sen4cap
common agricultural policy

Sentinels for Common Agricultural Policy

Lessons learnt and evolution of Sen4CAP system thanks to its users community to support the CAP Monitoring using Sentinel-1 and -2

Funded by European Space Agency

esa

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EO Experts

UCLouvain gisat SINERGISE e-geos AN ASI / TELESPAZIO COMPANY ROMÂNIA

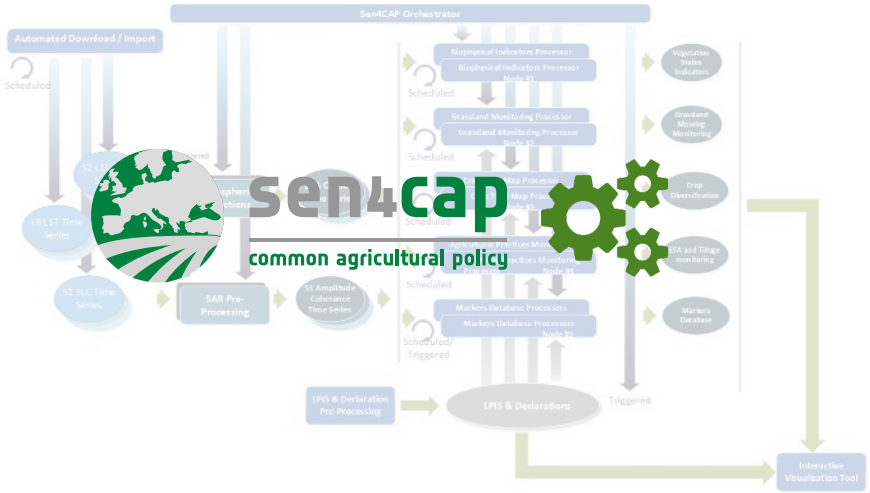
Sen4CAP system

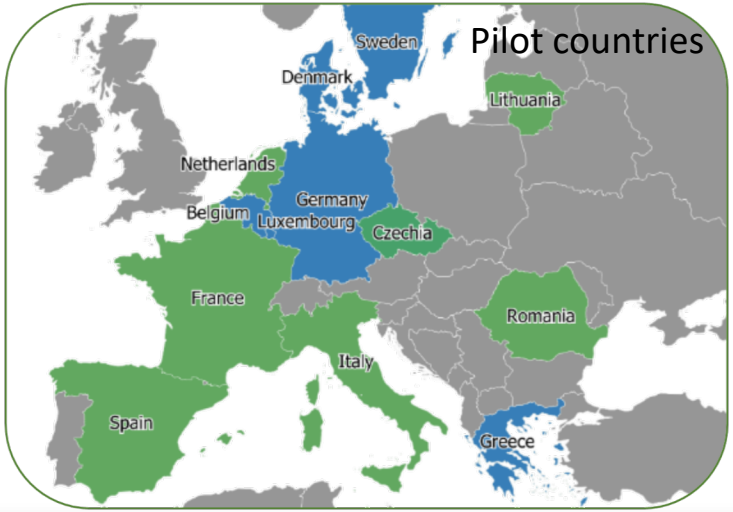
User group:
6+1 Paying Agencies

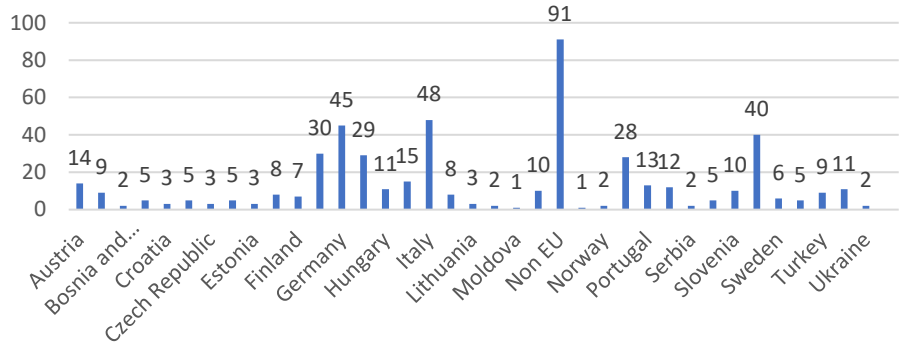
Guidance by DG-Agri, JRC, DG-Grow.

