The World Ecosystem Extent Dynamics Solution

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BC3 BASQUE CENTRE FOR CLIMATE CHANGE Klima Aldaketa Ikergai

IIASA International Institute for Applied Systems Analysis www.iiasa.ac.at

https://esa-worldecosystems.org/en

World ecosystems under pressure

"We lack information on the distribution of more than half of the world's ecosystems - thus have little ability to track changes"

"Many countries simply don't have the necessary monitoring tools to manage their ecosystems sustainably"

A Solution

World Ecosystem Extent Dynamics

globally applicable and **scalable EO-integrated solution**
for **mapping the extent** and distribution of terrestrial, freshwater and coastal (up to the intertidal zones) ecosystems,
monitoring their **changes in extent**,
with **country demonstrations**

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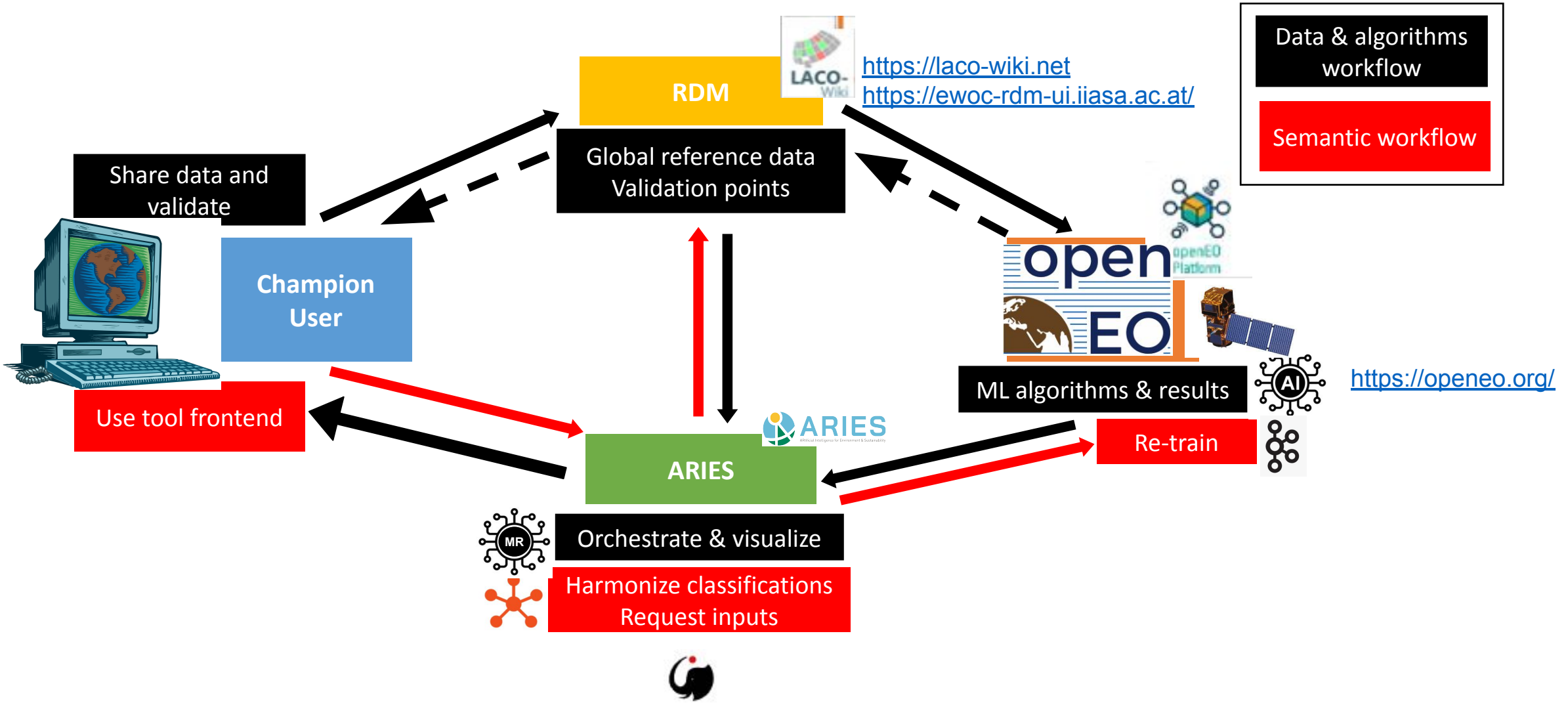
KO: 2 September 2024 | **Duration:** 24 months | World-series

