WEED, a solution for national ecosystem extent mapping

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On behalf of ESA and the consortium: ***VITO, BC3, IDIV, IIASA***
supported by DHI, JCU, Ecounting, U-Bonn; and champion users

SEEA-EA Technical Committee meeting

Virtual, 01 April 2025

esa vito

Outline

- Context (Marc)
- The solution (Bruno)

- Questions & discussion

SEEA Ecosystem Accounting underpins Multilateral Environmental Agreements

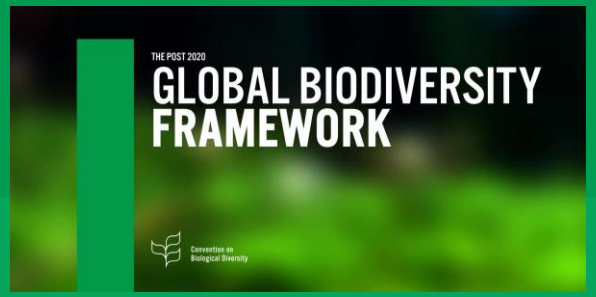
UN Convention to Combat Desertification (UNCCD)

UNCCD 2018-2030 Strategic Framework

Strategic Objective 1: to improve the conditions of ecosystems

Convention on Biological Diversity (CBD)

Post 2020 Global Biodiversity Framework (GBF) and its monitoring framework



UN Framework Convention on Climate Change (UNFCCC)

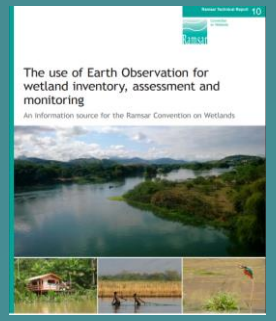
UNFCCC Paris Agreement

Glasgow Climate Pact

Ramsar Convention on Wetlands

Ramsar Strategic Plan (2016 – 2024)

Conservation and wise use of all wetlands



UN SEEA Ecosystem Accounting

International standard on Ecosystem Accounting that regulates the production of statistical accounts on ecosystem extent, condition and services, underpinning the development of monitoring frameworks of other MEAs.

Sustainable Development Goals (SDGs)

SDG Target 6.6
Protect and restore water-related ecosystems

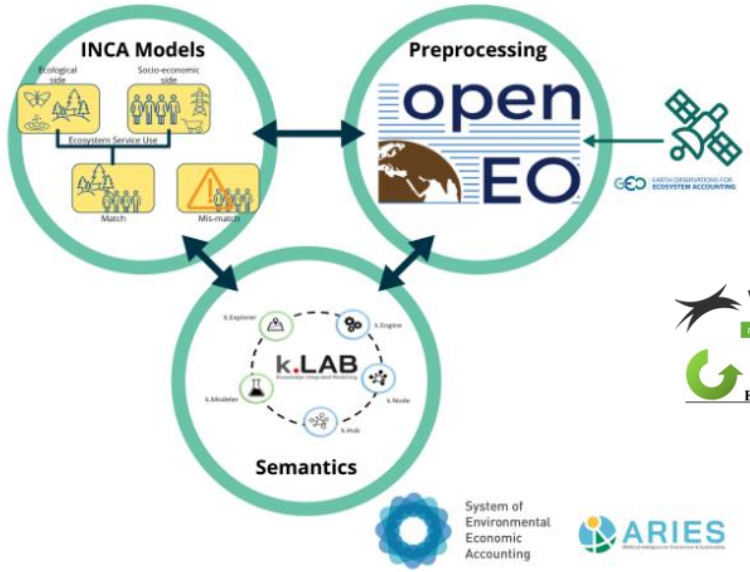
SDG Target 14.2
Sustainably manage and protect marine and coastal ecosystems

SDG Target 15.1
Ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems.

PEOPLE Ecosystem Accounting (2022-2024)

- Review of the **opportunities and challenges of integrating EO data in ecosystem accounting** for terrestrial and freshwater ecosystems.
- Co-development of **EO-based ecosystem account workflows** with European NSOs and supporting agencies (GR, IT, NL, NO, SV).
- Validation of **pilot demonstrators** to prove the added value of EO-based Ecosystem Accounts.
- Blueprint of **EA data platform architectures** connecting EUROSTAT INCA models with ESA OpenEO and UN ARIES4SEEA data platforms.
- Contribution to the international collaborative efforts to **advance the use of EO in ecosystem accounting** and support countries developing their national ecosystem accounts.
- Prepare a **R&D roadmap** to scale-up the use of EO in ecosystem accounting

https://esa-people-ea.org/



Ecosystem account*	Greece	Italy	Norway	Slovakia	the Netherlands
Ecosystem extent	X			X	
Forest ecosystem condition	X	X	X	X	X
Coastal ecosystem condition	X	X			X
Wood provision ecosystem service	X	X	X	X	
Nature-based tourism ecosystem service	X		X		

Programmatic context

The “**World Ecosystem Extent Dynamics**” (WEED) project is funded under the **“Applications” element of ESA “EO Science for Society” programme**, which main objective is to pioneer novel applications to support international policies on the environment and sustainable development.

The **World Series of the Application Element** aims at **global applicability**

Production of a global dataset or development of a **globally applicable methods**, with methodological consolidation, assessment of robustness, generalisation and transferability of methods, and **demonstration of large-scale deployments** (national scales or beyond), with the objective to produce **EO best practices and standards that can be applied across-countries.**