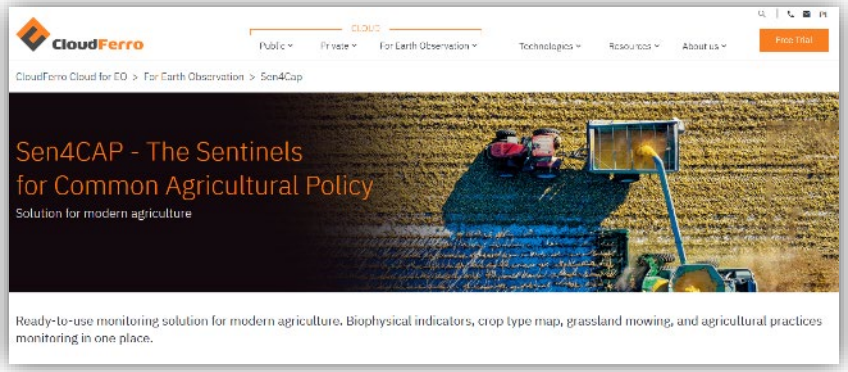
From an ESA project …

…to an open source system uptaken by the CAP community





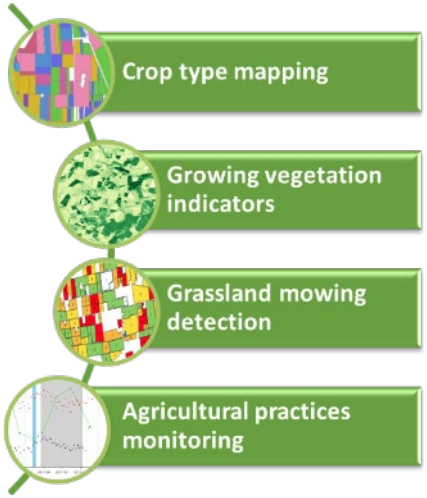




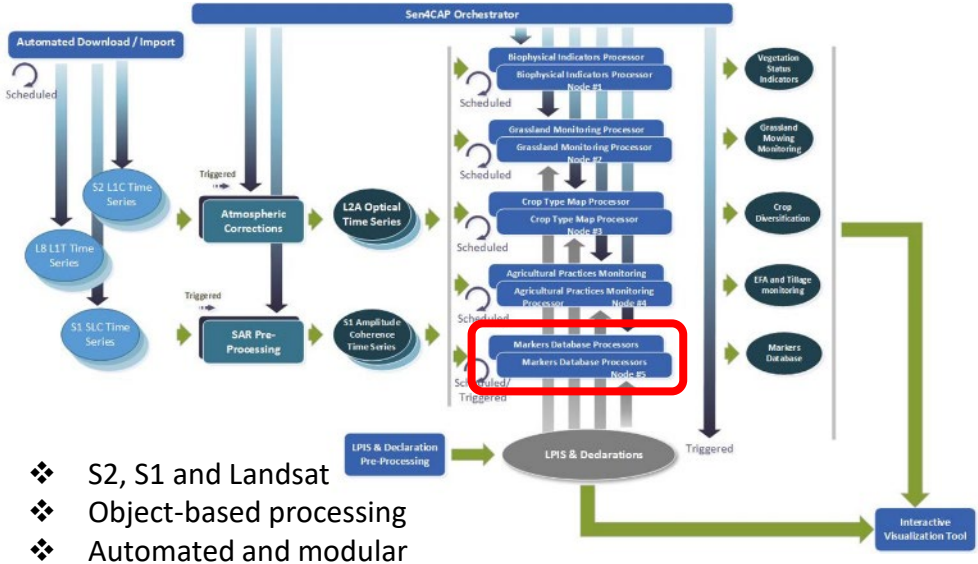
From a demonstration approach to a modular and evolutive tool

Provide evidence (demo products, algorithms) how Sentinel derived information can support the modernization and simplification of the CAP **in the post 2020 timeframe**

Use cases
Crop diversification
Permanent grassland identification
EFA-Land lying fallow
EFA-Catch crops
EFA-Nitrogen-fixing crops
Interactive visualization
… keeping in mind much more



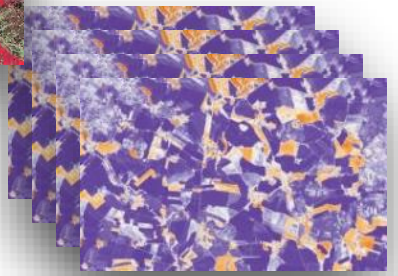
Sen4CAP open source system aiming for modularity

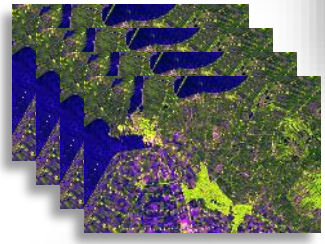


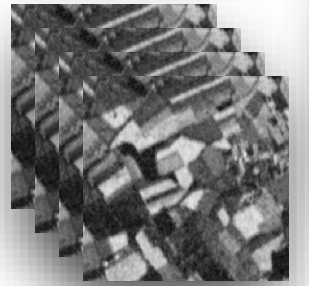
- S2, S1 and Landsat
- Object-based processing
- Automated and modular
- For NRT or off-line production
- Operated locally or on the cloud
- Dockerization for main components