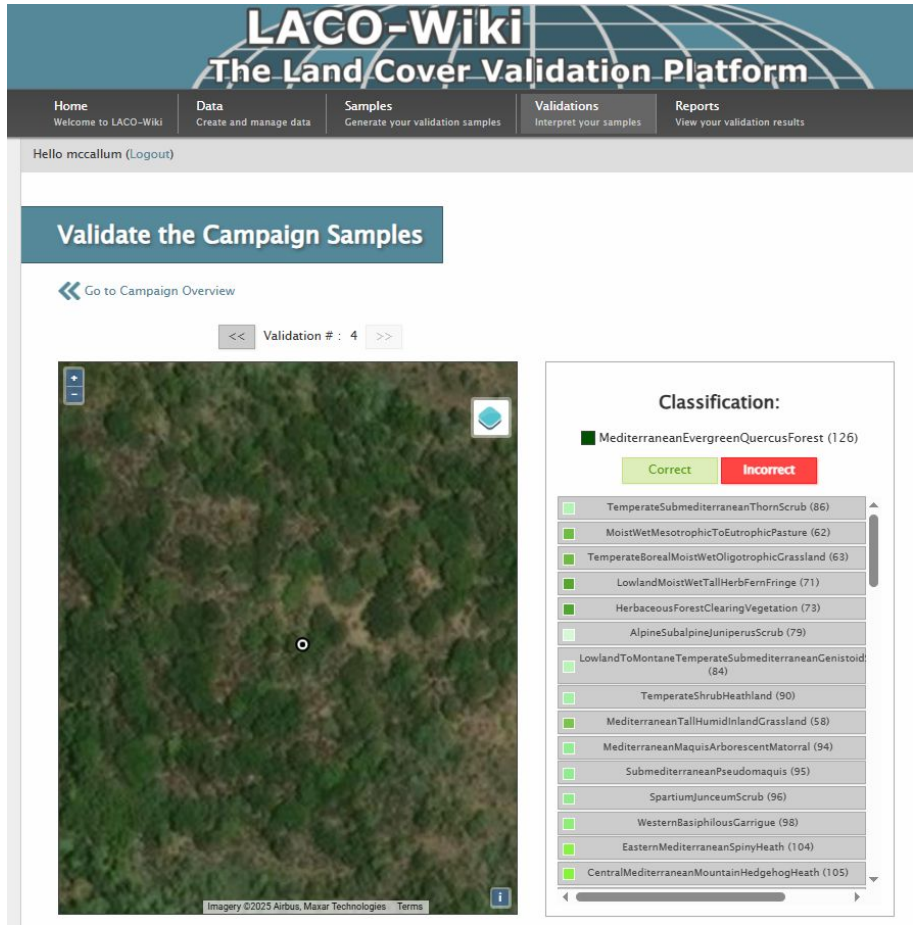
Our open toolbox solution



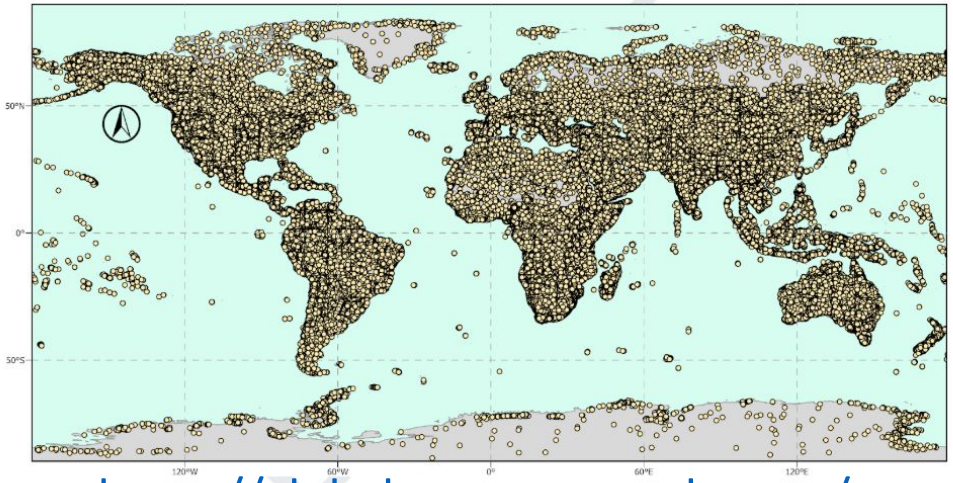
Champion Users

+ 5 additional countries to be selected (open to align)

Reference Data (Training/Validation)