Project Objectives

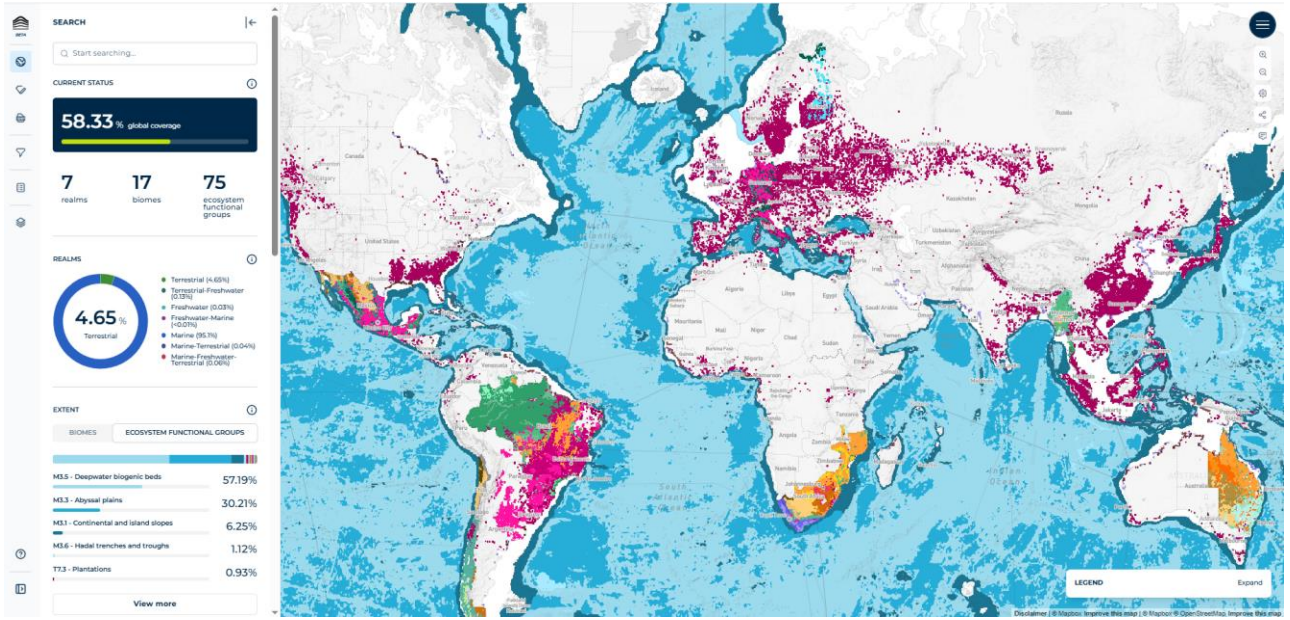
World Ecosystem Extent Dynamics (WEED)

The objective is to develop and demonstrate,
with some Champion Users,
globally applicable and **scalable EO-integrated solution**
for mapping the extent and distribution of terrestrial, freshwater and coastal (up to the intertidal zones) ecosystems
and monitoring their changes in extent,
with **country demonstrations** in European and global contexts.

KO: 2 September 2024 | Duration: 24 months | World-series

GEO-Atlas and WEED

- Global Ecosystem Atlas is the first **harmonized resource** dedicated to mapping and monitoring all the world's ecosystems.
- But current **synthesis map**
  - <5% of Terrestrial + Freshwater
  - 1 baseline map (many years)
  - 1 typology (IUCN GET Level-3)
  - No change mapped until 2027
- Need for **technology solutions**
  - Fill gaps
  - Monitor changes
  - More flexibility (e.g. EU typology)
- Gather **reference data**
  - Agreed protocol
  - Joint effort