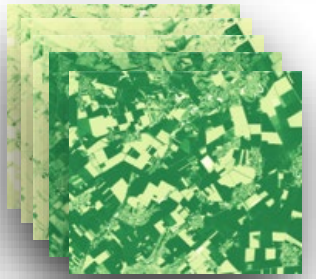
Version 4.0 release by the end of 2022

100+ features & markers per week, per parcel

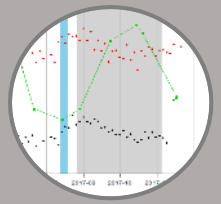


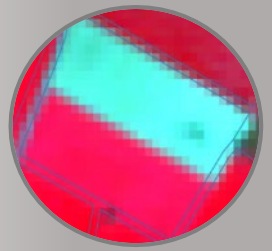




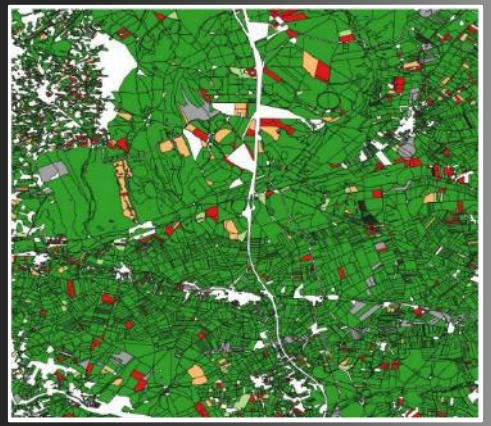


E.g. Spain : **17 millions parcels**
x **60+ metrics** + S2&1 signal
x 40 weeks / year

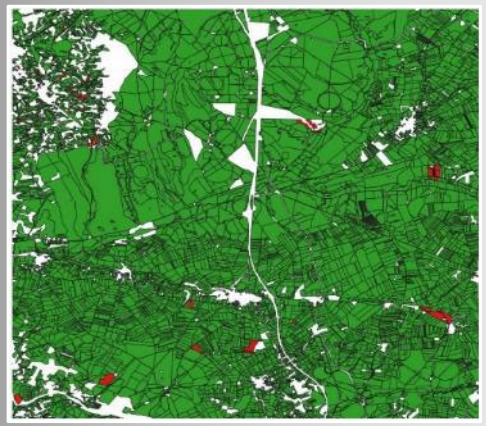




National crop type map over Lithuania

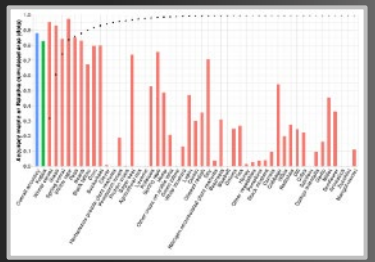


Parcel level Assessment

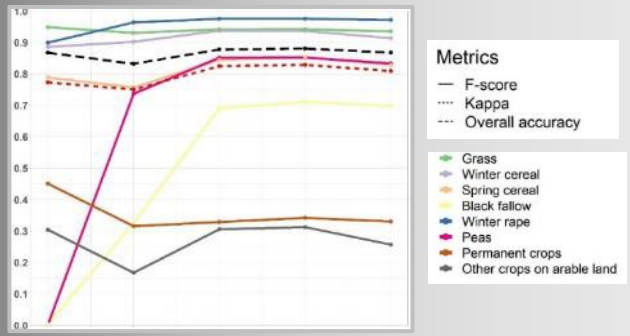


Holding level Assessment

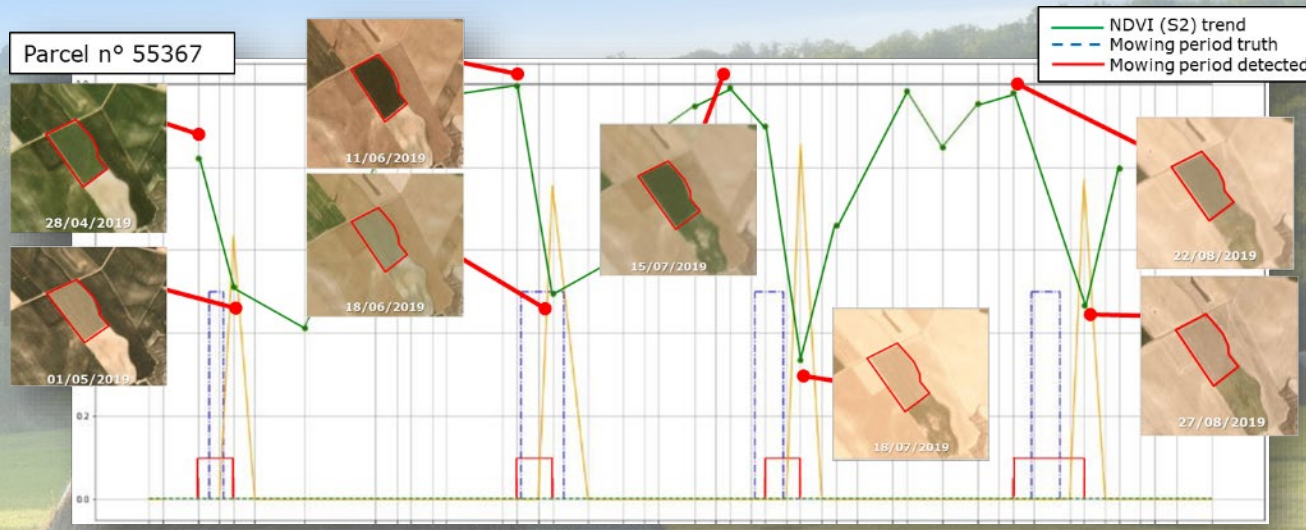
- ✓ > 100 crop types
- ✓ OA = 88% (2019 and 2020)
- ✓ Good performance for the 9 main crops (≈92% area)



