
Title	GIO land (GMES/Copernicus initial operations land) High Resolution Layers (HRLs) – summary of product specifications
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Creation date	2015-08-03
Subject	Summary of definitions and product specifications of GIO land HRLs
Status	Final
Publisher	GIO land team at the EEA
Type	Text
Description	<p>This document contains a summary of the definitions and product specifications for all GIO land High Resolution Layers (HRLs). The document is meant to provide summary information to potential users of the HRLs and the interested public at large.</p>
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Format	Word document
Source	European Environment Agency
Rights	Open access
Identifier	This is version 11 of 2015-08-03
Language	EN
Relation	<p>GMES/Copernicus Initial Operations Land Monitoring 2011-2013 Regulation (EU) No. 911/2010</p>

GIO LAND HIGH RESOLUTION LAYERS (HRL'S) – SUMMARY OF PRODUCT SPECIFICATIONS

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Introduction

In the context of Copernicus (formerly Global Monitoring for Environment and Security - GMES), and with a view to provide complementary and more detailed information on the existing Corine Land Cover (CLC), the European Environment Agency (EEA) has implemented the GMES/Copernicus Initial Operations land (GIO land). This includes the mapping of four¹ high resolution layers (HRLs) on land cover characteristics.

- 1) Degree of imperviousness;
- 2) Forest (tree cover density and forest type);
- 3) Wetlands;
- 4) Water bodies.

This document summarizes information relevant for end users of the GIO-land high resolution layers. It is meant to provide easily accessible information that goes beyond the standard xml metadata file provided with the datasets. This information can help users decide, if, and how they are going to use the datasets. This document does not replace the standard xml documents provided for each product.

1. Overview and availability

The HRLs cover 39 countries in Europe for the reference year 2012 (based mainly on 2011/2012 satellite images). All HRLs are freely available on the Copernicus land portal (<http://land.copernicus.eu/>), as mosaics covering the whole of the EEA39 area², in European Projection and in the original 20m spatial resolution and as a validated 100m products³. Products in national projections (20m spatial resolution only) are also produced, but provided directly by the countries, not through the Copernicus land portal. In addition to the products described in this document, two additional products were produced for the JRC for the 2012 reference year: a “*tree cover presence/absence*” product, and a “*tree type*” (both in 25m x 25m spatial resolution). These two products (internally called: service element 2), and documentation, are available directly through the JRC. The following table 1 summarizes the main products, table 2 provides details on availability of the individual products. More details, including on the raster coding of the products, can be found in chapter 3.

¹ Initially 5 HRL's were produced, including permanent grasslands. Due to quality concerns this product is currently under revision and is not available for download at the moment – permanent grassland is not further described in this document

² Initially, in 2015, part-mosaics will be made available in some cases, where individual countries are still missing

³ Validation currently pending, foreseen for late 2015

Imperviousness	
Degree of imperviousness 2012 (20m and 100m): IMD	Degree of imperviousness, values from 1-100%
Impervious density change 2009-2012 (100m): IMC	Mapping degree of change over time -100% to +100%
Forest	
Tree cover density (20m and 100m): TCD	Tree cover density, values from 1-100 %
Forest type (20m) consisting of two grids: FTY	Dominant leaf type. Binary product: coniferous and broadleaved. MMU of 0.5 ha and 10% tree cover density threshold applied (FAO definition) Support layer: Maps trees under agricultural use and in urban context derived from CLC2012 ⁴ and imperviousness 2012
Forest type (100m): FTY	Coniferous, broadleaved and mixed. Trees under agricultural use and urban context from additional support layer removed
Wetlands	
Wetland (based on 2006-2009-2012 data), (20m): WET	Wetland: Binary product: mapping “wetlands”, and “all non-wetland areas”
Wetland (based on 2006-2009-2012 data), (100m): WET	Occurrence of wetlands (0-100%)
Water bodies	
Permanent water bodies (based on 2006-2009-2012 data), (20m): PWB	Permanent water bodies, including small water bodies: Binary product, mapping “permanent water bodies” and “all other areas” not covered by permanent water bodies.
Permanent water bodies (based on 2006-2009-2012 data), (100m): PWB	Occurrence of permanent water bodies (0-100%)

Table 1: Overview listing of all main HRL products. Main products for download through the Copernicus land portal are mosaics (of the whole EEA39 area) and in European (LAEA) projection, 20m products are also available (directly through the country) for each country in the national projection.

