

Evolution of Copernicus Land Services based on Sentinel data
2019 IACS Workshop
CLMS-related H2020 projects session
Wednesday, 10th April 2019
08:30 – 18:00 CET
Valladolid (Spain), Consejería de Agricultura y Ganadería JCYL

ECoLaSS

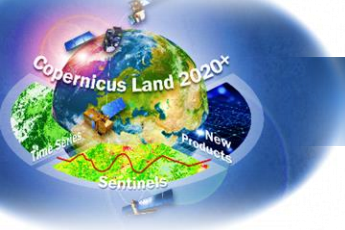


Horizon 2020
Call - Earth Observation:
EO-3-2016: Evolution of Copernicus services

ECoLaSS: “Evolution of Copernicus Land Services based on Sentinel data”

Eva Sevillano Marco, Katharina Schwab, Markus Probeck (GAF)

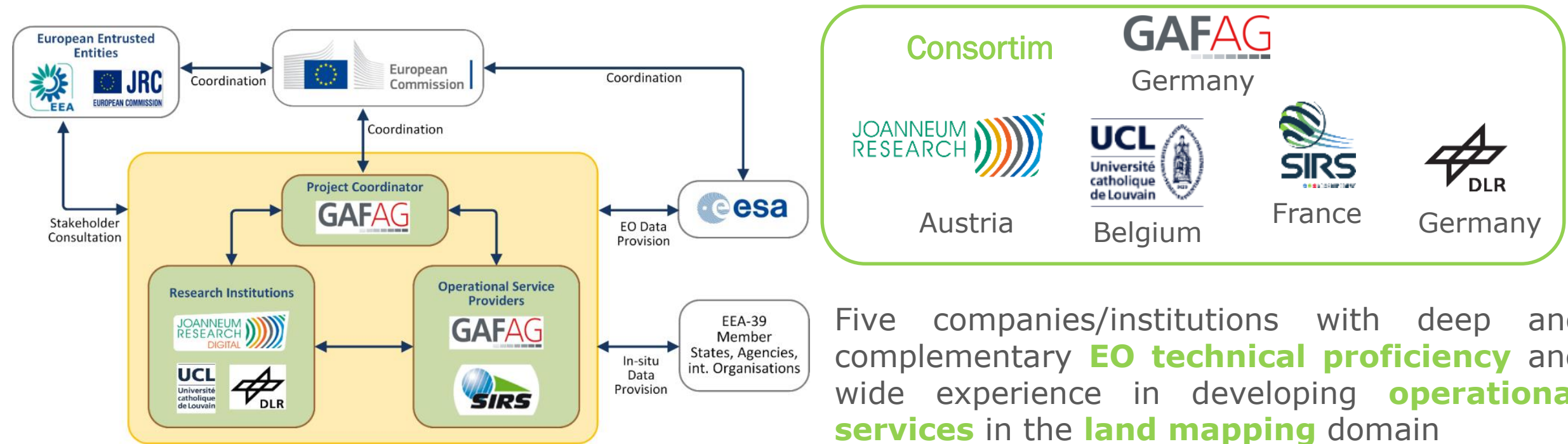




H2020 ECoLaSS – Partners involved

ECoLaSS: “**E**volution of **C**opernicus **L**and **S**ervices based on **S**entinel data”

Key Objective = **improve** existing & develop **novel** products/services for future operational pan-European & Global Copernicus Land Components 2020+:

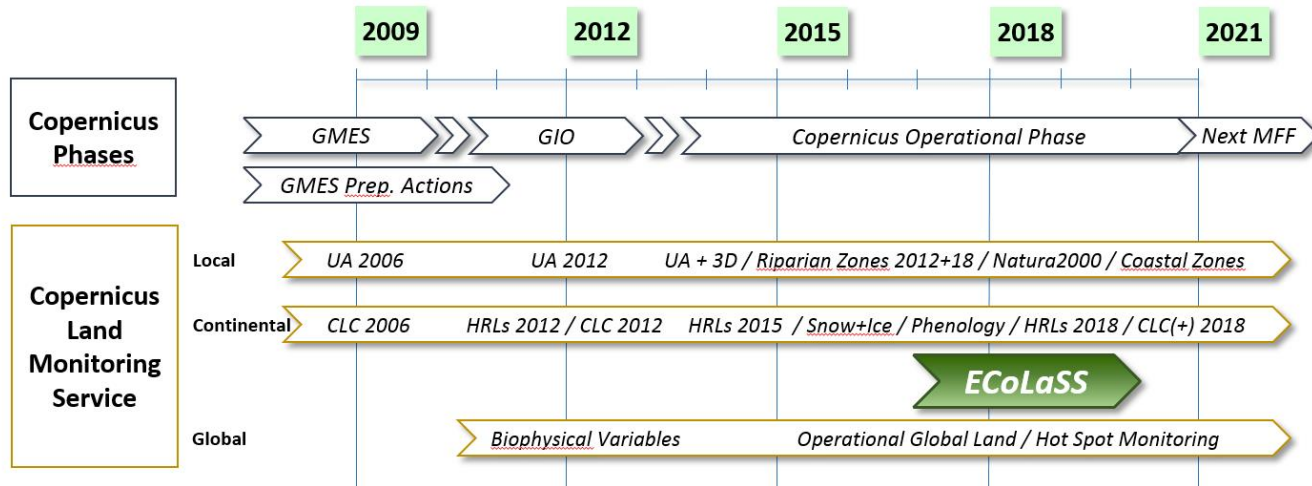


Five companies/institutions with deep and complementary **EO technical proficiency** and wide experience in developing **operational services** in the **land mapping** domain



H2020 ECoLaSS – Time scale

ECoLaSS concept within the **time lapse** of **Copernicus phases** development and the **Copernicus Land Monitoring Service** frame



Progress Jan 2017 Dec 2018



Dates & Timing

Dec 2015 Horizon 2020 WP,

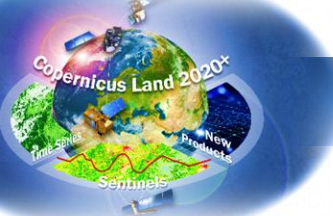
Call: „Evolution of Copernicus Land Monitoring Services“

- Jan 2017: Project Start

→ Runtime: Jan 2017 – Dec 2019 (3 years)

Reporting Period			Period 1																	Period 2																		
Project Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Meetings	KO																	PM1					PM2					PM3										
Milestones	M1																	M2					M3					M4										
WP No. / Work Package Title	WP Leaj																	Deliverable Code																				
Task 1: Project Coordination																																						
11	Administrative Management	GAF	D11.1	cont.																																		
			D11.2																																			
			D11.3																																			
			D11.4																																			
			D11.1																																			
			D11.2																																			
12	Scientific Coordination	GAF	D12.1																																			
			D12.2																																			
			D12.3																																			
Task 2: Consolidation of Copernicus Land Evolution Requirements																																						
21	Assessment of Service Evolution Requirements	GAF	D21.1																																			
22	Assessment of EO and other Data Requirements	SIRS	D22.1																																			
23	Assessment of Service Infrastructure/Architecture Requirements	DLR	D23.1																																			
Task 3: Automated High Data Volume Processing Lines																																						
31	Sentinel-1/2/3 Integration Strategies	DLR	D31.1																																			
32	Time Series Preparation	JR	D32.1																																			
33	Time Series Analyses for Thematic Classification	UCL	D33.1																																			
34	Time Series Analyses for Change Detection	JR	D34.1																																			
35	Time Series Consistency for HRL Product (Incremental Updates)	SIRS	D35.1																																			
Task 4: Thematic Proof-of-Concept/Prototype on Continental/Global Scale																																						
41	Time Series-derived Indicators and Variables	UCL	D41.1																																			
			P41.2																																			
42	Incremental Updates of HRL Layers	GAF	D42.1																																			
			P42.2																																			
43	Improved Permanent Grassland Identification	JR	D43.1																																			
			P43.2																																			
44	Crop Area and Crop Status/Parameters Monitoring	UCL	D44.1																																			
			P44.2																																			
45	New LC/LU Products	SIRS	D45.1																																			
			P45.2																																			
Task 5: Operationalisation Framework																																						
51	Stakeholder Consultation	GAF	D51.1																																			
52	Candidates for Operational Roll-out	GAF	D52.1																																			
53	Integration Plan into Copernicus Service Architecture	SIRS	D53.1																																			
			D53.2																																			
Task 6: Communication, Dissemination and Exploitation																																						
61	Communication, Dissemination & Exploitation	DLR	D61.1																																			
			D61.2																																			
			D61.3																																			
62	Market Opportunities & IPR Strategy	GAF	D62.1																																			
Ethics																																						
70	Ethics requirements	GAF																																				

