High Resolution Layer Grasslands - Product User Manual (PUM)

Copernicus Land Monitoring Service

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Content

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1. Executive summary

Copernicus is the European Union's Earth Observation Programme. It offers information services based on satellite Earth observation and in situ (non-space) data. These information services are freely and openly accessible to its users through six thematic Copernicus services (Atmosphere Monitoring, Marine Environment Monitoring, Land Monitoring, Climate Change, Emergency Management and Security).

The **Copernicus Land Monitoring Service (CLMS)** provides geographical information on land cover and its changes, land use, vegetation state, water cycle and earth surface energy variables to a broad range of users in Europe and across the world in the field of environmental terrestrial applications.

CLMS is jointly implemented by the **European Environment Agency (EEA)** and the European Commission's DG **Joint Research Centre (JRC)**.

The **High-Resolution Layer (HRL)** vegetated land cover characteristics are a set of harmonised yearly maps dedicated to the thematic themes **Tree Cover & Forests, Grasslands** and **Croplands**. Those include a rich suite of raster products mapping the yearly status of those land cover types at a spatial resolution of 10 meters and change layers at 3-yearly interval and 20-meter resolution. HRL vegetated land cover characteristics extends the time-series of the existing HRL's Tree Cover & Forests and Grasslands and complements the CLMS portfolio with new layer dedicated to the mapping of crop types and agricultural practices such as mowing, harvest and cover crops.

2. Background of the document

2.1 Scope

This Product User Manual is the primary document that users are recommended to read before using the product. It provides a description of the product characteristics, production methodologies and workflows, and information about the product quality of the annual provision of **HRL Grasslands**. Furthermore, it gives information on the terms of use and product technical support. More detailed information on the methodologies and processing workflows that were used to produce the products can be found in the Algorithm Theoretical Baseline Document (ATBD) [7].

2.2 Content and structure

In more detail, the document is structured as follows:

- Chapter 3 provides an overview of the lineage of the products in relation to previous productions;

- Chapter 4 contains a review of user requirements;

- Chapter 5 provides on overview of what is included in the **High Resolution Layers** vegetated land cover characteristics and how the comprised products relate to each other;

- Chapter 6 presents potential application areas and example use cases;

- Chapter 7 provides a description of the products including the nomenclature and class definitions, file naming, spatial resolution format(s), etc.;

- Chapter 8 summarizes the quality assessment, validation procedure and the results;

- Chapter 9 provides information about product access and use conditions as well as the technical product support.

3. Lineage of HRL Tree Cover and Forests, Grasslands, and Croplands

High Resolution Layers (HRL)s on **Tree Cover & Forests** had already been established in the **Copernicus Land Monitoring Service (CLMS)** portfolio since the reference years 2012 producing initially a **Dominant Leaf Type**, a **Tree Cover Density**, and a **Forest Type** map at a spatial resolution of 20 meters (Figure 3-1). Change layers and reference datasets were included with the reference year 2015. At the same time the accuracy targets were raised towards at least 90% user's and producer's accuracy. A further important step followed with the first production for the reference years 2018 (further referred to as **Historic HRL Forest 2018**) where the spatial resolution of the status layers was raised to 10 meters, the implementation of the change layers was partially reconsidered and target accuracies for the change layers were defined. In addition, new aggregated layer depicting the density of coniferous and broadleaved tree cover was introduced. With the **HRL Tree Cover & Forests** starting from the reference year 2018 the product specifications have been kept largely in line with the definitions used for the Historic HRL Forest 2018 whereas major changes concerned in particular the move to a yearly update cycle for the status layers and changes to some confidence layers (not shown in Figure 3-1). The new HRL Tree Cover & Forests therefore replace and extend the Historic HRL Forest 2018. This does not include an update of the change layer 2015 – 2018; the new status layers for 2018 are therefore not consistent with the original change layers 2015 – 2018.

HRL's on **Grasslands** had already been established in the Copernicus Land Monitoring Service (CLMS) portfolio since the reference years 2015 producing initially a status layer on the absence / presence of grassland (Figure 3-1) with a target Overall Accuracy of 85%. With the reference year 2018 the spatial resolution of the status layers was raised to 10 meters and a change layer with a target Overall Accuracy of 80% was introduced. With the **HRL Grasslands** starting from the reference year 2018 the product specifications have been kept largely in line with the definitions used for the **Historic HRL Grassland 2018** whereas major changes concerned in particular the move to a yearly update cycle for the status layers, an additional yearly **Herbaceous Cover** layer (including also temporary grassland in the reference year), new layers on the count and timing of Grassland Mowing (Minimum Mapping Unit of 0.25 ha) and changes to some confidence layers (not shown in detail in Figure 3-1). The new HRL Grasslands therefore replaces and extends the Historic HRL Grassland 2018. This does not include an update of the change layer 2015 – 2018; the new status layers for 2018 are therefore not consistent with the original change layers 2015 – 2018.

The **HRL Croplands** is a new set of layers dedicated to agriculture and comprises several yearly layers mapping crop types (10-metre spatial resolution) and agricultural practices such as harvest, fallow land and secondary crops (10-metre spatial resolution, Minimum Mapping Unit of 0.25 ha).
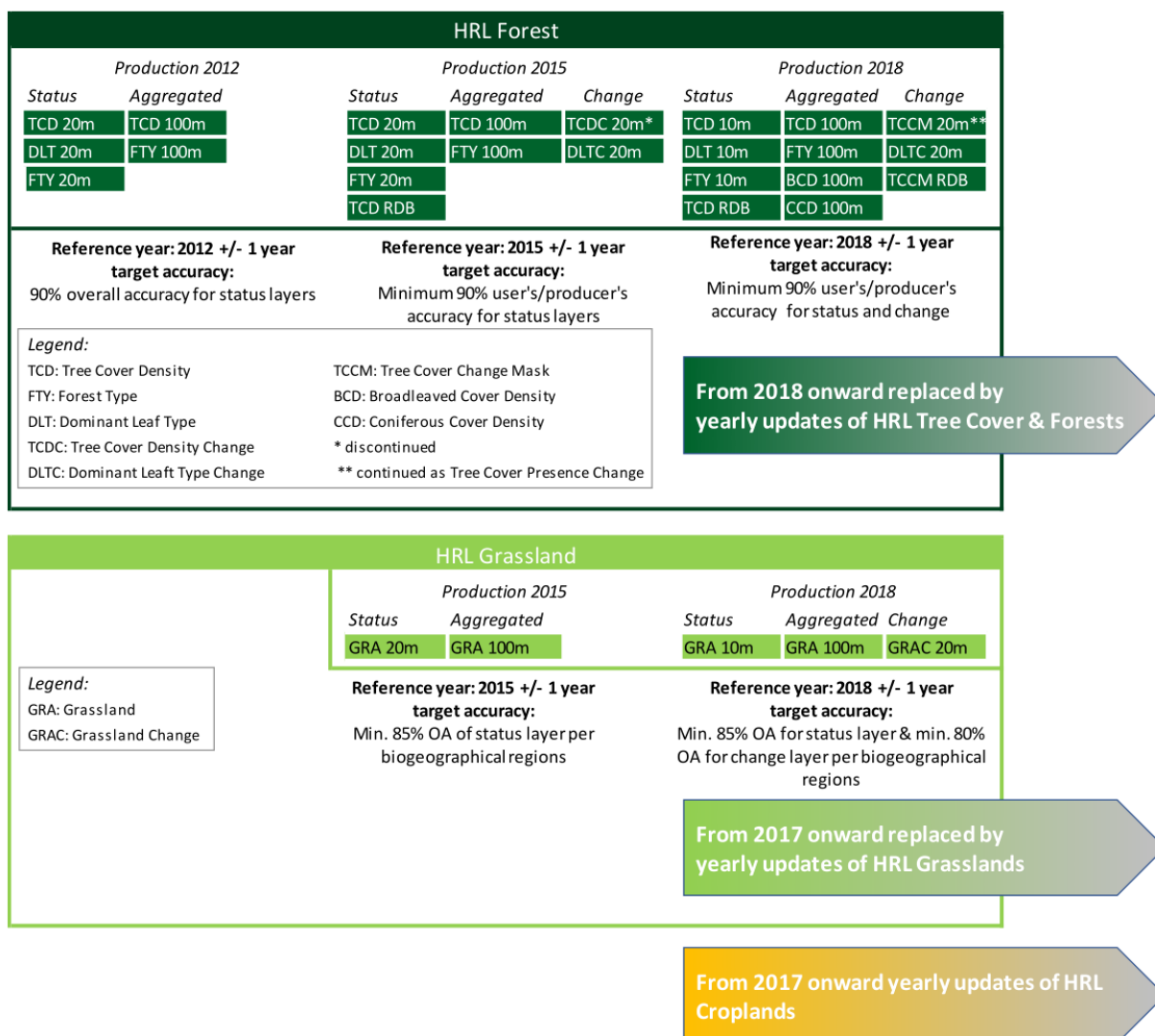
HRL Forest

	Production 2012			Production 2015			Production 2018	
Status	*Aggregated*		*Status*	*Aggregated*	*Change*	*Status*	*Aggregated*	*Change*
TCD 20m	TCD 100m		TCD 20m	TCD 100m	TCDC 20m*	TCD 10m	TCD 100m	TCCM 20m**
DLT 20m	FTY 100m		DLT 20m	FTY 100m	DLTC 20m	DLT 10m	FTY 100m	DLTC 20m
FTY 20m			FTY 20m			FTY 10m	BCD 100m	TCCM RDB
			TCD RDB			TCD RDB	CCD 100m	

Reference year: 2012 +/- 1 year
target accuracy:
90% overall accuracy for status layers

Reference year: 2015 +/- 1 year
target accuracy:
Minimum 90% user's/producer's accuracy for status layers

Reference year: 2018 +/- 1 year
target accuracy:
Minimum 90% user's/producer's accuracy for status and change

Legend:
TCD: Tree Cover Density
FTY: Forest Type
DLT: Dominant Leaf Type
TCDC: Tree Cover Density Change
DLTC: Dominant Leaft Type Change

TCCM: Tree Cover Change Mask
BCD: Broadleaved Cover Density
CCD: Coniferous Cover Density
* discontinued
** continued as Tree Cover Presence Change

From 2018 onward replaced by yearly updates of HRL Tree Cover & Forests

HRL Grassland

		Production 2015		Production 2018		
		Status	*Aggregated*	*Status*	*Aggregated*	*Change*
		GRA 20m	GRA 100m	GRA 10m	GRA 100m	GRAC 20m

Legend:
GRA: Grassland
GRAC: Grassland Change

Reference year: 2015 +/- 1 year
target accuracy:
Min. 85% OA of status layer per biogeographical regions

Reference year: 2018 +/- 1 year
target accuracy:
Min. 85% OA for status layer & min. 80% OA for change layer per biogeographical regions

From 2017 onward replaced by yearly updates of HRL Grasslands

From 2017 onward yearly updates of HRL Croplands

Figure 3-1 Evolution of HRL Forest and Grassland towards the three product groups HRL Tree Cover & Forests, HRL Grasslands, HRL Croplands.

