WP3 – Earth Observation data products

3rd Plenary Meeting, 25/05/2023

- *Jason Tsardanidis (NOA)*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869366.

Overview

- **Starting Strong**: Initial Objectives and Milestones Achieved
- **Pushing Boundaries**: Recent Improvements to ENVISION
- **Overcoming Obstacles**: How ENVISION Tackled Risks
- **Building for Impact**: Improving User Experience with ENVISION
- **Innovation Ahead**: ENVISION's Vision for the Future

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Initial Milestones

- Perform **cost-benefit analysis** of the DIAS providers

task 3.1

Budget → 25k €

CREODIAS powered by CloudFerro

- 18 months
- 2 VMs
- 2 x 40c/112GB RAM
- 2 x GPU (GeForce RTX 2080Ti)
- 2 x 1 TB SSD (internal)
- 15 TB HHD (common storage)

- **Design** and **develop EO data products** to **address customers' needs**
- Make PAs and CBs' **monitoring task more efficient, accurate** and **cost effective**
- EO based services **to monitor agricultural malpractices** and **their environmental impacts**

- **Auxiliary Data Collection (task 3.2)**
- **Analytics on Vegetation and Soil Index Time Series (task 3.3)**
  - Monitoring of GAECs and SMRs
  - Agricultural Practices Activity Detection
  - Comprehensive GIS and Analytics Tools
- **Cultivated Crop Type Maps (task 3.4)**
  - Dynamic Crop Type Maps
  - Alert Mechanism (traffic light system)
  - Supervision of Cross-Compliance (Greening I)
- **Grassland Mowing Events Detection (task 3.5)**
  - Accurate Reconstruction of Vegetation Indices
  - Mowing Events Identification

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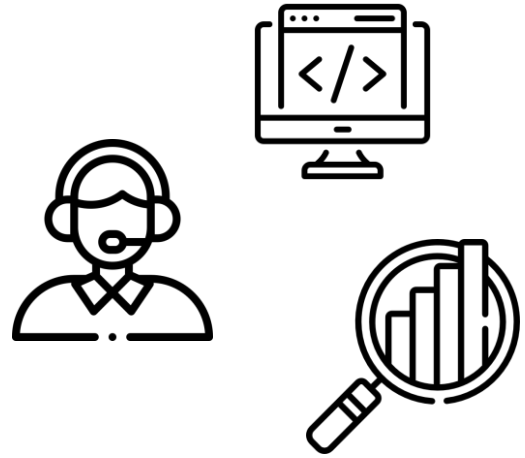
A Year in Review: What You Missed and What's New

- **Identified new requirements** and improved the current Service Business logic (within WP5)
  - Maintained continuous contact with BC users to satisfy their requests and hear their suggestions
- WP3 Products:
  - Production the services and evaluation of the results for the **last cultivation period** at **national** scale (2022)
  - Initialize the pipelines implementation for the **current cultivation period** (2023)
- Automated Pipelines for Increased Productivity (**workflow streamlining**)
- Cultivated Crop Type Maps
  - Included more crop type categories
  - Fine-tuned ML models
  - Increased accuracy
- Grassland Mowing Events Detection
  - Reduced **False-Negative** Cases predicted as Non-Compliant due to clouds
  - **Adopted pixel-wise** approach (when necessary)
  - **Lighthouse customers** implementation → Case of Flanders – LV
- Analytics on Vegetation and Soil Index Time Series
  - Finalized Agricultural Practices Monitoring services
  - Datacube API (On-Demand Access to the data/results)
- Provision of results/guidance on the refinement of the ENVISION platform (WP4)



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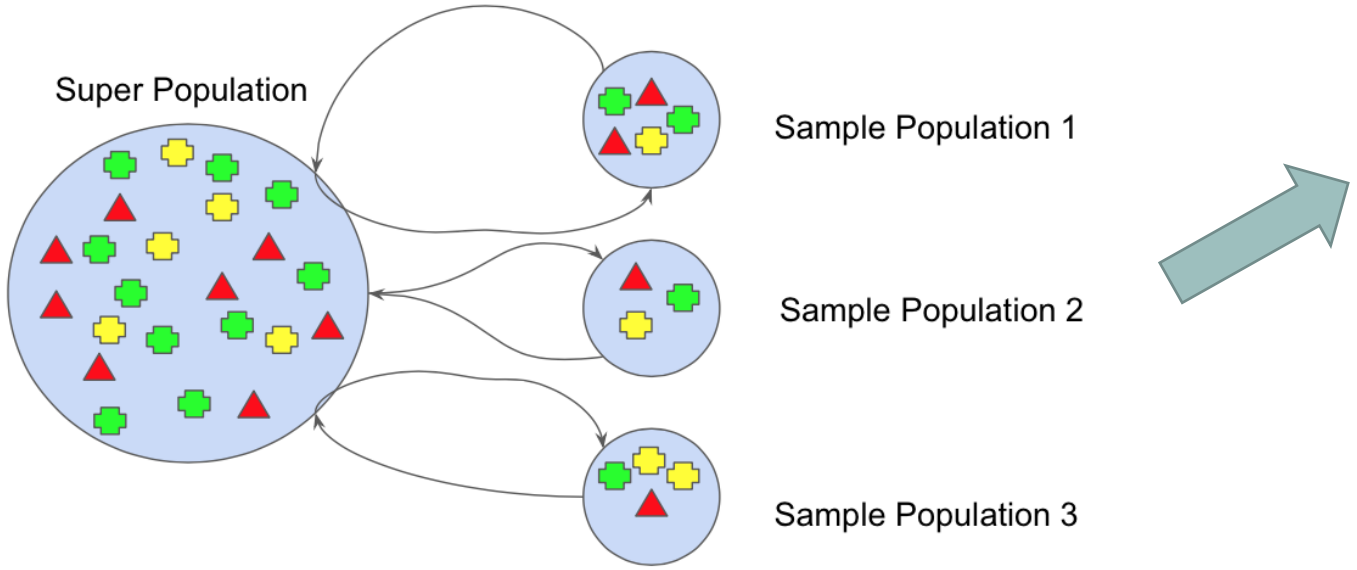
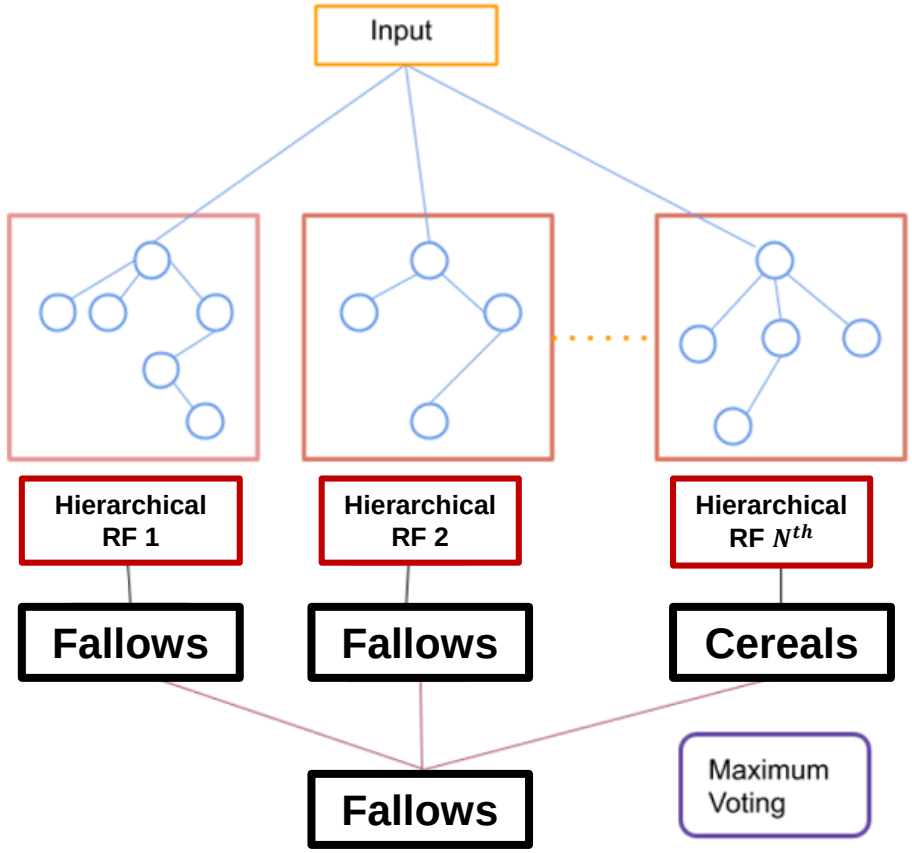
Cultivated Crop Type Maps
(New Approach)