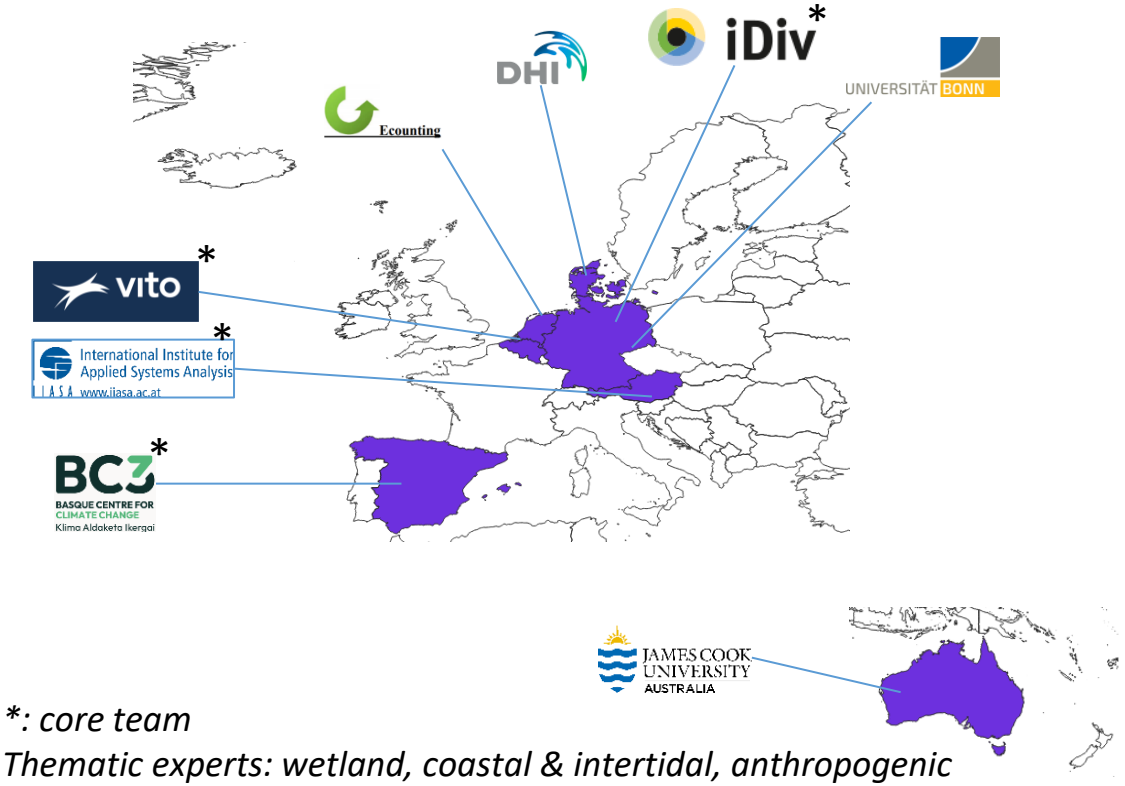
Outline

- Context (Marc)
- **The solution (Bruno)**

- Questions & discussion

Our team of Experts

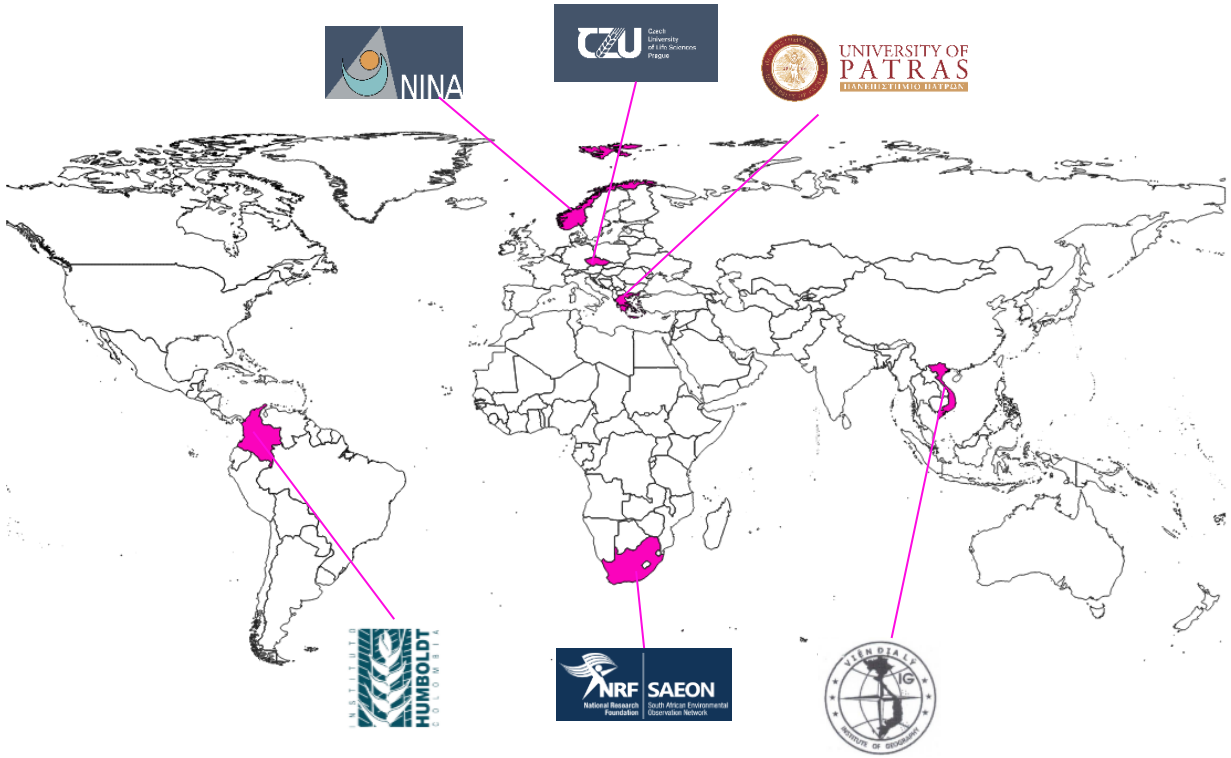
Development team



*: core team

Thematic experts: wetland, coastal & intertidal, anthropogenic

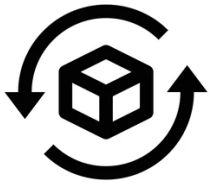
6 Champion Users



[OBJ-B] **Collaborate closely with national authorities** actively involving them in the co-development of the EO-integrated solution and in the validation of ecosystem extent maps, ensuring alignment with international standards and policy needs.

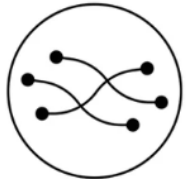
The outputs of the toolbox/solution

[OBJ-A] **Develop a globally applicable open-source toolbox** for a comprehensive mapping of the extent and distribution of ecosystem types, according to different ecosystem typologies, and for monitoring the temporal changes in the extent and distribution of ecosystem types.