Legend: KO Kick-Off Meeting, PM1 Interim Progress Meeting, PM2 Periodic Review Meeting, PM3 Final Meeting, D Deliverable, Document, M Milestone, P Product, WP No. Work Package Number

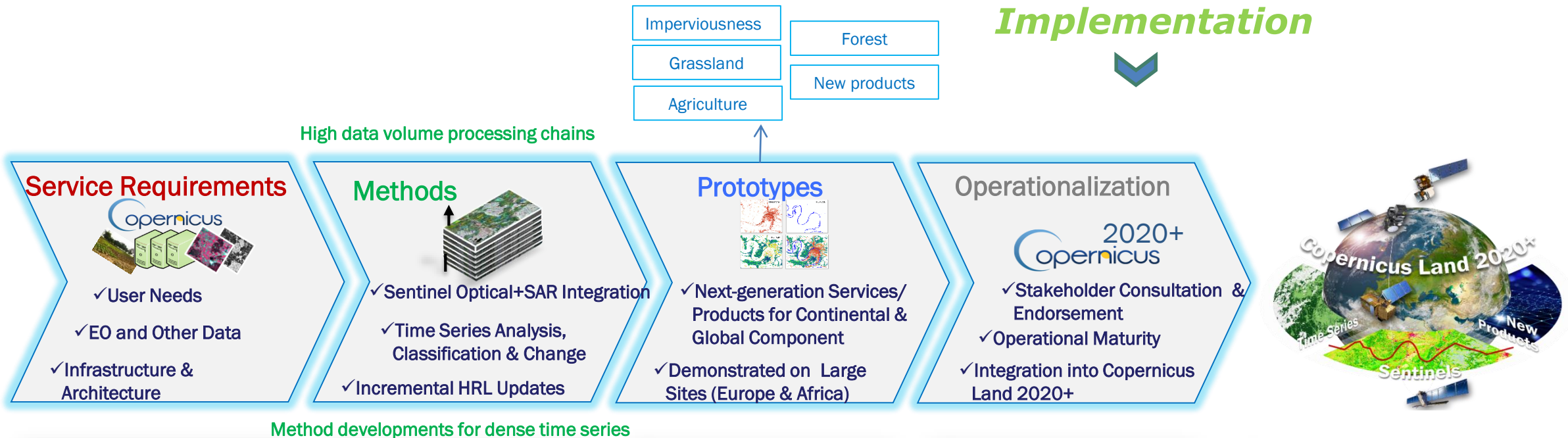


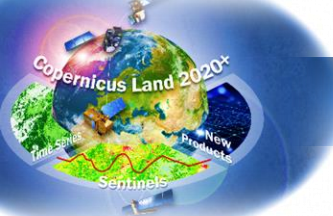
H2020 ECoLaSS – Objectives & Setup

OBJECTIVES

- **Innovative methods:** improve existing & develop novel **products** and **services**
- **Prototypes:** next-generation operational Copernicus Land Services demonstrated in large prototype sites of **biogeographical diversity + food security**
- **Operationalization framework:** benchmarking of prototypes for operational implementation into **Copernicus Land services +2020**

Implementation





H2020 ECoLaSS – Objectives & Setup

Implementation

Task 2 User Requirements

- Stakeholders surveys
- Thematic topics & Service evolution
- Earth Observation & In-situ data
- Architecture & Infrastructure



Task 5 Operationalization Framework

- Prototypes benchmarking for implementation into Copernicus Land Monitoring Services 2020+
 - Innovation & Technical excellence



Task 3 Innovative Methods

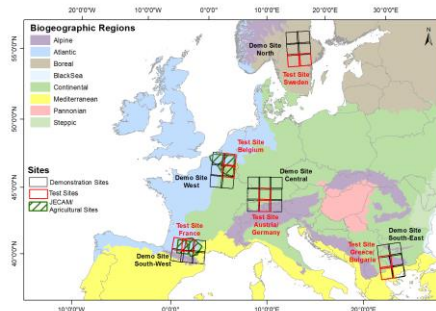
- Time series Sentinel optical+SAR
- Pre-processing & fusion
- Classification
- Change detection
- Incremental updates



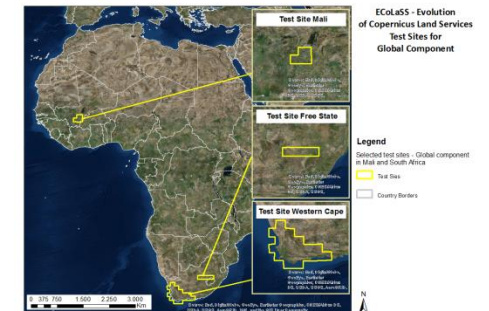
Task 4 Prototypes

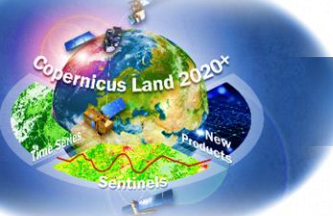
Demonstration in large sites of biogeographical diversity

Europe

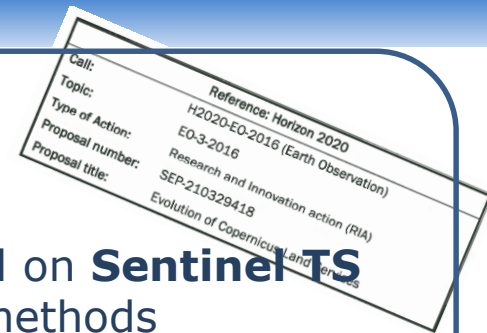


Africa

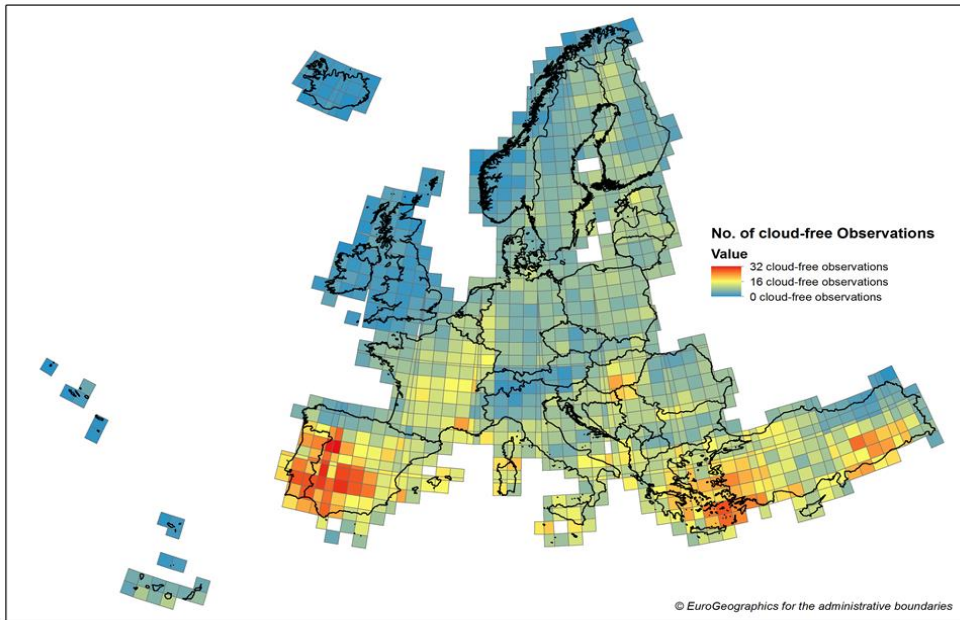




H2020 ECoLaSS – Challenges & Issues addressed



Copernicus Land Monitoring Service



Research needs

- LC/LU and change mapping**
- Multisensor** data (radar + optical)
- Automated** change monitoring based on **Sentinel TS**
- Improved **grasslands** identification methods
- Crop area** and **crop status** monitoring
- Methods to provide **yearly incremental updates in HRL**
- High volume data** processing lines