- Crops Classification
  - Pixel-wise approach (small parcels < 0.3 ha)
  - Training/Evaluation on different Hierarchical Levels
  - Combination of different ML models (stacking ensembles)
  - Smart Sampling of OTSCs





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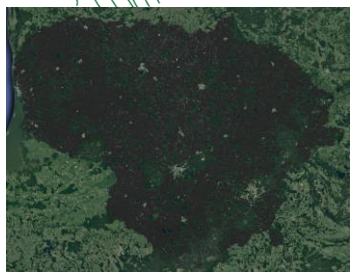
NPA 2022

- **Alpha Error** (False Positive Declared As Compliant) →
  Significant Improvement: Accuracy of Correct Declarations > 99%

- **Beta Error** (False Negative Declared As Compliant) →
  Improvement: Recall of False Declarations > 85%

- **Handle Overfitting**
  - Agreement with Applicants Declarations < 90%
- Declaration Confirmation:
  - 830842 cases confirm (~ 85%)
  - 66690 cases not confirm (~ 7%)
  - 85138 cases not clear decision



~1.100.000 cases

Crop Code	Crop Name	Quality ENVISION				Quality ENVISION				Quality ENVISION			
		Quality ENVISION 1st ITERATION				Quality ENVISION 2nd ITERATION				Quality ENVISION 3rd ITERATION			
		Support	Alpha	Beta	Reliability	Support	Alpha	Beta	Reliability	Support	Alpha	Beta	Reliability
KVŽ	Winter wheat	126	1%	33%	98%	128	2%	33%	98%	128	0%	33%	99%
KVV	Spring wheat	153	10%	11%	90%	153	8%	0%	92%	153	5%	0%	95%
MIV	Spring barley	122	8%	0%	92%	122	4%	0%	96%	122	2%	0%	98%
AVI	Oats	129	7%	100%	92%	129	3%	0%	97%	129	2%	0%	98%
RAŽ	Winter rape	141	1%	0%	99%	143	1%	0%	99%	143	0%	0%	100%
ŽIR	Peas	135	15%	0%	85%	134	12%	0%	88%	133	2%	0%	98%
GRI	Buckwheat	123	23%	10%	78%	133	5%	0%	95%	132	2%	0%	98%
PUP	Beans	132	40%	0%	60%	137	4%	0%	96%	136	0%	0%	100%
PDJ	Black fallow	128	33%	10%	70%	125	16%	14%	84%	122	5%	28%	92%
PDŽ	Green fallow	136	8%	11%	92%	135	8%	11%	92%	136	5%	6%	95%
DGP	Perennial pastures or meadows 5 years and more	139	0%	0%	100%	142	1%	0%	99%	142	1%	0%	99%
GPŽ	Pasture or meadow, perennial grass up to 5 years	121	6%	100%	79%	120	4%	100%	81%	121	4%	100%	81%
KUK	Corn	132	39%	0%	61%	135	5%	0%	96%	134	1%	0%	99%
RAV	Spring rape	133	98%	0%	13%	141	16%	0%	87%	137	2%	6%	97%
RUŽ	Winter rye	133	100%	0%	2%	135	3%	0%	97%	135	2%	0%	98%
MIŽ	Winter barley	141	100%	0%	1%	143	3%	0%	97%	144	2%	0%	98%
KRŽ	Winter triticale	122	4%	100%	94%	125	2%	50%	97%	124	2%	0%	98%
KRV	Spring triticale	127	100%	0%	10%	135	4%	8%	96%	135	2%	17%	97%

Essential!

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CAPO 2022

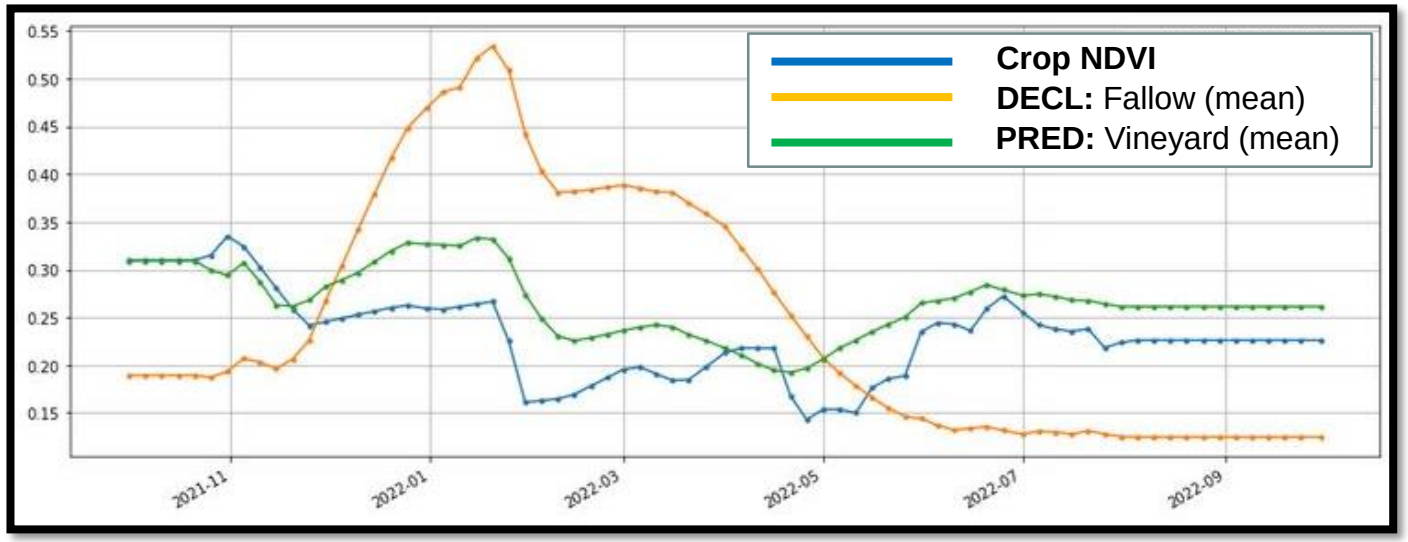
- **Alpha Error** (False Positive Declared As Compliant) → Significant Improvement
  - Accuracy of Correct Declarations > 90%
- **Beta Error** (False Negative Declared As Compliant) → Improvement
  - Recall of False Declarations ~ 33%
  - Precision of False Declarations ~ 40%
- More Crop Categories included
- **Handle Overfitting**
  - Agreement with Applicants Declarations < 88%
- Declaration Confirmation:
  - 242216 cases confirm (~ 80%)
  - 17459 cases not confirm (~ 6%)
  - 47649 cases not clear decision

