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# Copernicus Core Services Interface and Relevant Data Portfolio Guide

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## LIST OF ACRONYMS

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AP	Application (refers to CURE applications 01-11)
API	Application Programming Interface
CURE	Copernicus for Urban Resilience in Europe
C3S	Copernicus Climate Change Service
CAMS	Copernicus Atmosphere Monitoring Service
CCSI	Copernicus Core Service Interface
CDS	Climate Data Store
CSCDA	Copernicus Space Component Data Access
CLMS	Copernicus Land Monitoring Service
CLRTAP	Convention on Long-Range Transboundary Air Pollution
DEM	Digital Elevation Model
DIAS	Data and Information Access Services
DSM	Digital Surface Model
DWH	Data Warehouse
ECA&D	European Climate Assessment & Dataset
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variable
EEA	European Environment Agency
EFTA	European Free Trade Association
EIONET	European Environment Information and Observation Network
EMS	Emergency Management Service
ESA	European Space Agency
ESPG	European Petroleum Survey Group
EU	European Union
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FUA	Functional Urban Areas
GCOS	Global Climate Observing System
GDEM	Global Digital Elevation Model
GFCS	Global Framework for Climate Services
GHSL	Global Human Settlement Layer
GIS	Geographic Information System
HRL	High Resolution Layer
HR-VPP	High Resolution Vegetation Phenology and Productivity
ITT	Invitation To Tender
IOCR	In-Orbit Commissioning Review
JRC	Joint Research Centre
LAI	Leaf Area Index
LPS	Large point source
LST	Land Surface Temperature
MFF	Multiannual Financial Framework
MMU	Minimum Mapping Unit
MNDWI	Modified Normalized Difference Water Index



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MRT	Mean radiant temperature
NCDC	National Climatic Data Center
NDBI	Normalized Difference Built-up Index
NDVI	Normalized Difference Vegetation Index
NMHS	(European) National Meteorological and Hydrological Services
NMVOC	Non-methane volatile organic compounds
NRT	Near real-time
OGC	Open Geospatial Consortium
OSM	Open Street Map
PAN	Peroxyacetyl nitrate
PM	Particulate matter
PPI	Plant Phenology Index
RMSE	Root Mean Square Error
SPOT	Satellite Pour l'Observation de la Terre (Satellite for observation of Earth)
SRTM	Shuttle Radar Topography Mission
ST	Seasonal Trajectories
SWE	Snow Water Equivalent
UA	Urban Atlas
UERRA	Uncertainties in Ensembles of Regional ReAnalysis
UTC	Coordinated Universal Time
UHI	Urban Heat Island
VCi	Vegetation Condition Index
VHR	Very High Resolution
VI	Vegetation Index
WCRP	World Climate Research Programme
WKT	Well Known Text
WP	Work Package
WV	WorldView
UA	Urban Atlas
UTCI	Universal thermal climate index





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# 1 INTRODUCTION

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## 1.1 Purpose of the document

This document presents a consolidated summary of CURE (Copernicus for Urban Resilience in Europe) cross-cutting applications data needs and describes the CURE Interface concept to be implemented as part of the CURE services automation. It is based on detailed analysis of stakeholder needs and requirements as summarized in the CURE Summary of User Requirements Deliverable (D1.1), further reflecting these findings and providing detailed guidance both on

- content side providing detailed specification of each relevant data source for each particular CURE application implementation for particular front-runner pilot cities
- technical side outlining concept of CURE Interface providing support by means of automation of insertion of data resources needed by each CURE application

The concept and idea of the CURE system is to maximally exploit and profit from the Copernicus data portfolio. This covers both datasets from Copernicus Core Services (harmonized European data products acquired and managed in the frame of CLMS, CAMS, C3S and EMS services) and Copernicus Satellite data. The Copernicus data will represent the major and crucial data input for the CURE cross-cutting applications.

The Copernicus programme is the unique European operational asset for monitoring the Earth, coordinated and managed by the European Commission. The development of the observation infrastructure is performed under the aegis of the European Space Agency for the space component and by the European Environment Agency and EU countries for the in situ component. It consists of a complex set of systems which collect data from multiple sources: earth observation satellites and in situ sensors such as ground stations, airborne sensors, and sea-borne sensors. It processes this data and provides users with reliable and up-to-date information through a set of services related to environmental and security issues. The services address six thematic areas: land, marine, atmosphere, climate change, emergency management, and security. They support a wide range of applications, including environment protection, management of urban areas, regional and local planning, agriculture, forestry, fisheries, health, transport, climate change, sustainable development, civil protection, and tourism.

The goal of the WP2 is to identify relevant input datasets for all CURE cross-cutting application and their availability for relevant front-runner cities (AP01-11, corresponding front-runner cities as defined in the frame of WP1/WP3, and also listed in D1.1) and make as much as possible of them available via a standard CURE interface (Copernicus Core Services Interface - CCSI).

While focused on the operational Copernicus services, this document also provides an overview of the Copernicus satellite data, selected upcoming services and the non-Copernicus data streaming



from the local city open data repositories or other sources, which serve as additional inputs for some of the CURE applications.

AP	Cross-cutting applications	Berlin	Copenhagen	Sofia	Heraklion
01	Local Scale Surface Temperature Dynamics (FORTH)	●	●	●	●
02	Surface Urban Heat Island Assessment (DLR)	●	●	●	●
03	Urban Heat Emissions Monitoring (UNIBAS)				●
04	Urban CO <sub>2</sub> Emissions Monitoring (UNIBAS)				●
05	Urban Flood Risk (GISAT)		●		●
06	Urban Subsidence, Movements and Deformation Risk (GISAT)			●	●
07	Urban Air Quality (VITO)			●	
08	Urban Thermal Comfort (VITO)		●	●	
09	Urban Heat Storage Monitoring (FORTH)				●
10	Nature Based Solutions (TECNALIA)		●	●	
11	Health Impacts (socioeconomic perspective) ( <a href="#">ApHER</a> )		●	●	

● Application to be implemented for this city; ● Originally planned, but changed.

Figure 1: List of CURE cross-cutting applications for (finally assigned) front-runner cities



## 2 COPERNICUS CORE SERVICES INTERFACE

### 2.1 Analysis of assignment

#### 2.1.1 Copernicus Core Service Interface vision

Copernicus Core Service Interface (CCSI) should provide access to various data catalogue/repositories required by each CURE application. Access to various Copernicus products via CCSI will be provided through unified interface. CCSI should be simply expanded for new dataset on the requirement.

#### Vision interpretation

- By CCSI it means a subsystem of the CURE system that acts as an intermediary for requests from clients seeking products from Copernicus or other data repositories. By clients, it means CURE application or user acting via a dedicated web-based interface.
- Unified interface means that the interfaces of various interfaces will be hidden behind CCSI interface based on OGC OpenSearch standard.
- “Simple expands” mean that the design of interface should allow to map and add additional collection or repositories without changing of CCSI interface

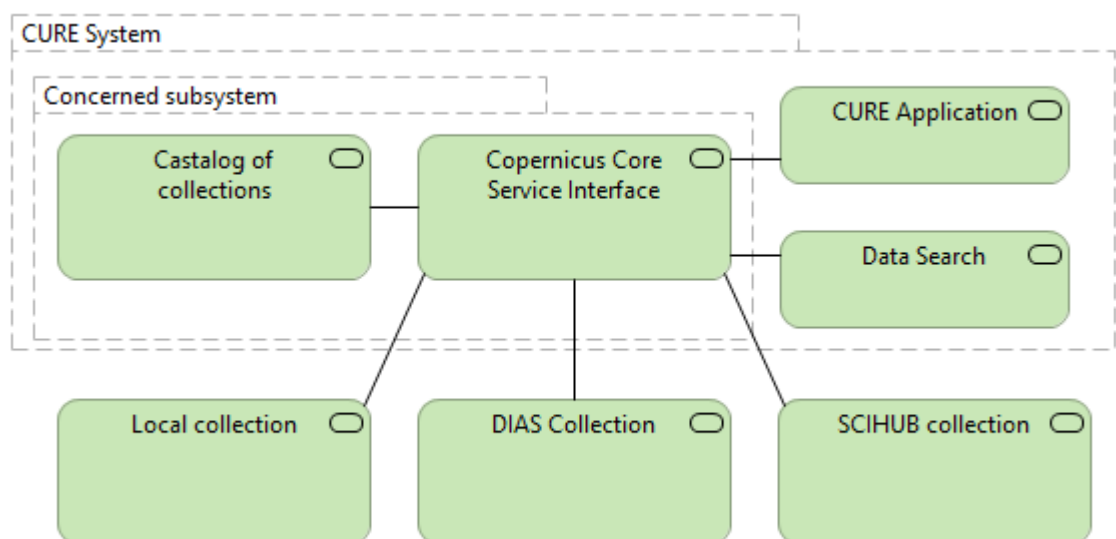


Figure 2: Logical model of the concerned subsystem environment



### 2.1.2 Model of requirements

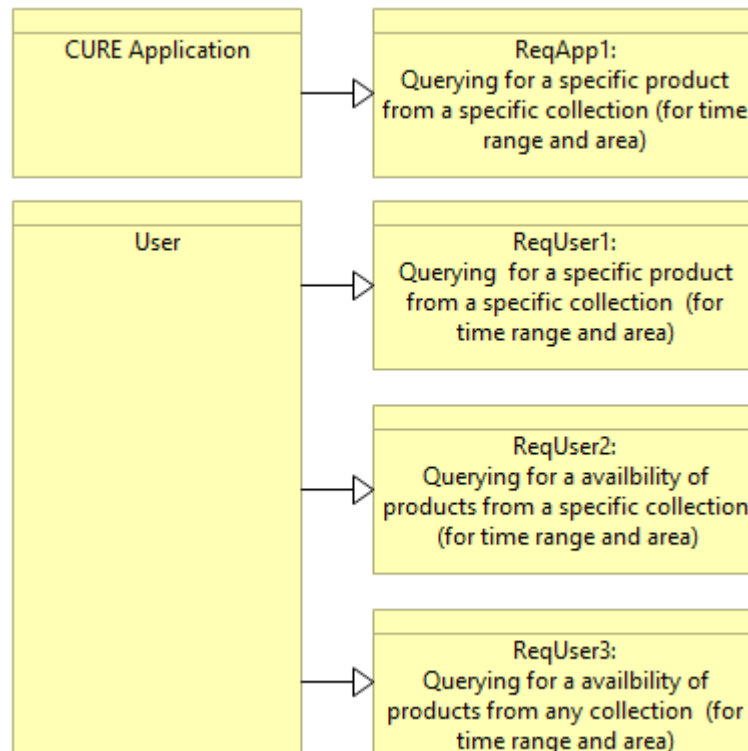


Figure 3: Model of expected requirements of actors on CCSI subsystem

Model of expected requirements is shown on figure 2. The CURE application and User were identified as two possible actors/clients interfacing CCSI. Expected use case queries from both actors are the same and differ only in the level of specificity about a certain product.

A CURE application, to access data of a certain predefined product, needs to get a signed link per request. Set of required products by each app is known and pre-defined.

The User, acting via web-based interface e.g. EO browser, can be also interested in a particular product but also could be interested in the availability of products for certain collections or any product for a certain location and time period. With an expanding set of integrated collections, especially for local collection, CCSI has the potential to become an interesting service.

Set of optional OpenSearch parameters should be chosen in respect of these needs.

### 2.1.3 Copernicus products required by CURE applications

Based on the summary of CURE application requirements on Copernicus Services (CURE Data Portfolio), CCSI should provide access to primary C3S, CAMS, CLMS and SciHub collections.

Requested Copernicus products can be split into two categories according to parameters needed to hit a certain product.



- one parameter product. These products are static and can be identified by single parameter i.e CLMS Urban Atlas 2012 for Berlin area is identified by a unique identifier DE001L1\_BERLIN\_UA2012
- multiple parameters products. These products are dynamic i.e. have various modifications and they are time dependent. E.g. CAMS ozone concentration needs to define the product family "cams-europe-air-quality", type of model, time, level above ground etc. Parameters vary for each product. It is suggested to cover these variable parameters behind one exposed nested attribute with prefix "custom" to simplify CCSI API parameters.

## 2.2 System design

### 2.2.1 Goal

Design of CCSI will be provide in three agile cycles

- The goal of the first cycle is provide interaction and searching over Copernicus Core Services and SciHub
- In the second cycle will be defined OpenSearch specification and tool for querying non-copernicus repositories. To access these repositories these repositories needs to implement OpenSearch defined within this cycle
- The third cycle will implement ontological search

### 2.2.2 Search Use cases

This section describes proposed query urls to match requirements defined in section 2.1.2. and pre-defined base API query parameters

ReqApp1: find resources for certain product for given time and location

- product can be identified by product id or product name from given  
In this case OpenSearch needs to have parameter identify product name  
PRODUCTID  
Example of url template for requesting Urban Atlas 2012 for Berlin:  
**`http://foo.bar/?q=productid=DE001L1_BERLIN_UA2012`**
- product can be identify by combination of COLLECTION and PRODUCT common name  
Example of url template for requesting 300m water body:  
**`http://foo.bar/?q=collection=CLMS&product=WB300_202009010000_GLOBE_PROBAV_V1.0.1&bbox=120,10,134,14&start=YYYY-MM-DD&end=YYYY-MM-DD`**
- product has to be specified by name of collection, product and a set of additional parameters. Product parameters are specified by the prefix CUSTOM and separate by ":" delimiter.



Example of url template requesting CAMS ozone concentration from model ESEMBLE for 50m above ground:  
***http://foo.bar/?q=collection=CAMS&product=cams-europe-air-quality-forecasts&custom:variable=ozone&custom:model=ensemble&custom:level=50&bbox=120,10,134,14&start=YYYY-MM-DD***

ReqUser1: same as ReqApp1

ReqUser2: find available products for certain collection  
In the case that from combination of parameters COLLECTION and PRODUCT, PRODUCT will not be used all available product will be return

Example of url template:

***http://foo.bar/?q=collection=CLMS&bbox=120,10,134,14&start=YYYY-MM-DD&end=YYYY-MM-DD***

ReqUser3: find all available products for certain collection  
If COLLECTION and PRODUCT are not used all available product from all collection will be return

Example of url template:

***http://foo.bar/?q=bbox=120,10,134,14&start=YYYY-MM-DD&end=YYYY-MM-D***



### 2.2.3 OpenSearch Parameters

Following table represents proposed OpenSearch query parameters derived from section 2.2.2. Parameters can be split into three categories. Parameters defined the resource like PRODUCTID, COLLECTION etc. General parameters describing response MAXRECORDS etc. The last, parameters inherited from [OpenSearch Geo and Time Extensions](#)

parameter	info
SEARCHTERMS	keyword or keywords desired by the search client
COLLECTION	(optional) name of requested collection. If not used all catalogs are returned
PRODUCT	(optional) name of requested product. If not used all product are returned
PRODUCTTYPE	
CUSTOM	parameter including additional variables of payload to identified specific resource
PRODUCTID	Original identifier as product i.e. 'WB300_202009010000_GLOBE_PROBAV_V1.0.1'
MAXRECORDS	number or results returned for request
PAGE	results are paged. This parameter specify an index of page
BOX	geographical bounding box. Coordinates in longitude, latitude in order west, south, east, north. CRS is epsg 4326, decimal degree
GEOMETRY	Area defined as WKT 2D geometry, coordinates in EPSG 432
LAT, LON and RADIUS	Three parameters define the circular



	area. Have to use it together. LAT and LON coordinates in EPSG 4326. RADIUS in meters
RELATION	Spatial relation to result set
START	Start of the search temporal interval. String in ISO 8601 format
END	End of the search temporal interval. String in ISO 8601 format
SORTORDER	Parameter specify if the result will be sort descending or ascending i.e from START or END

Table 1: Proposed CCSI OpenSearch query parameters

#### 2.2.4 OpenSearch Response

CCSI response will follow [OpenSearch 1.1 Draft 6](#) specification. Following table represents the subset of required metadata available for each collection or product in the OpenSearch search results. This subset is a first version that can be expanded on demand.

parameter	info
atom:title	A title given to the resource.
atom:id	A unique identifier of the entry
dc:identifier	The identifier of the resource within the search engine context
atom:link rel="self"	
atom:link rel="up"	Refers to a parent resource in a hierarchy of resources
atom:link rel="alternate"	Refers to a resource that is an alternate representation of the entry
atom:link rel="enclosure"	Location of the data resource described in the entry





atom:link rel="datapath"	Location of data resources within the infrastructure
dc:publisher	Name of publisher
atom:updated	Creation or update date of the metadata resource
atom:summary	An account of the content of the resource
dc:date	A date or range of dates relevant to the resource
georss:polygon	
atom:category	A topic of the content of the resource
eop: / gco: / ...	product earth observation related metadata

Table 2: Subset of CCSI OpenSearch response

#### 2.2.4.1 Accessing recourse data

Each <entry> element in CCSI search response will contain <link> element of type "enclosure" or "path". or both of available. Enclosure type will refer to downloadable URL link while path type will refer to file location on the filesystem available to 'mount' an object filestore as a filesystem or NFS proxy

#### 2.2.5 Error handling

Error type	description
400 Bad Request	Request has an invalid syntax
413 Request Entity Too Large	The request originates too many returnable hits
500 Internal Server Error	
501 Not Implemented	Unsupported operator



503 Service Unavaila	Service is temporarily not available
504 Gateway Timeout	Failing to produce a answer within a giving

Table 3: Error Handling

### 2.3 Subsystem Architecture

This section describe internal subsystems of CCSI modul and base processes between each parts of subsystem.

