Evoland
LAND MONITORING EVOLUTION

D1.4 EO and In-Situ Data Requirements Report – Final Version

Work Package 1 – Requirements Analysis

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Date: 13.11.2024

Funded by the European Union

Full Title	**Evolution of the Copernicus Land Service portfolio** (integrating novel EO data and latest machine learning algorithms to continuously monitor the status, dynamics and biomass of the land surface)			
Project number	101082130		**Acronym**	EVOLAND
Start date	01.01.2023		**Duration**	36 months
Granting authority	European Health and Digital Executive Agency (HaDEA)			
Project Coordinator	Vlaamse Instelling voor Technologisch Onderzoek N.V. (VITO)			
Date of delivery	**Contractual**	M22	**Actual**	M22
Type	R - Document, report		**Dissemination level**	SEN - Sensitive
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Keywords	EO & in situ data, data requirements, specifications and sources			

Document Revision History				
Version	**Issue date**	**Stage**	**Changes**	**Contributor**
0.1	31.08.2023	Draft	Populating template interim version	GAF
0.2	29.10.2024	Draft	Update to final version	GAF
1.0	13.11.2024	Final	Review and finalization of final version	GAF, VITO

Acronyms

Acronym	Description
ARD	Analysis Ready Data
BB	(CORINE Land Cover Plus) Backbone
CLC	CORINE Land Cover
CLCplus	CORINE Land Cover Plus (second generation CLC)
CLMS	Copernicus Land Monitoring Service
CO3D	Optical Constellation in Three Dimensions
DEM	Digital Elevation Model
DL	Deep Learning
EARSC	European Association of Remote Sensing Companies
ECMWF	European Centre for Medium-Range Weather Forecasts
ECOSTRESS	ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station
EFFIS	European Forest Fire Information System
ENMAP	Environmental Mapping and Analysis Program
EO	Earth Observation
ESA	European Space Agency
FNEWs	Remote sensing-based national recording system for forest damage (Fernerkundungsbasiertes Nationales Erfassungssystem für Waldschäden)
GCP	Ground Control Point
GEDI	Global Ecosystem Dynamics Investigation
GPP	Gross primary production
GSD	Ground Sampling Distance
HRLs	High Resolution Layers
ICESat-2	Ice, Cloud and Land Elevation Satellite
IMD	Imperviousness Density
ISS	International Space Station
LC	Land Cover
LIDAR	Light Detection and Ranging
LPIS	Land Parcel Identification System
LU	Land Use
LUCAS	Land use/cover area frame statistical survey
LWIR	Cryocooled long-wave infrared
MEA	maximum eligible area
MITECO	Ministry for the Ecological Transition and the Demographic Challenge
NASA	National Aeronautics and Space Administration
NFI	National Forest Inventory
NIR	Near-Infra Red
NISAR	NASA-ISRO Synthetic Aperture Radar
OLCI	Ocean and Land Colour Instrument
OSM	Open Street Map
PALSAR	Advanced Land Observing Satellite
SAR	Synthetic aperture radar

SLSTR	Sea and Land Surface Temperature Radiometer
SLU	Swedish National Forest inventory
SMI	Surface Soil Moisture Index
SPOT	Satellite Pour l'Observation de la Terre
SRAL	Synthetic Aperture Radar Altimeter
SWF	Small Woody Features
SWOT	Surface Water and Ocean Topography
TCD	Tree Cover Density
TRISHNA	Thermal InfraRed Imaging Satellite for High-resolution Natural resource Assessment
USGS	United States Geological Survey
VHR	Very High Resolution
VLCC	Vegetated Land Cover Characteristics
VNIR	Visible and near-infrared

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Applicable documents

ID	Applicable Document
[AD1]	D1.1 Service requirements report - interim version
[AD2]	D2.1 EO missions catalogue relevant for EvoLand - interim version
[AD3]	D2.3 Novel EO Datasets over EvoLand study sites - interim version
[AD4]	D2.8 Existing and novel in-situ and training datasets - interim version 2
[AD5]	D1.3 EO and in-situ data requirements report - interim version
[AD6]	D2.16 Methods Compendium – Interim Version
[AD7]	D3.1 EvoLand Prototypes Report - Interim version

List of methods development Tasks in EvoLand

Task 2.4 Weakly Supervised Learning

Task 2.5 Improved Spatial, Temporal, Spectral Resolution

Task 2.6 Continuous Monitoring and Change Detection

Task 2.7 Biomass Mapping

List of candidate prototypes in EvoLand

C1: Continuous Forest Monitoring (continuous/monthly, 10m)

C2: Forest Disturbances Mapping (continuous/monthly, 10m)

C3: Forest Biomass Mapping (yearly, 10m)

C4: Cover Crop Type Mapping (yearly, 10m)

C5: Cropland/Grassland GPP Monitoring (continuous/10-daily, 10m)

C6: Small Landscape Features (yearly, 2.5m)

C7: Improved Water Bodies Mapping (2 dates per year; phase 2: towards continuous/monthly, 10m)

C8: Continuous Imperviousness Monitoring (every 6 months; phase 2: continuous/monthly, 5m)

C9: Automated Land Use Mapping of Urban Dynamics (yearly, 10m)

C10: Continuous Mapping of Land Surface Categories (continuous: monthly to single scene, 10m)

C11: On-demand Land Cover Mapping (on demand)

Executive Summary

This report *D1.4 – EO and in-situ data requirements report - final version* is part of the first work package WP1 of the EvoLand project, which aims at providing general requirement analyses targeting prototypes for future new or improved Copernicus Land Monitoring Services (CLMS) products (developed in WP3), including the methods to produce them (developed in WP2). The leading question of this report D1.4, that focuses on requirements of EO- and in-situ data, has several aspects:

- Which kind of data are required for developing suitable methods in EvoLand to fulfil the thematic and technical specifications of the candidates?
- Which kind of data are required for the implementation and the validation of the candidate prototypes?
- Which kind of data would be required for a future upscaling of the candidates to pan-European or global perspectives and for being fully operational services?

The data inventory at hand contains a list of (i) already proven data sources for CLMS service implementation, of (ii) further data where the suitability for use for method development as well as prototype implementation and validation is assessed, and of (iii) upcoming missions and data sources which can only be assessed based on the current experiences or could be tested in phase 2 of the project if data would still become available on time (which in most cases will not be possible due to delays of the mission).

The inventory of data sources listed in Chapter 3 of this report consists of tables per data source listing platform and sensor characteristics, information on data distribution, as well as the current and potential future use of these for data to be fed into upcoming CLMS products. The use of the respective data source in the frame of the project is stated, as well as potential future use for operational services.

It represents the status at month 22 of the project and gives a picture of required data sources for the different tasks in EvoLand and for a “beyond project”-perspective. This report complements information on novel data sources elaborated in tasks *2.1 Novel EO Data Integration* and *2.2. Novel In-Situ and Training Data* and the respective reports, which will be updated by month 26 of the project.

While the list of EO-data sources is already quite comprehensive and promising – answering the needs of development and implementation as well as future perspectives – the availability of suitable in-situ data still shows gaps.

1 Introduction

1.1 About the project

EvoLand is a Horizon Europe project that will develop, test and roll out 11 innovative candidate prototypes in the key thematic domains of agriculture, forest, water, urban, and general land cover to shape the evolution of the Copernicus Land Monitoring Service (CLMS). The aim is to integrate novel Earth Observation and in-situ data and the latest Machine Learning techniques to continuously monitor the status, dynamics and biomass of the land surface.

The approach of this R&D project is characterized by a strong interlink between several work packages within this project to ensure that user needs, thematic specifications and the respective technical requirements are met to produce innovative candidate prototypes (see Figure 1).

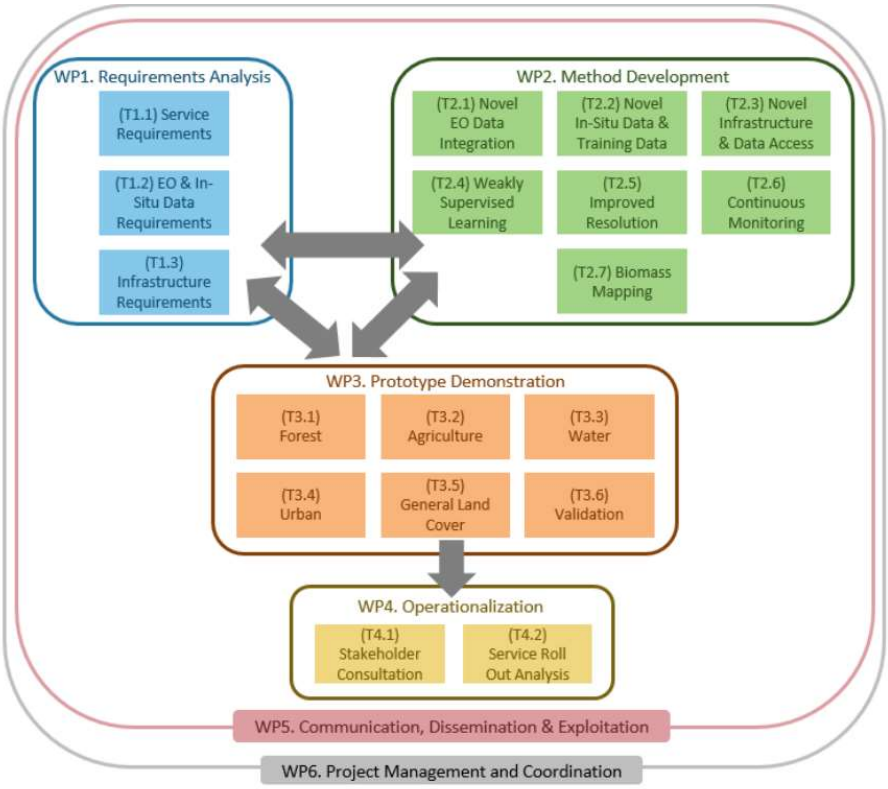

Figure 1. WP1 and its connections to the other WPs within EvoLand.

Thus, tasks within WP1 have an important role with their dedicated requirement analysis (WP1) of user and stakeholder needs and of the necessary prerequisites for a successful realisation of the envisaged candidate prototypes in order to meet the user needs. It is the thematic and technical basis for the development and testing

of new methodologies in WP2 as well as for the implementation of the candidate prototypes in WP3 under varying conditions (such as biogeographic regions, data availability and data suitability), in order to assess their potential for future upscaling and roll-out and hence their potential as operational future CLMS services. WPs 4 and 5 ensure the re-link to the users' and stakeholders' needs and the suitability of the operational feasibility for a roll-out scenario in a pan-European or global context. The links between the WPs are meant as constantly iterative loops to check during every step of the project that the requirements are met and that they are still in line with the results of the following WPs.

In the first project phase of Work Package 2 several methods have been developed [AD6], which are now refined, re-evaluated and extended in project phase 2 with delivery in Month 27. These methods are grouped within four different tasks:

- Task 2.4 Weakly Supervised Learning
- Task 2.5 Improved Spatial, Temporal, Spectral Resolution
- Task 2.6 Continuous Monitoring and Change Detection
- Task 2.7 Biomass Mapping

Eleven EvoLand prototypes have been developed as part of Work Package 3 in the first project phase, covering the topics around forest, agriculture, water, urban and general land cover [AD7]. The second round of prototypes will be updated until Month 33.

- C1: Continuous Forest Monitoring (continuous/monthly, 10m)
- C2: Forest Disturbances Mapping (continuous/monthly, 10m)
- C3: Forest Biomass Mapping (yearly, 10m)
- C4: Cover Crop Type Mapping (yearly, 10m)
- C5: Cropland/Grassland GPP Monitoring (continuous/10-daily, 10m)
- C6: Small Landscape Features (yearly, 2.5m)
- C7: Improved Water Bodies Mapping (2 dates per year; phase 2: towards continuous/monthly, 10m)
- C8: Continuous Imperviousness Monitoring (every 6 months; phase 2: continuous/monthly, 5m)
- C9: Automated Land Use Mapping of Urban Dynamics (yearly, 10m)
- C10: Continuous Mapping of Land Surface Categories (continuous: monthly to single scene, 10m)
- C11: On-demand Land Cover Mapping (on demand)

1.2 About this document

As part of WP1 this is the final version of the *EO and in-situ data requirements report (D1.4),* which documents the activities undertaken in EvoLand *Task 1.2 EO & In-situ Data Requirements*. It provides an update to the *EO and in-situ data requirements report - interim version (D1.3) that was delivered at Month 8 of the projects*.