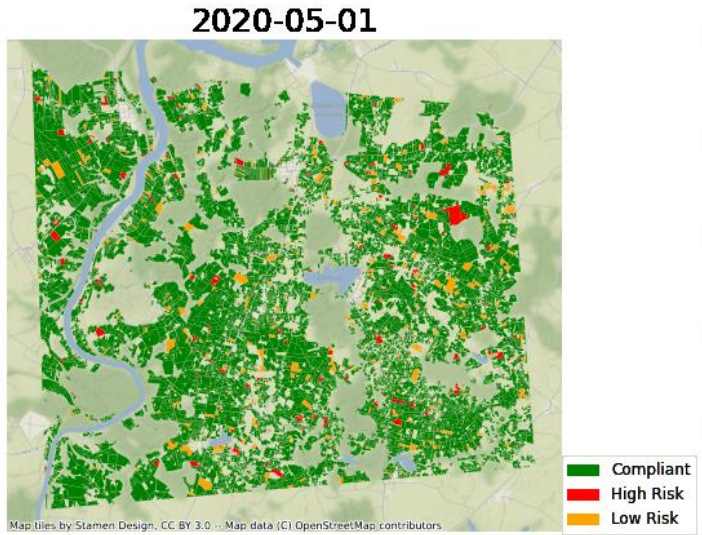
~325.000 cases

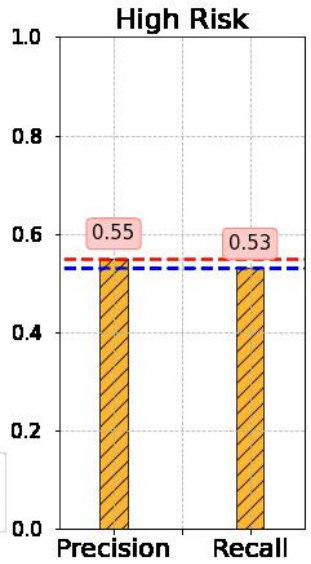
Crop Name	ENVISION 1st Iteration				ENVISION 2nd Iteration			
	Precision	Recall	F1-Score	Support	Precision	Recall	F1-Score	Support
Wheat	0,667	0,585	0,623	2730	0,708	0,859	0,776	2764
Barley	0,404	0,824	0,542	1765	0,678	0,851	0,755	1787
Oat	NA	NA	NA	NA	0,809	0,854	0,831	343
Peas	NA	NA	NA	NA	0,783	0,9	0,837	20
Ryegrass	NA	NA	NA	NA	1	1	1	2
Lucerne	NA	NA	NA	NA	1	0,75	0,857	8
Tomatoes	NA	NA	NA	NA	0,857	0,857	0,857	7
Cucumbers	NA	NA	NA	NA	0,889	0,8	0,842	10
Watermelons	NA	NA	NA	NA	0,796	0,804	0,8	92
Melons	NA	NA	NA	NA	0,833	0,625	0,714	8
Black-eyed Peas	NA	NA	NA	NA	0,893	0,833	0,862	60
Potatoes	0,761	0,741	0,751	474	0,753	0,832	0,791	481
Olive Trees	0,682	0,735	0,708	1057	0,827	0,878	0,852	1265
Walnut Trees	NA	NA	NA	NA	0,957	0,846	0,898	26
Fig Trees	NA	NA	NA	NA	0,857	0,857	0,857	7
Carob Trees	NA	NA	NA	NA	0,767	0,861	0,811	180
Citrus Fruit Trees	0,904	0,787	0,841	361	0,93	0,955	0,942	378
Banana Trees	NA	NA	NA	NA	0,95	1	0,974	38
Vineyards	0,785	0,889	0,834	1106	0,861	0,966	0,91	1227
Fallow	0,836	0,638	0,724	3803	0,817	0,6	0,692	4052
Permanent Grasslands	0,92	0,736	0,818	440	0,876	0,985	0,927	454
Vegetables Mixture	0,537	0,064	0,114	452	0,707	0,212	0,326	467
Orchard	NA	NA	NA	NA	0,964	0,645	0,773	166
Vicia	NA	NA	NA	NA	0,842	0,886	0,863	360
Traditional Trees	0,735	0,55	0,629	460	0,849	0,927	0,886	490
Onions	NA	NA	NA	NA	0,889	0,926	0,907	95
Triticale	0,526	0,145	0,227	69	0,575	0,694	0,629	72
Clover	NA	NA	NA	NA	0,893	0,909	0,901	55
Deciduous-Fruit Trees	0,618	0,359	0,454	284	0,864	0,734	0,794	312
Permanents Bushes Cultivations	NA	NA	NA	NA	1	0,8	0,889	10
Accuracy	**0,661**	**0,661**	**0,661**	**0,661**	**0,782**	**0,782**	**0,782**	**0,782**
Macro Average	**0,698**	**0,588**	**0,606**	**13001**	**0,847**	**0,822**	**0,825**	**15236**
Weighted Average	**0,706**	**0,661**	**0,66**	**13001**	**0,789**	**0,782**	**0,773**	**15236**

CCTM Services

- Traffic Light System (Smart Sampling for OTSCs)







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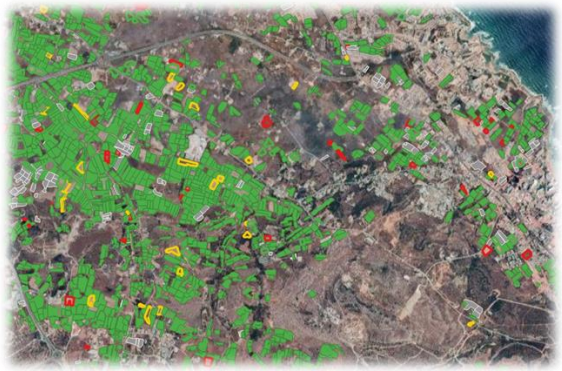
CCTM Services

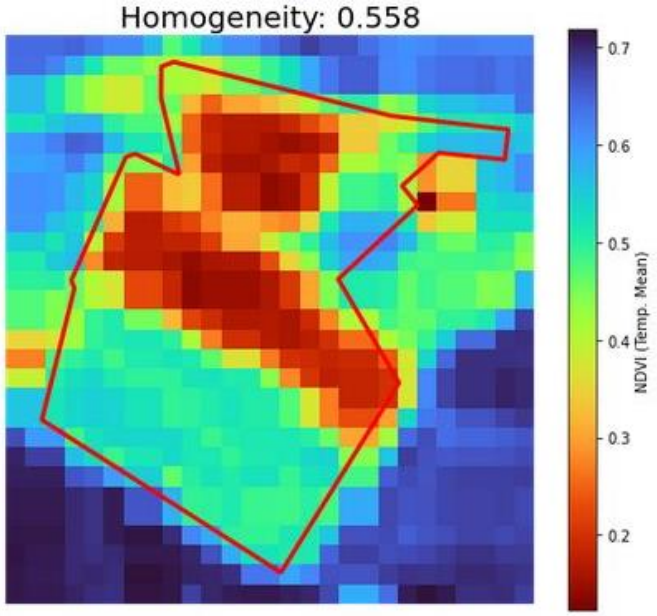
- Crops Diversification Compliance (Greening I)

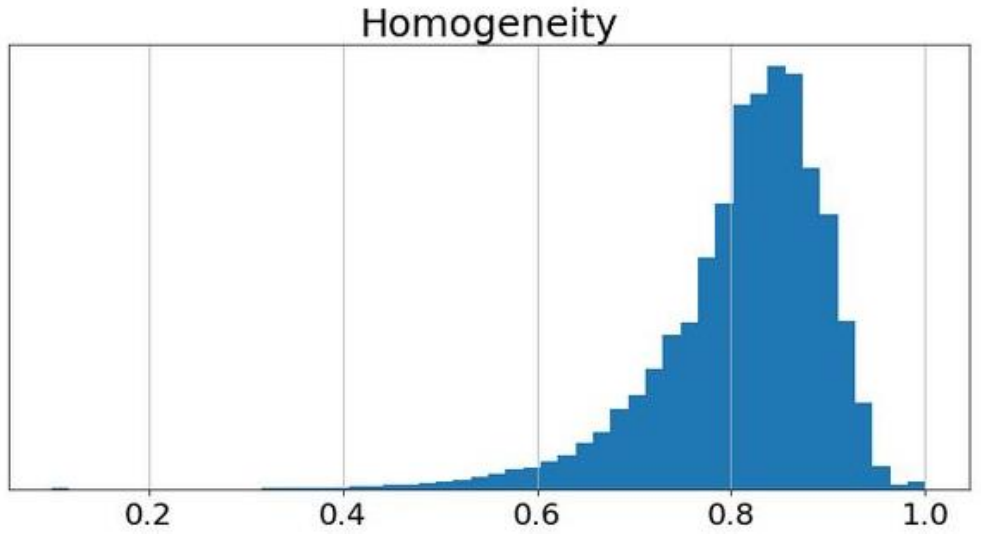


Category	Description	Crop diversification rules
Category1	TAL between 10 and 30 ha	• At least 2 different crop types • Main crop ≤ 75% of TAL
Category2	TAL greater than 30 ha	• At least 3 different crop types • Main crop ≤ 75% of TAL • 2 main crops ≤ 95% of TAL
Category3	TGrass and Fallow greater than 75% of TAL	Main crop ≤ 75% of remaining AL
Exemption1	TAL less than 10 ha	No crop diversification required
Exemption2	TGrass and Fallow greater than 75% of TAL and remaining AL less than 30 ha	No crop diversification required
Exemption3	PGrass, TGrass and Cwater greater than 75% of EAA and remaining AL less than 30 ha	No crop diversification required
Exemption4	Cwater = TAL	No crop diversification required

