

eurac research

Introduction to land cover mapping



Land cover / land use

Land cover (LC) can be defined as the “observed (bio) physical cover of the earth’s surface”, and is a synthesis of the many processes taking place on the land. It reflects land occupation (and its transformation) by various natural, modified or artificial systems and to some extent how these systems affect the land.

Examples:

- "grassland" is a cover term, while "rangeland" or "tennis court" refer to the use of a grass cover;
- "recreation area" is a land use term that may be applicable to different land cover types: for instance sandy surfaces like a beach; a built-up area like a pleasure park; woodlands; etc.

Land use (LU) is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Definition of land use in this way establishes a direct link between land cover and the actions of people in their environment.

Di Gregorio & Jansen, 2000

Land cover – a cross-cutting variable



WATER

Water resources / quality
Land + water use pattern

CLIMATE

Land change / GHG emissions
Water + energy exchanges

WEATHER

Land surface climate interactions
Vegetation characteristics

ENERGY

Bio-energy / biomass
Wind / hydro power assessments

ECOSYSTEMS

Change environment conditions
Services + accounting

HEALTH

Land change / diseases
Vectors / boundary conditions

AGRICULTURE

Cultivation pattern + forestry
Land degradations

DISASTERS

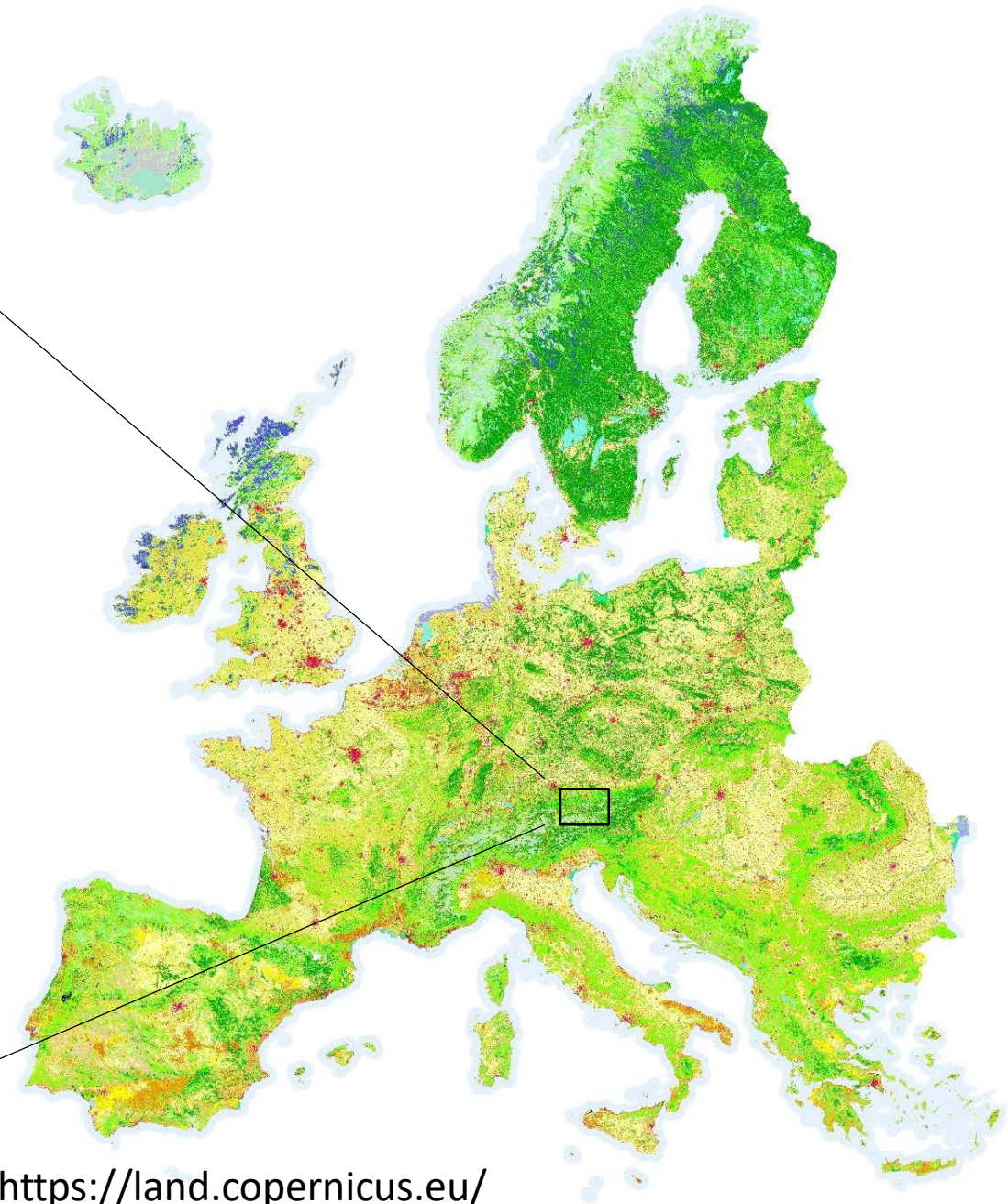
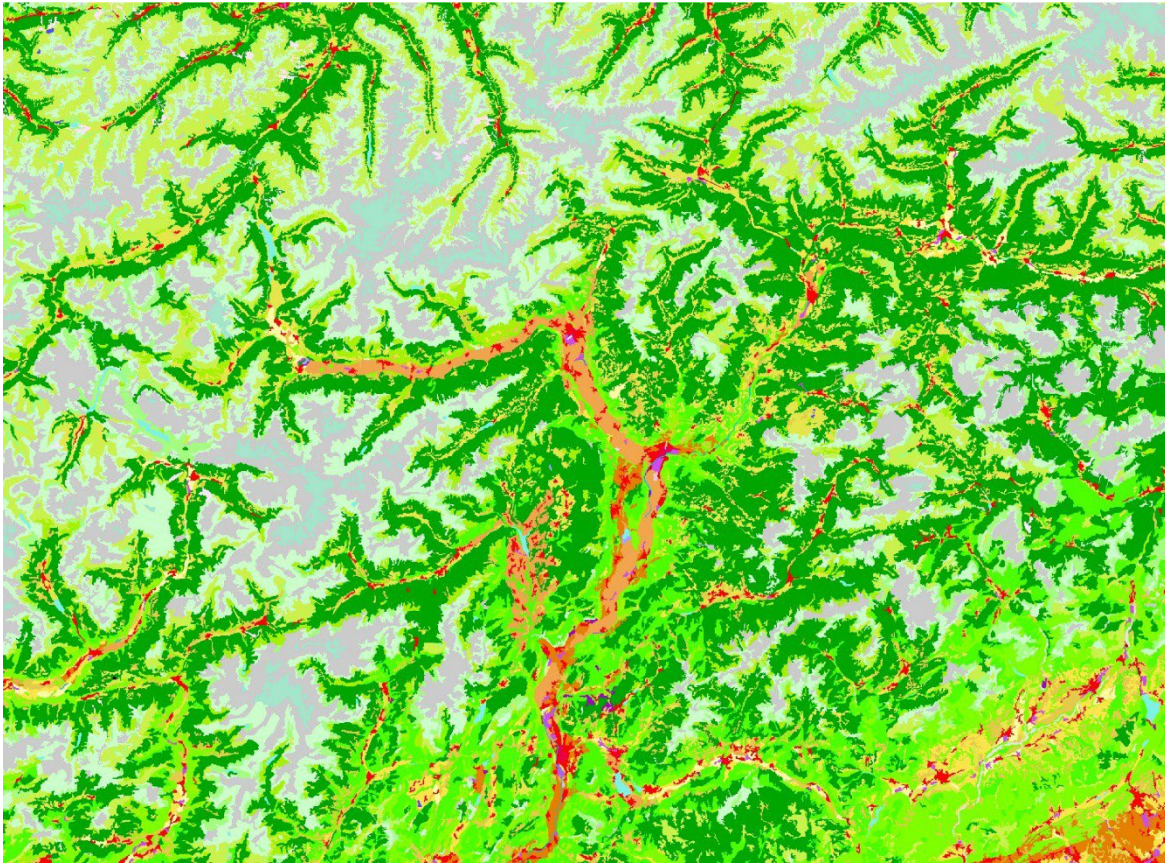
Fire monitoring
Land degradation assessments

