Final

Service Contract No 3436/R0-Copernicus/EEA.56665

CLC2018 Technical Guidelines

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Based on
CLC2006 Technical guidelines (EEA Technical report No 17/2007)
and
CLC2012 Addendum to the CLC2006 Technical Guidelines (ETC/SIA report)

25 October 2017

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1 INTRODUCTION

1.1 ABOUT THE DOCUMENT

The European Environment Agency (EEA) is a European Union public body whose role is to support the European Union in the development and implementation of environmental policy by providing relevant, reliable, targeted and timely information on the state of the environment and future prospects.
The Commission has entrusted the EEA with budget implementation tasks in the Copernicus Earth Observation programme. Pursuant to Article 7.2 of the Delegation Agreement with the European Union, the EEA shall be responsible for the coordination of the technical implementation of the pan-European continental component and the local component of the Copernicus land monitoring service and the cross-cutting in situ component, as well as for the necessary dissemination activities.
The key requirement to ensure availability of Copernicus land monitoring products in due time for assessments to be made in view of the SoER 2020 report, constitutes a major challenge in particular on the time line for the production of CORINE Land Cover 2018 (CLC2018).

These Technical Guidelines provide support for the update of CORINE land cover (CLC) data for the reference year 2018, similarly to its predecessors for CLC1990 [1], CLC2000 [2], CLC2006 [3] and CLC2012 [4]. According to the described standard methodology the CORINE Land Cover database for the year 2018 (CLC2018) will be derived by integrating the data of land cover changes between the years 2012–2018 (CLC-Change$_{2012\text{-}2018}$) - as primary product - with the revised land cover map of year 2012 (revised CLC2012) - as side product. Alternative, semiautomatic methodologies - if provide comparable results with the standard methodology - are allowed and welcome, but not discussed in this document. The enhanced version of CLC nomenclature is discussed in a separate document [5]. Orthocorrected satellite imagery called IMAGE2012 (taken in 2011 and 2012) and IMAGE2018 (taken mainly in 2017) should be used in deriving CLC-Change$_{2012\text{-}2018}$ and deriving CLC2018.

CLC2018 is traditionally implemented or managed by the Eionet National Reference Centres (NRCs) for land cover, where the best expertise as well as the ancillary data are available for mapping land cover changes. Verification of national products and integration of all national contributions will be provided by EEA, supported by the European Topic Centre on Urban, Land and Soil System (ETC-ULS).

The structure and content of this document is similar to the CLC2006 Technical Guidelines [3]. The first three chapters describe the background, organisation and main technical parameters of CLC2018 project within the Copernicus Pan-European Land Monitoring Programme. In this part, especially Chapter 3 (Satellite image basics) has changed significantly due the availability of ESA's Sentinel-2 imagery, considered as breakthrough in European land monitoring. Chapter 4 provides guidelines for mapping CLC-Changes (focusing on the "change mapping first" photointerpretation technology, applied by most of the participants). Chapter 5 is about ancillary data. Chapter 6 describes the automated generation of CLC2018. Chapters 4-6 have changed only modestly. Chapter 7 describes metadata. Chapters 8 is about the training of national teams and the procedure of verification. Verification need to be reorganised in order to keep track with the tight schedule of the project, while not to lose the high quality of products. Chapter 9 replaced the former chapter about "Deliverables" and describes the guidelines for delivery of the products.

The intended readers of this document are the members of national CLC national teams and other organisations involved in the production. The primary aim is to provide guidance on practical issues of production, with a basic overview of the theoretical considerations.

1.2 BRIEF HISTORY OF CORINE LAND COVER

CLC2018 is the fifth CORINE Land Cover inventory (Table 1). Brief history of CLC is presented below.

1.2.1 CLC1990

From 1985 to 1990, the European Commission implemented the CORINE Programme (Co-ordination of Information on the Environment). During this period, an information system on the state of the European environment was created and nomenclatures and methodologies were developed and agreed at EU level. Images acquired by earth observation satellites are used as the main source data to derive land cover information [6]. Satellite images were visually interpreted by using plastic overlays on top of 1:100.000 scale hardcopies. The first CORINE Land Cover project (CLC1990) has been implemented in most of the (that time) EU countries, as well as in the 10 so called Phare partner countries in Central and Eastern Europe.

Table 1 CORINE Land Cover inventories in Europe

Name	Start year	End year
CLC1990	1986	1999
CLC2000	2001	2006
CLC2006	2007	2010
CLC2012	2013	2015
CLC2018	2017	2018 (planned)

1.2.2 CLC2000

Following the setting up of the European Environment Agency (EEA) and the establishment of the European Environment Information and Observation Network (Eionet), the responsibilities of the CORINE databases - including the updates - rely on the EEA.

As CLC1990 was completed and came to use, several users at national and European level expressed their need for an updated CLC database. Updating was implemented within the IMAGE&CLC2000 project, which consisted of two main components:

- IMAGE2000: covering activities related to satellite image acquisition, ortho-rectification and production of European and national mosaic, and
- CLC2000 covering activities related to updating of CLC1990 based on IMAGE2000 (updated version is named CLC2000) and detection and interpretation of land cover changes (named CLC-Change$_{1990-2000}$) by using CLC1990, IMAGE1990 and IMAGE2000. In order to prevent propagating errors into CLC2000 – the geometric and thematic mistakes in CLC1990 have been corrected [7].

Improving the geometry of CLC layer and mapping CORINE land cover changes constituted the main novelties of CLC2000. The technology of drawing the interpretation on transparencies was discarded and replaced by CAPI (computer-assisted photo-interpretation).

1.2.3 CLC2006 under GMES

In 2005–2006, strategic discussions amongst member countries, the European Parliament and the main EU institutions responsible for environmental policy, reporting and assessment (DG ENV, DG AGRI, EEA, ESTAT and JRC) have underlined an increasing need for factual and quantitative information on the state of the environment to be based on timely, quality assured data, in particular in land cover and land use related issues. Based on requirements of DG Environment, DG Agriculture and other users for the period 2006–2008, the EEA put forward a proposal to collaborate with the European Space Agency (ESA) and the European Commission (EC) on the implementation of a fast track service precursor (FTSP) on land monitoring. The definition and implementation of the necessary satellite data procurement and processing was undertaken by ESA and JRC. CLC2006 was one of the components of GMES FTSP Land Monitoring [8], [9].

From a technical point of view, the main novelty of CLC2006 was the introduction of harmonised change mapping rules [10]. All changes exceeding 5 ha in size had to be mapped, not only those that were associated to existing polygons. CAPI was the prevailing method applied in interpreting of satellite images. Nevertheless, FI, IS, NO, SE and the UK applied a semiautomatic methodology. Concerning satellite imagery, the single date Landsat TM, used in CLC2000 was replaced by two satellite images (taken by usually IRS and SPOT-4) acquired in two different seasons.

1.2.4 CLC2012 under Copernicus

The fourth CLC inventory (CLC2012) was implemented as part of the GMES Initial Operations (GIO) initiated by DG ENTR of the European Commission. The coordination of the GIO land monitoring was delegated to EEA for implementation [11]. With CLC2012 the CLC time series have become embedded in the Copernicus programme, thus ensuring sustainable funding for the future.

The ESA Data Warehouse [12] has provided a satellite image catalogue and download system for all GMES-related activities, including CLC2012. Two satellite image coverages have been acquired (primarily IRS/ResourceSat and RapidEye and less extent SPOT-4 and SPOT-5) in 2011-2012. Gap filling in 2013 was targeting those areas which were not covered by imagery during the 2-year image acquisition period. The technical implementation of CLC2012 was similar to the CLC2006 inventory [4]. Majority of countries applied Computer Assisted Photointerpretation (CAPI) technology to map the CLC-Change layer first. Germany and Ireland joined the Scandinavian countries and Spain by applying a semi-automatic methodology based on the integration of existing land use data, satellite image processing and generalization.

1.2.5 CLC2018 in the frames of Copernicus

CLC2018, the 5th CLC inventory will be a continuation of previous CORINE Land Cover inventories. The project is coordinated by the EEA. Main highlights are:

- Sentinel-2 satellite imagery – the 1st European satellite dedicated for land monitoring [16] - will be provided as basic image data support representing land cover in 2017-2018. For gap-filling Landsat-8 data will be used.
- Shorter production time (see Tables 1 and 2) compared to previous inventories to be harmonised with SOER 2020.

Computer assisted photointerpretation is still the dominating method used by the participating countries, but alternative solutions (bottom-up approach) are emerging.

1.3 MAIN TECHNICAL PARAMETERS OF CORINE LAND COVER

The choice of minimum mapping unit (MMU = 25 hectares) and minimum width of linear elements (MMW = 100 metres) in CLC mapping represent a trade-off between cost and detail of land cover information [1]. These two basic parameters are the same for all the five CLC inventories.

The standard CLC nomenclature includes 44 land cover classes. These are grouped in a three-level hierarchy. The five main (level-one) categories are: 1) artificial surfaces, 2) agricultural areas, 3) forests and semi-natural areas, 4) wetlands, 5) water bodies [1]. All national teams had to adopt this standard nomenclature according to their landscape conditions. Although the 44 categories have not changed since the implementation of the first CLC inventory (1986-1998), the definition of most of the nomenclature elements was significantly improved [5].

Earth observation satellite imagery is the basis of CLC mapping, providing up-to-date information about the surface of the Earth in proper resolution. Raw satellite images first have to be pre-processed and enhanced to yield a geometrically correct document in national projection. In the CLC1990 inventory ortho-correction was usually not applied, and GCPs were mostly selected from 1:100.000 scale maps. Therefore, the geometric accuracy of IMAGE1990 products and that of the derived CLC1990 did not fulfil specification (Table 2). Started from the CLC2000 project satellite images are ortho-corrected by using DTM. The accuracy is characterised with an RMS error below 25 metres.

During the first CLC inventory the "traditional" photointerpretation method was used: an overlay was fixed on top of a satellite image hardcopy and the photo-interpreter drew polygons on it marking them with a CLC code. Later the overlay was digitised, topology was created and the CLC code entered. This procedure often resulted in several types of errors in geometry as well as in thematic content, which were mostly corrected later, within the frames of IMAGE&CLC2000.

In CLC2000 the method of drawing on transparencies was discarded, and the use of computer-assisted image interpretation (CAPI) was applied [2]. CAPI has become the main tool of producing all the subsequent CLC inventories, including CLC2018. The number of alternative solutions is growing slowly.

Main characteristics of subsequent CLC projects are summarised in Table 2.

1.4 CORINE Land cover changes

CORINE Land Cover Changes (CLC-Changes) are mapped first in the 2nd CLC inventory, CLC2000. It was a policy requirement to map changes smaller than the 25 ha, MMU size of CLC. The MMU of the CLC-Changes database was set to 5 ha[1]. The 100-meter minimum width is also valid for the CLC-Changes polygons for practical reasons. Changes should refer to real evolution processes. Starting from CLC2006, mapping CLC-Changes has been standardised: all CLC-changes larger than 5 ha have to be mapped [10]. See more details in Ch. 4.

[1] In case of a complex change polygon, size less than 5 ha is also allowed (see 4.3)

Table 2 Evolution of CORINE Land Cover

	CLC1990	**CLC2000**	**CLC2006**	**CLC2012**	**CLC2018**
Satellite data used dominantly	Landsat-4/5 TM single date (in a few cases Landsat MSS)	Landsat-7 ETM single date	SPOT-4 and / or IRS LISS III dual date	IRS, SPOT-4/5 and RapidEye	Sentinel-2 and Landsat-8 for gap filling
Time consistency	1986-1998	2000 +/- 1 year	2006+/- 1 year	2011-2012	2017-2018
Geometric accuracy satellite images	≤ 50 m	≤ 25 m	≤ 25 m	≤ 25 m	≤ 10 m (Sentinel-2)
CLC mapping MMU	25 ha	25 ha	25 ha	25 ha	25 ha
CLC mapping minimum width	100 m	100 m	100 m	100 m	100 m
Geometric accuracy CLC data	100 m	better than 100 m	better than 100 m	better than 100 m	better than 100 m
Thematic accuracy	≥ 85% (probably not achieved)	≥ 85% (achieved [13]	≥ 85%	≥ 85% (probably achieved)	≥ 85%
Change mapping	_	boundary displacement min. 100 m; change area for existing polygons ≥ 5 ha; isolated changes ≥ 25 ha	boundary displacement min. 100 m; all changes > 5 ha must be mapped	boundary displacement min. 100 m; all changes > 5 ha must be mapped	boundary displacement min. 100 m; all changes > 5 ha must be mapped
Production time	13 years	5 years	4 years	3 years	1,5 years
Documentat-ion	incomplete metadata	standard metadata	standard metadata	standard metadata	standard metadata
Access to the data	unclear dissemination policy	disseminat-ion policy agreed from the start	free access for all kind of users	free access for all kind of users	free access for all kind of users
Number of European countries involved[2]	22 (28)	32 (39)	38 (39)	39	not yet known

[2] During the official lifetime of the project (additional countries joining later)

1.5 Preparing for CLC2018

1.5.1 Participating countries

At the time of writing of this Manual, the final list of participating countries is not yet available. In order to continue the CLC time series, all the EEA39 countries are encouraged to participate in CLC2018: 33 EEA member states and 6 collaborating countries (see Fig. 1. and Table 3) with total area of 5.85 Mkm^2.

Table 3 CLC2018 participation (status: October 2017)

Country	Status	Country	Status
Albania	not eligible for Copernicus funding	Kosovo (under the UN Security Council Resolution 1244/99)	not eligible for Copernicus funding
Austria	√	Latvia	will not submit offer
Belgium	√	Liechtenstein	√ covered by Austria
Bosnia and Herzegovina	not eligible for Copernicus funding	Lithuania	√
Bulgaria	√	Luxemburg	will not submit offer
Croatia	√	Malta	√
Cyprus	no reply yet	Montenegro	not eligible for Copernicus funding
Czech Republic	√	The Netherlands	√
Denmark	will not submit offer	Norway	√
Estonia	√	Poland	√
Finland	√	Portugal	√
Former Yugoslav Republic of Macedonia	not eligible for Copernicus funding	Romania	√
France	√	Serbia	not eligible for Copernicus funding
Germany	√	Slovakia	√
Greece	√	Slovenia	√
Hungary	√	Spain	√
Iceland	√	Sweden	√
Ireland	√	Switzerland	not eligible for Copernicus funding
Italy	√	Turkey	not eligible for Copernicus funding; will provide national funding
		United Kingdom	√

Remarks:

“No reply yet” means: countries have not sent back the proposal for a Framework Contract until the deadline

“Not eligible for Copernicus funding” means: these countries might implement CLC2018 under a scheme different than Copernicus, similarly to CLC2012.

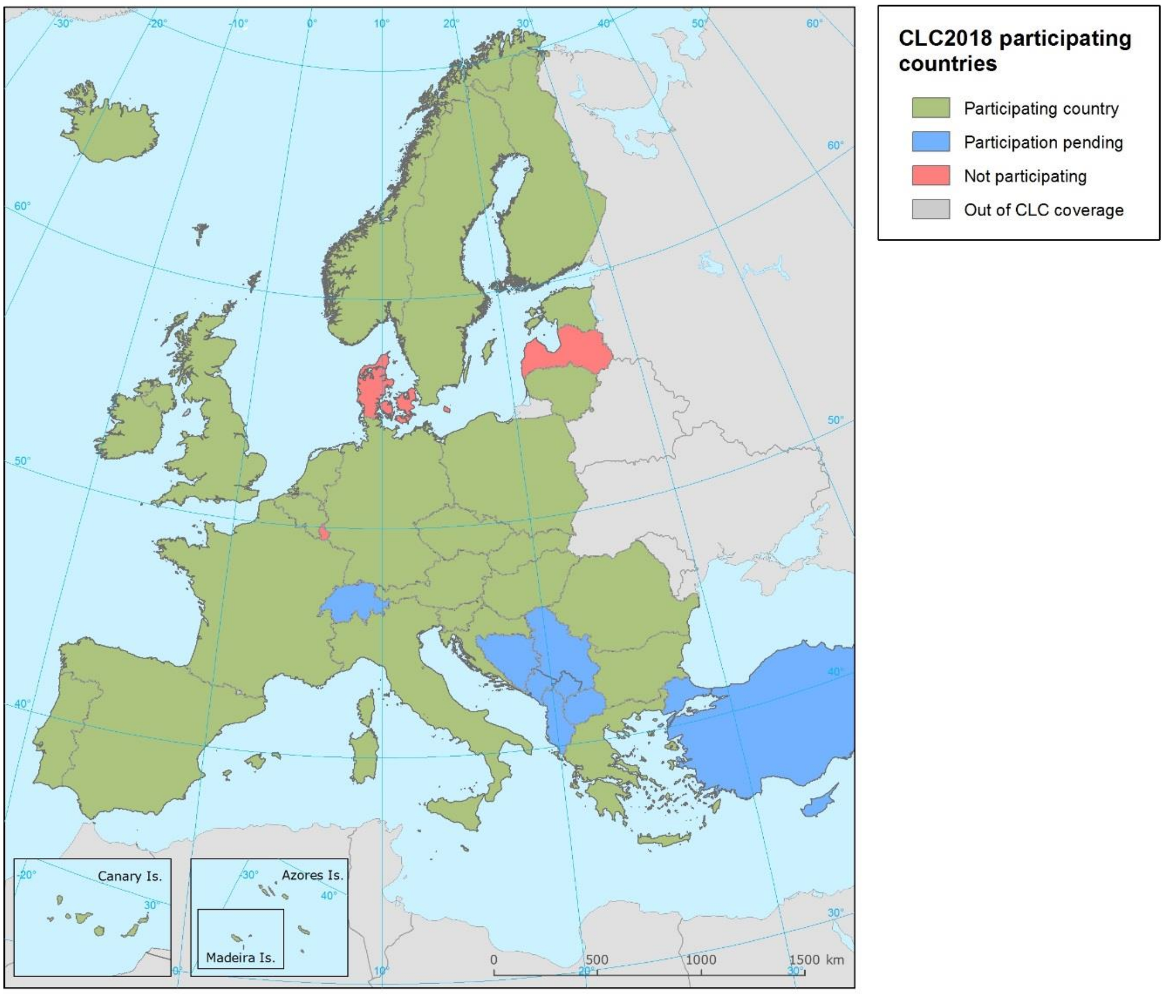


Figure 1 Countries participating in CLC2018 (Status October 2017)

1.5.2 Technical documents

Technical documents supporting the implementation of CLC2018 are presented below.