EO data **Sentinel TS 2014-present**
 spatial information on **various spatial scales**
biophysical variables
LC/LU status + change layers

Evolving **user requirements** and **state of the art R&D methodologies** driving Copernicus operational services

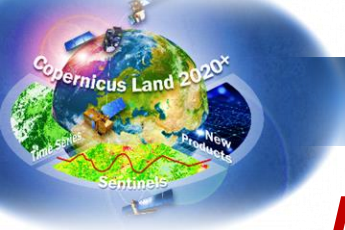
R&D results support informed discussion of Copernicus service portfolio

Multiresolution

Multisensor Multitemporal

Challenges & Issues

- HR local-continental-global scales
 - data gaps (e.g., cloud cover)
 - products consistency



Requirements

Service evolution

- Not much thought/interest about technical issues, specifications
- High interest in **Copernicus** satellite data (mostly **Sentinel-2**)
- Higher interest in local component/**higher resolution**

EO & Reference data

Input EO data

- Shortcomings VHR data: unequal European DTM, geometric accuracy
- S1 image frame position inconsistencies due to other radar interference
- S2 geometric and cloud masks inconsistencies

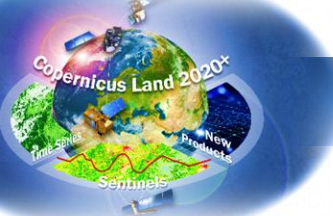
In-situ data

- CORDA is huge improvement
- Heterogeneity for thematic classification (e.g. ≈ IACS European coverage)

IT Infrastructure

- Network/data transfer, storage, processing, scalability capabilities
- Processing techniques will favour solutions that move software to data
- DIAS still not yet operationally mature

European-level Stakeholders:	EAA DG JRC DG GROW DG ENV DG AGRI DG CLIMA DG REGIO DG DEVCO DG CONNECT
National Stakeholders:	BKG (Germany) UBA (Germany) DLR (Germany) EAA (Austria) CGDD (France) CNIG (France) IGN (France) AFIGEO (France) CRAw (Belgium) ARC (South Africa)
Other Stakeholders:	EIONET EARSeL EARSC Operational CLMS implementation projects (such as HRLs 2015) R&D projects (other H2020 projects)



H2020 ECoLaSS – Outcomes

Requirements

Service Evolution Requirements in view of potential +2020 implementation

- state of the art
- product specifications
- identifying challenges
- shortcomings and lessons learned

CLMS global component

Existing: MR-HR Sentinel layers
New: phenology layers

CLMS local component

Existing: Natura2000, Urban Atlas
New: Coastal Zone Service

CLMS Pan-European component

Existing:

HRLs qualitative improvements & more frequent updates,
CLC+ spatial resolution and thematic content

New: Agriculture Service, phenology layer, generic products

Higher resolution

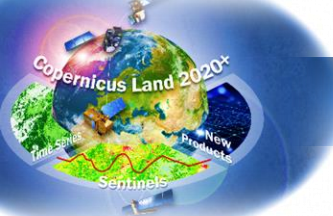
Frequent updates

Thematic content

Timeliness

Description of Future Cooperation	
Organisation: Department/Unit: Contact person:	
Please describe the overall mission/mandate and policy objective of your organisation and state which department/unit is responsible for following up on Copernicus Land Service.	
Policy Framework	
Role in Copernicus Land	
Please describe the role of your organisation in relation to the CURRENT implementation of Copernicus Land Service.	
Please describe the involvement of your organisation for FUTURE (2020+) Copernicus Land Service implementation.	
Policy-related Events/Milestones	
What are the policy-related events/milestones/reports for the work of your organisation within Land Services?	
Policy Drivers	
(a) Highlight the main environmental, regional/national and international drivers that influence implementation support for (either directly or indirectly) Copernicus Land Services. (b) Explain how these policies drive your geographical information needs.	
Use of Copernicus Land Products	
(a) Which Copernicus Land Service products are used in your organisation? (b) Where do you see the strengths and most valuable information? (c) Which do you see as most shortcoming, do you experience?	
End Users & Application	
Product Users	
(a) Which kind of users are the users? (b) Can you predict possible new users?	
End-use Application	
(a) What are the main applications? (b) What are your main objectives?	
Technical Support	
Evolution	
Please describe the evolution of product specifications, for which existing products do you consider an improvement/evolution as necessary and the reasons why?	
Evolution	
Please describe the evolution of product specifications for the products under evolution.	
New Services/Products	
Definition of New Service	
Which new Copernicus Land products do you envisage? (a) Mid-term (until 2020 Update) (b) Long-term (2020+)	
Key Specifications for New Services	
Please provide your ideas of specifications for these new products.	
Cross-cutting Services	
(a) Do you see the need for new cross-cutting Copernicus Services? (b) If yes, which?	
Implementation of Improved and New Services & Products	
Implementation Schedule	
What is your required schedule and plan for implementation of improved or new services/products into the operational Copernicus Land Monitoring Service portfolio?	
Infrastructure	
Do you have any specific requirements in terms of service provision via online platforms, data and information access services?	

2 versions (full + shortened):
Stakeholder Interview Questionnaire



H2020 ECoLaSS – Outcomes Methods & tests

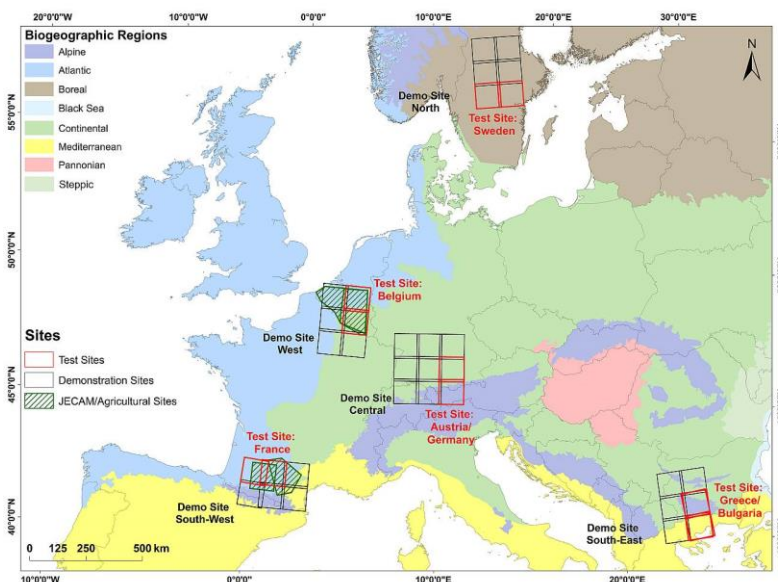
Methods development & tests

Larger prototype sites ($\approx 100\,000\text{ km}^2$) demonstration of candidates for Copernicus Land Service Evolution roll-out on a larger scale