4. Review of User Requirements

In the frame of the **Horizon 2020 (H2020)** project **ECoLaSS** a survey [5] of key stakeholders has been performed in order to evaluate the user requirements towards the evolution of existing and future **Copernicus** products. This survey also made use of the results from the Nextspace User Study [6] and revealed that **HRL** users like European institutions, service industry, research and academia, national agencies, regional administrations, NGS or private users would in general appreciate:

- High thematic quality/meaningful and application-oriented product definitions;

- Sufficient spatial and timely resolution concerning both, status layer and change layer;

- Short update cycles;

- Change monitoring;

- Free and open access;

- High technical quality;

- Standardized and comparable nomenclature;

- Transparent and scientific workflows and state-of-the-art methodology;

- Detailed documentation of these workflow and the respective methodology;

- Consistency of the Pan-European products enabling synergistic use of all products;

- Streamlining the pan-European product with global ones;

- Availability of historic data and compatibility of time series;

- Open access to the original Copernicus Sentinel data;

- Sophisticated product presentation and visualisation possibilities in an online viewer on the Copernicus platform;

- **IPCC** conformity.

While many of these requirements had already been satisfied with previous HRL reference years some could only be implemented within the current update:

- A long-standing thematic gap in the European **CLMS** portfolio concerning the monitoring of agriculture has been addressed though new products on crop types and agricultural activities. This also improves the separation between grassland and cropland and the IPCC conformity;

- Yearly update cycle for status layer;

- Grassland use intensity (or the dynamics of intensification/ extensification) is partially addressed through a new product on Grassland mowing.

Further requirements that remain to be considered for future updates are for example:

- More fine-grained differentiation among species-rich (extensively used) and separation from species-poor (intensively used) and managed grassland;

- Tree-species compositions and shifts between extensive and intensive management;

- Increased timeliness of availability of the products: The mid-term goal is a product provision at latest 12 months after the end of the reference year.

5. Product structure - What are the High Resolution Layers?

The **High Resolution Layers (HRL)** vegetated land cover characteristics portfolio consists of **Tree Cover & Forests, Grasslands** and **Croplands** products (Figure 5-1), which together cover most of what is defined as the Biotic component of the **EAGLE** Land Cover Components[1]. More specifically, the mapping is focused on surfaces with a vegetation cover above 30%; an exception to this is tree cover where the objective is to map tree cover with a continuous range of 1-100% **Tree Cover Density (TCD)**, i.e. also below 30%, as far as detectable from 10-metre resolution satellite imagery. This definition is also in line with the Sparsely Vegetated class in the **CLC+ Backbone Raster**[2] and considers that detection / classification of vegetation below this threshold is typically more error prone. The definition also aims at largely avoiding overlaps with the non-vegetated land cover characteristics such as **HRL Imperviousness**, which is focused on areas with less than 10% vegetation cover during any time of the year, for a reference period of 3 year.

Some overlaps between the three product groups are allowed by definition, for example areas with tree crops (i.e. olive, fruit and nut trees) which are included in both the Tree Cover & Forests and the Croplands products. Furthermore, specific vegetations types are not included in the HRLVLCC portfolio; this concerns areas dominated by natural shrubs (i.e. shrubs that are not under agricultural use) and associations of lichens and mosses.
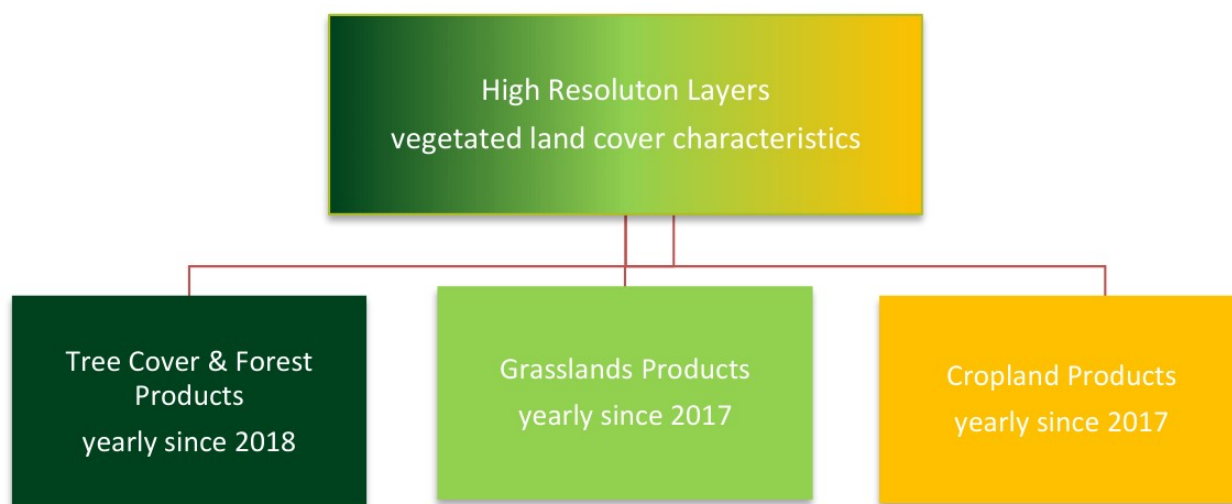

Figure 5-1: Products within the HRL vegetated land cover characteristics.

Given several interdependencies and potential overlaps among the **Grasslands, Croplands and Tree Cover & Forests** products, the overall workflow starts with the classification of **Base Vegetation Layer (BVL)**. A high-level description is provided for the overall workflow in Figure 5-2. The yearly BVL classification initially targets the separation of 5 basic land cover classes being:

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[1] https://land.copernicus.eu/en/eagle?tab=technical_implementation

[2] https://land.copernicus.eu/en/technical-library/product-user-manual-clc-backbone-2021

1. *herbaceous vegetation*;

2. *cropland*;

3. *tree cover - coniferous*

4. *tree cover - broadleaved*;

5. *tree crops* (i.e. nomenclature overlap between broadleaved tree cover and permanent crops in the Croplands product);

6. *background class* (including bare and sparsely vegetated areas and non-agricultural shrubs);

In a subsequent post-processing step two further classes are derived to delineate the:

7. potential *overlap herbaceous – cropland* (i.e. pixels which are classified as cropland and herbaceous at least once in the time-series);

8. The second derived class is derived from the intersection of all areas classified as tree cover and a preliminary version of the Tree Cover Density to delineate areas with low Tree Cover Density and hence allowed *overlaps of herbaceous and tree cover*.

The derived yearly BVL is considered for the downstream productions of Grasslands, Croplands and Tree Cover & Forests products as follows:

- For the production of the Grasslands layers: all areas classified as *herbaceous*, *overlap herbaceous – tree cover*, or *overlap herbaceous – Cropland* are considered as the potential maximum extent for the **Herbaceous Cover (HER)** layer. In addition, the BVL classification probabilities for the *herbaceous* class are used as the main input for the derivation of the **HER** layer.

- For the **Croplands** layers: the areas delineated as *cropland*, *overlap herbaceous –cropland*, or Tree Crops are considered as the maximum extent for the **CTY** classification and further refinement.

- For the **Tree Cover & Forests** layers: the areas classified as *tree cover*, *overlap herbaceous – tree cover*, *tree crops* and the respective probabilities are used directly to derive the respective change layers and yearly **DLT** and **TCD** status layers.

Within the areas identified as *overlap herbaceous – cropland*, a further harmonization step is carried out downstream. To this end the **CTY** classification initially includes a class for *fodder crops* which are transferred to the **HER** layer if occurring in the designated overlap class.
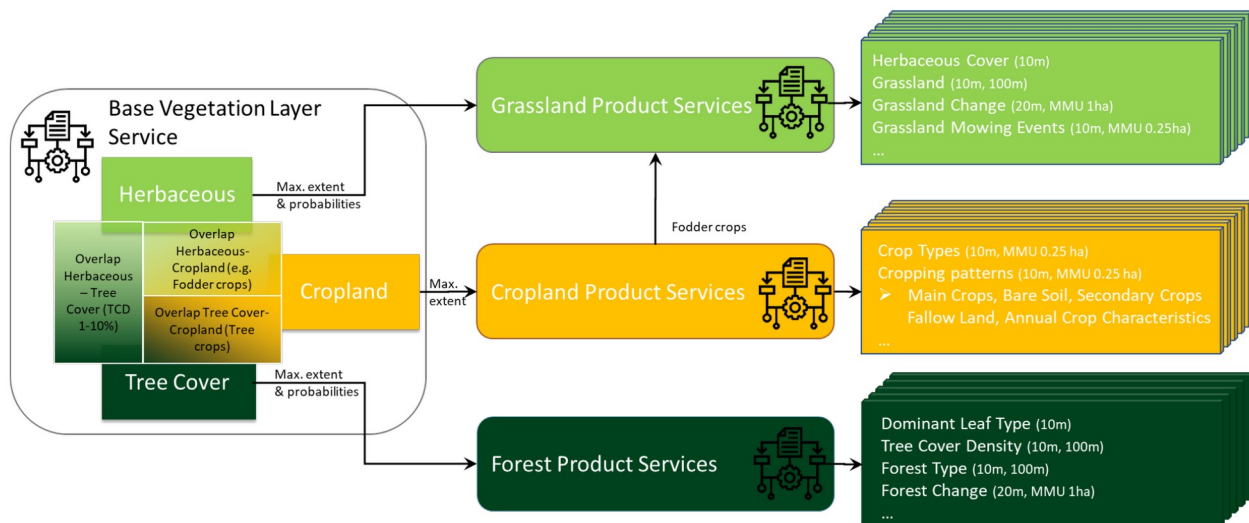
Figure 5-2: High-level overview of the relationship between the Base Vegetation Layer and the subsequent production of Grasslands, Croplands and Tree Cover & Forests products