1. Ecosystem **characteristics open data-cube**

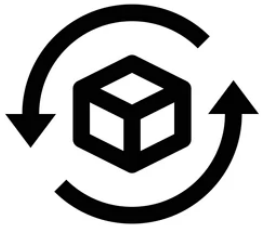
2. Ecosystem **Extent map**



3. Ecosystem **Dynamics**

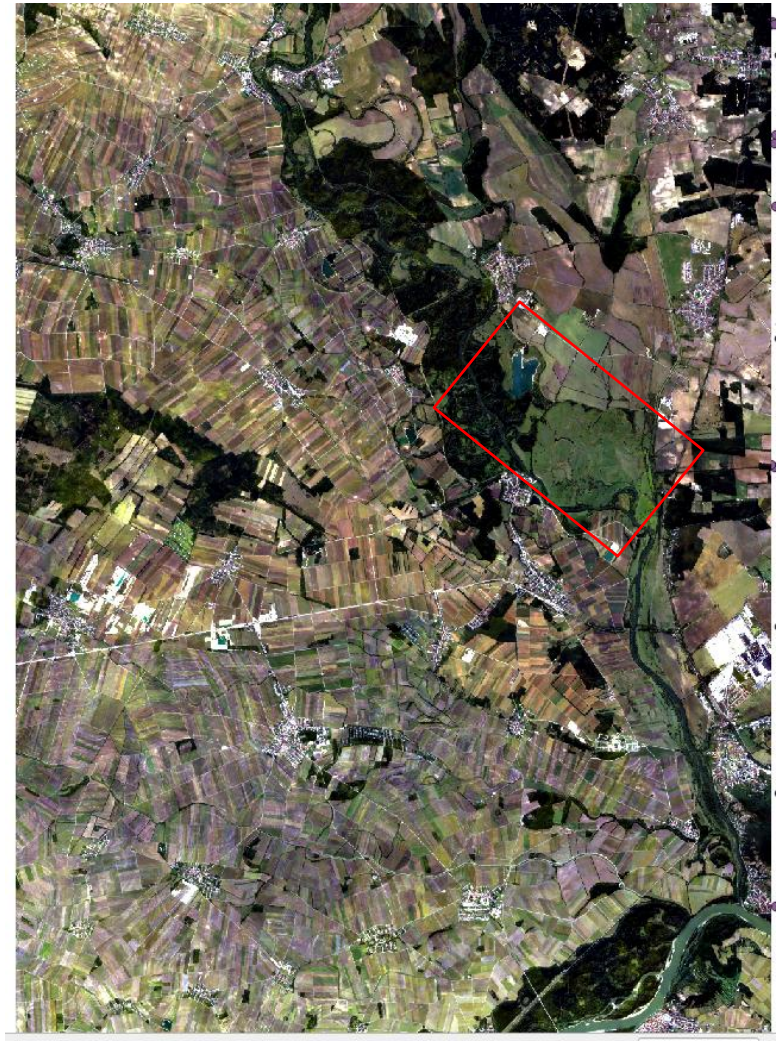
4. **Indicators** for policy support

The outputs of the toolbox/solution

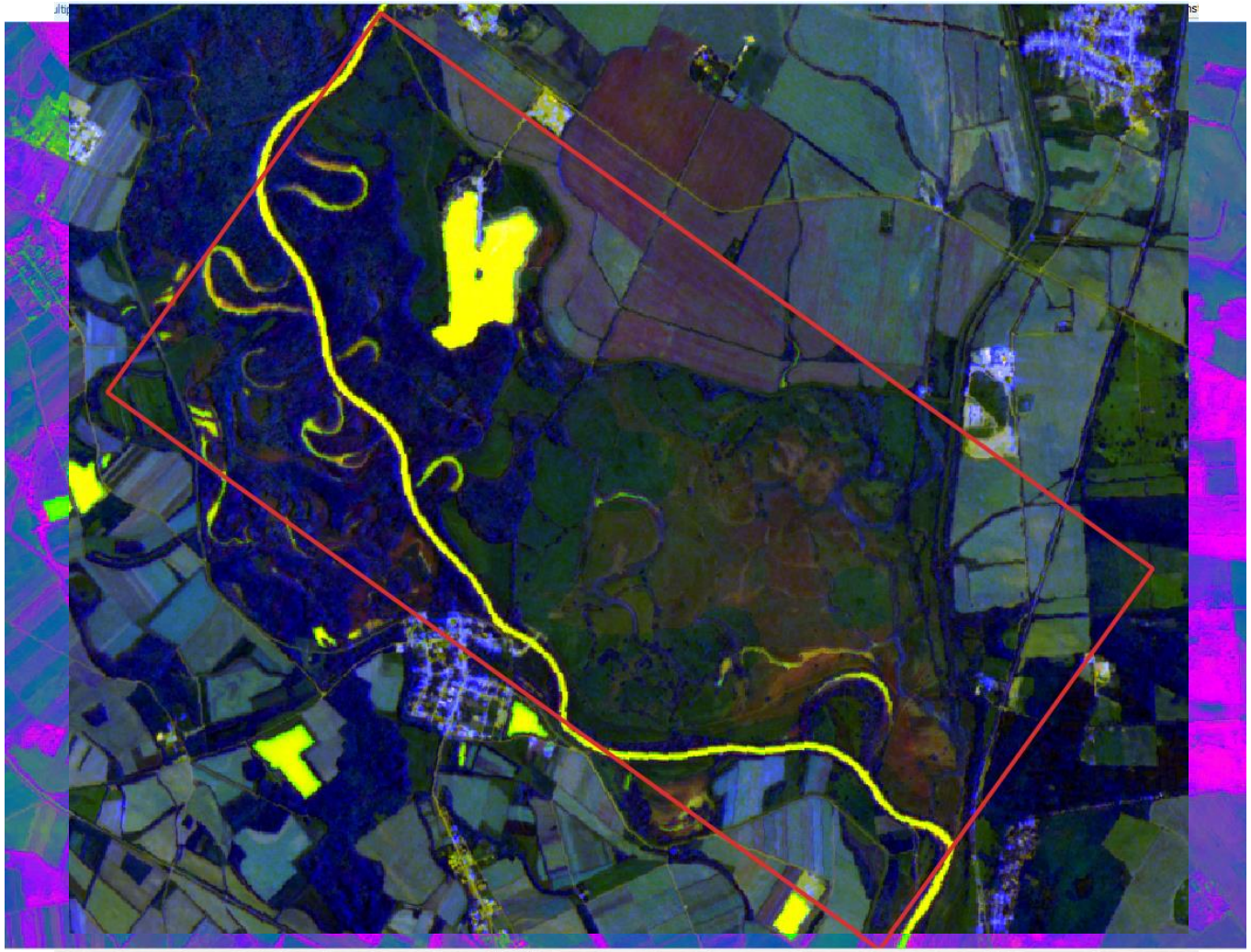


1. Ecosystem **characteristics open data-cube**
   - **Earth Observation (EO) data layers** (primarily biotic)
     - Optical indicators
     - Radar indicators
     - Contextual indicators
     - LIDAR indicators
     - Vegetation maps
   - **Non-EO direct data layers** (primarily abiotic)
     - Climate
     - Soil
     - Population
     - Topology
     - Land use (e.g. building type, agriculture use, etc.)
     - Night-time light
   - **National data layers**
     - Replace global public layers with ‘known’ and ‘best’ layers

Example: dynamic EO data cube



Optical EO + Radar EO

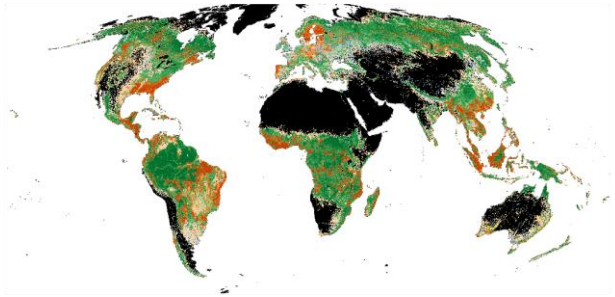


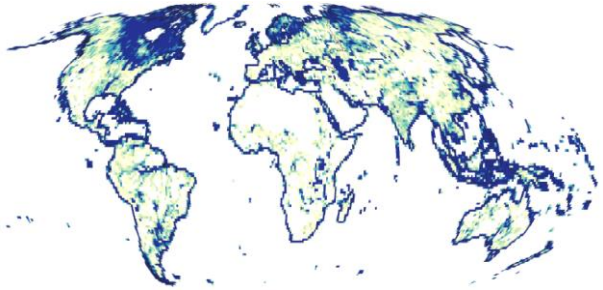
Wetland Slovakia

Example: Historical data cube

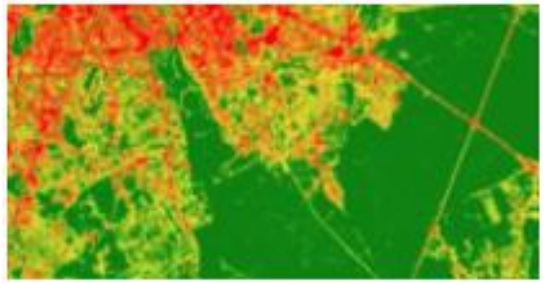
LAND COVER

Tree-canopy cover (bias-corrected)