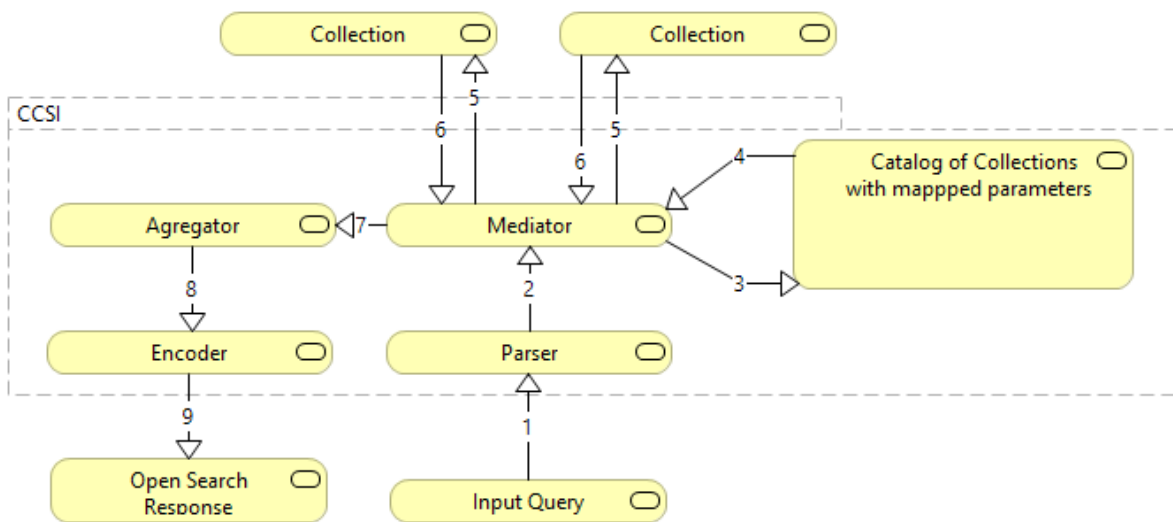


Figure 4: CCSI subsystem and process of building query and response

Process description:

1. Client send request that is accepted by parser
2. Parsersend parsed parameters (dict) into the mediator
3. Mediator based on input parameters ask for definition of requested collections from catalog
4. Catalog return collection definition i.e. endpoint and mapped parameters
5. Mediator send request on collection
6. Mediator accept response from collection
7. Mediator send responses into the aggregator
8. Aggregator collect response, sort them, check duplicates and send them to Encoder
9. Encoder return open search response



## 2.4 CCSI-repositories integration strategy

This section describes the strategy and necessary steps to integrate and search over known repositories into CCSI.

### 2.4.1 Copernicus Core Services

#### 2.4.1.1 CDSAPI

CDSAPI provides a simple way of how to access and download specific CAMS and C3S Copernicus data from the Copernicus Data Store. Interaction with API is intended to be one-layer when specific product parameters of CDSAPI payload will be caught in CUSTOM query parameters.

#### 2.4.1.2 CREODIAS

CREODIAS contain products from CAMS, CEMS, CLMS and CMEMS. All data are accessible through S3 or NFS protocol. The drawback of CREODIAS is the absence of the catalogue above the Copernicus collection. Copernicus products on the Creodias are stored at structured directories on the original product id. To integrate Creodias is necessary build-up own catalogue of resources. Build up of catalogue means crawl through Creodias store and coupling the single recourses with particular metadata describing the resource. Metadata can be scraped from a particular site of each Copernicus services or from catalogues published by other data providers.

#### 2.4.1.3 MUNDI

MUNDI provides access to CLMS. Interaction with Mundi can be provided through Mundi OpenSearch API provides metadata about products availability [Collection description](#). Download of products is possible through S3 endpoint [API Documentation](#)

### 2.4.2 Sentinel data

#### 2.4.2.1 Copernicus Open Access Hub

Hub provides access to Sentinel-1, Sentinel-2, Sentinel-3 and Sentinel-5P. Accessing the data is provided in two steps. Exposed [OpenSearch API](#) can be used to identify product UUID. Link on resources can be then obtained via [OData API](#). By knowing product UUID

#### 2.4.2.2 CREODIAS

CREODIAS has exposed “Finder” API allowing to access the catalog, finding the unique identifier and sending the order request

### 2.4.3 OpenStreetMaps

#### 2.4.3.1 HarvestOSM

HarvestOSM is a python library internally developed by Gisat. The library serves as a translator to generate OverpassQL statements that are sent on OpenStreetMap endpoints. Library allows creating complex statements including math and logic operations that are then executed on



OpenStreetMap servers. Accessing the OSM data through Overpass endpoint can be limited by service limitation for large data or for high request rate.

#### **2.4.3.2 Osmosis**

Using the osmosis it is an alternative to accessing OSM data via Overpass endpoints. Osmosis allows extracting specific key=value data from OSM data. These extracts can be sent directly or can be stored in PostgreSQL database depending on which variation will be more effective

### **2.4.4 Local Repositories**

#### **2.4.4.1 Berlin**

Berlin open data are accessible via [Berlin Simple Search](#) or through the exposed [CKAN Api](#) that allows standardised querying and data sharing of repository resources.

#### **2.4.4.2 Copenhagen**

Accessing the Copenhagen open data will be provided in the same manner as Berlin open data because both cities share the same [CKAN technology](#).

#### **2.4.4.3 Heraklion**

Heraklion provides their own [API](#) for data access. API consisting from several endpoints implementing GET methods. To interact with this API is necessary to write a mapper that will map each endpoint to set of keywords that will be used in CUSTOM query parameter.

### **2.4.5 Strategy for integration of local repositories without exposed api**

For these repositories will be defined OpenSearch endpoint fully integrated with CCSI with mapped parameters. If the municipalities want to integrate their repository to CCSI it will be required to expose this standardised OpenSearch endpoint that will follow CCSI standard. Optionally can develop a tool that will help to crawl repository and create indexes and establish endpoint.



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### 3 CURE DATA PORTFOLIO GUIDE

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The concept and idea of the CURE system is to **maximally exploit and profit from the Copernicus data portfolio**. This covers both datasets from **Copernicus Core Services** (harmonized European data products acquired and managed in the frame of CLMS, CAMS, C3S and EMS services) and **Copernicus Satellite data**.

The **Copernicus data will represent the major and crucial data input for the CURE applications which will be cross-cutting among the Copernicus Services data**.

Copernicus is the European system for monitoring the Earth and is coordinated and managed by the European Commission. The development of the observation infrastructure is performed under the aegis of the European Space Agency for the space component and by the European Environment Agency and EU countries for the in situ component. It consists of a complex set of systems which collect data from multiple sources: earth observation satellites and in situ sensors such as ground stations, airborne sensors, and sea-borne sensors. It processes this data and provides users with reliable and up-to-date information through a set of services related to environmental and security issues. The services address six thematic areas: land, marine, atmosphere, climate change, emergency management, and security. They support a wide range of applications, including environment protection, management of urban areas, regional and local planning, agriculture, forestry, fisheries, health, transport, climate change, sustainable development, civil protection, and tourism.<sup>1</sup>

**The goal of the WP2 is to identify relevant input datasets for all CURE cross-cutting applications and their availability for relevant front-runner cities** (AP01-11, corresponding front-runner cities as defined in the frame of WP1/WP3, and also listed in D1.1) **and make as much as possible of them available via a standard interface** (Copernicus Core Services Interface - CCSI - presented in the previous section of this report).

This section of the report summarizes all this relevant data, which will be made available via the CCSI, including relevant data repository, details of the access to specific CCS datasets as well as limitations in data availability if any. Beside this, this chapter also provides an overview of the Copernicus satellite data and the non-Copernicus data coming from the local city open data repositories or other sources, which will serve as additional inputs for some of the CURE applications.

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<sup>1</sup> [https://ec.europa.eu/growth/sectors/space/copernicus\\_en](https://ec.europa.eu/growth/sectors/space/copernicus_en)



### 3.1 Copernicus Core Services for CURE cross-cutting applications

The second main type of input data for the CURE applications will come from the Copernicus Core Services - in particular from:

- Copernicus Land Monitoring Service
- Copernicus Atmosphere Monitoring Service
- Copernicus Climate Change Service
- Copernicus Emergency Management Service

The scheme below illustrates from which Copernicus Core service/s the data are relevant for which of CURE cross-cutting applications.

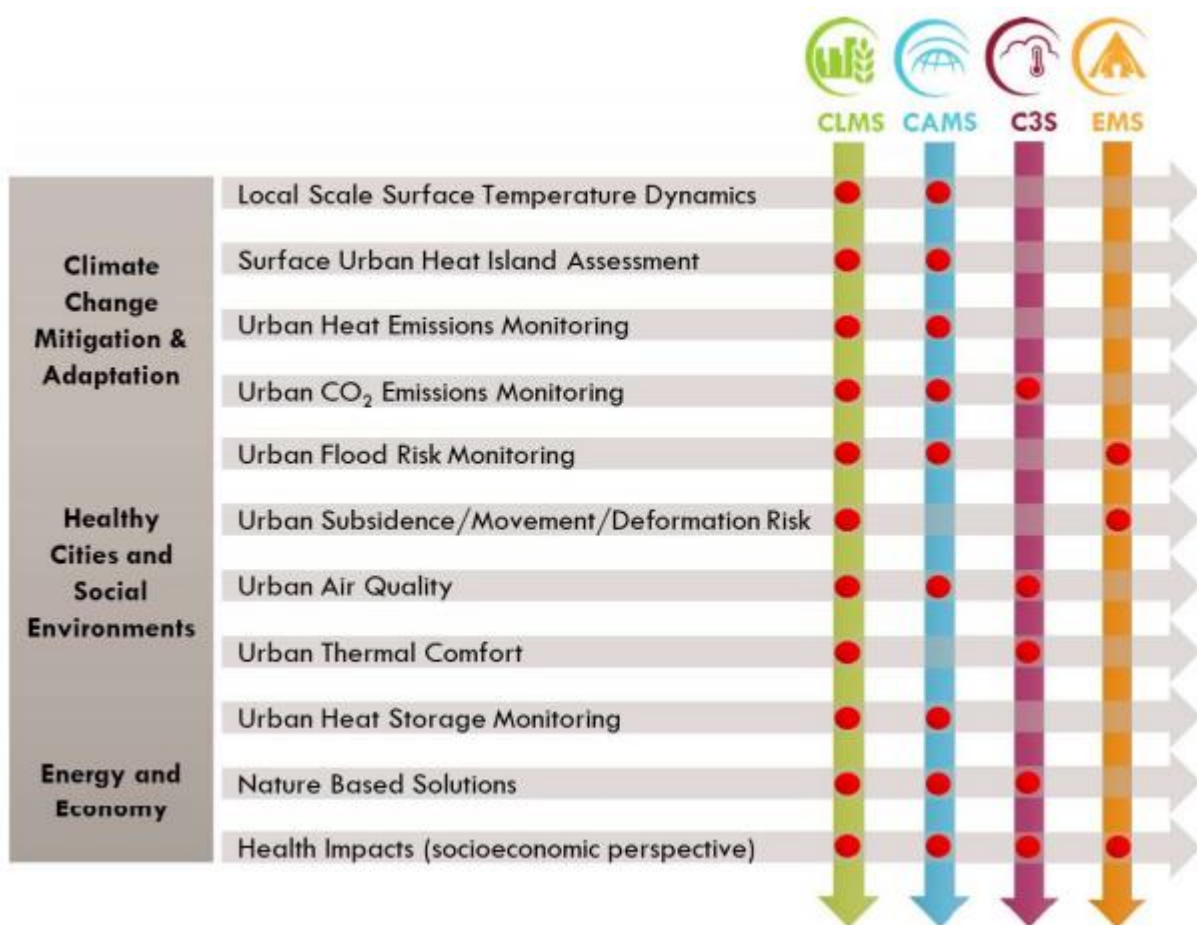


Figure 5: Relevance of the CCS data for particular CURE applications. (scheme taken from the project proposal). The red dots indicate which Core Service provides inputs to which of the applications.

#### 3.1.1 Access to Copernicus Core Services datasets

The datasets belonging to the Copernicus Core Services are stored and accessible in an harmonized way.



Primarily, the CCS datasets are stored in copernicus.eu domain repositories and can be accessed via the copernicus.eu data catalogues and stores. There are four main data CCS stores/repositories depending on the type of the data:

- The datasets from the Pan-European, Local and Imagery and reference data components of the Copernicus Land Monitoring Service can be downloaded from the **CLMS portal**<sup>2</sup>.
- The datasets belonging to the Global component of the CLMS can be downloaded from the **Copernicus Global Land Service portal**<sup>3</sup>.
- **Atmosphere Data Store**<sup>4</sup> for the Copernicus Atmosphere Service.
- **Climate Data Store**<sup>5</sup> for the Copernicus Climate Change Service and also for Emergency Management Service datasets.

The storage/accessibility of each CCS dataset in particular CCS repository is indicated in the tables presenting lists of relevant datasets from each type of CCS.

Also the Copernicus Core Services datasets are made available through the **Copernicus Data and Information Access Services (DIAS)**. During the next phase of the WP2 - implementation of the Copernicus Core Services Interface - it will be explored, tested and assessed from which repositories it will be most advantageous to grab the input CCS datasets.

The following chapters are dedicated to description of each of the three relevant Copernicus Core Services - CLMS, CAMS and C3S and corresponding data products characteristics, storage and access, as well as their planned use for relevant CURE apps and availability for relevant combinations of CURE apps, front-runner pilot cities and years, including potential gaps.

### 3.1.2 Copernicus Land Monitoring Service

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

CLMS products are divided into five categories:

- Systematic biophysical monitoring
- Land cover & land use mapping
- Thematic hotspot mapping
- Reference data

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<sup>2</sup> <https://land.copernicus.eu/>

<sup>3</sup> <https://land.copernicus.vgt.vito.be/>

<sup>4</sup> <https://ads.atmosphere.copernicus.eu/>

<sup>5</sup> <https://cds.climate.copernicus.eu/>



- Ground motion service

These categories enable applications to be developed in a wide range of areas. These include

- Spatial and urban planning
- Forest management
- Water management
- Agriculture & food security
- Nature conservation and restoration
- Ecosystem accounting
- Mitigation to climate change

The products and services (and their priorities) are continually evolving and their creation and development are defined in consultation with stakeholder communities, who receive advice from the Copernicus User Forum. The priorities are set by the European Commission and EU Member States and participating countries within the Copernicus Committee. The European Environment Agency (EEA) also works in collaboration with other Copernicus Services, such as Copernicus Marine Environment Monitoring and Copernicus Emergency Management, to create new products.

The Copernicus Land Monitoring Service has been jointly implemented by the European Environment Agency (EEA) and the Joint Research Centre (JRC) since 2011.

**The Copernicus Land Monitoring Service is free to access by any citizen or organisation in the world.**

Any citizen or organisation around the world can access the Copernicus Land Monitoring Service on a free, full and open access basis. This is in line with the Copernicus Programme's overall data and information policy which promotes the use and sharing of Copernicus information and data. There is no restriction on the use, reproduction or redistribution of the information and data.<sup>6</sup>

For the CURE applications, following data products of the CLMS will be used as the input data.