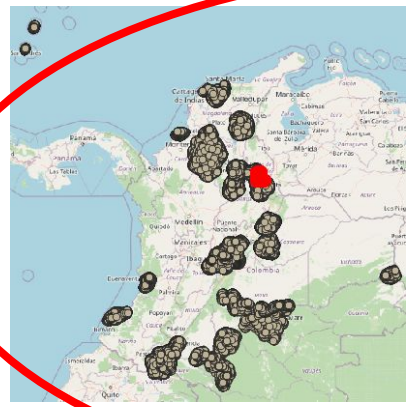


https://www.laco-wiki.net



n=80K

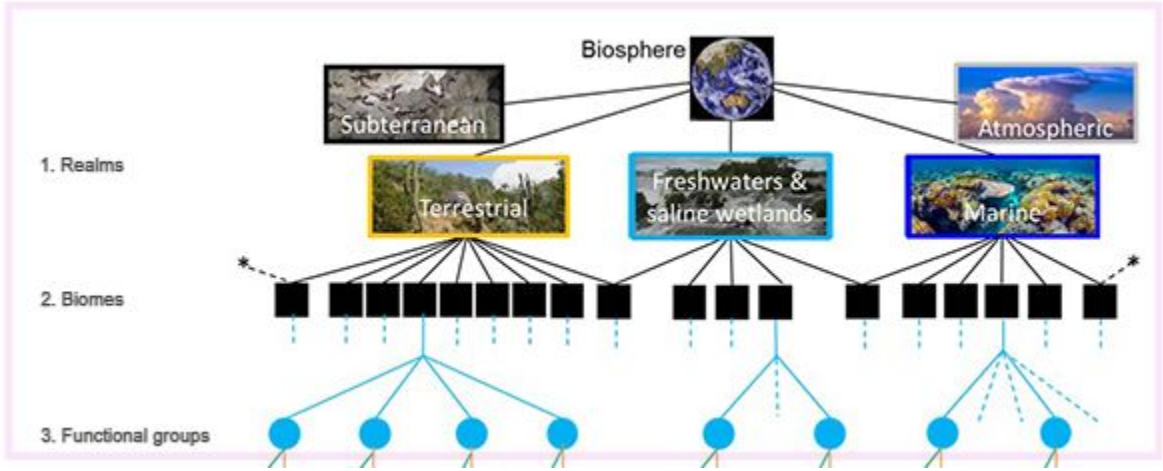
https://globalecosystemsatlas.org/



National Reference Data (Columbia)

Typologies

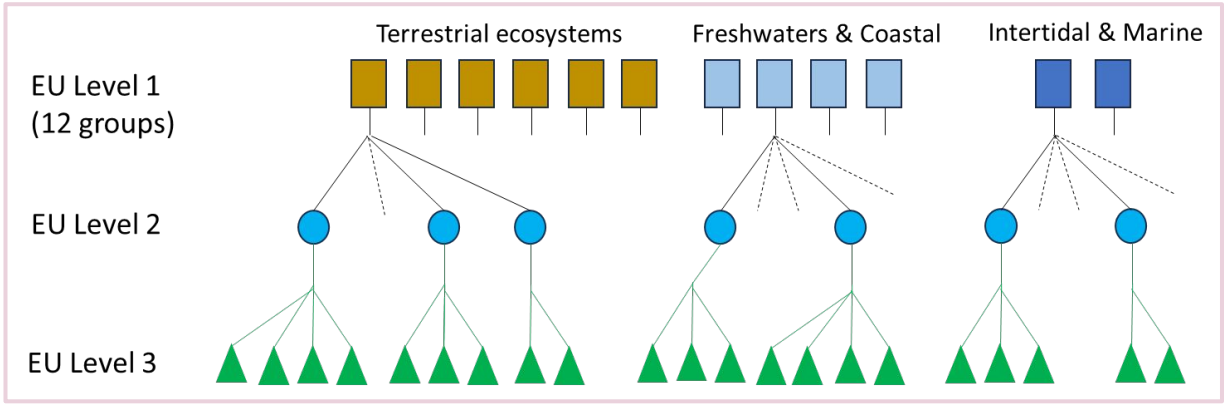
IUCN Global Ecosystem Typology



https://global-ecosystems.org/

Ecosystems are an order of magnitude more difficult to classify than land cover/land use

EU Ecosystem Typology / EUNIS



Ramsar Typology

The Ramsar typology, adopted in 1990, classifies wetlands into three main groups: marine and coastal, inland, and human-made. These groups are further divided into 42 specific wetland types, providing a framework for describing the diverse habitats found within Ramsar sites.

The outputs of the toolbox/solution

Ecosystems characteristics open data-cube (200+ layers)