No	Product	Spatial raster width	Projection ⁵	Availability for download
1	IMD (Degree of Imperviousness)	20m	National	Availability only directly through the country
2	IMD (Degree of Imperviousness)	20m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
3	IMD (Degree of Imperviousness)	100m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
4	IMC (Impervious density change 2009-2012)	100m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal

⁴ Where available at the time of production

⁵ All 13100m products are ONLY available in European (LAEA) projection

5	TCD (Tree cover density)	20m	National	Availability only directly through the country
6	TCD (Tree cover density)	20m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
7	TCD (Tree cover density)	100m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
8	FTY (Forest type: dominant leaf type)	20m	National	Availability only directly through the country
9	FTY (Forest type: dominant leaf type)	20m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
10	FTY (Forest type: dominant leaf type)	100m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
11	FAD (Forest Additional Support layer)	20m	National	No official product, available on request
12	FAD (Forest Additional Support layer)	20m	European (LAEA)	No official product, available on request
13	WET (Wetlands)	20m	National	Availability only directly through the country
14	WET (Wetlands)	20m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
15	WET (Wetlands)	100m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
16	PWB (permanent water bodies)	20m	National	Availability only directly through the country
17	PWB (permanent water bodies)	20m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal
18	PWB (permanent water bodies)	100m	European (LAEA)	Download, view and map service capabilities through Copernicus land portal

Table 2: Detailed list of all products, their projection, spatial resolution and availability.

2. Workflow

The workflow to produce the HRL's for the 2012 reference year, comprised a very complex, and interdependent back and forth between EEA, the Service Providers (SP's), 39 countries and the European Topic Centre (ETC), managed by EEA through a central online platform. The HRL production combines work by industry, and contributions from the EEA member and cooperating countries. These decentralised country contributions focus on the verification and enhancement steps of the production process. This workflow is depicted in very simplified

form in Figure 1 below. Intermediate HRLs were produced by the service providers (SP's), which form the input for the verification and enhancement phases that largely rely on country input and contributions. After a final integration step and quality control through independent technical checks, the final products are now being disseminated. An independent statistical validation is ongoing, and will be finalized before the end of 2015. ⁶

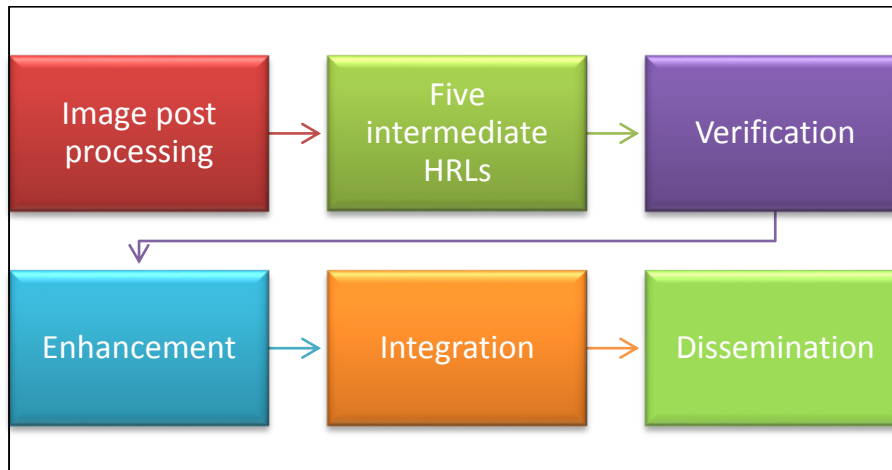


Figure 1: Workflow of HRL production (simplified)

3. High resolution layers short specifications and details

The following chapters 3.1 to 3.4 provide more details on the individual products, relevant for their practical use. Short descriptions of the products are followed by a detailed table listing the raster coding for each product, as well as the definitions used in the specifications (which land cover/land use is included, what is excluded).