The following sub-chapters detail each of these data products, including relevant Copernicus data repository, as well as limitations (if any) in data availability for relevant CURE apps, front-runner cities and years requested.

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<sup>6</sup> <https://land.copernicus.eu/>





CLMS data product	AP 01	AP 02	AP 03	AP 04	AP 05	AP 06	AP 07	AP 08	AP 09	AP 10	AP 11	Original Catalogue/Repository
<a href="#">Imperviousness</a>	yes	yes	yes	yes	yes	yes		yes		yes		<a href="https://land.copernicus.eu/land-files/">https://land.copernicus.eu/land-files/</a>
<a href="#">Urban Atlas</a>	yes	yes	yes						yes	yes		<a href="https://land.copernicus.eu/land-files/">https://land.copernicus.eu/land-files/</a>
<a href="#">Urban Atlas: Building Heights</a>	yes		yes				yes	yes	yes	yes		<a href="https://land.copernicus.eu/land-files/">https://land.copernicus.eu/land-files/</a>
<a href="#">Urban Atlas: Street Tree Layer</a>								yes		yes		<a href="https://land.copernicus.eu/land-files/">https://land.copernicus.eu/land-files/</a>
<a href="#">European Settlement Map</a>		yes										<a href="https://land.copernicus.eu/land-files/">https://land.copernicus.eu/land-files/</a>
<a href="#">European Image Mosaic - High Resolution</a>					yes	yes				yes		<a href="https://land.copernicus.eu/land-files/">https://land.copernicus.eu/land-files/</a>
<a href="#">EU-DEM</a>								yes	yes			<a href="https://land.copernicus.eu/land-files/">https://land.copernicus.eu/land-files/</a>
<a href="#">Tree Cover Density</a>								yes				<a href="https://land.copernicus.eu/land-files/">https://land.copernicus.eu/land-files/</a>
<a href="#">Phenology and Productivity Parameters</a>	yes											not available yet
<a href="#">Vegetation Indices</a>	yes											not available yet
<a href="#">Land Surface Temperature</a>										yes		<a href="https://land.copernicus.vgt.vito.be/">https://land.copernicus.vgt.vito.be/</a>
<a href="#">Surface Albedo</a>										yes		<a href="https://land.copernicus.vgt.vito.be/">https://land.copernicus.vgt.vito.be/</a>
<a href="#">Fraction of Green Vegetation Cover</a>										yes		<a href="https://land.copernicus.vgt.vito.be/">https://land.copernicus.vgt.vito.be/</a>
<a href="#">Leaf Area Index</a>										yes		<a href="https://land.copernicus.vgt.vito.be/">https://land.copernicus.vgt.vito.be/</a>
<a href="#">Vegetation Condition Index</a>										yes		<a href="https://land.copernicus.vgt.vito.be/">https://land.copernicus.vgt.vito.be/</a>
<a href="#">Normalized Difference Vegetation Index (NDVI)</a>								yes		yes		<a href="https://land.copernicus.vgt.vito.be/">https://land.copernicus.vgt.vito.be/</a>
<a href="#">Fractional Snow Cover / Snow Cover Extent</a>						yes						<a href="https://land.copernicus.vgt.vito.be/">https://land.copernicus.vgt.vito.be/</a>

Table 4. List of relevant CLMS datasets - summary for all apps

### 3.1.2.1 HRL Imperiousness

High Resolution Layer - Imperviousness products capture the percentage and change of soil sealing. Sealed/Impervious areas are characterized by the substitution of the original (semi-) natural land cover or water surface with an artificial, often impervious cover. These artificial surfaces are usually maintained over long periods of time. The imperviousness HRL captures the spatial distribution of artificially sealed areas, including the level of sealing of the soil per area unit.



The level of sealed soil (imperviousness degree 1-100%) is produced using a semi-automated classification, based on calibrated NDVI<sup>7</sup>.

The Imperviousness Density (IMD) available from 2006 is a thematic product showing the sealing density in the range from 0-100%.<sup>8</sup>

The Impervious Built-up (IBU) product available from the year 2018 on is a thematic product showing the binary information of building (class 1) and no building (class 0) within the sealing outline derived from the IMD. The production of the high resolution Built-up layer was coordinated by the European Environment Agency (EEA) in the frame of the EU Copernicus programme.<sup>9</sup>

The Impervious Built-up shows built-up areas, the part of the sealed surfaces where buildings can be found. Built-up areas are a sub-group of the sealed areas. It refers to areas where above-ground building constructions can be found. In contrast to the Imperviousness Density characterized by a continuous range of imperviousness measurements, Built-up in the HRL 2018 is a binary product, expressed as built-up or non-built-up areas. This product is new for the 2018 mapping campaign and is available in 10 meter resolution, as well as a 100 meter aggregated version called Share of Built-up (SBU).

<b>Copernicus Service</b>	CLMS
<b>Product family</b>	detailed thematic layers
<b>Product name + link</b>	<a href="#">Imperviousness</a>
<b>Relevant for CURE apps</b>	01, 02, 03, 04, 05, 06, 08, 10
<b>Reference years or time period available</b>	2006, 2009, 2012, 2015, 2018 (incl. IBU), change maps for each period
<b>Geographic coverage</b>	EEA39
<b>Spatial resolution, map scale or MMU</b>	10m (2015, 2018), 20m, 100m
<b>Update frequency</b>	3 years
<b>Delivery timeliness</b>	Decreasing: 1.5 years for the 2015 reference year
<b>Status</b>	Available for entire Europe

<sup>7</sup> <https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness>

<sup>8</sup> <https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness/status-maps/imperviousness-density-2018?tab=metadata>

<sup>9</sup> <https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness/status-maps/impervious-built-up-2018?tab=metadata>



<b>Roadmap</b>	Update for the 2018 reference year started in Q1 2019
<b>Main EO data sources used</b>	IRS-P6 LISS-III, SPOT 5 and Landsat 8 for the 2015 reference year
<b>Format</b>	Raster

Table 5. HRL Imperiousness specification

The product is stored in the main CLMS repository: <https://land.copernicus.eu/land-files/>. It is tiled into regular grid cells, so the user needs to specify the grid-cell code of interest. For the year 2018, the product can be downloaded by country. For each country, a single zip file is prepared to be downloaded. Inside this zip file, the layer is still divided into regular grid-cells. So if the user is only interested in the specific city, the volume of downloaded data can be limited by selection of appropriate tiles.

### 3.1.2.2 *Urban Atlas*

The Urban Atlas provides pan-European comparable land cover and land use data for Functional Urban Areas (FUA) with harmonized nomenclature<sup>10</sup> containing more than 20 detailed urban sub-classes. For the year 2018, the product is available for Heraklion and Sofia (published on 09/2020), not available yet for Berlin, Copenhagen (in production).

<b>Copernicus Service</b>	CLMS
<b>Product family</b>	European Hotspots
<b>Product name + link</b>	<a href="#">Urban Atlas</a>
<b>Relevant for CURE apps</b>	01, 02, 03, 05, 06, 09, 10
<b>Reference years or time period available</b>	2006, 2012, 2018 (Berlin, Copenhagen in production) and change maps (2006-12, 2012-18)
<b>Geographic coverage</b>	Increasing: 785 FUAs in EEA39 countries for the 2012 reference year

<sup>10</sup> [https://land.copernicus.eu/user-corner/technical-library/urban\\_atlas\\_2012\\_2018\\_mapping\\_guide\\_v6-1.pdf](https://land.copernicus.eu/user-corner/technical-library/urban_atlas_2012_2018_mapping_guide_v6-1.pdf)



Spatial resolution, map scale or MMU	Class dependent 0.25ha or 1ha MMU
Update frequency	6 years
Delivery timeliness	Depending on the availability and quality of the input imagery
Status	Available
Roadmap	Update for the 2018 reference year started in Q2 2019
Main EO data sources used	Multispectral SPOT 5, 6, Formosat-2 pan-sharpened
Format	Vector

Table 6. Urban Atlas specification

The product is stored in the main CLMS repository: <https://land.copernicus.eu/land-files/>. It can be downloaded separately for each FUA region of each city. A zip file with vector layer and nomenclature is downloaded.

### 3.1.2.3 Urban Atlas - Building Heights

A 10m high resolution raster layer containing height information is generated for core urban areas of capitals of the EEA39 as part of the Urban atlas. Height information is based on IRS-P5 stereo images and derived datasets like the digital surface model, the digital terrain model and the normalized DSM<sup>11</sup>.

Copernicus Service	CLMS
Product family	European Hotspots
Product name + link	<a href="#">Urban Atlas: Building Heights</a>
Relevant for CURE apps	01, 03, 07, 08, 09, 10

<sup>11</sup> <https://land.copernicus.eu/local/urban-atlas/building-height-2012?tab=metadata>



Reference years or time period available	2012
Geographic coverage	Core urban areas in the capitals of EU28 and EFTA countries
Spatial resolution, map scale or MMU	10m
Delivery timeliness	Depending on the availability and quality of the input imagery
Status	Available (except Heraklion)
Main EO data sources used	IRS-P5
Format	Raster

Table 7. Urban Atlas - Building heights specification

The product is stored in the main CLMS repository: <https://land.copernicus.eu/land-files/>. It can be downloaded separately for each FUA region of each city. A zip file with vector layer and nomenclature is downloaded.

#### **3.1.2.4 Urban Atlas - Street Tree Layer**

The Street Tree Layer (STL) is a separate layer from the Urban Atlas LC/LU layer produced within the level 1 urban mask for each FUA. It includes contiguous rows or a patches of trees covering 500 m<sup>2</sup> or more and with a minimum width of 10 meter over "Artificial surfaces" (nomenclature class 1) inside FUA (i.e. rows of trees along the road network outside urban areas or forest adjacent to urban areas should not be included).

The production of the Street Tree Layers was performed on the basis of SPOT 5 Supermode data used for the Urban Atlas 2012 production acquired between March and November months with a preference for spring and late summer imagery. An interactive automated classification approach was applied to identify contiguous rows or a patches of trees covering 500 m<sup>2</sup> or more and with a minimum width of 10 m. A post-processing routine was applied to provide the results in vector format.<sup>12</sup>

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<sup>12</sup> <https://land.copernicus.eu/local/urban-atlas/street-tree-layer-stl-2018?tab=metadata>



Copernicus Service	CLMS
Product family	European Hotspots
Product name + link	<a href="#">Urban Atlas: Street Tree Layer</a>
Relevant for CURE apps	08
Reference years or time period available	2012 (not available for CPH), 2018 (Sofia only)
Geographic coverage	Within selected FUAs (depending on availability of suitable satellite imagery) in Urban Atlas 2012, 2018
Spatial resolution, map scale or MMU	0.05ha MMU
Update frequency	6 years
Delivery timeliness	Depending on the availability and quality of the input imagery
Status	Available (limited)
Main EO data sources used	SPOT 5 Supermode
Format	Vector

Table 8. Urban Atlas - Street Tree Layer specification

The product is stored in the main CLMS repository: <https://land.copernicus.eu/land-files/>. It can be downloaded separately for each city. A zip file with a vector layer is downloaded. The availability of the Street Tree layer for the CURE front-runner cities is quite limited. For Copenhagen, it is not available at all. For Berlin and Heraklion, only the 2012 version is available. For Sofia, which is the second front-runner for which the AP08 should be implemented, both 2012 and 2018 versions are available.



### 3.1.2.5 European Settlement Map

The European Settlement Map is a spatial raster dataset that is mapping human settlements in Europe based on SPOT5 and SPOT6 satellite imagery. It is published with two associated data layers. It has been produced with GHSL technology by the European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, Global Security and Crisis Management Unit. This work has been partly financed by the Directorate General of Regional and Urban Policy, European Commission<sup>13</sup>.

From the HRL Imperviousness update for the year 2018 on, there was an integration of this (ESM) product with the Imperviousness Density product. From then on, the Impervious Built-up (IBU) product (representing integration of IMD and ESM) became a part of standard (regularly updated products) portfolio in the frame of HRL Imperviousness.

<b>Copernicus Service</b>	CLMS
<b>Product family</b>	detailed thematic layers
<b>Product name + link</b>	<a href="#">European Settlement Map</a>
<b>Reference years or time period available</b>	2012, 2015
<b>Geographic coverage</b>	EEA39
<b>Spatial resolution, map scale or MMU</b>	2.5m, 10m and 100m
<b>Update frequency</b>	Scientific product (not operational). Update frequency unknown
<b>Delivery timeliness</b>	Depending on the availability and quality of the input imagery
<b>Status</b>	Available
<b>Main EO data sources used</b>	SPOT 5 and SPOT 6 data of 2.5m pixel size
<b>Format</b>	Raster

<sup>13</sup> <https://land.copernicus.eu/pan-european/GHSL/european-settlement-map>



Table 9. European Settlement Map specification

The product is stored in the main CLMS repository: <https://land.copernicus.eu/land-files/>.

### 3.1.2.6 European Image Mosaic - High Resolution

High Resolution satellite imagery forms the input for the creation of many information products and services, such as land cover maps or high resolution layers on land cover characteristics. Having all the satellite imagery available to cover 39 countries of EEA (EEA39), it is worthwhile to process the individual image scenes into a seamless pan-European ortho-rectified mosaic.

Since 2000 the European Commission has tasked the European Space Agency (ESA) with the systematic acquisition of seamless European-wide coverages of satellite images at regular intervals. This time series of high resolution image mosaics provides the basis for underpinning and monitoring of Community policies.

The creation of such mosaics involves various processing steps such as radiometric smoothening between scenes from different dates and sensors, geometric correction to ortho-rectified products and minimizing cloud cover<sup>14</sup>.

Copernicus Service	CLMS
Product family	image mosaic
Product name + link	<a href="#">European Image Mosaic - High Resolution</a>
Relevant for CURE apps	05, 06, 10
Reference years or time period available	2006, 2009, 2012, 2015, 2018
Geographic coverage	EEA39
Spatial resolution, map scale or MMU	20m
Update frequency	3 years

<sup>14</sup> <https://land.copernicus.eu/imagery-in-situ/european-image-mosaics/high-resolution>





<b>Delivery timeliness</b>	Depending on the availability and quality of the input imagery
<b>Status</b>	Available
<b>Main EO data sources used</b>	SPOT-4/-5, RapidEye constellation, IRS-P6, Resourcesat-1, Resourcesat-2, Landsat, Sentinel-2 MSI
<b>Format</b>	Raster

Table 10. European Image Mosaic - High Resolution specification

The product is stored in the main CLMS repository: <https://land.copernicus.eu/land-files/>.

### 3.1.2.7 EU-DEM

EU-DEM v1.0 is a digital surface model (DSM) of EEA39 countries representing the first surface as illuminated by the sensors. It is a hybrid product based on SRTM and ASTER GDEM data fused by a weighted averaging approach. The statistical validation of EU-DEM v1.0 documents a relatively unbiased (-0.56 meters) overall vertical accuracy of 2.9 meters RMSE, which is fully within the contractual specification of 7m RMSE (European Commission 2009)<sup>15</sup>.

<b>Copernicus Service</b>	CLMS
<b>Product family</b>	reference data sets
<b>Product name + link</b>	<a href="#">EU-DEM</a>
<b>Relevant for CURE apps</b>	08, 09
<b>Reference years or time period available</b>	Since 2012
<b>Geographic coverage</b>	EEA39
<b>Spatial resolution, map scale or MMU</b>	25m

<sup>15</sup> <https://land.copernicus.eu/imagery-in-situ/eu-dem>



Update frequency	On demand
Delivery timeliness	N/A
Status	Available
Main EO data sources used	ASTER GDEM, SRTM
Format	Raster

Table 11. EU-DEM specification

The product is stored in the main CLMS repository: <https://land.copernicus.eu/land-files/>.

### 3.1.2.8 Tree Cover Density

The high resolution forest product consists of three types of (status) products and additional change products. The status products are available for the 2012 and 2015 reference years: 1. Tree cover density providing level of tree cover density in a range from 0-100% 2. Dominant leaf type providing information on the dominant leaf type: broadleaved or coniferous 3. A Forest type product. The forest type product allows to get as close as possible to the FAO forest definition. In its original (20m) resolution it consists of two products: 1) a dominant leaf type product that has a MMU of 0.5 ha, as well as a 10% tree cover density threshold applied, and 2) a support layer that maps, based on the dominant leaf type product, trees under agricultural use and in urban context (derived from CLC and high resolution imperviousness 2009 data). For the final 100m product trees under agricultural use and urban context from the support layer are removed. The high resolution forest change products comprise a simple tree cover density change product for 2012-2015 (% increase or decrease of real tree cover density changes)<sup>16</sup>.