BIODIVERSITY

Ecosystem characteristics
Habitats + fragmentation

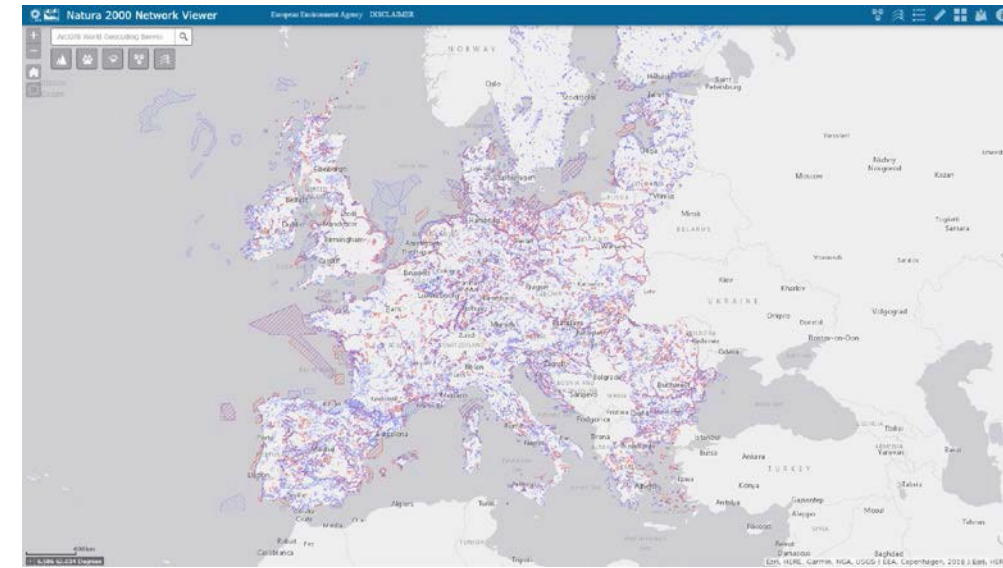
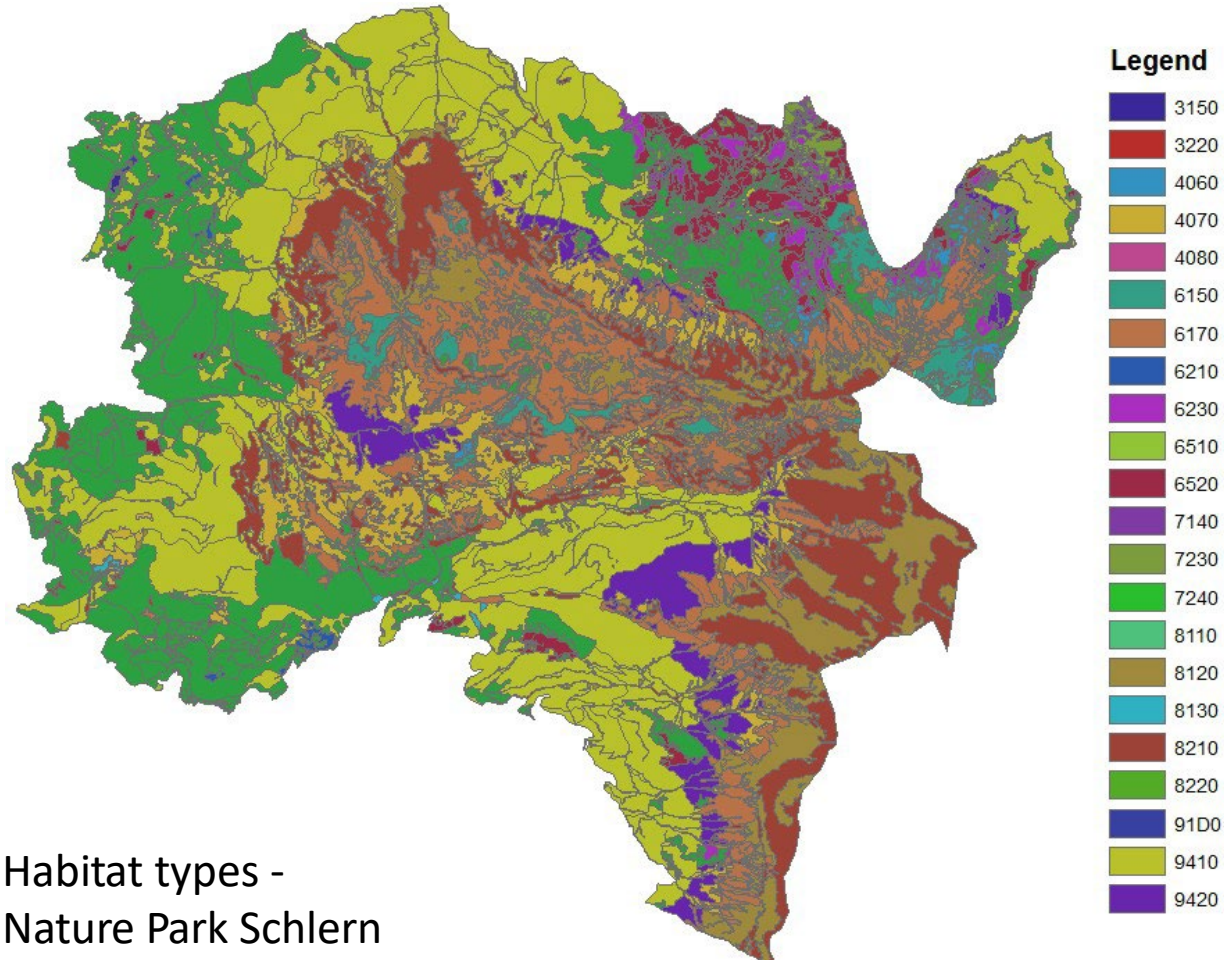
FAO, 2016

