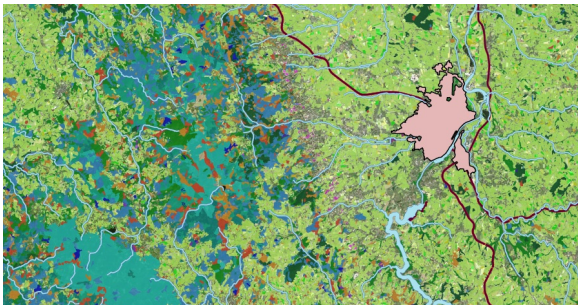




Land-Use/Land-Cover data: specificities & challenges

EuroSDR workshop "The use of Volunteer Geographic Information for producing and maintaining authoritative Land Use and Land Cover data"

Clément Mallet

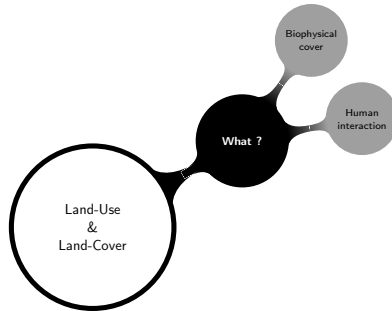
Tuesday, November 24, 2020

Univ. Gustave Eiffel, IGN-ENSG, LaSTIG, France

<https://www.umr-lastig.fr/clement-mallet/> – <https://maestriaproject.github.io/>

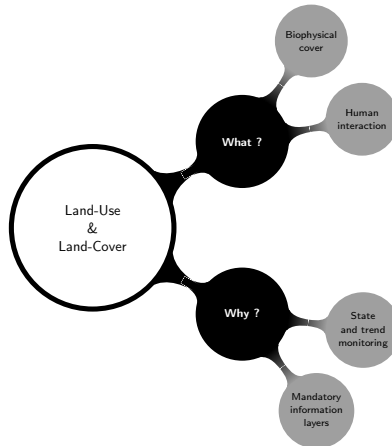
Introduction

What is land-cover & land-use (LCLU) ?



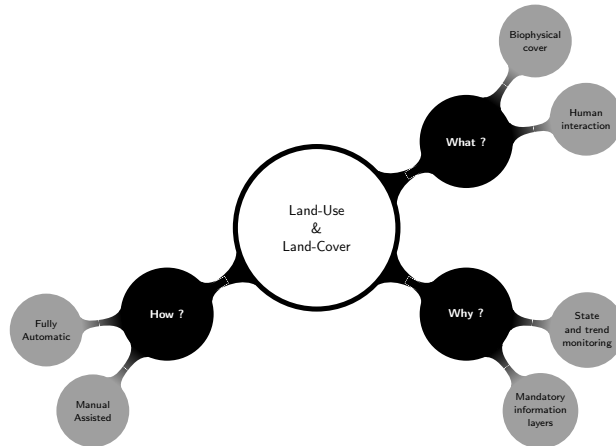
- Observed (bio-)physical cover on the Earth surface.
- Documents all types of objects/surfaces, whether it may not remain stable over time.

What is land-cover & land-use (LCLU) ?



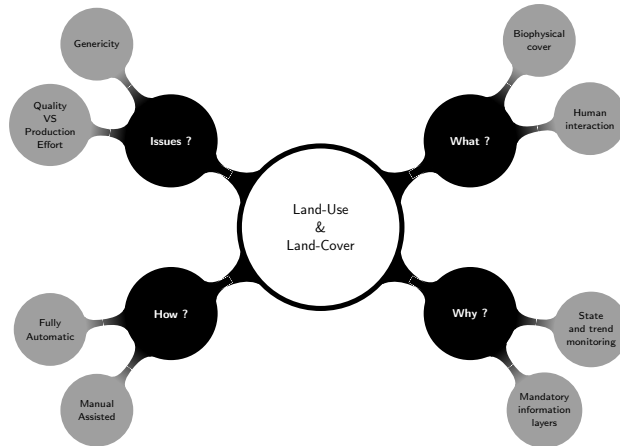
- Core information layers for a large variety of interdisciplinary scientific and environmental studies.
- **Accurate** and **up-to-date** maps over large areas are mandatory baseline datasets.

What is land-cover & land-use (LCLU) ?