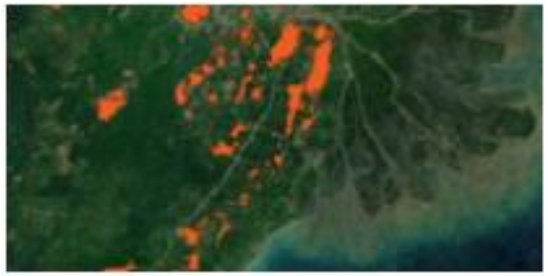


Artificial impervious cover

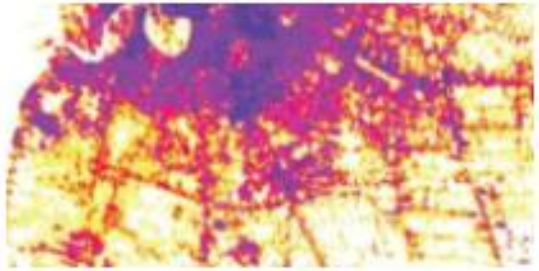


LAND USE

Mining operations



Human settlements



Night-time lights

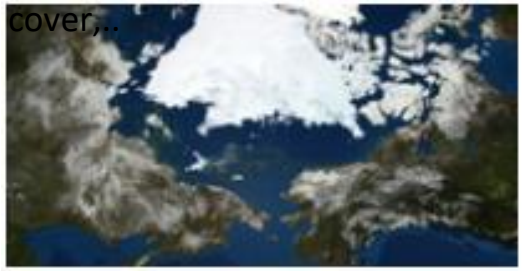
PHYS. ENVIRONMENT

Climate

Coastal fog, Droughts,...

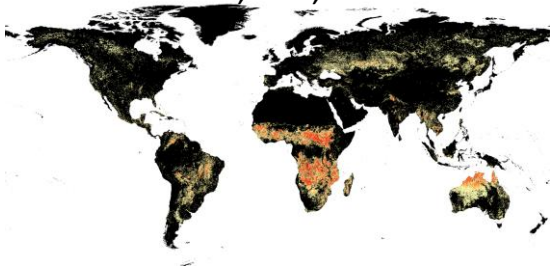
Cryology

Permafrost, Snow cover,..



Fire

Fire recurrence, size,..

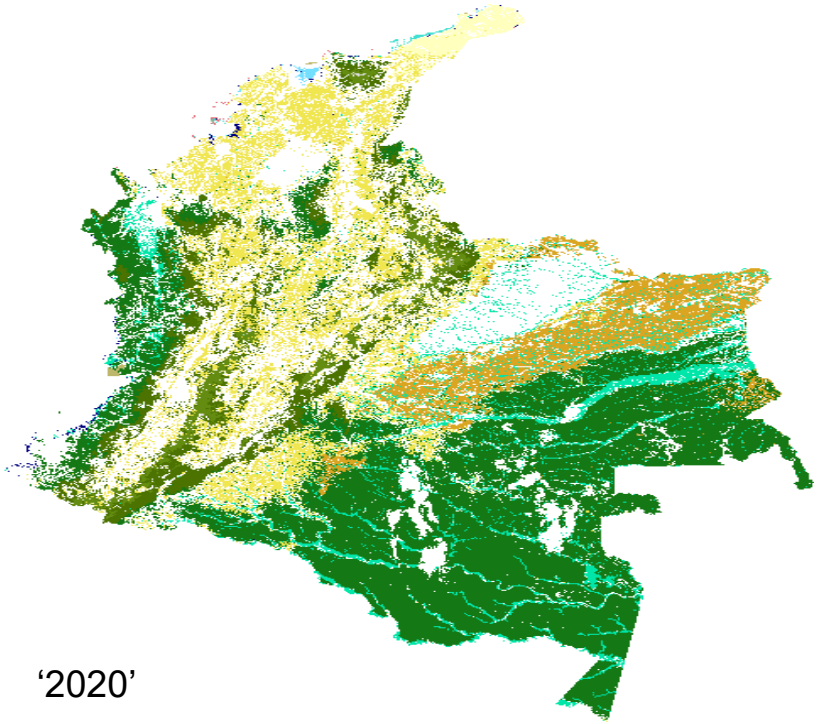


Credits: GLOBES project

The outputs of the toolbox/solution

2. Ecosystem **Extent map**
   - **Multi-scale** 10 – 100m (test <10m for Urban ecosystems)
   - **Multi-typology**
     - IUCN GET Level-3, explore Level-4 for national policies
     - EU extent / EUNIS Level-3
     - Ramsar
   - Exclusive (MECE-principle) and probabilities/**occurrences**
     - State-of-art AI Modelling (incl. foundation models)
     - Uncertainly layer
   - **Semantic** reasoning and **mediation**
     - Context awareness (use of data layers, automatic retrain of models to regional/national specificities)
     - Feedback loop for reference data (learning system)
     - Fuzzy logic to mediate semi-quantitative distributional criteria (cross-walking national maps)

Example : IUCN GET extent map Colombia



‘2020’

- CoastalRiverDelta
- FreezethawFreshwaterLake
- IceSheetGlacierPerennialSnowfield
- PermanentlyOpenRiverineEstuaryBay
- PhoticCoralReef
- PyricTussockSavanna
- SeagrassMeadow
- SownPastureField
- SubtidalSandBed
- ThornyDesertSemidesert
- TropicalAlpineGrasslandShrubland
- TropicalFloodedForestPeatForest
- TropicalSubtropicalLowlandRainforest
- TropicalSubtropicalMontaneRainforest