TAL = Total Arable Land; AL = Arable Land; EAA = Eligible Agriculture Area; TGrass = Temporary Grassland; PGrass = Permanent Grassland; Fallow = Land Lying Fallow; Cwater = Crop Under Water

- Parcels Homogeneity (Polycultures)

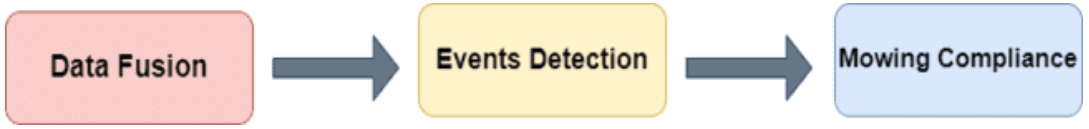




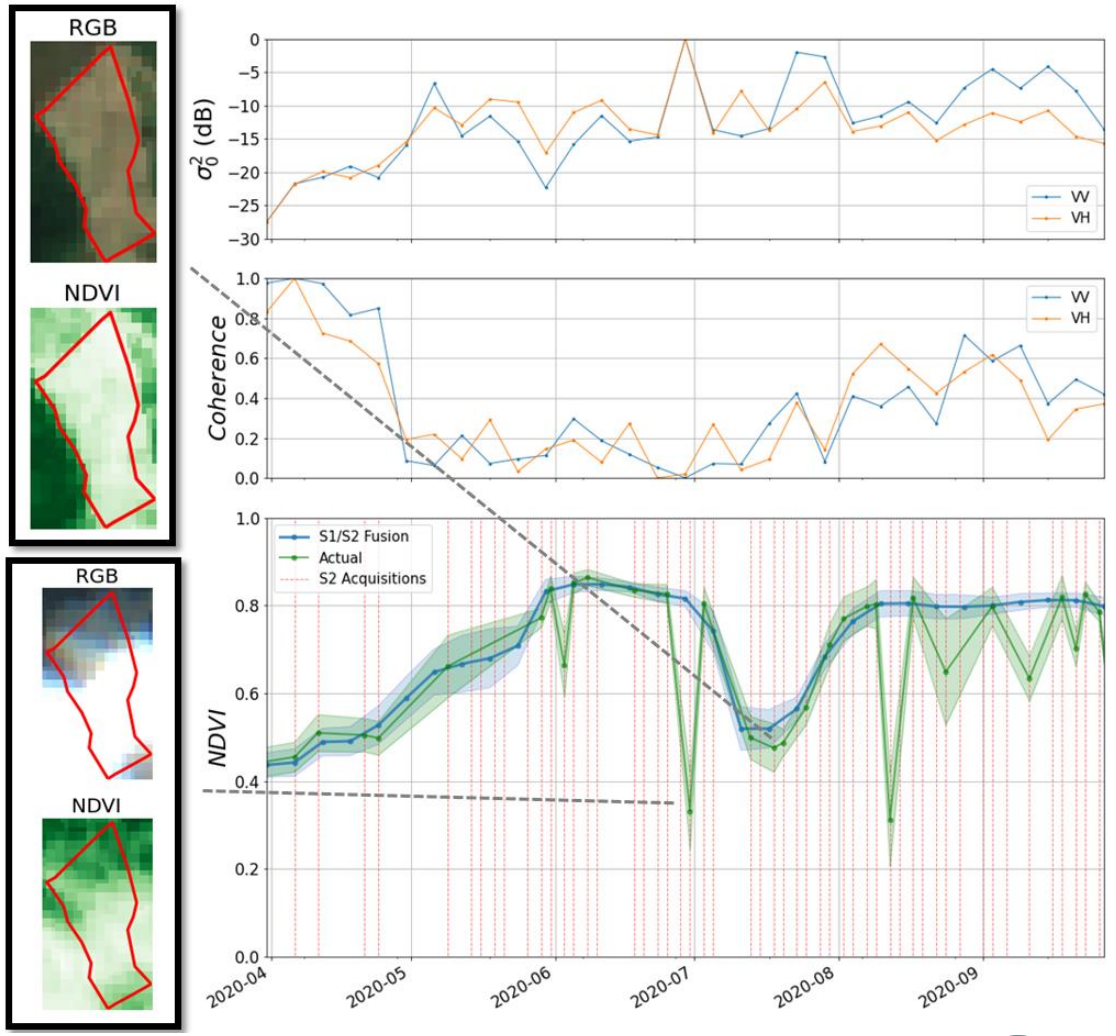
Grassland Mowing Events Detection

User Requirements:

- *"As a Controller, I would like grassland mowing and grazing layers every two weeks from June till November with more than 85% accuracy"*



- Reconstruction of Vegetation Indices based on S1 data (Cloud Coverage)
- Mowing events identification based on the new artificially created VIs
- Mowing compliance results according national regulations



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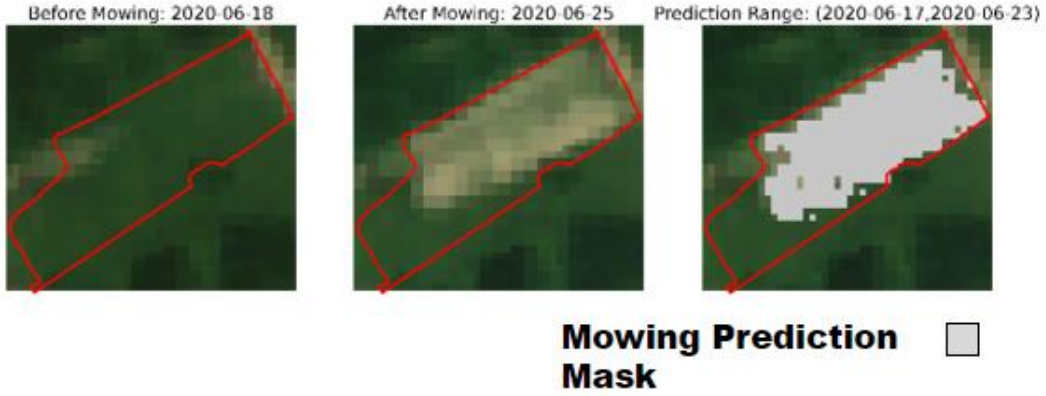
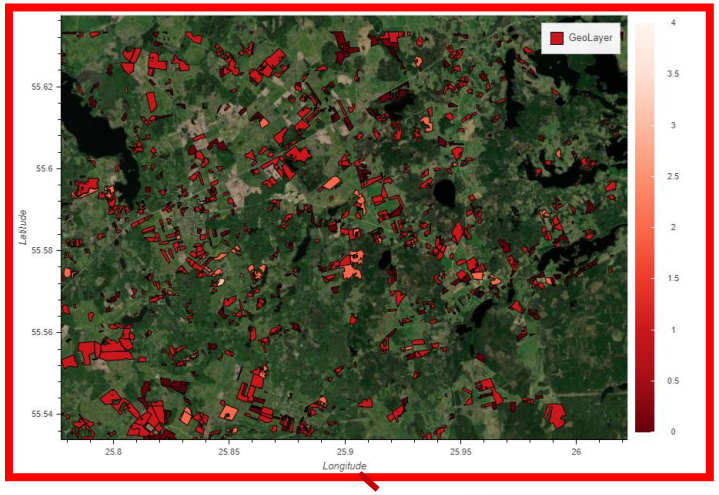
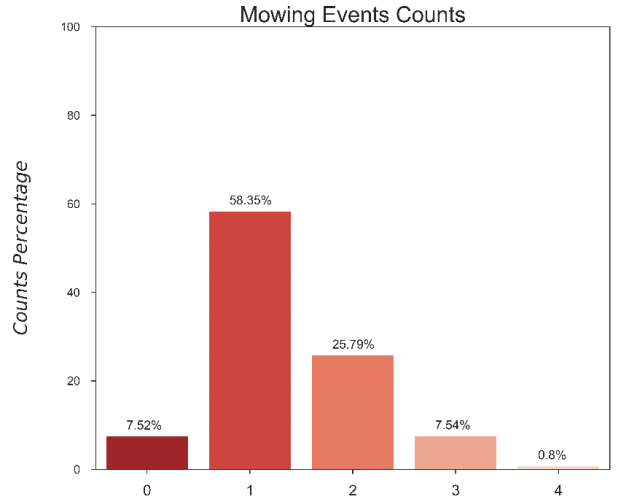
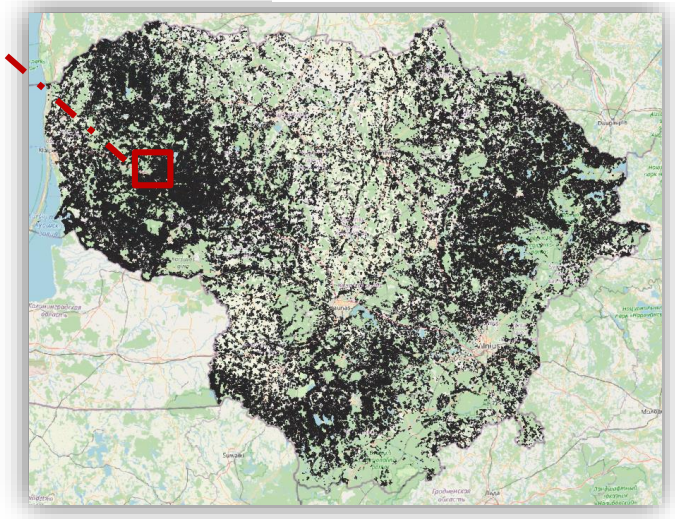
Grassland Mowing Events Detection