- Remote sensing has proved to be the only suitable solution.
- Operational methods routinely process satellite imagery today.

What is land-cover & land-use (LCLU) ?



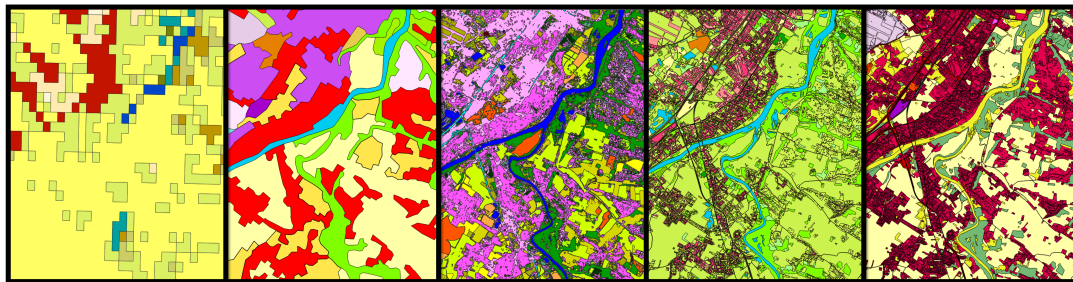
- The number, types, and definitions of classes (*nomenclature*) vary with the application and the geographical scale.
- **Main complexity:** trade-off computing/human resources ↔ quality.

Specificities

Multiple representations are now available

► Complementary information at multiple scales:

- Numerous (authoritative) producers;



Globcover

Corine Land Cover

OSO (l_2)

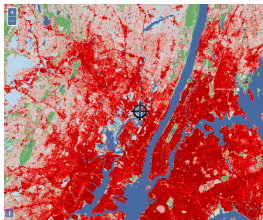
French LC

French LU

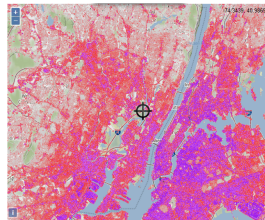
Multiple representations are now available

► Complementary information at multiple scales:

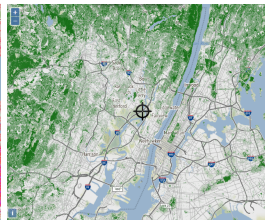
- Numerous (authoritative) producers;
- Hierarchical nomenclatures and thematical by-products;



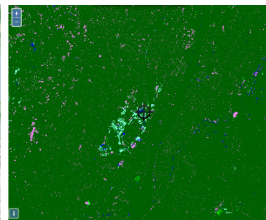
U.S. NLCD



Impervious surfaces



Tree Canopy



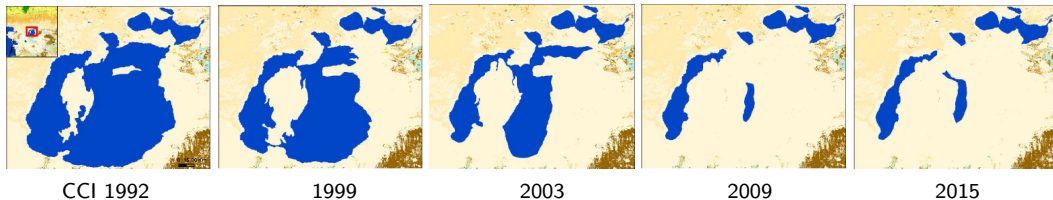
Change map

Yang et al. (2018). A new generation of the United States National Land Cover Database: Requirements, research priorities, design, and implementation strategies. *ISPRS Journal of Photogrammetry and Remote Sensing* 146.

Multiple representations are now available

► Complementary information at multiple scales:

- Numerous (authoritative) producers;
- Hierarchical nomenclatures and thematical by-products;
- Change detection over large time spans is now possible.



Li et al. (2018). Gross and net land cover changes in the main plant functional types derived from the annual ESA CCI land cover maps (1992–2015). *Earth Syst. Sci. Data* 10.

