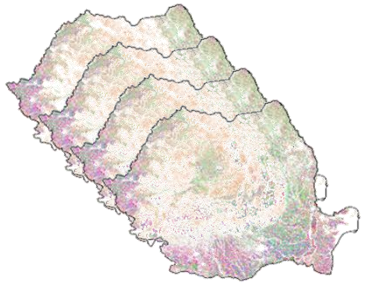


EO data providers

S2

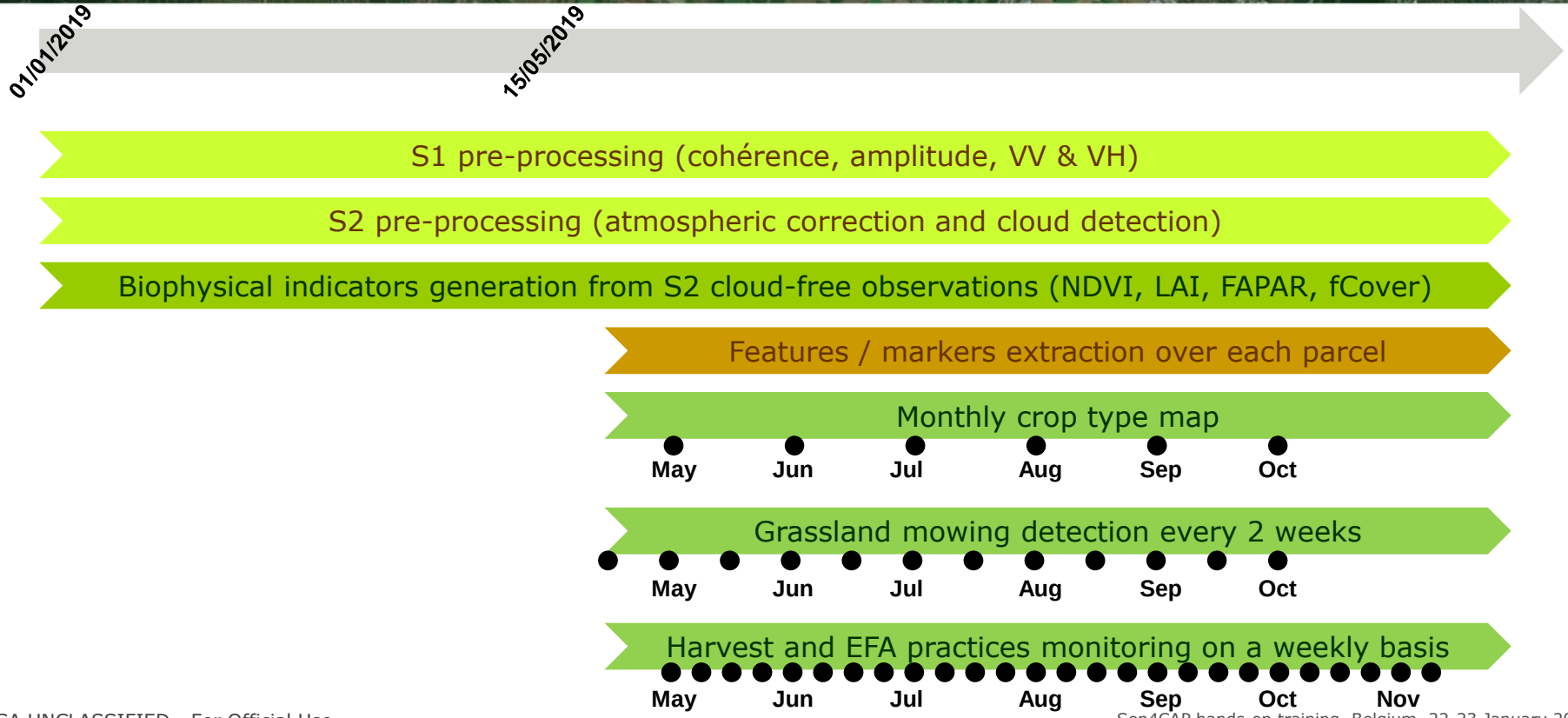
S1





LPIS / GSAA

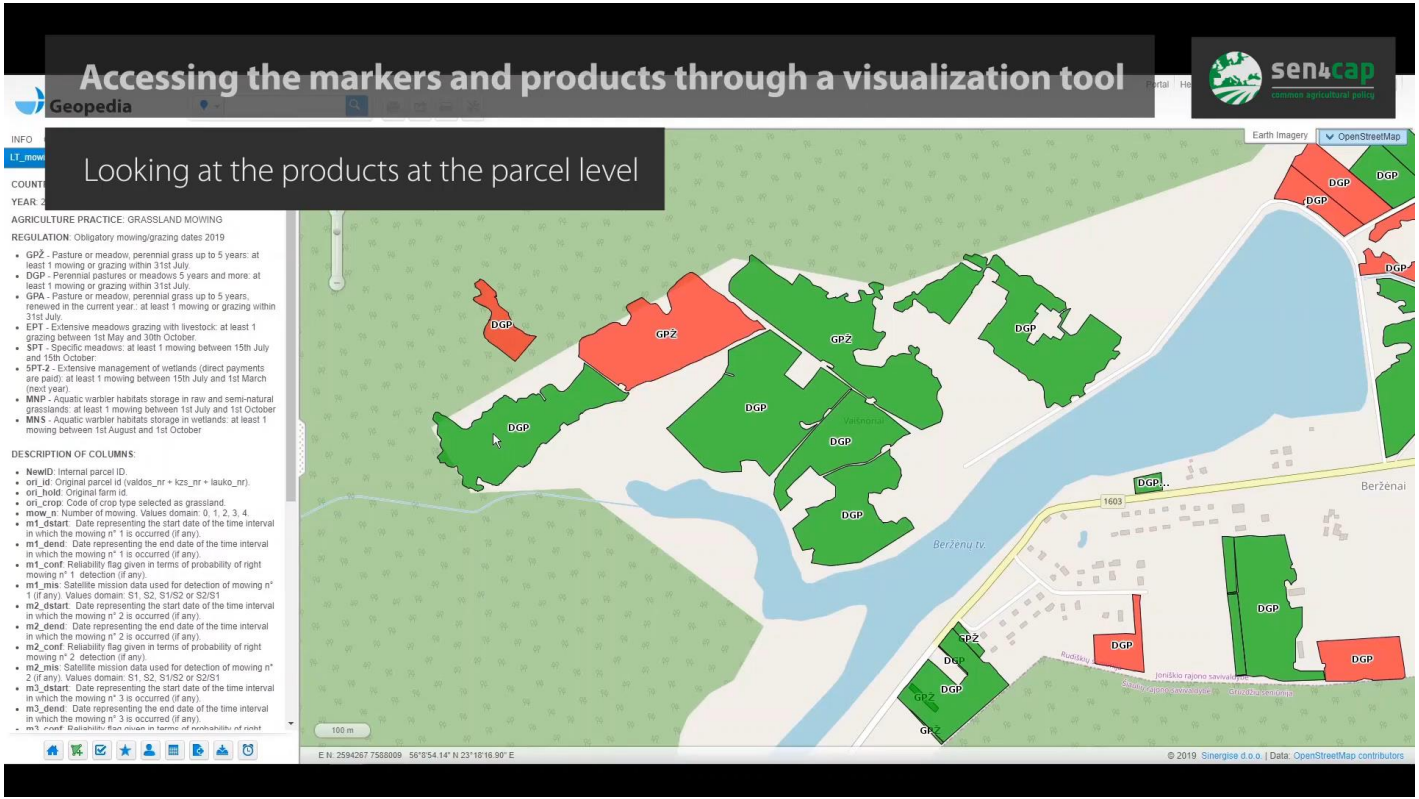
Continuous monitoring



ICT 2019 production

	Small country (Lithuania – 65.300 km²)		Large country (Romania – 238.400 km²)	
ICT ressources – Virtual Machine specifications				
CPU	• 8		• 16	
RAM	• 64GB		• 128GB RAM	
Storage	• 4TB HDD + 150GB SSD		• 4TB HDD + 250GB SSD	
Object storage (as of 07.11.2019)	• ~ 4 TB		• ~ 12 TB	
Products volumetry (including intermediate products)				
S2 L2A	~ 3.5 TB	**Total: 9.1 TB**	> 9 TB	**Total: > 21.2 TB**
S1 amplitude & coherence	~ 2 TB		~ 4 TB	
S2 NDVI, LAI, fCover, FAPAR	~ 1 TB		~ 2 TB	
Crop type map (every month May-Oct)	~ 2 TB		~ 4 TB	
Grassland mowing (every 2 weeks Apr-Oct)	~ 25 GB		~ 50 GB	
EFA practices (every week from May)	~ 600 GB		~ 2.2 TB	

Visualization tool to access all markers and products at parcel-level (Web application or WMS in QGIS)



Training agenda

- Wednesday 22 January, PM

14h00-14h20	○ Welcome and introduction (P. Defourny, UCLouvain)