Table 4 List of technical documents supporting the implementation of CLC2018

Subject / Title	Status, reference
CLC2018 Technical guidelines	updated, this document
CORINE Land Cover nomenclature	updated, separate document and online version [5]
Manual of CORINE Land Cover changes	separate document, updated [23]
ArcGIS macro programme for generating CLC2018	minor actualisation, separate document [26]
CLC QC Quick Guide - online / off-line manual	updated, separate document [27]
CLC2018 Support Package (software and user guide)	updated, separate document [31]
Step-by-step guidelines for IMAGE2018 selection	new, separate document [32]

2 COMPONENTS OF CLC2018

2.1 WORK PACKAGES

Like in the previous CLC inventories 7 work packages have been defined to implement CLC2018. Table 5 provides an overview of the role of contributing partners involved in the execution of each work package. The only novelty in Table 5 is WP 1.3, which is needed because of Sentinel-2 imagery (see more in Ch. 3.2.3)

Table 5 Work packages and the overview of the role of partners

Tasks	NRC	EEA	ESA	Service provider
WP 1.1 Satellite data acquisition (Sentinel-2 and Landsat 8)			**X**	
WP 1.2 Ortho-correction			**X**	
WP 1.3 Technical preparation of IMAGE2018 (Sentinel-2 and Landsat-8 (gap-filling)image provision)	x			**X**
WP 2 In-situ and ancillary data collection	**X**	**X**		
WP 3.1 Corine land cover change mapping 2012-2018	**X**	x		
WP 3.2 Generating CLC2018	**X**	x		
WP 4 Verification by Technical Team	x	**X**		
WP 5 Validation				**X**
WP 6 CLC data dissemination	**X**	**X**		
WP 7 Project management (NRCs)	x	**X**	x	x

X = leading organisation
x = organisation involved

This document describes in detail WP1.3, WP3 and WP4. Other WPs will be tackled only marginally.

2.2 PROJECT ORGANISATION

Pursuant to Article 5 of Regulation (EC) No 401/2009 on the EEA and the Eionet, the EEA may agree with the institutions or bodies which form part of Eionet (i.e. the NRCs, NFPs and ETCs) upon the necessary arrangements, in particular contracts, for successfully carrying out the tasks which it may entrust to them.
The Eionet members have already successfully cooperated with the EEA under the framework of the GMES/Copernicus Initial Operations (GIO land) 2011-2013 and other previous programmes and they enjoy thus a long standing experience and know-how in land monitoring related activities (in particular CLC production). The continued/renewed involvement of local experts will warrant the success of the project with access to local knowledge and ancillary data necessary to support the land cover change mapping.
So far, the production of CLC (as well as other Copernicus tasks executed in cooperation with the NRCs) has be done on the basis of grant agreements concluded with the Eionet

member countries. With the aim of streamlining and optimizing the performance process of the above-mentioned tasks in mind, this time service contracts are awarded instead. The service contracts are established within a framework contract between EEA and Eionet member countries, covering a 5 year period.
Service contracts do not require co-financing from the MS, while they still meet the result ownership requirement. The absence of co-financing inherent to service contract is deemed to be a factor that can contribute to the establishment of an operational team within the NRCs which could then perform on a more permanent and coherent way the tasks envisaged to be entrusted in both the local and pan-European components and could lead therefore to a greater commitment towards the achievement of the set objectives through maintaining a continuous flow of work and avoiding peaks and loosing know-how. Framework service contracts to be implemented through specific contracts will cover the whole period of the operational implementation phase of the current Copernicus delegation agreement which runs until 31.12.2021.
CLC2018 implementation (change mapping and CLC2012 revision) is therefore executed by national organizations nominated or selected in a tender by NRCs, or the NRCs themselves.
EEA and ETC/ULS will provide administrative and technical support. Similarly to previous CLC inventories, the CLC Technical Team will provide training on CLC mapping, performs verifications, give helpdesk on CLC production methodology and the photointerpretation software, and carry out technical verification.
Service Providers will be mainly involved in providing support in image coverage pre-selection, re-projection to national projections, and provision of the input data to the countries.

3 SATELLITE IMAGE BASICS FOR CLC2018

The purpose of this chapter is to provide an overview of the satellite imagery support dedicated for the CLC2018 project. To map CLC changes between 2012 and 2018 two sets of satellite images should be used: the ones used to derive CLC2012 (IMAGE2012) as well as the ones depicting the 2018 status (IMAGE2018). The characteristics of and access to these satellite images will be shortly described.

ESA has provided access to IMAGE2012 data through its Data Warehouse [12]. Sentinel-2 imagery – constituting the main IMAGE2018 data – will be accessible from the European Space Agency's (ESA) Copernicus Open Access Hub [14] or via a dedicated organisation set-up by EEA to provide support to countries in pre-processing of S2 imagery (see Ch. 3.2.3).

3.1 IMAGE2012

Normally, IMAGE2012 data are available for the participating national teams from their own satellite image archive. If this is not the case, access to IMAGE2012 is described briefly below.

For the period 2011-2013 the concept of Data Warehouse (DWH) has been developed by ESA. The new approach was based on the procurement of a set of common and pre-defined 'core' datasets acquired by the Copernicus Contributing Mission (CCM) and made broadly available to public organisations at European and national level. A data access portfolio [12] describes the datasets available. The agreement for data access intended to provide multiple right of use of the ortho-corrected satellite images in national projection, as long as traceability of use was ensured. National Teams were granted access to these data for internal use as soon as the DWH[3] Licence have been signed.

3.1.1 High-resolution satellite images

Two coverages of pan-European multi-temporal ortho-rectified satellite imagery covering all 39 participating countries with 12 nautical miles' sea buffer was provided by ESA for the period of 2011-2012, with all spectral bands and cloud masking. This set of imagery is called IMAGE2012. The raw images were projected into national projection system. These images were the main satellite data input for producing the core land cover data (CLC2012 and high-resolution layers). Two dates of acquisition (narrow and extended acquisition windows, specified by countries) with cloud-free data (meaning maximum 5 % cloud coverage) were collected.

In year 2011 high-resolution satellite images covering 1/3 of Europe have been acquired. In year 2012 the intention was to acquire images for 2/3 of Europe. In 2013 only gap-filling acquisitions have been carried out.

Characteristics of the main imagery types forming IMAGE2012 and relevant for CLC2012 are described in Table 6.

- Coverage-1 (1st priority by countries) was planned to be completed by the Indian IRS Resourcesat-1 and Resourcesat-2 satellites. Data were delivered in 20 m pixels in national projection. This dataset is included in CORE_01 of DWH.
- Coverage-2 (2nd priority by countries) was planned to be completed by the German RapidEye satellite constellation. RapidEye satellites include spectral bands in visible and near infrared bands, but not in SWIR band. Data were delivered in 20 m pixels in national projection. (A 5-m pixel size version in UTM projection also exists.) This dataset is included also in CORE_01 of DWH.

[3] Data Warehouse of the European Space Agency

- Images acquired by the French SPOT-4 and SPOT-5 satellites were used to complete coverage-1 as well as covarege-2.

In some cases, land cover might have changed between the two images acquired for CLC2012 (e.g. spread of construction or mining sites, clearcut of forest, burning shrubs and forests). In such cases the more recent image was to be used as reference during interpretation. Therefore, it **is strongly advised to make available all IMAGE2012 data for CLC2018**, in order to understand the photointerpretation in CLC2012 and avoid erroneous "revision" of CLC2012.

Table 6 Overview of the main parameters of IMAGE2012 satellite imagery used to derive CLC2012

	IRS Resourcesat 1,2 (coverage-1)	**RapidEye (coverage-2)**	**SPOT-4 and SPOT-5 (coverage-1 and 2)**
swath width (km)	141	20	60 – 80 (depending on looking angle)
No. of bands	4	5	4
bands	Green, red, NIR, SWIR	Blue, green, red, red-edge, NIR	Green, red, NIR, SWIR
ground sampling distance (m)	23.5	6.5	20 and 10
bit depth	7	12	8
to be found in DWH	Core_01	Core_01	Core_01
delivered resolution (m)	20	20	20
projection	national	national	national

Table 7 includes the recommended standard image band combinations in order to provide similar colours on screen as photointerpreters had got used with different satellite sensors. Images acquired by RapidEye satellites cannot be displayed with the same colours as IRS and SPOT images, because of the lack of SWIR band in RapidEye.

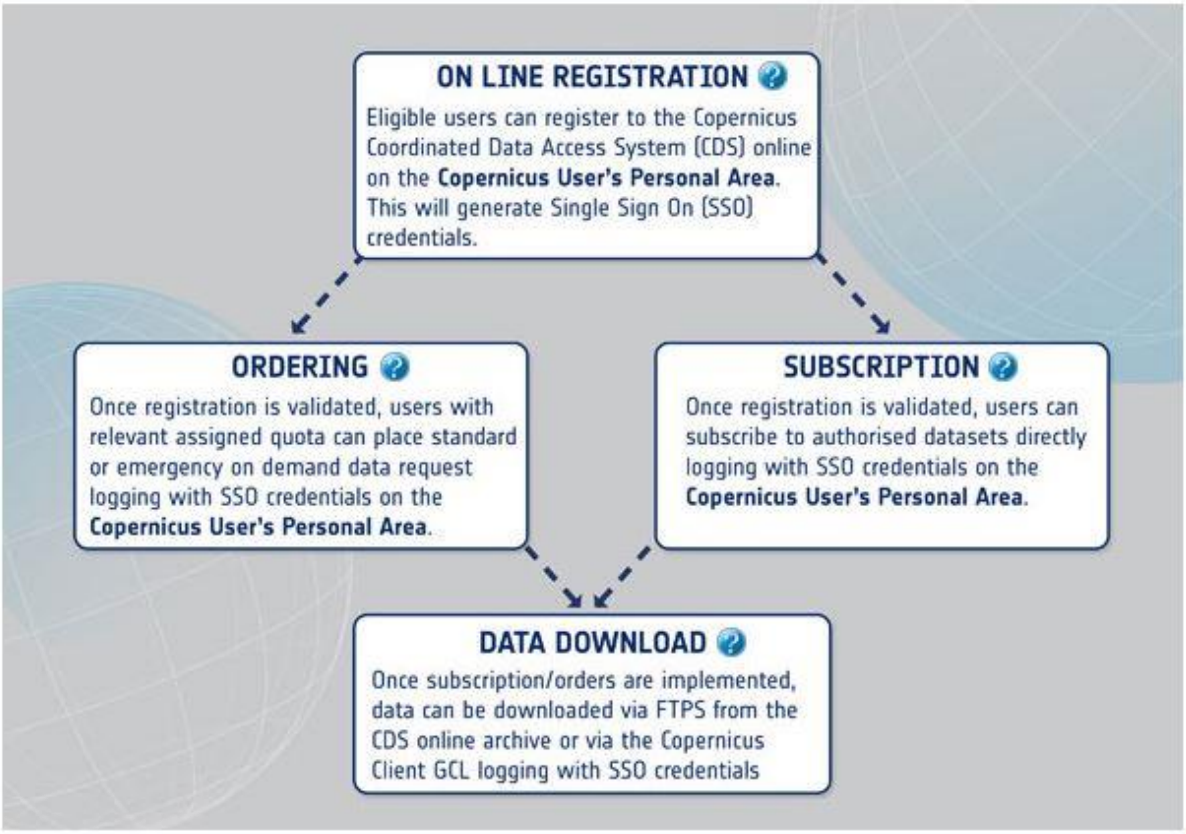
Table 7 Recommended standard colour rendition for photointerpretation of IMAGE2012

Colour	**IRS Resourcesat 1,2**	**SPOT-4,5**	**RapidEye**
Red (R)	band 3 (NIR)	band 3 (NIR)	band 5 (NIR)
Green (G)	band 4 (SWIR)	band 4 (SWIR)	band 3 (red)
Blue (B)	band 2 (red)	band 2 red)	band 2 (green)

3.1.2 Access to IMAGE2012 satellite imagery in ESA's DWH

The procedure for accessing 2012 imagery on ESA's DWH phase 1 was described in detail in the CLC2012 Addendum to the CLC2006 Technical Guidelines. [4]
However, since some procedures have slightly changed regarding "How to Access Data", new information about online registration, subscription and data download for the Data Warehouse phase 2 (2014-2020) is available under
https://spacedata.copernicus.eu/documents/12833/20397/CDS+Registration+Guidelines

For illustration purposes, CSCDA[4] data access is made up of four main processes, as shown in the schematic diagram below extracted from ESA's website



3.2 IMAGE2018

3.2.1 Technical characteristics of Sentinel-2 imagery

Sentinel-2 mission is a European earth polar-orbiting satellite constellation (Sentinel-2A and 2B) designed to feed the Copernicus system with continuous and operational high-resolution imagery for the global and sustained monitoring of Earth land and coastal areas [16].

The Sentinel-2 system is based on the concurrent operations of two identical satellites flying on a single orbit plane but phased at 180º, each hosting a Multi-Spectral Instrument (MSI) covering from the visible to the shortwave infrared spectral range (Figure 3) and delivering high spatial resolution imagery at global scale and with a high revisit frequency (Table 8) [17].

[4] Copernicus Space Component Data Access

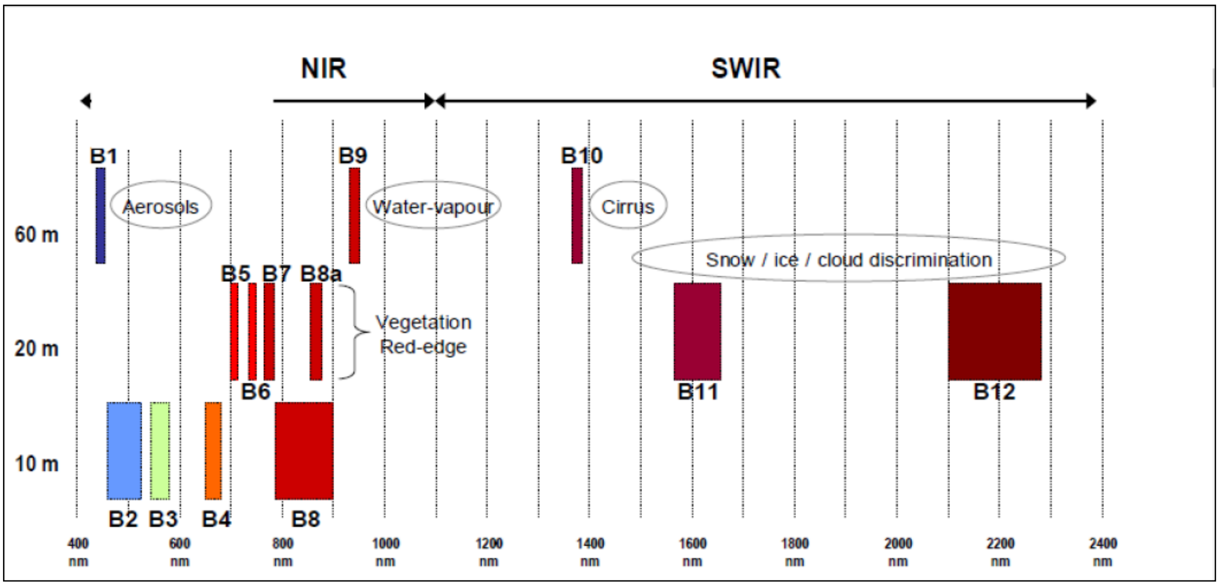


Figure 3: MSI Spectral-Bands versus Spatial Resolution [17].

Table 8 Overview of the main parameters of Sentinel-2 imagery

	Sentinel-2 Multispectral Imager (MSI)	
Swath width (km)	290	
Number of bands	13 (altogether)	
	4	in VIS
	6	in NIR
	3	in SWIR
Ground sampling distance (m)	10	bands 2,3,4 (VIS) and band 8 (NIR)
	20	bands 5,6,7,8a (NIR) and bands 11,12 (SWIR)
	60	band 1 (VIS), band 9 (NIR) and band 10 (SWIR)
Bit depth (recording)	12	
Repeat cycle at the Equator (days)	10 (with 1 satellite) 5 (with 2 satellites)	
Data access	free, full and open access	
Delivered resolution (m)	10 / 20 /60 (depending on band)	

Sentinel-2's high-resolution multispectral instrument is based on well-established heritage from France's SPOT missions and the US Landsat satellites. The multispectral imager is the most advanced of its kind – in fact it is the first optical Earth observation mission to include four bands in the 'red edge', which provide key information on vegetation state. Spectral bands of Sentinel-2 [18] are presented in Table 9 in comparison with bands of main satellite sensors used in previous CLC projects.

Table 9 Comparison of spectral bands of Sentinel-2 [18] with other EO satellites

	Bandwidth: lower wavelength – upper wavelength [μm]				
	Sentinel-2 MSI	**Landsat-7 ETM**	**IRS (Resource-sat) LISS-III**	**SPOT-4 HRV**	**Remark**
1	0.433-0.453				VIS band. Main use: atmospheric correction (aerosols)
2	0.458-0.523	0.45-0.52 (TM1)			VIS: blue band
3	0.543-0.578	0.53-0.61 (TM2)	0.52–0.59 (MS1)	0.50–0.59 (XI1)	VIS: green band
4	0.650-0.681	0.63-0.69 (TM3)	0.62–0.68 (MS2)	0.61–0.68 (XI2)	VIS: red band
5	0.698-0.713				NIR: vegetation red edge band
6	0.733-0.748				NIR: vegetation red edge band
7	0.773-0.793				NIR: vegetation red edge band
8	0.735-0.950	0.75-0.90 (TM4)	0.77–0.86 (MS3)	0.78–0.89 (XI3)	NIR band
8a	0.855-0.875				NIR: vegetation red edge band
9	0.935-0.955				NIR band. Main use: atmospheric correction (water vapor)
10	1.365-1.395				SWIR band. Main use: atmospheric correction (cirrus clouds)
11	1.565-1.655	1.55-1.75 (TM5)	1.55–1.70 (MS4)	1.58–1.70 (XI4)	SWIR band
12	2.100-2.280	2.09-2.35 (TM7)			SWIR band

Table 10 Recommended standard colour rendition for photointerpretation of S2 images

Colour	**Sentinel-2**
Red (R)	band 8 (NIR)
Green (G)	band 11 (SWIR)
Blue (B)	band 4 (red)

3.2.2 Sentinel-2 data access and product types

Access to Sentinel data is free, full and open for the broad Regional, National, European and International user community; data access mechanisms have been tailored to address the different requirements of the various use typologies. Starting in 2014, the Sentinel missions become Copernicus Contributing Missions (CCMs), enlarging significantly the overall operational Earth Observation capability to support fulfilling the needs of the Copernicus Services [19].

The Sentinel-2 User Products always refer to a given **Datatake.** Datatake definition refers to a continuous acquisition of an image from one Sentinel-2 satellite. The maximum length of an imaging Datatake is 15000 km (continuous observation from e.g. Northern Russia to Southern Africa).

Within a given Datatake, a portion of sensed image downlinked during a pass to a given receiving station is termed **Datastrip**. If a particular orbit is acquired by more than one receiving station, a Datatake is composed of one or more Datastrips.

Sentinel-2 User Products are provided as a compilation along a single orbit of elementary **Granules** of fixed size. In this respect, the product granularity corresponds to the minimum indivisible partition of one Sentinel-2 User Product. For Level-0, 1A and 1B products (Tables 11 and 12), these Granules are sub-images in MSI sensor reference frame of a given number of lines along-track and detector separated.

All Granules intersecting/touching the Region of Interest of the user are provided into the final User Product. For ortho-rectified products (Level-1C, Table 12), the Granules are called **Tiles**. A Tile consists of 100km x 100km sized ortho-images in cartographic reference frame UTM/WGS84 (Universal Transverse Mercator / World Geodetic System 1984) projection.

Table 11 Sentinel-2 products: Level 0 [17], [20]

Level-0	Contains raw data after restoration of the chronological data sequence at full space/time resolution. Level-0 product contains all the information required to generate the Level-1 (and upper) products.	One Level-0 product refers always to one Datatake; it can cover the full Datatake or its extract. It may refer to one or several Data-strips from the same Datatake.

