

Comparison of various types of land use and land cover data and example of their harmonisation

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Land Use and Land Cover

**Land use corresponds to
the socio-economic description
i.e., functional dimension of areas:**

**areas used for residential, industrial or
commercial purposes, for farming or forestry,
for recreational or conservation purposes,
etc.**

European Environment Agency



Land Use and Land Cover



the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it.

- **"grassland"** is a cover term,
- **"rangeland"** or **"tennis court"** refer to the use of a grass cover;

Food and Agriculture Organization of the United Nations (FAO)

Land Use and Land Cover

Food and Agriculture Organization
of the United Nations (FAO)



Land cover is the observed (bio)physical cover on the earth's surface.

it should be confined to the description of **vegetation and man-made features.**

Also, it is disputable whether **water surfaces** are real land cover.

However, in practice, the scientific community usually includes these features within the term *land cover*.

Land Use and Land Cover

Links with land cover are possible; it may be possible to infer land use from land cover and conversely.

But situations are often complicated and the link is not so evident.

Contrary to land cover, land use is difficult to 'observe'.



Land Use or Land Cover?

**Do we separate them
in the processed
data?**

**Yes, if we use appropriate
nomenclature**

**To be able to decide we have to
have a look at existing land use/
land cover data**

Geoharmonizer: EU-wide automated mapping system for harmonization of Open Data based on FOSS4G and Machine Learning



<https://opendatascience.eu/geoharmonizer-project/>



Geoharmonizer: EU-wide automated mapping system for harmonization of Open Data based on FOSS4G and Machine Learning

overall objective of the Action

data portal and a software suite

free and open-source software for geospatial data (FOSS4G) using **Machine Learning** algorithms

coverage of the entire Europe

all input data are **free data**

Geoharmonizer: EU-wide automated mapping system for harmonization of Open Data based on FOSS4G and Machine Learning

European Land Cover from satellite data

one of the main outcomes

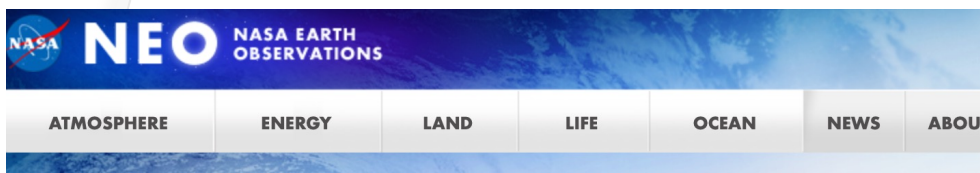
2000 - 2020

Land Use /Land Cover data were regarded from various views

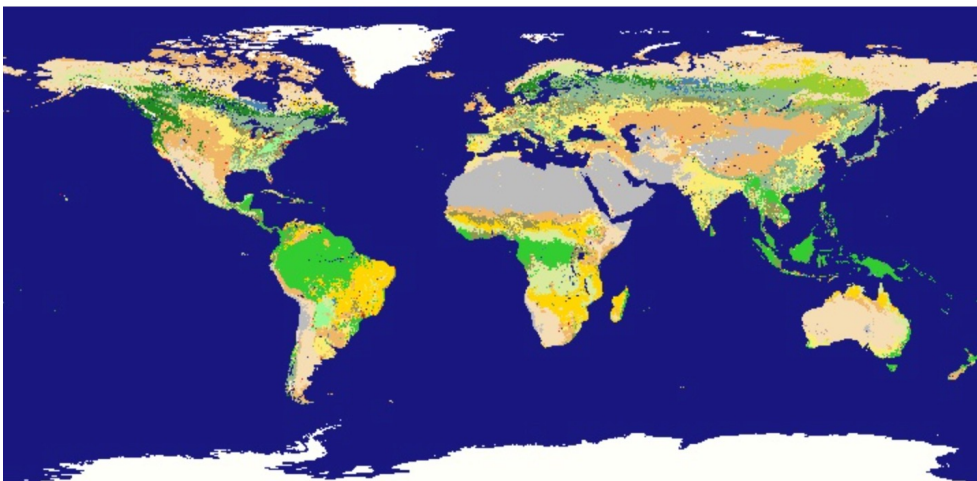
spatial coverage
thematic resolution
spatial resolution
temporal coverage

Spatial coverage

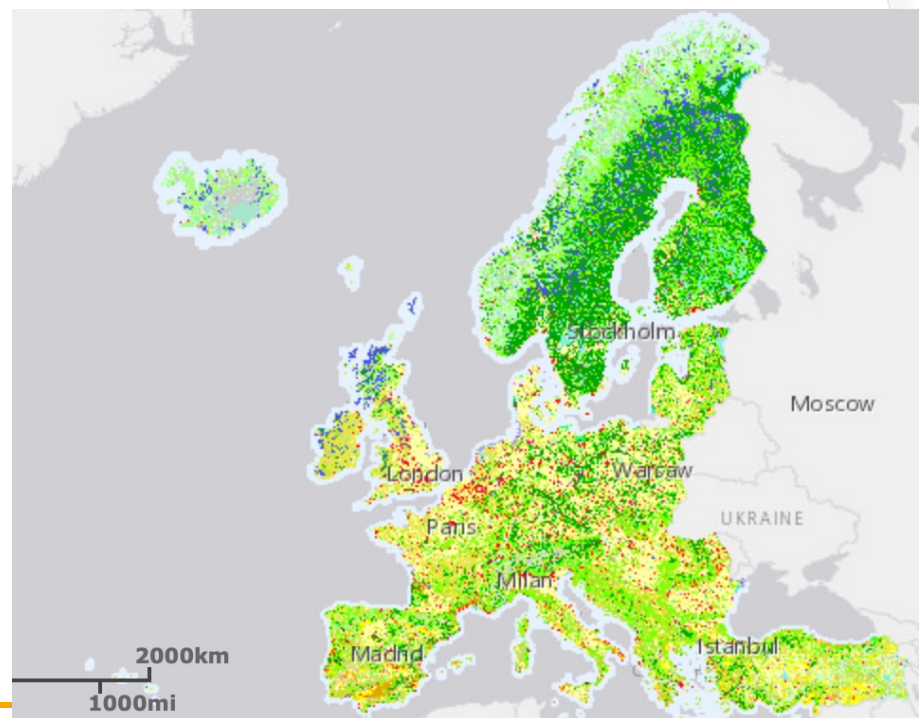
Global, Continental, National and Regional
Land Cover products



LAND COVER CLASSIFICATION (1 YEAR)



[NASA Land Cover \(2011\)](#)



CORINE Land Cover 2018,
Copernicus



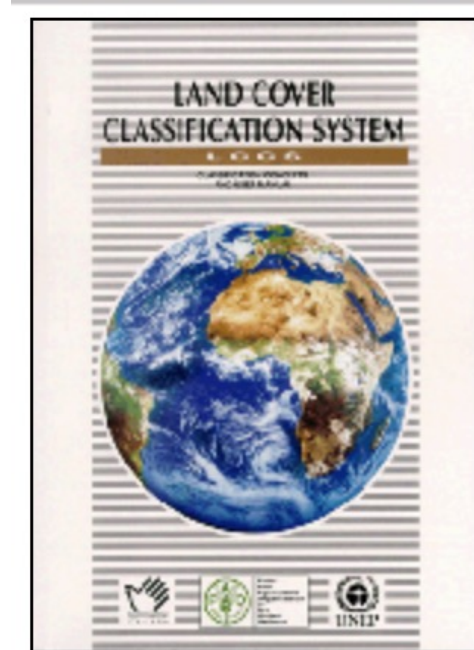
Spatial Coverage

Global data

LAND COVER NAME	MAINTAINER
<u>CCI Land Cover (2017)</u>	ESA
<u>GlobeLand30 (2000, 2010)</u>	National Geomatics Center of China
<u>GLC - SHARE</u>	Land and Water Division of FAO
<u>GLC2000 (2000)</u>	Joint Research Center (JRC)
<u>NASA Land Cover (2011)</u>	NASA
<u>Land Cover (GLCNMO)</u>	ISCGM, GSI of Japan
<u>Copernicus Global Land Service</u>	VITO

Global data

Product / Characteristics	ESA CCI LC	GlobeLand30	GLC - SHARE	GLC2000	NASA LC	Land Cover (GLCNMO)	CGLOPS-1 (VITO)
Thematic resolution (No. of classes)	22	10	11	23	17	20	23
Nomenclature model	LCCS	GlobeLand30	LCCS, FAO, <u>SEEA</u>	LCCS	IGBP	LCCS	LCCS
Spatial resolution / MMU	300m	30 m	1 km (source)	1 km (source)	1 deg 0.5 deg 0.25 deg	500 m	100 m



Nomenclature:

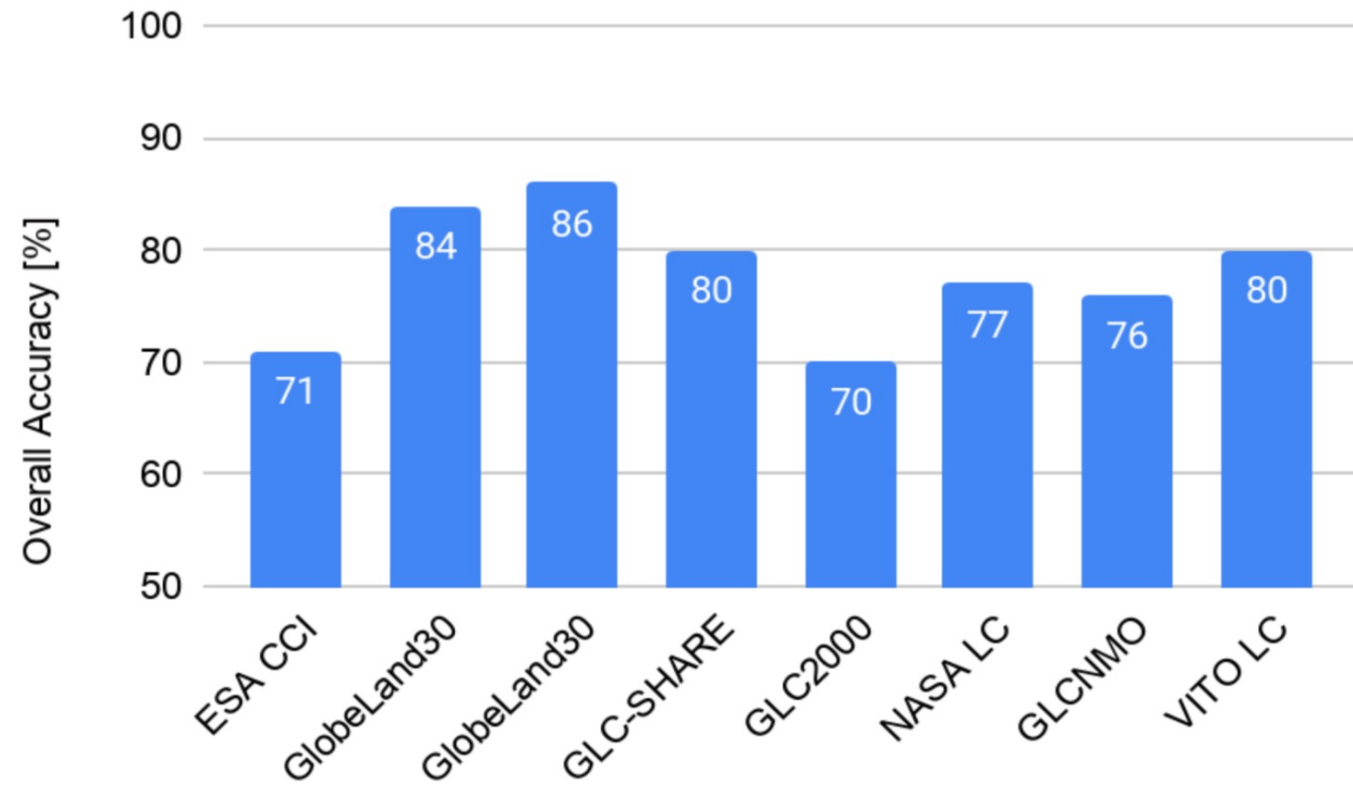
LCCS (FAO) <http://www.fao.org/3/x0596e/x0596e00.htm>

GlobeLand30 - <http://www.globeland30.org>

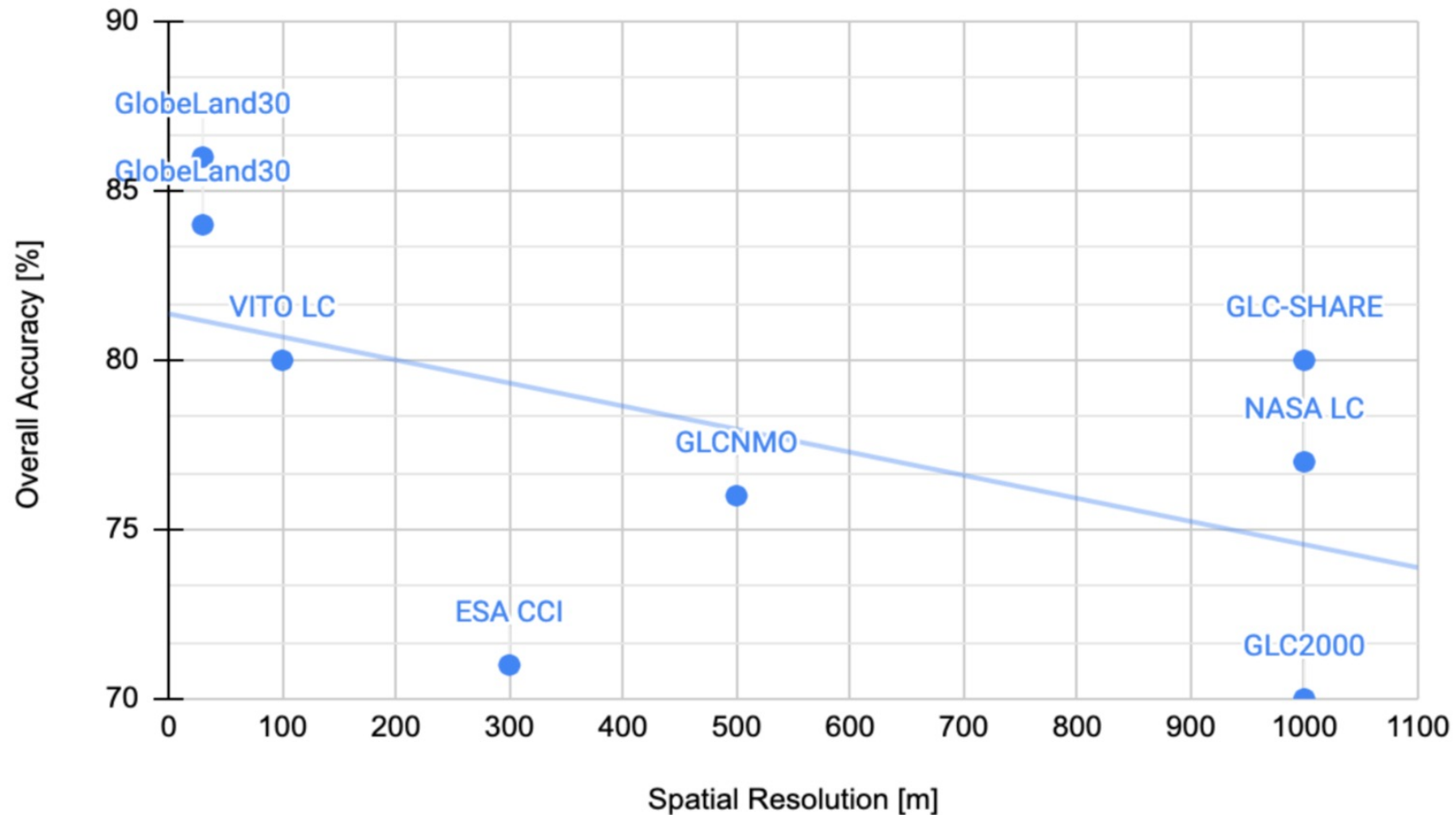
IGBP (International Geosphere-Biosphere Programme) - <http://www.igbp.net>