3.1. Imperviousness HRL

The product maps the degree of Imperviousness (in 1-100%), or soil sealing, and is based primarily on the analysis of NDVI (Normalized Difference Vegetation Index). All NDVI images are calibrated with the Imperviousness 2009 data, and built-up change candidates are mapped. The imperviousness layer contains two products: a 2012 status layer (degree of imperviousness 2012), as well as an imperviousness density change layer (2009-2012), based on the existing imperviousness product for 2009. This is the only HRL that has previously been mapped (2006 and 2009)⁷, and where therefore a time-series and change information is already available.

Please note that product 1 and 2 (degree of imperviousness, 20m x 20m, national and European projection) should not be used for change detection in a direct comparison with the 2009 20m status layer, given that additional sealing change analysis with thresholding, to remove noise and false change signals, is ONLY applied to the 100m change product (product no. 3) and the 100m change product (product no.4).

⁶ This means that the initial European mosaics (or part mosaics), available for download from August 2015, have not yet been independently validated.

⁷ Imperviousness 2006 and 2009 are available on request, but are subject to copyright of the Geoland2 project.

No	Product	Geo-metric resolution	Projec-tion	MMU	Classified feature	Raster coding
1	Degree of imperviousness 2012	20m	national	no	Degree of imperviousness 2012	0: all non-impervious areas 1-100: imperviousness values 254: unclassifiable (no satellite image available, or clouds, shadows, or snow) 255: outside area
2	Degree of imperviousness 2012	20m	LAEA	no	Degree of imperviousness	See product no.1
3	Degree of imperviousness 2012	100m	LAEA	no	The aggregated 100m x100m imperviousness layer 2012 results from updating the 2009 aggregated imperviousness layer by adding the aggregated 100m x100m imperviousness change layer (2012 – 2009) to the latter. This way, consistency between the 100m x 100m imperviousness layers will be maintained	0: all non-impervious areas 1-100: imperviousness values 254: unclassifiable (no satellite image available, or clouds, shadows, or snow) 255: outside area
4	Imperviousness density change 2009-2012	100m	LAEA	no	Change in imperviousness from 2009-2012. The 2009-2012 change layer at 100m results from the aggregation and re-projection of the 20m x 20m intermediate product	0-99: decreased imperviousness density 100: unchanged areas with imperviousness degrees of 1-100 101-200: increased imperviousness density 201: unchanged areas with imperviousness degrees of 0 202: 2009 omission error 203: 2009 commission error 254: unclassifiable (no satellite image available, or clouds, shadows, or snow) 255: outside area

Table 3: Details of imperviousness HRL and raster coding

Definitions for imperviousness HRL

Definitions	
Soil sealing imperviousness (used as synonyms)	The covering of the soil surface with impervious materials as a result of urban development and infrastructure construction. http://eusoiils.jrc.ec.europa.eu/library/themes/Sealing/ Destruction or covering of soils by buildings, constructions and layers of completely or partly impermeable artificial material (asphalt, concrete, etc.). It is the most intense form of land take. Sealed surfaces are part of built-up areas. An indicator of the intensity of land take is the proportion of the total built-up surface area which is sealed. http://ec.europa.eu/environment/soil/pdf/sealing/Soil%20sealing%20-%20Final%20Report.pdf . Soil sealing is also used to describe the covering or sealing of the soil surface by impervious materials by, for example, concrete, metal, glass, tarmac and plastic. http://glossary.eea.europa.eu
Built-up areas	Land consumed by settlements, infrastructure, and commercial and industrial areas.