Table 12 Sentinel-2 products: Level 1 [17], [20]

<table>
<tr><td>Level-1A</td><td>Corresponds to the systematic processing steps that must be applied before any further processing. It includes:
• decompression of the image data,
• geometric model computation: geolocation information, coarse interband / interdetector registration,
• SWIR pixels re-arrangement.
Allows a quick display of the detectors (sub-swaths) in full resolution by using standard commercial image processing software.</td><td rowspan="2">One Level-1A/B/C product:
• refers always to one Datatake;
• refer to one or several Datastrip from the same Datatake;
• may cover the full Datatake or an extract of the Datatake.</td></tr>
<tr><td>Level-1B</td><td>Radiometrically corrected and geo-refined product obtained by performing corrections on the Level-1A data and refining its geometric model.
The radiometric corrections are applied but the geo-refinement model is only appended to the metadata and not applied to the product. Corrections include:
• Radiometric corrections:
- dark signal, pixel response non-uniformity, crosstalk correction, defective pixels;
- high spatial resolution bands restoration: deconvolution and denoising based on a wavelet processing.</td></tr>
</table>

	• Physical geometric model refinement using GCPs provided by the GRI; this model is not applied to the image but appended to the metadata • Singular pixels detections (defectives pixels, saturations, no-data). No resampling is performed. The geometric model refinement is optional. A dedicated flag in the metadata notifies whether the geometric model provided is the raw model or the refined model.	
Level-1C	Geo-coded top-of atmosphere (TOA) reflectance with a sub-pixel multi-spectral and multi-date registration. Ortho-image product, i.e. a map projection of the acquired image using a DEM to correct ground geometric distortions. Note that the reflectance meaningful values go from "1" to "65535" as "0" is reserved for the NO_DATA. A cloud, land and water mask is associated to the product. L1C products are resampled with a constant GSD (Ground Sampling Distance) of 10m, 20m and 60m according to the native resolution of the different spectral bands.	

Table 13 Sentinel-2 products: Level 2A [20]

Level-2A	Bottom of atmosphere (BoA) reflectance in cartographic projection by using the ATCOR algorithm. Aerosol optical thickness and water vapor content are derived from the image itself. The possibility of making a standard core product, systematically available from the Sentinels core ground segment is currently being assessed as part of the CSC evolution activities.	

3.2.3 Landsat-8

In CLC2018 Landsat-8 data are planned to use in gap filling, i.e. in case no S2 imagery would be available for certain areas [30].

Landsat 8 is an Earth observation satellite of the USA launched on February 11, 2013. It is the eighth satellite in the Landsat program; the seventh to reach orbit successfully. It is a collaboration between NASA and the United States Geological Survey (USGS).

Landsat 8 consists of three key mission and science objectives:

- Collect 30-meter spatial resolution multispectral image (and a 15-meter resolution panchromatic) data affording seasonal coverage of the global landmasses for a period of no less than 5 years;
- Ensure that Landsat 8 data are sufficiently consistent with data from the earlier Landsat missions in terms of acquisition geometry, calibration, coverage characteristics, spectral characteristics, output product quality, and data availability to permit studies of landcover and land-use change over time;
- Distribute Landsat 8 data products to the general public on a nondiscriminatory basis at no cost to the user.

Landsat 8's Operational Land Imager (OLI) improves on past Landsat sensors. The OLI instrument uses a pushbroom sensor instead of whiskbroom sensors that were utilized on earlier Landsat satellites. The pushbroom sensor aligns the imaging detector arrays along Landsat 8's focal plane allowing it to view across the entire 185 kilometers swath cross-track field of view, as opposed to sweeping across the field of view. With over 7,000 detectors per spectral band, the pushbroom design results in increased sensitivity, fewer moving parts, and improved land surface information.

OLI collects data from nine spectral bands. Seven of the nine bands are consistent with the Thematic Mapper (TM, see Table 9) and Enhanced Thematic Mapper Plus (ETM+) sensors found on earlier Landsat satellites, providing for compatibility with the historical Landsat data, while also improving measurement capabilities. Two new spectral bands, a deep blue coastal / aerosol band and a shortwave-infrared cirrus band, will be collected, allowing scientists to measure water quality and improve detection of high, thin clouds.

Recommended standard colour rendition for photointerpretation of Landsat 8 images:

red (R): band 5 (NIR)

green (G): band 6 (SWIR

blue (B): band 4 (red)

3.3 SUPPORT ON IMAGE2018 PROVISION TO COUNTRIES

Because CLC2018 should be completed in 2018, the dedicated Sentinel-2 image acquisition campaign IMAGE2018 is confined to the year of 2017 (covering a single year, instead of 2 or 3 years of previous CLCs). S2 images will provide homogeneous, high quality multi-temporal imagery, which never existed in previous CLC inventories, to support high-quality identification of land cover changes in Europe.

Some facts to consider regarding the use of S2 imagery in CLC2018:

- Large number of S2 acquisitions: Expecting a 5-months long image acquisition period in 2017 (from mid-spring to mid-autumn), and considering the repetition period of 10 days (at Equator) and counting on a single satellite, there are minimum 15 acquisition opportunities over EEA39. For higher latitudes, there will be even more potential acquisitions due to the overlap between neighbour swaths. Having two Sentinel-2 satellites doubles the potential number of images to be acquired.
- Image selection: Images to be processed for CLC2018 will be optimally selected by means of quick-looks, by considering cloud cover and seasonality. An image taken in full vegetation cover (summer) and another one taken in partial vegetation cover (spring or autumn) are usually considered as optimal.
- As the majority of EE39 countries apply photointerpretation in deriving the CLC-Change$_{2012-2018}$ deliverable, an S2 image product, optimized to support this work is offered.
- Cartographic projection: ESA provides Sentinel-2 Level-1C images in UTM/WGS84 projection. National teams in EEA39 work in national projection. S2 imagery is delivered in national cartographic projection to support the work of National Teams.

CLC2018 are therefore produced under changed (but overall improved) input image conditions, based mainly on Sentinel 2 imagery from 2017. The change to Sentinel 2 data also means that ESA is not providing pre-selected and national projected coverages to the countries (as in the past).

To support the countries in the CLC production, a consortium of companies provides Sentinel-2 and Landsat 8 satellite imagery for the CLC2018 exercise (IMAGE2018) in contract with EEA.

The aim is to optimally provide two full image coverages for each country, with at least a six-week period between the two coverages per reference tile. For images, which the CLC national teams add to the coverage 1 or coverage2 we use the term "further images" in the documentation. In addition to these two coverages, the CLC national teams (altogether) can select a maximum of 3000 additional Sentinel 2 images, according to their specific needs, e.g. also images acquired outside of the defined acquisition windows. In the following, the term "additional images" is used for these images, which are not part of coverage 1 or coverage 2.

3.3.1 IMAGE2018 product types

The image product types available are:

1. The main visual product, re-projected into national projections, based on Sentinel 2 data (or Landsat 8 for gap filling)
2. Additionally the full products with no modifications, for those countries that want to go beyond visual interpretation

Table 14 Overview of IMAGE2018 product types

	Visual product	**Full product**
Sentinel 2A/B	• GeoTIFF, 16bit, 3 bands, no compression, ToA reflectance • False colour composite using S2 bands 8, 11 and 4 (NIR, SWIR, red) • 10 meter spatial resolution • Re-projection to national projection as specified by EEA with EPSG codes • No geometric improvements • No radiometric improvements • Band 11 brought to 10 m by HPF sharpening	• no modification of projection, format, naming convention, radiometry, meta data • all bands in original resolution
Landsat 8	• Re-projection to national projection as specified by EEA with EPSG codes • False colour composite using L8 bands 5, 6, 4 (NIR, SWIR, red) • 15 meter spatial resolution • No geometric improvements • DN to ToA reflectance conversion, followed by HPF sharpening	• no modification of projection, format, naming convention, radiometry, meta data • all bands in original resolution

3.3.2 Image selection workflow and timing

The service provider, based on the acquisition windows agreed, selects 2 coverages of Sentinel 2 imagery (or Landsat 8 gap filler), and provide countries with details on their suggested selection. Each country is provided with a FTP download that contains in separate directories the natural colour quicklooks of the pre-selected coverages and a shapefile with the image footprints and the names of the corresponding quicklooks. In a separate directory quicklooks of possible additional imagery are provided.

In the process of image selection, the countries have the opportunity to:

- Accept the pre-selected coverages as they are.
- Reject one or more images of the pre-selected coverage and select other images instead. If necessary, select further images for coverage 1 and/or coverage 2. In case that the final number of images exceeds the number of images that the service provider pre-selected by more than 10%, please contact[5] the service provider to find a solution.
- Select additional Sentinel 2 imagery if necessary (“additional images”). All member states in total can select a maximum of 3000 additional Sentinel 2 images. If the demands by all member states in total exceed 3000 images, EEA will find a solution for fair distribution.

The workflow is summarized in Table 15.

[5] Contact by replying to the e-mail informing about FTP download site.

Table 15 Workflow steps of IMAGE2018 selection

Workflow step	**Activity**	**Who is doing this?**	**Timing**
1	After closure of extended window, **pre-selection and documentation of imagery by SP**	SP (service provider)	Up to 4 weeks after closure of extended windows (with first deliveries starting 3rd October)
2	**Approval or rejection of pre-selected S2 image tiles**/LS8 scenes, possibly the selection of further S2 image tiles/LS8 scenes for the two coverages, and possibly selection of additional S2 image tiles. Based on shapefile, natural colour quicklooks and detailed instructions provided by SP	CLC national teams	Up to 2 weeks (total of 6 weeks after end of extended window, taking into account first delivery date)
3	**Production of imagery** and provision for FTP download	SP	Up to 4 weeks (total of up to 10 weeks after end of extended window, taking into account first delivery date)
4: Only in exceptional cases (in case country teams discover problems with images that were not visible in the quicklooks, but that require additional imagery)	Propose further S2 image tiles/LS8 scenes for the two coverages and/or further additional S2 image tiles.	CLC national teams	Up to 2 weeks (total of 12 weeks after end of extended window)
5: Only in exceptional cases	Only in accordance with the SP and EEA: Production of imagery and provision for FTP download	SP	Up to 4 weeks (total of up to 16 weeks after end of extended window)

Detailed step-by-step guidelines on how to evaluate pre-selected images and to select the additional imagery (if needed) is provided by the SP [32].

4 PRODUCTION OF CLC-CHANGE2012-2018

4.1 INTERPRETATION STRATEGY IN CLC2018

Chapter 4.1 is specific because of the use of Sentinel-2 data and valid for any methodology of deriving CLC-change2012-2018.

During the S2 image acquisition campaign in 2017 we can expect several images acquired for any area over the EEA39 (see Ch.3.2.3). Even if some of these images will be cloudy / partially cloudy, we can expect a number of useful or partially useful images, more in number than was available for former European CLC inventories. There are three main issues to be considered in proper satellite image selection:

1. Vegetation phenology (see also in Ch. 4.2.2.2.3): it is important to have an image taken in the peak of vegetation development.
    a. Forests: Broadleaved forests are leafless in May in Scandinavia and some species (e.g. *Robinia pseudoacacia*) can be leafless even in Central Europe in that period. The leaf development status depends on elevation also. Mapping forests is optimal by using images taken in July or August.
    b. Natural grassland and sparse vegetation: green vegetation should be visible to map these classes properly. As grass becomes yellow in summer under warm climate (Mediterranean, Iberian Peninsula, Turkey) images taken at spring (even May can be too late in some regions) are needed to map these classes.
    c. Non-irrigated arable land: like in b) spring images are needed to distinguish rain-fed crops (class 211) from abandoned arable land (class 231) in the Mediterranean, Iberian Peninsula and Turkey.
2. Water: proper mapping of water coverage in CLC often requires two satellite images, taken in different seasons. This way short term phenomena (e.g. flooding) will not result misclassification. Spring and summer imagery will support to avoid erroneous mapping of seasonal changes of water coverage of lakes and reservoirs (e.g. due to water abstraction for irrigation during summer).
3. Glaciers and permanent snow: images of not exactly the same date (optimally the date of smallest snow extent: late August or early September) are not comparable, thus using them leads to mapping false changes.
4. Fast-changing phenomena: especially constructions and mines, clearcutting of forest and burnt forests and shrubs. These phenomena can develop fast relative to the length of the S2 image acquisition period in 2017. Because the aim is to map the land cover status which is closest to the year of 2018 (nominal reference year of CLC2018), the **latest acquired useful (cloud free) image should be used**. However, as late season images can suffer from low Sun illumination angle, the practical end of the image acquisition period should be determined according the (extended) time window set by the country.

Text box 1:

How to understand „the latest acquired satellite image should be used to map fast-growing changes"?
Example:
The country sets the extended time window: 1st June – 15 September
There are S2 images acquired on: • 23 Aug, 50% clouded • 06 Sept, cloud free • 13 Sept, <5% clouded • 20 Sept, 80% clouded • 27 Sept, cloud free
Preference is given to use the image taken on 13 September

- An **S2 image taken in the peak vegetation** period (e.g. July) is considered as the main coverage (coverage-1) for photointerpretation / thematic processing.
- It is obligatory to use the **latest[6] acquired useful S2 image** (e.g. early September, mid-October, depending on latitude). This is considered coverage-2 for photointerpretation / thematic processing. This image **will be used primarily in verification by the CLC Technical Team.**
- The time difference between coverage-1 and coverage-2 should be at least 6 weeks.
- **Use both coverage-1 and coverage-2 in photointerpretation / thematic processing.** Otherwise there is a risk that the interpretation will be incomplete.
- Moreover, an image taken in May or early June can be proposed as coverage-3 for areas with warm climate (the Mediterranean, Iberian Peninsula, Turkey) for improved mapping of semi-natural vegetation as well as agriculture. The time difference between coverage-3 and coverage-1 is preferably also at least 6 weeks.

4.2 CHANGE MAPPING

This chapter is in large part a repetition of the similar chapter in CLC2006 Technical Guidelines [3] and in part included also in Addendum CLC2012 [4].

CLC-Change$_{2012-2018}$ is the primary product of the CLC2018 project. CLC-Change$_{2012-2018}$ is a "stand-alone" product (i.e. not derived by intersecting CLC2012 and CLC2018) and having a smaller MMU (5 ha) than the CLC status layers (25 ha).
The aim is to produce European coverage of **real land cover changes** that

- are larger than 5 ha;
- wider than 100 m,
- occurred between 2012 and 2018;
- are detectable on satellite images[7]; regardless of their position (i.e. connected to an existing CLC2012 polygon or being "island"-like).

[6] according to the image acquisition window defined for the region

[7] with support of dedicated in-situ data

Text box 2:

What does "real land cover change" mean?

Change codes should always represent the change process that happened in reality. When giving the codes, interpreter always must be able to answer the questions: what is the process described by the codes I gave? Is this process the same what I see on the image pair? Is this really a CLC change?

Example:

211-112 change means extension of built-up area (112) on non-irrigated arable land (211). The interpreter should see the irrigated arable land on the 2012 image, and should be convinced that this is not a long-time abandoned area (231) or area under construction (133). Moreover, he/she should be convinced that in 2018 the area is built-up (112) and not yet under construction (133).

This way interpreter can avoid mapping seasonal differences as change or giving attributes that are meaningless on the field. See more details in Ch. 4.2.1/Real change.

The proposed "change mapping first" approach (see Text box 3) provides a good means to answer these questions and map real land cover changes with MMU = 5 ha.

On the contrary, the "update first" approach followed by intersecting CLC2012 and CLC2018 would provide differences of two datasets with 25 ha MMU. These differences should be edited to get the real changes, moreover changes in the 5 ha – 25 ha size range will be neglected.

Because most of the participating countries still apply photointerpretation (CAPI) the previously standardised **"change mapping first" methodology** is promoted, like in CLC2006 and CLC2012 inventories. Obviously, like before, any alternative solutions capable to provide equivalent results are encouraged.

Text box 3:

What does "Change mapping first" method mean:?

"Change mapping first" means that changes are interpreted directly, based on comparison of reference images. Visual comparison of IMAGE2012 with IMAGE2018 satellite imagery (with CLC2012 vector data overlaid for spatial reference) is followed by direct delineation of change polygons.

Practically, if change occurred to a CLC2012 polygon, it should be transferred to the database of CLC changes, where the changed part will be delineated and kept as polygon (Fig. 4).

At the end of process CLC-Change$_{2012-2018}$ polygons will be combined with CLC2012 polygons in GIS to obtain CLC2018 database.

Necessary thematic / geometric correction (revision) of CLC2012 data must precede the delineation of change polygons in order to avoid error propagation from CLC2012 to CLC2018.

Consequently, change mapping consists of two steps, namely:

- CLC2012 correction (revision) and
- interpretation of changes that occurred between 2012 and 2018.

The two processes can be carried out consecutively or in parallel, but on level of individual polygons correction (revision) must always precede change delineation (see Ch. 4.2.2.1).

The basis of identification of changes is the interpretation of visually detectable land cover differences on images taken in 2012 and 2018. Ancillary data, such as topographic maps, orthophotos, HR layers (derived from satellite imagery), LPIS data, Google Earth imagery etc. are highly recommended to use (see Ch. 5).

Delineation of changes must be based on CLC2012 polygons in order to avoid creation of sliver polygons and false changes when producing CLC2018 database. This means that during interpretation of changes CLC2012 polygons must be visualised for and used by the interpreter so that outlines of CLC-Change$_{2012-2018}$ polygons exactly fit CLC2012 boundaries (Fig. 4).

Interpreter must give two CLC codes to each change polygon: code$_{2012}$ and code$_{2018}$, both included as separate attributes. These codes must represent the land cover status of the given polygon in the two dates respectively. **Change code pair thus shows the process that occurred in reality** and may be different from the codes occurring in the parent layer and / or in new CLC databases (due to generalisation applied in producing CLC2012 and CLC2018). See Text box 4.

Text box 4:

What does it mean: Change code pair should show the process that occurred in reality and may be different from the codes occurring in the parent layer and / or in new CLC database?

Example:

Think about a 243 polygon in CLC2018 including small (<25 ha but > 5 ha) agriculture land and small patches of forest.