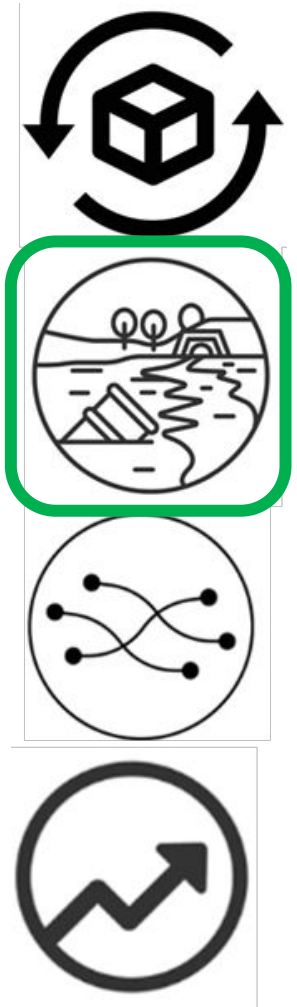
Wetland area in Slovakia

Sentinel-1
Sentinel-2
Contextual CNN
LIDAR

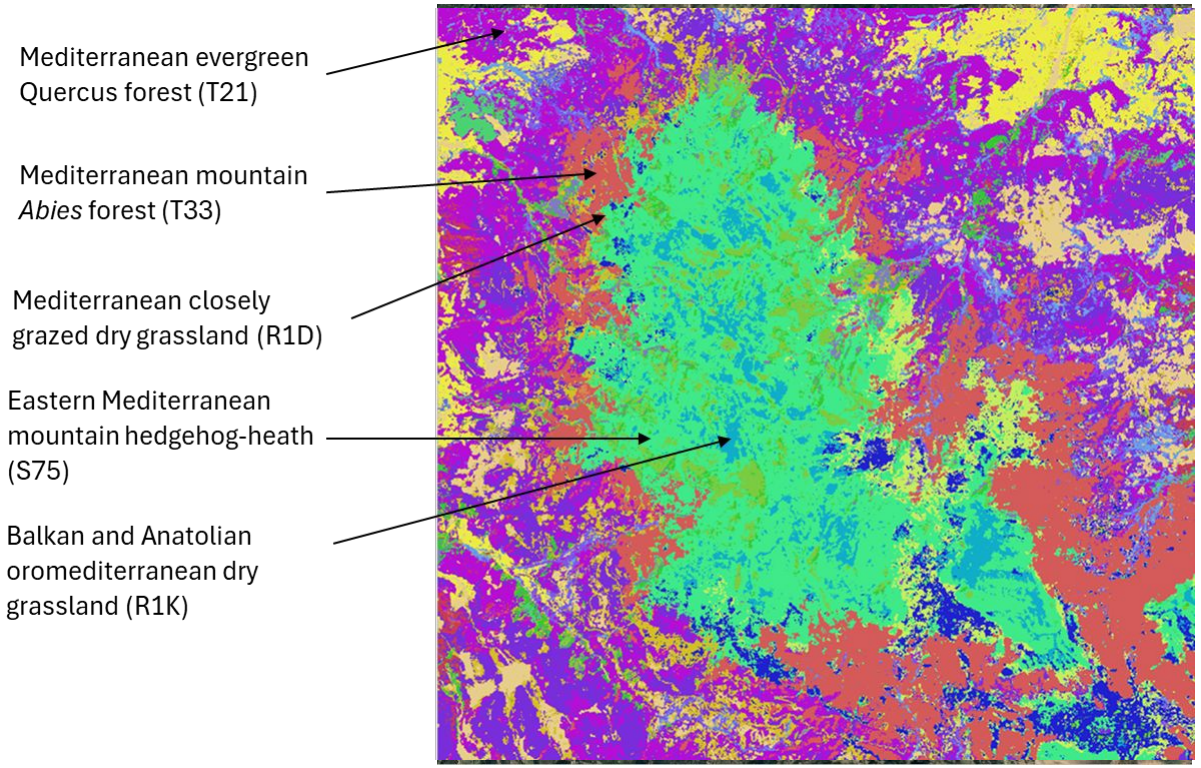
Climate, Fire,…
Soil
Nighttime light
Topology
Land use

Historical data (Globes)
Integration of National layers

Machine Learning



Ecosystem extent map



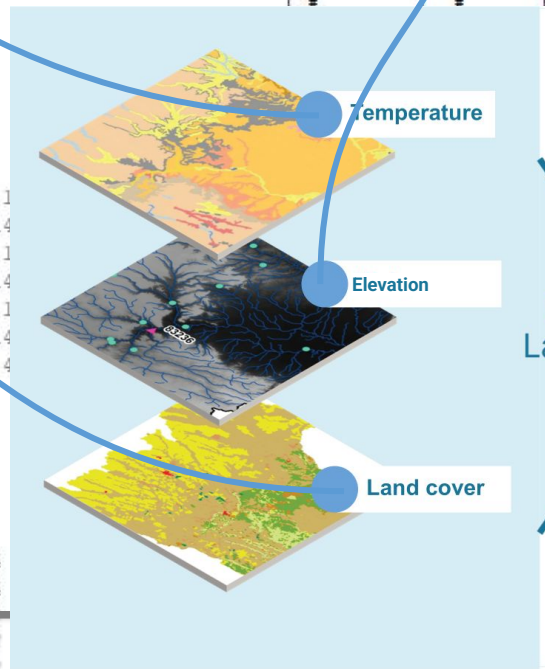
EUNIS habitat map in Greece

Machine *re*-learnings (AI)
Machine reasoning (context aware)
Semantic mediations (crosswalk)