Land cover – land use

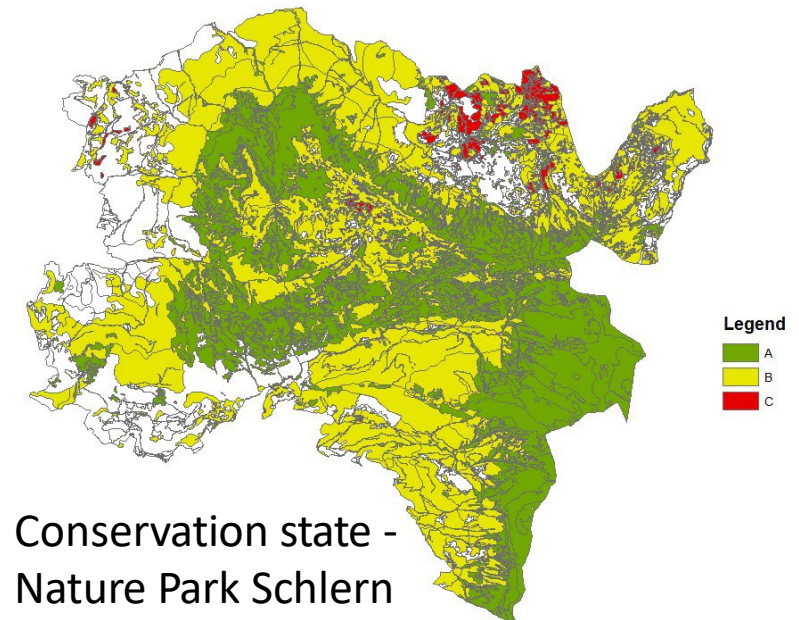


<https://land.copernicus.eu/>

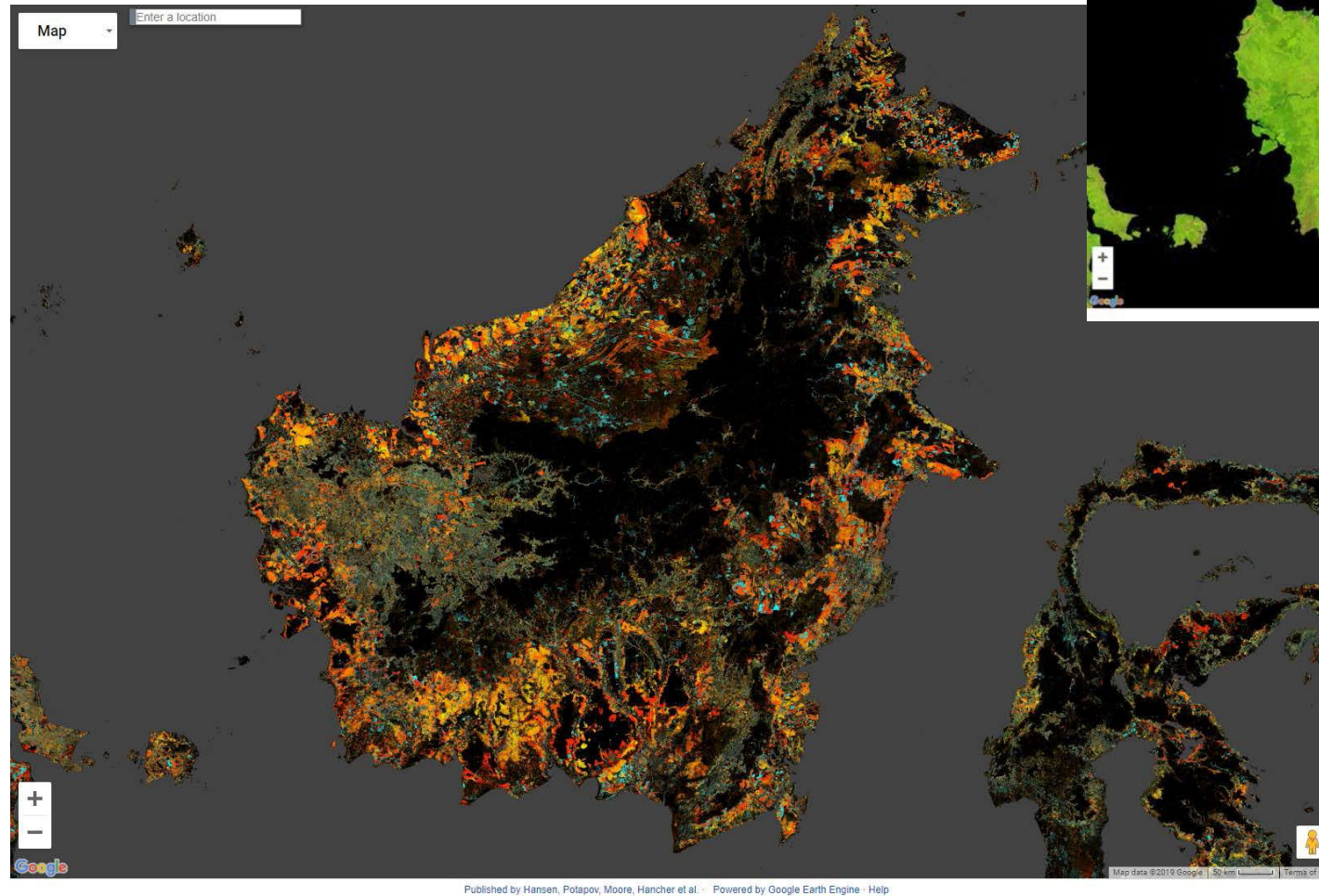
Habitat types



<http://natura2000.eea.europa.eu/>



Forest change

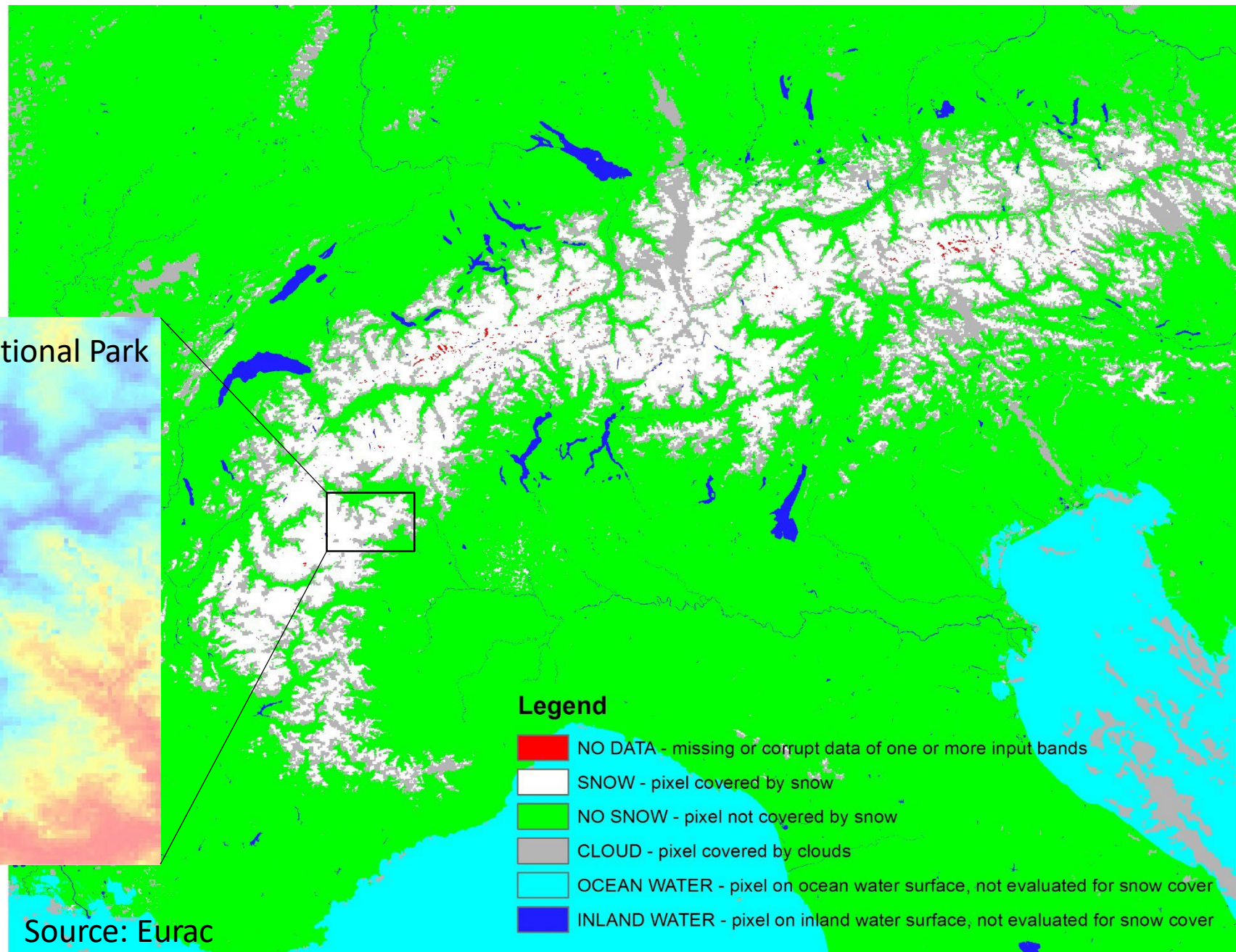
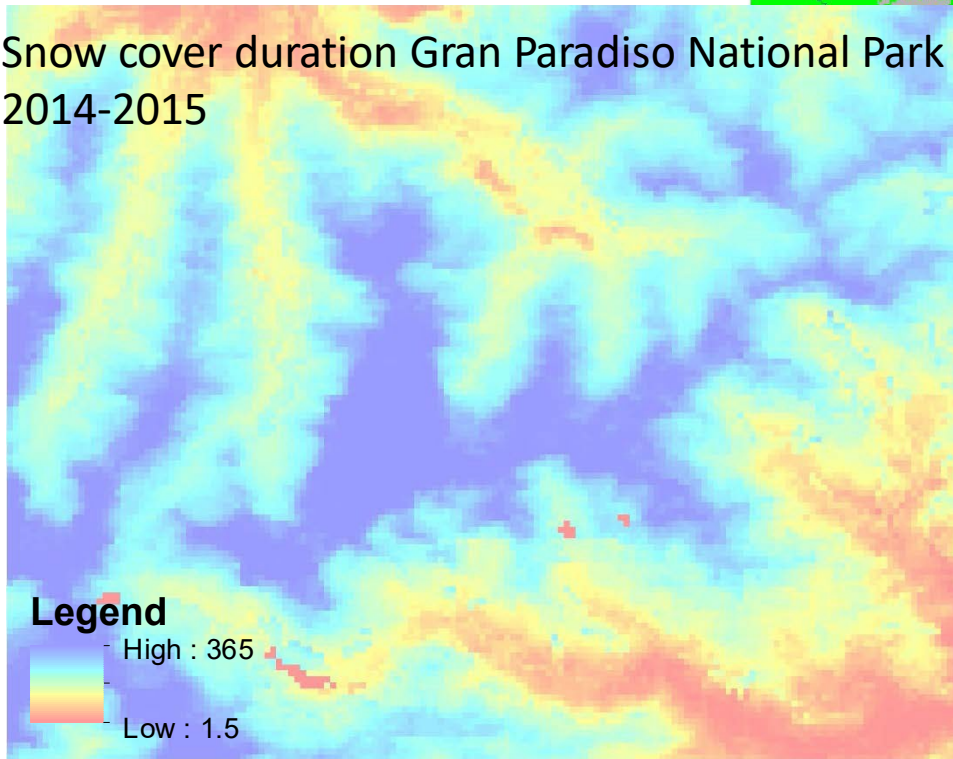