It aims at providing a comprehensive inventory of all EO and in-situ data needed (i) for the development of new methods [AD6], the following implementation and validation of the candidate prototypes [AD7] and (ii) of those data sources that would be suitable for a later roll-out and upscaling, respectively fully operational services. In that sense this report reflects the user's perspectives whereas the actual selection of specific datasets, and how they are integrated in the methodology from a producer's/provider's point of view, are further elaborated in tasks *2.1 Novel EO Data Integration* and *2.2. Novel In-Situ and Training Data* and the respective reports (*D2.1 EO missions catalogue relevant for EvoLand* – interim version [AD2]. *D2.3 Novel EO Datasets over EvoLand study sites - interim version* [AD3] and *D2.8 Existing and novel in-situ and training datasets – interim version 2* [AD4]*), as well as the deliverables containing the Methods Compendium* [AD6] *and the Prototypes Report* [AD7].

Whereas for the comprehensive inventory of all EO and in-situ data there are rather minor updates from the previous version of this report [AD5], the use in the EvoLand project reflects the method and prototype development in project phase 1, and additional aspects for future projections towards project phase 2 and possible operational CLMS products.

Although some data sources are crucial for applying the methods and carrying out the production of the prototypes, others are alternative data sources that have less impact on the development/implementation – or which might be available as alternate only in the future. The necessary information about the actual role in EvoLand will be given in the following chapters. The list of datasets was established in cooperation with project partners VITO, CESBIO, DLR, UT3, JR and CLS.

The document is structured as follows:

- Section 1 introduces the EvoLand project and the document
- Section 2 describes the relevance of EO- and in-situ data and the approach for collecting the EO- and in-situ data requirements in the frame of T1.2
- Section 3, 4, 5 contain the inventory of relevant EO- and in-situ datasets for EvoLand. It is divided into EO-data, EO-derived parameters and in-situ/ancillary data.
- Section 6 places particular emphasis on both the established and newly identified strengths and weaknesses of the listed datasets within the EvoLand context.
- Section 7 sums up the assessment and gives an outlook on the further use in EvoLand and beyond.

2 EO- and in-situ data requirements

2.1 Relevance of EO- and in-situ data in CLMS

Since its initiation in 1998 (Baveno Manifesto[1]) the Copernicus programme and the related Land Monitoring Services developed into a reliable data source for manifold users and uses for scientific, administrative or private usage at national, subnational as well as on international level. The growing user community and the demand for extending services, concerning thematic range as well as information depth within the services, led to a high variety of products and a constantly increasing complexity in these products. Orientation towards user needs is one of the key principles of the Copernicus programme and its related services. The availability of suitable and high-quality data for all steps throughout the production of a service is of utmost importance for getting highly accurate and reliable products. The Copernicus programme and the contributing missions offer a high-quality basis which is free of charge and covers a huge part of the data needs.

Beyond that, the market of EO and data has quickly evolved during the last decade. Recent and new data sources offer options for new products (such as forest disturbances, biomass. cover crop types, tree species, or land surface categories) and are able to feed innovative methodologies. In the frame of EvoLand latest generation and possibly already available novel data sources are planned to be tested for their potential to contribute to the improvement of the phase 2 prototypes in terms of accuracy and technical and thematic specifications, while still guaranteeing continuity and consistency with already existing products. However, future missions with identified potential for CLMS service developments are largely not yet available to be included into EvoLand developments, due to delays with the mission and launch of the satellites. Further future data sources are part of the data collection if they show potential as alternative or complementary data sources beyond the project, when it comes to scaled up operational services for the future CLMS portfolio.

2.2 Approach for EO- and in-situ data collection in EvoLand

To establish a comprehensive inventory of all data sources that could support the EvoLand candidate prototypes, an iterative approach was employed. First, a list of

[1] https://www.copernicus.eu/en/news/news/observer-looking-back-25-years-copernicus-milestones-key-moments

those EO, in-situ and ancillary data plus EO derived parameters was compiled. Some have been proven useful for existing services, complemented by those that could have potential to specific thematic domains. Currently available documentation of data sources like for the Sentinel fleet as well as official documents from involved entities (e.g. the position paper EARSC on modernisation strategy of Copernicus[2]) were carefully reviewed. Several iterations within the consortium helped to extend and consolidate this list. The EvoLand consortium partners which are highly experienced in the handling, provision and use of EO and other data since many years, brought together their knowledge about the datasets.

Leading questions have been:

- Which data sources would be needed for the method development in EvoLand?
- Which data sources would be needed to meet the user requirements?
- Which data sources would be needed for implementation and validation of the candidate prototypes?
- Which alternative data sources could be utilized?
- which upcoming satellite missions and data sources could be of use at a later stage of the project?
- Which data sources would be needed for a future operational service in a pan-European/global perspective?

Focus has been given to the specific needs of the methods to be developed. It is indicated at the beginning of the tables of Chapters 3 and 5 whether the following data sources could be of high interest for either Task 2.4 Weakly Supervised Learning, Task 2.5 Improved Spatial, Temporal, Spectral Resolution, Task 2.6 Continuous Monitoring and Change Detection or Task 2.7 Biomass Mapping.

Same accounts for the candidate prototypes, it is indicated which candidates on the basis of current knowledge (i.e., phase 1 outcomes and plans for phase 2) and assumptions (related to future operational services) would benefit most from the following data source. The candidates follow the specifications given in the proposal complemented by user needs from D1.1 [AD1].

[2] https://earsc.org/wp-content/uploads/2022/09/20220901_Copernicus-Evolution-Position-paper.pdf

3 Inventory of relevant EO data

The following chapters provide an overview of all potentially relevant data that can be named at the current project state with their specific characteristics and their use in EvoLand phase 1, and potential or planned use in phase 2. EO data, EO derived parameters and in-situ-/ancillary data are described separately in dedicated chapters. Both, currently available data and future data sources are listed, even if the data can actually not yet be integrated in the methodology due to the mission's launch data still being in the future or the data not yet available. They are still part of the list to provide an idea for potential future applications. Many of the data listed below are already used for the current CLMS productions, whereas others will be evaluated in the frame of EvoLand phase 2.

3.1 Sentinel missions

The main data source for the production of current and future CLMS products are without doubt two missions of the Sentinel fleet, namely **Sentinel-2** (see Table 2) and **Sentinel-1** (see Table 1). Especially the optical S-2 data plays a major role for almost all the services of the (current) portfolio, e.g. the HRLs 2018, the HRLs VLCC and NVLCC (currently under production), CLCplus, etc. For some of the existing products as well as some of the prototypes created within the frame of EvoLand also S-1 is essential or can bring added value when it comes to improvement of the accuracies or comparable parameters. To a smaller extent also **Sentinel-3** data (see Table 3) was reviewed and concluded to be not of prime target due to the low spatial resolution, but a possible extension of minor importance beyond EvoLand (e.g. for tasks like *Task 2.5 Improved Spatial/Temporal/Spectral Resolution)*.

Sentinel-1

Used for EvoLand Methods:

- Task 2.6 Continuous Monitoring and Change Detection
- Task 2.7 Biomass Mapping

Potentially useful for EvoLand Methods:

- Task 2.4 Weakly Supervised Learning

Used for EvoLand Candidates:

- C1: Continuous Forest Monitoring (for comparative purposes)
- C3: Biomass Mapping C11: On-demand Land Cover Mapping (on demand)

Potentially useful for EvoLand Candidates:

- C4: Cover Crop Type Mapping
- C8: Continuous Imperviousness Monitoring
- C10: Continuous Mapping of Land Surface Categories

Table 1. Sensor characteristics of satellites from the Sentinel-1 constellation.

Platform	
Name	Sentinel-1
Operational Status	S-1A operational, S-1C to be launched (planned Dec 2024)
Launch Date	S-1A: 03/04/2014
Life Expectancy	Min. 7 years with consumables for 12 years
Coverage	Full
Sensor	
Name	C-Band Synthetic Aperture Radar (C-SAR) Instrument
Type	SAR HR2 - MR1
Spatial resolution	5x5m (Strip map/Wave mode) to 20x40m (Extra-wide swath mode)
Swath width	20x20km (Wave-mode) to 250km (Interferometric Wide Swath)
Revisit time at equator (days) with or without programming	6 from the two-satellite constellation, 175 orbits in 12 days
Data Distribution	
Provider	ESA
Cost	Free
Licensing restrictions	ESA - User License
Accessibility	Through the Copernicus Hub (more generally the CSCDA) and other mirror sites
Current role in CLMS	
Service(s)	All Copernicus Services: - Cop Ocean - Cop Land Monitoring - Cop Security and Climate Change - Cop Emergency Response
Usage/function	production
Relevance	Medium
Current issues/gaps	- S-1B failure 12/2021 - lack of Analysis Ready Data (ARD)
Alternative	depending on the needs in terms of method, product, timeliness
Potential future role in CLMS	
Service(s)	- Monitoring the sea ice zones and the arctic environment - Monitoring land surface motion risks - Mapping of land surfaces and land use, such as forest, water, soil and agriculture - providing estimation of crop acreage, soil moisture information and forecast yields – making S-1 a valuable complement to the S-2 mission - Mapping support during humanitarian crises
Usage/function	production
Relevance	Medium
Potential issues/gaps	- gaps in imagery provision due to failure of S-1B - insufficient accuracy of geolocation in tropical regions (reported in S-America)
Alternative	pot. S-1C (to be launched end 2024)

Sentinel-2

Used for EvoLand Methods:

- Task 2.4 Weakly Supervised Learning methodology
- Task 2.5 Improved Spatial, Temporal, Spectral Resolution
- Task 2.6 Continuous Monitoring and Change Detection
  Task 2.7 Biomass Mapping

Used for EvoLand Candidates:

- all candidates (besides C6): C1, C2, C3, C4, C5, C7, C8, C9, C10, C11

Table 2. Sensor characteristics of satellites from the Sentinel-2 constellation.

Platform	
Name	Sentinel-2
Operational Status	S-2A/B/C operational, S-2D to be produced
Launch Date	S-2A: 03/04/2014, S-2B: 25/04/2016, S-2C: 05/09/2024
Life Expectancy	Min. 7 years with consumables for 12 years
Coverage	All continental land surfaces between latitudes 56° S and 82.8° N
Sensor	
Name	Multi-spectral Instrument
Type	Optical HR2
Spatial resolution	10-60m
Number of bands	13
Swath width	290 km
Revisit time at equator (days) with or without programming	5 from the two-satellite constellation, 2-3 in mid-latitudes (S-2C is not yet operational)
Data Distribution	
Provider	ESA
Cost	Free
Licensing restrictions	ESA - User License
Accessibility	Through the Copernicus Hub (more generally the CSCDA) and other mirror sites
Current role in CLMS	
Service(s)	Main instrument for Land Monitoring and Copernicus Emergency Response
Usage/function	production
Relevance	High
Current issues/gaps	- Gaps due to cloud presence - Debatable quality of the cloud mask (Sen2Cor, IDEPIX) - room for improvement - Insufficient numbers of GCPs and TPs – if not improved - Change in the denomination made by the ESA since December 2016 - Only daylight images can be acquired, where the target surface has a sun zenith angle below a certain threshold (82 degree)
Alternative	NA
Potential future role in CLMS	
Service(s)	Main instrument for Copernicus Land and Security services: - Land cover and use, change detection - Geophysical variables production - Risk mapping

	- Primary images used for fast mapping during disaster
Usage/function	production
Relevance	High
Potential issues/gaps	- Gaps due to cloud presence - Debatable quality of the cloud mask (Sen2Cor, IDEPIX) - rooms for improvement - Insufficient numbers of GCPs and TPs – if not improved - Change in the denomination made by the ESA since December 2016 - Only daylight images can be acquired, where the target surface has a sun zenith angle below a certain threshold (82 degree)
Alternative	NA

Sentinel-3

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods:

- Task 2.5 Improved Spatial, Temporal, Spectral Resolution

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates: NA

Table 3. Sensor characteristics of satellites from the Sentinel-3 constellation.