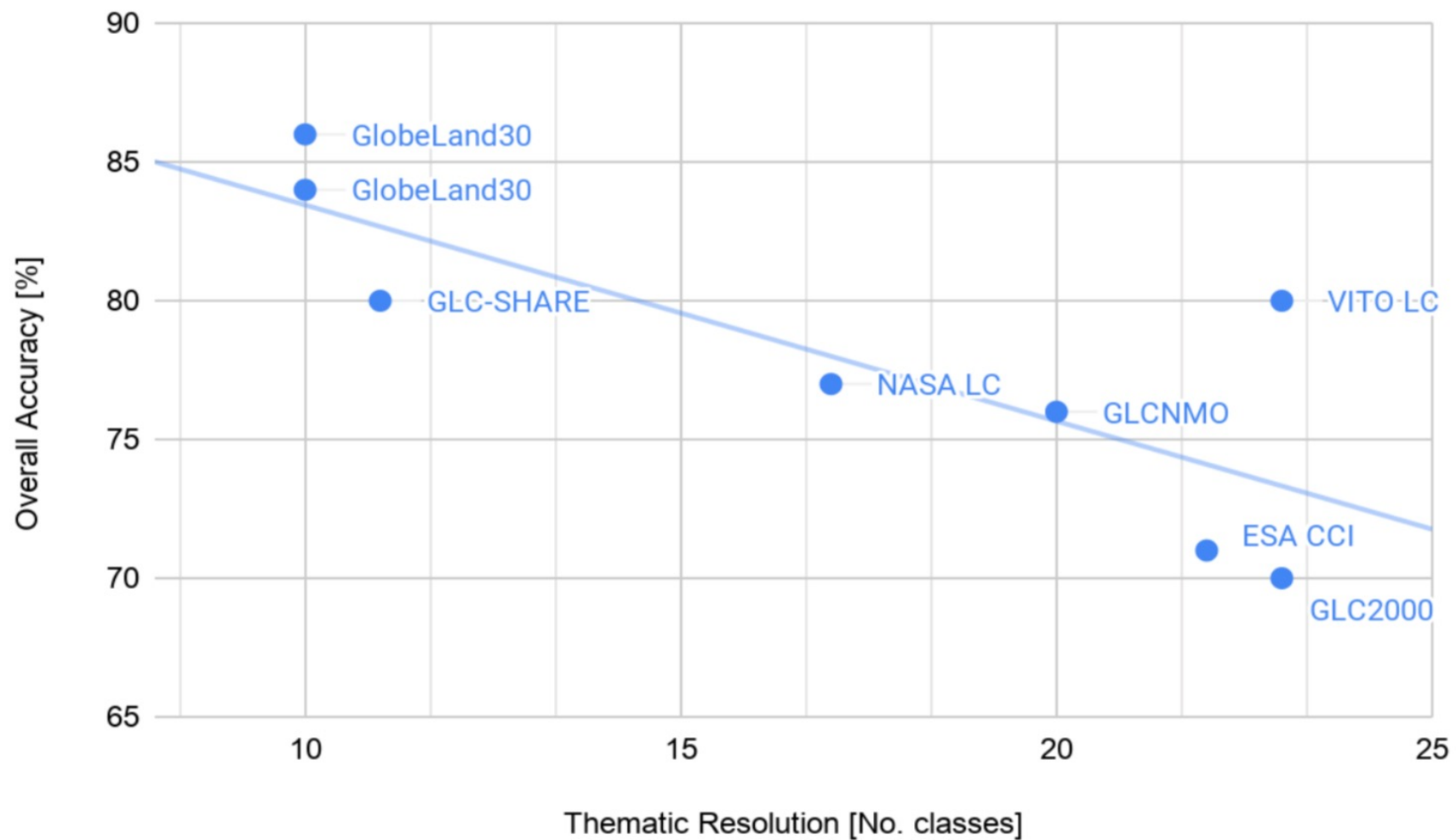
Global data - overall accuracy



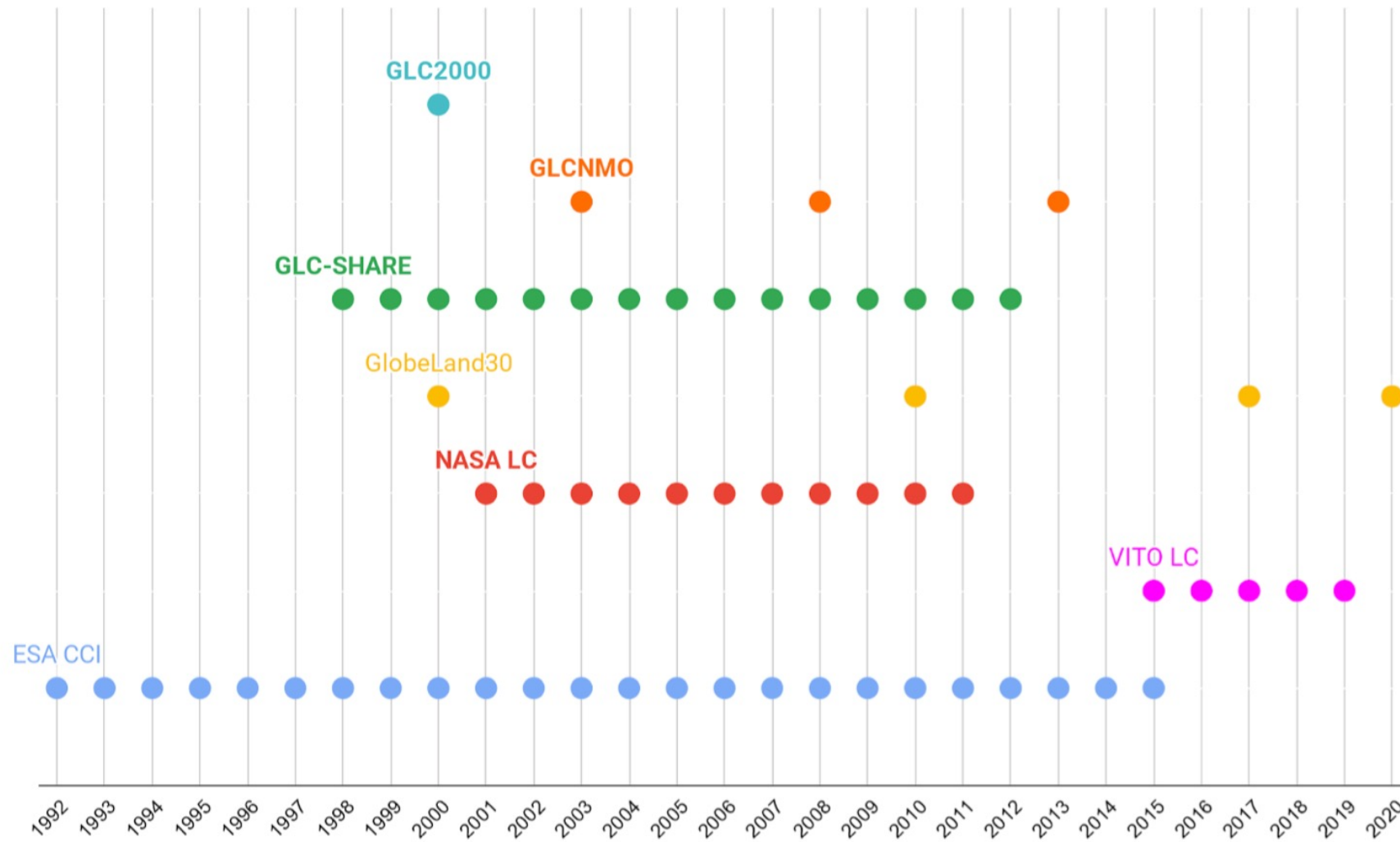
Global data – spatial resolution vs. overall accuracy



Global data - thematic resolution vs. overall accuracy



Global data – temporal coverage



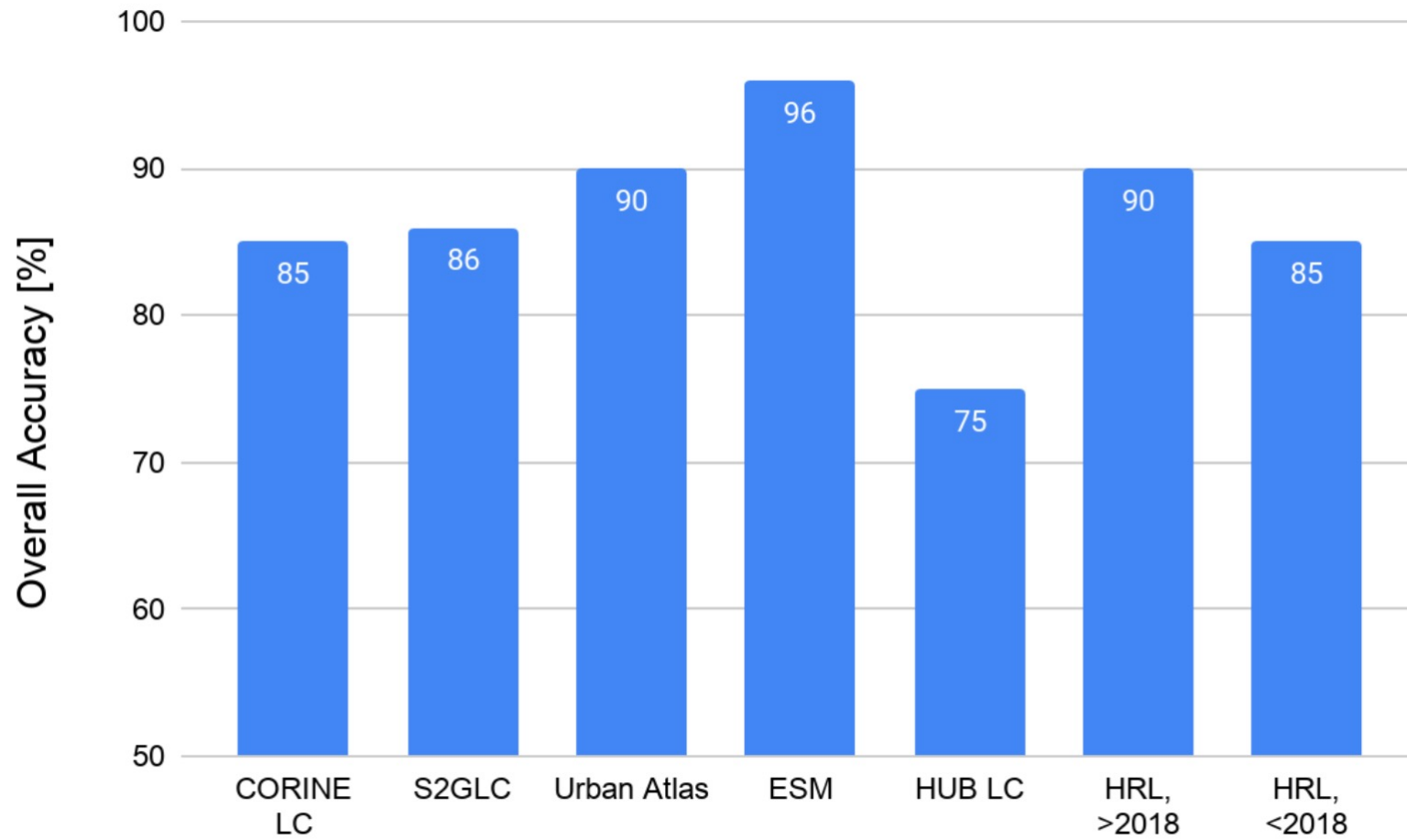
European – continental data

Land Cover name	Maintainer
CORINE Land Cover (1990 -2018)	EEA (EU Copernicus)
European Settlement Map (2016, 17) Urban Atlas	EEA (EU Copernicus)
Land Cover Map of Europe 2017 (S2GLC, ESA)	EEA (EU Copernicus)
Pan-European land cover (30 m) map of 2015 (based on Landsat and LUCAS data)	Pflugmacher, Rabe, Peters, Hostert (Humboldt University, Berlin)
High Resolution Layers	Copernicus

European data LC/LU

Product\ Characteristics	CORINE Land Cover (Copernicus)	Global Land Cover - Sentinel-2 S2GLC (ESA)	Urban Atlas (Copernicus)	European Settlement Map (Copernicus)	Pan-European LC (Humboldt University of Berlin)	High Resolution Layers (HRL) (Copernicus)
Spatial coverage	Europe (EEA39)	Europe	Europe (EEA39) 319 FUAs	Europe	Europe	Pan-European
Thematic resolution (No. of classes)	44	13	27 (17 urban classes 10 rural classes)	1	12	5
Nomenclature model	CORINE (LC/LU)	CORINE	CORINE compatible	-	CORINE compatible	CORINE compatible
Spatial resolution (pixel size)		10 m		2 m/10 m/100 m	30 m	10 m (20 m before 2018)