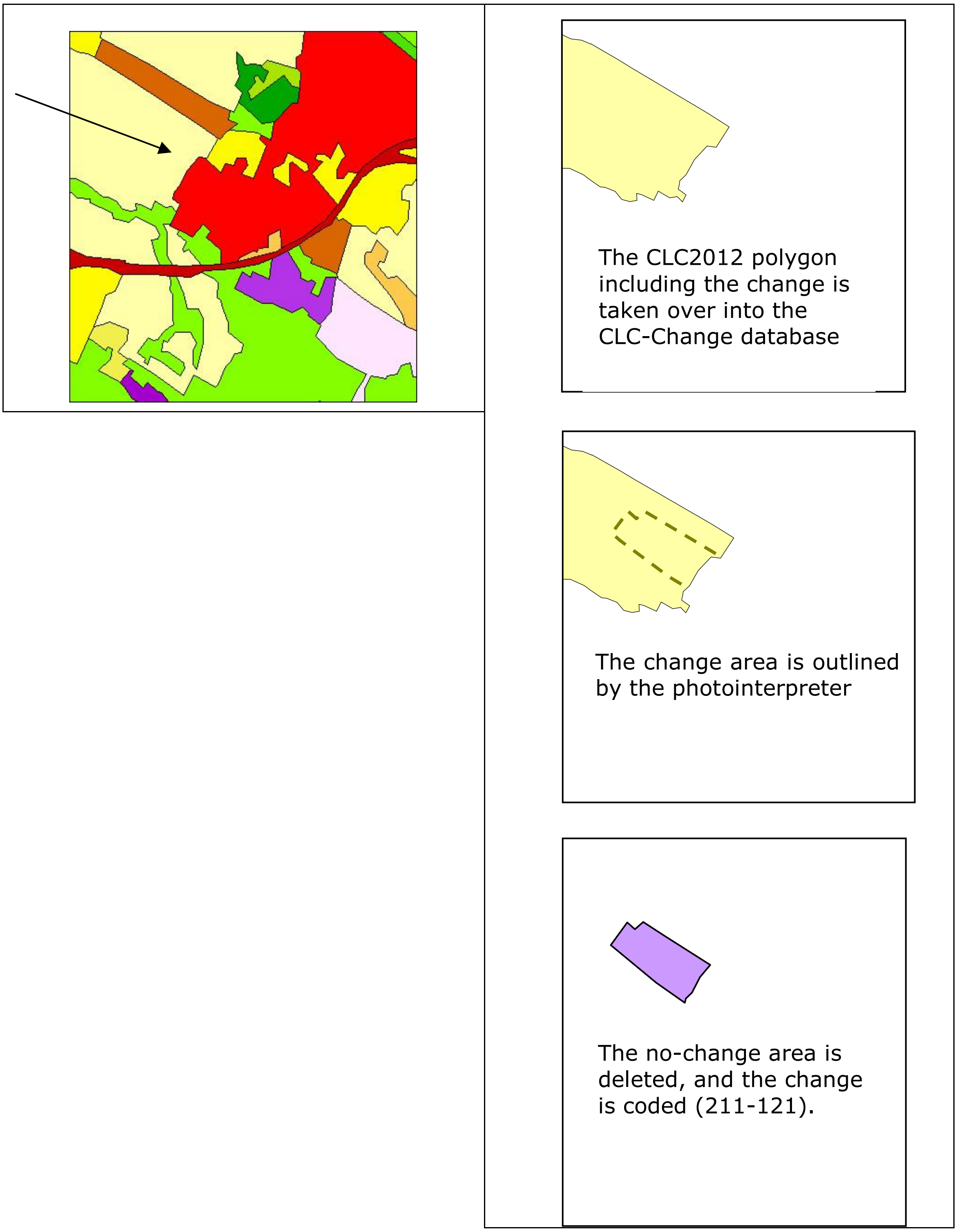
One of the forest patches (>5 ha) inside the polygon has been cut between 2012 and 2018.

The real change which has to be mapped is: 311-324, and not 243-324 (being a false change). Note, that the CLC2012 code should not be taken over automatically into CLC2018!

In CLC2018 the small (<25 ha) 324 polygon will be generalised to yield a 243 polygon.

In this example both attributes of the CLC-change polygons are different from code$_{2012}$ as well as from code$_{2018}$.

See more in Ch. 4.3.1 /Real change



4.2.1 Input vector data

There are two input vector layers to be used in implementation of CLC2018 change mapping. The first and most important of these is the CLC2012 database. Like in previous CLC exercises, a border-matched version of CLC2012 data has been produced by EEA in order to eliminate inconsistencies along state boundaries. As most of the borders were already matched during the CLC2000 and CLC2006 project, only a limited level of border matching took place this time.

For consistency reasons, all countries participating in CLC2018 update are expected to start the work with CLC2012 data extracted from the latest version of integrated European CLC2012 dataset.

In order to support this, border-matched CLC2012 and CLC-Change2006-2012 data (vector format, national projection) for all participating countries are available for download at:

https://forum.eionet.europa.eu/nrc_land_covers/library/copernicus-2014-2020/pan-european-component/corine-land-cover-clc-2018/support-files-clc-production/

Delivery contents:

CLC2018_support_XX.gdb – database in ESRI ArcGIS 10.0 file geodatabase format:
clc12_XX_nat .... CLC2012 status dataset

cha12_XX_nat .... CLC2006-CLC2012 change dataset

shapes/ - directory with data in ESRI shape format:

clc12_XX_nat.shp .... CLC2012 status dataset

cha12_XX_nat.shp .... CLC2006-CLC2012 change dataset

CLC2018_support_XX.xml – INSPIRE compliant metadata file in XML format
CLC2018_support_XX.pdf – Summary report for delivery (including CRS transformation parameters)

XX_nat.prj – Coordinate Reference System definition on ESRI PRJ file

4.2.2 Particular requirements concerning CLC2018 mapping

There are particular requirements of change mapping that were indeed mentioned, but (as shown by experience gathered during the CLC2012 verification process) probably not emphasised strongly enough.

4.2.2.1 CLC2012 revision

Occurrence of interpretation mistakes is an inherent characteristic of visual interpretation of remote sensing data, coming not necessarily from negligence, but insufficient information. During updating, by examining newly available satellite images or ancillary data, usually a number of thematic mistakes are discovered in the database to be updated. In order to avoid error propagation into CLC2018, mistakes discovered in CLC2012 are much recommended – in locations of changes absolutely necessary – to be corrected.

These are:

1. Systematic mistakes known from the previous inventory but not corrected yet and ones discovered during the recent change mapping (or verification). These are relatively easy to find by searching for the codes that show systematic mistakes. Systematic improvement of geometry can also be included here.
2. Random mistakes. These are usually ad-hoc discovered during change mapping, or can be systematically searched for by visually browsing the CLC2012 map in scale 1:30.000-40.000.

In case national team decides not to modify previously submitted CLC2012 data, the tool of technical change (polygons of any size in the change database having similar codes for 2012 and 2018) can be used for revision (and transfer of correction to CLC2018). If used for revision, technical changes can be larger than 25 ha. E.g. if a 50-ha polygon is coded as technical change (121-121) (see Ch. 4.3.1/ Technical change), it means that 50-ha industrial area was not mapped in CLC2012. By means of using technical change CLC2018 will include this 50-ha industry as revision.

The process of CLC2012 revision can be done either before starting change mapping or in parallel with change mapping (depending on the software used). However, interpreter must make sure that revision (correction) of an individual CLC2012 polygon is always done **before** a change is mapped in the same location.

4.2.2.2 CLC change interpretation

4.2.2.2.1 Geometry

a. The mapping of CLC changes must be done using the geometrical basis of CLC2012 polygon layer. The outline of change polygons must therefore match CLC2012 polygon border, otherwise false changes and geometric mistakes occur. This means that firstly, there should not be any narrow channels between or slivers around change polygon outlines and CLC2012 polygon outlines (Fig. 5); secondly, change polygon outlines should not criss-cross over CLC2012 outlines (Fig. 6). These mistakes can be most easily avoided by applying the recommended method of change mapping: taking over polygons from CLC2012 to change database, then drawing changes, then discarding not changed parts (Fig. 4).

b. Topological consistency must be kept. Change polygons should not overlap each other.

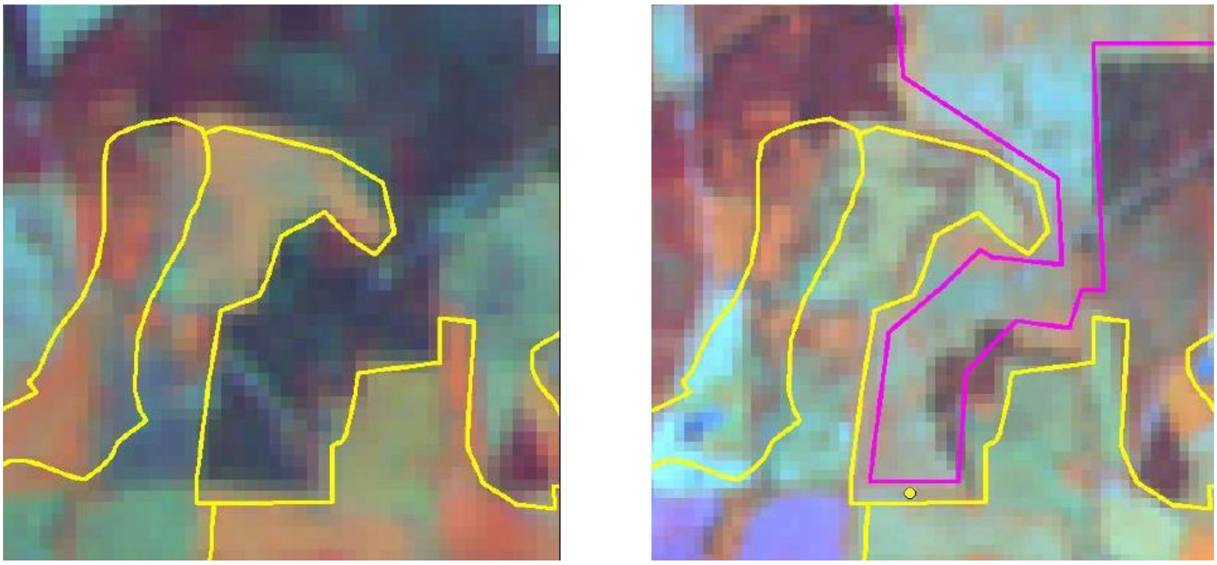


Figure 5 Mistake: Narrow channel between change outlines (right side, magenta) and CLC status layer outlines (yellow)

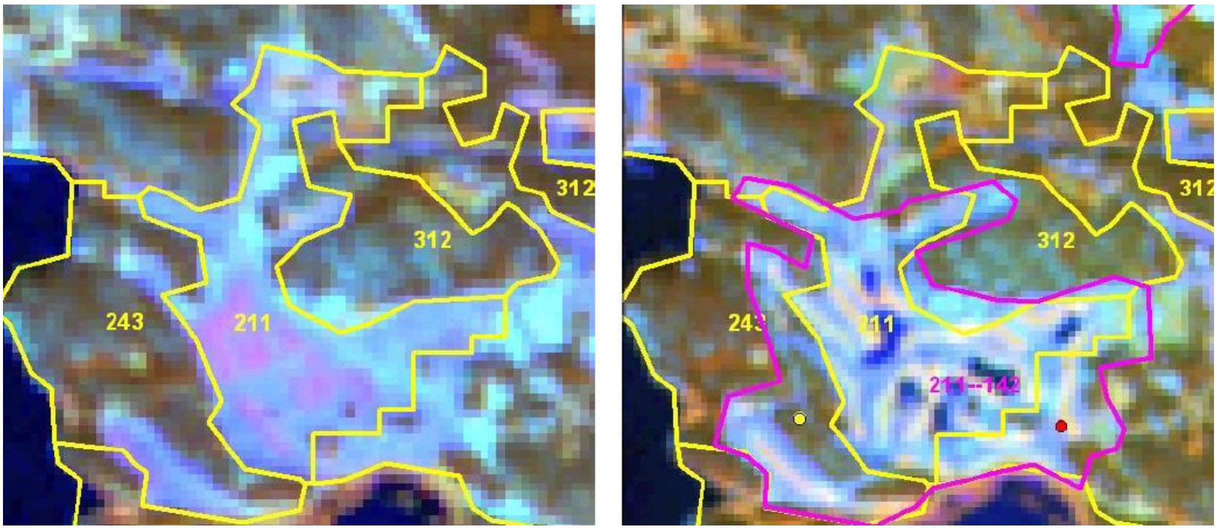


Figure 6 Mistake: Change outlines (right side, magenta) not matching CLC status layer outlines (yellow)

4.2.2.2.2 Coding

Interpreter should give two codes to each change polygon according to what is visible on the relevant imagery, one representing land cover in 2012 and the other in 2018. Change codes should always represent the change process that happened in reality. Therefore, codes can be different from respective codes in CLC2012 and CLC2018 databases (see Text box 4).

When giving the codes, interpreter always must be able to answer the question: what is the process described by the code I gave? Is this process the same what I see on the image pair? Is this really a CLC change? This way interpreter can avoid mapping seasonal differences as change or giving attributes that are meaningless on the field. See more details in 4.3.1/Real change.

4.2.2.2.3 Image dates

In order to avoid mapping seasonal differences as change, interpreter should always be aware of image dates (year and month at least). The best way to achieve this is to **include image date in the image file name**, so that it is visualised all the time (see S2 file names in Ch 3.2.3). It is the same reason that makes image mosaics of limited use for CLC change mapping; in a mosaic image dates are hard or impossible to check and radiometry (colours) are often strongly distorted. Knowing image dates is especially important in the following cases:

- Mapping vegetation of mountainous areas: vegetation reaches its full development / foliage cover only around June, so earlier images might mislead interpreter.
- Mapping hot and dry (Mediterranean and strongly continental) areas: vegetation is usually dried out by early summer, which is the "standard" date of images for land cover mapping. Thus vegetation (arable crops, grassland) is not detectable on such images, or it is almost impossible to distinguish arable fields from patches of natural grassland or even sparsely vegetated areas. Therefore, additional images from April/May are highly recommended to use in such areas (e.g. Iberian Peninsula, Anatolia). The same is true for distinguishing natural grassland areas from sparsely vegetated areas or bare rocks.
- Mapping changes of water bodies, especially reservoirs: being unaware of image dates might lead to mapping seasonal water level fluctuations (lakes shrinking due to summer heat and water take-up for irrigation) as permanent changes, which is a mistake. Same is true for Alpine rivers, where highest water level occurs in spring/early summer, due to snow melt.

- Mapping glaciers and permanent snow: images of not exactly the same date (optimally the date of smallest snow extent: late August or early September) are not comparable, thus using them leads to mapping false changes.

4.2.2.2.4 Nomenclature

Lessons learnt during previous CLC inventories and the respective verification processes have resulted in the creation of an enhanced version of the CORINE Land Cover nomenclature guidelines. It is required that the latest version of this document is used [5]. An online (html) version of the document is also made available.

4.3 PHOTOINTERPRETATION OF CHANGES

4.3.1 Figure legends and definition of terms

In the following chapter, schematic figures help to give guidelines on the way of interpreting changes. On these illustrating figures (Figs. 7-26) the same legend is applied. Colour polygons represent patches visible on the satellite image(s). Polygons with thick solid outlines represent land cover patches that form a CLC polygon at the given database. These are also marked with the corresponding CLC code. Polygons with dashed outline show patches whose land cover has changed. Patches without an outline represent patches of land cover that do not form valid polygon in the given database.

Each explanatory figure consists of four boxes:

- First box shows the land cover status visible on IMAGE2012 and the polygon outlines in CLC2018 database.
- Second box shows the land cover status visible on IMAGE2018 without polygon boundaries. Dashed outline marks patches that have changed.
- Third box shows polygons to be drawn in the CLC-Change database. Polygons marked with red T will be deleted from the final CLC-Change database (see term “technical change” below).
- Fourth box shows the polygons as present in CLC2018 database (as the results of GIS addition of CLC2012 and CLC-Changes – see Ch. 6).

<u>Patch</u>

Patch is a continuous area having a common CORINE land cover type in reality and being recognizable on the satellite image(s). A patch becomes a valid CLC polygon only if its size exceeds the MMU.

<u>Direct delineation of changes</u>

Change polygons are drawn directly on the corresponding image by means of CAPI and not generated by GIS operation (intersection of databases) – see also in Ch. 4.2. Human expertise has control over the whole procedure thus helping to avoid creation of impossible or false change polygons.

<u>Real change</u>

Like in CLC2012 the change layer is interpreted directly in CLC2012 project, thus change polygons do not necessarily have to inherit their code_{2012} and code_{2018} from the corresponding CLC2012/CLC2018 polygon, but can be modified. Interpreter is supposed to attribute to the change polygon the code_{2012} / code_{2018} code pair that best describes the process that the given land cover patch has undergone in reality <u>(see also in Text box 4)</u>. Code pairs thus reflect real processes instead of differences of two databases (Fig. 7).

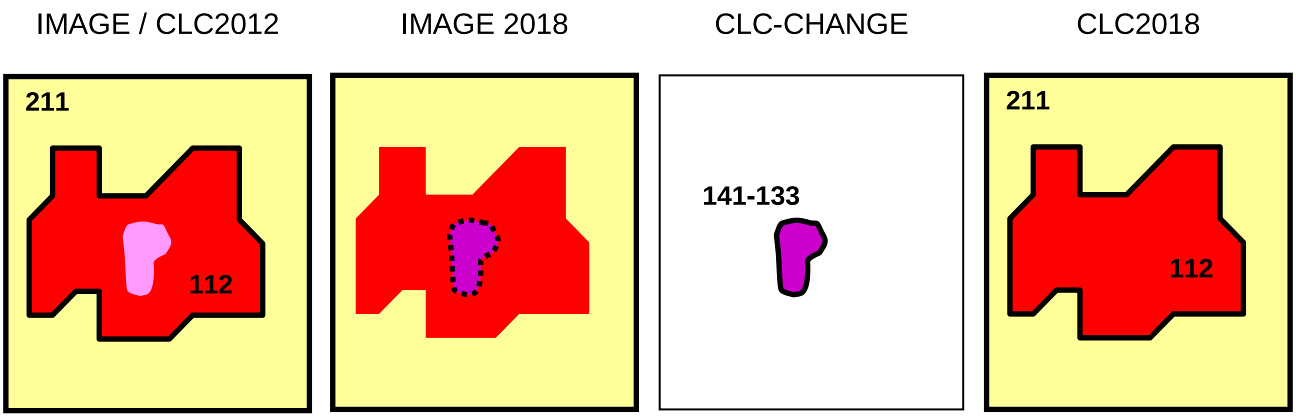


Figure 7 Principle of interpreting real change: the loss of urban green (141) < 25 ha by becoming a construction site (133) must be coded 141-133 in the CLC-Change database, although the patch is generalised into discontinuous urban fabric (112) in both CLC2012 and CLC2018.

Technical change (T)

Technical change polygon is an auxiliary change polygon used for avoiding some major (minimum 5 ha, maximum 25 ha) inaccuracies of CLC2018 database. They are applied exclusively in the cases listed in the change typology (Table 16, types E & F), which means that they should not be numerous. Technical change polygons do not represent a change of land cover in reality, but are consequences of the two different MMUs of CLC-Change (5 ha) and of CLC status layers (25 ha). They are used only in order to allow creation of a new polygon in CLC2018 by GIS operation, after this they are deleted from the CLC-Change database.

Technical change polygons are drawn by the interpreter during change mapping over those patches with size between 5 ha and 25 ha[8] and width ≥ 100 m.

- whose land cover has NOT changed between 2012 and 2018 (although might include < 5 ha changed patches);
- that are not present as polygon in CLC2012;
- still we want them exist as polygon / part of polygon in CLC2018.

Technical change polygons must be given **identical code$_{2012}$ and code$_{2018}$ AND an additional attribute** that makes them identifiable and makes possible to select them automatically. The attribute added to each change polygon should be named "technical", having a value 1 if the change polygon is technical, and value 0 if not.

The operation of identifying and delineating technical changes requires the interpreter's to foresee the CLC2018 database while interpreting CLC-Change$_{2012\text{-}2018}$.

The terms "changes" and "change polygons" without the tag "technical" in this document always mean real changes.

Complex change, elementary changes

[8] An alternative (exceptional) application of technical change was mentioned in Ch. 4.2.2.1 for correcting CLC2012. In this case the size of technical change polygon is not limited to below 25 ha.