The HRL Forest 2018 (09/2020) primary status layer Tree Cover Density (TCD) has been created in frame of the tender “EEA/IDM/R0/18/009 - High Resolution land cover characteristics for the 2018 reference year” as part of the EEA Copernicus Land Monitoring Service (CLMS, <https://land.copernicus.eu>). The TCD raster product provides information on the proportional crown coverage per pixel at 10m spatial resolution and ranges from 0% (all non-tree covered areas)

<sup>16</sup> <https://land.copernicus.eu/pan-european/high-resolution-layers/forests/tree-cover-density/status-maps/2012?tab=metadata>



to 100%, whereby Tree Cover Density is defined as the „vertical projection of tree crowns to a horizontal earth’s surface“.<sup>17</sup>

Copernicus Service	CLMS
Product family	detailed thematic layers
Product name + link	<a href="#">Tree Cover Density</a>
Relevant for CURE apps	08
Reference years or time period available	2012, 2015, 2018
Geographic coverage	EEA39
Spatial resolution, map scale or MMU	10m (2018), 20m, 100m
Update frequency	3 years
Delivery timeliness	Decreasing: 1.5 years for the 2015 reference year
Status	Available
Roadmap	Update for the 2018 reference year started in Q1 2019
Main EO data sources used	Sentinel-2, Landsat 8 for the 2015 reference year
Format	Raster

Table 12. Tree cover density specification

<sup>17</sup> <https://land.copernicus.eu/pan-european/high-resolution-layers/forests/tree-cover-density/status-maps/tree-cover-density-2018?tab=metadata>



The product is stored in the main CLMS repository: <https://land.copernicus.eu/land-files/>. For the years 2012 and 2015, it is tiled into regular grid cells, so the user needs to specify the grid-cell code of interest. For the year 2018, the product can be downloaded by country.

### **3.1.2.9 Phenology and Productivity Parameters**

Phenology and Productivity Parameters and Vegetation Indices are currently in production. As they were not available at the time of submission of this report. The AP01 developers (led by FORTH) are planning to prepare corresponding layers based on Sentinel-2 satellite imageries for the time-being.

The pan-European High-Resolution Vegetation Phenology and Productivity products (HR-VPP) are to be provided at a high spatial resolution (10 m x 10 m), and are derived from the Sentinel-2 constellation data (Sentinel-2A and Sentinel-2B: with a revisit time 5 of days). They will be generated over the entire EEA39 region (33 member countries and 6 cooperating countries) for the period January 1 2017 onwards.

Three types of HR-VPP products are proposed for users, they are:

- The raw Vegetation Index (VI). This will be a raw product generated in near real-time (NRT) providing for every pixel to record the status of the vegetation. The status is provided in four ways: Leaf Area Index (LAI), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Normalised Difference Vegetation Index (NDVI) and Plant Phenology Index (PPI);
- The Seasonal Trajectories (ST) product will be provided on an ongoing basis every 10 days derived from a function of the yearly time-series of the raw Plant Phenology Index, and hence generated together with the VPP product;
- The Vegetation Phenology Parameters (VPP) product will be generated on a yearly basis and provide metrics for up to two growing seasons, i.e. start of the season, end of season, seasonal productivity, etc.

The ideal user settings for the turnaround of NRT HR-VPP products after Sentinel-2 data sensing will be no later than 12 hours. The maximum limit acceptable for time-critical applications such as crop monitoring, seasonal biomass estimation, drought/flood impact etc is 24 hours. The other HR-VPP products are targeted to assess ecosystems, to monitor biodiversity and climate change and are requested on a yearly basis, no later than 3 months after the end of the calendar year.<sup>18</sup>

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<sup>18</sup> <https://land.copernicus.eu/pan-european/biophysical-parameters/high-resolution-vegetation-phenology-and-productivity>



Copernicus Service	CLMS
Product family	Vegetation and soil moisture
Product name + link	<a href="#">Phenology and Productivity Parameters</a>
Relevant for CURE apps	01
Reference years or time period available	2017 - yearly
Geographic coverage	EEA39
Spatial resolution, map scale or MMU	10 – 20m
Update frequency	As Sentinel 2 data
Delivery timeliness	Within 1-3 days after sensing
Status	Planned
Roadmap	Production starts in 2020
Main EO data sources used	Sentinel-2 A/B (Level 2A)

Table 13. Phenology and Productivity Parameters specification



### 3.1.2.10 Vegetation Indices

Phenology and Productivity Parameters and Vegetation Indices are currently in production. As they were not available at the time of submission of this report. The AP01 developers (led by FORTH) are planning to prepare corresponding layers based on Sentinel-2 satellite imageries for the time-being.

Copernicus Service	CLMS
Product family	Vegetation and soil moisture
Product name + link	<a href="#">Vegetation Indices</a>
Relevant for CURE apps	01
Reference years or time period available	2017 - yearly
Geographic coverage	EEA39
Spatial resolution, map scale or MMU	10-20m
Update frequency	5-10 days
Delivery timeliness	Yearly in Q1
Status	Planned
Roadmap	Production starts in 2020
Main EO data sources used	Sentinel-2 A/B (Level 2A)

Table 14. Vegetation Indices specification



### 3.1.2.11 Land Surface Temperature

The Land Surface Temperature (LST) is the radiative skin temperature of the land surface, as measured in the direction of the remote sensor. It is estimated from Top-of-Atmosphere brightness temperatures from the infrared spectral channels of a constellation of geostationary satellites (Meteosat Second Generation, GOES, MTSAT/Himawari). Its estimation further depends on the albedo, the vegetation cover and the soil moisture.

CLMS LST is a mixture of vegetation and bare soil temperatures. Because both respond rapidly to changes in incoming solar radiation due to cloud cover and aerosol load modifications and diurnal variation of illumination, the LST displays quick variations too. In turn, the LST influences the partition of energy between ground and vegetation, and determines the surface air temperature.

<b>Copernicus Service</b>	CLMS
<b>Product family</b>	Energy
<b>Product name + link</b>	<a href="#">Land Surface Temperature</a>
<b>Relevant for CURE apps</b>	10
<b>Reference years or time period available</b>	Oct 2010 - present
<b>Geographic coverage</b>	Global
<b>Spatial resolution, map scale or MMU</b>	5km
<b>Update frequency</b>	hourly
<b>Delivery timeliness</b>	Within 4 hours
<b>Status</b>	Available
<b>Main EO data sources used</b>	Imagers on-board geostationary satellites
<b>Format</b>	NetCDF



Table 15. Land and Surface Temperature specification

The Global Land Service provides the following LST-based products:

- LST: hourly LST from instantaneous observations
- LST10-DC: 10-day Land Surface Temperature with Daily Cycle
- LST10-TCI: Thermal Condition Index with a 10-day composite of Land Surface Temperature.

The product is stored in the <https://land.copernicus.vgt.vito.be/> repository.

### 3.1.2.12 Surface Albedo

The surface albedo quantifies the fraction of the sunlight reflected by the surface of the Earth. Different albedo concepts are defined:

1. The directional albedo or directional-hemispherical reflectance (also called black-sky albedo) is the integration of the bi-directional reflectance over the viewing hemisphere. It assumes all energy is coming from a direct radiation from the sun and is computed for a specific time.
2. The hemispherical albedo or bi-hemispherical reflectance (also called white-sky albedo) is the integration of the directional albedo over the illumination hemisphere. It assumes a complete diffuse illumination.

The Global Climate Observing System (GCOS) specified the black-sky albedo (directional albedo) as an Essential Climate Variable and the product is required for climate change purposes<sup>19</sup>.

Copernicus Service	CLMS
Product family	Energy
Product name + link	<a href="#">Surface Albedo</a>
Relevant for CURE apps	10
Reference years or time period available	1998- present
Geographic coverage	Global

<sup>19</sup> <https://land.copernicus.eu/global/products/sa>





Spatial resolution, map scale or MMU	1km
Update frequency	10-daily
Delivery timeliness	Within 3 days after the end of each decade
Status	Available
Main EO data sources used	PROBA-V
Format	NetCDF

Table 16. Surface Albedo specification

The product is stored in the <https://land.copernicus.vgt.vito.be/> repository.

### 3.1.2.13 Fraction of Green Vegetation Cover

The Fraction of Vegetation Cover (FCover) corresponds to the fraction of ground covered by green vegetation. Practically, it quantifies the spatial extent of the vegetation. Because it is independent from the illumination direction and it is sensitive to the vegetation amount, FCover is a very good candidate for the replacement of classical vegetation indices for the monitoring of ecosystems<sup>20</sup>.

Copernicus Service	CLMS
Product family	Vegetation and soil moisture
Product name + link	<a href="#">Fraction of Green Vegetation Cover</a>
Relevant for CURE apps	10
Reference years or time period available	Jan 2014 - present
Geographic coverage	Global

<sup>20</sup> <https://land.copernicus.eu/global/products/fcover>



Spatial resolution, map scale or MMU	300m
Update frequency	10-daily, with consolidations
Delivery timeliness	Within 3 days after end of the synthesis period, with consolidations
Status	Available
Main EO data sources used	PROBA-V
Format	NetCDF

Table 17. Fraction of Green Vegetation Cover specification

The product is stored in the <https://land.copernicus.vgt.vito.be/> repository.

#### 3.1.2.14 Leaf Area Index

The Leaf Area Index is defined as half the total area of green elements of the canopy per unit horizontal ground area. The satellite-derived value corresponds to the total green LAI of all the canopy layers, including the understory which may represent a very significant contribution, particularly for forests. Practically, the LAI quantifies the thickness of the vegetation cover.

LAI is recognized as an Essential Climate Variable (ECV) by the Global Climate Observing System (GCOS)<sup>21</sup>.

Copernicus Service	CLMS
Product family	Vegetation and soil moisture
Product name + link	<a href="#">Leaf Area Index</a>
Relevant for CURE apps	10
Reference years or time period available	Jan 2014 - present

<sup>21</sup> <https://land.copernicus.eu/global/products/lai>



Geographic coverage	Global
Spatial resolution, map scale or MMU	300m
Update frequency	10-daily, with consolidations
Delivery timeliness	Within 3 days after the end of synthesis period, with consolidations
Status	Available
Main EO data sources used	PROBA-V
Format	NetCDF

Table 18. Leaf Area Index specification

The product is stored in the <https://land.copernicus.vgt.vito.be/> repository.

### 3.1.2.15 Vegetation Condition Index

The Vegetation Condition Index (VCI) compares the current NDVI to the range of values observed in the same period in previous years. The VCI is expressed in % and gives an idea where the observed value is situated between the extreme values (minimum and maximum) in the previous years. Lower and higher values indicate bad and good vegetation state conditions, respectively<sup>22</sup>.

Copernicus Service	CLMS
Product family	Vegetation and soil moisture
Product name + link	<a href="#">Vegetation Condition Index</a>
Relevant for CURE apps	10
Reference years or time period available	Jan 2014 - present

<sup>22</sup> <https://land.copernicus.eu/global/products/vci>



Geographic coverage	Global
Spatial resolution, map scale or MMU	1km
Update frequency	10-daily
Status	Available
Main EO data sources used	SPOT-VGT, PROBA-V
Format	NetCDF

Table 19. Vegetation Condition Index specification

The product is stored in the <https://land.copernicus.vgt.vito.be/> repository.

### 3.1.2.16 Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI) is an indicator of the greenness of the biomes. As such, it is closely linked to the FAPAR<sup>23</sup>.

Even though it is not a physical property of the vegetation cover, it is very simple formulation

$$NDVI = (REF_{nir} - REF_{red}) / (REF_{nir} + REF_{red})$$

where REF\_nir and REF\_red are the spectral reflectances measured in the near infrared and red wavebands respectively, makes it widely used for ecosystems monitoring<sup>24</sup>.

Copernicus Service	CLMS
Product family	Vegetation and soil moisture
Product name + link	<a href="#">Normalized Difference Vegetation Index (NDVI)</a>
Relevant for CURE apps	08, 10

<sup>23</sup> <https://land.copernicus.eu/global/products/fapar>

<sup>24</sup> <https://land.copernicus.eu/global/products/ndvi>



Reference years or time period available	Jan 2014 - present
Geographic coverage	Global
Spatial resolution, map scale or MMU	300m
Update frequency	10-daily
Delivery timeliness	Within 3 days after end of synthesis period
Status	Available
Main EO data sources used	PROBA-V
Format	NetCDF

Table 20. NDVI specification

The product is stored in the <https://land.copernicus.vgt.vito.be/> repository.

### 3.1.2.17 Fractional Snow Cover / Snow Cover Extent

Snow cover is highly sensitive to changes in temperature (freezing/thaw) and precipitation (snowfall, rain, hail) and affects directly the albedo and thus the energy balance of the Earth's surface. It is a relevant input parameter for weather forecasts and climate change observations. Snow stores a significant mass of water and, with its high dynamic, has a strong effect on regional and global energy and water cycles. Together with the Snow Water Equivalent (SWE) product from passive microwave sensors, that provides information on the water content in the snow on plain areas, with limitations in mountainous areas, up-to-date knowledge about the snow cover extent is an important information for hydrological runoff modelling and for assessing natural hazards such as flood events.

Snow cover is specified as Essential Climate Variable (ECV) by the Global Climate Observing System (GCOS)<sup>25</sup>.

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<sup>25</sup> <https://land.copernicus.eu/global/products/sce>



Copernicus Service	CLMS
Product family	Cryosphere
Product name + link	<a href="#">Fractional Snow Cover / Snow Cover Extent</a>
Reference years or time period available	January 2018 - present
Geographic coverage	Northern Hemisphere
Spatial resolution, map scale or MMU	0.01 degree
Update frequency	daily
Delivery timeliness	Within 1 day
Status	Available
Format	NetCDF

Table 21. Fractional Snow Cover / Snow Cover Extent specification

The product is stored in the <https://land.copernicus.vgt.vito.be/> repository.

### 3.1.3 Copernicus Climate Change Monitoring Service

The Copernicus Climate Change Service (C3S) supports society by providing authoritative information about the past, present and future climate in Europe and the rest of the World.

The C3S mission is to support adaptation and mitigation policies of the European Union by providing consistent and authoritative information about climate change. We offer free and open access to climate data and tools based on the best available science. We listen to our users and endeavour to help them meet their goals in dealing with the impacts of climate change.

C3S relies on climate research carried out within the World Climate Research Programme (WCRP) and responds to user requirements defined by the Global Climate Observing System (GCOS). C3S provides an important resource to the Global Framework for Climate Services (GFCS).



C3S is implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Commission. ECMWF is an independent intergovernmental organisation serving its Member and Co-operating States and the broader community. The majority of C3S service elements are implemented by about 260 companies and organisations across Europe, which are selected based on competitive Invitations To Tender (ITTs)<sup>26</sup>.

The access to the C3S data are provided via the Climate Data Store (CDS): <https://cds.climate.copernicus.eu/#!/home>. It is freely available and functions as a one-stop shop to explore and download the climate data. A registration (for free) is needed to obtain access to the CDS. The store is developing in an interactive way, so new data are continuously being added into the repository.

A catalogue is available in the frame of the CDS: <https://cds.climate.copernicus.eu/cdsapp#!/search?type=dataset> for the users to be able to search for relevant datasets. This catalogue provides all the relevant information on each dataset, including detailed metadata.

Copernicus Service	CLMS data product	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	Original Catalogue/Repository
		01	02	03	04	05	06	07	08	09	10	11	
C3S	<a href="#">ERA5 hourly data on single levels from 1979 to present</a>							yes	yes				<a href="https://cds.climate.copernicus.eu/">https://cds.climate.copernicus.eu/</a>
C3S	<a href="#">ERA5-Land hourly data from 1981 to present</a>			yes				yes	yes				<a href="https://cds.climate.copernicus.eu/">https://cds.climate.copernicus.eu/</a>
C3S	<a href="#">E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations</a>				yes	yes	yes						<a href="https://cds.climate.copernicus.eu/">https://cds.climate.copernicus.eu/</a>
C3S	<a href="#">ERA5 hourly data on pressure levels from 1979 to present</a>								yes				<a href="https://cds.climate.copernicus.eu/">https://cds.climate.copernicus.eu/</a>
C3S	<a href="#">Thermal comfort indices derived from ERA5 reanalysis</a>								yes				<a href="https://cds.climate.copernicus.eu/">https://cds.climate.copernicus.eu/</a>

Table 22. List of relevant C3S datasets - summary for all apps

The following sub-chapters detail each of these data products, including relevant data repository, as well as limitations in data availability if any.