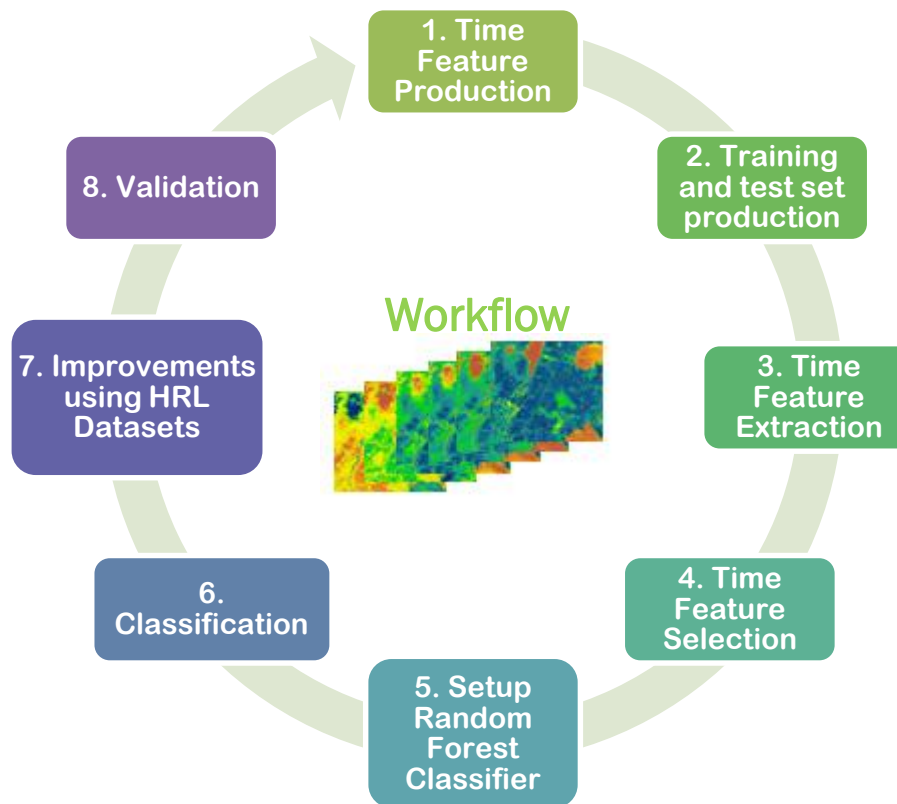
Test sites with specific in-situ data

- IACS-LUCAS-HRL-others

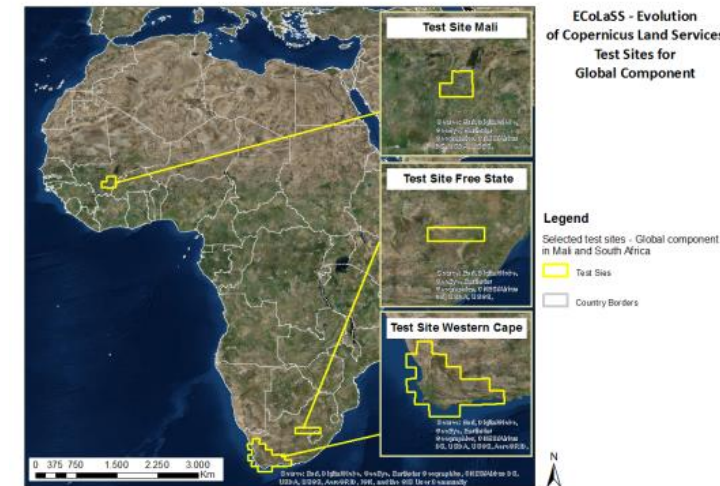
Europe



S2 tile $\approx 100 \times 100\text{ km}$

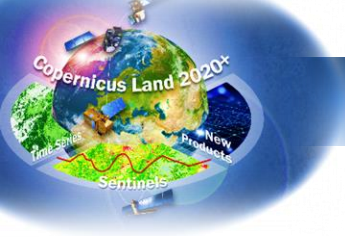


Africa



ECoLaSS - Evolution of Copernicus Land Services Test Sites for Global Component

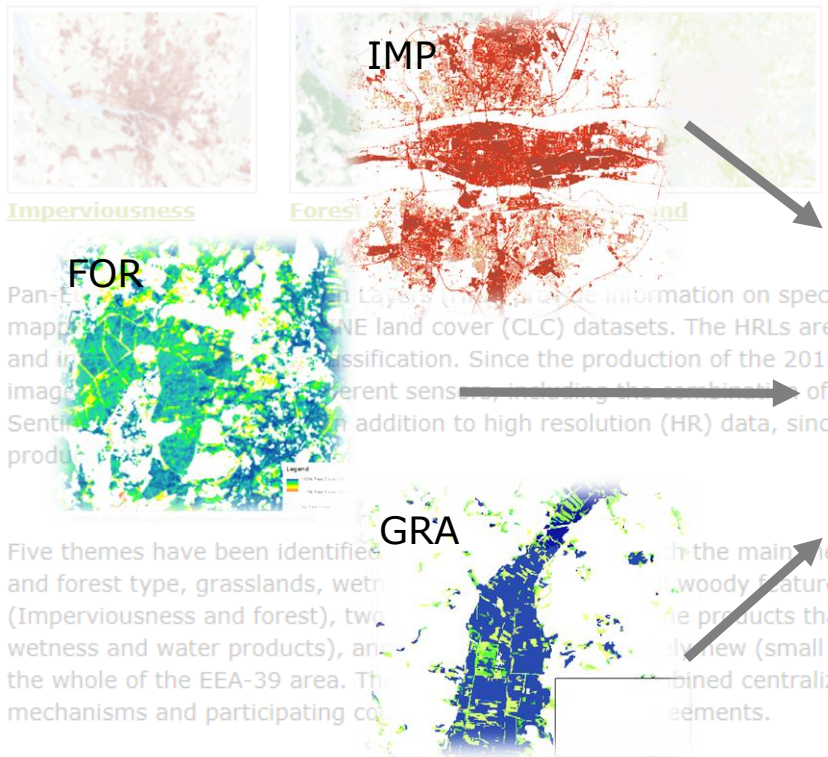
- JECAM (Joint Experiment for Crop Assessment and Monitoring) test sites in Belgium, France, Mali and South Africa ensure large crop and field size diversity, including grasslands and natural vegetation.



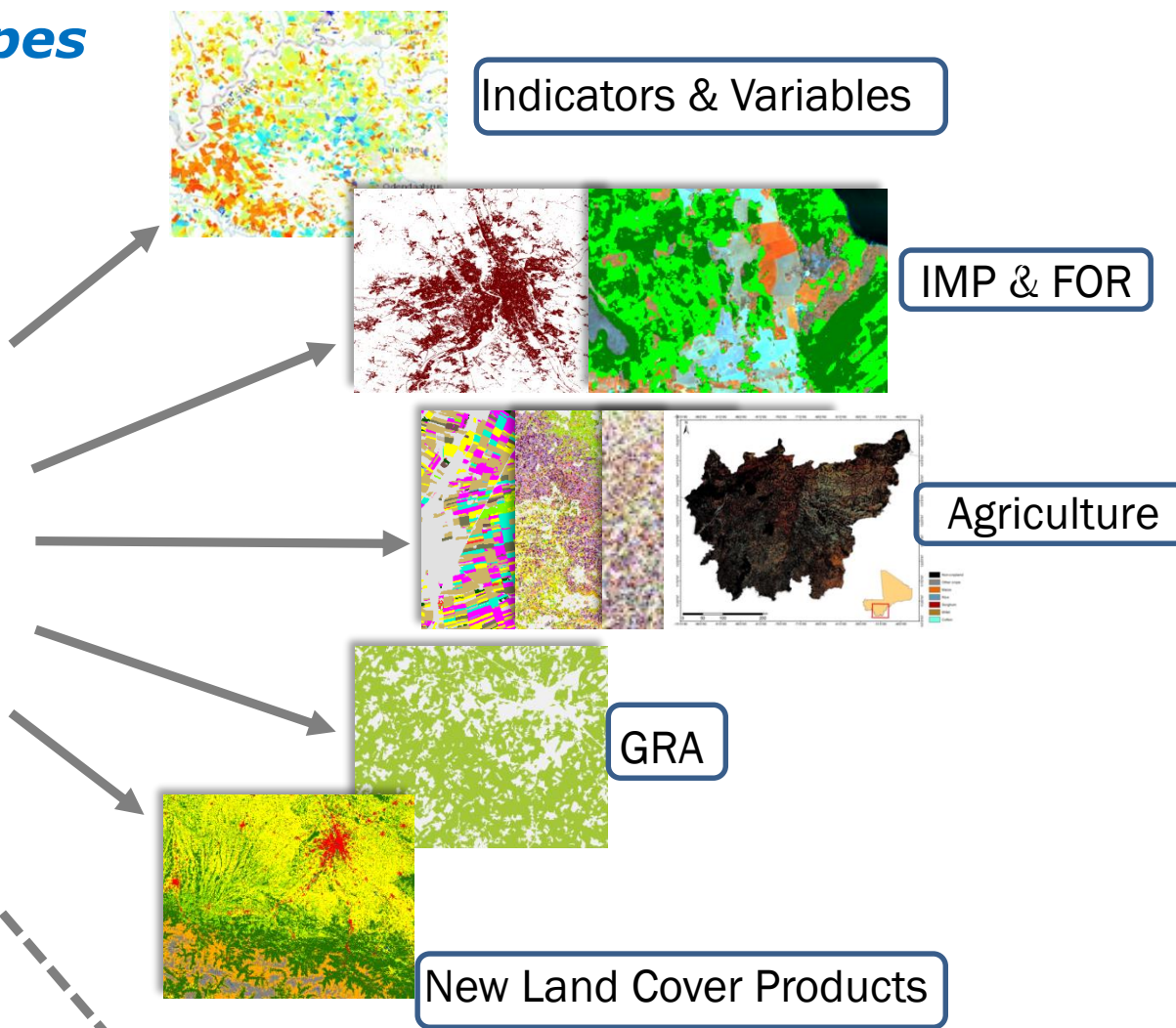
Background: High Resolution Layers (HRLs) 2015 → ECoLaSS Prototypes