Although the MMU for change mapping is 5 ha, in some cases change polygons < 5 ha are also mapped. When a new polygon is formed by taking area from several other polygons (e.g. a road construction), the individual connected change parts can be mapped even if they are < 5 ha, given that they altogether make up a > 5 ha complex change polygon. Elementary changes have to have a common code either in 2012 or in 2018 and must make up altogether > 5 ha (Fig. 8).

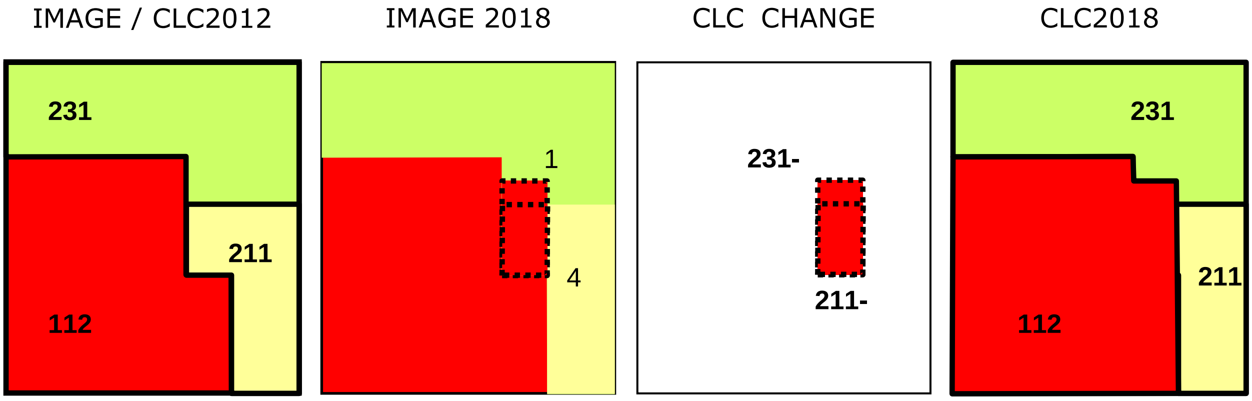


Figure 8 Complex change and elementary changes: Settlement (112) has taken 1 ha area from pasture (231) and 4 ha from arable land (211). These two elementary changes make up a complex change of 5 ha.

4.3.2 Most frequent thematic problems in mapping CLC-Changes

Photointerpreters must be aware that not all changes visible on the satellite images are treated as change by CLC. The most frequent mistakes are listed below. See more details in [23]:

- transient phenomena such as floods and temporary water-logging;
- seasonal changes in natural vegetation, such as difference of biomass;
- seasonal changes in agriculture, such as effects of crop rotation on arable land;
- forest plantation growth, still not reaching the height and / or canopy closure of forest;
- changes of water level of Mediterranean / Alpine / karstic water bodies;
- temporal changes in water cover of fishpond cassettes being part of their management;
- changes in distribution of patches of reed and floating vegetation in marshes;
- seasonal changes of snow spots in high mountains.

The introduction of false changes must also be avoided. Many of these can and should be excluded by pure logics. These vary from country to country (e.g. while normally sea water does not change into pasture, it might happen in the Netherlands), thus following examples are not exhaustive and not binding for all cases. However, in the overwhelming majority of the cases they can be considered valid.

Highly non-probable changes are for example (not a complete list, see more examples in [23]):

111 -> 112,121,131,132, ...	Densely built up areas seldom disappear
2xx-324, 321-324	Agriculture classes and natural grassland cannot be interpreted as burnt (by definition, see nomenclature [5])
322 -> 323	Bushy vegetation of different climatic zones does not change to each other
411 -> 412	Peatland needs longer than 10 years-long time to develop.

4.3.3 Change typology – guidelines for interpretation

The thumb rule of CLC2018 change mapping approach is that **ALL changes larger than 5 ha should be delineated regardless of their position** (whether being connected to existing CLC2012 polygon or being island-like, see Ch. 4.2)). In order to understand the context better, a typology of changes was created dividing all change cases into one of the following 8 theoretical types. Three databases play role in CLC update:

- revised CLC2012, which cannot contain polygons < 25 ha,
- CLC-Change$_{2012\text{-}2018}$, which cannot contain polygons < 5-ha (except elementary changes, see Fig. 8).
- CLC2018, which cannot contain polygons < 25-ha and is created using the previous two.

Based on existence / non-existence of a corresponding polygon in each of the three databases (CLC2012, CLC-Change$_{2012\text{-}2018}$, CLC2018) a typology of changes can be created [10].

Let us assign an L logical variable to each patch, which has a value of 1 (true) if the patch in its database reaches the corresponding size limit and consequently emerges as a polygon. The value of L is 0 (false) if the patch is below the corresponding size limit, and it does not form a polygon in the database. *A* refers to area in hectares.

$L_{2012} = 1$	if	$A_{2012} \geq 25$ ha,	$L_{2012} = 0$	if	$A_{2012} < 25$ ha;
$L_{ch} = 1$	if	$A_{ch} \geq 5$ ha,	$L_{ch} = 0$	if	$A_{ch} < 5$ ha;
$L_{2018} = 1$	if	$A_{2018} \geq 25$ ha,	$L_{2018} = 0$	if	$A_{2018} < 25$ ha.

The decision table with three logical variables (corresponding to the three databases) includes altogether $2^3 = 8$ different types (Table 16).

Table 16 Theoretical change types (T refers to technical change) [10]

Letter code	L_{2012} $A_{2012} \geq 25$	L_{ch} $A_{ch} \geq 5$	L_{2018} $A_{2018} \geq 25$	Short explanation	*Remark*
A	1	1	1	Simple change	*Occurs the most frequently*
B	1	0	1	Small change in existing polygon	*Occurs frequently; **not interpreted** -> max. 5 ha error in CLC2018*
C	1	1	0	Disappearance of polygon	*Seldom occurs*
D	1	0	0	Disappearance of polygon with small change	*Occurs very seldom, **not interpreted** -> max. 5 ha error in CLC2018*
E	0	1	1	Emerging of new polygon	***T** is used to avoid > 5 ha <25 ha error in CLC2018*
F	0	0	1	Emerging of new polygon with small change	***T** is used to avoid > 20 ha < 25 ha error in CLC2018*
G	0	1	0	Change only	*Occurs frequently*
H	0	0	0	Small change only	***Not interpreted***

Hereafter we give guidance on the way of handling each of the above types, illustrating them with examples. Of course, no universal recipe can be given for any of the cases. Thus, the following examples are schematic (they show a simplified reality) and do not list all possible combinations of codes and sizes. However, any change case falls under one of these theoretical types. The examples do not deal thoroughly with questions of generalisation, as these are well described in the CLC nomenclature document [5]. For figure legend see Ch. 4.3.1.

A. Simple change: a polygon > 25 ha in CLC2012 grows or decreases with a change > 5 ha resulting a polygon > 25 ha in CLC2018

Being the most frequently occurring change type, changes > 5 ha connected to an existing (> 25 ha) CLC2012 polygon are always mapped (Figs. 9 & 10).

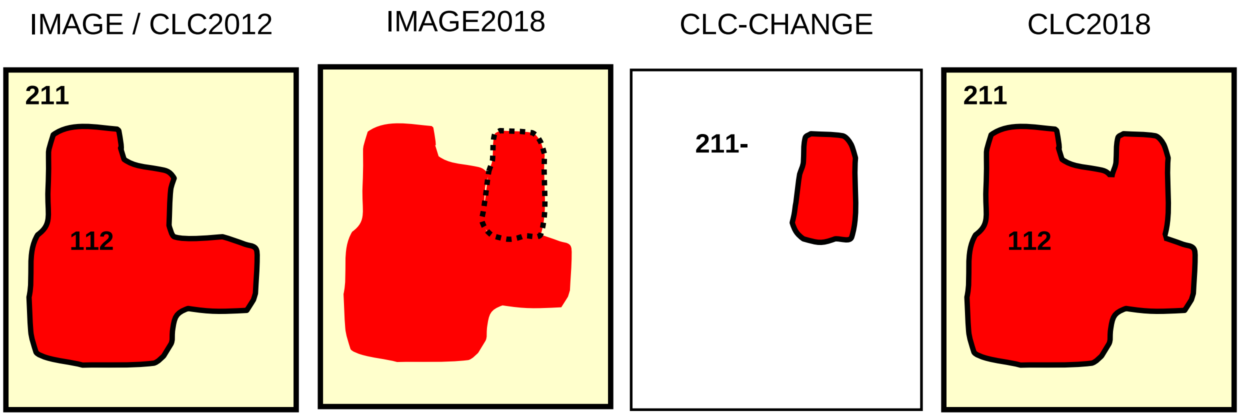


Figure 9 Simple change (growth): A settlement (112) > 25 ha grows with > 5 ha, occupying arable land (211)

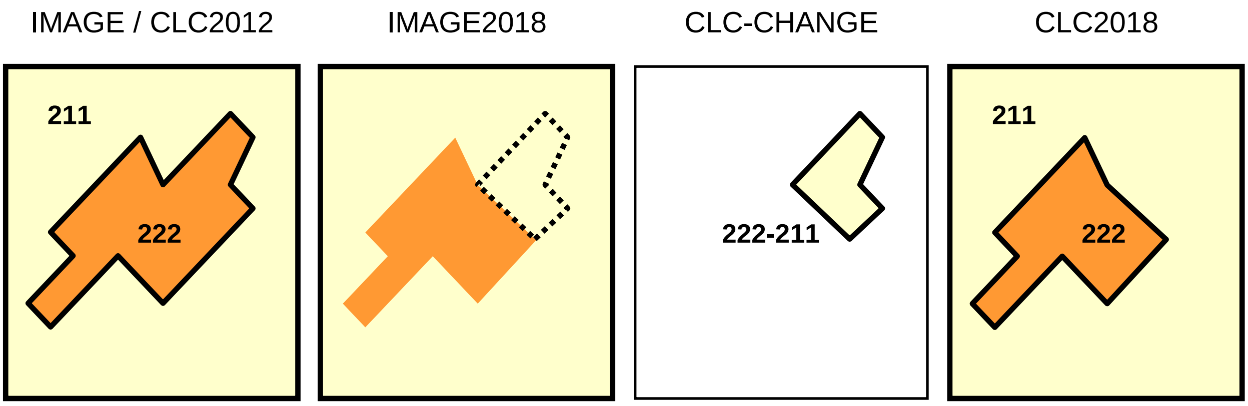


Figure 10 Simple change (shrinkage): A fruit orchard (222) > 25 ha decreases with > 5 ha, while area of arable land (211) is increasing. The resulting 222 polygon is still > 25 ha in 2018.

Following their delineation, change polygons must be given a $code_{2012}$ and a $code_{2018}$ representing the processes having occurred to the given patch in reality (see explanation at „real change" at Ch. 4.3.1).

B. Small change in existing polygon: < 5 ha change in polygon > 25 ha

No change polygons < 5 ha should be mapped except if they are elementary changes of a complex change > 5 ha (Ch. 4.3.1. and Fig. 8).

Remark: 10% exaggeration in size is allowed (i.e. 4.5 ha new industry is better to enlarge to 5 ha in order to keep it in CLC-Change).

C. Disappearing polygon: a polygon decreases to <25 ha with a change > 5 ha

If due to a change > 5 ha the size of a polygon decreases under 25 ha, it will disappear in CLC2018 because of generalisation, while the change polygon remains in CLC-Change. Only the part that has really changed must be delineated during change mapping (Figs. 11 and 12).

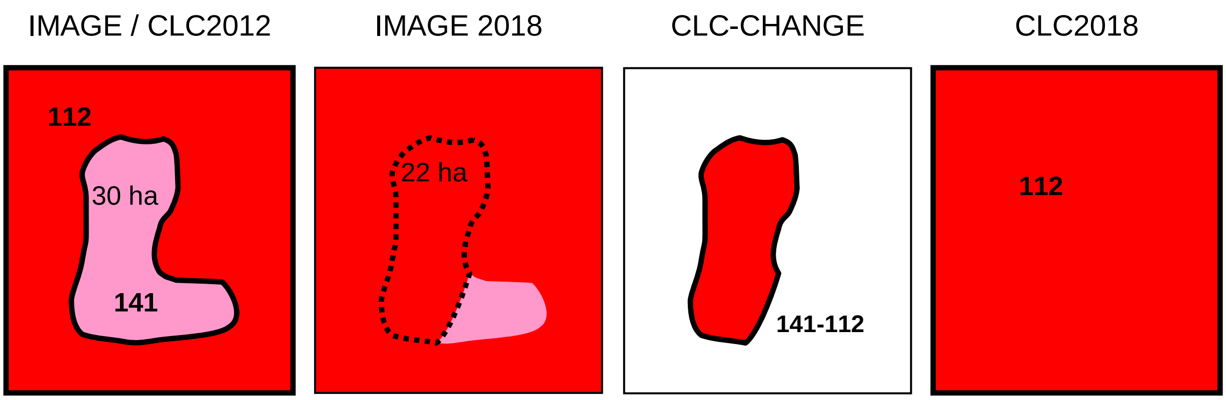


Figure 11 Disappearing polygon, case-1**:** Most of the area of a park (141) is built up so that the park's size actually decreases under 25 ha. Consequently, what is left of it is generalized into the settlement (112) in CLC2018.

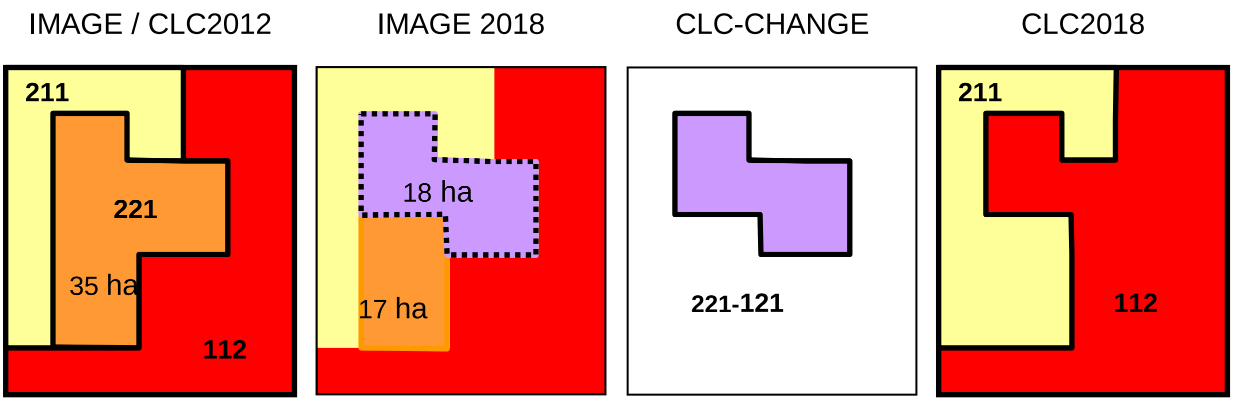


Figure 12 Disappearing polygon**,** case-2: Significant (> 5 ha, but < 25 ha) part of a vineyard (221) is occupied by new industry (121). A change polygon coded 221-121 is delineated in CLC-Change database. The area left from the vineyard is < 25 ha. Consequently, in CLC2018 the remaining vineyard and the new industry is generalized into arable land (211) and urban fabric (112), respectively.

D. Polygon disappearing with small change: a polygon decreases to < 25 ha with a change < 5 ha

In a few cases, existing polygons decrease to a size < 25 ha with a change < 5 ha. As change is < 5 ha, the changed patch should not be delineated. This causes a minor (< 5 ha) mistake in CLC2018.

Remark: 10% exaggeration in size is allowed (i.e. 4.5 ha new residential area is better to enlarge to 5 ha in order to keep it in CLC-Change).

E. New polygon: a polygons grows > 25 ha with a change > 5 ha

The simplest case of this type is the emerging of a new patch > 25 ha (Fig. 13).

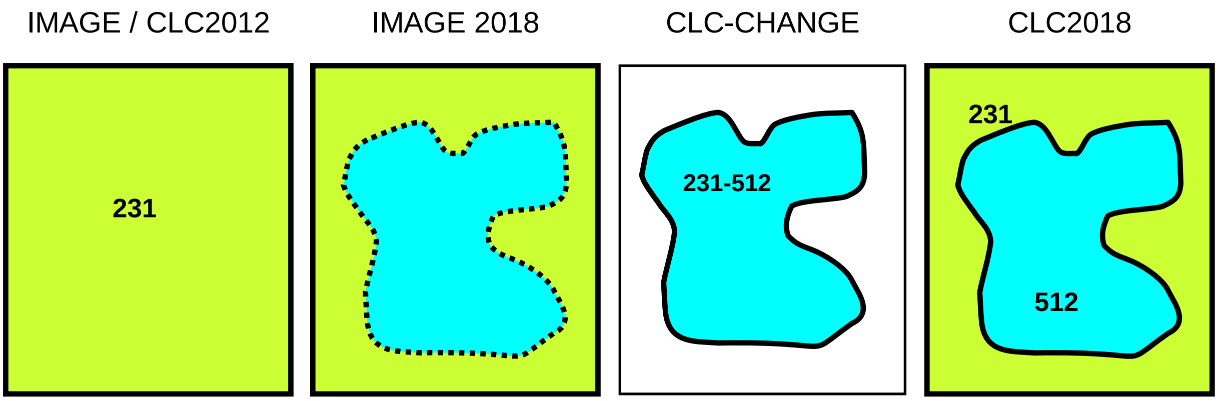


Figure 13 New polygon: A > 25 ha new fishpond (512) is established on former pasture (231).

If a patch that existed in 2012, but used to be < 25 ha (thus not mapped in CLC2012) grows with a change > 5-ha so that it exceeds the 25-ha limit in 2018, a so-called „technical change" polygon must also be applied. Besides delineating the real change (grown part of the polygon), the non-changed (originally existing) part must be delineated as well, with identical $code_{2012}$ and $code_{2018}$ and an additional attribute marking it as technical change. Using up the two types of change polygons, the patch will be included in CLC2018 automatically, whereas the technical change polygon will be deleted later from the final CLC-Change database (Fig. 13). (For more information on technical changes see its definition at Ch. 4.3.1).

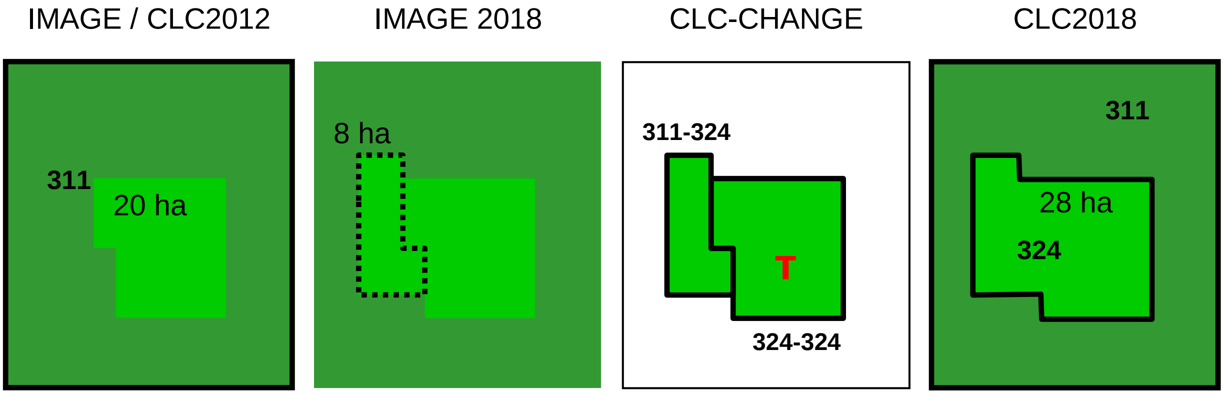


Figure 14 New polygon with Technical change, case-1: A 20 ha forest clearcut (324) grows with 8 ha. As a result, the clearcut's area exceeds 25 ha. Two change polygons must be delineated: an 8-ha real change (311-324) and a 20 ha technical change (324-324). The technical change will be deleted from final version of CLC-Change, while the corresponding change polygons will make up a 324 polygon in CLC2018.