- ✓ High accuracy achieved from May/June



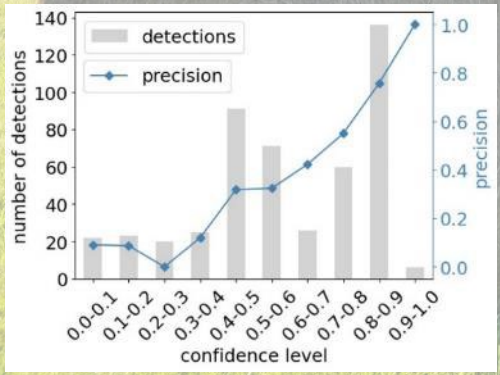
Mowing detection over all grassland parcels based on S1 & S2 time series



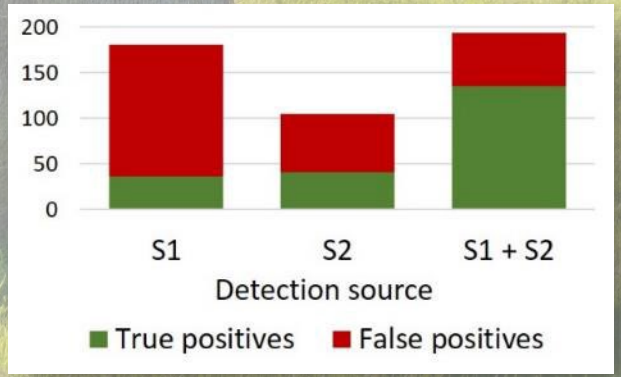
Independent validation in Belgium

- 427 grassland parcels
- 10 visits
- 09/04 to 20/07/2019
- 261 observed mowing events

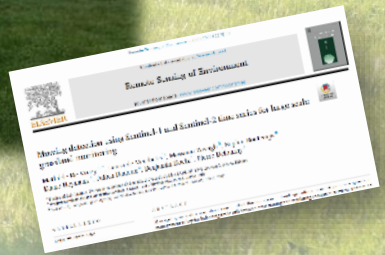
Reliability of the confidence levels



Complementarity of S1 and S2

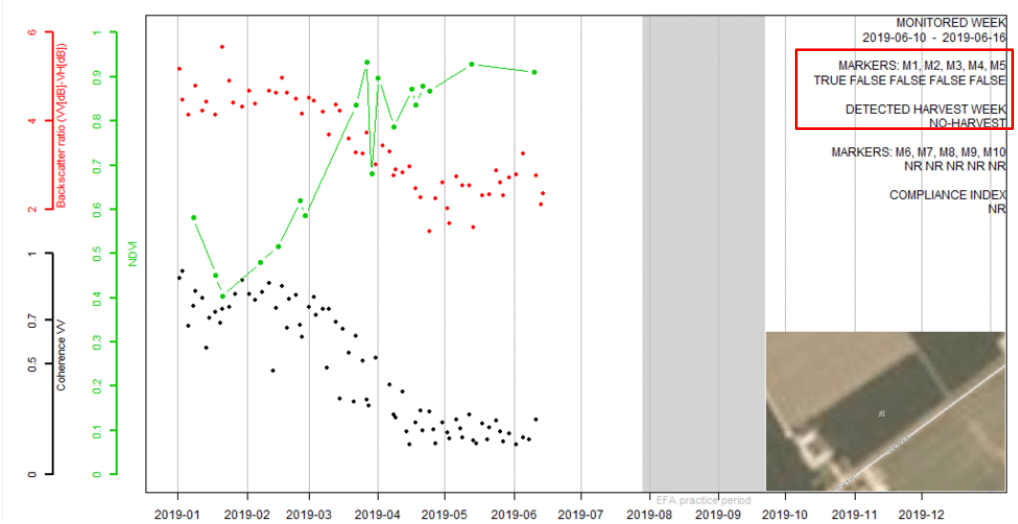


Most false positives in grazed parcels



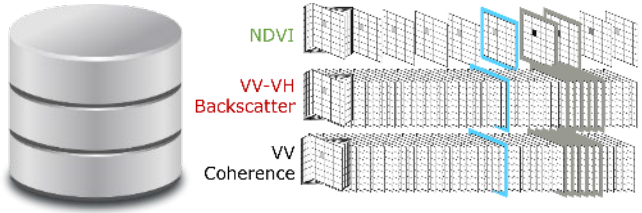
Harvest date detection based on 5 markers computed from 3 parallel time series