Credits: ARIES4SEEA

Cross-reference

- Land cover 2020
- Ecosystem Continental map 2011

In collaboration with experts

Example: EUNIS habitat map Greece

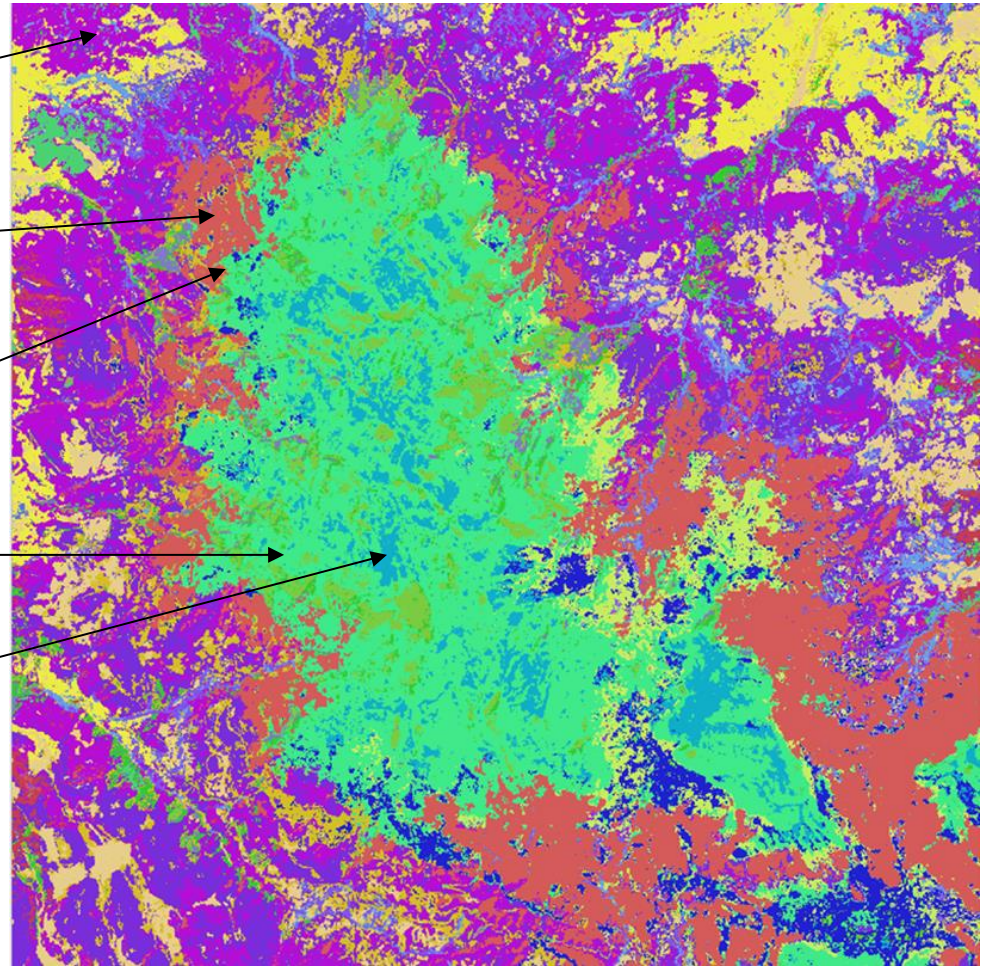
Mediterranean evergreen Quercus forest (T21)

Mediterranean mountain *Abies* forest (T33)

Mediterranean closely grazed dry grassland (R1D)

Eastern Mediterranean mountain hedgehog-heath (S75)

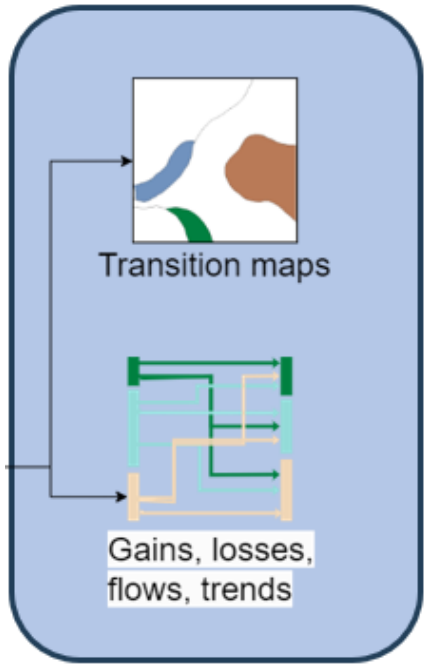
Balkan and Anatolian oromediterranean dry grassland (R1K)