Multiple representations are now available

► Complementary information at multiple scales:

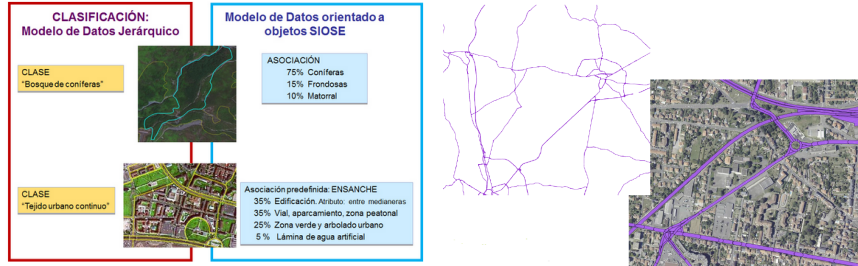
- Numerous (authoritative) producers;
- Hierarchical nomenclatures and thematical by-products;
- Change detection over large time spans is now possible.

► Representations:

- Interleaved spatial ↔ semantic accuracies.
- Various possible formats: raster/vector – discrete categories/class occurrences.

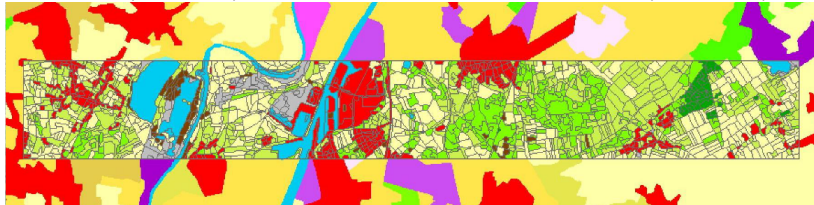
Managing multiple years or products

- Object-based/hardbone strategy: defining a permanent stable partition



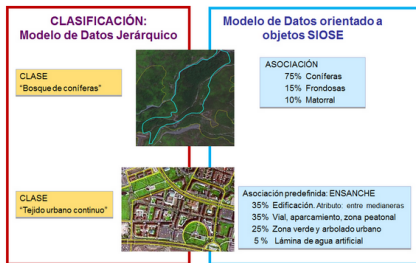
SIOSE (IGN-Spain)

"Skeleton" (IGN-France)



Hardbone → Softbone (CLC+)

- Object-based/hardbone strategy: defining a permanent stable partition



SIOSE (IGN-Spain)

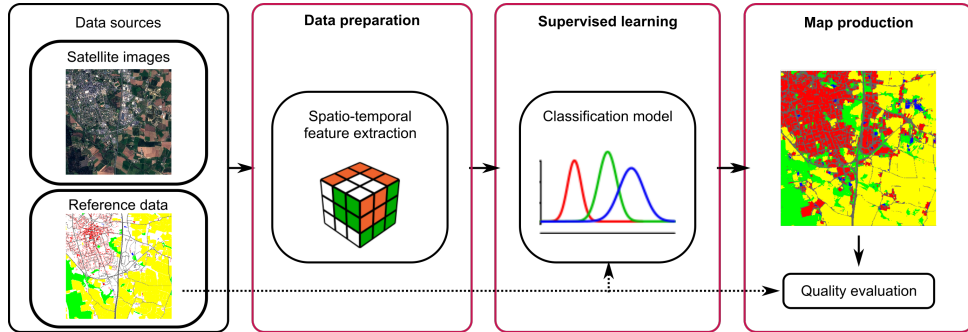


"Skeleton" (IGN-France)

- Consistent strategy across scales and/or countries;
- Smoother LU ↔ LC transformation;
- Suitable for change detection;
- Easy derivation of (harmonized) by-products.

Land-cover mapping using remote sensing imagery (1/2)

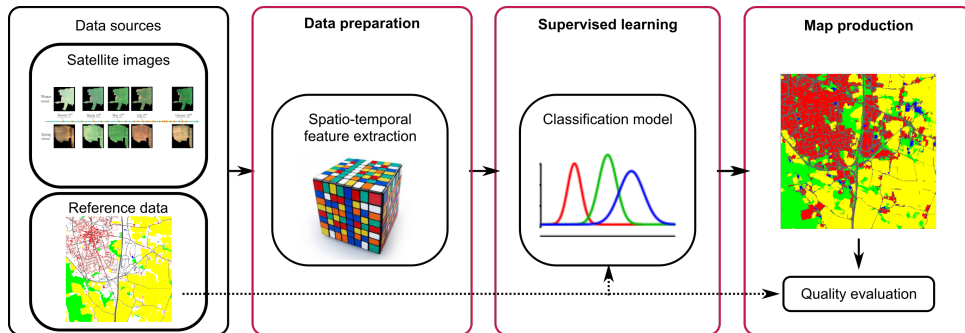
► Supervised classification of geospatial images: a change of paradigm



- 1 (low resolution) sensor = 1 map (1 km-100 m).