<sup>26</sup> <https://climate.copernicus.eu/>



### **3.1.3.1 ERA5 hourly data**

ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset using the laws of physics. This principle, called data assimilation, is based on the method used by numerical weather prediction centres, where every so many hours (12 hours at ECMWF) a previous forecast is combined with newly available observations in an optimal way to produce a new best estimate of the state of the atmosphere, called analysis, from which an updated, improved forecast is issued. Reanalysis works in the same way, but at reduced resolution to allow for the provision of a dataset spanning back several decades. Reanalysis does not have the constraint of issuing timely forecasts, so there is more time to collect observations, and when going further back in time, to allow for the ingestion of improved versions of the original observations, which all benefit the quality of the reanalysis product.

The assimilation system is able to estimate biases between observations and to sift good-quality data from poor data. The laws of physics allow for estimates at locations where data coverage is low, such as for surface temperature in the Arctic. The provision of estimates at each grid point around the globe for each regular output time, over a long period, always using the same format, makes reanalysis a very convenient and popular dataset to work with.

The observing system has changed drastically over time, and although the assimilation system can resolve data holes, the initially much sparser networks will lead to less accurate estimates. For this reason, ERA5 includes an uncertainty estimate that provides guidance on where products are expected to be more and where less accurate.

When complete, ERA5 will contain a detailed record of the evolution of the global atmosphere from 1950 onwards with a total size of about 9 Petabytes. ERA5 will replace the ERA-Interim reanalysis, which is now 10 years old.

Although the analysis procedure considers chunks of data in a window of 12 hours in one go, ERA5 provides estimates for each hour of the day, worldwide. This is made possible by the 4D-Var assimilation method, which takes account of the exact timing of the observations and model evolution within the assimilation window. This hourly output resolution is quite an improvement with respect to ERA-Interim, and provides a more detailed evolution of particular weather events.

Variables are produced at the surface and on model levels but are also interpolated to three other level types: pressure levels, potential temperature levels and one potential vorticity level. In order to make data access more manageable, the ERA5 dataset has been split into several records.

Daily updates are available about 5 days behind real time. Initial release data, i.e. data no more than three months behind real time, is called ERA5T. In the event that serious flaws are detected in ERA5T, this data could be different to the final ERA5 data. In practice, though, this will be very unlikely to occur. Based on experience with the production of ERA5 so far (and ERA-Interim in the





past), our expectation is that such an event would not occur more than once every few years, if at all. In the unlikely event that such a correction is required, users will be notified as soon as possible.

The present record is the "ERA5 hourly estimates of variables on single levels".<sup>27</sup>

Copernicus Service	C3S
Product family	reanalysis
Product name + link	<a href="#">ERA5 hourly data on single levels from 1979 to present</a>
Relevant for CURE apps	07, 08
Description	ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset using the laws of physics
Parameter	> 260 Variables.
Reference years or time period available	1979 – present
Geographic coverage	global
Spatial resolution, map scale or MMU	Reanalysis: 0.25°x0.25° (atmosphere), 0.5°x0.5° (ocean waves), Mean, spread and members: 0.5°x0.5° (atmosphere), 1°x1° (ocean waves)
Temporal Resolution	hourly
Update frequency	Daily
Delivery timeliness	after 5 days

<sup>27</sup> <https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview>



Status	Available
Format	GRIB/NetCDF

Table 23. ERA5 hourly data (a) specification

Copernicus Service	C3S
Product family	reanalysis
Product name + link	<a href="#">ERA5 hourly data on pressure levels from 1979 to present</a>
Relevant for CURE apps	08
Description	ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset using the laws of physics.
Parameter	Divergence, Fraction of cloud cover, Geopotential, Ozone mass mixing ratio, Potential vorticity, Relative humidity, Specific cloud ice water content, Specific cloud liquid water content, Specific humidity, Specific rain water content, Specific snow water content, Temperature, U-component of wind, V-component of wind, Vertical velocity, Vorticity (relative)
Reference years or time period available	1979 – present
Geographic coverage	global
Spatial resolution, map scale or MMU	Reanalysis: 0.25°x0.25°, Mean, spread and members: 0.5°x0.5°
Temporal Resolution	hourly
Update frequency	Daily



Delivery timeliness	after 5 days
Status	Available
Format	GRIB/NetCDF

Table 24. ERA5 hourly data (b) specification

Copernicus Service	C3S
Product family	reanalysis
Product name + link	<a href="#">ERA5-Land hourly data from 1981 to present</a>
Relevant for CURE apps	03
Description	ERA5-Land is a reanalysis dataset providing a consistent view of the evolution of land variables over several decades at an enhanced resolution compared to ERA5.
Parameter	> 50 variables
Reference years or time period available	January 1981 – present
Geographic coverage	global
Spatial resolution, map scale or MMU	0.1°x0.1°; Native resolution is 9 km
Temporal Resolution	hourly
Update frequency	monthly
Delivery timeliness	about three months relatively to actual date.



<b>Status</b>	Available
<b>Format</b>	GRIB/NetCDF

Table 25. ERA5 hourly data (c) specification

### 3.1.3.2 Thermal comfort indices derived from ERA5 reanalysis

This dataset provides a complete historical reconstruction for a set of indices representing human thermal stress and discomfort in outdoor conditions. This dataset, also known as ERA5-HEAT (Human thErMAl comfOrT) represents the current state-of-the-art for bioclimatology data record production.

The dataset is organised around two main variables:

- the mean radiant temperature (MRT)
- the universal thermal climate index (UTCI)

These variables describe how the human body experiences atmospheric conditions, specifically air temperature, humidity, ventilation and radiation.

The dataset is computed using the ERA5 reanalysis from the European Centre for Medium-Range Forecasts (ECMWF). ERA5 combines model data with observations from across the world to provide a globally complete and consistent description of the Earth’s climate and its evolution in recent decades. ERA5 is regarded as a good proxy for observed atmospheric conditions.

The dataset currently covers 01/01/1979 to near real time and is regularly extended as ERA5 data become available.

The dataset is produced by the European Centre for Medium-range Weather Forecasts<sup>28</sup>.

<b>Copernicus Service</b>	C3S
<b>Product family</b>	reanalysis
<b>Product name + link</b>	<a href="https://cds.climate.copernicus.eu/cdsapp#!/dataset/derived-utci-historical?tab=overview">Thermal comfort indices derived from ERA5 reanalysis</a>

<sup>28</sup> <https://cds.climate.copernicus.eu/cdsapp#!/dataset/derived-utci-historical?tab=overview>



Relevant for CURE apps	08
Description	This dataset provides a complete historical reconstruction for a set of indices representing human thermal stress and discomfort in outdoor conditions. This dataset, also known as ERA5-HEAT (Human thErMAL comforT) represents the current state-of-the-art for bioclimatology data record production.
Parameter	mean radiant temperature, universal thermal climate index
Reference years or time period available	1979-01-01 – near real time for the most recent version.
Geographic coverage	global except for Antarctica (90N-60S, 180W-180E)
Spatial resolution, map scale or MMU	0.25° x 0.25°
Temporal Resolution	hourly
Update frequency	Intermediate dataset updated daily in near real time, Consolidated dataset monthly updates with 2-3 month delay behind real time.
Status	Available
Format	NetCDF

Table 26. ERA5 thermal comfort specification

### 3.1.3.3 E-OBS daily gridded meteorological data for Europe

E-OBS is a daily gridded land-only observational dataset over Europe. The blended time series from the station network of the European Climate Assessment & Dataset (ECA&D) project form the basis for the E-OBS gridded dataset. All station data are sourced directly from the European National Meteorological and Hydrological Services (NMHSs) or other data holding institutions. For a considerable number of countries the number of stations used is the complete national network and therefore much more dense than the station network that is routinely shared among NMHSs (which is the basis of other gridded datasets). The density of stations gradually increases through collaborations with NMHSs within European research contracts.



Initially, in 2008, this gridded dataset was developed to provide validation for the suite of Europe-wide climate model simulations produced as part of the European Union ENSEMBLES project. While E-OBS remains an important dataset for model validation, it is also used more generally for monitoring the climate across Europe, particularly with regard to the assessment of the magnitude and frequency of daily extremes.

The position of E-OBS is unique in Europe because of the relatively high spatial horizontal grid spacing, the daily resolution of the dataset, the provision of multiple variables and the length of the dataset. Finally, the station data on which E-OBS is based are available through the ECA&D webpages (where the owner of the data has given permission to do so). In these respects it contrasts with other datasets.

The dataset is daily, meaning the observations cover 24 hours per time step. The exact 24-hour period can be different per region. The reason for this is that some data providers measure between midnight to midnight while others might measure from morning to morning. Since E-OBS is an observational dataset, no attempts have been made to adjust time series for this 24-hour offset. It is made sure, where known, that the largest part of the measured 24-hour period corresponds to the day attached to the time step in E-OBS (and ECA&D)<sup>29</sup>.

<b>Copernicus Service</b>	C3S
<b>Product family</b>	in-situ observations
<b>Product name + link</b>	<a href="#">E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations</a>
<b>Relevant for CURE apps</b>	04, 05, 06
<b>Description</b>	E-OBS is a daily gridded land-only observational dataset over Europe. The blended time series from the station network of the European Climate Assessment & Dataset (ECA&D) project form the basis for the E-OBS gridded dataset.
<b>Parameter</b>	Land surface elevation, Maximum temperature, Mean temperature, Minimum temperature, Precipitation amount, Sea level pressure, Surface shortwave downwelling radiation

<sup>29</sup> <https://cds.climate.copernicus.eu/cdsapp#!/dataset/insitu-gridded-observations-europe?tab=overview>



<b>Reference years or time period available</b>	v19.0e - January 1950 – December 2018; v20.0e - January 1950 – present
<b>Geographic coverage</b>	Europe
<b>Spatial resolution, map scale or MMU</b>	Two regular latitude-longitude grids are available: 0.1° x 0.1° and 0.25° x 0.25°
<b>Temporal Resolution</b>	daily
<b>Update frequency</b>	New versions added every 6 months
<b>Status</b>	Available
<b>Format</b>	NetCDF

Table 27. E-OBS specification

### 3.1.4 Copernicus Atmosphere Monitoring Service

The Copernicus Atmosphere Monitoring Service (CAMS) provides consistent and quality-controlled information related to air pollution and health, solar energy, greenhouse gases and climate forcing, everywhere in the world.

CAMS is implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Commission. ECMWF is an independent intergovernmental organisation supported by 34 states. It is both a research institute and a 24/7 operational service, producing and disseminating numerical weather predictions to its member states.

To provide and further develop the CAMS portfolio, ECMWF works with many service providers around Europe. By doing so, CAMS combines the expertise and infrastructure that exist in Europe to provide a range of services that are unequalled by any other organisation in the world.

To acquire all the observations that are needed to produce the CAMS services, ECMWF collaborates with the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) as well as many other organisations providing satellite and in-situ observations.



CAMS builds on many years of European research and development, and on existing European and national capacities, experience and know-how. The current portfolio of mature operational products was designed in close consultation with the (potential) users and developed through a series of EU-funded precursor projects starting in 2005.

CAMS has been fully operational since 1 July 2015. The current phase runs until the end of 2020, in alignment with the Multiannual Financial Framework (MFF) of the European Union. The scope of Copernicus after 2020 is currently under discussion as part of the definition of the new MFF. Based on strong support expressed by the European Member States, CAMS expects to secure continued provision of the existing services for the foreseeable future.<sup>30</sup>

The datasets collected in the frame of Copernicus Atmosphere Monitoring Service are stored and available in the Copernicus Atmosphere Data Store: <https://ads.atmosphere.copernicus.eu/#!/home>. The available datasets can be explored through the data catalogue: <https://atmosphere.copernicus.eu/catalogue#/> The user needs to create an account to be able to download the datasets.

Coper- nicus Service	CLMS data product	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	Original Catalogue/ Repository
		01	02	03	04	05	06	07	08	09	10	11	
CAMS	<a href="#">Flux inversion reanalysis of global carbon dioxide - Fluxes and atmospheric concentrations</a>				yes								<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European anthropogenic emissions - air pollutants</a>							yes					<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality validated reanalysis of nitrogen dioxide from model ensemble</a>							yes					<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality validated reanalysis of ozone from model ensemble</a>							yes					<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality validated reanalysis of PM10 from model ensemble</a>							yes					<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality validated reanalysis of PM2.5 from model ensemble</a>							yes					<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">Clear-sky surface solar irradiation</a>									yes			<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>

<sup>30</sup> <https://atmosphere.copernicus.eu/>







CAMS	<a href="#">European-scale air quality analysis from EURAD - nitrogen monoxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - NMVOCs</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - ozone</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - PANs</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - PM10</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - PM2.5</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - sulphur dioxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - ammonia</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - carbon monoxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - nitrogen dioxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - nitrogen monoxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - NMVOCs</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - ozone</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - PANs</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - PM10</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - PM2.5</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - sulphur dioxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - ammonia</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - carbon monoxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - nitrogen dioxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - nitrogen monoxide</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>



CAMS	<a href="#">European-scale air quality analysis from MATCH - NMVOCs</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>	
CAMS	<a href="#">European-scale air quality analysis from MATCH - ozone</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - PANs</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - PM10</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - PM2.5</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - sulphur dioxide</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - ammonia</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - carbon monoxide</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - nitrogen dioxide</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - nitrogen monoxide</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - NMVOCs</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - ozone</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - PANs</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - PM10</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - PM2.5</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - sulphur dioxide</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - ammonia</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - carbon monoxide</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - nitrogen dioxide</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - nitrogen monoxide</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - NMVOCs</a>																					yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>



CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from model ensemble - ozone</a>																			yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>	
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from model ensemble - PANs</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from model ensemble - PM10</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from model ensemble - PM2.5</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from model ensemble - sulphur dioxide</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - ammonia</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - carbon monoxide</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - nitrogen dioxide</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - nitrogen monoxide</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - NMVOCs</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - ozone</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - PANs</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - PM10</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - PM2.5</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>
CAMS	<a href="https://atmosphere.copernicus.eu/">European-scale air quality analysis from SILAM - sulphur dioxide</a>																				yes	<a href="https://atmosphere.copernicus.eu/">https://atmosphere.copernicus.eu/</a>

Table 28. List of relevant CAMS datasets - summary for all app

European scale air quality analysis data on different pollutants (Anthropogenic emissions, Carbon dioxide, Carbon monoxide, Nitrogen dioxide, Nitrogen monoxide, Sulphur dioxide, Ammonia, Ozone, PM10, PM2.5, PANs, NMVOCs) from different models (model ensemble, CHIMERE, EMEP, EURAD, LOTOS-EUROS, MATCH, MOCAGE, SILAM) are requested for the most recent years available - which, typically, is at least 2018, for some sets even more recent. From all the CURE applications, these data are relevant mostly for AP11 and AP07.

The following specifications are the same for all the CAMS datasets which will be used as the input data in the CURE project.



Copernicus Service	CAMS
Product family	regional real-time analyses
Product name + link	<a href="#">European-scale air quality analysis from CHIMERE - carbon monoxide</a>
Description	This service provides European-scale air quality analyses of carbon monoxide for every hour of the previous day provided by the CHIMERE model. The maps provided are only representative of large scale phenomena, they do not describe air pollution on a local level.
Parameter	carbon monoxide
Reference years or time period available	1 October 2015 - current
Geographic coverage	Europe (-25.0, 45.0, 30.0, 70.0)
Spatial resolution, map scale or MMU	0.1°x0.1°
Update frequency	hourly
Delivery timeliness	daily
Status	operational
Format	GRIB/NetCDF

Table 29. CHIMERE - CO specification

### 3.1.5 Copernicus Emergency Management Service

Copernicus EMS On Demand Mapping provides on-demand detailed information for selected emergency situations that arise from natural or man-made disasters anywhere in the world. Copernicus EMS Early Warning and Monitoring offers critical geospatial information at European



and global level through continuous observations and forecasts for floods, droughts and forest fires.