<https://www.globalforestwatch.org>

<http://earthenginepartners.appspot.com/science-2013-global-forest>

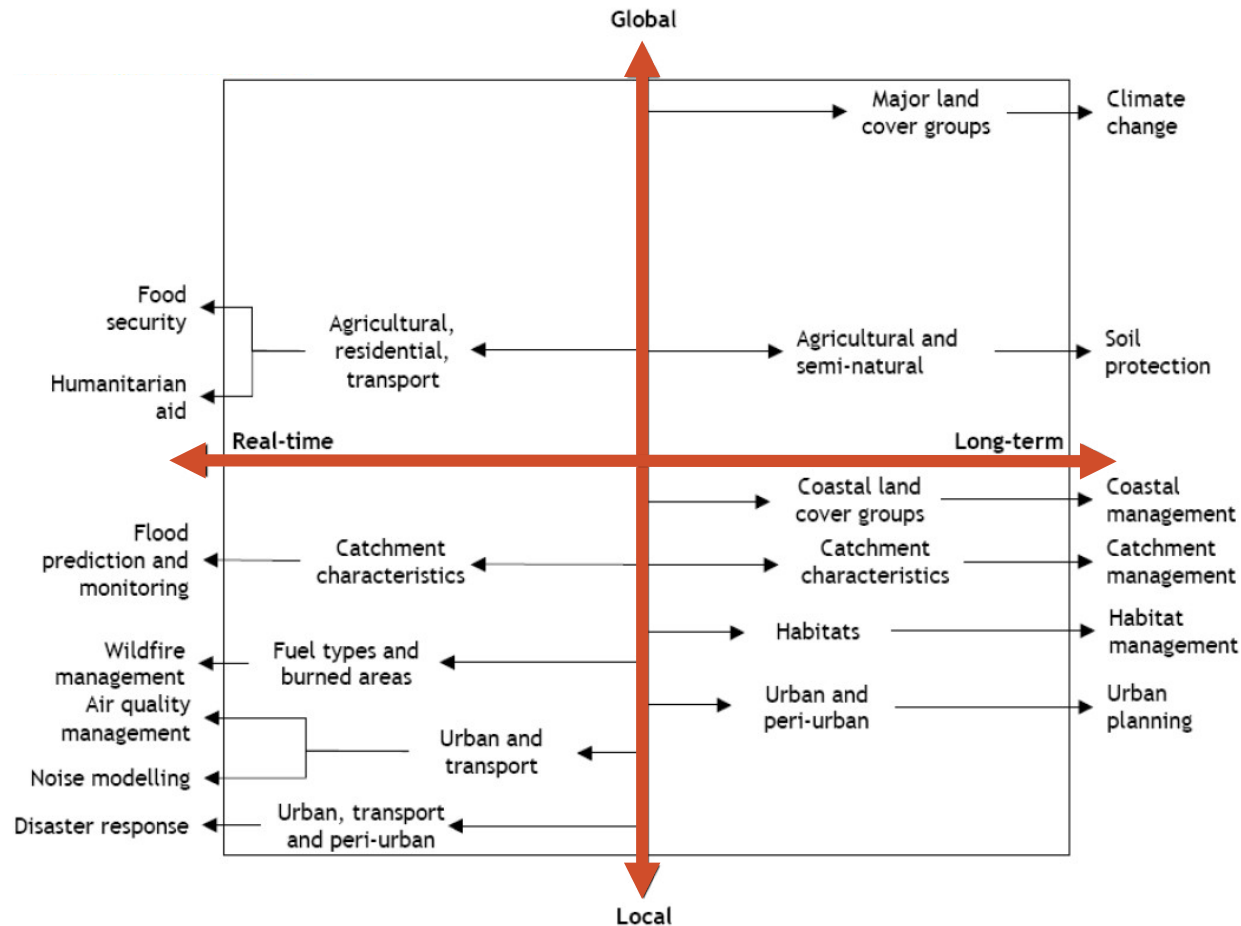
Snow cover

Snow cover duration Gran Paradiso National Park
2014-2015



Source: Eurac

Land cover maps – user needs



Use of land cover maps:

- Landscape characterization (composition, condition and dynamics)
- Input for environmental models
- As surrogate/proxies for other variables

Source: EC

Earth Observation and land cover mapping

Land cover mapping:

- Process of information extraction governed by a process of generalization and abstract representation of the real world

Earth Observation:

- Consistent monitoring of the Earth's surface
- Valuable source of land cover information
- Global products
- Continental products
- National products