In order to avoid inaccuracies being introduced into CLC2018, the same method is applied also in cases when the real change is > 25 ha so that it would make up a new polygon itself in CLC2018. This case too, a real change polygon must be drawn over the changed ("new") part and a technical change polygon must be drawn above the non-changed ("already existing") part if > 5 ha (Fig. 15).

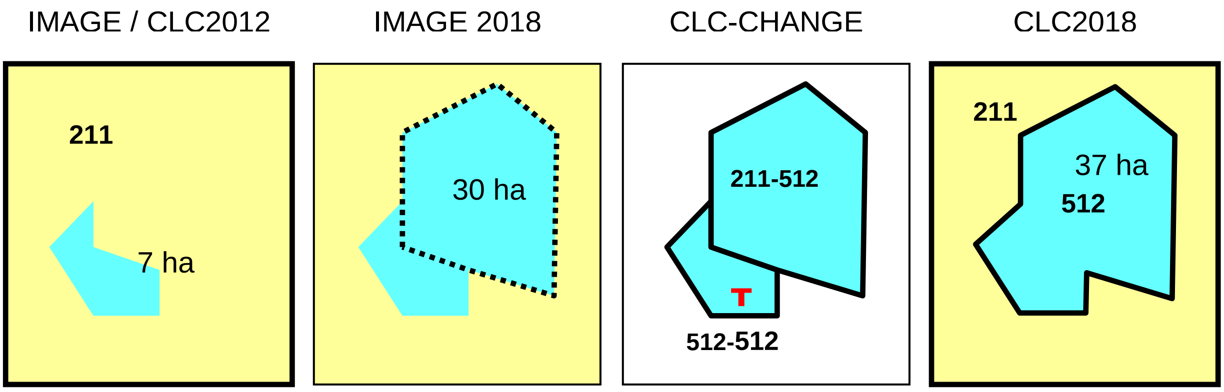


Figure 15 New polygon with Technical change, case-2: A 7 ha fishpond (512) grows with 30 ha. Although the change is > 25 ha, so the polygon would be enough to form new polygon in CLC2018, in order not to miss the 7-ha part, a technical change polygon (512-512) must also be delineated. This will be deleted from final version of CLC-Change, while CLC2018 will contain a correct 37 ha water body (512) polygon.

A special case of this type (combined with type C) is the code change of a polygon (Fig. 16).

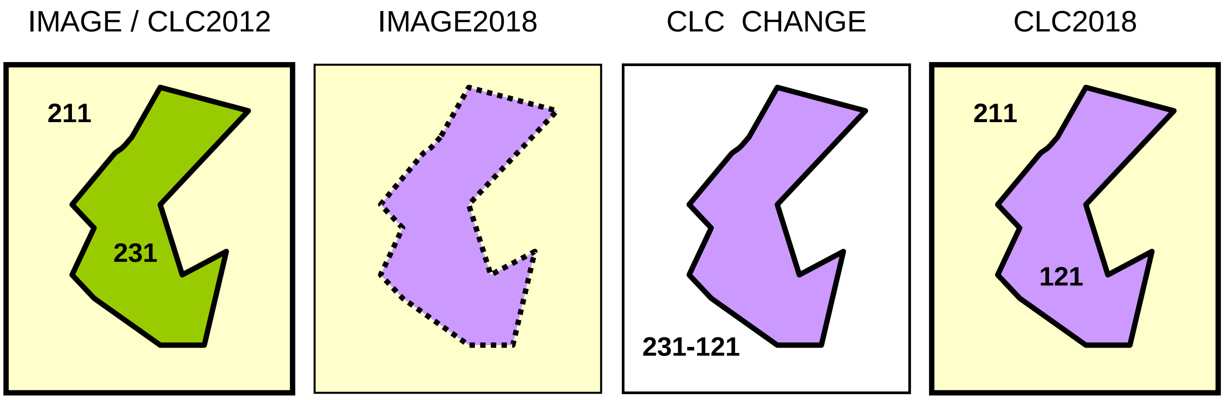


Figure 16 Code change: A new industrial unit (121) is built on a > 25 ha pasture (231), totally occupying its area. With a change 231-121 the pasture disappears, while a new industry emerges.

F. New polygon with small change: a polygon grows > 25 ha with a change < 5 ha

In the few cases when polygon grows over 25 ha with a real change < 5 ha, the real change should be added to the technical change polygon as well. Without using technical change, we would introduce a major (between 20 and 25 ha) mistake into CLC2018 Fig. 17). Using technical change the newly appearing polygon will be included in CLC2018, while the change database will not contain any polygon here (no real change > 5 ha).

Remark: 10% exaggeration in size is allowed (i.e. 4.5 ha new sport and recreation area is better to enlarge to 5 ha to keep it in CLC-Change; it leads to case E).

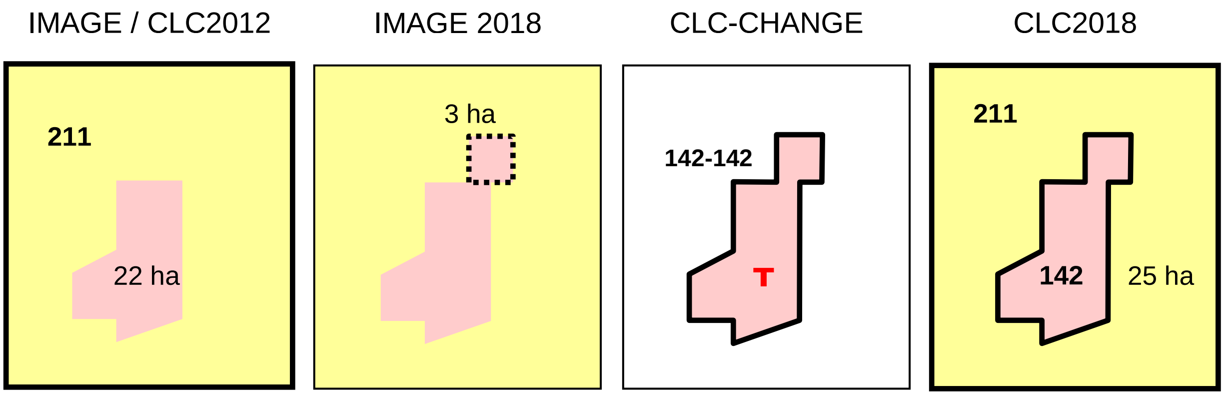
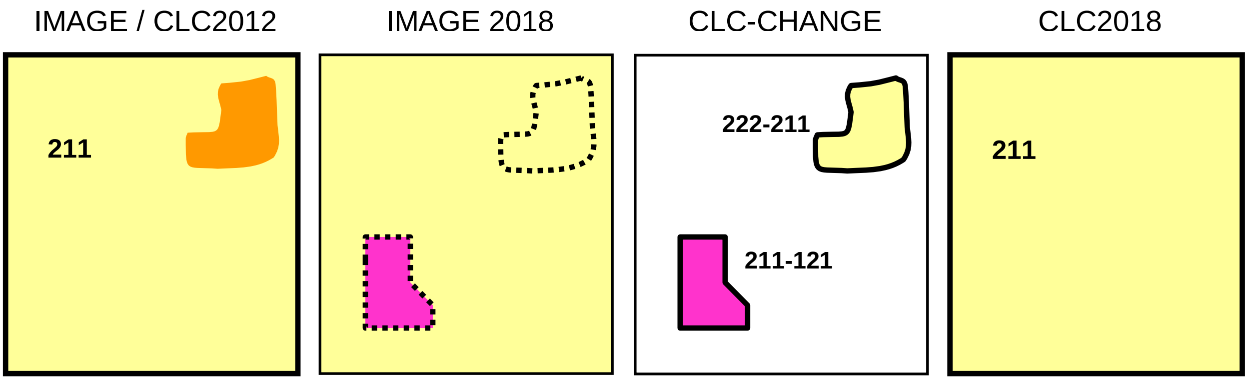


Figure 17 New polygon with small change: A 22 ha sport facility (142) grows with 3 ha, thus just reaching the 25 ha MMU. As changed part is < 5 ha, no real change polygon must be delineated. The polygon should however appear in CLC2018, so a 25-ha technical change (142-142) polygon must be drawn.

G. Only change: changes in a non-existing polygon

This type includes cases when the change polygon is not connected to a valid polygon neither in CLC2012 nor in CLC2018, while valid (> 5 ha) change occurred. This type of change also must be coded according to their real change process (Figs. 18 and 19).

Figure 18 Changes in non-existing polygons, case-1: A new small industrial unit (121) > 5 ha is built on former arable land (211), while a small patch of fruit orchard



(222) > 5 ha disappears because of being turned into arable land (211). Both patches must be delineated as changes (211-121 and 222-211), as being > 5 ha. No new polygons emerge in CLC2018, as corresponding change polygons are generalised.

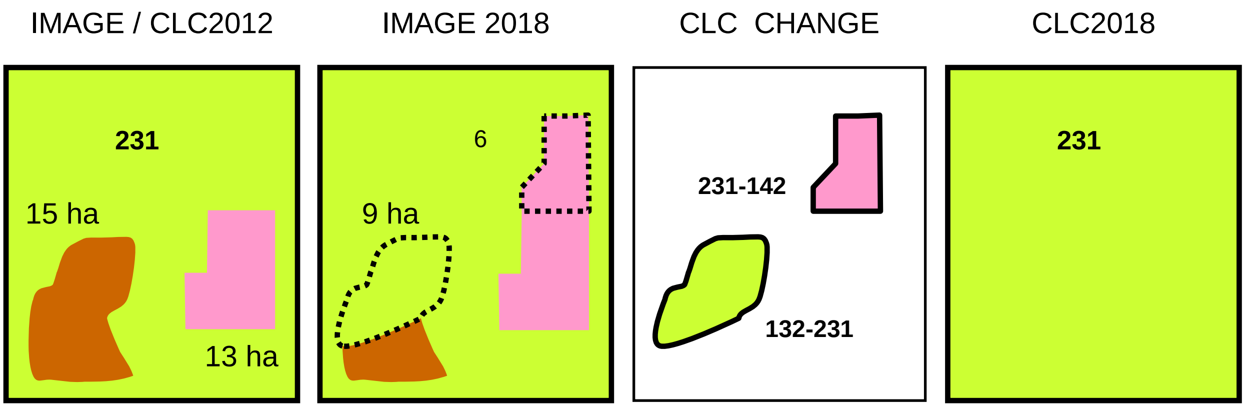


Figure 19 Changes in non-existing polygons, case-2: A 13 ha sport facility (142) expands with 6 ha, while in the neighbourhood 9 ha of a 15-ha dumpsite (132) is recultivated by being turned into grassland (231). Both changed areas are >5 ha thus resulting a valid polygon in CLC-Change database. However, none of them result a > 25 ha polygon in 2018.

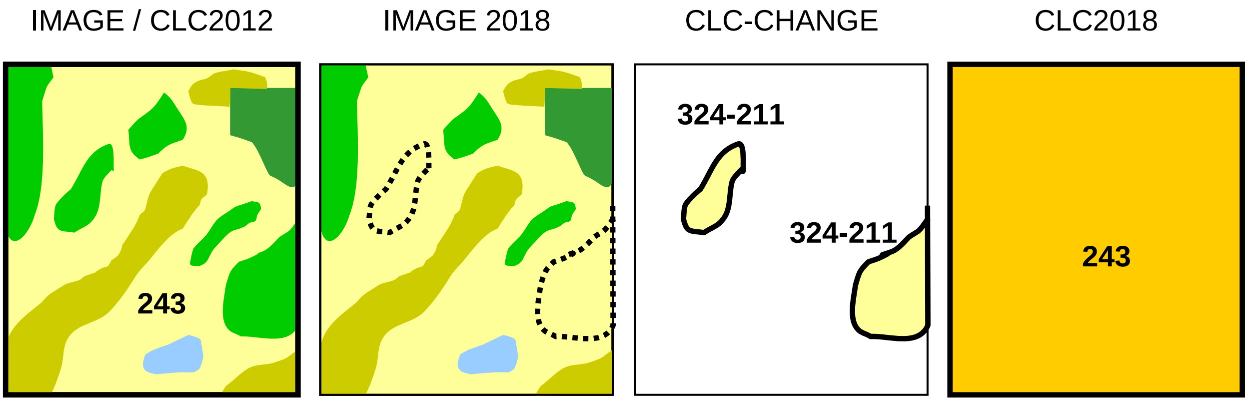
H. Small change (< 5 ha) in not existing polygon (< 25 ha)

As polygons in all three databases are smaller than their respective area limits, this case should not be dealt with.

4.3.4 Treating changes in by-definition heterogeneous classes – changes on landscape level

CLC nomenclature includes some land cover classes that by definition represent heterogeneous landscapes, thus certain polygons are made up a mosaic of smaller homogenous patches, most of them < 25 ha. This means a shift from a dominantly feature-level mapping generally applied by CLC to a landscape-level approach for classes especially: 242, 243 and 313.[9] If individual land cover changes occur within polygons of these classes in a way that they altogether change the characteristics of the area on a landscape level, then change polygons should be delineated on a landscape level, too. Let us take for example a 243 polygon, being mostly agricultural landscape with mosaic of small (< 25 ha) patches of semi natural features: forest, bushes, wetlands and / or natural grassland. If a few of the bushes are cut and turned into arable land, the main character of the polygon does not change, it is still an agricultural landscape with significant amount of natural features. This case changes must be mapped individually as 324-211, thus they will represent real changes in the CLC-Change database, whereas in CLC2018 the 243 polygon will be left unchanged as new 211 patches will be generalized into 243 (Fig. 20).

Figure 20 Changes in heterogeneous class 243 (no landscape level change): In a



heterogeneous landscape (243) a few patches of semi-natural vegetation (324) are turned into arable land (211). As still significant area of natural vegetation is left, the character of the polygon does not change, it is still best characterised with code 243. Change polygons delineated must represent the real process (324-211). Due to generalisation, the 243 polygon will be left unchanged in CLC2018.

It might happen however, that due to an economic / social impact (say change in EU subsidisation system) or for some natural phenomena all or most of the natural patches are turned into arable land, turning the whole landscape's character into agricultural. The area is not a mosaic of natural patches and agricultural land any more, but mostly arable land. This case the change happened on the landscape level, so the change polygon will include the whole area, its code pair being 243-211. It is only in these cases that the delineation of individual changes can be replaced by landscape-level change mapping (Figs. 21 and 22).

[9] Heterogeneous classes are not to be confused with general rule of CLC mapping i.e. all classes might have some portion with different land cover. E.g. Discontinuous urban fabric (112) might include < 25 ha parks, water bodies, industry etc.

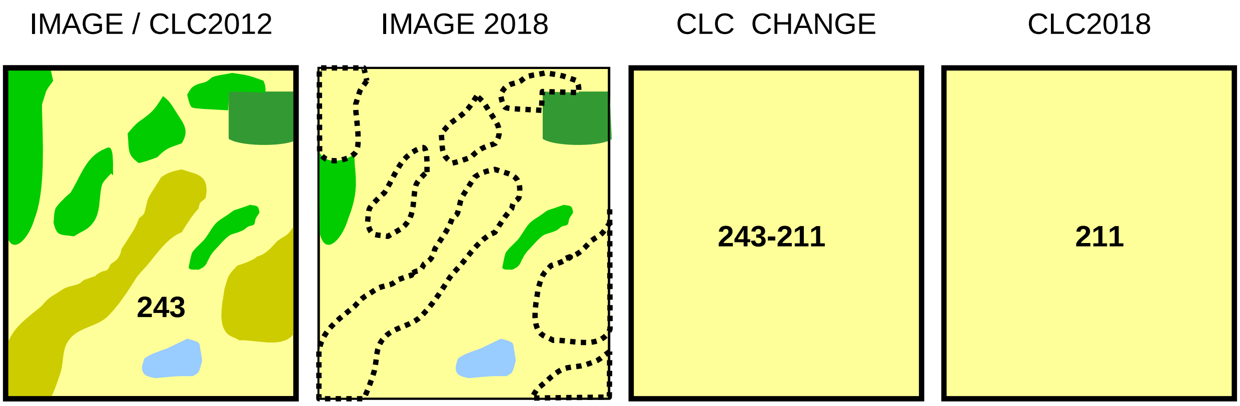


Figure 21 Changes in heterogeneous class 243 (landscape level change): In a heterogeneous landscape (243) most of patches of semi-natural vegetation (324, 321) are turned into arable land (211). As the area of natural vegetation left is not significant, the character of the whole area has changed. A 243-211 change polygon must be delineated.

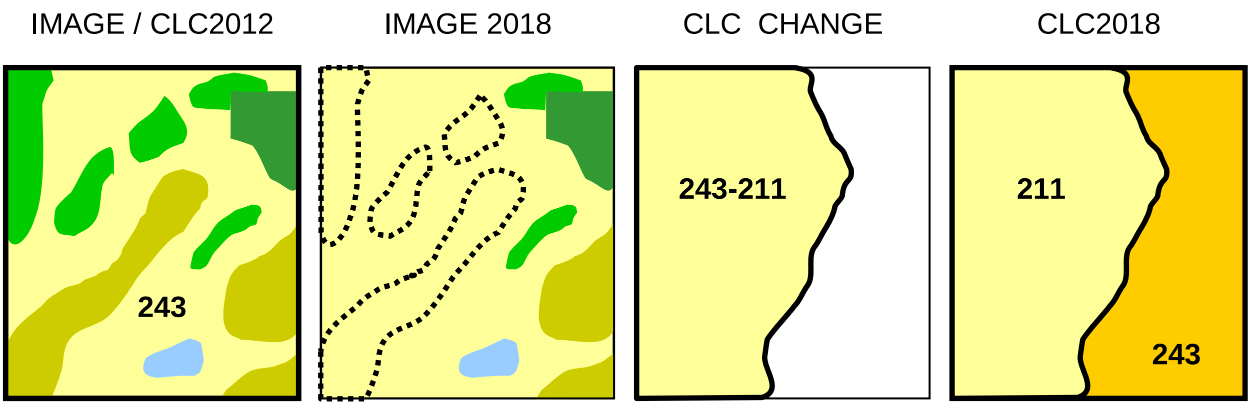


Figure 22 Changes in heterogeneous class 243 (landscape level change on part of the area only): In a part of a heterogeneous landscape (243) most of patches of natural vegetation (324, 321) are turned into arable land (211). The delineated change polygon (243-211) must cover only the changed part of the landscape.

Processes showing to the opposite direction (from homogeneous to heterogeneous landscape) should be treated similarly (Figs. 23 and 24).