- A sophisticated pixel-wise methodology based on DL architecture



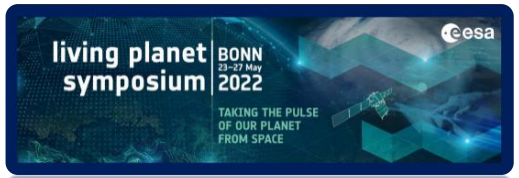






- Towards National Scale Quantification of Grassland Management Activity
- Several Mowing Detection Approaches:
  - Using ML (training samples required)
  - Threshold-based
- Novel Methodology

AGU FALL MEETING
New Orleans, LA & Online Everywhere
13–17 December 2021



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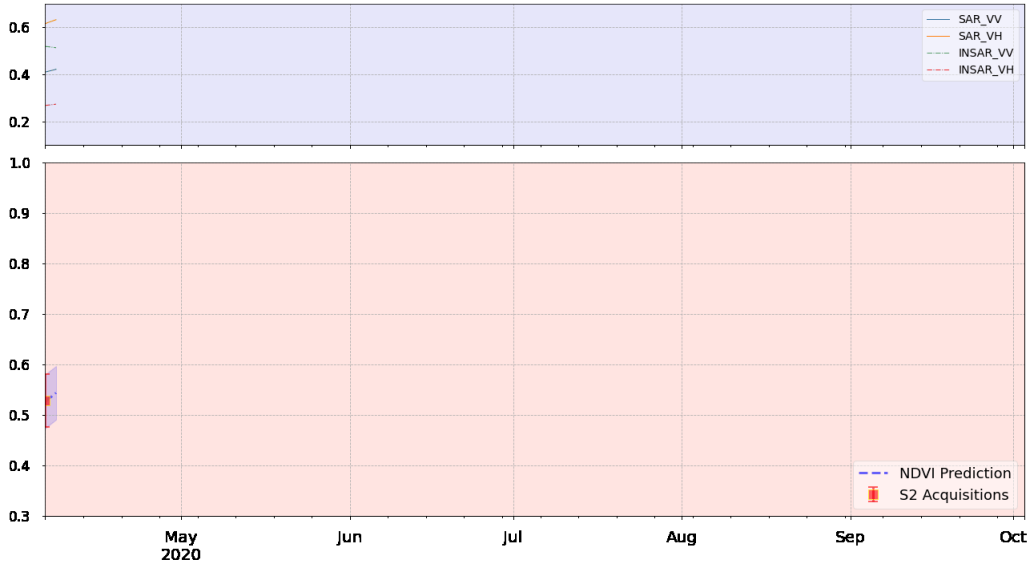
NPA 2022

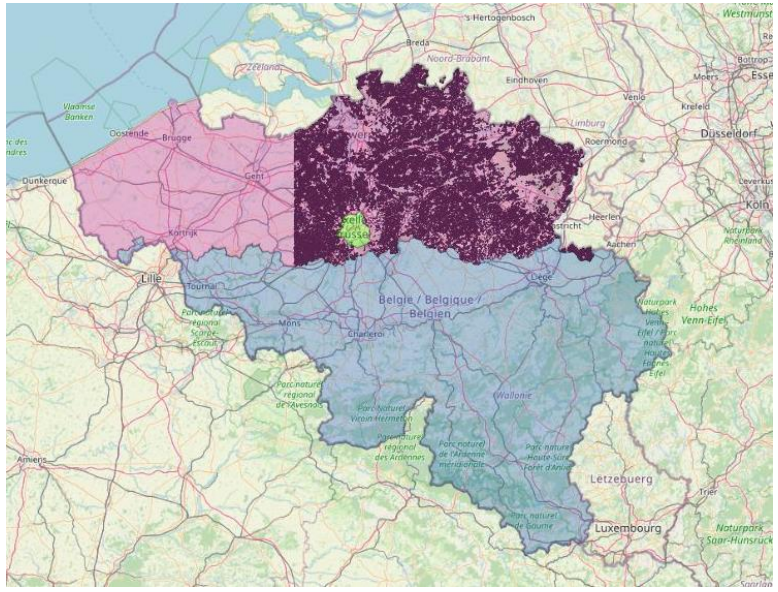
Crop type nr.	Crop type	Quality ENVISION 2022			
		ALFA and BETA parcels sum	Alfa(%)	Beta(%)	Accuracy(%)
1.	SNV - Mowing; >=0,5ha	193	0%	100%	98%
	SNV - Mowing; SGV>=0,5ha	103	0%	100%	98%



Lighthouse Customer (LV) - Flanders

- 107.726 cases provided for a pilot sub-area of Flanders (2021)

DEPARTEMENT LANDBOUW & VISSERIJ



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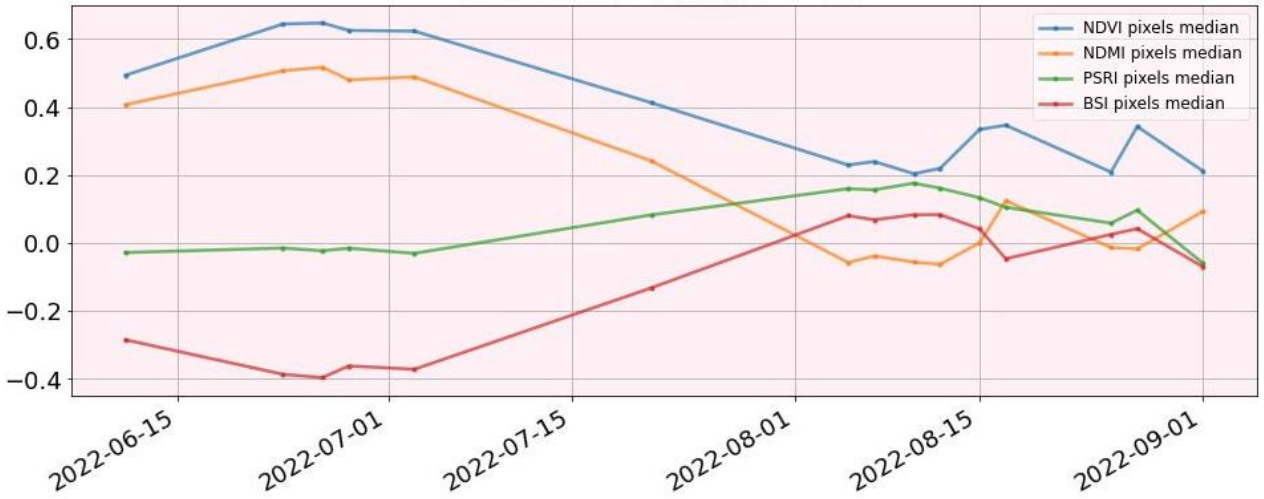
Analytics on Vegetation and Soil Index Time Series