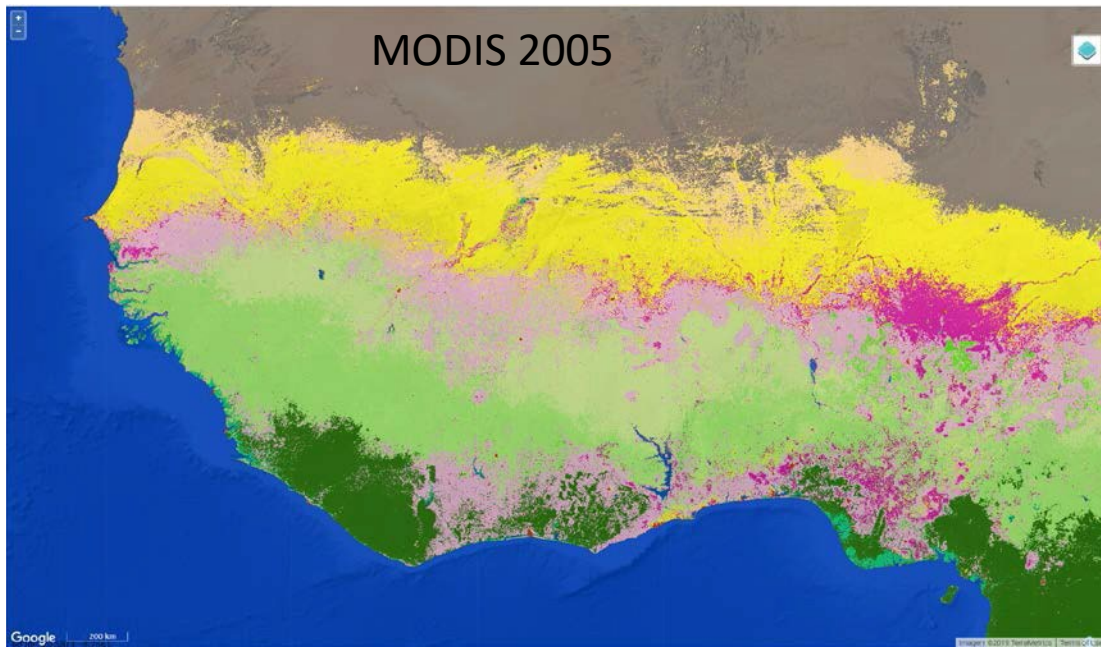


<https://www.esa.int>

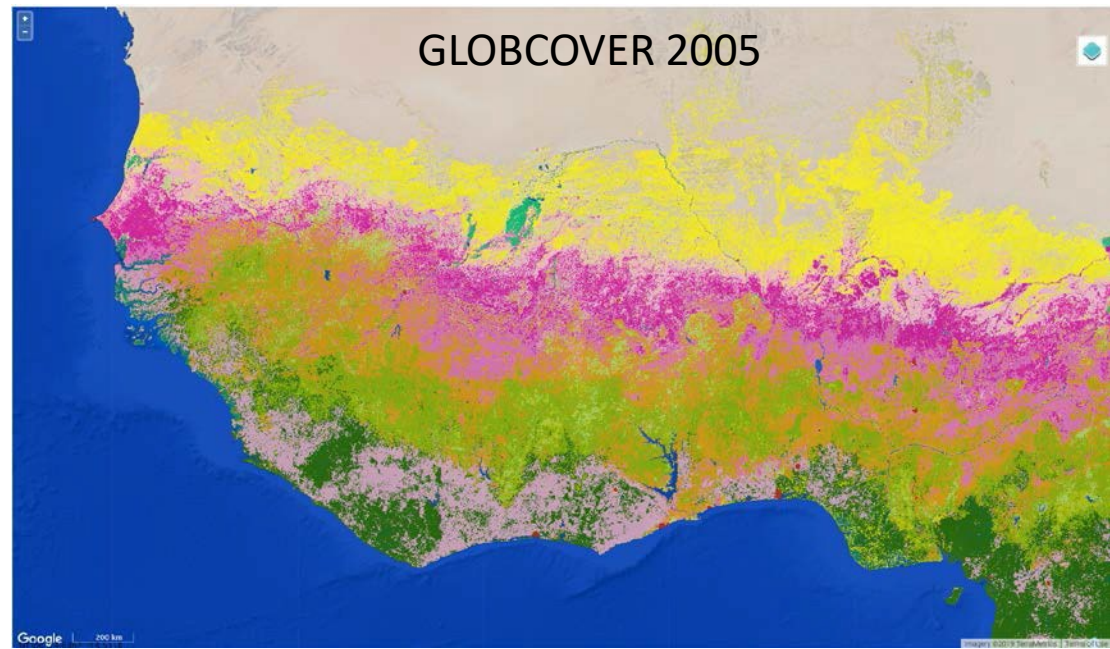
Global Earth Observation land cover products

Data set	Spatial resolution	Overall accuracy	Sensor	Classification Scheme	Period of data acquisition
GLCC 2.0	1 km	66.9	AVHRR	17 classes	1992 - 1993
MODIS Land Cover	500 m	71.6	MODIS	17 classes	yearly since 2001
GLC 2000	1 km	68.6	SPOT4 VEGETATION	22 classes	1992 - 1993
Globcover	300 m	73.1	MERIS	22 classes	2004 - 2006
CCI-LC 2000	300 m		MERIS	22 classes	1998-2002
CCI-LC 2005					2003-2007
CCI-LC 2010					2008-2012
CCI-LC 2015					2013-2017
World Cover 2020-2021	10 m	76.7%	Sentinel- 1/2	11 classes	
GlobeLand30 2000	30 m	78.6	Landsat	10 classes	2000
GlobeLand30 2010		80.3			2010