European data - overall accuracy



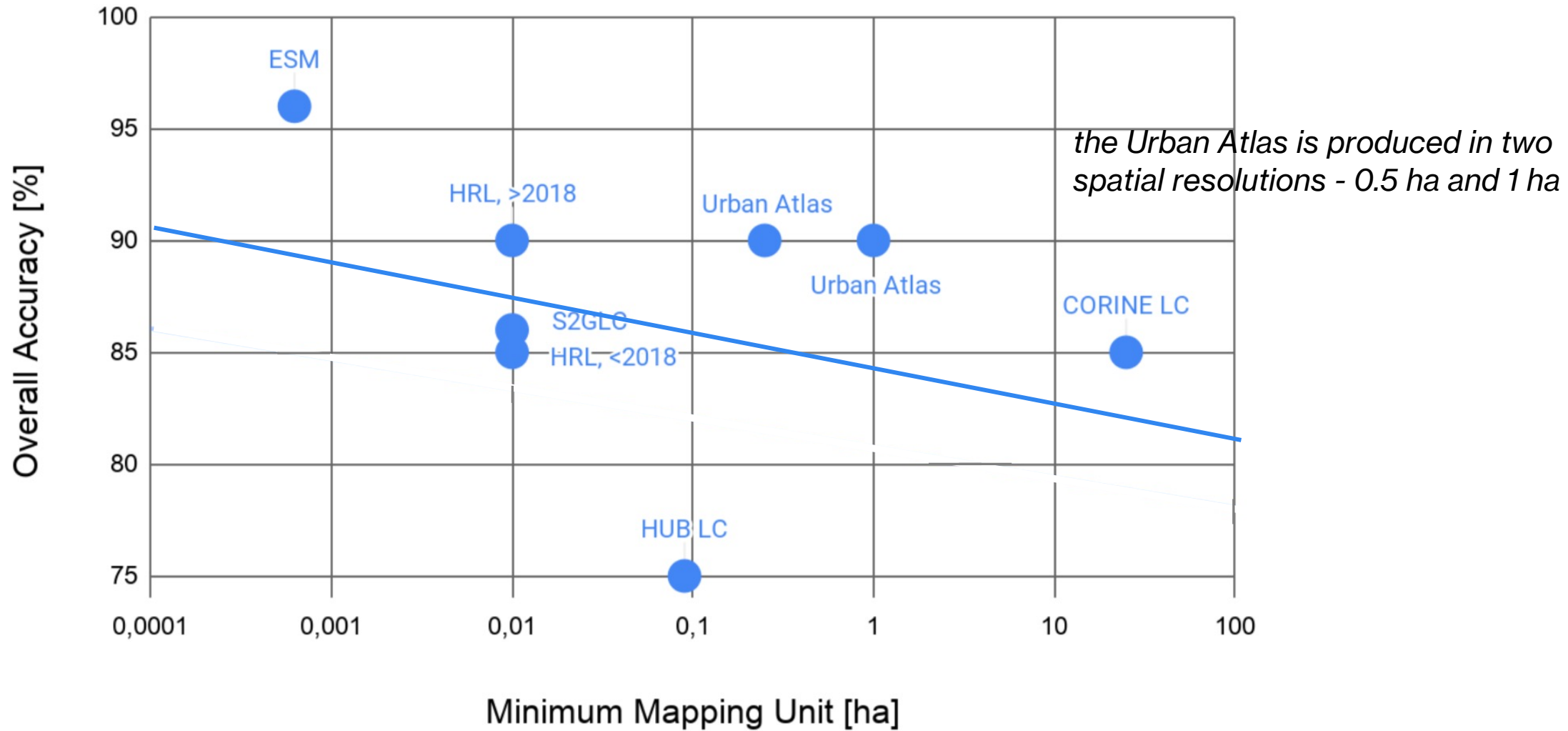
European data

thematic resolution vs. overall accuracy

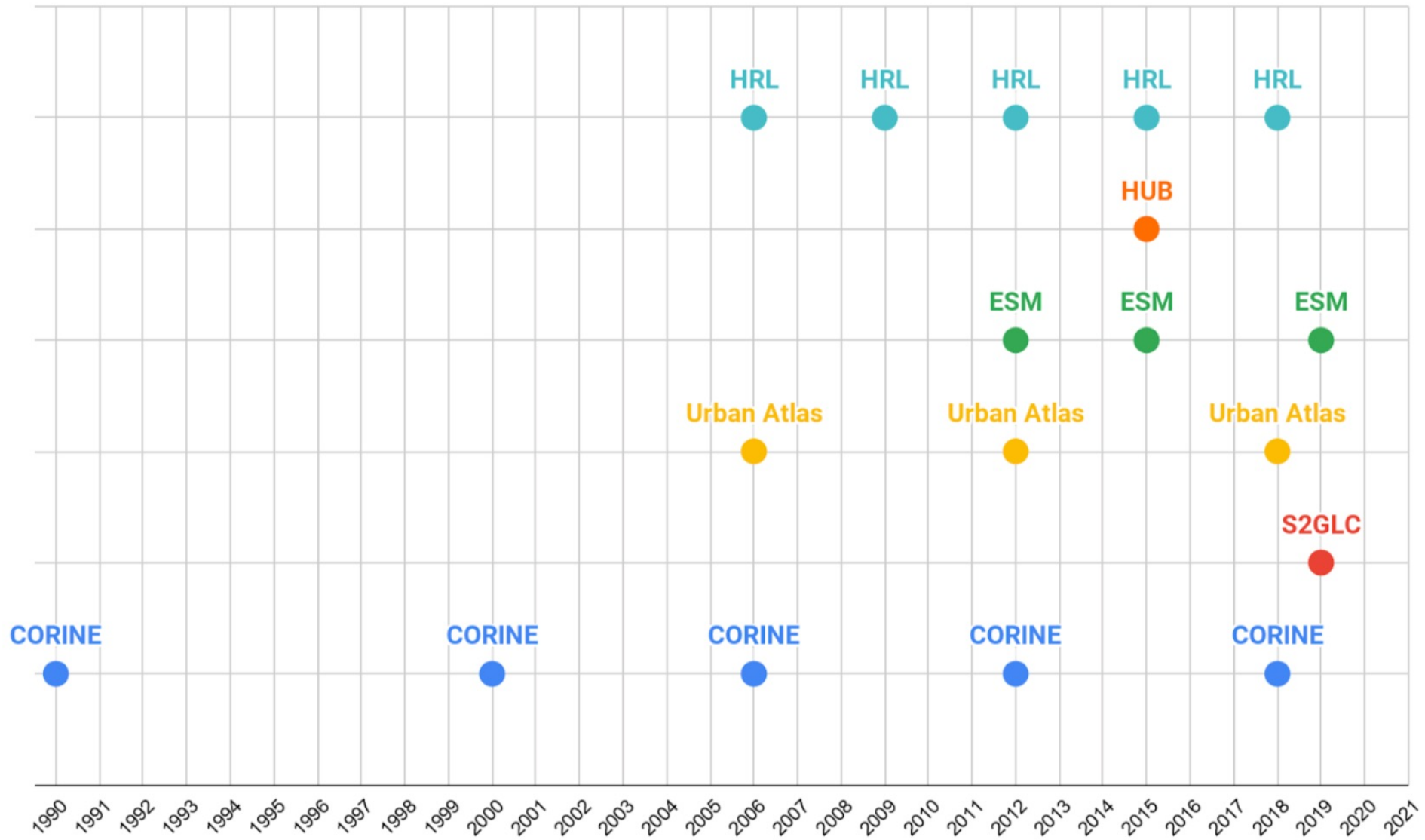


European LC data

spatial resolution and overall accuracy



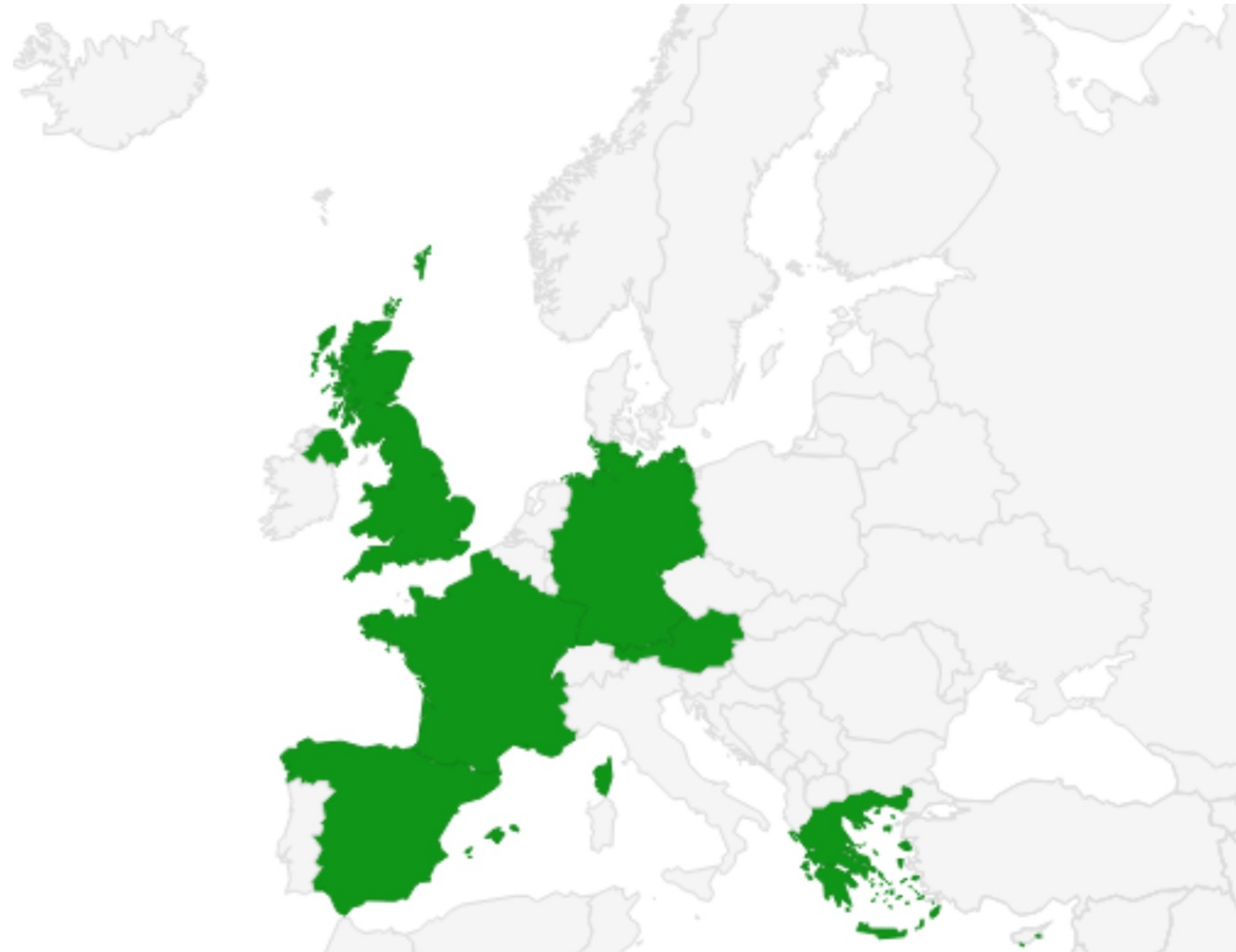
European data – temporal coverage



National Land Cover data – publicly available

Land Cover name	Maintainer
LISA	Austria, AT consortium
LandCover DE	Germany, DLR
SIOSE	Spain, National Reference Center on Land Cover and on Land Use and Spatial Planning
LGN (Dutch land use datasets from 1995 to 2018)	Netherlands, Wageningen Environmental Research
OSO Land Cover	France, Theia Data and Services centre
LC Greece	Greece, University of the Aegean
CLC50	Hungary, Institute of Geodesy, Cartography and Remote Sensing (FÖMI),

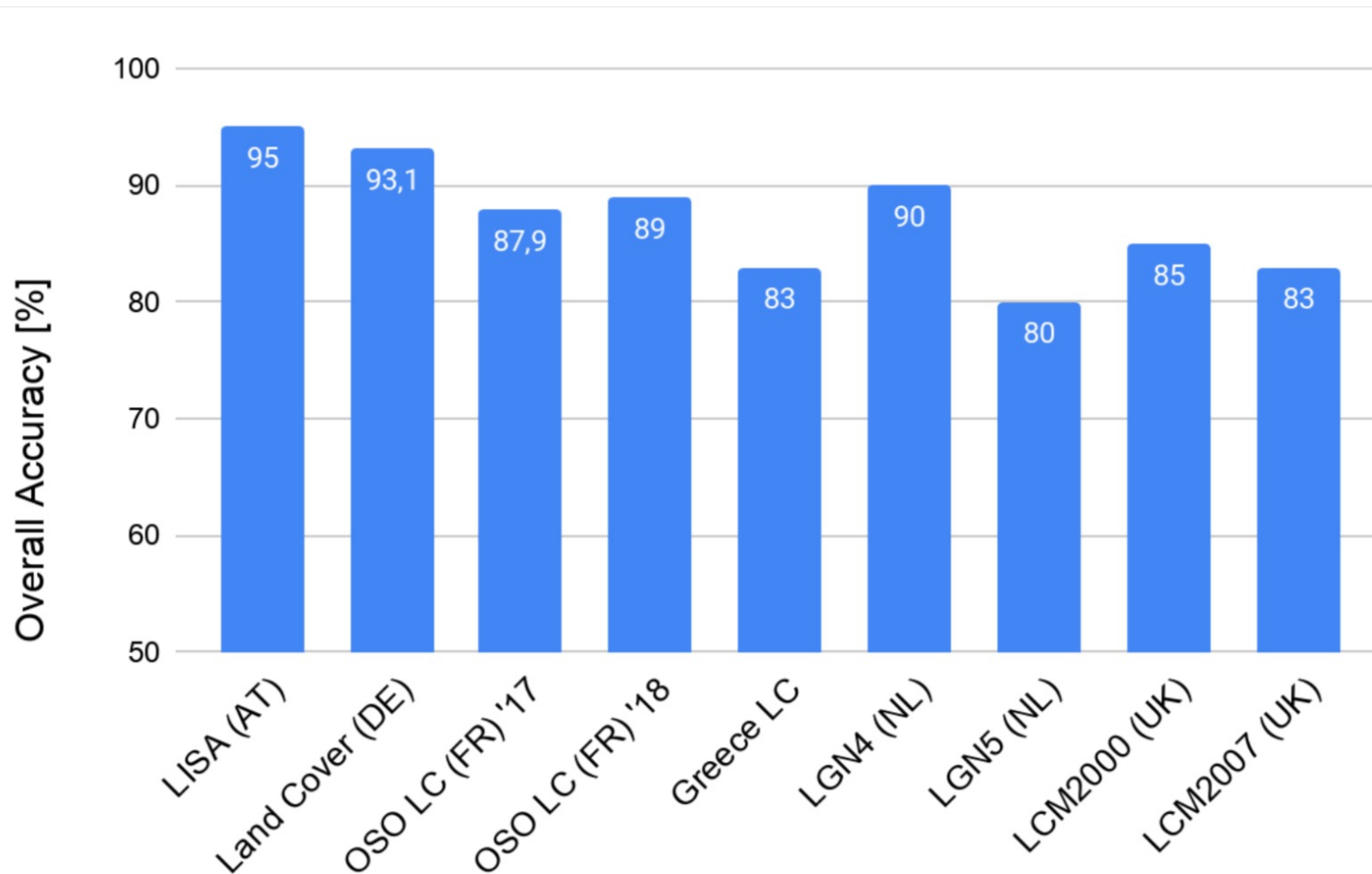
Map of
publicly
available
European
national data