ECoLaSS Prototypes

High Resolution Layers



**Improved
Pan-European
CLMS
(+ potential new
products)**



<https://land.copernicus.eu>





H2020 ECoLaSS – Outcomes Prototypes

Forest

Status layers 10 m

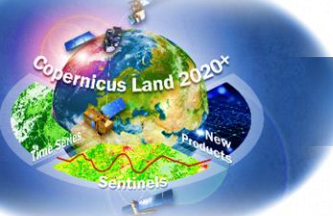
- Dominant Leaf Type (broadleaved/coniferous) 2017, 2018
- Tree Cover Density 2018

Change products 20 m

- Forest Cover Change (FCC) 2015-2017 & 2017-2018



- North, Central, and South-East demosites
- Sentinel-1 + Sentinel-2 data
- Reference data
 - HRLs 2015
 - VHR 2015 & 2017/2018



H2020 ECoLaSS – Outcomes Prototypes

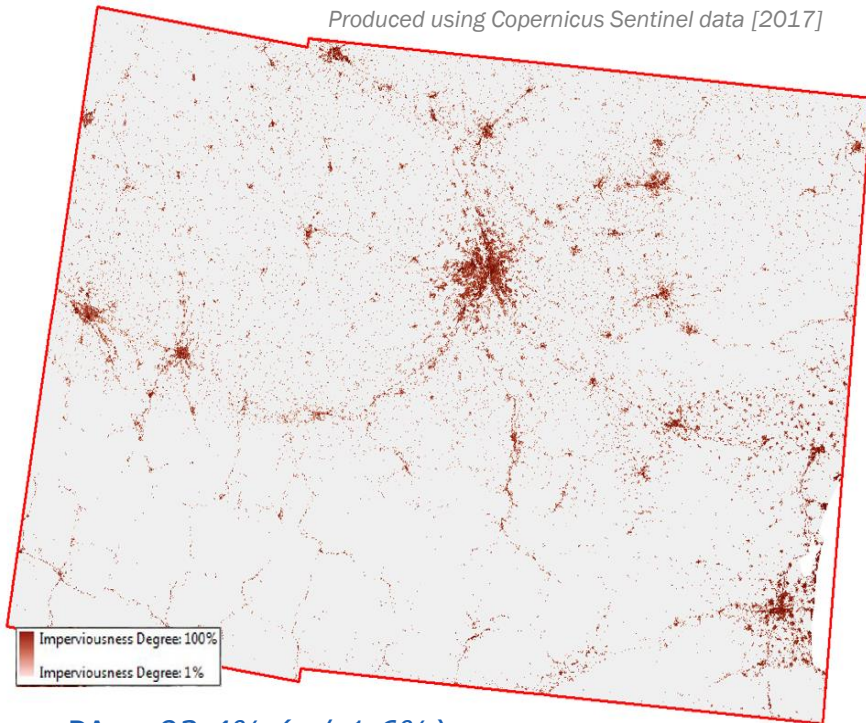
Imperviousness

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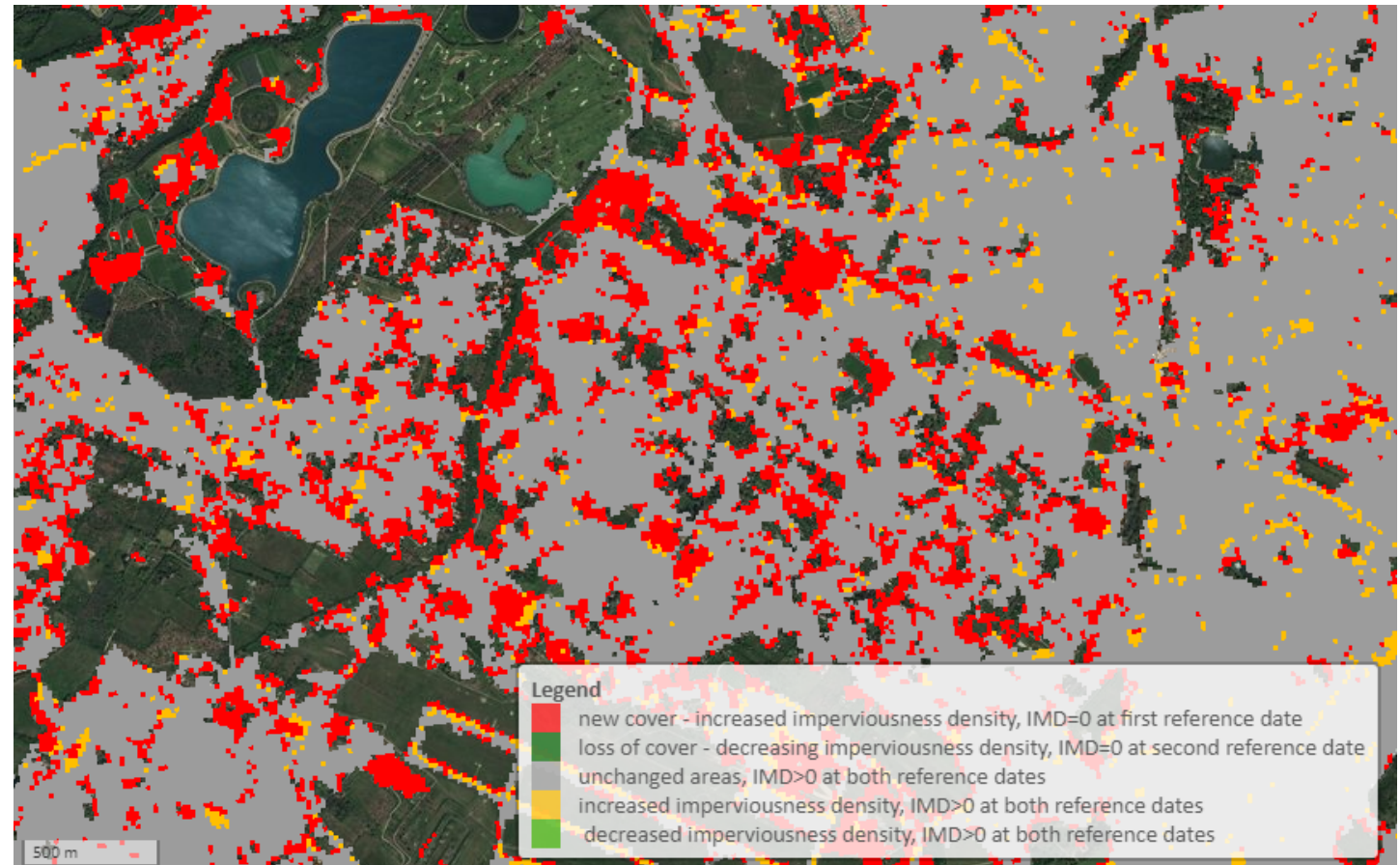
Status layers 10 m
Improved imperviousness degree
2017, 2018