Land-cover mapping using remote sensing imagery (1/2)

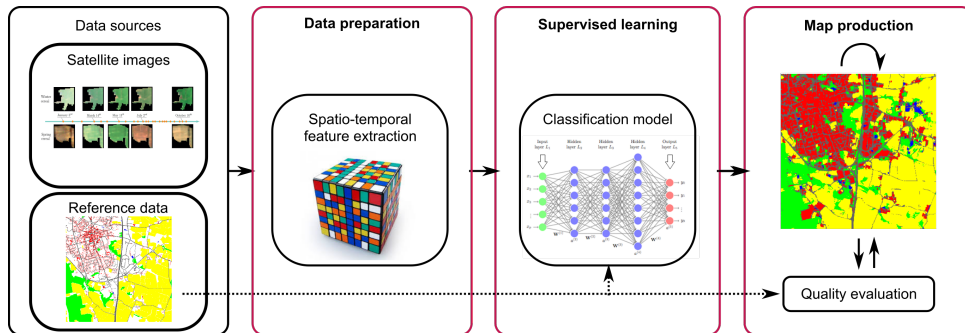
► Supervised classification of geospatial images: a change of paradigm



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- Mono-sensor → multi-sensor/temporal imagery.

Land-cover mapping using remote sensing imagery (1/2)

► Supervised classification of geospatial images: a change of paradigm

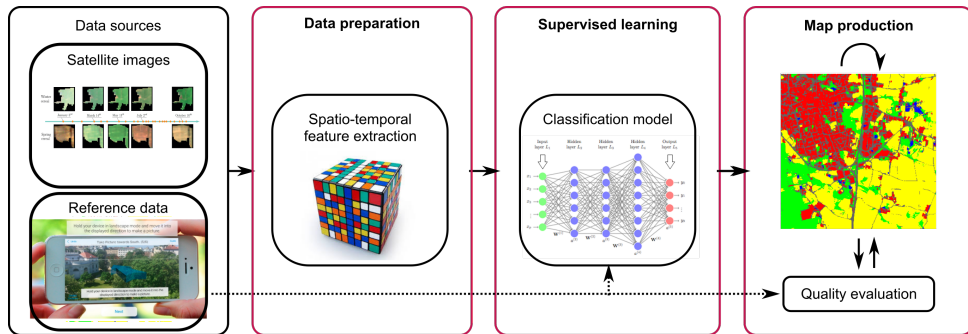


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- More complex classifiers and post-processing strategies.

Land-cover mapping using remote sensing imagery (1/2)

► Supervised classification of geospatial images: a change of paradigm



- 1 (low resolution) sensor = 1 map (1 km-100 m).
- Mono-sensor → multi-sensor/temporal imagery.

- More complex classifiers and post-processing strategies.
- Citizen science !

Table 1. Comparison of general characteristics of previous and current land cover paradigms.

Land Cover 1.0	Land Cover 2.0
Limited data options in terms of spectral, spatial, and temporal resolutions	A broad range of data options
Limited data availability	Mass data available (free, open archives)
Significant time and resources required to pre-process Earth observation data	Standardized, analysis-ready data products to greatly reduce or eliminate the need for pre-processing
Pre-processing and classification approaches developed on an <i>ad hoc</i> basis, often unique to the group developing the product or to the geographic area	Increasingly standardized and transparent approaches
Classification algorithms that are simplistic and make assumptions regarding the nature of the input data	Advanced algorithms that are flexible and make fewer assumptions regarding input data
High cost of data and processing	Low cost of data and processing
Single date representation, state not trends	Time series informed land cover, allows for both state and trends
Lack of agreement between land cover and land change products	Integration of land change information into land cover product development
Products not systematically generated	Systematically generated
Static products	More frequent products
Periodically updated, not necessarily temporally integrated	Frequently updated and temporally integrated
Difficulties in disseminating derived products	Ease of access and sharing of derived products

First initiatives (90's) → current situation.

Wulder et al. (2018). Land cover 2.0. *International Journal of Remote Sensing* 39(12).