6. Product application areas and examples of use cases

The **HRL Tree Cover & Forests, Grasslands** and **Croplands** set of products is designed for use by a broad user community as basis for environmental and regional analysis and for supporting political decision-making, such as the **Common Agricultural Policy (CAP), LULUCF (Land Use, Land Use Change and Forestry))** regulation, the **Nature Restoration Regulation (NRR)**, or the proposed European **Forest Monitoring Law (FML).** With the new products the **EEA** will ensure continuity and further densification of the well-established HRL Tree Cover & Forests and Grasslands product time series. Those include a rich suite of raster products at a 3-yearly interval mapping the status of those land cover types with a spatial resolution of 10-meter and change layers at 20-meter spatial resolution.

As an example, the following sections provide short information on (potential) use cases at national level, for which the **Copernicus HRL Grasslands** product represent a fundamental input.

6.1 Use case: Using Grassland Mowing data for CAP

The **Grassland Mowing Events** are derived using a **Sentinel-2** time-series analysis by identifying vegetation disturbances in the **Herbaceous Cover (HER)** layer. Those disturbances usually show a sharp drop of biophysical signal compared to a previously defined reference. The main difficulty is to distinguish mowing events from cloud-influenced observations or to miss mowing events due to longer cloud-related data gaps.

The information on mowing events can support the correct implementation of the European **Common Agricultural Policy (CAP)**.

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Figure 6-1: Left side: First Grassland Mowing Dates (GRAMD_1) 2021 displaying the start date of a mowing event at Airport Innsbruck, Austria Right side: Grassland Mowing Events (GRAME) 2021 displaying up to 4 mowing events at Airport Innsbruck, Austria. Background: ESRI World Imagery.

6.2 Use case: Land cover specific monitoring

Detailed and dynamic information on the state of the land as provided by the **Grasslands** layers allows to analyse regional trends in the area occupied by these land covers, which could be relevant information for authorities and policy makers. Furthermore, applications which require information on the land cover status can benefit from the **Grasslands**. For example, in case of biomass mapping often land cover specific parametrization is applied. Using the **HRL Grasslands**, allows to do this in a much more detailed and dynamic way. In case of the Evoland[3] project, it is intended to use these layers to apply specific parametrization over crop and grassland locations.

7. Product description

The **HRL Grasslands** layers are generally provided in 100km LAEA tiles as shown in Figure 7-1. The five French Oversea Territories are provided in UTM with the layout of the respective territory. The layers are available as Cloud-Optimized GeoTIFFs (COG) per reference year and 100km LAEA tile aligned with the **EEA reference grid**. Each raster file is accompanied by a Persistent Auxiliary metadata (PAM) XML and an INSPIRE XML.

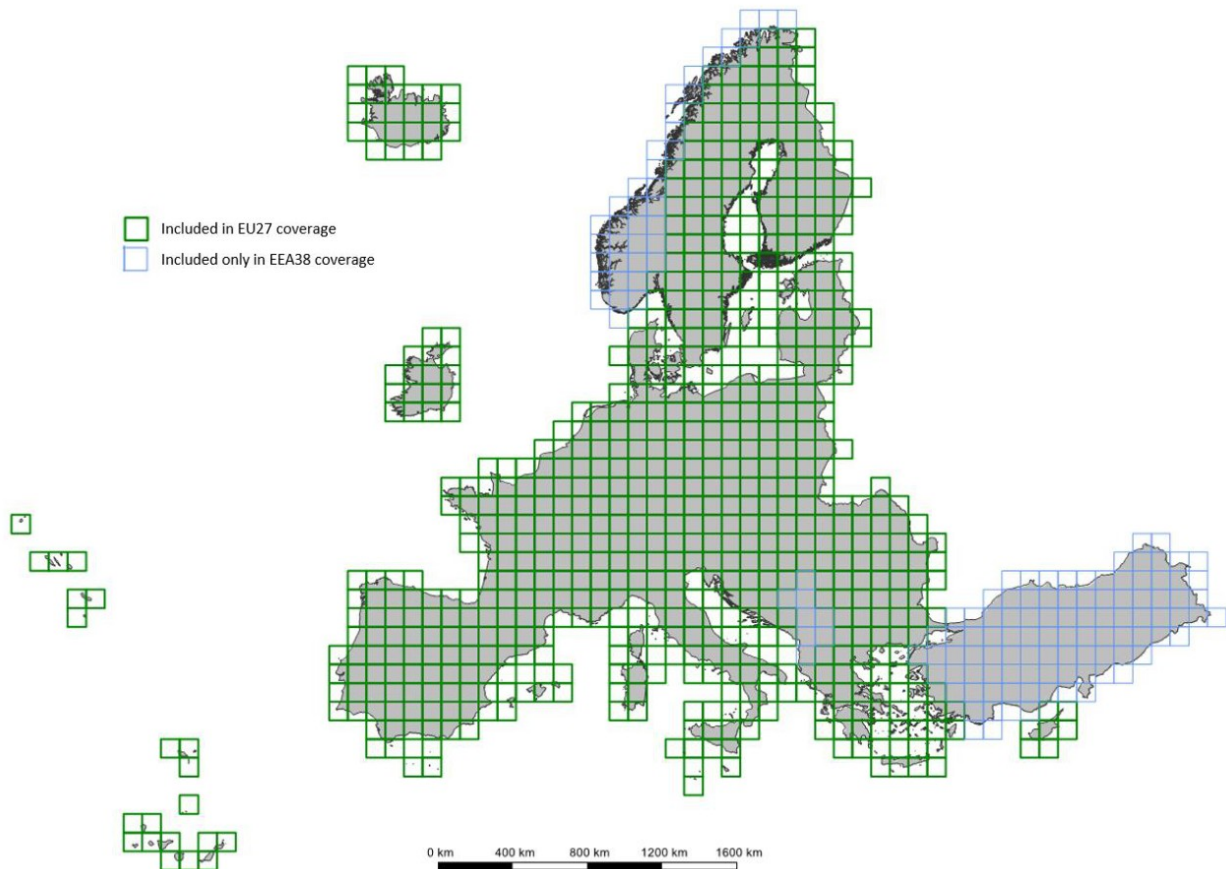[3] https://www.evo-land.eu/method/biomass-mapping/

Figure 7-1: LAEA tile layout incl. distinction between tiles to cover EU27 and EEA38.

The primary layers of the **HRL Grasslands** portfolio (Figure 7-4) include the produced **Grassland (GRA)** status layer and the **Herbaceous Cover (HER)** status layer at a 10-meter resolution. Within the extent of the yearly **HER** layer, **Grassland Mowing Events (GRAME)** and **Grassland Mowing Dates (GRAMD)** are provided on a yearly basis and at a 10-meter resolution. Further layers are the **Ploughing Indicator (PLOUGH)**, the **Grassland Change layer (GRAC)** as well as three accompanying confidence layers, the **Grassland Confidence Layer (GRACL)**, the **Grassland Change Confidence Layer (GRACCL)**, as well as the **Grassland Mowing Events Confidence Layer (GRAMECL)**.

The **Herbaceous Cover (HER)** is a yearly binary layer at a 10 meter spatial resolution displaying information on the presence / absence of herbaceous vegetation cover starting from the reference year 2017. It adheres to the below definition of herbaceous cover and constitutes the basis for all other HRL Grasslands layers. A high-level overview of the dependencies among the **HRL Grasslands** layers is provided in Figure 7-2. The **HER** layer contains permanent and temporary grasslands (e.g. seeded grassland and fodder crops), in case it was the dominant land cover in the respective reference year.

The **HER** layer enables advanced users to derive temporary grasslands according to the different definitions, using the **Ploughing Indicator (PLOUGH)** and **Grassland (GRA)** layers (see description below). The **HER** layer, together with the **PLOUGH** layer, serves as the basis for deriving the **GRA** status layer by