- Harvest and catch crop monitoring (EFA)



E.g. Netherlands 2019 (parcel with winter wheat, 2.5 ha)

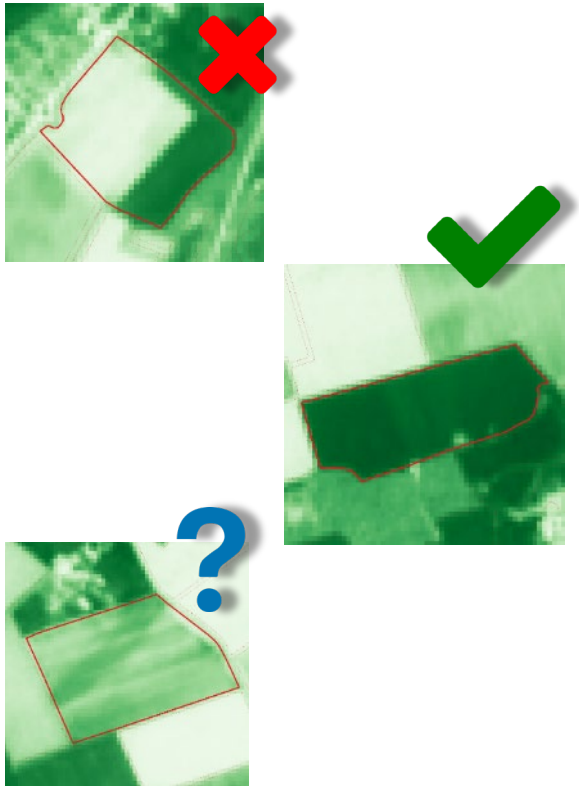
MARKERS FOR HARVEST		
M1	M1: Presence of vegetation in the main vegetation season (pre-requisite)	High values of NDVI
M2	M2: Loss of vegetation	Break in NDVI (decrease)
M3	Loss of vegetation	Break in backscatter ratio (increase)
M4	Low/no vegetation	High values of backscatter ratio
M5	Low/no vegetation (stable conditions)	Break in VV Coherence (increase) or high values of VV Coherence
MARKERS FOR DECLARED PRATICES		
M6	Presence of vegetation	High values of NDVI
M7	Growth of vegetation	Break in NDVI (increase)
M8	No loss of vegetation	No break in NDVI (decrease)
M9	No loss of vegetation	No increase of the backscatter ratio
M10	Presence of vegetation (dynamic conditions)	No Break in VV Coherence (increase) and no high values of VV Coherence



Harvest performance for all the monitored countries:

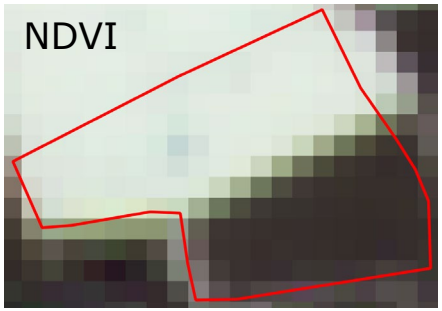
Within one week: 53% - 75%
Within two weeks: 69% - 89%