The European Flood Awareness Systems (EFAS) and Global Flood Awareness Systems (GloFAS) provide complementary flood forecast information to relevant stakeholders that support flood risk management at the national, regional and global level.

For the CURE apps, in particular the floods monitoring (AP05), the EMS “Floods” data will be relevant. For the AP06, the precipitation data from EFAS will be used as additional information for calibration of radar imageries (Sentinel-1).

The EFA data are available in the Copernicus Climate data Store: <https://cds.climate.copernicus.eu/>.

Copernicus Service	EMS data product	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	AP	Original Catalogue/ Repository
		01	02	03	04	05	06	07	08	09	10	11	
EMS	<a href="#">Flash flood indicators</a>					yes	yes						<a href="https://cds.climate.copernicus.eu">https://cds.climate.copernicus.eu</a>
EMS	<a href="#">Real-time river discharge forecasts</a>					yes							<a href="https://cds.climate.copernicus.eu">https://cds.climate.copernicus.eu</a>
EMS	<a href="#">River discharge thresholds</a>					yes							<a href="https://cds.climate.copernicus.eu">https://cds.climate.copernicus.eu</a>
EMS	<a href="#">flood forecasts</a>					yes							<a href="https://cds.climate.copernicus.eu">https://cds.climate.copernicus.eu</a>
EMS	<a href="#">river discharge reforecasts</a>					yes							<a href="https://cds.climate.copernicus.eu">https://cds.climate.copernicus.eu</a>

Table 30. List of relevant EMS datasets

### 3.1.5.1 European Flood Awareness Systems (EFAS)

The EFAS archive contains the operational output of EFAS as well as the historical simulations. The real-time EFAS forecasts are restricted to the EFAS partners, all data that is older than 30 days is open access. For more information of the model setup, please see the EFAS overview. The data download facilities provide access to the raw hydrological model output; the different ways to access the data are designed to help different usage. For more information on EFAS archive data and its accessibility, please see the EFAS archive wiki pages.<sup>31</sup>

<sup>31</sup> <https://emergency.copernicus.eu/index.html>



For the CURE AP05 and AP06, data on following data on “flash flood indicators”<sup>32</sup> can be exploited.

Copernicus Service	EMS
Theme + Link	<a href="#">Flash flood indicators</a>
Relevant for CURE App	05
Product	ERIC affected area
Description	river network which contributes to each ERIC reporting point, i.e. areas at risk from flash flooding (“ERIC Affected Area”).
Reference years or time period available	5 day forecast
Geographic coverage	Europe
Spatial resolution, map scale or MMU	1 x 1km
Delivery timeliness	near real time or 30 days

Table 31. ERIC affected area - specification

Copernicus Service	EMS
Theme + Link	<a href="#">Flash flood indicators</a>
Relevant for CURE App	05, 06

<sup>32</sup> <https://www.efas.eu/flash-flood-indicators>



Product	ERICHA hourly precipitation maps
Description	Hourly precipitation totals from the OPERA radar composite, updated every 15 minutes (“ERICHA hourly accumulation precipitation” layer).
Reference years or time period available	
Geographic coverage	Europe
Spatial resolution, map scale or MMU	1 x 1km
Update frequency	15 minutes
Delivery timeliness	near real time or 30 days

Table 32. ERICHA hourly precipitation maps - specification

Copernicus Service	EMS
Theme + Link	<a href="#">Flash flood indicators</a>
Relevant for CURE App	05
Product	ERICHA flash flood hazard maps





Description	Sections of the river network highlighted because their flash flood forecast probability over the next 4 hours meets certain criteria. The thresholds are based on regional climatic characteristics and river basin upstream area as published by the MeteoAlarm consortium ("ERICHA - FF hazard levels forecasts" layer).
Reference years or time period available	
Geographic coverage	Europe
Spatial resolution, map scale or MMU	1 x 1km
Update frequency	4 hours
Delivery timeliness	near real time or 30 days

Table 33. ERICHA flash flood hazard maps - specification

Copernicus Service	EMS
Theme + Link	<a href="#">Flash flood indicators</a>
Relevant for CURE App	05, 06
Product	ERICHA daily precipitation maps
Description	Daily gauge-adjusted radar rainfall accumulation over the last 24 hours ("ERICHA 24-h accumulations" layer).



Reference years or time period available	last 24 hours
Geographic coverage	Europe
Spatial resolution, map scale or MMU	1 x 1km
Delivery timeliness	near real time or 30 days

Table 34. ERICHA daily precipitation maps - specification

### 3.1.5.2 Global Flood Awareness System (GloFAS)

The Global Flood Awareness System (GloFAS), jointly developed by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF), is a global hydrological forecast and monitoring system independent of administrative and political boundaries. It couples state-of-the-art weather forecasts with a hydrological model and with its continental scale set-up provides downstream countries with information on upstream river conditions as well as continental and global overviews. GloFAS produces daily flood forecasts (since 2011) and monthly seasonal streamflow outlooks (since November 2017). GloFAS has been fully operational as a Copernicus Emergency Management Service since April 2018.<sup>33</sup>

For the CURE AP05 following forecast data from GloFAS can be exploited.

Product family	GloFAS 30-Day
Relevant for CURE App	05
Product name + link	<a href="#">Real-time river discharge forecasts</a>
Description	Produced by the GloFAS v2 modelling chain initialised from the GloFAS v2.0 river discharge initialisation run and forced with data from the ECMWF ENS medium- and extended-range forecasting system.

<sup>33</sup> <https://www.globalfloods.eu/>



Reference years or time period available	daily from 14 Nov 2018 - 4 Nov 2019
Geographic coverage	global
Spatial resolution, map scale or MMU	0.1°
Update frequency	daily
Status	operational

Table 35. Real-time river discharge forecasts - specification

Product family	GloFAS 30-Day
Relevant for CURE App	05
Product name + link	<a href="#">River discharge thresholds</a>
Description	These thresholds are used to generate the 30-day flood forecasts.
Reference years or time period available	2-, 5-, and 20-year return periods
Geographic coverage	global
Spatial resolution, map scale or MMU	0.1°
Update frequency	One set based on 1981-2017



Status	operational
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Table 36. River discharge thresholds - specification

Product family	GloFAS 30-Day
Relevant for CURE App	05
Product name + link	<a href="#">flood forecasts</a>
Description	Generated by comparing the GloFAS v2.0 real-time forecasts to the thresholds. This provides flood signals as maps of probability of threshold exceedence and forecast hydrographs with the river discharge evolution in the next 30 days.
Reference years or time period available	1 July 2018 - 13 Nov 2018
Geographic coverage	global
Spatial resolution, map scale or MMU	0.1°
Update frequency	daily
Status	operational

Table 37. Flood forecasts - specification

Product family	GloFAS 30-Day
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Relevant for CURE App	05
Product name + link	<a href="#">river discharge reforecasts</a>
Description	Forecast simulations generated for a set of past dates.
Reference years or time period available	1997-2019
Geographic coverage	global
Spatial resolution, map scale or MMU	0.1°
Update frequency	twice weekly
Status	operational

Table 38. River discharge forecasts – specification



## 3.2 Relevant Copernicus satellite data

Data from **Copernicus Sentinel missions**<sup>34</sup> will be exploited, to derive up-to-date or time-series information about the land cover, distribution and quality of sealed surfaces and vegetation (e.g. NDVI) - Sentinel-2 and 3 for AP01, 02, 05, 06 and 08 or as the input data for radar interferometry (Sentinel-1 for AP06). Moreover, data from the **Copernicus Additional Datasets**, i.e. VHR imageries from WorldView<sup>35</sup> or Pleiades<sup>37</sup> missions will be used to derive detailed information about the land cover structure, including actual positions of buildings, trees, water bodies or sealed and grass surfaces in the cities.

### 3.2.1 Access to Copernicus Satellite Data

The Copernicus satellite datasets are stored and accessible in a harmonized way. There are two access points to Copernicus satellite data managed by ESA:

The **Copernicus Open Access Hub**<sup>38</sup> (previously known as Sentinels Scientific Data Hub) provides complete, free and open access to Sentinel-1, Sentinel-2, Sentinel-3 and Sentinel-5P user products, starting from the In-Orbit Commissioning Review (IOCR). The access is provided through an interactive graphical user interface. The portal will also provide access to data produced by future Sentinel missions when available.

Second, the **Copernicus Space Component Data Access (CSCDA)**<sup>39</sup> portal provides access to the Copernicus collaborative ground segment. Anyone can view and discover data, but downloading images is restricted to public authorities, European projects and Copernicus services. From this repository, the VHR satellite imageries will be grabbed.

Sentinel Data are also available via the **Copernicus Data and Information Access Services (DIAS)**<sup>40</sup> platforms. In the CURE, we plan to enable the access (realized through the CURE Interface) to Sentinel data through the DIAS platforms. For example, the CreoDIAS<sup>41</sup> platform is considered to be used for the download of Sentinel-1 data for the AP06.

The benefits and bottlenecks of access to each of these archives will be further explored in the frame of the CURE Interface implementation and testing and based on the results of this assessment, the most appropriate way of access to Copernicus data archives will be selected for

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<sup>34</sup> <https://www.copernicus.eu/en/about-copernicus/infrastructure/discover-our-satellites>

<sup>35</sup> <https://spacedata.copernicus.eu/web/cscda/data-offer/missions/worldview-2>

<sup>36</sup> <https://spacedata.copernicus.eu/web/cscda/data-offer/missions/worldview-3>

<sup>37</sup> <https://spacedata.copernicus.eu/web/cscda/data-offer/missions/pleiades>

<sup>38</sup> <https://scihub.copernicus.eu/>

<sup>39</sup> <https://spacedata.copernicus.eu/web/cscda/home>

<sup>40</sup> <https://www.copernicus.eu/en/access-data/dias>

<sup>41</sup> <https://discovery.creodias.eu/dataset/sentinel-1-l1-grd-collection>



the CURE. In general, the final access implementation in the CURE Interface will also reflect the CURE Engine preferences.

The following sub-chapters are dedicated to a description of each of the above mentioned types of satellite data which will be exploited as the source of information for the CURE applications.

### 3.2.2 Sentinel-1

Sentinel-1 provides all-weather, day and night radar imagery for land and ocean services. The twin satellites Sentinel-1A and Sentinel-1B were respectively launched on 3 April 2014 and on 25 April 2016<sup>42</sup>.

Sentinel-1 is the first of the five missions that ESA is developing for the Copernicus initiative. The Sentinel-1 mission comprises a constellation of two polar-orbiting satellites, operating day and night performing C-band synthetic aperture radar imaging, enabling them to acquire imagery regardless of the weather.

Sentinel-1 works in a pre-programmed operation mode to avoid conflicts and to produce a consistent long-term data archive built for applications based on long time series.<sup>43</sup>

In the CURE project, the Sentinel-1 imageries will be exploited in particular as the input data for the AP06, which is dealing with the radar-interferometry method. This requires specific approaches to data pre-processing and calibration.

### 3.2.3 Sentinel-2

Sentinel-2 provides high-resolution optical imagery for land services. It provides for example, imagery of vegetation, soil and water cover, inland waterways and coastal areas. Sentinel-2 also delivers information for emergency services. The twin satellites Sentinel-2A and Sentinel-2B were respectively launched on 22 June 2015 and on 7 March 2017<sup>44</sup>.

The Copernicus Sentinel-2 mission comprises a constellation of two polar-orbiting satellites placed in the same sun-synchronous orbit, phased at 180° to each other. It aims at monitoring variability in land surface conditions, and its wide swath width (290 km) and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of Earth's surface changes. The coverage limits are from between latitudes 56° south and 84° north<sup>45</sup>.

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<sup>42</sup> <https://www.copernicus.eu/en/about-copernicus/infrastructure/discover-our-satellites>

<sup>43</sup> <https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1>

<sup>44</sup> <https://www.copernicus.eu/en/about-copernicus/infrastructure/discover-our-satellites>

<sup>45</sup> <https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2>



In the CURE project, the Sentinel-2 imageries will be exploited primarily as the input data for the AP01, where Sentinel-2 data will be used for updating the land cover fractions in 100 m spatial resolution. This will then be used to downscale Sentinel-3 thermal imagery. The pre-processing chain for Sentinels-2 should be fully automated.

For AP02, AP03 and AP09, the Sentinel-2 data will be used "indirectly" since these apps are using the land cover and Land Surface Temperature (LST) product of AP01.

### 3.2.4 Sentinel-3

The main objective of the Sentinel-3 mission is to measure sea surface topography, sea and land surface temperature, and ocean and land surface colour with high accuracy and reliability to support ocean forecasting systems, environmental monitoring and climate monitoring.

The Sentinel-3 mission is jointly operated by ESA and EUMETSAT to deliver operational ocean and land observation services.<sup>46</sup>

In the CURE project, the Sentinel-3 thermal imageries will be used as the input for AP01. Then, same as for Sentinel-2, the derived products built on Sentinel-3 will be used as the input for CURE apps AP02, AP03 and AP09.

### 3.2.5 Very High Resolution Satellite Data

For some of the CURE applications dedicated to monitoring in local scale, it is crucial to have good baseline information on the land cover, the vegetation and the built-up dynamics in very high spatial resolution (VHR) (less than 10 m), in order to achieve accurate update using Sentinel-2 (20 m). Therefore VHR imagery (WorldView-2 or 3 or Pleiades) will be used as a source of the detailed information about the structure of the land surface. However, these VHR imageries will be used as a basis for preparation of detailed land cover structure maps, which will then serve as the input for the CURE applications, not as the direct input for automated processing chains of the CURE apps. This is valid in particular for the CURE apps AP01, AP02 and AP08.

The VHR imageries for CURE are downloaded from the **Copernicus Data Warehouse**<sup>47</sup>, using the CURE quota (D3.5-D3.10).

The VHR imageries are only available on specific dates.- The availability of VHR scenes for 2020 is presented in figure below.

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<sup>46</sup> <https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-3>

<sup>47</sup> <https://spacedata.copernicus.eu/web/cscda/home>





› Basel	› Copenhagen	› München
– WV2 22-08-2017	– WV2 15-09-2016	– WV2 15-09-2016
– WV2 04-08-2019	– WV2 25-07-2018	– WV3 04-07-2019
– WV2 17-09-2019	– PH 10-09-2016	– PH 12-10-2018
– PH 25-12-2015	› Heraklion	› Sofia
– PH 26-02-2018	– WV2 01-09-2017	– WV2 19-09-2018
› Berlin	– WV2 10-03-2019	– WV3 11-04-2015
– WV3 15-04-2018	– WV3 13-07-2019	– WV3 11-08-2017
– WV3 29-04-2018	– WV3 26-07-2019	– PH 05-11-2015
– PH 14-11-2016	– PH 18-10-2015	– PH 23-11-2017
– PH 18-03-2018	– PH 11-03-2016	› Vitoria
› Bristol	› Ostrava	– WV3 17-08-2017
– WV3 16-01-2018	– WV2 27-08-2016	– WV3 23-03-2019
– WV3 14-05-2018	– PH 03-06-2017	– PH 20-09-2015

Figure 6: VHR Data availability for CURE cities.

The VHR data will only provide the baseline data to be used for the applications development process, which will then "stand alone" in the CURE System without the need for update of VHR data in the future.

### 3.3 Relevant non-Copernicus data (third-party data)

While the main and most important input data for the CURE applications will be represented by Copernicus Core Services datasets (or Copernicus satellite imageries), there is also an intention to integrate and exploit the local data sources where appropriate and beneficial.

There are two types of such third-party datasets - one is represented by generally available non-Copernicus data, with global coverage. Here, this group is represented by the OpenStreetMap or World Settlement Footprint. Second, the data from the local sources will be used. Such data will be typically provided by the city. Usually the cities are applying the Open Data policy nowadays so the data collections of the city repositories are made accessible as the open data. Alternatively, additional local data can be integrated which are not exposed as open data but will be provided by particular cities for purposes of the CURE project. Local data may come from some thematic projects or initiatives, which were realized in concerned cities in the past.

Obviously, there could be some limitations in feasibility of such local data integration into the CURE system, caused by different nature, format or storage and accessibility of relevant datasets in different cities, however, our general aim is to make the CURE application as independent as possible from other data sources rather than the Copernicus data, while enabling the integration of as much third-party data as possible in the CURE System.