Land take	Land take is the increase of artificial surfaces (housing areas; green urban areas; industrial, commercial and transport units; road and rail networks; etc.) over time. http://ec.europa.eu/environment/soil/pdf/sealing/Soil%20sealing%20-%20Final%20Report.pdf
Built-up area changes	Areas where the extent of the built-up areas has increased or decreased from one (observation) point/period to the other.
Sealing changes	Change of the degree of soil sealing from one observation point/period to the other. Those changes can occur in both, a) previously built-up areas (e.g. urban densification), and in b) newly built-up areas

Table 4: Definitions on some important terms used in imperviousness context

Elements included in the built-up area in imperviousness mapping 2006, 2009 and 2012	Elements excluded from the built-up area in imperviousness mapping 2006, 2009 and 2012
<ul style="list-style-type: none"> • Housing areas • Traffic areas (airports, harbours, railway yards, parking lots) • Industrial, commercial areas, factories • Amusement parks (excluding the pure green areas associated with them) • Construction sites with discernible evolving built-up structures • Single (farm) houses (where possible to identify) • Other sealed surfaces, which are part of fuzzy categories, such as e.g. allotment gardens, cemeteries, sport areas (visible infrastructure), camp sites (roads and infrastructure, possibly influenced by caravans), excluding green areas associated with them. Roads and railways associated to other impervious surfaces (no gaps manually filled, no roads manually digitised) • Water edges with paved borders 	<ul style="list-style-type: none"> • Mines, quarries and peat production • Dump sites • Construction sites without discernible evolving built-up structures • Meadows used for sports of any kind • Bare soil, rock, sparsely vegetated areas • Sand, sand pits • Glaciers, snow, water • Railway lines

Table 5: Elements included and excluded in imperviousness mapping

3.2. Forest HRL

There are two forest products⁸: tree cover density and forest type (consisting of two layers). For a more detailed list of the available products (including information on spatial raster width and projection), see table 8.

Forest	
Tree cover density (20m and 100m)	Tree cover density values from 1-100 %
Forest Type (20m) consisting of two grids	Dominant leaf type. Binary product: coniferous and broadleaved MMU of 0.5 ha and 10% tree cover density threshold applied
	Support layer: Maps trees under agricultural use and in urban context from CLC 2012 and imperviousness 2012
Forest Type (100m x 100m)	Coniferous, broadleaved and mixed. Trees under agricultural use and urban context from additional support grid removed

Table 6: Overview of the main forest HRLs

Tree cover density

The following definitions apply for the tree cover density product

- Tree cover density range 0-100%
- No MMU (minimum number of pixels to form a patch);
- Minimum Mapping Width (MMW): 20m.

Included Features	
Evergreen/non-evergreen broadleaved, sclerophyllous and coniferous trees	
Orchards, olive groves, fruit and other tree plantations, agro-forestry areas, forest nurseries, regeneration and transitional woodlands	
Alleys, wooded parks and gardens	
Groups of trees within urban areas	
Forest management/use features inside forests (forest roads, fire-breaks, thinning, etc.)	Included if tree cover can be detected from the 20m imagery
Forest damage features inside forests (partially burnt areas, storm damage, insect-infested damage, etc.)	
Excluded Features	
Open areas within forests (roads, permanently open vegetated areas, clear cuts, fully burnt areas, other severe forest damage areas, etc.)	Excluded if no tree cover can be detected from the 20m imagery
Shrub land	
Mediterranean bush land (macchia, garrigue, etc.)	
Dwarf pine/green alder in high/mountainous areas	

Table 7: Features to include and/or exclude in tree cover products

⁸ As part of GIO land an additional two forest products are being produced for the JRC, the so called "service element 2". These products are a) tree cover presence/absence and b) dominant leaf type. These products are being produced in 25m spatial resolution and will be available directly from the JRC.