Harvest Detection (NPA)

- Monitoring a combination of multiple VIs



Algorithm nr.	Algorithm type	Quality ENVISION 2022			
		ALFA+BETA parcels	Alfa(%)	Beta(%)	Reliability(%)
1.	Harvest Detection; >=0,5ha	197	0%	70%	96%
2	Harvest Detection; >=0,5ha v2	197	4%	5%	96%

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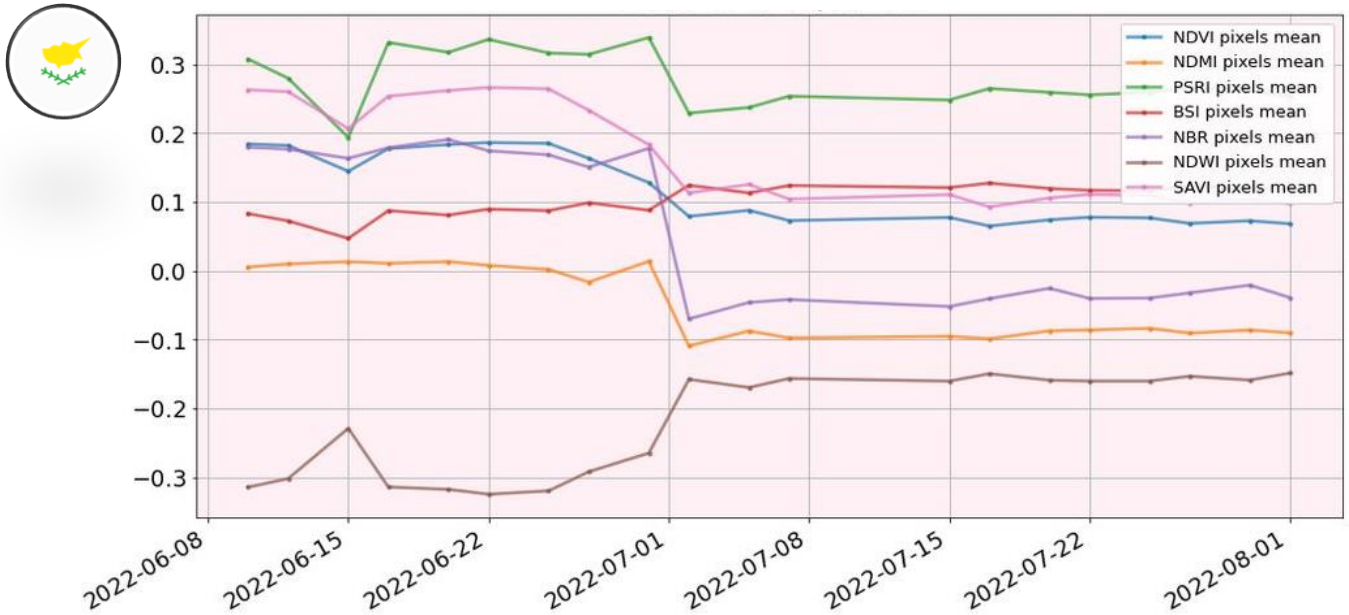
Analytics on Vegetation and Soil Index Time Series

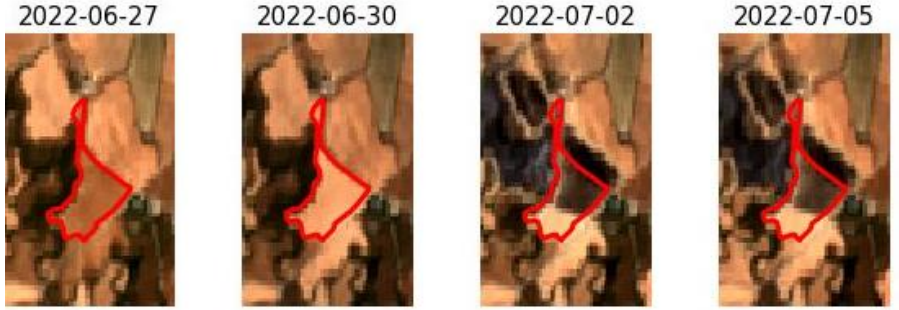
Stubble Burning Events Detection (Arable Land)

- Monitoring a combination of multiple VIs (NBR, NDMI, NDWI, PSRI, BSI)

- Case of Lithuania (confusion with tillage/plowing)
  - Pixel Level
  - Looking for homogeneous burnt sub-areas inside parcel (high std)
  - Other BIs (MIRBI)

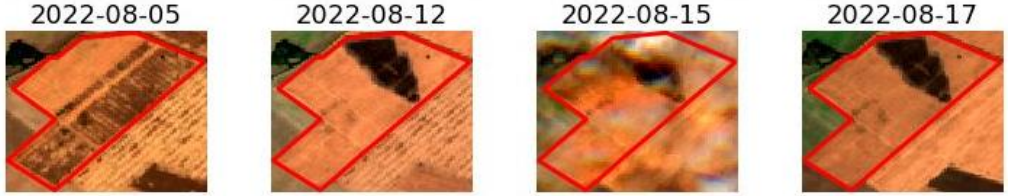
- CAPO 2022 → 219 cases detected (Precision > 90%)
- NPA 2022 → 127 cases detected (Precision ~ 25%)





Plowing

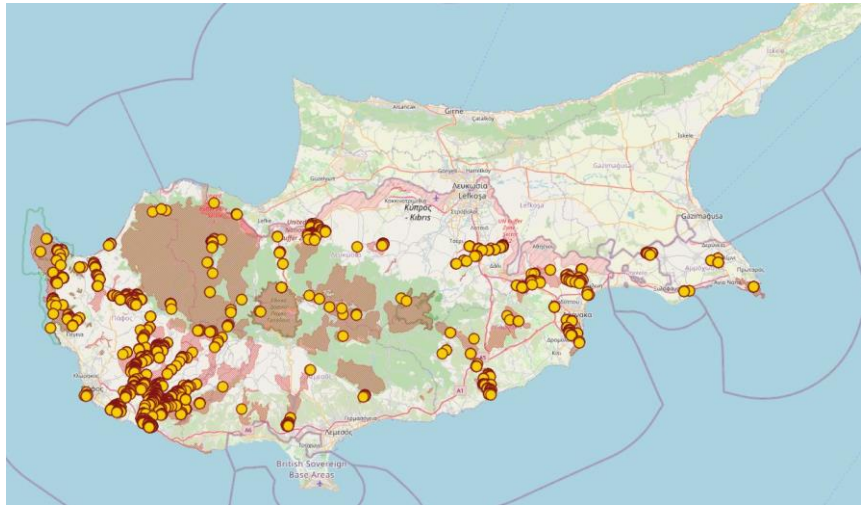
Burning of Stubbles

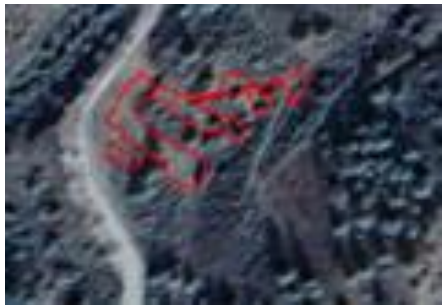


Analytics on Vegetation and Soil Index Time Series

Natura2000 Areas Illegal Activity Detection (CAPO)