Greece Peloponnese
Credits: PEOPLE-EA project

The outputs of the toolbox/solution

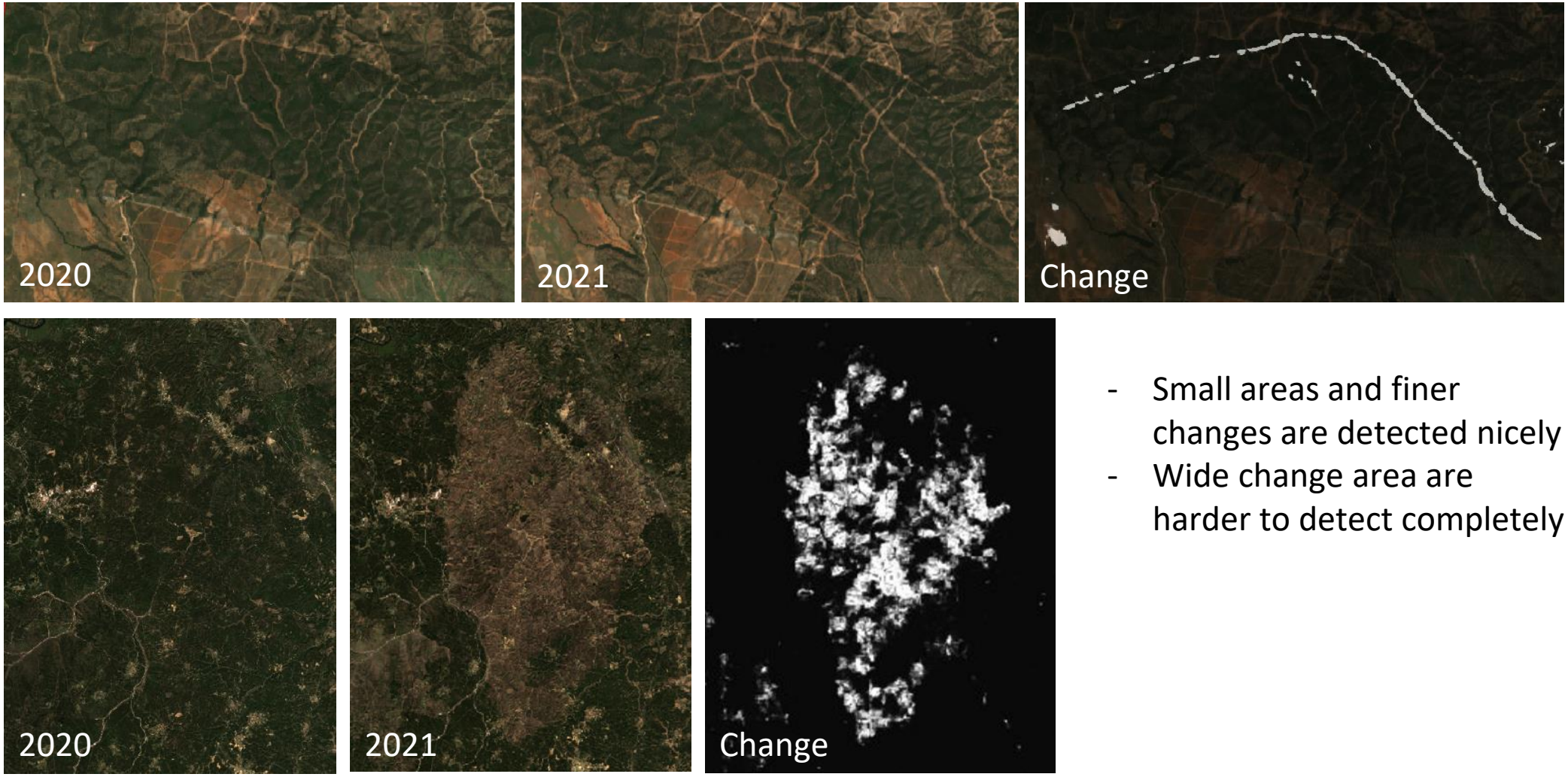
3. Ecosystem **Dynamics**



- Multi-temporal (min. 3 maps in period 2016-2024)
- State-of-art technologies (combine deep learning with domain knowledge / co-variances)
- Deal with seasonal variances (wetlands, water, intertidal ecosystems)
- Prime focus on abrupt changes (consistency)
- Exploration on detecting trends (gradual changes)

Example – deep learning changes

Portugal



- Small areas and finer changes are detected nicely
- Wide change area are harder to detect completely

The outputs of the toolbox/solution

4. **Indicators** for policy support
   - GBF A.2 indicator (natural ecosystems)
   - SEEA-EA extent account (incl. gains & losses, transitions)
   - Ramsar wetland indicator

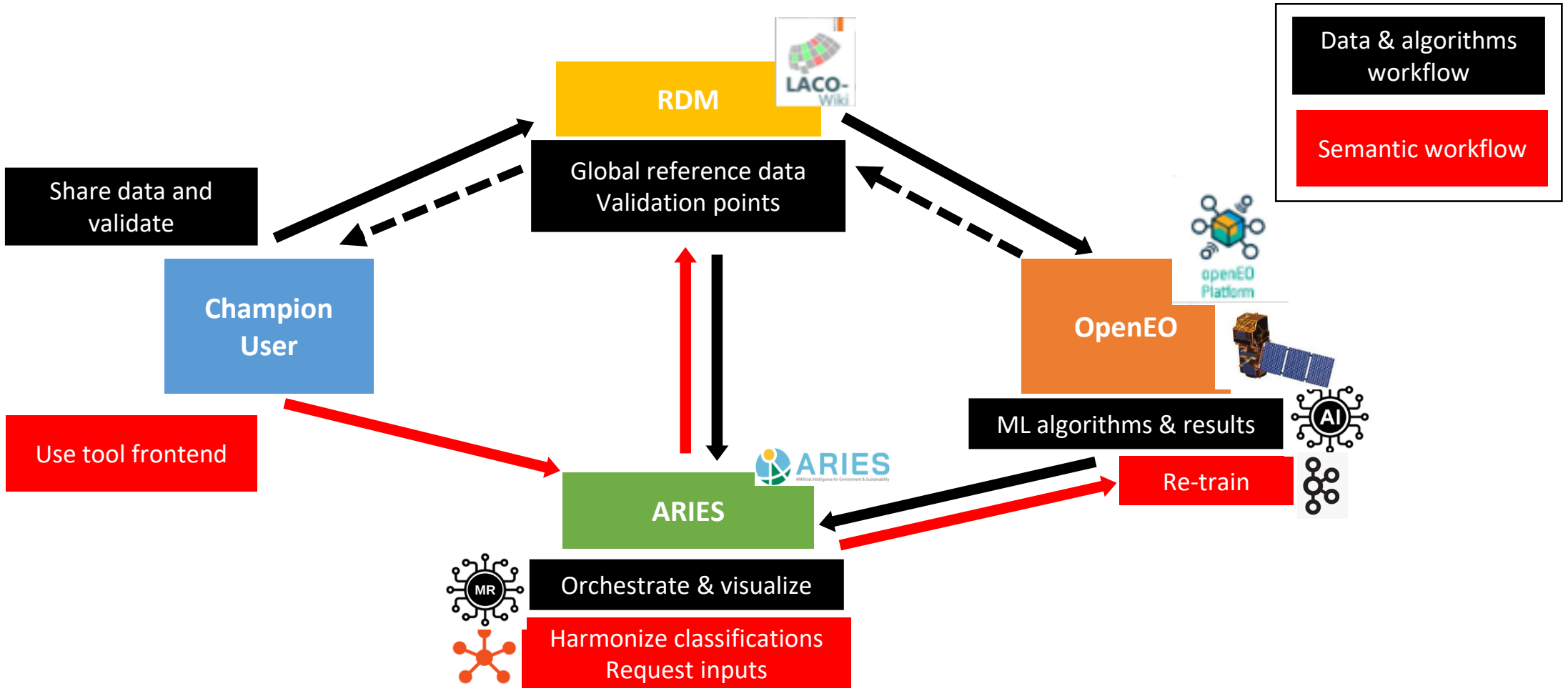
Example EU extent Slovakia 2020

value	Ecosystem Type	Opening area (ha)	Additions	Reductions	Net changes	Closing area 2020 V3_1 (ha)	Share of closing area
0	outside accounting area						
1	Settlements and other artificial areas					156,141	3.17%
2	Cropland					1,499,487	30.47%
3	Grassland					773,421	15.72%
4	Forest and woodland					2,108,915	42.86%
5	Heathland and shrub					226,793	4.61%
6	Sparsely vegetated ecosystems					17,209	0.35%
7	Inland wetlands					52,902	1.08%
8	Rivers and Canals					48,928	0.99%
9	Lakes and reservoirs					37,208	0.76%
10	Marine inlets and transitional waters					0	0.00%
11	Coastal beaches, dunes, and wetlands					0	0.00%
12	Marine ecosystems					0	0.00%
	Total Ecosystem Accounting Area					**4,921,004**	

value	Ecosystem Type	Opening area (ha)	Additions	Reductions	Net changes	Closing area (ha)	Share of closing area
0	outside accounting area					1321837	
4	*Forest and woodland - Totals*					*2,108,915*	*42.86%*
4.0	*Unallocated L2*					*305,258*	*6.20%*
4.1	*Broadleaved deciduous forest - Subtotals*					*1,065,434*	*21.65%*
4.1.0	*Unallocated L3*					0	*0.00%*
4.1.1	Riparian forest and woodland					*8,795*	*0.18%*
4.1.2	Broadleaved swamp woodland on non-acid and acid peat					*205*	*0.00%*
4.1.3	Fagus dominated forest					*762,934*	*15.50%*
4.1.4	Submediterranean and Mediterranean thermophilous deciduous forest					*293,500*	*5.96%*
4.1.5	Acidophilous [Quercus]- dominated woodland					-	*0.00%*
4.1.6	Temperate and boreal and Southern European Betula and *Populus tremula* forest on mineral soils					-	*0.00%*
4.1.7	Other broadleaved deciduous forest, excluding highly-modified plantations					-	*0.00%*
4.1.8	Highly modified broadleaved deciduous forests including stands of non-native trees species that have long been established in European ecosystems stands					-	*0.00%*
4.2	*Coniferous forests - Subtotals*					*311,248*	*6.32%*
4.3	*Broadleaved evergreen forest - Subtotals*					*226,453*	*4.60%*
4.4	*Mixed forests - Subtotals*					*200,522*	*4.07%*
4.5	*Transitional forest - Subtotals*					-	
4.6	*Plantations - Subtotals*					-	