National Land Cover data – publicly available

Product / Characteristics	LISA	Land Cover DE	SIOSE	OSO LC	LC Greece	CLC50 HU	LGN	LCM2015
Spatial coverage	Austria	Germany	Spain	France	Greece	Hungary	The Netherlands	UK
Thematic resolution (No. of classes)	13 and 12 attributes	7	20	23 (17 before 2018)	12	79	48 (39 before 2018)	21
Nomenclature model	CORINE compatible	CORINE	SIOSE	OSO LC	CORINE	CORINE level-3	LGN	JNCC Broad Habitats

National European data - overall accuracy



SIOSE products do not report overall accuracy

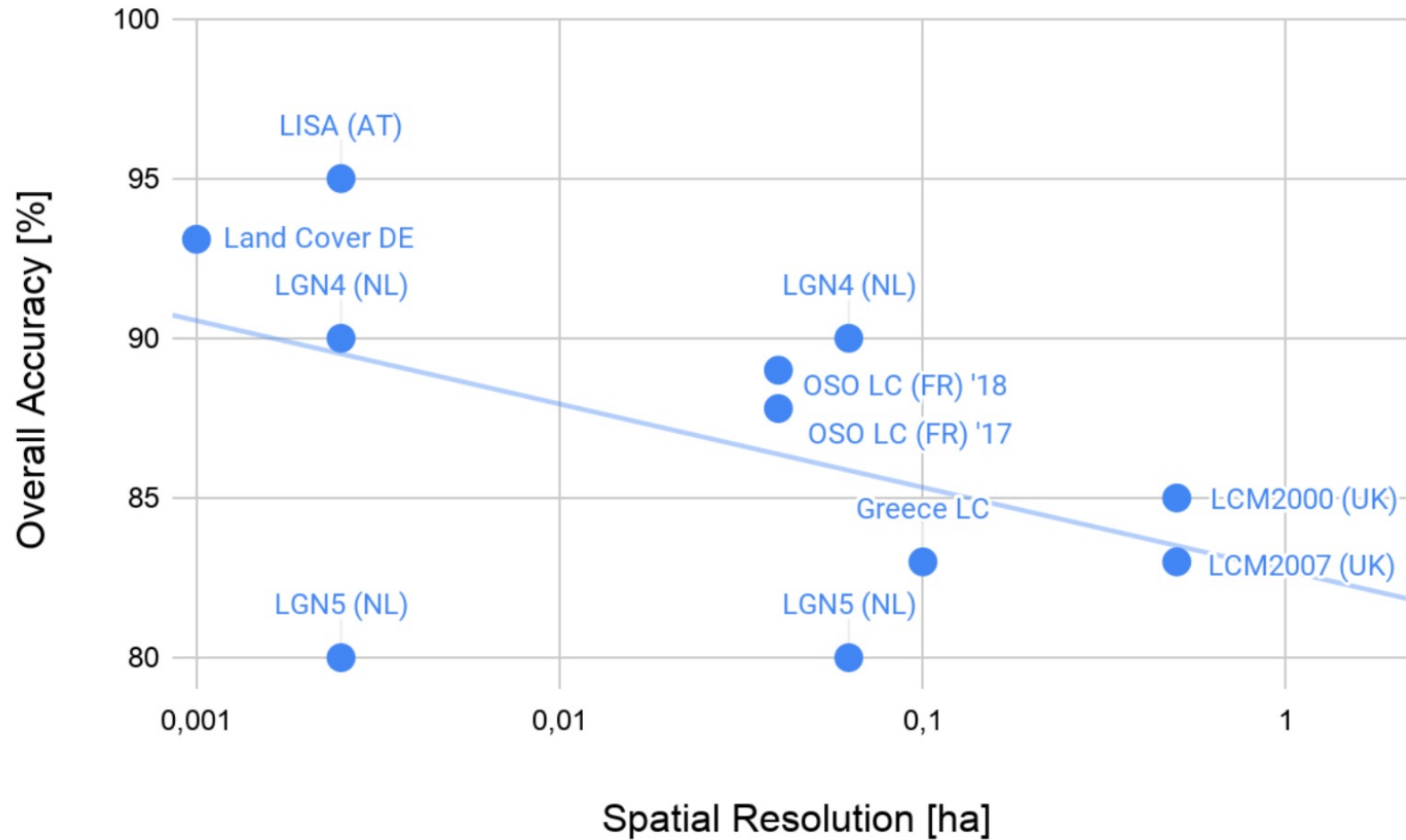
National European data

thematic resolution vs. overall accuracy

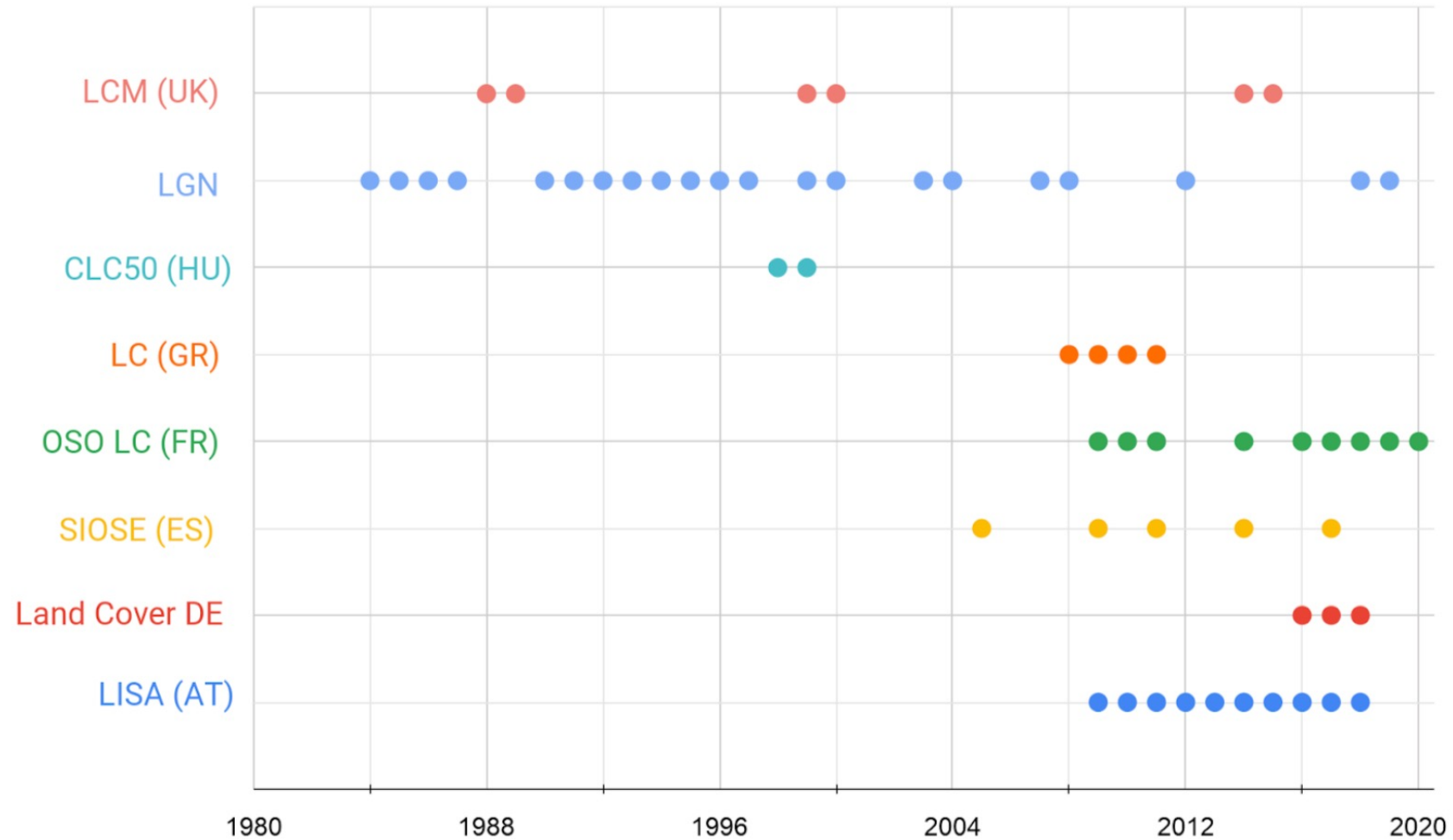


National European data

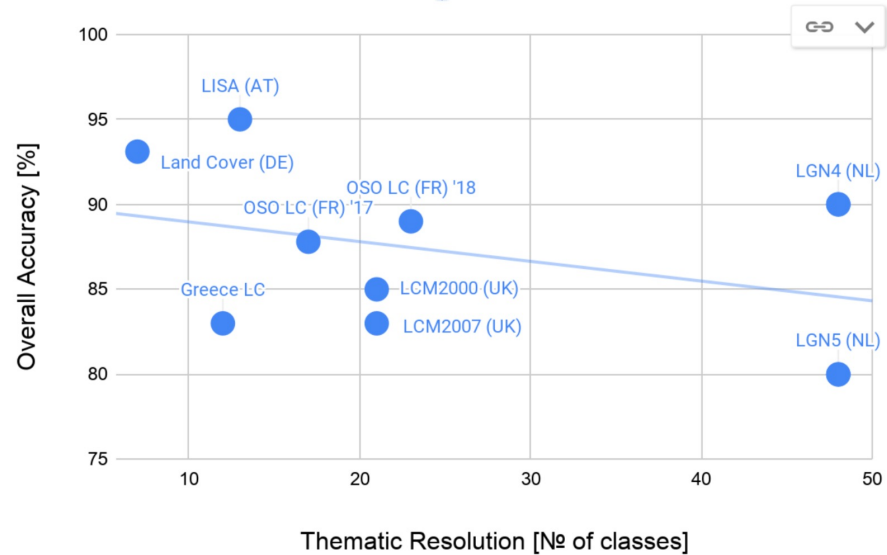
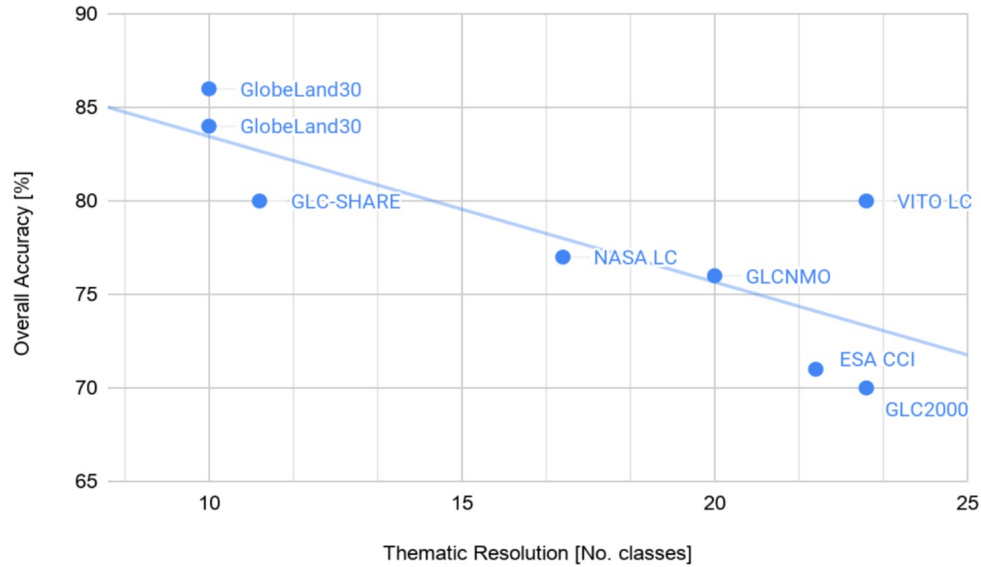
spatial resolution vs. overall accuracy



National European data – temporal coverage



Comparison **thematic resolution** and overall accuracy for global, continental and national European data



Conditions for good results of (land cover) classification

Input data

- **remote sensing data – wide choice**
 - good quality
 - representative spectral information
 - appropriate spatial resolution
 - necessary temporal resolution
- **all other spatial data – which are available**

Method incl. sample /training data

Software

Data used for the spatio-temporal data land cover/land use European model of Geoharmonizer

Land Cover Data

CORINE



Open street map



LUCAS



Satellite Data - open data

Landsat data

Sentinel 2

VIIRS/Suomi NPP
night light

Other data - timeless

DTM elevation
DTM slope

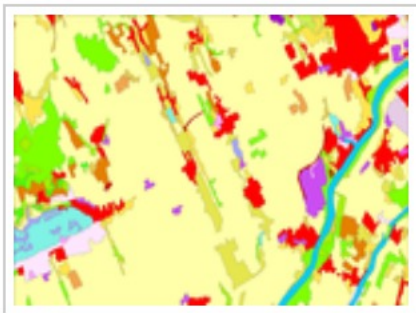
Monthly Geometric
Temperature

Global Surface Water
Historical occurrence (1984-
2019)

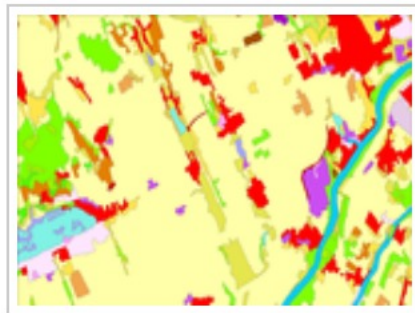
Free Land Cover data



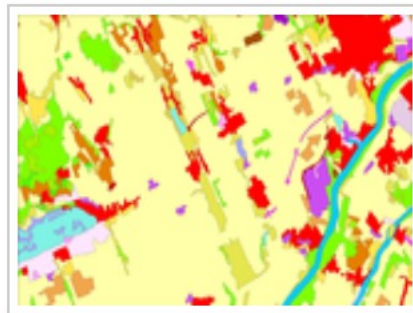
Year	Input data	Input Data Resolution	Participating Countries
CLC1990	Landsat-5 MSS/TM	50 m	27
CLC2000	Landsat-7 ETM	25 m	30
CLC2006	SPOT - 4/5 and ORS P6 LISS	25 m	38
CLC2012	IRS P6 LISS II and RapidEye	25 m	
CLC2018	Sentinel-2 imagery data; Landsat-8	10 m	39