- Monitoring a combination of multiple Vis (NDVI, NDMI, PSRI, BSI)
- Pixel Level
- Forest Areas → check only on boundaries
- Exclusion of Eligible Agricultural Areas from LPIS
- Output → A *.shp file* of geometry points for detected pixels





Before

After

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Analytics on Vegetation and Soil Index Time Series

Minimum Soil Cover for Soil Erosion

- Bare Soil Percentage based on combination of SAVI, NDVI and NBR2 indices
- Minimum Soil Cover Alert
  - RUSLE ESTIMATION

- CAPO
  - Inclusion of DEM (inclination over 20%)
  - VAST MAJORITY OF CASES CORRECT and cases that have not been predicted before
- NPA → ONLY FOR BLACK FALLOWS

Algorithm nr.	Algorithm type	Quality ENVISION 2022			
		ALFA+BETA parcels	Alfa(%)	Beta(%)	Reliability(%)
1.	Minimum Soil Cover; >=0.5ha	105	32%	36%	66%
2	Minimum Soil Cover; >=0.5ha (Recalculated on 15/03/2023) v2	82	0%	5%	98%

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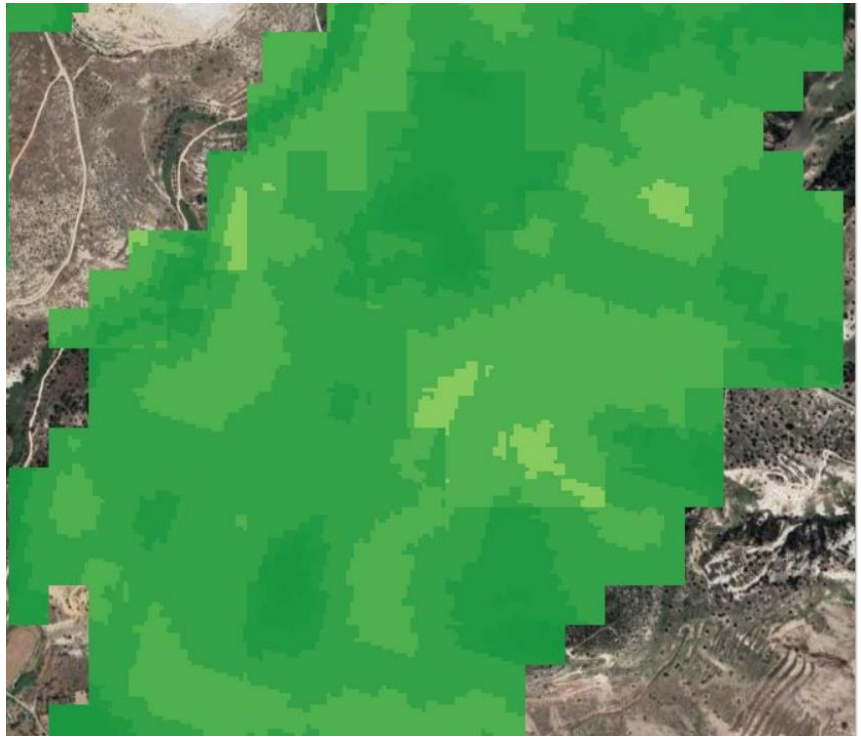
Analytics on Vegetation and Soil Index Time Series

Runoff Risk Assessment for the Reduction of Water Pollution in Nitrate Vulnerable Areas

- Calculation of parcels' **distance** to the closest water protected zone (in meters)
- Calculation of the predicted **annual soil loss** per parcel (tons per acre) based on RUSLE equation
- Based on the abovementioned, there is a **risk estimation** from very low to very high



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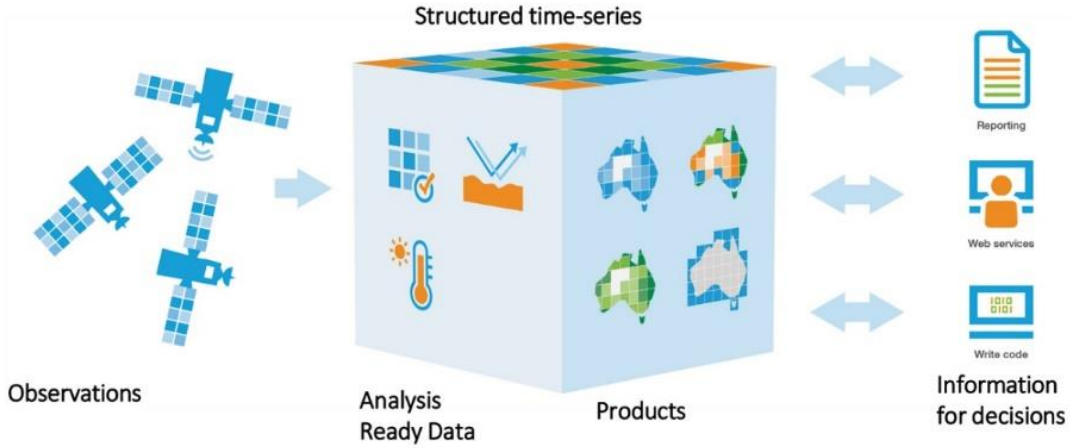
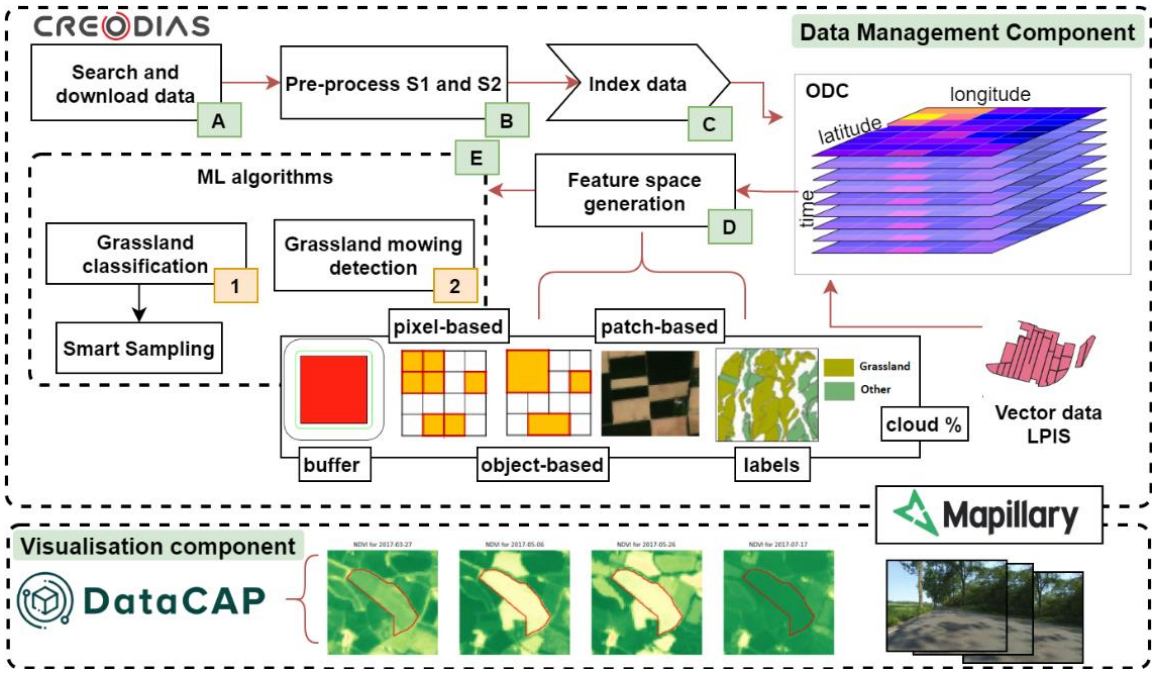
On-Demand Access to the data

- **DataCube API**: Scalable Geospatial MS Knowledge-Base Datasets via FTP:
  - Stores and provides of various dataset, from Sentinel missions to LPIS.
  - Enables direct retrieval of data in the form of plots and graphics.
    - Allows users to construct geospatial queries based on custom parameters and functionalities (images time series on request).
    - Provides multidimensional time-space statistics for monitoring and visualizing agricultural practices and land use.
  - ENVISION services results directly to users' in-house infrastructures.
  - Generates various feature spaces from the same data (pixel-based, object-based, patch-based).