Produced using Copernicus Sentinel data [2017]



PA = 92,4% (+/-1,6%)
UA = 85,1% (+/-1,7%)
Omission = 7,6%
Commission = 14,9%

2017 Belgium



Change products 20 m
○ Incremental imperviousness change 2015-2017 & 2017-2018



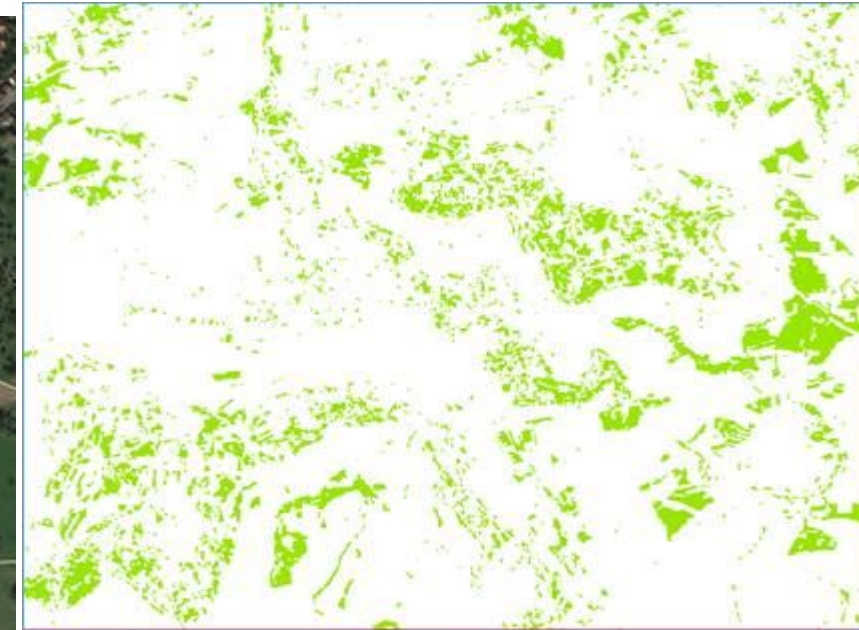
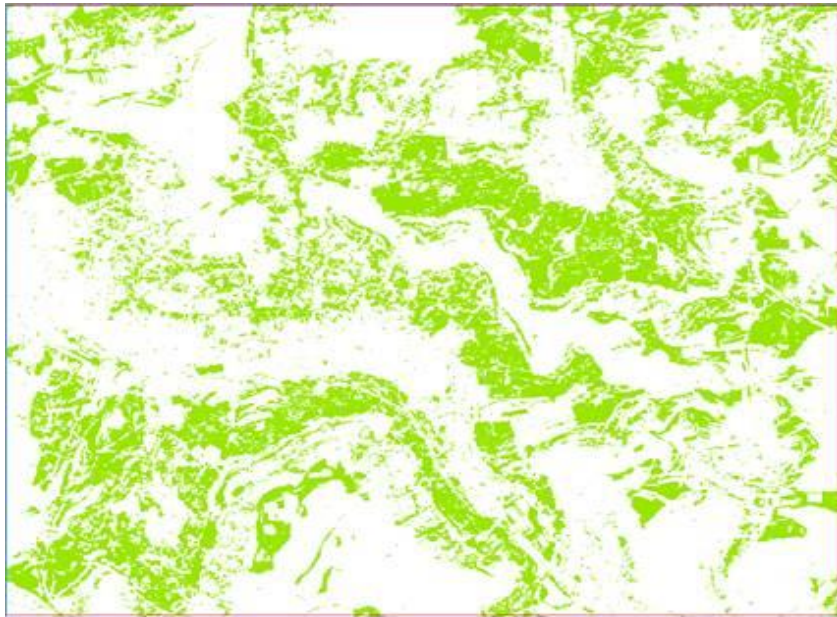
H2020 ECoLaSS – Outcomes Prototypes

Grasslands

S2

Grassland masks tests 2018

S1+S2



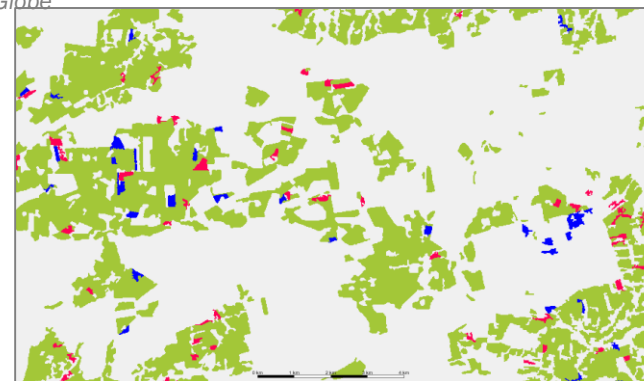
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Status layers 10 m

- Grassland mask 2017, 2018
- Use intensity 2018

Change products 20 m

- Grassland change 2015-2017 & 2017-2018



Class	HRL GRA 2015	ECoLaSS grassland prototype 2017
Grassland	10,365 km ² / 83.9 %	10,943 km ² / 83.2 %
Non-Grassland	53,957 km ² / 16.1 %	54,083 km ² / 16.8 %
Clouds/Cloud-Shadows	2 km ² / 0.0%	0 km ² / 0.0 %
Overall	64,324 km ²	65,023 km ²

© European Union, Copernicus Land Monitoring Service 2015, European Environment Agency (EEA).



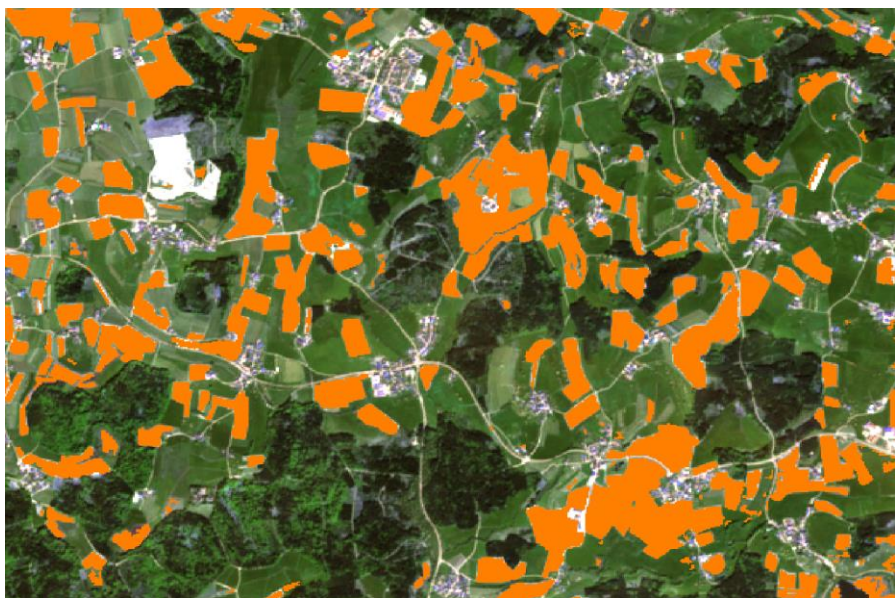
H2020 ECoLaSS – Outcomes Prototypes

Agriculture

Mali, Belgium/France, Central demosites
 -Sentinel-1 + Sentinel-2 TS
 -Reference data: IACS, HRLs 2015, LUCAS,
 Africa In-situ field data collected