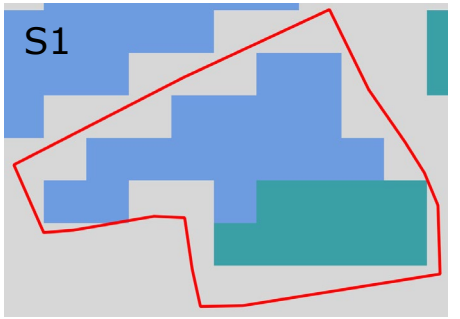
Spatial congruency assessment



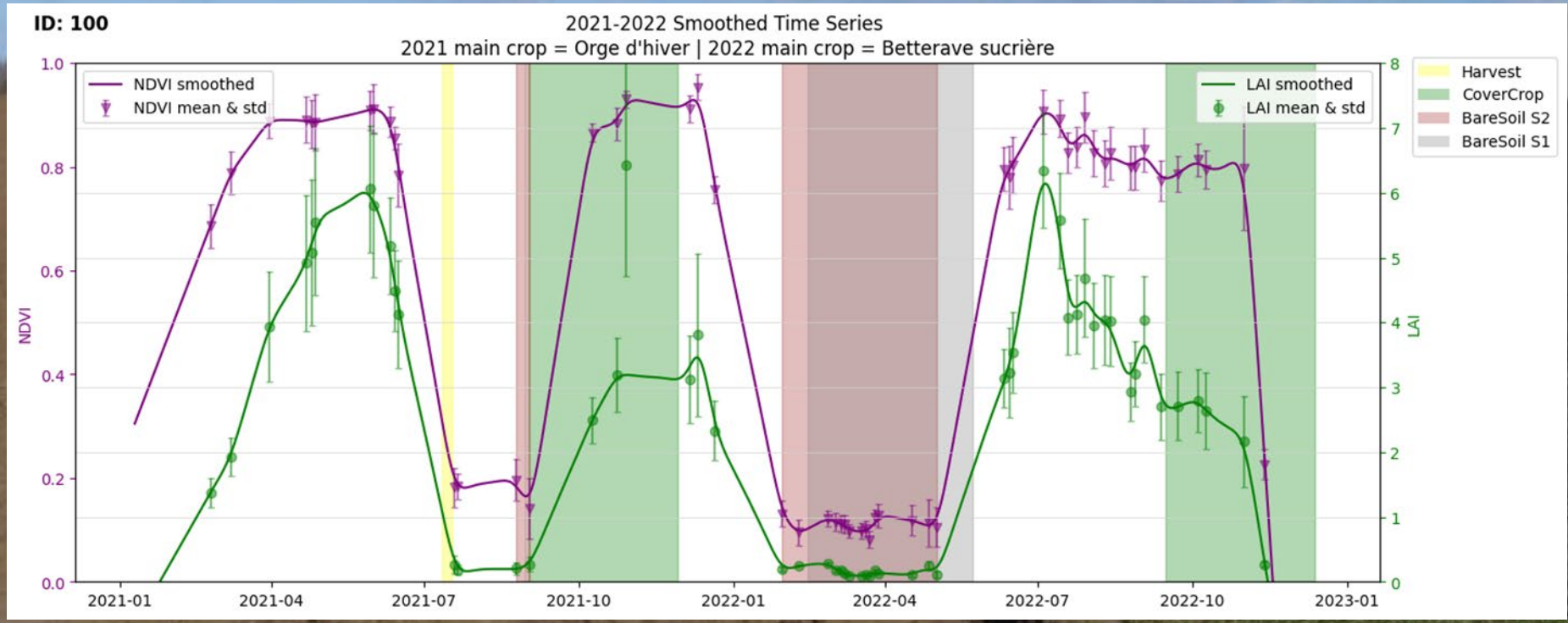
Based on:

- Sentinel-2 and Sentinel-1
- Clustering algorithm
- Compacity criterion
- Along-the-season analysis