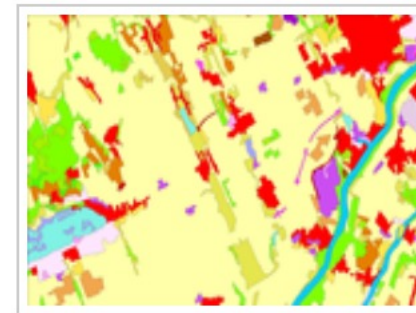
CLC 1990



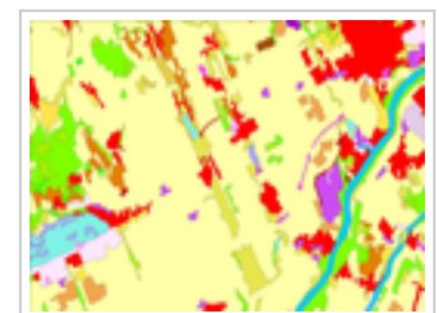
CLC 2000



CLC 2006



CLC 2012



CLC 2018





CORINE classes





Artificial surfaces
Agricultural areas

1. Artificial surfaces




1.1 Urban fabric

-  1.1.1. Continuous urban fabric
-  1.1.2. Discontinuous urban fabric



1.2 Industrial, commercial and transport units

-  1.2.1. Industrial or commercial units
-  1.2.2. Road and rail networks and associated land
-  1.2.3. Port areas
-  1.2.4. Airports

1.3 Mine, dump and construction sites

-  1.3.1. Mineral extraction sites
-  1.3.2. Dump sites
-  1.3.3. Construction sites

1.4 Artificial, non-agricultural vegetated areas




-  1.4.1. Green urban areas
-  1.4.2. Sport and leisure facilities

2. Agricultural areas

2.1 Arable land

-  2.1.1. Non-irrigated arable land
-  2.1.2. Permanently irrigated land
-  2.1.3. Rice fields

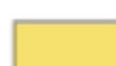



2.2 Permanent crops

-  2.2.1. Vineyards
-  2.2.2. Fruit trees and berry plantations
-  2.2.3. Olive groves

2.3 Pastures

-  2.3.1. Pastures

2.4 Heterogeneous agricultural areas

-  2.4.1. Annual crops associated with permanent crops
-  2.4.2. Complex cultivation patterns
-  2.4.3. Land principally occupied by agriculture
-  2.4.4. Agro-forestry areas



CORINE clases

Forest and
seminatural areas

Wetlands





Water bodies

3. Forest and seminatural areas

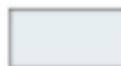

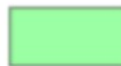


3.1 Forests

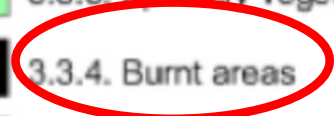
-  3.1.1. Broad-leaved forest
-  3.1.2. Coniferous forest
-  3.1.3. Mixed forest

3.2 Shrub and/or herbaceous vegetation associations

-  3.2.1. Natural grassland
-  3.2.2. Moors and heathland
-  3.2.3. Sclerophyllous vegetation
-  3.2.4. Transitional woodland shrub

3.3 Open spaces with little or no vegetation

-  3.3.1. Beaches, dunes, and sand plains
-  3.3.2. Bare rock
-  3.3.3. Sparsely vegetated areas
-  3.3.4. Burnt areas
-  3.3.5. Glaciers and perpetual snow



4. Wetlands

4.1 Inland wetlands



-  4.1.1. Inland marshes
-  4.1.2. Peat bogs

4.2 Coastal wetlands




-  4.2.1. Salt marshes
-  4.2.2. Salines
-  4.2.3. Intertidal flats

5. Water bodies

5.1 Inland waters

-  5.1.1. Water courses
-  5.1.2. Water bodies

5.2 Marine waters

-  5.2.1. Coastal lagoons
-  5.2.2. Estuaries
-  5.2.3. Sea and ocean












CORINE classes

Problems with

CORINE

We need to classify

Land Use classes

-  1.1.2. Discontinuous urban fabric
-  1.2.1. Industrial or commercial units
-  1.2.2. Road and rail networks and associated land
-  1.2.3. Port areas
-  1.4.1. Green urban areas
-  1.4.2. Sport and leisure facilities
-  2.1.1. Non-irrigated arable land
-  2.1.2. Permanently irrigated land
-  2.3.1. Pastures

CORINE classes

Example of **CORINE**
class



1.1.2. Discontinuous urban fabric

1.1.2



1.1.2



1.1.2



CORINE - definition and determination of classes

- **Method:**

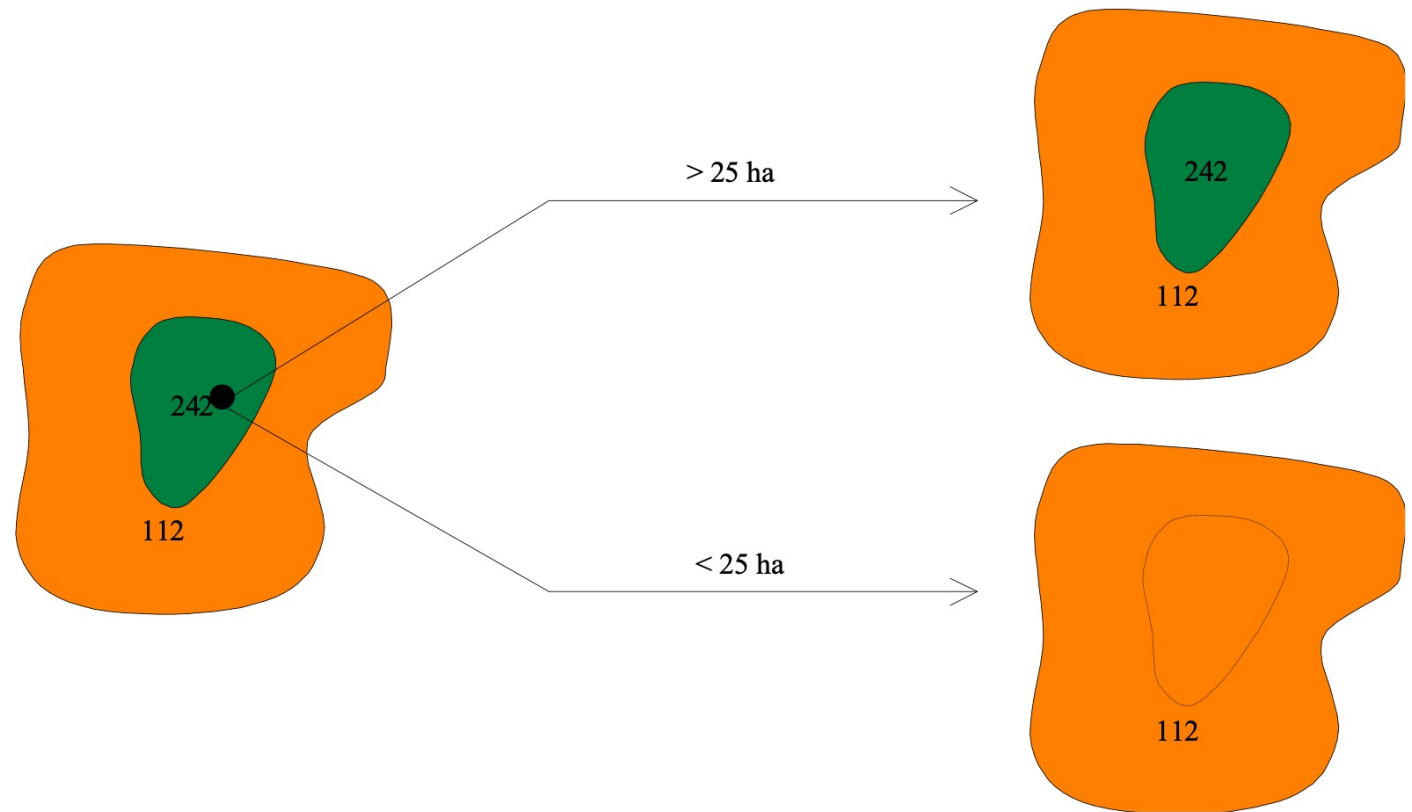
- visual interpretation using remote sensing data

- smallest mapped unit is 25 ha

- **Example:**

- vegetated space surrounded by discontinuous urban fabric

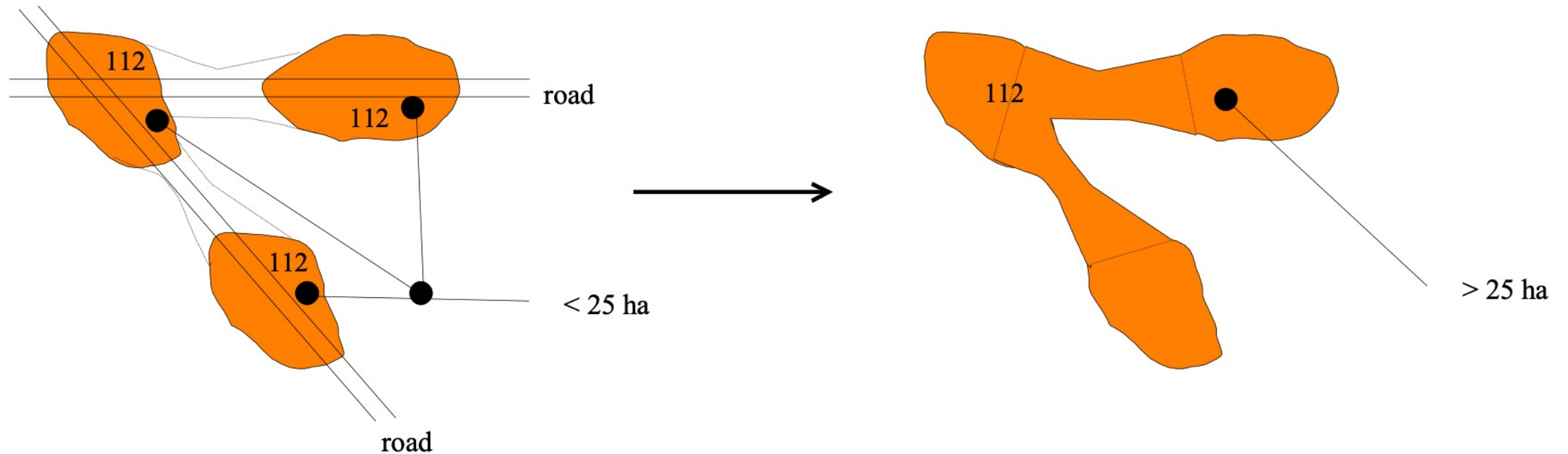
1.1.2. Discontinuous urban fabric areas



CORINE - definition and determination of classes

1.1.2. Discontinuous urban fabric areas

- grouped together if the distance < 300 m to reach **25 ha**
- exterior contour line leans on road network.



Open Street Map (OSM)

- The OSMs are an iterative ongoing work-in-progress.
- The aim is to produce maps which **can be relied upon**, equally well, or better than other maps.
- OpenStreetMap is not a complete or accurate map of the world
- and should not be used in such a manner that deficiencies, omissions, inaccuracies or errors could result in death, loss or injury.
- The monoclature respects keys and their values of individual countries
- Disclaimer.**the maps might not be reliable.**



Open Street Map



1 Primary features

1.1 Aerialway

1.2 Aeroway

1.3 Amenity

1.3.1 Sustenance

1.3.2 Education

1.3.3 Transportation

1.3.4 Financial

1.3.5 Healthcare

1.3.6 Entertainment, Arts & Culture

1.3.7 Others

1.4 Barrier

1.4.1 Linear barriers

1.4.2 Access control on highways

2 Additional properties

2.1 Addresses

2.1.1 Tags for individual houses

2.1.2 For countries using hamlet, subdistrict, district, province, state

2.1.3 Tags for interpolation ways

2.2 Annotation

2.3 Name

2.4 Properties

2.5 References

2.6 Restrictions


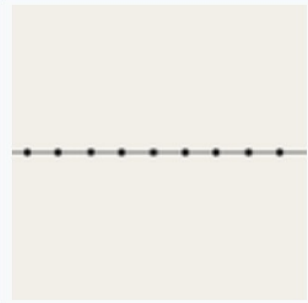





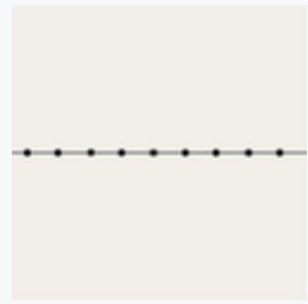




etc.

Open Street Map

1. Primary features

1.1. Aerialway

This is used to tag different forms of transportation for people or goods by using aerial wires. For example these may include cable-cars, chair-lifts and drag-lifts. See the page [Aerialway](#) for more information on the usage of these tags.

Key	Value	Element	Description	Map rendering	Image	Count
aerialway	cable_car		A cable car run. Just one or two large cars. The traction cable forms a loop, but the cars do not loop around, they just move up and down on their own side, rolling along static cables over which they are suspended.			3  1 337  11 
aerialway	gondola		An aerialway where the cabins go around in a circle			1  1 543  30 


Open Street Map



- 1 Primary features
 - 1.1 Aerialway
 - 1.2 Aeroway
 - 1.3 Amenity
 - 1.3.1 Sustenance

Amenity

Used to map facilities used by visitors and residents. For example: toilets, telephones, banks, pharmacies, cafes, parking and schools. See the page [Amenities](#) for an introduction on its usage.

Key	Value	Element	Comment	carto-Rendering ↗	Photo
Sustenance					
amenity	bar		Bar is a purpose-built commercial establishment that sells alcoholic drinks to be consumed on the premises. They are characterised by a noisy and vibrant atmosphere, similar to a party and usually don't sell food. See also the description of the tags amenity=pub;bar;restaurant for a distinction between these.		