14h20-14h35	○ Sen4CAP system and visualization tool: objective, overview, architecture, data flow (S. Bontemps, UCLouvain)
14h35-14h50	○ Subsidy application preparation (S. Bontemps, UCLouvain)
14h50-15h30	○ Crop type mapping from Sentinel-1 and Sentinel-2: concepts and methods, crop diversification use case (S. Bontemps, UCLouvain)
15h30-15h45	○ Biophysical indicators derived from Sentinel-2: concept and methods (P. Defourny, UCLouvain)
15h45-16h10	○ Break
16h10-16h50	○ Grassland mowing detection from Sentinel-1 and Sentinel-2: concepts and methods, permanent grassland monitoring use case (L. de Vendictis, e-GEOS)
16h50-17h30	○ Agricultural practices monitoring from Sentinel-1 and Sentinel-2: concepts and methods; EFA use case (L. Kucera, GISAT)
17h30-18h00	○ Questions and discussions

Training agenda

- Thursday 23 January

9h00-10h30	○ Hands-on training using Unix Virtual Machines on CREODIAS (P. Malcorps & S. Bontemps, UCLouvain; L. Nicola CS RO) ▪ First steps with the Sen4CAP system for an automated usage ▪ LPIS / GSAA data preparation and upload
10h30-11h00	○ Break
11h00-12h30	○ Hands-on training using Unix Virtual Machines on CREODIAS (continued) ▪ Manual usage of the Sen4CAP processors ▪ System installation and ICT requirements
12h30-14h00	○ Lunch

14h00-15h30	○ Hands-on training using the Sen4CAP products ▪ Products download from the system (P. Malcorps & S. Bontemps, UCLouvain; L. Nicola CS RO) ▪ Sen4CAP visualization tool (K. Bajec, Sinergise) ▪ Products exploration in visualization (or QGIS) (P. Malcorps, UCLouvain; L. de Vendictis, e-GEOS; L. Kucera, GISAT)
15h30-16h00	○ Break
16h00-17h00	○ Hands-on training using the Sen4CAP products ▪ Products exploration in visualization (or QGIS) (P. Malcorps, UCLouvain; L. de Vendictis, e-GEOS; L. Kucera, GISAT)
17h00-17h30	○ Questions and discussions

Sen4CAP support

- Website: http://esa-sen4cap.org/
- A Support User Manual (SUM)
- Product descriptions (data structure, interpretation, etc.) and quick user guide focusing on the use cases
- Algorithms Theoretical Basis Documents (ATBDs)
- An address for the questions: info@esa-sen4cap.org
- In a few months:
    - A section on the website with **FAQ**
    - A **forum** open for the Sen4CAP system users


Thank you for your attention
and your contribution
sen4cap
common agricultural policy