excluding all areas detected as ploughed within this period. However, an area can still be mapped as herbaceous even if a ploughing event occurred within a given year.
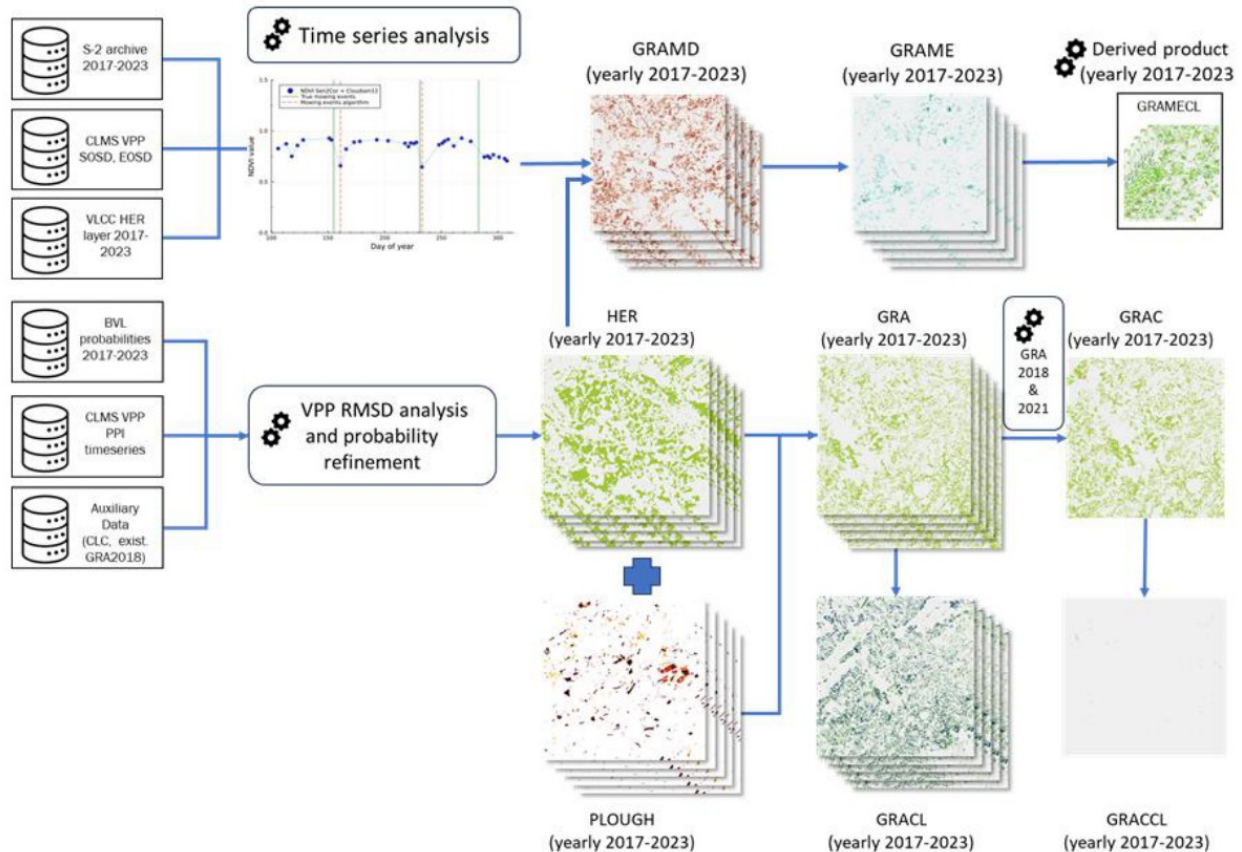

Figure 7-2: Worflow dependencies of HRL Grasslands layers

Before generating the **GRA** layer, the **Ploughing Indicator (PLOUGH)** is derived at 10 meter spatial resolution to define the permanent grassland area. For each pixel in the **HER** layer, the **PLOUGH** layer tracks the time since the most recent ploughing event or the last time it was not covered by herbaceous vegetation. It consists of codes 0 to 6, which represent the number of years that have passed since the last disruption of herbaceous cover (for reference year 2017: 1 = 2016 and 6 = 2011).

With the introduction of the **HER** layer, some changes are applied to the historical **PLOUGH** layers from the previous 2015 and 2018 productions to maintain consistency between the three layers: **PLOUGH**, **GRA** and **HER**. Class code (o) now indicates ploughing in current year, while the former class 0 (*no ploughing information*) has been reassigned to class code *253*. Class *100* has been introduced to contain all pixels that changed between two years due to variations in the **HER** layer, where no ploughing was detected.

The first reference year for **HRL Grasslands** is 2017, meaning that ploughing information dating back to 2011 would have been required for consistency. However, the data quality for 2015 and earlier is considered rather poor due to the 20 meter spatial resolution and the mix of available imagery including very few Sentinel-2 scenes, Landsat 5, Landsat 8 and the HR_IMAGE_2012 [8].

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Clipping the 10 meter **Grassland** layer with the 20 meter historic layers would introduce 20 meter edges, significantly affecting the final **Grassland** layer's appearance. As a result, the **PLOUGH** for the years before 2016 was not used to mask out grassland areas.

However, ploughing information for the historic years 2011 to 2015 is still available in the **PLOUGH** for reference year 2017 and can be utilized for specific applications. As more reference years are added, historic data will gradually diminish, and starting with 2023 reference year, the **PLOUGH** layer will rely solely on Sentinel-2 data.

The **Grassland (GRA)** status layer at 10 meter spatial resolution is therefore a direct derivative of the corresponding **HER** and **PLOUGH** layer. All herbaceous areas that indicate ploughing events or herbaceous disruptions in the current and previous five years are masked out, resulting in the permanent grassland areas.

The **HRL Grasslands** portfolio also includes the **Grassland Change (GRAC)** layer at 20 meter resolution, indicating *gain* and *loss* of permanent grassland vegetation between 2018 and 2021 with a Minimum Mapping Unit of 1ha.

The **Grassland Mowing (GRAM)** layers map the number (up to four) detected mowing events and their respective start dates. The **Grassland Mowing Events (GRAME)** layer provides annual pixel-based information, starting from 2017, and contains the number of mowing events (*0, 1, 2, 3, 4*) within the detected permanent and temporary grassland extent of the **Herbaceous Cover (HER)**.

The **Grassland Mowing Dates (GRAMD)** layers provides the *day-of-year (DOY)* for the start of each mowing event. Since up to four mowing events can be detected, **GRAMD** is provided in four individual raster datasets, each depicting the DOY for the first, second, third and fourth mowing event (**GRAMD_1, GRAMD_2, GRAMD_3, GRAMD_4**), respectively. This results in four **GRAMD** layers per reference year/per **GRAME** layer (Figure 7-3).
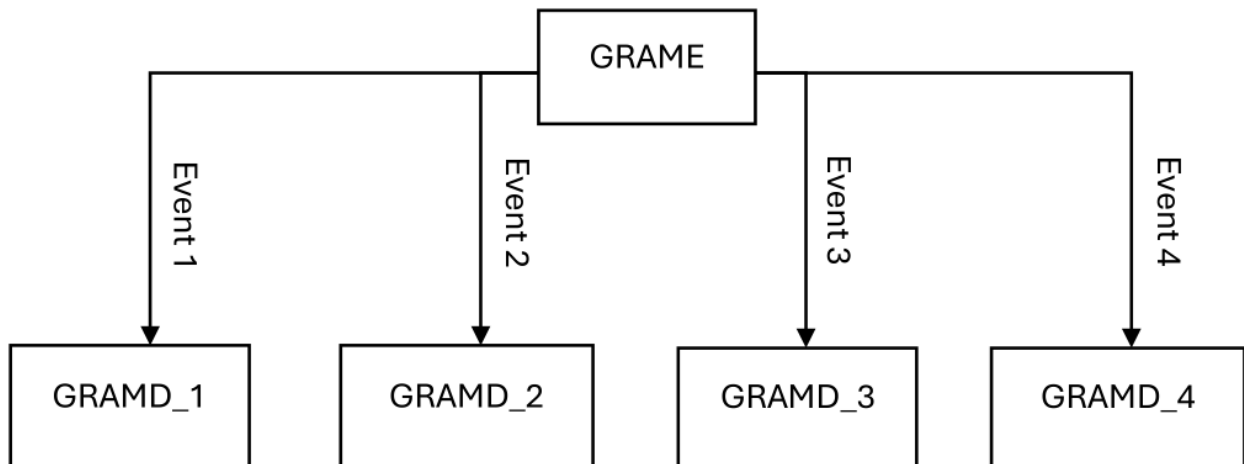

Figure 7-3: Grouping of GRAME and GRAMD for one reference year.

To reduce noise in the **GRAMD** layer, a GDAL sieve[4] filter is applied independently to each of the four **GRAMD** layers. This filter ensures that patches of DOY-values smaller than the threshold of 0.25 ha (25

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[4] https://www.evo-land.eu/method/biomass-mapping/

pixels) is replaced by the value of the largest neighbouring patch, but only if the size of the neighbouring patch is larger than the threshold. Since this filtering is applied individually to each **GRAMD** layer (GRAMD_1, GRAMD_2, ...), in some cases, the newly assigned value is already present in one of the other mowing event date layers at the same location (i.e. the same pixels). In such cases, it results in date duplication, where timing of the first mowing event (GRAMD_1) and the second mowing event (GRAMD_2) share the same DOY. This occurs in approximately 0.4 % of the herbaceous pixels. For further information, please refer to the ATBD[7].