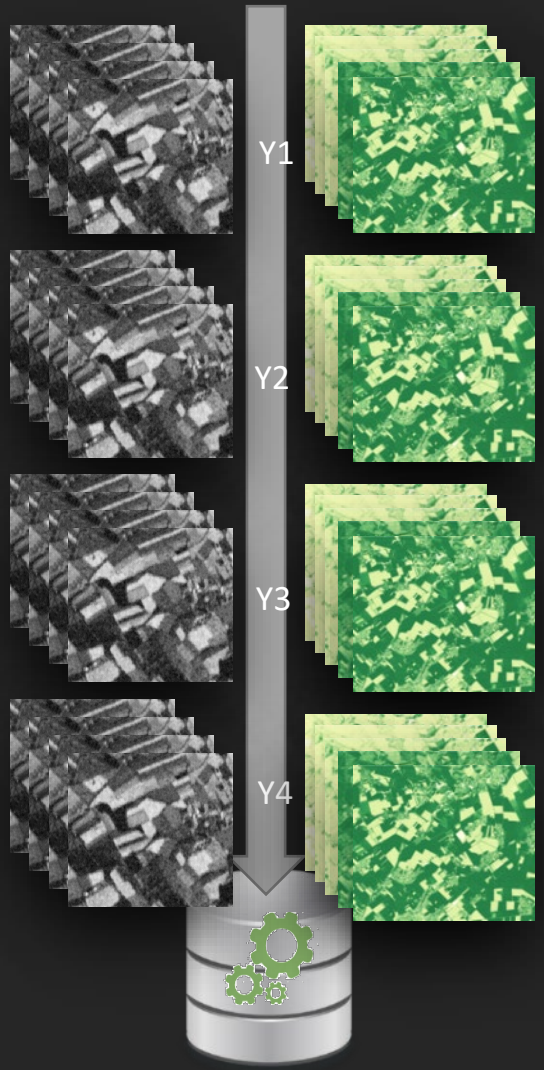




New advanced markers for bare soil detection



Multi-year rotation



Perennial Crop

Arable Land

Permanent Grassland

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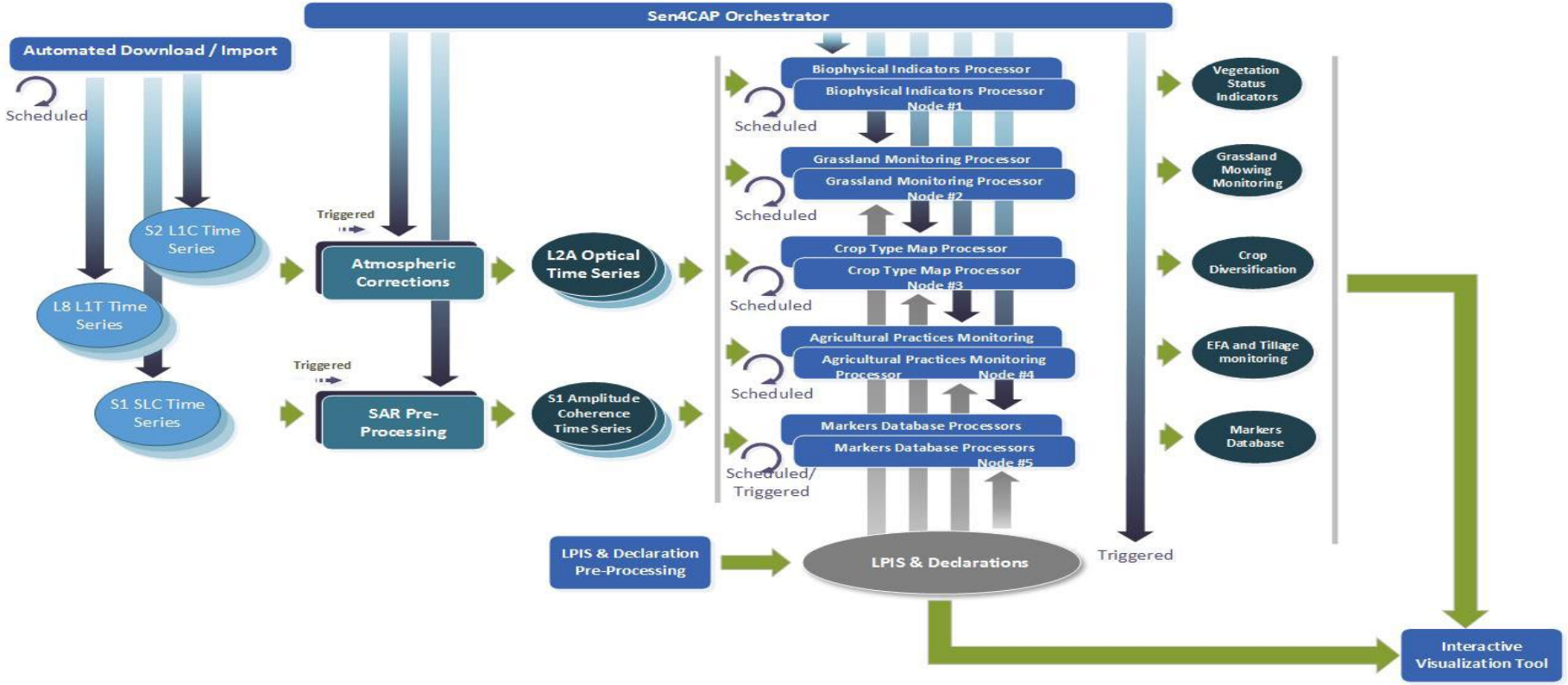
Current Sen4CAP architecture



Sen4CAP Issues

- **Monolithic system**
  - Large, "batteries included" system
  - Good to deploy and go, less good if you want to customize it
  - Not easy to execute a single processor without installing everything
  - Difficult to integrate in new monitoring solutions and applications
    - API exists, but it's somewhat limited and not very well documented
  - Each processor has 2 components: execution & orchestration
  - Processing is performed at S2 tile level
- **Code drops**
  - Development practices don't match open-source contributor expectations

Project Objectives

- **Sen4CAP functionality as cloud-based services**
  - Convert the **core functionalities** of SEN4CAP into **cloud-based services**
    - refactor into modular cloud-based services exposed via client libraries and API interfaces
  - **User access** through a **Python library** and standard **REST** Data Processing **APIs** (OGC Processes API or the openEO community standard)
  - **Modular design** – being able to use individual functionalities independently and decouple them for deployment, scaling and maintenance
  - **Containerization** and **microservices** architecture following OGC Application Packaging best practices
- **Public cloud deployment and integration**
  - Deploy the services in a public cloud environment (co-located with Sentinel data archives)
  - Onboard the services into the ESA Network of Resources (NOR) service catalogue

Project Objectives

- **Scientific enhancements**
  - Implement targeted scientific improvements

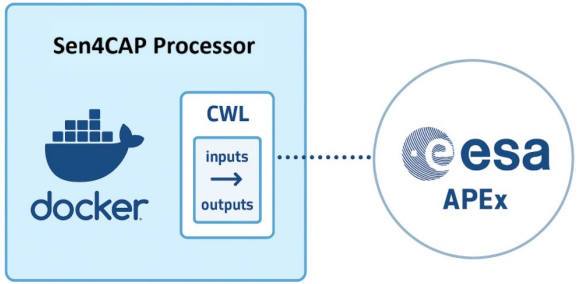
- **Open-Source development**
  - Release the Sen4CAP code as open-source, but well-structured and fully documented
  - Adhere to open-source development best practices
  - Support community contributions and long-term maintenance