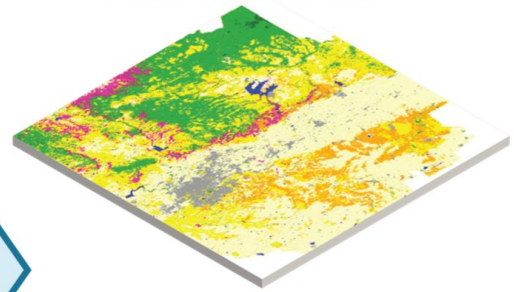
Multi scale (<10 – 100m)
Multi typology (IUCN L3+, EUNIS L3/EU L3, Ramsar)

Rule-based classification

```
define IUCN GLOBAL ECOSYSTEMS as {{
        landcover                    | aridity      | mean_annual_temperature | mean_warm_month_temperature | mountain | elevation | ecosystem_type
    ------------------------------------------------------------------------------------------------------------------------------------------------------------
        landcover:Forest             | >= 0.65      |      >= 18              |   #                         | false    |  #        | es.nca:TropicalSubtropicalLowlandRainforest ,
        landcover:Forest             | >= 0.65      |      >= 18              |   #                         | unknown  |  #        | es.nca:TropicalSubtropicalLowlandRainforest ,
        landcover:Forest             | 0.05 to 0.65 |      >= 18              |   #                         | #        |  #        | es.nca:TropicalSubtropicalDryForestThicket ,
        landcover:Forest             | >= 0.65      |      >= 18              |   #                         | true     |  #        | es.nca:TropicalSubtropicalMontaneRainforest ,
        landcover:Forest             | #            |      <= 0               |   #                         | #        |  #        | es.nca:BorealTemperateMontaneForestWoodland ,
        landcover:Forest             | #            |      0 to 18            |   #                         | true     |  #        | es.nca:BorealTemperateMontaneForestWoodland ,
        landcover:Forest             | #            |      0 to 18            |   #                         | #        |  #        | es.nca:TemperateForest ,
        landcover:ScrubHerbaceousVegetation | 0.03 to 0.2  |      0 to 10            |   #                         | #        |  #        | es.nca:CoolDesertSemidesert ,
        landcover:SeminaturalOpenSpace      | 0.03 to 0.2  |      0 to 10            |   #                         |          |           |
        landcover:ScrubHerbaceousVegetation | <= 0.03      |      > 0                |   #                         |          |           |
        landcover:SeminaturalOpenSpace      | <= 0.03      |      > 0                |   #                         |          |           |
        landcover:ScrubHerbaceousVegetation | 0.03 to 0.2  |      >= 10              |   #                         |          |           |
        landcover:SeminaturalOpenSpace      | 0.03 to 0.2  |      >= 10              |   #                         |          |           |
        landcover:Shrubland          | >= 0.2       |      >= 24              |   #                         |          |           |
        landcover:BareArea           | >= 0.2       |      #                  |   >= 1                      |          |           |
        landcover:BareArea           | >= 0.2       |      0 to 13            |   < 14                      |          |           |
        landcover:LichenMoss         | >= 0.2       |      #                  |   >= 1                      |          |           |
        landcover:LichenMoss         | >= 0.2       |      0 to 13            |   < 14                      |          |           |
        landcover:SparseVegetation   | >= 0.2       |      #                  |   >= 1                      |          |           |
        landcover:SparseVegetation   | >= 0.2       |      0 to 13            |   < 14                      |          |           |
        landcover:ScrubHerbaceousVegetation | >= 0.2       |      <= 10              |   >= 4                      |          |           |
        landcover:ScrubHerbaceousVegetation | >= 0.2       |      0 to 10            |   #                         |          |           |
        landcover:Shrubland          | >= 0.2       |      10 to 24           |   #                         |          |           |
        landcover:Grassland          | >= 0.2       |      10 to 18           |   #                         |          |           |
        landcover:TransitionalWoodlandScrub | >= 0.2       |      10 to 18           |   #                         |          |           |
        landcover:Grassland          | >= 0.2       |      >=18               |   #                         |          |           |
        landcover:TransitionalWoodlandScrub | >= 0.2       |      >=18               |   #                         |          |           |
        landcover:ScrubHerbaceousVegetation | #            |      <= 0               |   < 14                      |          |           |
        landcover:LichenMoss         | #            |      <= 0               |   < 14                      |          |           |
```