Additional layers complementing the **HRL Grasslands** portfolio are the **Confidence Layers (CL)** for which there are three: **Grassland Confidence Layer (GRACL), Grassland Mowing Events Confidence Layer (GRAMECL)** and **Grassland Change Confidence Layer (GRACCL)**. These indicate on the reliability of the classifications by providing additional information on the degree of separability of each grassland/change/mowing pixel from other land cover types. They show the confidence of the classifier for each pixel in the grassland/change/mowing classification with values ranging from *0-100% confidence*. This layer may be of interest e.g. for scientific valueadded applications, where the a-priori confidence of all input data is needed for overall error margin calculation.
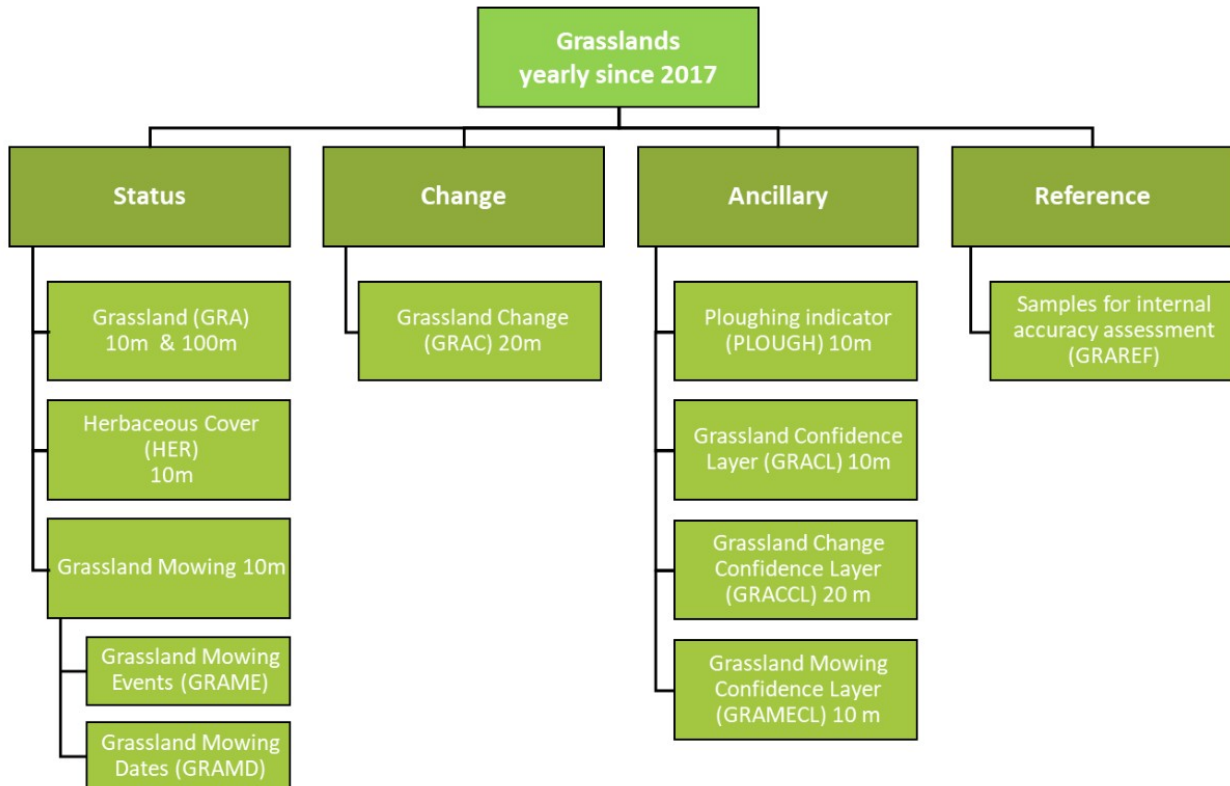

Figure 7-4: HRL Grasslands product portfolio

7.1 Thematic characteristics of the HRL Grasslands Product

In terms of thematic definition of the annual **Grassland (GRA)** status layer has been aligned with the **HRL Grassland 2015** and the *Historic HRL Grassland 2018* definition, ensuring consistency and comparability across the time series. Table 7-1 provides an overview of the **Land Cover (LC)** and **Land Use (LU)** features

that shall be included or excluded in the **HRL Grasslands**. The definition encompasses natural, semi-natural and managed or cultivated grasslands (according to their origin and utilization) as well as all types of grassland (permanent or seasonal) under highly heterogeneous biogeographic conditions (wet or dry climate, fertile or poor soil). Herbaceous cover within the context of the product is understood as herbaceous vegetation with at least 30% ground cover and with at least 30% graminoid species such as Poaceae, Cyperaceae and Juncaceae. The rate of 30% ground cover density shall be understood as a benchmark implicating that grasslands with ≥30% ground cover can usually be distinguished clearly from bare ground on earth observation data with the resolution of 10 meters.

Coastal grasslands, such as grey dunes and salt meadows with at least 30 % cover of graminoids cover, are included. The definition also tolerates non-woody plants such as lichens, mosses, sedges and herbs but excludes wetlands and other peat-forming ecosystems dominated by sedges, reed beds and helophytes dominated systems, tall forbs, fern, and shrub dominated vegetation. The definition includes extensive areas of agricultural grasslands (pastures and meadows) or herbaceous fodder crops and managed recreational grasslands (e.g. lawns). Arable fields with graminoids like winter wheat, barley and rye are explicitly excluded.

Table 7-1: Elements to be included/ excluded in the Herbaceous Cover and Grassland Status Layers

Elements included	Elements excluded
▪ Natural, semi-natural, agricultural / managed grass-covered surfaces ▪ Grasslands with scattered trees and shrubs covering a maximum 10% ▪ Heathland with high grass cover, maximum of 10% non-grass cover ▪ Coastal grasslands, such as grey dunes and salt meadows located in intertidal flat areas with at least 30% graminoid species of vegetation cover ▪ Sparsely vegetated grasslands (≥30% vegetation cover) ▪ Grasslands in urban areas: parks, urban green spaces in residential and industrial areas ▪ Semi-arid steppes with scattered Artemisia scrub ▪ Meadows: grasslands which are not regularly grazed by domestic livestock, but rather allowed to grow unchecked in order to produce hay ▪ Grasslands in urban areas: sport fields, golf courses ▪ Grasslands on land without use ▪ Natural grasslands on military sites	▪ Peat forming ecosystems dominated by sedges ▪ Reed beds and helophytes dominated systems ▪ Tall forbs, fern, shrub dominated vegetation ▪ Grasslands that have been observed as tilled in the reference year or the 6 years before (applicable for GRA but not for HER)) ▪ Rice fields ▪ Vineyards, orchards, olive groves, (if more than 10% shrubs or trees) ▪ Tundra dominated by shrubs and lichens ▪ Grasslands on fresh (and older) clear-cuts in the woods ▪ Sparsely vegetated grasslands with <30% vegetation cover

The two main yearly status layers are the **Herbaceous Cover (HER)** layer and the **Grassland (GRA)** layer that reflect the important distinction between permanent and temporary grassland.

While the criteria for the distinction of permanent and temporary grasslands vary across Europe, several countries use a persistence threshold of at least 6 years. The specification of the **GRA** layer follows this convention and defines permanent grassland as stable, continuously herbaceous vegetation for at least six years, with no ploughing events occurring during that period.

The newly introduced annual **HER** layer, on the other hand, still includes both permanent and temporary grasslands (e.g. seeded grassland and fodder crops that might have been tilled within the reference year) if it was the dominant land cover in the respective reference year.

The **PLOUGH** layer records detect tilling events annually for the respective reference year and the previous six years, serving as the primary input for distinguishing between temporary herbaceous cover and permanent grassland and thus allows the derivation of the **GRA** from the **HER** layer.

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The **Grassland Mowing (GRAM)** layers provide information on timing and number of mowing events where mowing is defined as the mechanical cutting of the herbaceous cover with mowing machines or scythes. Such interventions leave typical drops in the time-series of the **Normalized Difference Vegetation Index (NDVI)** which can be detected automatically (Figure 7-5). The **Grassland Mowing Dates (GRAMD)** layers records the **Day of Year (DOY)** of up to four mowing events for all pixels marked as permanent and temporary grassland in reference year in the HER layer of the respective year. The Minimum Mapping Unit for the **GRAMD** is set to 0.25ha (see Section 7 for further details on the implementation of the sieving mechanism). The **GRAME** layer is providing the total count of mowing events recorded per year.
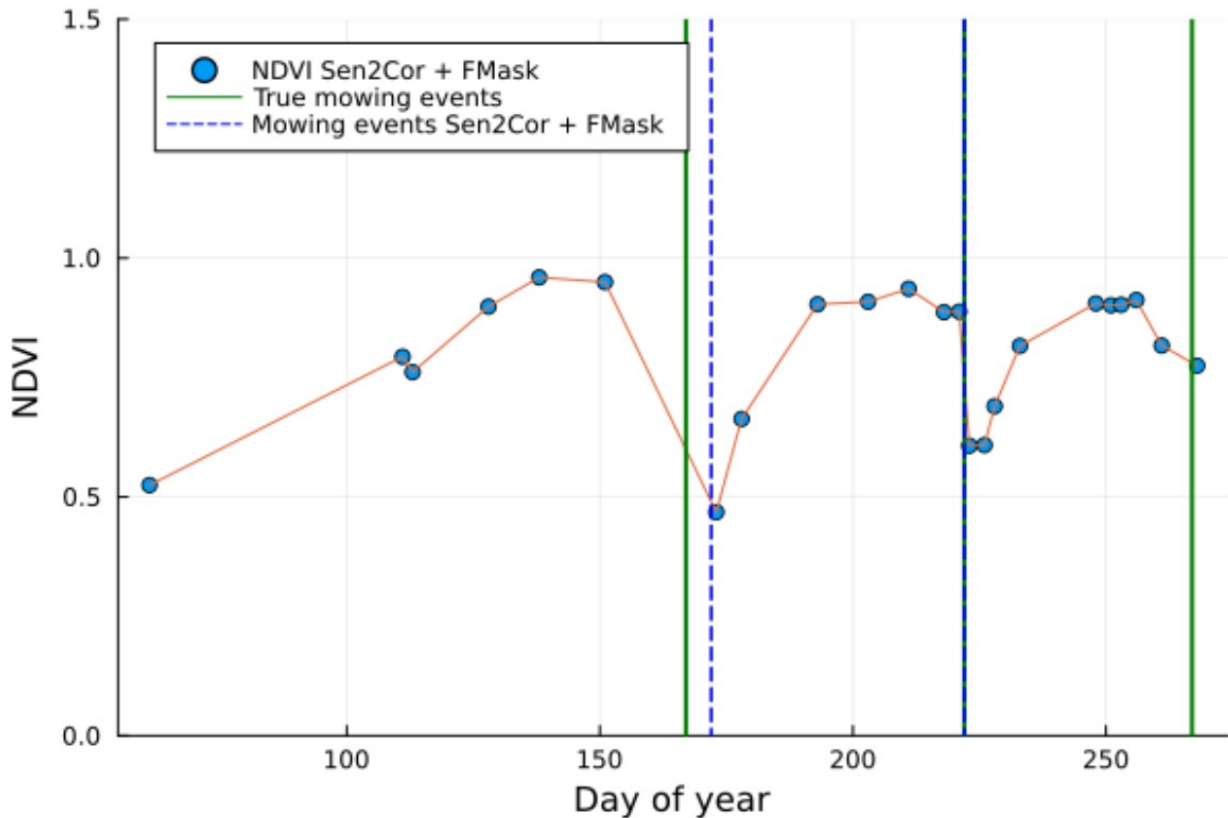

Figure 7-5: Exemplary NDVI time-series illustrating the typical drops after mowing events.