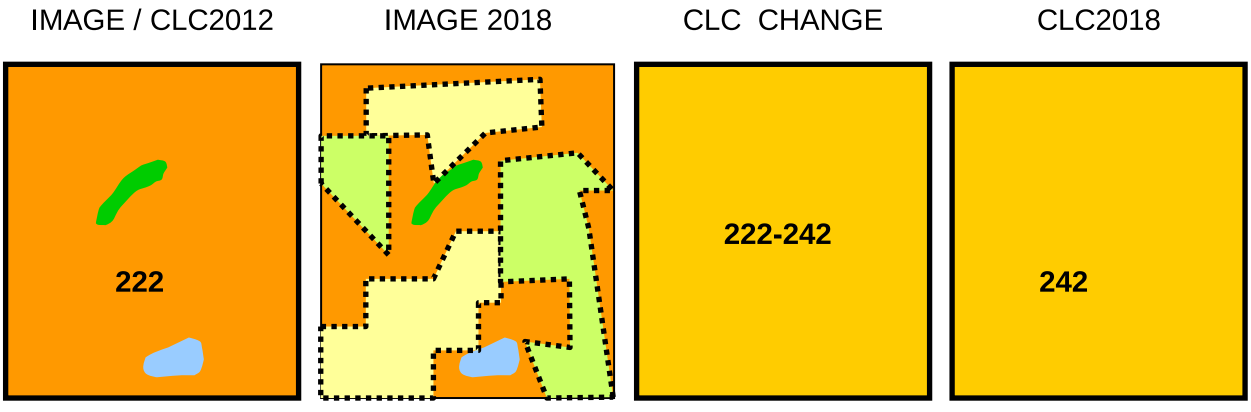


Figure 23 *A homogeneous landscape turned into heterogeneous landscape:* In an area dominantly occupied by orchards (222), a significant part of the plantations is

cut and turned into arable land and pasture. The landscape becomes heterogeneous agricultural landscape (242); orchards do not dominate it any more.

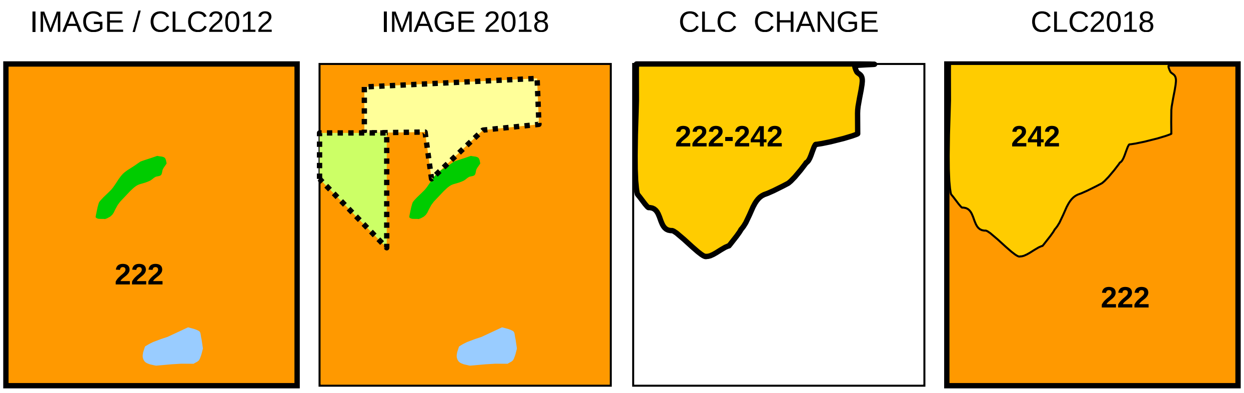


Figure 24 A homogeneous landscape partially turned into heterogeneous landscape***:*** If fruit tree plantations (222) are kept in a part of the same area, only the altered part should be delineated as change (222-242).

Similar approach should be applied for all three by-definition heterogeneous classes: i.e. 313, 242, 243.

4.4 CLC2018 Support Package (InterChange software)

The CLC2012 Support Package, developed by ETC-SIA has been successfully used by more than 20 national teams in implementing CLC2012. It is a set of standalone applications developed with Embarcadero Delphi XE2 and TatukGIS Developer Kernel. Thus, user does not need to purchase, install and tune any other software to carry out CLC change mapping [24]. The CLC2012 Support Package, being a specialized, task oriented software tool, significantly facilitated updating, change detection and mapping, quality control and correction of CLC databases by means of computer-assisted visual photointerpretation [4].

The tool has been upgraded for the CLC2018 project, called now CLC2018 Support Package [31]. Main novelties of the tool are as follows:

- supports the use of Sentinel-2 imagery,
- versions for both 32-bit and 64-bit operation systems,
- enhanced error checking function,
- new, more efficient editing tool ("re-shape") in the revision window,
- various convenience functions.

Like its predecessors, the CLC2018 Support Package consists of three modules:

1. **InterChange** for interpreting land cover changes: Provides a tool for the revision of CLC2012 land cover database and supports the interpretation of land cover changes in order to create the CLC-Change$_{2012-2018}$ database. The program provides a convenient and easy-to-use interface for editing polygons in CLC2012 and CLC-Change$_{2012-2018}$ databases, for viewing and modification of polygon data and for finding and correction (revision) of errors generated during interpretation and editing.
2. **InterCheck** for checking CLC databases: Serves the checking of revised CLC2012 (or CLC2018) and CLC-Change$_{2012-2018}$ data. InterCheck program has been prepared primarily for supporting the CLC Technical Team, although national central teams

might apply it as a tool for checking of the completed CLC2018 and CLC-Change 2012-2018 databases. Many file formats are supported, not only those that has been prepared with **InterChange.**

3. **LUCAS Photo Viewer**: Program displays the main data and field photos of the LUCAS2012 and LUCAS2015[10]) sampling point selected in InterChange or InterCheck program.

User registration

CLC2018 Support Package is available for all participating national teams **free of charge**. The submission of a **registration form** is the sole requirement of using the software. This (besides keeping record of users) enables developer to contact users in case an update of the software package is released. The registration form and the Support Package can be downloaded from: https://forum.eionet.europa.eu/nrc_land_covers/library/copernicus-2014-2020/pan-european-component/corine-land-cover-clc-2018/clc2018-support-package

Like before, detailed help, and printable user's guide (in English) as well as user support are inherent parts of the package. ETC-ULS provides helpdesk service, similarly to the CLC2012 exercise. Helpdesk contact: lehoczki.robert@bfkh.gov.hu

4.5 ALTERNATIVE SOLUTIONS FOR CLC2018

During the implementation of the CLC2012 project some countries applied procedures different from visual photo-interpretation for deriving CORINE Land Cover data. These solutions aimed to reduce human work-load and combined national GIS datasets, satellite image processing (IP) technology, on-screen digitization (visual photo-interpretation) and GIS-based generalisation. Most of these methods aimed to produce CLC status layer, but they were also successful in facilitating / partly solving the change mapping job.

Applying these GIS/IP based alternative change mapping solutions are encouraged, if results are compatible (in terms of technical features and accuracy) with the standard method.

In case of change mapping major issues of non-compliance were as follows (as experienced during CLC2006 and CLC2012 verifications):

- Changes mapped are often not "real" changes, i.e. they do not represent a change that occurred in reality;
- Changes are topologically incorrect (e.g. overlap with other changes) or geometrically incorrect (e.g. narrow or sliver polygons);
- Change outlines do not match boundaries of the CLC parent layer (i.e. CLC2006 in CLC2012 project).

These can be avoided by:

- First of all: not taking uncritically the changes derived from ancillary databases, but considering them as potential changes, which are to be visually checked and approved by interpreters or used as background information for interpreters in manual delineation of changes. This is especially true for changes of built-up areas, heterogeneous agricultural classes and non-forested natural classes. Forestry changes are easier to be automatically detected; they however also require at least partial visual control (especially forest growth);

[10] Because of the deadline of the submission of national CLC2018 results Q3 2018, LUCAS2018 data will be available too late to be applied in CLC2018.

- Making sure that source databases are timely, i.e. not outdated, but especially not fore dated (databases of buildings or spatial planning do often contain features that are planned to be raised, but in reality, are still not existing).

Taking CLC2012 database as a geometrical basis of change mapping is a necessary requirement. In the exceptional case when CLC2018 is produced first, and CLC-Change$_{2012-2018}$ are derived by backdating, geometrical and thematic compliance with new status layer (CLC2018) is still necessary.

5 ANCILLARY DATA

In-situ data in Copernicus programme by definition comprise all non-space-born data with a geographic dimension. Major use of in situ data in CLC project is to complement the satellite data in the course of production and to verify or validate results provided from space-born data.

The photointerpreter should be aware that primary source of information is IMAGE2012 and IMAGE2018, which are considered reference data concerning both date and thematic content. Recommended in-situ data include:

- Up-to date topographic maps (preferably at scale 1:25.000 / 1:50.000) to be used during interpretation, mapping and validation process;
- Orthophotos, taken optimally in 2012 and in 2017 (especially if topographic maps are out of date). Orthophotos are to be used in those cases only, which cannot be understood by interpreting satellite images.
- Thematic maps (built-up, vegetation, forestry, hydrology, snow and ice, etc.);
- Other ancillary data (e.g. LPIS, which has an utmost importance in precise mapping agriculture classes and their changes) for identification/interpretation and verification of land-cover mapping;
- LUCAS 2012 field survey data coordinated by Eurostat, including landscape photographs from visited points, covering EU27 [25]. LUCAS data can be displayed and analysed to support change mapping under CLC2018 [3].
- Results of HRLs produced by using IMAGE2012 and IMAGE2018 data (especially degree of imperviousness and tree cover density / forest type) encouraged to be used as supporting information to derive CLC2018.
- Ancillary data complementing the above, and being useful in CLC change mapping are Google Earth (GE) imagery (or equivalent): provides VHR image data, supporting the interpretation where no ortho-photos are available. Often multi-year time series are provided, which are very useful in understanding the evolution of the area. Major uses are: mapping fast-growing changes (e.g. constructions, mining, clear-cu, etc); identification of plantations (both fruit and forest), agroforestry (dehesa /montado) and scattered holiday cottages and their changes; use of crowd-sourced field photos (Panoramio) attached to these images. Interpreter however should always a) be aware of GE image dates; b) treat GE data with a due precaution as non-valid image dates might occur; and c) Panoramio field photos are often misplaced.

6 PRODUCTION OF CLC2018 DATABASE

In the CLC2018 project the CORINE Land Cover database is updated by the „change mapping first" approach (Ch. 4.2). During change mapping, discovered errors (thematic as well as geometric) of CLC2012 have to be corrected (Ch. 4.2.2.1), providing a revised CLC2012 dataset (or a layer of technical changes if revision is not to be done according to national project plan).

CLC2018 database will be produced by adding $CLC2012_{rev}$ and $CLC\text{-}Change_{2012\text{-}2018}$ in a GIS, like happened in CLC2012 project.

The two major prerequisites of producing CLC2018 out of $CLC2012_{rev}$ and $CLC\text{-}Change_{2012\text{-}2018}$ data by GIS is that

1. $CLC\text{-}Change_{2012\text{-}2018}$ outlines are geometrically based on $CLC2012_{rev}$ outlines.
2. Both $CLC2012_{rev}$ and $CLC\text{-}Change_{2012\text{-}2018}$ are topologically correct databases (no holes, no overlaps, no multi-part polygons, no dissolve errors).

If any of these conditions are not fulfilled, GIS operation will produce false result and slivers, therefore will give an incorrect CLC2018.

Integrating $CLC2012_{rev}$ and $CLC\text{-}Change_{2012\text{-}2018}$ in order to produce CLC2018 should rely on the equation:

$$CLC2018 = CLC2012_{rev} (+) CLC\text{-}Change_{2012\text{-}2018}$$

Where (+) means the following operation: $CLC2012_{rev}$ (revised CLC2012) and $CLC\text{-}Change_{2012\text{-}2018}$ databases are intersected, then CLC-Change polygons' $code_{2012}$ is replaced by $code_{2018}$, and finally neighbours with similar code are unified (Fig. 25). Small (<25 ha) polygons are generalized according to a priority table (Fig. 26). As an option, polygons slightly below the 25-ha limit (e.g. 23,5 ha) can be manually enlarged by a photo-interpreter (Fig. 27). The CLC Technical Team provides an ArcGIS toolbox written for the "intelligent" data integration, like in CLC2006 and CLC2012 projects [25].

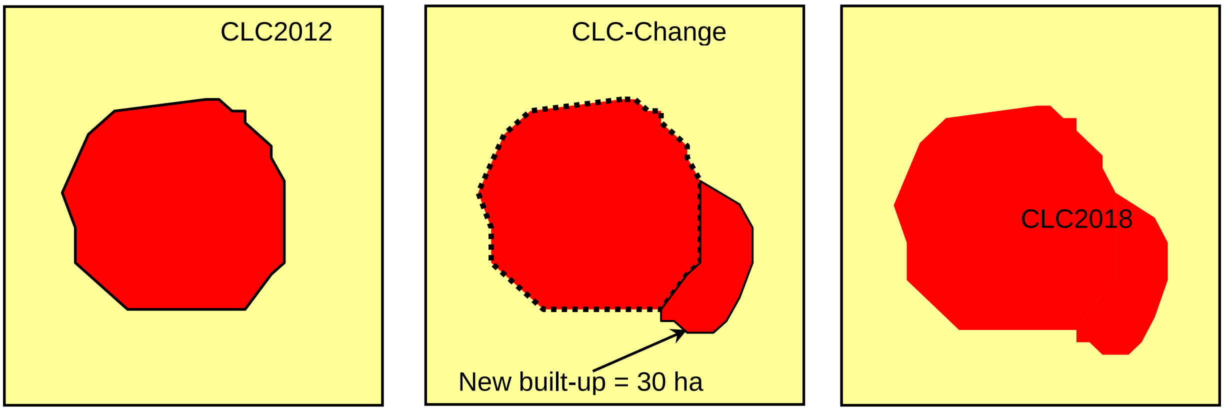


Figure 25 Increase of a settlement / decrease of arable land by 30 ha. As the change is >25 ha, the integration of $CLC2012_{rev}$ and $CLC\text{-}Change_{2012\text{-}2018}$ is straightforward and can be done automatically. The exact mathematical relation between the three databases ($CLC2012_{rev}$, $CLC\text{-}Change_{2012\text{-}2018}$, CLC2018) is fulfilled.

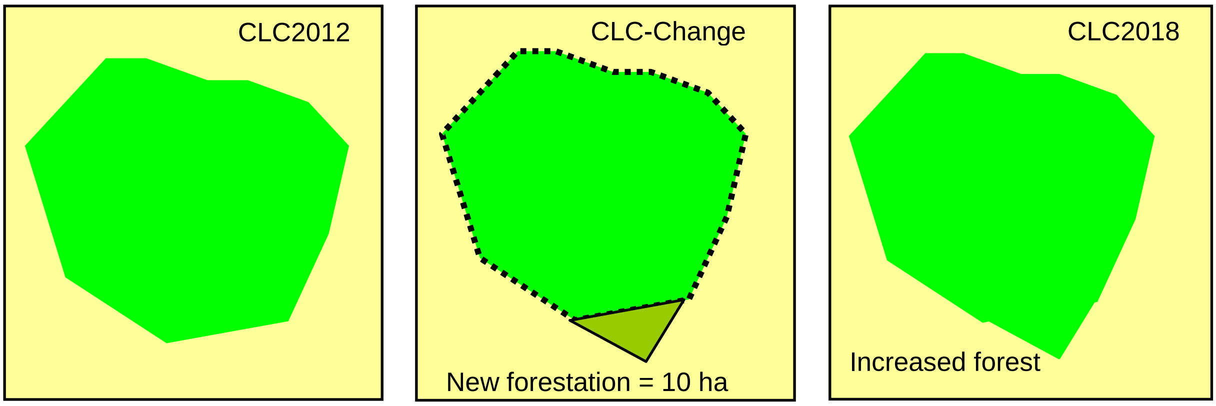


Figure 26 10 ha of new forest plantation on former arable land. As the change is <25 ha, the integration of CLC2012 and CLC-Change$_{2012-2018}$ is not straightforward and generalisation is needed. Using the priority table, this case can be solved automatically. The forest plantation area will be added to the area of the forest polygon. The exact mathematical relation between the three databases (CLC2012, CLC-Change$_{2012-2018}$, CLC2018) is not fulfilled.

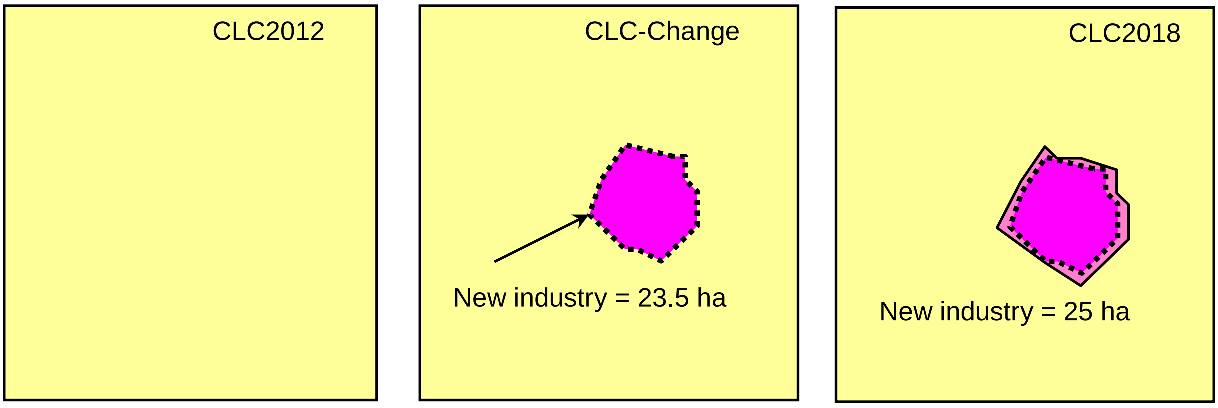


Figure 27 New industry (23.5 ha) on arable land. With an automatic process, this would have not appeared in CLC2018. However, with a slight exaggeration to reach the 25-ha limit, this object will be part of CLC2018. The exact mathematical relation between the three databases (CLC2012, CLC-Change$_{2012-2018}$, CLC2018) is not fulfilled. The generalization toolbox makes possible the setting up of a threshold above which polygons are manually generalized, allowing the above-described manual or automated exaggeration.

7 METADATA

Like in the CLC2012 project, two levels of metadata are produced in CLC2018 project.

7.1 WORKING UNIT-LEVEL METADATA

The purpose of the working-unit level documentation is to make note on all steps of production of the CLC-change database. National teams are responsible for preparing working unit-level documentation for their CLC databases, for internal use within CLC projects. The templates for CLC2012 and an example of a filled-in form can be found in Eionet Forum https://forum.eionet.europa.eu/nrc_land_covers/library/copernicus-2014-2020/pan-european-component/corine-land-cover-clc-2018/technical-guidelines/metadata/working-unit-level-documentation

7.2 COUNTRY-LEVEL METADATA

Country-level metadata mostly serve the users by informing them about the main parameters of the product. Country-level metadata are to be produced by the national teams for CLC-Change$_{2012\text{-}2018}$, CLC2018 and if applicable, for the revised CLC2012 databases.