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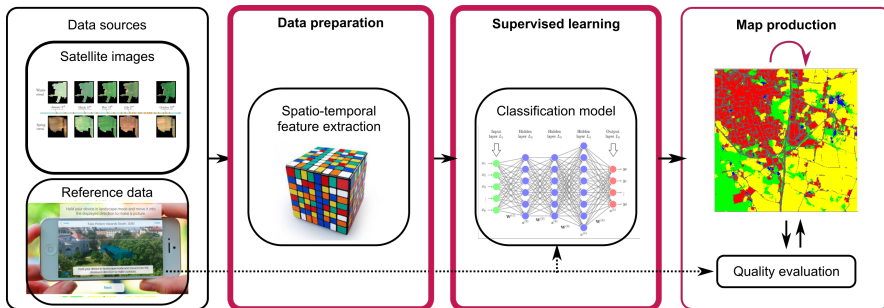
③ Supervised ② classification of ① geospatial images.

Wulder et al. (2018). Land cover 2.0. *International Journal of Remote Sensing* 39(12).

Challenges

► Ideal world:

■ Producer: automation + scalability + few parameters.

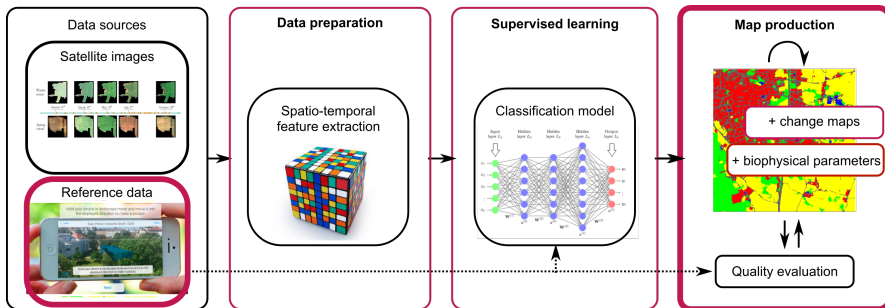


Challenges: data fusion, semi-supervised learning, reproducibility.

Mallet and Le Bris (2020). Current challenges in operational very high resolution land-cover mapping. *ISPRS Archives XLIII-B2*.

► Ideal world:

- Producer: automation + scalability + few parameters.
- End-user: high spatial/semantic accuracies + frequent updating + multi-purposes.

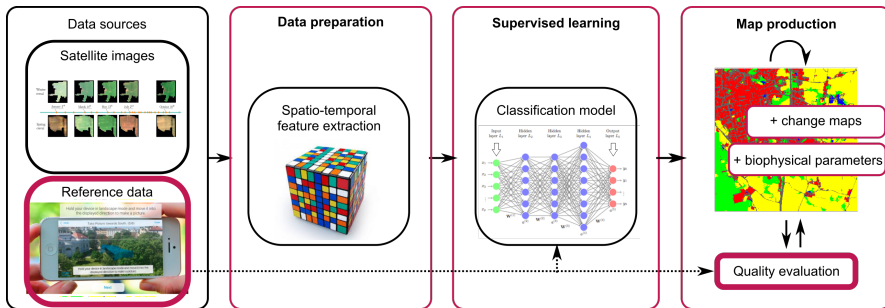


Challenges: learning from imbalanced and rare classes, multi-task learning.

Mallet and Le Bris (2020). Current challenges in operational very high resolution land-cover mapping. *ISPRS Archives XLIII-B2*.

► Ideal world:

- Producer: automation + scalability + few parameters.
- End-user: high spatial/semantic accuracies + frequent updating + multi-purposes.
- Everybody: harmonization / interoperability + qualified outputs.