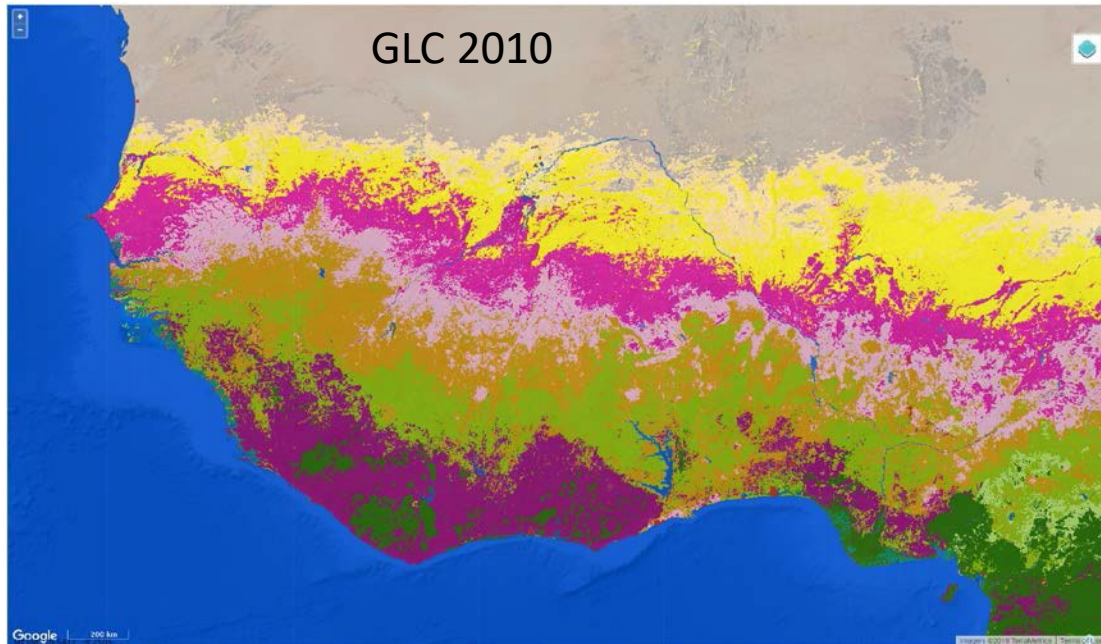
MODIS 2005



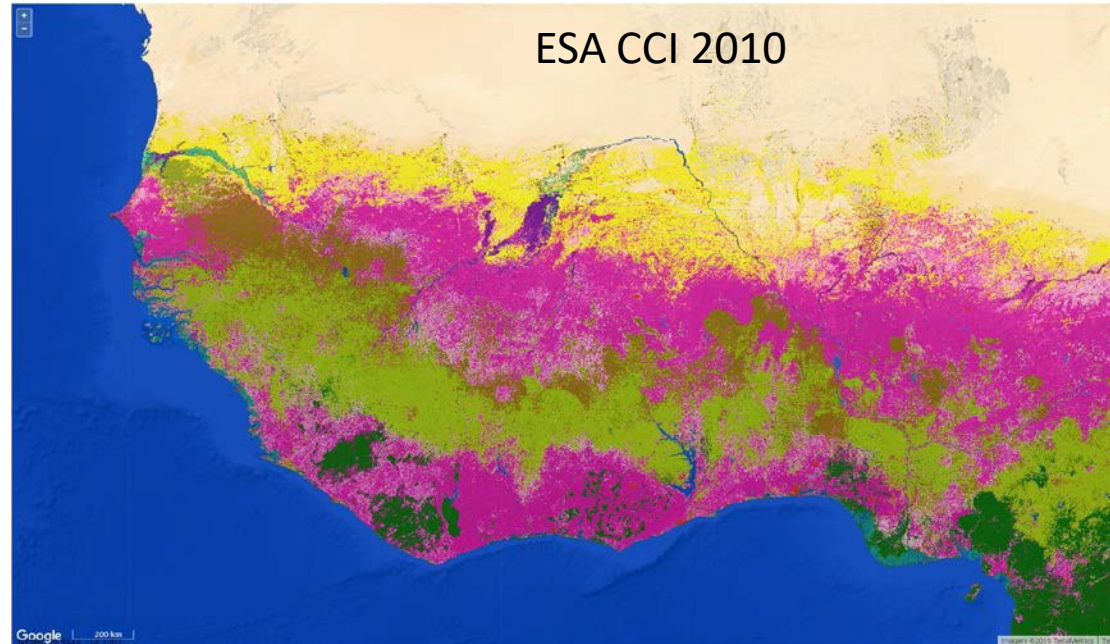
GLOBCOVER 2005



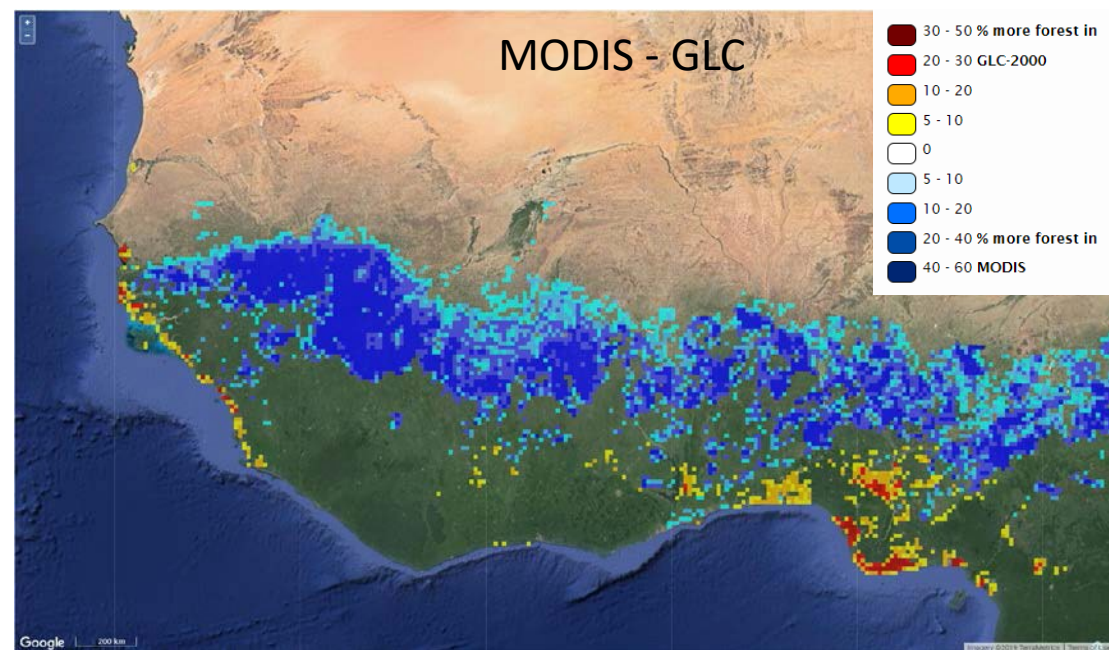
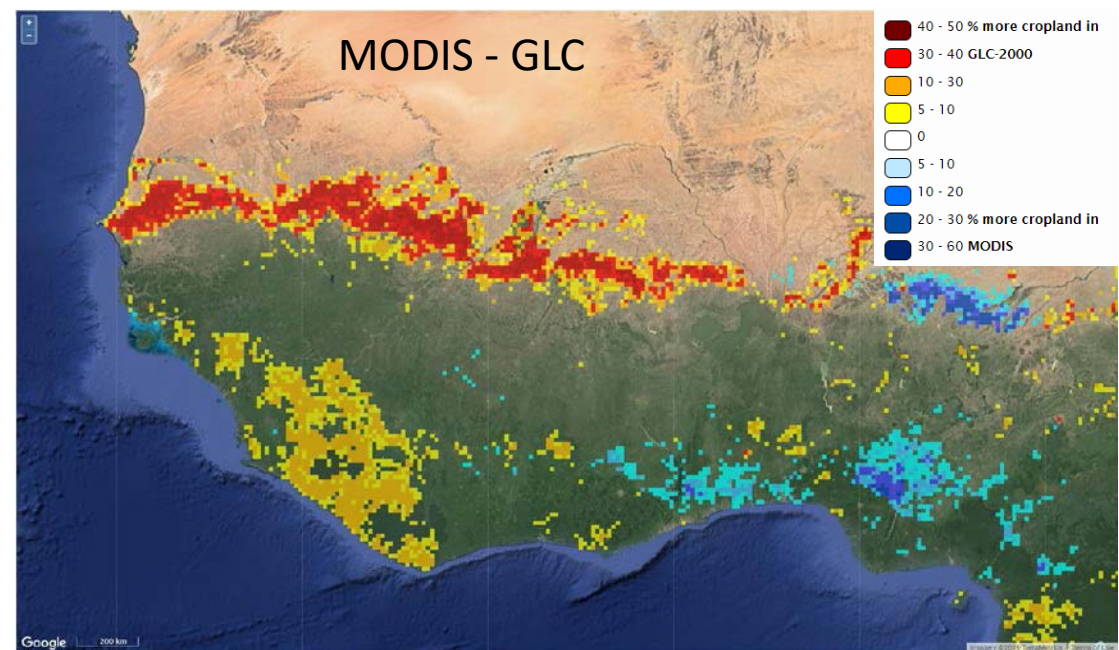
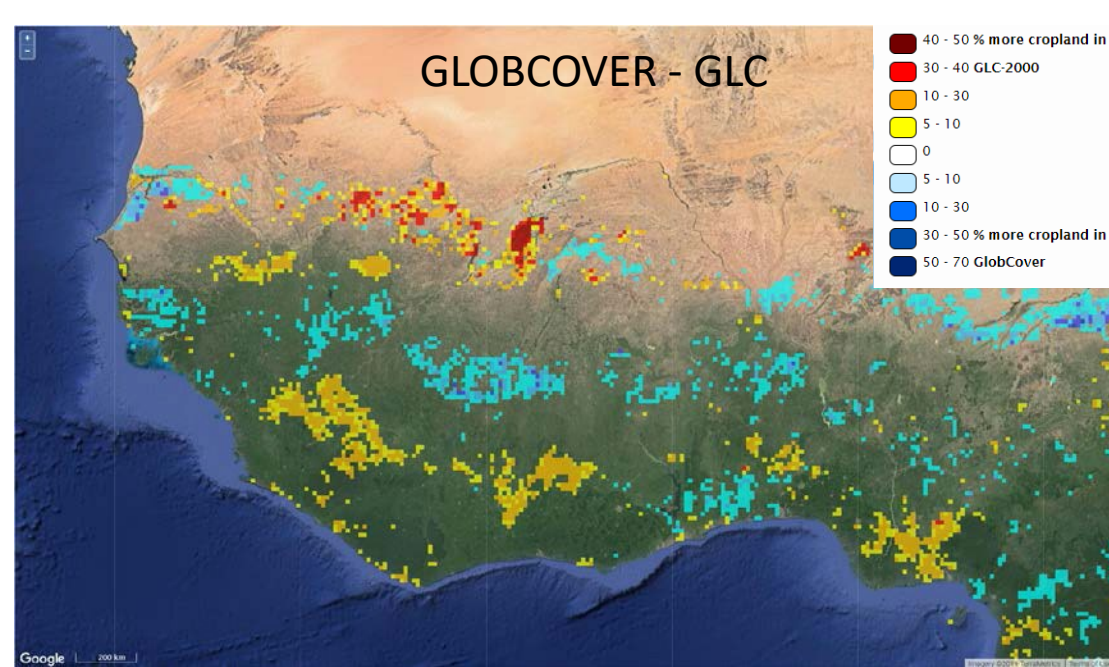
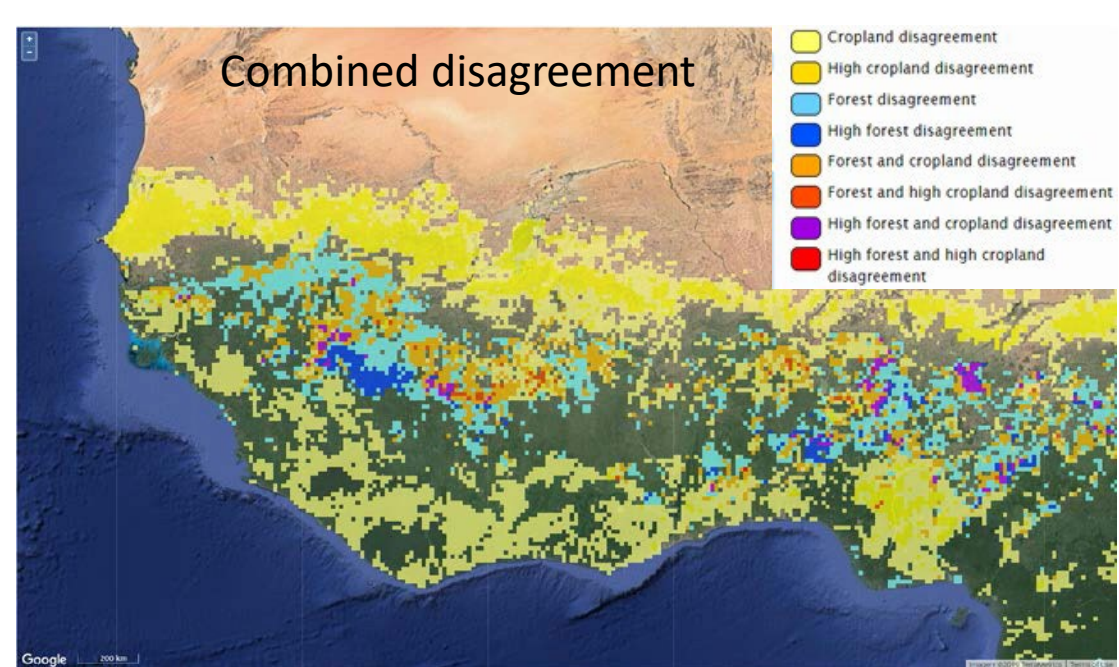
GLC 2010