Platform	
Name	Sentinel-3
Operational Status	Operational
Launch Date	Sentinel-3A: 16/02/2016 Sentinel-3B: 25/04/2018
Life Expectancy	Minimum of 7 years with consumables for 12 years
Coverage	Full
Sensor	
Name	OLCI, SRAL, SLSTR
Type	Optical MR2 - LR
Spatial resolution	300-1000 m
Number of bands	21 (nominal Earth View), 45 (spectral campaigns)
Swath width	1270 km
Revisit time at equator (days) with or without programming	27 days
Data Distribution	
Provider	ESA
Cost	Free
Licensing restrictions	ESA - User License
Accessibility	Through the Copernicus Hub (more generally the CSCDA) and other mirror sites
Current role in CLMS	
Service(s)	- Land monitoring, through the determination of land surface temperature (e.g. fire location and classification) - Land surface colour

	- Topographic data - Generation of vegetation products (biophysical index)
Usage/function	Additional/supporting data source
Relevance	Medium
Current issues/gaps	- OLCI operates during daylight, with a sun zenith angle of the sub-satellite point of less than 80 degree - SLSTR acquired data out of eclipse only in the visible channel. The IR and SWIR channels operate permanently
Alternative	NA
Potential future role in CLMS	
Service(s)	candidates using improved (super-)resolution methods
Usage/function	Additional/supporting data source
Relevance	Low
Potential issues/gaps	- No Surface reflectance - No ARD products - Low spatial resolution
Alternative	NA

3.2 Contributing missions

In addition to the Sentinel data some of the Copernicus Contributing Missions (CCM) play a relevant role in the context of EvoLand.

From the VHR to HR-1 missions, mainly **Pléiades** (see Table 4) are the main input data sources to the Agricultural candidate C6 on Small Landscape Features. Moreover, also **Pléiades Neo** (see Table 5), **PLANET** (Table 6) Satellite Pour l'Observation de la Terre - **SPOT 6/7** (see Table 7), **CO3D** (Table 8) and the **TanDEM-X** mission (see Table 9) – which were not used in EvoLand – are seen as data sources that could bring added value to future operational services based on the methods and the respective candidates developed in EvoLand (i.e. for C6 Small Landscape Features or potentially for urban or general land cover candidates). The future mission CO3D data would potentially be a valuable input for applications such as the agricultural candidate C6 (Small Landscape Features) and as well for applications in the urban context. As the commercial phase is only planned to start in mid 2027, this is unfortunately out of scope for the EvoLand project.

The HR-2 **Landsat 8/9** (see Table 10) missions are of interest regarding their potential to densify optical time series which could be useful for a number of prototypes and applications, as well as due to their thermal infrared channel.

From the *Task 2.7 Biomass Mapping* and Forest candidate C3 perspective, data from the spaceborne LiDAR mission Global Ecosystem Dynamics Investigation (**GEDI**) (see Table 11) are of utmost importance and one of the main datasets for input to the classification as well as for validation. Advanced Land Observing Satellite ALOS PALSAR-2 (see Table 12) also serves as input dataset providing L-band SAR data, and there is potential value in usage of the Ice, Cloud and Land Elevation Satellite - **ICESat-2** (see Table 13) laser altimeter data, which is however not planned to be tested in the context of the EvoLand project. The NASA-ISRO Synthetic Aperture Radar (**NISAR**) mission (see

Table 14) is seen as one of them most promising future sensor for biomass mapping (L-band SAR), as well as data from the BIOMASS mission (P-band SAR) (see Table 15). The **SWOT** mission data (Table 16), acquired by a SAR interferometric altimeter, show potential future relevance for water prototypes.

Other optical hyperspectral or thermal missions such as **EnMap** (Table 17) and the two new missions **OroraTech** (Table 18) and **ConstellR** (Table 19) have been partially used for testing purposes (EnMap) but are not included as input to the prototypes. Some of them, mainly ConstellR or the future mission **TRISHNA** (Table 20), show potential for future inclusion into agricultural, urban, forest or general land cover prototypes or methods described in Task 2.5 (Improved Spatial, Temporal, Spectral Resolution).

Future missions, such as CO3D, NISAR, BIOMASS or TRISHNA were considered promising at the beginning of the project. Due to delays with the missions and launch of the satellites these data are not yet operational and won't be available in time for the EvoLand project. However, since they could most likely be able to provide valuable input for future CLMS product developments, methods and applications, they remain listed in this chapter.

Pléiades

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C6: Small Landscape Features

Potentially useful for EvoLand Candidates: NA

Table 4. Sensor characteristics of satellites from the Pléiades constellation.

Platform	
Name	Pléiades 1A/1B
Operational Status	Operational mode: PHR-1A, PHR-1B until end of 2024
Launch Date	PHR-1A: 17/12/2011 PHR-1B: 02/12/2012
Life Expectancy	5 years by design but consumables have been sized for 7+ years; likely to be extended until end of 2026
Coverage	global
Sensor	
Name	Multi-spectral Instrument
Type	Optical
Spatial resolution (m)	0.5-2.8m
Number of bands	5
Swath width (km)	20 km
Revisit time at equator (days) with	1 with double-satellite constellation

or without programming	
Data Distribution	
Provider	CNES
Cost	DSP1
Licensing restrictions	Licence restrictions
Accessibility	Through DINAMIS service with restrictions nationalities
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Small landscape features mapping Urban Atlas Monitoring
Usage/function	Production
Relevance	High
Potential issues/gaps	NA
Alternative	NA

Pléiades-Neo

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates: NA

Table 5. Sensor characteristics of satellites from the Pléiades-Neo constellation.

Platform	
Name	Pléiades-Neo 3/4
Operational Status	Operational
Launch Date	PNEO3: 29/04/2021 PNEO4: 16/08/2021
Life Expectancy	10 years
Coverage	Global
Sensor	
Name	NA
Type	Optical
Spatial resolution (m)	30-120 cm
Number of bands	7
Swath width (km)	14 km
Revisit time at equator (days) with	1

or without programming	
Data Distribution	
Provider	AIRBUS Defence & Space
Cost	cost
Licensing restrictions	ADS user license
Accessibility	Through AirbusOneAtlas
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Small landscape features mapping Urban Atlas Monitoring
Usage/function	Production
Relevance	Medium
Potential issues/gaps	NA
Alternative	NA

PLANET

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates:

- C4: Cover Crop Type Mapping

Table 6. Sensor characteristics of the Planet mission.

Platform	
Name	Planet
Operational Status	Operational
Launch Date	2013-2018
Life Expectancy	2/3 years
Coverage	Global
Sensor	
Name	PSB.SD
Type	Optical
Spatial resolution (m)	8
Swath width (km)	20.6 km
Revisit time at equator (days) with	1

or without programming	
Data Distribution	
Provider	Planet labs
Cost	Cost
Licensing restrictions	NA
Accessibility	Planet data
Current role in CLMS	
Service(s)	Partially used
Usage/function	validation purposes (as part of VHR imagery)
Relevance	Medium
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Different services
Usage/function	validation
Relevance	Medium
Potential issues/gaps	Resolution
Alternative	Sentinel-2, further VHR

SPOT

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates: NA

Table 7. Sensor characteristics of satellites from the SPOT 6/7 constellation.

Platform	
Name	**S**atellite **P**our l'**O**bservation de la **T**erre - SPOT 6/7
Operational Status	Operational
Launch Date	SPOT 6: 09/09/2012 SPOT 7: 30/06/2014
Life Expectancy	10 years
Coverage	Global
Sensor	
Name	Multi-spectral Instrument
Type	Optical
Spatial resolution (m)	1.5-6 m
Number of bands	5
Swath width (km)	60 km
Revisit time at equator (days) with or without programming	1

Data Distribution	
Provider	AIRBUS Defence & Space
Cost	cost
Licensing restrictions	ADS user license
Accessibility	Through AirbusOneAtlas
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Small landscape features mapping Urban Atlas Monitoring
Usage/function	Production
Relevance	Low
Potential issues/gaps	NA
Alternative	NA

CO3D

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates: NA

Table 8. Sensor characteristics of the CO3D mission.

Platform	
Name	CO3D (Optical Constellation in Three Dimensions)
Operational Status	Not operational
Launch Date	2025 (commercial phase planned to start mid 2027)
Life Expectancy	6 years
Coverage	Global
Sensor	
Name	VIS + NIR (+ 3D products)
Type	NA
Spatial resolution (m)	0.5-1 m
Swath width (km)	One shot: 5km*7km One pass: 20Km*20Km
Revisit time at equator (days) with	1

or without programming	
Data Distribution	
Provider	AIRBUS Defence & Space
Cost	Cost
Licensing restrictions	ADS user license
Accessibility	NA
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Urban monitoring, small landscape features
Usage/function	Production
Relevance	Medium
Potential issues/gaps	Temporal revisit time, spatial resolution
Alternative	Pléiades

TanDEM-X

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates: NA

Table 9. Sensor characteristics of satellites from the TanDEM-X constellation.

Platform	
Name	TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurements)
Operational Status	Operational (extended)
Launch Date	Double-satellite constellation 21/06/2010, TerraSAR-X 15/06/2007
Life Expectancy	7 years
Coverage	Global land areas
Sensor	
Name	TerraSAR-X SAR Instrument
Type	X-Band SAR
Spatial resolution (m)	1-16 m
Swath width (km)	5-10 km x 10 km/30 km/100km

Revisit time at equator (days) with or without programming	11
Data Distribution	
Provider	DLR
Cost	12m & 30m DEM and CoSSC products: https://tandemx-science.dlr.de/pdfs/cofur_list_tdx_20110331.pdf, 90m DEM free of charge for scientific use
Licensing restrictions	https://tandemx-science.dlr.de/pdfs/TSX-TDX-user-license-v2.2.pdf
Accessibility	https://tandemx-science.dlr.de
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	for potential future forest biomass and forest canopy height services, it could be used for stratification urban candidates general LC
Usage/function	Production, calibration
Relevance	Low
Potential issues/gaps	NA
Alternative	none with reference to X-band SAR

Landsat

Used for EvoLand Methods:

- Task 2.5 Improved Spatial/Temporal/Spectral Resolution

Potentially useful for EvoLand Methods:

- Task 2.4 Weakly Supervised Learning

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates:

- C7: Improved Water Bodies Mapping

Table 10. Sensor characteristics of satellites from the Landsat 8/9 mission.

Platform	
Name	Landsat 8/9
Operational Status	Operational
Launch Date	Landsat 8: 2013 Landsat 9: 27/09/2021
Life Expectancy	Landsat 9: 5 years
Coverage	NA

Sensor	
Name	Operational Land Imager (OLI9, thermal Infrared Sensor (TIRS)
Type	Multi-spectral Instrument
Spatial resolution	15-100 m (HR2 – MR1)
Number of bands	11
Swath width	185
Revisit time at equator (days) with or without programming	16
Data Distribution	
Provider	NASA
Cost	Free
Licensing restrictions	None
Accessibility	https://earthexplorer.usgs.gov/
Current role in CLMS	
Service(s)	Land Monitoring Service
Usage/function	Production, gap-filling
Relevance	Medium
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	All with improved spatial resolution
Usage/function	Additional data source
Relevance	Medium
Potential issues/gaps	NA
Alternative	NA

GEDI

Used for EvoLand Methods:

- Task 2.7 Biomass Mapping

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C3: Forest Biomass Mapping

Potentially useful for EvoLand Candidates: NA

Table 11. Sensor characteristics of the GEDI mission.