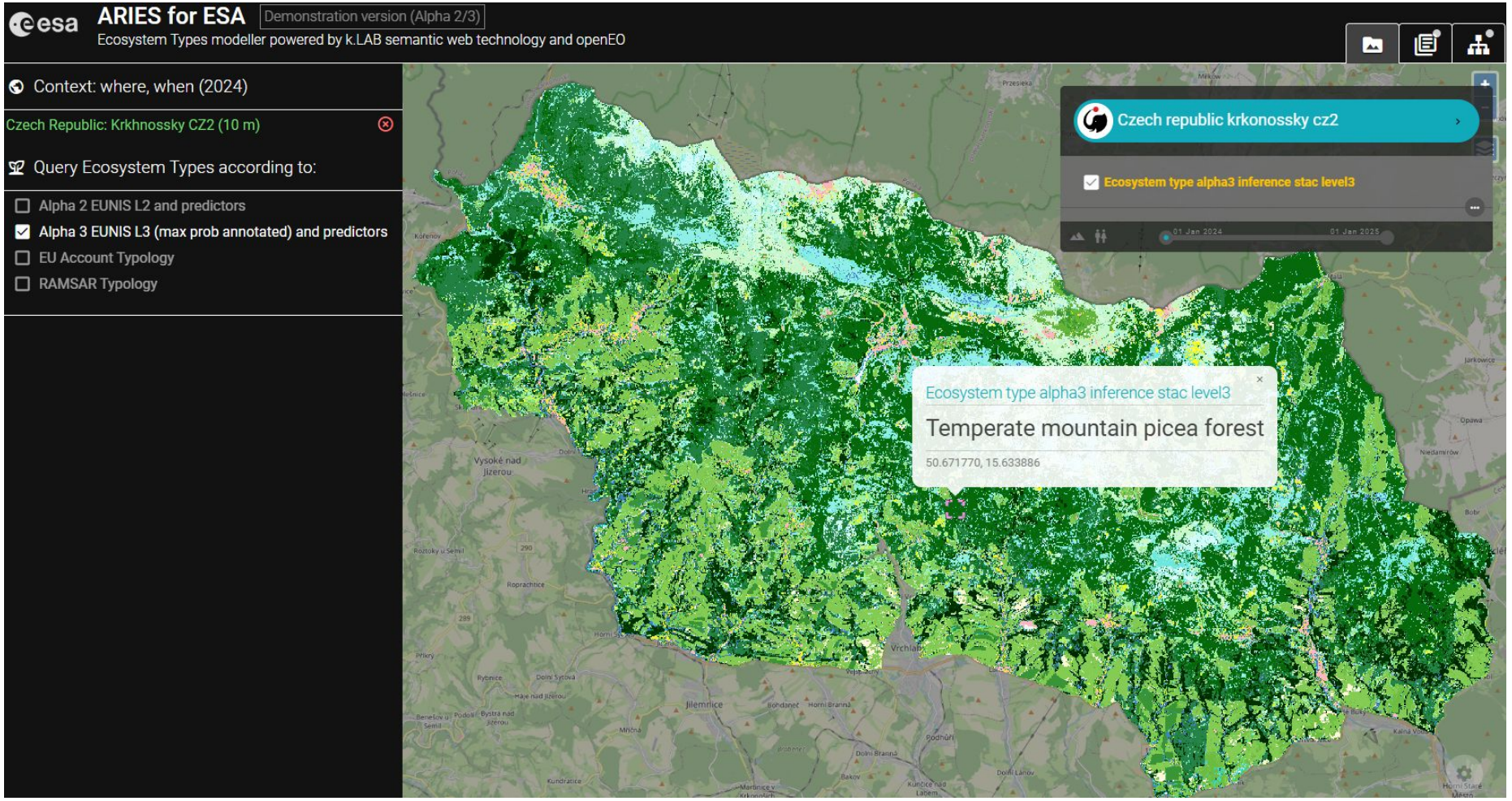


Extent Account



	Grassland	Forest Areas	Herbaceous Crops
Opening Extent	2,332	1,645	1,427
Closing Extent	2,010	1,603	1,591
Net Change in Extent	(122)	(42)	164