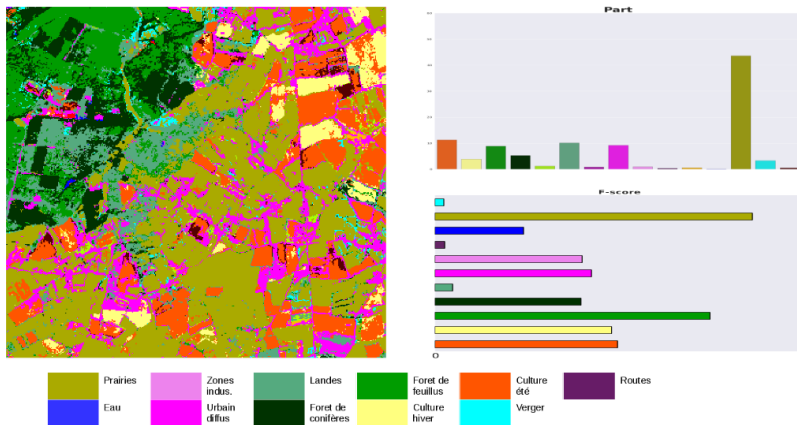


Challenges: map fusion, unbiased and comprehensive evaluation.

Mallet and Le Bris (2020). Current challenges in operational very high resolution land-cover mapping. *ISPRS Archives XLIII-B2*.

Moving towards genuine land-cover maps

- Classification outputs are not products nor geodatabases.
- Can we learn map specifications ? Acceptable accuracies (Minimal Mapping Unit. . .) ?

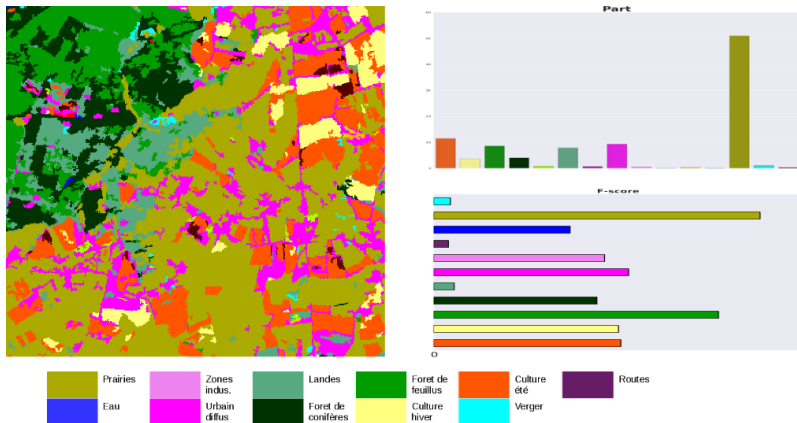


Raw per-pixel classification of Sentinel images.

Inglada et al. (2017). Operational High Resolution Land Cover Map Production at the Country Scale Using Satellite Image Time Series. *Remote Sensing* 9(1).

Moving towards genuine land-cover maps

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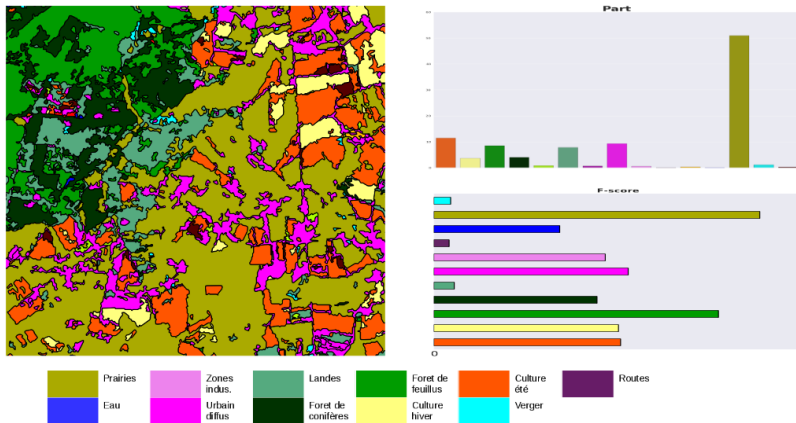


Noise removal with spatial consistency integration.

Inglada et al. (2017). Operational High Resolution Land Cover Map Production at the Country Scale Using Satellite Image Time Series. *Remote Sensing* 9(1).

Moving towards genuine land-cover maps

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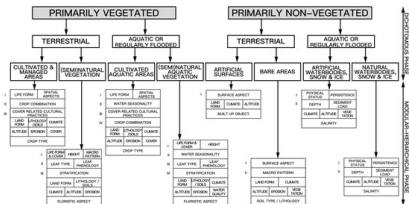
Derivation of vector data.

Inglada et al. (2017). Operational High Resolution Land Cover Map Production at the Country Scale Using Satellite Image Time Series. *Remote Sensing* 9(1).