Platform	
Name	**G**lobal **E**cosystem **D**ynamics **I**nvestigation (GEDI)
Operational Status	Operational on ISS
Launch Date	05/12/2018
Life Expectancy	2 years, then extended till 17/03/2023; restart collecting data in fall 2024-2030
Coverage	51.6°N and 51.6°S

Sensor	
Name	**G**lobal **E**cosystem **D**ynamics **I**nvestigation (GEDI)
Type	LiDAR
Spatial resolution (m)	The sole GEDI observable is the waveform from which all other data products are derived. Each waveform is captured with a nominal ~25m diameter.
Swath width (km)	Across-track width of ~4.2 km
Revisit time at equator (days) with or without programming	Variable
Data Distribution	
Provider	USGS, NASA
Cost	Free
Licensing restrictions	None
Accessibility	NASA's Land Processes Distributed Active Archive Center (LP DAAC) and Oak Ridge National Laboratory DAAC
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	for potential future forest biomass and forest canopy height services, it is planned to use GEDI data for calibration
Usage/function	Production, calibration
Relevance	High
Potential issues/gaps	From March 17th 2023 until fall 2024 the instrument will remain offline (stored on ISS). In 2024, GEDI will return to its original location and resume operations on the ISS until ~2030
Alternative	ICESAT-2, MOLI on ISS (planned JAXA mission)

ALOS PALSAR

Used for EvoLand Methods:

- Task 2.7 Biomass Mapping

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidate:

- C3: Forest Biomass Mapping

Potentially useful for EvoLand Candidates: NA

Table 12. Sensor characteristic of satellites from the ALOS PALSAR mission.

Platform		
Name	**A**dvanced **L**and **O**bserving **S**atellite ALOS-2 PALSAR-2	ALOS-4 PALSAR-3

Operational Status	operational	launched
Launch Date	24/05/2014	01/07/2024
Life Expectancy	10 years	7 years
Coverage	Global coverage in minimum 2 weeks (gapless cover in 42 or 56 days by stripmap mode), depending on operation mode (duty cycle 30 min/orbit)	Global
Sensor		
Name	**P**hased-**A**rray **L**-band **S**ynthetic **A**perture **R**adar-2- (PalSAR)	**P**hased-**A**rray **L**-band **S**ynthetic **A**perture **R**adar-3 (PalSAR)
Type	SAR	SAR
Spatial resolution (m)	Spotlight (3x1 m), Stripmap (3-10 m), ScanSAR (60 -100 m)	Spotlight (3x1 m), Stripmap (3-10 m), ScanSAR (25 m)
Swath width (km)	Spotlight (25x25 km), Stripmap (30-70 km), ScanScar (350-490 km)	Spotlight (35 km), Stripmap (100-200 km), ScanScar (700 km)
Revisit time at equator (days) with or without programming	14	14
Data Distribution		
Provider	JAXA	JAXA
Cost	https://www.eorc.jaxa.jp/ALOS/en/dataset/alos_open_and_free_e.htm	NA
Licensing restrictions	https://alos-pasco.com/en/uploads/ALOS-2_EULA_en.pdf	NA
Accessibility	https://alos-pasco.com/en/offer/ https://www.eorc.jaxa.jp/ALOS/en/dataset/alos_open_and_free_e.htm	NA
Current role in CLMS		
Service(s)	Currently not used in CLMS	Currently not used in CLMS
Usage/function	NA	NA
Relevance	NA	NA
Current issues/gaps	NA	NA
Alternative	NA	NA
Potential future role in CLMS		
Service(s)	The ALOS mosaics are used as pre-cursor of the NISAR free L-Band data (Launch planned for 2025). WP2 assesses the contribution of L-Band SAR data for forest biomass estimation. If L-band proves useful, the ALOS data could be used alongside ALOS PALSAR-3 and NISAR data from 2025 onwards	
Usage/function	experimental	NA
Relevance	Medium	Medium

Potential issues/gaps	NA	NA
Alternative	in future: NISAR L-Band and from 2028 onwards ROSE-L; NISAR will be launched early 2024 and provide free SAR L-Band data. In 2028 ROSE-L NA	

ICESat

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidate: NA

Potentially useful for EvoLand Candidates: NA

Table 13. Sensor characteristics of the ICESat-2 mission.

Platform	
Name	**I**ce, **C**loud and Land **E**levation **Sat**ellite: ICESat-2
Operational Status	Operational
Launch Date	15/09/2018
Life Expectancy	3 years (expected to continue beyond that)
Coverage	88°N – 88°S
Sensor	
Name	ATLAS (Advanced Topographic Laser Altimeter System)
Type	Advanced Topographic Laser Altimeter
Spatial resolution (m)	1 km
Swath width (km)	0.017
Revisit time at equator (days) with or without programming	91
Data Distribution	
Provider	NASA
Cost	Free
Licensing restrictions	https://nsidc.org/data/data-policies
Accessibility	https://nsidc.org/data/icesat-2/data
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	for calibration of forest canopy height and for forest biomass estimation
Usage/function	production

Relevance	Low
Potential issues/gaps	if ICESAT-2 fails, it needs to be replaced by airborne LIDAR data
Alternative	airborne LIDAR

NISAR

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods:

- was planned for T2.7 Biomass Mapping (but won't be available in time)

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates:

- was planned for C3: Forest Biomass Mapping (but won't be available in time)

Table 14. Sensor characteristics of the NISAR mission.

Platform	
Name	**N**ASA-**I**SRO **S**ynthetic **A**perture **R**adar (**NISAR**)
Operational Status	Not operational
Launch Date	Early 2025 (planned)
Life Expectancy	3 years
Coverage	Global, SAR mode depending on geo-location
Sensor	
Name	NASA-ISRO Synthetic Aperture Radar
Type	Dual band (S & L) SAR
Spatial resolution (m)	3-50 m, nominal average 12 m
Swath width (km)	240 km
Revisit time at equator (days) with or without programming	12 days
Data Distribution	
Provider	NASA
Cost	Free
Licensing restrictions	NA, plan: open-source license for research and commercial use
Accessibility	https://nisar.jpl.nasa.gov/data
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	

Service(s)	agriculture (soil moisture) monitoring, forest biomass estimation, natural hazards, etc.
Usage/function	Production
Relevance	High
Potential issues/gaps	NA
Alternative	NA

BIOMASS

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods:

- was planned for T2.7 Biomass Mapping (but won't be available in time)

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates:

- was planned for C3: Forest Biomass Mapping (but won't be available in time)

Table 15. Sensor characteristics of the BIOMASS mission.

Platform	
Name	BIOMASS
Operational Status	Not launched
Launch Date	2025
Life Expectancy	5,5 years
Coverage	Tropical regions
Sensor	
Name	P-band Synthetic Aperture Radar
Type	synthetic aperture radar operating at P-band (435 MHz); fully polarimetric; SAR frequency: 0.435GHz interferometric + tomographic imaging for deriving amount of biomass and carbon stored in forests
Spatial resolution (m)	50m
Swath width (km)	60m x 50m in Stripmap mode
Revisit time at equator (days) with or without programming	17 days repeat cycle for the baseline interferometric phase
Data Distribution	
Provider	ESA
Cost	NA
Licensing restrictions	no licensing restrictions
Accessibility	Distribution via ESA, open
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA

Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	for potential future forest biomass and forest canopy height products, BIOMASS could be used for production or calibration (over the tropical sites)
Usage/function	production / calibration
Relevance	High
Potential issues/gaps	Launch date not defined
Alternative	rely on L-band SAR only instead of P-band + L-band

SWOT

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidate: NA

Potentially useful for EvoLand Candidates:

- C7: Improved Water Bodies Mapping

Table 16. Sensor characteristics of the SWOT mission.

Platform	
Name	**S**urface **W**ater and **O**cean **T**opography (SWOT)
Operational Status	In-flight acceptance phase in progress
Launch Date	16/12/2022
Life Expectancy	3 years by design but 5 expected
Coverage	78°N – 78°S
Sensor	
Name	KaRIn
Type	SAR interferometric altimeter
Spatial resolution (m)	10-60 m
Swath width (km)	100 km
Revisit time at equator (days) with or without programming	11
Data Distribution	
Provider	CNES/NASA
Cost	Free
Licensing restrictions	NA
Accessibility	Through hydroweb.next (CNES) and PODAC (NASA)
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA

Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Water bodies mapping
Usage/function	Production
Relevance	Medium
Potential issues/gaps	NA
Alternative	NA

EnMap

Used for EvoLand Methods:

- Task 2.4 Weakly supervised learning

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidate: NA

Potentially useful for EvoLand Candidates: NA

Table 17. Sensor characteristics of the EnMap mission.

Platform	
Name	**En**vironmental **M**apping and **A**nalysis **P**rogram (EnMAP)
Operational Status	Operational
Launch Date	04/2022
Life Expectancy	5 years
Coverage	Global land
Sensor	
Name	
Type	Hyperspectral
Spatial resolution (m)	30 m
Swath width (km)	30 km
Revisit time at equator (days) with or without programming	27 (nadir), 4 (off-nadir)
Data Distribution	
Provider	DLR
Cost	Free
Licensing restrictions	https://www.enmap.org/data/resources/EnMAP_Data_License.pdf for commercial and scientific use
Accessibility	open user registration + science proposal + future scene request; access to historical data through https://planning.enmap.org
Current role in CLMS	
Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA

Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Land cover change, biomass estimation, agriculture monitoring, cf. https://www.enmap.org/science
Usage/function	Production
Relevance	Low
Potential issues/gaps	Dec 2022 EnMAP did not stream data, smooth operation did continue in Jan 2023
Alternative	PRISMA: https://www.asi.it/en/earth-science/prisma

OroraTech

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates: NA

Table 18. Sensor characteristics of the OroraTech mission.

Platform	
Name	OroraTech
Operational Status	Pilot satellite launched, second pilot and satellite constellation planned
Launch Date	FOREST-1: 01/2022 FOREST-2: 05/2023, satellite constellation: from 2025 (planned)
Life Expectancy	Each satellite ~2 years
Coverage	All land surfaces
Sensor	
Name	Proprietary thermal infrared cameras, known as FOREST (Forest Observation and Recognition Experimental Smallsat Thermal Detector)
Type	Multi-spectral Instrument
Spatial resolution (m)	80-200 m
Swath width (km)	410 km
Revisit time at equator (days) with or without programming	FOREST-1: 24 hours, FOREST-2: 12 hours, Constellation: 30 min
Data Distribution	
Provider	OroraTech
Cost	Contact company for info
Licensing restrictions	Contact company for info
Accessibility	Contact company for info
Current role in CLMS	

Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	change detection due to fire, forest applications
Usage/function	Production
Relevance	Low
Potential issues/gaps	NA
Alternative	NA

ConstellR

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates:

- C1: Continuous Forest Monitoring
- C2: Forest Disturbances Mapping
- C4: Cover Crop Type Mapping
- C8: Continuous Imperviousness Monitoring
- C9: Automated Land Use Mapping of Urban Dynamics

Table 19. Sensor characteristics of the ConstellR mission.

Platform	
Name	ConstellR
Operational Status	Pilot satellite launched 02/2022, full fleet launch to follow
Launch Date	Q4 - 2024 (planned)
Life Expectancy	NA
Coverage	NA
Sensor	
Name	Cryocooled long-wave infrared (LWIR) (patent pending)
Type	Multi-spectral Instrument
Spatial resolution (m)	50m GSD, 5-10m GSD VNIR
Swath width (km)	NA
Revisit time at equator (days) with or without programming	12 hours
Data Distribution	
Provider	ConstellR
Cost	Cost
Licensing restrictions	Contact company for info

Accessibility	Contact company for info
Current role in CLMS	
Service(s)	Currently Not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Drought, crop monitoring, urban mapping, forest applications
Usage/function	Production
Relevance	Medium
Potential issues/gaps	NA
Alternative	NA

TRISHNA

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates: NA

Table 20. Sensor characteristics of the TRISHNA mission.