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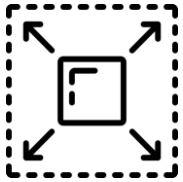
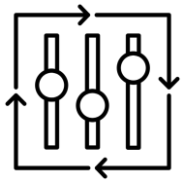
PAs Advantages



Scalability
precise results at any scale, from small AoIs to entire countries.

Advanced Algorithms
sophisticated Machine Learning and Deep Learning based routines for accurate results.



Customizable Analysis
Our services offer a variety of customizable analysis tools to meet specific needs and requirements.

Constant Direction
continuous guidance throughout the cultivation period, helping PAs monitor mowing events in real-time and make informed decisions.

Generalization Performance
reliable information across diverse regions, helping PAs make informed decisions about agriculture management.

Cloud Coverage Resilient
combination of Sentinel-1 and Sentinel-2 data to ensure higher accuracy, even in areas with extended cloud coverage and adverse weather conditions.

Cost-Effective
Our services reduce the need for costly manual field visits, saving time and resources for PAs.

Enhanced Monitoring
continuous monitoring of vegetation and soil over time, helping to detect potential problems early, decision-making and validations.

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The Next Day

User Requirements Gathering

- Auxiliary Data Collection
- Cost-Benefit Analysis

- DIAS Configuration
- Datacube env.

Services Development

- Testing Year 2022
- Products Optimization

Services ready to run for 2023

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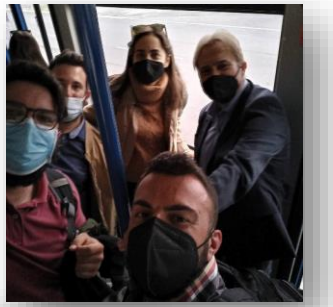
Everybody is happy!

“During the implementation of the Envision project, NPA worked closely with NOA to evaluate the reliability of products and services provided by technical partners. The NPA team tested 7 algorithms that fully address the existing CAP needs. The Grasslands Mowing Event Detection algorithm more than met our expectations, achieving 100 percent reliability during the quality assessment, which means a truly excellent product performance. Regarding the overall reliability of all algorithms, it reaches even 98 percent, and this is a very high score in product testing. So basically, the algorithms worked effectively and properly identified many cases according to different farming-related CAP requirements. We believe that in the future this could help increase productivity, reduce costs, speedy evaluate crop quality, identify nonconformities and reduce the time of physical field inspections.”

Aušrius Kučinskas,
Head of Direct Support Control Unit (NPA)

“CAPO is delighted to be working for the development of Earth Observation Services in collaboration with NOA. The sheer professionalism of it’s scientists and the depth of knowledge they possess, has helped us increase our own awareness around Earth Observation and their innovative approach and valuable guidance is pushing us towards new levels of accuracy in terms of results. Definitely a partner of choice for future collaborations”

George Farkonis,
Head of Larnaca District Offices (CAPO)



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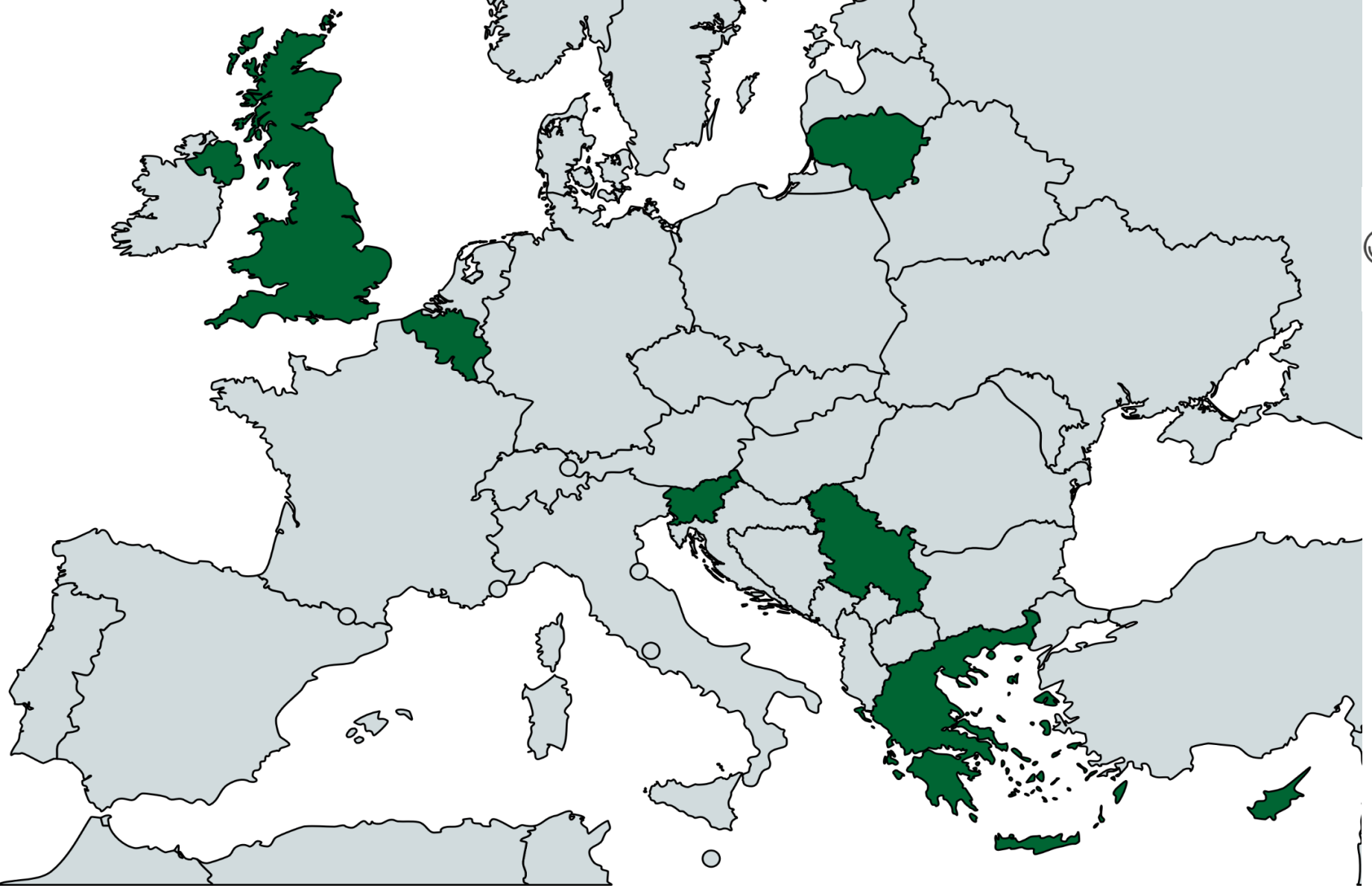

envision

DRAXIS ENVIRONMENTAL TECHNOLOGIES

ΕΘΝΙΚΟ ΑΣΤΕΡΟΣΚΟΠΕΙΟ ΑΘΗΝΩΝ · NATIONAL OBSERVATORY · ATHENS

NPA NATIONAL PAYING AGENCY

DEPARTEMENT LANDBOUW & VISSERIJ

ΚΥΠΡΙΑΚΟΣ ΟΡΓΑΝΙΣΜΟΣ ΑΓΡΟΤΙΚΩΝ ΠΛΗΡΩΜΩΝ · CYPRUS AGRICULTURAL PAYMENTS ORGANISATION

OCS Organic Control System

ILVO Flanders research institute for agriculture, fisheries and food

LEAF LINKING ENVIRONMENT AND FARMING

University of Reading

ITC INOVACIJSKO TEHNOLOŠKI GROZD · INNOVATION TECHNOLOGY CLUSTER

AGRIFOOD DIGITAL INNOVATION HUB

etam s.a. consulting services

INOSENS

AgroApps

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Thank you for your attention!

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