Processor Modernization & Optimizations

- **Modernize codebase, drop unneeded or obsolete components**
  - Python 3 port, more recent OTB, GDAL
  - Reduce coupling between processors and system database
  - Improve dependencies between processors (e.g. heterogeneity depends on L3B and crop type)
  - Run CI on GitHub, generate and publish HTML docs
- **Data access changes**
  - Support direct access to S3
  - Expose sub-Sentinel-2 tile processing
  - Consider offering output products as data cubes (Zarr)
  - Expose STAC for output products
  - Expose Zarr/S3-based API for chunk processing (caveat emptor!)
- **Performance analysis**
  - Upgrade SNAP and test DiapOTB for Sentinel-1 pre-processing
  - Test usage of existing backscatter and coherence products
  - Investigate chunk sizing to prevent throttling on DIASes

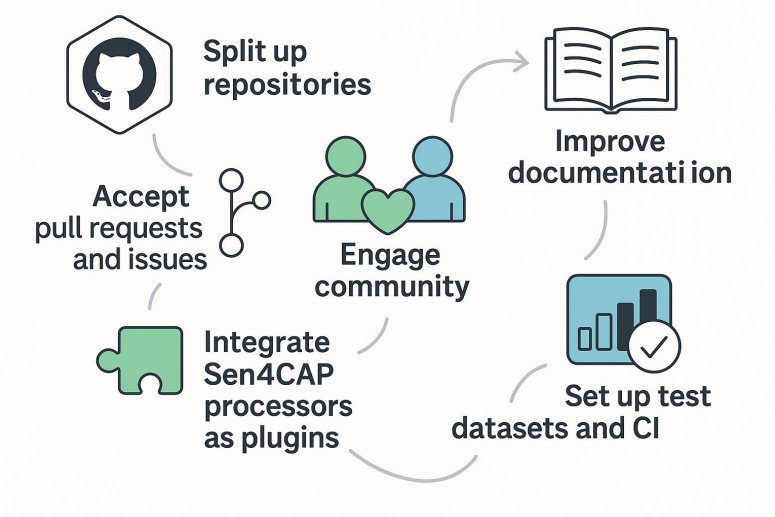
Containerization and SaaS

- **Containerization**
  - Base + processor-specific container images
  - CWL descriptors and OGC Application Packaging standard
  - Modularize Java services (e.g. Sentinel-1 pre-processing)
  - Decouple task graph creation from execution
- **Client APIs**
  - Python client libraries on PyPI or Conda
  - Reuse existing libraries (xarray / xcube)
  - API docs
- **SaaS integration**
  - Investigate ESA APEx or alternatives (e.g. TAO)
  - Try to include into the ESA NoR
  - Investigate EOEPCA+ integration, APIs
- **Keep support for on-premises installations**
  - System database
  - Set up a local executor
  - Use REST API, adapt using compatibility layers where required



Open-source Development

- **Development practices**
  - Split up repositories
  - Improve documentation
  - Accept pull requests and issues from users
  - Engage community more and encourage contributions
  - Set up test datasets and CI
  - Integrate processors as plugins and allow external processors



- **Other quality of life improvements**
  - **In-situ** data management

IaaS Sen4CAP Project Planning

Review	Comment	Timing
Kick-Off (KO)		March 2025
Preliminary Design Review (PDR)	Beginning of July 2025	KO + 4M
Mid Term Review (MTR)	November 2025	KO + 8M
Acceptance Review (AR)	March 2026	KO + 12M
Service Showcase Demonstration (SSD)	Collocated with a community event (Panta Rhei?)	KO + 14M
Service Readiness Review (SRR)	July 2026	KO + 16M
Final Review (FR)	September 2026	KO + 18M

New scientific development in Sen4CAP IaaS
3 propositions

Cover crops

Currently: detection of the cover crop presence

Proposition: quantifying the **biomass accumulation** that protects the soil and enhances the soil organic matter + other metrics to be identified (temporality, speed establishment, etc.)

Bare soil

Currently: focus on the winter period

Proposition: **extending the monitoring period** + other aspects to be identified (e.g. residues)

Tillage

Currently: not mature enough, focus on the short period after the harvest of the main crops

Proposition: improve the algorithm and its validation (Sentinel1-C of big help), extend the monitoring period

To be confirmed with you

Reference data

Next steps

- You will receive a survey by email
  - Who you are
  - Your opinion about scientific enhancement
  - Your opinion about cloudification process (input for design)

    => your answer by mid-June

- Preliminary Design Review (project meeting) early July


Thank you for your attention
and your contribution
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