Platform	
Name	**T**hermal Infra**R**ed **I**maging **S**atellite for **H**igh-resolution **N**atural resource **A**ssessment (TRISHNA)
Operational Status	Not operational
Launch Date	Planned for 2026
Life Expectancy	5 years
Coverage	Global
Sensor	
Name	TIR + VIS + NIR + SWIR
Type	NA
Spatial resolution (m)	57-90 m
Swath width (km)	1026 km
Revisit time at equator (days) with or without programming	8 days with same angle of incidence, 2-3 days with different angles
Data Distribution	
Provider	CNES
Cost	Free
Licensing restrictions	NA
Accessibility	Through the Geo Data Hub service
Current role in CLMS	

Service(s)	Currently not used in CLMS
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Urban monitoring, land use products
Usage/function	production
Relevance	Low
Potential issues/gaps	Spatial resolution
Alternative	Landsat

4 EO derived parameters

In addition to the above described EO data, a number of EO derived parameters could bring added value for some of the methods applied in EvoLand. In the context of the gross primary production (GPP) the Sentinel-2 fAPAR is an already used parameter of high relevance for the EvoLand agricultural candidate C5. It reflects the amount of incoming radiation that is absorbed for photosynthesis and thereby stands for the current photosynthetic activity of a plant which is crucial for a bunch of applications including yield prediction, crop phenology detection and Dry Matter Production estimation. The fAPAR is used to correct the maximum GPP based on AgERA5 Meteo data. Furthermore, the Sentinel-1 Surface Soil Moisture Index (SMI) as well as the Sentinel-1 Soil Water Index (SWI) which both quantify the moisture/water content at different soil depths could both have the potential to enhance the calculation of the GPP, but that would still have to be tested. With the calculation of a water stress indicator based on these parameters the GPP in drought or extremely wet conditions could be corrected. Another potentially useful dataset is the Sentinel-2 based seasonal trajectories, available from HR VPP. The candidates related to agriculture (C4-C6) could benefit from this product which provides the vegetation status on pixel level. Other information from HRL VLCC, that is used in the agricultural candidate C4 is the Start of Season (SoS) and End of Season (EoS), derived from Secondary crop emergence date (CPSCE) and Secondary crop season duration (CPSCD). Various parameters as described above are provided by the CLMS. They are openly available and free of charge.

5 In-situ-/ancillary data

Apart from EO data as basis and parameters derived from the EO data directly, a rather large number of different in-situ and ancillary data are necessary to guarantee high quality of all the CLMS now and in the future. From the EvoLand perspective the datasets listed below are of major interest. For some of them it is already clear that they are of high relevance and essential for producing certain candidates, whereas the relevance of others for a particular potential product is assessed during testing, implementation and validation.

5.1 Available in-situ-/ancillary data

LUCAS

One well known and often used dataset is that of the Land use/cover area frame statistical survey (LUCAS) (see Table 21). It is already part of the production of many of the CLMS, such as the HRLs or CLC. In the frame of EvoLand the LUCAS data will be especially needed within the weakly supervised learning with its different applications, for the mapping of cover crops, for the differentiation of tree types as well as the Land Cover differentiation where it plays a supportive role.

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates:

- C9: Automated Land Use Mapping of Urban Dynamics
- C4: Cover Crop Type Mapping

Table 21. Detailed characteristics of the LUCAS dataset.

Item	
Name	LUCAS
Type	Vector
Short description	The Land Use/Cover Area frame Survey (LUCAS) is a harmonised in situ land cover/land use data collection covering most of EU
Coverage	since 2009 coverage EU-28(27) Member States (less coverage in earlier surveys)
Spatial resolution (m)	2km spacing of LUCAS grid
Accuracy	https://ec.europa.eu/eurostat/documents/205002/769457/LUCAS-2018-Quality-Report.pdf
Reference year(s) available	2001, 2006, 2009, 2012, 2015, 2018, 2022 (not published yet)
Repetition rate	every 3 Years (except recent survey took place in 2022)
Data Distribution	

Provider	European Commission
Cost	Free
Licensing restrictions	None
Accessibility	Open
Source	Eurostat
Current role in CLMS	
Service(s)	CORINE Land Cover (CLC) and all other pan-EU mapping initiatives LUCAS is used for production, verification and validation processes LUCAS Copernicus module
Usage/function	Validation
Relevance	Medium
Current issues/gaps	point core data limitation in thematic and spatial/temporal resolution perspectives
Alternative	HRL VLCC, CLCplus raster
Potential future role in CLMS	
Service(s)	Verification and database of long-term changes to LC
Usage/function	Validation
Relevance	Medium
Potential issues/gaps	- 2021 shifted to 2022 - publishing delayed; next round unclear: 2024 or 2025 - known LUCAS issues (point core data limitation in thematic and spatial/temporal resolution perspectives); further limitations see LUCAS assessment report[3]
Alternative	national datasets - limited alternative

LPIS

For the production of the agriculture candidate Cover Crop Type Mapping, the Land Parcel Identification System (LPIS) data are of high importance since they provide thematic information as well as parcel outlines.

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C4: Cover Crop Type Mapping
- C6: Small Landscape Features

Potentially useful for EvoLand Candidates: NA

Table 22. Detailed characteristics of the LPIS data.

Item

[3] LUCAS Assessment, version: 1.1, 29/06/2023 - Deliverable in the frame of the second Specific Contract No 3506_R0-COPERNCA_EEA.58972 of the Framework Service Contract EEA/DIS/RO/20/002 - provision of services supporting the European Environment Agency's activities cross-cutting coordination of the Copernicus programme's in situ data activities – Geospatial Data.

Name	LPIS
Type	Vector
Short description	IT system based on ortho-imagery (aerial or satellite photographs) which records all agricultural parcels in the Member States. Two main purposes: i) clearly locate all eligible agricultural land contained within reference parcels ii) calculate their maximum eligible area (MEA).
Coverage	Current coverage EU-28(27) Member States, each LPIS database is controlled, managed, and controlled by the respective country
Spatial resolution (m)	Vector derived from ortho image, depending on resolution of image
Accuracy	Mixed. Human delineated boundaries which are not always accurate. The semiautomatic classifications are not yet highly reliable. Each member state has own agency responsible for the mapping). Introduces non uniformity errors.
Reference year(s) available	varying (per national/sub-national entity)
Repetition rate	varying per national/sub-national entity, thus not standardised)
Data Distribution	
Provider	European country governments
Cost	Country/subnational entity specific
Licensing restrictions	Country specific
Accessibility	Depending on country
Source	Depending on Country, European data center
Current role in CLMS	
Service(s)	To be filled
Usage/function	Calibration/validation
Relevance	High (if available)
Current issues/gaps	Access restrictions depending on providing entity
Alternative	HRL VLCC, CLCplus raster
Potential future role in CLMS	
Service(s)	Identification of land parcel structure and vegetation cover/dynamics in agricultural areas
Usage/function	calibration, validation, segmentation
Relevance	Medium - low
Potential issues/gaps	Not fully standardized across countries, each country has different updates and accuracy
Alternative	national datasets - limited alternative

NFI

The National Forest Inventory (NFI) plot data displayed in Table 23 have high relevance when it comes to the non-parametric estimation of forest canopy height and above ground woody biomass. They function as input data for calibration and validation and give valuable information on plot level for species, stem volume, above ground woody biomass and canopy height.

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods:

- Task 2.7 Biomass Mapping

Used for EvoLand Candidates:

- C3: Forest Biomass Mapping

Potentially useful for EvoLand Candidates: NA

Table 23. Detailed characteristics of the NFI plot data for Sweden and Spain.

Item		
Name	Swedish National Forest Inventory	Spain National Forest Inventory
Type	NFI plot inventory Sweden	NFI plot inventory Spain
Short description	-	-
Coverage	Available for whole Sweden demo site	Available for whole Spain demosite
Spatial resolution (m)	-	-
Accuracy	High	High
Reference year(s) available	Up to 2021	2008-2020 (depending on the region)
Repetition rate	Annual	-
Data Distribution		
Provider	Swedish National Forest inventory (SLU)	Ministry for the Ecological Transition and the Demographic Challenge (MITECO)
Cost	Free for research	Open data
Licensing restrictions	Strict licencing restrictions	-
Accessibility	Few plots can be downloaded directly; larger numbers have to be requested from SLU	Accessible as soon as data sets are published; updates highly varying per region
Source	-	-
Current role in CLMS		
Service(s)	NA	NA
Usage/function	NA	NA
Relevance	NA	NA
Current issues/gaps	NA	NA
Alternative	NA	NA
Potential future role in CLMS		
Service(s)	Potentially used for future forest canopy height and biomass service	Potentially used for future forest canopy height and biomass service
Usage/function	Validation	Validation
Relevance	High	High
Potential issues/gaps	No up-to-date data (time lag ~2 years)	No up-to-date data (time lag ~2 years)
Alternative	NA	NA

TropiSAR

Used for EvoLand Methods:

- Task 2.7 Biomass Mapping

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates:

- C3: Forest Biomass Mapping

Table 24. Detailed characteristics of the TropiSAR data.

Item	
Name	TropiSAR
Type	Plot data
Short description	P-Band radar; waveform is characterised by P and L simultaneous acquisitions
Coverage	157 ha of forest in French Guyana
Spatial resolution (m)	Range resolution of ~1.5m
Accuracy	-
Reference year(s) available	August – September 2009
Repetition rate	-
Data Distribution	
Provider	ESA
Cost	Free
Licensing restrictions	None
Accessibility	open
Source	https://earth.esa.int/eogateway/campaigns/tropisar
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Forest biomass estimation
Usage/function	Calibration, validation
Relevance	High
Potential issues/gaps	NA
Alternative	NA

LIDAR

Used for EvoLand Methods:

- Task 2.7 Biomass Mapping

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates: NA

Potentially useful for EvoLand Candidates:

- C9: Automated Land Use Mapping of Urban Dynamics

Table 25. Detailed characteristics of the LiDAR data Sweden and Spain.

Item		
Name	LiDAR data Sweden	LiDAR data Spain
Type	LiDAR point cloud	LiDAR point cloud
Short description		
Coverage	Whole Sweden prototype site	Whole Spain prototype site
Spatial resolution (m)	0.25-2 points per m^2	Raster from 2m
Accuracy	NA	NA
Reference year(s) available	2009-2019/2018-present	2008-2015/2015-present
Repetition rate	No regular repetition	No regular repetition
Data Distribution		
Provider	Lantmäteriet (belongs to Ministry of Rural Affairs and Infrastructure)	NA
Cost	free	free
Licensing restrictions	Depending on product	No restrictions for research
Accessibility	open	open
Source	https://www.lantmateriet.se/en/geodata/geodata-products/product-list/laser-data-download-forest/	http://centrodedescargas.cnig.es/CentroDescargas/locale?request_locale=en
Current role in CLMS		
Service(s)	NA	NA
Usage/function	NA	NA
Relevance	NA	NA
Current issues/gaps	NA	NA
Alternative	NA	NA
Potential future role in CLMS		
Service(s)	forest biomass estimation	forest biomass estimation
Usage/function	Calibration, validation	Calibration, validation
Relevance	High	High
Potential issues/gaps	NA	NA
Alternative	NA	NA

Open Street Map

Experience shows that Open Street Map (OSM) data can be useful complementing further in-situ data source. It will be tested if OSM data can support the production of the imperviousness monitoring candidates.

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C8: Continuous Imperviousness Monitoring

Potentially useful for EvoLand Candidates:

- C9: Automated Land Use Mapping of Urban Dynamics

Table 26. Detailed characteristics of the Open Street Map data.

Item	
Name	Open Street Map
Type	Vector
Short description	
Coverage	Global
Spatial resolution (m)	1 tile = 156 543 m / pixel (on Equator). Scale on screen: 1 tile = 1:500 million. Tile width: 1 tile = 360 ° of longitudes
Accuracy	Depending on existing data
Reference year(s) available	NA
Repetition rate	Continually extended by users
Data Distribution	
Provider	OpenStreetMap Foundation
Cost	Free
Licensing restrictions	There may be are additional restrictions when using other services which present OpenStreetMap data.
Accessibility	licensed under the Open Data Commons Open Database License
Source	https://www.openstreetmap.org
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Potential issues/gaps	NA
Alternative	NA

EFFIS

The Forest Disturbance Mapping requires data sources which give reliable information on the different kinds of disturbances and their occurrence in the respective area of interest. Such datasets are the Copernicus EFFIS data (see Table 27) giving valuable information on wildfires as well as the European Disturbance Maps (see Used for EvoLand Methods:

- Task 2.6 Continuous Monitoring and Change Detection

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C1: Continuous Forest Monitoring
- C2: Forest Disturbances Mapping

Potentially useful for EvoLand Candidates: NA

Table 28) where forest disturbances in general are mapped on an annual basis. Furthermore, the Database on Forest Disturbances in Europe coming from the European Forest Institute and the Copernicus Emergency Management Service are of use for the production/validation.

Used for EvoLand Methods:

- Task 2.6 Continuous Monitoring and Change Detection

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C1: Continuous Forest Monitoring
- C2: Forest Disturbances Mapping

Potentially useful for EvoLand Candidates: NA

Table 27. Detailed characteristics of the EFFIS data.