CORINE versus

Open Street Map

CORINE	OSM
<p data-bbox="529 496 741 544">polygons</p>	<p data-bbox="1442 386 2150 434"><u>nodes</u> - defining points in space</p> <p data-bbox="1220 465 2372 512"><u>ways</u> - defining linear features and area boundaries</p> <p data-bbox="1258 544 2333 648"><u>relations</u> - sometimes used to explain how other elements work together</p>
<p data-bbox="438 686 830 733">3 level categories</p> <p data-bbox="476 765 792 812">1st 5 classes</p> <p data-bbox="481 843 787 891">2nd 15 classes</p> <p data-bbox="476 922 792 969">3rd 44 classes</p>	<p data-bbox="1289 765 2303 812">29 Primary Features of the 1st hierarchy levels</p> <p data-bbox="1488 843 2104 891">2 levels of Primary Features</p> <p data-bbox="1472 922 2119 969">(202 values of landuse in CR)</p>
<p data-bbox="211 1076 1059 1180">Updated CLC illustrated nomenclature guidelines, Kosztra, B. et al.</p>	<p data-bbox="1245 1133 2346 1180">https://wiki.openstreetmap.org/wiki/Map_features</p>

Conversion between Open Street Map (202 tags in CR) and **CORINE** (2nd level 15 classes)

OSM	CORINE															
	11	12	13	14	21	22	23	24	31	32	33	41	42	51	52	
	Urban f	Industrial	Mine, dump	Artificial, non-	Arable land	Permanent c	Pastures	Heterogeneous	Forests	Scrub and/c	Open space	Inland wetla	Maritime we	Inland waters	Marine waters	Others
landuse																
<i>allotments</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>basin</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>brownfield</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>cemetery</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>commercial</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>construction</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>farmland</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>farmyard</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>forest</i>	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>garages</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>grass</i>	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>greenfield</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>greenhouse_hortic ulture</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>industrial</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>landfill</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>meadow</i>	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>orchard</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>plant_nursery</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>quarry</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>railway</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>recreation_ground</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>reservoir</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

LUCAS

Land Use/Cover Area frame Survey



„**Point data**“ at a systematic grid of 2 x 2 km

Years:

2005, 2009, 2012, 2015, 2018

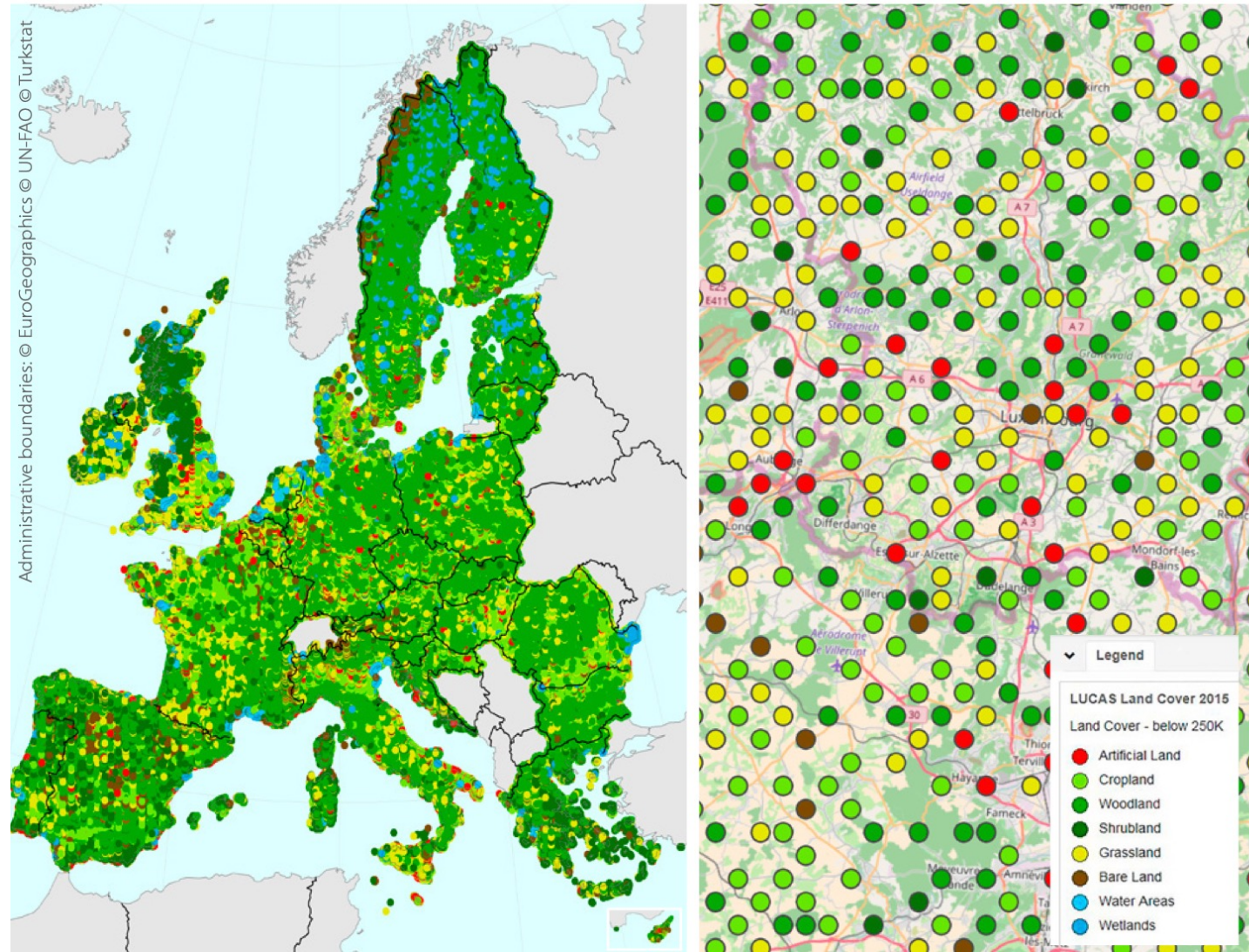
2015 over 270 000 points;

2018 1 090 863 points

Method

- field observation and
- photo-interpretation

ETRS89-extended / LAEA Europe as spatial reference system ([EPSG:3035](https://epsg.org/epsg/3035))



LUCAS

Land Cover

1st level
8 categories

2nd level
30 categories

3rd level
76 categories

Land cover			
A00	ARTIFICIAL LAND	A10	Roofed built-up areas
		A20	Artificial non-built up areas
		A30	Other artificial areas
B00	CROPLAND	B10	Cereals
		B20	Root crops
		B30	Non-permanent industrial crops
		B40	Dry pulses, vegetables and flowers
		B50	Fodder crops
		B70	Permanent crops: fruit trees
		B80	Other permanent crops
C00	WOODLAND	C10	Broadleaved woodland
		C20	Coniferous woodland
		C30	Mixed woodland
D00	SHRUBLAND	D10	Shrubland with sparse tree cover
		D20	Shrubland without tree cover
E00	GRASSLAND	E10	Grassland with sparse tree/shrub cover
		E20	Grassland without tree/shrub cover
		E30	Spontaneously re-vegetated surfaces
F00	BARE LAND AND LICHENS/MOSS	F10	Rocks and stones
		F20	Sand
		F30	Lichens and moss
		F40	Other bare soil
G00	WATER AREAS	G10	Inland water bodies
		G20	Inland running water
		G30	Transitional water bodies
		G40	Sea and ocean
		G50	Glaciers, permanent snow
H00	WETLANDS	H10	Inland wetlands
		H20	Coastal wetlands

Artificial land



© European Union LUCAS

Cropland



© European Union LUCAS

Woodland



© European Union LUCAS

Shrubland



© European Union LUCAS

Grassland



© European Union LUCAS

Bare land



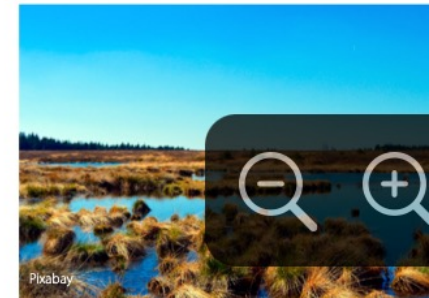
© European Union LUCAS

Water areas



© European Union LUCAS

Wetlands



Pixabay

LUCAS

Land Cover Categories

3rd level 76 subclasses

3 levels of the Artificial Land

A00 ARTIFICIAL LAND

A10 BUILT-UP AREAS

A11 Buildings with one to three floors

A12 Buildings with more than three floors

A13 Greenhouses

A20 ARTIFICIAL NON-BUILT UP AREAS

A21 Non built-up area features

A22 Non built-up linear features

LUCAS

Land Use Categories

4 sectors

33 subclasses

2 levels of Land Use – example of the secondary sector

U220 INDUSTRY AND MANUFACTURING

U221 Manufacturing of food, beverages and tobacco products

U222 Manufacturing of textile products

U223 Coal, oil and metal processing

U224 Production of Non-metal mineral goods

U225 Chemical and allied industries and manufacturing

U226 Machinery and equipment

U227 Wood based products

primary sector

secondary sector

tertiary sector

other use



LUCAS - link between LC and LU

FOO BARE LAND AND LICHENS/MOSS

Land Cover

links to

Land Use

F10 ROCKS AND STONES



This class includes

- Inland rock cliffs
- Areas of rock outcrop and limestone parent
- Scree
- Block litter and mountain top debris
- Land covered with recent volcanic features

- F10 ➤ U140 Scrapped or excavated areas for quarrying, mining purposes
- F10 ➤ U21x Rocky areas attached to energy production
- F10 ➤ U22x Rocky areas attached to industrial use
- F10 ➤ U31x Rocky areas attached to transport areas
- F10 ➤ U330 Construction sites
- F10 ➤ U34x Rocky areas attached to commercial services
- F10 ➤ U350 Rocky areas attached to community services
- F10 ➤ U36x Rocky areas used for recreational and leisure purposes
- F10 ➤ U370 Rocky areas attached to residential areas
- F10 ➤ U4x0 Rocky areas not used (inland rocks, top mountains)

LUCAS

Method of data collection

Homogeneous land cover

point "area" (7 m²),
i.e. 1,5 m radius

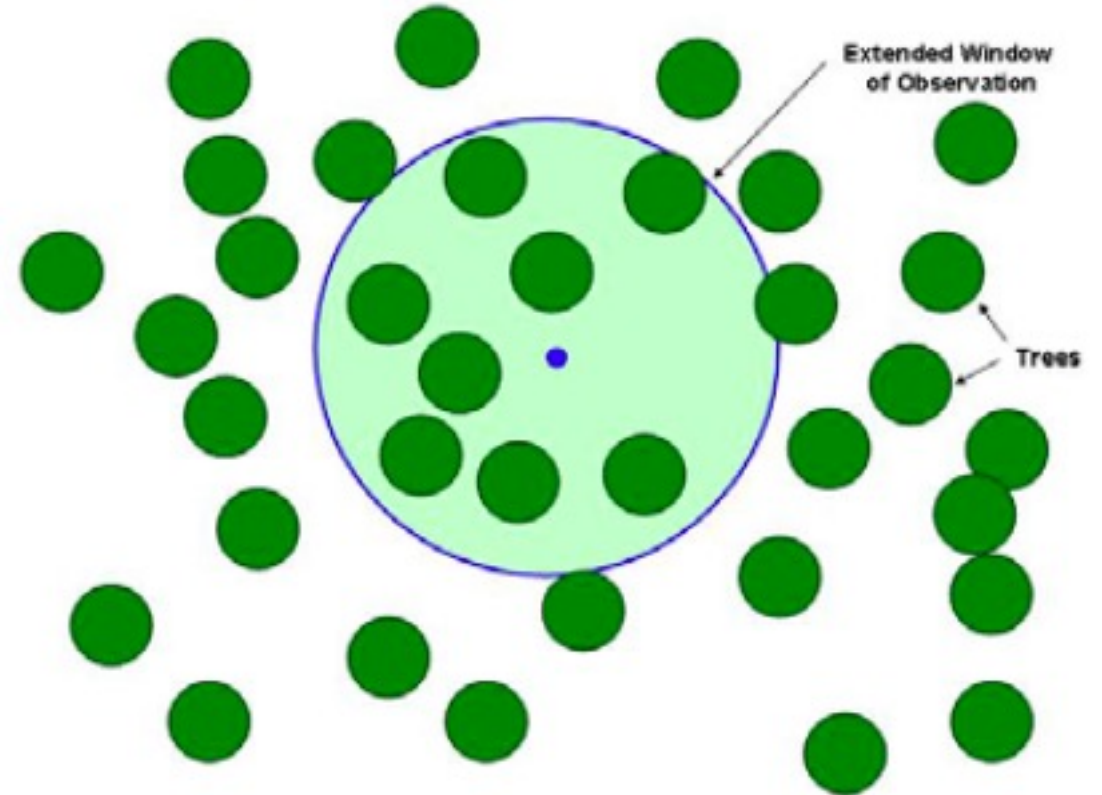


LUCAS

Method of data collection

Non-homogeneous land cover:
i.e., trees or shrubs interspersed with grassland,

Extended Window of Observation:
a radius of 20 meters, i.e., 0,13 ha



Radius 1,5 m



Radius 20 m



Conversion between

LUCAS (30 classes 2nd level) and CORINE (to 2nd level and 3rd level classes)

LUCAS 2nd level (LC2)	LC2 code	CORINE 2nd level code	CORINE 3rd level code	note
Roofed built-up areas	A10	11		
Artificial non-built up areas	A20	12	122	
Other artificial areas	A30			could be 122 or 132
Cereals	B10	21	211	contains rice
Root crops	B20	21	211	
Non-permanent industrial crops	B30	21	211	
Dry pulses, vegetables and flowers	B40	21	211	
Fodder crops	B50	21	211	possible pastures (23)
Permanent crops: fruit trees	B70	22	222	
Other permanent crops	B80	22		vineyards, olive groves, nurseries?
Broadleaved woodland	C10	31	311	
Coniferous woodland	C20	31	312	
Mixed woodland	C30	31	313	

Conversion between OSM and LUCAS for the project

LUCAS

OSM 10 Classes. - LUCAS

OSM 20 classes - LUCAS

Land cover			
A00	ARTIFICIAL LAND	A10	Roofed built-up areas
		A20	Artificial non-built up areas
		A30	Other artificial areas
B00	CROPLAND	B10	Cereals
		B20	Root crops
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		B80	Other permanent crops
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		D20	Shrubland without tree cover
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		E20	Grassland without tree/shrub cover
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		F30	Lichens and moss
		F40	Other bare soil
G00	WATER AREAS	G10	Inland water bodies
		G20	Inland running water
		G30	Transitional water bodies
		G40	Sea and ocean
		G50	Glaciers, permanent snow
H00	WETLANDS	H10	Inland wetlands
		H20	Coastal wetlands

Artificial	A10, A20
Cropland	B10..B40
	B50
Perennial crops	B70, B80
Forest	C10, C20
Shrubland	D20
Grassland	E20, B50?
Barren	F00
Wetlands	H00
Water	G10, G20, G40
Glaciers, permanent snow	G50

Roofed built-up areas	A10
Artificial non-built up	A20
Mine, dump	
Urban green	
Cropland seasonal	B10..B40
Irrigated cropland	
Pastures	B50?
Perennial crops	B70, B80?
Forest Broadleaf	C10
Forest Coniferous	C20
Forest Mixed	C30
Shrubland	D20
Natural grassland	E20
Barren	F00
Inland Wetlands	H10
Coastal wetlands	H20
Water bodies	G10
Water courses	G20
Ocean	G40
Glaciers, permanent snow	G50

Remote sensing data



Open data: Landsat, Sentinel Data

2000 -2019

Landsat data – Landsat 5 (TM), Landsat 7 (ETM+), Landsat 8 (OLI)

2015 - 2019

Sentinel-2

4 seasons :