Since country level metadata for CLC products include information common to all countries, a template XML file specific for CLC has been prepared[11] and can be found in Eionet Forum at https://forum.eionet.europa.eu/nrc_land_covers/library/copernicus-2014-2020/pan-european-component/corine-land-cover-clc-2018/technical-guidelines/metadata/country-level-metadata

Country-level metadata can be edited with the INSPIRE metadata editor and saved in a new XML file. Since the direct editing of an XML file is rather complicated, for metadata editing we recommend using the INSPIRE metadata editor available at http://inspire-geoportal.ec.europa.eu/editor/ General user guide can be found at [28].

Be aware that, currently, only INSPIRE core metadata elements can be entered and edited with this tool (not possible to add theme specific metadata). For this reason, other XML editors can also be used.

An example of a pdf file with metadata for country level CLC can be found in on Eionet Forum. It can be considered as an example of what can be written in the country specific XML file. Titles like abstract or resource constraints should be maintained. As for lineage, we give an example used for CLC Luxembourg.

[11] Country-level metadata for CLC2012 products is INSPIRE compatible and applies EEA's requirements which follow the "*Guidelines for creators of metadata related to spatial datasets*" found at: http://taskman.eionet.europa.eu/projects/sdi/wiki/Cataloguemetadata_guidelines

8 TRAINING AND VERIFICATION

Training and verification for CLC2018 are implemented by the CLC Technical Team under the guidance of the EEA, similarly to previous CLCs.

8.1 TRAINING

Since the CLC2006 project training of a National Team was organised only on the request of the national team. As the methodology of CLC2018 is the same as that of CLC2006 and CLC2012, training will be held only in exceptional cases on the request of the country in the questionnaire circulated in late 2016. The list of CLC2018 training courses foreseen (based on CLC2018 country survey) are presented in Table 17.

Table 17 Planned CLC2018 training courses (status 12/10/17)

Country	**Reason of training**	**Remark**
Albania	new team	A longer than usual training is foreseen to improve basic skills in photointerpretation
Cyprus	possibly new team	to be confirmed
Estonia	new team	The responsible national Environment Agency will provide photointerpreters
France	new team	Training for subcontractor needed
Greece	partly new team	new photointerpreters, but experienced QC team
Kosovo	possibly new team	to be confirmed
Lithuania	new team	
Portugal	new team, new method	new team of photo interpreters; partly new technology
Slovenia	new team, new method	Consultation on semi-automated use of national data
Switzerland	new team	Photointerpreters are selected on national tender or the direct assignment of the work. Should be checked if the working team is really new and the training course is needed.

8.2 VERIFICATION

Like in previous CLC projects, the CLC Technical Team will usually verify the revised parent status layer and the new CLC-Change layer ($CLC2012_{rev}$ and $CLC\text{-}Change_{2012\text{-}2018}$ databases). The reason to verify $CLC2012_{rev}$ is that according to the standard methodology CLC2018 is based on CLC2012, so producing a good quality CLC2018 requires as good as possible quality CLC2012.

In case of few countries where the CLC2018 database is directly produced, CLC2018 and $CLC\text{-}Change_{2012\text{-}2018}$ databases will be verified.

The aim of the verification is two-fold:

- to inform the EEA and the National Authority of the Member state about the work progress;

– to assist the country in producing a high-quality CLC update, which is harmonised in Europe.

Like in CLC2012, in CLC2018 two verification actions per country are planned Tables 18, 19):

1st verification (usually remote verification, i.e. not visiting the country, data sent to technical Team) is due when the first few working units are interpreted (e.g. 10-30% of the country). The main purpose of this action is to reveal problems in the early phase of implementation. Countries new in CLC, or having less-experienced CLC team might be visited. In countries working with regional teams (Italy and Spain) all regions need to send separately a sample for first verification. The sample size is standardised, but sample location is determined by national team.

2nd verification (in majority of cases remote verification) is due when around 75% of the country area is interpreted. The main purpose of this action is to check the database close to completion and suggest improvements if needed. The sample size is standardised, and sample location(s) are determined by CLC Technical Team. Like in 1st verification regions in Italy and Spain are checked separately. However, countries / regions having area below 20.000 km^2 will not requested to send a new sample for 2nd verification. In case of poor result, re-checking of the area of 1st verification might be requested.

It is the purpose to check altogether usually 10% of the country area (taking into consideration the 1st verification as well). The proposed standard size of the verification working unit (VWU) is about 50 km x 50 km area within a S2 image frame. The number of samples to be checked in 2nd verification depends on the size of the country/region. (Table 18).

Table 18 General scheme of verification in CLC2018

	1st verification	**2nd verification**	**Data to provide; data format**	**Remark**
sample selection by	national team	CLC2018 Technical Team		
sample size to verify	a single area, about 50 km x 50 km in size within a Sentinel-2 tile (or Landsat 8 image)	about 50 km x 50 km areas within Sentinel-2 tiles (or Landsat 8 image). Number of areas depends on size of the country / region (see Table 19).	revised CLC2012 (or CLC2018[12]) and CLC-Change2012-2018 in shapefile format	samples should be completed, i.e. full area interpreted
IMAGE2012 to provide	area(s) covering the sample interpretation(s)		IRS / SPOT / RapidEye data covering the sample area; in GeoTiff, LAN format	**all** used IMAGE2012 data have to be sent
IMAGE2018	ID (file name) of S2 (or Landsat-8) images used in deriving CLC data should be provided for each sample			images to be sent by NT only if not the centrally provided IMAGE2018 is used

[12] In case of some non-standard methodology if CLC2018 is produced first

Orthophotos and topographic maps				recommended if available; WMS access welcome

The InterCheck software (part of the CLC Support Package) will be used in the verification, like in CLC2012. The basic technical features of both databases will be checked (topology, MMU. validity of codes, neighbours with the same code, etc). Thematic remarks will be written into the CLC and CLC-Change databases (associated to a polygon or a specific location) if mistakes were found in order to orient the correction.

Table 19 CLC2018 verification plan

Country	Area (km^2)	Remark	number of VWUs, 1st verification	remark, 2nd verification	number of VWUs, 2nd verification
Liechtenstein	160	with Austria	0		0
Malta	316		1	recheck if needed	0
Luxembourg	2 586		1	recheck if needed	0
Cyprus	9 251		1	recheck if needed	0
Kosovo	10 908		1	recheck if needed	0
Montenegro	13 812		1	recheck if needed	0
Slovenia	20 273		1		1
Macedonia	25 713		1		1
Albania	28 748		1		1
Belgium	30 510		1		1
Switzerland	41 290		1		1
Netherlands	41 526		1		1
Denmark	43 094		1		1
Estonia	45 226		1		1
Slovakia	48 845		1		1
Bosnia and Herzegovina	51 129		1		1
Croatia	56 542		1		2
Latvia	64 589		1		2
Lithuania	65 200		1		2
Ireland	70 280		1		2
Serbia	77 453		1		2
Czech Republic	78 866		1		2
Austria	83 858		1		3
Portugal	91 568		1		3
Hungary	93 030		1		3
Iceland	103 000		1		3
Bulgaria	110 910		1		4
Greece	131 940		1		5
Romania	238 392		1		9
United Kingdom	244 820		1		9
Italy	301 318	regions	20	partly only recheck	16
Poland	312 685		1		12
Norway	323 802		1		12
Finland	338 145		1		13
Germany	357 050		1		13

Sweden	449 964		1		17
Spain	505 992	regions	19	partly only recheck	22
France	551 695		1		21
Turkey	783 562		1		30
Total:	**5 848 048**		**75**		**217**

The results of the verification will be expressed in qualitative terms as before, i.e. no quantitative accuracy assessment will be provided:

A (accepted) means: only minor problems were found;

CA (conditionally accepted) means: there are more problems but relatively easy to correct; following corrections the working unit is accepted;

R (rejected) means: there are many mistakes in the database (incorrect application of the nomenclature, omitted changes, false changes, etc.), which takes considerable work to correct. Each verification will be accompanied with a verification report and GIS file including the remarks.

Table 19 includes the verification plan for CLC2018.

All participating countries (except Liechtenstein, which is verified together with Austria)) and all regions in Italy and Spain are expected to send one verification working unit (VWU)[13] (about 50 km x 50 km in size) for 1st verification. The VWU should be selected from inside the respective S2 tile (or Landsat-8 image) in order to minimize the number of IMAGE2018images used in verification.

[13] The size of the verification working unit (50 km x 50 km) and its location is not necessarily coinciding with the size and location of production working unit

9 FINAL QUALITY CONTROL AND DELIVERY

9.1 DELIVERY PROCEDURE

Delivery of national CLC2018 products from National Team (NT) to the EEA is part of the CLC2018 planning in countries and follows the agreed CLC2018 projects schedule. Any foreseen alteration of the delivery schedule shall be indicated to the CLC Technical Team in advance, so these can be accommodated appropriately in the project plan.

National data can be considered as 'ready for delivery' after the following steps are fulfilled:

1. Last verification mission of CLC Technical Team took place and Verification Mission Report has been issued;

2. Recommendations specified in the Verification Reports have been integrated into the data by the NT;

3. Technical quality of deliverables has been checked internally by NT and screened using online tool (see Ch. 9.1.1) to conform to all specifications as defined in the CLC2018 Technical Guidelines.

The following deliveries [delivery file name] are expected from the countries (xx means the two character-long ISO code of the country):

- **CLC-Changes (2012-2018)** - [CHA18_xx]
- **CLC2018** - [CLC18_xx]
- **CLC2012 revised** – [CLC12_xx]
- **Metadata** as specified in Chapter 7

In addition, ESRI Geodatabase format introduced during CLC2006 is now considered as primary delivery format. ESRI Geodatabase, an object-oriented geographic database that provides framework for managing geographic data and their topological relations is considered as proprietary, but robust standard (both file and personal geodatabase is supported). For other file formats please consult with CLC Technical Team (contact: tomas.soukup@gisat.cz).

9.1.1 Online quality screening

When deliveries are ready to be uploaded into CDR folders dedicated for national CLC2018 deliveries, the NT performs final quality check using the CLC QC Tool - online technical quality screening service. Conformity to the CLC specifications as defined in these Technical Guidelines can be checked there and results are provided visually as well as reported via dedicated reports and errors correction supporting GIS files in automatic manner. The tool supports national teams in their DIY compliance checking in order to assure conformity of the final deliveries prior to upload to EEA CDR in a standard, transparent and more effective way. This shall streamline final data acceptance and provision of the DBTA Report - *the Database Technical Acceptance Report*.

CLC QC Tool integrates all formal, technical and topological checks as defined in these Technical Guidelines , which can be done in fully automatic way. This standard set of checks and their centralized implementation shall assure that all checks are done in a standard and transparent way and also that no checks are skipped or omitted. Based on the experience from delivery and acceptance task in the previous CLC updates, the aim of the tool is to support:

- streamlining of the delivery process;

- assurance of technical consistency and semantic correctness of each individual national CLC database produced by participating countries;
- smooth and fast integration of data into the seamless European CLC database

CLC technical quality screening service is available as web service via web address http://clcqc.gisat.cz (Fig. 28). All functionalities are run purely through web client and therefore doesn't impose any change to national team technical procedures, internal workflow or software environment setup. Eligible national team users will be notified with access information. For detailed information about the CLC QC Tool functionalities please consult documentation ([27]) and the online *CLCQC Tool Help* (http://clcqc.gisat.cz/help/AboutCLCQCTool.html). For any additional questions related to CLC2018 technical quality screening service please contact tomas.soukup@gisat.cz.

Figure 28 CLC QC Tool home page - http://clcqc.gisat.cz

9.1.2 DBTA Report

When online checked deliveries are uploaded into the CDR, the central technical team proceed with final acceptance. As mentioned, the DBTA report contains summary of data and metadata conformity checks as specified in the CLC2018 Technical Guidelines, and is therefore used either as

A - final data acceptance confirmation - to confirm that all delivery parts have been accepted by ETC/ULS without problems, listing all exceptions if present

or

B – a part of 'the request for improvement' from the ETC/ULS documenting inconsistencies found and guiding the NT in data improvement. In this case, the DBTA report draft is accompanied with supporting information and GIS files for such guidance and sent to National Team. Nevertheless, number of these iterations shall be minimized if not avoided at all by introducing the online technical quality screening service. Nevertheless, in case of some non-conformity still found in data, the NT will be notified with request to proceed with improvement of datasets, new online checking and new submission into the EEA Central Data Repository (CDR).

9.1.3 Final delivery

The final data delivery process is very simple. All deliveries shall be uploaded into the EEA Central Data Repository (CDR). In order to deliver data, you have to log in with your EIONET account and password in the relevant folder for your country in the Reportnet Central Data Repository (see list below). You should then carry out the following steps:

- Create the delivery envelope
- Activate the task
- Upload your files from your system to CDR
- Verify that the delivery is complete
- Release the envelope (Files which should not be available to the public can be locked)
- Finish

All final accepted deliveries (the DBTA report is issued) shall be uploaded into the EEA Central Data Repository (CDR) subfolder named "final" together with the DBTA report. National CLC2018 coordinators should liaise with National Focal Points on the delivery process to the EEA. If you need any assistance during the delivery process, do not hesitate to contact EIONET helpdesk at helpdesk@eionet.europa.eu.

The CDR folders for national CLC2018 deliveries:

AL http://cdr.eionet.europa.eu/al/eea/clc
AT http://cdr.eionet.europa.eu/at/eea/clc
BA http://cdr.eionet.europa.eu/ba/eea/clc
BE http://cdr.eionet.europa.eu/be/eea/clc
BG http://cdr.eionet.europa.eu/bg/eea/clc
CH http://cdr.eionet.europa.eu/ch/eea/clc
CY http://cdr.eionet.europa.eu/cy/eea/clc
CZ http://cdr.eionet.europa.eu/cz/eea/clc
DE http://cdr.eionet.europa.eu/de/eea/clc
DK http://cdr.eionet.europa.eu/dk/eea/clc
EE http://cdr.eionet.europa.eu/ee/eea/clc
ES http://cdr.eionet.europa.eu/es/eea/clc
FI http://cdr.eionet.europa.eu/fi/eea/clc
FR http://cdr.eionet.europa.eu/fr/eea/clc
GR http://cdr.eionet.europa.eu/gr/eea/clc
HR http://cdr.eionet.europa.eu/hr/eea/clc
HU http://cdr.eionet.europa.eu/hu/eea/clc
IE http://cdr.eionet.europa.eu/ie/eea/clc
IS http://cdr.eionet.europa.eu/is/eea/clc
IT http://cdr.eionet.europa.eu/it/eea/clc
LI http://cdr.eionet.europa.eu/li/eea/clc
LT http://cdr.eionet.europa.eu/lt/eea/clc
LU http://cdr.eionet.europa.eu/lu/eea/clc
LV http://cdr.eionet.europa.eu/lv/eea/clc
ME http://cdr.eionet.europa.eu/me/eea/clc
MK http://cdr.eionet.europa.eu/mk/eea/clc
MT http://cdr.eionet.europa.eu/mt/eea/clc
NL http://cdr.eionet.europa.eu/nl/eea/clc
PL http://cdr.eionet.europa.eu/pl/eea/clc

PT http://cdr.eionet.europa.eu/pt/eea/clc
NO http://cdr.eionet.europa.eu/no/eea/clc
RO http://cdr.eionet.europa.eu/ro/eea/clc
RS http://cdr.eionet.europa.eu/rs/eea/clc
SE http://cdr.eionet.europa.eu/se/eea/clc
SI http://cdr.eionet.europa.eu/si/eea/clc
SK http://cdr.eionet.europa.eu/sk/eea/clc
TR http://cdr.eionet.europa.eu/tr/eea/clc
UK http://cdr.eionet.europa.eu/gb/eea/clc
XK http://cdr.eionet.europa.eu/xk/eea/clc

9.2 COMPARISON TO 2012 DELIVERY PROCEDURE

As seen above the delivery workflow for CLC2018 update remains the same as in the case of CLC2012, where technical quality screening service have been already introduced. The workflow assures technical consistency of each national CLC delivery from countries in shorter time and enable subsequent smooth and fast integration of data into the seamless European CLC2018 products.

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List of abbreviations

ATCOR	Atmospheric and Topographic Correction
BOA	Bottom of Atmosphere (reflectance)
CAPI	Computer Assisted Photointerpretation
CLC	CORINE Land Cover
CLC90, CLC1990	The first CLC inventory for reference year 1990
CLC2000	CORINE Land Cover update for reference year 2000
CLC2006	CORINE Land Cover update for reference year 2006
CLC2012	CORINE Land Cover update for reference year 2012
CLC2018	CORINE Land Cover update for reference year 2018
CLC TT	CLC Technical Team
CCM	Copernicus Contributing Mission
CORINE	Co-ordination of information on the Environment
CSC	Copernicus Space Component
CSCDA	Copernicus Space Component Data Access system
DEM	Digital Elevation Model
DG AGRI	Directorate General for Agriculture
DG ENV	Directorate General for Environment
EC	European Commission
EEA	European Environment Agency
EEA39	EEA39 composed of : 33 member countries and cooperating countries
Eionet	European Environment Information and Observation Network
ESA	European Space Agency
ESTAT	EUROSTAT, statistical office of the EU
ETC ULS	European Topic Centre on Urban, Land and Soil Systems
ETM	Enhanced Thematic Mapper (US Landsat-7 sensor)
EO	Earth Observation
EU	European Union
FTSP	Fast Track Service Precursor (a term used in 2006 for CLC2006 and Imperviousness mapping)
GCP	Ground Control Points
GIS	Geographic Information System
GMES	Global Monitoring for Environment and Security (earlier name of Copernicus programme)
GRI	Global Reference Image
GDSD	ground sampling distance
IMAGE1990	Satellite image coverage for reference year 1990
IMAGE2000	Satellite image coverage for Europe, reference year 2000
IMAGE2006	Satellite image coverage for Europe, reference year 2006
IMAGE2012	Satellite image coverage for Europe, reference year 2012
IMAGE2012	Satellite image coverage for Europe, reference year 2018
IMAGE&CLC2000	IMAGE2000 & CORINE Land Cover 2000 project
INSPIRE	Infrastructure for Spatial Information in Europe
IP	image processing
IRS	Indian Remote Sensing (satellites)
JRC	Joint Research Centre
LC	Land Cover
LISS	Linear Self Scanning (sensor on-board of IRS satellites)
LPIS	Land Parcel Identification System
LUCAS	Land Use/Cover area framework statistical survey (Eurostat)
LULC	Land Use & Land Cover
MMU	minimum mapping unit
MSS	Multispectral scanner (US Landsat 1-3 sensor)
MS	Member States (of EEA)
MSI	Multispectral Imager (Sentinel-2 sensor)

NIR	Near Infrared (sensor band)
NRC	National Reference Centre
Phare	Poland and Hungary: Assistance for Restructuring their Economies (EU pre-accession aid in the 90s’)
SAFE	Standard Archive Format for Europe (Sentinels)
SOER	State of Environment Europe Report (EEA publication in every 5 yr)
SPOT	Système Probatoire d’Observation de la Terre (series of French EO satellites)
S2	Sentinel-2 (satellites)
QA/QC	Quality assurance/Quality control
SWIR	Short Wave Infrared (sensor band)
TG	Technical Guidelines
TM	Thematic Mapper (US Landsat-4 and Landsat-5 sensor)
TOA	Top of Atmosphere (reflectance)
UTM/WGS84	Universal Transverse Mercator projection; World Geodetic System 1984
VIS	visible and infrared (sensor bands)
VWU	Verification Working Unit
WP	Work Package
WU	Working Unit