Forest type products

Contrary to the tree cover density product, the forest type product is more closely aligned to the FAO forest definition⁹ in the sense that the 20m x 20m forest type products are produced from the tree cover density product applying a

- MMU = 0.5 ha (minimum number of pixels to form a patch);
- Minimum Mapping Width (MMW) = 20m;
- Tree cover density $\geq 10-100\%$.

In addition, trees under agricultural use and in urban context (from the additional support layer) are excluded for the 100m x 100m products (product no. 10). For EEA purposes, this means that fruit trees and olive groves tree are removed for the 100m product, while cover in traditional agroforestry systems such as Dehesa/Montado, is included.

No	Product	Geo-metric resolution	Projec-tion	MMU	Tree cover density Threshold	Classified feature	Raster coding
5	Tree cover density	20m	National	NO	0-100% ¹⁰	Tree cover density	0: all non-tree areas 1-100: tree cover density 254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside area
6	Tree cover density	20m	LAEA	NO	0-100%	Tree cover density	See product 1
7	Tree cover density	100m	LAEA	NO	0-100%	Tree cover density	0: all non-tree areas 1-100: tree density 254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside area
8	Forest type	20m	National	0.5ha	$\geq 10\%$	Broadleaved tree cover; coniferous tree cover;	Thematic pixel values for dominant leaf type layer 0: all non-tree areas 1: broadleaved forest 2: coniferous forest 254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside area
9	Forest type	20m	LAEA	0.5ha	$\geq 10\%$	Broadleaved tree cover; coniferous tree cover;	See product 8
10	Forest type	100m	LAEA	NO	$\geq 10\%$	Broadleaved forest; Coniferous forest, Mixed forest;	0: all non-forest areas (incl. trees in agricultural and urban context) 1: broadleaf forest 2: coniferous forest 3: mixed forest 254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside area

⁹ www.fao.org/docrep/006/ad665e/ad665e06.htm

¹⁰ Tree Cover Density range 0-100%: in the range 1-10%, the consortia will apply a consortia will apply a threshold that is as low as possible, given the level of detail that can be detected from the available 20m raster imagery and other factors

11	Forest Additional support layer (FAD)	20	national		na	additional support raster provided with information on "trees predominantly used for agricultural practices - broadleaved" and "trees in urban context – broadleaved and coniferous"	Thematic pixel values for additional support layer dataset on non-forest trees 0: all non-tree areas 3: trees predominantly used for agricultural practices – broadleaved (from CLC classes 2.2.2 and 2.2.3) 4: trees in urban context – broadleaved and coniferous (from HR Imperviousness Layer context) 5: trees in urban context – broadleaved and coniferous (from CLC class 1.4.1) 254: unclassifiable (no satellite image available, clouds, shadows, non-foliated deciduous broadleaved trees or snow) 255: outside area
12	Forest Additional support layer (FAD)	20	LAEA		na	additional support raster provided with information on "trees predominantly used for agricultural practices - broadleaved" and "trees in urban context – broadleaved and coniferous"	See product 11

Table 8: Detailed forest HRL products and raster coding

3.3. Wetlands HRL

This product is extracted from HR satellite data and other available data sources for the area of the EEA39 (39 member states and affiliated countries to the European Environment Agency). The products maps the occurrence of permanent wetland, as a binary product (wetland/non-wetland), with no MMU (Minimum Mapping Unit) and a 20m MMW (Minimum Mapping Width). To map permanent wetlands, multi-temporal imagery from 2006, 2009 and 2012, as well as a seasonal time series of medium-resolution (MR) images, are used in production. Wetlands and water (see chapter 3.4) are produced using the same workflow. Basically the spectral information contained in the multi-temporal input imagery is, as part of a highly automated workflow, transferred into statistical frequency indices for water and wetland presence. These are used in a last step for the final classification. A pixel cannot be classified as wetland and water at the same time (this is different for the other HRL's).