Item	
Name	EFFIS
Type	vector
Short description	Copernicus; European Forest Fire Information System/European Fire Database
Coverage	European and Mediterranean regions (currently 40 regions/ 22 countries for forest fire data base)
Spatial resolution (m)	Not specified, vector data derived from diverse high-resolution satellites (about 10-30m)
Accuracy	NA
Reference year(s) available	Since 2004
Repetition rate	Repetition rate per first event
Data Distribution	

Provider	EU Copernicus Program / Emergency Management Service (EMS)
Cost	Free
Licensing restrictions	
Accessibility	https://effis.jrc.ec.europa.eu/applications/data-and-services
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Future role in CLMS	
Service(s)	Forest disturbance mapping
Usage/function	Validation, reference
Relevance	High
Potential issues/gaps	Might not reflect any forest fire occurring, thus no source for omission error
Alternative	NA

Forest Disturbance Maps

Used for EvoLand Methods:

- Task 2.6 Continuous Monitoring and Change Detection

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C1: Continuous Forest Monitoring
- C2: Forest Disturbances Mapping

Potentially useful for EvoLand Candidates: NA

Table 28. Detailed characteristics of the European Disturbance Maps.

Item	
Name	European Disturbance Maps
Type	Raster
Short description	annual forest disturbances derived from Landsat satellite data
Coverage	35 European countries
Spatial resolution (m)	30 m
Accuracy	NA
Reference year(s) available	1986-2020
Repetition rate	Yearly
Data Distribution	
Provider	Senf, C. and Seidl, R. (2021) Mapping the forest disturbance regimes of Europe. Nature Sustainability. https://www.nature.com/articles/s41893-020-00609-y
Cost	Free

Licensing restrictions	NA
Accessibility	https://zenodo.org/record/3924381 https://zenodo.org/records/7080016
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Future role in CLMS	
Service(s)	Forest disturbance mapping
Usage/function	Training, validation, reference
Relevance	Medium
Potential issues/gaps	Some SLC-off artefacts visible in northern Serbia (both version 1.0.0 and 1.1.0). Known false disturbances mapped in Norway in 2020 in version 1.1.0
Alternative	NA

European Forest Disturbance Atlas

Used for EvoLand Methods:

- Task 2.6 Continuous Monitoring and Change Detection

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C1: Continuous Forest Monitoring
- C2: Forest Disturbances Mapping

Potentially useful for EvoLand Candidates: NA

Table 29. Detailed characteristics of the European Forest Disturbance Atlas.

Item	
Name	European Forest Disturbance Atlas
Type	Raster
Short description	annual forest disturbances derived from Landsat satellite data, including disturbance agents classification: - wind/bark beetle complex - fire, - harvest - mixed agents (where more than one agent occurred)
Coverage	35 European countries
Spatial resolution (m)	30 m
Accuracy	NA
Reference year(s) available	1985-2021
Repetition rate	Yearly

Data Distribution	
Provider	Viana-Soto, & Senf. (2023). European Forest Disturbance Atlas (2.0.0.) [Data set].
Cost	Free
Licensing restrictions	NA
Accessibility	https://zenodo.org/records/8389086
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Future role in CLMS	
Service(s)	Forest disturbance mapping
Usage/function	Training, validation, reference
Relevance	Medium
Potential issues/gaps	
Alternative	NA

FNEWs

Used for EvoLand Methods:

- Task 2.6 Continuous Monitoring and Change Detection

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C1: Continuous Forest Monitoring
- C2: Forest Disturbances Mapping

Potentially useful for EvoLand Candidates: NA

Table 30. Detailed characteristics of the FNEWs data

Item	
Name	Fernerkundungsbasiertes Nationales Erfassungssystem für Waldschäden (FNEWs)
Type	Vector
Short description	Remote sensing based National Detection System for Forest Damages (FNEWSs) for Germany
Coverage	4 study areas in Germany
Spatial resolution (m)	NA
Accuracy	99.1±0.1 % (Damaged areas were detected with a user accuracy of 84.4±2.0 % and a producer accuracy of 85.1±3.4 %)
Reference year(s) available	2018 to 2022
Repetition rate	NA

Data Distribution	
Provider	Thünen Institue
Cost	Free
Licensing restrictions	https://creativecommons.org/licenses/by/4.0/
Accessibility	https://atlas.thuenen.de/catalogue/#/search?q=FNEWS-Jahresprodukte%202018%20bis%202022&f=dataset&d=247%3Bdataset
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Forest disturbance mapping
Usage/function	Validation, reference
Relevance	Medium
Potential issues/gaps	No comprehensive data available; only available for 4 study areas in Germany up to now
Alternative	NA

VHR IMAGE

VHR IMAGE (provided by ESA via ADS) will mainly be used for validation purposes, even though it does not cover the whole reference period in EvoLand which is 2020-2022. Moreover, it will serve as additional reference data base for calibration during the testing phase. This is separately from other VHR data mentioned in this chapter (e.g. Pléiades and Pléiades-Neo), as well as VHR imagery from WMS sources such as GoogleEarth or BingMaps.

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C1: Continuous Forest Monitoring
- C2: Forest Disturbances Mapping
- Improved Water Bodies C7

Potentially useful for EvoLand Candidates: NA

Table 31. Detailed characteristics of the VHR image data.

Item	
Name	VHR IMAGE
Type	Raster
Short description	compilation of VHR acquisitions from multiple contributing missions, including primary satellite missions like Pléiades1A/1B,

	SuperView-1, WorldView-2, WorldView-3, Kompsat3/3A, and GeoEye-1, as well as back-up satellite missions like SPOT-6/7 (TrueSharp), TripleSat, Geosat-2, and Vision1.
Coverage	EEA-38+UK or on demand
Spatial resolution (m)	0.5-2m
Accuracy	NA
Reference year(s) available	2015, 2018, 2021
Repetition rate	3 yearly
Data Distribution	
Provider	ESA via ADS
Cost	Free
Licensing restrictions	TBC
Accessibility	Only for CLMS service providers, EU funded research
Source	https://spacedata.copernicus.eu/fr/optical-vhr-coverage-over-europe-vhr_image_2021-
Current role in CLMS	
Service(s)	CLMS
Usage/function	Production, validation
Relevance	High
Current issues/gaps	Heterogeneity of sensor/radiometry/spatial
Alternative	None
Potential future role in CLMS	
Service(s)	Urban monitoring, small landscape features detection
Usage/function	Production, validation
Relevance	High
Potential issues/gaps	Heterogeneity of sensor7radiometry/spatial resolution/acquisition dates, no stereo
Alternative	NA

Fluxdata GPP

Validation of innovative candidates requires new data sources. Fluxdata offer potential to be used to calibrate and validate the model for Grassland-/Cropland Biomass production and is tested in the frame of EvoLand.

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C5: Cropland/Grassland GPP Monitoring

Potentially useful for EvoLand Candidates: NA

Table 32. Detailed characteristics of the Fluxdata GPP.

Item	
Name	Fluxdata GPP

Type	Vector/csv
Short description	Ground measurements of fluxes and conversion of the fluxes to GPP
Coverage	Test/prototype sites
Spatial resolution (m)	NA
Accuracy	NA
Reference year(s) available	2017-2022
Repetition rate	Daily
Data Distribution	
Provider	ICOS
Cost	Free
Licensing restrictions	ICOS data is licensed under the Creative Commons Attribution 4.0 International license
Accessibility	Open
Source	ICOS data search
Current role in CLMS	
Service(s)	DMP service
Usage/function	Calibration, validation
Relevance	High
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Potential issues/gaps	Sensor artefacts which should be pre-processed first
Alternative	NA

AgERA5 Meteo

AgERA5 Meteo data will be used for the Grassland-/Cropland Biomass candidate. It will support the definition of the maximum possible GPP daily production based on incoming radiation and temperature dynamics. Meteo data will also serve for calibration of biomass parameters.

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- C5: Cropland/Grassland GPP Monitoring
- C11: On-demand Land Cover Mapping

Potentially useful for EvoLand Candidates: NA

Table 33. Detailed characteristics of the AGERA5 Meteo data.

Item	
Name	AgERA5 Meteo data
Type	raster
Short description	Daily information on incoming radiation and temperature dynamics
Coverage	EEA38+UK
Spatial resolution (m)	0.1°
Accuracy	NA
Reference year(s) available	2017-2022
Repetition rate	daily
Data Distribution	
Provider	ECMWF
Cost	Free
Licensing restrictions	Access to Copernicus Products is given for any purpose in so far as it is lawful, whereas use may include, but is not limited to: reproduction; distribution; communication to the public; adaptation, modification and combination with other data and information; or any combination of the foregoing.
Accessibility	open
Source	https://cds.climate.copernicus.eu/datasets/sis-agrometeorological-indicators?tab=overview
Current role in CLMS	
Service(s)	DMP service
Usage/function	Production
Relevance	High
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Gross Primary Production
Usage/function	Production
Relevance	High
Potential issues/gaps	Coarse spatial resolution compared to S-2
Alternative	NA

CLCplus BB Raster Product

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Urban Candidate C9

Potentially useful for EvoLand Candidates: NA

Table 34. Detailed characteristics of the CLCplus BB Raster Product.

Item	
Name	CLCplus BB Raster Product

Type	Raster
Short description	11-class wall-to-wall land cover raster product
Coverage	EEA38+UK
Spatial resolution (m)	10
Accuracy	>90%
Reference year(s) available	2018, 2021
Repetition rate	Every three years (every two years starting from 2021)
Data Distribution	
Provider	CLMS
Cost	Free
Licensing restrictions	https://land.copernicus.eu/en/data-policy
Accessibility	Access to data is based on a principle of full, open and free access as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013
Source	https://land.copernicus.eu/en/products/clc-backbone
Current role in CLMS	
Service(s)	
Usage/function	CLMS product - extends the CLMS product portfolio to better align with increasing requirements for European Land Cover and Land Use monitoring and reporting obligations
Relevance	High
Current issues/gaps	
Alternative	
Potential future role in CLMS	
Service(s)	
Usage/function	part of the new European baseline for European Land Cover and Land Use monitoring for the decade to come
Relevance	High
Potential issues/gaps	
Alternative	

HRL TCD

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Agricultural Candidate C6

Potentially useful for EvoLand Candidates: NA

Table 35. Detailed characteristics of the HRL TCD.

Item	
Name	High Resolution Layer Tree Cover Density
Type	Raster
Short description	Continuous tree cover density in the range from 0% to100%

Coverage	EEA38+UK
Spatial resolution (m)	10
Accuracy	>90%
Reference year(s) available	2012, 2015, 2018
Repetition rate	Three years
Data Distribution	
Provider	CLMS
Cost	Free
Licensing restrictions	https://land.copernicus.eu/en/data-policy
Accessibility	Access to data is based on a principle of full, open and free access as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013
Source	High Resolution Layer Tree Cover Density — Copernicus Land Monitoring Service
Current role in CLMS	
Service(s)	
Usage/function	CLMS product
Relevance	High
Current issues/gaps	
Alternative	
Potential future role in CLMS	
Service(s)	
Usage/function	CLMS product included in the future HRL VLCC product suite
Relevance	High
Potential issues/gaps	
Alternative	

HRL SWF

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for Evoland Candidates:

- Agricultural Candidate C6

Potentially useful for EvoLand Candidates: NA

Table 36. Detailed characteristics of the HRL SWF.

Item	
Name	High Resolution Layer Small Woody Features
Type	Raster, Vector
Short description	Includes herbaceous features like hedgerows, shrubs, and small clusters of trees
Coverage	EEA38+UK

Spatial resolution (m)	5/100
Accuracy	>= 80%
Reference year(s) available	2015, 2018
Repetition rate	Three years
Data Distribution	
Provider	CLMS
Cost	Free
Licensing restrictions	https://land.copernicus.eu/en/data-policy
Accessibility	Access to data is based on a principle of full, open and free access as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013
Source	High Resolution Layer Small Woody Features — Copernicus Land Monitoring Service
Current role in CLMS	
Service(s)	
Usage/function	CLMS product
Relevance	High
Current issues/gaps	
Alternative	
Potential future role in CLMS	
Service(s)	
Usage/function	CLMS product included in the future HRL VLCC product suite
Relevance	High
Potential issues/gaps	
Alternative	

HRL VLCC

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Agricultural Candidate C4 (field boundaries, cover crop locations, Season duration, emergence date)
- Forest Candidates C1, C2, C3 (Forest mask)

Potentially useful for EvoLand Candidates:

- Crop and grassland GPP: C5 (cropland, grassland locations and crop type info (C3/C4 crop).