Status layers 10 m

- Crop Mask 2016, 2017, 2018
- Crop type masks 2017, 2018



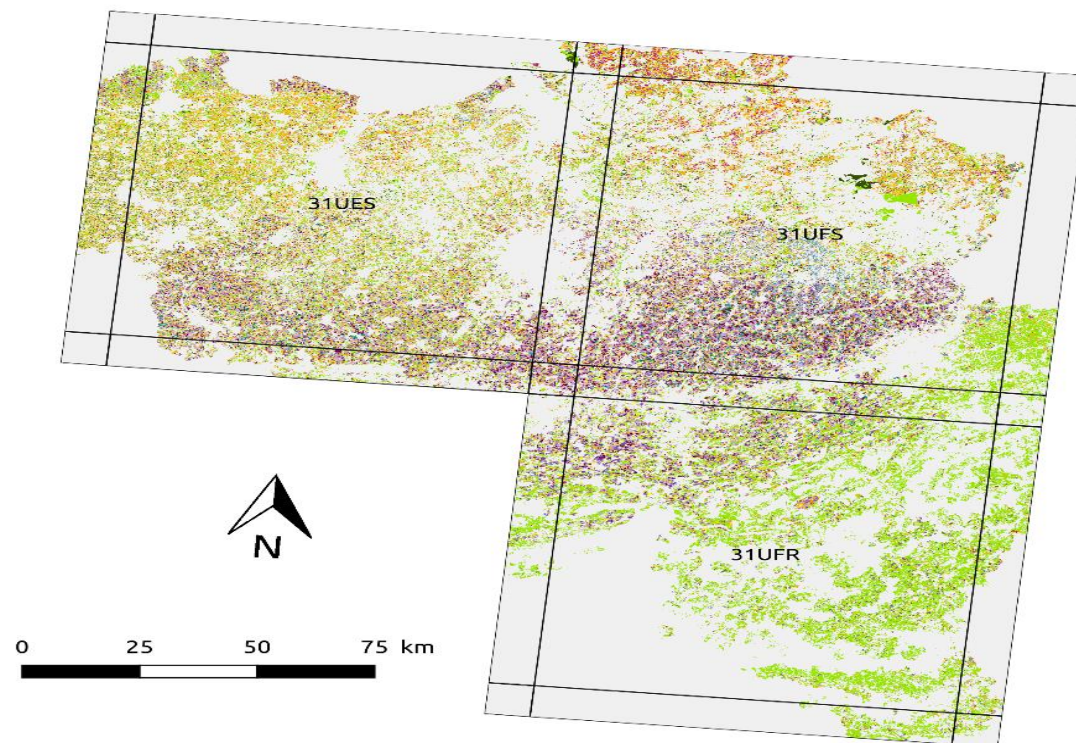
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Crop mask 2018

Legend

- Not classified
- Grassland
- Winter Wheat
- Maize
- Winter Barley
- Sugar Beet
- Spelt
- Rapeseed
- Potato
- Flax
- Summer Oat
- Other Vegetables
- Other Fodder
- Peas
- Summer Barley
- Summer Cereals
- Chicory
- Winter Cereals
- Summer Wheat
- Hemp
- Green Beans
- Onions
- Fruit Crops
- Other Crops
- Grape Vines

Crop types 2017



© European Union, Copernicus Land Monitoring Service 2015, European Environment Agency (EEA).



H2020 ECoLaSS – Outcomes Prototypes

New Land Cover

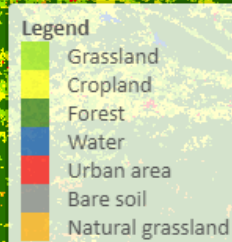
New land cover layer at 10m, with 7 classes that is being modified to include CLC+ recommendations

OA = 94%
PA = 82-99%
UA = 89-97%
Kappa = 0.8
F-Score = 0.37-0.48

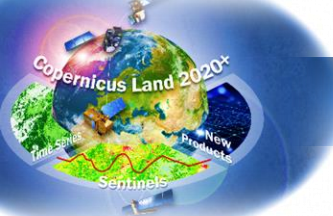
- **Data** 1 year coverage of S2 data only (yearly updates)
- **Production** Improved automation for faster production
- **Definition** Thematic harmonization between pan-European and global layers



Crop, grasslands and forest masks combination



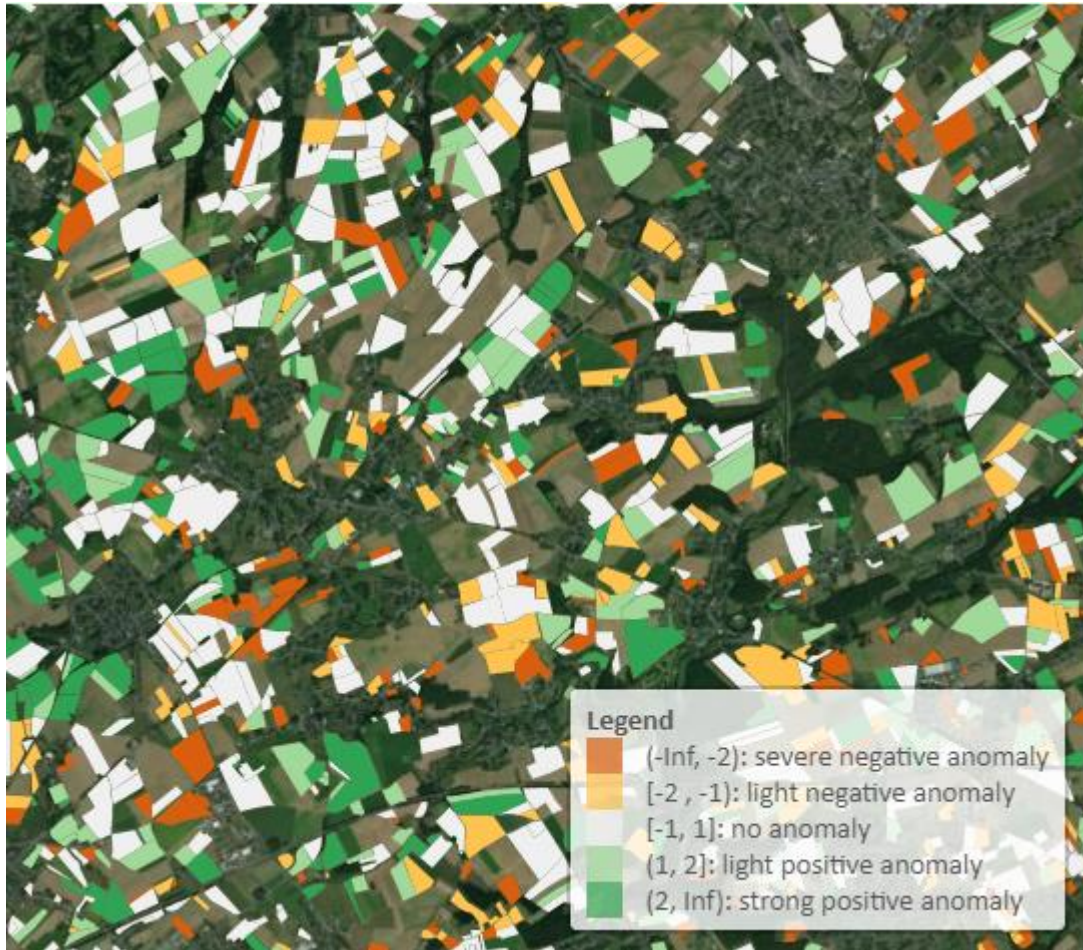
In ECoLaSS the prototypes include across products consistency by testing combination between HRLs