Wetlands	
Wetland (based on 2006-2009-2012 data), (20m)	Wetland: Binary product: mapping "wetlands", and "all non-wetland areas" not covered by wetlands
Wetland (based on 2006-2009-2012 data), (100m)	Occurrence of wetlands (0-100%)

Table 11: Overview of wetlands HRL products

Wetlands include the following landscape types:

- Wetlands associated with permanent water bodies;
- Wetlands not associated with permanent water bodies;
- Wetlands with vegetation (macrophyte) cover or without vegetation;
- Peatlands (having presence of surface water), and
- Coastal wetlands (salt marshes, salines, intertidal flats).

Land cover not to be considered as wetlands:

- temporary water-logging because of snow melt or heavy rains;
- permanent water surfaces (rivers, lakes, lagoons, estuaries, fish ponds), and
- wet agricultural fields, including rice fields.

No	Product	Geo-metric resolution	Projec-tion	MMU	Classified feature	Raster coding
1	Wetland (based on 2006-2009-2012 data), (20m)	20m	National	no	Wetland: Binary product: mapping "wetlands", and "all non-wetland areas" not covered by wetlands	0: all non-wetland areas 1: wetland 254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside the production unit
2	Wetland (based on 2006-2009-2012 data), (20m)	20m	LAEA	no	Wetland: Binary product: mapping "wetlands", and "all non-wetland areas" not covered by wetlands	0: all non-wetland areas 1: wetland 254: unclassifiable (no satellite image available, clouds, shadow or snow) 255: outside the production unit
3	Wetland (based on 2006-2009-2012	100m	LAEA	no	Occurrence of wetlands (0-100%)	0: all non-wetland areas 1-100:% wetland occurrence

	data), (100m)					254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside area
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Table 12: Details of wetlands HRL products and raster coding

3.4. Water bodies HRL

Water bodies	
Permanent water bodies (based on 2006-2009-2012 data), (20m)	Permanent water bodies, including small water bodies: Binary product, mapping “permanent water bodies” and “all other areas” not covered by permanent water bodies.
Permanent water bodies (based on 2006-2009-2012 data), (100m)	Occurrence of permanent water bodies (0-100%)

Table 13: Overview of water bodies HRL

Permanent water bodies use coverage from three satellite images (2006, 2009 and 2012), as well as a seasonal time series of medium-resolution (MR) images to identify areas with a constant presence of water. A pixel is classified as water if open water covers >90% of a pixel (including shallow open water and submerged vegetation).

Water includes the following landscape types:

- Permanent lakes, ponds (artificial and man-made) including fish ponds;
- Rivers, channels permanently with water, and
- Coastal water surfaces: lagoons, estuaries.

Land cover not to be considered as water:

- Sea and ocean, and
- Liquid dump sites.

No	Product	Geo-metric resolution	Projec-tion	MMU	Classified feature	Raster coding
1	Permanent water bodies (based on 2006-2009-2012 data)	20m	national	No	Permanent water bodies, including small water bodies: Binary product, mapping “permanent water bodies” and “all other areas” not covered by permanent water bodies.	0: all non-water areas 1: water 254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside the production unit
2	Permanent water bodies (based on 2006-2009-2012 data)	20m	LAEA	No	Permanent water bodies, including small water bodies: Binary product, mapping “permanent water bodies” and “all other areas” not covered by permanent water bodies.	0: all non-water areas 1: water 254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside the production unit
3	Permanent water bodies (based on 2006-2009-2012 data)	100m	LAEA	no	Occurrence of permanent water bodies (0-100%)	0: all non-water bodies areas 1-100:% water bodies occurrence

						254: unclassifiable (no satellite image available, clouds, shadows or snow) 255: outside area
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Table 14: Details of permanent water bodies products and raster coding