7.2 Download content, file naming convention and file format(s)

Table 7-2: Download content, file naming convention and file format(s) for HRL Grasslands layers

Name of layer	Acronym	Abbreviation	Data format	Metadata
Grassland	GRA	GRA_S2017_R10m GRA_S2018_R10m GRA_S2019_R10m GRA_S2020_R10m GRA_S2021_R10m	Tiles of Cloud-Optimized GeoTIFF aligned with the 100 km LAEA grid and with embedded colormaps, as well asseparate colour legends in the	XML metadata files according to INSPIRE metadata standards and GDAL-style Permanent Auxiliary Metadata (PAM)*.aux.xml

Name of layer	Acronym	Abbreviation	Data format	Metadata
			formats *.qml*, .sld and *.lyr	including statistics and Raster Attribute Table
Ploughing Indicator	PLOUGH	PLOUGH_S2017_R10m PLOUGH_S2018_R10m PLOUGH_S2019_R10m PLOUGH_S2020_R10m PLOUGH_S2021_R10m	Tiles of Cloud-Optimized GeoTIFF aligned with the 100 km LAEA grid and with embedded colormaps, as well asseparate colour legends in the formats *.qml*, .sld and *.lyr	XML metadata files according to INSPIRE metadata standards and GDAL-style Permanent Auxiliary Metadata (PAM)*.aux.xml including statistics and Raster Attribute Table
Herbaceous Cover	HER	HER_S2017_R10m HER_S2018_R10m HER_S2019_R10m HER_S2020_R10m HER_S2021_R10m		
Grassland Change	GRAC	GRAC_C2018-2021_020m		
Grassland Mowing Events	GRAME	GRAME_S2017_R10m GRAME_S2018_R10m GRAME_S2019_R10m GRAME_S2020_R10m GRAME_S2021_R10m		
Grassland Mowing Dates	GRAMD	GRAMD_1_S2017_R10m GRAMD_1_S2018_R10m GRAMD_1_S2019_R10m GRAMD_1_S2020_R10m GRAMD_1_S2021_R10m GRAMD_2_S2017_R10m GRAMD_2_S2018_R10m GRAMD_2_S2019_R10m GRAMD_2_S2020_R10m GRAMD_2_S2021_R10m GRAMD_3_S2017_R10m GRAMD_3_S2018_R10m GRAMD_3_S2019_R10m GRAMD_3_S2020_R10m GRAMD_3_S2021_R10m GRAMD_4_S2017_R10m GRAMD_4_S2018_R10m GRAMD_4_S2019_R10m GRAMD_4_S2020_R10m GRAMD_4_S2021_R10m		
Grassland Confidence Layer	GRACL	GRACL_S2017_R10m GRACL_S2018_R10m GRACL_S2019_R10m GRACL_S2020_R10m GRACL_S2021_R10m		
Grassland Change Confidence Layer	GRACCL	GRACCL_C2018-2021_R20m		
GRAME Confidence Layer	GRAMECL	GRAMECL_S2017_R10m GRAMECL_S2018_R10m GRAMECL_S2019_R10m GRAMECL_S2020_R10m		

Name of layer	Acronym	Abbreviation	Data format	Metadata
		GRAMECL_S2021_R10m		

7.3 Projection and spatial coverage

Table 7-3: Projection and spatial coverage for HRL Grasslands layers

Name of layer	Acronym	Spatial coverage	Coordinate reference system (WKT)
Grassland	GRA	5.751.002 km² (covering the full EEA-38)	PROJCS["ETRS89-extended / LAEA Europe", GEOGCS["ETRS89", DATUM["European_Terrestrial_Reference_System_1989", SPHEROID["GRS 1980",6378137,298.257222101, AUTHORITY["EPSG","7019"]], AUTHORITY["EPSG","6258"]], PRIMEM["Greenwich",0, AUTHORITY["EPSG","8901"]], UNIT["degree",0.0174532925199433, AUTHORITY["EPSG","9122"]], AUTHORITY["EPSG","4258"]], PROJECTION["Lambert_Azimuthal_Equal_Area"], PARAMETER["latitude_of_center",52], PARAMETER["longitude_of_center",10], PARAMETER["false_easting",4321000], PARAMETER["false_northing",3210000], UNIT["metre",1, AUTHORITY["EPSG","9001"]], AXIS["Northing",NORTH], AXIS["Easting",EAST], AUTHORITY["EPSG","3035"]]] **Except for French DOMs where the following CRS are used:** YT: EPSG 32738 RE: EPSG 32740 MQ: EPSG 32620 GP: EPSG 32620 GF: EPSG 32620
Ploughing Indicator	PLOUGH		
Herbaceous Cover	HER		
Grassland Change	GRAC		
Grassland Mowing Events	GRAME		
Grassland Mowing Dates	GRAMD		
Grassland Confidence Layer	GRACL		
Grassland Change Confidence Layer	GRACCL		
GRAME Confidence Layer	GRAMECL		

7.4 Spatial resolution

Table 7-4: Spatial resolution for HRL Grasslands layers

Name of layer	Acronym	Pixel size	MMU
Grassland	GRA	10 m	0.03 ha
Ploughing Indicator	PLOUGH	10 m	N/A
Herbaceous Cover	HER	10 m	N/A
Grassland Change	GRAC	20 m	1.0 ha for classes 1 and 2 only; no MMU for all other classes
Grassland Density	GRA	100 m	N/A
Grassland Mowing Events	GRAME	10 m	0.25 ha, smaller patches and isolated pixels can still be encountered in neighbourhoods where all patches are

Name of layer	Acronym	Pixel size	MMU
			below the MMU
Grassland Mowing Dates	GRAMD	10 m	0.25 ha, smaller patches and isolated pixels can still be encountered in neighbourhoods where all patches are below the MMU
Grassland Confidence Layer	GRACL	10 m	N/A
Grassland Change Confidence Layer	GRACCL	20 m	N/A
GRAME Confidence Layer	GRAMECL	10 m	N/A

7.5 Temporal information

Table 7-5: Temporal information for HRL Grasslands layers

Name of layer	Acronym	Reference year
Grassland	GRA	2017 2018 2019 2020 2021
Ploughing Indicator	PLOUGH	2017 2018 2019 2020 2021
Herbaceous Cover	HER	2017 2018 2019 2020 2021
Grassland Mowing Events	GRAME	2017 2018 2019 2020 2021
Grassland Mowing Dates	GRAMD	2017 2018 2019 2020 2021
Grassland Confidence Layer	GRACL	2017 2018 2019 2020 2021
GRAME Confidence Layer	GRAMECL	2017 2018 2019 2020 2021
Grassland Change	GRAC	2018 vs. 2021
Grassland Change Confidence Layer	GRACCL	2018 vs. 2021

7.6 Product characteristics and class codes

Table 7-6: Characteristics of HRL Grasslands layers

Name of layer	Acronym	Classified feature	Class coding
Grassland	GRA	Grassland / Non-grassland	0: all non-grassland areas 1: grassland 255: outside area
Ploughing Indicator	PLOUGH	The ploughing indicator estimates the temporal extent since the last ploughing activity observed on a grassland patch.	0: Indication of ploughing in current year 1-6: Number of years since last indication of ploughing. 100: Change in herbaceous cover 253: no ploughing information 255: outside area
Herbaceous Cover	HER	Permanent and temporary grassland and non-grassland in the reference year within each pixel.	0: non-grassland in reference year 1: temporary grassland in reference year 255: outside area
Grassland Change	GRAC	Grassland change 2018-2021 mask containing grassland loss, grassland gain and unchanged areas.	0: unchanged non-grassland in both years 1: grassland gain 2: grassland loss 10: unchanged grassland in both years 255: outside area
Grassland Mowing Events	GRAME	The Grassland mowing events layer will	0: no mowing detected 1-4:

Name of layer	Acronym	Classified feature	Class coding
		flag and map the number of mowing events on temporary or permanent grassland per year.	Number of mowing events detected 253: all non-herbaceous areas 255: outside area
Grassland Mowing Dates	GRAMD	The Grassland mowing dates layerwill flag and map the start date (DOY) of each of the four detected mowing events on temporary or permanent grassland per year.Each reference year is therefore split into four separate rasters, providing the DOY for each mowing event consecutively.	0: no mowing detected 1-366: Start (DOY) of each mowing event 65533: all non-herbaceous areas 65535: outside area
Grassland Confidence Layer	GRACL	Layer that measures the reliability of a pixel to be classified as grassland. For each grassland pixel, the prediction interval of the respective grassland coverage at 95% confidence.	0-100: Classification confidence 253: All non-grassland areas 255: outside area
Grassland Change Confidence Layer	GRACCL	Layer that measures the reliability of a pixel to be detected as grassland mowing. For each mowing pixel.	0-100: change confidence 253: All non-change areas 255: outside area
GRAME Confidence Layer	GRAMECL	Layer that measures the reliability of a pixel to be detected as grassland mowing. For each mowing pixel.	0-100: Mowing detection confidence 253: All non-mowing areas 255: outside area

8. Production quality assessment

The aim of this chapter is to inform about the procedures for internal validation and accuracy assessment for the status and change layer with full **EEA38** coverage. While the different layers have their own quality requirements, all have in common an assessment of the thematic quality which relies on comparing mapped information within the layers with reference data at selected locations.

This procedure contains 3 steps that will be described in the following sections:

- Sampling design

- Response design

- Statistical Analysis

The internal validation of the different **HRL Grasslands** layers follows scientifically accepted and operationally proven validation design, applied in previous productions of various HRL's of reference years 2012, 2015 and 2018. According to the product specifications, results will be presented in the form of **Overall Accuracies (OA), Producer's** and **User's Accuracies**.

8.1 Layers to be verified

While the full portfolio on **HRL Grasslands** includes numerous layers and reference years, only a subset of them is concerned by the internal verification exercise. The focus of the assessment has been set on

the primary layer being the **Grassland (GRA)** status layer and the **Grassland Change (GRAC)** layer. Furthermore, to keep the effort for the verification manageable the reference years 2018 and 2021 have been selected to align with the availability of important reference datasets such as **LUCAS** 2018 [2] the VHR IMAGE coverages of 2018 and 2021 imagery and readily harmonised GSAA datasets. An overview of the verified layers and their target accuracies is given in Table 8-1.