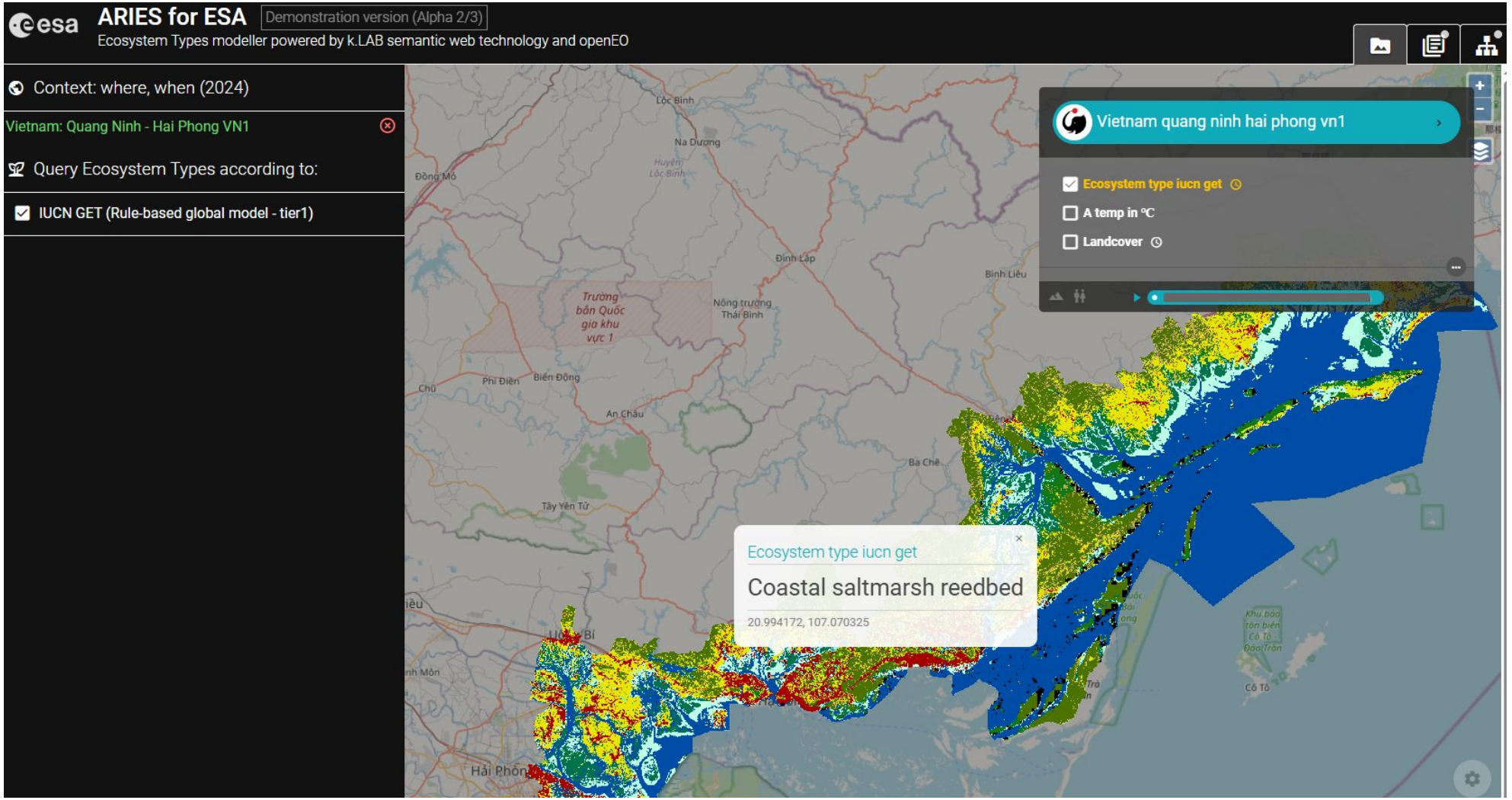
Ecosystem Map User Interface: Czech



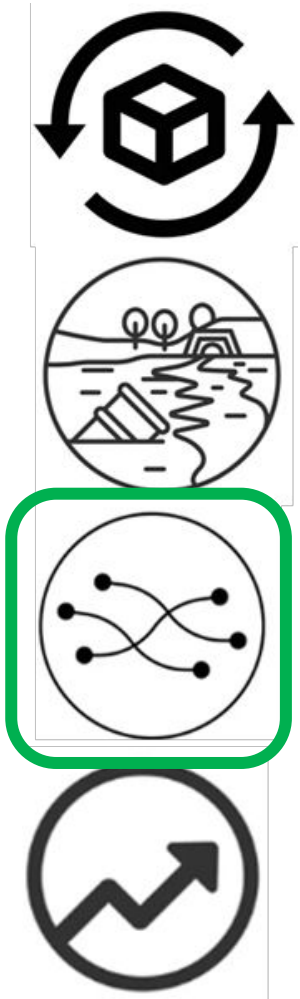
Initial Qualitative Validation

- Delineation seems to work quite well
- Major classes mapped
- Confusion mainly in non-natural classes (industrial, cropland, rocks, …), linear features and some natural classes (fjords, mountaintops …)
- Influences of spatial resolution of input datasets noticed (mixed pixels, unclassified parts, ..)