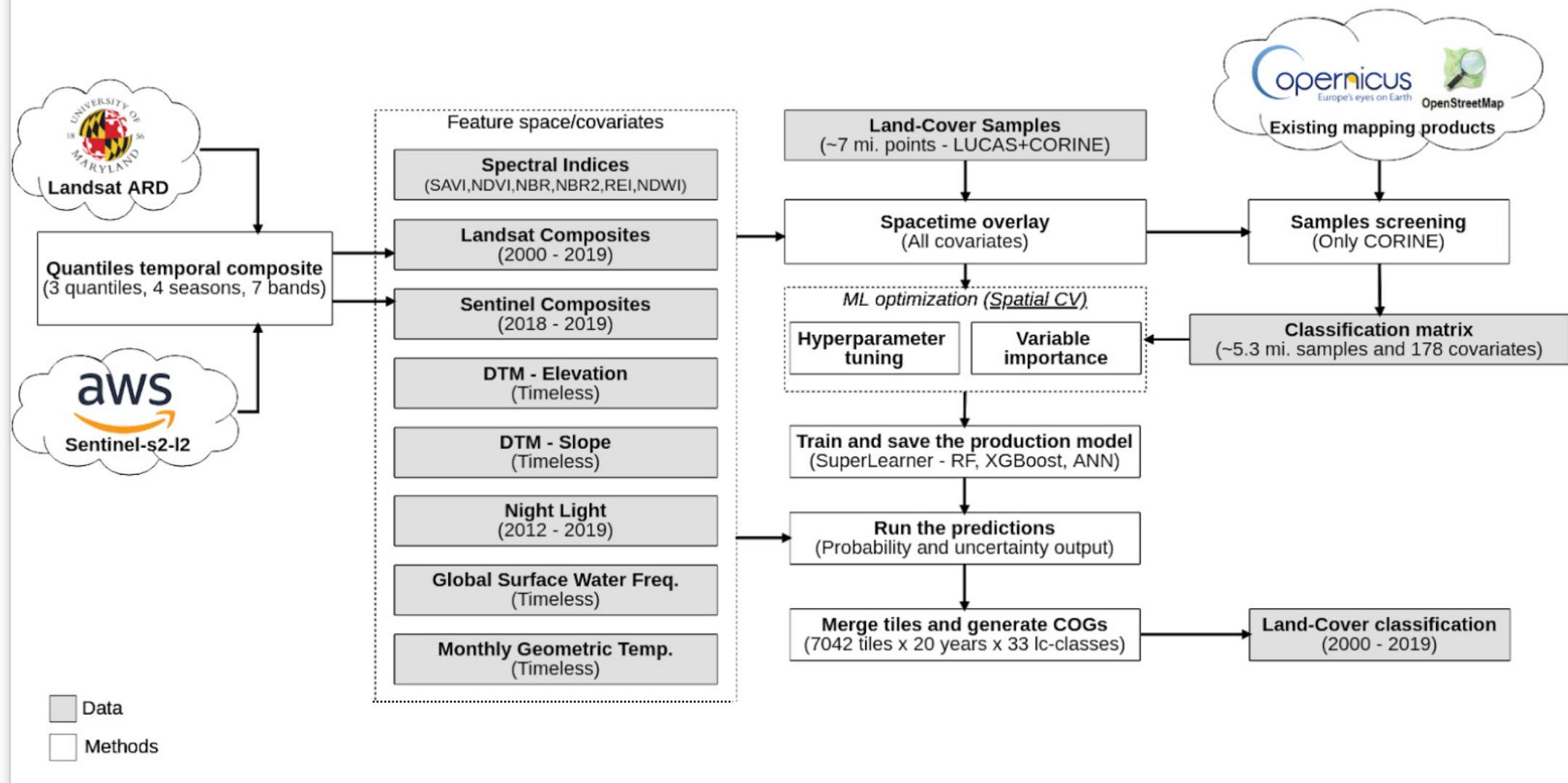
Winter: December 2 of previous year until March 20 of current year

Spring: March 21 until June 24 of current year

Summer: June 25 until September 12 of current year

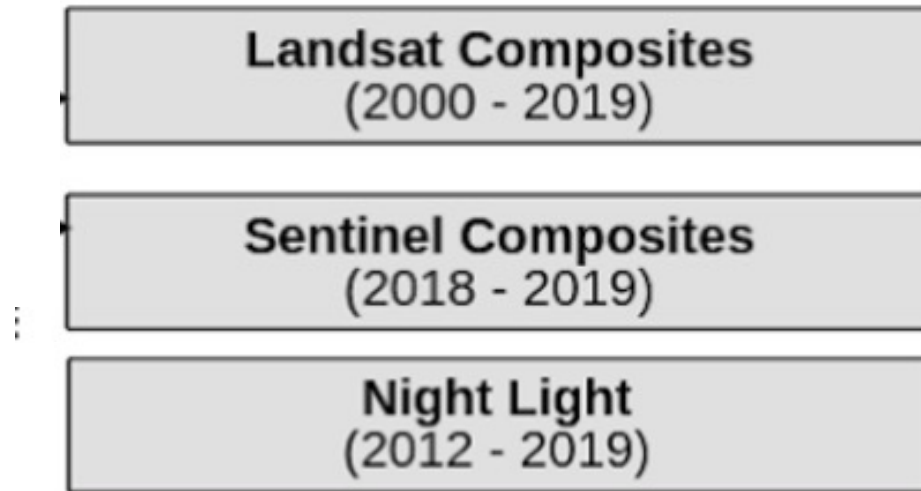
Fall: September 13 until December 1 of current year

EU land cover mapping - workflow



EU land cover mapping: workflow

satellite data
preprocessing

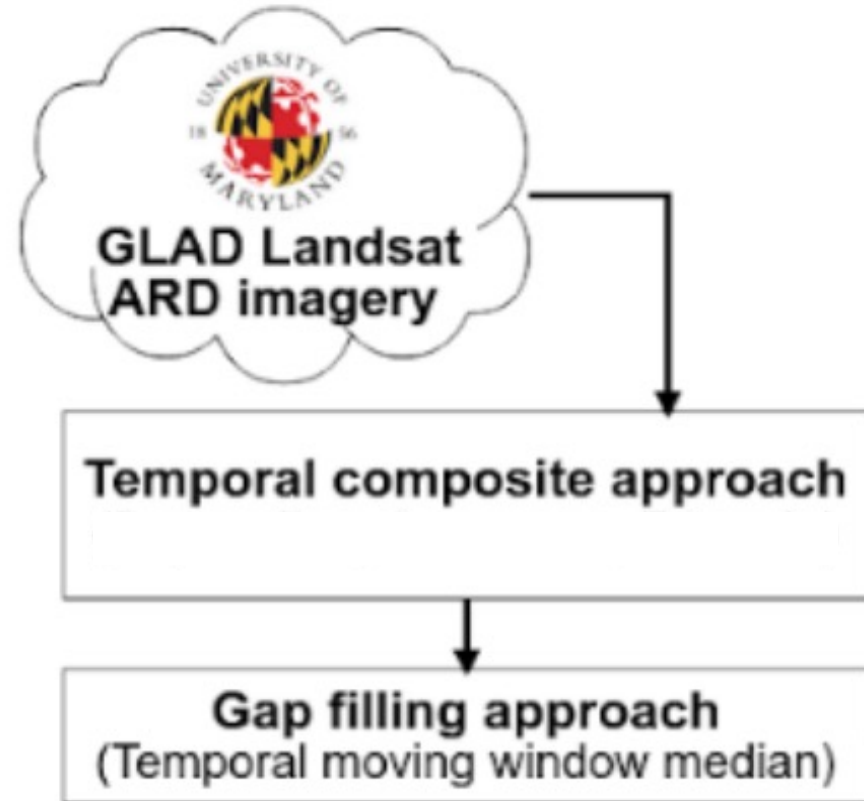


Night Light / VIIRS/NPP

Visible Infrared Imaging Radiometer Suite (VIIRS/NPP) is nighttime radiance product

EU land cover mapping: workflow

1st step
satellite data pre-
processing gap filling

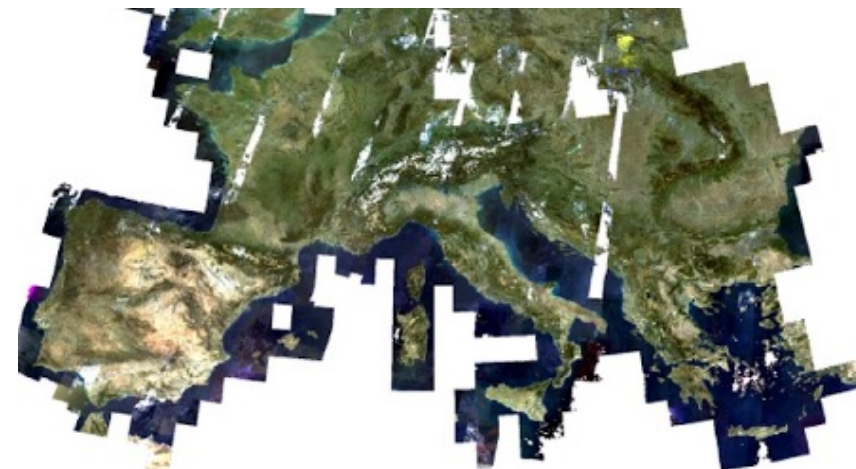


Gap Filling for Landsat Mosaics

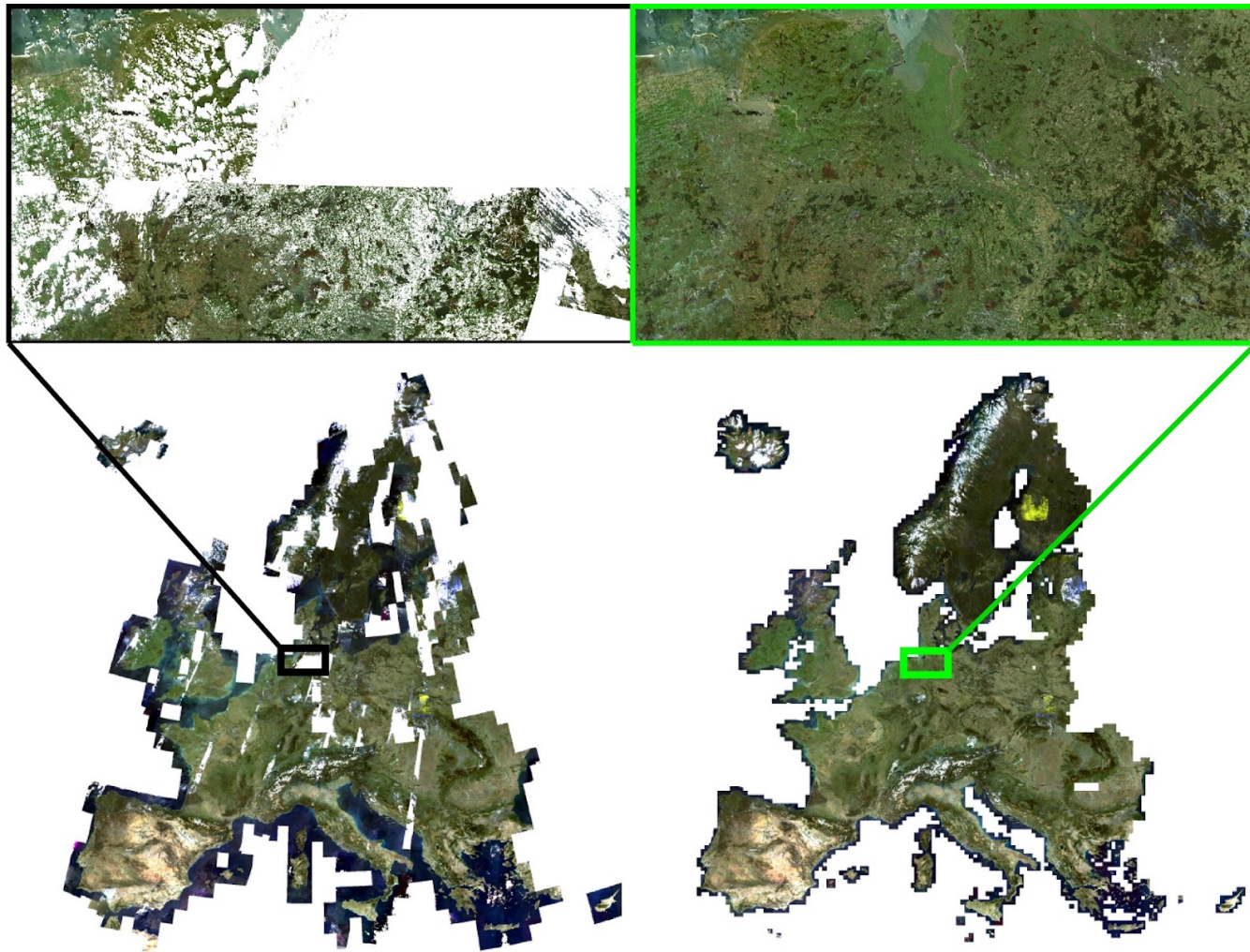
Where: clouds, shadows, non-existing data,

Method: based on
Landsat Analysis Ready Data (GLAD ARD)
developed by the [Global Land Analysis and Discovery](#) (GLAD)

*(Landsat Analysis Ready Data for Global Land Cover and Land Cover Change Mapping
Peter Potapov *, Matthew C. Hansen , Indrani Kommareddy, Anil Kommareddy,
Svetlana Turubanova, Amy Pickens, Bernard Adusei, Alexandra Tyukavina and Qing Ying
Remote Sens. 2020, 12, 426; doi:10.3390/rs12030426)*



Gap Filling for Landsat Mosaics



Method: Temporal Moving Window Median-TMWM
temporal_step=8

Production:

All the [GeoHarmonizer tiles](#) were gapfilled generating 23,661,120 individual files,

7 bands (Blue, Green, Red, NIR, SWIR1, SWIR2 and Thermal),

20 years (2000 - 2019) and 4 seasons were processed.