Table 37. Detailed characteristics of the HRL VLCC.

Item	
Name	High Resolution Layer Vegetated Land Cover Characteristics
Type	Raster
Short description	New HRL, grouping former HRLs Forest, Grassland and Small Woody Features and introducing further new layers related to agriculture
Coverage	EEA38+UK
Spatial resolution (m)	10
Accuracy	>90%
Reference year(s) available	Not yet publicly available; Ref. years to come: 2017 to 2021
Repetition rate	yearly
Data Distribution	
Provider	CLMS
Cost	Free
Licensing restrictions	NA
Accessibility	NA
Source	NA
Current role in CLMS	
Service(s)	
Usage/function	CLMS product
Relevance	High
Current issues/gaps	
Alternative	
Potential future role in CLMS	
Service(s)	
Usage/function	CLMS product
Relevance	High
Potential issues/gaps	
Alternative	

HRL IMD

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Urban Candidate C8

Potentially useful for EvoLand Candidates: NA

Table 38. Detailed characteristics of the HRL IMD.

Item	
Name	High Resolution Layer Imperviousness
Type	Raster
Short description	Continuous sealing density in the range from 0% to100%
Coverage	EEA38+UK

Spatial resolution (m)	10
Accuracy	>90%
Reference year(s) available	2006, 2009, 2012, 2015, 2018
Repetition rate	Three years
Data Distribution	
Provider	CLMS
Cost	Free
Licensing restrictions	https://land.copernicus.eu/en/data-policy
Accessibility	Access to data is based on a principle of full, open and free access as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013
Source	https://land.copernicus.eu/en/products/high-resolution-layer-imperviousness
Current role in CLMS	
Service(s)	Capture the spatial distribution and change over time of artificially sealed areas at the continental level Two primary products—Imperviousness Density, which provides data on sealing density in the range from 0% to 100% and Built-up, which provides binary data on presence/absence of built-up areas at 10m resolution
Usage/function	CLMS product
Relevance	High
Current issues/gaps	Lack of timeliness of product provision and product frequency (3 years)
Alternative	GHSL, CLCplus raster, ESA WorldCover
Potential future role in CLMS	
Service(s)	Scope and the geographical coverage of the products will remain the same.
Usage/function	CLMS product included in the future HRL NVLCC product suite
Relevance	High
Potential issues/gaps	
Alternative	GHSL, CLCplus raster, ESA WorldCover

ESA WorldCover

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Urban Candidates C8, C9
- General LC candidates C10
- Crop and grassland GPP: C5

Potentially useful for EvoLand Candidates: NA

Table 39. Detailed characteristics of the ESA WorldCover data.

Item	
Name	ESA WorldCover
Type	Raster
Short description	Global 11- class land cover raster layer based on S-1 & S-2 data
Coverage	Global
Spatial resolution (m)	10
Accuracy	>75%
Reference year(s) available	2020, 2021
Repetition rate	NA
Data Distribution	
Provider	ESA
Cost	Free
Licensing restrictions	https://creativecommons.org/licenses/by/4.0/
Accessibility	available free of charge for all users on Terrascope and the AWS Open Data Registry
Source	https://esa-worldcover.org/en/data-access
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	Urban and General Land Cover Services
Usage/function	currently for EvoLand testing: cropland and grassland locations and urban areas – but will be replaced by VLCC/NVLCC in the future
Relevance	Medium
Potential issues/gaps	will be replaced by future VLCC/NVLCC product
Alternative	VLCC/NVLCC

Copernicus DEM

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Forest Candidate C3
- Improved Water Bodies C7
- General LC candidates C10, C11

Potentially useful for EvoLand Candidates: NA

Table 40. Detailed characteristics of the Copernicus DEM.

Item	
Name	High Resolution Layer Vegetated Land Cover Characteristics
Type	Raster
Short description	
Coverage	EEA38+UK, Worldwide
Spatial resolution (m)	10, 30, 90
Accuracy	90% (vertical and horizontal)
Reference year(s) available	NA
Repetition rate	NA
Data Distribution	
Provider	ESA
Cost	Free
Licensing restrictions	https://dataspace.copernicus.eu/sites/default/files/media/files/2024-08/cscda_esa_user_license_08.2024.pdf
Accessibility	Glo-30 & Glo-90 are available publicly; EEA-10 is restricted to specific user groups
Source	https://spacedata.copernicus.eu/de/collections/copernicus-digital-elevation-model
Current role in CLMS	
Service(s)	CLMS
Usage/function	Production
Relevance	High
Current issues/gaps	
Alternative	NA
Potential future role in CLMS	
Service(s)	CLMS
Usage/function	Production Shadow estimation
Relevance	High
Potential issues/gaps	
Alternative	NA

Cadastral Data

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Urban Candidate C9

Potentially useful for EvoLand Candidates: NA

Table 41. Detailed characteristics of the Cadastral data.

Item	
Name	Dependent on specific countries
Type	Vector

Short description	Delineations of cadastral parcels. Availability depending on country
Coverage	Dependent on specific countries
Spatial resolution (m)	NA
Accuracy	NA
Reference year(s) available	Dependent on specific countries
Repetition rate	Dependent on specific countries
Data Distribution	
Provider	Countries
Cost	Sometimes free, sometimes fee required
Licensing restrictions	Dependent on specific countries
Accessibility	Dependent on specific countries
Source	Dependent on specific countries
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	CLMS (Potentially Urban Atlas change layer and updated product)
Usage/function	Improving the delineation of changes
Relevance	Can help the delineations but huge files as input to download and use. Can't be automated
Potential issues/gaps	Dependent on specific countries
Alternative	NA

Global Surface Water Explorer GSWE

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Improved Water Bodies C7

Potentially useful for EvoLand Candidates: NA

Table 42. Detailed characteristics of the GSWE.

Item	
Name	Global Surface Water Explorer
Type	
Short description	A virtual time machine that maps the location and temporal distribution of water surfaces at the global scale over the past 3.8 decades, and provides statistics on their extent and change to support better informed water-management decision-making.
Coverage	Global

Spatial resolution (m)	30
Accuracy	Commission error: <1%; Omission error: <5%
Reference year(s) available	1984-2021
Repetition rate	irregular
Data Distribution	
Provider	European Commission
Cost	free
Licensing restrictions	This dataset is released with a full and open access conforming to the Copernicus Regulation
Accessibility	Joint Research Centre Data Catalogue - Access conditions - European Commission
Source	Global Surface Water Explorer
Current role in CLMS	
Service(s)	CLMS - Water bodies product
Usage/function	Global maximum extent from 1984 to 2021 which serves as ROI for water bodies production
Relevance	High
Current issues/gaps	Some water areas could never be properly covered in this dataset, and thus might deteriorate the water body estimates.
Alternative	None
Potential future role in CLMS	
Service(s)	CLMS - Water bodies product
Usage/function	Global maximum extent from 1984 to 2021 which serves as weighting factor for probabilistic water area determination
Relevance	Medium
Potential issues/gaps	Some water areas could never be properly covered in this dataset, and thus might deteriorate the water body estimates.
Alternative	Prevent the use of this dataset and rely solely on the water indices

Google Open building

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Urban Candidate C8

Potentially useful for EvoLand Candidates: NA

Table 43. Detailed characteristics of the Google Open building data.

Item	
Name	Open building footprint
Type	Vector
Short description	The dataset consists of 3 parts: building polygons, building points and score thresholds.
Coverage	Africa and the Global South (Africa, South Asia, South-East Asia, Latin America and the Caribbean)

Spatial resolution (m)	Vector file derived from a deep learning model (U-Net) trained to determine the footprints of buildings from high resolution satellite imagery (50 cm)
Accuracy	Estimated 80%/90% precision level
Reference year(s) available	NA
Repetition rate	Update and extension to new areas/features envisaged
Data Distribution	
Provider	Google's Ghana office
Cost	Free
Licensing restrictions	The data is shared under the Creative Commons Attribution (CC BY-4.0) license and the Open Data Commons Open Database License (ODbL) v1.0 license.
Accessibility	Open
Source	https://sites.research.google/gr/open-buildings/
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	NA
Usage/function	Training, calibration and validation
Relevance	Medium
Potential issues/gaps	Only available for Africa and the Global South (Africa, South Asia, South-East Asia, Latin America and the Caribbean)
Alternative	Open Street Map or Microsoft building footprint

Microsoft building footprint

Used for EvoLand Methods: NA

Potentially useful for EvoLand Methods: NA

Used for EvoLand Candidates:

- Urban Candidate C8

Potentially useful for EvoLand Candidates: NA

Table 44. Detailed characteristics of the Microsoft building footprint data.

Item	
Name	Microsoft building footprint
Type	Vector (GeoJSON)
Short description	The dataset consists of open building footprints around the world
Coverage	Global
Spatial resolution (m)	Vector file derived from semantic Segmentation (recognizing building pixels on an aerial image using deep neural networks (DNNs)) and Polygonization (converting building pixel detections into polygons)

Accuracy	Depending the region: - Between 70% and 86% (Recall metric) - Between 92% and 95 (Precision metric)
Reference year(s) available	Vintage of extracted building footprints depends on the vintage of the underlying imagery (Imagery between 2014 and 2024 including Maxar, Airbus, and IGN France imagery)
Repetition rate	NA
Data Distribution	
Provider	Microsoft/Bing Maps
Cost	Free
Licensing restrictions	This data is licensed by Microsoft under the Open Data Commons Open Database License (ODbL).
Accessibility	Open
Source	https://github.com/microsoft/GlobalMLBuildingFootprints/?tab=readme-ov-file#readme
Current role in CLMS	
Service(s)	NA
Usage/function	NA
Relevance	NA
Current issues/gaps	NA
Alternative	NA
Potential future role in CLMS	
Service(s)	NA
Usage/function	Training, calibration and validation
Relevance	High
Potential issues/gaps	NA
Alternative	Open Street Map

5.2 Further required in-situ and ancillary data

The survey among the partners showed a high need of up to date, accurate in-situ data providing a broad range of information for calibration, training, production and validation purposes. Despite the many options listed above, there is still a lot of data lacking to fully exploit the potential of the methodologies, to cover all thematic and technical specifications of the candidates and to reliably validate the results. The following in-situ-/ancillary information would ideally be needed as open access data with reference years on demand (minimum yearly), but are currently not/not freely available, or show other limitations (i.e. restricted usage, insufficient coverage, insufficient accuracy, incompatible reference years etc. – criteria see chapter 6.1):

- Ground truth vector data covering detailed LC/LU with very high accuracy (>95%) for calibration and validation purposes; best to be obtained by photo interpretation;

- Ground truth data on specific forest management (e.g. oil palm plantations) with very high accuracy (>95%) for calibration, training and validation;
- Ground truth data on forest disturbance agents for calibration, training and validation; Very importantly, such ground truth data should include temporal attributes, e.g.
    - Start time of disturbance
    - Time of forest management actions (e.g. removal of trees after windthrow or bark beetle infestation)
    - The accuracy of such time marks should be in the range of 1-2 weeks
- Ground truth data on leaf types and tree species composition for validation; and
- Ground truth data for cover crop types for calibration, production, validation.
- Ground truth data on built-up/sealed areas available at global/pan-European level with a high degree of spatial consistency for calibration, training and validation. Such in-situ data do exist, but the level of quality varies greatly from region/country to region/country.

In order to reduce the in-situ data gap to some extent, a sampling tool will be developed in the frame of EvoLand, focussing on agricultural training areas and collecting land surface as a starting point. This will be further described in D2.11 Training dataset for AI purposes - final version due to February 2025.

Further details on novel in situ data are provided in report *D2.8 Existing and novel in-situ and training datasets - interim version 2* [AD4], as well to be updated until in February 2025.