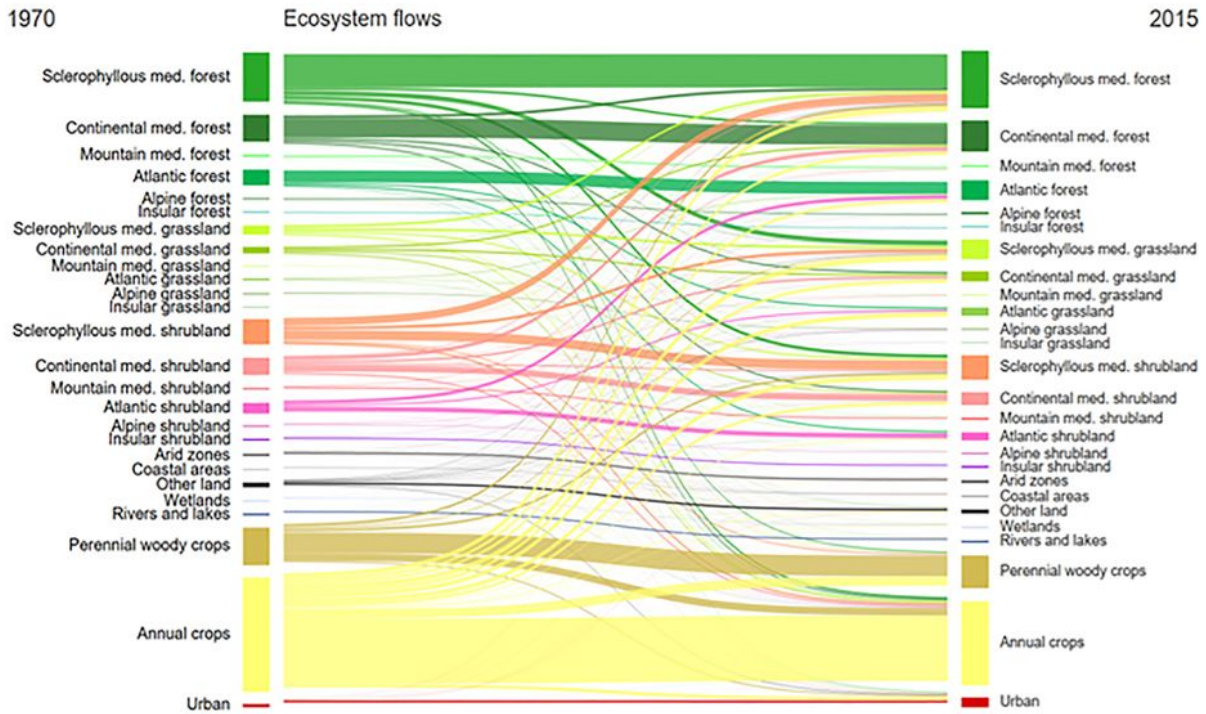
Ecosystem Map User Interface: Vietnam



The outputs of the toolbox/solution



Ecosystem dynamics



[How the ecosystem extent is changing: A national-level accounting approach and application - ScienceDirect]

2018 – 2024 period

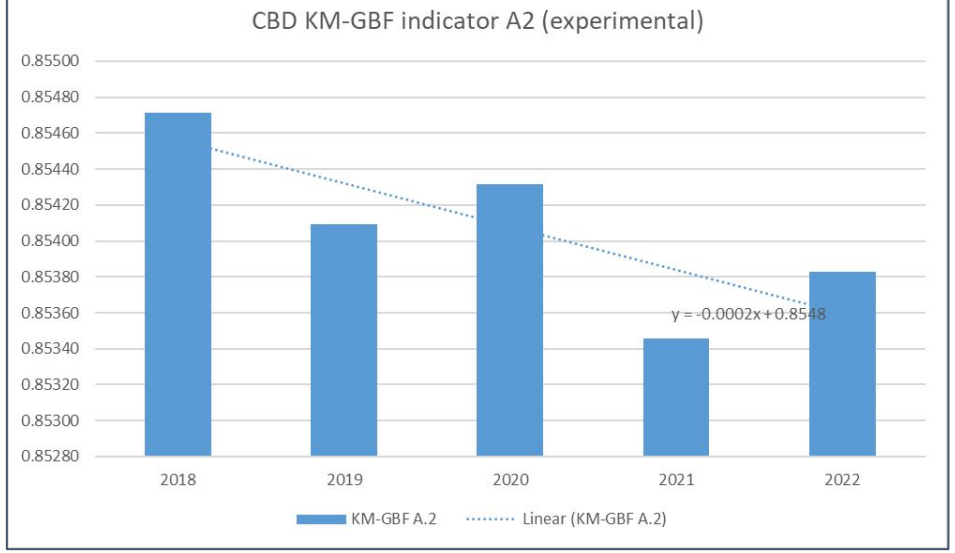
State-of-art (DL with domain knowledge / co-variances)

Abrupt changes
Gradual changes

Seasonal variances as complementary information

The outputs of the toolbox/solution

Indicators for policy support



GBF A.2 indicator (extent)

value	Ecosystem Type	Opening area (ha)	Additions	Reductions	Net changes	Closing area (ha)	Share of closing area
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*					-	

SEEA Ecosystem Accounting Table

Timing

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)

May/June 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

3 cycles

Toolbox ready for scale-up

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.

March 2026

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.

December 2026

Questions

https://esa-worldecosystems.org/en