H2020 ECoLaSS – Outcomes Prototypes

Indicators

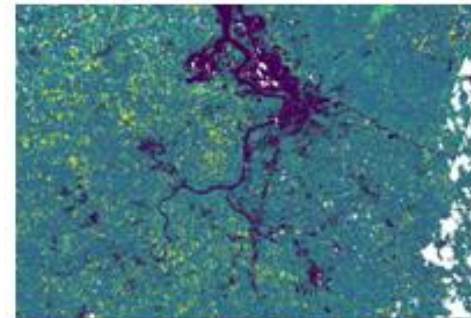
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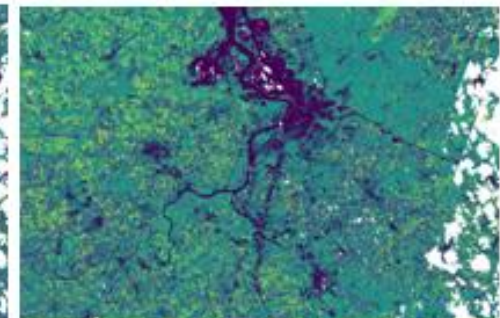
Experimental prototypes related to Indicators and Variables

- Crop growth condition
- Crop Emergence Date Map
- Generic Land Cover Metrics
- Maximum phenology layer (Max month NDVI)
- Multi-annual trends & potential change

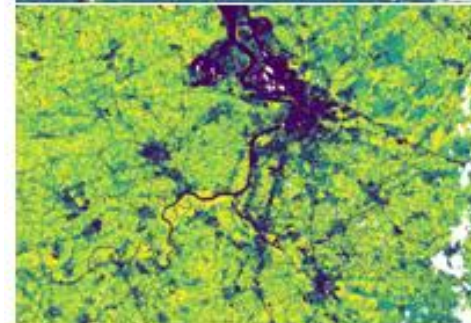
Start of season
(March, April, May)



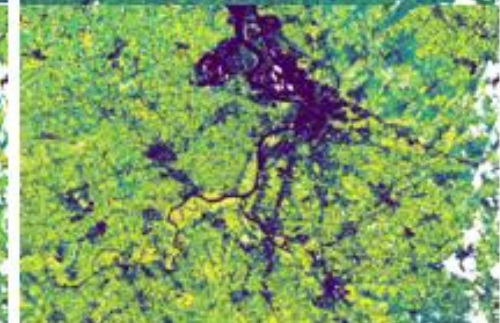
Peak of season
(May, June, July, August)



End of season
(August, September, October, Winter)



Length of season
(6, 7, 8, 9 months)



Crop growth condition S2 2017 Belgium test



Methods & prototypes

- Sentinel-1/2/3 integration
- Sentinel/TS Pre-processing
- TS classification
- TS change detection
- Incremental updates

Benchmarking Approach



High-volume data processing chains:
automated, flexible & customizable



Prototypes:

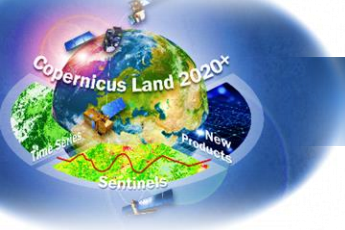
- Indicators and variables
- HRL incremental updates
- Grassland characterisation
- Crop status/monitoring
- New Products

Operational roll-out candidates

Time series indicators	Crop growth condition	New product
	Crop Emergence Date Map	New product
	Generic Land Cover Metrics	New product
	Multi-annual trends & potential change	New product
Imperviousness incremental update	Improved IMD status layer at 10m	Improved product
	Incremental IMD change	Improved product
Forest incremental update	Improved DLT status layer at 10m	Improved product
	Incremental tree cover (mask) change	Improved product
Improved Grassland	Improved Grassland status layer at 10m	Improved product
New Agriculture product	New crop mask status layer at 10m	New product
	New crop type status layer at 10m	New product
New Products	CLC evolution	New product

Assessment matrix

- long term evolution
- portfolio complementarities
- answering identified needs
- political support
- state of the art
- maturity/timing
- EO & in-situ availability
- processing capacity
- automation level
- roll-out potential
- cost/benefit
- documentation



Evaluation candidate prototypes

Assessment matrix

Service/product candidate	long-term evolution	portfolio complementarity	answering identified needs	political support	respecting core vs. DS	State of the art/Innovation	Maturity/ Timing	adequate EO availability	adequate in-situ availability	processing capacity (platform, SW)	Automation level	practically proven Roll-out potential	Cost/ benefit (forecast)	Documentation	Overall score
improved IMD status layer at 10m	-	o	+	++	++	+	++	++	+	++	++	+	+	+/**	59,50
incremental IMD change	++	+	++	++	++	++	+	+	o	++	+	+	+	+/**	61,50
improved DLT status layer at 10m	-	o	+	++	++	+	++	++	+	++	+	+	+	+/**	58,50
incremental forest cover change	++	+	++	++	++	o/+	+	+	o	++	+	+	+	+/**	60,00
Improved Grassland status layer at 10m	o	o	++	++	++	+	++	++	+	++	+	+	+	+/**	60,50
New crop mask status layer at 10m	++	++	++	-	++	++	o	++	-	++	+	+	+	+/**	58,50
New crop type status layer at 10m	++	++	++	-	++	++	o	++	--	++	+	o	+	+/**	56,50
CLC evolution	+	+	++	+	++	++	o	++	o	o	o	-	+	+	54,00
Crop growth condition	++	+	+	o	o	++	+	++	--	++	++	+	+	+	56,00
Crop Emergence Date Map	++	+	o	o	o	++	o	+	--	++	+	+	+	+/**	52,50
Generic Land Cover Metrics	++	+	+	+	+/**	+	-	+	o	++	o	-	+	o	51,50
Multi-annual trends & potential change	++	+	o	o	+/**	+	-	++	o	++	o/+	-/o	+	o	51,50

AND THE WINNER IS...



++	very satisfactory/relevant/applicable
+	satisfactory/relevant/applicable
o	neutral
-	not satisfactory/relevant/applicable
--	not at all satisfactory/relevant/applicable



Evaluation candidate prototypes

CONCLUSIONS

- ✓ The prototypes **improve** the **Copernicus HRLs** and **develop new** products, fulfilling identified **requirements** ➔
- ✓ **Benchmarking** analysis evaluate **prototypes** against **manifold criteria** (e.g. long-term evolution, maturity/timing, automation level, cost/benefit (forecast)).

	Copernicus HRL	ECoLaSS HRL
Spatial Resolution	20m	10m
Temporal Resolution	3 years	1 year
Methodology	manual & automated processing	mostly automated
Themes	Imperviousness Forests Grassland Water & Wetness Landcover	Imperviousness Forests Grassland Landcover Temporal Indicators Agriculture

Service or product candidate	Score	Verdict
Incremental IMD Change	61.50	most promising
Incremental Forest Change	60.50	
Improved Grassland Status Layer at 10m	60.00	
Improved DLT Status Layer at 10m	58.50	high potential
Improved IMD Status Layer at 10m	59.50	
New Crop Mask Status Layer at 10m	58.50	
New Crop Type Status Layer at 10m	56.50	
Crop Growth Condition	56.00	experimental
CLC Evolution	54.00	
Crop Emergence Date Map	52.50	
Generic Land Cover Metrics	51.50	
Multi-Annual Trends and Potential Change	51.50	

- ✓ HRL Status layers 10 m/ Change layers 20 m
- ✓ **Updates** propel services **continuous** production: yearly update feasible through automated TS exploitation
- ✓ Incorporating **phenological** and **statistical parameters** to accurate masks, continuous scales are derived for a tailored management
- ✓ Challenges: **timeliness** production for operational services at **pan-European** and **global scales** in a proper spatial resolution & products **consistency** (status, change, updates)



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www.ecolass.eu

Follow us:



GAFAG L. Moser, M. Probeck, K. Schwab, G. Ramminger, E. Sevillano & Team

SIRS C. Sannier, S. Villerot, B. Desclée, A. Masse & Development Team

JOANNEUM RESEARCH H. Gallaun, M. Schardt, P. Miletich, J. Deutscher, K. Granica

UCL P. Defourny, E. Khalil, J. Wolter, I. Moreau, X. Blaes

DLR B. Leutner, A. Metz-Marconcini, I. Klein, A. Hirner, T. Esch



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