Table 8-1: Layers to be verified and target accuracies

Layer	Target accuracy
GRA 10m 2018	85% overall accuracy
GRA 10m 2021	85% overall accuracy
GRAC 20m 1821	80% overall accuracy

8.2 Sampling Design

The sampling approach is dedicated to assessing the accuracies of the **HRL Grasslands** layers at pan-European level and corresponds to a non-stratified, systematic and random sampling approach based on the 2 km by 2 km LUCAS grid. For the assessment of status products, 10 000 samples are randomly selected over the extended LUCAS grid (Figure 8-1). It is likely that this initial drawing will not overlap many Grassland changes between 2018 and 2021 due to the "rarity" of changes. The same is true for the HRL Tree Cover & Forest changes which have been validated with the same point set. Therefore, 4 000 additional samples are randomly drawn specifically in the changes' strata of **Tree Cover & Forests** and **Grasslands** products (2 000 in the tree cover change strata, 2 000 in the grasslands change strata), for a total of 14 000 points samples (Primary Sampling Units) across **EEA38**.

Figure 8-1: Spatial distribution of 14.000 Primary Sampling Units.

8.3 Response Design

The response design is the protocol used for retrieval of the validation/reference information for all sample units. Two types of datasets are used to perform the interpretation of samples units: guiding data and reference data.

Guiding data are those used for production of **HRL Grasslands** layers and consist mainly of timeseries of **Sentinel-2** data.

Reference data are complementary and independent data that can provide more spatial details and landscape context:

- **VHR_IMAGE_2018**[5] and **VHR_IMAGE_2021**[6]: very high resolution optical earth observation imagery, covering **EEA38** for the reference years 2018 and 2021 (+-1 year). Note that at time of this exercise, the VHR_IMAGE_2021 coverage is not 100% complete. These datasets comprise earth observation imagery between 2 and 4m spatial resolution.

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[5] https://dataspace.copernicus.eu/explore-data/data-collections/copernicus-contributing-missions/collections-description/VHR-IMAGE-2018

[6] https://dataspace.copernicus.eu/explore-data/data-collections/copernicus-contributing-missions/collections-description/VHR-IMAGE-2021

- Other external datasets:

  o **Bing maps image**/ cartography layer

  o **Open Street Map** data

  o **Google Earth Image** / cartography data

  o **LUCAS** data for the year 2018 (where available)

  o **GSAA** data for the year 2018 and 2021 (where available)

The interpretation workflow consists of thematic plausibility analysis of a sample units. This means that the class assigned by the layer is known by the interpreter during the interpretation. Depending on the layer, the interpretation workflow can differ in ways described below.

Each point sample (Primary Sampling Unit) is interpreted for each layer using the reference and guiding data. The use of **Sentinel-2** time series allows to assess the "permanent" characteristic of the herbaceous coverage over the previous years. For the **Grassland (GRA)** status layer, the interpretation is focused on the reference pixel in which the point sample is allocated considering also the direct neighbourhood to account for the **MMU** of 0.03 ha. Similarly, the interpretation of a grassland change considers the wider spatial context (typically parcel level) to consider the MMU of 1 ha when evaluating the **Grassland Change (GRAC)** layer. No SSU is used for the interpretation of the samples with respect to grasslands.

8.4 Statistical Analysis

For the **HRL Grasslands** product the thematic accuracy levels are defined in terms of **Overall Accuracy, Producer's Accuracy** and **User's Accuracy** are computed as well and provided for information.

- The **Overall Accuracy (OA)** or **Recognition Rate (Rr)** is measured by the sum of the diagonal of the Confusion Matrix divided by the total number of controlled points: $OA \operatorname{or} R_r = \dfrac{\sum\limits_{\alpha=i}^{m} \left(\alpha\,\alpha \right)}{T}$.

  The Overall Accuracy assesses the overall agreement between classified and reference data sets. However, for single class themes, it does not necessarily provide a realistic assessment of the quality of the map produced because there can be substantial unbalance between omission and commission errors.

- The row and column totals and the diagonal of the Matrix are used to assess two further types of accuracy, the User's and Producer's Accuracy:

  o **Producer's Accuracy (PA)** for a given class = αα/Cα, representing an (inversely proportional) measure of Omission Error. For instance, an observation has been identified as tree-covered in the validation dataset but was actually classified as another class: it has been omitted from the target class.

  o **User's Accuracy (UA)** for a given class $\alpha\,\alpha / R\alpha$, representing an (inversely proportional) measure of the Commission Error (or contamination risk), i.e. errors due to the wrong

allocation of an observation (i.e. mapped landcover) to a landcover class. For instance, an observation is classified as broadleaved tree cover but identified as belonging to another class during the validation process: this observation has contaminated another class.

As mentioned in , unequal sampling intensity resulting from the stratified systematic sampling approach for change layers will be accounted for by applying a weight factor ((p)) to each Sample Unit, based on the ratio between the number of samples and the size of the stratum considered:

$$\hat{p}_{ij} = \left(\frac{1}{N}\right) \sum_{x \in (i,j)} \frac{1}{\pi_{uh}^*}$$

Where i and j are the columns and rows in the matrix, N is the total number of possible units (population) and π is the sampling intensity for a given stratum.

This is because the samples from the smaller strata (i.e. change layers) show a higher sampling intensity than those from the larger strata (i.e. status layers). Therefore, a correction for the sampling intensity will be applied to the error matrices produced following the procedure described by [3] and applied by [4], leading to a weighting factor inversely proportional to the inclusion probability of samples from a given stratum. Not applying this correction could result in underestimating or overestimating map accuracies. On the following sections, **confusion matrices will be presented in both weighted and unweighted version.** While the weighted versions provide statistically corrected results for accuracy figures, the application of weights make the matrix cells number difficult to read: the cells contain the number of validation samples for each category with their respective weights applied. The unweighted matrices, on the other hand, present accuracy figures that are less accurate (as the over-representation of change samples is not corrected), but the matrix cells contain number of samples for each category without their weights applied, making it far easier to understand how many validation samples falls into each category.

8.5 Verification Results

The **HRL Grasslands** status layers for the reference years 2018 and 2021 should reach an overall accuracy of 85%. Figures derived from this verification exercise show that this target is largely exceeded, where overall accuracies are always above 95%, reflecting the high level of quality of the **Grassland (GRA)** status layer, both at **EU27** (Table 8-2) and **EEA38** (Table 8-3) level. The same applies for the **Grassland Change (GRAC)** layer which exceed the **Overall Accuracy** of 80% for both the EU27 and the EEA38 (Table 8-4).

Table 8-2: GRA validation results at EU27 Level

GRA18 - EU27 (Weighted)

Product	Ref. 0	Ref. 1	Total	User Acc.	CI95%
0	5425.442	60.025	5485.467	98.9%	0.21%
1	39.049	1185.702	1224.751	96.8%	0.35%
Total	5464.490	1245.728	6710.218		
Prod. Acc.	99.3%	95.1%			
CI95%	0.17%	0.36%			

Overall Accuracy: 98.52%

GRA18 - EU27 (Unweighted)

Product	Ref. 0	Ref. 1	Total	User Acc.	CI95%
0	7235	67	7302	99.1%	0.19%
1	52	2350	2402	97.8%	0.29%
Total	7287	2417	9704		
Prod. Acc.	99.3%	97.2%			
CI95%	0.17%	0.27%			

Overall Accuracy: 98.77%

GRA21 - EU27 (Weighted)

Product	Ref. 0	Ref. 1	Total	User Acc.	CI95%
0	5457.654	61.040	5518.694	98.9%	0.21%
1	34.036	1157.488	1191.525	97.1%	0.33%
Total	5491.690	1218.528	6710.218		
Prod. Acc.	99.4%	95.0%			
CI95%	0.16%	0.36%			

Overall Accuracy: 98.58%

GRA21 - EU27 (Unweighted)

Product	Ref. 0	Ref. 1	Total	User Acc.	CI95%
0	8215	70	8285	99.2%	0.18%
1	46	1373	1419	96.8%	0.35%
Total	8261	1443	9704		
Prod. Acc.	99.4%	95.1%			
CI95%	0.15%	0.36%			

Overall Accuracy: 98.80%

Table 8-3: GRA validation results at EEA38 Level

GRA18 - EU38 (Weighted)

Product	Ref. 0	Ref. 1	Total	User Acc.	CI95%
0	7840.101	105.291	7945.392	98.7%	0.19%
1	170.154	1654.325	1824.479	90.7%	0.49%
Total	8010.254	1759.616	9769.870		
Prod. Acc.	97.9%	94.0%			
CI95%	0.24%	0.40%			

Overall Accuracy: 97.18%

GRA18 - EU38 (Unweighted)

Product	Ref. 0	Ref. 1	Total	User Acc.	CI95%
0	10228	219	10447	97.9%	0.24%
1	225	3070	3295	93.2%	0.42%
Total	10453	3289	13742		
Prod. Acc.	97.8%	93.3%			
CI95%	0.24%	0.42%			

Overall Accuracy: 96.77%

GRA21 - EU38 (Weighted)

Product	Ref. 0	Ref. 1	Total	User Acc.	CI95%
0	7873.779	107.153	7980.932	98.7%	0.19%
1	165.138	1623.801	1788.938	90.8%	0.48%
Total	8038.917	1730.953	9769.870		
Prod. Acc.	97.9%	93.8%			
CI95%	0.24%	0.40%			

Overall Accuracy: 97.21%

GRA21 - EU38 (Unweighted)

Product	Ref. 0	Ref. 1	Total	User Acc.	CI95%
0	11398	160	11558	98.6%	0.20%
1	218	1966	2184	90.0%	0.50%
Total	11616	2126	13742		
Prod. Acc.	98.1%	92.5%			
CI95%	0.23%	0.44%			