To be able to feed the CURE apps with such ancillary data sources (through the CURE Interface), it is necessary to specify and respect harmonized format of such third-party input datasets needed for the application, which has to be maintained for all the cities (and also for new cities, for which the services will be implemented in the future). Such format should be specified by each service provider, including data format (raster, vector), spatial resolution, coordinated system (ESPG), mandatory attributes etc. In case the new service user will dispose of the input data in different forms, it will be always necessary to first transform such data into the format native for that particular CURE application. This can be done either directly by the users (in case they will have detailed specification of the data format available and technical/GIS skills needed) or by the service provider.

Following sub-chapters present main types of the third-party input data, which are expected to be integrated into the CURE system to be used by different CURE apps.

### 3.3.1 OpenStreetMap

OpenStreetMap (OSM<sup>48</sup>) is a collaborative project to create a free editable map of the world. The geodata underlying the map is considered the primary output of the project. The creation and growth of OSM has been motivated by restrictions on use or availability of map data across much of the world, and the advent of inexpensive portable satellite navigation devices.

In the CURE apps, the OpenStreetMap is planned to be used for the AP04 and AP07 (building layout and road map).

Although this dataset is available in global coverage, while using the OpenStreetMap as the input data, the character of this dataset has to be taken into consideration - i.e. it is an un-official source collected on volunteer basis, which may have gaps or limited reliability in some cities/areas.

### 3.3.2 World Settlement Footprint

Global human settlement mask in so far unique spatial detail and consistency, derive from Landsat-8 and Sentinel-1 data (10m spatial resolution). This dataset produced by the German Aerospace Center (DLR)<sup>49</sup> is the first map, using mass collections of radar and optical satellite imagery, to provide a global overview of the world's human settlements.

The **WSF-Evolution** uses six million satellite images from 1985 to 2015, almost the complete archive of the US Landsat missions, to illustrate the worldwide growth of human settlement on a year-by-year basis. This new feature will be released later this year.

Reliably monitoring global urbanization is of key importance to accurately estimate the distribution of the continually expanding population, along with its effects on the use of resources,

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<sup>48</sup> [www.openstreetmaps.org](http://www.openstreetmaps.org)

<sup>49</sup> [https://www.dlr.de/EN/Home/home\\_node.html](https://www.dlr.de/EN/Home/home_node.html)



infrastructure needs, socio-economic development, etc. In this context, while in the last few years several global layers mapping the actual settlement extent have been proposed, so far only few datasets outline the settlement growth over time, which is fundamental for modelling ongoing trends and implementing suitable planning strategies. Furthermore, the existing products are mostly available for few time steps in the past and their quality is often rather poor.

To overcome this limitation the DLR and the Google Earth Engine Team designed and implemented a novel iterative technique for outlining the past settlement extent from Landsat imagery available from late 1984 to present. First, under the assumption that pixels categorized as non-settlement at a later time cannot be marked as settlement at an earlier time, all areas excluded from the World Settlement Footprint (WSF) 2015 (i.e., the currently existing most updated and accurate mask outlining the 2015 global settlement extent) are discarded a priori from the analysis. Next, for each target year in the past all available Landsat scenes acquired over the investigated area of interest are gathered and cloud masking is performed. Key temporal statistics (i.e., temporal mean, minimum, maximum, etc.) are then extracted for different spectral indices including the normalized difference built-up index (NDBI), the normalized difference vegetation index (NDVI) and the modified normalized difference water index (MNDWI). Going backwards in time, training samples for the given target year are iteratively extracted by applying morphological filtering to the settlement mask derived for the previous time step, as well as excluding potentially mislabeled samples by adaptive thresholding on the temporal mean NDBI, MNDWI and NDVI. Finally, random forest classification is performed.

Extensive experimental analyses over several test sites assessed the great effectiveness and robustness of the methodology. Accordingly, it has been employed within the Google Earth Engine environment for generating the WSF Evolution, i.e. a novel dataset outlining the growth of settlement extent globally at 30m spatial resolution on a yearly basis from 1985 to 2015. In particular, the layer has been derived by processing the entire Landsat-5/7 archive including more than 7M scenes. The WSF Evolution is currently undergoing a comprehensive quality assessment against 1.1M labels collected from crowdsourcing photointerpretation of historical VHR Google Earth imagery. The layer will be released open and free by the end of 2020 and is expected to become a revolutionary product in support to a variety of end users in the framework of several thematic applications.

The details on methodology used for production of this dataset are provided e.g. in dedicated article<sup>50</sup>.

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<sup>50</sup> <https://www.nature.com/articles/s41597-020-00580-5>



The WSF Evolution data are planned to be used by GISAT as additional input data for the AP06, as a source of information about the development of built-up area in the city of Heraklion and surroundings in the period between 1990 and 2015.

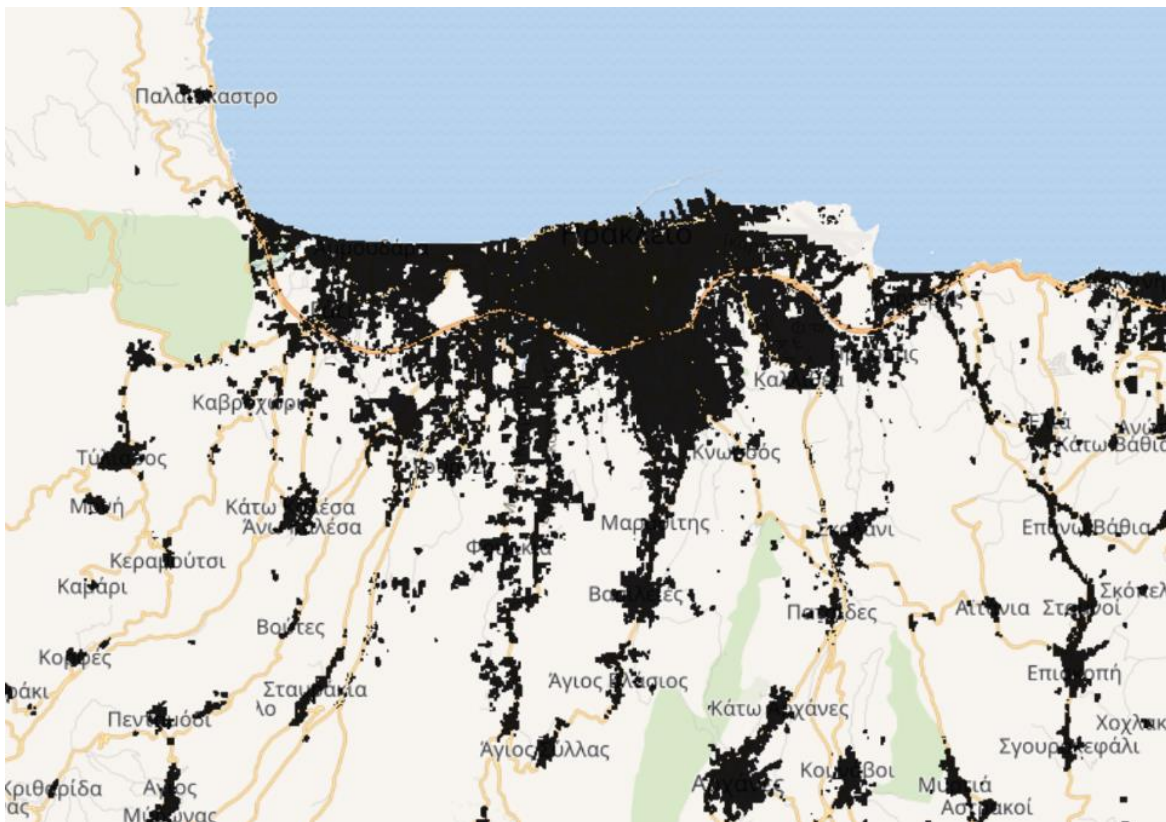


Figure 7: Example of World Settlement Footprint - Heraklion wider area 2015

### 3.3.3 Local city data

In most of the CURE applications, the Copernicus or third-party harmonized datasets at Global/European level (like OSM or WSF) will be combined and integrated with local city data and information.

Thematically, the cadastral maps, traffic data, emissions data, air quality, meteo-data (air temperature) from ground meteo stations, data on buildings, patient register data or LIDAR data etc. may serve as additional inputs for the CURE apps or for validation purposes etc. Usually, such datasets are collected by the bottom-up approach by the city or local data providers and stored/operated by the cities. Also, in some cases, local urban planning documents and information on local regulations in the city (e.g. regulations on the installation of green roofs) can be helpful for the service providers.



The front-runner cities were already requested about availability and accessibility of relevant local datasets in the frame of WP1. As described in D1.1, the front runner cities are applying the open data policy and have their own open data repositories:

- **Berlin:** <https://www.govdata.de/dl-de/by-2-0>
- **Copenhagen:** <https://www.opendata.dk/city-of-copenhagen>
- **Heraklion:** <https://smartcity.heraklion.gr/en/home/>  
(<https://smartcity.heraklion.gr/opendata/en/group>)
- For **Sofia**, some datasets are available through online platform such as air quality measurement stations: <https://platform.airthingsproject.com/> and other related data e.g., Green Sofia is shared with CURE.

The machine-access to these repositories will be tested in the frame of the CURE Copernicus Core Services Interface implementation and where feasible, the automated ingestion of these local open data into relevant CURE applications will be enabled. For such cases, the harmonized schemes will be defined for the structure of such third-party input datasets (in sense of format, attributes needed etc.), to secure the replicability of the process of local data input for new user cities. However, in some cases, feasibility of such automated data input processes may be limited, as the structure and format of the local data may differ city by city or country by country. Our general WP2 aim is to automate the process of input of the local data into CURE applications as much as possible.



### 3.4 Data packages for cross-cutting applications

This chapter presents a list of input datasets needed for the 11 CURE cross-cutting applications development in WP3. The details on data availability for selected front-runner cities and time-horizons are presented, and potential gaps in data or limitations are described for each CURE application.

For the initial phase of the project (before the CURE Interface will be ready and able to feed the apps by the input data in an automated way), a data package will be prepared for each of the apps, containing all necessary input data for that particular app. These data packages will be shifted to the app developers/service providers (WP3) to ensure that they have all the necessary input data available at this stage of the project. In the next stages of the project, the data supply for the apps will be secured in an automated way, in the frame of the CURE Interface implementation (described in the previous section of this report).

#### 3.4.1 AP01 Land Surface Temperature Dynamics (FORTH, DLR, TECNALIA)

The AP01 will be implemented for all four front-runners cities: Berlin, Copenhagen, Heraklion and Sofia. The plan is to implement the service for the most recent year with available data (2018) and also for the year around 2015 to enable to follow changes in the UHI etc.

Copernicus Satellite	Sentinel-2
Copernicus Satellite	Sentinel-3
CLMS	<a href="#">Imperviousness</a>
CLMS	<a href="#">Urban Atlas</a>
CLMS	<a href="#">Urban Atlas: Building Heights</a>
CLMS	<a href="#">Phenology and Productivity Parameters</a>
CLMS	<a href="#">Vegetation Indices</a>
C3S	<a href="#">UERRA regional reanalysis for Europe on single levels from 1961 to 2019</a>
C3S	<a href="#">UERRA regional reanalysis for Europe on single levels from 1961 to 2020</a>
third-party	Baseline Land Cover from VHR (from the DWH)
third-party	Land Cover Dynamics (Vegetation Dynamics (from NDVI) (from the DWH)
third-party	Land Cover Dynamics (Built-up Dynamics) (from the DWH)

Table 39. List of relevant datasets for AP01

HRL Imperviousness is available for both requested years - 2015 and 2018 for all front-runner pilot cities. The Urban Atlas was requested for the same years, however, this dataset is standardly produced for the years 2012 (not 2015) and 2018. For the year 2012, the Urban Atlas is available



for all four cities. For the year 2018, the cities of Berlin and Copenhagen are in production in the time of submission of this report. The Urban Atlas Building Heights are available for the year 2012 for Berlin, Copenhagen and Sofia. This dataset is not available for Heraklion.

Phenology and Productivity Parameters and Vegetation Indices needed for the AP01 were not available at the time of submission of this report. The AP01 developers (led by FORTH) are planning to prepare corresponding layers based on Sentinel-2 satellite imageries on their own for the time-being for the front-runner cities.

The Sentinel-2 data will be used for updating the land cover fractions in 100 m spatial resolution. This will then be used to downscale Sentinel-3 thermal imagery.

The UERRA regional reanalysis for Europe on single levels is required from January 2016 to December 2020. They are available each day at 00, 06, 12 and 18 UTC for whole this period.

For the Land Surface Temperature Dynamics monitoring in local scale, it is important to have good baseline information on the land cover, the vegetation and the built-up dynamics in very high spatial resolution (VHR) (less than 10 m), in order to achieve accurate update using Sentinel-2 (20 m). Therefore VHR imagery (WorldView-2) is used to produce VHR land cover maps (classification scheme: buildings, paved, vegetation, bare soil, water) and vegetation and built-up dynamics for specific dates that data are available.

### 3.4.2 AP02 Surface Urban Heat Island Assessment (DLR, FORTH, UWE)

The AP02 will be implemented for all four front-runners cities: Berlin, Copenhagen, Heraklion and Sofia. The plan is to implement the service for the most recent year with available data (2018) and also for the year around 2015 to enable to follow changes in the UHI etc.

CLMS	<a href="#">Imperviousness</a>
CLMS	<a href="#">Urban Atlas</a>
CLMS	<a href="#">European Settlement Map</a>
third-party	Building lay-out (OpenStreetMaps)
third-party	Land Cover Dynamics (Built-up Dynamics) (from the DWH VHR data)
third-party	Land Cover Dynamics (Vegetation Dynamics (from NDVI) (from the DWH VHR)

Table 40. List of relevant datasets for AP02

As for the AP01, the HRL Imperviousness is available for both requested years - 2015 and 2018. The Urban Atlas was requested for the same years, however, this dataset is standardly produced for the years 2012 (not 2015) and 2018. For the year 2012, the Urban Atlas is available for all four cities. For the year 2018, the cities of Berlin and Copenhagen are in production in the time of submission of this report. The European Settlement Map is available for years 2012 and 2015.



In the implementation of the SUHII product, the availability of very high spatial resolution (VHR) (less than 10 m) information on vegetation and built-up dynamics will be used: i) to derive suitable training data for the intended model aimed at estimating the percent impervious surface from Sentinel-2 multi-temporal imagery; and ii) to effectively validate it. To this purpose, the same baseline information to be derived in the frame of the AP01 shall be used in addition to accurate building outlines available from OpenStreetMap.

### 3.4.3 AP03 Urban Heat Emissions Monitoring (UNIBAS, FORTH)

The AP03 will be implemented for Heraklion. The plan is to implement the service for the most recent year with available data (2018).

CLMS	<a href="#">Imperviousness</a>
CLMS	<a href="#">Urban Atlas</a>
CLMS	<a href="#">Urban Atlas: Building Heights</a>
C3S	<a href="#">ERA5-Land hourly data from 1981 to present</a>
third-party	Building heights

Table 41. List of relevant datasets for AP03

The Imperviousness and Urban Atlas for Heraklion will be delivered for the year 2018 as requested.

As the Urban Atlas: Building Heights product originally requested is not available for the city of Heraklion, the service will rely on local datasets for building heights (for the front-runner cities such datasets were prepared during previous projects).

From the ERA5-Land hourly data, following variables were requested by the service provider, for the period 2017-2019:

- air temperature (2 m)
- dew point temperature (2 m)
- Wind speed u,v (10 m)
- leaf area index (high and low vegetation)
- forecast albedo
- surface solar rad. downwards
- surface thermal rad. downwards
- surface solar net radiation
- surface net thermal radiation
- surface latent heat flux
- surface sensible heat flux
- surface pressure
- total precipitation





### 3.4.4 AP04 Urban CO2 Emissions Monitoring (UNIBAS, FORTH)

The AP04 will be implemented for Heraklion. The plan is to implement the service for the most recent year with available data (2018).

CLMS	<a href="#">Urban Atlas</a>
CAMS	<a href="#">Flux inversion reanalysis of global carbon dioxide - Fluxes and atmospheric concentrations</a>
C3S	<a href="#">E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations</a>
third-party	OpenStreetMap road classification
third-party	Traffic Data

Table 42. List of relevant datasets for AP04

For the AP04, the Urban Atlas for the year 2018 will be used. It will be complemented by the Flux inversion reanalysis of global carbon dioxide, which is available for whole period between 1979 and 2018 in the Copernicus Atmosphere Data Store and by E-OBS daily gridded meteorological data for Europe derived from in-situ observations, for the period 2011 - 2019.