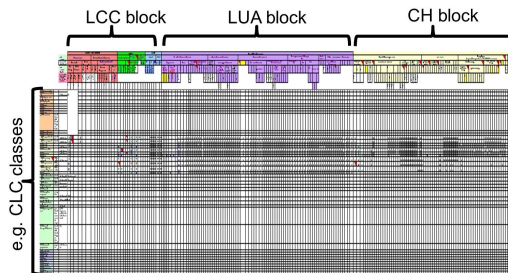
How to get closer to map interoperability ?

► Consistent and comparable maps. Harmonization of :

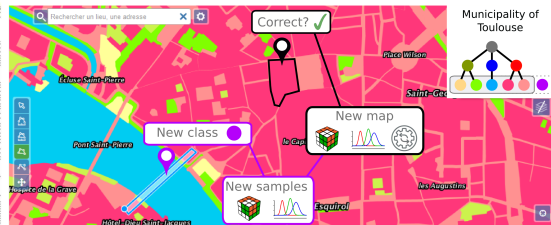
- Reference and validation data collection;
- Class definition;
- Enrichment and validation protocols.



Land-Cover Classification System (LCCS)



Eagle matrix



Paysages application (LandSense project)

Improving map qualification

► Comprehensive validation is mandatory. Today:

- Over limited areas;
- For dominant classes;
- Spatially biased.

Table 3-7: Adjusted contingency matrix that considers the CCI-LC 2015 map and the "certain" and "homogeneous" points of the GlobCover 2009 validation dataset. Green cells mark diagonal cells while yellow cells represent other samples that also mark a clear agreement between the product and the reference.

	REFERENCE: GLOBCOVER 2009 VALIDATION DATASET																							SUM	User Acc. (%)
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220		
PRODUCT: CCI-LC 2015 MAP	0	245	27	0	0	4	0	0	0	1	0	0	6	7	0	0	0	2	5	0	0	0	297	92	
	20	5	5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	12	83	
	30	18	2	0	0	2	1	0	0	1	0	0	2	1	0	0	0	0	1	0	0	0	28	71	
	40	12	0	0	0	3	1	0	0	0	0	0	2	3	0	2	0	0	0	0	0	0	23	39	
	50	4	2	0	0	224	2	1	0	8	0	0	0	0	0	0	0	0	0	0	0	0	241	96	
	60	5	0	0	0	18	44	1	4	31	0	0	16	3	0	1	0	0	2	0	0	1	126	60	
	70	1	0	0	0	2	2	35	2	28	0	0	8	5	1	1	0	0	5	0	2	2	1	95	66
	80	0	0	0	0	0	0	0	12	2	0	0	2	1	0	0	0	0	0	0	0	0	0	17	82
	90	0	0	0	0	1	6	2	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	13	31
	100	5	0	0	0	3	1	0	0	1	0	0	3	6	1	1	0	0	0	1	1	0	0	23	35
	110	1	0	0	0	1	0	0	0	0	0	0	0	1	2	0	2	0	0	2	0	0	0	9	22
	120	15	2	0	0	4	4	1	0	1	0	0	92	10	0	10	0	0	1	1	7	0	1	149	62
	130	25	1	0	0	0	0	1	1	1	0	0	13	48	0	8	0	0	0	2	2	1	1	104	46
	140	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	1	0	2	0	1	9	33
	150	3	0	0	0	0	0	0	0	0	0	0	7	4	1	9	0	0	0	0	1	17	0	42	21
	160	0	0	0	0	4	1	0	0	0	0	0	0	0	1	1	0	5	1	1	0	0	0	14	36
	170	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	7	71
180	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	0	0	3	0	0	1	0	9	33
190	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	21	86
200	0	1	0	0	0	0	0	0	1	0	0	1	2	1	4	0	0	0	1	135	1	6	153	88	
210	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	78	0	81	96	
220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	25	26	96	
	SUM	340	43	0	0	267	62	41	19	79	0	0	154	99	10	38	6	6	18	30	168	84	35	1499	
	Prod. Acc.(%)	79	79	N/A	N/A	86	74	85	63	94	N/A	N/A	63	54	30	24	83	83	17	60	80	93	71	75.38	

Land Cover CCI - Product User Guide (2017).



Thank you for your attention !

`clement.mallet@ign.fr`
`https://maestriaproject.github.io/`