Credits: PEOPLE-EA project

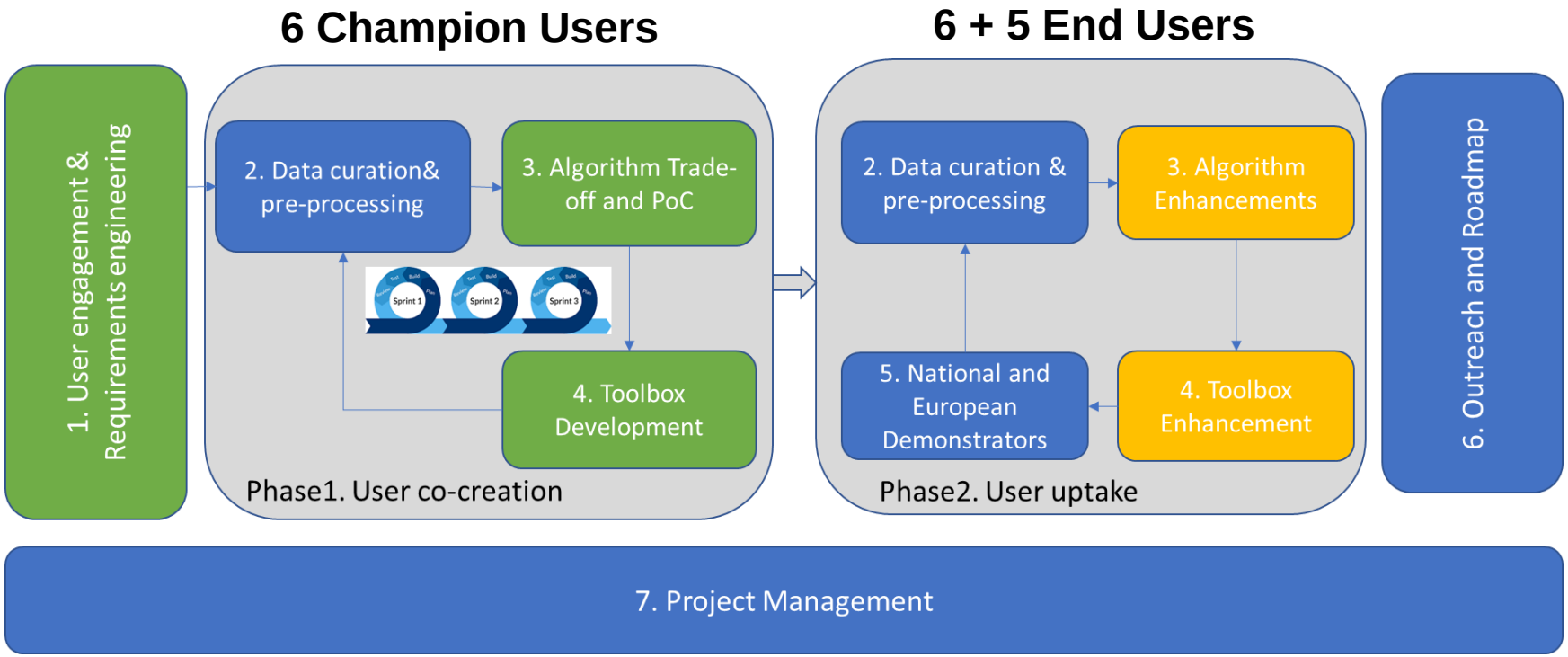
Our open toolbox solution (simplified)



[OBJ-C] **Integrate all workflows of the EO-integrated solution into an end-to-end processing system** hosted on high-performance cloud computing infrastructures, following the FAIR principles, ensuring compliance with interoperability standards.

2 Phases

Countries create their own ecosystem extent maps -> *submit to GEO-Atlas*



[OBJ-D] Demonstrate the robustness and transferability of the methods by **executing large-scale demonstrations in selected countries, within and outside of Europe**, producing and validating national ecosystem extent maps following ecosystem typologies selected with the national authorities, and showcasing the utility of these ecosystem extent maps in policy contexts.

Timeline

First Alpha version of toolbox

Proof-of-Concept

System generates ecosystem extent maps in zones from champion users (Colombia, Vietnam, South-Africa, Norway, CzechR, Greece)

April 2025

Toolbox improvements, co-creation

Pilot maps

Sub-national maps from champion users

Additional test zones optimized to cover all EFG (coastal, wetlands, ...), includes dynamics

Beta version of toolbox ready

Ready for validation

Able to generate ecosystem extent maps (EU, GET, Ramsar typologies) for 6 champion users + additional 5 (data poor) countries at national scale, incl. dynamics + indicators.

December 2025

1.0 version of toolbox ready for global deploy

Ready for public launch

Validated for 11 countries. EU continental available.

Able to generate ecosystem extent maps across any country at globe.

October 2026

Take-away message

#1

- An ***innovative solution*** for ecosystem mapping & detecting their dynamics
- A challenging project, with several R&D aspects

#2

- **Multi**-EO, Multi-modal (incl. non-EO), Multi-scale, Multi-typology (L3/L4+)
- **State-of-art** algorithms, **context aware** and self-learning (expert controlled)
- Feedback cycle on in-situ samples (suspicious & gaps), uncertainties

#3

- **Co-creation** agile approach
- **FAIR** principles, decentralized approach (e.g. Copernicus LAC)
- National agencies are trained to generate their maps (capacity building)

#4

- A **DIY** toolbox for countries to report on international environmental agreements (e.g. CBD, SEEA EA, Ramsar, etc.)

Questions

https://esa-worldecosystems.org/en