6 Assessment of the EvoLand data source collection

6.1 General requirements for EO- and in-situ-/ancillary data

Quality, quantity and availability of data are the most important prerequisite for obtaining high quality results. Generally, the suitability of all data types (EO- and in-situ data) could be estimated according to the following criteria:

- Availability of data
- High coverage (minimum pan-European, sometimes global coverage desired)
- High update frequency (respectively revisit time, update rates) and timely availability of data
- High spatial resolution
- High information depth of data (to allow for broad range of usages)
- High and standardized pre-processing level (minimizing the effort on the service providers' side, enabling harmonized data pre-processing)
- High quality control level
- Consistency and long-term perspective of EO missions (including life-time of the sensor or availability of continuing/complementing missions), hence providing long time series for previous years as well as ensuring continuity in the future
- Complementary data sources for flexibility, e.g. in term sensor failure (e.g., S-1 failure), data gaps, artefacts or other availability issues
- Additional data sources for validation
- High performance infrastructure for accessing the data
- Consistency with existing pixel grids + existing products

In addition to these criteria, for ground truth data accounts:

- Suitable nomenclature with transparency and meaningfulness of class definitions
- Accurate geolocation
- Standardized reporting (concerning update schedules, data collection approach, publishing, content to be reported)
- Continuity/repeatability of data collection

Novel methodological approaches could complement limitations to a certain extent, but still they rely on quality and quantity (especially DL approaches) of input data for calibration and training. Moreover, the data processing results need to be verified with reliable reference data to proof their accuracy.

6.2 Intermediate assessment of EvoLand data sources

User feedback in the service requirement analysis of *T1.1 Service Requirements Analysis* (AD1) confirmed the envisaged high-level specifications of the planned candidate prototypes and thus strengthens the need for high quality input data for production and validation, considering both, EO and in-situ data.

6.2.1 EO data

Chapter 3 provides a tabular overview on the use and future potential use of EO data in EvoLand as well as for CLMS services, including an assessment of the relevance of the respective data source.

The analysis of needed and available EO data showed that all methodologies that are being developed and tested during the project phase – 2.4 Weakly Supervised Learning, 2.5 Improved Spatial, Temporal, Spectral Resolution, 2.6 Continuous Monitoring and Change Detection and 2.7 Biomass Mapping – depend on short revisit times, accurate geolocation, standardized and high processing level, available ARD, very good cloud/shadow masks, and high reliability (continuous and consistent provision of data guaranteed to keep time series complete). This is mandatory to meet the candidates' specifications. The Sentinel fleet, specifically Sentinel-2, covers most of the requirements, which makes it by far the most frequently used data source.

All SAR data, in the EvoLand context mainly Sentinel-1, and for biomass mapping also ALOS and potential further upcoming sensors, are characterised by their insensitivity to clouds and daylight, can thus also observe during night-time, enabling the acquisition of dense time series. The anomaly related to the instrument electronics power supply of S-1B, which caused a critical failure, will be an issue for dates from 2023 onwards. From the project's mid-term perspective, no prototypes use Sentinel-1 data as main input data source, and the prototypes target mainly the years 2020–2022, hence sensor failure has not been so much of an issue, but will be an issue for future implementations.

Further limitations to be compensated by workarounds are: unregular noisiness and the lack of ARD for S-1 and missing surface reflectance for S-3 data. In general, it would be appreciated if processing levels could be provided in a standardized manner for all data to reduce the effort for pre-processing and harmonization on the side of the service providers.

Optical Sentinel data are crucial for nearly all methodologies and beneficial for numerous applications, making them valuable to almost all EvoLand candidates. The spectral bands of Sentinel-2 offer rich information depth for land cover classification across various domains, and in EvoLand, Sentinel-2 data will be integral to nearly all candidates. For example, the strong relationship between spectral information and the GPP on the field makes it highly valuable for the

agriculture-related Crop-/Grassland biomass candidate C5. Same accounts for the Forest related candidates C1-Continuous Forest monitoring and C2-Forest disturbance mapping, where S-2 data will be the main data source for detecting tree cover and disturbances as well as it will contribute to identify disturbance agents. The potential and added value of further EO data sources from contributing missions was planned to be evaluated in the frame of EvoLand as well. Nevertheless, some of the data that was planned to be tested, like for example NISAR and BIOMASS data for the biomass candidate, will not be available in time for the EvoLand project. Other data from the GEDI and ALOS missions were found useful input for the prototype implementation of C3 - Forest Biomass Mapping.

Further, AgERA5 METEO has been an input data source for the agricultural candidate C5 - Cropland/Grassland GPP Monitoring and the general land cover prototype C11 - On-demand Land Cover Mapping.

6.2.2 In-situ-/ancillary data

Chapter 5 provides a tabular overview on the use and future potential use of in-situ data in EvoLand as well as for CLMS services, including an assessment of the relevance of the respective data source.

Whereas there is a broad availability of optical and SAR EO data with broad coverage, and high potential to complement limits of one data source by another data source, the situation for ground truthing/in-situ data is different. Most of the data sources are limited in coverage and in temporal and spatial resolution. Availability is often an issue when it comes to national or sub-national providers where access is less standardized nor centralized and not all data are open, which consequently requires additional effort to collect the data. Acquisition procedures are not standardized as well, this accounts for scheduling/reference years, for content, for the respective workflows, for nomenclature, for class definitions and for quality assessment procedures as well. Further, technical format as well as thematic content is often heterogeneous, and harmonization is on the service provider side. Plus: the data requirements for ground truthing data highly differ per product, so there is hardly a data source that would be usable in a straightforward manner for the various purposes during production. Especially new technologies like Deep Learning require a huge amount of high-quality training data. Even if new techniques like weekly supervised learning are explored during this project, the quality of the final products depends highly on the available training data.

In EvoLand, ground truth data for vegetation-related candidates, including general land cover candidates, play a major role. Those data sources would need to provide at least yearly updates, in some cases finer-resolved (ideally monthly information) of high accuracy and exact geolocation and a broad range of thematic classes – for agriculture, for forestry, and, ideally, for less frequent and specific LC classes (important for candidate C11-On demand LC mapping).

LUCAS is the most common data source in this perspective provides nearly pan-European coverage and an extensive nomenclature. It has the potential to serve as a basis for several candidates in EvoLand, nevertheless, it has its limitations. LUCAS does not provide yearly updates for the EvoLand reference years 2020-2022; additionally, more dense information during the whole vegetation period would be needed - especially for the agriculture related candidates, for illustrating dynamics in a continuous monitoring and for change monitoring; the core information per point is spatially limited, since not covering a pixel respectively a larger area; more general limitations of LUCAS are mentioned in the new LUCAS Assessment report[4]. Considering those shortcomings, the LUCAS data has not yet been used in any prototype, so far.

For the EvoLand Candidates, which represent new potential services, further new data are being tested for their usability. That accounts for example for the forest disturbance as well as for the On-demand LC mapping when it comes to map very specific LC such as oil palm plantations or LC outside Europe. Data sources like NFI and TropiSAR are promising in this regard.

Often, several data sources are needed to cover the requirements of the specific prototype candidates. For example for the verification of the forest disturbances and even more for verifying the respective disturbance agents and getting a broader picture of verified disturbance events, there is no single data set, providing the needed information. Several ancillary data sets are needed and some of them, such as EFFIS or EMS, depend on the comprehensiveness of reporting, which is not always mandatory, so some events are missing in these data sets. Such information gaps would have to be covered by additional data sets, but those are very rare or not available at all.

In-situ data in general are needed for different purposes: for calibration and training, for production and for validation. As mentioned, the requirements for in-situ data are various, strongly depending on the technical and thematic specifications of the envisaged product. So, often several data are needed in the course of the production, some of them have a single purpose such as the FLUXdata GPP data are used for calibration and validation of the model. Where in-situ data are not sufficient, ancillary data originating from other CLMS products (e.g. HRLs CLCC and NVLCC or others) are needed to complement and enrich calibration and training data and are also part of the validation procedures. These data sets also serve as a baseline for assessing how new methods perform during testing in EvoLand.

[4] LUCAS Assessment, version: 2.2, 20/09/2024 - Deliverable in the frame of the second Specific Contract No 3506_R0-COPERNCA_EEA.58972 of the Framework Service Contract EEA/DIS/RO/20/002 - provision of services supporting the European Environment Agency's activities cross-cutting coordination of the Copernicus programme's in situ data activities – Geospatial Data.

7 Conclusion and outlook

The inventory of data sources listed in this report *D1.4 – EO and in-situ data requirements report - final version* consists of tables per data source listing a number of criteria to provide relevant information for assessing the usefulness of the respective data source in the frame of the project. It represents the status at month 22 of the project and gives a picture of required data sources for the different tasks in the project and for a "beyond project"-perspective. Thus, the inventory tries to answer to data requirements:

- **from a method development perspective**: data that are required for developing suitable methods on selected test sites in EvoLand to fulfil the thematic and technical candidate specifications;
- **from an implementation perspective of the candidate prototypes**: data that are required for the implementation and validation of the candidate services on larger prototype sites, meeting the candidate specifications plus ensuring adequate validation procedures; and
- **from a future CLMS portfolio-perspective:** data that would be required for a future upscaling into operational services with roll-out at pan-European or even global level.

The broad experience of the consortium members in various previous projects was a highly valuable source for this task. Several data sources were taken up into the inventory in this project since they have already been proven as reliable and value-adding basis for product generation and validation in previous projects, including current CLMS services, which are partially among the prototypes for future improved CLMS products. Well-known examples are the Sentinel missions as for EO data, the LUCAS in-situ data or VHR data for training/validation purposes.

The development phase started in April 2023 and is still in progress as part of project phase 2, so the evaluation of how the intended data sources will meet the expectations or about any additional benefits or limitations is ongoing and will only be available once the final Deliverables of the Methods Compendium and Prototypes Reports will be developed. Same accounts for the tables themselves and the listed criteria. After phase 1 of the project, more insight has now been gained concerning which data sources will really have added value for the realization of the candidate prototypes and hence a better assessment for the requirements for potential operationality can be given. Tables were adapted, criteria updated and missing information was integrated. Related to new and upcoming missions, however, the catalogue information is updated, but by the time of writing the final version of this report, no additional future data sources were known.

Main focus during the project will be given to meeting the specifications prioritized by the user requirements, documented in *D1.1 – Service requirements report - interim version* [AD1] which is due to be updated soon. The comprehensive analysis

complemented by interviews with users and stakeholders confirmed that main requirements of the users and stakeholders concerning new services are:

- Higher update frequency
- Timeliness
- High reliability and accuracy
- Information depth
- Extension of existing CLMS products but also consistency within current and future products
- Extension of the current service portfolio by extending services as well as by adding new ones, adapting to the user and stakeholder needs

When considering a beyond EvoLand perspective (scaling up, operational services), the aim on development side is a high automation level of methods and meaningful production time to guarantee timeliness and high update rates. So basic requirements considering EO- and in-situ data sources from user/service provider perspective are:

- High coverage (minimum pan-European areas covered, sometimes global coverage desired)
- High update frequency (respectively revisit time)
- High and standardized pre-processing level (minimizing the effort on the service providers' side, enabling harmonized data pre-processing)
- High quality control level
- Consistency and long-term perspective of EO missions, providing long time series for previous years as well as ensuring continuity in the future
- High information depth of data (allowing for a broad range of usages)
- Complementary data sources for flexibility, e.g. in terms of sensor failure (e.g. S-1 failure), data gaps, artefacts, or other availability issues.
- Additional data sources for validation
- High performance infrastructure for accessing the data

Not all of these requirements can be covered. Whereas the resulting inventory of EO- and in-situ data and of EO-derived parameter consists of proven data sources which have already been a valuable part of the production of many CLMS services, and which have also been successfully tested and used for prototyping in project phase 1, for in-situ data, there is still a gap between needs and availability of suitable data sources for production and for validation, which is a known issue also for other projects and products. The data that would ideally be needed for training or validation is often not available. As it is the case for some of the data listed in Chapter 5.2.

Workarounds and potential gap-filling solutions were conceptualized and if possible tested in EvoLand phase 1, for more information it is referred to the report on *D2.7 – Existing and novel in-situ and training datasets - interim version* [AD4] and its next update, as well as the Methods Compendium [AD6] and Prototype Report [AD7]. Specific interest has been given to new candidates which don't have any precursor and therefore less experience to build upon, such as the forest

candidates C2-forest disturbance, C3-Forest biomass, the agricultural candidate C5-Cropland/Grassland GPP monitoring and the General LC mapping candidate C11-On-demand land cover mapping.

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