From the non-Copernicus data, the OSM road classification and traffic data from local sources will serve as additional inputs for the AP04.

### 3.4.5 AP05 Urban Flood Risk (GISAT, Geoville, DLR)

The AP05 will be implemented for Heraklion. The plan is to implement the service for the most recent year with available data (2018).

CLMS	<a href="#">Urban Atlas</a>
CLMS	<a href="#">European Image Mosaic - High Resolution</a>
CLMS	<a href="#">EU-DEM</a>
C3S	<a href="#">E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations</a>
EMS	<a href="#">Flash flood indicators</a>
EMS	<a href="#">Real-time river discharge forecasts</a>
EMS	<a href="#">River discharge thresholds</a>
EMS	<a href="#">flood forecasts</a>
EMS	<a href="#">river discharge reforecasts</a>

Table 43. List of relevant datasets for AP05



The Urban Atlas 2018, European Image Mosaic - HR for the same year and EU-DEM will be used for the AP05 from the CLMS portfolio. The E-OBS daily gridded meteorological data for Europe derived from in-situ observations for the year 2019 will be exploited as a source of information about the precipitation. The EMS flood, river discharge and precipitation indicators are available for relevant years.

### 3.4.6 AP06 Urban Subsidence, Movements and Deformation Risk (GISAT, VITO)

The AP06 will be implemented for Heraklion. The plan is to implement the service for the most recent year with available data (2018).

Copernicus Satellite	Sentinel-1
CLMS	<a href="#">Urban Atlas</a>
CLMS	<a href="#">European Image Mosaic - High Resolution</a>
CLMS	<a href="#">EU-DEM</a>
C3S	<a href="#">E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations</a>
EMS	<a href="#">Flash flood indicators</a> (on precipitations)
third-party	Word Surface Footprint (Evolution)
third-party	Permanent scatterers (PS) infrastructure

Table 44. List of relevant datasets for AP06

The AP06 will be built on the Sentinel-1 radar imageries, on which the radar interferometry methods will be applied.

Data selection of Sentinel-1 SLC imagery is implemented directly using tools and infrastructure available on creodias.eu. Images are selected semi-automatically by query on hub's API via the cloud provider: by definition of geographic and temporal constraints specified by polygon and start and end of time period. API response is processed using script into format suitable for further filtering. Filtered output (granule IDs) is used for order specification. Order is submitted within the ordering system and after its order approval scenes from rolling or long-term archives are made available by linking to a virtual mounted drive. Typically, all available Sentinel-1 scenes are ordered and pre-processed.

This source of information about the Earth's surface will be supplemented by data from the CCS portfolio. In particular, the Urban Atlas layer for the year 2018 will be used, together with European Image Mosaic - HR for the same year for detailed information about the land cover structure in the areas of interest and the EU-DEM as a source of information about the terrain on location. The E-OBS daily gridded meteorological data for Europe derived from in-situ observations for the year



2018/2020 will be exploited as an additional source of information about weather conditions on specific days and times of the Sentinel-1 acquisitions, to be able to calibrate the radar imageries. The EMS precipitation indicators are available for relevant years in dense time-series - they can be used for Sentinel-1 imageries calibration, if needed.

From the third-party data, the World Settlement Footprint Evolution is planned to be used for the AP06, to enable follow the development of built-up land in time.

To be able to obtain more precise reference information by exploiting ground-data, permanent scatterers (PS) infrastructure can be used, if available in-situ.

### 3.4.7 AP07 Urban Air Quality (VITO)

The AP07 will be implemented for Sofia. The plan is to implement the service for the most recent year with available data (2018).

CAMS	<a href="#">European anthropogenic emissions - air pollutants</a>
CAMS	<a href="#">European-scale air quality validated reanalysis of nitrogen dioxide from model ensemble</a>
CAMS	<a href="#">European-scale air quality validated reanalysis of ozone from model ensemble</a>
CAMS	<a href="#">European-scale air quality validated reanalysis of PM10 from model ensemble</a>
CAMS	<a href="#">European-scale air quality validated reanalysis of PM2.5 from model ensemble</a>
C3S	<a href="#">ERA5 hourly data on single levels from 1979 to present</a>
C3S	<a href="#">ERA5-Land hourly data from 1981 to present</a>
CLMS	<a href="#">Urban Atlas: Building Heights</a>
third-party	OpenStreetMap (Building Lay-out, Road Map)
third-party	3D city model
third-party	Traffic Data
third-party	Emissions (point-source - local bottom-up data)

Table 45. List of relevant datasets for AP07

For the CAMS datasets, the most recent year available of the data is used, which is the year 2018. For the air pollutants, the data for the year 2016 are available. The Urban Atlas Building Heights are available for the year 2012. From the third-party datasets, the OpenStreetMap is planned to be used to derive information about the building lay-out and road map.

The air quality app models the ambient air pollution in Sofia at a high resolution (order of tens of meters). The air quality model thus requires high resolution emission input for all the sectors that are important in the city under consideration. For all European cities this includes road transport and industrial emissions, but in addition the residential sector is important for some pollutants for



several cities (e.g. cities with a high load of wood or coal heating). Within CURE, the following data sources are required to compute the emission input:

- The OpenStreetMaps (openstreetmaps.org) road map is used to downscale the CAMS Regional traffic emissions to individual roads. The downscaling can additionally be complemented with detailed local traffic data to improve the spatial pattern of the emissions.
- Industrial point source emissions are either based on the official reporting of the countries to the EU, i.e. from the large point source (LPS) data reported under the CRLTAP convention, as available on the European Environment Information and Observation Network (EIONET) of the European Environmental Agency (EEA). Local information on point sources can be added.
- Residential emissions of the CAMS Regional Emissions dataset are spread over all buildings contained in OpenStreetMaps (openstreetmaps.org). Alternatively, local bottom-up data can be used.

The air quality map considers the street canyon effects, and thus requires information on building heights and lay-outs. For capital cities, the building height layer of CLMS suffices, for other cities a detailed 3D city model is required. In addition, the validation of the app requires air quality measurements.

### 3.4.8 AP08 Urban Thermal Comfort (VITO)

The AP08 will be implemented for Copenhagen and Sofia. The plan is to implement the service for the most recent year with available data (2018-2019).

C3S	<a href="#">ERA5 hourly data on pressure levels from 1979 to present</a>
C3S	<a href="#">ERA5 hourly data on single levels from 1979 to present</a>
C3S	<a href="#">ERA5-Land hourly data from 1981 to present</a>
C3S	<a href="#">Thermal comfort indices derived from ERA5 reanalysis</a>
CLMS	<a href="#">Imperviousness</a>
CLMS	<a href="#">Tree Cover Density</a>
CLMS	<a href="#">Urban Atlas: Building Heights</a>
CLMS	<a href="#">Urban Atlas: Street Tree Layer</a>
CLMS	<a href="#">Normalized Difference Vegetation Index (NDVI)</a>
CLMS	<a href="#">EU-DEM</a>
third-party	Land Cover from VHR
third-party	Measurements from local meteorological stations (for validation)

Table 46. List of relevant datasets for AP08



For the AP08, the ERA5 hourly data and thermal comfort indices for the years 2018-2019 will be used. The NDVI data from CLMS will be used for the same years. The HRL Imperviousness is available for the year 2018, the Three Cover Density for the year 2015 and the Building Heights from Urban Atlas for 2012. The Urban Atlas Street Tree Layer is available for the year 2018, but only for Sofia, not available for Copenhagen.

For the Thermal Comfort app, it is important to have detailed information on the land cover, vegetation and the built-up area in very high spatial resolution (VHR) (less than 10 m), in order to calculate accurate shading and thermal property maps, needed as input for the Wet Bulb Globe Temperature simulations. Therefore VHR imagery (WorldView-2) is used to produce VHR land cover maps (classification scheme: buildings, paved, vegetation, bare soil, water) and vegetation and built-up dynamics for specific dates that data are available (see AP01). In addition, meteorological measurements of air temperatures, humidity and wind speeds are needed to validate the results of this app. These data can be downloaded free of charge from the NCDC global measurement dataset<sup>51</sup>.

### 3.4.9 AP09 Urban Heat Storage Monitoring (FORTH, UNIBAS)

The AP09 will be implemented for Heraklion. The plan is to implement the service for the year 2016/17. Some of the input data will be re-used from the AP01.

CAMS	<a href="#">Clear-sky surface solar irradiation</a>
CLMS	<a href="#">Urban Atlas</a>
CLMS	<a href="#">Urban Atlas: Building Heights</a>
CLMS	<a href="#">Phenology and Productivity Parameters</a>
CLMS	<a href="#">Vegetation Indices</a>
CLMS	<a href="#">EU-DEM</a>
third-party	In-situ air temperature
third-party	Material Maps (from URBANFLUXES)
third-party	Buildings and Trees Height (from URBANFLUXES)

Table 47. List of relevant datasets for AP09

Urban Atlas Building Heights requested are not available for Heraklion. The rest of the requested Copernicus CS datasets are available.

For the Urban Heat Storage Monitoring in local scale, the same baseline land cover, vegetation and built-up dynamics information is necessary to AP01. In addition, 3D information on the buildings and trees height is necessary, information on the building materials and their thermal properties,

<sup>51</sup> <https://gis.ncdc.noaa.gov/maps/ncei/cdo/hourly>



as well as air temperature measurements. 3D info for Heraklion and Basel are available from the URBANFLUXES project. Meteorological measurements including air temperature, are available from the FORTH stations network for Heraklion and the UNIBAS stations network for Basel.

### 3.4.10 AP10 Nature Based Solutions (Tecnalia, DLR, FORTH)

The AP10 will be implemented for Sofia. The plan is to implement the service for the most recent year with available data (2018).

CLMS	<a href="#">Imperviousness</a>
CLMS	<a href="#">Urban Atlas</a>
CLMS	<a href="#">Urban Atlas: Building Heights</a>
CLMS	<a href="#">Urban Atlas: Street Tree Layer</a>
CLMS	<a href="#">Land Surface Temperature</a>
CLMS	<a href="#">Land Surface Temperature</a>
CLMS	<a href="#">Surface Albedo</a>
CLMS	<a href="#">Fraction of Green Vegetation Cover</a>
CLMS	<a href="#">Leaf Area Index</a>
CLMS	<a href="#">Normalized Difference Vegetation Index (NDVI)</a>
CLMS	<a href="#">Vegetation Condition Index</a>
CLMS	<a href="#">European Image Mosaic - High Resolution</a>
third-party	Cadastral maps
third-party	3D city models City GMS / LIDAR scanning data
third-party	Data on buildings incl. age of buildings construction
third-party	Information on potential regulations on the installation of green roofs

Table 48. List of relevant datasets for AP10

All the requested datasets from CLMS are available for the year 2018 for Sofia. For the LST information, the LST product from CURE AP01 will be exploited, with the same spatial resolution (100 m) as the CLMS LST product, but the AP01 LST product accounts for urban surface as well, while the CLMS products assume the surface a mixture of vegetation and bare soil, therefore not suitable for cities. The CLMS LST product may be used for comparisons.

Additionally, from the third-party input data, the VHR information on the city structure in 2D and 3D is needed for the AP10. Therefore, the local cadastral maps and 3D city models (from City GMS or LIDAR scanning) need to be provided by the city. These inputs should serve in particular for identification of listed buildings. Also, the service providers are interested in data on buildings' age of construction, in case such data can be provided by the city. The information on regulations on the installation of green roofs (if there are some regulations that limit installation) would be also helpful for the service provider.



### 3.4.11 AP11 Health Impact (ApHER, VITO)

The AP10 will be implemented for Copenhagen and Sofia. The plan is to implement the service for the most recent year with available data (2018).

CAMS	<a href="#">European-scale air quality analysis from CHIMERE - carbon monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from CHIMERE - nitrogen dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from CHIMERE - nitrogen monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from CHIMERE - NMVOCs</a>
CAMS	<a href="#">European-scale air quality analysis from CHIMERE - ozone</a>
CAMS	<a href="#">European-scale air quality analysis from CHIMERE - PANs</a>
CAMS	<a href="#">European-scale air quality analysis from CHIMERE - PM10</a>
CAMS	<a href="#">European-scale air quality analysis from CHIMERE - PM2.5</a>
CAMS	<a href="#">European-scale air quality analysis from CHIMERE - sulphur dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - ammonia</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - carbon monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - nitrogen dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - nitrogen monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - NMVOCs</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - ozone</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - PANs</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - PM10</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - PM2.5</a>
CAMS	<a href="#">European-scale air quality analysis from EMEP - sulphur dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - ammonia</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - carbon monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - nitrogen dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - nitrogen monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - NMVOCs</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - ozone</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - PANs</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - PM10</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - PM2.5</a>
CAMS	<a href="#">European-scale air quality analysis from EURAD - sulphur dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - ammonia</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - carbon monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - nitrogen dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - nitrogen monoxide</a>



CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - NMVOCs</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - ozone</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - PANs</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - PM10</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - PM2.5</a>
CAMS	<a href="#">European-scale air quality analysis from LOTOS-EUROS - sulphur dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - ammonia</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - carbon monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - nitrogen dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - nitrogen monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - NMVOCs</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - ozone</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - PANs</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - PM10</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - PM2.5</a>
CAMS	<a href="#">European-scale air quality analysis from MATCH - sulphur dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - ammonia</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - carbon monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - nitrogen dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - nitrogen monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - NMVOCs</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - ozone</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - PANs</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - PM10</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - PM2.5</a>
CAMS	<a href="#">European-scale air quality analysis from MOCAGE - sulphur dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - ammonia</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - carbon monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - nitrogen dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - nitrogen monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - NMVOCs</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - ozone</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - PANs</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - PM10</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - PM2.5</a>
CAMS	<a href="#">European-scale air quality analysis from model ensemble - sulphur dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - ammonia</a>





CAMS	<a href="#">European-scale air quality analysis from SILAM - carbon monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - nitrogen dioxide</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - nitrogen monoxide</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - NMVOCs</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - ozone</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - PANs</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - PM10</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - PM2.5</a>
CAMS	<a href="#">European-scale air quality analysis from SILAM - sulphur dioxide</a>
third-party	Patient register data
third-party	Air Quality street data

Table 49. List of relevant datasets for AP11

For the CURE AP11, the CAMS data about air quality will be widely used, complemented by local street data on air quality and data from patient registers of the cities.



## 4 CONCLUSION

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The aim of WP2 is to identify relevant source datasets required as input for the CURE cross-cutting applications development (WP3) and make them available in an automated way via a standard CURE Interface (for WP4).

This document provides both:

- detailed specification of each data source for each particular CURE applications implementation for particular city
- concept and technical specifications of the CURE Interface providing support by means of automation of data resources needed by each CURE application

The main focus is put on the datasets currently or in the future available in the frame of Copernicus portfolio of Core Services. Copernicus data portfolio represents a huge source of valuable and harmonized information and, in the CURE project, we aim to maximally exploit its benefits. Among others, the use of Copernicus data as the main input for the CURE applications secures easy replicability for most of European cities in the future. While implementing the CURE Interface allowing access to the CCS repositories, we also aim to maximally exploit the possibilities provided by DIAS.

Although this document is mainly dedicated to Copernicus resources, yet provides ideas and solutions also for non-Copernicus input datasets, in particular for Open Data sources in general and available in CURE cities in particular. In this first deliverable, we focus on the front-runner pilot cities, where also user requirements are consolidated to the level that even detailed data requirements can be evaluated and summarized. Follower cities will be included in the document update according to the project schedule.

Beside the above described work, in order to facilitate further CURE applications development, automation and testing, also offline data packages have been prepared for each particular CURE application implementation for particular cities to bridge these needs until the CURE Interface is fully implemented. The final CURE interface will be implemented during the next project period in close collaboration with WP4 and WP3 to fulfil needs of both the CURE System implementation as well as of particular thematic applications.



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- Copernicus Global Land Service website: <https://land.copernicus.vgt.vito.be/>
- Copernicus Land Monitoring Service website: <https://land.copernicus.eu/>
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- Sentinel Online: <https://sentinels.copernicus.eu/>