Gap Filling for Landsat Mosaics

Long-Term Median Improvement

Pixels with gaps are filled in by the following options

9 priorities combined with 3 different sizes

1st – 3rd priority = windows 1, 2, 3 from **the same season**: *median value*

4th – 6th priority = windows 1, 2, 3 from **fall and spring**: *average of medians*

7th – 9th priority = windows 1, 2, 3 from **spring, summer and fall**: *median*

3 sizes of moving windows:

window 1: 8 neighboring periods - 4 before and after

window 2: 16 neighboring periods – 8 before and after

window 3: 24 neighboring periods – 12 before and after

The 1st preference the same season with window 1

EU land cover mapping: workflow

Multispectral image enhancement

Spectral Indices (SAVI,NDVI,NBR,NBR2,REI,NDWI)

Soil Adjusted Vegetation Index

$$SAVI = \frac{1.5 * (NIR - Red)}{(NIR + Red + 0.5)}$$

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Normalized Burn Ratio

$$NBR = (NIR - SWIR) / (NIR + SWIR)$$
$$NBR2 = (SWIR1 - SWIR2) / (SWIR1 + SWIR2)$$

Riparian Ecosystem Index

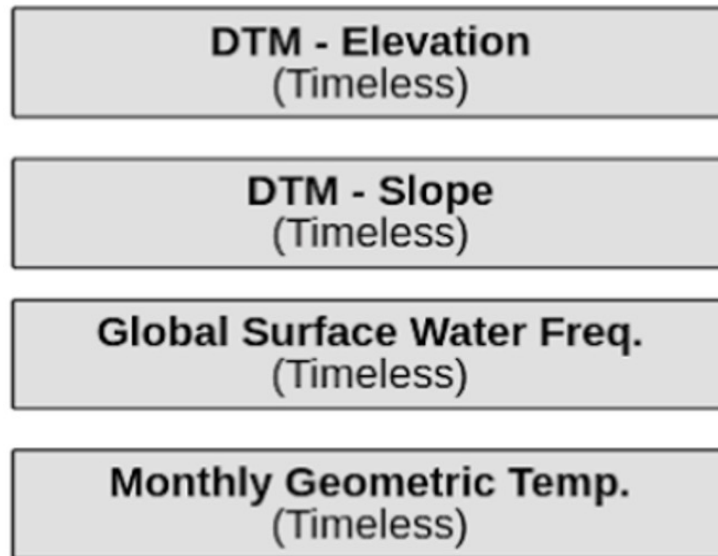
$$REI = NIR2 - B/NIR2 + B \times NIR2$$

Normalized Difference Water Index

$$NDWI = \frac{(\rho_{857} - \rho_{1241})}{(\rho_{857} + \rho_{1241})}$$

EU land cover mapping - workflow

Other data layers



Global Surface Water

Value	Label
0	Not water
1	1% occurrence
100	100 % occurrence
255	No data

Global Surface Water

1984 – 2019 JRC: <https://global-surface-water.appspot.com/download>

Monthly Geometric Temperature

Spatio-temporal interpolation of daily temperatures for global land areas at 1km resolution

[Milan Kilibarda](#) et al

<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2013JD020803>

EU land cover mapping: workflow

training and testing
pixel selection



Training data	Validation data
Lucas (80%)	Lucas (20%) Corine (100%)
Corine (80%)	Corine (20%) Lucas (100%)
All (80%)	All (20%)

7 million pixels selected
5,3 mi used for classification

EU land cover mapping – workflow

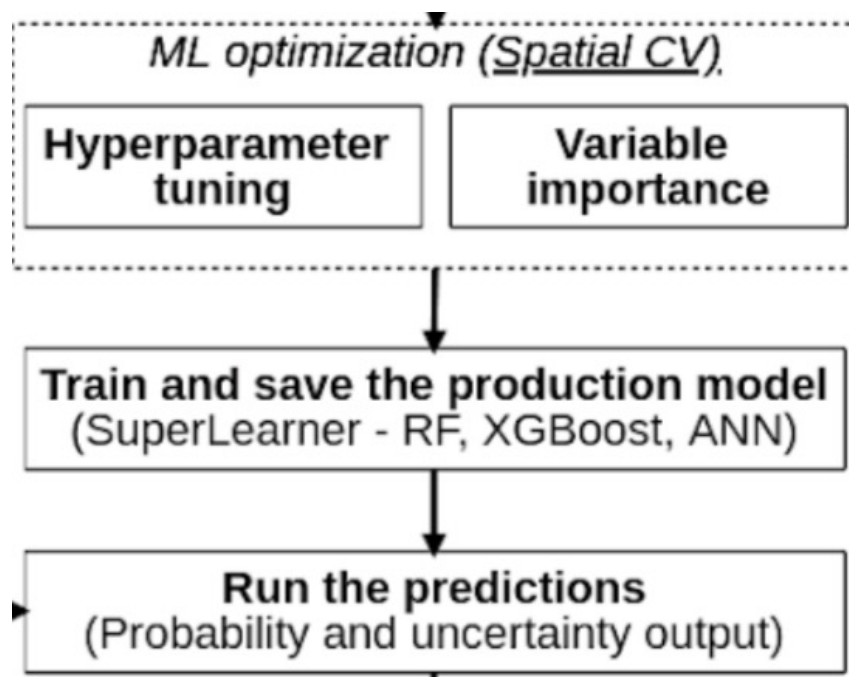
training and testing
pixels selection

Improvement of selection of pixels

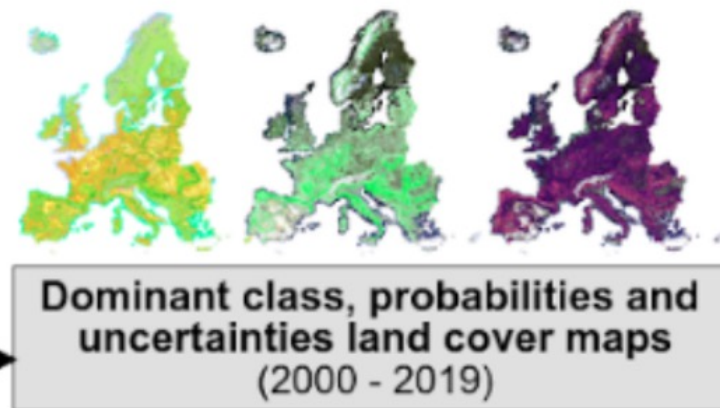
lc_class	condition	tree_cover	grasslands	imperv
111: Urban fabric	AND			
122: Road and rail networks and associated land	OR			>
131: Mineral extraction sites	AND	equals 0	equals 0	
141: Green urban areas	OR	> 0	> 0	
211: Non-irrigated arable land	AND	equals 0		
221: Vineyards	AND		equals 0	
222: Fruit trees and berry plantations	AND		equals 0	
223: Olive groves	AND		equals 0	

EU land cover mapping – workflow

classification



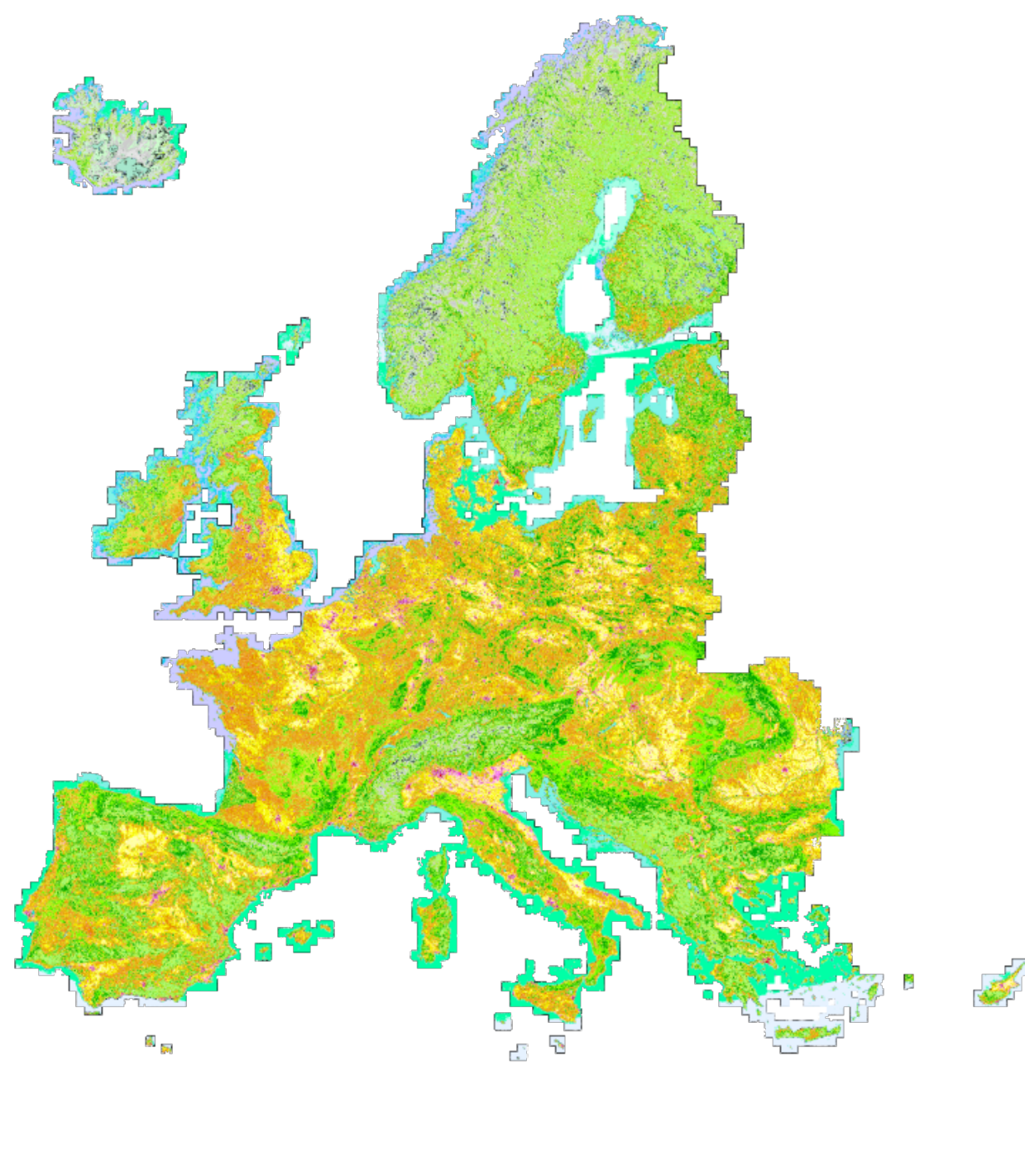
Classification matrix
5,3 mi pixels
178 covariates



- 111-Urban fabric
- 122-Road and rail networks and associated land
- 123-Port areas
- 124-Airports
- 131-Mineral extraction sites
- 132-Dump sites
- 133-Construction sites
- 141 Green urban areas
- 211-Non-irrigated arable land
- 212-Permanently irrigated arable land
- 213-Rice fields
- 221-Vineyards
- 222-Fruit trees and berry plantations
- 223-Olive groves
- 231-Pastures
- 311-Broad-leaved forest
- 312-Coniferous forest
- 321-Natural grasslands
- 322-Moors and heathland
- 323-Sclerophyllous vegetation
- 324-Transitional woodland-shrub
- 331-Beaches, dunes, sands
- 332-Bare rocks
- 333-Sparsely vegetated areas
- 334-Burnt areas
- 335-Glaciers and perpetual snow
- 411-Inland wetlands
- 421-Maritime wetlands
- 511-Water courses
- 512-Water bodies
- 521-Coastal lagoons
- 522-Estuaries
- 523-Sea and ocean

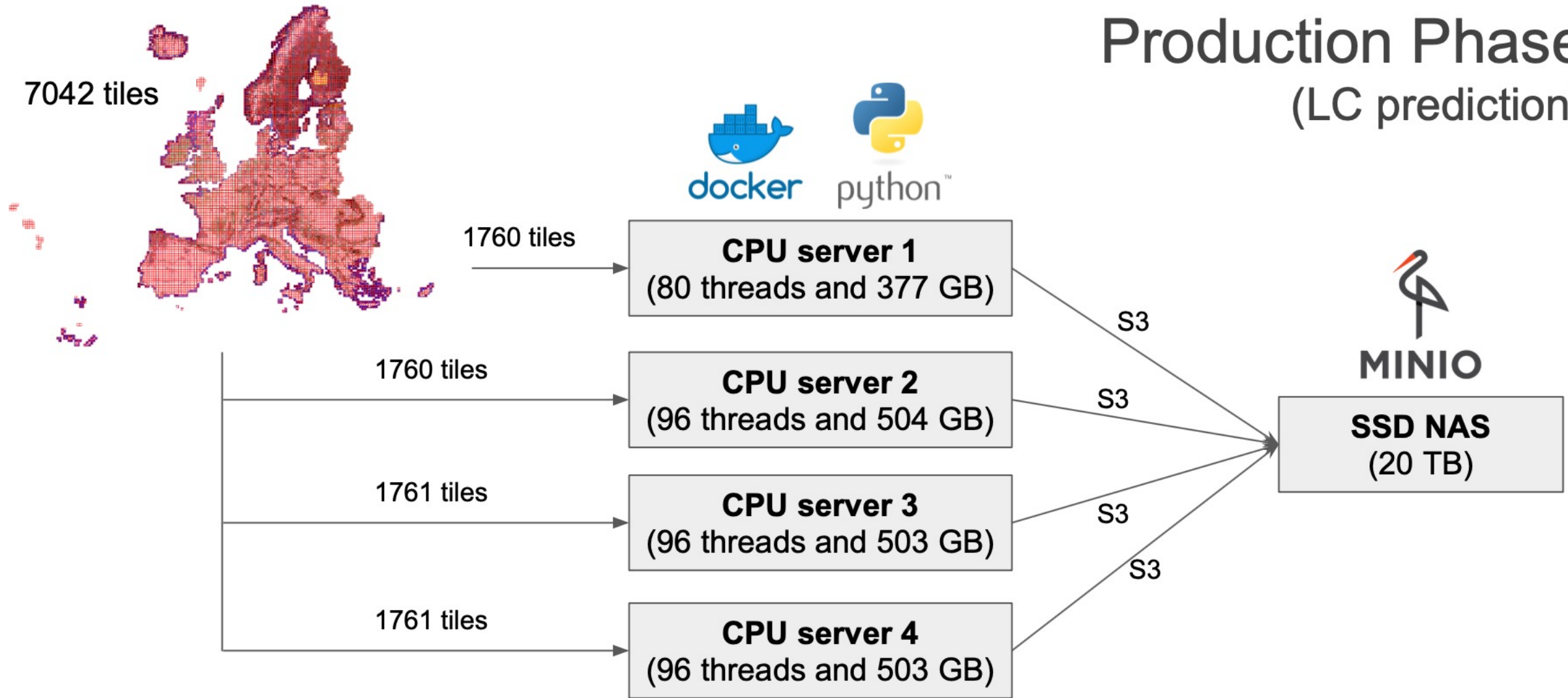
Unclassified CORINE classes:

- 112 Discontinuos urban fabric
- 121 Industrial or commercial units
- 142 Sport and leisure activities
- 24 Heterogenous agricultural areas
- 313 Mixed forest
- 412 Peat bogs
- 422 Salines
- 423 Inertidal flats



Production Phase

(LC prediction)



7042 tiles x 3.5 min / 4 server

4.2 days

Conclusion

Land Cover, its classification and harmonization is a complex problem due to:

1) Existing detailed nomenclatures and their harmonization

- a. which are a combination of LU and LC
- b. and therefore the class definitions mostly do not respect spectral feature space
- b. where many classes in one nomenclature comprise more classes of the other nomenclature

2) Atmospheric conditions – even though gap filling methods are able to replace non-existing data, the training phase uses many pixels where the spectral values is a combination of spectral values even of all seasons.

Conclusion

The project is based on **open data** – therefore we are limited in the remote sensing data choice which means a relatively low number of remote sensing data especially before Sentinel-2

The rest of the project will be focused on

the nomenclature tuning and

training of the machine learning models to improve the accuracy which has not yet reached acceptable values.

The project ends in June 2022