ESA CCI 2010



<https://application.geo-wiki.org/Application/>



<https://application.geo-wiki.org/Application/>

MODIS 2005

- Evergreen needleleaf forests
- Evergreen broadleaf forests
- Deciduous needleleaf forests
- Deciduous broadleaf forests
- Mixed forests
- Closed shrublands
- Open shrublands
- Woody Savannahs
- Non-Woody Savannahs
- Grasslands
- Permanent wetlands
- Croplands
- Urban and built-up areas
- Cropland/natural vegetation
- Snow and ice
- Barren and sparsely vegetated
- Water

GLOBCOVER 2005

- Post-flooding or Irrigated croplands
- Rainfed croplands
- Mosaic Cropland/grass or shrub or forest
- Mosaic grass or shrub or forest/Cropland
- Closed-open broadleaved evergreen/semi-deciduous forest
- Closed broadleaved deciduous forest
- Open broadleaved deciduous forest
- Closed needleleaved evergreen forest
- Open needl. decid. or everg. forest
- Closed-open mixed broadleaved-needleleaved forest
- Mosaic Forest or shrub/Grassland
- Mosaic Grassland/Forest or shrub
- Closed to open shrubland
- Closed to open grassland
- Sparse vegetation
- Closed-open broadleaved forest regularly flooded
- Closed broadleaved forest permanent flooded
- Closed to open vegetation regularly flooded
- Artificial areas
- Bare areas
- Water bodies
- Permanent snow and ice
- Water/No data

GLC 2010

- Tree Cover, broadleaved, evergreen
- Tree Cover, broadl. decid, closed
- Tree Cover, broadl. decid, open
- Tree Cover, needle-leaved, evergreen
- Tree Cover, needle-leaved, deciduous
- Tree Cover, mixed leaf type
- Tree Cover, regularly flooded, fresh
- Tree Cover, regularly flooded, saline
- Mosaic: Tree cover/Other nat veg
- Tree Cover, burnt
- Shrub Cover, closed-open, evergreen
- Shrub Cover, closed-open, deciduous
- Herbaceous Cover, closed-open
- Spare Herbaceous or sparse Shrub
- Regularly flooded Shrub and/or Herb.
- Cultivated and managed areas
- Mosaic: Cropland/Tree Cover/natural veg
- Mosaic: Cropland/Shrub or Grass Cover
- Bare Areas
- Water Bodies (natural & artificial)
- Snow and Ice (natural & artificial)
- Artificial surfaces and associated areas

ESA CCI 2010

- Cropland, rainfed
- Herbaceous cover
- Tree or shrub cover
- Cropland, irrigated or post-flooding
- Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)
- Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)
- Tree cover, broadleaved, evergreen, closed to open (>15%)
- Tree cover, broadleaved, deciduous, closed to open (>15%)
- Tree cover, broadleaved, deciduous, closed (>40%)
- Tree cover, broadleaved, deciduous, open (15-40%)
- Tree cover, needleleaved, evergreen, closed to open (>15%)
- Tree cover, needleleaved, evergreen, closed (>40%)
- Tree cover, needleleaved, evergreen, open (15-40%)
- Tree cover, needleleaved, deciduous, closed to open (>15%)
- Tree cover, needleleaved, deciduous, closed (>40%)
- Tree cover, needleleaved, deciduous, open (15-40%)
- Tree cover, mixed leaf type (broadleaved and needleleaved)
- Mosaic tree and shrub (>50%) / herbaceous cover (<50%)
- Mosaic herbaceous cover (>50%) / tree and shrub (<50%)
- Shrubland
- Shrubland evergreen
- Shrubland deciduous
- Grassland
- Lichens and mosses
- Sparse vegetation (tree, shrub, herbaceous cover) (<15%)
- Sparse tree (<15%)
- Sparse shrub (<15%)
- Sparse herbaceous cover (<15%)
- Tree cover, flooded, fresh or brakish water
- Tree cover, flooded, saline water
- Shrub or herbaceous cover, flooded, fresh/saline/brakish water
- Urban areas
- Bare areas
- Consolidated bare areas
- Unconsolidated bare areas
- Water bodies
- Permanent snow and ice
- No data

<https://application.geo-wiki.org/Application/>

The Land Cover Classification System (LCCS)

- A comprehensive methodology for description, characterization, classification and comparison of most land cover features identified anywhere in the world, at any scale or level of detail



Food and Agriculture
Organization of the
United Nations

LCCS was created in response to a need for:

- A harmonized and standardized collection of land cover data
- Availability of land cover data for a wide range of applications and users
- Comparison and correlation of land cover classes

The Land Cover Classification System (LCCS)

Objective:

- To produce a world-wide reference system for land cover able to combine a high level of flexibility with an absolute level of standardization of the class definition between different users

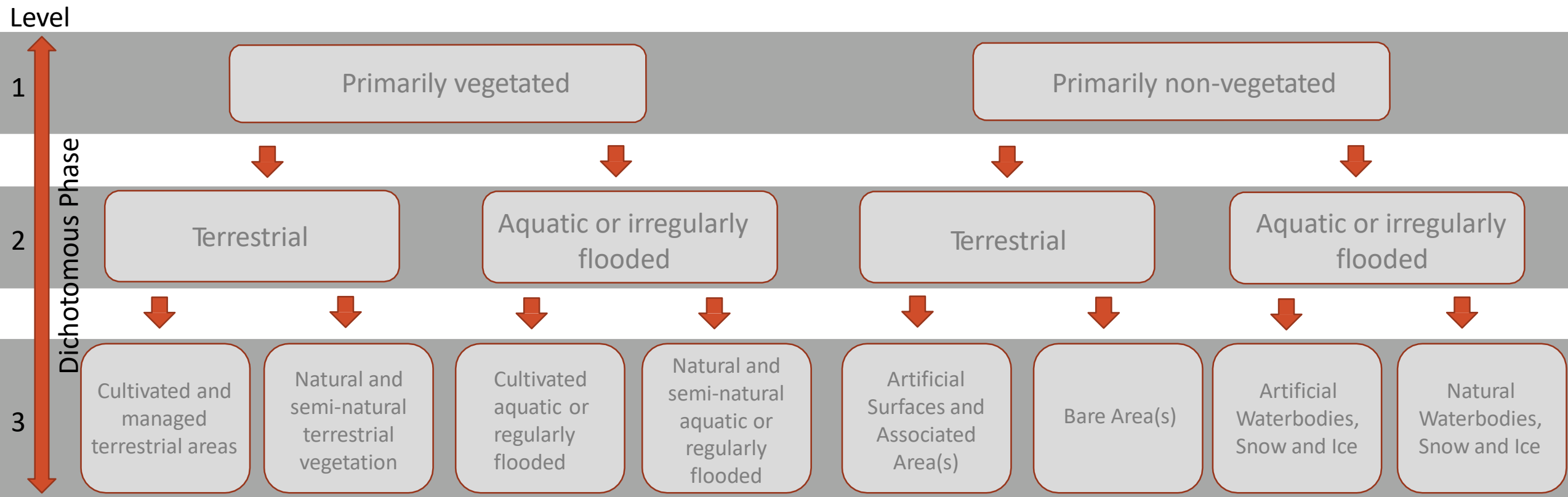
Idea:

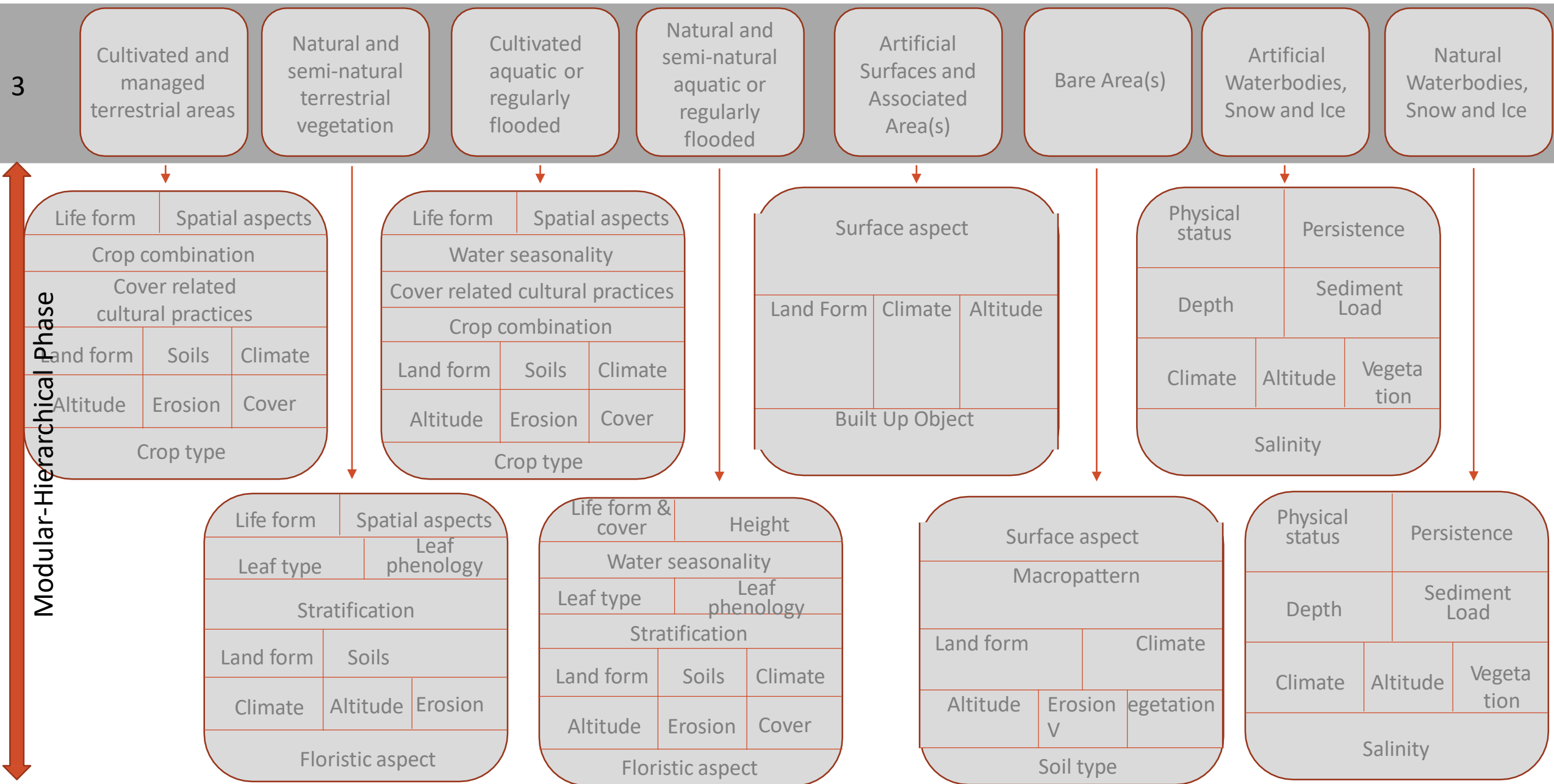
- A system that allows the creation of classes without to oblige the user to relate to a pre-defined list of names

LCCS consists of:

- an initial Dichotomous Phase, where eight major land cover types are distinguished
- a subsequent Modular-Hierarchical Phase where the set of classifiers and their hierarchical arrangement are tailored to the major land cover type

The LCCS system





Current state of land cover mapping

<https://esa.int>

Copernicus Programme:

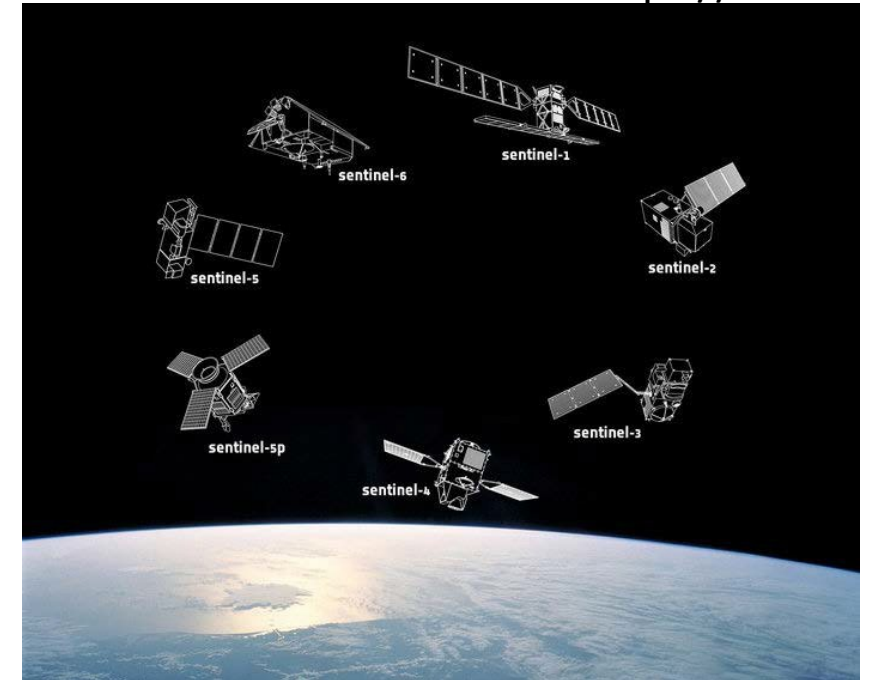
- European Union's Earth Observation Programme

Components:

- Space component
- In-Situ component
- Data services

Data policy:

- Full free and open data access
- Observation data is going to be continually provided at least until 2030



Copernicus Data Services



Pan-European Component

I) Corine Land Cover:

- Inventory initiated in 1985 (reference year 1990) with updates in 2000, 2006, 2012, and 2018
- 44 classes in three hierarchical levels
- 25 ha minimum mapping unit (MMU)
- Accompanying change layers highlight changes in land cover with an MMU of 5 ha
- Data sources changed from Landsat, Spot-4/5 to Sentinel-2
- Production time decreased from 10 years to 1.5 years

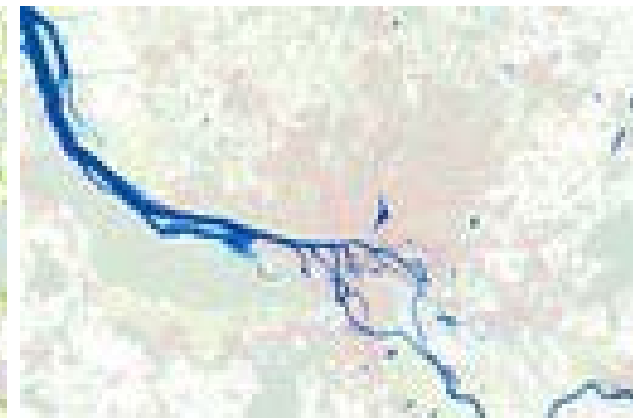
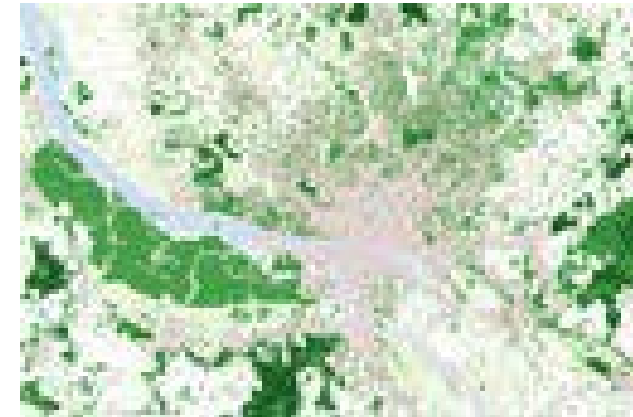


<https://land.copernicus.eu/>

Pan-European Component

II) High resolution layers:

- Imperviousness density (2009, 2012, 2015, 2018)
- Tree cover density (2012, 2015, 2018)
- Dominant leaf type (2012, 2015, 2018)
- Forest type (2012, 2015, 2018)
- Grassland (2015, 2018)
- Water and wetness (2015, 2018)



<https://land.copernicus.eu/pan-european/high-resolution-layers>

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

Wulder, 2018