Overall Accuracy: 97.25%

Table 8-4: GRAC validation results for EU27 and EEA38

GRAC1821 - EU27 (Weighted)

Product	Stable	New GRA	Loss of GRA	Total	User Acc.	CI95%
Stable	6647.69	13.03	30.18	6690.90	99.4%	0.17%
New GRA	0.03	0.42		0.45	92.8%	1.61%
Loss of GRA	8.39		10.47	18.87	55.5%	3.08%
Total	6656.12	13.45	40.65	6710.22		
Prod. Acc.	99.9%	3.1%	25.8%			
CI95%	0.07%	1.08%	2.71%			

Overall Accuracy: 99.23%

GRAC1821 - EU27 (Unweighted)

Product	Stable	New GRA	Loss of GRA	Total	User Acc.	CI95%
Stable	8111	17	57	8185	99.1%	0.20%
New GRA	15	192		207	92.8%	1.61%
Loss of GRA	186		1126	1312	85.8%	2.16%
Total	8312	209	1183	9704		
Prod. Acc.	97.6%	91.9%	95.2%			
CI95%	0.32%	1.69%	1.33%			

Overall Accuracy: 97.17%

GRAC1821 - EU38 (Weighted)

Product	Stable	New GRA	Loss of GRA	Total	User Acc.	CI95%
Stable	9696.12	16.03	33.18	9745.32	99.5%	0.13%
New GRA	2.36	0.50	0.00	2.86	17.5%	1.67%
Loss of GRA	9.57		12.12	21.69	55.9%	2.18%
Total	9708.04	16.53	45.30	9769.87		
Prod. Acc.	99.9%	3.0%	26.8%			
CI95%	0.06%	0.75%	1.94%			

Overall Accuracy: 99.37%

GRAC1821 - EU38 (Unweighted)

Product	Stable	New GRA	Loss of GRA	Total	User Acc.	CI95%
Stable	11642	21	60	11723	99.3%	0.15%
New GRA	148	225	1	374	60.2%	2.15%
Loss of GRA	256		1389	1645	84.4%	1.59%
Total	12046	246	1450	13742		
Prod. Acc.	96.6%	91.5%	95.8%			
CI95%	0.33%	1.22%	0.88%			

Overall Accuracy: 96.46%

9. Terms of use and product technical support

9.1 Terms of use

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Product technical support is provided by the product custodian through Copernicus Land Monitoring Service – Service desk. Product technical support does not include software specific user support or general GIS or remote sensing support.

More information on the products can be found on the Copernicus Land Monitoring Service website (https://land.copernicus.eu/).

10. List of Abbreviations & Acronyms

Abbreviation	Name
ATBD	Algorithm Theoretical Basis Document
BVL	Base Vegetation Layer
CAP	Common Agricultural Policy

Abbreviation	Name
CL	Confidence Layer
CLC	CORINE Land Cover
CLMS	Copernicus Land Monitoring Service
CLS	Collecte Localisation Satellites
COG	Cloud-Optimized GeoTIFFs
CORINE	Coordination of information on the environment
DOY	Day Of Year
EAGLE	EIONET Action Group on Land monitoring in Europe
ECoLaSS	Evolution of Copernicus Land Services based on Sentinel Data
EEA	European Environment Agency
EEA38	The 32 member and 6 cooperating countries of the EEA
EIONET	European Environment Information and Observation Network
EO	Earth Observation
EU	European Union
EU27	The 27 member states of the EU
GIS	Geographic Information System
GRA	Grassland Status Layer
GRAC	Grassland Change Layer
GRACCL	Grassland Change Confidence Layer
GRACL	Grassland Confidence Layer
GRAM	Grassland Mowing
GRAMD	Grassland Mowing Dates
GRAME	Grassland Mowing Events
GRAMECL	Grassland Mowing Events Confidence Layer
GSAA	GeoSpatial Aid Application
H2020	Horizon2020
HER	Herbaceous Cover Layer
HR	High Resolution
HRL / HRLs	High Resolution Layer / High Resolution Layers
HRL VLCC	High Resolution Layer – Vegetated Land Cover Characteristics
ID	Identification Number
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
LAEA	Lambert Azimuthal Equal Area projection
LC	Land Cover
LU	Land Use
LUCAS	Land Use / Cover Area frame Survey
LULUCF	Land Use, Land Use Change and Forestry
MMU	Minimum Mapping Unit
NDVI	Normalized Difference Vegetation Index

Abbreviation	Name
NVLCC	Non-Vegetated Land Cover Characteristics
OA	Overall Accuracy
PA	Producer Accuracy
PAM	Permanent Auxiliary metadata
PLOUGH	Ploughing Indicator
Rr	Recognition Rate
SSU	Secondary Samples Units
UA	User's Accuracy
UK	United Kingdom
UTM	Universal Transverse Mercator
VHR	Very High Resolution
VITO	Vlaamse Instelling voor Technologisch Onderzoek
XML	Extensible Markup Language

11. References

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[7] CLMS Vegetated HRL ATBD (2024). HRL Algorithm Technical Basis Document

[8] CLMS HRL Grassland 2015 (2017). HRL Grassland 2015 Product Specifications

12. Annex I – Colour tables for HRL Grasslands

Table 0-1: Colour palette and attributes of GRA layer

Class Code	Class Name	Red	Green	Blue	
0	all non-grass areas	240	240	240	
1	grassland	163	199	56	
255	outside area	0	0	0	

Table 0-2: Colour palette and attributes of HER layer

Class Code	Class Name	Red	Green	Blue	
0	non-grassland in reference year	240	240	240	
1	permanent and temporary grassland in reference year	116	151	11	
255	outside area	0	0	0	
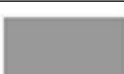
Table 0-3: Colour palette and attributes of PLOUGH layer

Class Code	Class Name	Red	Green	Blue	
0	Indication of ploughing in current year	66	0	0	
1	1 year since last indication of ploughing	128	0	0	
2	2 years since last indication of ploughing	199	60	18	
3	3 years since last indication of ploughing	230	107	37	
4	4 years since last indication of ploughing	247	153	59	
5	5 years since last indication of ploughing	252	201	91	
6	6 years since last indication of ploughing	255	236	140	
100	Change of herbaceous cover	229	251	17	
253	no ploughing information	240	240	240	
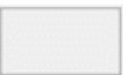
Class Code	Class Name	Red	Green	Blue	
255	outside area	0	0	0	
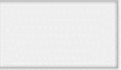
Table 0-4: Colour palette and attributes of GRAC layer

Class Code	Class Name	Red	Green	Blue	
0	unchanged non-grassland in both years	240	240	240	
1	grassland gain	0	141	246	
2	grassland loss	255	0	0	
10	unchanged grassland in both years	163	199	56	
254	unclassifiable in any of parent status layers	153	153	153	
255	outside area	0	0	0	
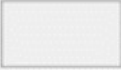
Table 0-5: Colour palette and attributes of GRACL layer

Class Code	Class Name	Red	Green	Blue	
0	0% grassland confidence	194	82	60	
1-49	1-49% grassland confidence	colour shades in between	colour shades in between	colour shades in between	colour shades in between
50	50% grassland confidence	123	237	0	
51-99	51-99% grassland confidence	colour shades in between	colour shades in between	colour shades in between	colour shades in between
100	100% grassland confidence	12	47	122	
253	all non-grassland areas	240	240	240	
255	outside area	0	0	0	
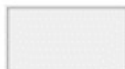
Table 0-6: Colour palette and attributes of GRACCL layer

Class Code	Class Name	Red	Green	Blue	
0	0% grassland change confidence	194	82	60	
1-49	1-49% grassland change confidence	colour shades in between	colour shades in between	colour shades in between	colour shades in between
50	50% grassland change confidence	123	237	0	
51-99	51-99% grassland change confidence	colour shades in between	colour shades in between	colour shades in between	colour shades in between
100	100% grassland change confidence	12	47	122	
253	all non-grassland change areas	240	240	240	
255	outside area	0	0	0	
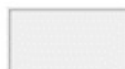
Table 0-7: Colour palette and attributes of GRAMECL layer

Class Code	Class Name	Red	Green	Blue	
0	0% grassland mowing confidence	194	82	60	
1-49	1-49% grassland mowing confidence	colour shades in between	colour shades in between	colour shades in between	colour shades in between
50	50% grassland mowing confidence	123	237	0	
51-99	51-99% grassland mowing confidence	colour shades in between	colour shades in between	colour shades in between	colour shades in between
100	100% grassland mowing confidence	12	47	122	
253	All non-mowing areas	240	240	240	
255	outside area	0	0	0	

Table 0-8: Colour palette and attributes of GRAME layer

Class Code	Class Name	Red	Green	Blue	
0	all non-mowing areas	240	240	240	
1	all grassland areas that have been mowed once	237	248	251	
2	all grassland areas that have been mowed twice	178	226	226	
3	all grassland areas that have been mowed three times	102	194	164	
4+	all grassland areas that have been mowed four times or more times	35	139	69	
253	all non-herbaceous areas	240	240	240	
255	outside area	0	0	0	

Table 0-9: Colour palette and attributes of GRAMD layer

Class Code	Class Name	Red	Green	Blue	
0	no mowing detected	240	240	240	
1	01.01.YYYY mowing date	255	237	195	
2-181	02.01.YYYY - 30.06.YYYY mowing date	colour shades in between	colour shades in between	colour shades in between	colour shades in between
182	01.07.YYYY mowing date	175	74	51	
183-364	02.07.YYYY - 30.12.YYYY mowing date	colour shades in between	colour shades in between	colour shades in between	colour shades in between
366	31.12.YYYY mowing date	113	12	2	
65533	all non-herbaceous areas	240	240	240	

Class Code	Class Name	Red	Green	Blue	
65535	outside area	0	0	0	■

13. Document History:

Record of changes made to the document over time after the initial published version, including version numbers, dates of revisions, and a summary of modifications. This table must be only included in the initial PUM published version and without the personal information ("Created by:" filed must be removed).

Version	Date	Short description of changes
1.0	2025-03-28	Initial published issue